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THE NEA POWER PLANT

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NORWAY

THE NEA POWER PLANT

The Nea Power Station is situated on the upper part of the Nea River, in the mountain about 120 km east of Trondheim, close to the border between Sweden and Norway.

Three Francis type turbines, each of 70.000 H.P. are installed in the station utilizing a gross head of 376 m between Vessingsjø intake reservoir at 674 m and the outlet in the river Nea at 298 m above sea level.

The maximum flow through each turbine is 16 cu.m per sec. and the total energy production is about 600 mill. kWh a year.

Reservoirs for the power station are the lakes Sylsjøen and Essandsjøen, and below these the smaller intake reservoir Vessingsjø mentioned above.

Sylsjøen, which is an artificially enlarged lake

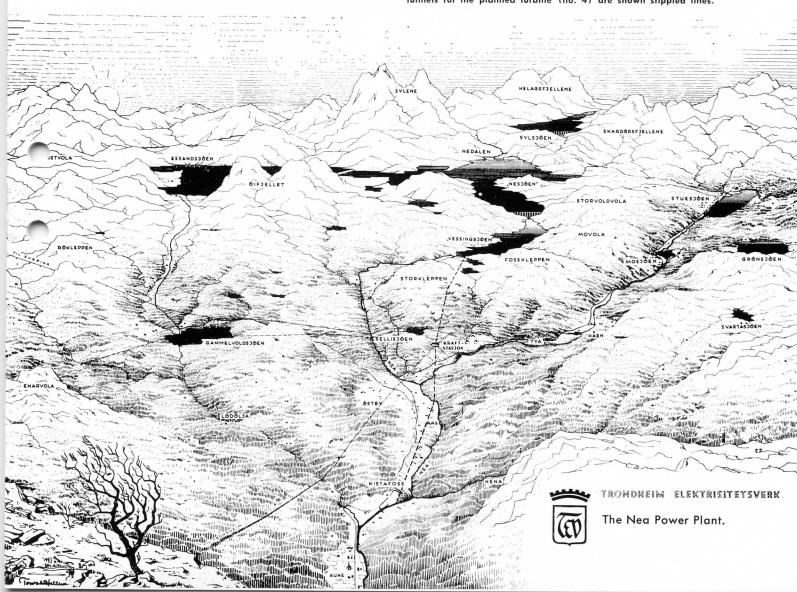
on the Swedish side of the border, is formed by the Nea River at 851 m above sea level and contains 185 mill. cu.m.

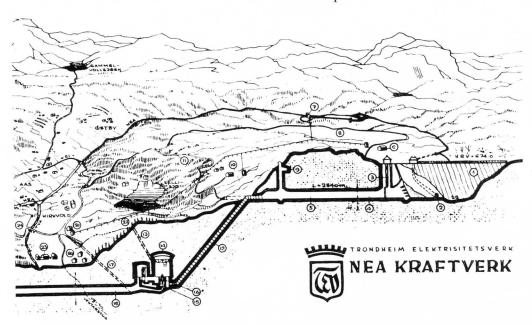
Essandsjøen, which is the source of a tributary of Nea, is a lake on the Norwegian side of the border, regulated by a dam and containing 145 mill. cu.m. The smaller intake reservoir Vessingsjøen, holding 35 mill. cu.m. is formed by a dam across the Nea Valley somewhat downstream from where the tributary of Essandsjøen joins the river Nea.

Plans are made for a second power station utilizing the head between Sylsjøen and the river Nea. This station will have an output of 20.000 kW with a net head of about 100 m.

Another plan is the building of a 30 m high dam across the Nea Valley somewhat upstream

Fig. 1. The map illustrates the drainage area of the Nea Power Plant. Also shown are the headrace- and discharge tunnels (stippled lines). Electric transmission lines from the plant leads to Sweden (to the left) and to Trondheim (bottom left). Headrace tunnels for the planned turbine (no. 4) are shown stippled lines.





- 1. Intake reservoir (Vessingsjøen).
- 2. By-pass tunnel.
- 3. Intake.
- 4. Headrace tunnel.
- Power plant for the errection of plant Nea.
- 8. Road to Vessingsjøen.
- 9. Surge tank.
- 10. Pipe tunnel.
- 11. Road to the surge tank.
- Steel lined pressure shaft.
- 13. Tunnel for electric cables.
- 14. Power station.
- 15. Turbines.
- 16. Generators.
- 17. Transformers.
- Outdoor electric installations.
- 19. Discharge tunnel.
- 20. Transport tunnel.
- 21. Housing for plant engine
- 22. Electric cables from item
- 23. Administration office.
- 24. Rock dumping.

from Vessingsjø. This dam will form a third large reservoir, holding 350 mill. cu.m. for the Nea Power station and will serve as tailwater level for the future station mentioned above.

This reservoir — called Nesjøen is shown on the map, fig 1. Plans are also made for building a power station producing about 20.000 kW between the Nesjø and the Vessingsjø.

From the intake reservoir — Vessingsjø — the headrace (a 3.000 m long tunnel of 26 sq. m in cross section) leads the water to a surge tank system. From here it passes through a trash rack and a horizontal conduit mounted in a tunnel. This penstock is equipped with a butterfly valve and two air inlet valves. The steel lined pressure shaft is inclined at 33° to the horizontal. — The internal diameter of the lining is 3.300 mm.

The above mentioned butterfly valve, which is furnished with a by-pass gate valve, will automatically close if the flow increases above 48 cu.m per sec. corresponding to full gate opening of the three turbines. A signal for closing will then be given by a device which is installed in the pipe and acts by a lever principle. In the case of pipeline fracture, for example, the flow will increase, and the resulting increase in velocity will tilt the lever, which in return will operate the mechanical closing mechanism of the valve. The latter may in addition be operated by remote electric control from the power station.

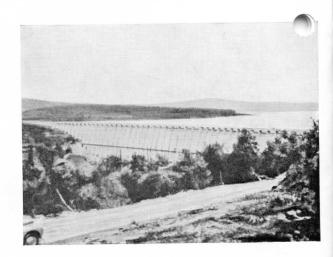
The two air inlet valves — mounted downstream from the butterfly valve — will open to avoid vacuum in the pipe when the butterfly



valve is closed and the pressure shaft is being drained. They will not close until the shaft is again filled with water and the air expelled.

The lower end of the pressure shaft divides into three branch pipes furnishing water to the same number of turbines. The underground station is excavated out of solid rock.

A hydraulically operated main gate valve equipped with a bypass is mounted on each branch leading to a turbine. Ahead of these are valve units for draining the pressure shaft, one on each branch. Each unit consists of a gate valve and a needle valve. The pressure shaft draining pipe leads to the turbine draft tube.



The turbines are of the vertical Francis reaction type. The spiral casings are made of cast steel, and on each is mounted a relief valve equipped with an energy absorber from which water may pass directly into the draft tube.

The draft tubes have outlets to a 5.900 m long discharge tunnel of 36 sq.m cross section. This has a smooth concrete floor and leads to the river Nea, joining the latter just below a small waterfall named Kistafoss, which thus is utilized by the Nea Power Station.

The entrance to the station hall is a tunnel 1200 m long, sloping 1:8.5.

From the transformers, located in the hall, leads a 900 m long cable tunnel to outdoor electric installations.

When all three turbines are running on full load, the tail-water level is about 3 m above the centerline of the spiral casings (the latter being on a level of 300.5 m). If, however, only one turbine is on load, the tail-water level is about 1 m above the mentioned centerline. This comparatively large variation in the tail-water level is due to the friction losses in the long discharge tunnel.

Leakage in the power station hall is drained through covered ditches into a sump at one end of the hall. The sump is emptied by two automatically working centrifugal pump units with outlets to the discharge tunnel.

Above the pump room is mounted a 400 kW auxiliary turbine.

Cooling water for the transformers, generators, turbine governors and bearings is steadily supplied by one of two pump units fed from a supply tank, which in turn is supplied by drain-pipes from the sealing rings in the turbine covers.

One pump unit is held in reserve while the other is working. The reserve pump goes automatically into operation if the other should fail.

If none of the main turbines are working, the supply tank is fed by the discharge of the auxiliary turbine.

As an additional reserve a water tank located above the station hall will supply the cooling system for a while if both pumps are out of working order.

To the Nea Power Station KVÆRNER has delivered the following equipment:

Gates for dams and intakes.

The all-welded lining for the pressure shaft with butterfly valve and branch pipe.

Main gate and drain valves for the turbines.

Vertical Francis turbines with governors.

Discharge draft tubes with gates.

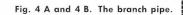
Auxiliary turbine.

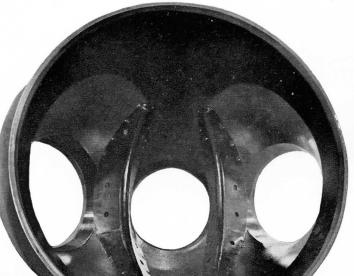
Pumps and piping for cooling water.

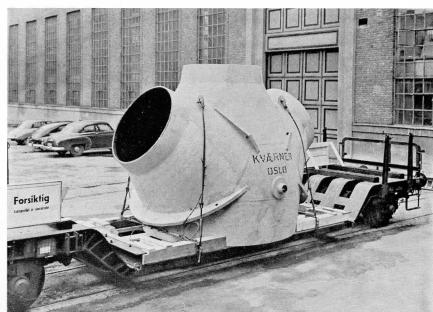
Drain pumps.

Turbine unit No. 1 was put into operation for the first time in April 1960, the second unit in August, and the third unit will be started in November this same year.









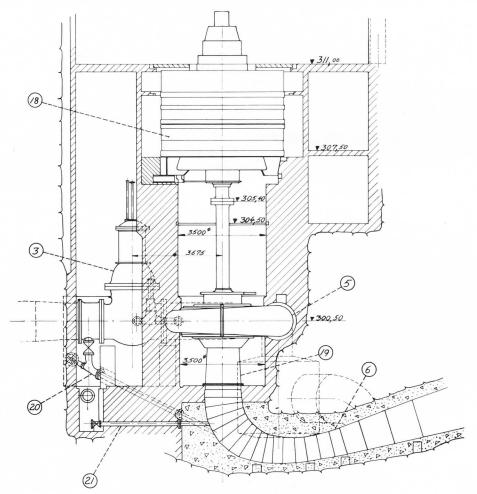


Fig. 5. Sectional elevation of one of the three identical power producing units.

- 1. Branch pipe.
- 2. Connecting pipe.
- 3. Main gate valve.
- 4. By-pass valve. 5. Spiral casing.
- 6. Discharge draft tube.7. Relief valve and energy absorber.
- 8. Outlet from energy absorber.
- 9. Turbine governor.
- 10. Actuator cabinet.
- 11. Ejector discharge pipes.
- 12. Pressure pipe for aux. turbine.
- 13. Auxiliary turbine.
- 14. Discharge pipe from aux. turbine.
- 15. Top view of vertical draining units.
- 16. Motors for vertical cooling pumps.
- 17. Staircase and lift.
- 18. Generator.
- 19. Draft tube cone.
- 20. Drainage valve for pressure shaft.
- 21. Draft tube drain.

Fig. 6. General plan view showing the turbines in the Nea Power Station.

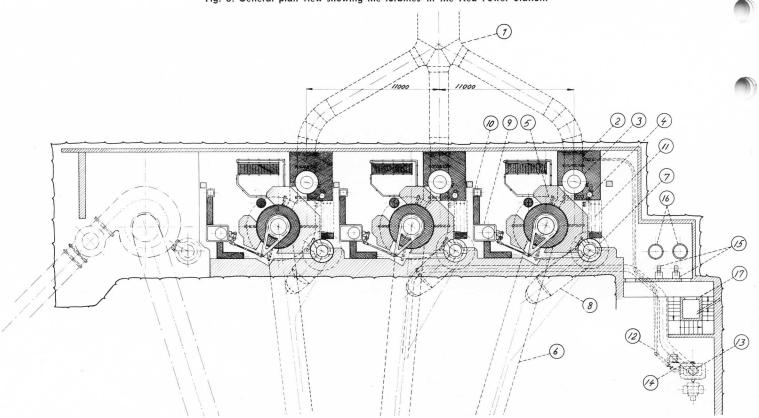




Fig. 7. A layer of stainless steel being welded on the turbine cover by the application of an automatic welding machine.

Provisions are made for installation of another 40.000 H.P. Francis turbine in the same station hall, working on water from the rivers Tya and Lødølja. These will communicate with a small lake, Sellisjøen above the Nea Power Station as shown in fig. 1. From this lake, serving as an intake reservoir, a pressure shaft down to the turbine will give a net head of about 200 m. In the station hall, room is provided for the turbine and draft tube.

Downstream from the discharge tunnel of Nea Power Station still another station is under construction, having a headrace tunnel with a total length of 10.000 m. As an additional benefit this power development will prevent heavy floods which previously caused considerable damage, especially in the winter time.

About one half of the electric energy produced at Nea Power Station will be transmitted to the Swedish capital of Stockholm, and the other half will be transmitted to the Norwegian city of Trondheim.

Transmission lines are shown on the map fig. 1.

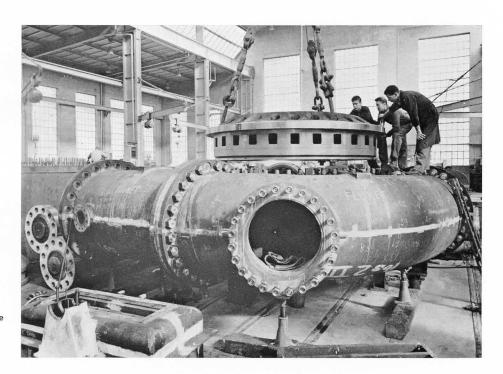
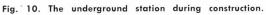


Fig. 8. Shop assembly of a turbine



Fig. 9. From the fitting shop. The spiralcasing of a Nea turbine in the background left and the runner in the center of the picture.



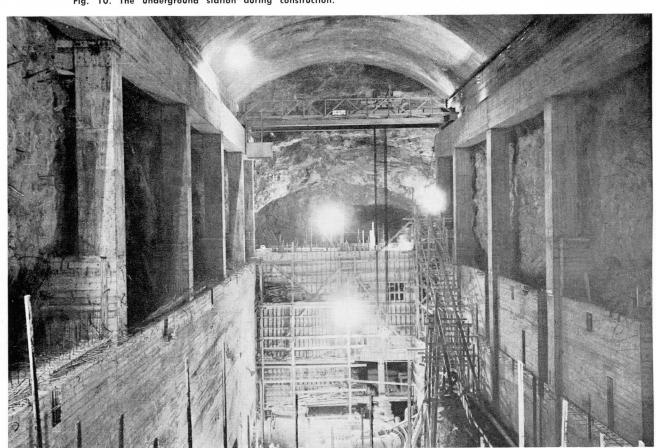




Fig. 17. View on the generator floor showing the control room in the background

The Vertical Francis Reaction Type Turbines of Nea Power Station

These turbines are to-day three in number and have the following identical data:

Output: N = 70.000 H.P.Normal speed: n = 500 rpmNet head: He = 362 m.

The spiral casing with stay ring consists of four parts of cast steel with flanged connections. The inlet diameter is 1300 mm. To the spiral casing is mounted a relief valve with an energy absorber. The casing is also furnished with a drainage arrangement.

The cast steel turbine covers are of a strong and rigid design representing a new development purposely introducing components which minimize deflections under load. The small clearances thus possible between guide vanes and covers will give practically no leakage through the closed guide vanes or at low-load conditions,

consequently the possibility of erosion from cavitation is negligiable.

On the inside surface of the covers, exposed to water flows at very high speed, a 3 mm layer of stainless steel is welded by the application of a special welding procedure. This layer of stainless steel is given a smooth and polished surface, offering a high resistance to corrosive action and cavitation attacks.

The guide vanes are made from stainless steel castings exactly shaped by means of a copy milling machine and grinding.

The runner is made of cast steel and has vanes of steel plates. The vane outlets are of stainless steel. The outlet area of the ring is also protected by a 3 mm layer of stainless steel. The runner is flanged to the 500 mm dia. transmission shaft by means of bolts and keys. The runner of turbine No. 1 has now been operating on full load for about four months with tail water

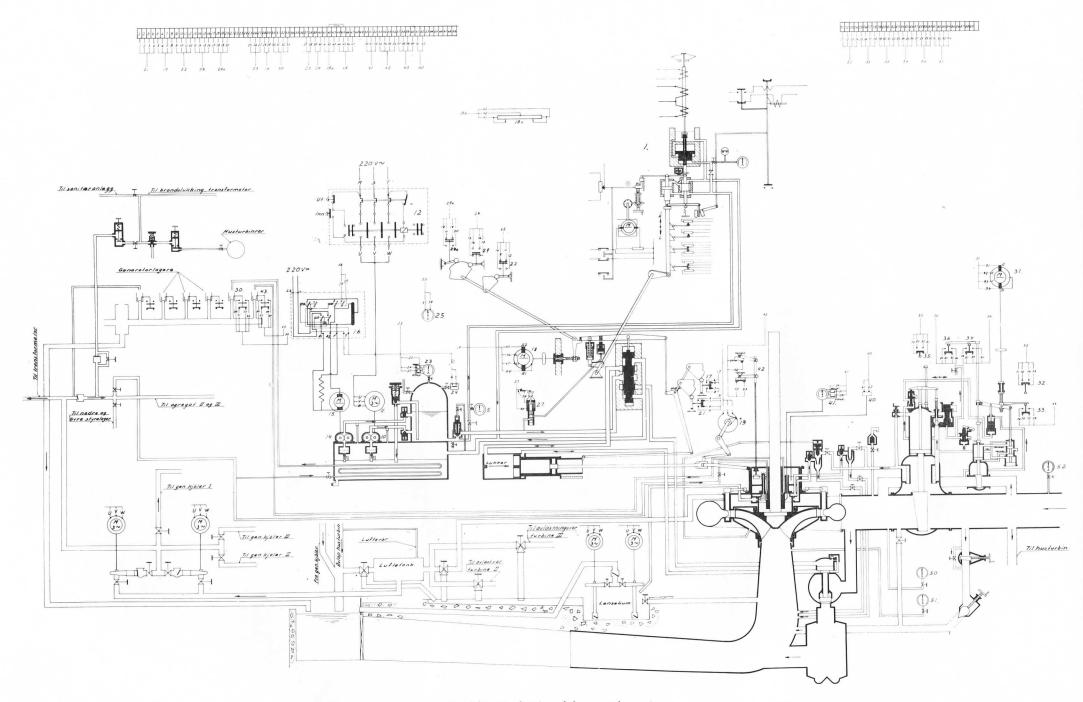


Fig. 12. Schematic drawing of the governing system.

level only about 1 m above the turbine center, rendering very satisfactory operation results.

For high reliability in service the runner is designed with a rather low specific speed, and very careful consideration is given to the shape of the vanes. A further advantage of a low specific speed is a moderate runaway speed, which for the Nea turbines is about 60 % above normal speed.

The hydraulic sealing box has five sealing rings with sealing surfaces of brass. They are non-touching and are less sensitive to sand in the water than sealing boxes of the carbon ring type.

Channels between the sealing rings are drained by two automatically operated ejector pumps when the turbine is not running. For this purpose there is also a third manually operated ejector in reserve.

When the turbine is in operation, ejectors are not necessary as the leakage is drained by centrifugal forces. The automatic ejectors are started by pressure governed valves, starting the ejectors before the turbine is brought to a standstill.

Water of high pressure for the ejectors is provided from the pressure side of the main gate valve.

The sealing box is made of cast iron, serving at the same time as center cover and bearing for the regulating ring. Upon this center cover the combined shaft bearing bracket and oil reservoir are mounted. From the reservoir the oil flows through a cooler into the turbine guide bearing. From below the bearing the oil is forced by centrifugal force upwards to the reservoir again. The reservoir is furnished with conventional signal equipment giving alarm when oil temperature or oil level is not normal.

The guide vanes are connected to the regulating ring through lever arms and links. The guide vane bearings and the guide mechanism are grease lubricated, the nipples being accessible from the turbine floor.

The regulating ring is connected to the servomotor through a lever rod system, making the turbine output a linear function of the servomotor stroke.

The turbine design is such that it eliminates the necessity of air to the draft tube usually supplied radially through the cone connecting turbine and tube. The cone may easily be disconnected. The bottom cover may also easily be loosened and lowered by means of jack screws, giving access to the runner. The runner is dismantled downwards without any troublesome disconnection of the regulating gear and without removing the generator rotor.

The guide vanes may also be dismounted downwards by disconnecting their levers.

The regulating ring, the upper cover, the bearing, the sealing box and the turbine shaft are dismantled upwards.

The Turbine Governors and Relief Valves of Nea Power Station

The turbines are furnished with identical electro hydraulic governors of a design resulting from co-operation between the electrical manufacturer ASEA, Sweden, and KVÆRNER.

The working capacity of each governor is abt. 10000 kgm (abt. 32 ton feet). An oil pressure of 15 kg per sq.cm (abt. 213 lbs. per sq.in.) is maintained in a receiver by electrically driven worm gear pumps. A relief valve returns excess oil back to the oil sump.

The turbine relief valve is illustrated in fig. 12. Of special interest is the interplay between the governor and the turbine relief valve. The system makes impossible a rapid closing of the guide vanes except when the relief valve opens simultaneously. If the relief valve fails to open, the governor will close the guide vanes at a slower speed than normal, thus simulating the conditions when the relief valve functions normally. This arrangement prevents the hydraulic pressure rising above normal.

The Main Turbine Gate Valves of Nea Power Station

Each turbine is equipped with a main gate valve. This valve and its by-pass valve is operated by hydraulic servomotors governed by a pilot valve system shown in fig. 12.

At starting-up-signal from the control room the by-pass valve adjusts itself to ½ of full open position. It remains in this position until approximately full hydraulic pressure in the spiral casing is achieved. Then it automatically adjusts itself to full gate opening. By the latter action the

main gate valve also opens automatically, at the same time signalling to the control room that the turbine is ready for starting.

The spiral casing is furnished with an air outlet valve which closes automatically when all the air has been expelled.

Automatic closing of the main gate valve is also provided.

Upstream from the main gate valves, combined expansion and dismantling boxes are fitted.

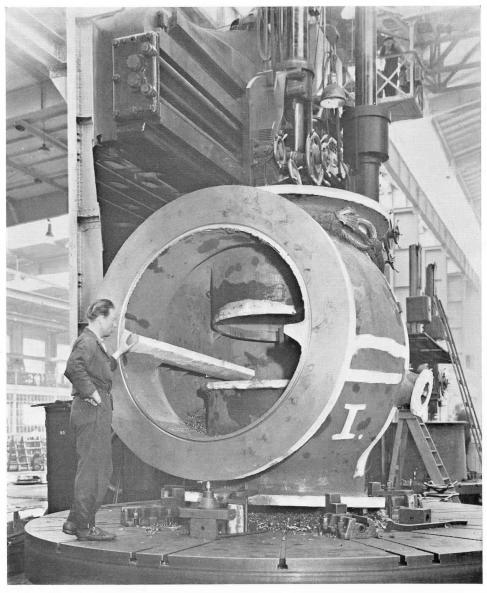


Fig. 13. The gate valve housing on the milling machine.