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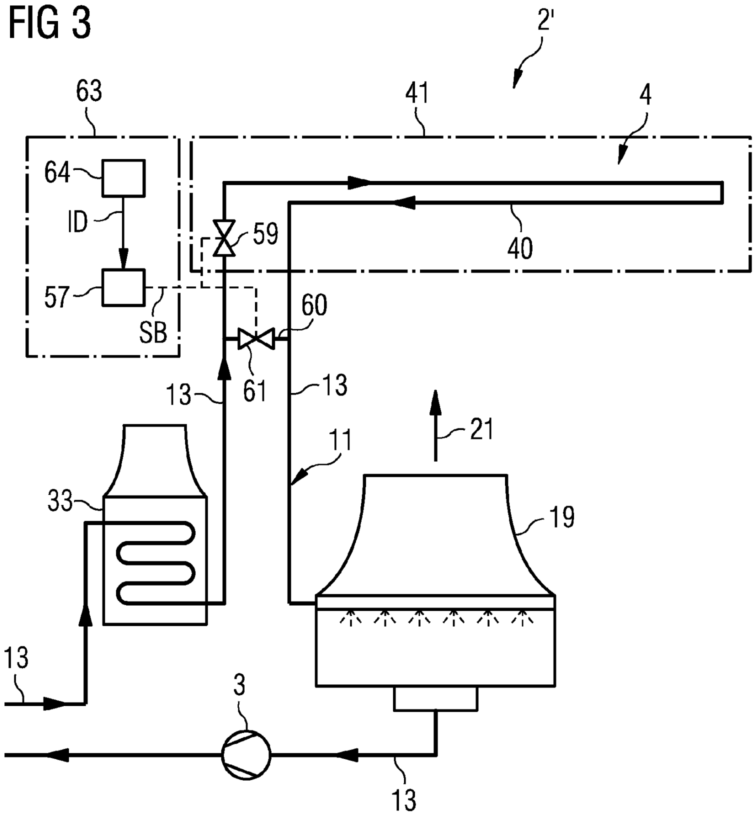
(54) Methods for cooling a carrier fluid of an electric power plant, electric power plants and cooling system

(57) The invention concerns a method for cooling a carrier fluid (5), which carrier fluid (5) is used to drive a turbine (29) in an electric power plant (2'). According to a first embodiment of the invention at least part of a cooling process is realized by leading the carrier fluid (5) and/or a cooling fluid (13, 46) for cooling the carrier fluid (5) underground a soil to a depth (41) in which the soil is substantially cooler than the ambient air. According to a second embodiment of the invention at least part of a cooling process is realized by supplying at least some of the carrier fluid (5), and/or at least some of a cooling fluid (13) used to cool the carrier fluid (5), from a cold storage (51) which stores fluid at a significantly lower temperature than the temperature of the carrier fluid (5) in the turbine (29). The invention also concerns electric power plants (2') and a cooling system (4) operating according to the embodiments of these methods.

FIG 3



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Description

[0001] The present invention concerns methods for cooling a carrier fluid, which carrier fluid is used to drive a turbine in an electric power plant. The invention also concerns electric power plants with a carrier circuit with a carrier fluid which carrier fluid in operation drives a turbine of the power plant. Furthermore, the invention concerns a cooling system for such power plants

[0002] In electric power plants a typical way of how to generate power out of heat is to bring a carrier fluid to a certain heat level and thus to provide it with a certain level of kinetic energy. The carrier fluid, such as water, evaporates and becomes vapour. The water, which is put under a considerable pressure of about 270 bar, is converted into vapour, which means additionally increasing the volume of the carrier fluid. Thus, the vapour has enough energy to drive a large turbine the movement of which will then move the generator. After driving the turbine this steam has to be cooled down, which is usually done in a condenser. Such condenser is often a heat exchanger with a cooling circuit along which a carrier circuit with the carrier fluid is led. Thus, the carrier circuit is a pipe system which is connected to the turbine, the cooling circuit is filled with cooling liquid which is brought into indirect contact with the carrier fluid and which is considerably cooler than the carrier fluid before condensation. Part of the heat of the carrier fluid, i.e. the steam, is thus transferred to the cooling liquid in the cooling circuit so that the steam becomes water again.

[0003] In today's power plants using such technology, in order to cool down the temperature within the cooling circuit, use is made of wet cooling towers or of dry cooling towers. In wet cooling towers part of the cooling liquid, again typically water, will be evaporated and released into the air. The other part of the cooling fluid may either be reused within the cooling circuit or released into a river from which even colder water is extracted in return in order to feed the cooling circuit again with fresh cooling water at river temperature.

[0004] Such a power plant according to the state of the art is depicted in Fig. 1. A power plant 2 some components of which are schematically shown in this figure has a carrier circuit 1 and a cooling circuit 11. In the carrier circuit 1 carrier fluid 5, in this case water 5, respectably water vapour is pumped through a pipe system. by means of a carrier circuit pump 3. In order to cool the water vapour 5 down to a considerably lower temperature in order to transform it into liquid water 5 again, a heat exchanger 9 is used. The condensated water is pumped off by a carrier circuit pump 3. The heat exchanger 9 is also connected to the cooling circuit 11 with cooling fluid 13, namely cooling water 13. The cooling water 13 is extracted from a river 27 and pumped by a cooling circuit pump 23 to the heat exchanger 9. Before reaching the heat exchanger 9 the cooling water 13 has about the temperature of the river 27. After leaving the heat exchanger 9 the cooling water 13 has extracted a lot of heat from the water vapour 5 in the carrier circuit 1. It is therefore considerably hotter than before and also needs to be cooled down in order to be led back into the river 27. For that purpose a wet cooling tower 19 is used. Here the hot cooling water 13 from the cooling circuit 11 is sprayed into the tower whilst air 17 is ventilated in the cooling tower 19. Steam clouds 21 result from this process while the rest 25 of the cooling water 13 is led back into the river 27 at a considerably lower temperature level than before entering the wet cooling tower 19.

[0005] According to that principle, the a considerable portion of cooling water 13 that was used to condense the water vapour 5 in the heat exchanger 9 will evaporate into the air in the wet cooling tower 19. This provides for a very high cooling efficiency as there result considerably lower temperatures of the remaining rest 25 of the cooling water 13. As the efficiency of the power plant 2 depends directly on the ability of this cooling system to cool down the carrier fluid 5, this kind of condenser system provides for a high power plant efficiency overall. However, wet cooling towers consume large quantities of water. Depending on the ambient conditions that consumption reaches values well above 500 kg/s of water for a 500 MW power plant.

[0006] Therefore, an alternative to wet cooling towers are a so-called dry cooling towers the principle of which will be described with reference to Fig. 2. A dry cooling tower 33 directly cools down a carrier fluid 5 within a carrier circuit 1. The carrier fluid 5 comes from a turbine 29 in a power plant 2. The turbine 29 drives a generator 31 which generates electric power from the rotation of the turbine 29. Within the dry cooling tower 33 the water 5 is led through a pipe system 37, which functions as a fin-tube heat exchanger. In order to cool the pipe system 37, a ventilator 35 provides for fresh air which is ventilated around the pipe system 37 so that a constant stream of air 17 is led around the pipe system 37. The carrier fluid 5 thus slowly cools down in the pipe system 37 and can be pumped back to a heating unit (not shown) by means of a carrier circuit pump 3. Such heating unit may comprise a heating chamber in which substances (oil, coal, waste and other burnable materials) are burnt or may comprise a nuclear reactor or a solar-thermal field.

[0007] Dry cooling towers 35 do not necessarily require water supply, however they are limited in their effectivity by the ambient temperature. High ambient temperature will result in a less efficient thermodynamic process as the condenser temperature in the dry cooling tower 35 and thus the respective pressure at the turbine 29 exit will increase.

[0008] It is also possible to combine both a wet cooling tower 19 and a dry cooling tower 35 within one power plant. However, there is still a certain dilemma for the operation of any power plants based on either or both cooling technologies. In some regions water is scarce and/or the air is very hot at peak times. Usually both these effects can be found at the same time. These arid places, such as deserts, however have the advantage that usually a lot of solar energy is readily available. Thus, it proves to be a major problem to provide for an effective cooling system while enough heating energy would theoretically be available at very low costs.

[0009] It is the object of the invention to optimise further the cooling processes for condensation power plants. In particular, it is the object of the invention to preferably reduce the consumption of water or indeed any other cooling fluid during such process.

[0010] This object is met by a method according to claim 1, by a method according to claim 7, by an electric power plant according to claim 13 and also according to claim 14.

[0011] According to a first embodiment of the invention, the method of the above-mentioned kind is enhanced by the fact that at least part of a cooling process is realized by leading the carrier fluid and/or a cooling fluid for cooling the carrier fluid underground a soil to a depth in which the soil is substantially cooler than the ambient air. In other words, use is made of an underground region where the carrier fluid and/or the cooling fluid is cooled. The thermal intertia of the underground soil are thus used. Even in deserts, the underground soil is relatively cold in comparison with daytime ambient temperature above ground which is mainly due to a strong cooling effect at night times.

[0012] Two principles may be used in the context of this embodiment: Direct cooling of the carrier fluid can be realized by routing the carrier circuit of this carrier fluid through the underground region. Indirect cooling means that a cooling fluid such as water or another fluid with a high heat capacity is routed through pipes in the underground. This cooling fluid then cools the carrier fluid in a heat exchanger.

[0013] The method according to the invention may be realized instead of using evaporation or ventilation techniques as described above or in addition to using any of such techniques. Thus, an underground region below the surface level of the soil in the area of the power plant is used as a cooling region in which the carrier fluid and/or the cooling fluid is cooled at least partially.

[0014] As for the definition of "underground", essentially any region below the surface of the soil can be considered to be underground. For the purpose of the invention it is necessary to cool the carrier fluid and/or the cooling fluid so that the underground region must be substantially cooler than the ambient air, i.e. the air above ground. That means that there is at least a temperature difference of 10°C, more preferably 20°C between the ambient air and the underground region in which the cooling takes place. It is further preferred to lead the carrier fluid and/or the cooling fluid in an underground region which is at least 0.5 m, more preferably at least 1 m below the surface level of the soil. In this region pipes for transporting the fluid are led along a certain length so that the temperature of the underground region will absorb effectively some of the higher temperature of the fluid. Such length of pipes is preferably at least 10m, more preferably at least 20m, but the pipes need not necessarily be led in only direction but may comprise turns and windings for example in the way of a typical heat exchanger. As for the carrier fluid as well as for the cooling fluid, they may comprise a liquid such as water and/or a gas such as air. They may comprise the same material but may also comprise different materials, for instance water as the carrier fluid and oil as the cooling fluid. The cooling circuit in which the cooling fluid is transported may also comprise several separate cooling sub-circuits so that for instance a first cooling fluid is cooled down by a second cooling fluid in a heat exchanger or the like.

[0015] According to a second embodiment of the invention such cooling effect may also be achieved by means of a method of the above-mentioned kind, whereby at least part of a cooling process is realized by supplying at least some of the carrier fluid, and/or at least some of a cooling fluid used to cool the carrier fluid, from a cold storage which stores fluid at a significantly lower temperature than the temperature of the carrier fluid in the turbine. Such cold storage may be situated underground as described above, but may also be above ground level and then preferably comprise a thermally isolated container. This container is preferably fed with a liquid or gas which has been cooled underneath the soil. However, it is also possible to have a cold storage which receives fluid at a low temperature level at night time and then stores the cold temperature during daytime. For instance, such cold storage may be realized as a large basin which is opened at night so that its content (i.e. the fluid) becomes cold and which is closed and thermally isolated during daytime in order to maintain the low temperature level for as long a time as possible. The cold storage can also be fed with fluid which has been cooled down by a cooling process above ground (e.g. by air to liquide heat exchange, which means using dry cooling techniques) and/or underground (i.e. according to the first embodiment of the invention).

[0016] Both principal embodiments of the method according to the invention have one uniting principle: low temperature is stored or provided in a certain place. In the first embodiment, the low temperature is stored in the underground region due to the low underground temperatures which are available anyway. In the second embodiment the invention makes use of a specially designated container in which the low temperature is artificially preserved. In both embodiments of the invention no evaporation techniques are necessary and the loss of water due to cooling and condensation is considerably reduced. A ventilation technique is also not essential, although such technology can be used in addition to the cooling technology according to the invention.

[0017] Accordingly, depending on the use of either of the embodiments described above, an electric power plant of the above-mentioned kind can be realised in two different ways, which may be combined or used separately.

[0018] In accordance with the first embodiment of the method according to the invention, an electric power plant of the above-mentioned kind can be enhanced by the fact that at least part of the carrier circuit and/or part of at least one cooling circuit with a cooling fluid used to cool the carrier fluid is led underground to a depth that is substantially cooler than the ambient air.

[0019] For that purpose the power plant preferably comprises underground pipes and/or tanks. The underground region serves as a "heat sink" or as a kind of low temperature reservoir. Such pipes or tanks are preferably made of a material with a high heat transfer coefficient so that transfer of heat from the fluid into the underground region outside the pipe or tank is as effective as possible. Therefore, the heat transfer coefficient of such pipe or tank is preferably above 15 W/mK, most preferably above 100 W/mK, i.e. at least in the range of the transfer coefficient of metals such as stainless steel or above. It is thus most preferred to use thermally unisolated pipes or tanks. The heat transfer can further be even enhanced by heat transfer enhancement means such as fin tubes.

[0020] Secondly, i.e. additionally or alternatively an electric power plant of the above-mentioned kind can be enhanced by the fact that at least part of the carrier fluid and/or at least part of a cooling fluid used to cool the carrier fluid is stored in a cold storage at a significantly lower temperature than the temperature of the carrier fluid in the turbine.

[0021] Such cold storage may be realised as a container or tank above ground or below ground level. It may be incorporated into buildings of the power plant in order to reduce the need for thermal isolation but may also be situated outside such buildings in order to be further away from the heating process. Such container is preferably thermally isolated so that little heat will be transferred into the inside of the container which in return means that the low temperature inside the cold storage is maintained as long as possible. Especially it is preferred that the cold storage will keep the temperature of its contents at a certain level which does not exceed 20°C above its lowest level during the course of one day. This is the preferred value for the cold storage in a state in which it is filled with the designated fluid during a day on which no fluids are inserted or taken out of the cold storage.

[0022] As outlined above, both embodiments of the power plant according to the invention also follow the common principle which has been described with reference to the two embodiments of methods according to the invention. In a combination of these embodiments, the cold storage is supplied underground under the surface of the soil and thus need not necessarily be equipped with isolating means because the isolation is actually realised by the surrounding soil instead of additional isolating material.

[0023] Lastly, the invention also concerns a cooling system for an electric power plant in which at least part of a carrier circuit with a carrier fluid and/or part of at least one cooling circuit with a cooling fluid used to cool the carrier fluid is led underground to a depth that is substantially cooler than the ambient air and/or in which cooling system at least part of the carrier fluid and/or at least part of the cooling fluid is stored in a cold storage at a significantly lower temperature than the temperature of the carrier fluid in the turbine.

[0024] With such a cooling system according to the invention, power plants can be re-equipped so as to become a power plant according to the invention of either of the embodiments described above.

[0025] Particularly advantageous embodiments and features of the invention are given by the dependent claims, as revealed in the following description. Thereby, features revealed in the context of one of the methods may also be realized in the context of the respective other method and/or in the context of any one of the embodiments of the electric power plant according to the invention unless the contrary is explicitly stated.

[0026] It is particularly preferred that the cooling is carried out in an electric power plant in a hot environment. Such a hot environment is particularly given in desert surroundings or in similarly arid environments. They can be characterised by the fact that during at least 100 days of the year a top temperature of 40°C is reached. In such circumstances water is particularly scarce. This implies that the water consumption of power plants directly competes with water needs for food production and urban life so that it is likely that local life and food production will have the highest priority over power generation. Therefore, power plants in such regions can only be successfully operated if they have a very low water consumption foot print, i.e. as little water losses in operation as possible. Using the methods according to the invention is particularly helpful in order not to waste valuable water for power generation. Such water can now be saved for other purposes such as agriculture and home use.

[0027] At the same time solar impact in such regions is at a particularly high level. Therefore, such arid environments offer the possibility to operate solar power plants, however, up to now there was the dilemma concerning efficient cooling as described in the introductory paragraphs. It is therefore preferred that the cooling is performed for a carrier fluid in a solar power plant, in particular in a concentrated solar power plant. Firstly such solar power plants are often situated in arid zones as described above. Secondly, such power plants, in particular concentrated solar power plants, produce carrier fluids with very high temperatures. Concentrated solar power plants are characterised by the fact that light rays from the sun are concentrated onto small spots so that they produce very high temperatures in these spots. The result is that the temperatures generated by concentrated solar power plants are particularly high and sufficient for power plant cycle. However the efficiency of the cycle is determined by the lower temperature of the cold end (condensation). This temperature defines the achievable lowest pressure at the turbine exit. The lower it is the higher the efficiency and therefore the extracted power output of the power plant. This can be enhanced by the methods according to the invention.

[0028] In order to further cool down any of the fluids additional cooling apart from the cooling realised by the method according to the invention may be necessary. A first possibility is that the cooling according to the invention is performed for a carrier fluid in a power plant comprising an air cooled condenser or dry cooling tower which carries out part of the cooling. As shown before, dry cooling towers with ventilators have the advantage that, again, essentially no cooling fluid is lost into the air. The combination of the cooling method according to the invention with a cooling method using air cooled condenser makes possible a closed cooling circuit or a closed carrier circuit in which no fluid is lost to the ambient environment.

[0029] A second possibility which also includes additional cooling is that the cooling according to the invention is performed in a power plant comprising a wet cooling system which carries out part of the cooling. The first and the second possibility may be combined so that in fact three cooling systems together provide for the overall cooling effect of the carrier fluid and/or the cooling fluid. However, the cooling method according to the invention may also be combined with a wet cooling system only. This means that a wet cooling tower takes over some of the cooling while the rest of the cooling is performed by the cooling system according to the invention. As outlined above, wet cooling provides for the most effective cooling overall so that a particularly effective system is realized whereby the methods according to the invention help to reduce fluid consumption. Whether the wet cooling tower is situated upstream or downstream the cooling system according to the invention can be chosen according to both technical preferences and according to the availability of space as well as in dependence of other preassumptions. In some special cases, however, tt is preferred to place to wet cooling tower downstream the cooling system according to the invention. This is particularly the case when the water losses of the wet cooling tower are to be reduced by the cooling system, which can be enhanced by such arrangement of the two cooling systems.

[0030] To sum up, combining such different cooling systems with the method according to the invention provides for a system with increased efficiency. It also makes possible the temporary use of either cooling methods at different times. For instance, a main cooling circuit may comprise an dry cooling tower system while only in peak times there is operated a cooling system according to the invention.

[0031] Whereas it is possible to simply lead the carrier fluid and/or the cooling fluid through a pipe system underground, it is preferred that the carrier fluid and/or the cooling fluid is cooled in a heat exchanger connected to a cooling circuit. Such cooling circuit contains a cooling fluid. The carrier fluid may be cooled directly in the heat exchanger or cooling fluid is cooled in the heat exchanger by a second cooling fluid circulating in the cooling circuit. The latter means that two cooling circuits altogether are used, both containing cooling fluid, whereby the cooling fluids in the different cooling circuits may be different in kind but need not necessarily be.

[0032] As for the method according to the second embodiment of the invention (i.e. employing a cold storage), the cold storage is preferably situated underground at a depth that is substantially cooler than the ambient air. This in fact means that both embodiments of methods according to the invention are combined so that the cooling takes place underground in an underground cold storage. This is particularly advantageous for example because no isolation means for firmly isolating the cold storage are needed as would usually be the case if the cold storage was above ground.

[0033] It is particularly preferred that such cold storage is replenished with fluid at night time which fluid is then supplied during daytime. That means that the carrier fluid and/or the cooling fluid are a cooled down at night time and collected in the cold storage so that they can be supplied during daytime, in particular during those times of the day when the weather is particularly hot.

[0034] Additionally, some of the carrier fluid and/or some of the cooling fluid can be stored in a plurality of cold storages. For instance, there may be one main cold storage for what may be labelled "normal operation" and a second additional cold storage for operation times under severe conditions such as very hot weather or a times of peak power consumption. However, different cold storages may also be used at different time, e.g. on different days, so that the time to recover the low temperature in each of the cold storages is longer. Also, all cold storages may be used in parallel at any given time in order to provide for a combined cooling effect.

[0035] The cooling methods according to the invention are particularly useful for those times in which cooling of the carrier fluid is particularly necessary. Therefore, they are most preferably applied under extreme heat conditions and/or during times of peak power consumption.

[0036] For such extreme conditions it is further preferred that use of the cooling method is initiated by a driving unit according to variable input data pertaining to temperature information and/or power consumption information. Such a driving unit receives information about ambient temperature and/or information about the current power consumption within the power supply network and therefrom derives orders to activate or de-activate those parts of the power plant which will operate the cooling system according to the invention. For instance valves into and/or out of the cooling system according to the invention can be opened and closed depending on such orders of the driving unit. This means that the cooling system can be opened and closed off according to current need.

[0037] Other objects and features of the present invention will become apparent from the following detailed descriptions considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for the purposes of illustration and not as a definition of the limits of the invention.

[0038] In the drawings, like reference numbers refer to like objects throughout. Objects in the diagrams are not necessarily drawn to scale.

Fig. 1 shows a schematic view of a power plant with a first cooling system according to the state of the art,

Fig. 2 shows a schematic view of a power plant with a second cooling system according to the state of the art,

Fig. 3 shows a schematic view of a power plant with a cooling system according to a first embodiment of the invention,

Fig. 4 shows a schematic view of a power plant with a cooling system according to a second embodiment of the invention,

Fig. 5 shows a schematic view of a power plant with a cooling system according to a third embodiment of the invention,

Figure 6 shows a detailed view of a part of the cooling system of Fig. 5.

[0039] Figs. 1 and 2 have been described above in the context of the description of the state of the art

[0040] Figure 3 shows a power plant 2' according to a first embodiment of the invention. In this and the following figures, the other components of the power plant 2' such as the heating chamber, the turbine, the generator and the power system are not shown for reasons of clarity.

[0041] In a cooling circuit 11 cooling fluid 13, here cooling water 13, is pumped through a pipe system by a cooling circuit pump 3. First it passes a dry cooling tower 33 of the kind which has been described in the context of Fig. 2. Then the cooling water 13 is led further below the ground into the soil into an underground depth 41. Part of the cooling circuit 11 is thus an underground pipe 40, in which the cooling water 13 can be cooled down by the low temperatures in the underground depth 41. The underground pipe 40 thus constitutes a cooling system 4. The cooling water 13 is further led into a wet cooling tower 19 of the kind described in Fig. 1. Water vapour leaves the wet cooling tower 19 in the form of steam clouds 21. The rest of the cooling water 13 is then collected and pumped to a heat exchanger (not shown) to cool a carrier fluid of the power plant 2'.

[0042] The underground pipe 40 and thus the cooling system 4 can be fed with cooling water 13 via a first valve 59, whereas a direct connection 60 circumventing the underground pipe 40 can be opened and closed by a second valve 61. If the cooling water 13 is to be cooled in the underground tube 41 the first valve 59 is opened whereas the second valve 61 is preferably closed. On the other hand, if the cooling by the dry cooling tower 33 and the wet cooling tower 19 is sufficient in itself to cool down the cooling water 13 to the desired low temperature, the second valve 61 can be opened while the first valve 59 can be closed in order to cut off the connection into the underground pipe 40. For that purpose a control unit 63 gives orders SB to both the first valve 59 and the second valve 61 by which orders the two valves are operated. The control unit 63 comprises an input interface 64 for information data ID, for example information about the ambient temperature of the power plant 2' and/or about current power consumption of the power network which is fed by the power plant 2'. A driving unit 57 derives from these information data ID the orders SB which will close and open the first valve 59 and the second valve 61. Therefore opening and closing the valves 59, 61 is dependent on those information data ID supplied via the interface is 64. In other words, the underground tube 40 can be cut off or given access to in dependence of the information data ID. For instance, during day time under hot weather conditions the information data ID will contain information about high temperatures. The information data may also comprise date and time information from which there can be extracted in arid zones a certain expected temperature level. For instance, the information that it is midday will suffice in deserts as an indication of very hot ambient temperatures without an extra measurement of the temperatures. From the information data ID the driving unit 57 derives orders SB to open the first valve 59 and to close the second valve 61 so that additional cooling in the underground tube 40 is made available. The same may be the case in times of extremely high power consumption in the power supply network.

[0043] Such control unit 63 can be used in any of the following embodiments as described with reference to Figs. 4 and 5. It is therefore not shown in the following figures.

[0044] Figure 4 shows a power plant 2' according to a second embodiment of the invention. Again cooling water 13 is pumped through a cooling circuit 11 by a pump 3. It passes a dry cooling tower 33 as described before before entering an underground depth 41 in which a heat exchanger 45 is situated. In the heat exchanger 45 the cooling water 13 is cooled down and led further into a wet cooling tower 19 as described with reference to Fig. 3. The heat exchanger 45 is supplied with a second cooling liquid 46 which is led through a second cooling circuit 47 by a second cooling circuit pump 49. This second cooling circuit 47 is in the underground depth 41 so that it is cooled by the underground soil. The second cooling circuit 47 together with the heat exchanger 45 and the second cooling circuit pump 49 therefore constitutes a cooling system 4 according to a second embodiment of the invention.

[0045] Figure 5 shows a power plant 2' according to a third embodiment of the invention. For the sake of clarity common features with Figs. 3 and 4 are not mentioned again. After leaving the dry cooling tower 33, the cooling water 13 is led again into an underground depth 41 in which a cold storage 51 is situated. It may be noted that such cold storage 51 can also be situated above ground in which case it is preferably thermally isolated from the outside.

[0046] The cold storage 51 is shown in more detail in Fig. 6. It is realized as a basin in which the cooling water 13 is stored in great amount. For the purpose of cooling the cooling water 13 an additional pipe system 53 with a pump 55 is led underground so that the cooling water 13 is cooled underground and led back into the cold storage 51. From the cold storage 51 the cooling water 13 goes back into the cooling circuit 11 as shown in Fig. 5.

[0047] Although the present invention has been disclosed in the form of preferred embodiments and variations thereon, it will be understood that numerous additional modifications and variations could be made thereto without departing from the scope of the invention. As mentioned above, the cold storage can also be positioned above ground and it is not absolutely necessary to use dry cooling towers and/or wet cooling towers in addition to the cooling system used to realize the method according to the invention.

[0048] For the sake of clarity, it is to be understood that the use of "a" or "an" throughout this application does not exclude a plurality, and "comprising" does not exclude other steps or elements.

Claims

1. Method for cooling a carrier fluid (5), which carrier fluid (5) is used to drive a turbine (29) in an electric power plant (2'), whereby at least part of a cooling process is realized by leading the carrier fluid (5) and/or a cooling fluid (13, 46) for cooling the carrier fluid (5) underground a soil to a depth (41) in which the soil is substantially cooler than the ambient air.

2. Method according to claim 1, whereby the cooling is carried out in an electric power plant (2') in a hot environment.

3. Method according to claim 1 or 2, whereby the cooling is performed for a carrier fluid (5) in a solar power plant, in particular in a concentrated solar power plant.

4. Method according to any of the preceding claims, whereby the cooling is performed for a carrier fluid (5) in a power plant (2') comprising an air cooled condenser (35) which carries out part of the cooling.

5. Method according to any of the preceding claims, whereby the cooling is performed in a power plant (2') comprising a wet cooling system (19) which carries out part of the cooling.

6. Method according to any one of the preceding claims, whereby the carrier fluid (5) and/or the cooling fluid (13) is cooled in a heat exchanger (45) connected to a cooling circuit (47).

7. Method for cooling a carrier fluid (5), which carrier fluid (5) is used to drive a turbine (29) in an electric power plant (2'), whereby at least part of a cooling process is realized by supplying at least some of the carrier fluid (5), and/or at least some of a cooling fluid (13) used to cool the carrier fluid (5), from a cold storage (51) which stores fluid at a significantly lower temperature than the temperature of the carrier fluid (5) in the turbine (29).

8. Method according to claim 7, whereby the cold storage (51) is situated underground at a depth (41) that is substantially cooler than the ambient air.

9. Method according to claim 7 or 8, whereby the cold storage (51) is replenished with fluid at night time which fluid is then supplied during daytime.

10. Method according to any of claims 7 to 9, whereby some of the carrier fluid (5) and/or some of the cooling fluid (13) is stored in a plurality of cold storages (51).

11. Method according to any of the preceding claims, whereby the cooling method is applied under extreme heat conditions and/or during times of peak power consumption.

12. Method according to claim 11, whereby use of the cooling method is initiated by a driving unit (57) according to variable input data (ID) pertaining to temperature information and/or power consumption information.

13. Electric power plant (2') with a carrier circuit (1) with a carrier fluid (5) which carrier fluid (5) in operation drives a turbine (29) of the power plant, whereby at least part of the carrier circuit (1) and/or part of at least one cooling circuit (11, 47) with a cooling fluid (13, 46) used to cool the carrier fluid (5) is led underground to a depth (41) that is substantially cooler than the ambient air.

14. Electric power plant (2') with a carrier circuit (1) with a carrier fluid (5) which carrier fluid (5) in operation drives a turbine (29) of the power plant, whereby at least part of the carrier fluid (5) and/or at least part of a cooling fluid (13, 46) used to cool the carrier fluid (5) is stored in a cold storage (51) at a significantly lower temperature than the temperature of the carrier fluid (5) in the turbine (29).

15. Cooling system (4) for an electric power plant (2') in

which at least part of a carrier circuit (1) with a carrier fluid (5) and/or part of at least one cooling circuit (11, 47) with a cooling fluid (13, 46) used to cool the carrier fluid (5) is led underground to a depth (41) that is substantially cooler than the ambient air and/or in which cooling system at least part of the carrier fluid (5) and/or at least part of the cooling fluid (13, 46) is stored in a cold storage (51) at a significantly lower temperature than the temperature of the carrier fluid (5) in the turbine (29).

FIG 1 State of the Art

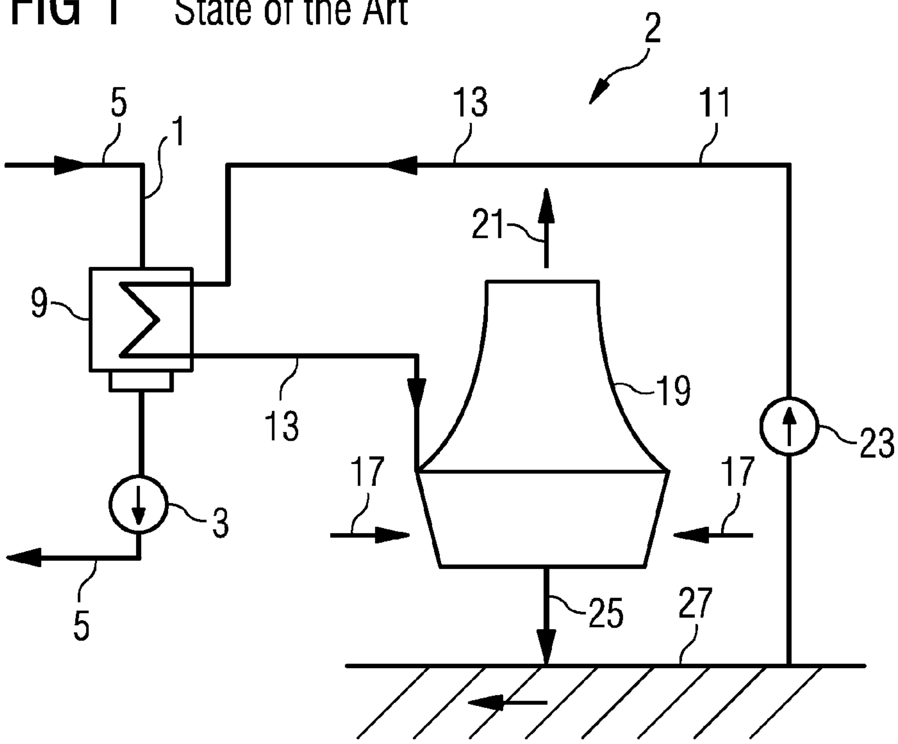


FIG 2 State of the Art

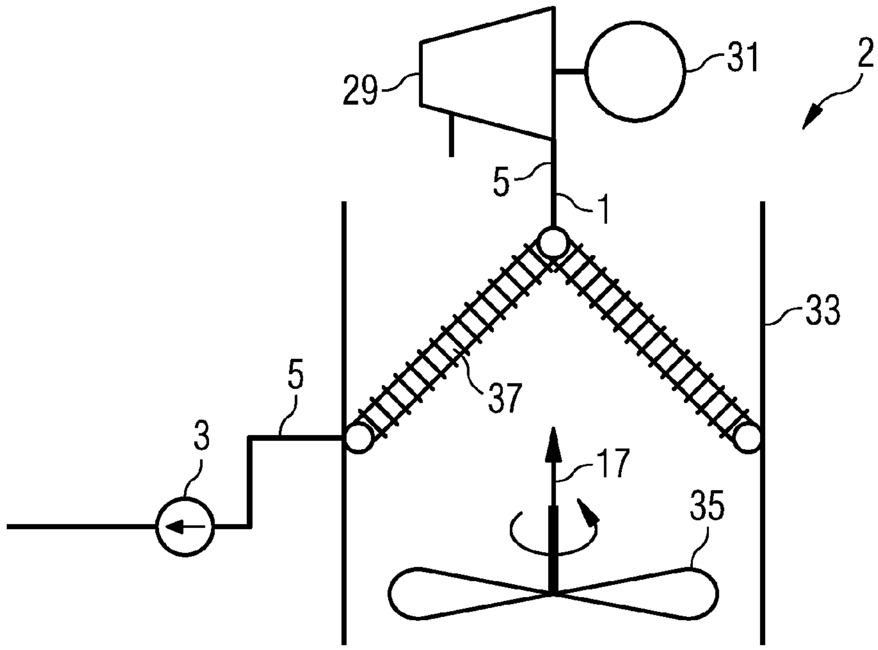


FIG 3

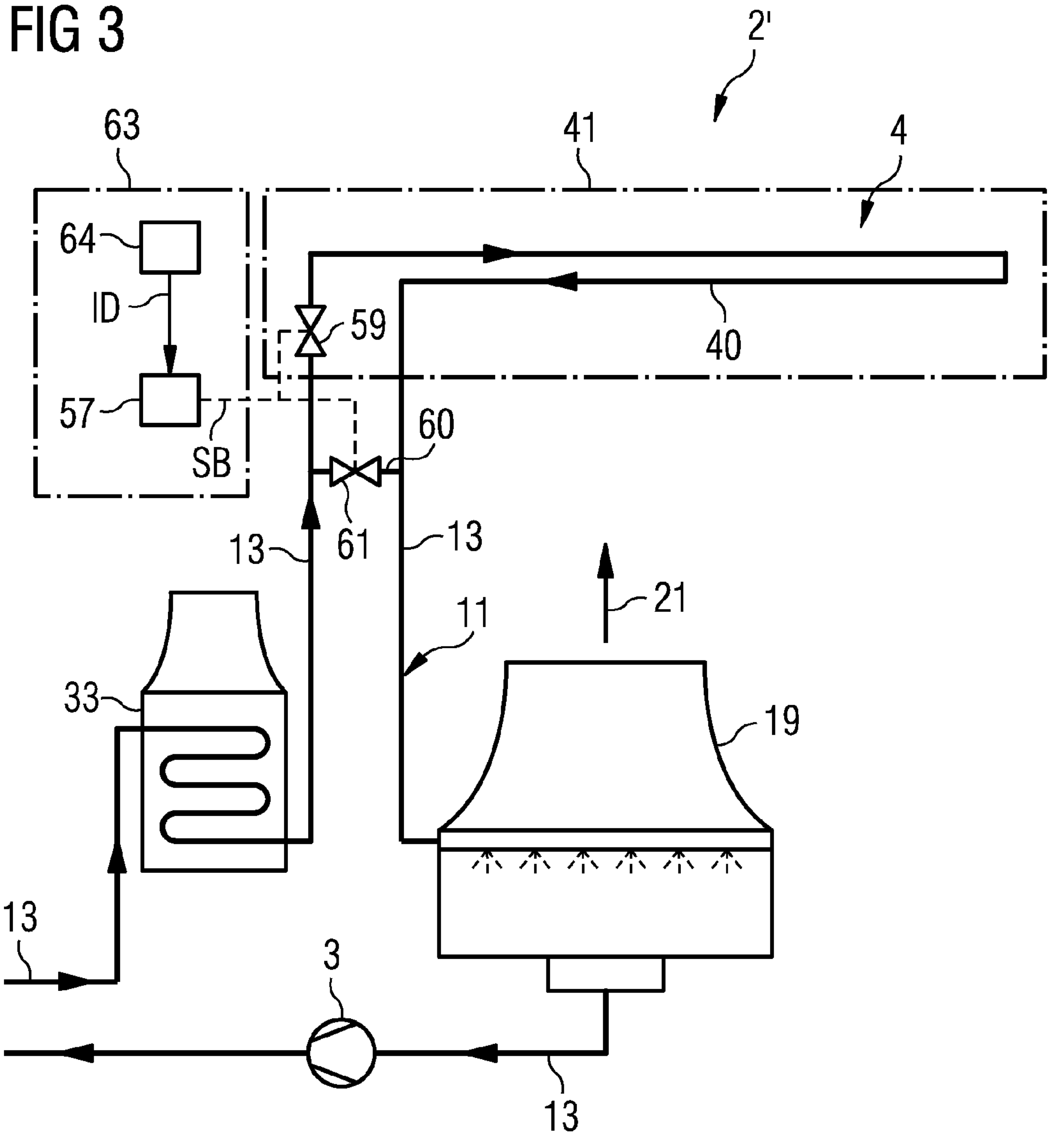


FIG 4

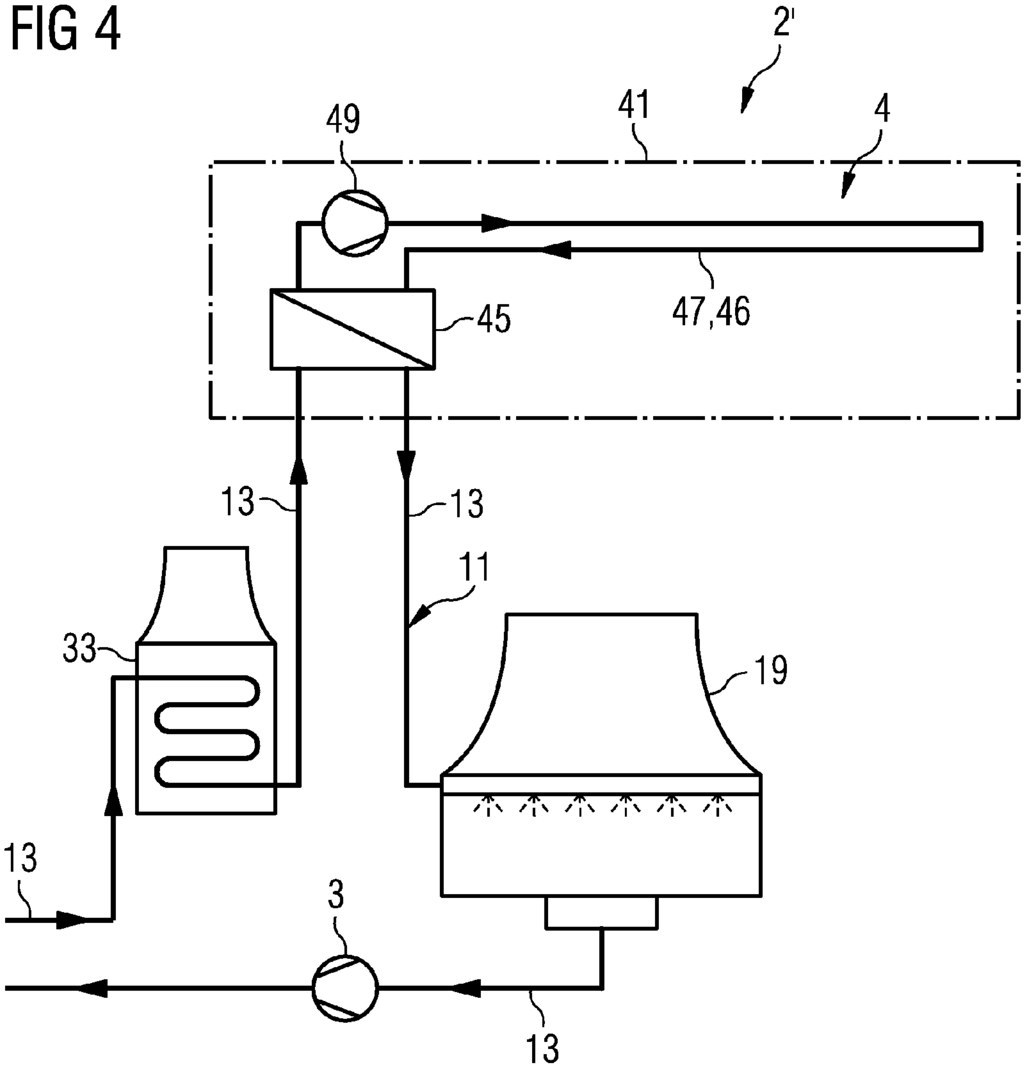


FIG 5

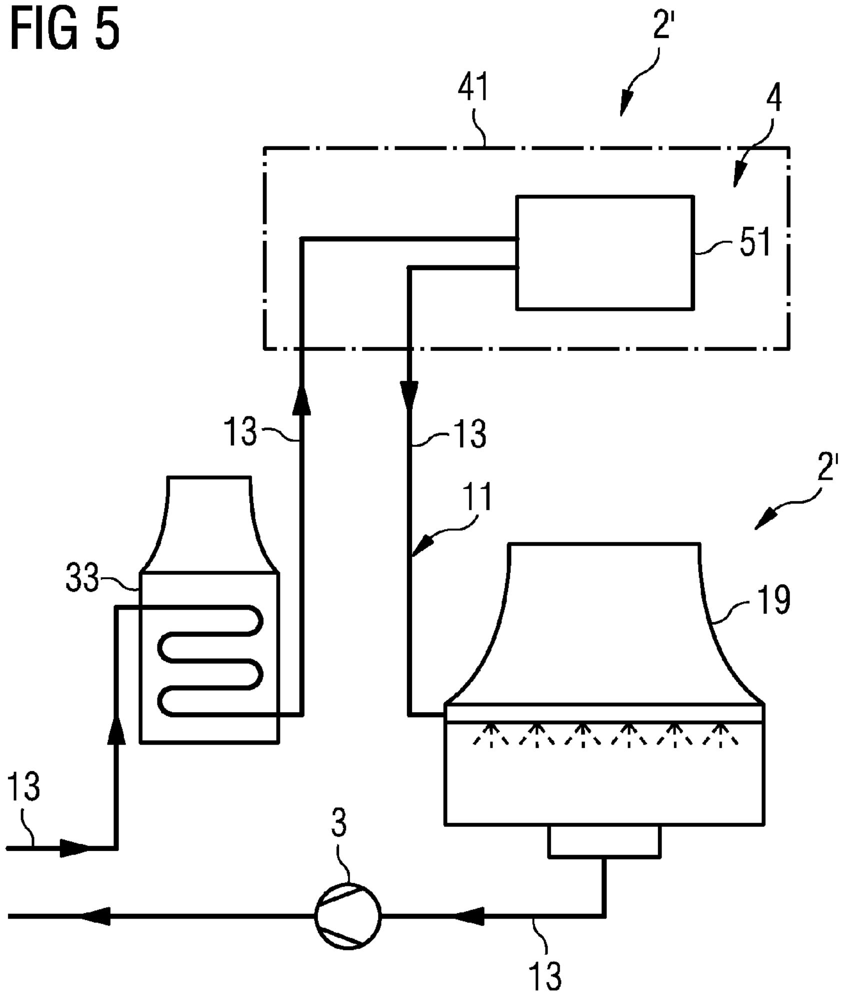
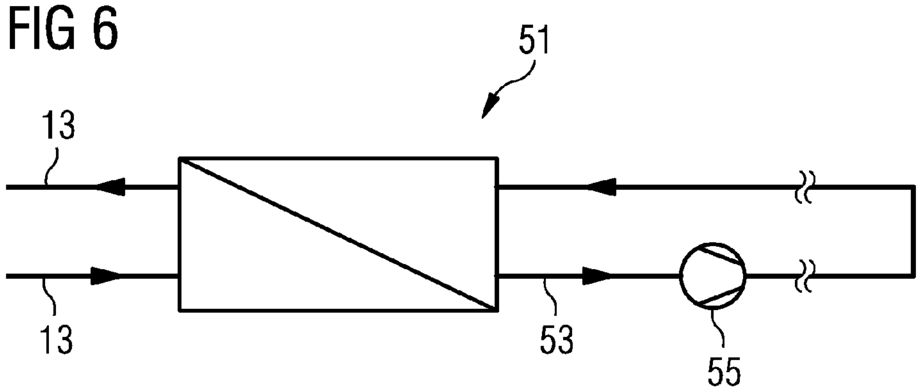


FIG 6



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EUROPEAN SEARCH REPORT

Application Number
EP 10 18 8875

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2009/064378 A2 (AUSRA INC [US]; ELLIS ERIK [US]; VENETOS MILTON [US]) 22 May 2009 (2009-05-22) * paragraphs [0014] - [0107]; figure 1 *	1-3,6-8, 10,11, 13-15	INV. F01K9/00 F25D3/00 F28B9/06
X	US 2009/121488 A1 (BHATTI MOHINDER SINGH [US] ET AL) 14 May 2009 (2009-05-14)	1-3,6, 13,15	
Y	* figure 1 *	4,5	
X	US 7 340 899 B1 (RUBAK JEFFREY [US] ET AL) 11 March 2008 (2008-03-11) * figures 2,9 *	7,9-11, 14,15	
X	US 4 315 404 A (SCHMITT RICHARD L ET AL) 16 February 1982 (1982-02-16)	7,12	
Y	* column 1, line 1 - column 9, line 53; figures 1,2 *	4	
Y	US 2006/075682 A1 (BULLINGER CHARLES W [US] ET AL) 13 April 2006 (2006-04-13) * figures 9,10 *	5	
A	US 4 449 368 A (HAYNIE TIMOTHY J [US]) 22 May 1984 (1984-05-22) * figure 3 *	1,4	

TECHNICAL FIELDS SEARCHED (IPC)

F01K
F25D
F28B
F24J
F23K
F23L

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	4 July 2011	Lepers, Joachim

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04-07-2011

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2009064378 A2	22-05-2009	US 2009179429 A1	16-07-2009
US 2009121488 A1	14-05-2009	CN 101429879 A	13-05-2009
US 7340899 B1	11-03-2008	NONE	
US 4315404 A	16-02-1982	NONE	
US 2006075682 A1	13-04-2006	AU 2005295110 A1	20-04-2006
		CA 2583553 A1	20-04-2006
		EP 1805283 A2	11-07-2007
		JP 2008516183 A	15-05-2008
		WO 2006042308 A2	20-04-2006
US 4449368 A	22-05-1984	NONE	

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