

Candidate's answer Paper A (Electricity/Mechanics)

Claims

- 1) Apparatus for energy storage comprising an upper reservoir (1) and a lower reservoir (5), a quantity of a first fluid (23), a flow passage (6) for communication of the first fluid (23) between the upper and lower reservoirs (1, 5) and displacement means for displacing at least some of the first fluid (23) from the lower reservoir (5) into the upper reservoir (1) characterised in that the displacement means comprises a second fluid (21, 22), the second fluid being less dense than the first fluid, and means for forcing the second fluid into the lower reservoir.
- 2) Apparatus as claimed in claim 1 wherein the second fluid is a fuel gas (21).
- 3) Apparatus as claimed in claim 2 in which the displacement means comprises connection means (54, 51) for closeable connection of the lower reservoir (5) to a gas tanker.
- 4) Apparatus as claimed in claim 2 or claim 3 which is suitable for the storage of the fuel gas.
- 5) Apparatus as claimed in any of claims 1 to 4 wherein the displacement means comprises a pump (2) for pumping the second fluid (21, 22).
- 6) Apparatus as claimed in any of claims 1 to 5 which also comprises means for generating energy (8, 13) from the flow of the second fluid.
- 7) Apparatus as claimed in claim 6 when dependent in claim 5 wherein the pump (8) and the means for generating energy (8, 13) are reversible unit (8, 10, 13).
- 8) Apparatus as claimed in any of claims 1 to 7 wherein the upper and lower reservoirs (1, 5) are underground cavities.
- 9) Apparatus as claimed in claim 7 which also comprises a return passage (17) for flow of the second fluid between the reversible unit (8, 10, 13) to the upper reservoir.
- 10) A method of storing energy comprising providing an upper reservoir (1), a lower reservoir (5), a flow passage (6) for fluid flow between the upper and lower reservoirs (1, 5), and a quantity of a first fluid (23) characterised in that the method comprises the step of forcing a second fluid (22), which is less dense than the first liquid, into the lower reservoir, thereby displacing at least some of the first liquid into the upper reservoir.

Note to examiner

My claim 1 covers all three embodiments of the invention. However, the necessity of covering the embodiment of Fig 3 has meant that the closest prior art is D1, rather than the known gas storage system referred to in the inventor's letter. Furthermore, it appears that the systems of Figs 1 and 2 are much closer to the client's commercial interests than Fig. 3. For this reason I would prefer to file two applications the first having a claim as follows directed to Figs 1 and 2.

Claim – Apparatus for storing a gas comprising means for introducing the gas (21) into a lower reservoir (5) characterised in that the apparatus also comprises an upper reservoir (1), a quantity of a liquid (23), a flow passage (6) for communication of the liquid between the upper and lower reservoirs and means for introducing the gas under pressure into the lower reservoir.

The second application would have a claim 1 of similar scope to the current claim 1 but the dependent claims would focus on the features of Fig 3.

- It appears to me to be essential that the first fluid is a liquid but I have followed the inventor in using "fluid".
- The use of 2 separate applications for Figs 1 and 2 and Fig 3 would also avoid the problem that the turbine is equally essential in Fig 3 embodiment but is not present in Fig 1. I now feel that two applications is definitely the best way.

An Energy Storage System

This invention relates to an energy storage system and to a method of storing energy.

D1 describes a pumped energy storage system which comprises upper and lower reservoirs which contain a quantity of a liquid. The first reservoir is connected to the second reservoir via conduit 44 through which the liquid may flow between the reservoirs. The system also comprises a reversible pump/turbine 32 which can pump the liquid from the lower reservoir to the upper reservoir. When energy is required, the liquid is allowed to flow back through the conduit 44, thereby turning the turbine and generating energy.

However, that known system requires the provision of a pumping chamber underground in between the two reservoirs and tunnels for access to that chamber which is both difficult and costly. Furthermore, passages are also required between the reservoirs and the surface to allow air to escape.

The present invention provides an apparatus as claimed in claim 1.

The use of a second fluid which is less dense than the first fluid allows the pumping station to be located above the ground and requires a less complex arrangement of conduits and passages than the known system.

Furthermore, the apparatus of the invention also has the advantage that, as well as storing the potential energy of the liquid, the second fluid may be a fuel gas and the apparatus can then simultaneously be used as a means to store the fuel gas. Advantageously, the reservoirs are underground cavities, for example, cavities in salt formations. Apparatus in which gas is stored in underground cavities is known. In that system *gas is pumped under pressure into the underground cavities. A pump can be used to compress the gas when filling the cavity. Some of the energy used in this process can be recovered by a turbine when the gas is subsequently released from the cavity. Electricity generated by a generator coupled to the turbine can be supplied to the electricity network.*

It is normally necessary to use large cavities to permit storage of considerable quantities of natural gas. However, with very large cavities, no significant pressure builds up within the cavity when a relatively small quantity of gas is contained therein. In such a case, recovery of the natural gas becomes costly as it must be sucked out of the cavity.

In the present invention, where the second fluid is a fuel gas, it is easily recovered simply by allowing the first liquid to flow back into the lower reservoir from the upper reservoir under the influence of gravity.

Advantageously, the displacement means ... as claim 3. In that case the energy already stored in the compression of the gas on the tanker is used to transfer the first liquid into the upper reservoir with no need for a separate pump to be used.

Advantageously, the apparatus comprises a pump ... as claim 5. Where the second fluid is compressible eg a fuel gas that allows it to be stored under increased pressure, thereby increasing the capacity of the lower reservoir.

Preferably, the apparatus also comprises a means for generating energy ... as claim 6. In this way the pressure energy of the gas can be recovered.

Preferably, the apparatus ... as claim 9. This allows the same amount of the second fluid to be used more than once.

Specific embodiments will now be described for the purposes of illustration only.