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(54) **Vacuum system**

(57) A tunnelling system, comprises a vacuum source (28), an accumulator vessel (30), and a tunnelling device (12). The accumulator vessel (30) has an inlet (34) connected to the tunnelling device (12) and an outlet (36) connected to the vacuum source (28).

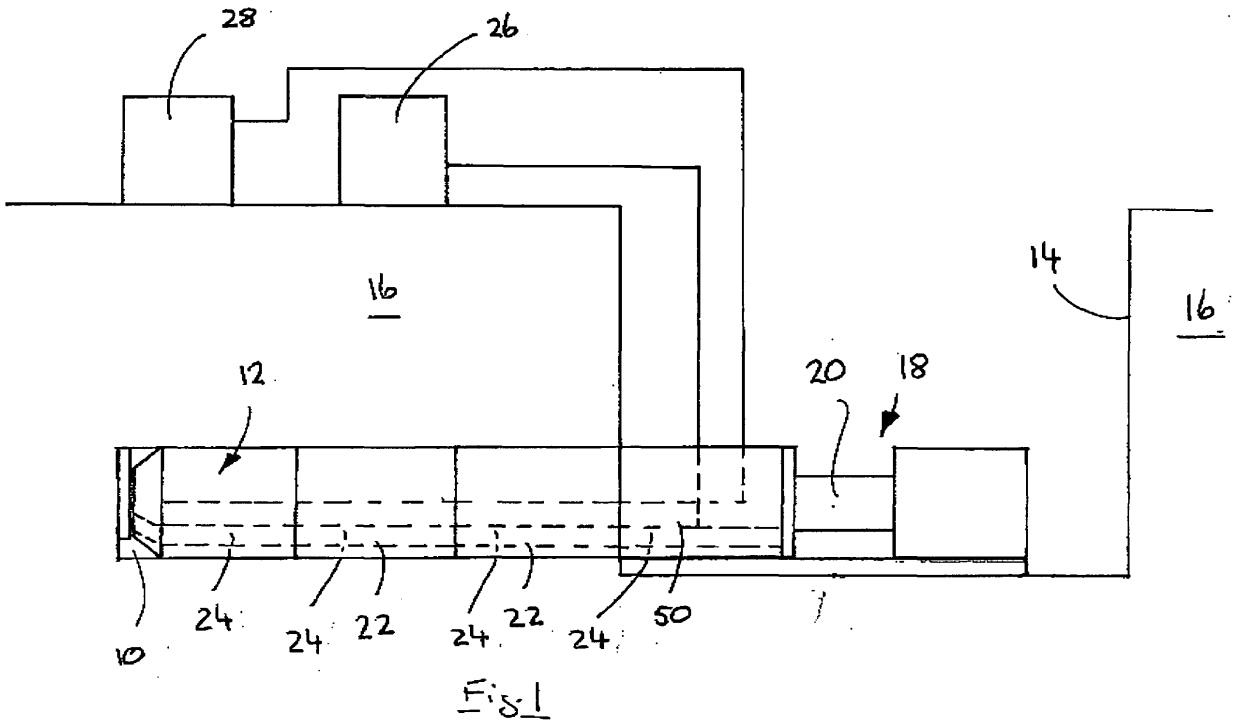

Fig 1

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Description

[0001] The present invention relates to a vacuum system for use in conjunction with a tunnelling device and particularly, though not exclusively, to a tunnelling device which is advanced through the ground by the application of pressure from a jacking means.

[0002] It is known to excavate a tunnel using a cutter apparatus or head which is advanced through the ground by pressure applied to the rear of the head by a hydraulic jack or ram. The pressure may be applied directly to the head or via on or more spacers positioned between the head and the ram. The cutter head typically comprises a hollow cylindrical body which is provided at its forward end with a rotatable cutter blade. In use, the blade breads up the ground ahead of the of the cutter head. The broken up ground is typically removed by the recirculation of bentonite slurry through the cutter head. The slurry entrains the broken up ground and permits its removal from the tunnel. In order to circulate the slurry in the required manner, a relatively complex slurry supply system must be provided. For example, the cutter head, and any intermediate spacers, require internal supply and return pipe work, and the slurry supply means require adequate filtration means to remove material entrained within the slurry.

[0003] According to a first aspect of the present invention there is provided a tunnelling system, the system including a vacuum source, an accumulator vessel and a tunnelling device, the accumulator vessel having an inlet connected to the tunnelling device and an outlet connected to the vacuum source, wherein the tunnelling device includes a hollow body having a longitudinal axis and a cutter blade mounted to a forward end of the body and rotatable about said axis, the body being provided with an end face wall at the forward end of the body having at least one aperture therein, the body further being provided with an internal chamber behind the end face wall having an outlet connected to the vacuum source and accumulator vessel.

[0004] In use, the vacuum source is operable to draw air from the tunnelling device and through the accumulator vessel. Material dislodged by the tunnelling device is entrained in the airflow and drawn into the accumulator vessel. The material is separated from the airflow and retained in the vessel.

[0005] In a preferred embodiment the vessel inlet is positioned in an upper portion of the vessel. Preferably, the vessel outlet is also positioned in an upper portion of the vessel. The inlet and outlet may advantageously be provided in the roof or top of the vessel. In such an embodiment separation of the material form the airflow may be effected by gravity.

[0006] The vessel is preferably provided with a means for removing material deposited therein by the vacuum source. Said means may comprise an extraction mechanism operable to convey material deposited in the vessel to the exterior of the vessel. Advantageously, the extraction mechanism is positioned in a lower region of the vessel. The extraction mechanism may include a movable conveyor element. The conveyor element may comprise a screw or auger. The vessel may be shaped so as to direct material deposited therein towards the extraction mechanism. For example, the walls of the vessel in the vicinity of the extraction mechanism may be inclined, tapered or otherwise angled in the direction of the extraction mechanism.

[0007] The vacuum source preferably includes a vacuum pump. The vacuum source may be incorporated into or attached to the vessel. In an alternative embodiment the vacuum source may be separate to the vessel and connected hereto by the provision of appropriate piping or tubing.

[0008] According to a second aspect of the present invention there is provided a tunnelling device including a hollow body having a longitudinal axis and a cutter blade mounted to a forward end of the body and rotatable about said axis, the body being provided with an end face wall at the forward end of the body having at least one aperture therein, the body further being provided with an internal chamber behind the end face wall having an outlet connectable, in use to a vacuum source.

[0009] In a preferred embodiment the chamber is defined between the end face wall and an internal partition wall of the body. The partition wall may be provided with an aperture to permit air to enter the chamber from the rear of the device. The cutter blade is advantageously carried on a shaft which extends through the chamber. The shaft may be provided with a blade or paddle operable to agitate material present within the chamber. The device may be provided with a liquid conduit operable to convey liquid through the hollow body to the cutter blade. The conduit may be connected to a port or aperture provided in front end face of the body.

[0010] An embodiment of the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 shows a representation of a tunnelling system incorporating a vacuum system according to the present invention;

Figure 2 shows a representation of a vacuum system according to the present invention; and

Figure 3 shows a cross-sectional view of a cutter apparatus according to an aspect of the present invention.

[0011] Figure 1 illustrates the formation of a. tunnel 10 utilising a cutter apparatus 12 of the type described. The tunnel 10 extends from a shaft 14 which has been sunk into the ground 16 through which the tunnel is to extend. Within the shaft 14 there is provided a jacking unit 18 including an extensible ram 20. In figure 1 there are shown a number of spacer elements 22 positioned between the jacking unit 18 and the cutter apparatus 12. The spacers 22 each comprise a cylindrical body having

a diameter substantially equal to that of the after portion of the cutter apparatus 12. Each spacer 22 further includes an internal tube 24 which is of the same diameter as a tube 24 of the cutter apparatus 12. There is also provided a power source 26 for a cutter blade drive mechanism of the cutter apparatus 12 and a vacuum system 28 connected to the tubes 24 of the cutter apparatus 12 and spacers 22. The vacuum system 28 will be described in greater detail below

[0012] In order to commence a tunnelling operation, the ram 20 of the jacking unit 18 is retracted and the cutter apparatus 12 lowered into the shaft 14 and onto a launch bed of the jacking unit 18. The power and vacuum sources 26,28 are connected to the apparatus 12 and the ram 20 extended so as to advance the cutter apparatus 12 towards the wall of the shaft 14. Upon contact with the shaft wall the drive mechanism is operated so as to rotate the cutter blade of the apparatus 12, Operation of the vacuum source 28 is also commenced. Continued pressure form the ram 20 advances the apparatus 12 into the ground 16, while the rotation of the cutter blade causes the break up of material ahead of the apparatus 12. The broken up material is swept towards one or more apertures in the forward face of the apparatus 12. The material then passes into the internal tube 24 of the apparatus 12 whereupon it is removed by the vacuum source. It will be appreciated that the vacuum system 28 directs the material to a suitably configured container or the like remote from the shaft 14.

[0013] Once the apparatus 10 has been advanced to the full extent of the ram 20, the ram 20 is retracted and the power and vacuum connections to the apparatus 12 are disconnected. A spacer 22 is then placed on the launch bed and the power and vacuum connections re-established with the cutter apparatus 12 through the spacer 22. The ram 20 is then extended as before to advance the cutter apparatus 12 further into the ground 16. The cutter blade is rotated as before, and material is removed by the vacuum source 28. Additional spacers 22 are introduced in the manner described above to move the cutter apparatus 12 and excavate the tunnel.

[0014] Referring now to figure 2 there is shown a more detailed view of the vacuum system 28. The system 28 includes an accumulator vessel generally designated 30 and a vacuum pump 32. The vessel 30 comprises a substantially hollow body constructed from a material such as, for example steel. The vessel 30 is provided with an inlet 34 connectable via appropriate tubing or piping to the internal tube 24 of the cutter apparatus 12, and an outlet 36 connectable via appropriate tubing or piping to the vacuum pump 32. Both the inlet and outlet 34,36 are provided in an upper portion of the vessel 30. In a lower portion of the vessel 30 there is provided an auger 38 which is rotatable about its longitudinal axis 40 as indicated by arrow 42. The auger 38 is rotatable by a motor (not shown). Portions 44 of the walls of the vessel 30 above the auger 38 are inclined so as to, in use, direct material entering the vessel 30 to the auger 38. The vessel 30 is further provided with a vacuum relief valve 46 which is operable to permit air to enter the vessel 30 therethrough.

[0015] The vacuum pump 32 is provided with an inlet 48 which is connectable via appropriate tubing or piping to the accumulation vessel outlet 36, and an outlet 50 which is vented to atmosphere. The pump 32 is operable by a motor 52.

[0016] In use, the cutter apparatus 12 is connected to the accumulation vessel inlet 24 and the vacuum pump 32 to the accumulation vessel outlet 36. The cutter apparatus 12 is operated and advanced in the manner described above to excavate a tunnel, and the vacuum pump 32 operated to draw material cut by the cutter apparatus 12 through the internal tubes 24 of the cutter apparatus 12 and spacers 22. The nature of the material is dependent upon the composition of the ground through which the cutter apparatus is advanced. The material may, for example, comprise soil, clay, gravel, stones, water and the like. The material is entrained in the airflow generated by the vacuum pump 32 enters the accumulation vessel 30 through the inlet 34 as indicated by arrow 54. The material is able to fall towards the auger 38 as indicated by arrow 56, while the airflow which previously entrained the material passes to the vessel outlet 36 as indicated by arrow 58. The airflow minus the material passes through the vacuum pump 32 and is vented to atmosphere as indicated by arrow 60.

[0017] As use of the system 28 continues, it will be understood that the material accumulates in the vessel 30 on and around the auger 38. The auger 38 can be rotated to remove material from the vessel 30 via an appropriate port (not shown) in the lower region of the vessel 30.

[0018] Figure 3 shows a cross-sectional view of a cutter apparatus, generally designated 12, according to an aspect of the present invention. The apparatus 12 includes a substantially circular tubular body 62 having a substantially circular front end face wall 64. The apparatus 12 further includes a rotatable cutter 66 mounted ahead of the end face wall 64. The cutter 66 is mounted to a shaft 68 which extends through the end face wall 66 and is axially aligned with the longitudinal axis of the body 62. The shaft 68 is provided with a drive connection 69 to which an appropriate drive means can be connected to effect rotation of the cutter 66. Within the body 62 there is provided a chamber 70 which is defined between the end face wall 64 and an internal partition wall 72 of the body. The partition wall 72 includes an outlet aperture 74 to which is connected an extraction tube 24.

[0019] The front end face wall 64 is provided with a plurality of apertures 76 through which material loosened by the cutter 66 can pass as indicated by arrows 80. The partition wall 72 is provided with a plurality of apertures 78 through which air can pass as indicated by arrows 82.

[0020] In use, material dislodged by the cutter 66 passes through the apertures 76 and into the chamber 70. The material is removed from the chamber 70 through

the extraction tube 24 by the airflow induced by the vacuum pump as indicated by arrow 84. The presence of apertures 80 in the partition wall 72 permits air to enter the chamber 70 from behind the cutter 66 to replace the air removed from the chamber 70 by the pump.

[0021] The apparatus 12 may optionally be provided with a water feed line 86 to the front end face wall as indicated by broken lines. The feed line may be utilised to inject water onto and around the cutter 66 to assist in excavation work. The shaft 68 may optionally be provided with a stirrer or paddle 88 located within the chamber 70 to agitate material contained therein and hence reduce the possibility of blockages forming in the chamber 70 or further downstream.

Claims

1. A tunnelling system, the system including a vacuum source, an accumulator vessel and a tunnelling device, the accumulator vessel having an inlet connected to the tunnelling device and an outlet connected to the vacuum source, wherein the tunnelling device includes a hollow body having a longitudinal axis and a cutter blade mounted to a forward end of the body and rotatable about said axis, the body being provided with an end face wall at the forward end of the body having at least one aperture therein, the body further being provided with an internal chamber behind the end face wall having an outlet connected to the vacuum source and accumulator vessel.

2. A system as claimed in claim 1, wherein the vessel inlet is positioned in an upper portion of the vessel.

3. A system as claimed in claim 1 or claim 2, wherein the vessel outlet is positioned in an upper portion of the vessel.

4. A system as claimed in claim 2 and 3, wherein the inlet and outlet are provided in the roof or top of the vessel.

5. A system as claimed in any preceding claim, wherein the vessel is provided with a means for removing material deposited therein by the vacuum source.

6. A system as claimed in claim 5, wherein said means comprise an extraction mechanism operable to convey material deposited in the vessel to the exterior of the vessel.

7. A system as claimed in claim 6, wherein the extraction mechanism is positioned in a lower region of the vessel.

8. A system as claimed in claim 6 or claim 7, wherein the extraction mechanism includes a movable conveyor clement.

9. A system as claimed in claim 8, wherein the conveyor element comprises a screw or auger.

10. A system as claimed in any of claims 6 to 9, wherein the vessel is shaped so as to direct material deposited therein towards the extraction mechanism.

11. A system as claimed in, claim 10, wherein the walls of the vessel in the vicinity of the extraction mechanism are inclined, tapered or otherwise angled in the direction of the extraction mechanism.

12. A system as claimed in any preceding claim, wherein the vacuum source includes a vacuum pump.

13. A system as claimed in any preceding claim, wherein the vacuum source is incorporated into or attached to the vessel.

14. A system as claimed in any of claims 1 to 12, wherein the vacuum source is separate to the vessel and connected hereto by the provision of appropriate piping or tubing.

15. A system as claimed in any preceding claim, wherein the chamber of the tunnelling device is defined between the end face wall and an internal partition wall of the body.

16. A system as claimed in claim 15, wherein the partition wall is provided with an aperture to permit air to enter the chamber from the rear of the tunnelling device.

17. A system as claimed in any preceding claim, wherein the cutter blade of the tunnelling is carried on a shaft which extends through the chamber.

18. A system as claimed in claim 17, wherein the shaft is provided with a blade or paddle operable to agitate material present within the chamber.

19. A system as claimed in any preceding claim, wherein the tunnelling device is provided with a liquid conduit operable to convey liquid through the hollow body to the cutter blade.

20. A system as claimed in claim 19, wherein the conduit is connected to a port or aperture provided in front end face of the body.

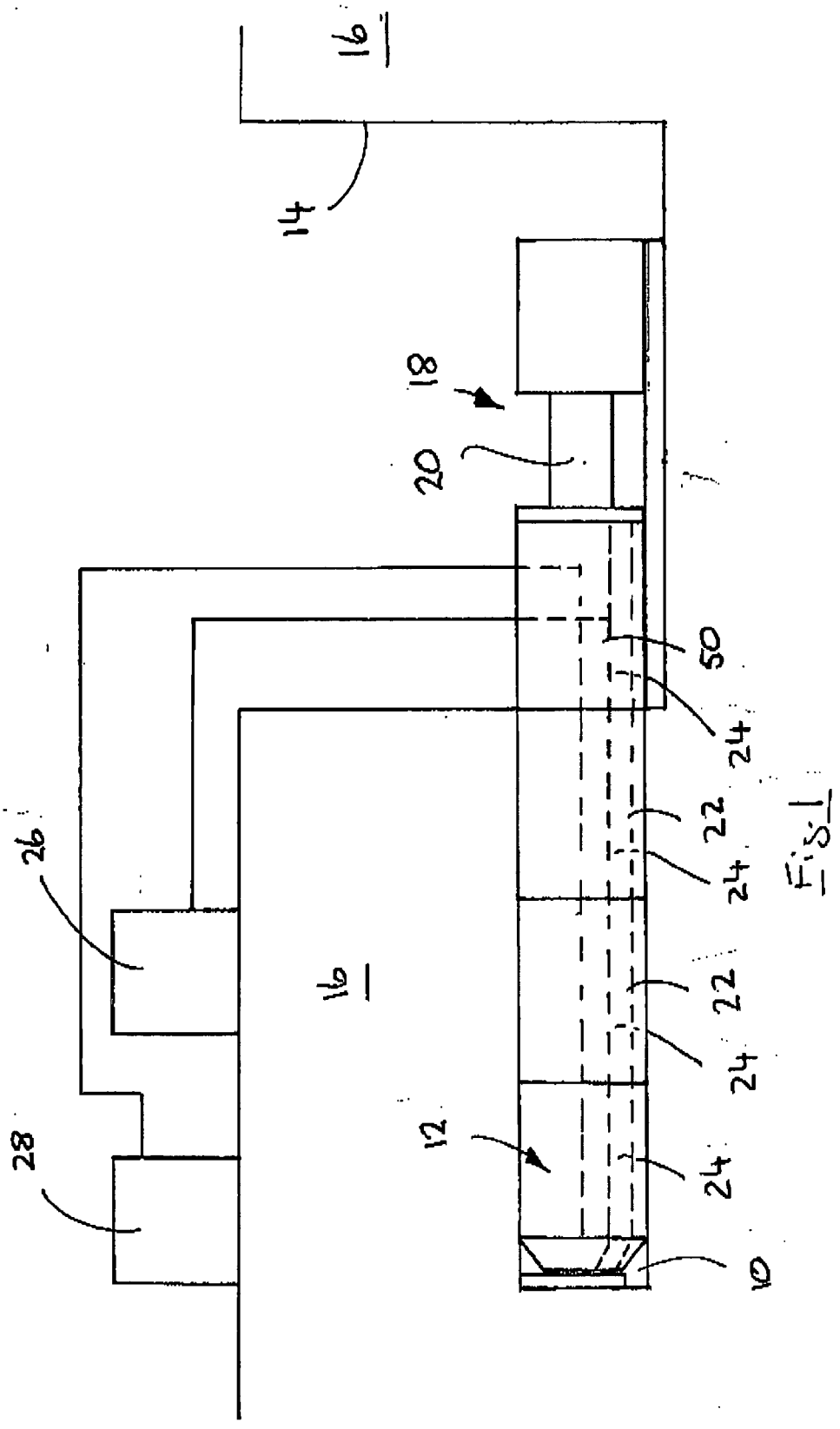

Fig. 1

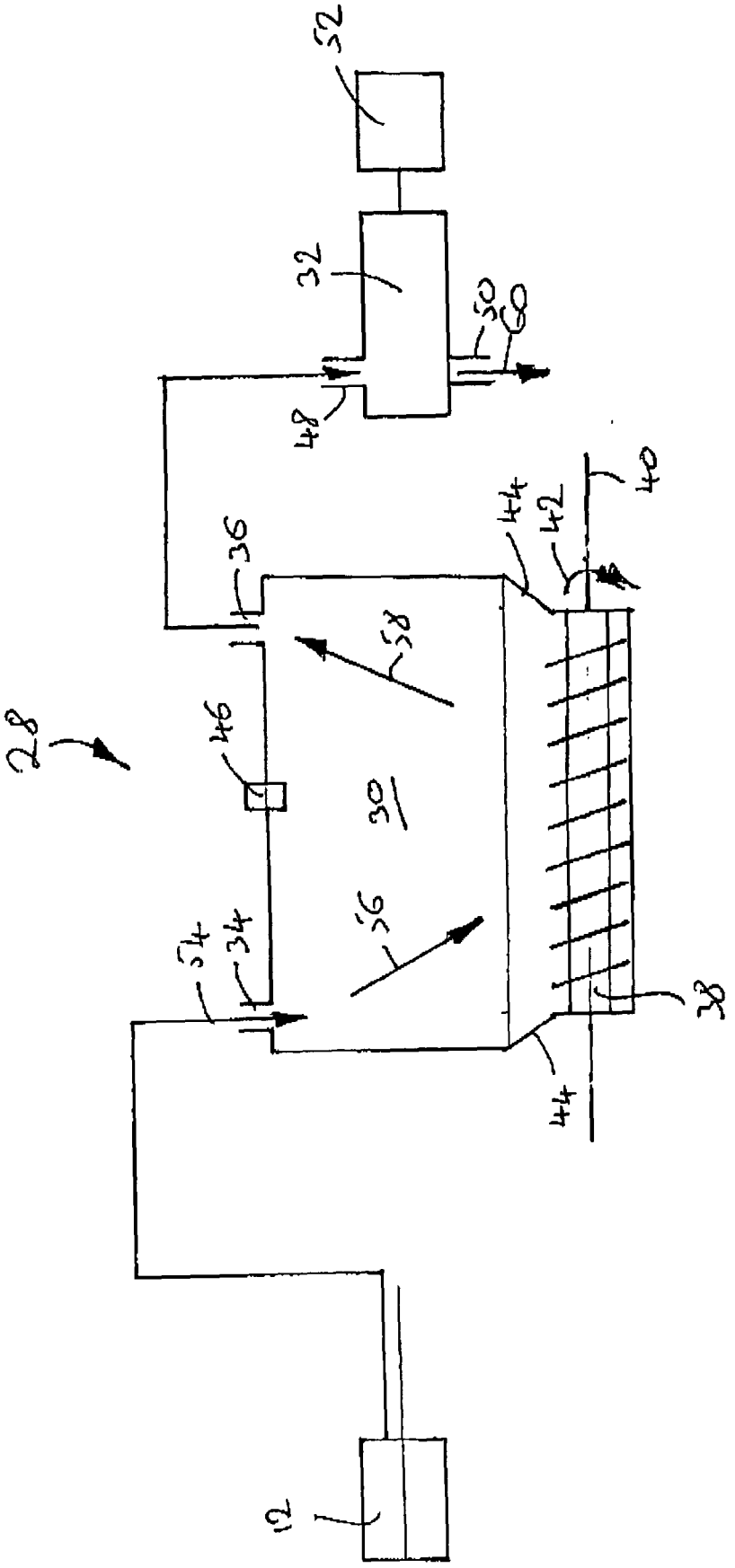

Fig. 2

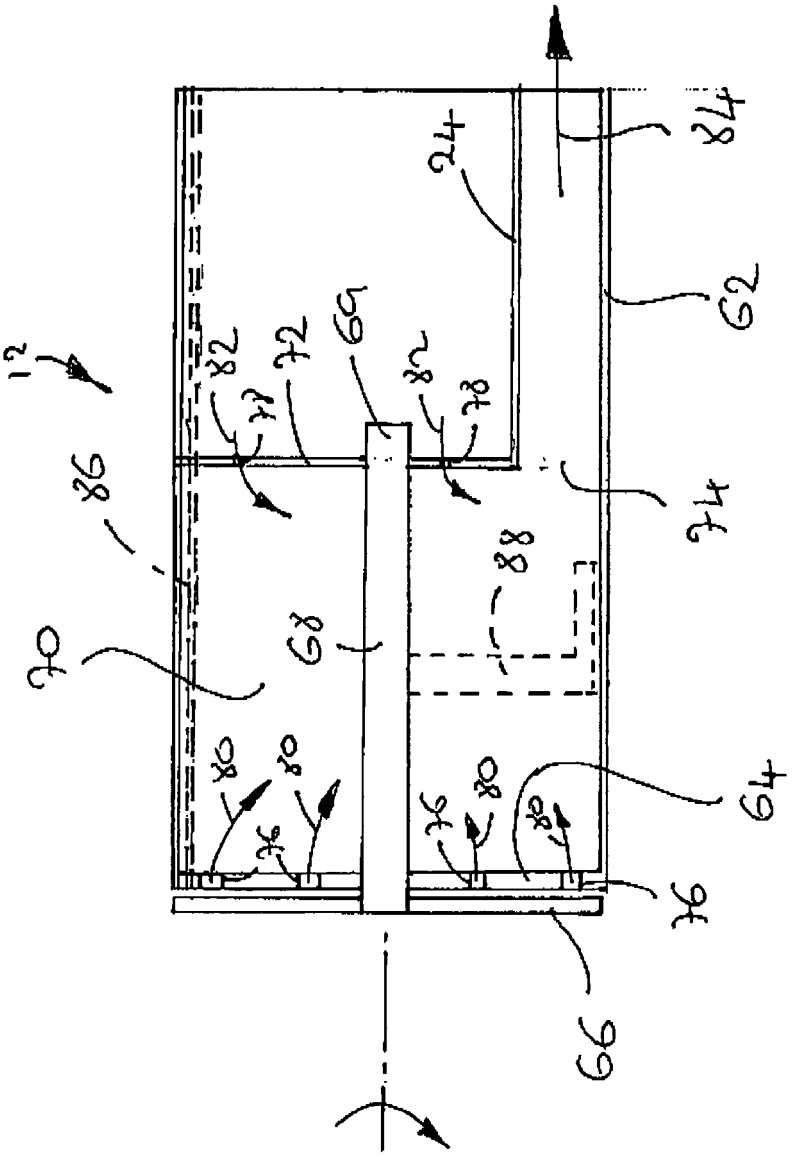

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 07 25 0114

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	20 April 2007	Morrish, Susan

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Munich	20 April 2007	Morrish, Susan

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