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HEAT STORAGE IN AN UNINSULATED WATER PIT

(Construction and testing of a 500 m^3 store)

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ABSTRACT

Design and construction of a 500 m^3 warm water pit have been carried out.

The store is situated on the campus of the Technical University in Lyngby, Denmark.

The pit with a pyramidal geometry has been dug into the ground from the ground level. The store/soil interfaces are made waterproof with a plastic liner, but no insulation materials are used. The floating lid is heat insulated and protected against evaporation from the pit and against climatic conditions by use of a plastic liner and a butyl liner. Simulation of the anticipated different types of solar collectors is created by circulating the pit water above a heat exchanger fed by a gasfired boiler. Approximately 80 sensors are measuring temperatures in the water and in the soil under and around the pit.

A finite-difference technique for calculating temperatures in the surrounding soils is used. The testing as well as numerical calculations are in progress. This work is expected to be finished in the autumn of 1983.

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INTRODUCTION

The main purpose of the design and construction of the storage pit was to gain experience by allowing extreme reductions in the investment costs for heat stores without seriously increasing the operating costs. Only very low investments can ensure an over all operating cost for heat storages making seasonal storage of solar and waste heat feasible.

Preliminary investigations favour warm water stores placed either totally in the ground or partly buried in the ground with the diggings placed around as embankments, forming a pit of conical or pyramidical geometry.

This paper gives the results of the design and construction of a 500 m^3 warm water test pit, which is *uninsulated* at the store/soil interface.

The store is situated on the campus of the Technical University in Lyngby, Denmark. The ground water level is located 40 m below the ground surface, and the soil has not given geotechnical problems in relation to the excavation of the heat store.

DESIGN AND CONSTRUCTION OF THE STORE

The pit with a pyramidal geometry has been dug into the ground from the ground level, see a cross section in figure 1. The store/soil interfaces are made waterproof by using a 2.5 mm polyethylene plastic liner. A photo of the lining work is shown in figure 2.

The floating lid is heat insulated by 0.5 m polystyrene and protected against evaporation from the pit and against climatic conditions by use of a 2.5 mm polyethylene plastic bottom liner and a 1.0 mm butyl rubber liner for the topside. The lid was constructed in a "dry dock" next to the store and was easily floated to the final position. A photo of the final plant is shown in figure 3. The construction was completed in 3 months during the summer of 1982.

EXPERIMENTATION

Approximately 80 sensors are measuring temperatures in the water and in the soil under and around the pit. The temperatures are scanned automatically once an hour. Every day the data logger system prints all the daily mean temperatures on paper and on tape (for later transfer to our computer center).

The heat input to the water in the pit is generated by a gas boiler, see charge system in figure 4. The first charge period started in September 1982 with a water temperature of 15^{o}C, and a temperature of 60^{o}C was attained one and a half months later with a heat input of 50 kW per day at the most.

The discharge system is shown in figure 5, and the first discharge bringing the temperatures from 60^{o}C to 30^{o}C was completed after about five weeks. The cooling effect had a peak power of 22 kW.

Contrary to normal operations with a water storage, a uniform temperature distribution in the water is aimed at during the charge and discharge. A temperature difference between top and bottom has been limited to 0.3°C.

EXAMINATION OF THE SOIL CONDITIONS

In order to calculate the temperatures of the surrounding soil the thermal properties of the soil must be known. It is shown by Hansen et al. (1982) that the thermal properties can be determined with good accuracy by a normal geotechnical examination. For this purpose the grain size distribution, the dry density, the degree of saturation and the porosity must be known.

The soil can roughly be described as a 4-5 m thick layer of clay. Under this layer, sand with different degrees of saturation was found. The thermal conductivity lies between 0.8 W/m °C and 2.2 W/m °C, and the thermal diffusivity lies between 17.0 m^2/yr and 31.4 m^2/yr.

NUMERICAL CALCULATIONS

A mathematical model for 1/8 of the store and the surrounding soil has been established. In the model the method of finite differences have been used to calculate the temperatures of the surrounding soil. The grid points in a horizontal plane and in a vertical plane are shown in figure 6.

CONCLUDING REMARKS

The testing as well as the numerical calculations are in progress. This work is expected to be finished in the autumn of 1983.

The design and the construction of the 500 m^3 warm water pit have given a considerable experience in many ways. The described layout of the storage is too small economically as a seasonal storage, but work for new solutions on economic sizes of water storage pits is in progress.

ACKNOWLEDGEMENT

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BIBLIOGRAPHY

Hansen, Kurt K. and Preben N. Hansen (1982): SEASONAL HEAT STORAGE IN UNDERGROUND WARM WATER STORES (Construction and testing of a 500 m^3 store). D. Reidel Publishing Company (for CEC), Solar Energy Applications to Dwellings, Volume 2, Series A page 404 ff.

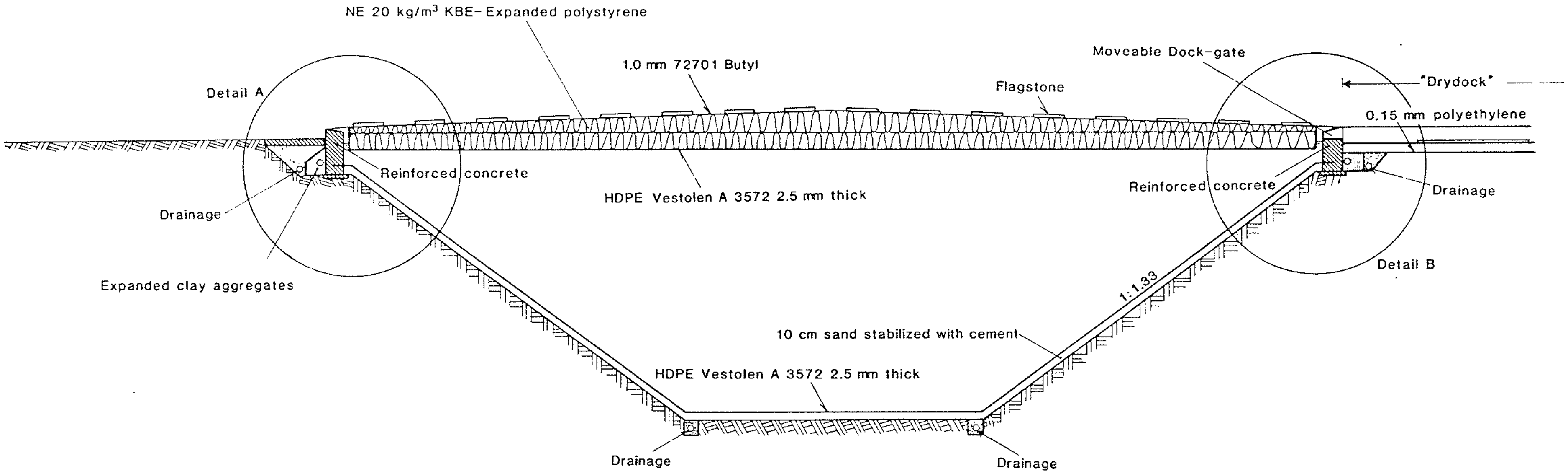


Figure 1. Sectional view of the 500 m^3 test pit.

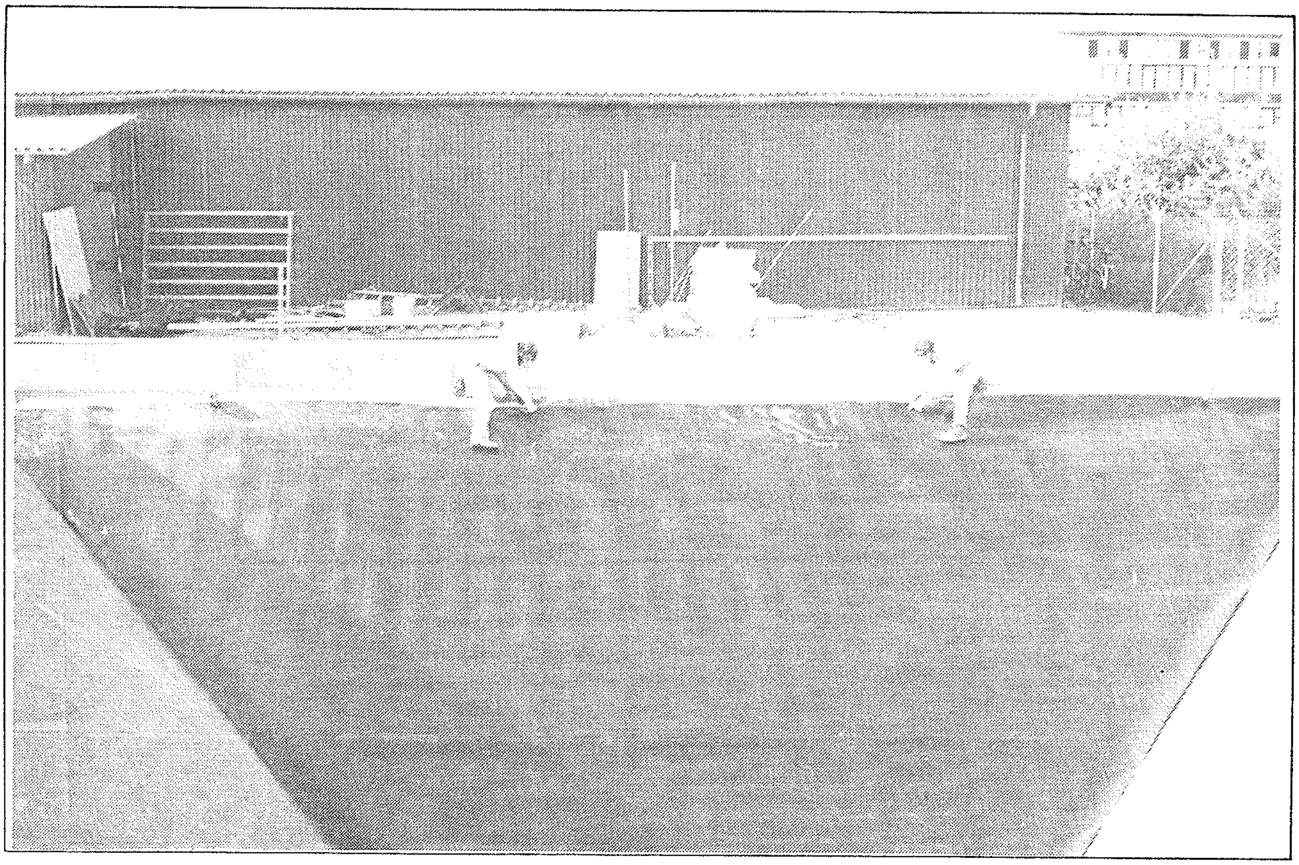


Figure 2. The lining work in progress.

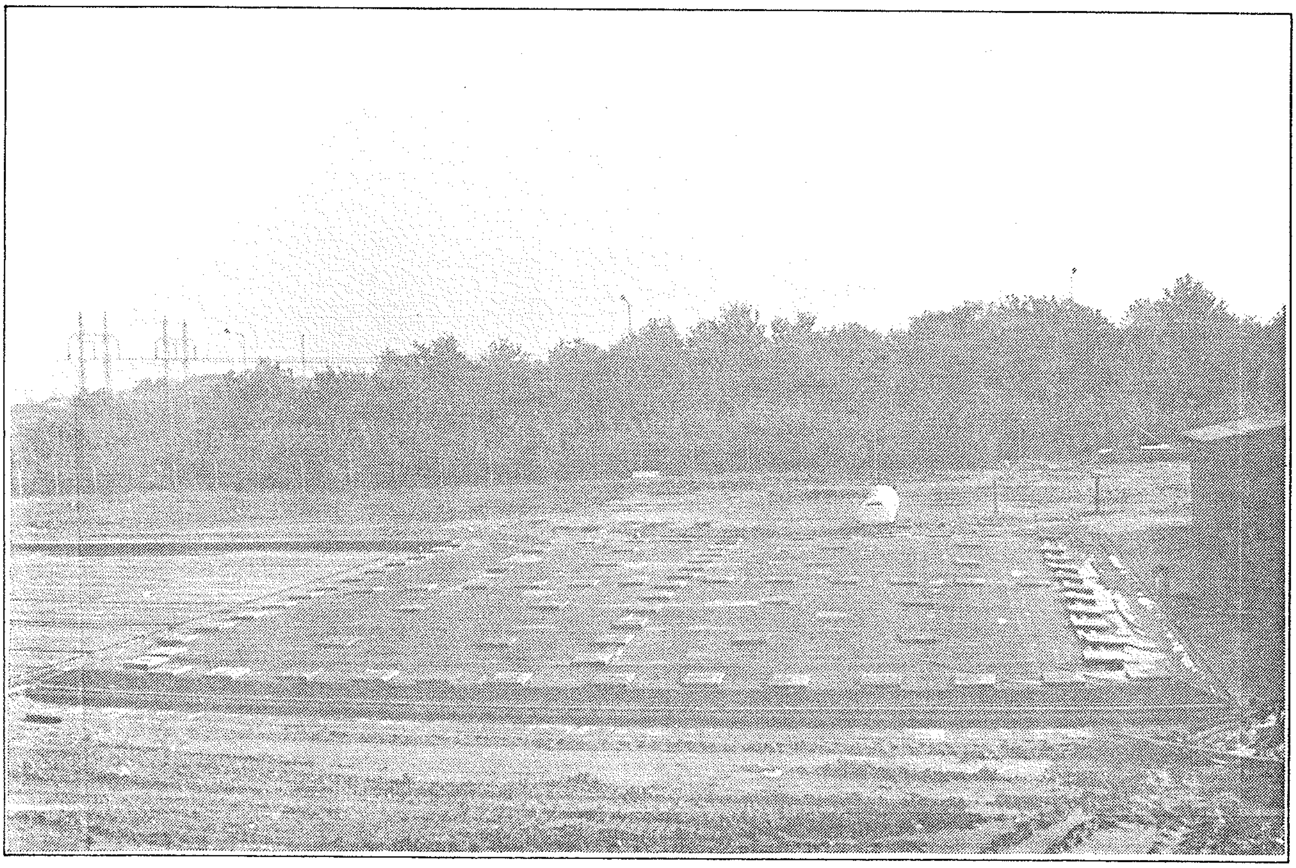


Figure 3. The final plant. The "dry dock" where construction of the lid was undertaken, is partly seen to the left.

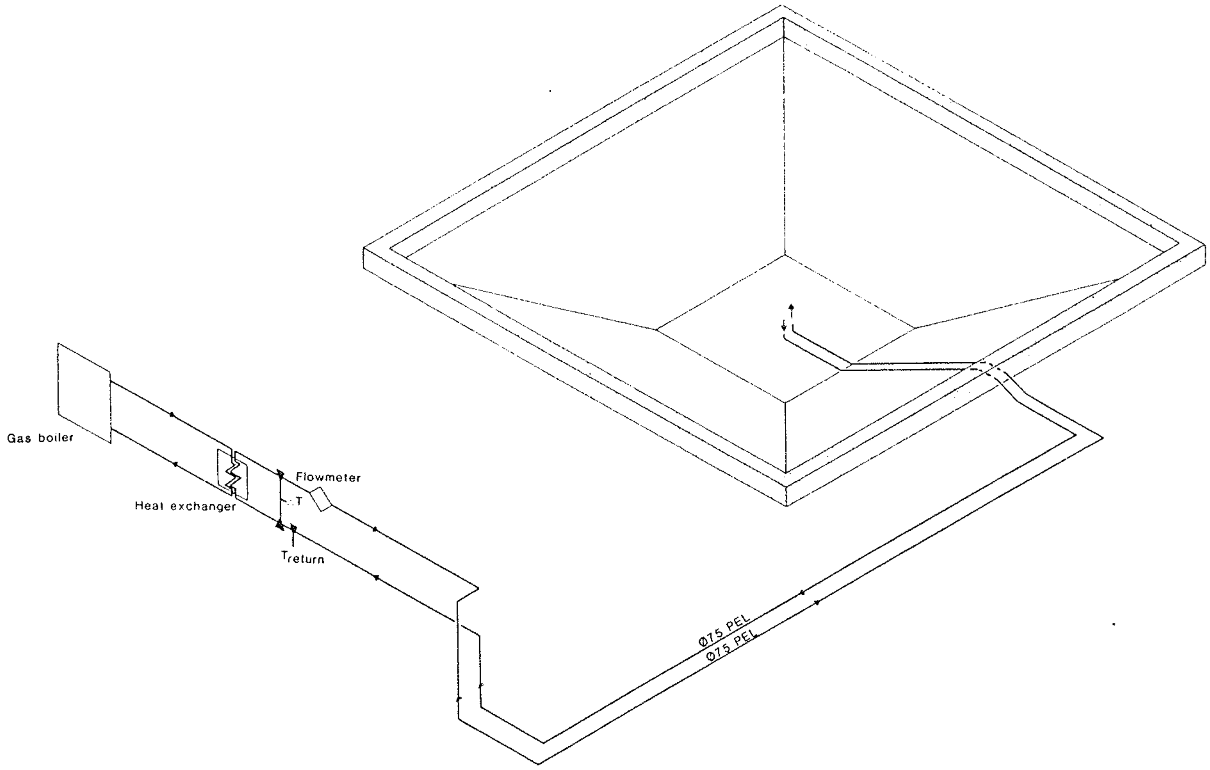


Figure 4. The charge system.

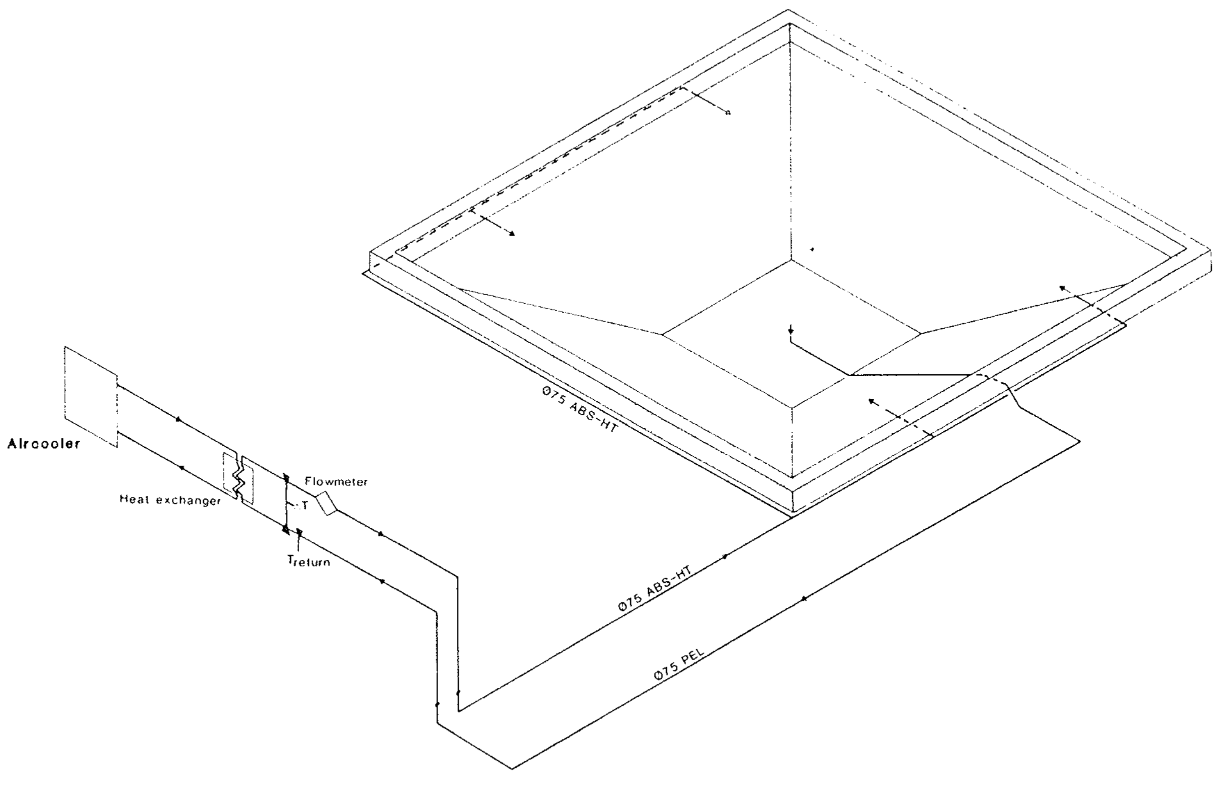
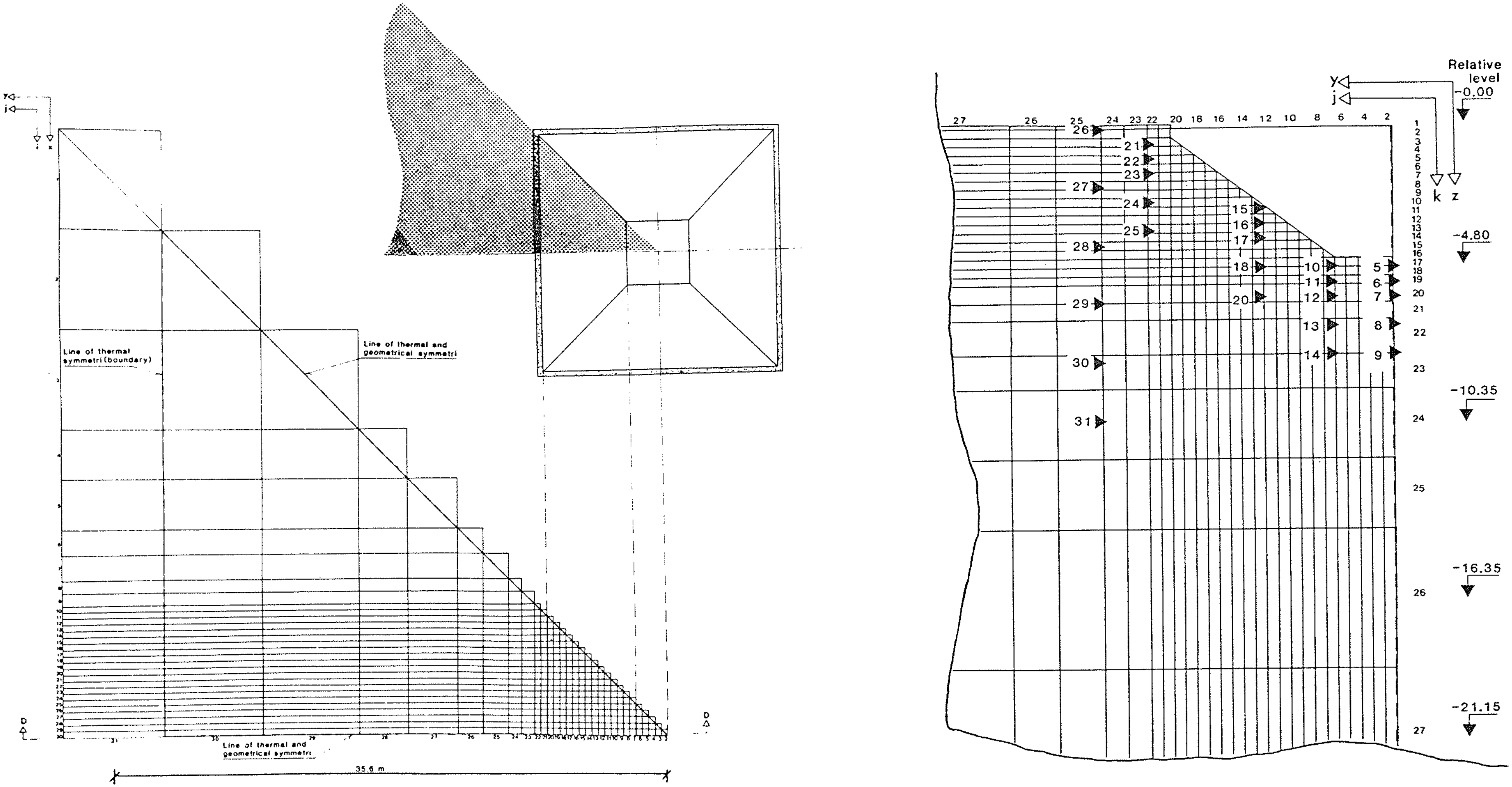


Figure 5. The discharge system.



NOTE : ▶ Measuring points

Figure 6. Position of the grid points in horizontal plane to the left and vertical plane to the right.