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(54) **Method for pumping drainage water from a pumping station into a discharge water flow destination**

Verfahren zum Pumpen von Drainagewasser von einer Pumpstation in einen Wasserabfluss

Procédé pour pomper de l'eau de drainage d'une station de pompage vers une évacuation

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Description

The invention relates to a method for pumping drainage water from a pumping station into a discharge water flow destination, the pumping station comprising a pump well in which rainwater etc. flows through an inflow water main pipe line provided under the ground level, and a plurality of drainage pumps installed at at least two different installation levels for discharging said inflow water in said pump well into the discharge water flow destination.

At present, in cities so as to meet the problems of a flood caused by a rainfall and the inundation of rivers etc., a drainage water system is provided. This drainage water system is conventionally constructed such that a drainage water pumping station is provided on a down stream of an inflow water main pipe line and has a plurality of drainage pumps.

The rainwater etc. is gathered in the inflow water main pipe line of the drainage water pumping station. The gathered inflow water is led into the drainage water pumping station and is discharged by means of drainage pumps toward rivers, lakes and marshes or the sea as a discharge water flow destination.

Besides, in generally, in correspondence with the fluctuation of the inflow water amount, the discharge water amount is adjusted in accordance with the operation of the drainage pumps in the drainage water pumping station. Such drainage pumps are provided dividable with a plural number depending on the necessary discharge water amount. By controlling the running number of the drainage pumps the control or the adjustment for the discharge water amount is carried out in the drainage water pumping station.

Further, when an operator of the drainage water pumping station attends to control finely the discharge water amount, in generally it is carried out to combine a vane angle control of the drainage pump and a speed control of the drainage pump. By the reason of the difficulty for obtaining of the required area of land or the required area of site etc. for the equipment of the drainage water pumping station, the following drainage water system construction has been employed currently in the city.

The conventional drainage water system is constructed such that, the inflow water main pipe line is provided under the ground level. Further, so as to fit the above inflow water main pipe line construction the drainage water pumping station itself is also provided under the ground level.

A conventional underground drainage water pumping station is described in, for example, the document (Ehara Jihou No. 109, 1979, pages 13-16).

The underground drainage water system shown in the above document comprises mainly an inflow water main pipe line which is disposed on the discharge water subject district, two pump wells and a plurality of drainage pumps surrounding two pump wells. The plurality of drainage pumps are circularly arranged surrounding two pump wells.

In this underground drainage water system, two pump wells relating to two independent drainage water systems are provided independently with the same drainage water pumping station, and further the plural drainage pumps relating to the respective drainage water system are arranged at the semi-circular shape state surrounding the two pump wells. These drainage pumps are arranged circularly and horizontally in only one plane. Further, a pump construction building in this drainage water system is formed to have a circular shape from the upper end to the lower end.

With the construction of the underground drainage water system stated above, by means of the inflow water main pipe line the inflow water is led into the pump wells of the drainage water pumping station. The discharge water amount is controlled by the number and the speed of the running drainage pumps.

When a great depth underground drainage water system is employed, the necessary pump head for the drainage pump becomes high depending on the installation depth of the inflow water main pipe line.

In the above stated prior art, it is necessary to operate all of the drainage pumps at the whole range from the minimum water level to the maximum water level of the pump well. As a result, the power cost for discharging the discharge water from the drainage pumps and the equipment cost for installing the pump construction building are high due to the necessity of the higher pump head for the drainage pump.

Further, the more the necessary number of the drainage pumps increases, the more the construction area (the projection area) for the pump installation construction building enlarges, accordingly the working amount including the underground digging working increases.

The problem underlying the invention is to provide a method for pumping drainage water from a drainage water pumping station into a discharge water destination which is very efficient and requires little space.

Starting out from the method of the generic kind this problem is solved in that dependent on the rise of the drainage water level in the pump well the drainage water is first pumped by a plurality of drainage pumps of a lower level and then by a plurality of drainage pumps of a higher level.

In a preferred method of the invention, from a lower installation level to a higher installation level the pump head of the drainage pumps decreases and the capacity of the drainage pumps increases.

The method of the invention is very efficient as in case of a high water level in the well the drainage pumps of an upper installation level can be used for pumping. Since the difference between the level of an upper drainage pump and the level of the water destination is relatively low, less power is required in a wide range. Thus the drainage pumps of the upper installation level can be designed to have a low pump head and a high capacity. In case the water level in the well is low, the drainage pumps of a lower installation level are used for pumping. Since in this case fast pumping is not required, the drainage pumps of the lower installation level can be designed to have a high pump head and a low capacity.

The invention will be explained in detail by means of the accompanying drawings:

Brief Description of the Drawings:

Fig. 1 is a longitudinal sectional schematic view showing one embodiment of a drainage water pumping station according to the present invention;

Fig. 2 is a detailed sectional view showing a section of a drainage pump arrangement of the drainage water pumping station of Fig. 1;

Fig. 3 is a schematic view showing a first-stage drainage pump group disposed on a high installation level;

Fig. 4 is a schematic view showing a second-stage drainage pump group disposed on a low installation level; and

Fig. 5 is a chart explaining the effects of the embodiment shown in Fig. 1 and showing a characteristic curve line Q of the relation between a discharge water amount (m^3/s) and a total pump head (m) of parallelly running drainage pumps, a characteristic curve line P of the relation between a discharge water amount (m^3/s) and a pump required (kW) per single drainage pump, and a loss curve line L of the individual, parallelly running drainage pumps.

In the embodiment of the drainage pump station of Fig. 1 and 2 inflow water such as rainwater is gathered in an inflow water main pipe line 1 which is installed in a discharge water subject district and the inflow water flows into a pump well 2. The inflow water in the pump well 2 is pumped up by a plurality of drainage pumps 3 and discharged into a discharge water flow destination (river 6) via a collecting delivery pipe line 4 and a drainage water passage 5.

The drainage pumps 3 in this embodiment comprise a first-stage drainage pump group PH and a second-stage drainage pump group PL. The first-stage drainage pump group PH and the second-stage drainage pump group PL are arranged at two different installation levels.

The first-stage drainage pump group PH has a low pump head and a large capacity, and the second-stage drainage pump group PL has a high pump head and a small capacity. The first-stage drainage pump group PH is disposed on an upper installation level and the second-stage drainage pump PL is disposed on a lower installation level. The first-stage drainage pump group PH comprises a plurality of drainage pumps, namely a drainage pump PH1, a drainage pump PH2, ... , and a drainage pump PHn (n: a natural number) being installed in the drainage water pumping station. Also, the second-stage drainage pump group PL comprises a plurality of drainage pumps, namely a drainage pump PL1, a drainage pump PL2, ... , and a drainage pump PLn (n: a natural number) being installed in the drainage water pumping station.

In this embodiment of the present invention, the first-stage drainage pump group PH comprises four drainage pumps and also the second-stage drainage pump group PL comprises four drainage pumps. However, it is preferable to install a first-stage drainage pump group PH comprising between at least three drainage pumps and seven drainage pumps. Further, it is preferable to install a second-stage drainage pump group PL comprising between at least three drainage pumps and seven drainage pumps.

In this embodiment of the present invention, the discharging pump groups are arranged at two installation levels in the drainage water pumping station, however, an arrangement at three or four installation levels etc. is possible as well.

The drainage pumps of the first-stage drainage pump group PH are circularly installed at the same installation level and arranged symmetrically at the same interval, as shown in Fig. 3. The drainage pumps of the second-stage drainage pump group PL are circularly installed at the same installation level and arranged symmetrically at the same interval, as shown in Fig. 4.

A suction tube 7 of the first-stage drainage pump group PH is in communication with the pump well 2 via a ring-like collecting suction sump 9. A suction tube 8 of the second-stage drainage pump group PL is in communication with the pump well 2 via a ring-like 10 collecting suction sump 10.

Each of the collecting suction sumps 9 and 10 is circularly formed in correspondence with the circular arrangement of the first-stage and the second-stage drainage pump groups PH and PL. The suction tube 7 of the first-stage drainage pump group PH is provided with a suction sluice valve 11. The suction tube 8 of the second-stage drainage pump group PL is provided with a suction sluice valve 12.

The delivery pipe line 4 having a longitudinal shape is provided around the drainage pump group 3 and connected with both a delivery pipe line 13 of the first-stage drainage pump group PH and a delivery pipe line 14 of the second-stage drainage pump group PL.

An upper portion of the delivery pipe line 4 is in communication with a river 6 via the discharge water passage 5. The pipe diameter of the delivery pipe line 4 becomes thinner towards the lower installation level in correspondence with the discharge water amount of each of the installation levels.

The above drainage pump groups 3 are installed in an underground pump construction building 20 which is arranged at a side portion of the pump well 2. An outer shape of an underground pump construction building 20 is formed in a circular cone shape spreading toward the upper portion as shown in Fig. 1.

A reason for employing the above stated construction is such that the installation area of the second-stage drainage pump group PL, which has the high pump head and the small capacity and is installed at the lower installation level, can be small in comparison with that of the first-stage drainage pump group PH, which has the low pump head and the large capacity and is installed at the upper installation level.

An electric motor 15 is provided on each drainage pump of the first-stage drainage pump group PH and an electric motor 16 is provided on each drainage pump of the second-stage drainage pump group PL, respectively.

Further, as shown in Fig. 2, the underground pump construction building 20 can be formed to have a circular cone shape spreading toward the upper portion at the lower portion and to have the circular column shape at the upper portion. The outer shape of the underground pump construction building 20 shown in Fig 2 is a modified example of the outer shape of the underground pump construction building shown in Fig. 1. This underground pump construction building 20 provides maintenance areas 17 and 18 for maintaining the first-stage and the second-stage drainage pump group PH and PL and the motors 15 and 16.

As shown in Fig. 2, an upper end of the delivery pipe line 4 is formed to be exposed or project over the ground. At the exposed portion of the delivery pipe line 4, for example, it can provide a jet of water or the waterfall 21. Further, the upper ground portion of the underground pump construction building 20 can be used as a park 22 etc., as shown in Fig. 1.

The difference in level between the water level Ho of the river 6 forming the discharge water flow destination and the installation level of the first-stage drainage pump group PH is smaller than the difference in level between the water level Ho of the river 6 and the installation level of the second stage drainage pump group PL.

With the above drainage water pumping station construction, according to the embodiment of the present invention, as to the first stage drainage pump group PH disposed on the high installation level, the facts will be explained as follows.

The difference in level between the water level Ho of the river 6 and the installation level of the first-stage drainage pump group PH is smaller than the difference between the second-stage drainage pump group PL and the water level Ho. Therefore the necessary pump head of the first-stage drainage pump group PH is small, and the discharge water power can be reduced.

In particular, as the first-stage drainage pump group PH disposed on the high installation level can have the low pump head and the large capacity, it has a high pump efficiency covering a wide range, and therefore the effect of remarkably reducing the discharge water power can be attained.

Further, in the drainage water system, in case the water level of the pump well 2 is low, the discharge water amount may be small and in proportion to the rise of the water level of the pump well 2 the discharge water amount can be made to increase.

For example, as shown in Fig. 1, at an intermediate portion between the low water level LWL (for example, water level: -60 m) of the pump well 2 and the low water level HWL (for example, water level: -15 m) of the pump well 2, an intermediate water level MWL1 (for example, water level: -45 m) and an intermediate water level MWL2 (for example, water level: -30 m) for controlling a running number in the drainage pump are set, respectively.

In accordance with the rise in the water level the drainage pumps of the first-stage drainage pump group PH disposed on the upper installation level can be operated one after another, and thereby the discharge water power can be reduced effectively.

Further, since the first-stage and the second-stage drainage pump groups PH and PL are installed at at least two installation levels, the necessary construction area for the underground pump construction building 20 can be small. As a result, the working amount including the underground digging working can be reduced and also the increase in the construction cost for the underground pump construction building 20 can be restrained.

In particular, since each of the first-stage and the second-stage drainage pump groups PH and PL is circularly arranged, the outer shape of the underground pump construction building 20 can be formed to have the circular cone shape as shown in Fig. 1, and accordingly the effect of remarkably reducing the construction cost for constructing the underground pump construction building 20 can be attained.

Further, when the water level of the pump well 2 is low, it is rather unnecessary to discharge the water speedily, as the second-stage drainage pump group PL disposed on the lower installation level has the high pump head and thus the second-stage drainage pump group PL may have the small capacity.

Accordingly, the construction area for each floor gradation state of the underground construction building 20 is made smaller gradually towards the lower installation level. When at least the outer shape of the low portion of the underground pump construction building 20 forms the circular cone shape spreading toward the upper portion, in particular since the digging amount at the deep underground portion can be reduced, the effect of remarkably reducing the construction cost of the underground pump construction building 20 can thus be attained.

Herein, one example of the reduction effect in the discharge water power according to the embodiment of the present invention will be explained referring to Fig. 5.

Fig. 5 shows a characteristic curve line Q of a discharge water amount (m^3/s) and a total pump head (m) 20 of parallelly running drainage pumps, a characteristic curve line P of a discharge water amount (m^3/s) and a pump required (kW) per single drainage pump, and a loss curve line L of the individual, parallelly running drainage pumps, respectively.

The installation number and the rating of the first-stage and the second-stage drainage pump groups PH and PL according to one example of the present invention and the installation number and the rating of the drainage pump group PL' according to the comparative example are shown in Table 1.

In this comparative example, all of the drainage 5 pumps of the drainage pump group PL' have the same rating, further these drainage pumps of the drainage pump group PL' are installed at the low installation level of the above embodiment of the present invention, namely similar to the second-stage drainage pump group PL.

Table 1

(Example of the Present Invention)	
Drainage pump PH disposed on high gradation floor	
number	2
rate pump head	30 m
rate capacity	82 m^3/s
rate required pump power	35 MW
Drainage pump PL disposed on low gradation floor	
number	2
rate pump head	50 m
rate capacity	40 m^3/s
rate required pump power	25 MW
(Comparative Example)	
Drainage pump PH disposed on high gradation floor	
number	4
rate pump head	50 m
rate capacity	50 m^3/s
rate required pump power	30 MW

Further, in Fig. 5, the solid lines show the drainage pumps of the embodiment according to the present invention and the broken lines show the drainage pumps according to the comparative example, and an affixed number attached to the reference code of each curve line indicates a parallelly running number of the drainage pumps.

Each of the characteristic curve lines Q1, Q2, Q3 and Q4 shows the discharge water amount and the total pump head under the pump condition with one number running, the pump condition with two numbers running, the pump condition with three numbers running and the pump condition with four numbers running, according to the present invention. Each of the characteristic curve lines Q1', Q2', Q3' and Q4' shows the discharge water amount and the total pump head under the pump condition with one number running, the pump condition with two numbers running, the pump condition with three numbers running and the pump condition with four numbers running, according to the prior art.

A characteristic curve line PH_h shows the pump net head of the first-stage drainage pump group PH according to the present invention. A characteristic curve line PL_h shows the pump net head of the first-stage drainage pump group PL according to the present invention.

A characteristic curve line PHp shows the discharge water amount and the required pump power of the first-stage drainage pump group PH according to the present invention. A characteristic curve line PLp shows the discharge water amount and the required pump power of the second-stage drainage pump group PL according to the present invention. A characteristic curve line PL'p shows the discharge water amount and required pump power of the drainage pump group according to the prior art.

Each of the characteristic curves L1, L2, L3 and L4 shows the loss curve line under the pump condition with one number running, the pump condition with two numbers running, the pump condition with three numbers running and the pump condition with four numbers running according to the present invention.

In Fig. 5 and the above stated conditions, the running numbers of the drainage pumps are controlled in accordance with the change in the water level of the pump well 2. As a result, in case the time for one number running, two numbers running, three numbers running and four numbers running in the drainage pumps is one hour, respectively, and further the necessary discharge water power required for the drainage pumps can be obtained, the following results as shown in Table 2 are achieved.

Table 2

(Example of the Present Invention)
Required discharge water power (MWH)
1 number x 20 MWH
2 number x 21.5 MWH
2 number x 20.7 MWH + 1 number x 27 MWH
2 number x 20 MWH + 2 number x 23 MWH
Total 217.4 MWH
(Comparative Example)
Required discharge water power (MWH)
1 number x 25 MWH
2 number x 27 MWH
3 number x 26 MWH
4 number x 25 MWH
Total 257 MWH

As shown from the above calculation results, the necessary discharge water power in the embodiment according to the present invention can be reduced to about 85 % in comparison with the prior art shown in the comparative example.

The above results are caused mainly by the following conditions. Since the first-stage drainage pump group PH having the low pump head and the large capacity has the high pump efficiency covering the wide range of the discharge water amount, the first-stage and the second-stage drainage pump groups PH and PL are installed at different installation levels as shown in this embodiment according to the present invention.

Further the rating of the first-stage drainage pump group PH disposed on the high installation level is set to have the low pump head and the large capacity in comparison with the second-stage drainage pump group PL disposed on the lower installation level.

As explained above, according to the embodiment of the present invention the following various remarkable effects can be obtained.

Each of the first-stage and the second-stage drainage pump groups PH and PL is installed at a different installation level, the first-stage drainage pump group PH being disposed on a high installation level such that the difference in the installation level between the water level Ho of the river 6 defining the discharge water flow destination and the high installation level is smaller than that of the second-stage drainage pump group PL and the water level Ho.

Accordingly, the necessary pump head in the first-stage drainage pump group PH becomes small, therefore the discharge water power in the first-stage drainage pump group PH can be reduced.

In particular, with the rating of the first-stage drainage pump group PH disposed on the high installation level, when the ratings of the low pump head and the large capacity for the first-stage drainage pump group PH are employed, since such an employed low pump head and large capacity pump has the high pump efficiency covering the wide range, the effect of remarkably reducing the discharge water power in the first-stage drainage pump group PH can be attained.

Further, since the first-stage and the second-stage drainage pump groups PH and PL are installed at two installation levels, the necessary construction area of the underground pump construction building 20 can be small.

As a result, the working amount Including the underground digging working can be reduced and further the increase in the construction cost for the underground pump construction building 20 can be restrained. In particular, when the first-stage and the second-stage drainage pump groups PH and PL are arranged in the circular shape, the above stated remarkable reduction effects can be attained.

When the water level of the pump well 2 is low, it is rather unnecessary to discharge the water speedily. Therefore, the second-stage drainage pump group PL disposed on the low installation level has a high pump head and a small capacity.

Accordingly, the construction area at each installation level of the underground pump construction building 20 can be made smaller towards the lower installation level. When at least the outer shape of the low portion of the underground pump construction building 20 is formed to have the circular cone shape spreading toward the upper portion, in particular the digging amount at the deep underground portion can be reduced, and therefore the effect of remarkably reducing the construction cost for constructing the underground pump construction building 20 can be attained.

Further, according to the increase in the water level of the pump well 2, the operation of the first-stage and the second-stage drainage pump groups PH and PL can start from the low floor gradation state (the second-stage drainage pump group PL) to the high floor gradation state (the first-stage drainage pump group PH) in sequence. Therefore, since it is not required to operate the drainage pump at the low pump head unnecessarily, the discharge water power can be reduced effectively.

Claims

1. A method for pumping drainage water from a pumping station into a discharge water flow destination, the pumping station comprising

   - a pump well (2) in which rainwater etc. flows through an inflow water main pipe line (1) provided under the ground level, and
   - a plurality of drainage pumps (PH, PL) installed at at least two different installation levels for discharging said inflow water in said pump well (2) into the discharge water flow destination,

   characterized in that

   - dependent on the rise of the drainage water level in the pump well (2) the drainage water is first pumped by a plurality of drainage pumps (PL) of a lower level and then by a plurality of drainage pumps (PH) of a higher level.

2. Method according to claim 1, characterized in that from a lower installation level to a higher installation level the pump head of the drainage pumps (PH, PL) decreases and the capacity of the drainage pumps (PH, PL) increases.

Patentansprüche

1. Verfahren zum Pumpen von Abwasser aus einer Pumpstation zu einem Bestimmungsort für eine geförderte Wasserströmung, wobei die Pumpstation

   - einen Pumpenschacht (2), in den Regenwasser etc. durch eine unterhalb der Bodenfläche vorgesehene Einströmwasser-Hauptrohrleitung (1) fließt, und
   - mehrere Abwasserpumpen (PH, PL) umfaßt, die auf wenigstens zwei unterschiedlichen Einbauebenen angebracht sind, um Einströmwasser in dem Pumpenschacht (2) in den Bestimmungsort für die geförderte Wasserströmung zu fördern,

   dadurch gekennzeichnet, daß das Abwasser abhängig von dem Anstieg des Abwasserspiegels in dem Pumpenschacht (2) zuerst durch mehrere Abwasserpumpen (PL) einer unteren Ebene und dann durch mehrere Abwasserpumpen (PH) einer höheren Ebene gepumpt wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß von einer niedrigeren Einbauebene zu einer höheren Einbauebene die Druckhöhe der Abwasserpumpen (PH, PL) abnimmt und die Leistung der Abwasserpumpen (PH, PL) ansteigt.

Revendications

1. Procédé pour pomper de l'eau de drainage d'une station de pompage vers une destination de refoulement d'eau, la station de pompage comprenant

   - un puits de pompage (2) dans lequel des eaux de pluie et autres s'écoulent dans une canalisation principale

(1) d'eau d'arrivée disposée sous le niveau du sol, et
- une pluralité de pompes d'exhaure (PH, PL) installées au moins à deux niveaux d'installation différents pour refouler à la destination de refoulement d'eau l'eau d'arrivée présente dans ledit puits de pompage,

caractérisé en ce que

- en fonction de la montée du niveau de l'eau de drainage dans le puits de pompage (2), l'eau de drainage est d'abord pompée par une pluralité de pompes d'exhaure (PL) situées à un niveau inférieur, puis par une pluralité de pompes d'exhaure (PH) situées à un niveau supérieur.

2. Procédé selon la revendication 1, caractérisé en ce que, d'un niveau inférieur d'installation à un niveau supérieur d'installation, la hauteur de refoulement des pompes d'exhaure (PH, PL) diminue et la capacité des pompes d'exhaure (PH,PL) augmente.

FIG. 1

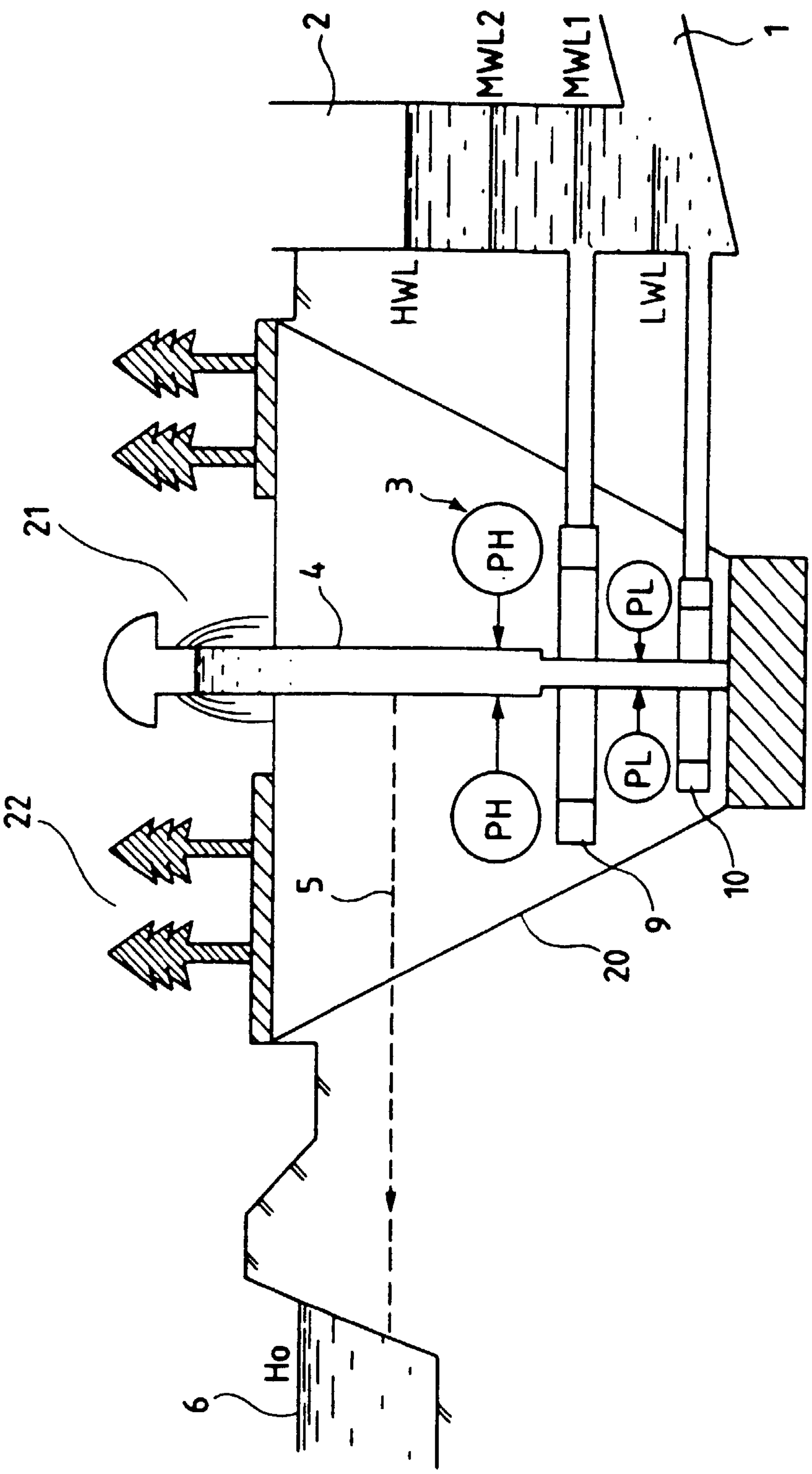


FIG. 2

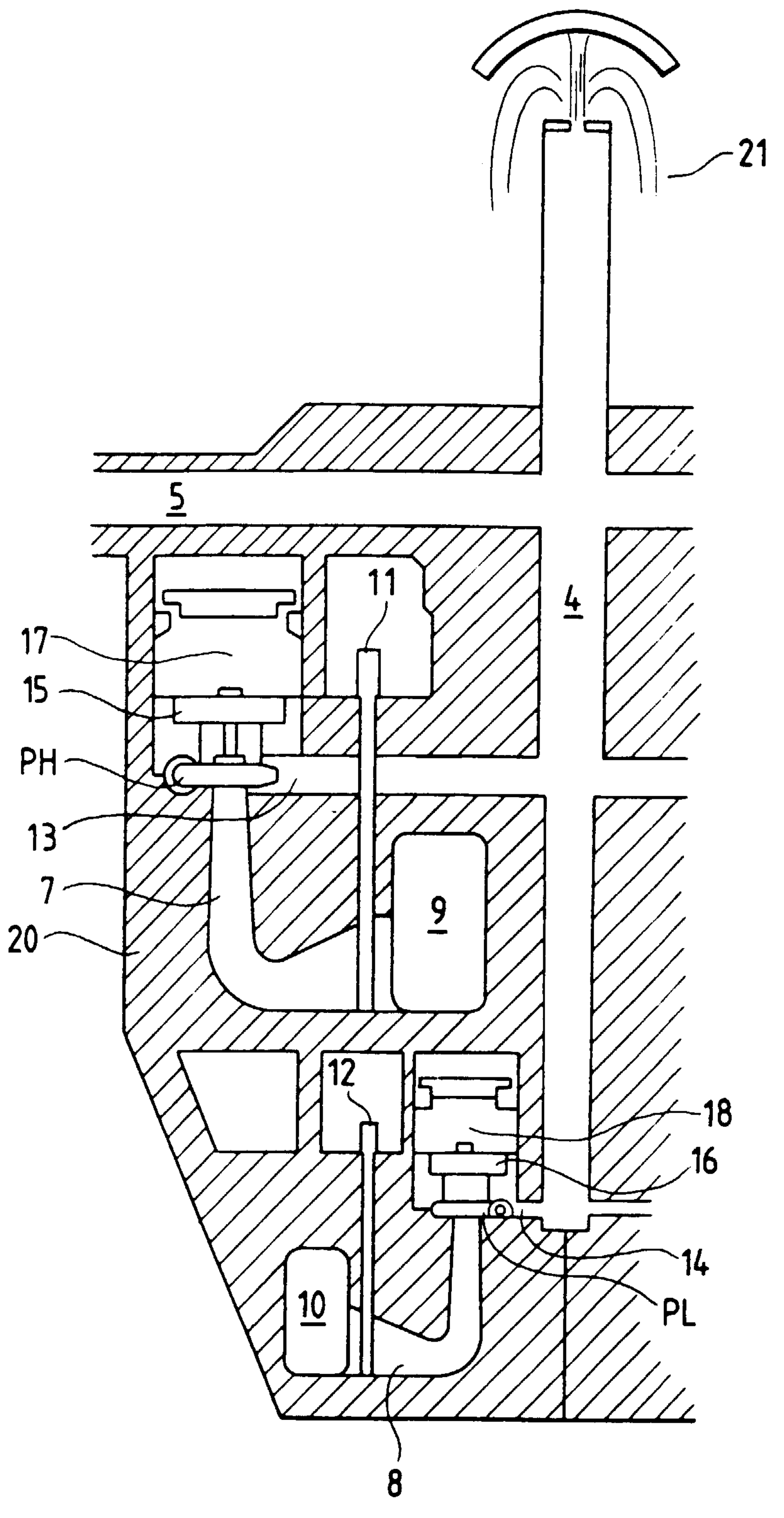


FIG. 3

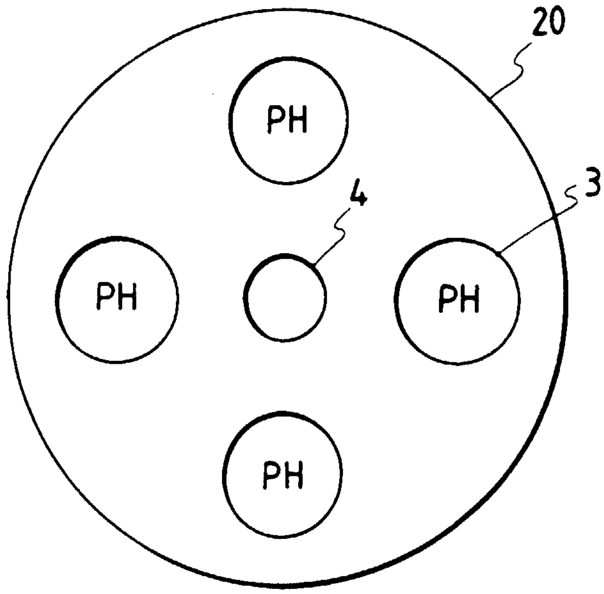


FIG. 4

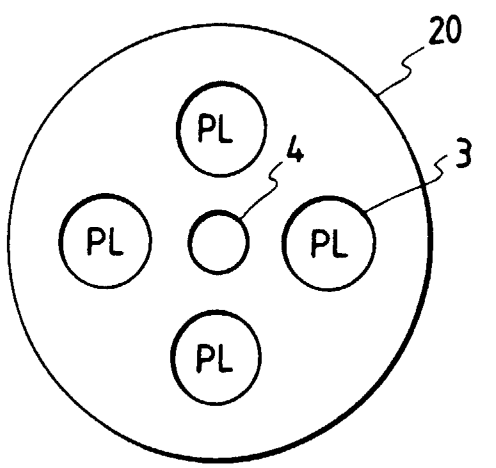
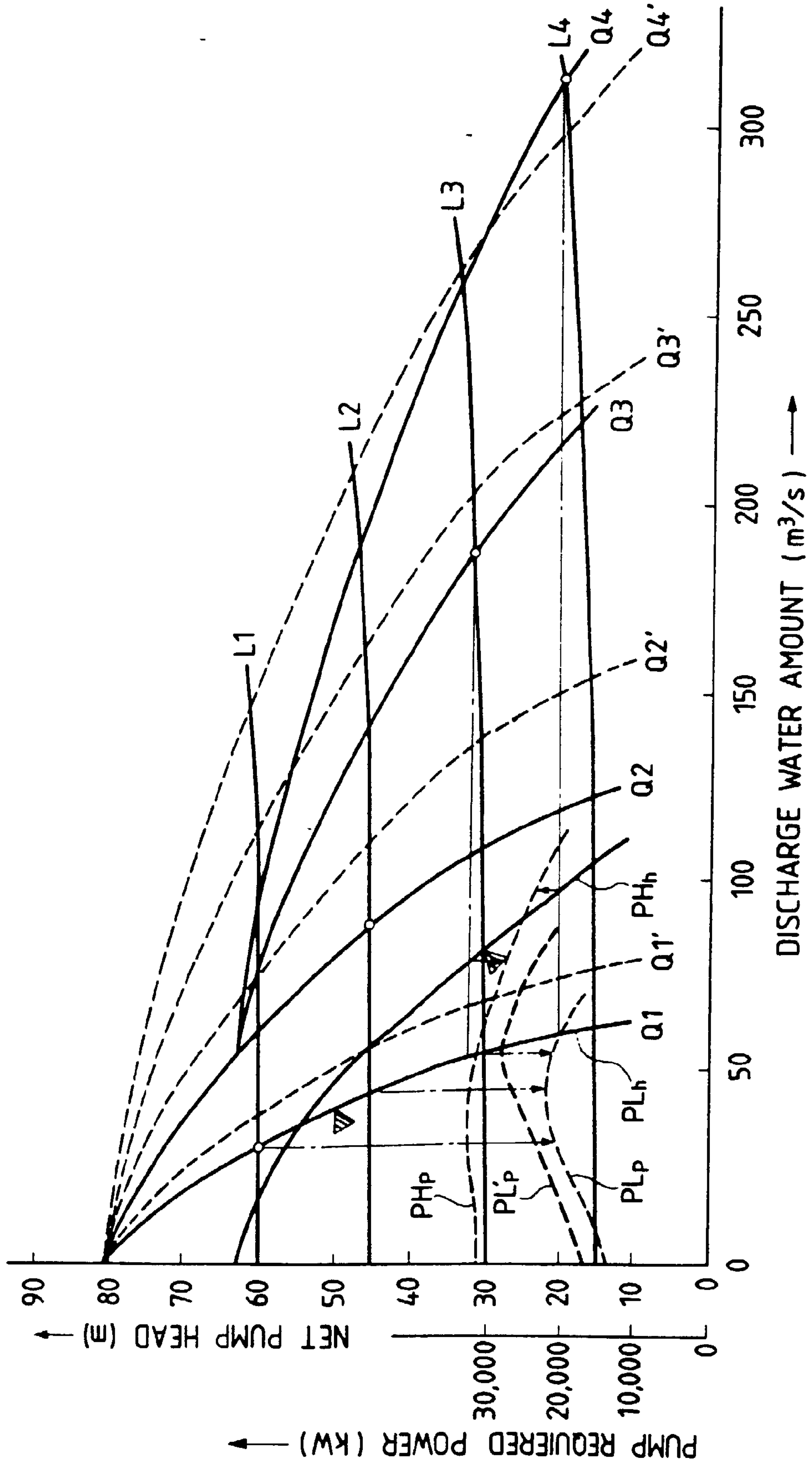


FIG. 5


NET PUMP HEAD (m)
PUMP REQUIERED POWER (KW)
DISCHARGE WATER AMOUNT (m³/s)
0
10
20
30
40
50
60
70
80
90
10,000
20,000
30,000
50
100
150
200
250
300
L1
L2
L3
L4
Q1
Q1'
Q2
Q2'
Q3
Q3'
Q4
Q4'
PHp
PL'p
PLp
PLh
PHh