# Dewatering of Mines Using Modern Submersible Technology

## Modern Dalgıç Tulumba Teknolojisi Kullanılarak Ocak Sularının Atılması

Benkt ANDE (*)

ÖZET

Madenlerdeki suların etkili şekilde drenajı, pompa sistemlerinin birbirleriyle koordineli çalışması ve verimlerinin uyumu ile mümkündür.

Pompaların seçimi ve sistemleri madenlerin derinlik ve genişliklerine bağımlıdır.

Kuru montajlı temiz su pompaları, ana pompa istasyonlarına hakim olmakla beraber son yıllarda daha güçlü dalgıç pompalar piyasaya sürülmüş ve böylece madenlerin drenajı bir çok olayda dalgıç pompalarla çözülmüştür.

Bu yazı madenlerdeki çeşitli ve önemli pompalama işlemlerini kömür madenlerindeki anti-grizu uygulamalarını ve her bir vak'adaki basit pompa ihtiyaçlarını içermektedir.

Geleneksel drenaj sistemlerinde ince katı maddelerin askıda kalmaları ve atılmaları için yeni ve sade bir teknik olan dalgıç mikserlerin kullanılışı bazı ayrıntıları ile açıklanmaktadır.

ABSTRACT

The efficient dewatering of mines is a matter of coordinating a system of pumps with appropriate capacities.

The choice of pump type and pumping system is dependent on the depth and width of the mine.

Dry installed, clean-water pumps continue to dominate the main pumping stations. In spite of this, in recent years more powerful submersible pumps have come on the market.

This paper will cover all the various major applications of pumps within a mine. The explosion-proof pumps for the coal mining is covered as well.

A new simple technique using the submersible mixer for the resuspensioning and removal of fine solids in traditional dewatering systems is described in some detail.

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## 1. INTRODUCTION

As long as there have been mines, there have been problems with removing unwanted water. One of the first mechanized mine pumps was described by Mr. Agricola, "the first mining engineer", back in 1556.

Until the 18th century water was the limiting factor in how deep a mine could be operated. The development of the steam engine was a milestone in the mine pumping. In 1705 Newcomer invented his engine and installed the first one in a coal mine in Wolverhampton.

The next major mile stone in the mine dewatering was, of course, the introduction of the electrical motor, and, finally, also the invention of the submersible pump was released

This type of pump was capable of pumping highly polluted and abrasive water. Thus it became possible to pump unsettled mine water.

Submersible pumps opened up a new pump technology and a new pumping philosophy, which includes the following major advantages:

- no risk of flooding the motor, as in the case of traditional pumps
- ability to pump unsettled mine water containing abrasive particles
- portability

## 2. SUBMERSIBLE PUMPS IN THE MINING INDUSTRY

The general design of a submersible drainage pump :

The basic material in this kind of pump is normally aluminium for portability but other materials are rubber or with some restrictions, Polyurethane lining, high chrome steel and stainless steel.

Starting from the bottom of the pump, the liquid passes a wide based, springloaded strainer before it reaches the pump inlet.

Impurities which pass the openings will also pass through the rest of the pump, which virtually prevents clogging.

The semi-opened impeller is made of high-chrome steel with a hardness of rockweil C 60. Stainless steel impellers are also available for corrosive conditions.

The impeller is trimmed against the rubber-lined pump housing bottom. With this design it is possible to adjust for wear, thus maintaining maximum performance.

The liquid is guided by the large diameter, rubber-lined diffusor, pass the motor for cooling purpose and leaves the pump through the rotatable discharge outlet on .the side of the outer casing.

The motor is sealed off from the hydraulic and by the tandem face seal arrangement on the shaft, operating in an oil chamber. The oil acts as a lubricant and cooling medium and provides an extra buffer between the pump liquid and the motor.

The completely encapsulated and dry-running motor is of a single or three phase squirrel-cage type, with either two or four poles. Most motors have series-connected thermal switches built into the stator windings, to protect against overheating.

The junction chamber on the top of the pump, in which the cable leads are connected to the terminal board, is sealed off from the motor, to prevent burn-out should moisture enter due to damage to the cable. Water sealing and strain relief functions are seperated.

The choice of pump depends upon the specific application:

## 2.1. **Face Pump**

Small, submersible units are used to keep water out of the mine working stopes and pumps it to some larger, more centrally located stage pumps at the same level. These small submersible face pumps are in the size up through 6 kW and with a max 4 inch discharge. These pumps meet the basic requirements for a face pump which are waer resistant, submersible, able to withstand dry running, has small dimensions, and be portable, all important factors when talking about working stop drainage.

## 2.2. Stage **Puap**

The characteristics of a stage pump are mainly the same as for the face pump, however, in this case of a medium size. The capacity is larger, as this pump installation takes care of water coming both from a number of face pumps plus water coming by garavity flow in ditches to the stage pump.

The stage pumps are preferably located at the suitable intervals along the drifts or ramps in order to collect thé roadway drainage. In such a system the water coming in to the roadways can be pumped to the next pump instaead of flowing by gravity in ditches, and there accumulate solids. This will also reduce the need for maintenance of the road, particularly of damages from errosion.

### 2.3. **Feeder Pump**

The main task for this pump type is to pump between levels, the installation has the character of being each mine level's main pump station. However the big difference between the feeder and main pump, is that a feeder pump installation is not permanent, which the main pump station is. Also, a feedaf pump installation has to operate with static heads of 50-70 metres, compared to a main pump which has to operate at significantly higher heads.

The water collected at the feeder pump comes from face/stage pumps and by gravity through ditches, i.e. un - settled water.

As this pump installation is mostly found at the development stage in a mine, it has to be regarded as a semi-permanent system. The two conditions, unsettled water and semi-permanent system. The two conditions, unsettled water and semi-permanent, speak for mobility and no need for the excavation of costly settlers.

Submersible heavy duty pumps in the sizes of 20-40 kW are common here. They have to:

- have a duty point between 50- 70 metres,
- be portable,
  and
- be able to pump unsettled water.

Feeder pumps should be designed for tandem operation this is an important feature in modern mining, where vertical shafts are replaced by ramps. In a modern mine lay-out total pump head is becoming more important feature than the static head. This means that the pumps selected must be flexible with regards to head requirements.

## 2.4. Temporary shaft Pump

When sinking mine shafts, such pumps have to be used which can follow the work, pumping from different levels up to the surface. It is also important to have a pump design of a " slimline " configuration to save space. Submersible pumps are becoming more popular (often the only solution) here, where they offer space saving and flexibility.

The temporary pump system for shaft sinking is mostly a two phase system consisting of in-shaft pumps as well as pumps in the temporary stations. The location of a temporary pump station is determined by :

1) the location of the major aquifer
2) the distance that the in-shaft system effectively can lift the water,
3) the characterics of the pumps available for the temporary station and
4) the excavation of slots as part of the shaft sinking job.

Instead of costly excavations of slots, only used for a temporary station, shaft water rings are used to collect both the water which seeps through the shaft wall and water coming from the in-shaft pumps.

The static pump head for the in-shaft pump is normally not more than 40-50 metres. In order to keep down the need for maintenance of the pumps, installed in such an extremely tough condition as shaft sinking, frequent rotation of the pumps and a high level of back-up is necessary. For this reason the pump system chosen should have a high degree of flexibility allowing the pumps to be installed both as in-shaft pumps, and in the temporary station.

To conclude, the pump for a shaft sinking job most meet the following requirements:

- submersible
- flexible, in respect to easy service (portable) and have wide variations in pump head
- "slim-line", thus space saving
- be able to take abrasive water

## 2.5. Stationary Shaft **Pump**

From service and maintenance reasons, complex pumping systems are not normally placed at the bottom of a shaft. Shaft pumps must be able to operate during long periods without any attendance, compared to the other installations described.

The main character of a shaft pump application is the same as for a feeder pump. The required pumping capacity varies, of course, but normally less in comparison to the feeder pumps.

Most of the water has already been collected in varios spots above the shaft bottom. Another difference is that as stationary shaft pump should have more of a sludge pump characteristics since a large portion of what is collected at the bottom of the shaft is sludge with a high solids content.

## 2.6. Main **Pump**

While the face, stage and feeder pump installations in a mine are the mine's water veins, the main pump station is the mine's water heart

In any mining operation where water occurs the main pump station plays one of the major roles, if not the most important one.

The very existance of the mine, the safety of per - sonnel and machinery, depend on the reliability of the main pump station. Consequently, the main pump is not only the mine's water heart but the very heart of the mine.

There are mainly three different configurations for the main pump station, namely:

- the horizontally mounted multi-stage centrifugal clean water pump driven by a non-submersible electric motor
- the horizontally mounted non-submersible electrically driven centrifugal pump of heavy-duty design
- the fully submersible electric pumping unit.

This paper will not cover the advantage and disadvantages of the non-submersible alternatives except for the major drawbacks of these systems, which are the costly need for bulky settlers or holding tanks, and the risk of flooding the motor.

When designing a settling basin, the question is how big should it be? There is a trade off between its size and the estimated peak capacity needed. If the basin is made too small, the "clean-water basins, pump chambers etc., make a good case for the use of larger pumps.

If, however, space for a pumping arrangement is already available on the intermediate levels, it could be more economical to have multiple lifts due to reduced excavation cost for the necessary sumps needed.

In the case where there is only space available for the pump station, a system of series-connected pumps is an alternative. However, the question is then which design criteria should be used for piping and fittings of the lower sections of the system. This lower section must be protected against the gravity head above the station in case of failure of the upper pump(s). Check valves can be installed, but any valves can fail, and then the " savings " in a series configuration over using sumps could very soon turn into a loss.

To summarize, the multistage clean water pump arrangement has a number of weak points, such as:

- Unable to pump contaminated water including abrasive particles, thus requiring expensive settling and clean water basins, and costly handling and disposal of the accumulated sediment.

- The electrical pump motor used is not water-proof. The risk of a complete break-down is always present if flooding occurs and that presents a situation when maximum pumping capacity is needed more than ever. Seperate pump chambers are needed.

- Mon of the commom alternatives are easy to service.

- Limitation as regards to mobility. The above non-submersible system permanent/stationary.

- A drainage system is required in order to drain water downwards before pumping it up again.

- The cost for horizontal drainage has a tendency to increase since the location of larger pump stations have to be protected from damages from the working stope areas.

The way to overcome these problems is to us elareg heavy duty, high'head submersible feeder pumps in combination with the already presented submersible feeder pumps. The submersible main pump, i.e. pump and motor combined in a single completely submersible unit, has appreciable advantages over today's common main pump arrangement, with it's typical drawbwcks. The submersible heavy duty concept will eliminate each of the disadvantages of a dry installed non submersible centrifugal pump.

- The heavy duty submersible doesn't require any costly installation of settling and clean water basins since the pump is able to handle contaminated water including abrasive particles. Ho handling cost of accumulated sediment.

- It is of course completely impervious to damp and water.

- Routine checks can easily be carried out right at the installation site. As the pump is easy to transport, the entire unit can be taken to a workshop for major overhaul and repaires.

- The character of mobility requires less stand-by equipment.

- Since the submersible pump does not require any special foundations, settling basins etc., a simple drainage circuit preventing the water to drain downwards is all that is needed.

- With the flexible submersible concept no costly excavation of protecting chambers for the main pump installation is needed. The location is a part of the mine's development stage closer to the work areas, i.e less cost as regards to the horizontal drainage circuit.

Submersible pumps intended for installations in underground mines are currently available in sizes from the smallest face pump of 1 kW up to the largest typical main pump of 90 kW with a max output of about 9000 lit/min, or for the high head version a total head of 200 metres. Also available is a 180 kW pump with a max output of 3000 lit/min or a total head of larger submersible units is a result of the market demand to simplify and reduce the cost of pumping stations, settling basins etc.

## 3. PUMPS IM OPEN-PIT MINES

The superiority of using submersible pumps In the dewatering of open-pit mines Is already well established. Two main types of systems are used, depending on the layout of the mine and the local conditions regarding groundwater and rainfall.

In fairly flat and level mines covering an extensive area, small and medium size wear-resistant submersible pumps can be installed in simple pumping stations or sumps. As a rule, the station will merely consist of a pit or a prefabricated perforated concrete pipe.

These pumps deliver the water to a main pumping station which then pumps it out of the mine. In principle, the main station can be of the same simple design as the smaller stations and the same types of pumps can be used, although of larger sizes.

In deeper mines with relatively moderate lateral expansion (small bottom diameter) it is normally preferable to install the pumping capacity at one location. At places where the water inflow is highly irregular, and at times extremely large, the submersible pumps can be installed on rafts that follow the level of the water as it rises and falls.

Since wear-resistant submersible pumps with comparatively large capacities at delivery heads of 300-350 m are now available, water can often be pumped out of the mine in one single stage. Where this is not possible, an intermediate pumping station of the same simple type can be arranged or non-submersible booster pumps can be used. However, these must be adequately protected in tough climates and installed high enough in order not to become flooded. Such flooding have occurred in areas with periods of heavy rainfall with resulting costly consequences.

## 4. PUMPS IN GASSY AREAS

In coal mining, as well as in many other industrial branches, combustible materials, which can form explosive gas, are present.

Accidental ignition of such explosive atmospheres, i.e. by an electrical spark or an excessively hot surface, may cause an explosion which will endanger life and property.

Much of the safety progress in mining is a result of different safety acts. International, national and local acts and regulations have been essential tools in the challenge to reduce the risks in coal mining.

In 1912 the Association of German Electrical Engineers (VDE) issued the first directives, dealing with the protec - tion of electrical equipment in mines where hazard of fire-damp existed. Since then many countries have established their own national regulations.

In 1975 the European Economic Community released a decree covering the use of electrical devices in explosive atmosphere, i.e. in hazardous locations.

From here a joint standard valid in most of the European countries has been worked out and published by CENELEC.

It would lead too far to go into any details on this subject of explosive areas and explosion-proof equipment but basically one should know that in an electrical installalion the ignition sources can be :

- mechanical sparks,
- heated surfaces,
- electrical arcs and sparks

and to avoid the **mechanical sparks** created by a collision, friction etc. is just a matter of selecting the right material for the product.

The **exterior surfaces** of the equipment must not ex - ceed the maximum permissible temperature. The way not to exceed this temperature is to choose the right material quality and to design the equipment for good heat transfer.

To avoid **electrical arcs and sparks,** the enclosure for the electrical equipment must be designed in such a way that it can withstand the pressure created if an explosion inside occurs.

Sparks created inside the same enclosure must also be prevented from propogating to the outside. This is done by using closer tolerances and increased slit depth in the design.

Since the beginning of the I960's explosion proof submersible pumps for the coal mining industry have been a-vailable.

## 5. SUBMERSIBLE MIXERS IM THE MINING OPERATION

**A** new line of submersible mixers for solid suspension and blending applications are now available. The unique installation principle consists of an integrated submersible electric motor, propeller and a guide bar.

One of the key advantages with the new mixer is the opportunity to adjust the mixer after it has been installed. This guarantees that the required mixing result can be reached. The system is also very flexible. It can be in - stalled in all types of tanks and is independent of tank volume and shape. Since the mixer is submerged it is almost completely silent.

As a result of the unique installation principle and flexibility this new mixer concept now makes mixing and resuspension possible in fields where mixers or other traditional equipment in the past have proven to be economical.

One example where this new concept is successfully employed as cost-cutter is for the resuspension of the accumulated mud in mines ' settling basins, adjacent to the multistage clean-water pumps, to such a degree that it can be pumped out by means of a submersible heavy-duty vortex impeller pump.

In the case where heavy-duty pumps are employed in - stead of clean-water pumps, the settling basin is replaced by a holding tank. A common problem in this case is that solids in the water settle out in the tank, this sediment either blocks the pump inlet or is too dense, causing excessive wear on the pump. Various methods to keep the sediment in suspension are known, of which the most common is to use compressed air. However, this method is costly and it diverts air needed elsewhere. Furthermore, the mixing result is usually poor.

With a submersible mixer it is easy to achieve com - plete and uniform mixing which is important for an efficient operation of the pumps. Add to this the savings in costly compressed air, in pipes etc.

## 6. Resuspension Of Lagoons

There are primarily two reasons why it is necessary to clean up deposit sludge lagoons. One is environmental restrictions, and the other necessity of reusing the laaonns. The cost of tailing disposal tends to increase as a result of increased safety and ecological awareness, more complex mineral processing when mining lower-grade ores etc. Today the cost of the tailing handling in many mining operations is the major operating cost. There is therefore a growing interest in methods for minimizing these costs.

The water content In a tailing will vary from operation to operation. The tailing slurry may contain anywhere from 15-20 % up to 80-85 % water by weight, i.e. the physical properties of tailings can vary a lot. Generally speaking, the nateure og tailings is such that it never dries out. It can be seen in conditions from moist to wet and often in quite plastic (tixo-tropic) form, and will flow if given the opportunity. In general one can state that lagoon cleaning by using traditional equipment is quite a large problem and a high cost operation. The situation has now improved, as one can use a submersible mixer and a heavy duty submersible pump mounted on a raft.

This combination has shown a very good performance and is technically superior, compared to more regular equipment such as draglines, front-end loaders etc. Also the investment cost for such a raft is considerably lower.

## 7. Concluding Comments

The intention with this paper has been to give a broad overview of water handling within the mining industry and, in particular, mine drainage all the way from the face to the surface.

In particular the use of submersible heavy duty pumps has been presented, as it is being increasingly accepted as a way to solve the drainage part of the operations. Today this also includes large submersible pumps as the " main pump " in the mine.

References;

1. HEDBOM U. "Submersible Pumps in the Mining Industry"
Svensk Bergs- och Brukstidning 4/1978

2. KRATZ O. "Submersible pumps for mine drainage", Mining Equipment Int., 1982

3. KRATZ 0. " Guide to underground mining and dewatering of mines ", Flygt AB publication 1983

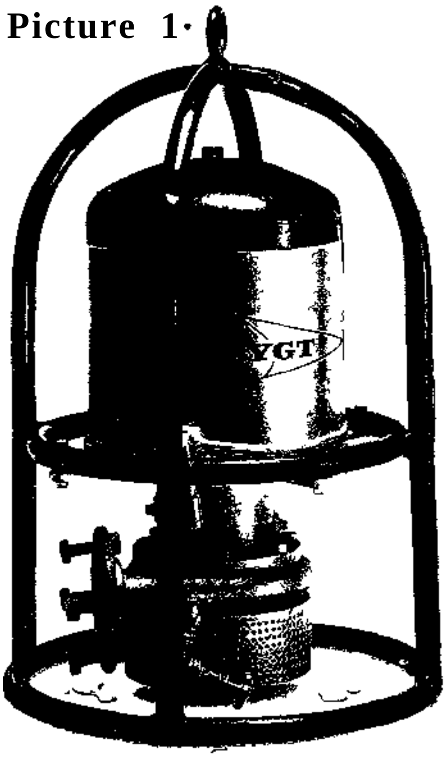
4. HEDBOM U. & KRATZ 0. " Submersible mixers for mining and mineral processing ", Flygt AB publication, 1985

5. ANDEN B. " Main Dewatering of mines, new cost saving techniques ", Mining Water, Granada, Spain, Sept.1985 Proceedings of the Second Int. Congress, convened by the Int.Mine Water Assoc.(IMWA)

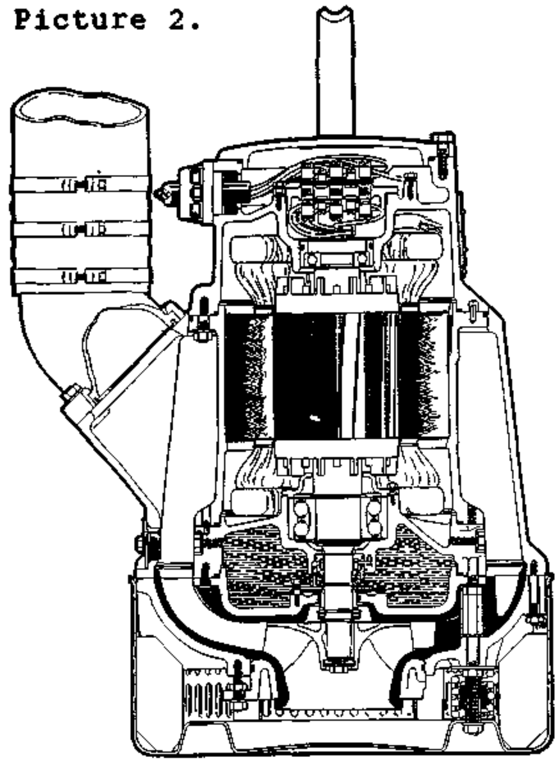
" New submersibles Assume Main Mine Dewatering Duties ", E & MJ, Nov. 1987

" Drainage of Mines " Mintech. '89, The annual Review of Int. Mining Technology and Development

Picture 1·



Picture 2.



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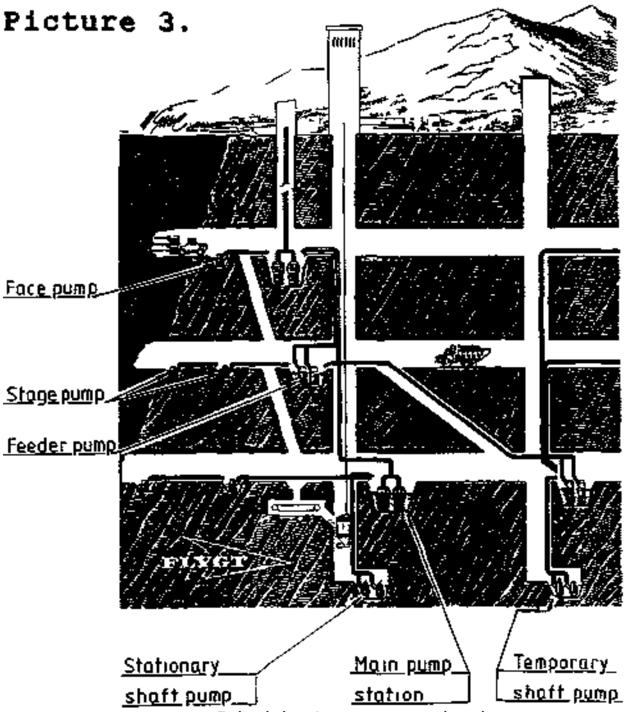


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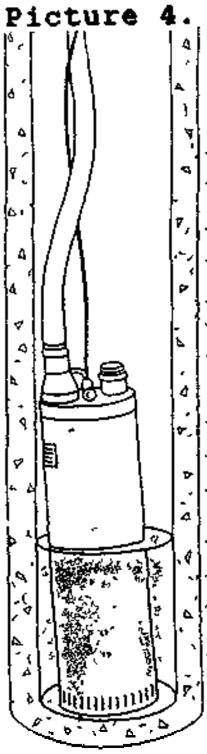
Picture 4.



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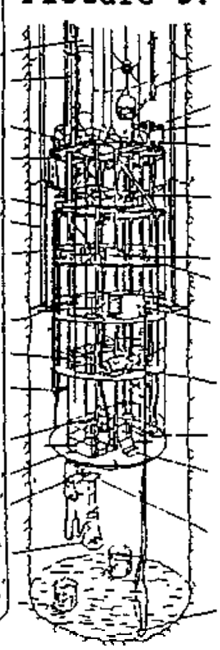
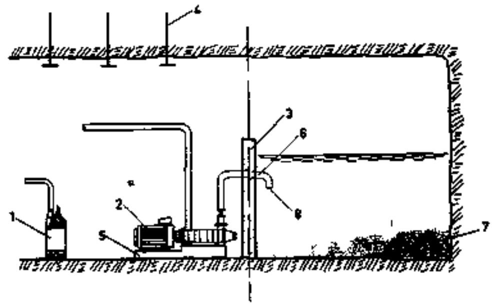


## Picture 6.

THE MULTISTAGE CLEAN-WATER SYSTEM

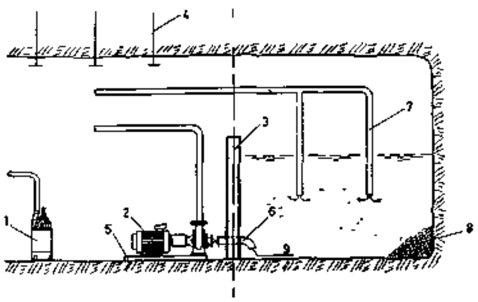



**DRY PUMP CHAMBER**

**WET PUMP CHAMBER (settling tank)**

## Picture 7.

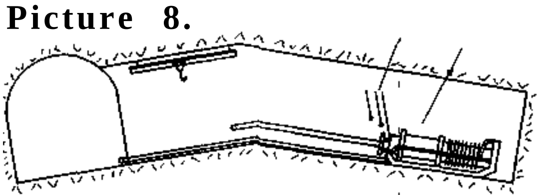
THE HEAVY DUTY SYSTEM




DRY PUMP CHAMBER

WET PUMP **CHAMBER** (Holding tank)

## Picture 8.



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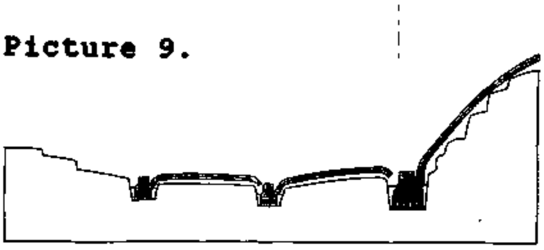

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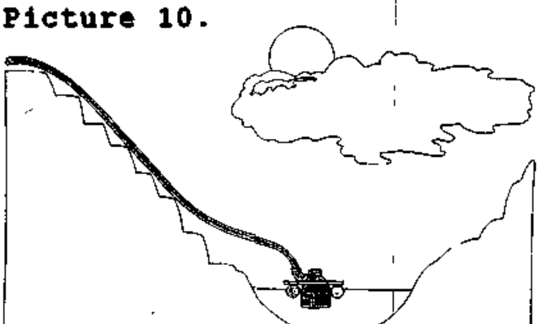

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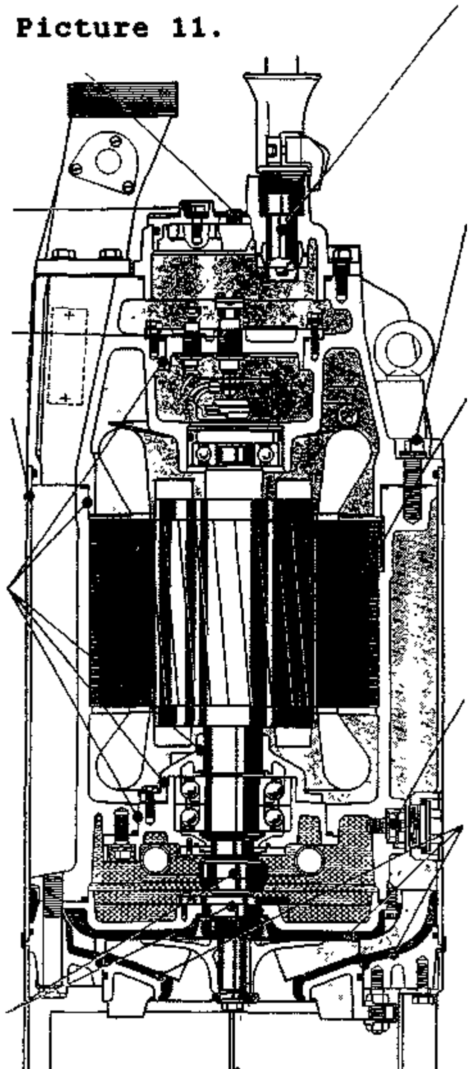

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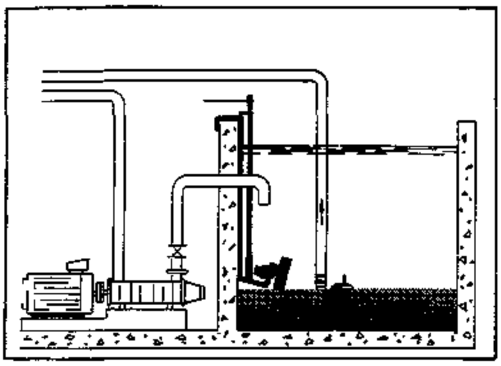


**Mixer and submersible heavy-duty pump installation for cleaning of settling basin.**

## Picture 12.

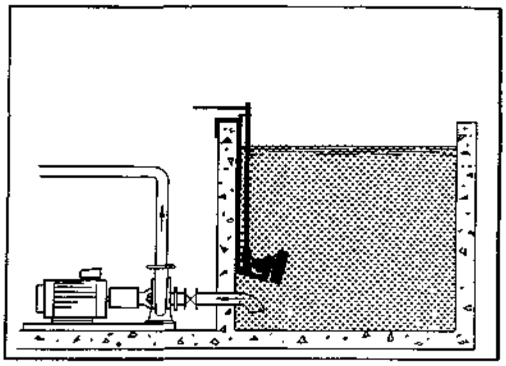
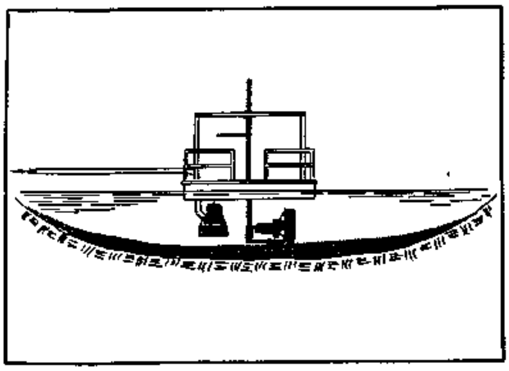


**Illustration showing** the submersible mixer in holding **dam for** complete and uniform mixing

## Picture 14.



Lagoon **cleaning with the mixer-pump-raft concept.**

## Picture 15,