



(86) Date de dépôt PCT/PCT Filing Date: 1995/04/26

(87) Date publication PCT/PCT Publication Date: 1995/11/09

(45) Date de délivrance/Issue Date: 2005/12/20

(85) Entrée phase nationale/National Entry: 1996/10/29

(86) N° demande PCT/PCT Application No.: AU 1995/000242

(87) N° publication PCT/PCT Publication No.: 1995/030067

(30) Priorités/Priorities: 1994/04/29 (PM 5380) AU;
1994/12/22 (PN 0252) AU

(51) Cl.Int.⁶/Int.Cl.⁶ E21C 47/02, E21C 47/04, E21C 27/00

(72) Inventeurs/Inventors:

MARSHALL, GORDON ALEXANDER, AU;
ABELA, RENE PAUL, AU

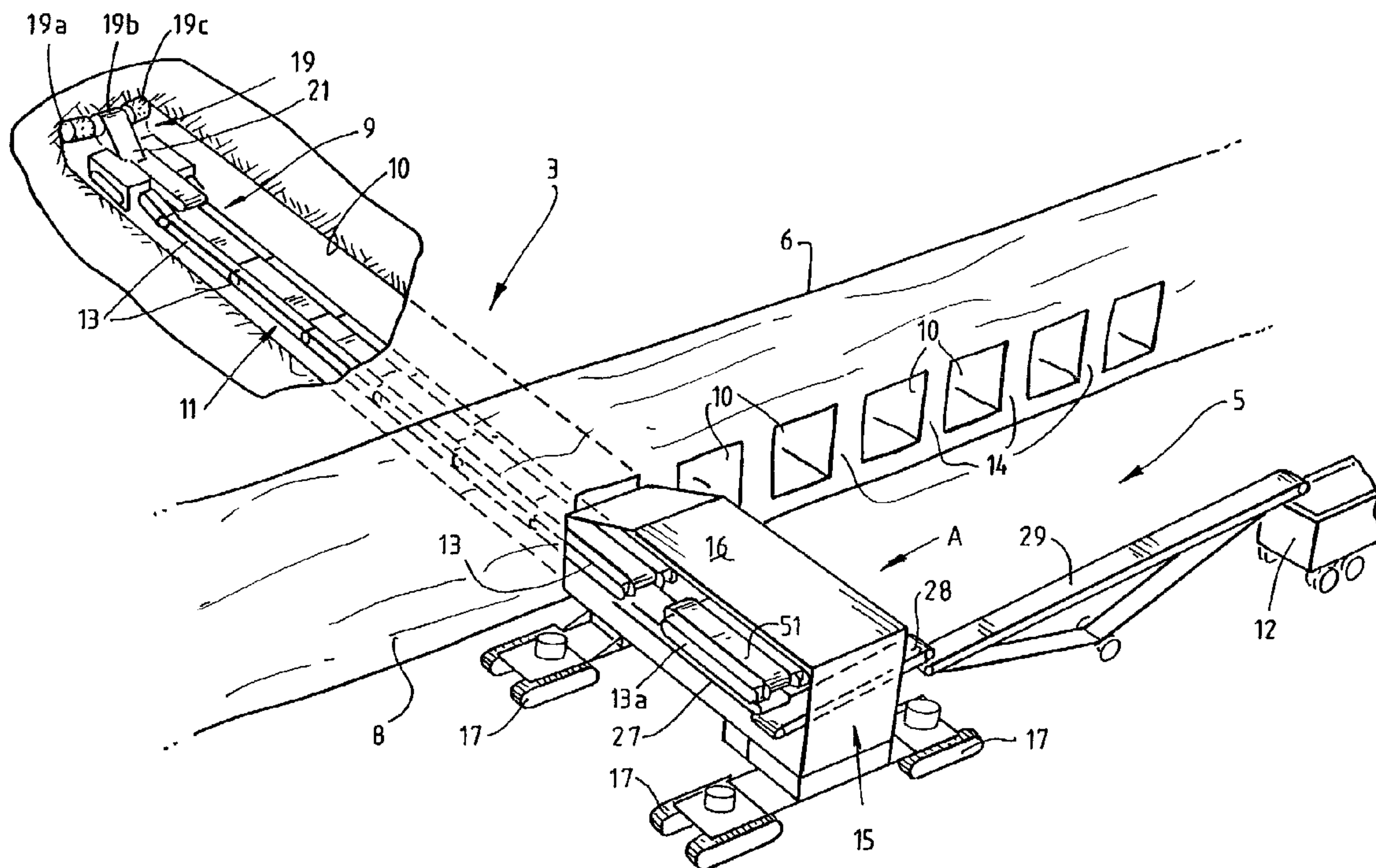
(73) Propriétaire/Owner:

THE BROKEN HILL PROPRIETARY COMPANY
LIMITED, AU

(74) Agent: OYEN WIGGS GREEN & MUTALA LLP

(54) Titre : SYSTEME D'ABATTAGE SUR PAROI HAUTE AVEC EVACUATION DU CHARBON (OU DU MINERAL)

(54) Title: A HIGHWALL MINING SYSTEM WITH MINING AND REMOVAL OF COAL (OR ORE)



(57) Abrégé/Abstract:

A highwall mining system for mining aggregate material from a seam (8) extending from a highwall (6) is disclosed. The system comprises a mining means (9) for cutting coal from the seam (8) to form a drive (10) in the seam (8) and a conveying means (11) formed from a plurality of conveyor units (13) releasably coupled together for conveying coal from the drive (10). The system further comprises a driving means for driving the mining means (9) and the conveying means (13) into the seam (8) to form the drive (10).



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification⁶:

E21C 47/02, 47/04, 27/00

A1

(11) International Publication Number:

WO 95/30067

(43) International Publication Date:

9 November 1995 (09.11.95)

(21) International Application Number: PCT/AU95/00242

(22) International Filing Date: 26 April 1995 (26.04.95)

(30) Priority Data:

PM 5380

29 April 1994 (29.04.94)

AU

PN 0252

22 December 1994 (22.12.94)

AU

(71) Applicant (for all designated States except US): THE BROKEN HILL PROPRIETARY COMPANY LIMITED [AU/AU]; 600 Bourke Street, Melbourne, VIC 3000 (AU).

(72) Inventors; and

(75) Inventors/Applicants (for US only): MARSHALL, Gordon, Alexander [GB/AU]; 4 Mabel Street, Camberwell, VIC 3124 (AU). ABELA, Rene, Paul [AU/AU]; 67 Metella Road, Toongabbie, NSW 2146 (AU).

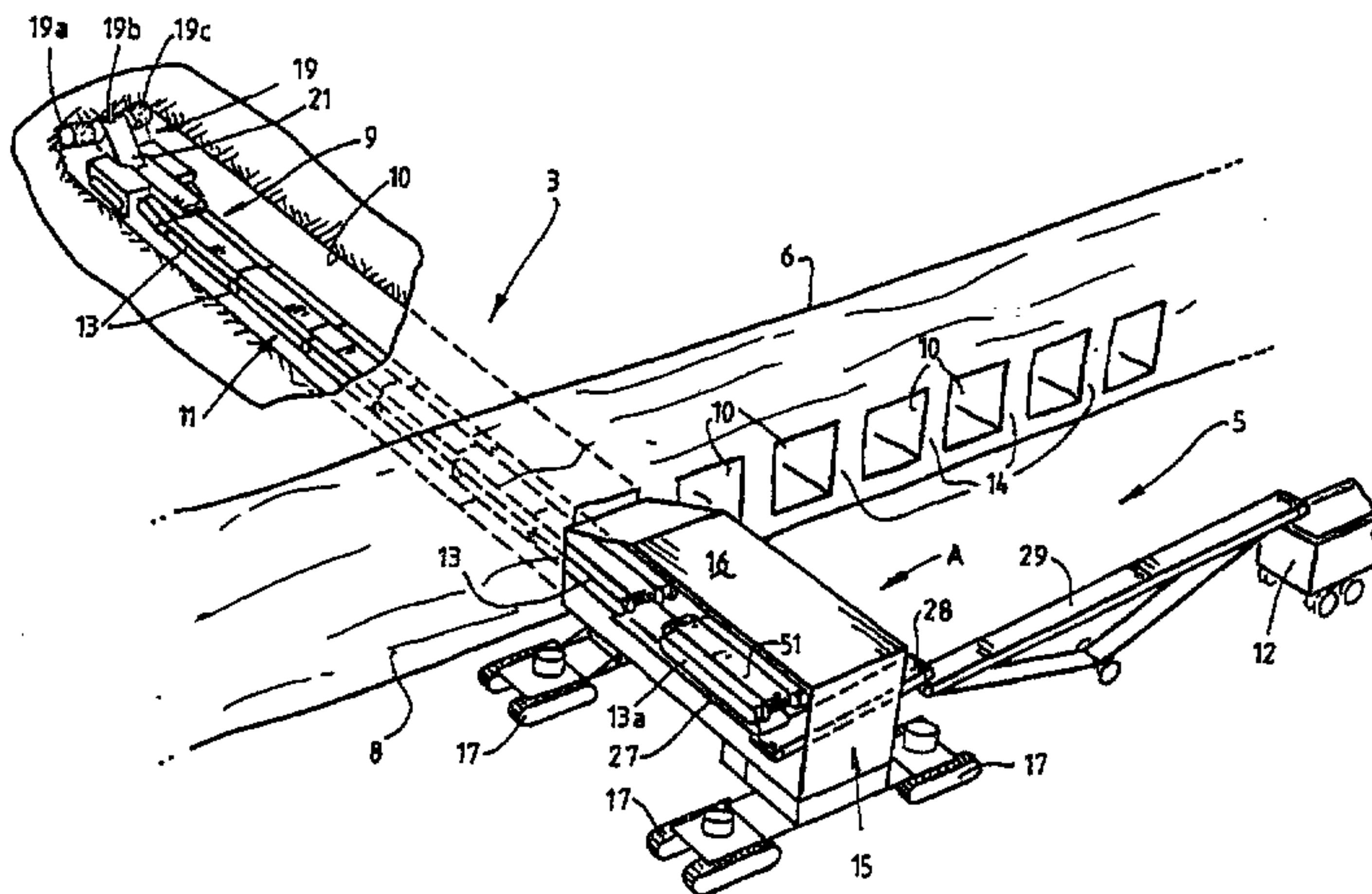
(74) Agent: GRIFFITH HACK & CO.; 509 St. Kilda Road, Melbourne, VIC 3004 (AU).

(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).

Published

With international search report.

(54) Title: A HIGHWALL MINING SYSTEM WITH MINING AND REMOVAL OF COAL (OR ORE)



(57) Abstract

A highwall mining system for mining aggregate material from a seam (8) extending from a highwall (6) is disclosed. The system comprises a mining means (9) for cutting coal from the seam (8) to form a drive (10) in the seam (8) and a conveying means (11) formed from a plurality of conveyor units (13) releasably coupled together for conveying coal from the drive (10). The system further comprises a driving means for driving the mining means (9) and the conveying means (13) into the seam (8) to form the drive (10).

- 1 -

A Highwall mining system with mining and removal of coal (or ore).

The present invention relates to highwall mining of aggregate material.

5 The present invention relates particularly, although by no means exclusively, to a highwall mining system for mining coal from a seam extending from an exposed face in a wall of an open cut mine.

10 In basic terms, the known highwall mining systems comprise a mining means for cutting coal from a seam to form a drive, a conveying means for conveying coal from the drive, and a driving means for driving the mining means and the conveying means into the seam and thereafter from the drive.

15 Highwall mining of coal offers the potential for low cost recovery of coal that cannot normally be recovered economically by conventional surface or underground mining operations.

20 One of the earliest highwall mining systems is disclosed in U.S. patent 2,826,402 of Alspaugh et al. In the Alspaugh system the driving means for the mining means and the conveying means is coupled to the mining means. In addition, the conveying means comprises a plurality of modular conveyor units releasably coupled together.

25 Furthermore, the Alspaugh system includes a launch vehicle positioned at the entry of the drive, and the launch vehicle includes a conveyor unit addition assembly which lifts a new conveyor unit into position behind the rearmost conveyor unit of the conveying means so that the new

30 conveyor unit can then be coupled to the rearmost conveyor unit. It is necessary to stop the forward movement of the

- 2 -

mining means and the conveying means in order to add a new conveyor unit to the conveying means.

Other known highwall mining systems are disclosed in U.S. patent 2,780,451 of Alspaugh et al and U.S. patent 3,135,502 of Muehlman. In these highwall mining systems the driving means for the mining means and the conveying means is also coupled to the mining means. However, in each case, the conveyor units are coupled together into a continuous train and there is no need for a conveyor unit addition assembly of the type proposed in Alspaugh U.S. patent 2,826,402.

As the highwall mining industry has developed there has been an increasing recognition that it is preferable that the driving means be located outside rather than inside a drive. As a consequence, the coupling together of the conveyor units has become a more important consideration in order to ensure effective transfer of the force applied by the driving means to the mining means and to ensure directional control of the mining means and the conveying means.

An example of the increased emphasis on the coupling together of conveyor units is the highwall mining system disclosed in Australian patent 638,367 and patent application 644,257 of Addington Resources, Inc. The conveyor units disclosed in the Addington patent/patent application are of the same general type as proposed by Alspaugh, Muehlman, and others, and the conveyor units comprise a framework mounted on a wheel assembly and a belt conveyor extending the length of the conveyor unit. However, the conveyor units are also characterised by a clevis and tongue assembly to couple together the conveyor units. The clevis/tongue assembly requires a removable locking pin to be manually inserted to complete the assembly and to couple together the conveyor units.

- 3 -

Similarly, it is necessary that the locking pin be manually removed from the clevis/tongue assembly to uncouple the conveyor units. The clevis/tongue assembly forms a semi-rigid coupling which limits relative sideways movement of the conveyor units and thus provides a reasonable degree of directional control.

The driving means disclosed in Addington patent application 644,257 comprises two sets of tandem drive cylinders, each set having one drive cylinder on each side of the conveying means, and the drive cylinders on each side of the conveying means being longitudinally aligned and spaced apart. The arrangement is such that the two sets of drive cylinders act co-operatively as a "walking" system to advance by pushing the mining means and the conveying means. The pushing force is transferred from the drive cylinders to the mining means and the conveying means via "pusher arms" coupled to the drive cylinders which are arranged to bear against lugs extending from the sides of the conveying means.

In another known highwall mining system disclosed in U.S. patent 4,014,574 of Todd, the conveyor units are of a different construction and comprise rigid box sections which transfer to a mining means the force applied by a driving means located on a launch vehicle. A new conveyor unit can only be added to the conveying means by disengaging and withdrawing the driving means to allow a new conveyor unit to be positioned and coupled to the rearmost conveyor unit of the conveying means and to the driving means.

An object of the present invention is to provide a highwall mining system which is an alternative system to and alleviates at least some of the disadvantages of the known highwall mining systems described in the preceding paragraphs.

According to the present invention there is provided a highwall mining system for mining aggregate material from a seam comprising:

- 5 (a) a mining means for cutting aggregate material from the seam and thereby forming a drive in the seam;
- 10 (b) a conveying means for conveying mined aggregate material from the drive, the conveying means comprising a plurality of modular conveyor units having a means for releasably mechanically coupling together the conveyor units; and
- 15 (c) a driving means for driving the mining means and the conveying means into the seam to form the drive.

It is preferred that the coupling be a mechanical coupling.

20 It is preferred that the coupling means of the highwall mining system be formed to allow limited relative rotation of adjacent conveyor units about a horizontal axis that is perpendicular to a longitudinal axis of the conveying means and substantially no relative rotation about a vertical axis.

25 It is preferred particularly that the coupling means also be formed to allow limited relative rotation of adjacent conveyor units about the longitudinal axis of the conveying means.

30 It is preferred more particularly that the coupling means be formed to allow substantially no relative translation of adjacent conveying units in longitudinal,

- 5 -

horizontal and vertical directions.

It can readily be appreciated that such an arrangement allows a pushing force to be transferred from conveyor unit to conveyor unit along the length of the conveying means to move the conveying means forward without jackknifing or buckling the conveyor units while allowing angular displacement in a vertical plane to allow the conveying means to follow the contours of the drive and to transfer a controlled pushing force on to the back of the mining means to increase or provide the "sumping" forces for the cutting and mining of aggregate material.

It can also readily be appreciated that such an arrangement minimises free-play in the general longitudinal direction of the conveying means and the mining means and hence the direction of advance. The minimising of free-play is advisable to control the position and straight alignment of the conveying means and the mining means and to control the forces acting on and in them. For example, the axial force within the conveying means may change from tension to compression or from compression to tension in the course of excavation of a drive due to changes in the seam incline angle, the number of conveyor units used, and/or the mining means operation, such as from "sumping" to "shearing".

It is preferred that the limited relative rotation be no more than 20°.

It is preferred particularly that the limited relative rotation be no more than 8°.

The term "substantially no relative rotation" is understood herein in the context of normal engineering tolerances and working clearances in the coal mining industry.

It is preferred that the mining means and the conveyor units comprise a means of the type described above for releasably coupling together the mining means and the conveyor units.

- 5 It is preferred that each conveyor unit of the highwall mining system comprise a belt or a chain conveyor extending over the length of the conveyor unit.

It is preferred that each conveyor unit comprise a wheel assembly.

- 10 It is preferred particularly that each conveyor unit comprise a single wheel assembly.

It is preferred more particularly that the single wheel assembly be located at one end of the conveyor unit.

- 15 It is preferred that each conveyor unit be adapted to accommodate transverse slope of the drive.

- 20 It is preferred that the coupling means comprise a male member and a complementary female member connected to the conveyor units such that the male member of one conveyor unit can be releasably received in the female member of an adjacent conveyor unit to couple together the conveyor units.

It is preferred that each male member be coupled to an associated conveyor unit for pivotal movement about a horizontal axis of the conveyor unit.

- 25 It is preferred particularly that the horizontal axis be coincident with or in the region of the axis of the wheel assembly.

It is preferred more particularly that the

- 7 -

horizontal axis be coincident with the axis of the wheel assembly.

It is preferred that each male member and each female member comprise cut-out sections that are arranged so that when the male member of one conveyor unit is received in the female member of an adjacent conveyor unit by relative movement of the conveyor units towards each other the cut-out sections form an opening that is transverse to the longitudinal direction of the conveying means.

With such an arrangement, it is preferred that the coupling means further comprise a locking pin that is moveable into the opening thereby to prevent disengagement of the male and the female members.

It is preferred that the cut-out sections form a circular opening.

It is preferred that the coupling means comprise a means for moving the locking pin into and from locking engagement in the opening. It is noted that the locking pin moving means may be actuated manually or automatically.

It is preferred that the coupling means comprise a pair of the male members on each side at one end and a pair of the female members on each side at the other end of each conveyor unit.

With such an arrangement, it is preferred that the openings formed when, in use, the male members of one conveyor unit are received in the female members of an adjacent conveyor unit be aligned.

It is preferred that the highwall mining system further comprises a means for electrically coupling a new

- 8 -

conveyor unit to the end conveyor unit of the conveying means automatically as the male members of one conveyor unit are received in the female members of the other conveyor unit.

5 It is preferred that the highwall mining system further comprises a control means for actuating the supply of electrical power to the new conveyor unit after a series of pre-conditions for supply have been met.

10 It is noted that the supply of electrical power may be manually or automatically actuated via the control means.

15 It is preferred that the highwall mining system further comprise a controlling means for controlling forward movement of the mining means and the conveying means so that the mining means and the conveying means can move forward together at a predetermined rate of advance into the seam without there being any uncontrolled forward movement of the mining means and/or the conveying means in response to the incline of the seam and/or during the addition of a new conveyor unit to the conveying means.

20 The controlling means is an important feature of the present invention in order to operate the highwall mining system in a dipping seam where it is necessary that the mining means and the conveying means move forward together in a controlled way. It is an important feature, by way of example, in order to avoid the risk that the conveying means, when on an inclined surface, may apply excessive force onto the back of and thereby jam or damage the mining means. It is also an important feature in order to prevent uncontrolled forward movement of the mining means on an inclined surface that may result in uncontrolled cutting of aggregate material and unwanted reaction forces acting on the mining means due to the

- 9 -

mining means engaging the seam.

The controlling means is also an important feature in order to control or restrain the conveying means and the mining means, not only while advancing, but also on withdrawal and/or while stationary and/or while adding or removing conveyor units to extend or shorten the length of the conveying means so that maintaining the position of the conveying means and mining means does not rely only on friction between the conveying means and the mining means and the ground.

The term "dipping seam" is understood herein to mean a seam that is inclined downwardly or upwardly at an average angle of incline of at least 4° to the horizontal over the length of the seam and/or in the region of the seam where highwall mining is to be utilised.

It is noted that the term "dipping seam" is understood herein to cover seams which undulate and have sections which are horizontal or slightly inclined (upwardly or downwardly) provided that over the length of the seam there is an average angle of incline downwardly or upwardly of at least 4°.

It is also noted that the direction of advance of highwall mining into the seam is understood to be generally in the direction of the downward incline of the dipping seam and typically at, but not limited to, a right angle to the general direction of the highwall where the seam is exposed.

It is preferred that the controlling means be located externally to the drive.

It is preferred that the driving means of the highwall mining system be located externally to the drive

10 -

and arranged for pushing the mining means and the conveying means into the seam and for pulling the mining means and the conveying means from the drive.

5 In one arrangement it is preferred that the mining means of the highwall mining system be a continuous miner that is not self-propelled.

10 In an alternative arrangement it is preferred that the mining means be a continuous miner that is self-propelled so that the driving means comprises the continuous miner.

It is preferred that the mining means be a high capacity self-propelled continuous miner.

15 It is preferred that the mining means be a continuous miner which comprises a plurality of cutting picks on a rotatable cutting drum mounted on the end of a boom that is supported for pivotal movement about a horizontal axis.

20 It is preferred particularly that the mining means be remotely controlled and tele-operated from outside the drive.

In addition, it is preferred particularly that the mining means have side pusher pads for steering and bottom pusher pads for transverse levelling.

25 It is preferred that the highwall mining system comprise a launch platform adapted to be positioned at the entrance to the drive, the launch platform comprising a deck for supporting and guiding the mining means initially into the seam to start the drive and thereafter for
30 supporting and guiding the conveying means into the drive as the drive is extended into the seam.

- 11 -

It is preferred that the launch platform comprises a means for adjusting the angle of inclination of the deck relative to a support frame of the launch platform.

5 In one arrangement, it is preferred that the launch platform further comprises a launch platform conveyor for receiving and discharging aggregate material from the end of the conveying means.

10 It is preferred particularly that the launch platform conveyor be a belly conveyor.

In an alternative arrangement, it is preferred that the launch platform comprises a side discharge conveyor parallel to the deck for receiving aggregate material discharged from the conveying means.

15 With such an arrangement it is preferred that the launch platform further comprises a discharge assembly for transferring aggregate material discharged from the rearmost conveyor unit of the conveying means onto the side discharge conveyor.

20 It is preferred particularly that the discharge assembly be adapted to be coupled to the rearmost conveyor unit of the conveying means.

It is preferred that the launch platform comprise the controlling means.

25 In addition, or alternatively, it is preferred that the launch platform comprise the driving means.

It is preferred that the controlling means and the driving means be combined together.

- 12 -

In one arrangement, it is preferred that the combined driving/controlling means comprise a rack and pinion drive assembly.

5 With such an arrangement, it is preferred that the rack and pinion drive assembly comprises a rack bar mounted to at least one side of the mining means and each conveyor unit and a drive pinion on the launch platform for engaging the rack bar.

10 It is preferred that the drive pinion be hydraulically driven.

It is preferred that the rack and pinion drive assembly comprise a plurality of the drive pinions spaced apart in a line.

15 It is preferred that the rack and pinion drive assembly comprise a rack bar on both sides of each conveyor unit and a plurality of drive pinions for engaging each rack bar.

20 In an alternative arrangement, it is preferred that the combined driving/controlling means comprise a sliding plate assembly having a plate member located for sliding movement below the mining means and the conveyor units on the launch platform and a drive means for sliding the plate member, with the plate member comprising a means for engaging the mining means and/or one of the conveyor
25 units of the conveying means and/or a new conveyor unit to be added to the conveying means.

30 In an alternative arrangement, it is preferred that the combined driving/controlling means comprises two sets of tandem drive cylinders, each set having one drive cylinder on each side of the conveying means, and the drive cylinders on each side of the conveying means being

- 13 -

longitudinally aligned and spaced apart.

It is preferred that the driving/controlling means further comprises a means for engaging one of the conveyor units coupled to each drive cylinder.

5 It is preferred that the engaging means comprises a locking plate which is movable between an extendable position at which the locking plate engages a lug extending from a side of the conveyor unit and a retracted position at which the locking plate is clear of the lug, and the
10 locking plate comprises a recess for receiving the lug.

 It is preferred that the two sets of drive cylinders act co-operatively as a "walking" system to advance by pushing, and to withdraw by pulling, the mining means and the conveying means. With such an arrangement,
15 during advance into the seam, and similarly on withdrawal from the seam, the two sets of drive cylinders act cyclically so that one set retracts while the other set controls the advance rate of the mining means and the conveying means.

20 Alternatively, the combined driving/controlling means may comprise reciprocating drive cylinders and/or sets of linear tracks, linear and/or rotary drives, chains, cables or other mechanical devices driven by electric or hydraulic means.

25 It is preferred that the launch platform comprise an anchoring means to releasably anchor the launch platform against a pit floor and/or a highwall to react against pushing and pulling forces generated on the launch platform.

30 By way of example, the anchoring means may comprise:

- 14 -

- (a) grouser plates supporting the base of the launch platform;
- (b) ground engaging pins on the launch platform; and
- 5 (c) means of reacting back into the highwall at its toe and above the seam.

It is preferred that the launch platform comprise self-propelled tracks for mobility. It is noted that the tracks may act as a form of the anchoring means.

10 It is preferred that the launch platform comprise an extensible and/or removable front for providing a supporting structure for the mining means and the conveying means between the launch platform and the drive entry.

15 It is preferred that the launch platform comprise a means for adjusting the angle of inclination of the deck, such as hydraulic jacks, so that the deck can be adjusted to be:

- (a) substantially horizontal, for example, for operations such as maintenance; or
- 20 (b) inclined at an angle suitable for entry of the mining means and the conveying means into a drive in a dipping seam.

25 It is preferred that the highwall mining system further comprise a means for adding conveyor units to the conveyor train.

In this connection, it is preferred that the launch platform comprise, a guide track or guide rollers for guiding additional conveyor units in turn to the end of

- 15 -

the conveying means and into the drive, and delivery/discharge platforms on opposite sides of the guide track or guide rollers for storing conveyor units prior to addition to or after removal from the conveying means.

5 It is preferred that the launch platform further comprises pinch rollers to engage each conveyor unit being added/removed from the conveying means to align, guide, control and drive the conveyor unit while on the launch platform.

10 It can readily be appreciated that the pinch rollers provide a means of preventing uncontrolled movement of the conveyor units in response to the inclination of the launch platform.

15 It is preferred that the delivery/discharge platforms prevent uncontrolled movement of the conveyor units while supporting the conveyor units. As a consequence, it may be possible to stack more than one conveyor unit on each of the delivery/discharge platforms.

20 It is preferred that the conveyor unit addition means comprise an overhead crane or other suitable means mounted on the launch platform for selectively transferring conveyor units from the delivery/discharge platforms to the end of the conveying means and from the end of the conveying means to the delivery/discharge platforms.

25 It is preferred that the overhead crane, or other suitable means, has sufficient rigidity and holds the conveyor unit in such a manner as to prevent uncontrolled movement of the conveyor units while being handled by the crane.

30 It is preferred that the launch platform be adapted to receive delivery or discharge of conveyor units

- 16 -

from either side of the launch platform conveyor and comprise a means for preventing uncontrolled movement of the conveyor units not coupled to the conveying means but supported by the launch platform.

5 It is preferred that the highwall mining system further comprise a loading/unloading machine for transferring conveyor units between the launch platform and the pit area.

10 It is preferred particularly that the loading/unloading machine be a wheeled or tracked machine with a loading head for lifting and engaging the conveyor units in such a manner as to prevent uncontrolled movement of one or more conveyor units while being handled by the machine.

15 In addition, it is preferred that the loading head be adjustable to tilt longitudinally and/or transversely and/or rotate about a horizontal and/or a vertical axis to handle the conveyor units. These loading head motions are particularly desirable where the
20 loading/unloading machine is operating on a different inclined angle to the inclined angle of the launch platform.

25 It is preferred that the launch platform comprise safety hand rails or fences or other safety devices along both sides of the launch platform conveyor.

30 It is preferred particularly that the hand rails or fences be removable or have openings or moving sections, such as sliding gates, to allow access for the loading/unloading of the conveyor units over the belly conveyor directly by the loading machine or other means.

 It is preferred that the highwall mining system

- 17 -

further comprises:

- 5 (a) a circulation means located on or in the region of the mining means for circulating the atmosphere at least at the forward end of the drive;
- 10 (b) an inertisation means for maintaining the concentration of oxygen in the atmosphere in the drive lower than the concentration of oxygen required for explosion of methane gas and/or dusts and/or other flammable materials in the drive, the inertisation means comprising:
- 15 (i) an inertisation gas injection means for injecting an inertisation gas into the drive, the inertisation gas injection means having an outlet for inertisation gas located during the early stages of forming the drive
- 20 (a) on or in the region of the mining means and, thereafter, (b) on or in the region of the mining means and/or at the entrance of the drive and/or between the entrance of the drive and the mining means; and
- 25 (ii) a barrier means to restrict gas flow into and from the drive.

30 The term "inertisation gas" is understood to mean a gas that contains either no oxygen or a concentration of oxygen that is low enough to maintain the concentration of oxygen in the drive below that required for explosion of methane gas and/or dusts and/or other flammable materials in a drive.

- 18 -

It is noted that the circulation means and the inertisation means are described in more detail in International application PCT/AU94/00385 of the applicant and the disclosure in the provisional applications is
5 incorporated herein by reference.

The present invention is described hereinafter by way of example with reference to the accompanying drawings, in which:

Figure 1 is a perspective view, largely in
10 schematic form, of the mining means, the conveying means, and the launch platform (with substantial detail omitted) of one embodiment of a highwall mining system in accordance with the present invention located in an open-cut mine;

Figure 2 is a side elevation of the launch
15 platform of the highwall mining system as viewed in the direction of the arrow A in Figure 1;

Figure 3 is a top plan view of the launch platform shown in Figure 2 with the upper section of the launch platform removed;

Figure 4 is a section along the line 4-4 in
20 Figure 3 and shows in side elevation the forward end of a new conveyor unit to be added to the conveying means and the rearward end of the rearward conveyor unit of the conveying means prior to the new conveyor unit being added
25 to the conveying means;

Figure 5 is a side elevation similar to that shown in Figure 4 but after the new conveyor unit has been added to the conveying means;

Figure 6 is a section along the line 6-6 in
30 Figure 5;

- 19 -

Figure 7 is a section along the line 7-7 in Figure 4;

Figure 8 is a section along the line 8-8 in Figure 5;

5 Figures 9 and 10 are sections which illustrate in detail the coupling means shown on the right-hand side of Figures 7 and 8, respectively, modified to include an alternative embodiment of a means for moving the locking pin between the unlocked position as shown in Figure 9 and
10 the locked position as shown in Figure 10;

 Figures 11 to 15 are a series of schematic side elevations which illustrate various stages in a sequence for adding a new conveyor unit to the rearward end of the rearward conveyor unit of the conveying means when the
15 mining means and the conveying means of the highwall mining system are driven/controlled by a sliding plate assembly in addition to or alternatively to the rack and pinion system shown in Figures 2 to 6;

 Figure 16 is a section along the line 16-16 in
20 Figure 15;

 Figure 17 is a section along the line 17-17 in Figure 16 with the contact arms of the sliding plate assembly in an operative position in which the contact arms engage lugs on the underside of the new conveyor unit and
25 the mining means;

 Figure 18 is a section similar to that shown in Figure 17 with the contact arms in a retracted position;

 Figure 19 is a schematic side elevation of the highwall mining system that is similar to the side
30 elevations of Figures 11 to 15 which illustrate an

- 20 -

alternative embodiment of a means for driving/controlling the movement of the mining means and the conveying means which is based on an assembly of tandem drive cylinders carrying locking plates for engaging the conveyor units;

5 Figure 20 is a side elevation which illustrates in detail the locking plate on one of the tandem drive cylinders shown in Figure 19 in the extended position with the locking plate engaging a lug extending from one side of a conveyor unit of the conveying means;

10 Figure 21 is a side elevation similar to that shown in Figure 20 with the locking plate in a retracted position;

 Figure 22 is a section along the line 22-22 in Figure 20;

15 Figure 23 is a schematic side elevation of the highwall mining system that is similar to the side elevation of Figure 18 which illustrates an alternative embodiment of a means for driving/controlling the movement of the mining means and the conveying means;

20 Figure 24 is a side elevation showing in detail the coupling means for coupling together the forward conveyor unit of the conveying means and the mining means;

 Figure 25 is a top plan view, in diagrammatic form, which illustrates in detail the coupling means shown
25 on the right-hand side of Figures 7 and 8, respectively, modified to include an alternative embodiment of a means for moving the locking pin.

 Figure 26 is a partially sectional, side
elevation of another embodiment of a highwall mining system
30 in accordance with the present invention located in an

- 21 -

open-cut mine;

Figure 27 is an end elevation of the launch platform of the highwall mining system as viewed in the direction of the arrow "X" in Figure 26;

5 Figure 28 is an end elevation of the launch platform of the highwall mining system as viewed in the direction of the arrow "Y" in Figure 27;

Figure 29 is a cross-section along the line A-A in Figure 26; and

10 Figure 30 is a cross-section along the line B-B in Figure 26;

Figure 31 is a cross-section along the line C-C in Figure 26; and

15 Figure 32 is a partly sectioned side elevation, with considerable detail removed, of another embodiment of a tiltable deck of a highwall mining system to that shown in Figures 26 to 31.

20 The highwall mining system, generally identified by the numeral 3, shown in Figures 1 to 25 is positioned in an open cut mine 5 to cut coal from a coal seam 8 extending from the exposed face of the highwall 6 of the mine 5.

The basic components of the highwall mining system 3 are:

- 25 (a) a mining means 9 for cutting coal from the seam 8 to form a drive 10 in the seam 8;
- (b) a conveying means 11 formed from a plurality of conveyor units 13 releasably

- 22 -

coupled together for conveying coal from the drive 10;

(c) a launch platform 15 located at the entrance to the drive 10:

- 5 (i) for supporting and guiding the mining means 9 initially into the seam 8 to start the drive 10 and thereafter for supporting and guiding the conveying means 11
- 10 into the drive 10 as the drive 10 is extended into the seam 8;
- (ii) for adding new conveyor units 13 to the conveying means 11 and;
- 15 (iii) for discharging coal from the drive 10 into a surge bin or truck 12 for transportation from the mine 5; and
- 20 (d) a combined driving/controlling means (not shown in Figure 1) located on the launch platform 15 for driving the mining means 9 and the conveying means 13 into the seam 8 and thereafter for withdrawing the mining means 9 and the conveying means 11 from the drive 10 in a controlled manner without
- 25 there being any uncontrolled movement of the mining means 9 and the conveying means 11 in response to the incline of the seam 8 and/or during the addition of a new conveyor unit 13a to the conveying means
- 30 11.

The launch platform 15 is mounted on an assembly

- 23 -

of caterpillar tracks 17 and is movable along the exposed face of the highwall 6 so that the highwall mining system 3 can form a plurality of drives 10 in the seam 8 which are separated by support pillars 14 of unmined material.

5 The mining means 9 comprises a track-mounted continuous miner having a cutting assembly of a plurality of cutting picks (not shown) on a rotatable cutting drum 19 (which comprises 3 separate segments 19a, 19b, 19c) mounted on the end of a boom 21 that is supported for pivotal
10 movement about a horizontal axis. The cutting assembly of the mining means 9 is electrically powered from the launch platform 15 by means of an electrical cable 25 wound onto a reel 101 (Figure 2).

 It is noted that whilst the mining means 9 is
15 described as being driven (together with the conveying means 13) by the combined driving/controlling means on the launch platform 15, the present invention is not so restricted to such an arrangement. In particular, it is within the scope of the present invention for the mining
20 means 9 to include a drive means.

 With reference to Figures 1 and 2, the launch platform 15 comprises a rigid support frame which includes an overhead continuous shield 16 as a safety measure for operators working on the launch platform 15.

25 With particular reference to Figures 2 and 3, the launch platform 15 comprises, a receiving conveyor 27 (generally known as a "belly conveyor") for receiving coal discharged from the rearmost conveyor unit 13 of the conveying means 11.

30 With reference to Figures 1 to 3, the launch platform 15 further comprises a side discharge conveyor 28 for receiving coal from the receiving conveyor 27 and

- 24 -

discharging the coal onto a truck loading conveyor 29 and into the surge bin or truck 12 (Figure 1).

5 The dimensions of the launch platform 15 are selected so that there is sufficient space for a new conveyor unit 13a to be positioned on the launch platform 15 as shown in Figures 1 to 3 and moved into engagement with the rearmost conveyor unit 13 of the conveying means 11 as the mining means 9 and the conveying means 11 move forwardly into the drive.

10 The conveyor unit addition assembly of the launch platform 15 comprises an overhead crane 31 having a hoist assembly 33 for supporting a new conveyor unit 13a and for moving the new conveyor unit 13a from a loading station 35 on one side of the launch platform 15 to a conveyor unit
15 addition position. When located at the conveyor unit addition position, the new conveyor unit 13a is positioned on a guide track 169 for the mining means 9 and the conveying means 11 and is aligned with the rearmost conveyor unit 13 of the conveying means 11.

20 The conveyor unit addition assembly further comprises pinch rollers 171 (Figures 2 and 3) which are pivotally mounted to move to positions on the sides of the guide track 169 to contact the new conveyor unit 13a and to align, guide, control and drive the new conveyor unit 13a
25 towards the rearmost conveyor unit 13 of the conveying means 11.

30 With reference to the figures generally, and in particular Figure 3, each conveyor unit 13 comprises a belt or a chain conveyor 51 which extends between the forward and the rearward ends of the conveyor unit 13 and is operable to receive coal from an immediately upstream conveyor unit 13 and to deliver the coal to an immediately downstream conveyor unit 13.

- 25 -

It is noted that the conveyor unit addition assembly may include a means to connect electrical power to a new conveyor unit 13a so that the belt 51 is operating prior to connection of that new conveyor unit 13a to the conveying means 11. This enables the highwall mining system to operate to add a new conveyor unit 13a to the conveying means 11 without interrupting the flow of aggregate material from the conveying means 11.

Each conveyor unit 13 further comprises a single wheel assembly 91 located towards one end of the conveyor unit 13. As can best be seen in Figures 17 and 18, the wheel assembly 91 comprises an axle 53 (Figures 4 and 5) which supports a pair of wheels 55.

Each conveyor unit 13 further comprises a coupling means for mechanically coupling the conveyor unit 13 to a forward and/or rearward conveyor unit 13 and/or to the mining means 9.

With reference to Figures 3 to 8, a preferred embodiment of the coupling means comprises a pair of male members 57 on each side at one end of each conveyor unit 13 and a pair of female members 59 on each side at the other end of each conveyor unit 13.

The pairs of male and female members 57, 59 are arranged so that when a new conveyor unit 13a is moved towards the rearmost conveyor unit 13 of the conveying means 11 the male members 57 are received in the female members 59 to couple together the conveyor units 13, 13a.

The male members 57 are mounted for limited pivotal movement, typically of the order of 8°, about the axle 53 of the wheel assembly 91 in order:

(a) to facilitate coupling of the male members

57 and the corresponding female members 59;
and

- 5 (b) to allow limited scope for the conveyor units 13 to follow undulations along the length of the drive.

The female members 59 are fixed to the conveyor units 13.

10 With further reference to Figures 4 to 8, each male member 57 comprises 3 co-planar prongs 61 which are separated by 2 cavities 63, and each female member 59 comprises 2 prongs 65 separated by a central cavity 67. The arrangement is such that:

- 15 (a) the central prong 61 of each male member 57 is adapted to be received in the central cavity 67 of a corresponding female member 59; and

- (b) simultaneously, the prongs 65 of each female member 59 are adapted to be received in the cavities 63 of the male member 57.

20 It can readily be appreciated that once the male members 57 are received in the female members 59 by relative movement of adjacent conveyor units 13 towards each other (and are locked in position as described hereinafter) the coupling formed does not allow relative
25 rotation of the adjacent conveyor units 13 about a vertical axis.

30 The prongs 61, 65 and the cavities 63, 67 are tapered in order to assist alignment of the male and female members 57, 59 as a new conveyor unit 13a is moved towards the rearmost conveying unit 13 of the conveying means 11.

- 27 -

It is noted that the alignment of the male and female members 57, 59 is further assisted by the rack and pinion drive system described hereinafter as one embodiment of the combined driving/controlling means.

5 In addition, with reference to Figures 4 and 5, it is noted that the alignment of the male and female members 57, 59 is further assisted by roller assemblies 240, 242 mounted to the launch platform 15.

10 The lower edge of the central prong 61 of each male member 57 comprises a semi-circular cut-out section 71, and the upper edge of the lower prong 65 of each female member 59 comprises a semi-circular cut-out section 73. The arrangement of the cut-out sections 71, 73 is such that when the male members 57 are received in the female members
15 59 the cut-out sections 71, 73 form circular openings.

In an alternative arrangement the male and/or female members 57, 59 may comprise complete circular openings which are brought into alignment when the male members 57 are received in the female members 59.

20 The coupling means further comprises a locking pin 79 which is adapted to be positioned in the openings to lock together the male and female members 57, 59.

 The locking pin 79 is arranged for sliding movement between an unlocked position (Figure 7) and a
25 locked position (Figures 6 and 8). In the locked position the locking pin 79 extends into the openings formed by each pair of male and female members 57, 59. It can readily be appreciated that once the locking pins 79 are engaged the coupling allows substantially no relative translation of
30 adjacent conveyor units 13.

With reference to Figure 7, it is noted that, in

- 28 -

the unlocked position, the locking pins 79 are clear of the openings formed by the male and female members 57, 59 on the outer sides of each pair of male and female members 57, 59 but are not clear of and extend into the openings formed by the male and female members 57, 59 on the inner sides of each pair of male and female members 57, 59. In this position, the locking pins 79 do not interfere with movement of the male and female members 57, 59 into a position in which the male members 57 are received in the female members 59 because each locking pin 79 comprises a cut-out section 81 which defines a gap to allow the central prongs 63 of the male member 57 to move relative to the corresponding female member 59.

With reference to Figures 6 to 8, the coupling means further comprises a means for moving each locking pin 79 between the unlocked and locked positions.

The locking pin moving means comprises a tongue 103 which is supported for movement in the direction of movement of the mining means 9 and the conveying means 11 and has a slot 105 at an angle, typically 45°, to the direction of movement of the conveying means 11. The locking pin 79 comprises a horizontal slot 107 and a vertical pin 109 which extends through the mid-point of the slot 107. The tongue 103 is positioned in the slot 107 with the vertical pin 109 extending through the slot 105. The locking pin 79 is retained so that it can only slide between the locked and unlocked positions. It can readily be appreciated that, with such an arrangement, movement of the tongue 103 in the direction of movement of the conveying means 11 (towards the right in Figure 6) will cause the vertical pin 109 in the locking pin 79 to slide in the slot 105 and thereby move the locking pin 79 sideways into or from the locked and unlocked positions. The locking pin moving means further comprises a compressed gas assembly 111 for moving the tongue 103.

- 29 -

With reference to Figures 9 and 10, an alternative form of the locking pin moving means comprises a cylindrical housing 83 extending between and connected to the female members 59 of each pair of male and female members 57, 59 such that the associated locking pin 79 extends co-axially through the housing 83.

An annular sleeve assembly 97 is mounted via an annular face plate 99 to the locking pin 79 and is constructed so that the outer surfaces of the sleeve assembly 97 contact and can slide against the internal wall 102 of the housing 83. The sleeve assembly 97 includes annular surfaces 116 and 118.

The locking pin moving means further comprises sources of gas or hydraulic fluid (not shown) which are in separate fluid communication with the sleeve assembly 97 via inlets/outlets 103, 104. The arrangement is such that the supply of gas or hydraulic fluid to the sleeve assembly 97 via inlet/outlet 103, whilst the inlet/outlet 104 is open, acts against the annular surface 116 and causes the sliding pin 79 to move to the right from the unlocked position shown in Figure 9 to the locked position shown in Figure 10. In addition, the arrangement is such that the supply of gas or hydraulic fluid to the sleeve assembly 97 via inlet/outlet 104, whilst inlet/outlet 103 is open, acts against the annular surface 118 and causes the sliding pin 79 to move to the left from the locked position shown in Figure 10 to the unlocked position shown in Figure 9.

The locking pin moving means further comprises a radially mounted locking pin 106 which is received in a recess 107 in the sleeve assembly 97 when the locking pin 79 is in the locked position as shown in Figure 10.

With reference to Figure 25, an alternative form of the locking pin moving means comprises a housing 251

- 30 -

positioned between each pair of male and female members 57, 59 such that the associated locking pin 79 extends co-axially through the housing 251. The housing 251 defines an annular chamber 253, and an annular plate 255 connected to the locking pin 79 divides the chamber 253 into volumes 257a, 257b. The locking pin 79 moving means further comprises separate sources of compressed gas (not shown) which can be selectively connected via retractable valve/head assemblies 261a, 261b and conduits 263a, 263b to the volumes 257a, 257b.

In an alternative arrangement (not shown) the retractable valve/head assemblies 87a, 87b are not used and the source of compressed gas is connected manually to the conduits 263a, 263b.

The arrangement shown in Figure 25 is such that when the valve/head assembly 261a is in a forward position and communicates with the conduit 263a, and the other valve/head assembly 261b is in a rearward position spaced from the conduit 263b, the compressed gas supplied along the conduits 261a, 263a causes volume 257a to expand and thereby moves the locking pin 79 into the locked position. Similarly, when the valve/head assembly 261b is in a forward position and communicates with the conduit 263b, and the other valve/head assembly 261a is in a rearward position spaced from the conduit 263a, the compressed gas supplied along the conduits 261b, 263b causes the volume 257b to expand and thereby moves the locking pin 79 into the unlocked position. An additional gas-actuated locking pin (not shown) is provided to hold the locking pin 79 in the unlocked or locked positions.

In an alternative arrangement the locking pin moving means comprises an accumulator (not shown) in the conduit 263a which stores a pre-charge of compressed gas that is released when the male members 57 are received in

- 31 -

the female members 59 to cause sudden expansion of the volume 257a to move the locking pin 79 quickly into the locked position.

It is noted that the locking pin moving means may
5 comprise any other suitable means, including mechanically actuated means.

The coupling means described in the foregoing description relates to the coupling together of adjacent conveyor units 13. A modified form of the coupling means
10 is used to couple together the mining means 9 and the first conveyor unit 13.

With reference to Figure 24, the modified coupling means comprises the coupling means as shown in Figures 3 to 8 and further comprises a link member 215 on
15 each side of the mining means 9 which is pivotally connected at one end indicated by the arrow P_1 to the main frame of the mining means 9 and at the other end indicated by the arrow P_2 to the axle 53 of the rear wheel assembly of the mining means 9.

20 With reference to Figures 2 to 6, one preferred embodiment of the combined driving/controlling means comprises a rack and pinion drive system for driving the mining means 9 and the conveying means 11 into the seam 8 and from the drive 10 thus formed in the seam 8.

25 The rack and pinion drive system comprises, rack bars 43 mounted on each side of the mining means 9 and the conveyor units 13, and 8 hydraulically powered drive pinions 45 mounted on the launch platform 15 and arranged to engage the rack bars 43 and thereby to drive the mining
30 means 9 and the conveying means 11.

With particular reference to Figure 3, the drive

- 32 -

pinions 45 are arranged in 2 parallel lines with 4 drive pinions 45 in each line so that there are 4 drive pinions 45 on one side and 4 drive pinions 45 on the other side of the mining means 9 and the conveying means 11.

5 A feature of the rack and pinion drive system is that it provides drive to the mining means 9 and the conveying means 11 at a number of points along each side of the path of movement of the mining means 9 and the conveying means 11.

10 Another feature of the rack and pinion drive system is that it does not interfere with the conveyor unit addition assembly, and therefore a new conveyor unit 13a can be added to the conveying means 11 without
15 disconnecting the drive to the mining means 9 and the conveying means 11. This is particularly important when the highwall mining system operates in "dipping" seams to avoid the risk that the conveying means 11 may apply
20 excessive force onto the back of and thereby jam or damage the mining means 9. This is also particularly important when the highwall mining system operates to add a new
25 conveyor unit 13 to the conveying means 11 without interrupting the flow of aggregate material from the conveying means 11.

 It can also readily be appreciated that in
25 addition, in more general terms, the rack and pinion system drives the mining means 9 and the conveying means 11 in a controlled manner and prevents any uncontrolled forward and/or rearward movement. In these circumstances, the rack and pinion system is a combined driving and controlling
30 means.

 In situations where it is required that the mining means 9 and the conveying means 11 be held stationary it is the rack and pinion drive system, and more

- 33 -

particularly the hydraulic motors (not shown), that hold the mining means 9 and the conveying means 11 in position.

It is also preferred that the rack and pinion drive system further comprises friction or other brakes
5 (not shown) to provide emergency braking should there be a failure of the hydraulic motors of the drive pinions 45. In this context it is noted that, by providing 8 drive pinions 45, the rack and pinion drive system has a high level of redundancy if there is a failure of one or more
10 drive pinions 45.

It is also preferred that the mining means 9 and the conveyor units 13 comprise friction or other brakes (not shown) to provide additional emergency braking, if required, in the event of a failure of the hydraulic motors
15 of the drive pinions 45.

With reference to Figures 11 to 18, another preferred embodiment of the combined driving/controlling means comprises a sliding plate assembly on the launch platform 15. The sliding plate assembly can be used in
20 place of or in conjunction with the rack and pinion system and, as is the case with the rack and pinion system, allows only controlled movement of the mining means 9 and the conveying means 11.

With particular reference to Figures 16 to 18,
25 the sliding plate assembly comprises a plate member 123 which is positioned for sliding movement above the belly conveyor 27 and below the conveyor units 13 on the launch platform 15. The plate member 123 comprises L-shaped guide surfaces 125 which bear against and are thereby supported
30 by guide rails 127 that are welded to I-beams 129. The I-beams 129 form part of the rigid support frame of the launch vehicle 15 and, as shown in the figures, support and are parallel to the guide track 169 for the mining means 9

- 34 -

and the conveying means 11. As will be apparent from Figures 16 to 18, the guide rails 127 support the plate member 123 for sliding movement in the direction of movement of the mining means 9 and the conveying means 11.

5 The plate member 123 comprises a means to engage a conveyor unit 13. The engaging means comprises 4 contact arms 135. Each contact arm 135 is pivotally mounted at one end 137 to the plate member 123 and at the other end 139 to the free end of a piston arm 141 of a piston/cylinder assembly 43. The piston/cylinder assembly 143 is also pivotally connected to the plate member 123. The arrangement is such that extension or retraction of the piston arm 141 causes the contact arm 139 to swing about the end 137 and such movement, assuming the appropriate positioning of a conveyor unit 13 as shown in Figure 17, moves the contact arm 135 into line with a lug 147 which depends downwardly from the underside of the conveyor unit 13. As a consequence, when in this operative position, sliding movement of the plate member 123 causes the contact arm 135 to bear against the lug 147.

The sliding plate assembly 121 further comprises a drive assembly for sliding the plate member 123. The drive assembly comprises a continuous chain drive 131 connected to each side of the plate member 123.

25 The operation of the sliding plate assembly is described hereinafter with reference to Figures 11 to 15 in the context of the addition of a new conveyor unit 13a to the rearward end of the last conveyor unit 13 of the conveying means 11 and in the context that the sliding plate assembly is used in conjunction with the rack and pinion system.

In each of Figures 11 to 15, the mining means (not shown) and the conveying means 11 are moving towards

- 35 -

the right-hand side of the figure into a drive 10 and coal is being transferred from the drive 10 along the conveyor units 13 of the conveying means 11.

5 With reference to Figure 11 the arrows identified by the arrow X indicate the flow of coal from the last conveyor unit 13 of the conveying means 11 onto the belly conveyor 27. The coal is thereafter moved by the belly conveyor 27 towards the left of the figure and is discharged at the location identified by the arrow Y onto
10 the discharge conveyor 28. The figure also shows a new conveyor unit 13a in a position ready to be added to the conveying means 11.

 In Figure 11, the plate member 123 is positioned with the contact arm 135 in an operative position engaging
15 the rearmost conveyor unit 13 of the conveying means 11. In this position, the sliding plate assembly and the rack and pinion system, or other push/pull drive system, operate together to move the mining means 9 and the conveying means 11 forward in a controlled manner.

20 In order to add the new conveyor unit 13a shown in the figures to the rearmost conveyor unit 13 of the conveying means 11, the plate member 123 is disengaged from the rearmost conveyor unit 13 by moving the contact arms 135 to the inoperative position shown in Figure 18 and
25 thereafter moving the plate member 123 to the left of Figure 12 as indicated by the arrow P in Figure 12.

 It is noted that during this process, the mining means 9 and the conveying means 11 are held in a controlled and secure manner by means of the rack and pinion system
30 (or other device - not shown). In this connection, the arrangement is such that the rack and pinion system may be holding the mining means 9 and the conveying means 11 stationary or driving the assembly forward into the seam 8.

- 36 -

In addition, it is noted that the plate member 123 is an obstruction to the flow of coal from the rearmost conveyor unit 13 of the conveying means 11 into the belly conveyor 27 and therefore during the recycling step shown in Figure 12 it is necessary that there be no coal being discharged from the rearmost conveyor unit 13 of the conveying means 11.

The purpose of the recycling step shown in Figure 12 is to reposition the plate member 123 underneath the new conveyor unit 13a and, as is shown in Figures 13 and 14, thereafter to engage the new conveyor unit 13 via the contact arms 135 and to move the new conveyor unit 13a forward to be coupled to the rearmost unit 13 of the conveying means 11. At that point, the sliding plate assembly and the rack and pinion or other drive system operate again in conjunction to move the mining means 9 and the now lengthened conveying means 11 into the drive 10.

With reference to Figure 15, the final step in the procedure involves operation of the conveyor unit addition assembly described previously to position another new conveyor unit 13b.

With reference to Figures 19 to 22, another preferred embodiment of the combined driving/controlling means comprises a forward set and a rearward set of tandem drive cylinders on the launch platform 15, with one drive cylinder of each set on each side of the guide track 169 of the launch platform 15.

The side elevation of Figure 19 illustrates one of the drive cylinder 119a of the forward set and one of the drive cylinders 119b of the rearward set. It can readily be appreciated that there are correspondingly positioned drive cylinders 119a, 119b on the other side of

- 37 -

the conveying means 11 on the launch platform 15.

The driving/controlling means further comprises a means for engaging pins 163 extending from the sides of the conveyor units 11. The engaging means is connected to the forward end of the piston of each drive cylinder 119a, 119b and includes a support frame 66 having a flange 167 which is arranged for sliding contact on the guide track 169 for the mining means and the conveying means 11 in response to actuation of the respective drive cylinder 119a, 119b. The engaging means further comprises a locking plate 168 having a cut-out section 170 for receiving and engaging a pin 163 of a conveyor unit 13. The cut-out section 170 is formed in the upper end of the locking plate 168 and is defined by sides 217 and a base 219. The locking plate 168 is supported by the support frame 66 to be vertically movable between a retracted position as shown in Figure 21 in which the locking plate 168 is clear of the pin 163 and a locked position as shown in Figures 19, 20, 22 in which the locking plate 168 engages the pin 163 of a conveyor unit 11. It can readily be appreciated that the locking plate 168 and, in particular, the construction of the cut-out section 170 with the sides 217, prevents uncontrolled forward and/or rearward movement of the conveyor unit 13.

In use, the two sets of drive cylinders 119a, 119b act co-operatively as a "walking" system to advance by pushing and to withdraw by pulling the mining means 9 and the conveying means 11. With such an arrangement, during advance into the seam 8, the two sets of drive cylinders 119a, 119b act cyclically so that one set retracts while the other set controls the advance rate of the mining means 9 and the conveying means 11.

With reference to Figure 23, another preferred embodiment of the combined driving/controlling means is

- 38 -

similar to that shown in Figures 19 to 22 and comprises:

- 5 (a) a single set of drive cylinders 203, with one drive cylinder 203 on each side of the guide track 169 for the mining means 9 and the conveying means 11;
- (b) the engaging means shown in Figures 19 to 22 connected to the drive cylinders 203; and
- 10 (c) an additional engaging means of the type shown in Figures 19 to 22 but modified so as to be fixed to the guide track 169.

15 With such an arrangement, the engaging means is operable when the drive cylinders 203 reach the limit of their forward travel to engage and hold pins 163 on a conveyor unit 13 of the conveying means 9 while the drive cylinders 203 are recycled to engage and move forward a rear conveyor unit 13a and thereafter move forward the mining means 9 and the now-lengthened conveying means 11.

20 The highwall mining system further comprises a means for supplying electrical power to operate the mining means 9 and the conveying means 11.

25 With reference to Figure 2 the electrical power supply means comprises the continuous electrical cable 25 which is wound onto the reel 101 on the launch platform 15 and is connected to the miner end of the mining means 9 and the conveying means 11.

During advance of the mining means 9 and the conveying means 11 into a seam 8 the electrical cable 25 is automatically fed from the reel 101 on the launch platform

- 39 -

15 and is guided into and supported by receptacles (not shown) in each conveyor unit 13 in the conveying means 11.

During withdrawal of the mining means 9 and the conveying means 11 from the seam 8 the electrical cable 25
5 is removed automatically from the receptacles in the conveyor units 13 and wound back on the reel 101 on the launch platform 15.

As a consequence, manual handling of these electrical cables and hoses is avoided.

10 With reference to Figures 4 and 5, the electrical power received at the miner end is distributed back along the conveying means 11 to operate the belt or chain conveyor 51 through cables 115 extending along the length
15 of each conveyor unit 13 and electrical couplings 117, 119 at the end of each conveyor unit 13.

The electrical couplings 117, 119 on each conveyor unit 13 are arranged such that, when the male/female members 57, 59 of a new conveyor unit 13a engage the corresponding male/female members 57, 59 of the
20 rearmost conveyor unit 13 of the conveying means 11, the electrical couplings 117, 119 on the new conveyor unit 13 also engage the rearmost conveyor unit 13 so that electrical power can be supplied via the rearmost conveyor unit 13 to power the belt or chain conveyor 51 of the new
25 conveyor unit 13a.

The highwall mining system further comprises an on-board controller (not shown) on the launch platform 15 and microprocessors (not shown) on each conveyor unit 13. Control signals from the on-board controller and the
30 microprocessors are transmitted through the various electrical cables using conventional methods of electrical

- 40 -

control signal transmission including a down-line carrier system of transmission (not shown).

5 The microprocessor on the rearmost conveyor unit 13 on the conveying means 11 actuates the supply of electrical power to a new conveyor unit 13a after the new conveyor unit 13a is connected to the rearmost conveyor unit 13 after a series of pre-conditions have been satisfied. The conditions may include, by way of example:

- 10 (a) sensing completion of the engagement of the locking pins 79 to thereby complete mechanical coupling of the new conveyor unit 13a to the conveying means 11;
- (b) sensing connection of the electrical cable coupling 117, 119; and
- 15 (c) sensing the correct positioning of flame-proof equipment.

The main features of the above-described mechanical and electrical couplings of the highwall mining system are as follows:

20

- (a) mechanical coupling:
- (i) automatic, mechanised or manual operation (of the locking pin 79 - no manual handling of the locking pin 79;
- 25 (ii) automatically aligned for coupling by rack and pinion drive system and by guide (and "pinch") rollers on the launch platform 15;

- 41 -

- 5 (iii) coupling allows limited rotation around the conveyor unit axle centreline (this assists in the use of the rack and pinion drive system - the rack bars 43 pass over the centreline of the axle);
- 10 (iv) allows for one degree of freedom (vertical rotation around approximately horizontal axle) while minimises free-play in the other 5 degrees of freedom to facilitate:
- 15 (1) "roller chain" type action to follow the seam roll;
- 20 (2) minimal longitudinal free play for control of conveyor/miner positions (viz. the relationship between freeplay, control and movement lag due to clearance take up) and axial forces;
- 25 (3) minimal lateral rotation or twisting in the horizontal plane to maintain straight alignment of the conveying means 11 (which is very important for maintaining pillar thicknesses and for the push-to-advance type
- 30 drive system);

- 42 -

5 (4) minimum twisting or rotation in the vertical plane around the longitudinal axis of the conveying means 11 (to maintain overlapping conveyor pulley alignments); and

(b) electrical coupling:

- 10 (i) aligned and coupled automatically (no manual handling and connection);
- 15 (ii) power to a new conveyor unit 13 is switched on automatically by control circuitry (not by manually operated switch);
- (iii) incorporates control cable (no separate cable - no manual handling and connection);
- 20 (iv) coincides with mechanical coupling; and
- (v) held or locked in position by the mechanical coupling.

25 With reference to Figures 26 to 31, another embodiment of the highwall mining system, generally identified by the numeral 303, is positioned in an open cut mine 305 to cut coal from a coal seam extending from the exposed face of the highwall 306 of the mine 305.

30 The basic components of the highwall mining system 303 are:

- (a) a mining means 309 for cutting coal from

- 43 -

the seam to form a drive 310 in the seam;

- 5 (b) a conveying means 311 formed from a plurality of conveyor units (only one of which is shown in the figures) releasably coupled together and with a forward conveyor unit releasably coupled to the mining means 309 for conveying coal from the drive 310;
- 10 (c) a launch platform 315 located at the entrance to the drive 310, the launch platform 315 including:
- 15 (i) a tiltable deck 313 which extends the length of the launch platform 315 for supporting and guiding the mining means 309 and the conveying means 311 into the drive 310;
- (ii) a means for discharging coal from the drive 310 for transportation from the mine 305;
- 20 (iii) an assembly for adding new conveyor units to the conveying means 311; and
- 25 (d) a combined driving/controlling means located on the launch platform 315 for driving the mining means 309 and the conveying means 311 into the seam and thereafter for withdrawing the mining means 309 and the conveying means 311 from the drive 310 in a controlled manner without
- 30 there being any uncontrolled movement of

- 44 -

the mining means 309 and the conveying means 311 in response to the inclination of the seam and/or during the addition of a new conveyor unit to the conveying means 311.

The mining means 309 comprises a track-mounted continuous miner having a plurality of cutting picks (not shown) on a rotatable cutting drum 319 mounted on the end of a boom 321 that is supported for pivotal movement about a horizontal axis. Whilst not shown in detail, it is preferred that the mining means 309 be of the type described above in relation to Figures 1 to 25.

In addition, the mining means 309 also comprises a pair of piston/cylinder assemblies (not shown) which extend from opposite sides of the miner and can be separately and selectively extended/retracted to vary the contact with the sides of the drive 310 and thereby to steer the miner.

Each conveyor unit of the conveying means 311 comprises a belt or a chain conveyor 351 which extends between the forward and the rearward ends of the conveyor unit and is operable to receive coal from an immediately upstream conveyor unit and to deliver the coal to an immediately downstream conveyor unit. Whilst not shown in detail, it is preferred that each conveyor unit be of the type described above in relation to Figures 1 to 25.

In addition, each conveyor unit further comprises a coupling means (not shown) for mechanically coupling the conveyor unit to a forward and/or rearward conveyor unit and/or to the mining means 309. Whilst not shown in detail, it is preferred that the coupling means be of the type described above in relation to Figures 1 to 25.

- 45 -

5 The launch platform 315 is mounted on an assembly of skids 317 and is movable along the exposed face of the highwall 306 so that the highwall mining system 303 can form a plurality of drives 310 in the seam which are separated by support pillars of unmined material.

 The launch platform 315 comprises a rigid support frame which includes an overhead shield 316 and a front face shield (not shown) as a safety measure for operators working on the launch platform 315.

10 The tiltable deck 313 of the launch platform 315 is pivotally mounted to the support frame by pivot connections 338 at a central section on each side of the deck 313.

15 A pair of hydraulic piston/cylinder assemblies 330 (Figures 26 and 30) is provided at the rear end of the launch platform 315 for raising, lowering, and locking in a selected position, the rear section of the tiltable deck 313 thereby to tilt the deck 313. Each piston/cylinder assembly 330 is connected at an upper end 332 to the support frame and at a lower end 334 to the tiltable deck 313.

20 The tiltable deck 313 enables the mining means 309 and the conveying means 311 to be aligned as required to mine a coal seam without having to adjust the inclination of the whole of the launch platform 315. As a consequence, it is possible to ensure that walkways and other work platforms of the launch platform 315 are horizontal and not inclined. This is an important feature from the viewpoint of safety.

30 The forward end of the tiltable deck 313 includes a pair of extendible members 340 for contacting the toe of

- 46 -

the highwall 306 and reacting against the pushing and pulling forces generated on the launch platform 315. Each extendible member 340 comprises an inner element 342 with a forward contact surface 344 which telescopes in an outer element 346.

The coal discharge means of the launch platform 315 includes a conveyor assembly 350 (Figures 26 and 31) positioned on the tiltable deck 313 and a side discharge conveyor assembly 352 which runs parallel to the tiltable deck 313.

The conveyor assembly 350 includes a chain conveyor 354 and a cross chain conveyor 356. The conveyors 354, 356 are arranged so that the chain conveyor 354 receives coal from the rearmost conveyor unit of the conveying means 311 and transfers the coal to the cross chain conveyor 356. The cross chain conveyor 356 delivers coal to the side discharge conveyor assembly 352 which transports the coal to a surge bin or truck or other means (not shown) for removing the coal from the mine.

With reference to Figures 26 and 30, the conveyor unit addition assembly of the launch platform 315 comprises a side loading platform 390 which is pivotally mounted at a forward end to the support frame by pivot connections 392. A hydraulic piston/cylinder assembly 394 is provided at the rear end of the side loading platform 390 for raising and lowering the side loading platform 390 between the horizontal position shown in Figure 26 and an inclined position at which the side loading platform 390 is at the same angle of inclination as the tiltable deck 313.

The purpose of the side loading platform 390 is to receive and support a new conveyor unit to be added to the conveying means 311 (or removed from the conveying

- 47 -

means 311 during withdrawal of the mining means 309 and the conveying means 311 from the drive 310). In this connection, the conveyor unit addition assembly further comprises a mechanism 391:

- 5 (i) for initially gripping a new conveyor unit when the side loading platform 390 is at the horizontal position and, thereafter;
- 10 (ii) for transferring the new conveyor unit to the tiltable deck 313 and aligning the new conveyor unit correctly on the tiltable deck 313 when the side loading platform 390 is in the raised position.

The combined driving/controlling means of the launch platform 315 comprises:

- 15 (i) a sliding plate assembly which allows only controlled pushing/pulling movement of the mining means 309 and the conveying means 311; and
- 20 (ii) a brake means (not shown) which is operable during the procedure for adding a new conveyor unit while advancing or for removing a conveyor unit while withdrawing, as described below.

25 Whilst not clearly shown in the figures, the sliding plate assembly is of the type described above in relation to Figures 1 to 25.

The highwall mining system further comprises a means for supplying electrical power to the conveying means 311.

- 48 -

The electrical power supply means comprises a continuous electrical cable 325 which is wound onto a reel 301 on the launch platform 315 and is connected to the miner end of the mining means 309 and the conveying means 311.

During advance of the mining means 309 and the conveying means 311 into a seam the electrical cable 325 is automatically fed from the reel 301 on the launch platform 315 and is guided into and supported by receptacles (not shown) in each conveyor unit of the conveying means 311.

During withdrawal of the mining means 309 and the conveying means 311 from the seam the electrical cable 325 is removed automatically from the receptacles in the conveyor units and wound back on the reel 301 on the launch platform 315.

As a consequence, manual handling of these electrical cables and hoses is avoided.

The electrical power received at the miner end is distributed back along the conveying means 311 through cables (not shown) extending along the length of each conveyor unit and electrical couplings (not shown) at the end of each conveyor unit 313.

The electrical couplings on each conveyor unit 313 are arranged such that, when a new conveyor unit mechanically engages the rearmost conveyor unit of the conveying means 311, the electrical couplings on the new conveyor unit also engage the rearmost conveyor unit so that electrical power can be supplied via the rearmost conveyor unit to power the belt or chain conveyor of the new conveyor unit.

- 49 -

The highwall mining system further comprises an on-board controller (not shown) on the launch platform 315 and microprocessors (not shown) on each conveyor unit 313. Control signals from the on-board controller and the
5 microprocessors are transmitted through the various electrical cables using conventional methods of electrical control signal transmission including a down-line carrier system of transmission (not shown).

The microprocessor on the rearmost conveyor unit
10 on the conveying means 311 actuates the supply of electrical power to a new conveyor unit after the new conveyor unit is connected to the rearmost conveyor unit after a series of pre-conditions have been satisfied.

In use of the highwall mining system described
15 above, under normal operating conditions, the conveyor assembly 350 is coupled to the rearmost conveyor unit of the conveying means 311 and, in response to the forward movement of the sliding plate assembly, the mining means 309, the conveying means 311, and the discharge conveyor
20 350 are pushed and move along the tiltable deck 313 and progressively into the drive 310.

When the rearmost conveyor unit reaches a forward position at which it is necessary to add a new conveyor unit to the conveying means 311, the sliding plate assembly
25 is disengaged from the rearmost conveyor unit after the brake means is applied to prevent uncontrolled forward movement of the mining means 309 and the remainder of the conveying means 311.

Simultaneously, the flow of coal on the conveying
30 means 311 is interrupted and the conveyor assembly 350 is disconnected from the rearmost conveyor unit and moved rearwardly by the sliding plate assembly along the tiltable

2189132

- 50 -

deck 313.

A new conveyor unit is then positioned by the conveyor unit addition assembly on the deck 313 in the gap between the conveyor assembly 350 and the rearmost conveyor unit of the conveying means 311.

Thereafter, the sliding plate assembly is engaged with the new conveyor unit, and the conveyor assembly 350 is coupled to the new conveyor unit, and the combined assembly is then coupled to the previously rearmost conveyor unit. During this sequence of steps, the side loading platform 390 of the conveyor unit addition assembly is lowered to the horizontal position shown in Figure 1 and a new conveyor unit is loaded onto the side loading platform 390 by a front end loader (not shown).

Finally, the flow of the coal is re-commenced, and the sliding plate assembly is actuated to push the mining means 309 and the extended conveying means 311 forward into the drive 310 to resume mining of coal.

Figure 32 illustrates an alternative embodiment of the tiltable deck 313 shown in Figures 26 to 31.

With reference to Figure 32, the tiltable deck, generally identified by the numeral 465, comprises a front deck 403 and a rear deck 413.

The front deck 403 is mounted to pivot around horizontal pivots 405 in the direction of the arrow W shown in the figure. A pair of hydraulic cylinders 407 is provided at a forward part of the launch platform 315 for raising, lowering, or locking in a selected position, the front deck 403 to adjust the inclination of the front deck 403 to suit the dip of a seam.

- 51 -

As with the tiltable deck 313, the front deck 403 includes a pair of extendible members 340 for contacting the toe of the highwall 306 and reacting against the pushing and pulling forces generated on the launch platform 401.

The rear deck 413 may be fixed in an approximately horizontal position as shown in Figure 32. Alternatively, the rear deck 413 may be mounted to pivot around the horizontal pivots 405 and thereby raised or lowered from the rear by a pair of hydraulic cylinders (not shown) of the type shown in Figures 26 to 31. As a consequence, the rear deck 413 may be raised to be aligned with the front deck 403 for adding, per arrow Z, a new conveyor unit 450 to the conveying means 311. In addition, the rear deck 413 may be positioned as shown in Figure 32 to simplify the procedure for positioning a new conveyor unit on the rear deck 413.

The above described highwall mining system 303 has significant advantages over the known highwall mining systems.

Many modifications may be made to the preferred embodiment described above without departing from the spirit and scope of the present invention.

-52-

CLAIMS:

1. A highwall mining system for mining aggregate material from a seam comprising:

(a) a mining means for cutting aggregate material from the seam and thereby forming a drive in the seam;

(b) a conveying means for conveying mined aggregate material from the drive, the conveying means comprising a plurality of modular conveyor units having a means for releasably coupling together the conveyor units, the coupling means comprising a male member and a complementary female member connected to the conveyor units such that the male member of one conveyor unit can be received in the female member of an adjacent conveyor unit to couple together the conveyor units, and each male member being coupled to an associated conveyor unit for pivotal movement about a horizontal axis of the conveyor unit; and

(c) a driving means for driving the mining means and the conveying means into the seam to form the drive.

2. The system defined in claim 1 wherein the mining means is a continuous miner that is propelled by a means located remotely from the continuous miner.

3. The system defined in claim 1 wherein the mining means is a continuous miner that is self-propelled so that the driving means comprises the continuous miner.

4. The system defined in any one of claims 1 to 3, wherein the mining means is a continuous miner which comprises a plurality of cutting picks on a rotatable cutting drum

-53-

mounted on an end of a boom that is supported for pivotal movement about a horizontal axis.

5. The system defined in any one of claims 1 to 4 wherein the coupling means is formed to allow limited relative rotation of adjacent conveyor units about a horizontal axis that is perpendicular to a longitudinal axis of the conveying means and substantially no relative rotation about a vertical axis.

6. The system defined in claim 5 wherein the limited relative rotation is no more than 20°.

7. The system defined in claim 6 wherein the limited relative rotation is no more than 8°.

8. The system defined in any one of claims 5 to 7 wherein the coupling means is formed to allow limited relative rotation of adjacent conveyor units about the longitudinal axis of the conveying means.

9. The system defined in any one of claims 1 to 8 wherein the coupling means is formed to allow substantially no relative translation of adjacent conveying units in longitudinal, horizontal and vertical directions.

10. The system defined in any one of claims 1 to 9 wherein each conveyor unit comprises a belt or a chain conveyor extending over the length of the conveyor unit.

11. The system defined in any one of claims 1 to 10 wherein each conveyor unit comprises a wheel assembly.

12. The system defined in claim 11 wherein each conveyor unit comprises a single wheel assembly.

-54-

13. The system defined in any one of claims 1 to 12 wherein the male and the female members of adjacent conveyor units are positioned to be engaged automatically.

5 14. The system defined in claim 11 or claim 12 wherein the horizontal axis is coincident with or in the region of an axis of the wheel assembly of the conveyor unit.

10 15. The system defined in claim 14 wherein the horizontal axis is coincident with the axis of the wheel assembly.

15 16. The system defined in any one of claims 13 to 15 wherein each male member and each female member comprise cut-out sections that are arranged so that when the male member of one conveyor unit is received in the female member of an adjacent conveyor unit by relative movement of the conveyor units towards each other the cut-out sections form an opening that is transverse to the longitudinal direction of the conveying means.

20 17. The system defined in claim 16 wherein each male member comprises 3 prongs separated by 2 cavities and each female member comprises 2 prongs separated by a central cavity such that the central prong of each male member is adapted to be received in the central cavity of each female member and simultaneously the prongs of each female member are adapted to be received in the cavities of each male member.

25 18. The system defined in claim 17 wherein the cutout sections are formed in one of the prongs of the male member and one of the prongs of the female member.

30 19. The system defined in any one of claims 16 to 18 wherein the coupling means further comprises a locking pin that is

-55-

moveable into the opening thereby to prevent disengagement of the male and the female members.

20. The system defined in claim 19 wherein the cutout sections
5 form a circular opening.

21. The system defined in claim 19 or claim 20 wherein the
coupling means comprise a means for moving the locking pin
into and from locking engagement in the opening.

10 22. The system defined in any one of claims 13 to 21 wherein
the coupling means comprises a pair of the male members of
each side at one end and a pair of the female members on
each side at the other end of each conveyor unit.

15 23. The system defined in claim 22 wherein each opening that is
formed when, in use, the male members of one conveyor unit
are received in the female members of an adjacent conveyor
unit are aligned.

20 24. The system defined in any one of claims 1 to 23 further
comprising a means for electrically coupling a new conveyor
unit to an end conveyor unit of the conveying means
automatically.

25 25. The system defined in any one of claims 13 to 23 further
comprising a means for electrically coupling a new conveyor
unit to an end conveyor unit of the conveying means
automatically as the male members of one conveyor unit are
30 received in the female members of the other conveyor unit.

26. The system defined in any one of claims 1 to 25 further
comprising a means for supplying electrical power to
operate the mining means and the conveying means.

35

-56-

27. The system defined in claim 26 wherein the electrical power supply means comprises an electrical cable adapted to be connected to a source of power external to the drive and to the mining means.

5

28. The system defined in claim 26 or claim 27 wherein the electrical power supply means comprises a cable extending the length of each conveyor unit and a male or a female electrical coupling at each end of the cable.

10

29. The system defined in claim 28 wherein the electrical couplings are positioned so that when a new conveyor unit is mechanically coupled to an end conveyor unit of the mining means, simultaneously, the male or female electrical coupling of one conveyor unit engages complementary electrical coupling of the other conveyor unit.

15

30. The system defined in claim 29 further comprising a control means to actuate the supply of electrical power to the new conveyor unit.

20

31. The system defined in any one of claims 1 to 30 further comprising a launch platform adapted to be positioned at an entrance to the drive, the launch platform comprising a deck for supporting and guiding the mining means initially into the seam to start the drive and thereafter for supporting and guiding the conveying means into the drive as the drive is extended into the seam.

25

32. The system defined in claim 31 wherein the launch platform comprises controlling means.

30

33. The system defined in any one of claims 1 to 30 further comprising a launch platform adapted to be positioned at an entrance to the drive, the launch platform comprising a

35

-57-

deck for supporting and guiding the mining means initially into the seam to start the drive and thereafter for supporting and guiding the conveying means into the drive as the drive is extended into the seam, and the launch platform comprises the driving means for pushing the mining means and the conveying means into the seam and for pulling the mining means and the conveying means from the drive.

34. The system defined in any one of claims 31 to 33 wherein the launch platform further comprises a launch platform conveyor for receiving and discharging aggregate material from the end of the conveying means.

35. A highwall mining system for mining aggregate material from a seam comprising:

(a) a mining means for cutting aggregate material from the seam and thereby forming a drive in the seam;

(b) a conveying means for conveying mined aggregate material from the drive, the conveying means comprising a plurality of modular conveyor units having a means for releasably coupling together the conveyor units, each coupling means comprising a male member and a complementary female member connected to the conveyor units such that the male member of one conveyor unit can be received in the female member of an adjacent conveyor unit to couple together the conveyor units,

(c) a means for electrically coupling a new conveyor unit to an end conveyor unit of the conveying means automatically as the male members of one conveyor unit are received in the female members of the other

-58-

conveyor unit and allowing concurrent electrical and mechanical coupling; and

- (d) a driving means for driving the mining means and the conveying means into the seam to form the drive.

36. A highwall mining system for mining aggregate material from a seam comprising:

- (a) a mining means for cutting aggregate material from the seam and thereby forming a drive in the seam;

- (b) a conveying means for conveying mined aggregate material from the drive, the conveying means comprising a plurality of modular conveyor units having a means for releasably coupling together the conveyor units, each coupling means comprising a male member and a complementary female member connected to the conveyor units such that the male member of one conveyor unit can be received in the female member of an adjacent conveyor unit to couple together the conveyor units, each coupling means further comprising a means for automatically locking the male and female members together when the male member of one conveyor unit is received in the female member of the adjacent conveyor unit; and

- (c) a driving means for driving the mining means and the conveying means into the seam to form the drive.

37. A highwall mining system for mining aggregate material from a seam comprising:

- (a) a mining means for cutting aggregate material from the seam and thereby forming a drive in the seam;

-59-

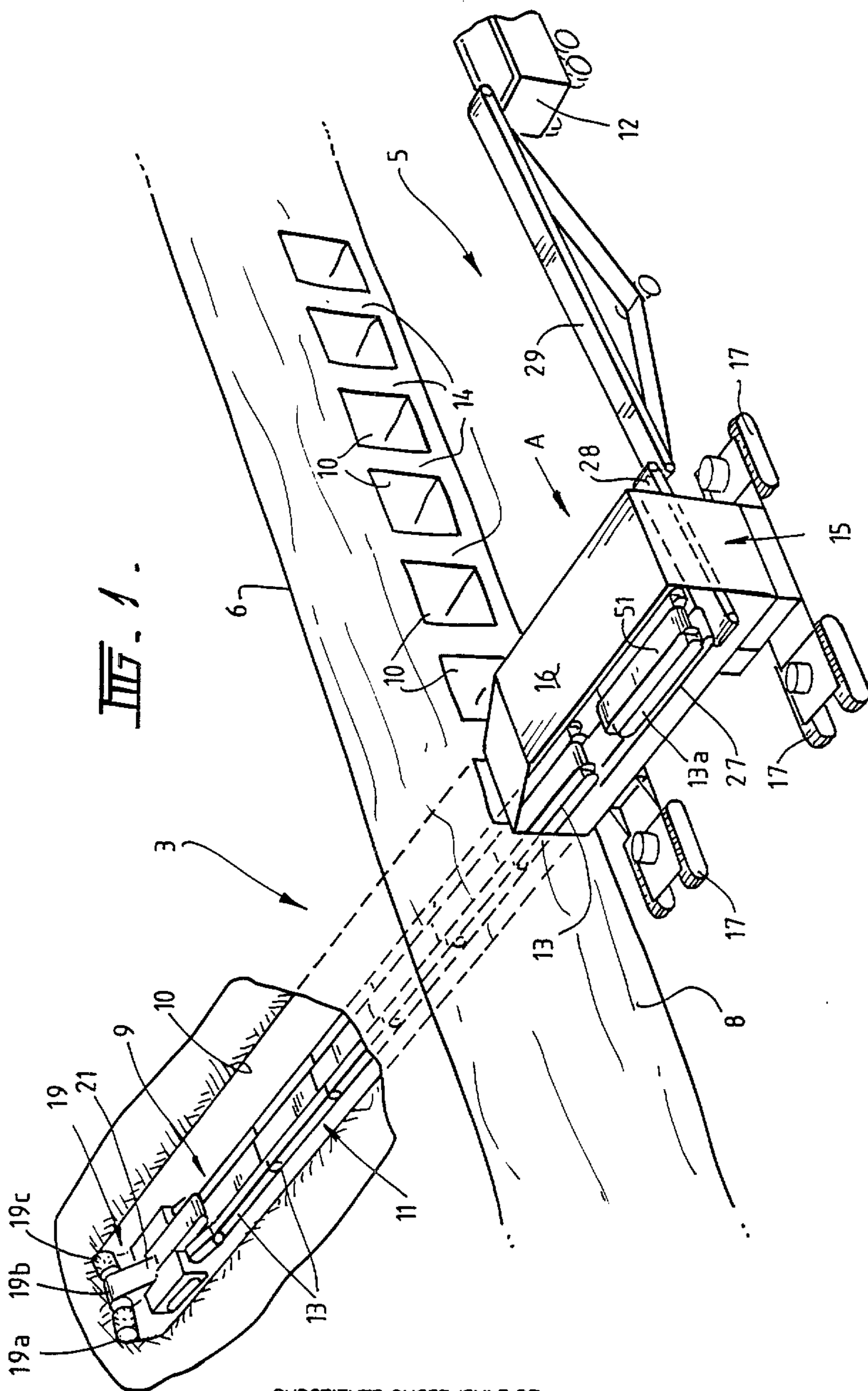
(b) a conveying means for conveying mined aggregate material from the drive, the conveying means comprising a plurality of modular conveyor units having a means for releasably coupling together the conveyor units;

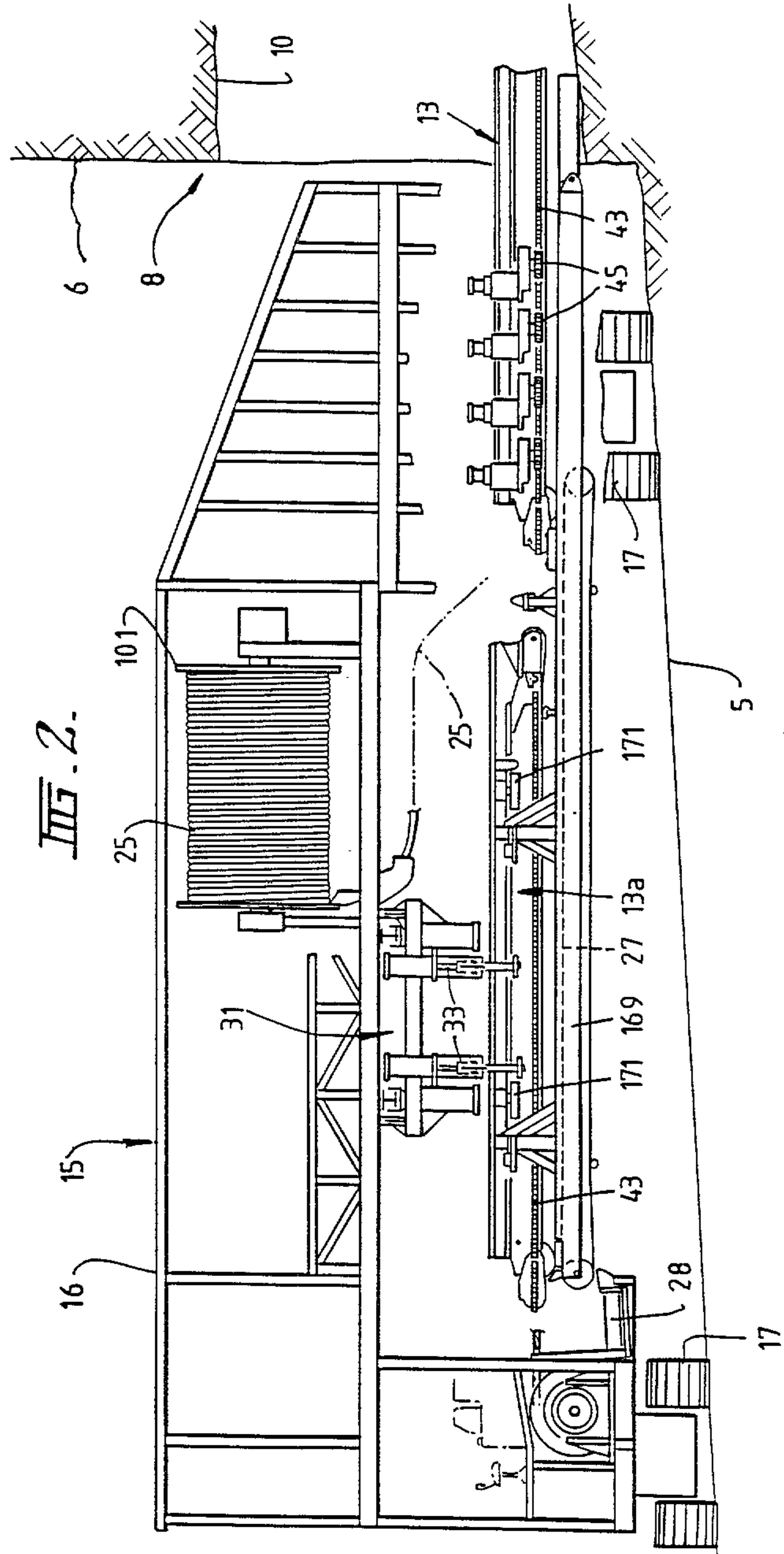
5

(c) a means for electrically coupling a new conveyor unit to an end conveyor unit of the conveying means automatically as the new conveyor unit is moved toward the end conveyor unit; and

10

(d) a driving means for driving the mining means and the conveying means into the seam to form the drive.





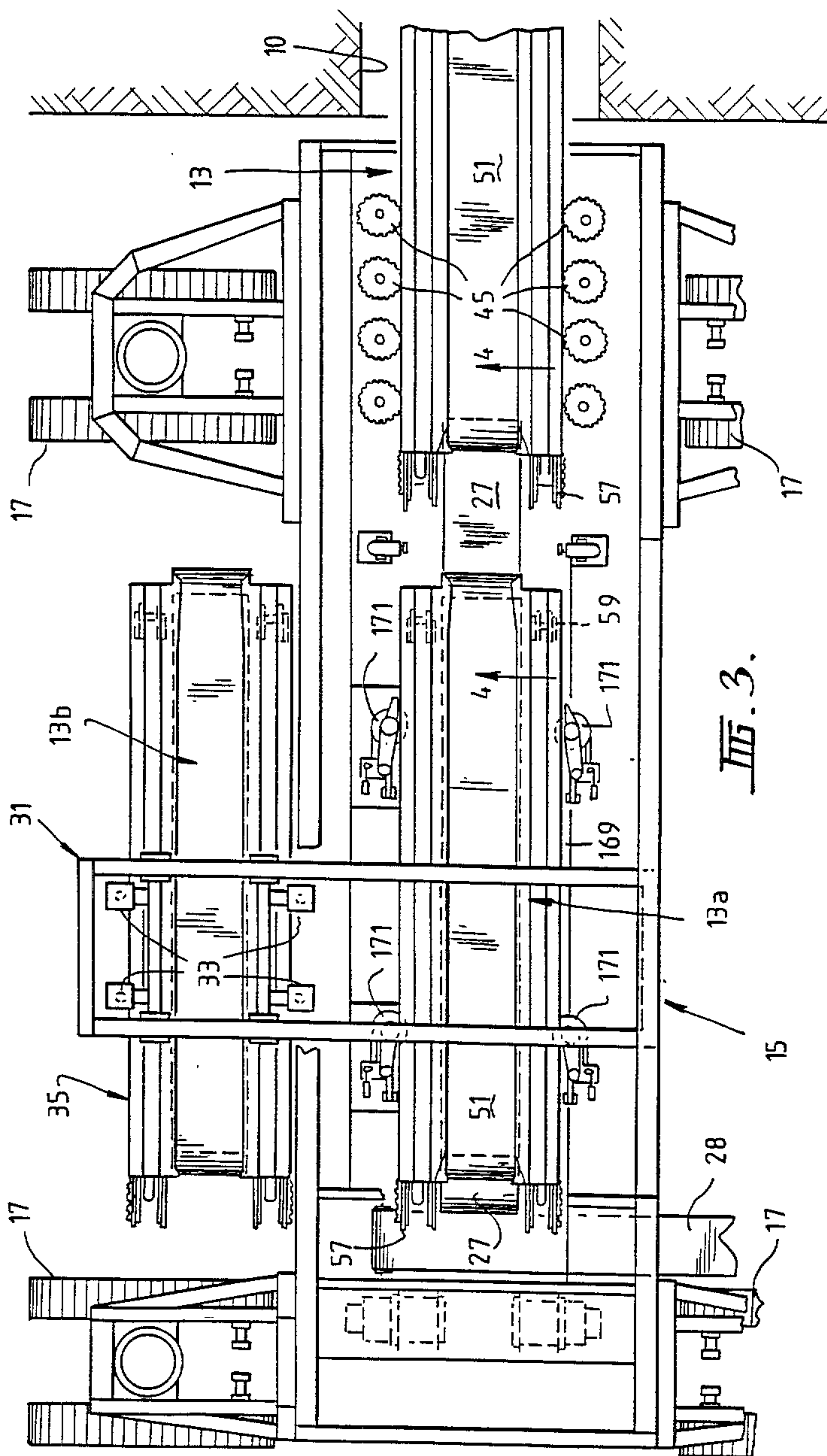
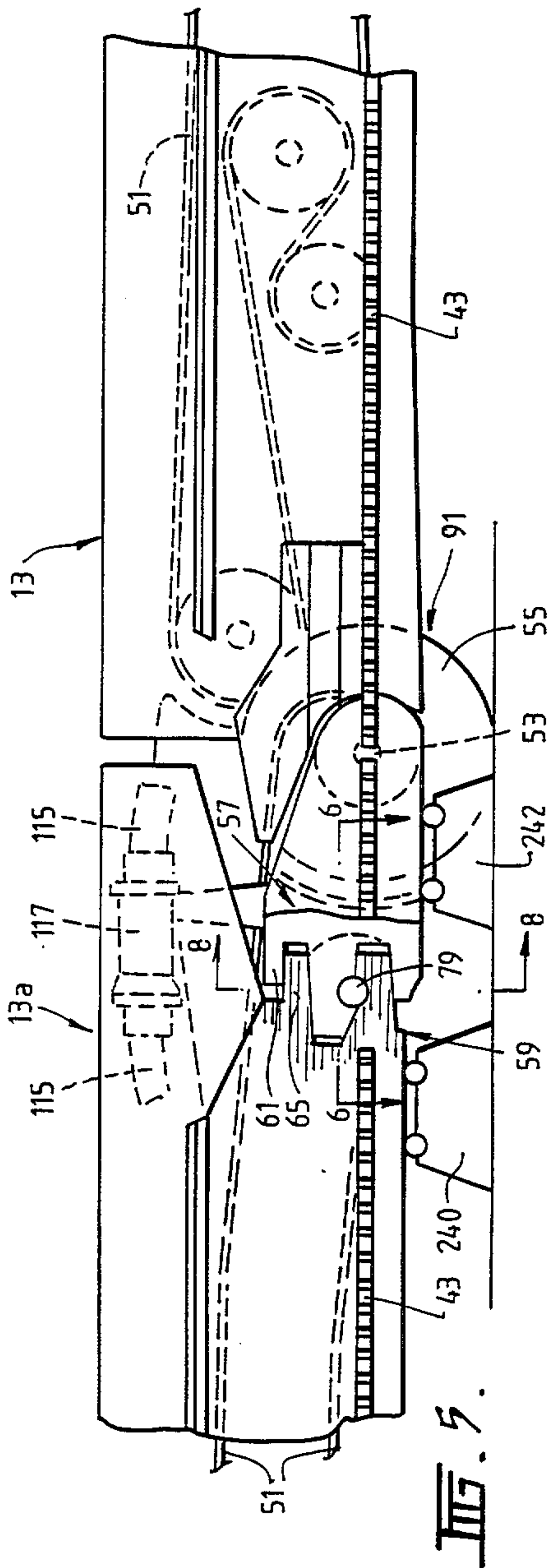
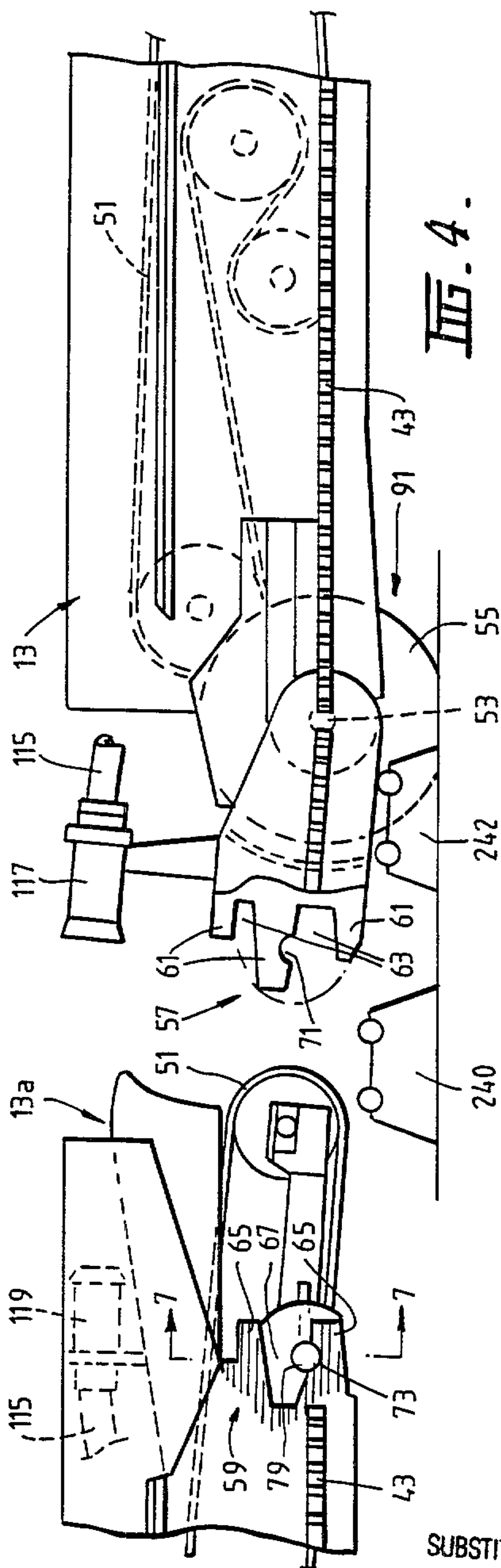


FIG. 3.

4/22



5 / 2 2

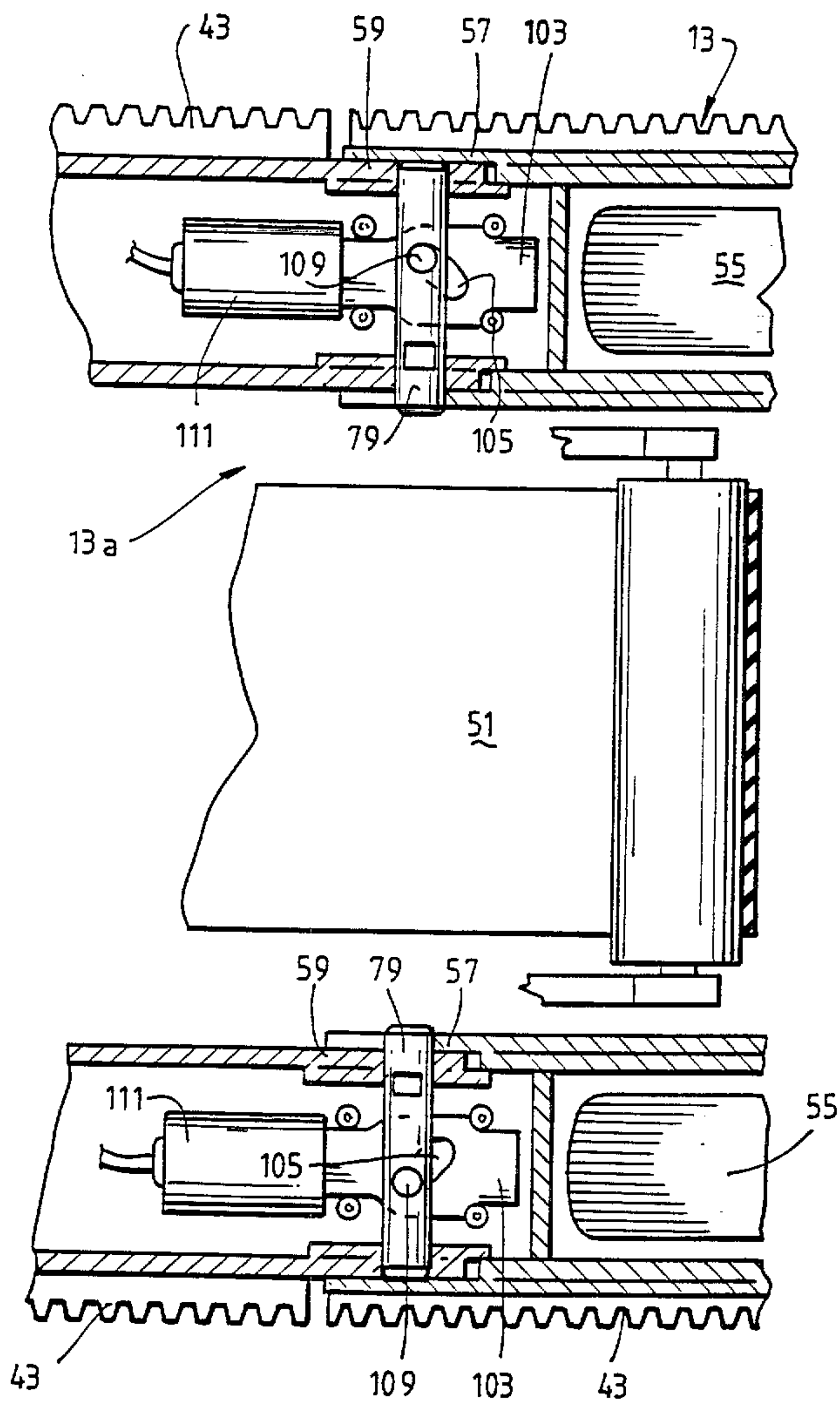
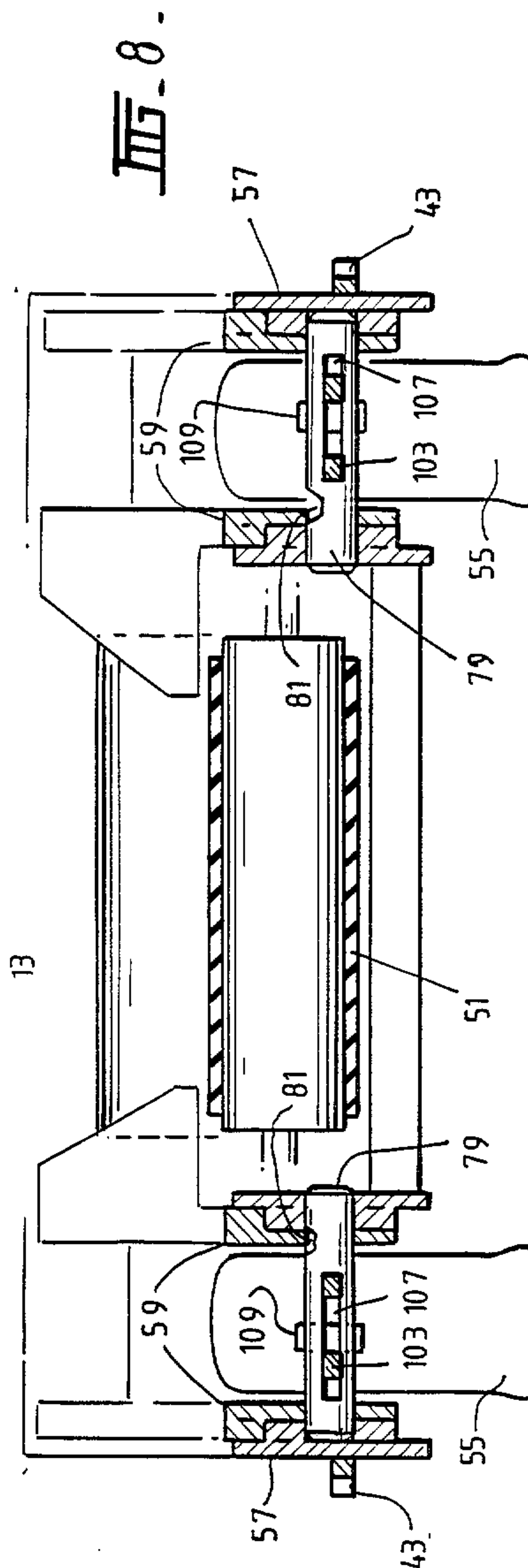
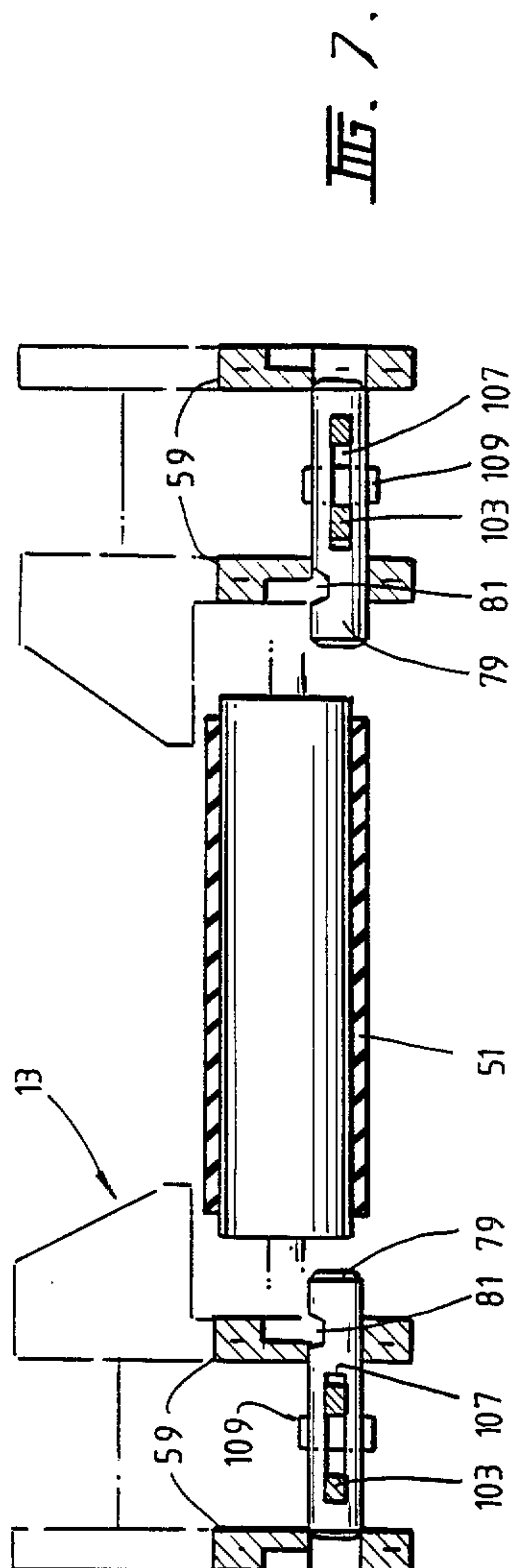
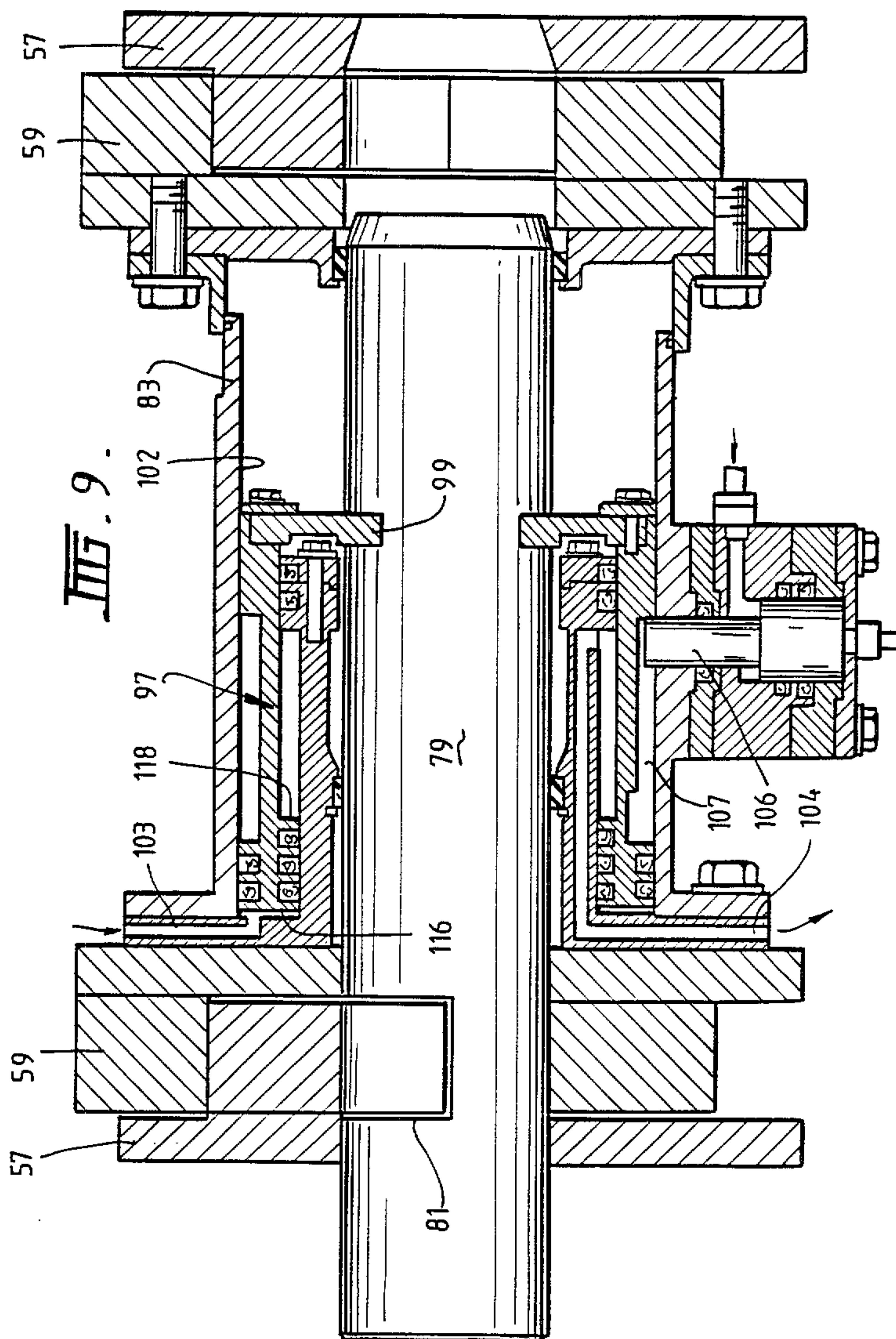
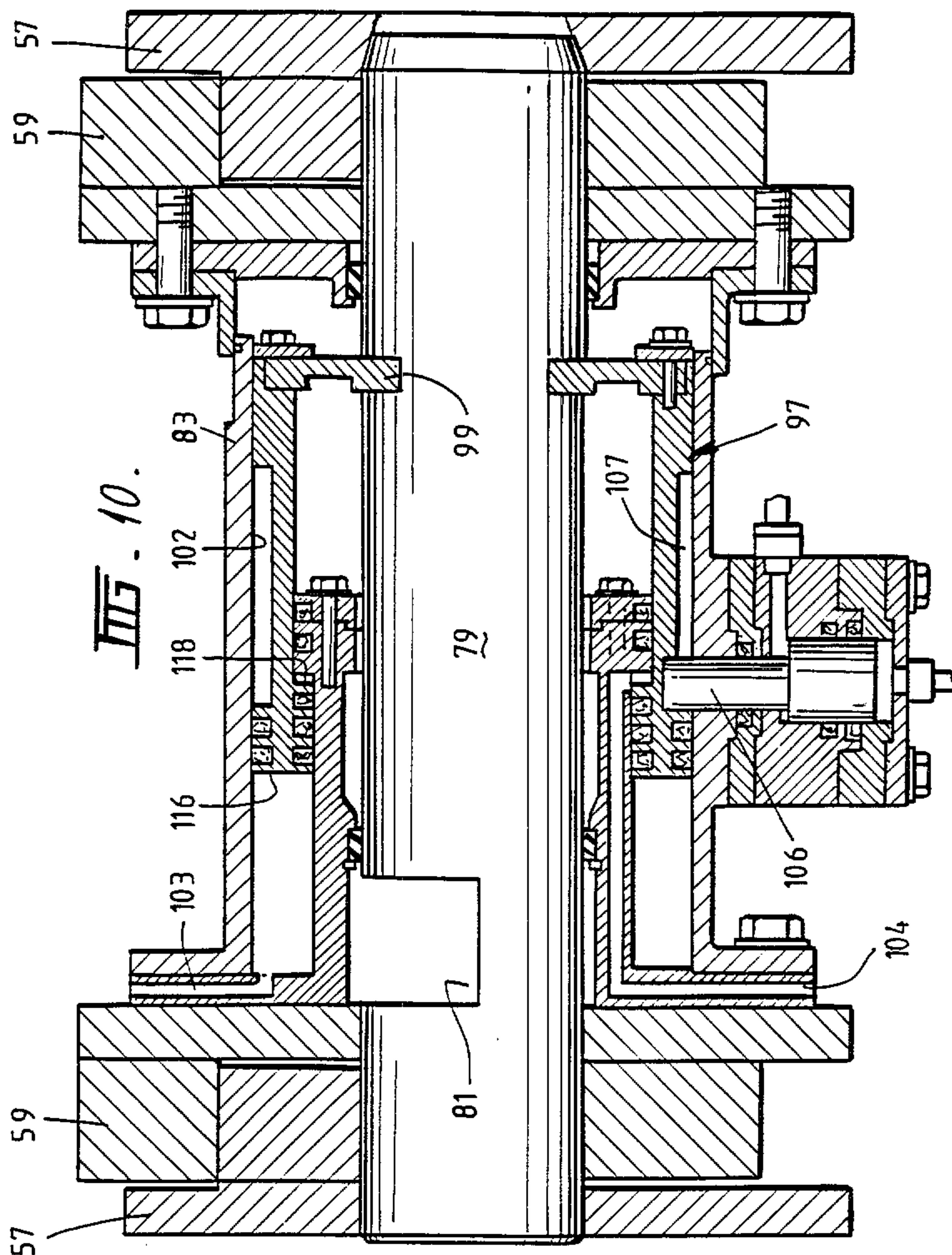


FIG. 6.







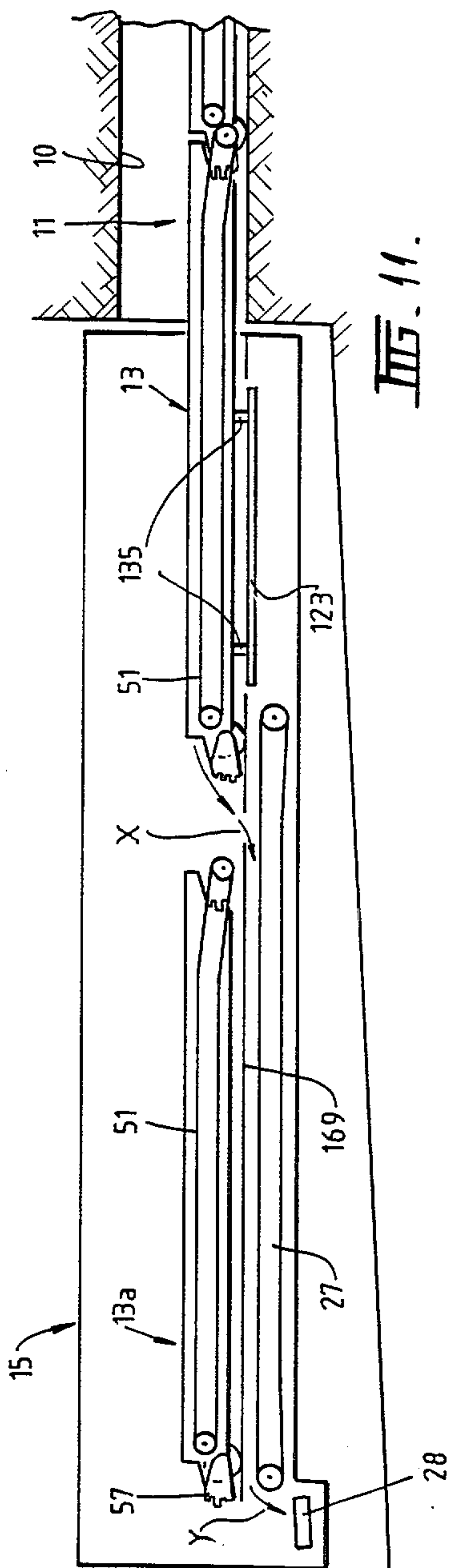


Fig. 11.

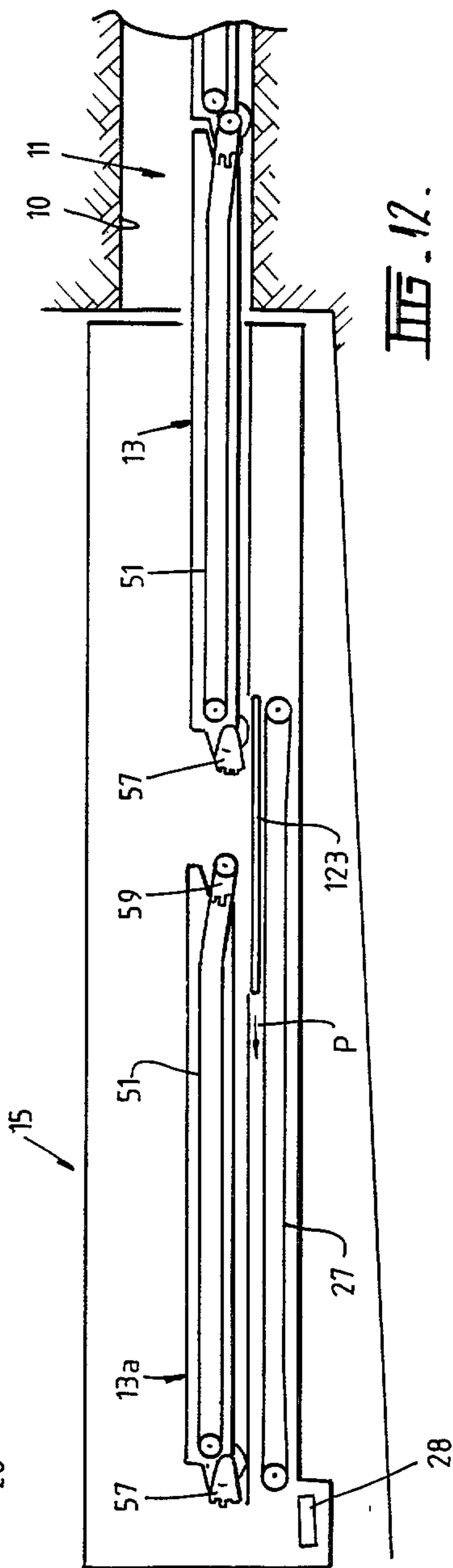
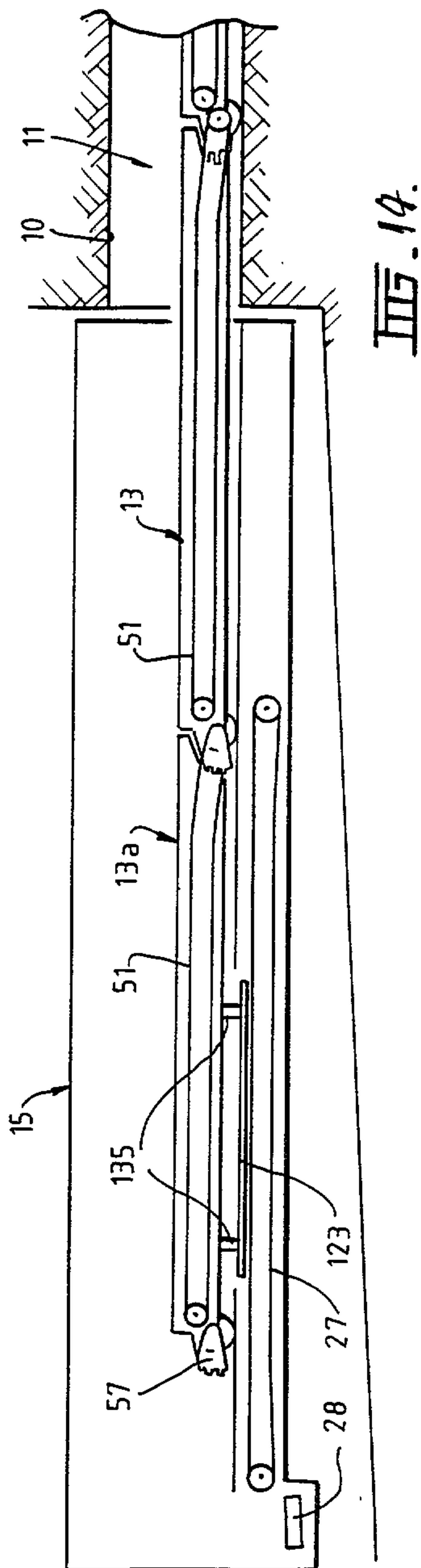
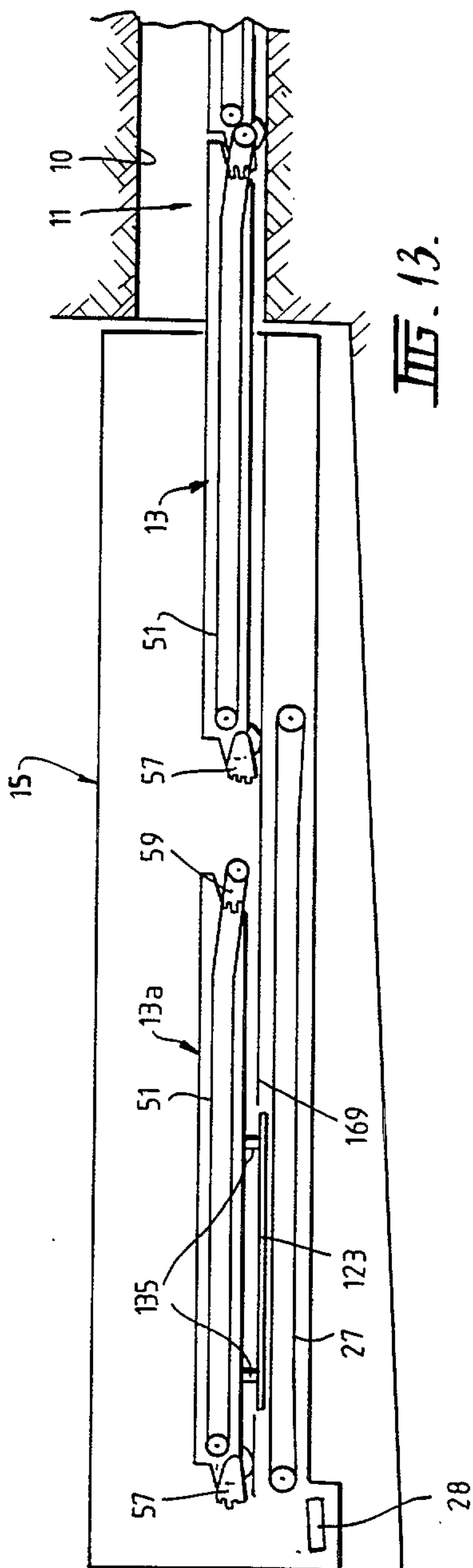


Fig. 12.



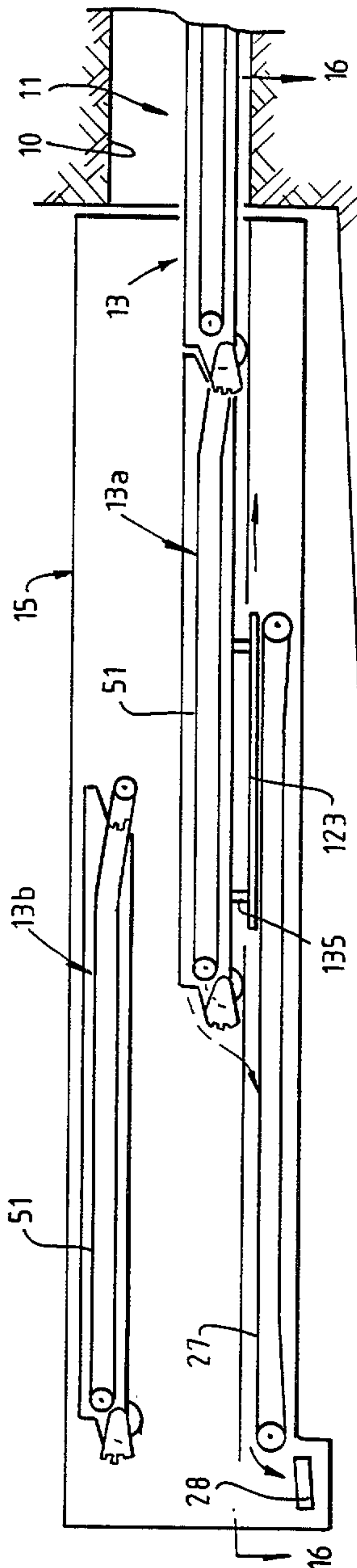


Fig. 15.

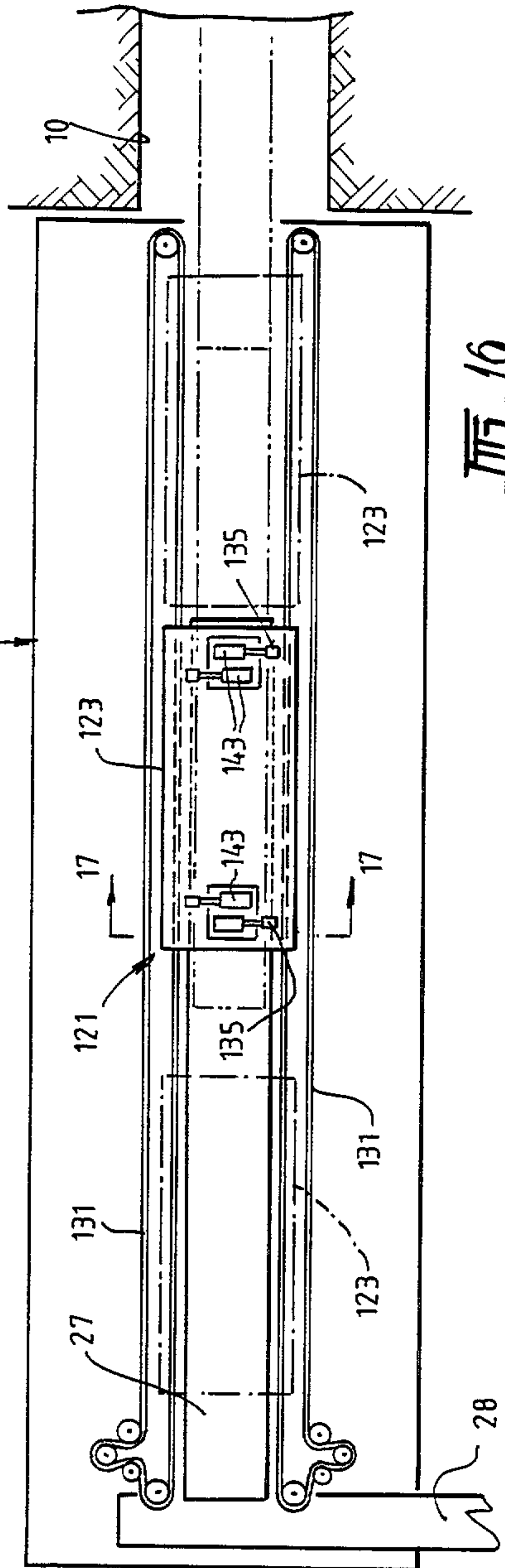


Fig. 16.



12/22

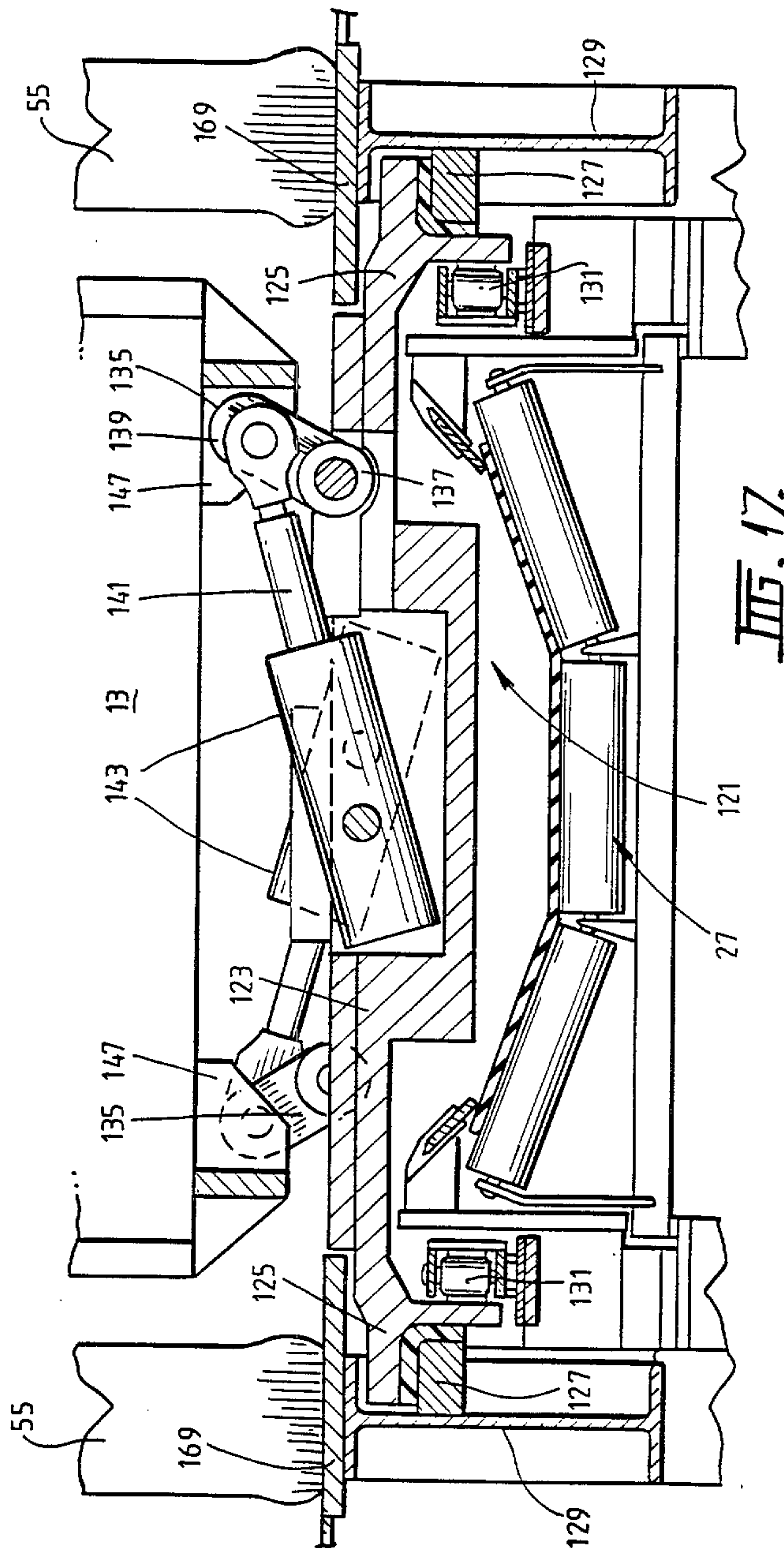
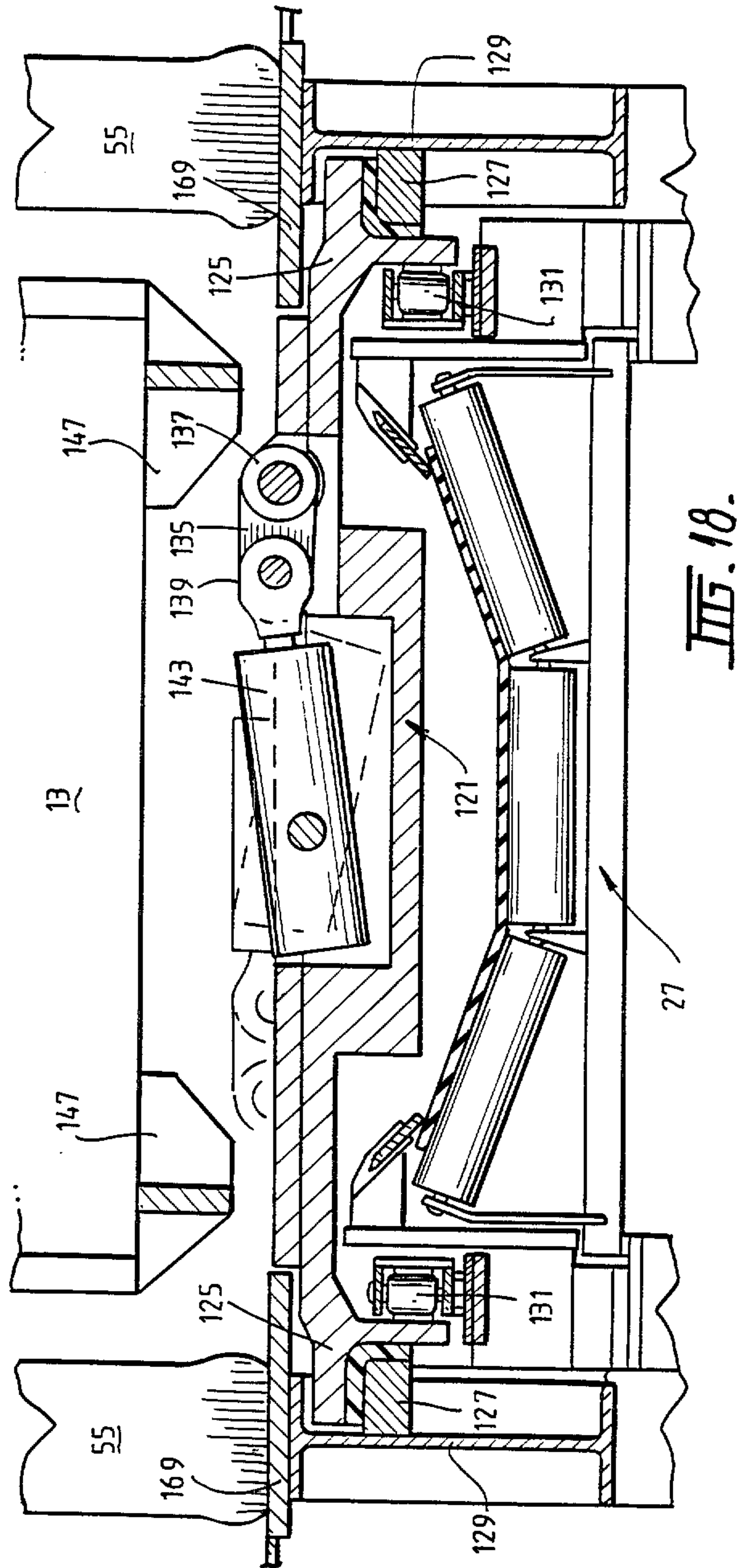
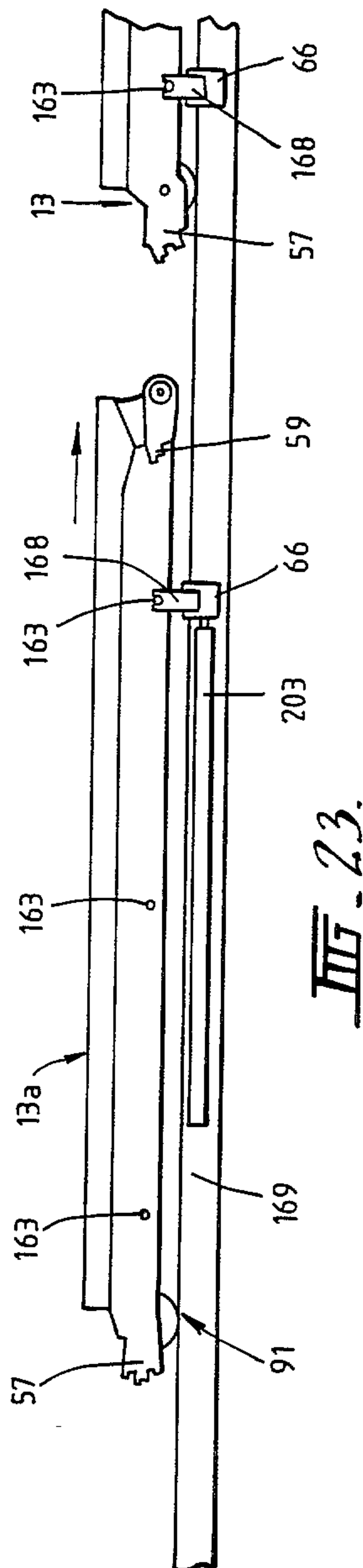
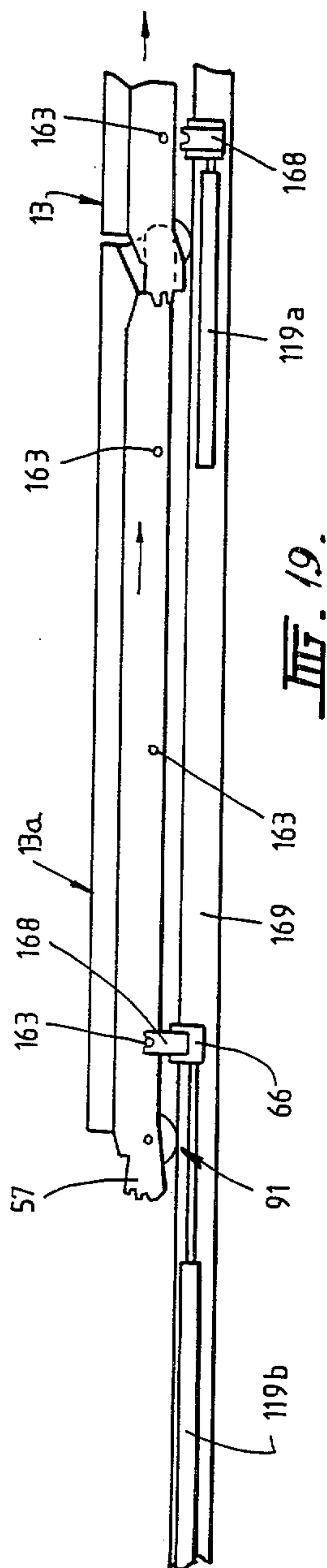
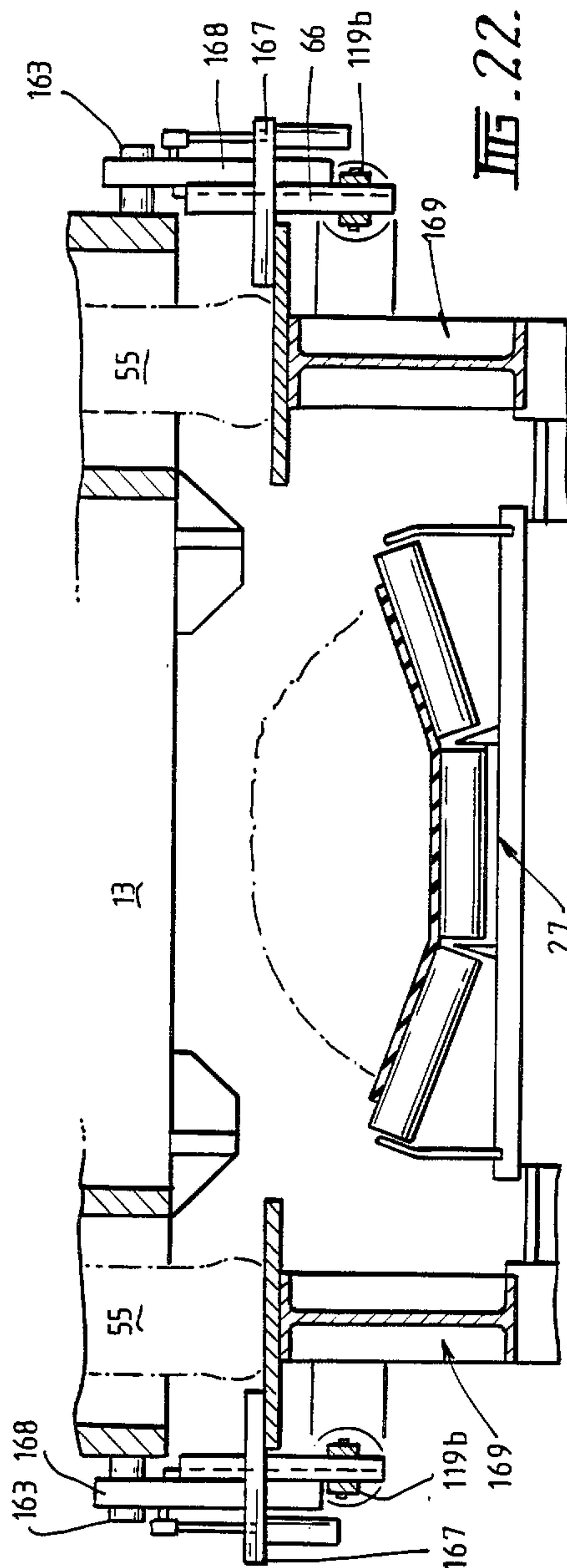
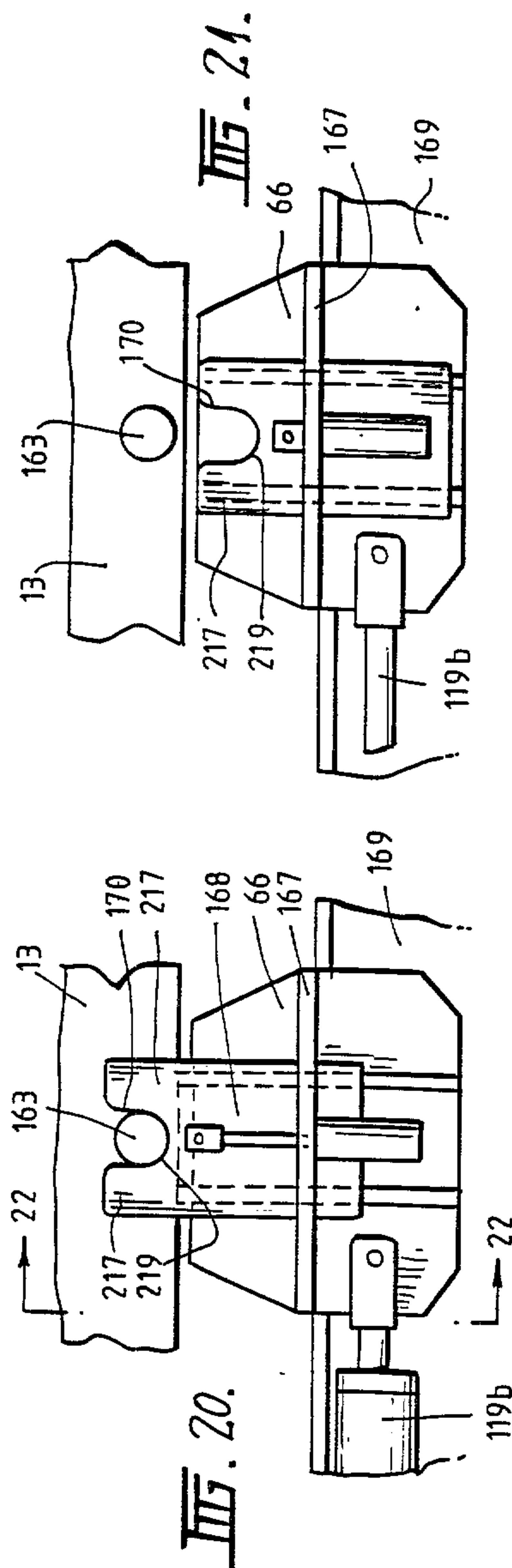


FIG. 17.

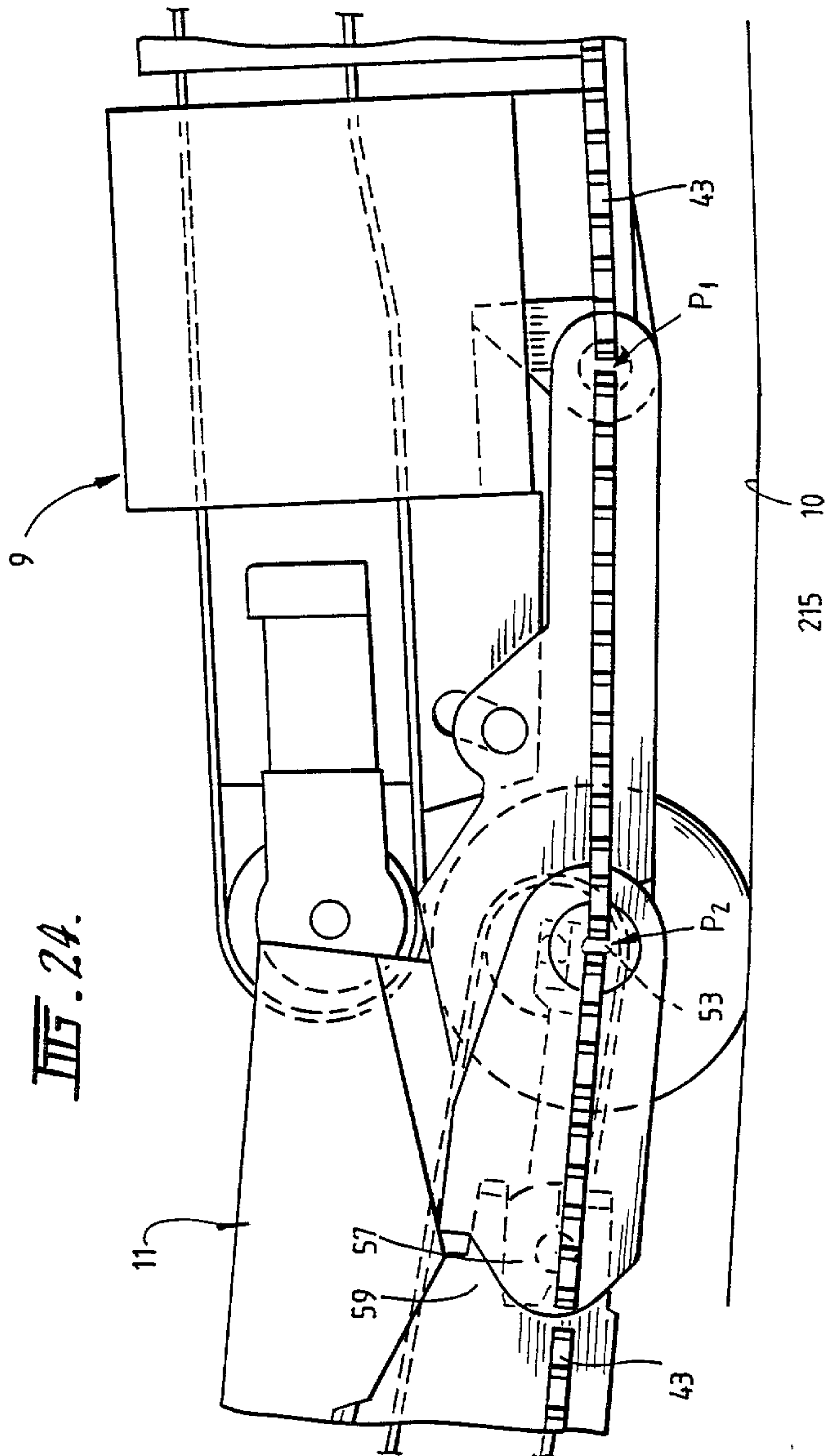


14/22

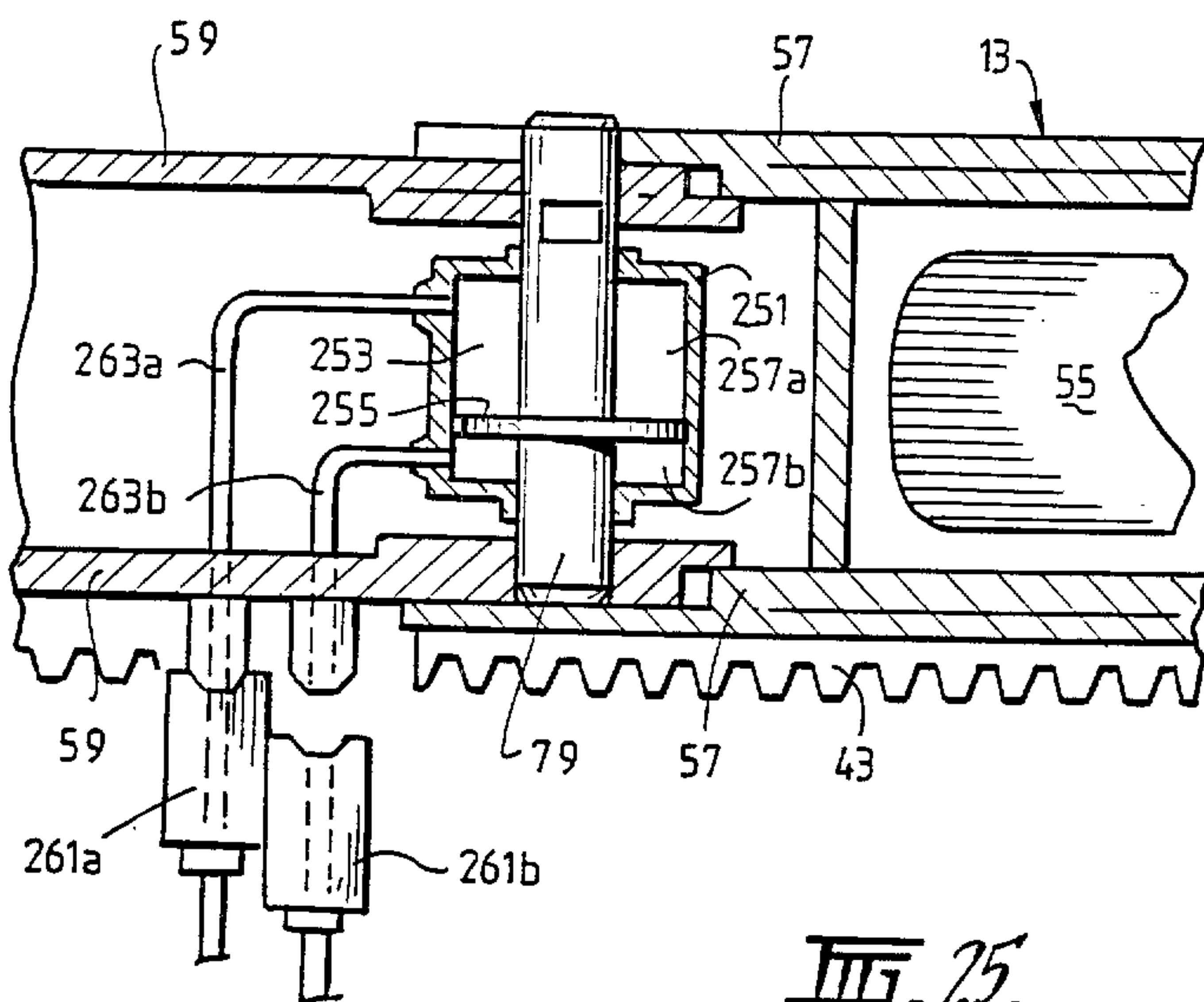




16 / 2 2

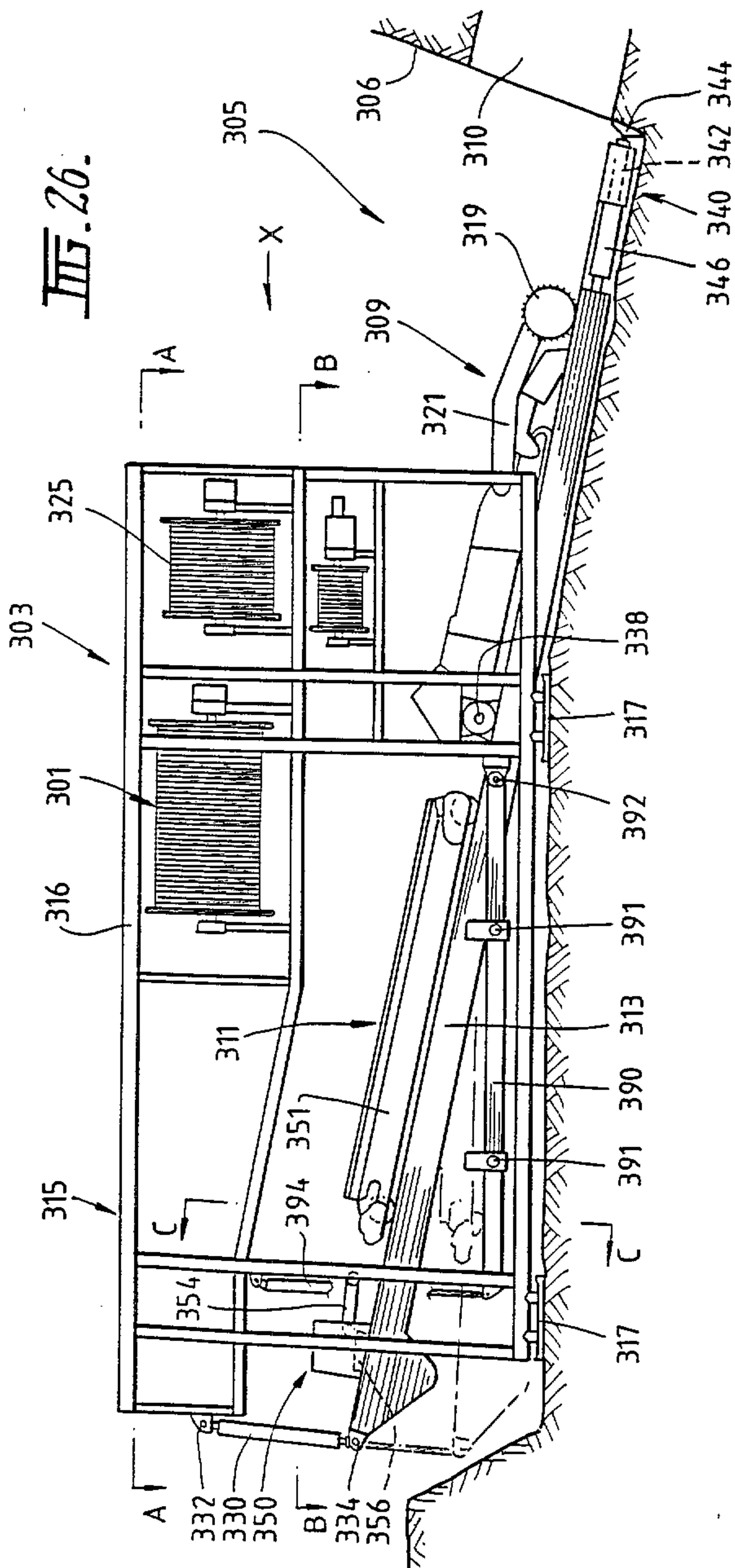


17 / 2 2

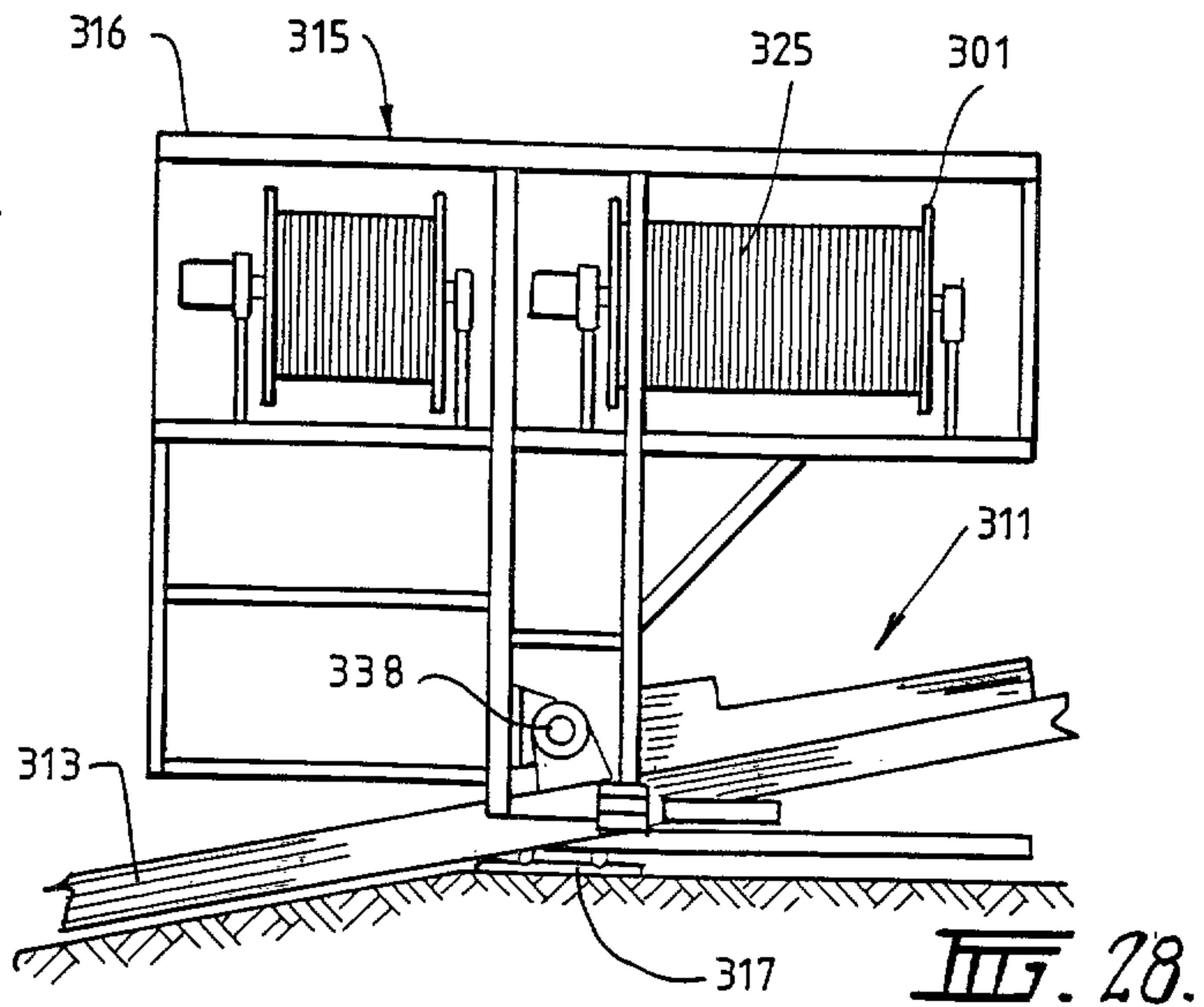
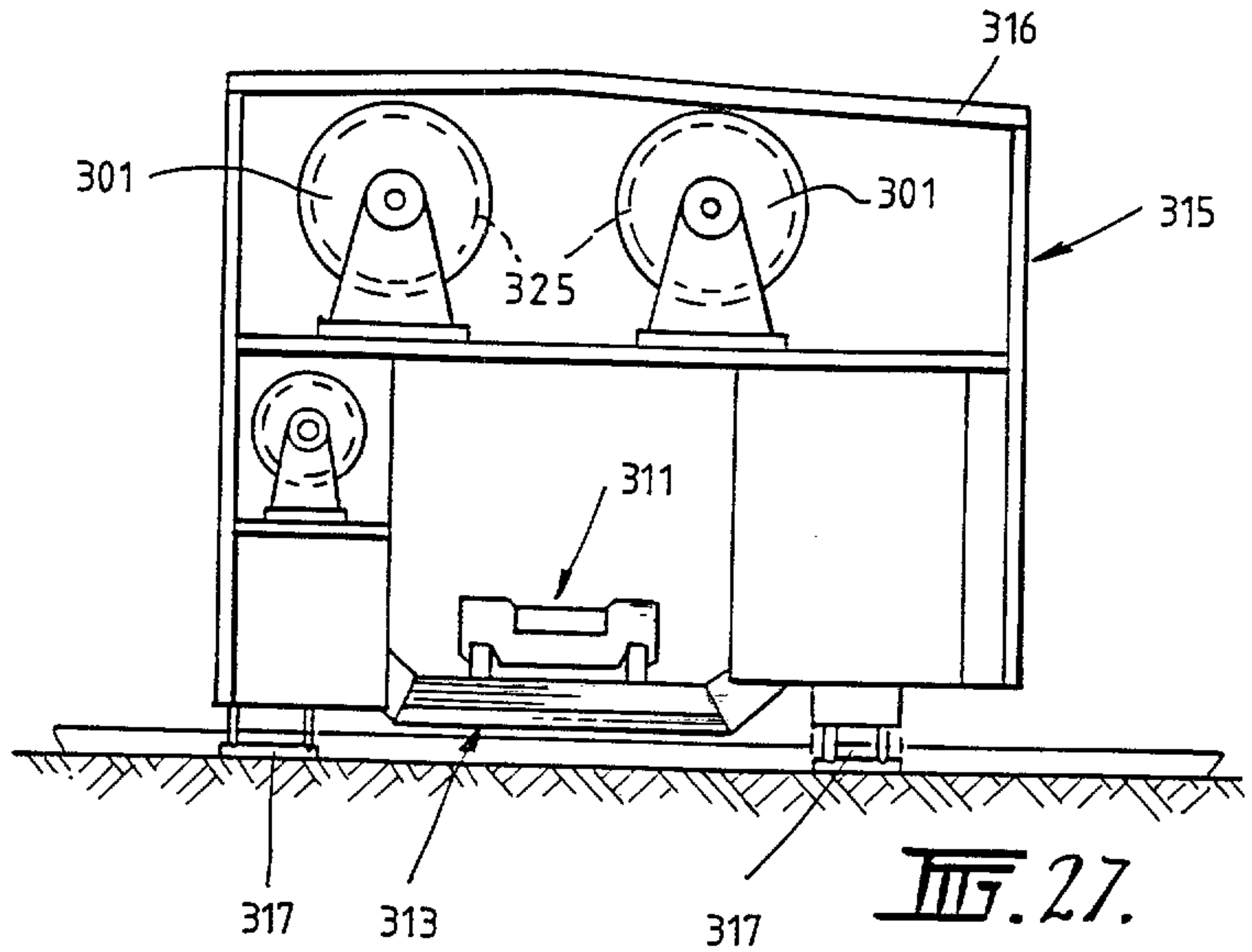
*FIG. 25.*

18 / 2 2

Fig. 26.



19 / 2 2



20 / 2 2

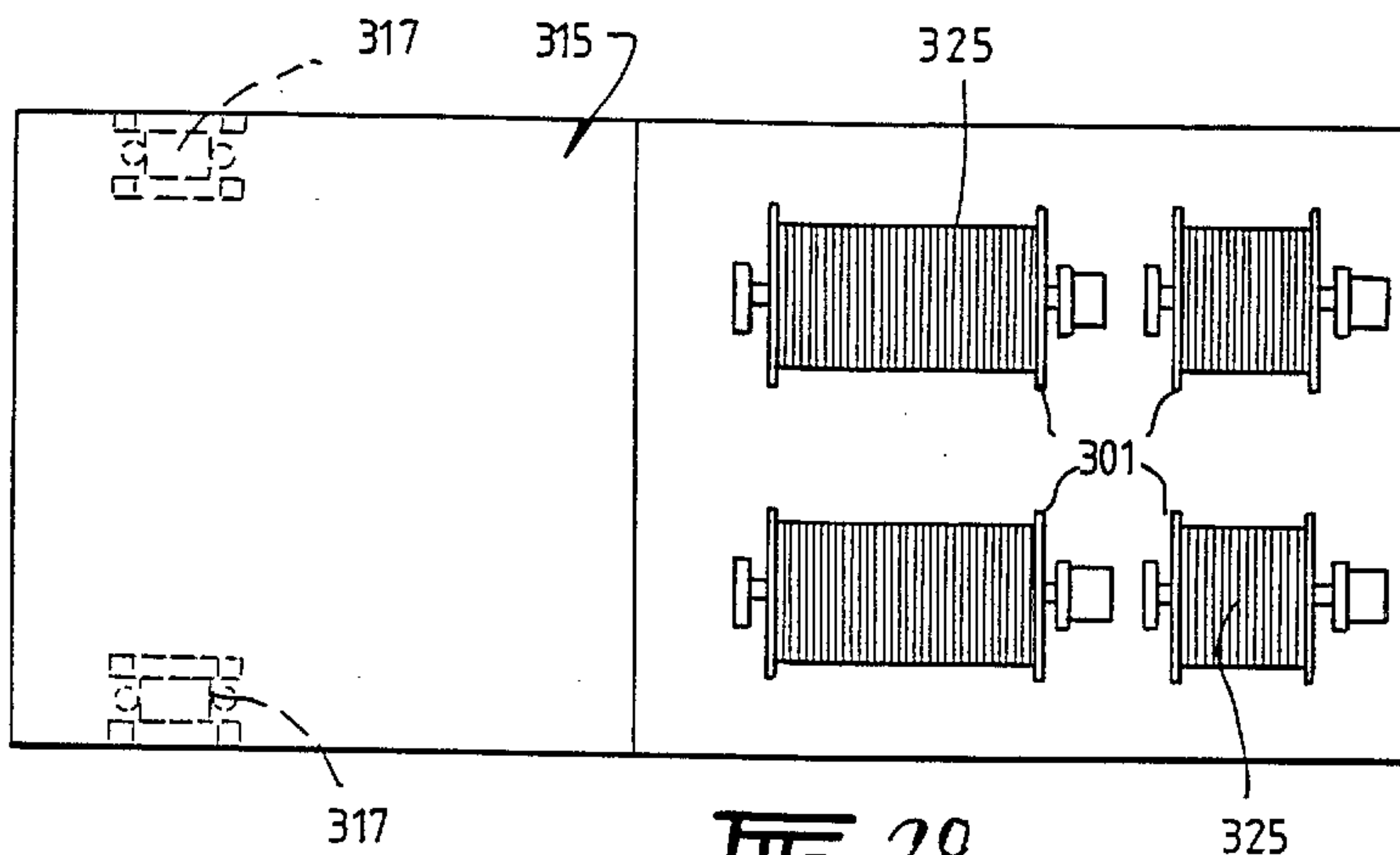


FIG. 29.

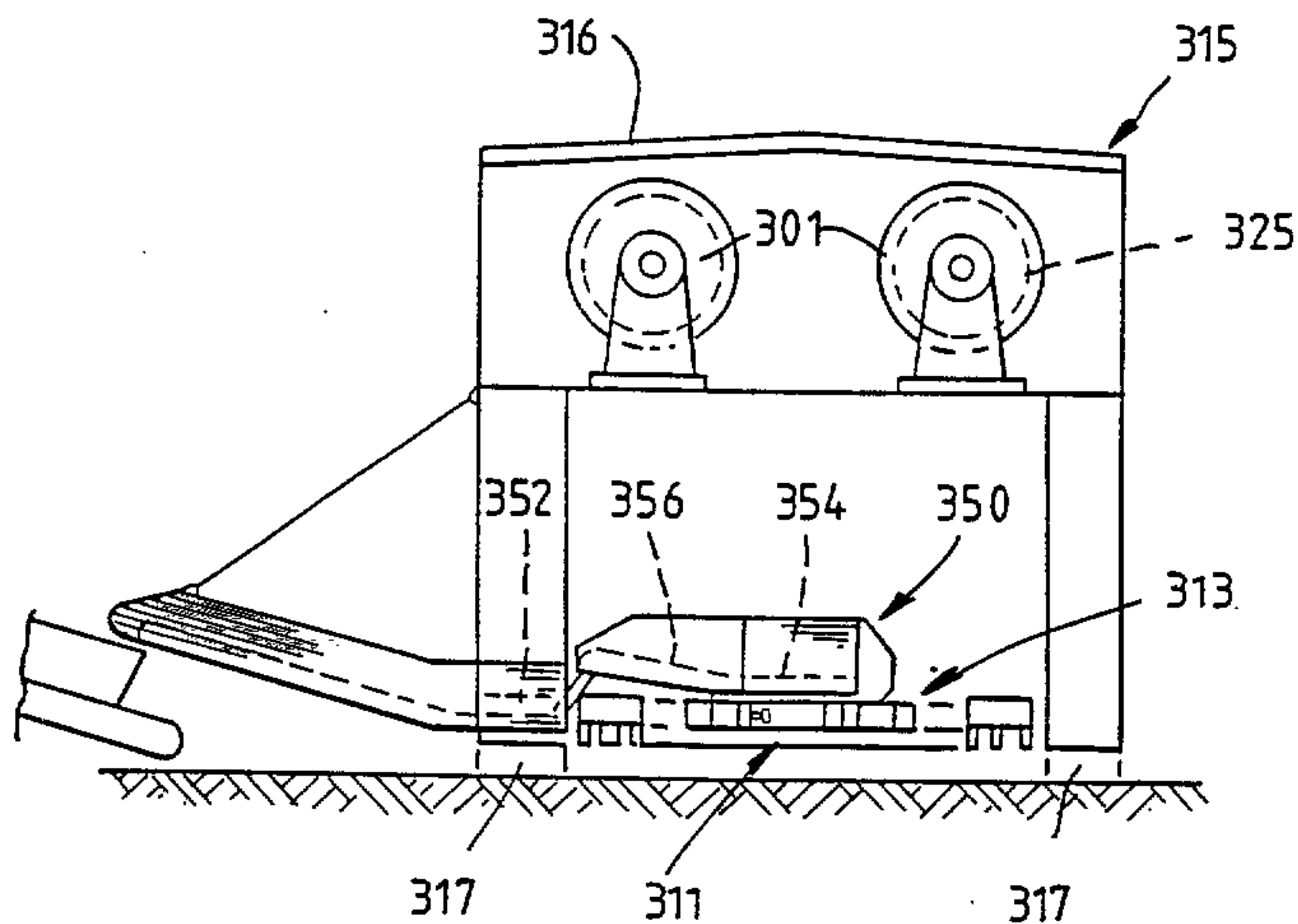
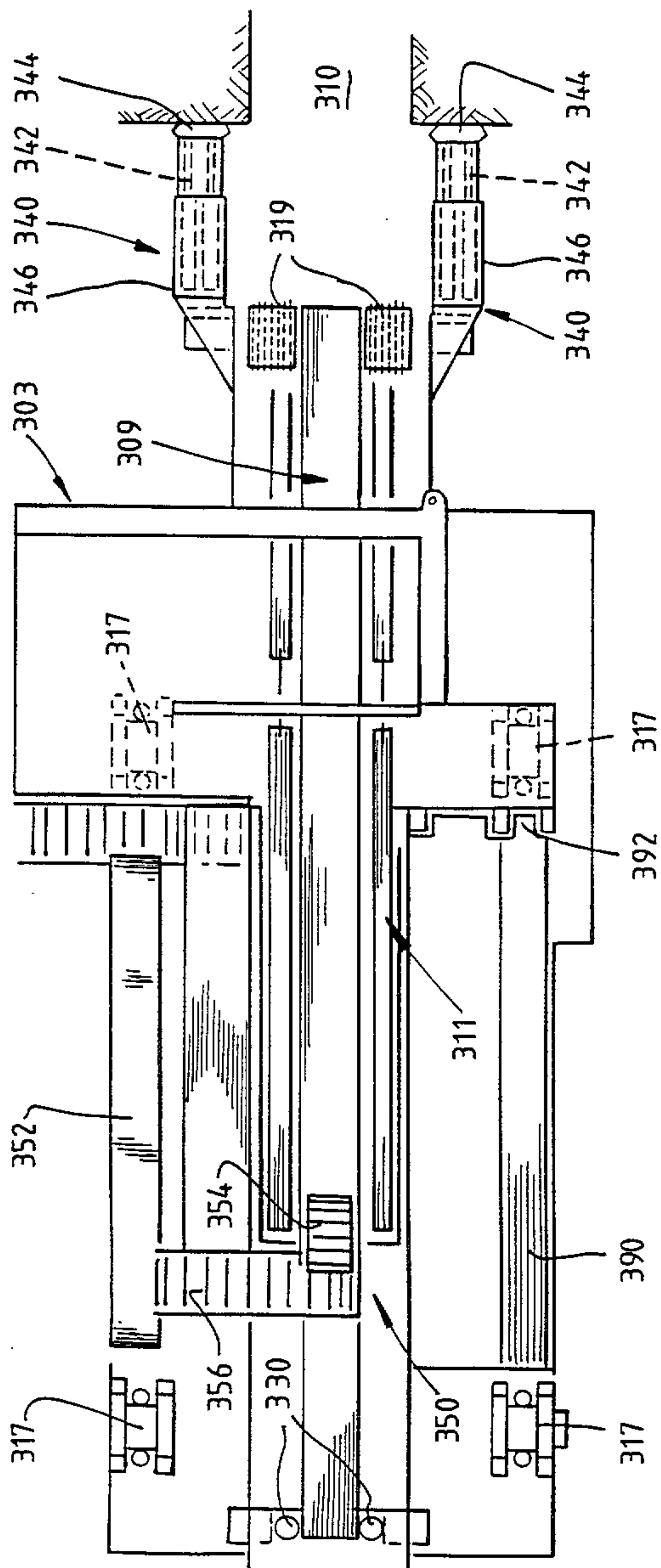


FIG. 31.

21 / 22

III. 30.



SUBSTITUTE SHEET (RULE 26)

