PATENT SPECIFICATION (11) 1 594 031

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(21) Application No. 38696/77 (22) Filed 16 Sept. 1977
(31) Convention Application Nos.
2 641 785 (32) Filed 17 Sept. 1976 in
2 641 855
(33) Fed. Rep. of Germany (DE)
(44) Complete Specification published 30 July 1981
(51) INT. CL.³ E21D 23/04
(52) Index at acceptance
E1P 2E1B 2E5D 2E5L 2E5M 2E7 2E8
E1F 58

(54) ADVANCING SUPPORT STRUCTURES FOR GALLERIES IN MINES AND TUNNEL CONSTRUCTION

(71) We, SALZGITTER MASCHINEN AKTIENGESELLSCHAFT, a German joint stock Company, of 3327 Salzgitter-Bad, Federal Republic of Germany, do hereby

declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following Statement:–

This invention relates to a self-advancing underground roof support, in particular a preliminary support for galleries in mines and tunnel construction, of the kind comprising a pair of support units movable relatively to each other for effecting advancement of the support, each support unit having an arched frame carrying roof-supporting members extending forwardly and rearwardly therefrom, the roof-supporting members of one support unit interfitting between, and overlapping, the roof-supporting members of the other support unit, and means for moving the pair of support units towards and away from each other for effecting advancement of the support.

A known advancing gallery support structure is disclosed in German Published Application (DOS) No. 2,363,488. In this known support structure there is provided two interposed pairs of frames which advance turn by turn, the leading frame of the trailing pair of frames directly following the leading frame of of the leading pair of frames. The execution of an advancing step requires both frames of a pair to be released and advanced and then to be retightened in their fresh positions. This has the drawback that the load-bearing ability of the support structure is reduced by half during advance and until the step has been completed and the two frames retightened. The result is that the roof tends to sag undesirably during this time with a consequent reduction of the subsequent load-bearing capacity of the support structure. A further drawback of this known support structure is that it is of limited length necessitating the positioning of permanent supports in sections of the gallery which for geological, engineering or organisational reasons should best still be supported by a temporary support structure. Finally there is the drawback that the advance of the trailing frames controls the erection of the permanent supports. Consequently the work of erecting and completing the permanent support must be organisationally synchronised with the rate of advance of the face, a requirement which cannot always be fulfilled, and which is likely to cause difficulties in operation.

The drawbacks mentioned above of this known support structure have been overcome by the support system described and claimed in U.K. Patent Specification No. 1,561,496. This known support system comprises a plurality of roof supports of the kind referred to arranged one behind the other, the support system providing adequate roof support when the individual roof supports of the kind referred to have their support units spaced apart or contracted together. This known support system therefore makes it possible to separate the work of setting up the permanent structure spatially from the work at the face, and to install the advancing gallery support system so that the excavation of the face does not directly determine the progress of the installation of the permanent gallery structure.

The advance of a preliminary gallery support structure must, however, be carried out in such a way that it follows a predetermined path, irrespective of differences in the level of the gallery floor. It should also be possible to control the direction of the advance, e.g. to follow curves in the horizontal and/or vertical plane.

The first part of this problem has been solved by a known advancing preliminary gallery support structure described in German Patent Specification No. 1,089,710. This known gallery support structure comprises separate slidingly interengaged units each comprising a plurality of frames attached to a rail, the frames being ranged behind each other in the longitudinal direction of the gallery. The rails of an adjacent pair of units slidingly interengage with each other so that either unit is able to slide in the longitudinal direction relative to the other

unit. The units are each provided with variable length props for supporting the units on the floor and the props of one unit are raised from the floor when it is desired to move that one unit longitudinally relative to the other unit. However, the interengaging rails of this known gallery support structure are rigid and prevent curves in the vertical and/or horizontal plane from being followed (i.e. the second part of the problem referred to above).

The present invention seeks to solve both parts of the problem referred to above by the provision of a self-advancing underground roof support of the kind referred to, which can be used to provide a support system comprising a plurality of such supports arranged one behind the other, and which is able to follow curves in the vertical and/or horizontal plane.

According to the present invention a self-advancing underground roof support of the kind referred to is characterised in that the pair of support units, which are supported on the floor by variable length props, are connected together by rails above extensible parts of the props, in that each rail is fixed to one support unit by means of a horizontal pivot and is supported in the other support unit in guide means to enable the said other support unit to slide along the rail, to turn relative to the rail about a substantially horizontal axis, and to turn relative to the rail about a substantially vertical axis, and in that the support units include thrust piston drive units having moving parts which engage portions of the rails which are positioned outwardly of the pivots and guide means parallel to the direction of advancement of the support and which act substantially perpendicularly to the rails for effecting the tilting of the rails.

Each of the support units can thus be turned relative to the rails about horizontal axes enabling the self-advancing underground roof support to negotiate steps in the floor of a gallery. The provision of said guide means enables the support unit which is advancing at any given time to be moved along the rails, either by moving the rails together with the advancing unit whilst the other support unit remains stationary or by moving the advancing along the rail whilst the latter remains stationary. The thrust piston drive units acting on the rails are used to deflect the rails and thus determine the amount by which the support units can be deflected in the vertical plane as the support units advance.

The invention has the advantage that the self-advancing underground roof support is guided accurately without having to be used in a straight gallery section. On the contrary, it can advance through horizontal and/or vertical curves without difficulty. For this reason, this roof support is particularly suitable for galleries with many curves, such as, for example, the headings in coal mines.

Preferably, and according to a further feature of the invention, a rail is arranged on each side of the support, the moving means being provided by two further thrust piston drive units each connected at its opposite ends to different ones of the pair of support units together with another thrust piston drive unit arranged in the roof of the support.

By variously loading the thrust piston drive units, curves in the vertical and/or horizontal plane can be traversed in a controlled manner. If the thrust piston drive units are driven synchronously in and out, then the self-advancing underground roof support is moved in a straight line.

Suitably each rail is mounted on each support unit between two substantially vertical walls which house either a pivot pin for the said pivot or a pair of pins, one above and one below the rail concerned, constituting the said guide means, the thrust piston drive units acting on the rails being pivotally suspended with their cylinders between the walls on pivoting axes parallel to the said pins, whilst the piston rod ends appertaining thereto terminate in shoes which engage upper surfaces of the rails concerned and run in straight guides provided in the walls.

The mounting of the rails between substantially vertical walls ensures the precise guiding of the support units on the rails and at the same time enables the said pins to be fixed according to requirements, and also provides a protected housing for the cylinder of the thrust piston drive units which act on the rails. These thrust piston drive units are suspended free from moment between the walls, so that they cannot be damaged even with high stressing.

Each support unit may be provided with a pair of said props along each of its sides one behind the other and connected together by common baseplates, each prop being mounted to allow a limited deflection out of the vertical, and a pair of transversely extending curved arch segments extending from one side to the other side of the support above the props.

In this way stable support units are created which thus require only a small amount of bracing to support the weight of the underground roof in order to be able to carry out their movement function.

Occasionally, i.e. particularly when traversing caved-in sections of a gallery, it is impossible for the pair of support units not to lose contact with the roof. In this instance, it is not possible to brace the stationary unit as opposed to the advancing unit. However it is still possible for the support to advance, even when there is no contact with the roof, by arranging for at least one extensible support

element to be arranged both at the front of the front support unit and at the rear of the rear support unit. This makes it possible for the support unit advancing at the time to be additionally braced against the floor.

More specifically, the arrangement is designed so that the or each extensible support element arranged at the front of the front support unit is attached to the front support unit and the or each extensible support element arranged at the rear of the rear support unit is attached to the rear end of the rails or an associated rail.

A self-advancing underground roof support of this kind has the advantage that it can follow the progress of the driving of the gallery directly, and it is therefore particularly suitable for gallery driving with full or partial cutting machines; in addition, it provides the preliminary support for a gallery which receives its permanent supports at a suitable distance from the working face. According to the nature of the roof found, it can be necessary to complement the support of the roof by the roof-supporting members, e.g. capping plates, on the frames by using cladding. Cladding mats often have fastenings which make it possible to produce from a number of successive lengths of matting a strip of matting which can be pulled taut, extending in the longitudinal direction of the gallery and providing a relatively stronger cladding than other mats which do not have any fixed fastenings, or only an inadequate number. A taut strip of mats also has the advantage that the mats cannot be released from their interconnection.

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

Figure 1*a* is a side view of the lower part of a self-advancing underground roof support according to the invention,

Figure 1*b* is a partly section side view of the upper part of the support shown in Figure 1*a*,

Figures 2*a* and 2*b* are end views of the roof support of Figure 1*a*, Figure 2*a* showing one side and the roof of the support and Figure 2*b* showing the other side of the support,

Figure 3 gives three illustrations arranged one under the other, each showing schematically in side view two phases of the advancing process of the roof support shown in Figures 1*a*, 1*b* and 2*a*, 2*b*,

Figure 4 shows in plan three roof supports, each as shown in Figures 1*a*, 1*b*, 2*a* and 2*b*, arranged adjacent to each other and positioned on a curve, and

Figure 5 shows in side view three illustrations of the advance of an embodiment of a self-advancing underground roof support according to the invention when contact with the roof has been lost.

Figures 1*a* and 1*b* show a self-advancing underground roof support, given the general reference numeral 1, and comprising two support units 2 and 3. The support units are of identical construction in their main parts, so that it will suffice initially to describe only one of the support units.

Each support unit has two frames 4 and 5, which each form a curved or arched segment which consists of a continuous I – structural section, bent to correspond to the contour of a gallery roof. The two frames 4 and 5 are linked together by means of connecting pieces 6. Roof-supporting members in the form of frame capping plates 7 are arranged at intervals round the contours of the frames 4, 5 and are pivoted in the way shown in Figure 1*b*. The mounting of the frame capping plates is not the subject of the invention so that the following indication will suffice: Each frame capping plate has a horizontal linkage 8, by means of which not only the frame capping plate but also a linkage lever 9 and the piston rod 10 of a thrust piston drive unit are also attached pivotably in their turn, whilst the free end of the lever 9 is attached at a hinge 13. By moving the thrust piston drive mechanism 11 out, the frame capping plates can be braced against the roof of the gallery.

The frame capping plates 7 of the support unit 2 are arranged in such a way that the frame capping plates 18 of the support unit 3 slot in between the frame capping plates 7, and the capping plates 7 and 18 partially overlap.

The support 1 suitably constitutes one of a plurality of similar supports arranged one behind the other to provide a support system. Although not shown, any adjacent pair of supports are so arranged that the capping plates 18 of the rear support unit 3 of the leading support 1 overlap the capping plates of the front support unit (not shown) of the trailing support (also not shown), and that these capping plates 18 slot in, or interfit, between the capping plates of the other support.

As can be seen from the illustration in Figure 2*a* and 2*b*, the frames 4 and 5 are joined by means of gusset plates 20 and 21, together with a heavy baseplate 22 which is attached to a box-type construction 23. On the outer face of the box-type construction 23 nearest to the gallery roof there are two substantially vertical walls which are made of heavy metal plates 24 and 25, respectively. These plates are fitted at the bottom with a baseplate 26. This construction forms a rigid guide 27 on the front support unit 2 and a correspondingly rigid guide 28 on the rear support unit 3. It should be noted that the baseplate 26 in the rigid guide 27 on the front support unit slopes from the top rear towards the front bottom, whilst in the guide 28 on the rear support unit 3 it slopes from the top front towards the rear bottom.

Between the two perpendicular plates of the guide units 27 and 28 a rail 29 is arranged. The rail 29 is fixed to the front support unit 2 by means of a pivot 30. The pivot, which can be seen in Figure 2, consists of a pin 31, which passes through the crosspiece 32 of the rail as well as the two side walls 24 and 25. The rail 29 can therefore be deflected about the pivot 30 in a generally vertical plane. The amount of its deflection is determined by a thrust piston drive unit which acts on the free end 35 of the rail 29. A shoe 36 is attached to the piston rod end of the thrust piston drive unit and comprises a crossbolt 38 which is guided in a substantially vertical straight guide formed by an elongate hole 37 provided in each of the vertical walls 24 and 25. The thrust piston drive unit is pivotably suspended by its cylinder 41 via a horizontal pin 39 in brackets 40 and 42. The rail can therefore be movably supported on its end 35 with its upper face 44 under the shoe 36 without any moment being transmitted to the thrust piston drive unit.

On the rear rigid guide 28 of the support unit 3 the rail 29 is guided by means of guide means 48. The guide means 48 is formed from two horizontal link pins 49, 50, as can be seen in Figure 2*b*. The upper face 51 of the end 35 of the rail 29 is supported on the link pin 50, whilst the lower face 53 of the end 35' of the rail 29 is supported on the lower link pin 49. Accordingly, the rail 29 can turn or be deflected relative to the support unit 3 in the guide means 48 about a horizontal axis and about a vertical axis and can also be slidingly displaced relative to the support unit 3 in the guide means 48 formed by the link pins 49 and 50.

Behind the guide means 48 formed by the pins 49 and 50 the rail 29 is again supported on a shoe 55 of a thrust piston drive unit which is not shown in Figures 1*a*, 1*b*, 2*a* or 2*b*. This thrust piston drive unit is arranged and constructed like the thrust piston drive unit 41 of the front support unit 2. It is therefore similarly suspended and is supported on the upper face of the end 35' of the rail 29.

In each box-type construction there are brackets 60 to take horizontal linkage bolts 61, by which cylinders 62 of each two props or supports 63, 64 are pivotably mounted; the extensible parts 65 and 66 of the latter being connected at their ends to base-plates 67 on which the extensible parts 65 and 66 are supported via ball ends 68 and 69. The arrangement of the props 63 and 64 is the same in both support unit 2 and support unit 3, so that a description of this relative to support unit 3 is unnecessary.

The props 63 and 64 are also fitted so that they can be deflected 5° out of the vertical in any direction, as Figures 1*a* and 2*a* show at 57. This construction allows each unit to adapt to differences in the level of the floor of the gallery.

The advancing mechanism in the construction example shown consists primarily of a thrust piston drive unit 70, appertaining to each of the rails 29, the cylinder of which is given the reference 71 or 72 respectively (Figures 1*a* and 2*b*), its piston rod being designated 73. The piston rod of each thrust piston drive unit is linked with a clevis 74 via a horizontal link bolt 75 to a bracket 76 on the rigid guide 27 concerned, whilst the cylinder 71, 72 is linked via a forked bracket 77 by means of a similarly horizontal link bolt 78 to the rear rigid guide 28.

In addition to the two thrust piston drive units 70, the advancing mechanism comprises another thrust piston drive mounted in the gallery roof at 80, and shown at 81.

The advance movement of the above described support 1 is shown schematically in Figures 3 and 4. In the upper illustration in Figure 3 the synchronous expansion or outwards movement of the thrust piston drive units 71, 72 and 81 is represented. The front support unit 2, with its capping plates 7 lowered, advances as the piston rods of the drive units 71, 72 and 81 move out, the rear support unit 3 being braced against the gallery roof by its capping plates 18 (position shown on the right in the upper illustration in Figure 4). When the piston rods of the drive units 71, 72 and 81 are fully extended, the capping plates 18 are lowered, the support unit 2 is held fast by the bracing of its capping plates 7 against the gallery roof, and the piston rods of the drive units 71, 72 and 81 are moved in causing the rear support unit 3 to advance towards the front support unit 2.

If a fault in the floor of the gallery, as indicated at 90 in the phase shown on the left in the central illustration, is to be traversed downwards, then the piston rod of the thrust piston drive unit 56 is moved in and the piston rod of the thrust piston drive unit 41 is moved out. This causes the rail 29 to be deflected about the horizontal axes of its pivot 30 and the guide means 48, in which the rail 29 is in turn guided. By moving the thrust piston drive units 71, 72 and 81 out, the support unit 2 can then move with the rail 29 as the latter slides in the guide means 48.

Conversely, to overcome a step 91 upwards (right-hand phase in the central illustration in Figure 3), the piston rod of the thrust piston drive unit 56 is moved out and the piston rod of the thrust piston drive unit 41 is moved in, the rail 29 being deflected upwards so that the support unit 2 can be moved forwards and upwards by movement on the two rails arranged at the sides of the support 1.

In the lower illustration in Figure 3 variations in the slope of the gallery are indicated at 92 and 93. In order to be able to set the support units 2 and 3 of the support perpen-

dicular to the stratification, the thrust piston drive units are moved out differently.

To overcome an upwards deflection 92 in the slope, the piston rod of the upper thrust piston drive unit 81 is moved out by a lesser amount than the piston rods of the thrust piston drive units 71 and 72, so that the support unit 2 is deflected about the pivot 30. At the same time, by moving out the piston rods of the thrust piston drive units 56 and 41 the necessary incline of the rails 29 is produced, so that the support 1 can be moved on the path produced by the rails 29. On the other hand, with a variation in the slope corresponding to 93 in the right-hand phase in the lower illustration in Figure 3, the upper thrust piston drive unit 81 is moved out more than the thrust piston drive units 71 and 72 arranged on the side walls. The position of the rails 29 is again produced by the extended position of the thrust piston drive units 56 and 41.

As was explained with reference to the lower illustration in Figure 3, by moving the piston rods of the thrust piston drive units 71 and 72 and/or 81 by different amounts, curves can also be traversed, as is shown in Figure 4.

An embodiment is shown in Figure 5 which makes an advancing movement possible without contact with the gallery roof. For this purpose, an extensible support element 100 is arranged on the front support unit 2 of the support 1. The support element 100 comprises a thrust piston mechanism, the cylinder of which is attached at 101 to the front of the rigid guide 27, the piston rod 102 being fitted with a skid 103 in the form of a shoe which can be supported on the gallery floor 104. The rear end 35' of each rail 29 is in turn fitted with an extensible support element or mechanism 105, the cylinder of which is attached at 106 to the outer end of the rail, whilst the piston rod 107 is fitted with the guide skid 108 and can rest on the floor 104.

The upper illustration in Figure 5 shows the advance movement of the rear support unit 3. Here, the extensible support element or mechanism 105 is operated by the extension of its piston rod 107. The rail is thus supported and forms a bridge on which the rear support unit 3 can advance forwards with the props 65, 66 retracted by moving the piston rods into the thrust piston drive units 81 and 71, 72.

The central illustration in Figure 5 shows the advance movement of the front support unit 2. Here, the piston rod 102 of the extensible support element 100 is extended and is supported on the floor 104. By moving the piston rods out of the cylinders of the thrust piston drive units 81 and/or 71 and/or 72, the rail 29, together with the front support unit 2, can move forwards, guided through the two link pins 49 and 50. In this instance the extensible support element or mechanism 105 is moved in or contracted.

The lower illustration in Figure 5 shows the two extensible support elements 100 and 105 contracted. This state again enables the support units 2 and 3 to be employed with their capping plates 7 and 18, respectively, extended.

In the specification of our co-pending Application No. 08754/80 (Serial No. 1 594 032), which has been divided from the present application, there is described and claimed a method of lagging a roof of a gallery and a self-advancing underground roof support.

WHAT WE CLAIM IS:–

1. A self-advancing underground roof support comprising a pair of support units movable relatively to each other for effecting advancement of the support, each support unit having an arched frame carrying roof-supporting members extending forwardly and rearwardly therefrom, the roof-supporting members of one support unit interfitting between, and overlapping, the roof-supporting members of the other support unit, and means for moving the pair of support units towards and away from each other for effecting advancement of the support, characterised in that the pair of support units, which are supported on the floor by variable length props, are connected together by rails above extensible parts of the props, in that each rail is fixed to one support unit by means of a horizontal pivot and is supported in the other support unit in guide means to enable the said other support unit to slide along the rail, to turn relative to the rail about a substantially horizontal axis, and to turn relative to the rail about a substantially vertical axis, and in that the support units include thrust piston drive units having moving parts which engage portions of the rails which are positioned outwardly of the pivots and guide means parallel to the direction of advancement of the support and which act substantially perpendicularly to the rails for effecting the tilting of the rails.

2. A self-advancing underground roof support according to claim 1, in which the pair of support units are connected by a pair of rails arranged along opposite sides of the support, and in which the moving means comprises three further thrust piston drive units each connected at its opposite ends to different ones of the pair of support units, two of said further drive units being arranged along opposite sides of the support and the other further drive unit being arranged in the roof of the support.

3. A self-advancing underground roof support according to claim 1 or 2, in which each rail is mounted on each support unit between two substantially vertical walls

which house either a pivot pin for the said pivot or a pair of pins, one above and one below the rail concerned, constituting the said guide means, the thrust piston drive units acting on the rails being pivotally suspended with their cylinders between the walls on pivoting axes parallel to the said pins, whilst the piston rod ends appertaining thereto terminate in shoes which engage upper surfaces of the rails concerned and are guided in straight guides provided in the walls.

4. A self-advancing underground roof support according to any of the preceding claims, in which each support unit has a pair of the said props arranged along each side of of the support one behind each other and connected together by common baseplates, each prop being mounted to allow a limited deflection out of the vertical, and a pair of transversely extending curved arch segments extending from one side to the other side of the support above the props.

5. A self-advancing underground roof support according to any of the preceding claims, in which the guide means is arranged on the front support unit and the said pivot is arranged on the rear support unit.

6. A self-advancing underground roof support according to any of the preceding claims, in which at least one extensible first support element is arranged at the front of the front support unit and at least one extensible second support element is arranged at the rear of the rear support unit.

7. A self-advancing underground roof support according to claim 6, in which the or each first support element is attached to the front support unit and is fitted with a skid for resting on the ground, and the or each second support element is attached to the rear end of the rails or an associated rail and is fitted with a skid for resting on the ground.

8. A self-advancing underground roof support constucted and arranged substantially as herein described with reference to, and as illustrated in, the accompanying drawings.

9. A self-advancing underground roof support system comprising a plurality of self-advancing underground roof supports according to any of the preceding claims arranged one behind the other in the direction of advancement, the roof-supporting members of the trailing support unit of the leading support of any adjacent pair of supports interfitting between, and overlapping, the roof-supporting members of the leading support unit of the trailing support.

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Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1981. Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

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Sheet 1

FIG. 1a

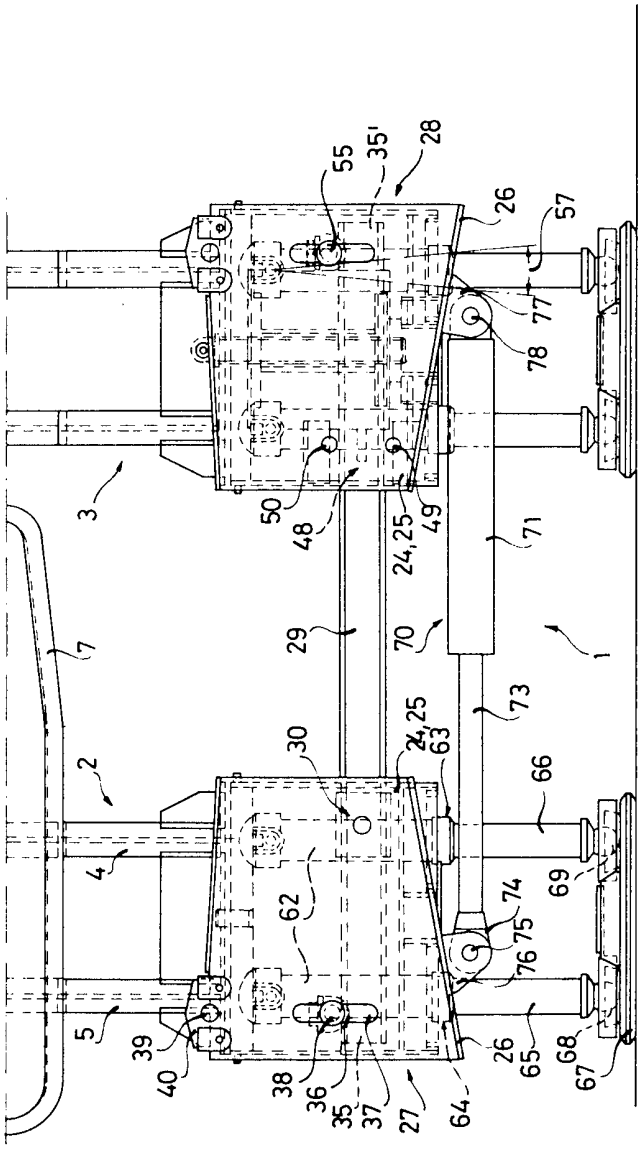

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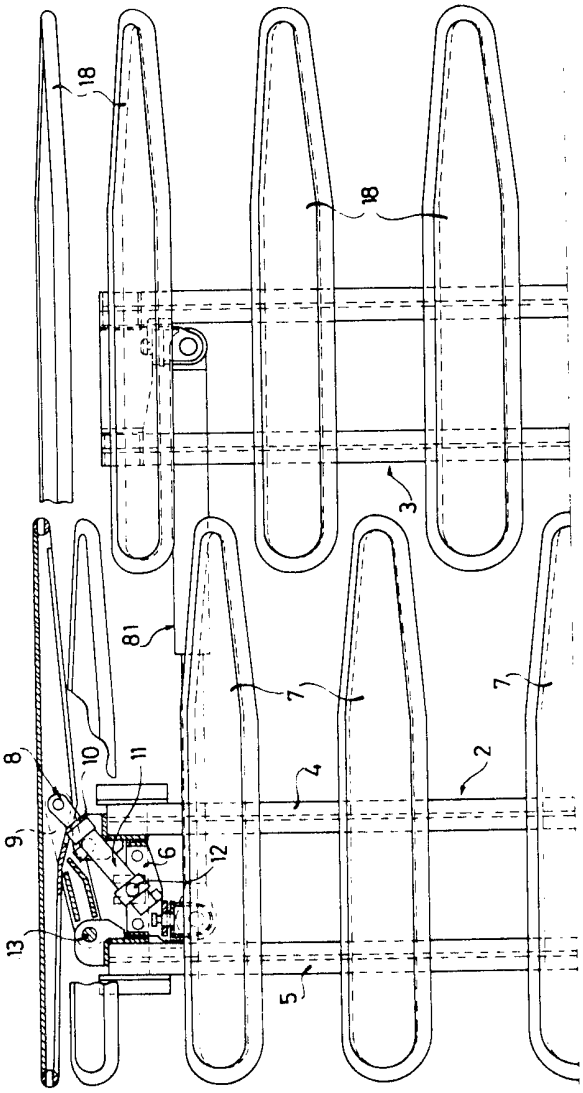
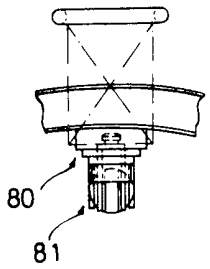
FIG. 1b

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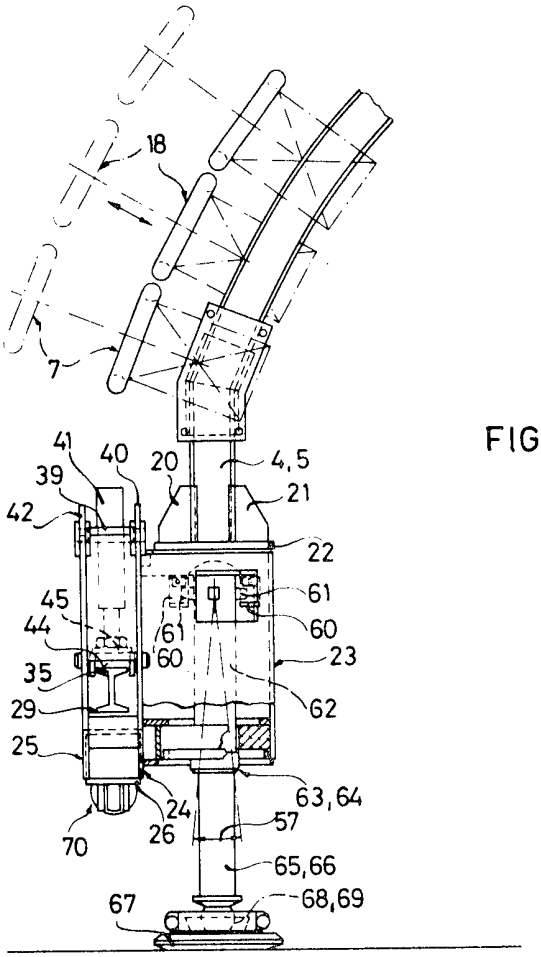
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FIG. 2a

FIG. 2b

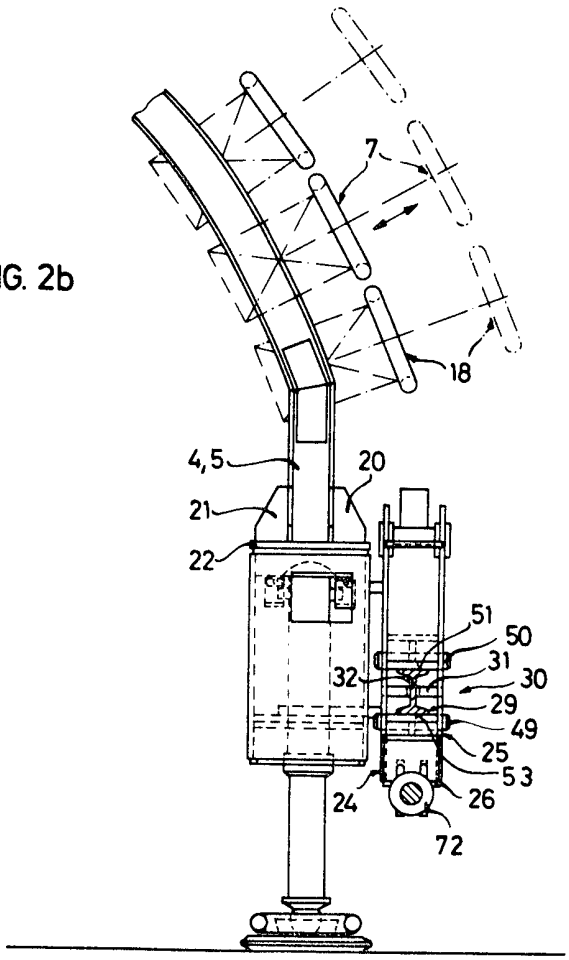
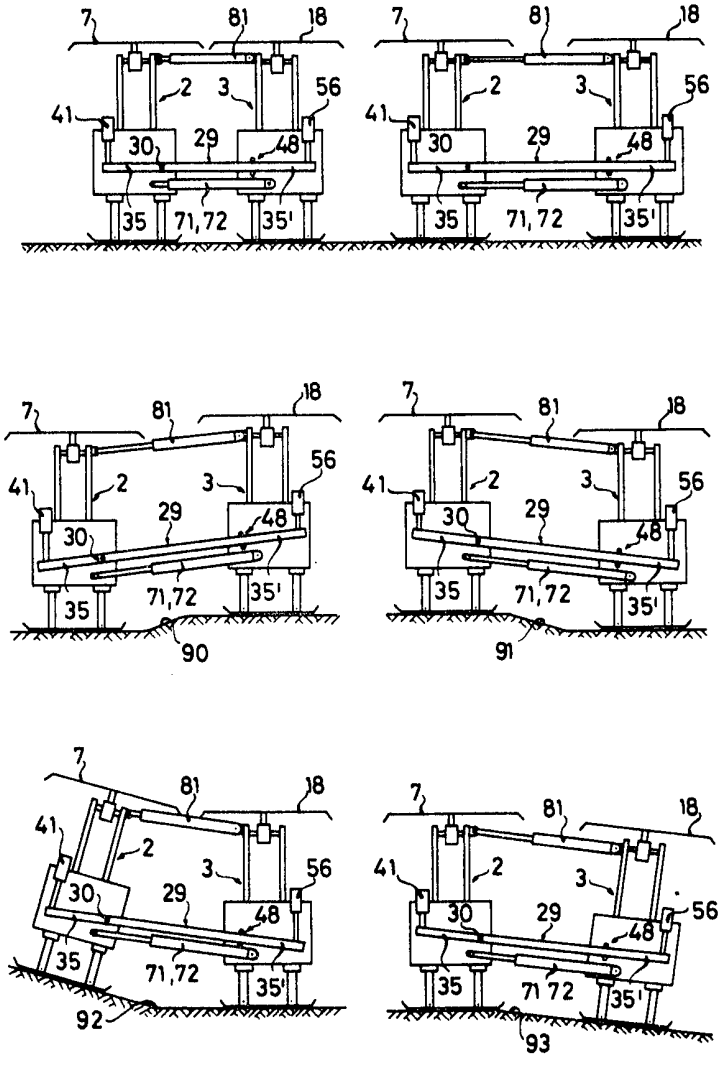


FIG. 3



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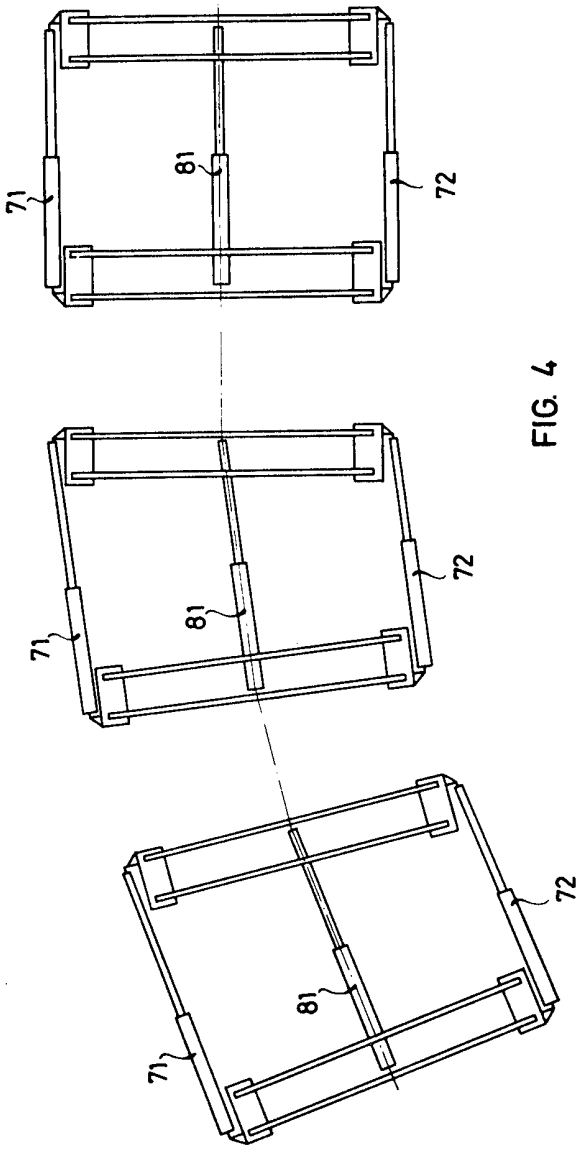
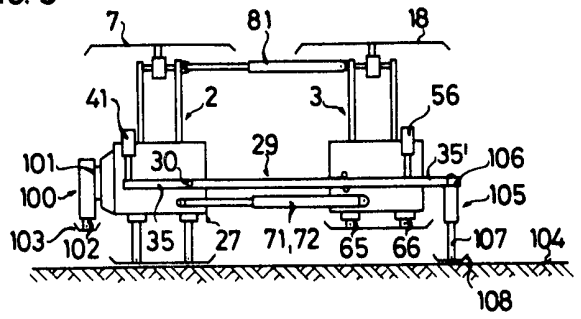


FIG. 4

FIG. 5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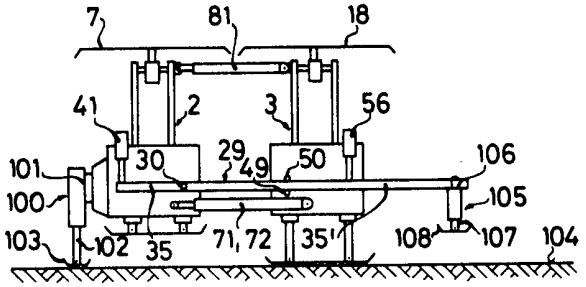
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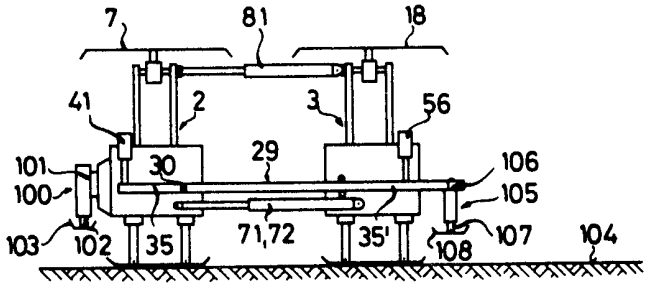
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