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(54) **VARIABLE-WIDTH BOGIE WITH ROTATING AXLES AND A STATIONARY APPARATUS FOR CHANGING TRACK WIDTH**

DREHGESTELL MIT VARIABLER BREITE MIT DREHACHSEN UND STATIONÄRE VORRICHTUNG ZUR ÄNDERUNG DER SPURBREITE

BOGGIE À LARGEUR VARIABLE COMPRENANT DES ESSIEUX TOURNANTS ET INSTALLATION FIXE POUR CHANGER LA LARGEUR DE VOIE

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(73) Proprietor: **Patentes Talgo, S.L.**

28290 Madrid (ES)

(72) Inventor: **LÓPEZ GÓMEZ, José Luis**

E-28023 Madrid (ES)

(74) Representative: **Carpintero Lopez, Francisco**

Herrero & Asociados, S.L.

Cedaceros 1

28014 Madrid (ES)

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Description

Field of the Invention

[0001] The invention relates to a bogie with means for traveling on tracks having different gauges, and more particularly to a bogie with rotating axles provided with a gauge changing device in cooperation with a changing installation arranged between two tracks having different gauges, and to a fixed track gauge change installation.

Background of the Invention

[0002] The applicant of this invention developed several decades ago a track gauge changing system, object of patent ES 332,453, in response to Renfe's initiative to ask for tenders for solutions to prevent passengers from having to change trains at the Spanish-French border, which up until that time had to be done due to the different gauge of the tracks on the Iberian peninsula (1668 mm) in relation to European tracks (1435 mm).

[0003] On one hand, that system involves incorporating in railway units a translation device of the wheels of their axles and, on the other hand, a fixed installation assembled between the tracks having different gauges. The operation for changing the distance between wheels is performed automatically, without human intervention, with the passage of the train over said installation in five continuously occurring phases; in the first phase, the wheels are released from their vertical loads; in the second phase, the wheel axle assemblies are released from a lateral locking mechanism holding them in their running position; in the third phase, the wheels, which are released from the vertical load and from their lateral lock, enter into guides which, as the axle moves forward, laterally move them to their new running position, in accordance with the new track gauge; in the fourth and fifth phases, the wheel assemblies are laterally locked again and the vertical load is applied to the axle again, thereby concluding the change operation.

[0004] After this innovation, which was a major milestone in railway technology, the applicant of this invention has made different developments to apply the system to different railway structures: independent axles, bogies, freight bogies and motor bogies and, among them, the one described in patent ES 2 130 039 "*Conjunto de eje ferroviario dotado de cambio automático de ancho de vía y adaptable a bogies convencionales de mercancías*" ("Railway Axle Assembly provided with Automatic Track Gauge Change and Adaptable to Conventional Freight Bogies"), which can be incorporated the conventional freight bogies to replace the assembled fixed-gauge axles without requiring a substantial modification thereof.

[0005] The axle integrates two independent running assemblies (wheel with short axle or half-axle and two bearings), the gauge change between wheels being performed by the simultaneous transverse movement of the two running assemblies in a manner similar to that used

in TALGO trains although, rather than including locking devices in the two bearings of each running assembly, they only incorporate the locking device in the inner bearing.

[0006] Structurally, the axle assembly comprises an axle chassis on which are assembled the two running assemblies and their locking systems, a connection device between running assemblies, two translation frames of the brake blocks, an electrical continuity system between the wheels or an electrical shunting system and a device for detecting hot inner bearings.

[0007] Although the technology described in patent ES 2 130 039 has facilitated the adaptation of traditional freight bogies to variable track gauges, the railway industry constantly demands new solutions to face the different problems posed by the adaptation of railway freight wagons to tracks having different gauges. In this sense, it must be indicated that, particularly in Spain, the implementation of the European gauge in the highspeed network has intensified the technological needs relating to the track gauge change. Prior art document EP 0 873 929 A2 discloses still another interesting solution to the problem of changing gauge. Apart from many common features, a major difference disclosed by the bogie of the prior art with respect to that of the invention is the fact that only the lateral bearing parts are lifted during change of gauge, while the wheels still remain in contact with the rails. The bogie of the invention has load-free wheels instead. The present invention aims to meet this demand.

Summary of the Invention

[0008] An object of the present invention is to provide a freight bogie that can adapt to railroad tracks having different gauges in which the non-suspended weight component is minimized.

[0009] Another object of the present invention is to provide a freight bogie that can adapt to railroad tracks having different gauges in which the risk of the accidental unlocking of the device which allows varying the distance between the wheels is minimized.

[0010] These and other objects are achieved with a bogie comprising a bearing platform of a railway wagon and at least one rotating axle on which are assembled two wheels by means of a coupling device which allows their lateral movement and which is provided with a track gauge change device using means which prevent/allow the lateral movement of each wheel such as a lock which is vertically movable when actuated by locking/unlocking guides provided for that purpose in a fixed installation for performing the track gauge change, in which:

- Said coupling device has connected thereto locking guides by means of which its lateral movement is controlled so as to be located in the positions corresponding to the two track gauges.
- Said rotating axle includes bearing parts of said platform internally including bearings and housings to

receive said locking guides and said lock, as well as means to facilitate its locking/unlocking by cooperating with those of said fixed installation;

- Said rotating axle incorporates at its ends bushes fixed to the axle.
- Said bearing parts also include a side chassis with support shoes which may rest on the fixed installation and a central collar serving as support for the end of the axle during the passage through the fixed installation through a semicircular bush connected to said central collar.

[0011] In a preferred embodiment of the invention the bogie also comprises a bolt as an additional safety element connected to each lock through a horizontal spring for the purposes of preventing its vertical movement in cooperation with a retaining element of said bolt connected to a bearing part.

[0012] Another object of the invention is to provide a fixed installation to perform the gauge change operation adapted to a bogie provided with means which minimize the risk of the accidental unlocking of the device which allows varying the distance between the wheels.

[0013] This object is achieved with a fixed installation for performing the track gauge change comprising sliding and bearing guides, lateral movement guides and locking/unlocking guides, in which the head of the locking/unlocking guides is configured such that it can laterally move said bolt, overcoming the force of said horizontal spring.

[0014] Other features and advantages of the present invention will be understood from the following detailed description of an illustrative and non-limiting embodiment of its object in relation to the attached drawings.

Brief Description of the Drawings

[0015]

Figures 1A to 1E are cross-section views of half an axle of the bogie according to the present invention in the five phases of the track gauge change process. Figures 2A to 2E show side views of half an axle of the bogie according to the present invention in the five phases of the track gauge change process. Figures 3A and 3B are simplified side-section and cross-section views of the axle of the bogie according to the present invention showing the basic elements of the track gauge change device. Figures 3C, 3D and 3E show plan and section views of the ring incorporating the locking guides. Figure 4 is a plan view of the fixed track gauge change installation. Figure 5 is a section view of the track gauge change installation, taken along line A-A of Figure 4.

Detailed Description of Preferred Embodiments

[0016] The bogie according to the present invention includes:

- A platform the load of which is transmitted through the suspension springs 11 .
- At least one rotating axle 2 on which there are assembled at each of its ends:

a) A wheel 1 by means of a coupling device allowing its lateral movement.

b) A bearing part 10 of said platform,

c) A track gauge change device using means which prevent/allow the lateral movement of the wheel 1 such as a lock 22 which is vertically movable when actuated by means provided for that purpose in the fixed installation.

[0017] In the embodiment of the invention illustrated in the figures the coupling device for coupling the wheel 1 to the axle 2 comprises:

- A bush 3 integral with the wheel 1 and sliding on the axle 2 including at its end a ring 7, with an axial inner bearing 8, to which the locking guides 18 are fixed.
- A tubular element 4 fixed to the central part of the axle 2 by means of the bushes 5 and 6.

[0018] There is a separating bush 9 between the wheel 1 and the bearing axial 8 to constantly maintain the distance.

[0019] The bush 3 cooperates with the tubular element 4 for the lateral movement of the wheel 1 during the gauge change operation. For that purpose the tubular element 4 can be provided with inner grooving and the bush 3 can include a head 3' cooperating with said grooving during the lateral movement of the wheel 1 in the gauge change operation taking place, as will be seen below in further detail, by means of the movement of the locking guides 18, integral with the bush 3 which, in cooperation with the lock 22, determines the two positions of the wheel 1 corresponding to the two track gauges involved.

[0020] The bearing parts 10 are in contact with the axle 2 through the bearings 12 and include inner housings to receive said locking guides 18 and said lock 22 as well as stops 20 provided to serve as positioning and insertion means for the lock 22.

[0021] The central part of the axle 2 on which the wheels 1 are located in the positions corresponding to the two track gauges by means of the coupling device which has been described has a larger diameter than that of its end parts. There is a bush 8' serving as a stop for the movement of the bush 3 in the area of transition between the two gauges. At the ends of the axle 2 there is arranged a bush 13 together with a cover 15 fixed to the axle 2 by means of screws serving as a protective element for the same during the track gauge change op-

eration as well as for the stop of the bearings 12.

[0022] The bearing parts 10 also include a side chassis with support and sliding shoes 16 in the fixed installation, for which purpose they have nylon guides 17 and a central collar serving as support for the end of the axle 2, covered by the bush 13, during the passage through the fixed installation through a semicircular bush 14 connected to said central collar which is preferably made of bronze. As will be seen below, during the track gauge change operation, the bogie is supported and slides on these shoes 16, the wheels 1 being load-free.

[0023] As a person skilled in the art will understand, this configuration of the side chassis of the bearing parts is determined at least in part by the arrangement of the centering and sliding guide rails 19. If these rails had any other arrangement, the configuration of the side chassis would logically be modified such that it carried out the indicated functions.

[0024] The lock 22 is formed by two vertical rods connected to one another by a hollow bridge designed so that the head of the double T-shaped unlocking guide 24 of the fixed track gauge change installation is introduced through said bridge, and it has nylon guides 23. To prevent accidental locking/unlocking, the lock includes pretensed safety springs 28 to prevent unwanted vertical movements of the lock 22 when it is not in contact with the unlocking guide 24.

[0025] In the embodiments shown in the figures, the fixing device has an additional safety element formed by the bolt 25, connected to the lock 22 and laterally movable, overcoming the force of the horizontal spring 21, and a retaining element 26 connected to the bearing part 10. When the spring 21 is at rest, the bolt 25 is in contact with the retaining element 26 preventing the vertical movement of the lock 22. In order for this movement to be possible it is necessary to apply a force in the spring 21 which laterally moves the bolt 25 and prevents its being retained by the retaining element 26.

[0026] The track gauge change process upon the passage through the mentioned fixed installation, the essential components of which are listed below, is described below in reference to Figures 4 and 5:

- Ends of the rails 31 of the larger-gauge track.
- Ends of the rails 32 of the smaller-gauge track.
- Centering and sliding guide rails 19.
- Unlocking and locking guides 24 of the locks 22.
- Translation guides 27 of the wheels 1.

[0027] The fixed installation is bidirectional, the change from a larger to smaller gauge track being performed in one direction while the reverse is performed in the opposite direction.

[0028] The track gauge change process of a wagon reaching the installation from the larger-gauge track is performed as follows.

First Phase

[0029] When the wheels 1 reach the downward area of the end of the rails 31 the gradual lowering of the bogie starts until the sliding shoes 16 contact with the centering and sliding guide rails 19. After this time, the wheels 1 are load-free, remaining that way during the entire change process until contacting with the smaller-gauge rails 32 at the end of said process.

Second Phase

[0030] Once the axle 2 is centered and supported on the centering and sliding guides 19, the heads of the end of the unlocking guides 24 are introduced into the bridge of the lock 22 and given the downward profile of this guide, the force of the vertical springs 28 is overcome and the locks 22 are forced to drop down, leaving the locking guides 18 unlocked, therefore being free to move laterally, and with them the wheels 1.

[0031] In the preferred embodiment of the invention in which the fixing device includes the bolt 25 as an additional safety element, in this phase it is also necessary to act on the horizontal spring 21 in order to laterally move the bolt 25, thereby preventing the retaining element 26 from preventing the lock 22 from dropping. For this purpose one of the sides of the head of the unlocking guides 24 of the fixed installation has a double T-shape with a progressively variable gauge from the ends to the center, smaller at the ends than in the center, as can be seen by comparing figures 1B and 1C; therefore the guide 24 serves as an element for actuating the horizontal spring 21 controlling the lateral movement of the bolt 25.

[0032] For their part the guides 27 cause the lateral movement of the coupling device for coupling the wheels 1 to the axle 2 until reaching the position corresponding to the smaller-gauge track 32.

Third Phase

[0033] The downward profile of the guide 24 forces the lock 22 to move up, locking the guide 18 in the new position.

[0034] In the preferred embodiment of the invention including the bolt 25 and the guide 24 with one of the sides of the variable gauge head, at the end of the phase the spring 21 remains at rest and the bolt 25 is retained by the retaining element 26.

Fourth Phase

[0035] When the wheels 1 reach the rails 32 the shoes 16 are no longer supported in their sliding guides 19, the track gauge change operation ending.

[0036] Although the present invention has been described entirely in relation to preferred embodiments, it is obvious that modifications can be introduced in its scope as the latter is not considered to be limited by the

foregoing embodiments, but rather by the contents of the following claims.

Reference Numbers

[0037]

1 wheel
2 rotating axle
3 bush
3' cooperating head
4 tubular element
5 bush
6 bush
7 ring
8 inner axial bearing
9 separating bush
10 bearing part
11 suspension spring
12 bearings
13 bush
14 semicircular bush
15 cover
16 support and sliding shoes
17 nylon guides
18 locking guides
19 centering and sliding guide rails
20 stops
21 horizontal spring
22 lock
23 nylon guides
24 locking/unlocking guides
25 bolt

26 retaining element
27 translation guides of the wheels
28 vertical safety springs
31 rails of the larger-gauge track
32 rails of the smaller-gauge track

Claims

1. A bogie comprising a bearing platform of a railway wagon and at least one rotating axle (2) on which two wheels (1) are assembled by means of a coupling device which allows their lateral movement and which is provided with a track gauge change device using a lock (22) which prevents/allows the lateral movement of each wheel (1) and which is designed to be vertically moved when actuated by locking/unlocking guides (24) provided for that purpose in a fixed installation for performing the track gauge change, whereby
 - a) said coupling device has connected thereto locking means (18) laterally guided in the longitudinal direction of the axle (2) by means of which the lateral movement of said coupling device is controlled so as to be located in the positions corresponding to the two track gauges;
 - b) said rotating axle (2) includes bearing parts (10) of said platform internally including bearings (12) and housings to receive said locking means (18) and said lock (22), such that said lock (22) is designed to cooperate with the locking/unlocking guides (24) of the fixed installation and comprises pretensed safety springs (28) to prevent unwanted vertical movements of the lock (22) when it is not in contact with the unlocking guide (24);
 - c) said rotating axle (2) incorporates at its ends bushes (13) fixed to the axle;
 - d) said bearing parts (10) also include a side chassis with support shoes (16) and a central collar serving as support for the end of the axle (2) during the passage through the fixed installation through a semicircular bush (14) connected to said central collar.
2. The bogie according to the claim 1, **characterized in that** the central part of the axle (2) on which the wheels (1) are located in the positions corresponding to the two track gauges has a larger diameter than that of its side parts in contact with said bearing parts (16) through the bearings (12).
3. The bogie according to any of claims 1-2 **character-**

ized in that said coupling device comprises a bush (3) integral with the wheel (1) and sliding on the axle (2) cooperating with a tubular element (4) fixed to the central part of the axle (2) and including at its end a ring (7), with an inner axial bearing (8), to which the locking means (18) are fixed.

4. The bogie according to any of claims 1-3, **characterized in that** it also comprises a bolt (25) connected to each lock (22) through a horizontal spring (21) for the purposes of preventing its vertical movement in cooperation with a retaining element (26) of said bolt (25) connected to the bearing part (10) .
5. A fixed installation for performing the track gauge change as the bogie according to claim 4 moves over it, comprising sliding and bearing guides (19) designed to cooperate with a bush arranged on the axle of the bogie, lateral movement guides (27) and locking/unlocking guides (24), **characterized in that** the head of the of locking/unlocking guides (24) is configured such that it can laterally move said bolt (25), overcoming the force of said horizontal spring (21).
6. The fixed installation for performing the track gauge change according to claim 5, **characterized in that** said locking/unlocking guides (24) have a double T-shaped profile and one of the half-flanges of its head has a progressively variable gauge, from smaller to larger from the end to the center of the guide, in the longitudinal direction.

Patentansprüche

1. Fahrgestell mit einer Lagerplattform eines Schienenwagens und zumindest einer Drehachse (2), an der zwei Räder (1) mittels einer Kopplungsvorrichtung montiert sind, die deren seitliche Bewegung erlaubt, und das mit einer Spurweitenänderungsvorrichtung versehen ist, die eine Sperre (22) verwendet, die die seitliche Bewegung des jeweiligen Rads (1) verhindert/ermöglicht, und die so ausgelegt ist, dass sie vertikal bewegt wird, wenn sie durch Verriegeln/Entriegeln von Führungen (24) betätigt wird, die für diesen Zweck in einer festen Installation zum Durchführen der Spurweitenänderung vorgesehen sind, wobei
 - a) die Kopplungsvorrichtung eine daran angeschlossene Verriegelungseinrichtung (18) hat, die in der Längsrichtung der Achse (2) seitlich geführt ist, durch die die seitliche Bewegung der Kopplungsvorrichtung so gesteuert wird, dass sich diese in den Positionen entsprechend den beiden Spurweiten befindet;
 - b) die Drehachse (2) Lagerteile (10) der Plattform aufweist, die im Inneren Lager (12) und Ge-

häuse zum Aufnehmen der Verriegelungseinrichtung (18) und der Sperre (22) aufweisen, und zwar derart, dass die Sperre (22) so ausgelegt ist, dass sie mit den Verriegelungs-/Entriegelungsführungen (24) der festen Installation zusammenwirkt und vorgespannte Sicherheitsfedern (28) aufweist, um unerwünschte vertikale Bewegungen der Sperre (22) zu verhindern, wenn diese mit der Entriegelungsführung (24) nicht in Kontakt ist;
 c) in der Drehachse (2) an ihren Enden Buchsen (13) eingebaut sind, die an der Achse befestigt sind;
 d) die Lagerteile (10) außerdem einen Seitenrahmen mit Stützschuhen (16) und einem mittleren Kragen aufweisen, der als eine Stütze für das Ende der Achse (2) während des Durchtritts durch die feste Installation durch eine halbrunde Buchse (14) dient, die mit dem mittleren Kragen verbunden ist.

2. Fahrgestell gemäß Anspruch 1, **dadurch gekennzeichnet, dass** der mittlere Teil der Achse (2), an der sich die Räder (1) in den Positionen entsprechend den beiden Spurweiten befinden, einen Durchmesser hat, der größer ist als jener seiner Seitenteile, die mit den Lagerteilen (16) durch die Lager (12) in Kontakt sind.
3. Fahrgestell gemäß einem der Ansprüche 1 - 2, **dadurch gekennzeichnet, dass** die Kopplungsvorrichtung eine Buchse (3) aufweist, die einstückig mit dem Rad (1) ist und an der Achse (2) gleitet, die mit einem röhrenartigen Element (4) zusammenwirkt, das an dem mittleren Teil der Achse (2) befestigt ist, und die an ihrem Ende einen Ring (7) mit einem inneren Axiallager (8) aufweist, an dem die Verriegelungseinrichtung (18) befestigt ist.
4. Fahrgestell gemäß einem der Ansprüche 1 - 3, **dadurch gekennzeichnet, dass** es außerdem einen Bolzen (25) aufweist, die mit der jeweiligen Sperre (22) durch eine Horizontalfeder (21) zum Zwecke einer Verhinderung seiner vertikalen Bewegung in Zusammenarbeit mit einem Rückhalteelement (26) des Bolzens (25) verbunden ist, das mit dem Lagerteil (10) verbunden ist.
5. Feste Installation zum Durchführen der Spurweitenänderung bei dem Fahrgestell gemäß Anspruch 4, das sich darüber bewegt, mit Gleit- und Lagerführungen (19), die so ausgelegt sind, dass sie mit einer Buchse zusammenwirken, die an der Achse des Fahrgestells angeordnet ist, seitlichen Bewegungsführungen (27) und Verriegelungs-/Entriegelungsführungen (24), **dadurch gekennzeichnet, dass** der Kopf der Verriegelungs-/Entriegelungsführungen (24) so konfiguriert ist, dass er den Bolzen (25)

seitlich bewegen kann, wobei die Kraft der Horizontalfeder (21) überkommen wird.

6. Feste Installation zum Durchführen der Spurweitenänderung gemäß Anspruch 5, **dadurch gekennzeichnet, dass** die Verriegelungs-/Entriegelungsführungen (24) ein doppelt T-förmiges Profil haben, und dass einer der Halbflansche von seinem Kopf eine progressiv variable Spur von kleiner zu größer von dem Ende zu der Mitte der Führung in der Längsrichtung hat.

Revendications

1. Bogie comprenant une plateforme de palier d'un wagon ferroviaire et au moins un essieu rotatif (2) sur lequel deux roues (1) sont assemblées au moyen d'un dispositif de couplage qui permet leur mouvement latéral et qui est prévu avec un dispositif de changement d'écartement de voie à l'aide d'un verrou (22) qui empêche/permets le mouvement latéral de chaque roue (1) et qui est conçu pour être verticalement déplacé, lorsqu'il est actionné par des guides de verrouillage/déverrouillage (24) prévus à cet effet, dans une installation fixe pour réaliser le changement d'écartement de voie, moyennant quoi :

a) ledit dispositif de couplage a, raccordés à ce dernier, des moyens de verrouillage (18) latéralement guidés dans la direction longitudinale de l'essieu (2) au moyen duquel le mouvement latéral dudit dispositif de couplage est contrôlé afin d'être positionné dans les positions correspondant aux deux écartements de voie ;

b) ledit essieu rotatif (2) comprend des parties de palier (10) de ladite plateforme, comprenant intérieurement des paliers (12) et des boîtiers pour recevoir lesdits moyens de verrouillage (18) et ledit verrou (22), de sorte que ledit verrou (22) est conçu pour coopérer avec les guides de verrouillage/déverrouillage (24) de l'installation fixe et comprend des ressorts de sécurité pré-tendus (28) pour empêcher les mouvements verticaux involontaire du verrou (22) lorsqu'il n'est pas en contact avec le guide de déverrouillage (24) ;

c) ledit essieu rotatif (2) comprend, au niveau de ses extrémités, des manchons (13) fixés à l'essieu ;

d) lesdites parties de palier (10) comprennent également un châssis latéral avec des patins de support (16) et un collier central servant de support pour l'extrémité de l'essieu (2) pendant le passage à travers l'installation fixe par le biais d'un manchon semi-circulaire (14) raccordé audit collier central.

2. Bogie selon la revendication 1, **caractérisé en ce que** la partie centrale de l'essieu (2) sur lequel les roues (1) sont positionnées dans les positions correspondant aux deux écartements de voie, a un plus grand diamètre que celui de ses parties latérales en contact avec lesdites parties de palier (16) par le biais des paliers (12).

3. Bogie selon l'une quelconque des revendications 1 à 2, **caractérisé en ce que** ledit dispositif de couplage comprend un manchon (3) solidaire avec la roue (1) et coulissant sur l'essieu (2) coopérant avec un élément tubulaire (4) fixé à la partie centrale de l'essieu (2) et comprenant au niveau de son extrémité, une bague (7), avec un palier axial interne (8), auquel les moyens de verrouillage (18) sont fixés.

4. Bogie selon l'une quelconque des revendications 1 à 3, **caractérisé en ce qu'il** comprend également un boulon (25) raccordé à chaque verrou (22) par le biais d'un ressort horizontal (21) afin d'empêcher son mouvement vertical en coopération avec un élément de retenue (26) dudit boulon (25) raccordé à la partie de palier (10).

5. Installation fixe pour réaliser le changement d'écartement de voie lorsqu'un bogie, selon la revendication 4, se déplace sur cette dernière, comprenant des guides de coulisement et de palier (19) conçus pour coopérer avec un manchon agencé sur l'essieu du bogie, les guides de mouvement latéral (27) et les guides de verrouillage/déverrouillage (24), **caractérisée en ce que** la tête des guides de verrouillage/déverrouillage (24) est configurée de sorte qu'elle peut déplacer latéralement ledit boulon (25), venant à bout de la force dudit ressort horizontal (21).

6. Installation fixe pour réaliser le changement d'écartement de voie selon la revendication 5, **caractérisée en ce que** lesdits guides verrouillage/déverrouillage (24) ont un profil en forme de double T et l'une des demi-bridges de sa tête a un écartement progressivement variable, du plus petit au plus grand, de l'extrémité au centre du guide, dans la direction longitudinale.

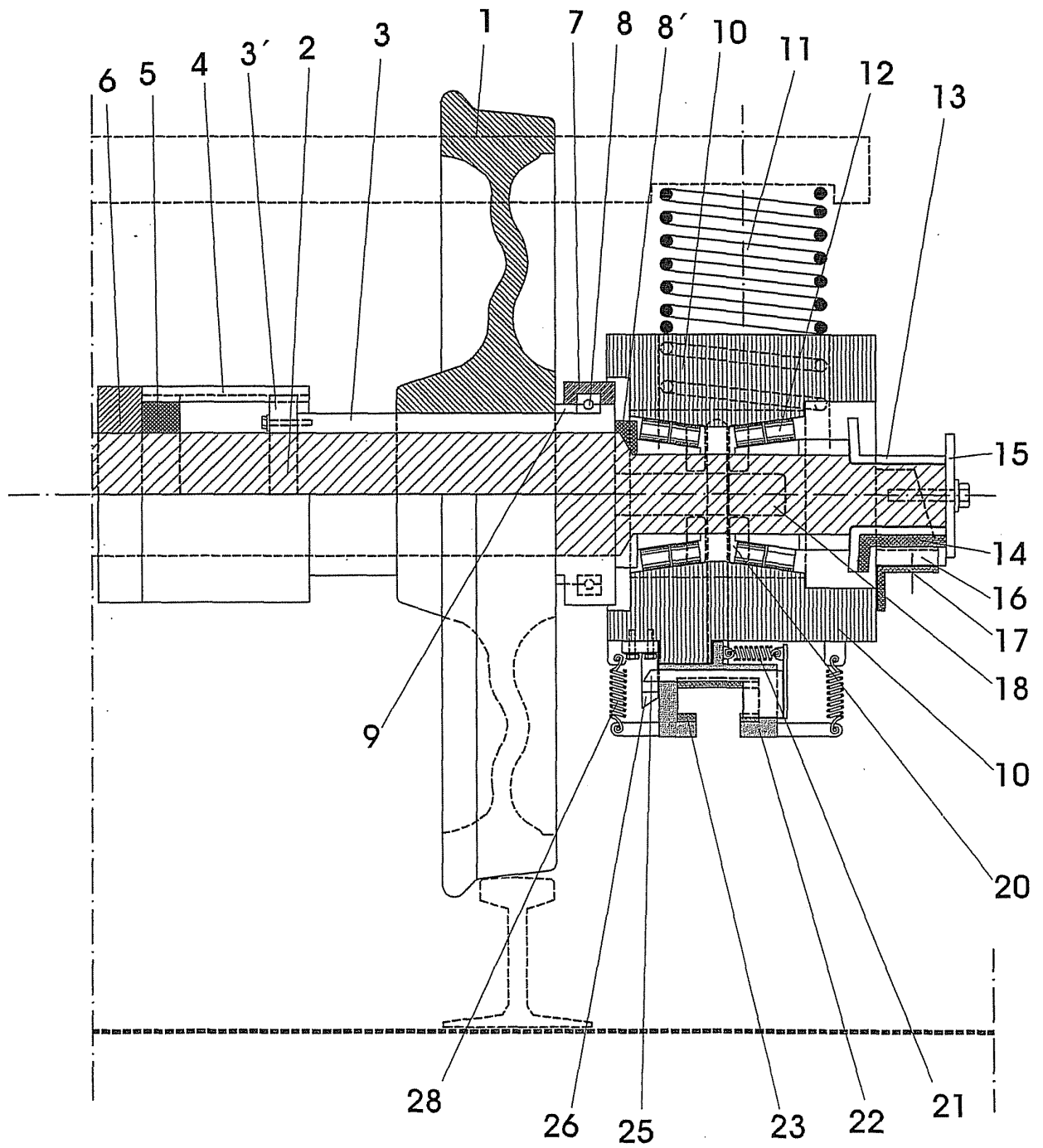


FIG. 1A

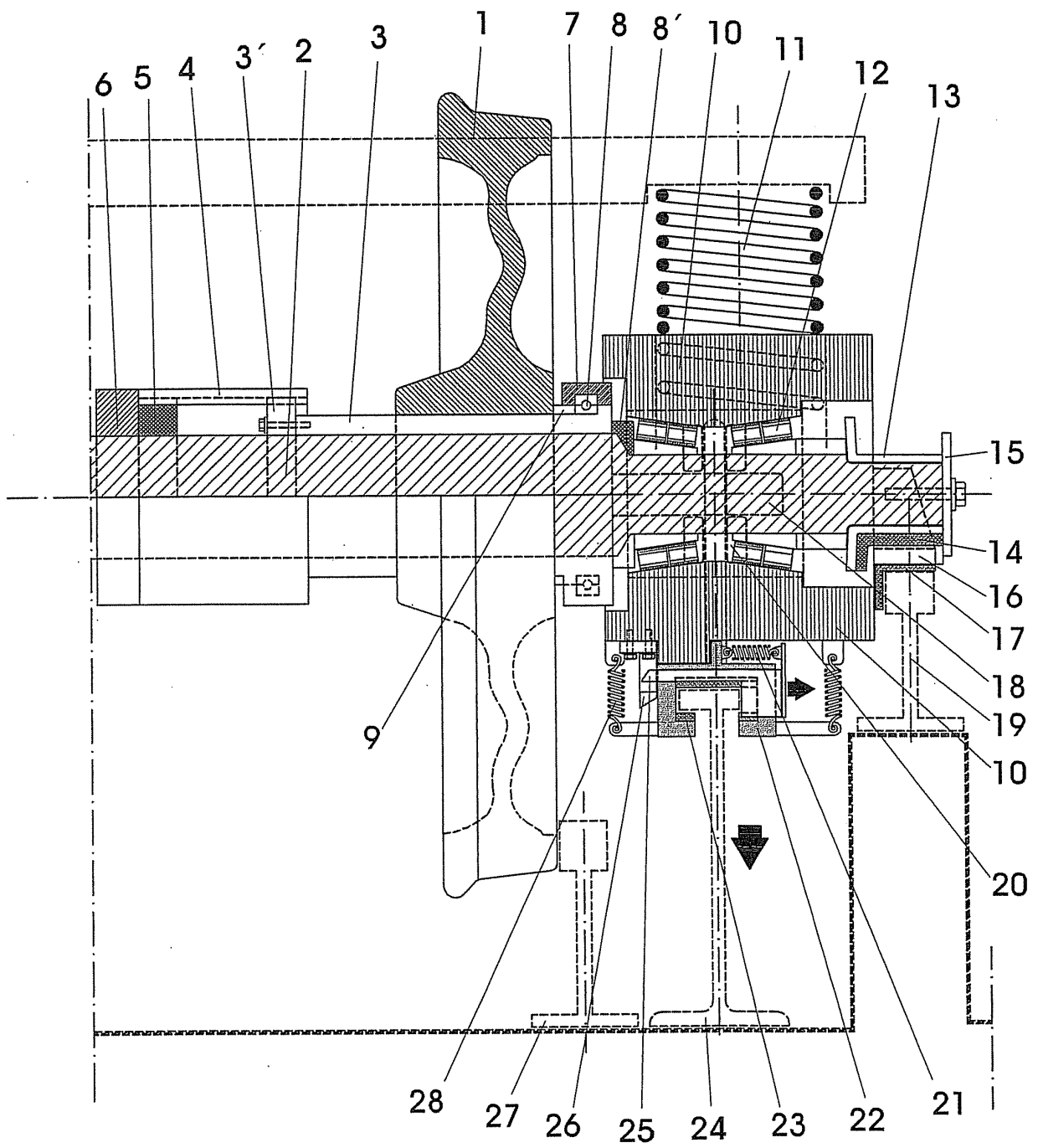


FIG. 1B

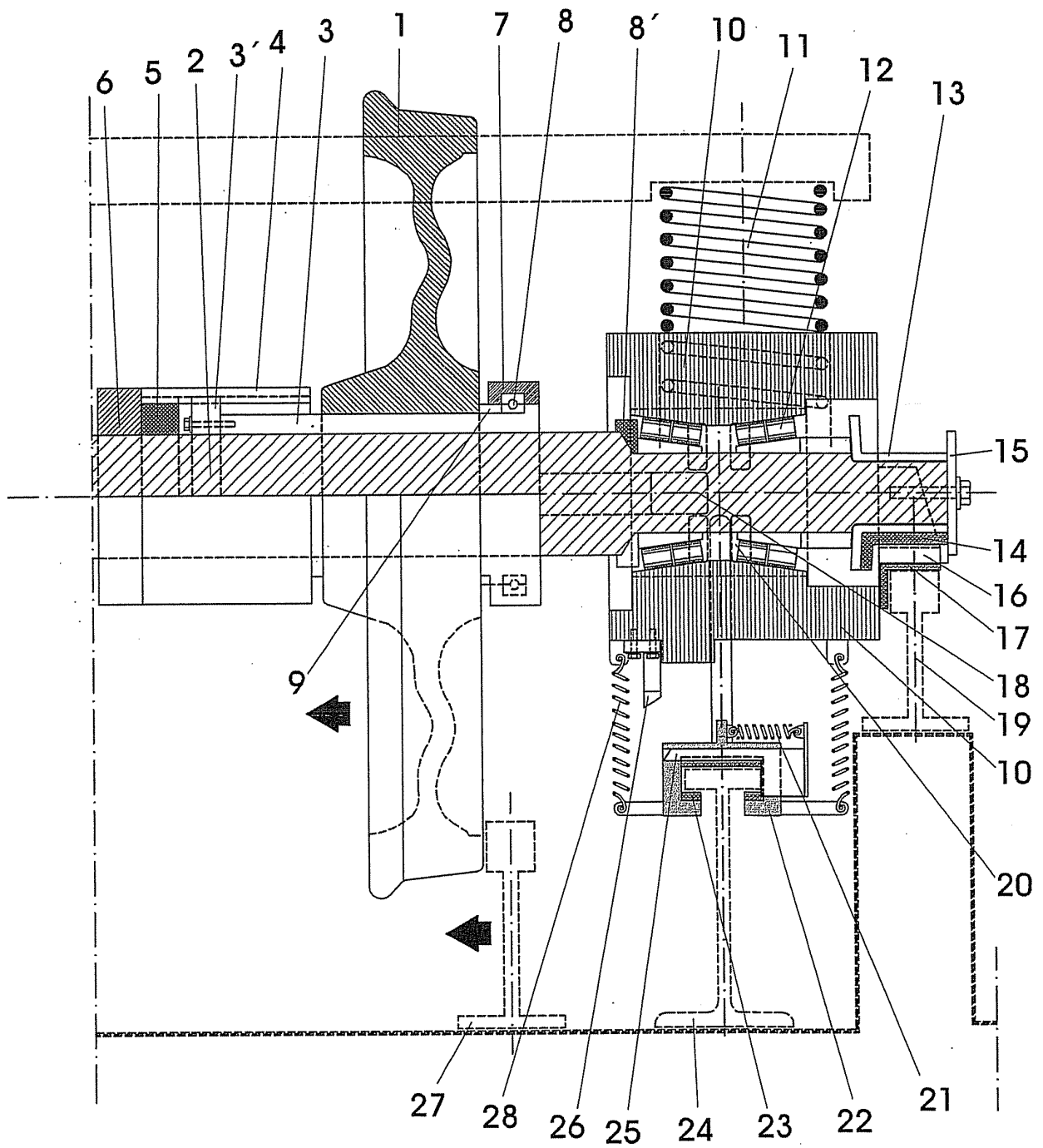


FIG. 1C

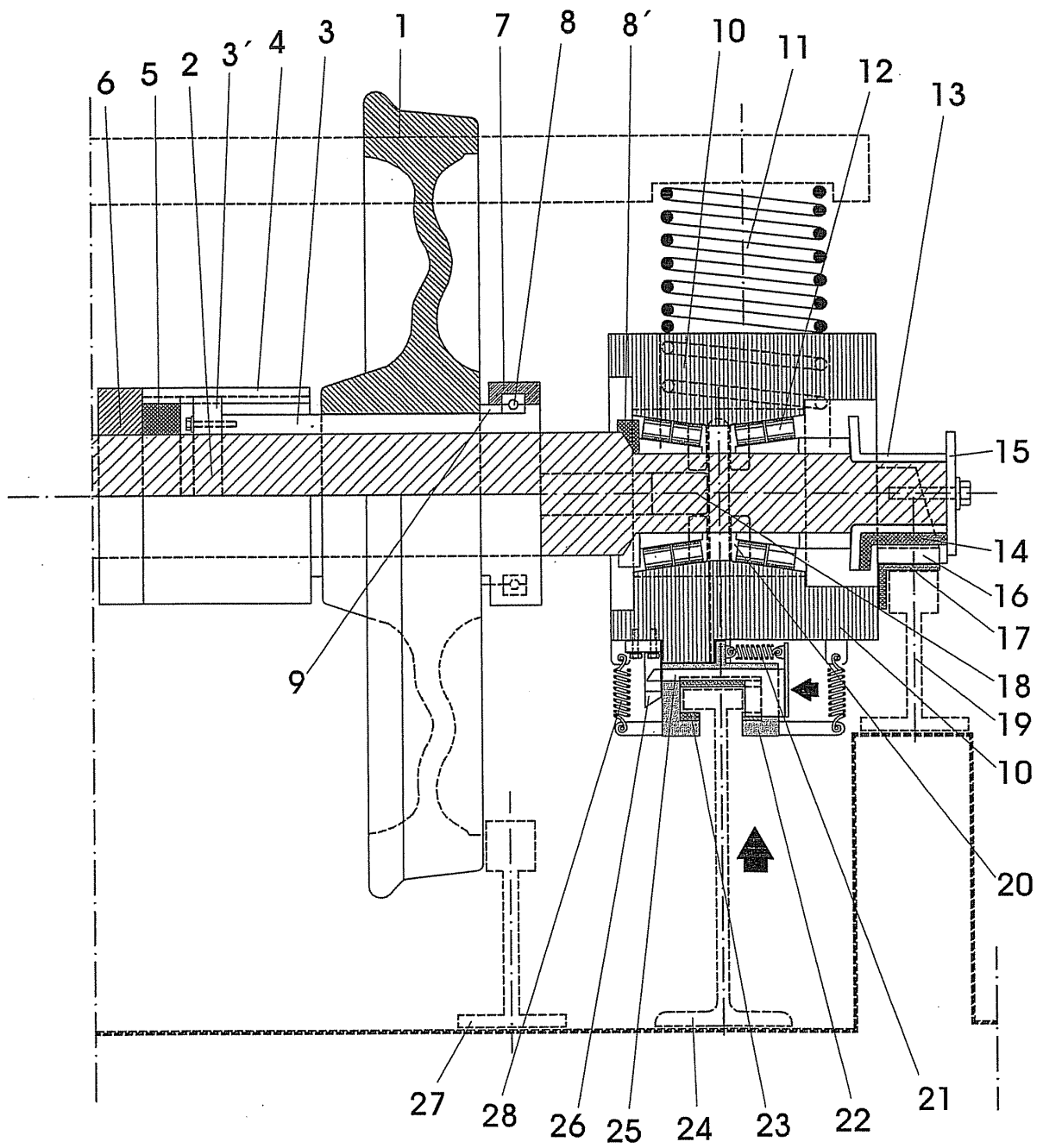


FIG. 1D

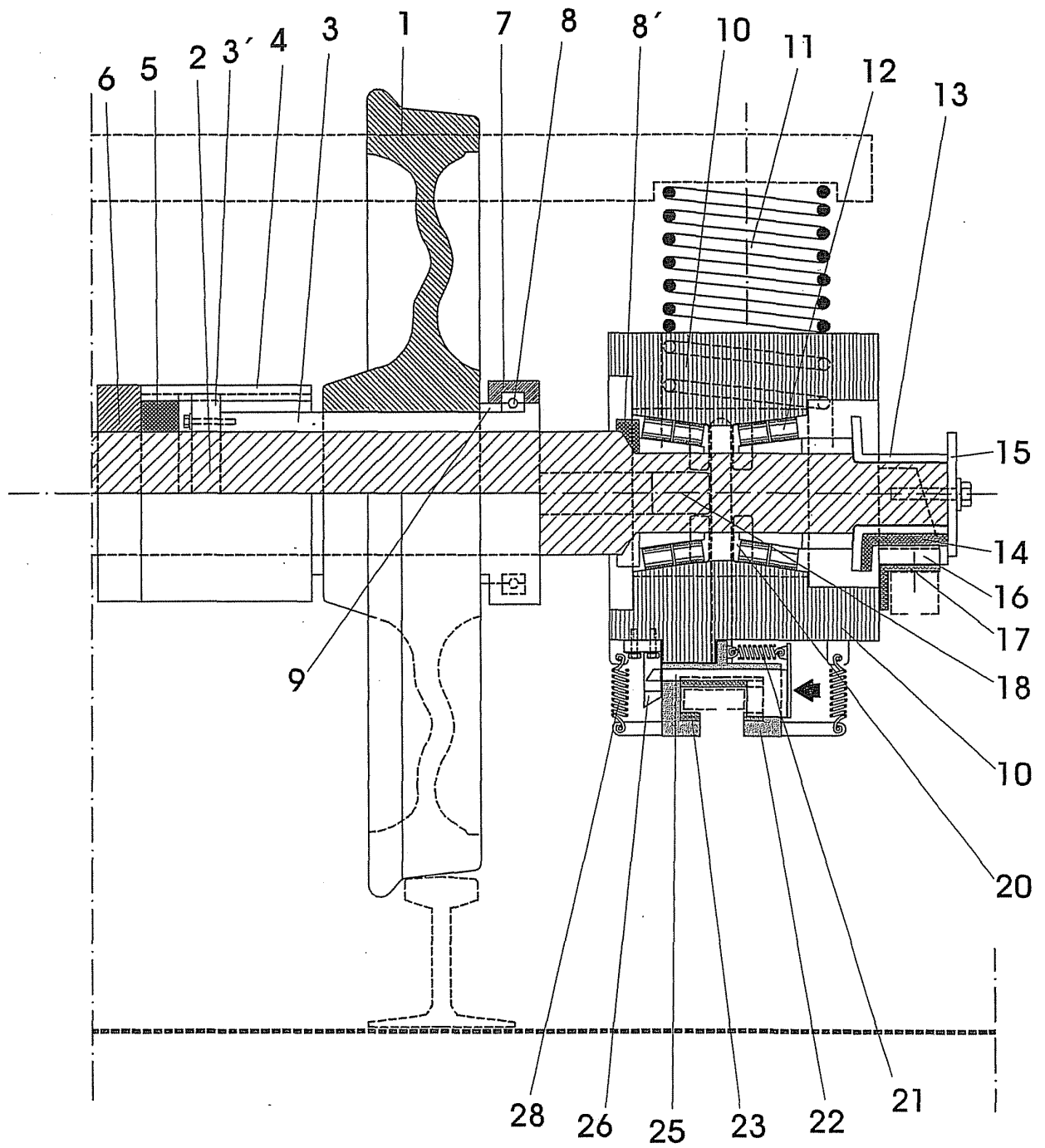


FIG. 1E

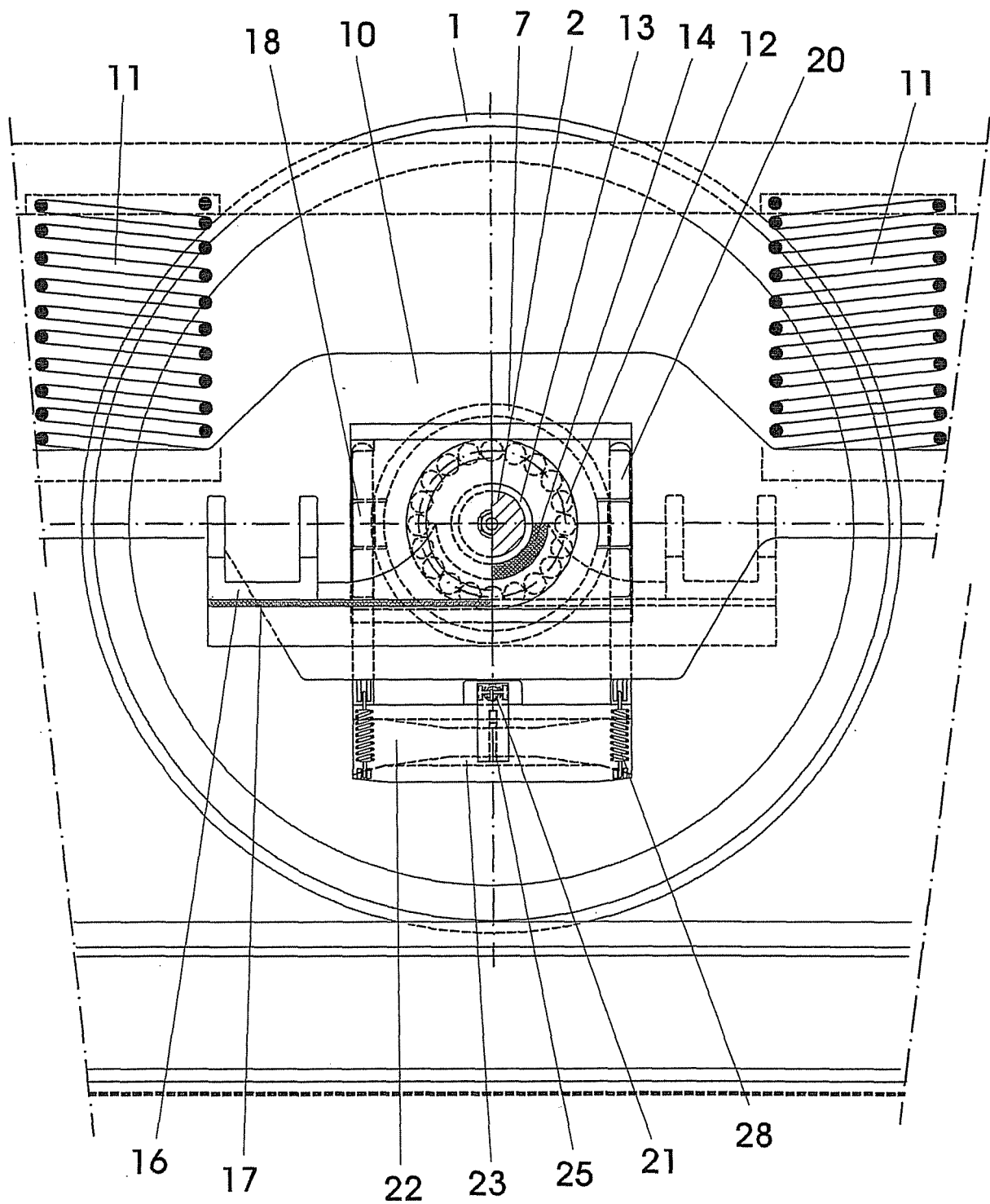


FIG. 2A

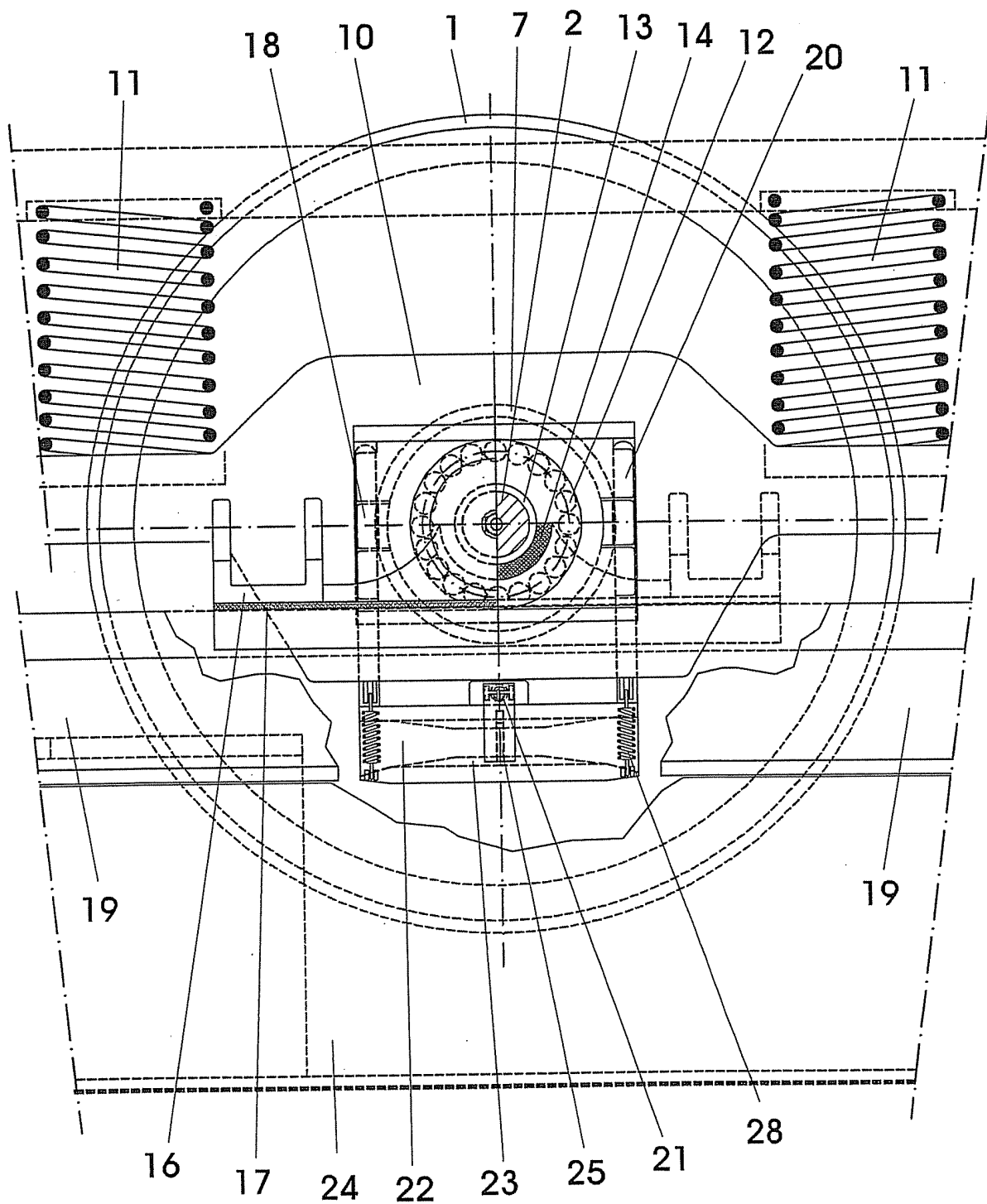


FIG. 2B

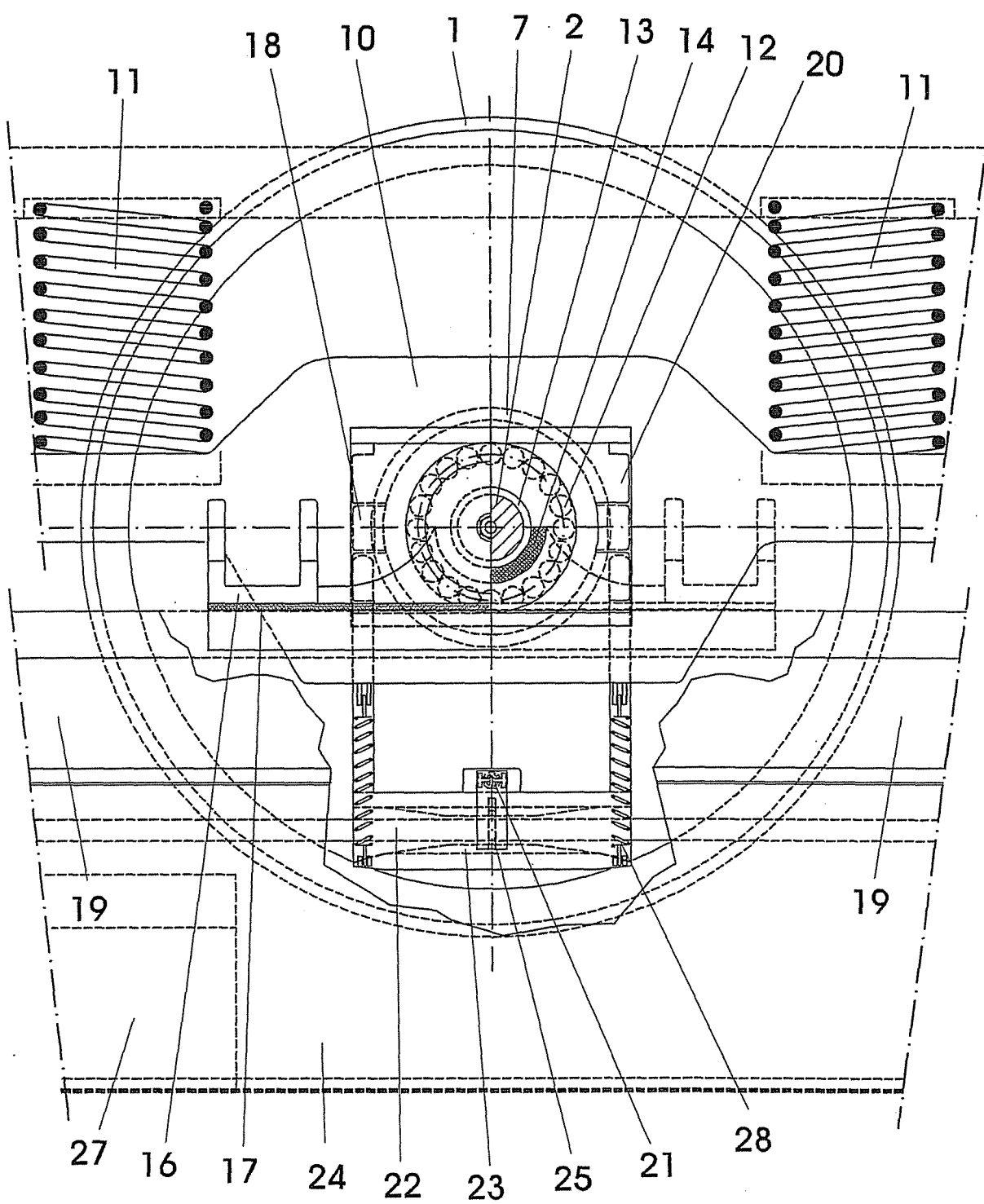


FIG. 2C

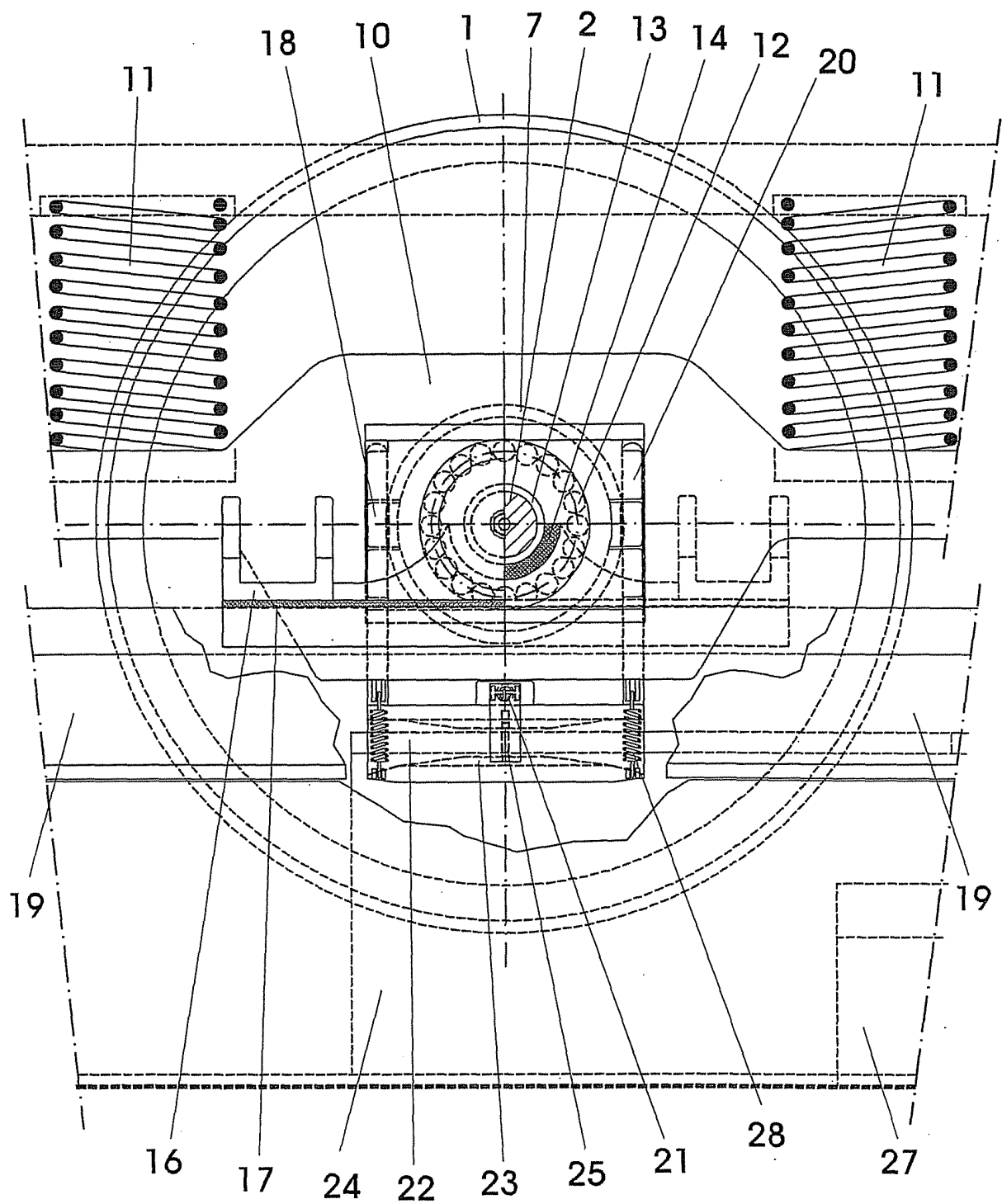


FIG. 2D

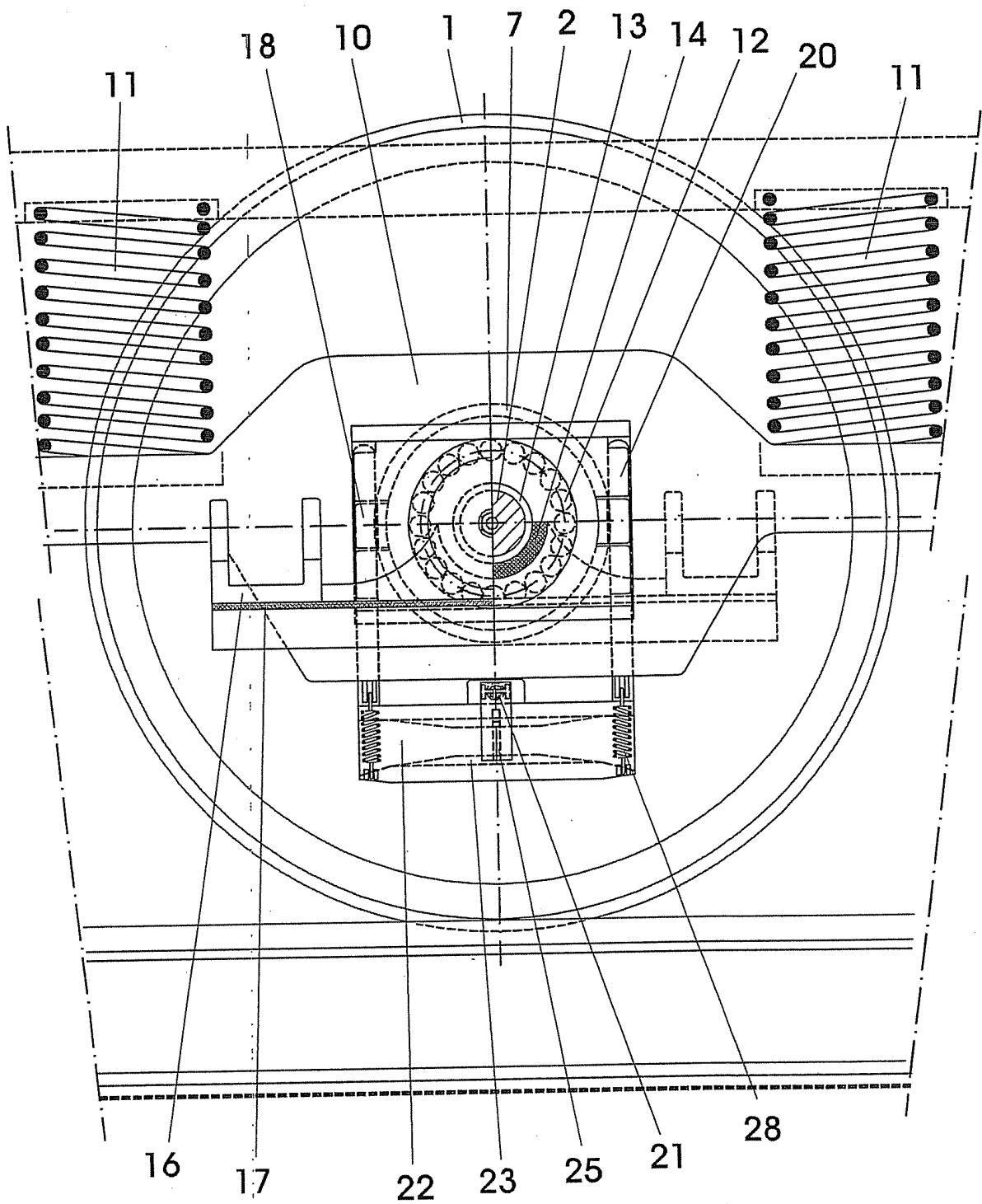


FIG. 2E

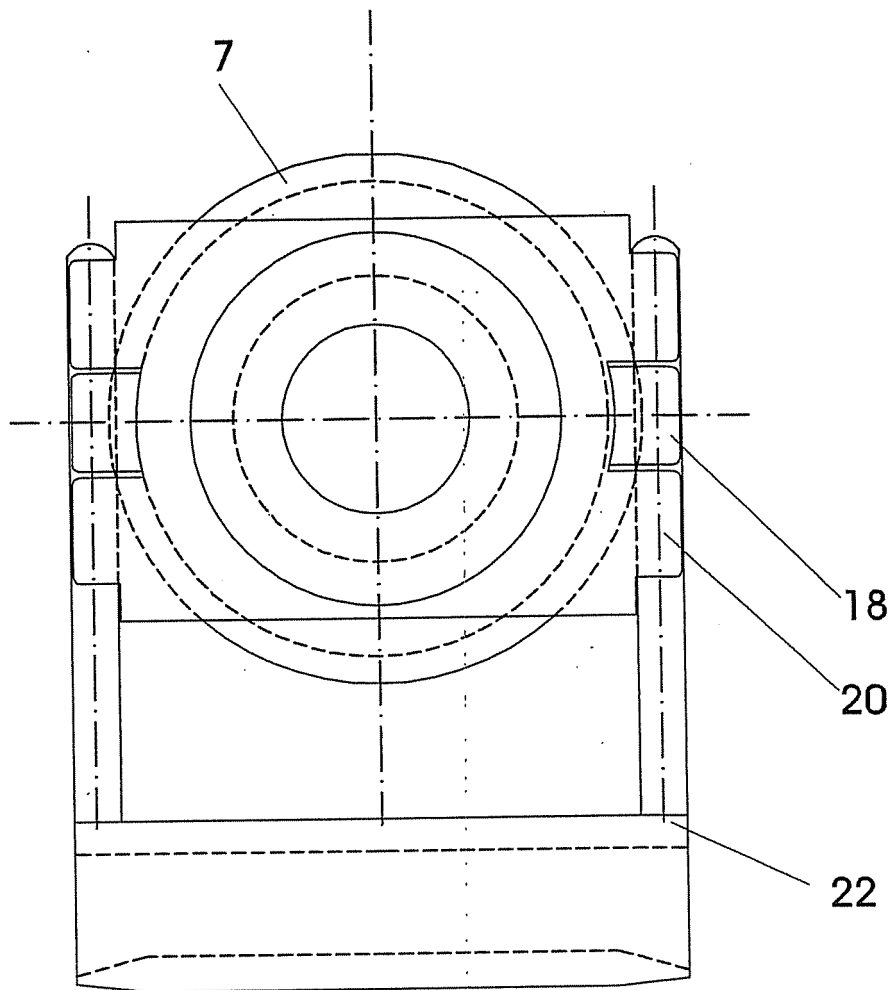


FIG. 3A

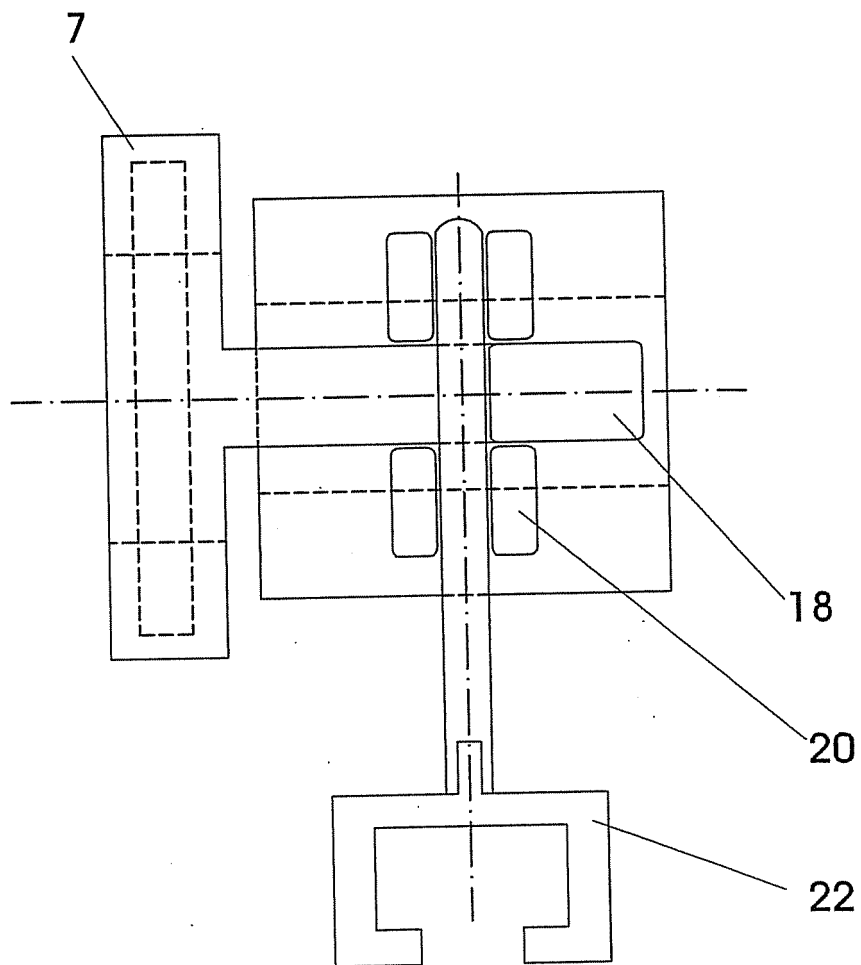


FIG. 3B

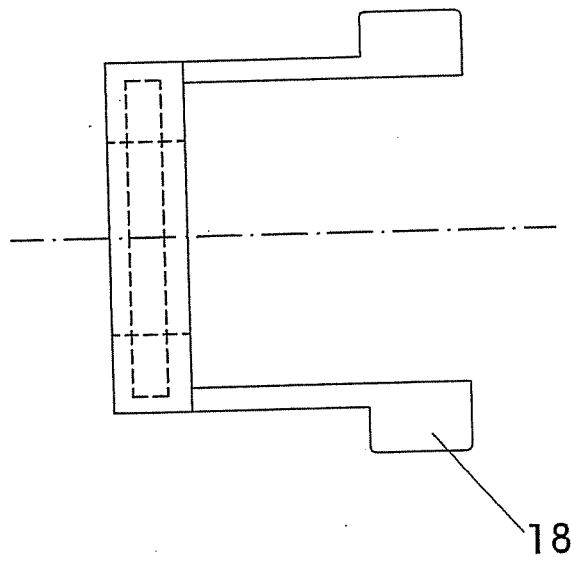
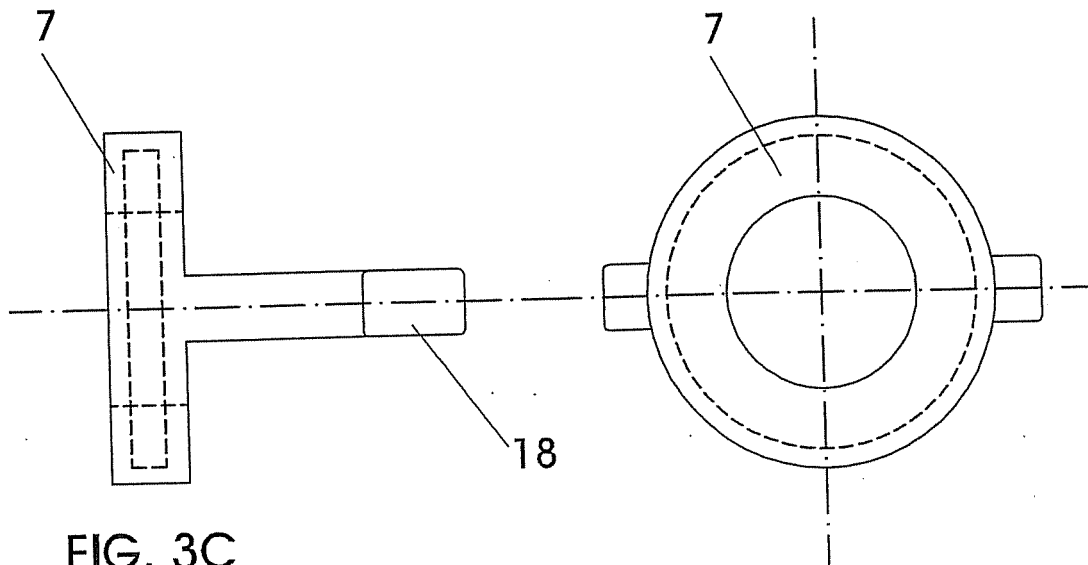


FIG. 3E

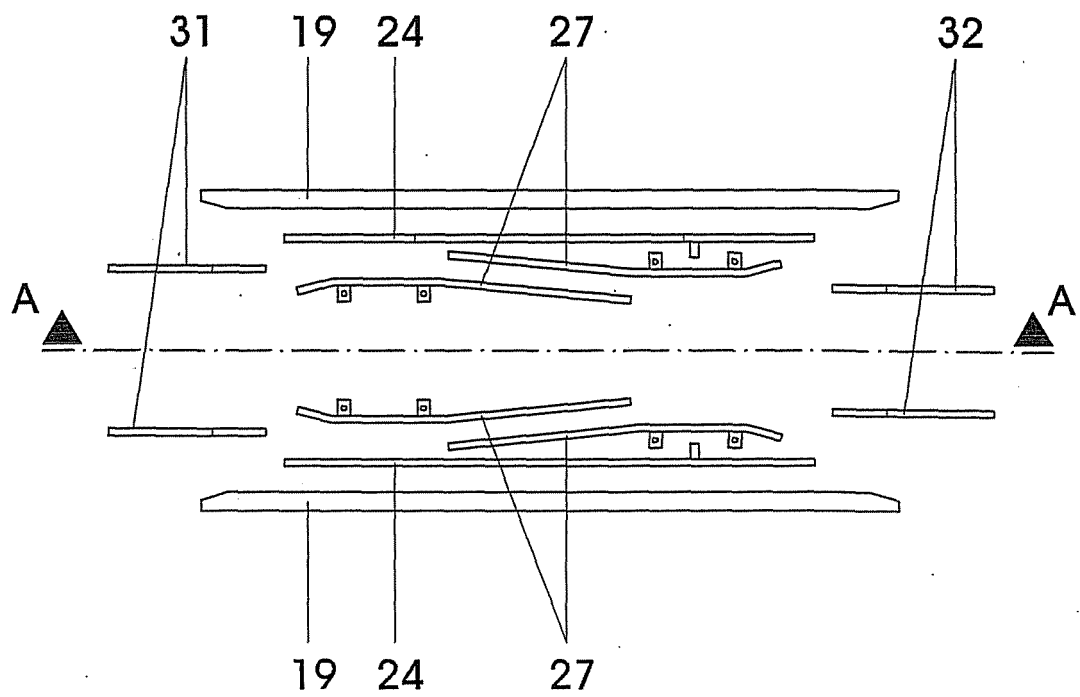


FIG. 4

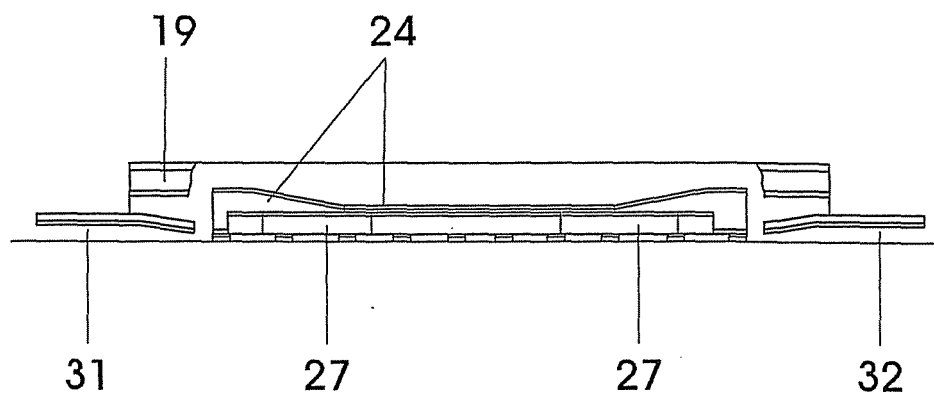


FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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