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APPRAISAL REPORT ON THE EFSTIDALUR HYDRO-ELECTRIC PROJECT UPPER BRÚARÁ RIVER. ICELAND

English version of an excerpt
from an Appraisal Report to the
State Electricity Authority, on
the hydro-electric potential of
the upper reaches of Brúará River
dated May 1962.

English version prepared
by the State Electricity
Authority
Sept. 1962

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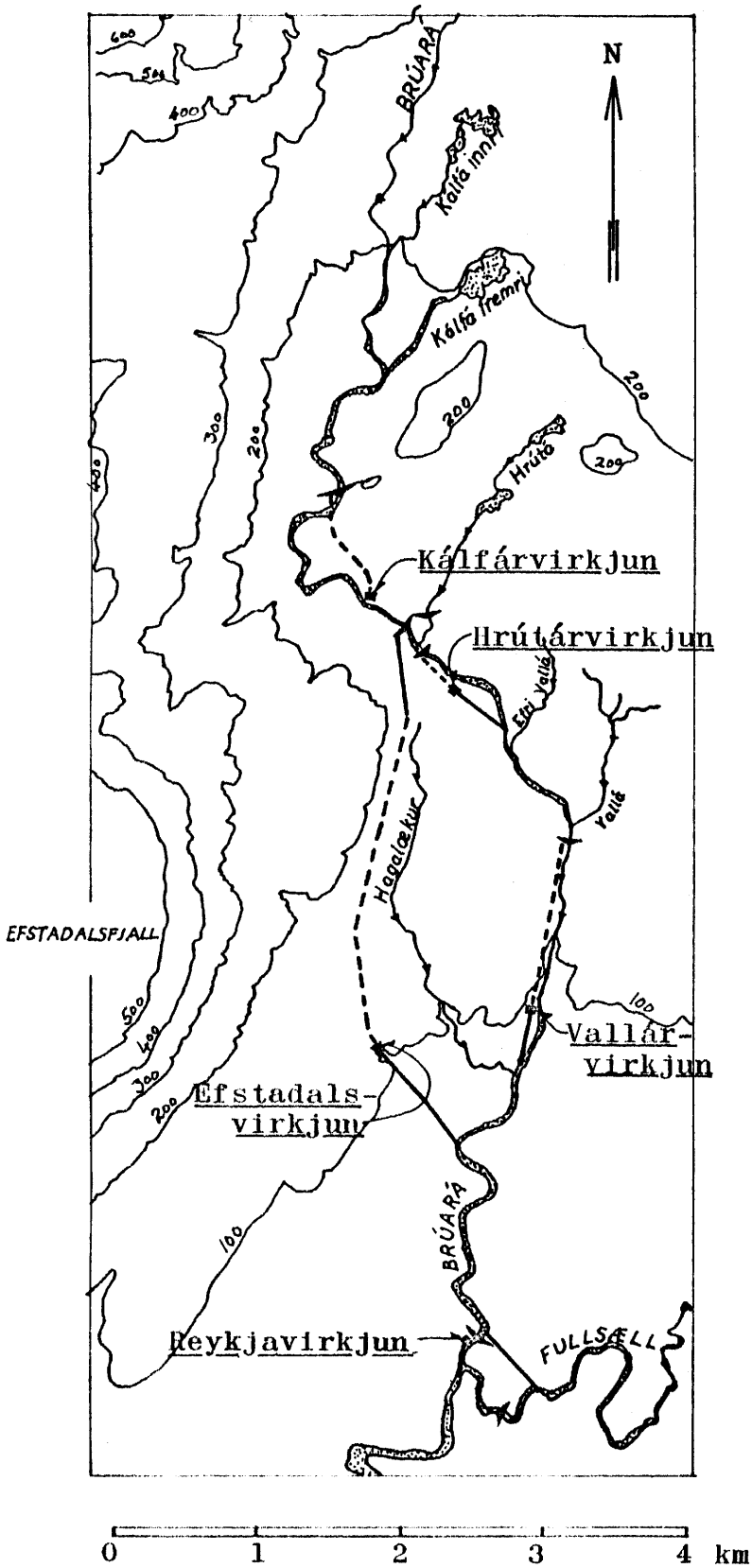

Skýringar
LEGEND

- Stífla DAM
- Orkuver POWERPLANT
- Skurður CANAL
- Pípa PIPE

THE STATE ELECTRICITY AUTHORITY
BRUARA DEVELOPMENT
PLAN OF UPPER BRUARA

RAFORKUMÁLASTJÓRI

VIRKJUN BRÚARÁR
YFIRLITSMYND AF EFRI BRÚARÁ

T.: S.F. R.: Y.: S.: SA. Dags. 13.2.'62

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Nr. A 2297

Summary of Hydro-electric Developments in the Upper Reaches of Brúará River, showing Capacity, Energy Output and Costs

Scheme	Power Plants	Head-water elev. m	Tail-water elev. m	Gross head m	Installed capacity MW	Energy output GWh/a	Cost of product. plant Mkr.	Cost of transm. plant Mkr.	Total construct. cost Mkr.	Energy cost from generator aur/kWh	Energy cost at Sog aur/kWh
A	Kálfá Project	182	160	22	3.00	24	79	...	...	33	...
	Efstidalur Project	156	80.5	75.5	18.20	146	222	29	251	15	18
	Reykir Project,1.alt.	80.5	73	7.5	2.56	20	48	...	...	24	...
	Total, Scheme A	.	.	105	23.76	190	349	42	291	18	22
B	Kálfá Project (=Scheme A)	182	160	22	3.00	24	79	...	...	33	...
	Hrútá Project, 1.alt.	150	127	23	5.35	43	76	...	...	18	...
	Vallá Project	120	84	36	9.90	79	128	...	...	16	...
	Reykir Project,2.alt	83.2	73	10.2	3.58	29	58	...	...	20	...
	Total, Scheme B	.	.	91.2	21.83	175	341	43	384	19	24
C	Kálfá Project (=Scheme A)	182	160	22	3.00	24	79	...	...	33	...
	Hrútá Project, 2.alt.	160	127	33	7.70	62	102	32	262	16	20
	Vallá Project (=Sch.B)	120	84	36	9.90	79	128			16	
	Reykir Project, 2.alt (=B)	83.2	73	10.2	3.58	29	58	...	...	20	...
	Total, Scheme C	.	.	101.2	24.18	194	367	44	411	19	23

Notes: 1. Annual charges assumed 10% of first cost
2. Transmission losses from plant to Sog assumed 7%
3. Import duties & taxes are included in first cost

Rate of Exchange: 1 U.S. $ = 43 Icel. krónur; 1 U.S. mill = 4.3 Icel. aurar (aur)

The abbreviation "Mkr." is used throughout this Report for "millions of Icelandic krónur"

Table of Significant Data of Efstidalur Project

Normal headwater elevation		157 m
" tailwater "		80.5 m
Discharge at rated capacity		30 kl/s
Normal gross head		76.5 m
" net head		71 m

Dam

Type	earthdam with concrete spillway	
Length of earth dam		400 m
" " spillway		60 m
Elevation of spillway crest		157 m
" " earth dam crest		159 m
Maximum dam height		7 m
Spillway capacity (h= 1.3 m)		195 kl/s

Water conductors

Intake canal		
Length		550 m
Width of bottom		11 m
Slopes		1:3
Maximum depth		3 m
Intake		
Elevation of threshold section		151 m
Intake opening		4.6x5 m^2
Speed in intake opening		1.3 m/s
Gate type	wheeled gate	16 m^2
Headrace pipe		
Type	wood stave pipe, steel girdled	
Length		ab. 2450 m
Cross section area		11.4 m^2
Diameter		3.8 m
Flow velocity		2.65 m/s
Surge tower		
Type	steel tank, concrete base	
Diameter		15 m
Cross section area		177 m^2
Bottom elevation		140.2 m
Water level, normal		154.0 m
" " maximum		168.3 m
" " minimum		147.0 m
Penstock		
Type		steel pipe
Diameter at upper end		3.3 m
" " lower end		2.9 m
Length		150 m
Tailrace canal		
Type	excavated in soil & rock; unlined	
Length		ab.1040 m
Width at bottom	5 m and	20 m
Maximum depth		25 m

Head losses	
Total head losses at 100% flow	5.5 m
" " " in % of gross head	7.2%
" " " at 90% flow	4.5 m
" " " in % of gross head	5.8%

Power house

Type	Semi-underground
Turbine	
Type	Francis with vertical shaft
Net head, ordinary	71.5 m
Power at ord. net head and 30 kl/s	25 800 H.P. (m)
Speed	250 RPM
Generator	
Capacity	22.7 MVA
P.F.	0.8
Voltage	10.5 kV
Speed	250 RPM
Main transformer	
No. of windings	3
No. of phases	3
Capacity	22.7/2/22.7 MVA
Voltage; L.V. winding	10.5 kV
" ; I.V. "	11 kV
" ; H.V. "	66 kV

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Reykjavík, May 27 1962

Summary Letter.

The State Electricity Authority
Laugavegur 118
Reykjavík

Gentlemen,

We are forwarding with this letter an Appraisal Report on the hydroelectric development of the upper reaches of Brúará River, above its confluence with Hagaós River, the outlet of Lake Apavatn. However, we wish to emphasize that the appraisals of the Kálfárvirkjun and Reykjavirkjun plants are of a more preliminary nature than those of the other plants, and that these two projects were included merely for the sake of completeness.

For the Dynjandi Project farther downstream on the Brúará, we have previously sent you a similar report.

Three schemes have been drawn up for the over-all development of the reach of Brúará River in question, each consisting of 3-4 seperate developments. In a summary table at the front of this Report, the main data of each of these schemes are shown.

According to this summary, the total installed aapacity of all power plants envisaged is 21.83 - 24.18 MW, depending on the over-all scheme adopted, the total annual energy output in a dry year 175 - 194 GWh; the first cost of production plant alone Mkr. 341- 367 but Mkr. 384-411, also by schemes, when the transmission plant

required to transmit the power to Írafoss on the Sog is included. Assuming annual charges amounting to 10% of first cost, the energy cost from generators would be 18 - 19 aurar/kWh, but 22 - 24 aurar/kWh at the 138 kV busbar at Írafoss, again depending on the scheme. This low energy cost for hydro-plants of the size in question here, is caused by the favourable conditions for development found on the Brúará River.

Of the individual projects, the most promising ones appear to be the Efstidalur Project in Scheme A, and the Hrútá Project, 2. alternative plus the Vallá Project in Scheme C. These two schemes are mutually exclusive, as far as these Projects are concerned.

The Efstidalur Project has a rated capacity of 18.2 MW and an energy output in a dry year of 146 GWh. Estimated construction cost of production plant is Mkr. 222, that of production and transmission plant together Mkr. 251. Estimated energy cost, assuming annual charges to be 10% of first cost is 15 aurar/kWh from generator and 18 aurar/kWh at Írafoss.

Similar figures for the two-stage alternative, Hrútá plus Vallá, are: Installed capacity of both plants 17.6 MW; annual energy 141 GWh; first cost of production plant Mkr. 230; of production plus transmission plant Mkr. 262. Energy cost from generator 16 aurar/kWh; at Írafoss 20 aurar/kWh.

The cost of transmitting the power from Sog to Reykjavík is not included in the above figures. The reason is that it may be assumed that a second transmission line from Sog to Reykjavík will be constructed in a few years, for the reason of reliability of supply in the Reykjavík area, regardless of whether or not the Projects in question here will be constructed. Only the incremental cost of transmitting the extra power over the two lines would be

chargeable to the Projects, and this incremental cost will presumably be very low, since each line would operate at little more than half its thermal capacity.

All import duties and taxes on materials, plant and equipment brought in from abroad for the Projects are included in the cost figures.

Stream-flow records for Brúará River at the sites of the Projects here discussed are not available. A water stage recorder was installed near the Efstidalur site in Aug. 1961. When this recorder has been in operation for a suitabel time, a correlation between the discharge there and at Dynjandi may be established. At the latter place records are available for 14 years, and they may then be "adjusted" with the aid of this correlation. The capacity and energy figures stated above are based on assumptions about the stream-flow. It is felt that these assumptions are conservative rather than the opposite, and this seems to be confirmed by the records of the Efstidalur recorder since its installation, although too much significance should not be attached to records of so short a duration.

Brúará River is almost a pure lindá river in the reach in question here, being fed to nearly 100% by springs issuing from the ground a short distance above the intakes. There will thus be neither troubles from ice nor sedimentation in the operation of the plants.

Our studies strongly indicate that the Projects in question here are very favourable, especially the Efstidalur Project or the Hrútá plus Vallá Projects. All the sites are located in inhabitated regions, at short distance from existing motor roads. The conditions for the actual construction work are thus favourable. Mapping, subsurface explorations and other investigations are well advanced and may easily

be completed in short time. Since all the Projects are of the surface type, with all major structures at ground surface, the risks due to unsound soil or rock formations are less here than at various sites that have been under consideratinn in the past few years.
Each of the Projects could easily be completed in the course of 1 - 2 years.

With this in mind, we are of the opinion that at least some of these Projects in the upper part of Brúará River are sufficiently favourable as to merit further study for the purpose of ascertaining whether or not some of them might be suitable to meet the power requirements of Southern Iceland in the immediate future.

Sincerely yours,

Sigurður Thoroddsen
(sign)

1. Introduction. Location of Site.

The Efstidalur Project is situated in the upper reaches of Brúará River, a tributary to the Hvítá River, Southern Iceland. The geographic location is shown on the location map, drwg. No. A 2297, at the beginning of this Report. Of the other Projects shown on the map, Kálfárvirkjun and Reykjavirkjun are developments of the reaches of Brúará River immediately upstream and downstream, respectively, of the Efstidalur Project, while the Hrútárvirkjun and the Vallárvirkjun together represent a two-stage alternative to the Efstidalur Project. This alternative was found to possess no advantages over a single-stage development. These other Brúará Projects will not be discussed in the present Report.

2. Stream Flow. Power and Energy.

Brúará River is a typical lindá river, i.e. it is fed almost entirely by springs. Surface run-off is confined to the snowmelting period. Accordingly, the flow is extremely uniform.

Due to pervious geologic formations covering parts of the water divides their exact location and the size of the drainage area cannot be accurately determined.

Prior to initiation of our design, the following results of individual streamflow measurements were made available to us by the State Electricity Authority's Hydrologic Survey (S.E.A.H.S.).

Date of measurements	Feb.16 1958	Aug. 11. 1960	Sept. 21. 1961
Stream-flow in kilolitres per second (kl/s)			
Brúará River, above confluence with Hrútá River	18,5	approx. 22	23,5
Hrútá River 1 km approx. above confluence with Brúará River	7,3	8,3	8,3
Hrútá River, at confluence with Brúará River			9,0
Brúará River, at highway bridge near tailrace of proposed plant			37,3
Brúará River at Dynjandi			53,8

The greatest floods occurring in Brúará River in the development area considered here were estimated by S.E.A.H.S. at 200 kl/s approximately.

The uniform flow of Brúará River; the relatively long water conductors and the small pondage available all indicate that the plant should be designed for a high plant factor, i.e. base load operation. We selected a design plant factor of 91% (8000 hours), and a flow of 30 kl/s at rated plant capacity. This gives a rated generator capacity of 18.2 MW and an annual energy output of 146 GWh.

The figures were selected on the basis of a dry year. In a normal year, the plant factor would approach 100%.

Since only a very limited pondage is available at the plant, firm capacity is somewhat less than 18,2 MW.

When our work on the Report was well advanced, the first stream flow records of a water level recorder installed near the site in Aug. 1961 became available. Although of a short duration, owing to the extreme uniformity of the flow, these records are valuable in establishing a correlation between the flow at the site and that at Dynjandi, where the stream-flow has been measured for 14 years.

A preliminary comparison seems to indicate that the capacity and energy output figures are conservative and may require modification in a final design. However, because of the very short duration of simultaneous records, an uprating of the Project was not felt justified at this appraisal stage.

The water temperature at the intake will be above zero centigrade throughout the year, owing to the spring water feeding the river immediately upstream.

For similiar reasons there is no sediment transport. Operating troubles caused by ice or sedimentation will therefore be non-existent.

3. Description of Efstidalur Project

3.1 Dam and Intake Canal (Drwgs A-2279; 2280)

The damsite was selected some 200 m above the confluence of the Brúará and Hrútá Rivers. The dam extends across both rivers and the tonguenbetween them.

Information about the geology at the damsite as well as at the sites of other structures of the Efstidalur Project, was obtained from Mr. Haukur Tómasson, geologist of the S.E.A.

Both rivers, Brúará and Hrútá, are flowing on basalt rock, but the left bank of Hrútá River is of moraine, upon which the left end of the dam will abut.

The dam is an earth-fill dam, except for a concrete spillway formed as a gravity dam across the Brúará river-bed. The length of the spillway is 122 m; its crest is at el. 157 m. The crest of the earth-fill sections at el. 159 m.

The greatest flood occurring at the damsite is not knovn, but at the Dynjandi gauging station, farther downstream on the Brúará, the maximum observed flood during a 10-year observation period was 194 kl/s. In view of that, the spillway, as described above, should have ample discharging capacity.

A cut-off trench beneath the dam, down to bedrock, is contemplated. In the bottom of the trench, the rock will be tightened with cement sludge. The impervious core of the dam will be of loessy soil, with sand and gravel filters on both sides. The bulk of the fill will consist of compacted moraine and gravel, which materials are found in ample quantities near the damsite. However, no sampling and testing of these local materials have as yet been carried out.

The intake canal, which leads southward from the pond, is excavated to a bottom elevation of 154 m. Its left bank is formed as an earth-fill embankment with filters and drains, and is in a direct continuity of the dams across the rivers. The right bank is retained by the slopes of Efstadalsfjall.

The crest of the left bank is at el. 160 m.

According to results of diamond core drilling and permeability tests, the basalt which forms the bedrock at the sites of the dam and the intake canal, is very cracked and pervious down to a depth of 30-40 m, offering very little resistance to the ground-water flow. Where moraine overlies the bedrock, the water is under artesian pressure. It has been assumed that rock grouting can essentially be limited to the end of the intake canal, since the structures in question here are comparatively low; the height of the dam being less than 5 m at most places.

3.2 Intake (Drwg A-2281)

The intake is situated in the middle of a retaining wall lying athwart to the canal alignment, at its lower end.

The retaining wall, which is of concrete, extends down to bedrock. Beneath the wall, the rock is tightened by cement grouting. The canal is made deeper near the end; creating a suitable depth at the intake.

The intake is of a traditional and simple design, since no operating troubles can arise, from ice or other causes. The flow velocity through the thrashracks will be ab. 1.5 m/s.

The intake gate will be of the quick-closing type, hydraulically operated and remotely controlled. An air-inlet is located below the gate. The inlet may be used as a manhole.

A shelter, 7 m by 5 will house the hoisting equipment.

3.3 Headrace Pipe (Drwgs A-2279; 2284)

The headrace pipe will be a wood-stave pipe, steel girdled, 3.3 m dia. Its length from intake to surge tower is ab. 2450 m. It will follow the landscape; for the most of its length it lies on a gravel terrace along Efstadalsfjall. Then it lies across a depression to the surge tower, which is sited on a hillock some distance to the north of farm Efstidalur (see drwg.)

On its route, the pipe crosses three brook channels, dry except during snow-melt. The largest of them has to be bridged, whereas culverts will suffice in the other two.

Since the pipe will curve up and down with the landscape along its route, it must at two places be fitted with draining valves and at two places with air outlet.

The pipe will be bedded up to its middle in a drained gravel fill. A grass-covered earth-fill, 50 cm thick on top, with side slopes of 1:1.5, will cover the pipe.

The pipe will be connected to the intake at one end and to the surge tower at the other, by steel tubes. Manholes will be on the pipe at every 300 m.

3.4 The Surge Tower (Drwg A-2281)

The surge tower is a circular steel tank, 15 m dia, on a concrete foundation. The height of the tank is 28 m; of the foundation 6 m. The duct through the foundation will be steel lined, 3.8 m dia at the pipe end tapering down to 3.3 m downstream of the tank, where a quick-closing valve will be inserted. The valve is housed in a shelter, 7.5 m by 10.5 m. Below the valve, the pipe is fitted with an air-duct, which lies into the tank and up above its top, to protect the duct against frost.

3.5 Penstock

Below the surge tank and the quick-closing valve is the penstock, a steel pipe 150 m in length, 3.3 m dia. The penstock is straight in plan but with two curves in elevation: One at the turbine; the other at an edge of a flat slope some distance above the powerhouse, where the penstock will be fastened by a concrete anchor. Between the anchor and the valve, the pipe rests on ring girders supported by steel columns, pivoted at their lower ends and founded on concrete blocks. On this part, the pipe will be equipped with one expansion joint. Thermal insulation of this part of the pipe is not contemplated, since it is not required; there being no danger that the water will freeze. From the anchor to the turbine, the penstock will be embedded in concrete.

3.6 The Powerhouse. (Drwgs A-2282; 2283)

The powerhouse is situated in a depression or a gullet which cuts into the hills along Efstadalsfjall.

The gullet is deepened by excavation and connected to Brúará River by a deep canal that will become the tailrace canal of the plant. The powerhouse is at the upper end of this canal, where it has reached a depth of 25-30 m.

The powerhouse is conventional in all respects and does not call for a detailed description; reference is made to the drawings.

The machine halls lies athwart to the canal. A side building is on its eastern side.

Besides the machine hall with an erection bay the powerhouse also contains a control room, a switchgear room, offices, hall and a washroom on the upper floor. A side room houses the step-up transformer. From that room, the transformer may be moved into the erection bay for maintenance and overhaul. For removing the core, the transformer may be lifted into a pit in the floor of the erection bay.

On the lower floor of the side building there is a work-shop, store rooms and a room for the station supply transformers. Below this floor is also a small basement, which may be used as a store room, and to give access to the bulkhead gate.

3.7 The Tailrace Canal (Drwgs A-2279; 2284)

The tailrace canal leads the water back to Brúará River. Its length is little over 1000 m. The lowest part of the canal crosses the river twice, and for the last 250 m the canal lies practically in the riverbed, being merely a deepening of the natural channel. At this place, the river bottom consists of "deigulmór", which expectedly is easily excavable with suitable equipment.

As already stated, the canal is very deep, some 30 m by the powerhouse, but the depth decreased as the surrounding ground gets lower.

The soil on the canal route has been partly explored, as indicated on the drawings.

The bottom width of the canal is 5 m. Side slopes of 4:1 in rock and 1:2 in soil have been assumed. Besides, the rock is stripped of soil for a distance of 5 m from the rock excavation. Of course, the canal must be fenced off and other precautions taken to prevent accidents.

3.8 Roads

An access road to the powerhouse will lie along the right bank of the tailrace canal. Its length from the highway to the powerhouse will not exceed 1000 m. From the powerhouse, the road will follow the pipeline to the intake works and the dam. The length of this latter part will be some 3500 m. No noteworthy difficulties should, therefore, arise in connection with the transport of materials and equipment to the site.

3.9 Mechanical and Electrical Plant and Equipment

3.9.1 Turbine

The power plant is to contain one aggregate. The chief characteristics of the turbine are as follows:

Type -	Francis
Arrangement -	vertical shaft
Net head -	71.5 m
Rated capacity -	25 800 HP metric
Efficiency at rated capacity -	0,90
Turbine flow at rated capac. and net head of 71.5 -	30 kl/s
Speed -	250 RPm

3.9.2 Generator

Rated capacity -	22.7 MVA
Efficiency at rated capacity -	0,96
P.F. -	0,8
No. of phases -	3
Frequency -	50 Hz
Voltage -	10,5 kV
Speed -	250 RPm
Type -	Vertical shaft

3.9.3 Connection of Electrical Equipment

Plan A-2292 illustrates the single line diagram of the power plant. The generator will be connected to a 10.5 kV single busbar from which cables will lead to the main transformer. The 10.5 kV switchgear is of the indoor type, in sheet steel cubicles.

3.9.4 Main Transformer. Switchgear

The main transformer of the power plant is a three-winding transformer, rated 10,5/11/66 kV, 22.7/2/22.7 MVA.

The 11 kV winding is contemplated for a rural line from the plant. If, however, it should not be necessary to make an arrangement for this possibility, an ordinary two winding transformer could be used, leaving out the 11 kV winding.
The transformers are placed in a room off the erection bay in the machine hall re drwg. A-2283.

The switchyard with circuit breakers, switches current and potential transformers and other equipment for outgoing 66 and 11 kV lines is placed near the power house.

3.9.5 Station Supply

The station supply comes from the 10,5 kV bus-bars, through two 250 kVA transformers, 10,5/0,4 kV. These transformers are equipped with automatic on load voltage regulation.

The low voltage terminals are connected to 400 V bus-bars, from which the station supply is taken. These bus-bars together with circuit-breakers.and other equipment are kept in closed steel cubicles. The transformers are two for safety's sake.

All Station supply equipment is placed in a side wing of the powerhouse,see drawing.

3.9.6 Control Room

The control room of the power plant is in the previously mentioned wing, where all the necessary control equipment will be placed together with meters, relays and terminal equipment of a carrier communication over the transmission line.

3.9.7 Transmission Line and Tie-in at Írafoss

It is intended to transmit the energy to Írafoss by a single circuit 66 kV transmission line on double wood poles. The line would be about 29.2 km in length.

At Írafoss the voltage is raised to 138 kV in a special transformer, 22,7 MVA, 66/138 kV, and the line connected to the 138 kV busbars at Írafoss. This transformer is equipped with automatic on load voltage regulation.

It is to be expected that a new 138 kV line has been built from Sog to Reykjavík when the power plant begins to operate.

4. Cost

4.1 General

The cost estimates presented in this Report are in the form usually adopted by our firm to such estimates.

Included in the cost figures are all import duties and taxes on material and equipment, but excluded are riparian rights; compensations for land use and quarrying rights, and the cost of preparatory studies and site investigations.

The cost of mechanical and electrical plant and equipment was estimated on the basis of information obtained from West-German manufacturers about similar items for the Tungufell Project on the Hvítá, the Vallá Project on the Brúará (cf. page of this Report), the Dynjandi Project on the Brúará and the Árbæjarfoss Project on the Rangá. The cost of the woodstave pipeline was based on information from a Scandinavian manufacturer, Skandinavisk Trærör A/S, Norway Sweden; that of the steel penstock and the surge tank on information received from mechanical workshops in Reykjavík that erect similar structures.

In accordance with our usual practice we have added to the direct construction cost, such items as contingences, engineering cost and interests during construction. These items were estimated as follows:

1. Contingencies and commisdions 20% of direct cost.
2. Engineering, 8% ± of direct cost plus contingencies.
3. Interest during construction, 9,5% ± of direct cost plus contingencies plus engineering.

The first of these items was selected rather on the high side since the site investigations are not yet completed. The third item is also probably somewhat too high, since the construction period of the plant should not exceed 2 years.

4.2 Cost Summary

Production Plant:

Power plant structures	Mkr.	12.07
Reservoir, dams and water conductors	"	106.97
Turbine and generator	"	29.40
Accessory electrical equipment	"	3.70
Misc. power plant equipment	"	3.20
Roads	"	1.17
Total, Production Plant	Mkr.	156.51

Transmission Plant:

Efstidalur substation	Mkr.	5.40
Transmission line, Efstidalur-Írafoss (Wood-pole line, 66 kV; 29.2 km)	Mkr.	8.80
Extension of Írafoss substation	"	6.30
Total, Transmission Plant	Mkr.	20.50
Total, Direct Cost	Mkr.	177.01
Contingencies & Comissions ab. 20%	"	35.40
	Mkr.	212.41
Engineering, ab. 8%	"	17.00
	Mkr.	229.41
Interest during construction ab. 9.5%	"	21.59
Total Construction Cost	Mkr.	251.00

5. Site Investigations:

5.1 Topographic Mapping

Aerial topographic maps of the development area to a scale of 1:5000 with 2 m contours are available. A longitudinal profile of the reach of river to be developed is also available.

For final design, mapping to a larger scale of the sites of structures and their immediate vicinity will be required.

5.2 Geology

For the present design, information on the general geology of the area was obtained from S.E.A. geologist Mr. Haukur Tómasson.

Diamond core drilling near the damsite performed in the summer of 1961 showed that an underground power house near the dam and a tailrace tunnel would be a somewhat questionable arrangement. Accordingly, in the present report, a scheme has been selected, with a wood-stave

pipeline, surge tank and steel penstock leading to a surface powerhourse at the end of a tailrace canal.

Besides the core drilling, the soil layers at the site of the principal structures have been explored. This work was not completed when our report was written, but we have been kept informed about the results.

Before a final design is made, these explorations of the sites of structures will have to be completed. The job of carrying out these investigations is a rather small one.

5.3 Search for Construction Materials

Some search for construction materials in the general vicinity of Brúará River was carried out in connection with the Dynjandi Project. From this it may be concluded that construction materials in sufficient quantities and of adequate quality may be obtained within a reasonable hauling distance from the sites in question here. However, before an invitation of tender is prepared, further search and testing will be required.

5.4 Hydrology

As previously mentioned, a water stage recorder has been installed near the site of the Project. A preliminary rating curve has been prepared by S.E.A. H.S. but some more stream-flow measurements have to be made to complete the curve. An attempt should be made as soon as practicable to establish a correlation with the gauge at Dynjandi where 14 years of records are at hand.

A P P E N D I X

Detailed Cost Estimates

1. Civil Engineering Works	Unit	Quantity	Unit Price Krónur	Price Krónur	Total Krónur
Dam					
Concrete dam					
Soil excavation	m^3	4.000	60	240.000,-	
Rock "	l.s.			150.000,-	
Concrete	m^3	2.360	1.100	2596.000,-	
Concrete forms, plain	m^2	1.400	270	378.000,-	
" " curved	m^2	440	430	189.200,-	
Steel reinforcement	kg	15.000	13,20	198.000,-	
Concrete joint sealings	m	100	1.000	100.000,-	
Painting and finish	l.s.			50.000,-	3901.200,-
Earth dam east of Brúará					
Soil excavation	m^3	16.200	30	486.000,-	
Rock and/or soil excavation for cut-off	m^3	1.000	300	300.000,-	
Gravel filters and fill	m^3	9.000	80	728.000,-	
Earth fill	m^3	5.500	80	440.000,-	
Riprap lining	m^3	4.000	120	480.000,-	
Slush grout	l.s.			100.000,-	
Finish	l.s.			50.000,-	2584.000,-
Headrace canal					
Excavation in peat	m^3	108.000	25	2700.000,-	
" " gravel and sand	m^3	21.000	40	840.000,-	
" " rock	m^3	5.000	400	2000.000,-	
Slush grout	l.s.			180.000,-	
Loess fill	m^3	10.000	100	1080.000,-	
Gravel and sand filters and riprap	m^3	13.200	80	1056.000,-	
Finish, draining and sodding	l.s.			250.000,-	8106.000,-
Intake					
Preparation of rock	l.s.			60.000,-	
Concrete	m^3	1.530	1100	1683.000,-	
" forms	m^2	1.950	280	546.000,-	
Steel reinforcement	kg	25.000	13,20	330.000,-	
Grouting of rock	l.s.			500.000,-	
Finish, painting, electric installation; lights	l.s.			430.000,-	
Thrashracks drains, slots airducts, pipe connector and bulkhead gate	l.s.			325.000,-	
Wheeled gate 4 m by 4 m	l.s.			750.000,-	4624.000,-

	Unit	Quantity	Unit Price Krónur	Price Krónur	Total Krónur
Cofferdams					
Dams and pumping	l.s.			700.000,-	700.000,-
Headrace Pipe					
Soil excavation	m^3	24.500	40	980.000,-	
Gravel fill	m^3	24.500	80	1960.000,-	
Earth fill	m^3	29.500	40	1180.000,-	
Drain pipes, 6" dia	m	3.300	35	115.500,-	
Laying of drain pipes	l.s.			220.000,-	
Brook culverts	pcs.	3		200.000,-	
Wood stave pipe, 3.8 m dia, with accessories, delivered to site	m	2.450	18000	44100.000,-	
Assembling of wood-stave pipe	m	2.450	1310	3209.500,-	
Manholes	pcs.	7		70.000,-	
Fenches and sodding	l.s.			250.000,-	52.285.000,-
Surge Tower					
Soil excavation	m^3	600	30	18.000,-	
Concrete	m^3	1.100	1100	1210.000,-	
Concrete forms, plain	m^2	400	270	108.000,-	
" " curved	m^2	600	430	258.000,-	
Steel reinforcement	kg	11.000	13,20	145.200,-	
Steel tank, incl. erection		121.000	25	3025.000,-	
Steel lining	kg	20,000	25	500.000,-	
Quick-closing gate; delivered to site	pcs.	1		1600.000,-	
Mounting of gate	l.s.			260.000,-	
Painting; insulation of valve chamber; doors; windows, etc.	l.s.			450.000,-	7.574.200,-
Penstock					
Excavation in soil	m^3	2.000	30	60.000,-	
Concrete	m^3	810	1100	891.000,-	
" forms	m^2	350	270	94.500,-	
Steel reinforcement	kg	10.000	13,20	132.000,-	
Steel pipe, mounted	kg	128.000	25	3200.000,-	
Finish	l.s.			100.000,-	4.477.500,-
Power house					
Excavation in soil	m^3	4.500	30	135.000,-	
" " rock	m^3	10.200	300	3060.000,-	
Concrete	m^3	600	1100	660.000,-	
"	m^3	1.000	1200	1200.000,-	
" forms for turbine and draft tube	m^2	500	400	200.000,-	

	Unit	Quantity	Unit Price Krónur	Price Krónur	Total Krónur
Power house cont.					
Concrete forms, other	m^2	4.500	270	1215.000,-	
Steel reinforcement	kg	140.000	13,20	1848.000,-	
Insulation of outer walls and finish	m^2	400	200	80.000,-	
Roofs, inside insulation and finish	m^2	420	400	168.000,-	
" , bitumen filt	m^2	420	100	42.000,-	
Roofgutters and down-pipes	l.s.			40.000,-	
Painting, indoors and outdoors	l.s.			220.000,-	
Partition walls with glass	l.s.			70.000,-	
Flooring	m^2	650	70	45.500,-	
Floor tiles	m^2	300	460	138.000,-	
Windows	l.s.			180.000,-	
Doors - outdoors	l.s.			85.000,-	
" - indoors	l.s.			25.000,-	
Spiral staircase, steel staircase and various handrails	l.s.			50.000,-	
Sanitary installations, water supply, etc.	l.s.			60.000,-	9.521.500,-
Tailrace canal					
Excavation in soil	m^3	170.000	30	5100.000,-	
" " rock	m^3	63.000	200	12600.000,-	
Cofferdams, pumping	l.s.			1000.000,-	18.700.000,-
Yard, outdoor finish, switchyard, roads					
Foundations of switchyard structures, fences, etc.	l.s.			200.000,-	
Outdoor finish	l.s.			600.000,-	
Roads	l.s.			1125.000,-	1.925.000,-
Houses for station operators	l.s.			1500.000,-	1.500.000,-
Contractor site facilities	l.s.			4500.000,-	4.500.000,-
Civil engineering works, total direct cost					120.398.400,-

2. **Machinery and electrical plant and equipment:**

Turbine with accessories		
One Francis turbine with vertical shaft 25.800 H.P. (m), 250 RPM., together with necessary accessories	Mkr.	11.4
Machine hall crane and misc. mechanical equipment	Mkr.	3.0
Generator with accessories		
One generator with vertical shaft, 22.800 kVA; PF 0,8; 10,5 kV; 250 RPM, together with accessories	Mkr.	16.4
Accessory electrical equipment	Mkr.	3.5
Installation cost	Mkr.	2.0
Total direct cost	Mkr.	36.3
Grand Total, direct cost of production plant	Mkr.	156.7

Transmission plant

Efstidalur Substation:

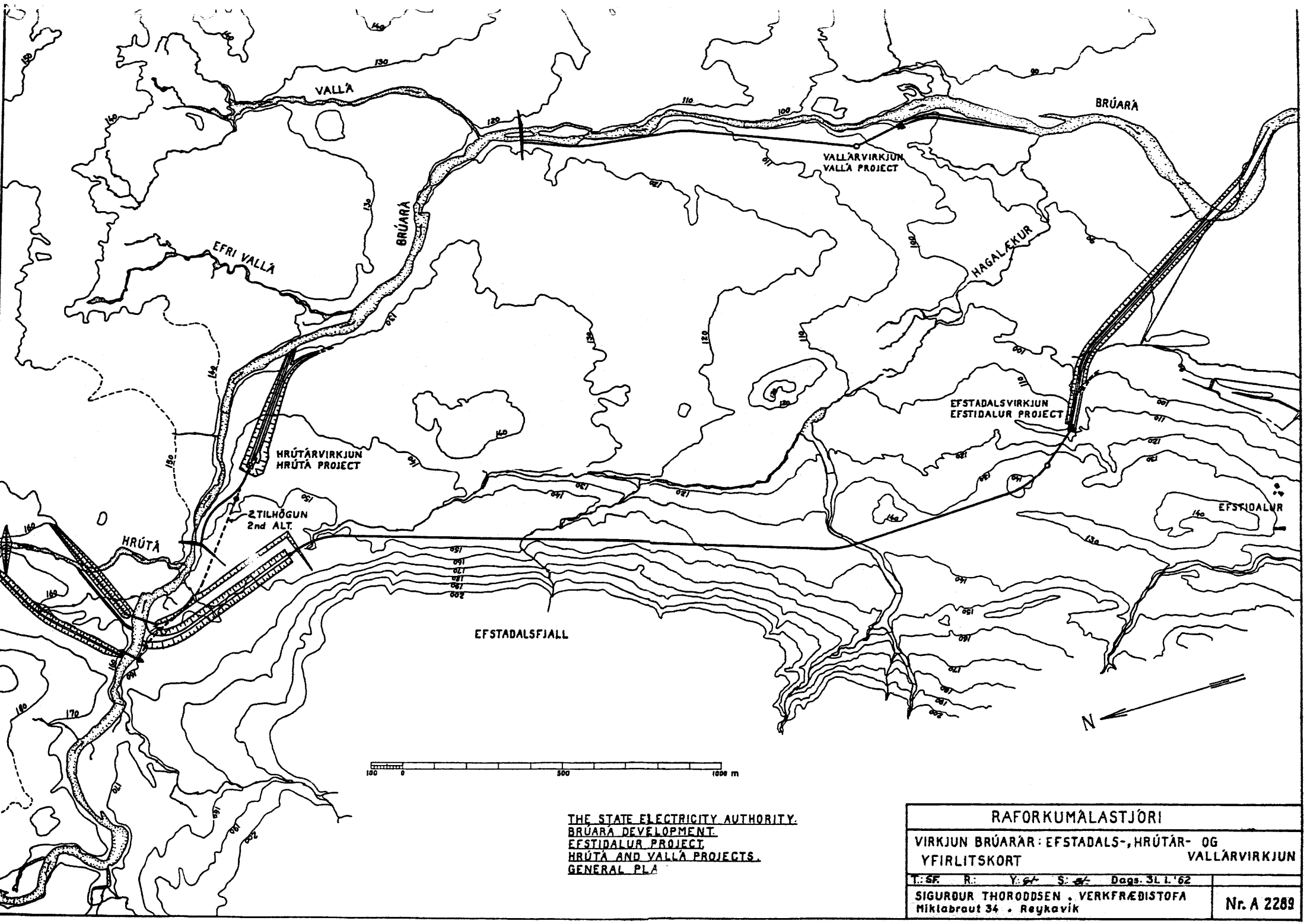
Transformer, 22.700/2000/22700 kVA, 10,5/11/66 kV	Mkr.	3.9
Circuit breakers, meters, controlling equipment, etc.	Mkr.	1.0
Installation	"	0.5
	Mkr.	5.4

Tie-in at Irafoss

Transformer, 22.800 kVA; 66/33 kV	Mkr.	3.1
Circuit breakers, meters, controlling equipment, etc.	Mkr.	2.5
Installation	Mkr.	0.7
	Mkr.	6.3

Transmission line

Irafoss-Efstidalur 29,2 km at kr. 300.000	Mkr.	8.8
Total cost, transmission plant	Mkr.	20.5



THE STATE ELECTRICITY AUTHORITY.
BRÚARÁ DEVELOPMENT.
EFSTIDALUR PROJECT.
HRÚTÁ AND VALLÁ PROJECTS.
GENERAL PLA

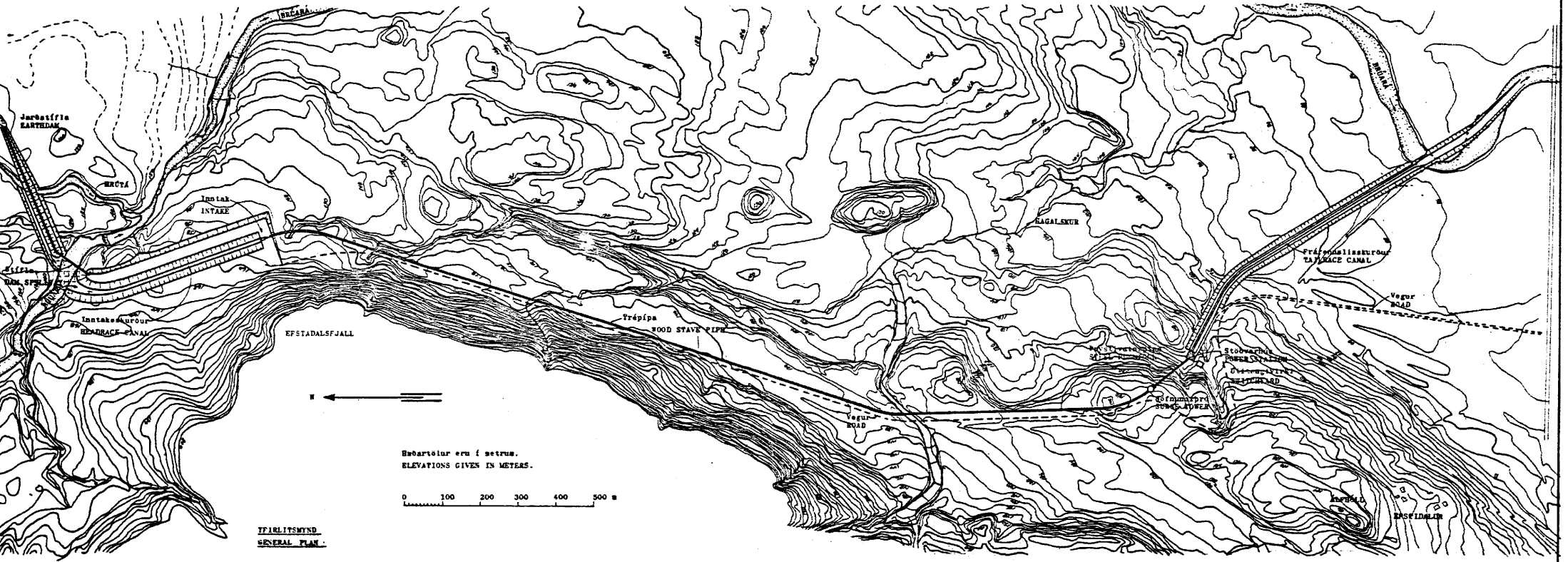
RAFORKUMÁLASTJÓRI

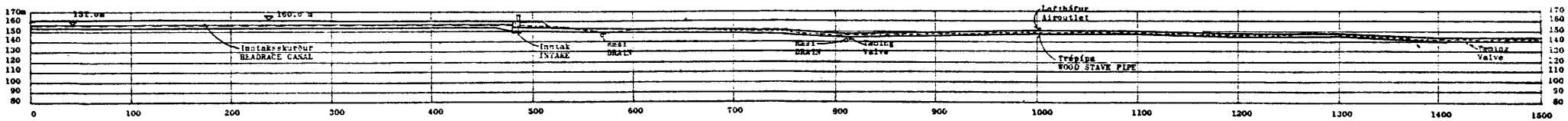
VIRKJUN BRÚARÁR: EFSTADALS-, HRÚTÁR- OG VALLÁRVIRKJUN
YFIRLITSKORT

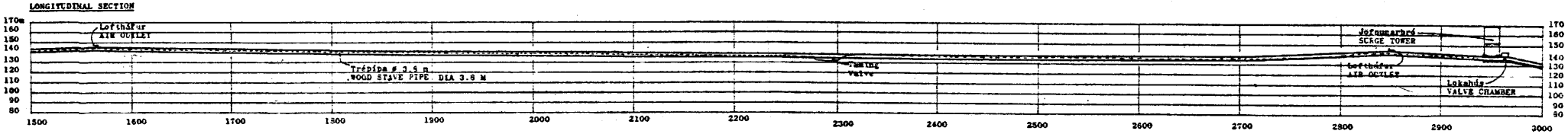
T.: SF. R.: Y.: S: Dags. 3L 1. '62

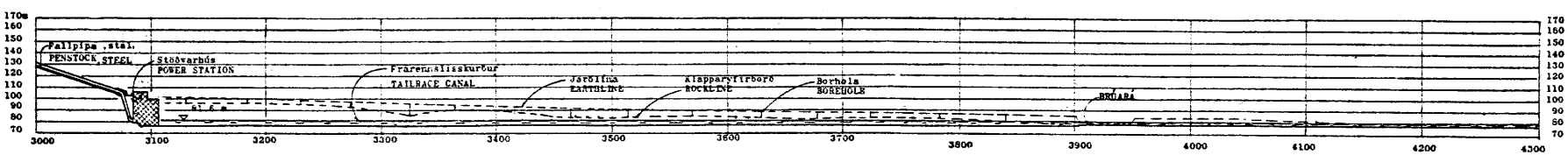
SIGURÐUR THORODDSEN . VERKFRÆÐISTOFA
Miklabraut 34 . Reykavík

Nr. A 2289









RAFORKUMÁLASTJÓRI

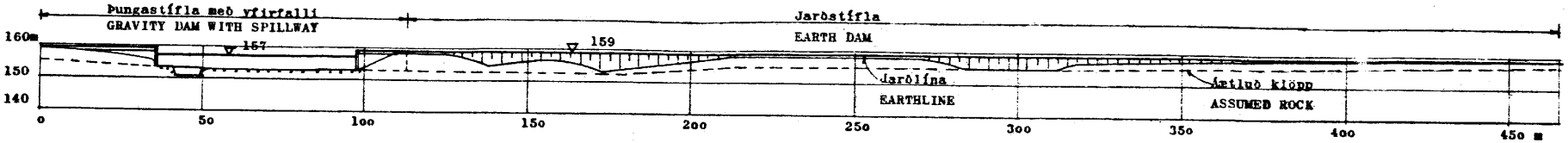
THE STATE ELECTRICITY AUTHORITY
BRUARA DEVELOPMENT. EFSTIDALUR PROJECT
GENERAL LAYOUT, LONGITUDINAL SECTION

VIRKJUN BRÚARÁR . EFSTADALSVIRKJUN
YFIRLITSMYND OG LANGSKURÐUR.

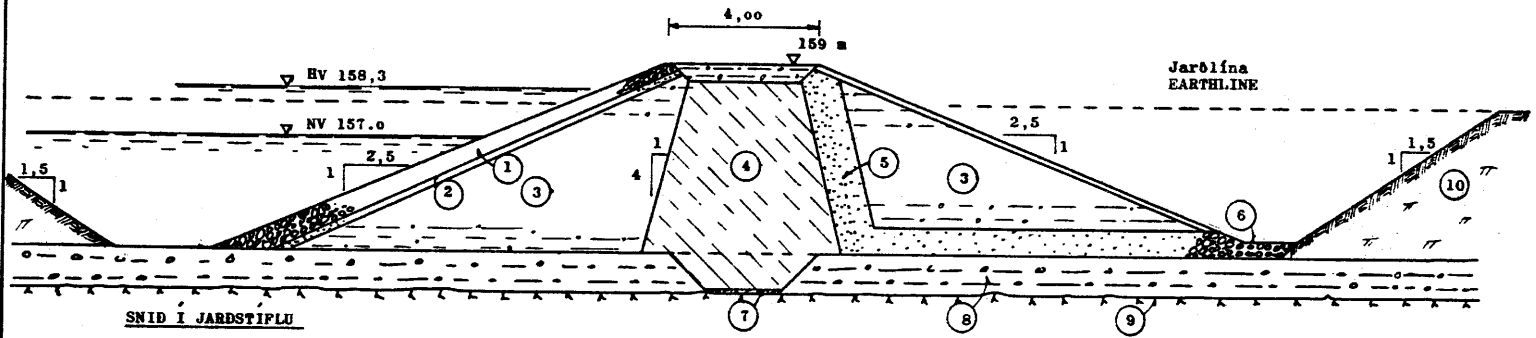
E: Hb T: Hb Y: SÞ S: SÞ Dags: 19.1.1962 | M:

SIGURÐUR THORODDSEN . VERKFRÆÐISTOFA
Miklubraut 34. Reykjavík. Sími 14578

Nr. A-2279

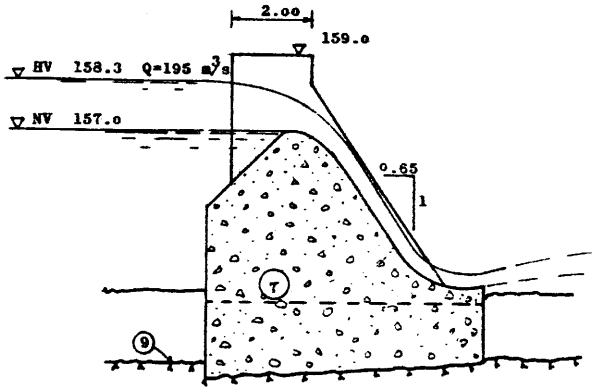


STÍFLA, SÉÐ ANDSTREYMIS
DAM, DOWNSTREAM WIEW



SNIÐ Í JARÐSTÍFLU
SECTION THROUGH EARTH DAM

0 5 10m

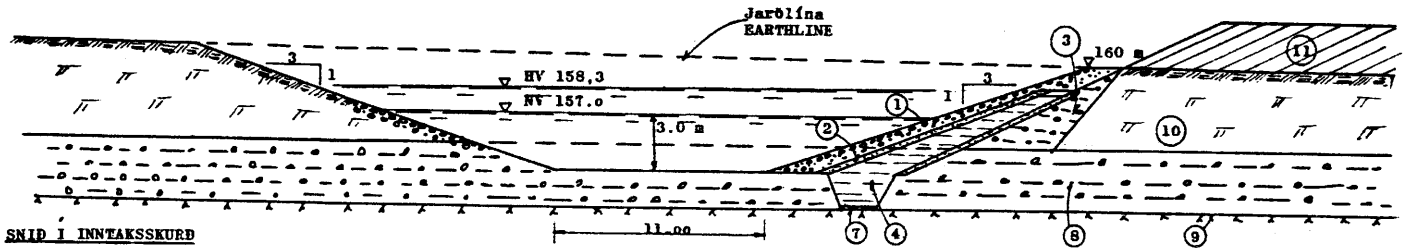


SNIÐ Í YFIRFALL
SECTION THROUGH SPILLWAY

0 5 10m

SKÝRINGAR LEGEND

① :Grjótvörn RIPRAP
② :Sand- og malarsíur FILTERS
③ :Fylling úr möl eða mórenu GRAVEL OR MORAINE
④ :Pokmoldarkjarni LOESS
⑤ :Sand-og malarsíur FILTERS AND DRAIN
⑥ :Grjótvörn ROCK TOE
⑦ :Steinsteypa CONCRETE
⑧ : Gróf mórena COARSE MORAINE
⑨ :Klöpp ROCK
⑩ :Mýrarjarðvegur PEAT
⑪ :Uppmokstur SPOILBANK



SNIÐ Í INNTAKSSKURÐ
SECTION THROUGH HEADRACE CANAL

0 10 20m

Hæðartölur og ónefnd mál eru í metrum
ELEVATIONS AND DIMENSOINS GIVEN IN METERS

THE STATE ELECTRICITY AUTHORITY
BRUARA DEVELOPMENT. EFSTIDALUR PROJECT.
DAM AND HEADRACE CANAL.

RAFORKUMÁLASTJÓRI

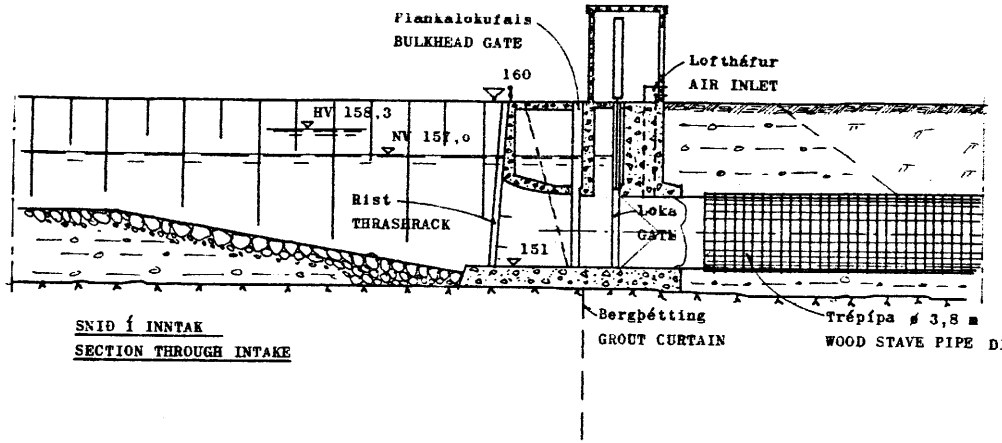
VIRKJUN BRÚARÁR EFSTADALSVIRKJUN

STÍFLA OG INNTAKSSKURÐUR

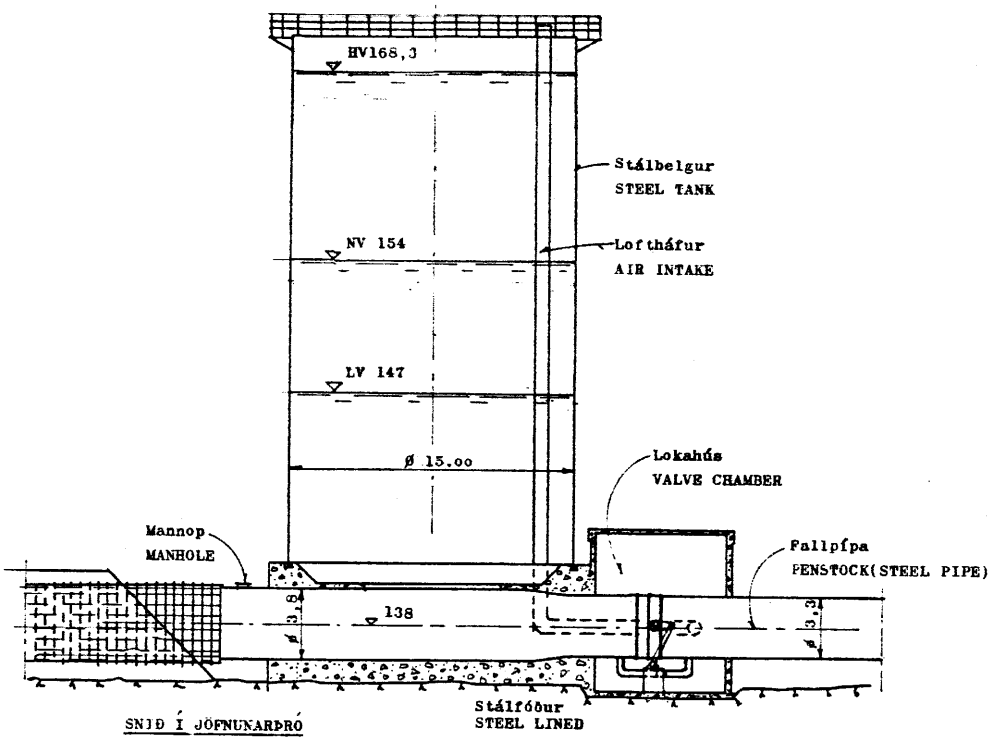
R.: HÞ T.: HÞ Y. S. Dags. 17.1.1962 M:

SIGURÐUR THORODDSEN VERKFRÆÐISTOFA
Miklubraut 34. Reykjavík . Sími 14575.

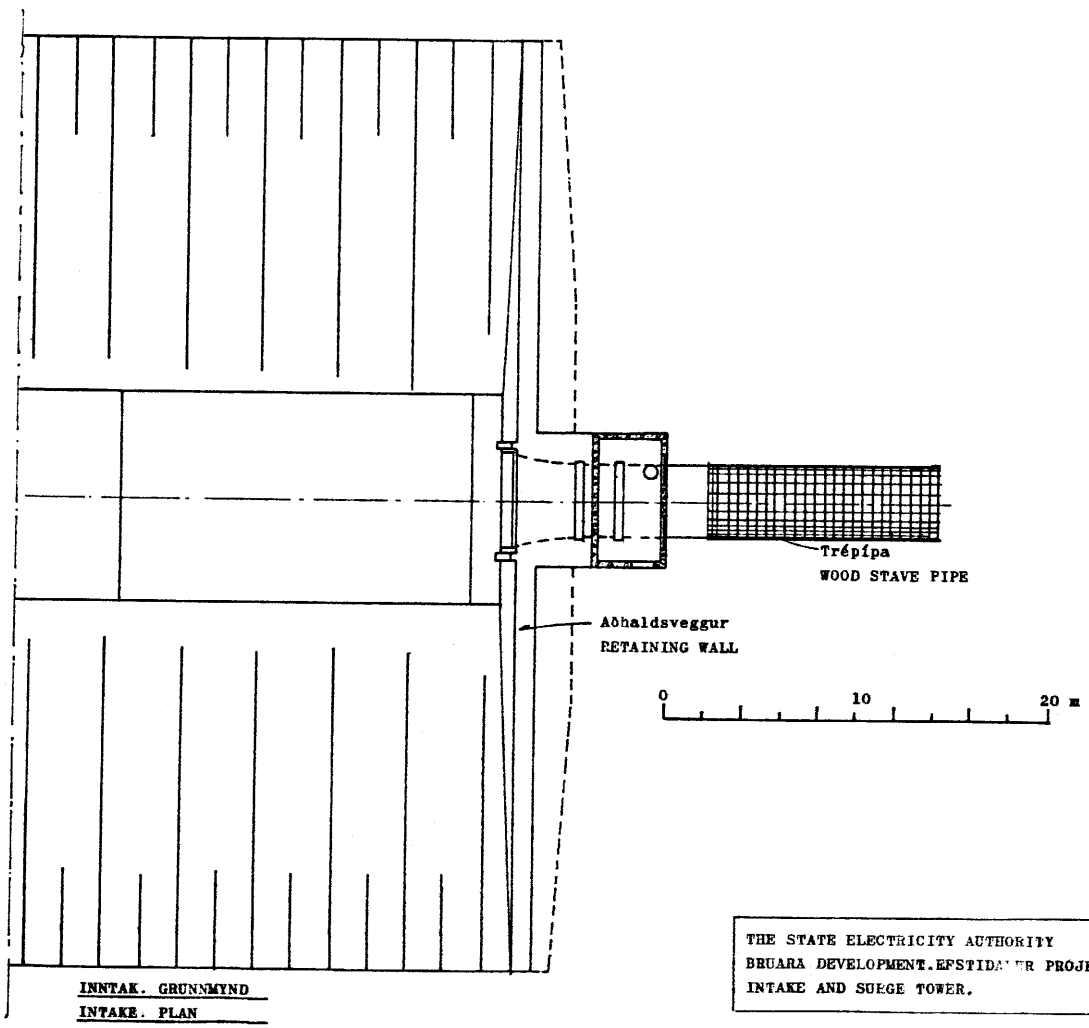
Nr.A-2280



SNIÐ Í INNTAK
SECTION THROUGH INTAKE

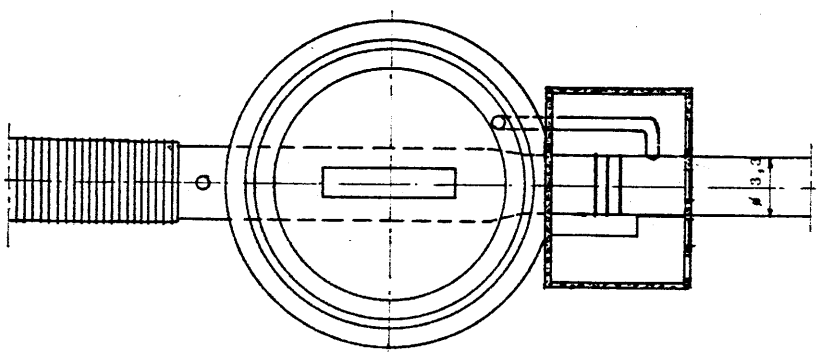


SNIÐ Í JÖFNUNARÞRÓ
SECTION THROUGH SURGE TOWER



INNTAK. GRUNNMYND
INTAKE. PLAN

Hæðartölur og ónefnd mál eru í metrum.
ELEVATIONS AND DIMENSIONS GIVEN IN METERS.



JÖFNUNARÞRÓ. GRUNNMYND
SURGE TOWER. PLAN

THE STATE ELECTRICITY AUTHORITY
BRUARA DEVELOPMENT. EFSTIDALUR PROJECT
INTAKE AND SURGE TOWER.

RAFORKUMÁLASTJÓRI

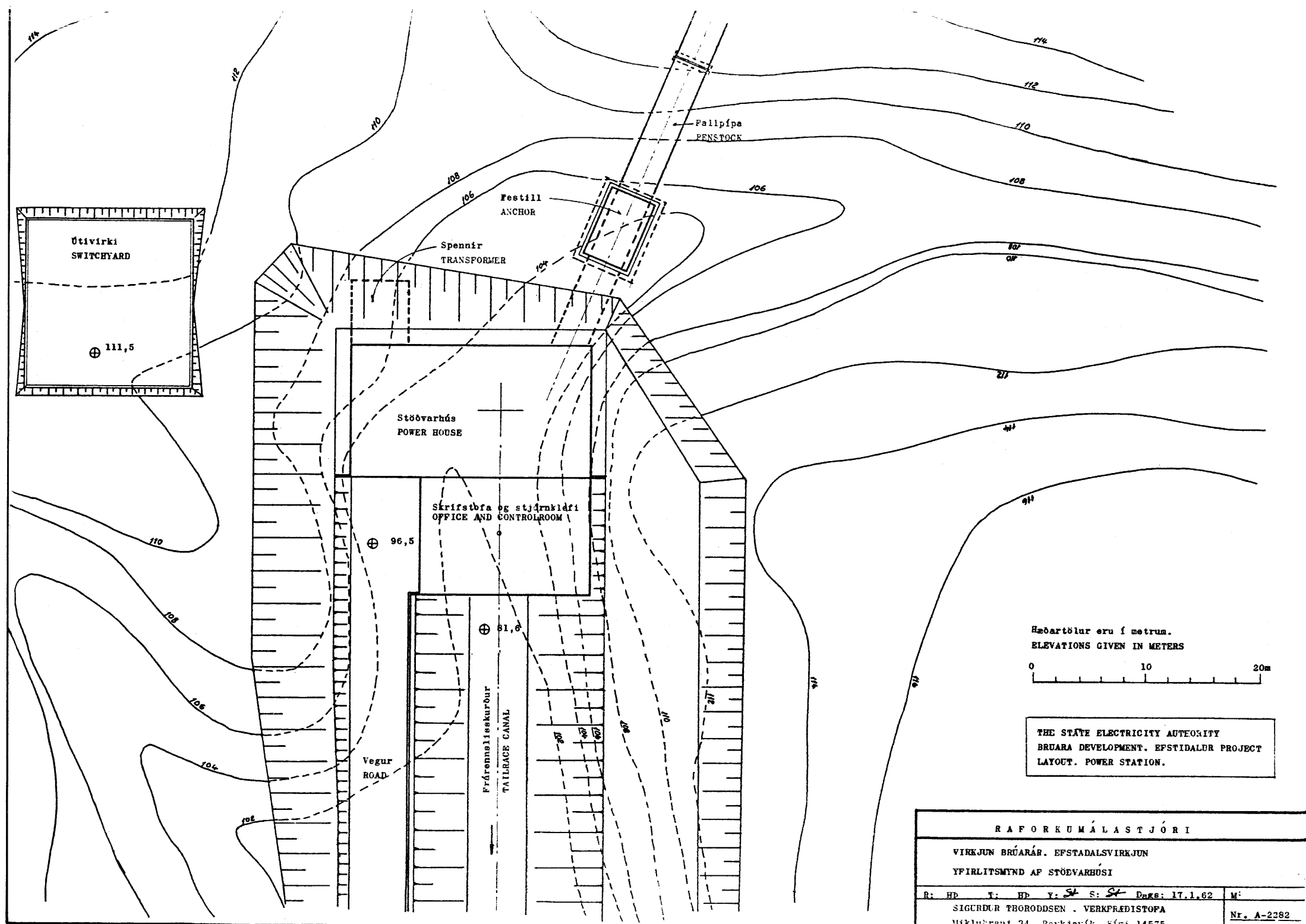
VIRKJUN BRÚARÁR . EFSTADALSVIRKJUN

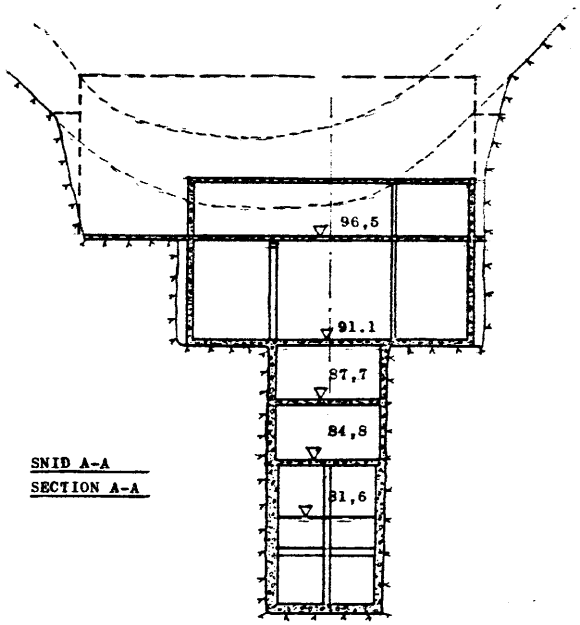
INNTAK OG JÖFNUNARÞRÓ

R: ÞÞ	T: ÞÞ	Y:	S:	Dags: 17.1.1962	M:

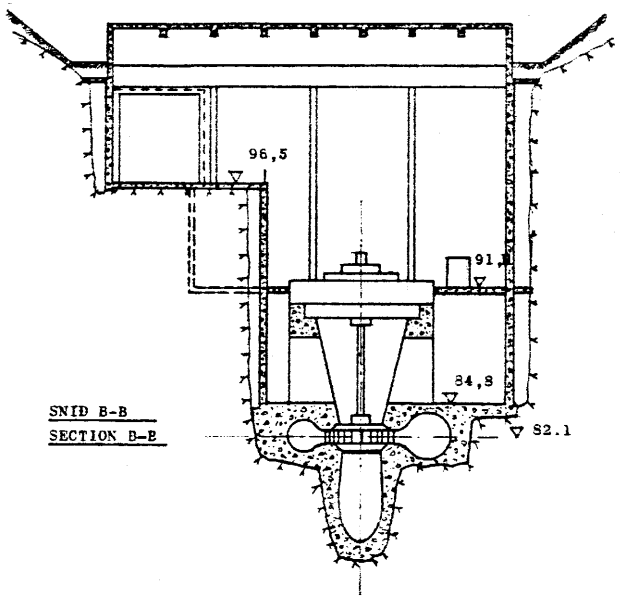
SIGURÐUR THORODDSEN, VERKFRÆÐISTOFA
Miklubraut 34, Reykjavík, Sími 14575.

Nr. A-2281

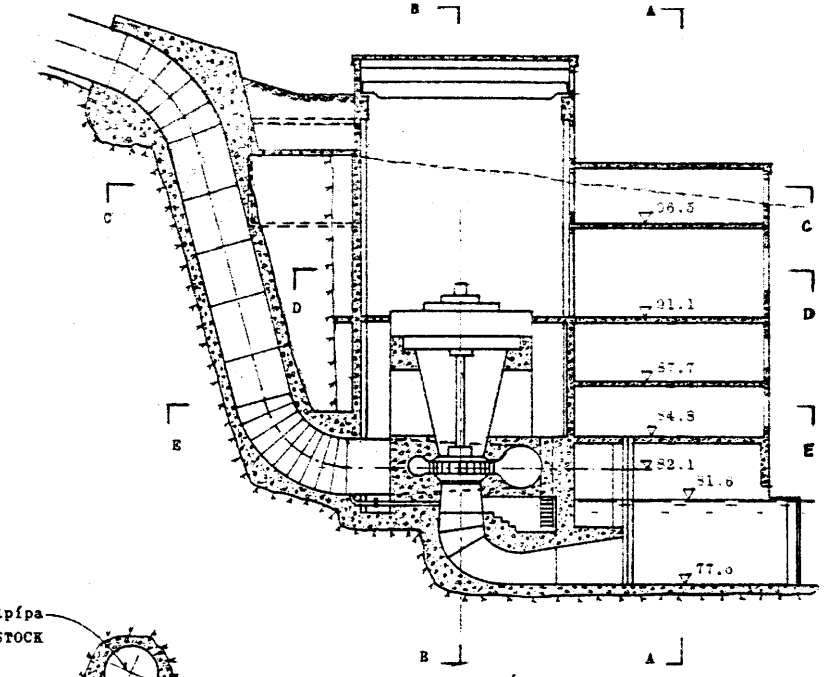

Fallpípa
PENSTOCK
Festill
ANCHOR
Spennir
TRANSFORMER
Útivirki
SWITCHYARD
111,5
Stöðvarhús
POWER HOUSE
Skrifstofa og stjórnklefi
OFFICE AND CONTROLROOM
96,5
81,6
Vegur
ROAD
Frárennslisskurður
TAILRACE CANAL
Hæðartölur eru í metrum.
ELEVATIONS GIVEN IN METERS
0
10
20m
THE STATE ELECTRICITY AUTHORITY
BRUARA DEVELOPMENT. EFSTIDALUR PROJECT
LAYOUT. POWER STATION.
RAFORKUMÁLASTJÓRI
VIRKJUN BRÚARÁR. EFSTADALSVIRKJUN
YFIRLITSMYND AF STÖÐVARHÚSI
R: HÞ T: HÞ Y: SÞ S: SÞ Dags: 17.1.62
M:
SIGURÐUR THORODDSEN . VERKFRÆÐISTOFA
Miklubraut 34. Reykjavík. Sími 14575.
Nr. A-2282



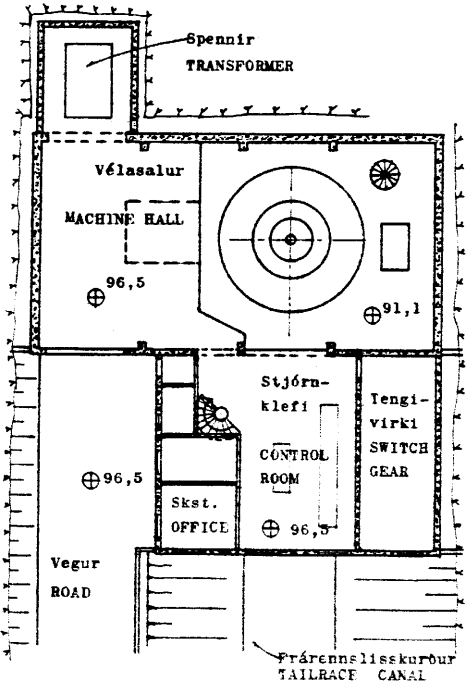
SNIÐ A-A
SECTION A-A



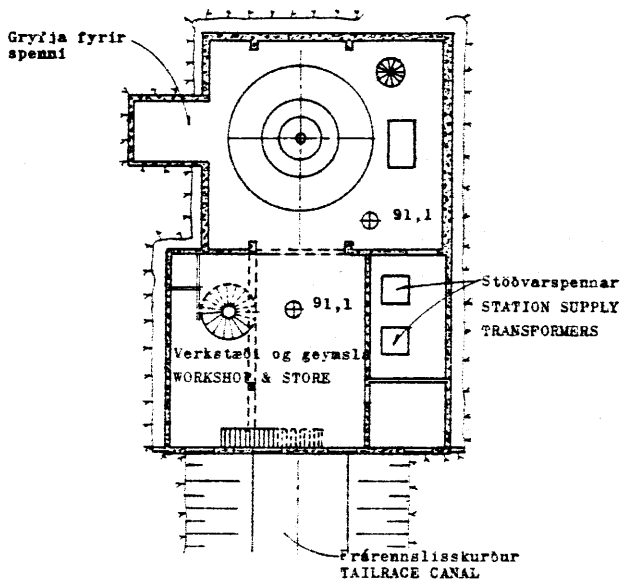
SNIÐ B-B
SECTION B-B



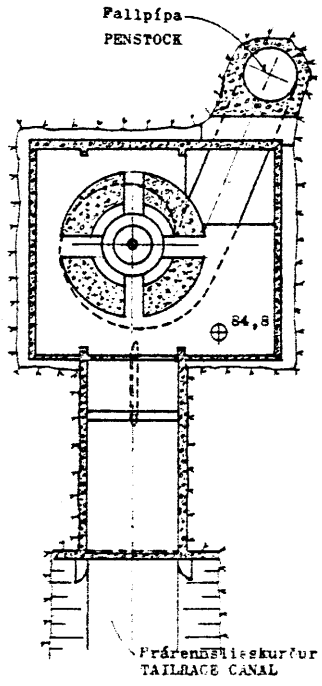
SNIÐ GEGNUM STÖÐVARHÚS
SECTION THROUGH POWERHOUSE



SNIÐ C-C
SECTION C-C



SNIÐ D-D
SECTION D-D



SNIÐ E-E
SECTION E-E

VÉLAR		UNIT	
FRANCISTÚRBÍNA		FRANCIS TURBINE	
Nettófall	71,5 m	NET HEAD	71,5 m
Virkjað rennsli	30 kl/s	DISCHARGE	30 kl/s
Afl	25800 hö	POWER	25800 HP metric
Snúningshraði	250 sn/mín	SPEED	250 RPM
RAFALL		GENERATOR	
Afl	22,7 MVA	POWER	22,7 MVA
cos	0,8	P.F.	0,8
Spenna	10,5 kV	VOLTAGE	10,5 kV
Snúningshraði	250 sn/mín	SPEED	250 RPM

Hæðartölur eru í metrum
ELEVATIONS GIVEN IN METERS

10 0 10 20m

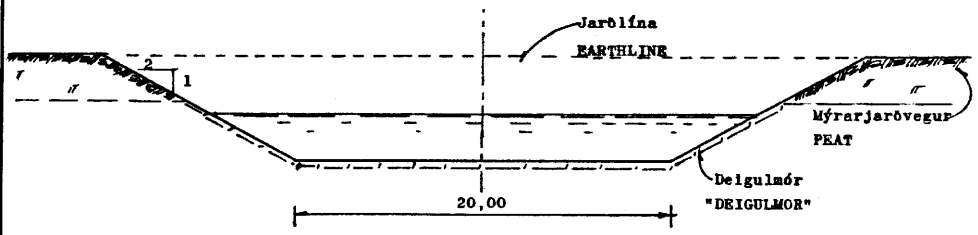
THE STATE ELECTRICITY AUTHORITY
BRUARA DEVELOPMENT, EFSTIDALUR PROJECT
POWER STATION.

RAFORKUMÁLASTJÓRI

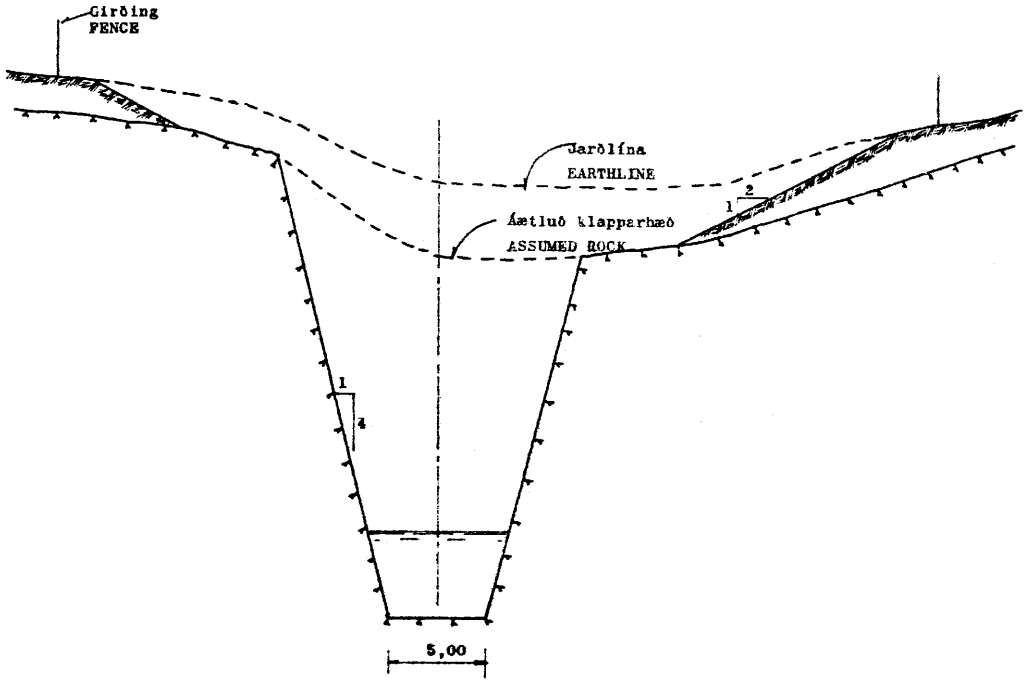
VIRKJUN BRÚARÁR . EFSTADALSVIRKJUN
STÖÐVARHÚS

R: EP T: HP Y: SV S: SV Dags: 18.1.1962 | M:

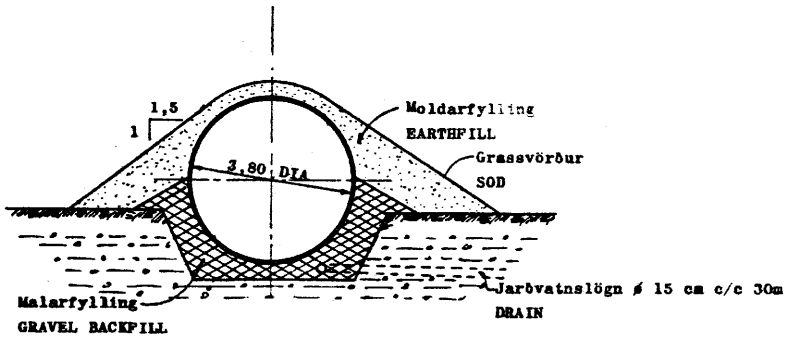
SIGURÐUR THORODDSEN . VERKFRÆÐISTOFA
Miklubraut 34, Reykjavík. Sími 14575 | Nr. A-2283



SNIÐ Í FRÁRENNSLISSKURÐ, NEDSTA HLUTA
SECTION THROUGH TAILRACE CANAL, LOWEST PART

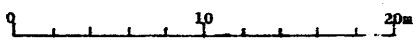


SNIÐ Í FRÁRENNSLISSKURÐ, EFRI HLUTA
SECTION THROUGH TAILRACE CANAL, UPPER PART



SNIÐ Í TRÉPÍPU
SECTION THROUGH WOOD STAVE PIPE

Mál eru í metrum
DIMENSIONS GIVEN IN METERS



THE STATE ELECTRICITY AUTHORITY
BRUARA DEVELOPMENT. EFSTIDALUR PROJECT
WOOD STAVE PIPE, TAILRACE CANAL.

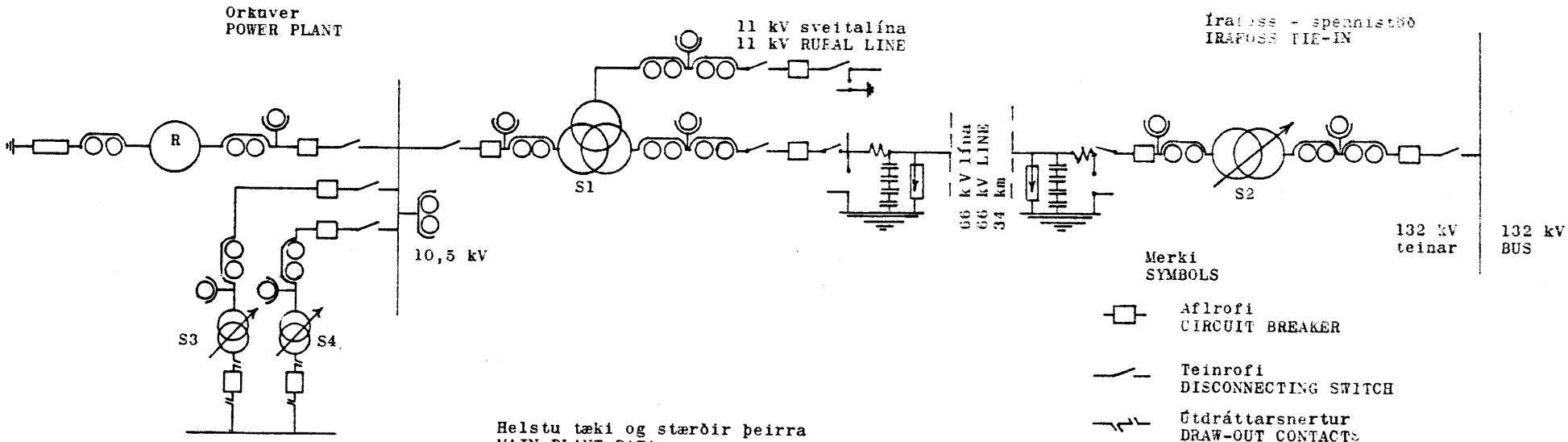
RAFORKUMÁLASTJÓRI

VIRKJUN BRÚARÁR . EFSTADALSVIRKJUN
TRÉPÍPA OG FRÁRENNSLISSKURÐUR

R: HÞ	T: HÞ	Y: SÞ	S: SÞ	Dags: 18.1.1962	M:

SIGURÐUR THORODDSEN . VERKFRÆÐINGUR
Miklubraut 34, Reykjavík . Sími 14575.

Nr. A-2284



Merki
SYMBOLS

- Aflrofi — CIRCUIT BREAKER
- Teinrofi — DISCONNECTING SWITCH
- Útdráttarsnertur — DRAW-OUT CONTACTS
- Jarðtengiviðnám — GROUNDING IMPEDANCE
- Eldingarvari — LIGHTNING ARRESTER
- Straumælispennir — CURRENT TRANSFORMER
- Spennumælispennir — POTENTIAL TRANSFORMER
- Tengiþéttir — COUPLING CAPACITOR
- Sperrispóla — WAVE TRAP

Helstu tæki og stærðir þeirra
MAIN PLANT DATA

R
Rafali, 22,8 MVA, 10,5 kV, cos 0,8
GENERATOR, 22,8 MVA, 10,5 kV, 0,8 p.f.

S1
Spennir, 22,8/2/22,8 MVA, 10,5/11/66 kV
TRANSFORMER, 22,8/2/22,8 MVA, 10,5/11/66 kV

S2
Spennir, 22,8 MVA, 66/132 kV, með sjálfvirkri spennustillingu undir álagi
TRANSFORMER, 22,8 MVA, 66/132 kV, WITH AUTOMATIC ON-LOAD VOLTAGE REGULATION

S3=S4
Spennar, 250 kVA, 10,5/0,4 kV, með sjálfvirkri spennustillingu undir álagi
TRANSFORMERS, 250 kVA, 10,5/0,4 kV, WITH AUTOMATIC ON-LOAD VOLTAGE REGULATION

THE STATE ELECTRICITY AUTHORITY
BRUARA DEVELOPMENT: EFSTIDALUR PROJECT
SINGLE LINE DIAGRAM

RAFORKUMÁLASTJÓRI

VIRKJUN BRÚARÁR. EFSTADALSVIRKJUN
EINLÍNUTENGUMYND

R: T: Y: S: Dags. 12.2.62

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