(19) DANMARK

(10) **DK/EP 3106608 T3**

Patent- og
Varemærkestyrelsen

(12) Oversættelse af
europæisk patentskrift

(51) Int.Cl.: ***E 21 D 9/12 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2021-04-26**

(80) Dato for Den Europæiske Patentmyndigheds
bekendtgørelse om meddelelse af patentet: **2021-02-24**

(86) Europæisk ansøgning nr.: **16174897.5**

(86) Europæisk indleveringsdag: **2016-06-17**

(87) Den europæiske ansøgnings publiceringsdag: **2016-12-21**

(30) Prioritet: **2015-06-19 EP 15172922**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

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(54) Benævnelse: **Tunnelgravemaskine og fremgangsmåde til udgravning af en tunnel**

(56) Fremdragne publikationer:
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US-A- 2 753 971
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DESCRIPTION

[0001] The present invention relates to a tunneling machine and a method of excavating a tunnel.

Background of the invention

[0002] Tunneling machines, also known as tunnel boring machines (TBM) are frequently used when building subterranean tunnels. Such tunnels may be use in particular for creating underground rail systems, but other purposes are equally feasible such as tunnels for road vehicles and tunnels for larger sewage- and water systems or similar utilities. Such tunnels may extend from about 10 meters to several kilometers and having a width of from about a meter up to several meters or even some tens of meters.

[0003] Tunneling machines typically comprise an elongated frame having approximately the same width as the tunnel to be excavated. When a tunnel pipe segment is to be excavated, the tunneling machine is inserted into the tunnel by means of an actuator. The front of the tunneling machine comprises an excavating mechanism which is capable of removing material from the tunnel front. The material comprises soil, rock, sand and other materials found in the earth. The material will be in the form of a particulate material after being removed from the tunnel wall by the excavating mechanism.

[0004] The particulate material must be transported away from the excavating mechanism and out of the tunnel in order to clear the tunnel pipe segment and allow the tunneling machine to advance forward into the tunnel. Typically, the particulate material is transported to the rear end of the elongated frame by means of a conveying mechanism, and thereafter the particulate material is loaded onto a soil transporter. When the soil transporter is fully loaded with particulate material, the boring activities are interrupted and the soil transporter is moved through the tunnel to the outside, where the particular material is off-loaded at a suitable location whereupon the soil transporter is returned to the rear end of the frame and the boring process may be re-started.

[0005] Several technologies exist for removing particulate material from tunneling machines. Some relevant technologies are described in the following documents:
US 4 353 676 A relates to a storage bunker for tunnel boring. The storage bunker received the discharge form a boring machine allowing the boring machine to operate continuously.

[0006] US 2 753 971 A relates to a material gathering, receiving storing and delivering apparatus. The apparatus receives material substantially continuously and discharges it at controlled rate into a shuttle car.

[0007] WO 95/30065 relates to a device for driving a tunnel or drain pipe. The device

comprises a thick matter pump which pumps the soil from a sealable stone trap adjacent a cutting chamber of the drive head to the outside.

[0008] WO 2008/043511 relates to a tunneling machine with a transport system. The machine comprises a transport band for transporting material away from the drilling head.

[0009] EP 0 114 452 A1 relates to a machine for digging a tunnel. The machine comprises a screw conveyor for transporting material away from the drilling head.

[0010] DE 30 15 319 relates to a tunneling machine which has a transport band.

[0011] US 3 574 405 relates to an apparatus for continuous excavation of tunnels. The apparatus comprises a conveyor which conveys material to carriages.

[0012] DE 28 40 280 relates to a tunneling machine which has a conveyor operating at two different velocities being a first slow velocity when the transport wagon is away from the tunneling machine and a faster velocity when the transport wagon is located adjacent the tunneling machine.

[0013] DE 34 34 936 relates to a digging machine having a transport band and US 4 767 253 relates to a tunnel cleaning train having a distributor.

[0014] One problem arising when using tunneling machines as described above is that the tunneling machine must be stopped when the soil transporter is away from the loading position at the rear end of the frame of the tunneling machine, i.e. when the soil transporter is off-loading or moving. At the beginning of the tunnel pipe segment the problem is non-significant, since the distances between the rear end of the frame and the outside of the tunnel pipe segment is small. As the length of the tunnel pipe segment increases, the time needed for transporting the soil transporter between the loading station at the rear end of the frame and the unloading station outside the tunnel pipe segment becomes significant. The time period when the tunneling machine is stopped and cannot work increases accordingly.

[0015] DE 28 40 280 provides a kind of solution to the present problem, however, the amount of particulate material which may be removed from the tunnel wall when the soil transporter is away from the loading position is limited by the size of the conveyor. Thus, it is an object of the present invention to provide technologies allowing the tunneling machine to be capable of running continuously also in longer tunnel pipe segments.

Summary of the invention

[0016] The above object and further objects which are evident from the below detailed description are according to a first aspect of the present invention achieved by a tunneling machine comprising an elongated frame for being inserted into a work area inside a tunnel or

an unfinished tunnel, the frame defining a front end and a rear end, the tunneling machine further comprising:

an actuator for moving the frame within the work area,

an excavating mechanism located at the front end of the frame for excavating particulate material from the work area,

a buffer tank located between the front end and the rear end of the frame (36), the buffer tank comprises a sloping bottom,

a first conveyor for receiving the particulate material from the excavating mechanism at the front end of the frame and transporting the particulate material to the buffer tank,

a soil transporter for receiving the particulate material from the buffer tank at the rear end of the frame and transporting the particulate material from the rear end of the frame to the outside of the work area, and

a second conveyor for transporting the particulate material from the buffer tank to the soil transporter, the second conveyor running only when the soil transporter is at the rear end of the frame, the second conveyor is extending from the sloping bottom of the buffer tank to the top of the soil transporter, the second conveyor comprises a primary conveyor extending within the buffer tank and reaching from the bottom of the buffer tank to the outside of the buffer tank, and a secondary conveyor extending outside the buffer tank, the secondary conveyor reaching fully enclosed from the primary conveyer to the soil transporter.

[0017] In order to excavate a tunnel pipe segment, the tunneling machine is moved to a front wall in the tunnel pipe segment. A tunnel pipe segment is in the present context construed to be the work area inside the tunnel or the unfinished tunnel. The front wall is the location in the tunnel pipe segment where the tunnel pipe segment should be extended. The frame holds all equipment necessary for the tunneling machine to operate. The actuator typically interacts with the side wall or the rear wall of the tunnel pipe segment and pushes the frame toward the end wall of the tunnel. The excavating mechanism is pushed against the end wall of the tunnel pipe segment in order to loosen the material and may thus differ depending on the type of material encountered in the ground.

[0018] During normal operation, the particulate material excavated by the excavating mechanism is transported to the buffer tank by means of the first conveyor. The first conveyor may be a belt conveyor, a screw conveyor, a bucket conveyor or the like. The buffer tank is off-loaded into a soil transporter. The soil transporter comprises a storage compartment for storing the particulate material and a number of wheels for allowing the soil transporter to move. When the storage compartment has been filled with particulate material, the soil transporter is moved to the outside of the tunnel pipe segment and the particulate material is off-loaded at an appropriate location. Normally only one soil transporter is used due to the

limited space inside the tunnel pipe segment.

[0019] When the soil transporter is en route between the rear end of the frame of the tunneling machine and the outside of the tunnel the excavating mechanism may continue to operate since the particulate material will simply accumulate in the buffer tank. The buffer tank should have an appropriate size in order to be able to accumulate all particulate material generated by the excavating mechanism while the soil transporter is away from the rear end of the frame of the tunneling machine. When the empty soil transporter has returned to the rear end of the frame of the tunneling machine, the buffer tank is again off-loaded into the soil transporter and the soil transporter returns to the outside of the tunnel pipe segment for off-loading the particulate material.
A sloping bottom will make it easier to empty the buffer tank in the limited space within the tunnel pipe segment.

[0020] In order to further simplify the off-loading of the particulate material from the buffer tank into the soil transporter, the buffer tank may comprise a conveyor which is operating to move the particulate material from the buffer tank to the storage compartment of the soil transporter when the soil transporter is adjacent the rear end of the frame of the tunnel excavating machine. When the storage compartment of the soil transporter is filled, the second conveyor stops and the soil transporter proceeds to the outside of the tunnel pipe segment for off-loading the particulate material. When the soil transporter returns to the rear end of the frame of the tunnel excavating machine, the second conveyor is restarted to transport the particulate material which has accumulated in the buffer tank to the storage compartment of the soil transporter.
The buffer tank may be completely emptied without moving or tilting the buffer tank. The conveyor part inside the buffer tank may operate independently of the conveyor part outside the buffer tank

[0021] According to a further embodiment of the first aspect, the excavating mechanism constitutes an excavator. An excavator may be used for digging into loose materials such as sand etc. It may be controlled by an operator situated adjacent the front end of the frame.

[0022] According to a further embodiment of the first aspect, the excavating mechanism constitutes a drilling head. A drilling head may be used for hard materials such as granite etc. The drilling head comprises a rotating boring head comprising disc cutters.

[0023] According to a further embodiment of the first aspect, the primary conveyor constitutes a carrier comprising a linear actuator, a beam connected to the linear actuator and extending within the buffer tank above the sloping bottom, and a plurality of pivotable plates extending from the beam towards the sloping bottom. The pivotable plates are pivoable between a substantially vertical orientation and a substantially horizontal orientation pointing towards the soil transporter. When the actuator is moved towards the soil transporter, the plates will be in the substantially vertical orientation and accumulate particulate material which will be moved towards the soil transporter by the substantially vertical plates whereas - when the actuator

moves away from the outlet - the plates will pivot into the substantially vertical orientation and slip above the accumulated piles of particulate material. When the actuator is again moved towards the soil transporter, the plates will assume the substantially vertical orientation and again convey the particulate material towards the soil transporter. In this way, sand and other fine materials may be more efficiently conveyed.

[0024] According to a further embodiment of the first aspect, the second conveyor is a screw conveyor. A screw conveyor is advantageous to use for transporting the particulate material since it requires only a small amount of space.

[0025] According to a further embodiment of the first aspect, the second conveyor is operating with a higher velocity than the first conveyor. In order to minimize the waiting time of the soil transporter and thereby the risk of having to stop the excavating mechanism, the second conveyor should be able to transport the particulate material from the buffer tank to the storage compartment of the soil transporter at a much higher velocity than the excavating mechanism generates particulate material and the first conveyor transports particulate material from the excavating mechanism to the buffer tank.

[0026] According to a further embodiment of the first aspect, the soil transporter is driven by a cable. The soil transporter may have its own drive mechanism, however, preferably the soil transporter may be driven by a cable which is connected to a drive mechanism, such as an electrical motor, located on the frame and/or outside the tunnel pipe segment. In this way the weight of the soil transporter is reduced since it must not include the drive mechanism.

[0027] According to a further embodiment of the first aspect, the soil transporter has a storage compartment corresponding to the storage volume of the buffer tank. In this way the complete volume of particulate material in the buffer tank may be transferred to the storage compartment of the soil transporter.

[0028] According to a further embodiment of the first aspect, the tunneling machine further comprises a mechanism for introducing concrete tunnel segments into the tunnel segment. Advantageously, the tunneling machine also has the capability of lining the tunnel pipe segment by introducing concrete tunnel segments into the tunnel pipe segment. Preferably, the frame is thus resting on the concrete tunnel segments, which may be continuously pushed into the tunnel pipe segment as the excavating mechanism clears a new portion of the tunnel pipe segment.

[0029] According to a further embodiment of the first aspect, the soil transporter is adapted to move a specific volume of particulate material from the rear end of the frame to the outside of the tunnel pipe segment, unload the particulate material and move from the outside of the tunnel pipe segment to the rear end of the frame at approximately the same time as it takes to fill the buffer tank with the specific volume of particulate material. The velocity of the soil transporter may thus be adapted to the length of the tunnel pipe segment. Operating the soil transporter at high velocity will require more energy and thus at the beginning of the

excavating process, the soil transporter may travel at a lower velocity, thereby requiring less amount of energy to operate.

[0030] According to a further embodiment of the first aspect, the actuator is a hydraulic actuator having a counter hold inside the tunnel pipe segment and/or outside the tunnel pipe segment. The frame of the tunneling machine may be driven into the tunnel pipe segments by hydraulic power and may either arrest itself against the side walls of the tunnel pipe segment or the rear wall of the tunnel pipe segment, i.e. a wall opposite the location of the excavating mechanism, or both, in order to push the excavating mechanism towards the end wall of the tunnel pipe segment.

[0031] According to a further embodiment of the first aspect, the buffer tank has a storage volume of between $1m^2$ and $100m^2$. Such volumes are suitable for ensuring a continuous operation of the tunneling machine.

[0032] The above object and further objects which are evident from the below detailed description are according to a second aspect of the present invention achieved by a method of excavating a tunnel by using a tunneling machine comprising an elongated frame for being inserted into a work area inside a tunnel or an unfinished tunnel, the frame defining a front end and a rear end, the tunneling machine further comprising:

an actuator,

an excavating mechanism located at the front end of the frame,

a buffer tank located between the front end and the rear end of the frame, the buffer tank comprises a sloping bottom,

a first conveyor located between the excavating mechanism and the buffer tank,
a soil transporter, and
a second conveyor for transporting the particulate material from the buffer tank to the soil transporter, the second conveyor running only when the soil transporter is at the rear end of the frame, the second conveyor is extending from the sloping bottom of the buffer tank to the top of the soil transporter, the second conveyor comprises a primary conveyor extending within said buffer tank and reaching from the bottom of the buffer tank to the outside of the buffer tank, and a secondary conveyor extending outside the buffer tank, the secondary conveyor reaching fully enclosed from the primary conveyer to the soil transporter,

the method comprising the steps of:

moving the frame within the work area by using the actuator,

excavating particulate material from the tunnel wall by using the excavating mechanism, transporting the particulate material from the excavating mechanism to the buffer tank by using the first conveyor,

receiving the particulate material from the buffer tank into the soil transporter at the rear end of the frame, and

transporting the particulate material from the rear end of the frame to the outside of the work area.

[0033] The above method according to the second aspect is preferably used in connection with the tunneling machine described above in connection with the first aspect.

Brief description of the drawings

[0034]

FIG. 1 is a perspective view of a tunneling machine according to a first example not falling under the scope of protection of the present invention.

FIG. 2 is a side view of a tunneling machine according to a second example not falling under the scope of protection of the present invention.

FIG. 3A is a close-up side view of the tunneling machine according to the second example.

FIG. 3B is a close-up side view of the tunneling machine according to the first example.

FIG. 4 is a perspective view of a rear part of a tunneling machine according to an embodiment of the present invention.

FIG. 5 is a side view of the tunneling machine according to the embodiment of the present invention.

FIG. 6 is a side view of a tunneling machine according to a third example not falling under the scope of protection of the present invention.

FIG. 7A is a first view of a series of views describing the working principle of the tunneling machine according to the third example.

FIG. 7B is a second view of a series of views describing the working principle of the tunneling machine according to the third example.

FIG. 7C is a third view of a series of views describing the working principle of the tunneling machine according to the third example.

Detailed description of the drawings

[0035] FIG. 1 shows a perspective view of a tunneling machine 10 according to a first

background example. The tunneling machine 10 is located below ground inside a tunnel pipe segment 12. The tunneling machine 10 comprises an excavating mechanism in the form of a drilling head 14. The drilling head 14 is capable of loosening ground materials at the end wall A of the tunnel pipe segment 12. The loosened ground materials constitute a particulate material 16 which is transported to a buffer tank 18 by a first conveyor 20. The first conveyor 20 may constitute a screw conveyor, belt conveyor, bucket conveyor or a combination thereof as illustrated here.

[0036] The particulate material 16 is further transported from the buffer tank 18 to a soil transporter 22 by means of a second conveyor 24. The soil transporter 22 constitutes a vehicle which transports the particulate material to the outside of the tunnel, Optionally, a further conveyor as shown here is used in case the soil transporter 22 cannot reach the surface, or other plausible means may be applied, such as a lift etc. In the present embodiment the tunneling machine is pushed into the tunnel pipe segment 12 by means of an actuator 26 together with concrete tunnel segments 28 which are used to line the side wall B of the tunnel pipe segment 12 and provide reinforcement of the tunnel pipe segment 12. The tunneling machine is thereby fixated to the concrete tunnel segment 28 and will move forward together with the row of concrete tunnel segments 28. The tunneling machine 10 is typically powered by hydraulics from a station 30 located outside the tunnel pipe segment 12. The actuator is supported by the rear wall C. Alternatively, the tunnel side wall B is used as support.

[0037] The second conveyor 24 comprise a primary conveyor 24a inside and adjacent the bottom of the buffer tank 18 and a secondary conveyor 24b outside the buffer tank 18 leading from the buffer tank 18 to the soil transporter. The primary conveyor 24a is in the present embodiment a screw conveyor whereas the secondary conveyor 24b is a belt conveyor.

[0038] FIG. 2 shows a side view of a tunneling machine 10' according to a second background example. Instead of drilling head, the present embodiment makes use of an excavator 14'. An excavator 14' may be used for soft grounds such as sand. A drilling head as in the previous embodiment is used for harder grounds such as rock.

[0039] The soil transporter is driven in and out of the tunnel pipe segment 12 by means of a cable 32 which is connected to the soil transporter 22 and to a motor driven spindle 34. As the tunnel pipe segment 12 becomes longer, the soil transporter 22 must move faster in order to be able to move to the outside of the tunnel pipe segment 12, off-load the particulate material 16 and return to the buffer tank 18 before the buffer tank 18 is filled. FIG. 3A shows a close-up side view of the tunneling machine 10' according to the second example. The excavator 14' is capable of operating continuously as the particulate material 16 excavated by the excavator 14 is temporarily stored in the buffer tank 18. The bucket 14', the first conveyor 20, the buffer tank 18 and the second conveyor 24 are all mounted on a frame 36 which is fixated to the side wall B of the concrete tunnel pipe segment 28. When the soil transporter 22 is located adjacent the second conveyor 24, the storage compartment 38 of the soil transporter 22 is filled with the particulate material of the buffer tank 18.

[0040] When the storage compartment 38 of the soil transporter 22 is filled, the second conveyor 24 is stopped and the soil transporter 22 is pulled out of the tunnel pipe segment 12 by means of the cable 32, emptied and returned to the second conveyor 24. As the soil transporter 22 returns, the second conveyor 24 is re-started. The second conveyor 24 operates at a higher velocity than the first conveyor 20 in order to quickly fill the storage compartment 38 of the soil transporter.

[0041] FIG. 3B shows a close-up side view of the tunneling machine 10 according to the first example. The tunneling machine 10 is provided with a rotating drilling head 14" instead of the excavator for being able to penetrate harder soil materials.

[0042] FIG.1 and FIG.3B show examples of the so called EPB method having a closed tunnel front, whereas FIG. 2 and FIG.3A show the open front method. There exist basically two methods of lining a tunnel. The first method named pipejacking is disclosed above and makes use of hard lining segments which are pushed into the tunnel pipe segment. The second method called segment lining uses segments which are mounted at the tunnel front, i.e. the lining string does not move.

[0043] FIG. 4 shows a perspective view of a rear part of a tunneling machine 10'" according to the present invention. The present tunneling machine 10'" is similar to the above tunneling machines except that the second conveyor 24 is enclosed from its receiving end which is located within the buffer tank 18 to its delivering end which is located above the soil transporter 22. The second conveyor is divided into a primary conveyor 24a located within the buffer tank 18 and extending partially outside the buffer tank 24, and a secondary conveyor 24b extending from the primary conveyor 24a to the soil transporter 22. The secondary conveyor 24b is in the present case a substantially enclosed screw conveyor. In this way, any spillage may be avoided.

[0044] FIG. 5 shows a side view of the tunneling machine 10'" according to the embodiment of the present invention. The primary conveyor 24a reaches from the bottom of the buffer tank 18 to the outside of the buffer tank 18, whereas the secondary conveyor 24b reaches fully enclosed from the first conveyor part 24' to the soil transporter 22. The interconnection between the first conveyor part 24' and the second conveyor part 24" is in the present case also enclosed.

[0045] FIG. 6 shows a side view of a tunneling machine 10"" according to a third background example. In the present tunneling machine 10"", the buffer tank 18 is provided with a carrier 40, acting as the primary conveyor of the previous embodiments. The carrier 40 comprises a hydraulic linear actuator 42 which is movable in a back and forth direction as shown by the arrows. The actuator 42 is connected to a beam 46 extending through the buffer tank 18 at a distance from the bottom of the buffer tank 18. The beam 46 comprises a number of plates 46, each being pivotally connected to the beam 44 via a respective pivot 48. The plates 46 extend from the beam 44 in a perpendicular direction relative to the beam 44 and towards the bottom of the buffer tank 18. The buffer tank 18 features an opening 50 at which location, particulate

material 16 will enter the secondary conveyor 24b.

[0046] FIG. 7A shows a first view of a series of views describing the working principle of the tunneling machine 10"" according to the third example. The plates 46 are pivotable towards the opening 50 and non-pivotable towards the opposite direction. When the actuator 42 moves the plates 46 towards the opening 50, the particulate material 16 will be carried along the plates 46 towards the opening 50.

[0047] FIG. 7B shows a second view of a series of views describing the working principle of the tunneling machine 10"" according to the third example.

[0048] When the actuator 42 has reached its most contracted position, it turns and moves the plates 46 away from the opening 50. In this situation, the plates 46 will pivot and slide above the particulate material 16 which has been accumulated by the plate 46.

[0049] FIG. 7C shows a third view of a series of views describing the working principle of the tunneling machine 10"" according to the third example.

[0050] When the actuator 42 has reached its most extended position, it will again reverse towards the opening and the plates 46 will pivot back above the particulate material 16 and carry the particulate material towards the opening 50.

[0051] The present third example is particularly advantageous when conveying sand and similar fine particulate materials which may otherwise easily cause spillage and clogging.

Reference numerals with reference to the figures

[0052]

10. Tunneling machine
12. Tunnel pipe segment
14. Excavating mechanism
16. Particulate material
18. Buffer tank
20. First conveyor
22. Soil transporter

24.
Second conveyor
24a.
Primary conveyor
24b.
Secondary conveyor
26.
Actuator
28.
Concrete tunnel pipe segment
30.
Hydraulic station
32.
Cable
34.
Spindle
36.
Frame
38.
Storage compartment
40.
Carrier
42.
Hydraulic actuator
44.
Beam
46.
Plates
48.
Pivot
50.
Opening
A.
Tunnel front
B.
Tunnel side wall
C.
Rear wall

REFERENCES CITED IN THE DESCRIPTION

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KRAV

1. En tunnelgravemaskine (10) omfattende en langstrakt ramme (36) til indsættelse i et arbejdsområde (12) inden i en tunnel eller en ufærdig tunnel, hvilken ramme (36) definerer en forende og en bagende, hvilken tunnelgravemaskine er (10) yderligere omfatter:

en aktuator (26) til at bevæge rammen (36) inden for arbejdsområdet (12),

en udgravningsmekanisme (14) placeret ved den forreste ende af rammen (36) til udgravning af partikelformet materiale (16) fra arbejdsområdet (12),

en buffertank (18) placeret mellem den forreste ende og den bageste ende af rammen (36), hvor buffertanken (18) omfatter en skrånende bund,

en første transportør (20) til at modtage det partikelformede materiale (16) fra gravemekanismen (14) ved den forreste ende af rammen (36) og transportere det partikelformede materiale (16) til buffertanken (18),

en jordtransportør (22) til modtagelse af det partikelformede materiale (16) fra buffertanken (18) ved den bageste ende af rammen (36) og transport af det partikelformede materiale (16) fra den bageste ende af rammen (36) til uden for arbejdsområdet (12) og

en anden transportør (24) til transport af det partikelformede materiale (16) fra buffertanken (18) til jordtransportøren (22), hvilken anden transportør (24) kun kører, når jordtransportøren (22) er ved den bageste ende af rammen (36), hvor den anden transportør (24) strækker sig fra den skrånende bund af buffertanken (18) til toppen af jordtransportøren (22), hvilken anden transportør (24) omfatter en primær transportør (24a), der strækker sig inden i buffertanken (18) og strækkende fra bunden af buffertanken (18) til ydersiden af buffertanken (18), og en sekundær transportør (24b), der strækker sig uden for buffertanken (18), idet den sekundære transportør (24b) strækker sig helt omsluttet fra den primære transportør (24a) til jordtransportøren (22).

2. Tunnelgravemaskine (10) ifølge krav 1, hvor gravemekanismen (14) udgør en gravemaskine eller et borehoved.

3. Tunnelgravemaskine (10) ifølge et hvilket som helst af de foregående krav, hvor den primære transportør (24a) udgør en bærer omfattende en lineær aktuator (26), en bjælke forbundet med den lineære aktuator (26) og som forløber inden i buffertanken (18) oven over den skrånende bund, og et antal drejelige plader, der strækker sig fra bjælken mod den skrånende bund.

4. Tunnelgravemaskine (10) ifølge et hvilket som helst af de foregående krav, hvor den anden transportør (24) er en skruetransportør.

5. Tunnelgravemaskine (10) ifølge et hvilket som helst af de foregående krav, hvor den anden transportør (24) fungerer med en højere hastighed end den første transportør (20).

6. Tunnelgravemaskine (10) ifølge et hvilket som helst af de foregående krav, hvor jordtransportøren (22) drives af et kabel (32).

7. Tunnelgravemaskine (10) ifølge et hvilket som helst af de foregående krav, hvor jordtransportøren (22) har et opbevaringsrum, der svarer til opbevaringsvolumenet af buffertanken (18).

8. Tunnelgravemaskine (10) ifølge et hvilket som helst af de foregående krav, hvor tunnelmaskinen (10) yderligere omfatter en mekanisme til indføring af betontunnelsegmenter (28) i arbejdsområdet (12).

9. Tunnelgravemaskine (10) ifølge et hvilket som helst af de foregående krav, hvor jordtransportøren (22) er indrettet til at bevæge et specifikt volumen af partikelformet materiale (16) fra den bageste ende af rammen (36) til uden for arbejdsområdet (12), aflæsse partikelmaterialet (16) og bevæge sig fra uden for arbejdsområdet (12) til den bageste ende af rammen (36) på omtrent samme tid, som det tager at fylde buffertanken (18) med det specifikke volumen af partikelformet materiale (16) og/eller, hvor aktuatoren (26) er en hydraulisk aktuator med et modgreb inden i arbejdsområdet (12) og/eller uden for arbejdsområdet (12), og/eller hvor buffertanken (18) har et lagervolumen på mellem 1 m^2 og 100 m^2.

10. Fremgangsmåde til udgravning af en tunnel ved anvendelse af en tunnelgravemaskine (10) omfattende en langstrakt ramme (36) til indsættelse i et arbejdsområde (12) inden i en tunnel eller en ufærdig tunnel, hvilken ramme (36) definerer en forreste ende og en bagende, hvilken tunnelgravemaskine (10) yderligere omfatter:

en aktuator (26),

en udgravningsmekanisme (14) placeret ved den forreste ende af rammen (36),

en buffertank (18) placeret mellem den forreste ende og den bageste ende af rammen (36), hvor buffertanken (18) omfatter en skrånende bund,

en første transportør (20) placeret mellem gravemekanismen (14) og buffertanken (18),

en jordtransportør (22) og

en anden transportør (24) til transport af det partikelformede materiale (16) fra buffertanken (18) til jordtransportøren (22), hvilken anden transportør (24) kun kører, når jordtransportøren (22) er ved den bageste ende af rammen (36), hvor den anden transportør (24) strækker sig fra den skrånende bund af buffertanken (18) til toppen af jordtransportøren (22), hvilken anden transportør (24) omfatter en primær transportør (24a), der strækker sig inden i buffertanken (18) og rækker fra bunden af buffertanken (18) til ydersiden af buffertanken (18), og en sekundær transportør (24b), der strækker sig uden for buffertanken (18), idet den sekundære transportør (24b) strækker sig fuldt omsluttet fra den primære transportør (24a) til jordtransportøren (22),

hvilken fremgangsmåde omfatter trinnene:

bevægelse af rammen (36) inden for arbejdsområdet (12) ved anvendelse af aktuatoren (26),

udgravning af partikelformet materiale (16) fra tunnelvæggen ved anvendelse af udgravningsmekanismen (14),

transport af det partikelformede materiale (16) fra gravemekanismen (14) til buffertanken (18) ved anvendelse af den første transportør (20),

modtagelse af det partikelformede materiale (16) fra buffertanken (18) i jordtransportøren (22) ved den bageste ende af rammen (36), og

transport af det partikelformede materiale (16) fra den bageste ende af rammen (36) til uden for arbejdsområdet (12).

DRAWINGS

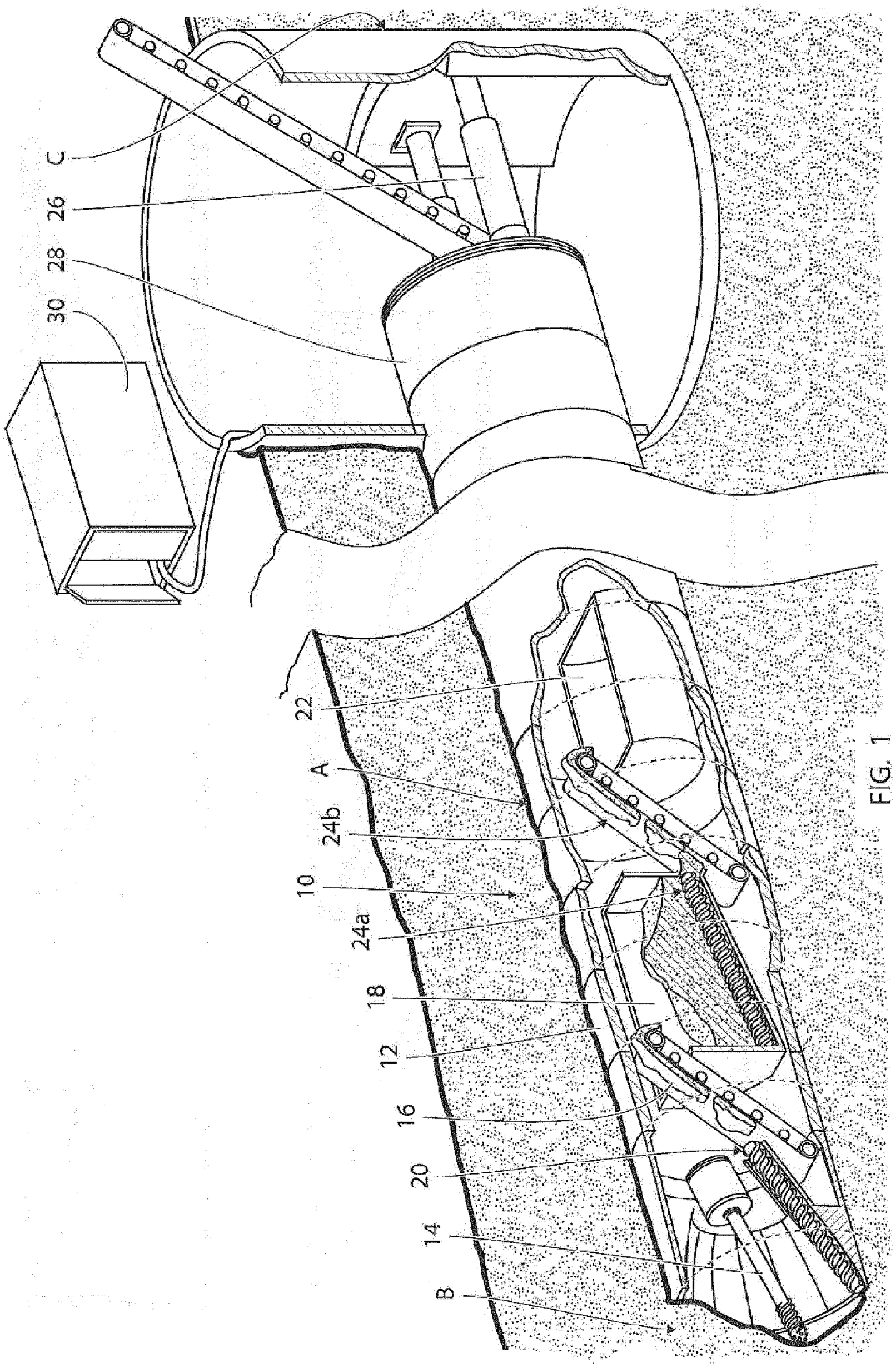

FIG. 1

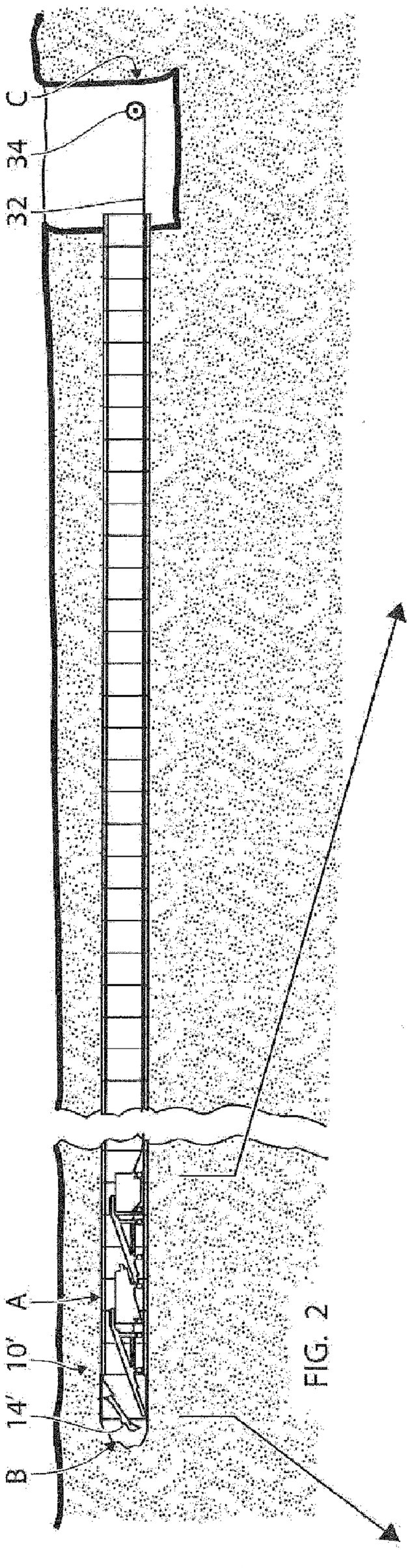

FIG. 2

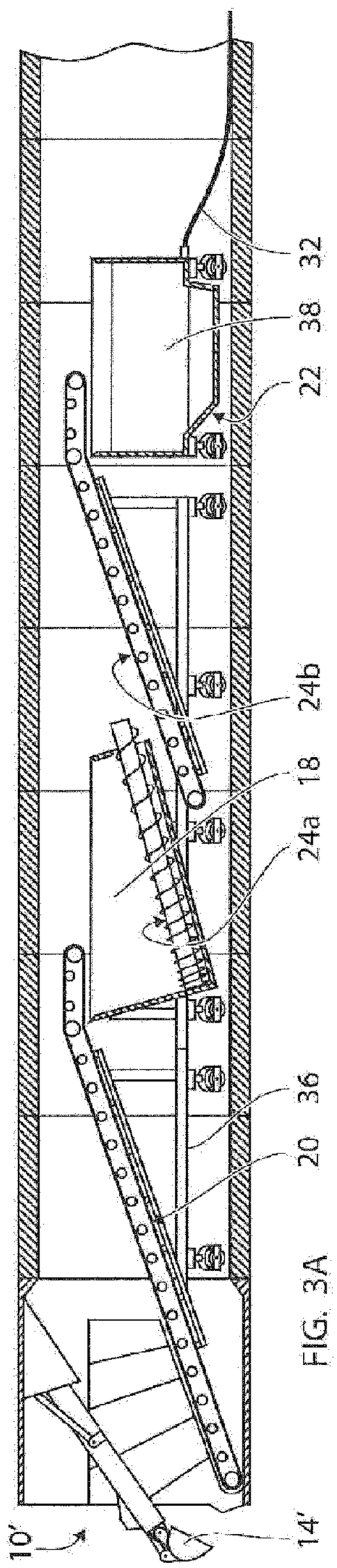

FIG. 3A

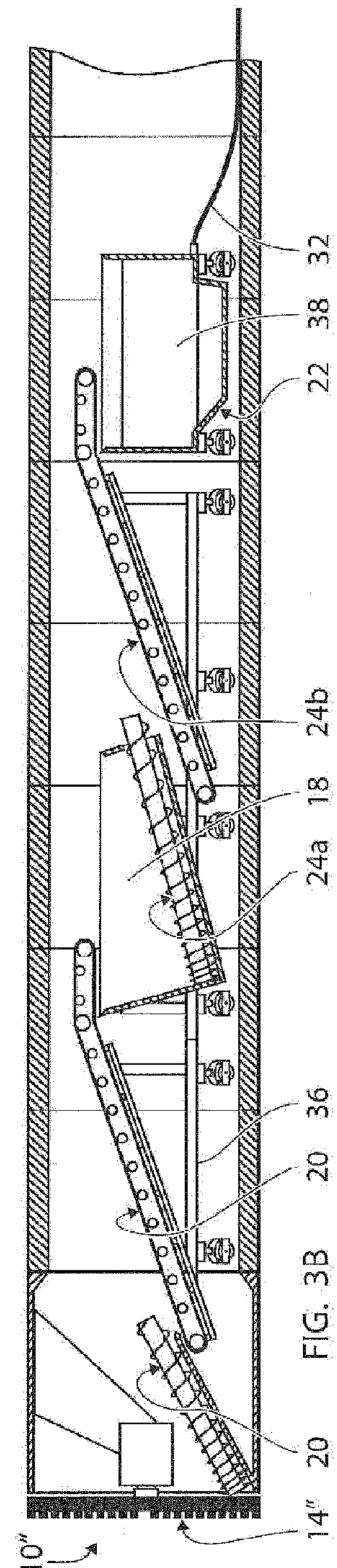

FIG. 3B

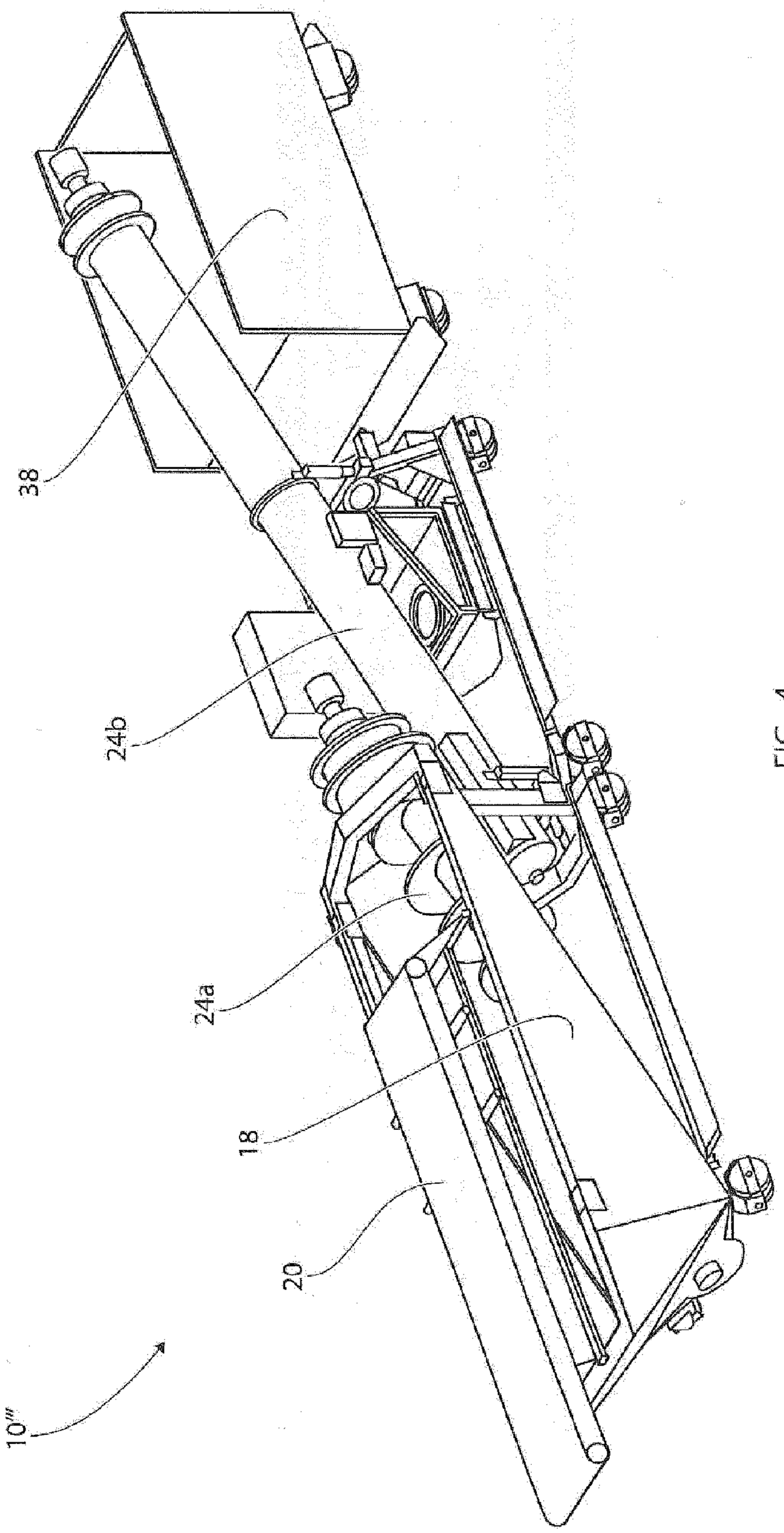

FIG. 4

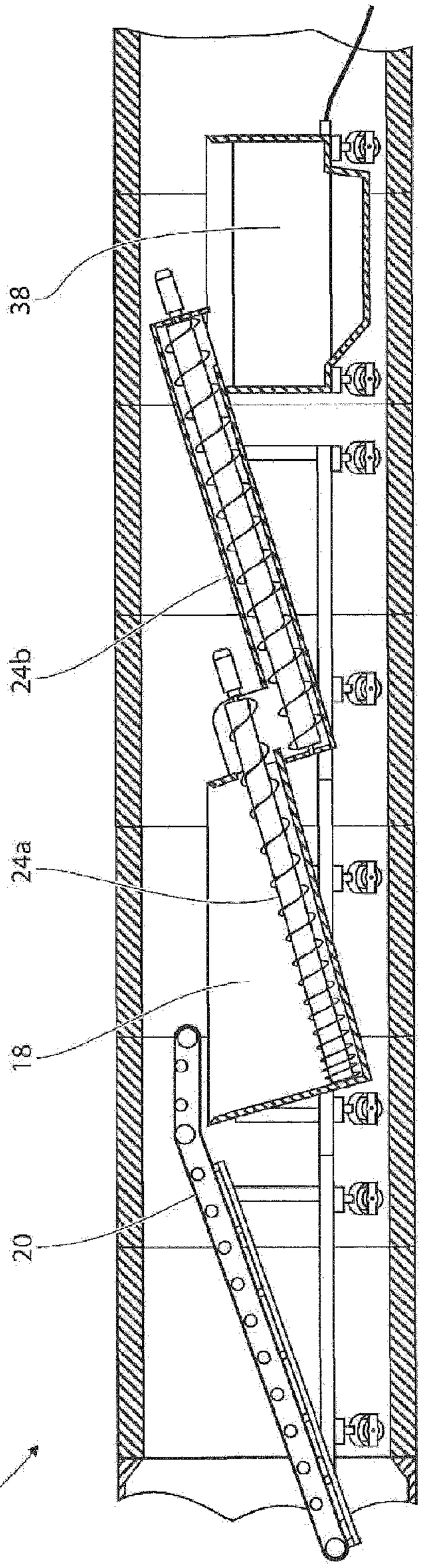

FIG. 5

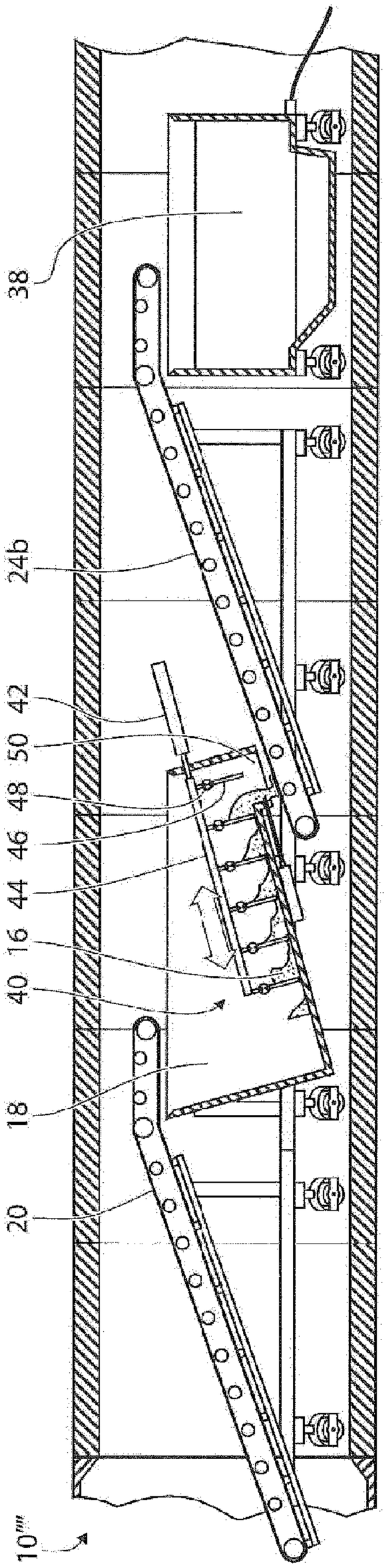

FIG. 6

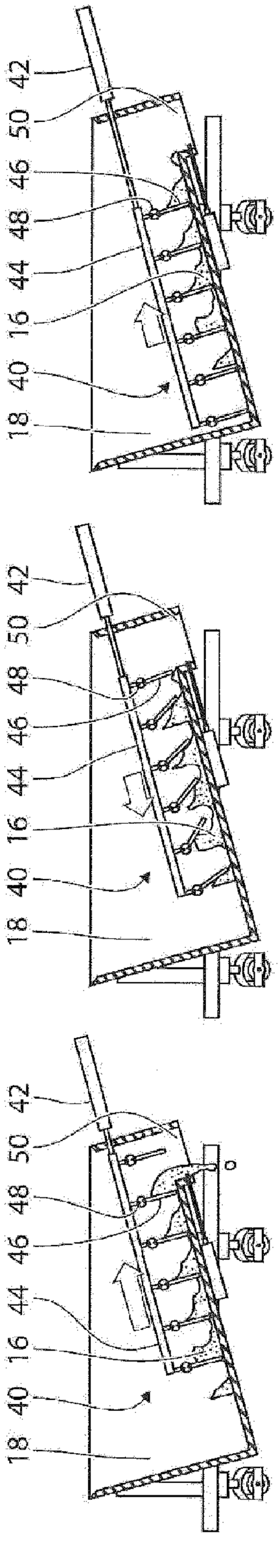

FIG. 7C

FIG. 7B

FIG. 7A