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(71) Applicant
Hitoshi Kinno,
99—3 Nakashimada-cho, 4-chome, Tokushima-shi, Japan

(72) Inventor
Hitoshi Kinno

(74) Agent and/or address for service
Haseltine, Lake & Co., Hazlitt House, 28 Southampton Buildings, Chancery Lane, London, WC2A 1AT

(54) Pumped storage system at tidal power site

(57) The system has a first main basin 1 enclosed from the sea 10 by a barrage 2 having a sluice 3 which is opened only during flood tide periods and also a main turbine 4 which generates electricity twice a day during ebb tide periods, and a second basin 5 disposed adjacent to the main basin 1 and enclosed by a barrage 6 having a reversible pump-turbine assembly 7, 8, 15, the pump 7 being driven by the main turbine 4 to lower the water level in the second basin 5 at night. The turbine 8 generates electricity during appropriate daylight hours. Also, the turbine 8 can be operated as a pump 15 which feeds sea water into the second basin 5 in order to increase its water level and to protect the barrage 6 from storm damage. An off-shore dyke 17 of the second basin provides reclaimed land usable as a fish farm.

FIG. 1

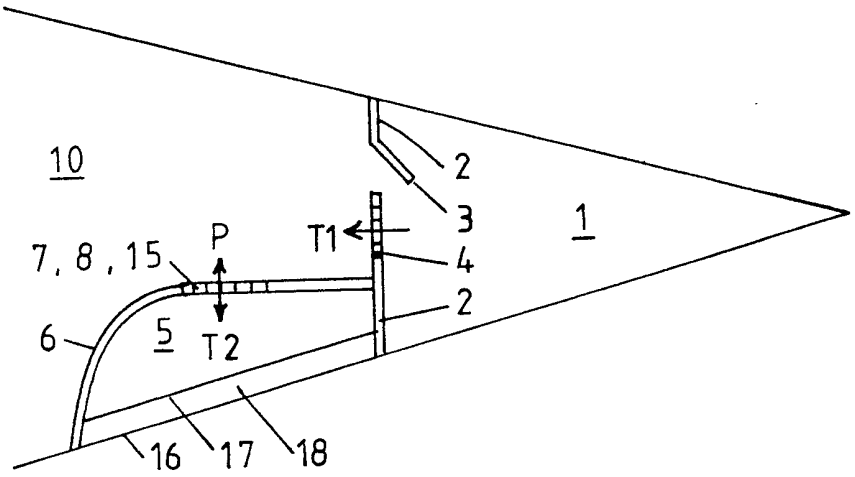

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FIG. 1

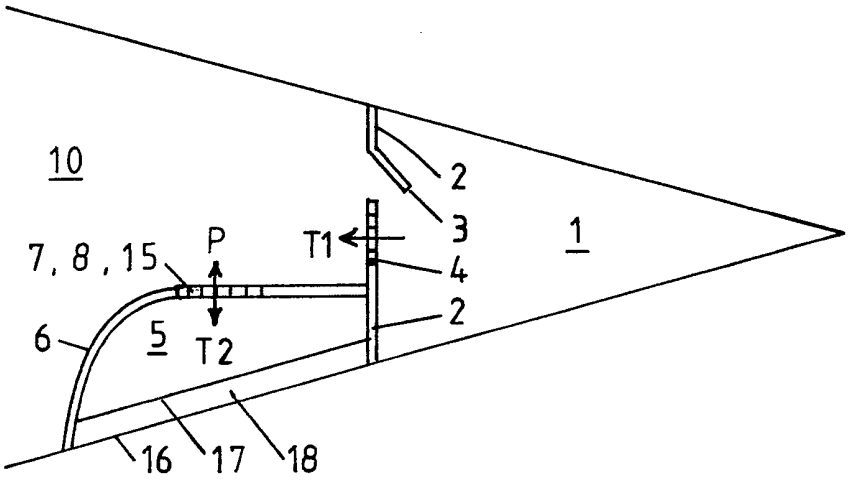
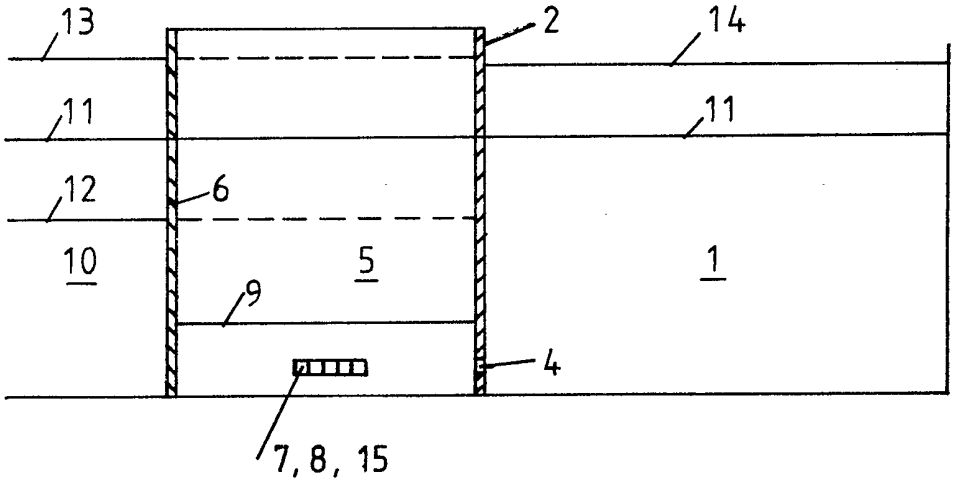


FIG. 2



SPECIFICATION

Pumped Storage System at Tidal Power Site

The present invention relates in general to the pumped storage system installed at the tidal power scheme which has single basin and single acting mode, and it relates more particularly to a new and improved method and apparatus for keeping uniform output power with high efficiency during day-time.

It is well known in the tidal power scheme having single basin and single action mode that it's output power pulsate twice a day, this is very low quality power for the grid and night-time output energy which cannot be avoided once a day is less value.

Hitherto two basin system has been considered in order to retime the night-time output energy to day-time energy. However, it is used import energy from the grid, that is no good because it gives large random and pulsate disturbances to the grid compared with uniform output energy as fossil and nuclear energy.

Viewed from above aspect the present invention provides the second basin nearby the main basin where a set of pump-turbine is mounted in the second barrage. If one day is divided into two time ranges at night-time (20.00 hrs to 08.00 hrs) and day-time (08.00 hrs to 20.00 hrs), the whole output power at night-time is used for driving power of pump at the second basin at which the water level in the second basin drops down of which potential can be used for turbine head at the second basin in the next day-time.

Day-time generation can be obtained from the two turbine's series operation namely main turbine T1 and the second basin turbine T2.

The remarkable difference of the present invention from the hitherto considered two basin system is no use of import energy from the grid, and the pump is operated at low tide period only while the main turbine T1 is working under it's high head period. On the contrary, the turbine T2 generate at higher tide level than the tide level at T1 is working at day-time, this makes the cause of high efficiency of the pumped storage system.

Some embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which:

Fig. 1 is a groundplan of the two basin system according to the present invention;

Fig. 2 is a side view of Fig. 1, partly sectioned, that shows water level relations between sea, main basin and the second basin.

Referring to Fig. 1 and Fig. 2, the main basin 1 is closed from sea 10 by a barrage 2 in which sluices 3 and turbine 4 are mounted. And the second basin 5 is closed by a barrage 6 in which pump 7 and turbine 8 are mounted. The pump 7 and turbine 8 are conventional bulb type pump-turbine.

At flood tide, if sea level 13 is higher than main basin level 14, sea water come into basin 1 through sluices 3. At ebb tide and night-time, sluices 3 is closed and if head of turbine 4 become larger than a lower limit value, for instance 4 m, turbine 4 start and it's output power drives the pump 7, then water level 9 of the second basin 5 drops below than mean tide level 11. Turbine 4 works about 5 hrs at spring and 3.5 hrs at neap provided the minimum turbine head is specified. Pump 7 works same time with turbine 4.

At day-time, if sea level 12 is enough low, turbine 4 generate electric power while water level 14 of the main basin 1 drops to the mean tide level 11. When turbine 4 is rest for the reason of sea level 13 is too high to operate turbine 4, turbine 8 can be operated during remaining day-time so as to keep uniform output power at which the head of turbine 8 is much higher than the head of pump 7, this makes the overall efficiency of the pumped storage system more than 100% despite of total machine efficiency is 70%.

Referring to Fig. 1, there is shown another embodiment of the invention wherein turbine 8 can be operated as pump 15 toward the second basin 5 from sea 10 by using the grid energy. Then water level in the second basin 5 can be kept to higher level than sea level. This is useful to protect the barrage 6 from emergency as extra high tide or storm.

Also pump 7 and pump 15 could keep the both water level of sea 10 and the second basin 5 to same level by using their pumping ability even while sea level is changing quickly. This ability is useful for closing off or repairing of the barrage 6.

Referring to Fig. 1, there is shown another embodiment of the invention wherein initial coastline 16 moves toward new coastline 17 because water level in the second basin 5 is kept lower than before level at no barrage. If a dyke is built on the new coastline 17 or more off-shore side, the new reclaim land 18 can be used for fish farm where intake and drain of sea water are very easy by using the pump 7 and pump 15, particularly using weekend surplus tidal energy come from the turbine 4.

CLAIMS

1. A pumped storage system at a tidal power site that comprises two basins, wherein the first main basin has a single-acting mode of operation by which a main turbine generates electricity twice a day during ebb tide periods and whose sluices are opened during flood tide periods to refill the first main basin, and wherein the second basin is disposed adjacent to the first main basin and has a pump-turbine assembly in its barrage whose pump is driven by power derived from said main turbine during low electricity demand periods to lower the second basin level, and wherein the turbine of said second basin assembly generates electricity during high electricity demand periods which coincide with said flood tide periods using the head of water between the lowered level of the second basin and the flood tide sea level.

2. A system as claimed in claim 1, wherein the turbine of the second basin assembly can be operated as a pump by reverse rotation or blade angle change using power derived from an electricity supply grid so that sea water may be fed into the second basin until its water level becomes sufficiently high to protect the second basin barrage from damage by an extra high tide or by a storm.

3. A system as claimed in claim 1 or claim 2, wherein the pump-turbine assembly in the second basin is operable as a two-direction pump so that it may be used to keep the water in the second basin at substantially the same level as that of the sea by pumping from the higher water level side to the lower water level side in order to facilitate work during closure and/or repair of the second basin barrage.

4. A system as claimed in claim 1, 2 or 3, wherein a dyke is built offshore from the initial coast line of the second basin in order to produce reclaimed land.

5. A system as claimed in claim 4, wherein the reclaimed land is used as a marine fish farm whose intake and drainage of sea water is obtained *via* the second basin.

6. A pumped storage system at a tidal power site substantially as described herein with reference to the accompanying drawings.

7. A method of operating a pumped storage system at a tidal power site according to any preceding claim, wherein the turbine power output and the pump power input can be kept in substantial uniformity during each power cycle by adjusting the blade angle and/or by changing the speed of rotation of the turbine or pump impeller in order to minimise power disturbance to the electricity supply grid to which, in use, the system will be connected.

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