RAFMAGNSSKRIFSTOFAN

The State Electricity Authority

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# L A X Á R V I R K J U N.

11.500 HP Hydroelectric
Development on River Laxá.

INVITATION OF TENDER:

Hydraulic Turbine.

Electric Generator.

Transformers and Switchgear.

Reykjavík, September 1st, 1948.

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## I. Introduction.

The 40 square km lake Mývatn is situated at elevation 277 m above sae level in the north-eastern area of Iceland (lat 65° 35', long 17° 0' approx). The river Laxá has its origin in the west end of the lake and flows northwards as shown on drawing F. nr. 1170.

Of the total gross head of the river about 75 m are concentrated at a place called Brúar. Here the river falls from el. 107 to el. 32 m on a length of approx. 1800 m as shown on drawing F. nr. 1067. For different raesons the last 8 m of this head will not be utilized so the gross head that will be developed at Brúar is 67 m, viz. from el. 1o7 m. to el. 40 m.

In the years 1938-1939 the municipality of Akureyri erected a 2000 HP hydroelectric development in the upper part of the waterfalls at Brúar, from el. 107 to el. 69 m. An extension of 4000 HP capacity was installed in 1944. The capacity of this development is thus 6000 HP now. A general plan of this development is shown on drawing F. nr. 1067. This development does not utilize more than abt. 40% of the waterflow and can therefore be extended by approx 9000 HP.

Power from the present development is transmitted to Akureyri and Húsavík through 33 kV high tension transmission lines. The capacity of the development is now totally inadequate for the above mentioned municipalities, besides it is intended to extend the transmission system to the herring oil factories at Hjalteyri and Dagverdareyri and to the village Dalvík including different other localities.

The following three alternative hydroelectric developments can be taken into consideration for fulfilment of the increasing electric power demand, viz.

1. Full development of the upper parts of the falls at Brúar. Thus approx. 9000 HP can be developed as mentioned above.

2. Full development of the lower part of the falls at Brúar, i.e. the head from el. 69 m to el. 40 m. The total capacity of such a development is approx. 11.500 HP.

3. Development in the neighbourhood of Mývatn at a place called Sandvatn. Gross head is abt. 100 m and capacity up to 40.000 HP.

Investigations have shown that it is advantageous to develop the lower part of the falls at Brúar now, i.e. the head between el. 69 m to el. 40 m. A general plan of this development

is shown on drawing F. nr. 1067. The transmission voltage to Akureyri will be 66 kV as shown on drawing F. nr. 1170. Later on a 66 kV line will be erected from Akureyri to a power plant at Skeidsfoss, see drawing F. nr. 1170. The capacity of the power plant at Skeidsfoss is now 2400 HP and will soon be extended up to 5000 HP. Power from this development, which is owned by the municipality of Siglufjordur is transmitted to Siglufjord through a 22 kV transmission line. At Siglufjord the greatest herring oil factories are located. These factories have own dieselelectric and steamelctric plants of several thousand HP capacity.

The new development in Laxá at Brúar must therefore be able to operate in parallell with the present 6000 HP development, including the future 9000 HP unit in that station and besides be able to operate in parallell with a larger system to which different power plants are connected, and then first above all the future 40.000 HP development at Sandvatn. The voltage at Sandvatn will probable be 132 kV.

It is intended to control the new 11.500 HP station from the existing one.

II. Waterflow, head and station capacity.

The flow of Laxá is very eaven and is abt. 30-40 m3/sec. Maximum flood is not believed to exceed 150 m3/sec. It is proposed to utilize approx. 35 m3/sec.

As shown on drawing F. nr. 1067 and A-523 headwater elevation of the proposed development is 69 m and tailwater elevation 40 m above sea level. The gross head is thus 29 m. Elevation of the headwater will be practically the same as the tailwater elevation of the existing power plant. At exceptional flow elevation of the headwater will not exceed 70 m.

Elevation of the tailwater is 40 m above sea level. At exceptional flow this elevation will raise to 41,5 m. The minimum tailwater el. is 39,5 m. (seldom below 40m). The total ultimate output of the station has been computed to 11,500 HP which will be developed in one 11.500 HP vertical unit. The turbine should be designed for:

| | | |
|---|---|---|
| Normal headwater elevation | 69 | m |
| Max. " " | 70 | " |
| Min. " " | 69 | " |
| Normal tailwater " | 40 | " |
| Max. " " | 41,5 | " |
| Min. " " | 39,5 | " |
| Normal gross head " | 29 | " |
| Normal net head | 28 | " |

Full load output 11.500 HP by 28 meters net head.

III. Transport facilities, weather conditions etc.

Material and equipment for the development on Laxá will be unloaded at Húsavík. The weight of the heaviest pieces is limited by the unloading conditions there. It is believed that 25 metric tons can be handled with, however, the heaviest shipping weight should preferrably not exceed 18-20 tons. Equipment for the new main transformer station at Akureyri (see Transformer and Switchgear section) will be unloaded at Akureyri. Also here heaviest shipping weight should preferrably not exceed 18-20 tons although 25 tons can probably be unloaded.

As regards weather conditions heavy storms and snowfall often occurs at wintertime accompanied with a temperature down to 15 deg. below zero centigrade. Occasionally the temperature drops down to 20 deg. C below zero and exceptionally down to 35 deg. below zero C (once every 30-35 years or so). Temperature in summertime seldom exceeds 20 deg. C, however, up to 30 deg. C is not exceptional.

Lightning is very rare, sometimes years between and seldom more frequently than 1 to 3 times a year. Regular thunderstorms never occur.

The water in Laxá is generally clear. However in summertime the river contains some lower biological elements originating from the lake Mývatn. In wintertime there is often a quite considerable transport of sand and gravel which is ground up from the river bed by ice. The sand is of volcanic origin and very finely grained. This must especially be considered with regard to the strainers for cooling water for bearings, alternator and transformers.

The temperature of the water varies from just about zero centigrade in winter to 10-20 deg. C in summer.

In winter it sometimes happens that a great deal of ice and snow is stuffing up above the dam of the present development. It will be tried to design the new dam in such a way that this trouble will be mitigated.

Sometimes the river is blocked with ice up at the lake Mývatn. This, however, does not occur more than for 1 to 5 days a year, and it is intended to clear out the river nearest to the lake so this trouble might be eliminated.

## IV. Hydraulic Turbine Section.

### a) Description.

Existing Development.

The existing power station is installed with:

One horisontal Francis turbine from Kværner Bruk A/S, Oslo, Norway, 2000 HP. 500 R.P.M.

One horisontal Francis turbine from James Leffel & Co., Springfield, U.S.A., 4000 HP. 300 R.P.M.

Gross head is 38 meter and the penstock (wood stave pipe) is approximately 690 meters long, see drawing 1067, with an inside diameter of 2.1 meter. Both turbines are fitted with a relief valve. Total closing time of governors (at no load) is approx. 5 sec. and total opening time approx. 30 sec.

Proposed development.

Drawing A-521 shows the general layout of the proposed 11500 HP development. Drawing A-522 shows the dam. From the intake structure of the dam where an intake gate will be installed the water will be conducted to a surge tower in a wood stave pipe of 4.0 meters inside diameter. From the surge tower the water is conducted to the powerhouse through a steel pipe of 4.0 meter inside diameter. Length of pipe measured from dam to center of surge tower is 272 meters and from center of surge tower to center of turbine 106 meter. The water from the turbine will be discharged into an open channel leading to the river bed.

Drawing A-523 shows a cross section of the pipe line and drawing A-524 proposed main arrangement of the powerhouse. The turbine is a vertically mounted Francis spiral turbine with plate steel spiral casing designed for 11.500 HP (1 HP = 75 kgm/sec.) by 28 m net head. The turbine should be without a relief valve. It is not intended to install a valve between the turbine and the penstock unless it is considered necessary or adviseable by manufacturer. The turbine manufacturer is requested to propose the most suitable type of surge tank and state its main dimensions so that the guaranties with regard to speed and pressure mentioned below will be kept.

It is intended to control the new station from the existing power station.

### b) Materials and Workmanship.

All materials shall be of the best available quality in each instance.

All materials and equipment shall conform to applicable standard specifications officially recognized in the country of its manufacture.

All work shall be performed in a thorough and workmanlike manner and shall conform to the best practice in the manufacture of 1st class equipment.

c) Guarantee of performance.

Manufacturer is to state and guarantee the efficiency of the turbine at full load, 75, 50 and 25% load and maximum efficiency. The efficiency will be tested after erection, by the Gibson method of testing efficiency of hydraulic turbines. Manufacturer is further to state and guarantee the speed rise (drop) and the pressure rise (drop) by 1/4, 1/2, 3/4 and full load thrown off (on) which con be obtained with a reasonable flywheel effect in the generators rotor (mutually agreed upon with generator manufacturer) and with reasonable dimensions on the surge tank.

Speed rise should not exceed 28% and pressure rise preferable not 30-40%.

d) Manufacturers quotation, specefications and drawings.

Manufacturer is requested to give his recommendations as to the speed of the unit and base his quotations on the speed, which gives the most economical unit.

Manufacturer is further requested to submit with his quotation, specifications and general drawings describing the proposed equipment in such manner as to give a complete picture on the equipment, on which his offer is based including main dimensions, kind of materials and the following:

Runaway speed of the turbine.
Net and gross weight of the turbine with acessories.
Weight of runner, shaft and hydraulic thrust.
Drawings of overall dimensions, diameter of runner.
Governor capacity in kgm.
Prescribed flywheel effect in the generators rotor.
Transport - and mounting weights.
Type and main dimensions of a suitable surge tower.
Size of motor for operating the valve at the turbine intake, if such a valve is considered necessary.

In case of acceptance of manufacturers offer, complete information necessary for design of the powerhouse will be required.

Manufacturer is requested to inform as to the time required for preparing complete drawings necessary for designing the substructure of the power house.

e) Shop inspection.

Laxárvirkjun reserves its right to have its representative inspect the materials and equipment during its manufacture.

f) Shipping and delivery time.

Manufacturer shall deliver the equipment f.o.b. in an export port having shipping facilities to Iceland and state the earliest date possible for the delivery and shipping of the equipment. Laxárvirkjun will take care of the transport from Icelandic harbour to the site of erection.

g) Erection.

Manufacturer shall supervise the erction of the turbine with the auxiliary equipment and furnish experienced and skilled workmen for this particular work, so as to keep the erection time to a minimum.

The manufacturers superintendent shall coordinate his work with other work in progress during the erection in such a manner as will expedite the whole project.

Laxárvirkjun will provide for: 1) electric power at 220 volts, 50 cycles a.c., and 2) skilled and common labour for the erection.

h) Field tests.

After the erection of the complete unit the turbine will be tested to determine whether the manufacturers guarantees have been fulfilled.

Tests for determination of the water consumption will be made according to the Norman R. Gibson method for measuring flow in closed conduits.

i) Contract.

An agreement regarding the manufacture and delivery of the above described and below specefied equipment between the manufacturer and Laxárvirkjun shall be established in a contract, in which price, terms of payment and the requirements stated under paragraphs a) to h) above shall be fixed with such amendments as might be mutually agreed upon by the manufacturer and Laxárvirkjuns representative.

j) Specifications.

1 - Vertically mounted Francis spiral turbine with riveted steel plate casing for direct coupling to a three phase electric generator, 50 cycles a.c., designed for:

Full load output 11.500 horse power (1 HP = 75 kgm/sec.) by 28.0 meters net head complete with draft tube and turbine pit-liner, guide bearing, protection devices against overspeed, cooling and lubricating system, drainage and necessary tachometer, pressure and vacuum gauges. Runner to be of corrosion resisting material, preferably of stainless steel.

1 - Hydraulic governor, complete with all accessories and with remote controlled speed adjustment and stroke limiter.

Governor to be controlled from a permanent magnet generator on the shaft of the unit.

Hand control.

The governor to be suitable for both single and parallell operation.

1 - Suitable valve at the turbine intake, motor operated (see section IV a). Hand operation of the valve should also be possible.

1 - Set of spare parts as recommended by manufacturer.

## V. Electric Generator Section.

### a) Description.

The electric generator is a vertically mounted 3 phase a.c. 50 cycles generator rated 10.000 kVA by power factor 0,8, voltage between phases 6.000 to 6.600 volts or 10.000 to 11.000 volts at manufacturers choice, for direct coupling to the hydraulic turbine described under IV. Hydraulic Turbine Section to be erected in the powerhouse at river Laxá shown on the general lay out drawings A-521 and A-523. See also drawing A-524. It is intended to control the generator from the existing power station on Laxá, see section I and VI.

The generator shall be furnished with a shuntwound, directly coupled exciter and pilot exciter on the same shaft. Also a permanent magnet generator for controlling the turbine governor. The generator shall be designed as an enclosed self cooled machine normally operated with a surface aircooler to cool the enclosed air. This surface aircooler shall be directly attached to the machine, and capable of cooling the generator effectively at 20° C inlet temperature of the cooling water. It shall, however, be possible to take hot air from the generator cooling system for heating of engine room when needed.

The inlet and outlet ducts for this purpose shall be fitted with handoperated and automatic doors controlled by a fire extinguishing equipment.

The stator windings shall be starconnected with all 6 terminals brought out to current transformers for differential protection of the generator. The neutral point of the windings will be grounded through a resistor according to manufacturers recommandations. The generator shall be designed to withstand accidental load with normal load in two phases, and no load in the third. The insulation of the stator windings shall be of the vacuumpressure impregnated type of Class B. Six temperature detectors shall be provided for in the stator windings. There will also be required temperature detectors for the thrust and

guide bearings of the machine.

Guide and thrust bearings to have a mercury type temperature indicator, oil level gauge and a remote type oil level indicator with high and low level alarm contacts..

The generator should be furnished with an automatic voltage regulator, of modern high speed type, complete with all necessary relays and transfer switches, designed for the main and the pilot exciter. The voltage regulator shall be capable of preventing abnormal changes in the voltage of the generator and permit faultless parallell operation with the generators of the present development and future development. See section I and VI.

The regulator shall be designed to compensate independently for resistance and reactance voltage drop of 10 to 15% in the proposed 66 kV line to Akureyri (approx. 55 km long, see section VI, a.).

The main exciter shall be equipped with a motor operated field rheostat, arranged for remote control from the switchboard, and designed for use either with the automatic voltage regulator or with manual voltage control.

The pilot exciter shall be provided with manually operated field rheostat. A discharge resistor shall be provided for in the main exciter field.

Breaker and field discharge resistance shall be provided for in the main field of the generator.

The generator shall be equipped with brakes operated by oilpressure from the turbine governor. The braking system shall be able to lift the rotor and runner sufficiently for lubricating the thrust bearing when starting up after a shut down.

The generator shall be furnished with necessary piping system for cooler, bearings, automatic brakes and fire protection (the carbon dioxide type).

Arrangement of piping shall be made as to cause the least possible disturbance when the generator is dismantled.

The generator shall be effectively insulated against stray current which might injure to the bearings of the unit.

b) <u>Materials and workmanship</u>.

All materials shall be of the best available quality for the purpose for which they are used.

All materials and equipment shall conform to applicable standard specifications officially recognized in the country of its manufacture.

All work shall be performed in a thorough and workmanlike manner and shall conform to the best practice in respect of manufacture of 1st class equipment.

c) Guarantee of performance.

Manufacturer is to state and guarantee:

1) the efficiency of generator unit including/excluding exciters and rheostats at 25, 50, 75 and 100 per cent of rated kVA by unity power factor and 0.8 power factor.

2) maximum full load regulation at rated voltage and speed, in per cent of rated voltage.

3) maximum indicated temperatures at rated kVA, in the stator by detectors and in the field by resistance.

d) Manufacturers quotation, specifications and drawings.

Manufacturer is requested to give his recommendations as to the speed of the unit and base his quotation on the speed which gives the most economical unit. See Turbine Section IV.

Manufacturer is further requested to submit with his quotation specification and general drawings describing the proposed equipment in such a manner as to give a complete description of the apparatus on which his offer is based including main dimensions, kind of materials and the following:

1) General data regarding the bearings.

2) Statement of the stress of materials and safety factors for the stator, rotor, bearings, shaft and exciters under all conditions of operation of the unit. Runaway speed of the unit.

3) No load saturation curve.

4) Full load saturation curves by unity power factor and 0.8 power factor.

5) Synchronous impendance.

6) Requirements of cooling water for the surface aircooler and for the bearings.

7) Net and gross weight of the machinery including heaviest transport and mounting weight and dimensions of the bulkiest pieces.

8) Capacity of the powerhouse crane, and necessary lifting height.

In case of acceptance of manufacturers offer, there will be required complete information necessary for design of the powerhouse. Manufacturer is requested to inform as to the time required for preparing complete drawings necessary and for giving complete information for the designing of the powerhouse.

e) Shop inspection and tests.

Laxárvirkjun reserves its rights to have its representative inspect the materials and equipment during its manufacture and assembly in the shop.

The generator shall be assembled in the shop and tested as follows:

1) Dielectric tests of armature and field windings.

2) Resistance of armature and field windings.

3) No load saturation tests (incl. no load heat run).

4) Short circuit saturation test (incl. short circuit heat run).

5) Overspeed test.

6) Short circuit test.

7) Tests for determination of the $I^2R$ losses in the armature and field windings, friction and windage losses, core losses and stray losses. The result from these tests will be used to determine the water consumption and efficiency of the hydraulic turbine according to the Norman R. Gibson method.

8) Deviation factor of waveform.

9) Determination of the flywheel effect ($WR^2$).

10) Determination of synchronous reactance, short circuit ratio, transient reactance, negative sequence and zero sequence reactances.

11) Test on insulation against stray currents and test on autom brakes.

The main exciter and the pilot exciter shall be subjected to following tests:

1) Heat run to determine the temperature rise after continuous output at rated load.

2) Test to determine saturation and regulation curves.

3) Measurements of resistance of the armature and field windings.

4) Test to determine losses and efficiency.

5) Test of commutation.

6) Test to determine the response ratio of the excitation system.

7) Dietectric test of windings.

The manufacturer shall conduct these tests in the presence of Laxárvirkjun's representative and furnish certified copies of these tests in form of curves to be mutually agreed upon by both parties.

f) Shipping and delivery time.

Manufacturer shall deliver the equipment f.o.b. in an export port having shipping facilities to Iceland and state the earliest date possible for the delivery and shipping of the main equipment.

Laxárvirkjun will take care of the transport from Icelandic harbour to the site of erection.

g) Erection.

Manufacturer shall supervise the erection to the equipment and furnish experienced and skilled workmen for this particular work so as to keep the erection time to a minimum.

The manufacturers superintendent shall coordinate his work with other work in progress during the erection in such manner as will expedite the whole project.

Laxárvirkjun will provide for:

1) Electric power at 220 volts 50 cycles a.c.

2) Skilled and common labour for the erection.

h) Field tests.

After the generator together with the turbine and auxiliary equipment has been erected, the generator shall be tested with regard to temperature guarantees, max. effect etc. as mutually agreed upon by both parties. These tests shall be made with instruments and equipment provided for by the manufacturer at the expense of the Laxárvirkjun.

The main exciter and pilot exciter rheostat shall be tested to determine their proper function, and the voltage regulator shall be tested and adjusted to determine its sensitivity and response.

i) Contract.

An agreement regarding the manufacture and delivery of the equipment described above and specified below between the manufacturer and Laxárvirkjun shall be established in a contract, in which price, terms of payment, and the requirements stated under paragraphs a) - h) above shall be fixed with such amendments as might be mutually agreed upon by the manufacturer and Laxárvirkjun's representative.

j) Specification.

1 - Vertically mounted 3 phase 50 cycles a.c. generator rated 10000 kVA by power factor 0.8 star connected 6/6,6 or 10/11 kV

at manufacturers choice for direct coupling to hydraulic turbine, complete with bearings, exciter, pilot exciter and permanent magnet generator, surfaceaircooler and fire extinguishing system, automatic brakes and jacks and complete piping system and housing.

1 - High speed automatic voltage regulator complete with relays and transfer switches.

1 - Motor operated field rheostats for the main exciter.

1 - Hand operated field rheostats for the pilot exciter.

1 - Discharge resistance with discharge switch for the main exciter field.

1 - Breaker and discharge resistance for suppression of the main field of the generator.

1 - Set spare parts comprising:

1/6th Set of stator windings.

1 Set of thrust pads for the thrust bearing.

3 Set of brushes for generator slip rings, main exciter, pilot exciter.

Other spare parts if/as recommended by manufacturer.

## VI. Switchgear and transformer section.

### a) Description.

Accompanying one line diagram F. nr. 1168 shows the present high tension supply system of the Laxárvirkjun together with the extensions necessary for this project.

### Present System.

The present system consists of the existing hydroelectric power station at Brúar on Laxá installed with:

1 unit 4000 HP horisontal Francis turbine + 3500 kVA, 6/6,6 kV 3-phase, 50 cycles, cos $\varphi$ = 0.8 generator. R.P.M. = 300

1 unit 2000 HP horisontal Francis turbine + 1750 kVA, 6/6,6 kV 3-phase, 50 cycles, cos $\varphi$ = 0.8 generator. R.P.M. = 500

See also section IV a.

The generators are parallelled on the 6,6 kV side through a double busbar system (metal clad switchgear, interrupting capacity 100 MVA, type Reyrolle). The neutrals of the generators are unearthed but earthing can be arranged. The voltage regulator for

the 1750 kVA generator is from Brown Bovery and for the 3500 kVA generator from Westinghouse. The outgoing 33 kV lines from the power station are feeded through two transformers of corresponding size to the generators as shown on drawing F. nr. 1168. The neutral points of the transformers are grounded through potential transformers. The vector diagram is D2 according to VDE, the impedance approx 4% and the no load ratic 36/6-6,3 kV. Taps are provided on the high tension side for 34,5-33-31,5 and 30 kV. The station supply is 220 V, 3-phase, 3-wire and the metal clad is controlled from a 110 V, D.C. battery. All the equipment in the station is indoors.

A single circuit 33 kV wood pole overhead transmission line, 60 km. long with three 50 sq.mm. copper conductors transmits the power to the existing main transformerstation in Akureyri in which the voltage is stepped down to 6,6 kV in two transformers of exactly similar size and design as the transformers described above. The neutral points of these transformers are also grounded through potential transformers. The power supplied at 6,6 kV is distributed inside the town area and there stepped down to the consumers voltage 220 volts in 300 kVA substations.

The existing 6,6 kV distribution system in Akureyri is tied in with a small hydroelectric plant in Akureyri (500 HP).

The 33 kV overhead transmission line from Laxá to Húsavík is 25 km long, with three 50 sq.mm. copper conductors (on wood poles). At Húsavík the voltage is stepped down to 6,6 kV and distributed inside the town area.

The projected extension of the system will comprise 5 sections.

1. Transformers, switchgear and equipment for the new 11.500 HP plant on Laxá.

2. Equipment for head water control of the new 11.500 HP plant in Laxá.

3. Transformers, switchgear and equipment for a new main transformer station in Akureyri.

4. A new single circuit 66 kV transmission line from Laxá to Akureyri, approx. 55 km. long with three 70 $m/m^2$ or 95 $m/m^2$ copperconductors (wood poles or steal).

5. Transformers and equipment for the 6,6 kV distribution inside the town of Akureyri.

The equipment for the sections 1 and 3 will be covered by the following description and specification whereas the equipment for the sections 2, 4 and 5 will be contracted for separately.

The new 66 kV transmission line will be able to carry the whole capacity of the Laxá stations to Akureyri (2000 + 4000 + 11.500 HP) and the existing 33 kV line to Akureyri will not normally be operated in parallell with the new 66 kV line. The 33 kV line

will be used for rural distribution and in case of emergency. A temporary parallell operation of the two lines should, however, be possible.

As mentioned before lightning is very rare. The new 66 kV line will therefore be built without ground wires and if the line is well insulated the advantage of a Petersen coil would probable not be great. It is therefore intended to ground the neutral point of the 66 kV transformers directly, both in Laxá and Akureyri.

The new 11.500 HP power station in Laxá.

The one line diagram for this station is shown on drawing F. nr. 1169. According to the drawing the equipment will comprise one 10000 kVA transformer one 3500 kVA transformer one suitable transformer for the station supply with necessary breaker (or fuses) and a suitable low tension panel, emergency station supply can be arranged from the station supply circuit of the existing station a single 66 kV busbar system with three 66 kV oil circuit breakers, six sets of 66 kV disconnecting switches, two sets of 66 kV potential transformers and one set of 66 kV lightning arresters, neutral resistance, disconnecting switches and current and potential tranformers for the 10000 kVA generator circuit and necessary relays, meters etc. mounted on suitable panels.

It is intended to have all the 66 kV equipment outdoors except the 10000 kVA transformer. It is also intended to operate the station from the existing station and the 66 kV switchgear is located near to the existing station as shown on drawing F. nr. 1171. Drawing A-524 shows the proposed main arrangement of the power house. Although this drawing is scaled the dimensions are only approx, and will be changed in collaboration with an architect as to suit the material offered. The 10000 kVA transformer is located inside the powerhouse and a 66 kV overhead line goes from the transformer to the 66 kV switchgear as shown on drawing F. nr. 1067. A 66 kV underground cable instead of an overhead line can be considered. Place for necessary controlpanels in the existing station will be arranged for.

The capacity of the D.C. battery in the existing station is probably too small and the manufacturer will therefore be asked for a tender on such a battery. Same applies to the existing 100 kVA transformer for the station supply and the manufacturer will therefore be asked for a tender on a 300 kVA transformer.

With regard to relays, meters etc. it is felt that they should not be specified in detail. Manufacturer will therefore be requested to offer this item in accordance with best modern practice and in case manufacturers main offer is accepted the specification can be changed if necessary, as mutually agreed upon by manufacturer and Laxárvirkjuns representative.

Manufacturer will be requsted to give separately an approximate tender on power and control cables, conducting, supporting and insulating material and also on a suitable crane in the power house.

The new main transformerstation in Akureyri.

The one line diagram for this station is shown on drawing F. nr. 1166 and the main arrangement of the station on drawing F. nr. 1165 and 1167. According to the drawings the equipment will comprise two step down transformers 6000 kVA each one 1500 kVA step up transformer for rural electrification one 100 kVA transformer for station supply a single 66 kV busbar system with one 66 kV circuitbreaker, four sets of 66 kV disconnecting switches, one set 66 kV potential transformers and one set 66 kV lightning arresters, a 6,6 kV double busbar metal clad switchgear with 10 oilcircuitbreakers and necessary current and potential transformers, one grounding transformer, one low tension panel for station supply, one D.C. battery with accessories and necessary relays, meters etc. mounted on suitable panels.

As mentioned above drawing F. nr. 1165 and 1167 show the proposed main arrangement of the station. Although a scale (1:100) is shown on the drawings the dimensions are only approximate and the size of the building etc., will be changed in collaboration with an architect as to suit the material offered. Manufacturer will be requested to give an approximate tender on power and control cables, conducting supporting and insulating material and a crane in the erection hall. According to the drawings the two 6000 kVA transformers are indoors but otherwise all the 66 kV material is outdoors. (The 1500 kVA transformer is not shown on the drawings, but this transformer will be outdoors). It is then understood that the 6000 kVA transformers will be of the force cooled type. The station will be located not far from a small river and water pumps will probable have to be used. The exact location of the station has not been determined yet and the particulars of the water pumps can therefore not be given here. This question will therefore have to be dealt with later.

In case it is possible with regard to shipping facilities, self cooled transformers instead of force colled transformers will be considered. Manufacturer will therefore be requested to offer alternatively self cooled transformers. In case the self cooled type is selected the transformers will be placed outdoors and the station rearranged accordingly.

The size of the grounding transformer has not been calculated yet and this item will therefore have to be dealt with later.

b) Materials and Workmanship.

All materials shall be of the best available quality for the purpose for which they are intended.

All materials and equipment shall conform to applicable standard specifications officially recognized in the country of its manufacture. All work shall be performed in a thorough and workmanlike manner and shall conform to the best practice in respect of manufacture of 1st class equipment.

c) Guarantee of performance.

Manufacturer is to state and guarantee:

1) The efficiency of each of the transformers at 25, 50, 75 and 100% of rated kVA by unity and 0.8 power factor.

2) No load losses, % exciting current at rated voltage, % impedance for each of the transformers, by 75° C and 55° C temp. rise.

3) Temperature rise by top oil and by resistance for each of the transformers.

d) Manufacturers quotation, specifications and drawings.

Manufacurer is requested to submit with his quotation, specifications, dimension-drawings and all data necessary for the design of the power station in Laxá and the transformerstation in Akureyri, describing the proposed equipment in such a manner as to give a complete description of the apparatus on which his offer is based, including:

1) Requirements of cooling water for the oilimmersed force cooled transformers.

2) Net and gross weight of the transformers and heaviest tranport and mounting weight, and necessary lifting heigth of crane.

3) Requirements for insulating oil.

4) Test voltages for transformers' and power circuitbreakers' bushings.

e) Shop inspection and tests.

Laxárvirkjun reserves itself right to have its representative inspect the materials and equipment during manufacture and assembly in the shop.

The 10.000 kVA, the 3.500 kVA and one 6.000 kVA transformer shall be subjected to a heat run to ascertain the temperature rise. (No load and short circuit heat run).

Each of the transformers shall be subjected to low-frequency and impulse test completely assembled and necessary test to check manufacturers guarantees.

The manufacturer shall conduct these tests in the presence of Laxárvirkjun's representative and furnish certified copies of these tests.

f) Shipping and delivery time.

Manufacturer shall deliver the equipment f.o.b. in an export port having shipping facilities to Iceland and state the earliest date possible for the delivery and shipping of the equipment.

Laxárvirkjun will take care of the transport form Icelandic port to the site of erection.

g) Erection.

Manufacturer shall supervise the erection of the equipment and furnish experienced and skilled workmen for this particular work so as to keep the erection time to a minimum.

The manufacturers superintendent shall coordinate his work with other work in progress during the erection in such manner as will expedite the whole project.

Laxárvirkjun will provide for:

1) Electric power at 220 volts, 50 cycles, a.c.

2) Skilled and common labour for the erection.

h) Field tests.

Laxárvirkjun reserves itself right to repeat any test made in manufacturers shop, after the complete installation of the equipment.

These tests shall be carried out with instruments and equipment provided for by the manufacturer at the expense of the Laxárvirkjun.

i) Contract.

An agreement regarding the manufacture and delivery of the equipment described above and specified below, between the manufacturer and Laxárvirkjun shall be established in a contract, in which price, the terms of payment and the requirements stated under paragraphs a) - h) above shall be fixed with such amendments as might be mutually agreed upon by the manufacurer and Laxárvirkjun.

j) Specification.

The new 11.500 HP power station in Laxá.

Item 1. One, three-phase 10.000 kVA, 50 cycles indoor transformer of the oil immersed force cooled type with water cooler, heat exchanger and oilpumps, voltage ratio at no load

6300/66000 or 10500/66000 volts at manufacturers choice (see generator section) connected delta on the low voltage side and wye on the high voltage side with the neutral point brought out for solid grounding. H.V. and L.V. connections to be brought out through bushings. Transformer to be complete with all conventional accessories including Buchholz relay or similar devices.

Max. temperature of the cooling water is 20°C.

Spare parts.

One complete set of primary and secondary coils for one leg of the transformer and one L.V. and one H.V. bushing.

Item 2. One three-phase 3500 kVA, 50 cycles outdoor transformer of the oil immersed, self cooled type, 6300/66000 volts at no load. Otherwise as the transformer specified under item 1. except L.V. brought out through a cable box.

Spare parts.

One complete set of primary and secondary coils for one leg of the transformer and one H.V. bushing.

Item 3. One suitable 3-phase transformer for the station supply (220 volts, 3-phase, 3 wire) see drawing F. nr. 1169, including necessary breaker (or fuses) current transformer and low voltage control panel.

Item 4. One three-phase 300 kVA, 50 cycles indoor transformer of the oil immersed self cooled type, 230 volts on the low voltage side and provided with tappings on the high voltage side to provide for variation between 6000 and 6600 volts in eight equal steps, these tappings being controlled by an on-load tap changing equipment arranged for remote automatic control, the control instruments being mounted on a suitable instrument panel. H.V. side to be delta connected with the connections brought out through a cable box. Low voltage side to be wye connected with the neutral point brought out for solid grounding and the low voltage connections through a cable box.

Transformer to be complete with all conventional accessories.

Item 5. Three outdoor oil circuitbreakers, 3-pole, 400 or 600 A, 66 kV, 500 MVA interrupting capacity, automatic remote controlled from a 110 volts D.C. battery furnished with multiratio current transformers in all bushings and if considered adviseable by manufacturer, with reclosing features.

Spare parts.

Three 66 kV bushings.

Item 6. Four 3-pole, 66 kV, 400 or 600 A outdoor manually operated disconnecting switches complete with operating mechanism and two sets of suitable disconnecting switches, 66 kV outdoor type manually operated, complete with operating mechanism, to use with potential transformers. See drawing F. nr. 1169.

N o t e:

One of the switches to have grounding devices, see drawing F. nr. 1169.

One complete set of insulators for one disc. switch.

Item 7. Two sets, 66 kV potential transformers, outdoor type.

Spare parts.

One 66 kV bushing.

Item 8. One set 66 kV lightning arresters, outdoor mounting, for protecting the 66 kV line to Akureyri. Neutral solidly grounded.

Spare parts.

One 66 kV lightning arrester (for one phase).

Item 9. Twelve suitable current transformers, necessary potential transformers and a three pole disconnecting switch for use with the 10000 kVA generator. See drawing F. nr. 1169.

Item 10. One suitable current transformer, one 1-pole disconnecting switch and a suitable grounding resistance for use in the 10000 kVA generator's neutral.

Item 11. One 110 volts D.C. battery with suitable rectifier of sufficient capacity for operation of the station. Also a suitable battery control panel.

Item 12. Relays, meters, signal, alarm, syncronizing and control equipment for the station in accordance with best modern practice. Relays, meters etc. mounted on suitable panels, preferably flush mounted at least on the front side. It should be remembered that it is intended to control the new station from the existing one.

Item 13. Under this item the manufacturer is asked to give separately an approximate tender on power and control cables, conducting, supporting and insulating material. Also on a suitable travelling crane in the power house.

The new main transformerstation in Akureyri.

Item 14. Two, three-phase 6000 kVA, 50 cycles, indoor transformers

of the oil immersed, force cooled type with water cooler, heat exchanger and oil pumps, voltage ratio at no load 60000/6300 volts. Taps to be provided on the 60 kV side for 57000 and 63000 volts. These taps to be brought out from the H.V. winding to off load tap changing switches arranged for external operation. Transformers connected delta on the low voltage side and wye on the high voltage side with the neutral point brought out for solid grounding. H.V. and L.V. connections to be brought out through bushings. Transformers to be complete with all conventional accessories including Buchholz relays or similar devices.

Max. temperature of the cooling water is 20°C.

See also section VI, a, with regard to cooling water.

Spare parts.

One complete set of primary and secondary coils for one leg. One L.V. and one H.V. bushing.

Item 15. Two three phase 6000 kVA, 50 cycles outdoor transformers of the oil immersed self cooled type. Otherwise as item 14. This item is an alternative to item 14.

Item 16. One, three phase 1500 kVA, 50 cycles outdoor transformer of the oil immersed self cooled type. Voltage ratio 6300/11000 volts at no load. Taps to be provided on the 11 kV side for 10000 and 10500 volts. These taps to be brought out from the H.V. winding to off load tap changing switches arranged for external operation.

Transformer connected delta on the L.V. side and wye on the H.V. side with the neutral point brought out through a fully insulated bushing.

L.V. connection to be brought out through a cable box, H.V. through bushings.

Transformer to be complete with all conventional accessories.

Spare parts.

One H.V. bushing.

Item 17. One three phase 100 kVA, 50 cycles indoor transformer of the oil immersed self cooled type. Otherwise as item 4.

Item 18. One outdoor oilcircuitbreaker similar to breakers specified under item 5.

Spare parts.

Two bushings.

Item 19. Three, 3-pole manually operated 66 kV, 400 or 600 A outdoor disconnecting switches complete with operating mechanism. One of the switches to have grounding devices, see drawing F. nr. 1166. Also one set suitable disconnecting switches for the 66 kV P.T.s, manually operated outdoor type, complete with operating mechanism.

Spare parts.

Complete set of insulators for one disc. switch.

Item 20. One set 66 kV potential transformers, outdoor type.

Item 21. One set 66 kV lightning arresters, outdoor mounting, for protection of the incoming 66 kV line from Laxá. Neutral of the system solidly grounded.

Spare parts.

One lightning arrester (for one phase).

Item 22. A 6,6 kV, 1200 A, double busbar metal clad switchgear, 3-phase, 50 cycles, electrically operated from a 110 V D.C. battery. Metal clad to be of modern design with ten oilcircuitbreakers (see drawing F. nr. 1166) and necessary potential and current transformers.

Buses to be air insulated and interrupting capacity to be 250 MVA.

Item 23. One 110 volts D.C. battery with suitable rectifier of sufficient capacity for operation of the station. Also a suitable battery control panel.

Item 24. One low tension (220 volts) control panel for 5 outgoing feeders as shown on drawing F. nr. 1166 with automatically operated air break switches for each outgoing feeder.

Item 25. Relays, meters signal alarm and control equipment for the station in accordance with best modern practice,

Relays, meters etc. to be mounted on the metal clad and suitable panels, preferable flush mounted at least on the front side.

For instance following relays protection and metering will be required.

Differential, Buchholz, temperature and overcurrent protection for the 6000 kVA transformers. Also necessary devices for oil flow and cooling water flow. Overcurrent and ground fault protection for incoming 66 kV line.

Overcurrent and ground fault protection for each of the outgoing 6,6 kV feeder.

Following metering for incoming power from Laxá.

Volts and amps.

Indicating kW and kVAr meters.

Registrating (recording) kW meter.

kWh meter.

Ammeters for each of the 6000 kVA transformer circuits and temperature measurements. Voltmetering between phases and from phase to ground on the 6,6 kV metal clad. Ammeters for each of the 5 outgoing feeders.

1500 kVA transformer circuit.

Amps, kWh and recording (registrating) watthour demand meter with 1/2 hour intervals.

100 kVA transformer circuit.

Volts and total amps at 220 volts and total kWh.

Item 26. One grounding transformer. See section VI, a.

Item 27. Under this item the manufacturer is requested to give separately an approximate tender for a crane in the erection hall and power and control cables, conducting supporting and insulating material.