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(54) **A TUNNELING MACHINE AND A METHOD OF EXCAVATING A TUNNEL**

(57) The present invention relates to a tunneling machine comprising an elongated frame for being inserted into a tunnel pipe segment. The frame defines a front end and a rear end. The tunnelling machine further comprises an actuator for moving the frame within the tunnel pipe segment, an excavating mechanism located at the front end of the frame for excavating particulate material from the tunnel pipe segment, and a buffer tank located be-

tween the front end and the rear end of the frame. A first conveyor receives the particulate material from the excavating mechanism at the front end of the frame and transports the particulate material to the buffer tank. A soil transporter receives the particulate material from the buffer tank at the rear end of the frame and transports the particulate material from the rear end of the frame to the outside of the tunnel pipe segment.

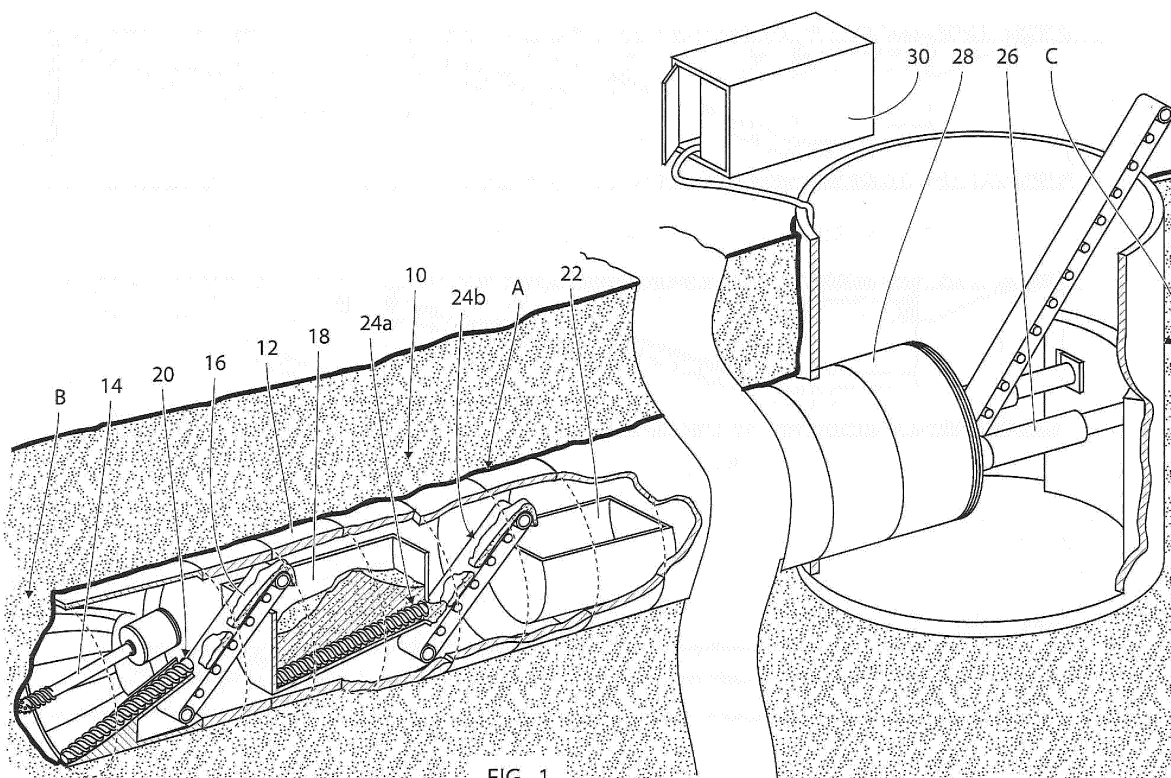


FIG. 1

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:

[0006] 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.

[0007] 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.

[0008] 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.

[0009] DE 30 15 319 relates to a tunneling machine

which has a transport band.

[0010] US 3 574 405 relates to an apparatus for continuous excavation of tunnels. The apparatus comprises a conveyor which conveys material to carriages.

5 **[0011]** 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.

10 **[0012]** 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.

15 **[0013]** 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.

20 **[0014]** 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

40 **[0015]** 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 tunnel pipe segment, the frame defining a front end and a rear end, the tunneling machine further comprising:

an actuator for moving the frame within the tunnel pipe segment,

50 an excavating mechanism located at the front end of the frame for excavating particulate material from the tunnel pipe segment,
a buffer tank located between the front end and the rear end of the frame,

55 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, and

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 tunnel pipe segment.

[0016] 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.

[0017] 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.

[0018] 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.

[0019] 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.

[0020] 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 bor-

ing head comprising disc cutters.

[0021] According to a further embodiment of the first aspect, the buffer tank comprises a sloping bottom. A sloping bottom will make it easier to empty the buffer tank in the limited space within the tunnel pipe segment.

[0022] According to a further embodiment of the first aspect, the tunnel excavating machine further comprises 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. 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.

[0023] According to a further embodiment of the first aspect, the second conveyor is extending from the sloping bottom of the buffer tank to the top of the soil transporter. In this way the buffer tank may be completely emptied without moving or tilting the buffer tank.

[0024] According to a further embodiment of the first aspect, the second conveyor comprises a primary conveyor extending within the buffer tank and a secondary conveyor extending outside the buffer tank. In this way, the conveyor part inside the buffer tank may operate independently of the conveyor part outside the buffer tank.

[0025] 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.

[0026] According to a further embodiment of the first aspect, the secondary conveyor is enclosed between the buffer tank and the soil transporter for preventing spillage.

[0027] 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.

[0028] 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.

[0029] 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.

[0030] 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.

[0031] 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.

[0032] 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.

[0033] 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.

[0034] According to a further embodiment of the first aspect, the buffer tank has a storage volume of between 1 m² and 100m². Such volumes are suitable for ensuring a continuous operation of the tunneling machine.

[0035] 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 method of excavating a tunnel by using a tunneling machine comprising an elongated frame for being inserted into a tunnel pipe segment, 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,
a first conveyor located between the excavating mechanism and the buffer tank, and
a soil transporter,

the method comprising the steps of:

moving the frame within the tunnel pipe segment 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 tunnel pipe segment.

[0036] 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

[0037]

FIG. 1 is a perspective view of a tunneling machine according to a first embodiment of the present invention.

FIG. 2 is a side view of a tunneling machine according to a second embodiment of the present invention. FIG. 3A is a close-up side view of the tunneling machine according to the second embodiment of the present invention.

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

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

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

FIG. 6 is a side view of a tunneling machine according to a fifth embodiment 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 fifth embodiment of the present invention.

FIG. 7B is a second view of a series of views describing the working principle of the tunneling machine according to the fifth embodiment of the present invention.

FIG. 7C is a third view of a series of views describing the working principle of the tunneling machine according to the fifth embodiment of the present invention.

Detailed description of the drawings

[0038] FIG. 1 shows a perspective view of a tunneling machine 10 according to a first embodiment of the present invention. 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.

[0039] 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.

[0040] 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.

[0041] FIG. 2 shows a side view of a tunneling machine 10' according to a second embodiment of the present invention. 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.

[0042] 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.

[0043] FIG. 3A shows a close-up side view of the tunneling machine 10' according to the second embodiment of the present invention. 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.

[0044] 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.

[0045] FIG. 3B shows a close-up side view of the tunneling machine 10 according to a first embodiment of the present invention. The tunneling machine 10 is provided with a rotating drilling head 14" instead of the excavator for being able to penetrate harder soil materials.

[0046] 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.

[0047] FIG. 4 shows a perspective view of a rear part of a tunneling machine 10^{'''} according to a fourth embodiment of 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.

[0048] FIG. 5 shows a side view of the tunneling machine 10^{'''} according to the fourth 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.

[0049] FIG. 6 shows a side view of a tunneling machine 10^{'''} according to a fifth embodiment of the present invention. 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.

[0050] FIG. 7A shows a first view of a series of views describing the working principle of the tunneling machine 10^{'''} according to the fifth embodiment of the present invention. 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.

[0051] FIG. 7B shows a second view of a series of views describing the working principle of the tunneling

machine 10^{'''} according to the fifth embodiment of the present invention. 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.

[0052] FIG. 7C shows a third view of a series of views describing the working principle of the tunneling machine 10^{'''} according to the fifth embodiment of the present invention.

[0053] 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.

[0054] The present fifth embodiment 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

[0055]

- | | | |
|----|------|------------------------------|
| 25 | 10. | Tunneling machine |
| | 12. | Tunnel pipe segment |
| | 14. | Excavating mechanism |
| | 16. | Particulate material |
| | 18. | Buffer tank |
| 30 | 20. | First conveyor |
| | 22. | Soil transporter |
| | 24. | Second conveyor |
| | 24a. | Primary conveyor |
| | 24b. | Secondary conveyor |
| 35 | 26. | Actuator |
| | 28. | Concrete tunnel pipe segment |
| | 30. | Hydraulic station |
| | 32. | Cable |
| | 34. | Spindle |
| 40 | 36. | Frame |
| | 38. | Storage compartment |
| | 40. | Carrier |
| | 42. | Hydraulic actuator |
| | 44. | Beam |
| 45 | 46. | Plates |
| | 48. | Pivot |
| | 50. | Opening |
| | A. | Tunnel front |
| | B. | Tunnel side wall |
| 50 | C. | Rear wall |

Claims

- 55 1. A tunneling machine comprising an elongated frame for being inserted into a tunnel pipe segment, said frame defining a front end and a rear end, said tunneling machine further comprising:

- an actuator for moving said frame within said tunnel pipe segment,
 an excavating mechanism located at said front end of said frame for excavating particulate material from said tunnel pipe segment,
 a buffer tank located between said front end and said rear end of said frame,
 a first conveyor for receiving said particulate material from said excavating mechanism at said front end of said frame and transporting said particulate material to said buffer tank, and
 a soil transporter for receiving said particulate material from said buffer tank at said rear end of said frame and transporting said particulate material from said rear end of said frame to the outside of said tunnel pipe segment.
2. The tunneling machine according to claim 1, wherein said excavating mechanism constitutes an excavator or a drilling head.
 3. The tunneling machine according to any of the preceding claims, wherein said buffer tank comprises a sloping bottom.
 4. The tunneling machine according to any of the preceding claims, wherein said tunnel excavating machine further comprising a second conveyor for transporting said particulate material from said buffer tank to said soil transporter, said second conveyor running only when said soil transporter is at said rear end of said frame.
 5. The tunneling machine according to claim 3 and 4, wherein said second conveyor is extending from said sloping bottom of said buffer tank to the top of said soil transporter.
 6. The tunneling machine according to claim 5, wherein said second conveyor comprises a primary conveyor extending within said buffer tank and a secondary conveyor extending outside said buffer tank.
 7. The tunneling machine according to claim 6, wherein said primary conveyor constitutes a carrier comprising a linear actuator, a beam connected to said linear actuator and extending within said buffer tank above said sloping bottom, and a plurality of pivotable plates extending from said beam towards said sloping bottom.
 8. The tunneling machine according to any of the claim 6-7, wherein said secondary conveyor is enclosed between said buffer tank and said soil transporter for preventing spillage.
 9. The tunneling machine according to any of the claims 5-8, wherein said second conveyor is a screw conveyor.
 10. The tunneling machine according to any of the claims 5-9, wherein said second conveyor is operating with a higher velocity than said first conveyor.
 11. The tunneling machine according to any of the preceding claims, wherein said soil transporter is driven by a cable.
 12. The tunneling machine according to any of the preceding claims, wherein said soil transporter has a storage compartment corresponding to the storage volume of said buffer tank.
 13. The tunneling machine according to any of the preceding claims, wherein said tunneling machine further comprises a mechanism for introducing concrete tunnel segments into said tunnel pipe segment.
 14. The tunneling machine according to any of the preceding claims, wherein said soil transporter is adapted to move a specific volume of particulate material from the rear end of said frame to the outside of said tunnel pipe segment, unload said particulate material and move from the outside of said tunnel pipe segment to the rear end of said frame at approximately the same time as it takes to fill said buffer tank with said specific volume of particulate material, and/or, wherein said actuator is a hydraulic actuator having a counter hold inside said tunnel pipe segment and/or outside said tunnel pipe segment, and/or, wherein said buffer tank has a storage volume of between 1m² and 100m².
 15. A method of excavating a tunnel by using a tunneling machine comprising an elongated frame for being inserted into a tunnel pipe segment, said frame defining a front end and a rear end, said tunneling machine further comprising:

an actuator,
 an excavating mechanism located at said front end of said frame,
 a buffer tank located between said front end and said rear end of said frame,
 a first conveyor located between said excavating mechanism and said buffer tank, and
 a soil transporter,

said method comprising the steps of:

moving said frame within said tunnel pipe segment by using said actuator,
 excavating particulate material from said tunnel wall by using said excavating mechanism,
 transporting said particulate material from said excavating mechanism to said buffer tank by us-

ing said first conveyor,
receiving said particulate material from said
buffer tank into said soil transporter at said rear
end of said frame, and
transporting said particulate material from said 5
rear end of said frame to the outside of said tun-
nel pipe segment.

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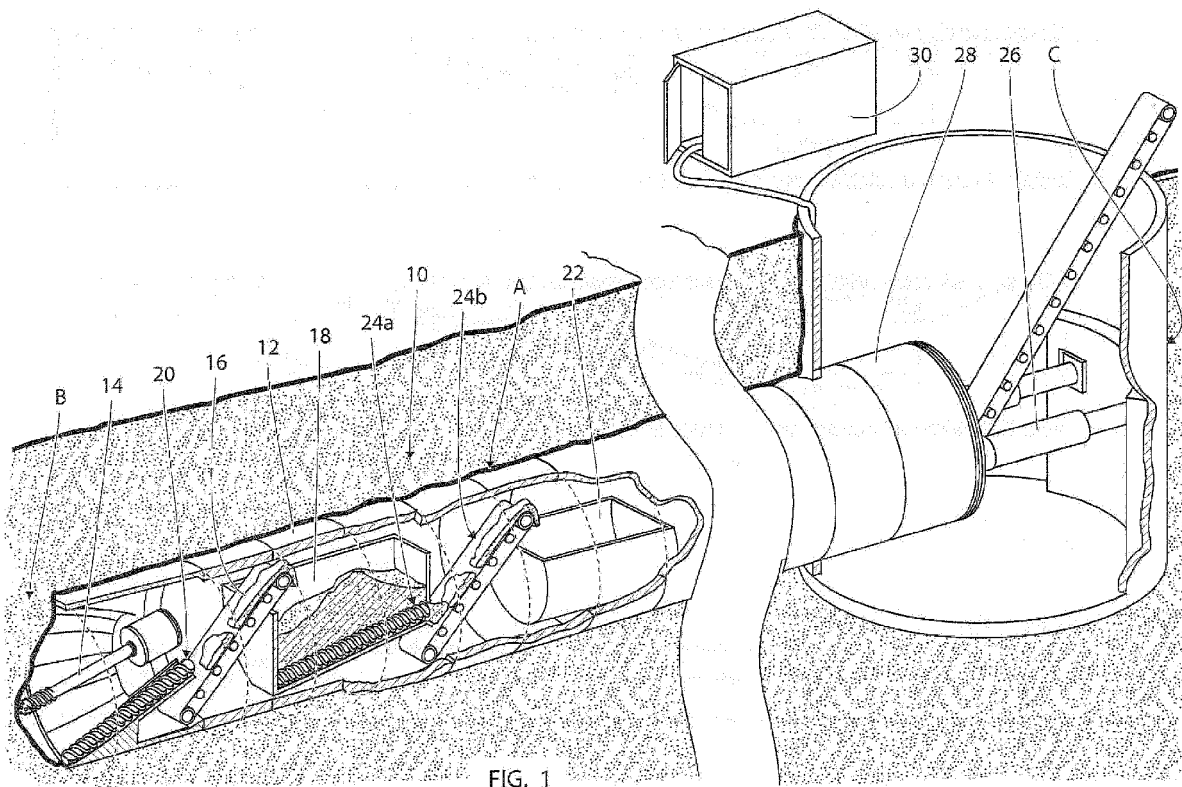
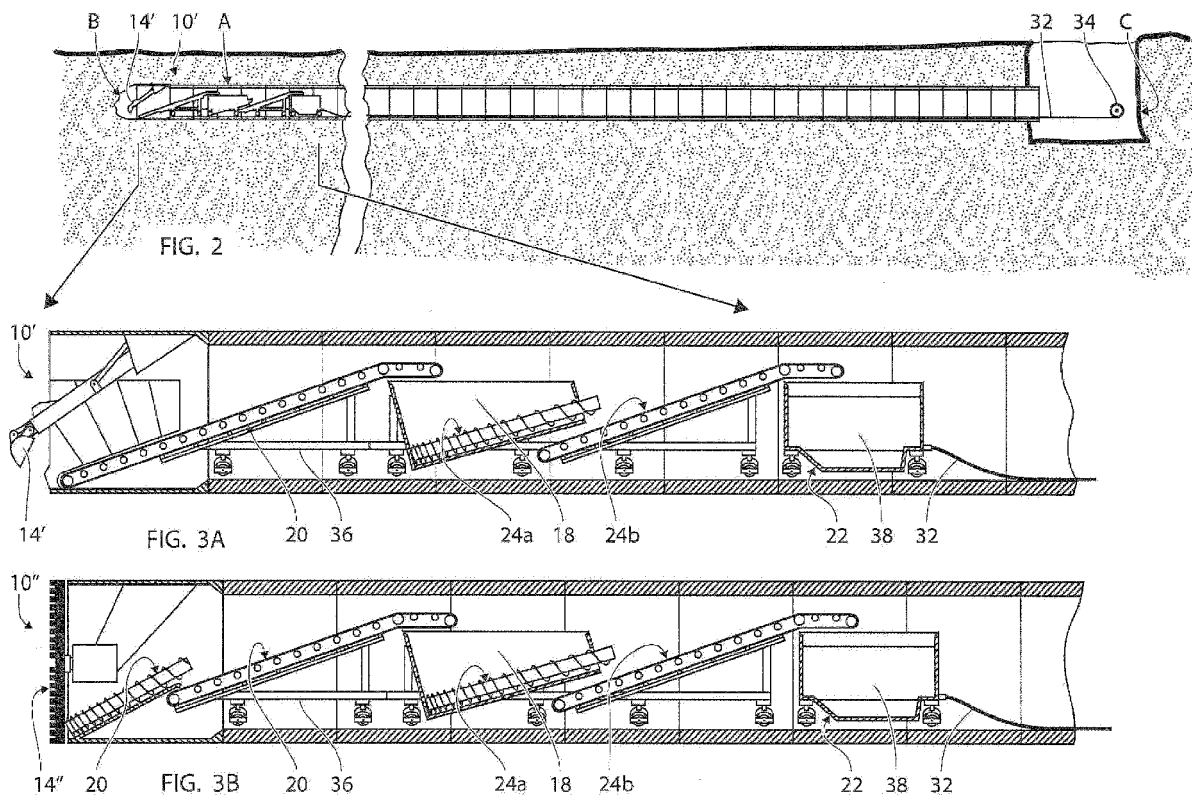


FIG. 1



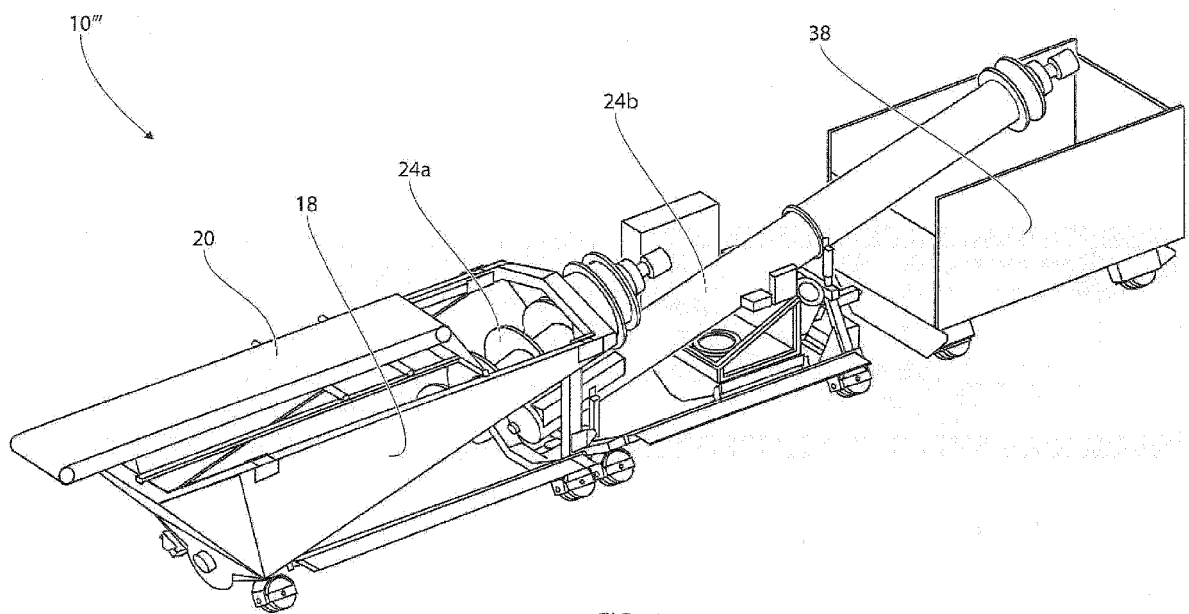


FIG. 4

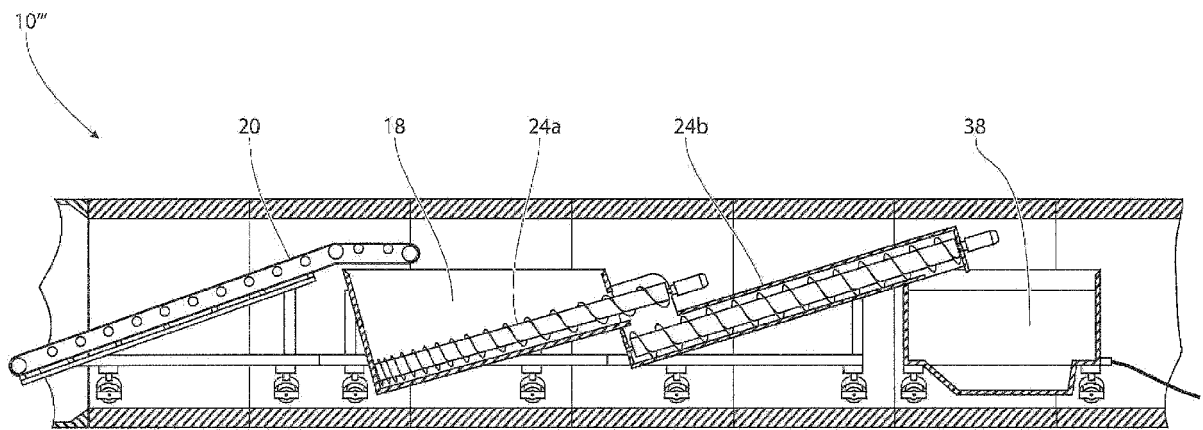


FIG. 5

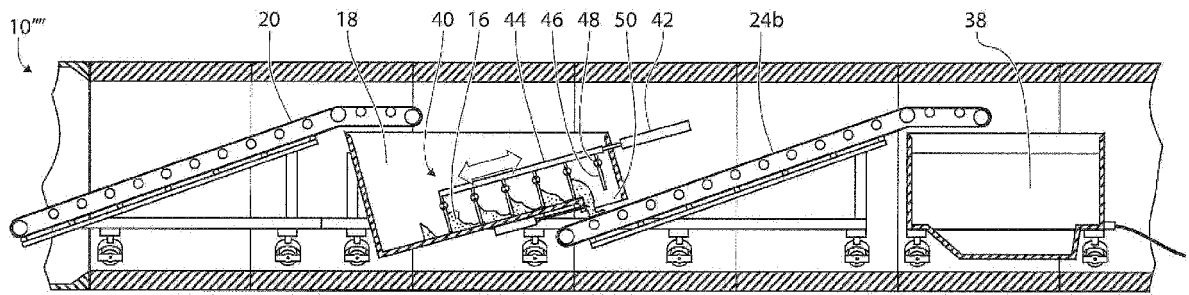


FIG. 6

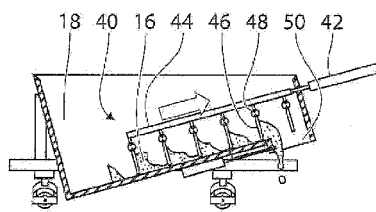


FIG. 7A

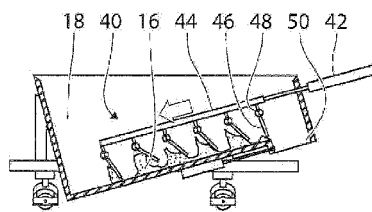


FIG. 7B

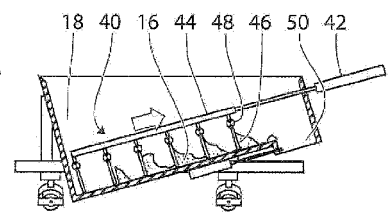


FIG. 7C

REFERENCES CITED IN THE DESCRIPTION

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