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(54) **IMPROVED WORK VEHICLE AND RELATED CONTROL METHOD**

(57) Work vehicle (1) comprising a body (3) and a chassis (2), the chassis (2) carrying the body (3) and comprising ground engaging means (5) for allowing the motion on ground, wherein the body (3) extends along a longitudinal axis (A), a transversal axis (B) transversal with respect to the longitudinal axis (B) and is carried over the chassis (2) along a vertical axis (C) perpendicular to both the longitudinal and transversal axes (A, B),

the body (3) comprising a movable portion (6) carried in a movable manner with respect to the remaining portion of the body (3) in order to vary its position along at least one direction according to one among the axes (A, B, C) between a closed configuration wherein the movable portion (6) is attached to the remaining portion of the body (3) and an opened configuration wherein the movable portion (6) is extended with respect to the remaining portion of the body (3) along the at least one direction.

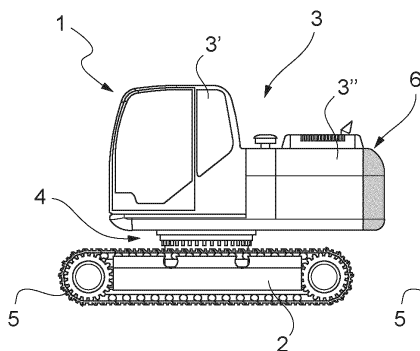


FIG. 1A

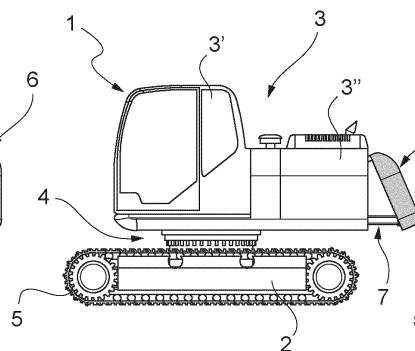


FIG. 1B

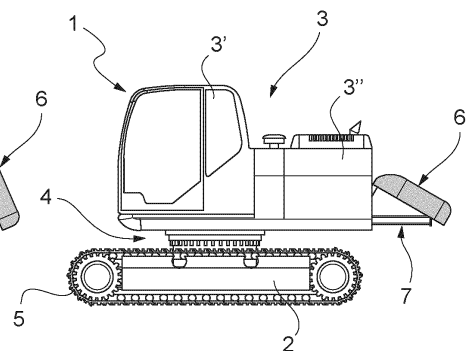


FIG. 1C

Description

TECHNICAL FIELD

[0001] The present invention concerns a work vehicle such as an earth moving machine.

[0002] The present invention finds its preferred, although not exclusive, application in excavators. Reference will be made to this application by way of example below.

BACKGROUND OF THE INVENTION

[0003] Work vehicles such as earth moving machine are provided with an operative element that can be elongated in order to reach the working position. An example of such machine is an excavator.

[0004] In particular, referring to earth moving machine it is known that they comprise a chassis movable on ground and a body, carried by the chassis in particular in a rotatable manner, that carries the operative element.

[0005] When the operative element is fully extended with respect to the body and loaded, it is evident that the stability of the machine is compromised due to the variation of the gravity center thereof.

[0006] Accordingly, it is known to provide counterweights on the body or to make the body so heavy to counteract to a loaded condition in the maximum extension of the operative element.

[0007] However, the aforementioned solutions lead to different drawbacks.

[0008] First, the counterweights cannot be easily removed by the body and the body cannot be lightened at occurrence, therefore the fuel consumption due to the weight of the body is high.

[0009] Furthermore, in such peculiar operative conditions, such as in slopes or during sudden movements of the operative element, the above weight of the body cannot balance the gravity center, thereby leading to potential accidents such as roll over, tip over, collapse of the operative element.

[0010] In addition, the variation of the gravity center of the machine leads to discomfort during operation of the machine by the driver.

[0011] Moreover, the greater weight may limit the transport of the machine on roads or may require a different classification of the machine thereby increasing the rent/acquisition costs.

[0012] Therefore, the need is felt to provide a earth-moving machine that reduces the risk of accidents due to gravity center variation in loaded condition in all range of operation of the operative element while reducing its weight, the fuel consumption and the limitations listed above.

[0013] An aim of the present invention is to satisfy the above mentioned needs in a cost-effective and optimized manner.

SUMMARY OF THE INVENTION

[0014] The aforementioned aim is reached by a work vehicle and a related control method as claimed in the appended set of claims.

BRIEF DESCRIPTION OF DRAWINGS

[0015] For a better understanding of the present invention, a preferred embodiment is described in the following, by way of a non-limiting example, with reference to the attached drawings wherein:

- Figures 1A-1B-1C are schematic lateral views of a work machine according to the invention in different operative conditions;
- Figure 2 is a rear perspective view of a portion of the work machine according to the invention with parts removed for sake of clarity in a first exemplarily operative condition;
- Figure 3 and 4 are a rear perspective view of the portion of work vehicle of Figure 2 in further exemplarily operative conditions;
- Figures 5 and 6 are front perspective views of the portion of the work machine in the operative conditions of Figures 2 and 4;
- Figure 7 is a rear enlarged perspective view with sectioned portions of a portion of the work machine according to the invention with parts removed for sake of clarity in a first exemplarily operative condition; and
- Figure 8 is a further rear enlarged perspective view a portion of the work machine according to the invention with parts removed for sake of clarity in a first exemplarily operative condition;

DETAILED DESCRIPTION OF THE INVENTION

[0016] The attached figures disclose a work vehicle 1, in particular an earthmoving machine, such as a excavator, comprising a vehicle body 3 carried by a chassis 2 in particular in a movable manner, such as via a rotating joint 4, and provided with an operative element such, as a boom.

[0017] The chassis 2 is movable on ground via ground engaging means 5, represented by crawlers in the exemplarily shown embodiment.

[0018] The body 3 essentially comprises a cabin portion 3' configured to define a driving space and a main portion 3'' configured to house the transmission means of the vehicle such as engine, pumps, tanks and any other needed operational system. The body 3, as known, carries the operative element.

[0019] In detail, the body 3 extended along a longitudinal axis A direction that coincides, in a standard operation, with the travelling direction of the vehicle and along a transversal axis B direction that is transversal, in particular orthogonal, to longitudinal axis A.

[0020] The body 3 is rotatably carried by rotating joint 4 about a vertical axis C that is perpendicular to both longitudinal and transversal axes A, B.

[0021] According to the invention (See figures 1A-1B-1C), the body 3, in particular main portion 3", comprises a movable portion 6 that is carried in a movable manner with respect to the remaining portion of body 3 in order to vary its position along at least one direction among the aforementioned longitudinal, transversal or vertical axes A, B, C directions between a closed configuration wherein the movable portion 6 is attached to the remaining portion of the body 3 and an opened configuration wherein the movable portion 6 is extended with respect to the remaining portion of the body 3 along the aforementioned at least one direction.

[0022] In the exemplarily shown embodiment, the movable portion 6 is configured so that a bottom portion thereof move along the longitudinal direction axis A to increase the extension of the vehicle along such direction and the top portion of the movable portion 6 is configured to decrease its distance with respect to ground, i.e. along vertical direction axis C.

[0023] The work vehicles 1 further comprises actuator means (as disclosed in the following) and a control unit configured to control the actuator means for carrying the movable portion 6 in a position between the closed and the open configurations.

[0024] In particular, the control unit is configured to control the actuator means on the base of signals/data received by sensor means and/or input means of the work vehicle 1.

[0025] In particular, the control unit is an electronic control unit and comprises elaboration means configured to acquire data from sensor means and/or input means of the work vehicle 1 and estimate a value of the gravity center of the work vehicle.

[0026] In case of purely controlled actuation of the actuator means by the driver he can control the input means, such as button or an icon or a display to control the movement of the movable portion 6.

[0027] In case of automatic control system, if the estimated value is above a predetermine safety threshold, then the actuator means are controlled to move the movable portion 6 in a determine position to allow the gravity center to return under the preset safety threshold.

[0028] Such determined position is calculated by the control unit combining the data retrieved by sensor means and by predetermined data of the vehicle such as its weight, the position of the operative elements and dimensions and weight of the movable portions.

[0029] In detail, sensor means may be of any typology configured to allow determination of the gravity center of the vehicle such as inclinometers, weight sensors, pressure sensors, load sensors, displacement or angular sensors etc.

[0030] Making reference to figures 2 to 6, it is disclosed into detail an embodiment of the movable portion 6, in particular a rear portion of the body 3 with respect to

longitudinal axis A direction.

[0031] The movable portion 6 movably carried by a handling system 7 that is operationally interposed between the movable body 6 and a frame 8 of the body 3 of the vehicle.

[0032] In detail, the frame 8 comprises a base portion that extends on a plane defined by longitudinal and transversal axes A, B. In the disclosed embodiment the base portion comprises a pair of uprights 8', 8" extending parallel to longitudinal axis A, a pair of transversal elements 8a, 8d extending parallel to transversal axis B and connected between the uprights 8', 8" in particular a first transversal element 8a is connected to extremities of the uprights 8', 8" while a second transversal element 8b is connected in an intermediate position thereof distanced along longitudinal axis A with respect to the first.

[0033] The base portion in the disclosed embodiment further pair of longitudinal elements 8c', 8c" parallel to the uprights 8', 8" and laterally comprised therebetween and connected to their extremities to the transversal elements 8a, 8b.

[0034] The frame 8 further comprises an elevated portion 8b extending from the base portion along the vertical axis C and in the disclosed embodiment extending from one of the transversal elements 8a, 8d in particular to the first transversal elements 8a.

[0035] The movable portion 6 is carried by the first transversal element 8a and the elevated portion 8b by the handling system 7 in order to assume the closed configuration wherein it is substantially parallel to the plane defined by the first transversal element 8a and the elevated portion 8b, i.e. by transversal and vertical axes B and C and in the open configuration the movable portion 6 is inclined with respect to such plane such that a top edge thereof gets closer to the ground and a bottom edge thereof tends to get away from the first transversal element 8a.

[0036] The handling system 7 comprises in detail an actuation portion 7' and a guidance portion 7". The actuation portion 7' is configured to provide a pushing or recalling force to the bottom edge of the movable portion 6 thereby moving this latter parallel to longitudinal axis A while the guidance portion 7" is configured to control the movement of the top edge along a path along vertical axis C.

[0037] In particular, the path is inclined with respect to vertical axis C.

[0038] In detail (see figure 8) the guidance portion 7" comprises a pair of guides 11 each provided with a bracket 12 and a slot 14. The bracket 12 is configured to be connected to the movable portion 6, in particular to the top edge thereof, from one side and to a block 15 via a pin 13 configured to slide within slot 14.

[0039] As show schematically, the block 15 moves via a prismatic coupling within the slot 14 and is connected fixedly to the pin 13 that is indeed connected to the bracket 12 in a rotatably free manner, e.g. by a bushing.

[0040] Therefore the bracket 12 defined with the pin 13

via a hinge connection while is fixedly connected to the top portion of the movable portion 6 on the other side.

[0041] The slot 14 of each guide is advantageously realized on the lateral walls of the elongated portion 8b for a predetermined length.

[0042] The actuation portion 7' essentially comprises at least a linear actuator 17, for instance a hydraulic cylinder, that is operatively interposed between the base portion 8 and the bottom edge of the movable portion 6 and configured to extend or retract in order to push out or recall the bottom edge of the movable portion 6 along the longitudinal axis A.

[0043] Accordingly the linear actuator 17 comprises a housing carried rigidly by the base portion 8 and a rod movably sliding within the housing and whose free terminal portion is coupled via a lever system 22 (described in further detail below) to the bottom edge of the movable portion 6.

[0044] The actuation portion 7' further advantageously comprises a pair of sliding arms 19 slidably housed within the longitudinal elements 8c', 8c'' and configured to assist the movement of the bottom edge of the movable portion 6 along the longitudinal axis A.

[0045] In the disclosed embodiment two sliding arms 19 are present, in particular a sliding arm for each of the lateral sides of the cylinder 17 and are connected to their free terminal portions via a lever system 22 to the bottom edge of the movable portion 6.

[0046] In detail, each sliding arm 19 comprises a sliding block 21, that has preferably a substantially squared cross section in the exemplarily disclosed embodiment, configured to slide within the respective longitudinal element 8c', 8c''. The longitudinal element 8c', 8c'' is therefore hollow and defines a space suitable for allowing the inside sliding of the sliding block 21.

[0047] The sliding block 21 can be entirely housed within the space defined by the longitudinal element 8c', 8c'' in particular the sliding block 21 is housed inside a seat 24 defined by the respective longitudinal element 8c', 8c'' in the closed position of the movable portion 6 and can be extracted till a maximum extension in the open position of the movable portion 6.

[0048] The maximum extension is per se defined by the maximum extension of the linear actuator 17.

[0049] In detail, (see figure 7) each sliding block 21 is provided with sliding means 23 configured facilitate the sliding of the block 21 within its seat 24.

[0050] In the shown embodiment, sliding means 23 are realized as pads. In particular, one pad can extend from the inner side of the seat 24 and cooperate by contact with the sliding block 21 or can be carried by this latter and extends to contact the inner surface of the seat 24. Both embodiments are exemplary shown in the drawings.

[0051] With respect to lever system 22 (see figures 5, 6, 7 and 8) each comprises a pin 22' that is rotatably carried about an axis parallel to transversal axis B by the respective actuator 17/sliding arm 19 and a cam portion 22'' that is rigidly carried by movable portion 6 and rota-

tably supported by the pin 22' in a cantilevered manner.

[0052] The operation of the embodiment of the invention as described above is the following making reference to figures 1A-1B-1C.

5 **[0053]** When needed, the driver may control via input means the handling system 7 to control the movement of the movable portion 6 to pass from the closed to the open configuration or an intermediate position thereof.

10 **[0054]** In case of automatic control system, the control unit acquires the data from sensor means and elaborates the value of center of gravity of the work vehicle 1. If such value is over a preset safety threshold value, then the control unit controls the handling system 7 to pass the movable portion 6 from the closed to the open position.

15 **[0055]** In view of the above, if the control unit is an electronic control unit, the present invention further concerns a method for controlling the center of gravity of a work vehicle comprising the following steps:

- 20 i. Acquiring data from input means and/or sensor means;
- ii. Elaborating the acquired data at step i) via control unit to estimate a gravity center of the work vehicle;
- 25 iii. Evaluate if the estimated value of the gravity center at step ii) is below or above a predetermined safety value;
- iv. If the estimated value is below the predetermined safety value, return to step i), otherwise proceed to step v)
- 30 v. Control the handling system for moving the movable portion in an established position between the closed or open configuration.

35 **[0056]** In particular, the established position can be calculated by the control unit by interpolating the estimated value of the gravity center and predetermined data of the work vehicle as listed precedingly.

[0057] For instance, knowing (memorized) the weight of the vehicle, its inclination and the position of the operative element (via sensor means), an equilibrium of torques acting on the work vehicle may be calculated deriving therefore a value of the position of the movable portion that allow to maintain the gravity center below a predetermined threshold.

45 **[0058]** In view of the foregoing, the advantages of a work vehicle and related control method according to the invention are apparent.

[0059] Thanks to the proposed system it is possible to vary the gravity center of the work vehicle thereby maintaining this latter below a safety threshold condition in case of need.

[0060] Accordingly, risks of accidents is reduced and consequently safety of the driver is increased.

50 **[0061]** Moreover, since the movable portion is itself part of the vehicle body and may vary its position, the body of the work vehicle may be realized lighter, i.e. without known counterweights since the variation of position of the movable portion allows to vary its inertial

moment, i.e. lower the gravity center.

[0062] Simulations occurred demonstrate that in the open configuration the work vehicle has a lifting gain of about 6%. Therefore the productivity and the object handling of the work vehicle is increased.

[0063] Moreover, the proposed handling system that allows a roto translation of the movable portion allows in a very compact manner to vary the extension along the extension axis of the work vehicle without lowering the free distance with respect to the ground.

[0064] In this way the gravity center is lowered/inertia is increased without substantially compromising the drivability of the work vehicle.

[0065] It is clear that modifications can be made to the described work vehicle and control method which do not extend beyond the scope of protection defined by the claims.

[0066] For example, the typology, dimension, shape of the work vehicle and the dimension/shape and arrangement of the movable portion may vary.

[0067] Clearly, more movable portion may be present or a movable portion that opens on the transversal side of the vehicle instead on the rear side as disclosed.

[0068] The handling system may be realized differently with respect to the disclosed one and similarly the lever system. Moreover, the lever system may comprise different elements with analogous function with respect to the described one.

Claims

1. Work vehicle (1) comprising a body (3) and a chassis (2), said chassis (2) carrying said body (3) and comprising ground engaging means (5) for allowing the motion on ground,

wherein said body (3) extends along a longitudinal axis (A), a transversal axis (B) transversal with respect to said longitudinal axis (B) and is carried over said chassis (2) along a vertical axis (C) perpendicular to both said longitudinal and transversal axes (A, B),

said body (3) comprising a movable portion (6) carried in a movable manner with respect to the remaining portion of said body (3) in order to vary its position along at least one direction according to one among said axes (A, B, C) between a closed configuration wherein said movable portion (6) is attached to the remaining portion of said body (3) and an opened configuration wherein said movable portion (6) is extended with respect to the remaining portion of said body (3) along said at least one direction.

2. Work vehicle according to claim 1, wherein said movable portion (6) is moved so that a bottom portion thereof increases its distance from the remaining

portion of said body (3) and so that a top portion thereof decreases its distance with respect to ground.

3. Work vehicle according to claim 1 or 2, wherein said body (3) comprises a frame (8) and a handling system (7) operatively interposed between said frame (8) and said movable portion (6) and configured to control the movement of said movable portion (6) between the closed and the opened configurations.

4. Work vehicle according to claim 3, wherein said handling system (7) comprises an actuation portion (7') and a guidance portion (7''), said actuation portion (7') being configured to provide a pushing or recalling force to a bottom portion of said movable portion (6) along one between said longitudinal or transversal axes (A, B) while said guidance portion (7'') is configured to assist the movement of a top portion of said movable portion (6) along said vertical axis (C).

5. Work vehicle according to claim 4, wherein said guidance portion (7) comprises a bracket (12), a block (15) and a pin (13), the bracket (12) said block (15) being housed in a sliding manner within a slot (14) realized in said frame (3), said bracket (12) being fixedly carried by said top portion of said movable portion (6) from one side and being rotatably free coupler to said pin (13) on the other side.

6. Work vehicle according to claim 5, wherein said bracket (12) and said pin (13) define a hinge connection.

7. Work vehicle according to any of claims 3 to 6, wherein said actuation portion (7') comprises at least one linear actuator (17).

8. Work vehicle according to claim 7, wherein said actuation portion (7') further comprises a pair of sliding arms (19).

9. Work vehicle according to claim 7 or 8, wherein said linear actuator (17) comprises a housing fixedly carried by said frame (8) and a rod sliding housed within said housing and connected via a lever system (22) to said bottom portion of said movable portion (6).

10. Work vehicle according to any of claims 7 to 9, wherein said sliding arms (19) each comprises a sliding block (21), each sliding block (21) being slidably housed within said frame (8) and being connected via a lever system (22) to said bottom portion of said movable portion (6).

11. Work vehicle according to claim 10, wherein each sliding arm (19) comprises sliding means (23) con-

figured to facilitate the sliding of said sliding arm (19) within said frame (8).

12. Work vehicle according to claim 9 or 10, wherein said lever system (22) comprises a pin (22') and a cam portion (22''), said pin (22') being rotatably carried from one side by the respective linear actuator (17) or sliding arm (19) along an axis (B) perpendicular to the extension of said linear actuator (17) or sliding arm (19) and carrying from the opposite side said cam portion (22''), said cam portion (22'') being fixedly carried by said movable portion (6). 5
13. Work vehicle according to any of claims 3 to 12, further comprising an control unit, input means and sensor means, said control unit being configured to acquire data from said input means and/or sensor means and elaborate the acquired data to control consequently said handling system (7) . 10
14. Work vehicle according to claim 13, wherein said input means comprises a button or an icon on a display. 15
15. Work vehicle according to claim 13 or 14, wherein said sensor means are sensors configured to acquire physical quantities that can be related to the gravity center of said work vehicle. 20
16. Method for controlling the center of gravity of a work vehicle (1) according to any of claims 13 to 15, comprising the following steps: 25
 - i. Acquiring data from input means and/or sensor means; 30
 - ii. Elaborating the acquired data at step i) via control unit to estimate a gravity center of the work vehicle; 35
 - iii. Evaluate if the estimated value of the gravity center at step ii) is below or above a predetermined safety value; 40
 - iv. If the estimated value is below the predetermined safety value, return to step i), otherwise proceed to step v) 45
 - v. Control the handling system for moving the movable portion in an established position between the closed or open configuration. 50

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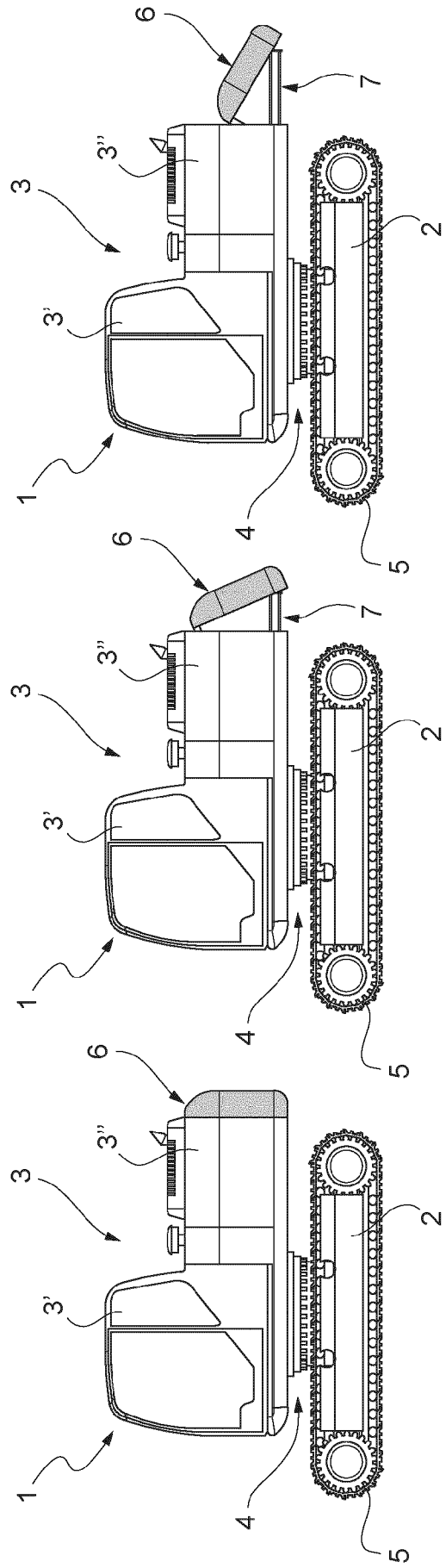


FIG. 1A

FIG. 1B

FIG. 1C

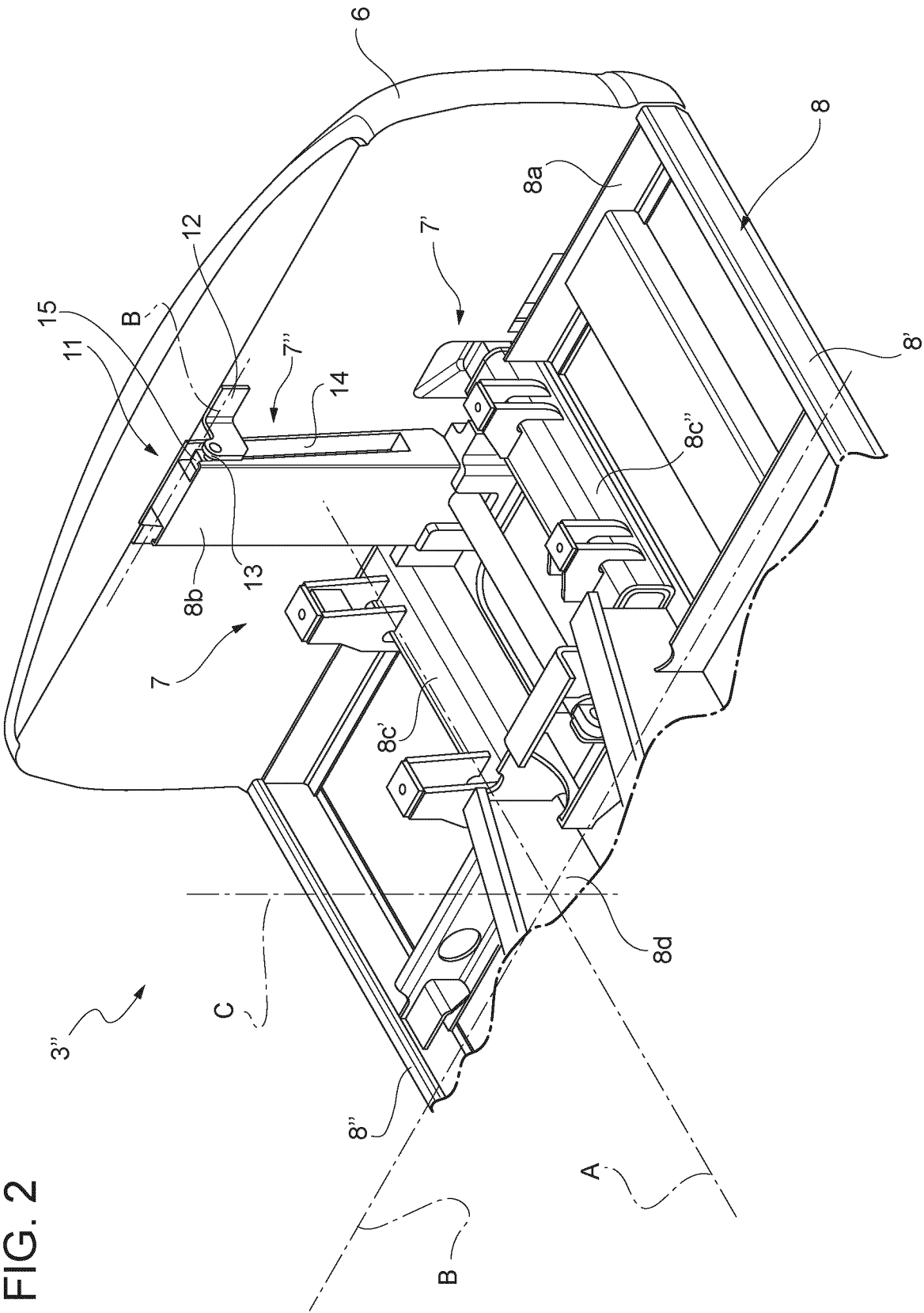
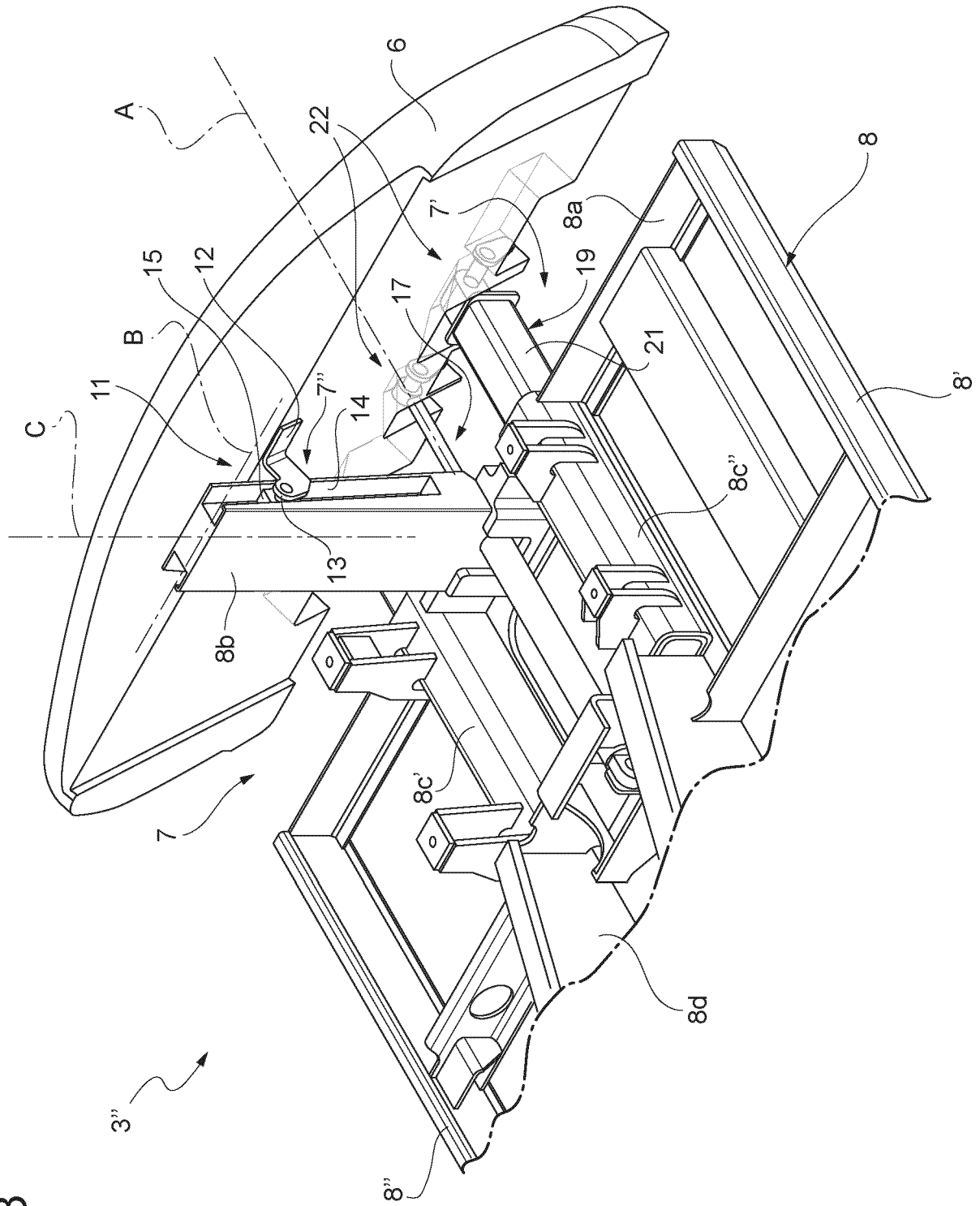
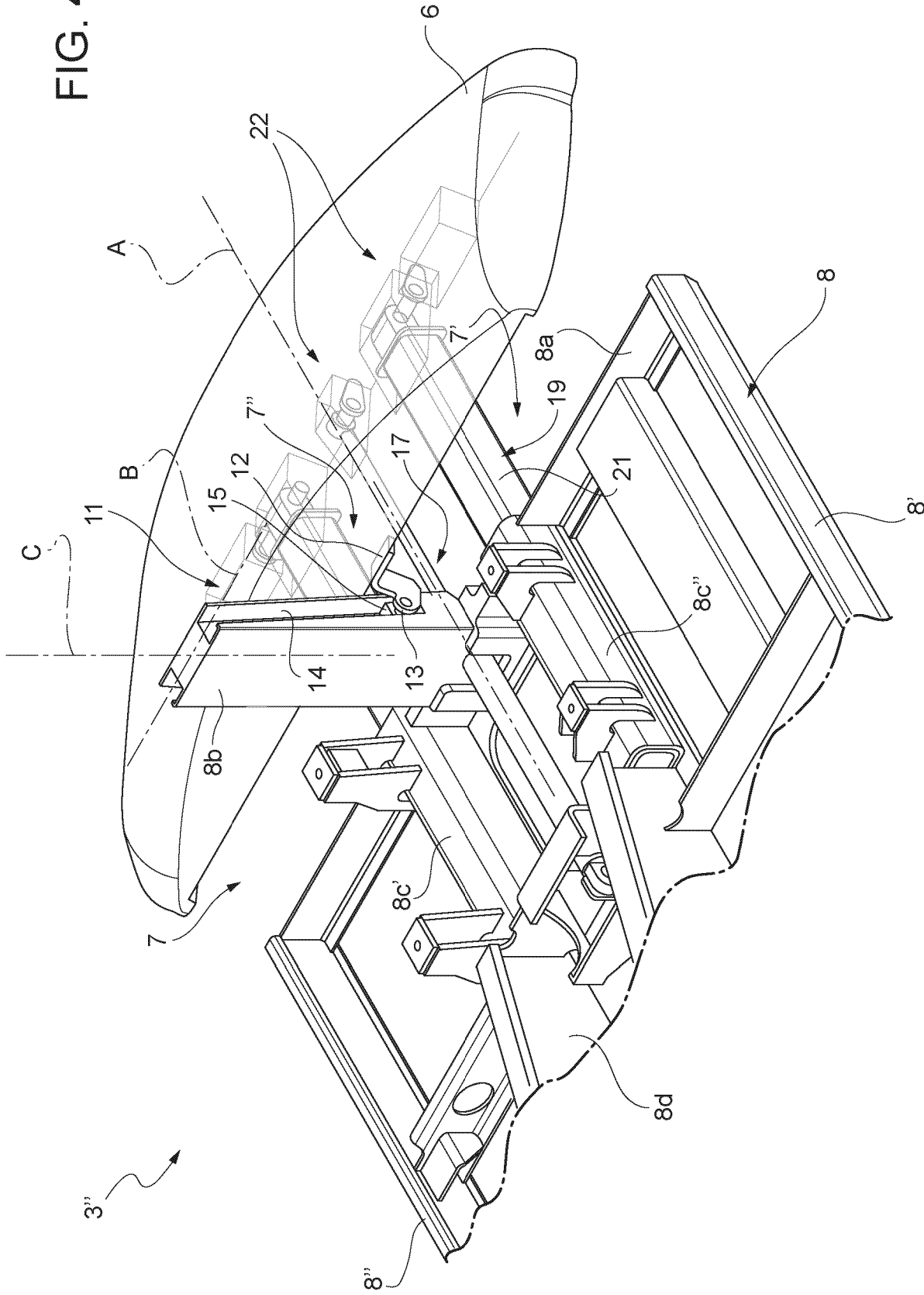


FIG. 2



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G
F

FIG. 4



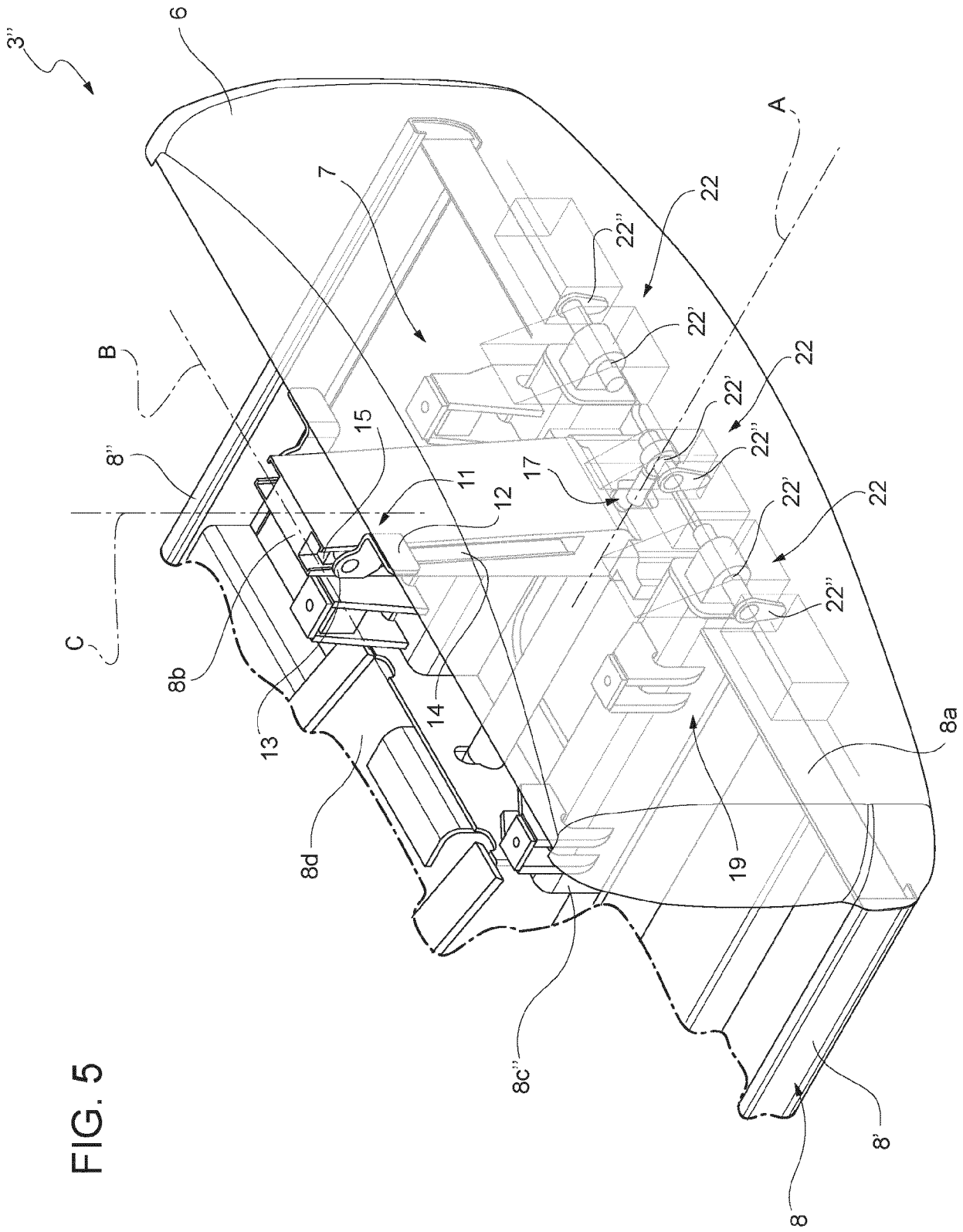


FIG. 5

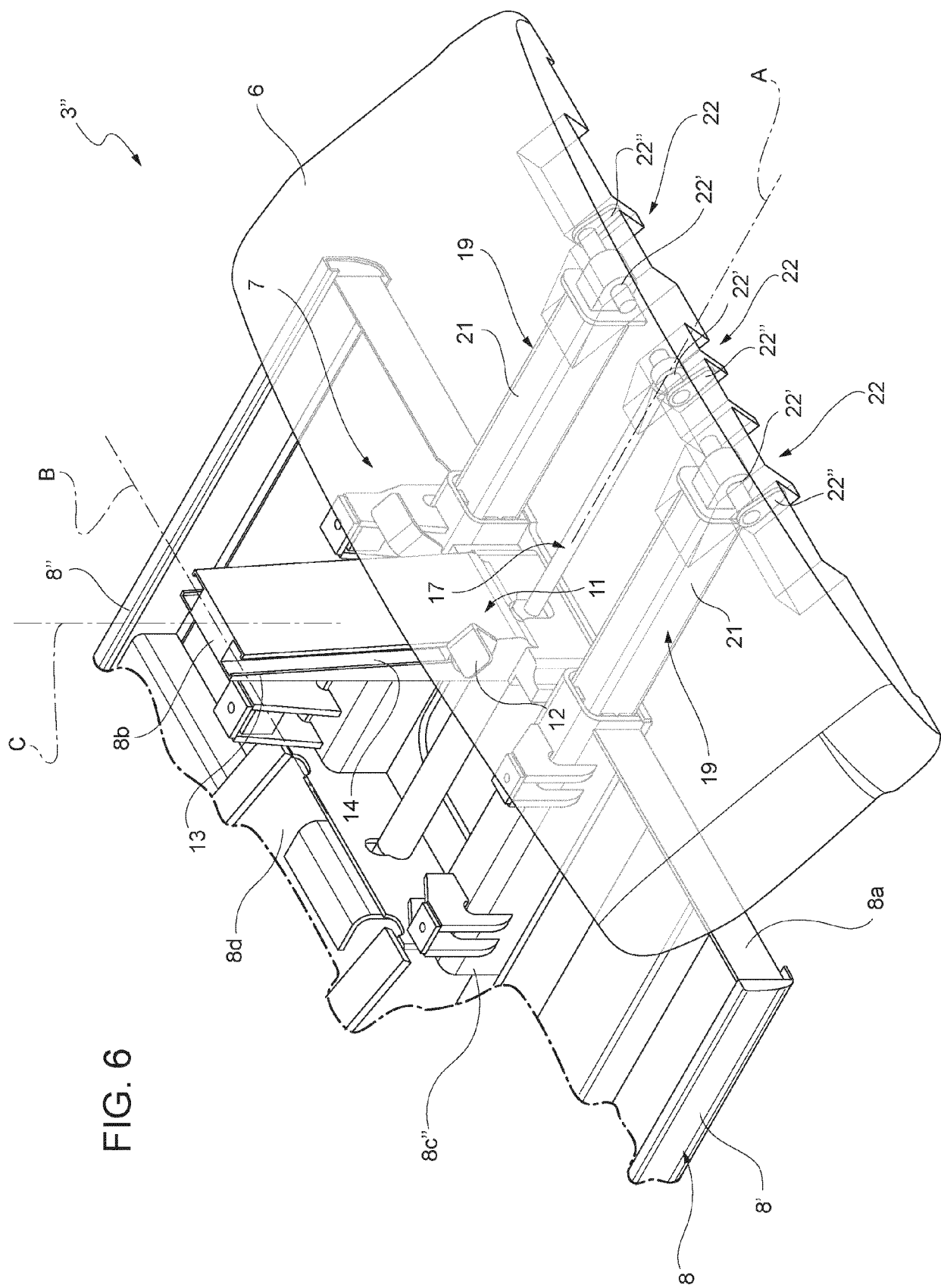


FIG. 6

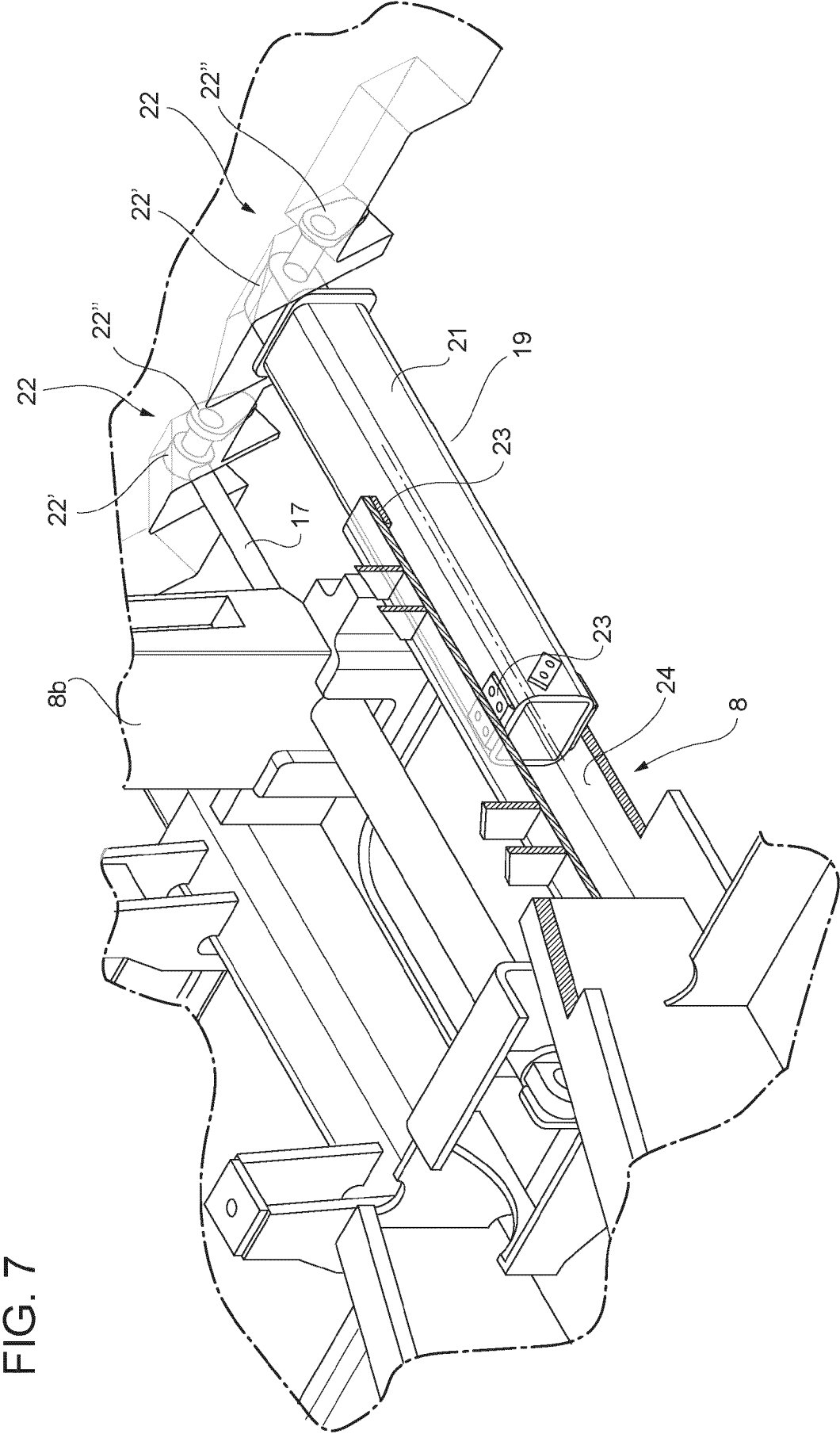
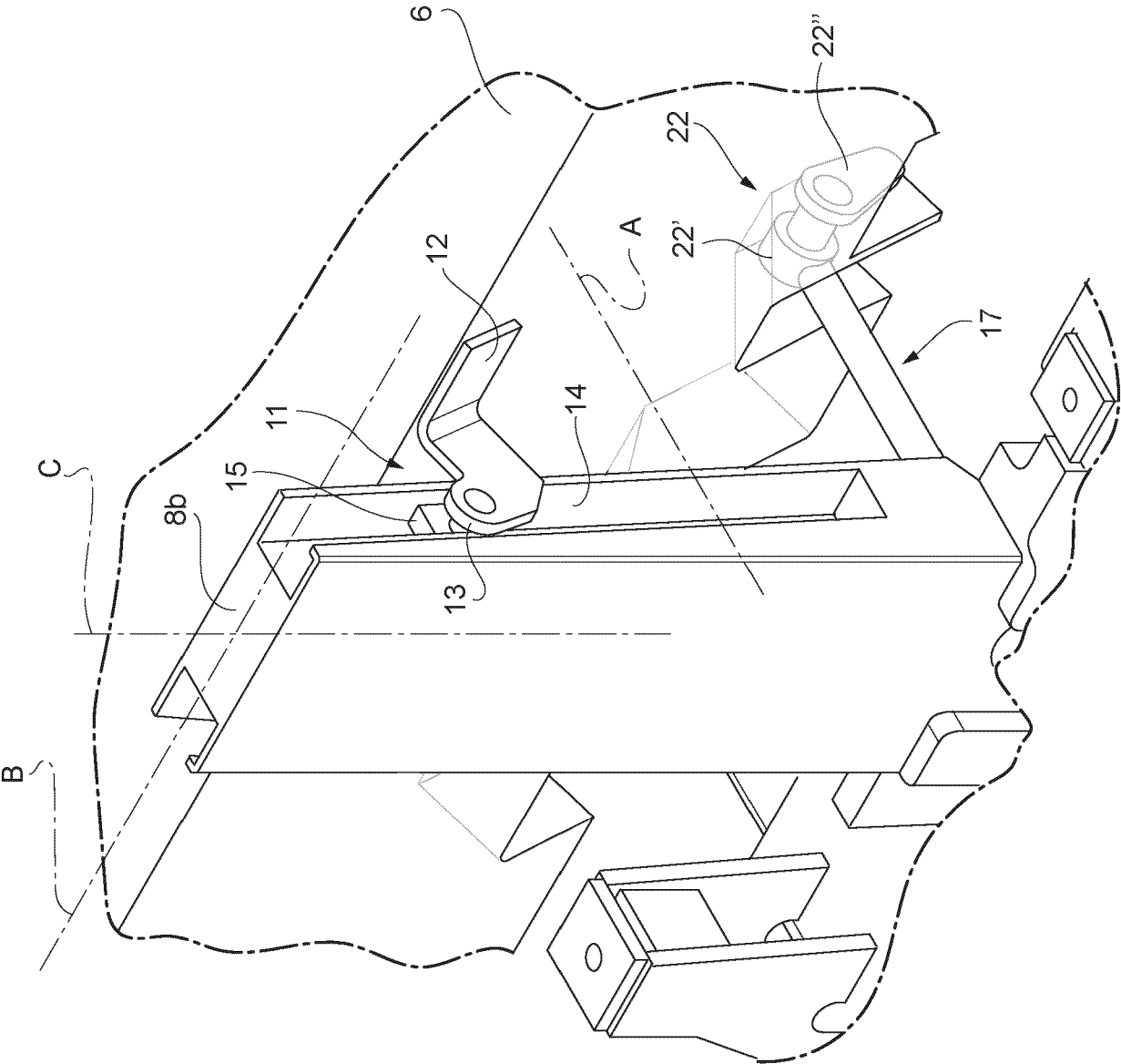


FIG. 7

FIG. 8





EUROPEAN SEARCH REPORT

Application Number

EP 24 20 0375

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 January 2025	Examiner Clarke, Alister
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 24 20 0375

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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