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A REPORT
on
Roznow Dam

Prepared by
Project Treasure Island
for
Directorate of Intelligence, USAF
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This report contains information requested on the Roznow Dam on the Dunajec River in Poland. The dam serves for the control of flood and navigation on the Wisla (Vistula) River, and for the production of power as a peak-load hydroelectric power plant.

The information submitted is the result of a study of French, German, Polish, Russian and Slovak open sources published between 1930 and 1952. The most valuable information was found in sources listed under Nos. 1, 10, 12, 15, 16, and 18.

The report was compiled in accordance with the P.V.D. questionnaire as follows:

I. Functions

A. The system of which the dam forms a part

See map, Fig. 1.

The Roznow Dam is one of a series of dams built by the Polish government on the Vistula River and its affluents. It is followed 13 km downstream, by the Czchow Dam which forms a tailwater pondage below the Roznow Dam. The function of these dams is to control floods and navigation on the upper Vistula River, electric power production being only a secondary aim.

The construction of a third dam (rock-fill) and a reservoir was recently started (1952) in the upper reaches of the Dunajec River, at Czorsztyn.

B. The dam within the system

The Roznow Dam forms the main storage reservoir on the Dunajec River.

The Roznow Dam has three functions:

(1) Control of floods.

(2) Control of navigation.

(3) Power production.

1. Control of flood

For the control of floods, the Roznow Reservoir has an abundant storage capacity (230,000,000 cu m at high water) which assures the protection of an area of about 200,000 ha of arable land from devastating floods, such as the 1934 flood.

2. Control of navigation

The control of navigation is obtained by coordinated operation of the Roznow and Czchow Reservoirs.

The peak-load Roznow Power Plant works on the average, 6 to 8 hours a day utilizing its daily pondage.

During the remaining hours it stores water without any spillway discharge. This irregularity of discharge is eliminated by the Czchow Reservoir operating 24 hours a day.

Thus the flow in the Dunajec and Vistula rivers is regulated from season to season by the Roznow Dam and within every 24 hours by the Czchow Dam.

An improvement of navigation on the Vistula River by lowering the river level at high water and raising it 25 cm in time of drought or low water is thereby achieved.

3. Power production

The third function of the Roznow Dam and Power Plant is power production. The Roznow Plant is operated as a peak-load power plant for the Roznow-Czchow-Tarnow-Warsaw transmission line.

C. Highways and railways resting on the dam or adjacent thereto (Figs. 2 and 3)

Some 27 km of new paved roads were built in the immediate vicinity of the dam.

New roads, 7-m wide (5 m paved) totalling 6.7 km were built on the left bank, while on the right bank the 8-m wide (5 m paved) roads total 17.8 km. In addition, 3 km of roads connect both banks. The connecting road runs atop the dam.

A reinforced concrete bridge 407-m long was built across the river and another large bridge was planned in 1941. The location of these bridges is not indicated.

In order to transport material and equipment needed for the construction, a narrow-gauge railroad connecting Roznow with the state railroads was built in 1936 (Fig. 3). A temporary wooden bridge across the river was built for this railroad.

D. Navigation locks in connection with the dam

No navigation locks were built, as the Dunajec River is a typical mountain stream, not suitable for navigation.

II. Location and designation

A. Data which will make possible pin-pointing the installation

Roznow is in the province of Cracow (Wojewodztwo Krakowskie), county of Nowy Sacz (powiat Nowosadecki). It is located on the 80th km of the Dunajec River, 25 km north of Nowy Sacz and 3 km upstream from the village of Roznow.

B. Official, local, and popular names of dams and dependent installations

Roznow.

III. Dimensions

A. Dam

See Figs. 2, 3, 4, 5, 6 and 23.

1. Maximum and minimum head on dam

Maximum head is 31.50 m (in spring and fall).

Normal head varies between 26.01 m and 30.01 m.

Minimum head is 19.50 m (only a short time before the flood period).

2. Maximum and minimum depth of water below dam

See Figs. 5 and 6.

3. Total height of dam above river bed and above foundations

See Figs. 5 and 6.

Height above river bed is 35 m.

Height above foundations is 47 m.

4. Elevation of bottom of penstocks at dam

There are no outside penstocks, only intakes built into the dam.

5. Total thickness at base and at high water level

See Figs. 5 and 6.

Thickness at base is 38 m.

Thickness at crest is 8 m.

Thickness at high water level is 5.5 m.

6. Slopes of dam faces

See Figs. 5 and 6.

Upstream slope 1:0.1

Downstream slope, upper part 1:0.7 - lower part 1:0.8

7. Length at crown, across river bed and along spillway

See Figs. 2, 3, 4 and 23.

Length at crown is 550 m.

Length along spillway is 105 m.

B. Reservoir

1. Capacity

The total capacity is 230,000,000 cu m at the highest water level.

The effective capacity is 166,100,000 cu m.

The reservoir has, during the summer months, a 50,700,000-cu m standing reserve for reception of flood water.

2. Area

The area of the reservoir is given as 1,700 ha and 1,800 ha.

3. Length, width, and depth (including profiles)

The reservoir is 18 km long, and 1 km wide at its widest point. Its depth at the dam is 35 m.

4. Detailed plan in vicinity of the dam

See Figs. 2, 3, 4, 7, 8, 9, 17 and 23.

The valley at the dam site is at an elevation of 246.00 m, while the highest surrounding hills rise to 420.00 m. These hills, belonging to the Beskid Mountains, are covered with pine forest. The dam crest is at the elevation of 272.00 m.

C. Navigation locks in connection with the dam

No navigation locks were built since the Dunajec River is not navigable.

IV. Hydrological data

The catchment area of the Dunajec River extends into the High Tatra Mountains to elevations of 2,600 m and into the Beskid Mountains to elevations of 1,200 m. It comprises a catchment area of 4,850 sq km for the Dunajec River with all its affluents, and a catchment area of 2,080 sq km for the Dunajec River alone.

The yearly precipitation in this area ranges from 900 mm to 1,200 mm in the Tatra Mountains. An exceptionally heavy rainfall of 700 mm in one month occurred in 1934.

The Dunajec River has all the characteristics of a mountain stream, i.e. a wide difference between average and high flow, a steep incline and it carries a considerable amount of silt and boulders.

Flow characteristics of the Dunajec River:

Minimum flow	5 cu m/sec.
Medium flow	44 cu m/sec (180 days a year).
High flow	1,400 cu m/sec (every four years).
Unusual flood flow	3,500 cu m/sec (July, 1934).
Average flow	60 cu m/sec.

The medium and the high water can be entirely stored in the reservoir and released when necessary to maintain a normal flow in the Dunajec River.

Unusual flood peaks, like in 1934, can be reduced from 3,500 cu m/sec to 2,600 cu m/sec.

The yearly discharge varies greatly, according to records kept from 1914 to 1935. With the exception of the unusual flood year of 1934, the total water discharge varied from 940,000,000 cu m in the dry year of 1917 to 3,280,000,000 cu m in 1926.

V. Foundation conditions and soil characteristics under and near the dam

The central and upper strata of the Tatra Mountains consist of Jura limestone, which, in its higher layers is superimposed with crystalline rock, mostly granite. North of the town of Nowy Sacz, the Dunajec River breaks in a deep cut through a very wide zone of flysch. This consists of a thick and extensive deposit of mostly sandstone, belonging to the early Tertiary System and in part to the Cretaceous and Permian Systems. The Roznow Dam is in this flysch zone.

The river bed is filled 10 m deep with boulders of various sizes, below which lies a 2 to 3 m thick heavy fissured sandstone. This sandstone is partly uniform and partly of a conglomerate structure.

Between the layers of sandstone are layers of clay slate from 0.05 m to 0.20 m thick.

Faulty strata are frequently encountered. Sound rock is found at the elevation 228.00 m or about 12 m under the river bed.

The various layers of the bottom rock form an angle of 20 to 25 degrees with the axis of the dam (Fig. 5). Thus different sections of the dam stand on different layers of rock. This created difficulties in the laying of foundations. Bores, 50 m deep and 65 mm in diameter were drilled on the upstream side of the dam, 3 m apart, to build a grouting curtain. (Fig. 5). Another row of 35-m deep bores was made under the foundations 2.5-m apart from the first row. A third series of 20-m deep bores was made additionally in 1941 from the lower inspection gallery, also spaced at 3 m, and injected with grout under 25- atm pressure. The ratio of the grout mixture was from 1: 1 to 1: 5 as the absorption of the porous rock was very high. An average of 650 kg of grout per unit meter was used.

In order to eliminate uneven setting of the dam blocks, a 3-m thick foundation base of reinforced concrete was laid.

Under the powerhouse, where the subsoil was found to be of the poorest quality, grouting wells 7 m deep and 1.50 m to 2 m in diameter were filled with cement and reinforced with rails in order to increase resistance against sliding (Figs. 10 and 11). A total of 10,000 m of wells were filled with 7,000 tons of cement. In 1940, an additional grouting curtain was made along the mountain ridge (Fig. 2), with a total length of 800 m, in order to prevent seepage through the ridge into the valley.

VI. Design data

A. Structural type or types

See Figs. 12, 13, 14, 15 and 16.

The dam was originally planned as a buttress type, but the soil conditions made it necessary to build a gravity dam, with the exception of the central part. This part consists of four sections, each 17 m wide, built as a buttress dam with 5-m thick slabs on the upstream facing. The powerhouse stands in this central part (Fig. 4). This is considered to be a weak point in the structure, since the subsoil conditions in this section of the river bed are the poorest.

B. Materials used

Plastic concrete was used with sand at grain sizes graded according to the sieve curve from 0 to 80 mm, as follows:

0.25	-	2 mm	18 %
2.00	-	10 mm	40 %
10.00	-	30 mm	62 %
30.00	-	80 mm	100 %

The concrete was produced on the spot; the sand and gravel for the mix were obtained from the river bed 3.5 km upstream.

The quantity of Portland cement per cu m of concrete is 300 kg in a layer 2 m thick on the upstream face of the dam and 1 m thick on the downstream face; it is 250 kg in other parts of the dam.

The compressive strength for concrete samples was found to be 250 kg/sq cm after 28 days, and 330 kg/sq cm after 180 days. The dam volume is some 385,000 sq m of concrete. Reinforcement for the concrete is made of steel rods 36 mm in diameter, auxiliary rods 20 mm and 24 mm, and tying rods 14 mm in diameter. The quantity of reinforcement used was in average 4 kg per cu m of concrete and 160 t per block. The total weight of steel structures and reinforcements in the powerhouse and spillways is about 2,300 tons.

C. Design criteria

The distribution of stresses in the dam was calculated according to the French method of Pigeaud.

Stresses in the lowest joint of the foundation, for the elevation of 228.00 m (the highest water level is 270.00 m) were found to be as follows:

Upstream Toe	Reservoir Full	Reservoir Empty
Normal Stresses	N_1 = 2.11 kg/sq cm	N_1 = 9.03 kg/sq cm
Inclined and External Normal Unit Stresses	(A = 4.20 kg/sq cm (B = 2.10 " " "	(A = 9.05 kg/sq cm (B = 0 " " "
Shearing Stresses	C_{max} = ---	C_{max} = 2.268 kg/sq cm

Downstream Toe	Reservoir Full	Reservoir Empty
Normal Stresses	N_2 = 7.887 kg/sq cm	N_2 = 0.644 kg/sq cm
Inclined and External Normal Unit Stresses	A = 11.667 kg/sq cm B = 0 " " "	A = 0.956 kg/sq cm B = 0 " " "
Shearing Stresses	C_{max} = 2.916 kg/sq cm	C_{max} = 0.240 kg/sq cm

The compressive stresses do not exceed 35 kg.

By comparing normal stresses for the elevation 238.70 m on the upstream side with the possible maximum uplift of 3.13 kg/sq cm (for the difference of water levels 270.00 m and 238.70 m), a ratio of compressive stresses to the uplift was obtained as 1:2 (Θ = 0.5). For the elevation 228.00 m this ratio is more favorable, namely 1: 1.57 (Θ = 0.636). To improve these conditions a grout curtain was made (see Section V).

The stability factor was calculated at 1.8. The highest soil pressure in the normal and spillway sections of the dam is 9.4 kg/sq cm and in the powerhouse section 10.45 kg/sq cm.

The horizontal friction coefficient at the bottom, taking the uplift into account, is 0.54 and 0.42 respectively.

D. Details and equipment

1. Spillways

a) The spillway section of the dam (Fig. 3, 4 and 6) is 105 m long, and consists of seven concrete blocks 15 m wide each, forming seven spillways 6.2 by 12 m each. The spillways are closed by tainter gates, made of 8 mm thick steel plates.

In addition to the tainter gates, there are stoplogs made of steel channel bars each 80 x 80 x 8 mm.

b) Underneath the main spillways there are five auxiliary discharge sluices (Figs. 6, 17, 18 and 19). Their axis is at an elevation of 242.5 m or 21 m below the threshold of the spillways. The sluices are funnel-shaped and have a 6-m inlet diameter which is reduced to 3.5 m along a length of 2.2 m. The sluices are made of 12 mm thick steel plates, welded, and imbedded in the foundation of the dam.
Each sluice is closed by rolling gates 2.7 m by 3.7 m, operated by a servomotor with oil under 25 atm pressure. The gates can be also operated by hand. The servomotors and other operating mechanisms of the discharge sluices are located in the middle inspection gallery.
When all main spillways are open, 3,200 cu m/sec can be discharged.

2. Inlet conduits

See Fig. 20.

The intake conduits to the powerhouse are made of steel plate, 12 mm thick, welded and reinforced with steel rings. They are 5.5 m long, have 3.8 m in diameter and are imbedded in the dam. They are equipped with 2.55 m x 6-m double rolling gates, both of which are operated by a servomotor with oil under a 25 atm pressure.

The gates close by their own weight.

Racks at each intake consist of three panels, each 2.4 m wide and 10.5 m high.

Stoplogs are covered with steel sheets. They are operated by a gantry crane running along the crown of the dam in the powerhouse section. The same crane is used to remove the racks.

3. Inspection galleries

See Figs. 5, 6 and 20.

There are three inspection galleries in the dam. The lower gallery with a diameter of 3 m is at the elevation of 228.76 m. The middle inspection gallery is 2 m high, 1 m wide, located at the elevation of 248.79 m. The upper inspection gallery is 2 m high, 1 m wide and is located at a level of 263.34 m. There is a top gallery, some 4.5 m high and 3.10 m wide at the elevation of 266.50 m.

In the lower inspection gallery instruments were installed to measure the bottom pressure, movements of separate sections of the dam, and the temperature of the subsoil.

4. Cranes

See Fig. 20.

There is a gantry crane in the powerhouse section of the dam for the operation of stoplogs and racks.

There is also a crane within the powerhouse.

5. Fishway (Fig 4)

A fishway is built in the dam, consisting of 78 chambers, each 6 m long, 3.5 m wide and 0.4 m deep. This fishway is located at the right end of the dam. It was built on the basis of experience in Scotland.

6. Drainage of the dam

See Fig. 5

The drainage in the dam occurs through vertical drainage holes spaced at 2 m and 2.50 m from the upstream face. The drains discharge into the inspection galleries and lead to a pumping shaft which also serves for the drainage of the suction tubes of the turbines.

Perforated cement drain tubes, 30 cm in diameter are used.

7. Expansion joints

Two copper sheets, 2 mm thick are cemented between the separate concrete sections (blocks) of the dam, 1 m from the upstream side. A 0.20 x 0.20 m vertical asphalt-filled hole reinforced by a 5-cm thick rope of tarred hemp, runs from the expansion joint.

VII. Special data on power dams

A. Capacity (kva), present and proposed

Installed

62,400 kva; (50,000 kw) (1942).

B. Output (kwhr/yr) achieved and proposed

The annual output of energy varies between 51,000,000 kwhr and 190,000,000 kwhr a year and averages 126,000,000 kwhr against an expected annual output of 142,000,000 kwhr.

C. Powerhouse

See Figs. 3, 7, 14, 15 and 20.

1. Location

The powerhouse is located approximately in the center of the dam and of the Dunajec River valley (Figs. 3 and 4). The choice of this location for the dam on the poorest subsoil foundation, was later criticized as the weakest point of the structure.

2. Structure

See Figs. 20, 21 and 22.

The powerhouse is of reinforced concrete, built into the dam, which in this part is of the buttress type. It is 68 m long, resting on four blocks, each 17 m wide. The inlet conduits, turbine niches, and draft tubes are built into the wall of the dam.

3. Installations

See Fig. 20.

The powerhouse at Roznow is equipped with four Kaplan vertical 12,500-kw, 214-rpm turbines coupled with four vertical 3-phase, 15,600-kva, 6-kv, 214-rpm generators. Each turbine has a flow capacity of 50 cu m/sec. The total weight of

the four turbines is 375 t. The total weight of the four generators is 325 t. The generators are connected to double 6-kv buses.

A 140-kw Diesel-generator unit is installed for the plant's own use.

4. Number, dimensions, location and type of penstocks

There are no penstocks at the dam. The inlet conduits for the turbines are described in Chapter VI - D - 2.

D. Places of installations served; ties with power grids

The Roznow Hydroelectric Power Plant is connected by a 150-kv single transmission line with Moscice (Tarnow) - Warszawa. It is also interconnected with the base-load hydroelectric power plant of Czchow and thermal power plants of Moscice and Nisko.

Due to the adoption of Soviet high-voltage norms in Poland, it was proposed (1946) to change the 150-kv single transmission line into a double 110-kv line. The Roznow-Warsaw high-voltage transmission line is part of a power grid, planned before the war and greatly developed during the Poland 6-Year Plan. The grid is shown in Fig. 24 as it was planned in 1937. Since then the transmission lines to Warsaw and Lodz were completed.

E. Location and description of transformer yards and transmission system

There are four 6/150-kv transformers. Information on their location is not available.

VIII. Historical data

A. Name and background of the designer

The construction of the dam and of the powerhouse was started by the Polish Government in June 1935. The construction plans were revised by two Swiss experts in hydroelectric structures. The Polytechnical Institute of Warsaw cooperated in performing laboratory tests and experiments.

The construction was done by two French enterprises, the Societe des Grands Travaux de Marseille (Society of Great Works of Marseille) and la Regie Generale des Chemins de Fer et Travaux Publics (The General Administration of Railroads and Public Works) - which in Poland formed the corporation "Zapory i Roboty Hydrauliczne" (Dams and Hydraulic Works). During the German occupation from October 1939, the completion of the project was in the hands of the occupation authorities in Cracow, specifically the "Water-Economy Division".

B. Dates of construction

Work began in June, 1935. A 30-kv, 50-km line from Moscice (near Tarnow) was built to supply electric energy needed for the construction work. A 19-km long, narrow-gauge (750 mm) railroad track was built to connect Roznow with the State railroads. The point of connection is at the Marcinkowice Railroad Station.

The first half of the foundation pit was dug and local installations needed for the construction were built in 1936. About 120,000 cu m of concrete were laid in 1937. About 160,000 cu m of concrete were laid in 1938. It was planned to complete the construction of the dam by mid 1941. The powerhouse was put into operation in early 1942.

C. Sources of materials

Cement - from Polish cement factories.

Concrete - produced in own mixing yard at Roznow.

Steel rods and shapes - from Polish steel plants.

Power plant equipment - mostly from German firms. The turbines are made by Escher-Wyss and Co.

D. Records of war damage, failures, removal of equipment, etc.

No information available, except that the major part of drafts and blueprints were destroyed during the German campaign in Poland and had to be re-designed under German occupation authorities.

E. Data on conditions of structure at any date

The last detailed data are from 1947.

F. Proposals for enlargement, alterations or extension of functions

No plans are known except for the change of voltage from 150-kv to 110-kv.

IX. Graphical material

A. Photographs, especially those taken during construction

Photographs attached to this report are shown in Figs. 2, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22 and 23.

B. Working drawings, general and detailed

Not available.

C. Record and publication drawings

Drawings attached to this report are shown in Figs. 1, 2, 3, 4, 5, 6, 20 and 24.

D. Sketches by persons who have seen installations

Not available.

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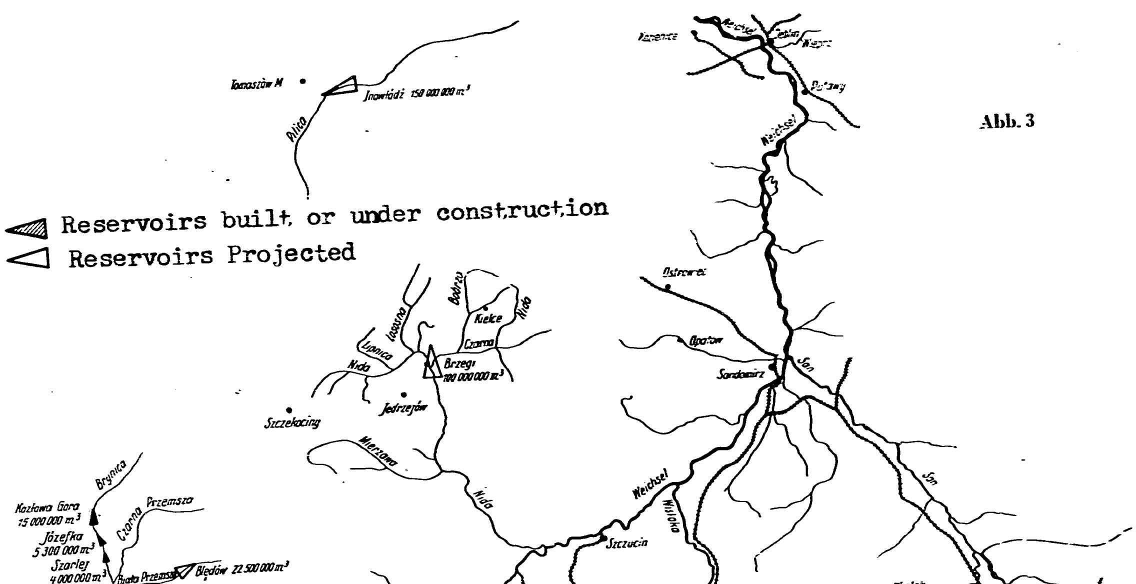
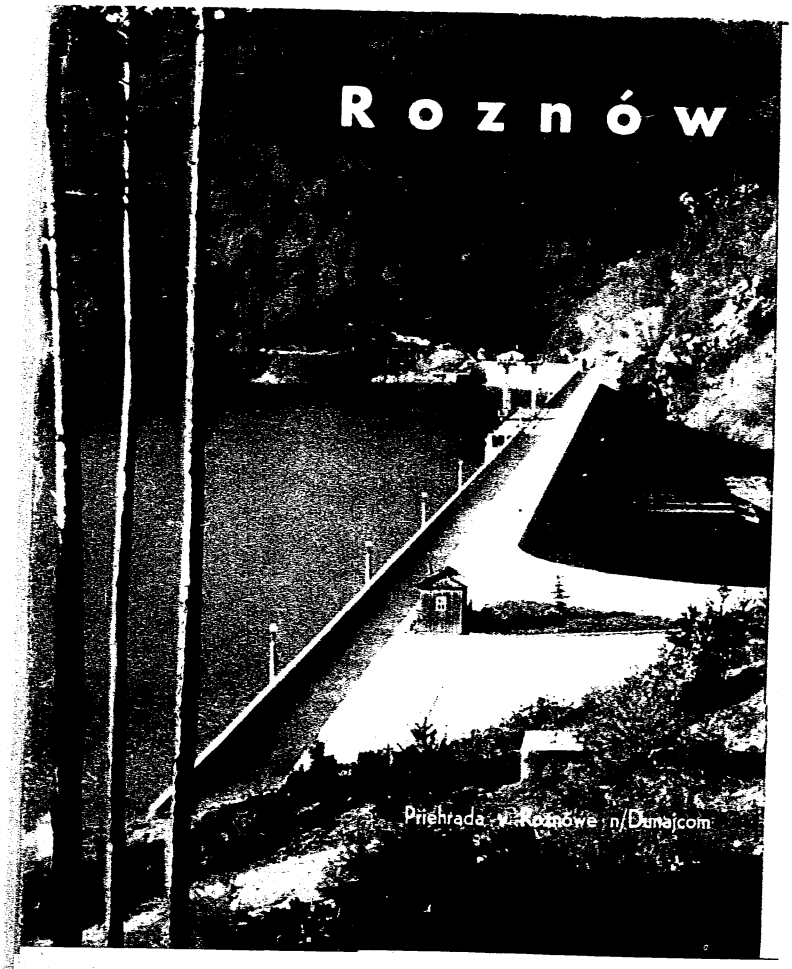
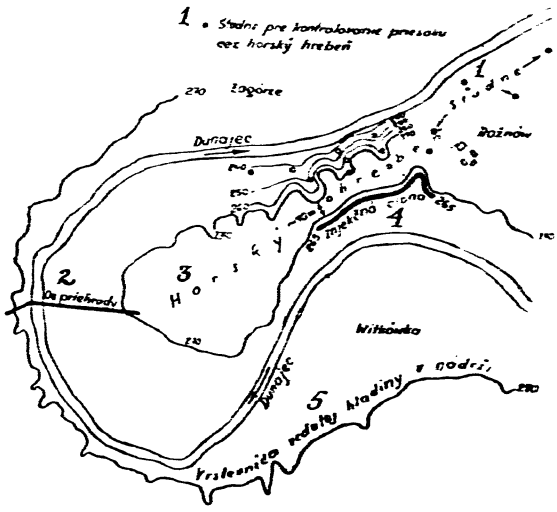


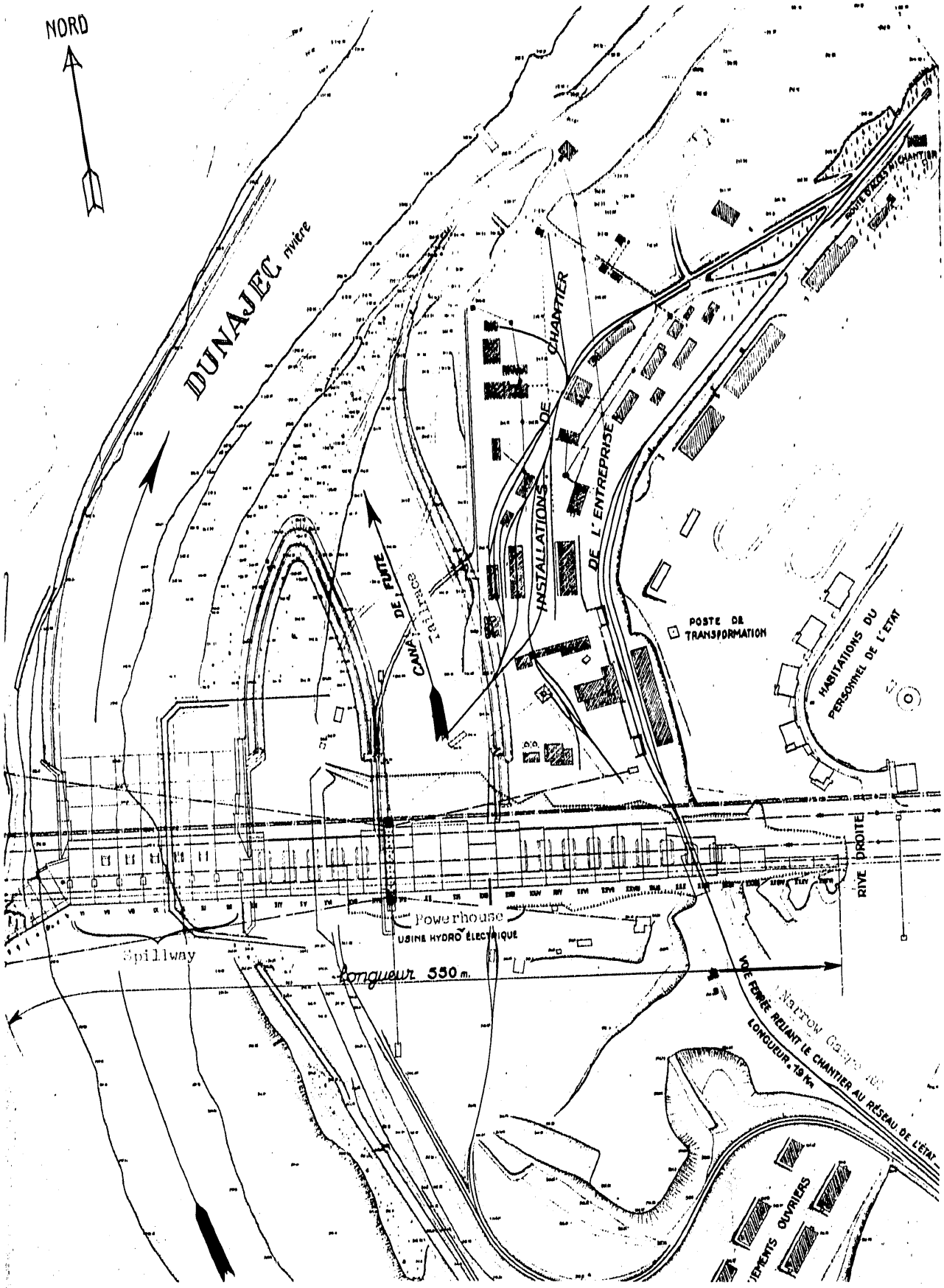
ROZNŎW DAM, POLAND. The Vistula River System. Source: Deutsche Wasserwirtschaft, Munich, Febr.1941, No.2, p.65



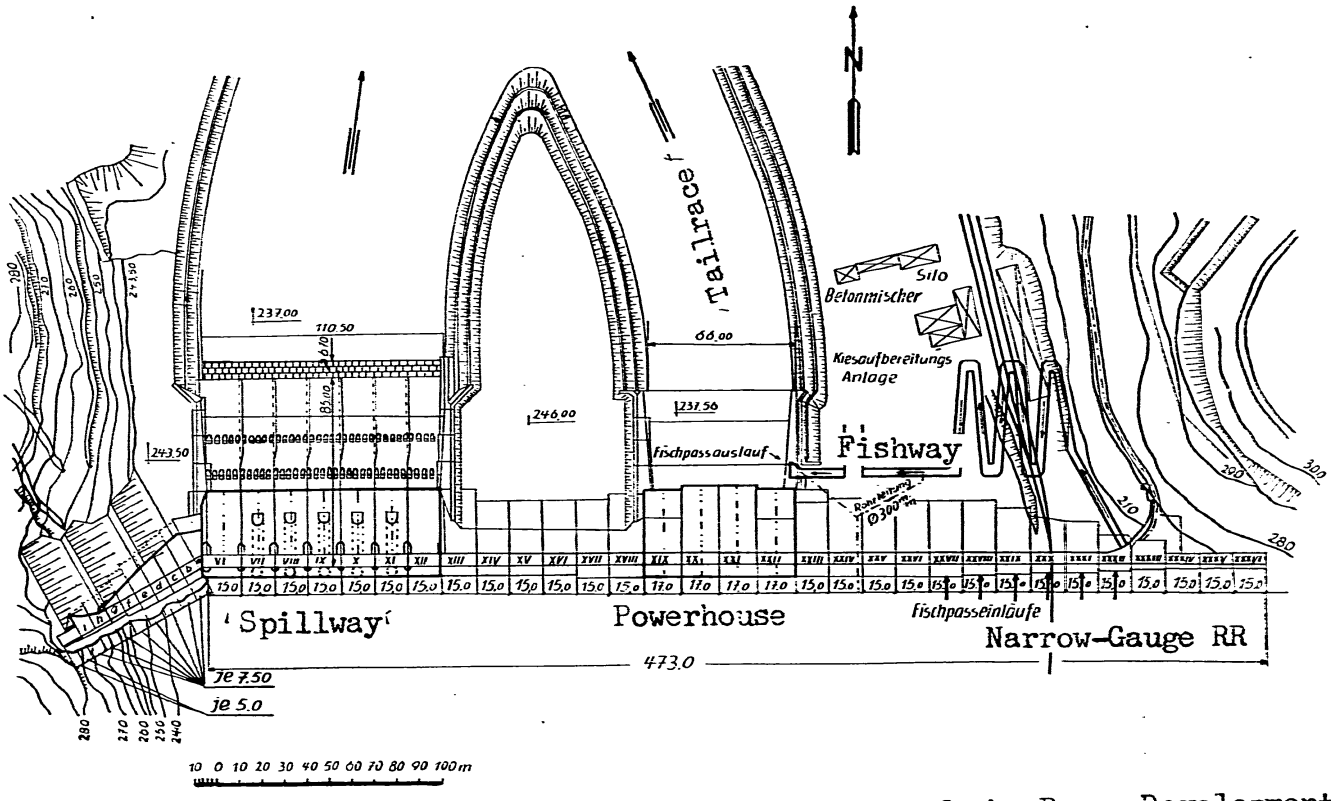
ROZNOW DAM, POLAND. View of Dam. Source: Technik (Bratislava), 1949, No.2-6. back cover



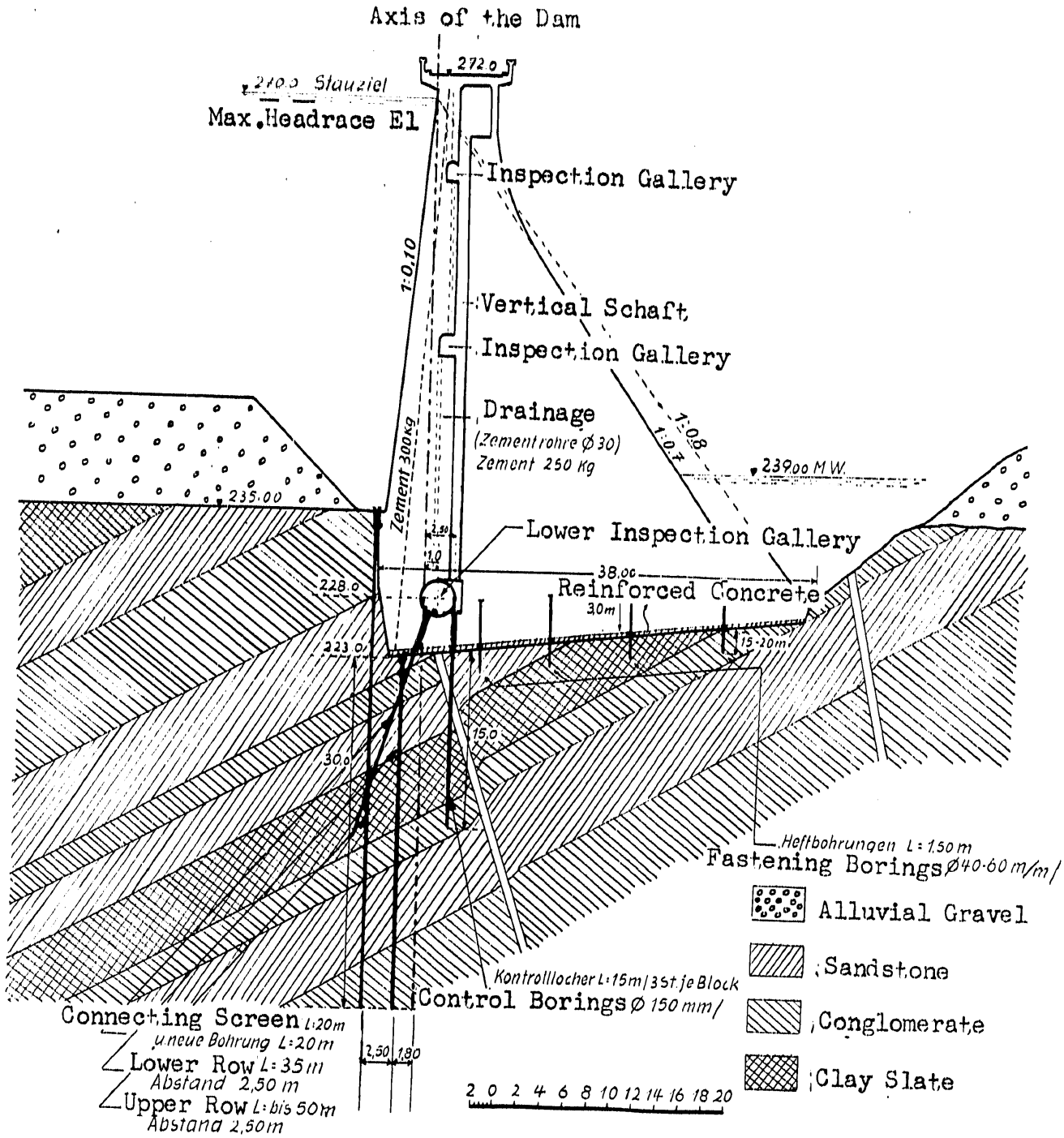
ROZNOW DAM, POLAND. Situation Plan 1)Shafts for the control of seepage through the mountain ridge 2)Axis of the dam 3)Mountain range 4)Grouting curtain 5)Max. water level in reservoir.Source: Technik(Bratislava), 1949, No. 2-6, p.64



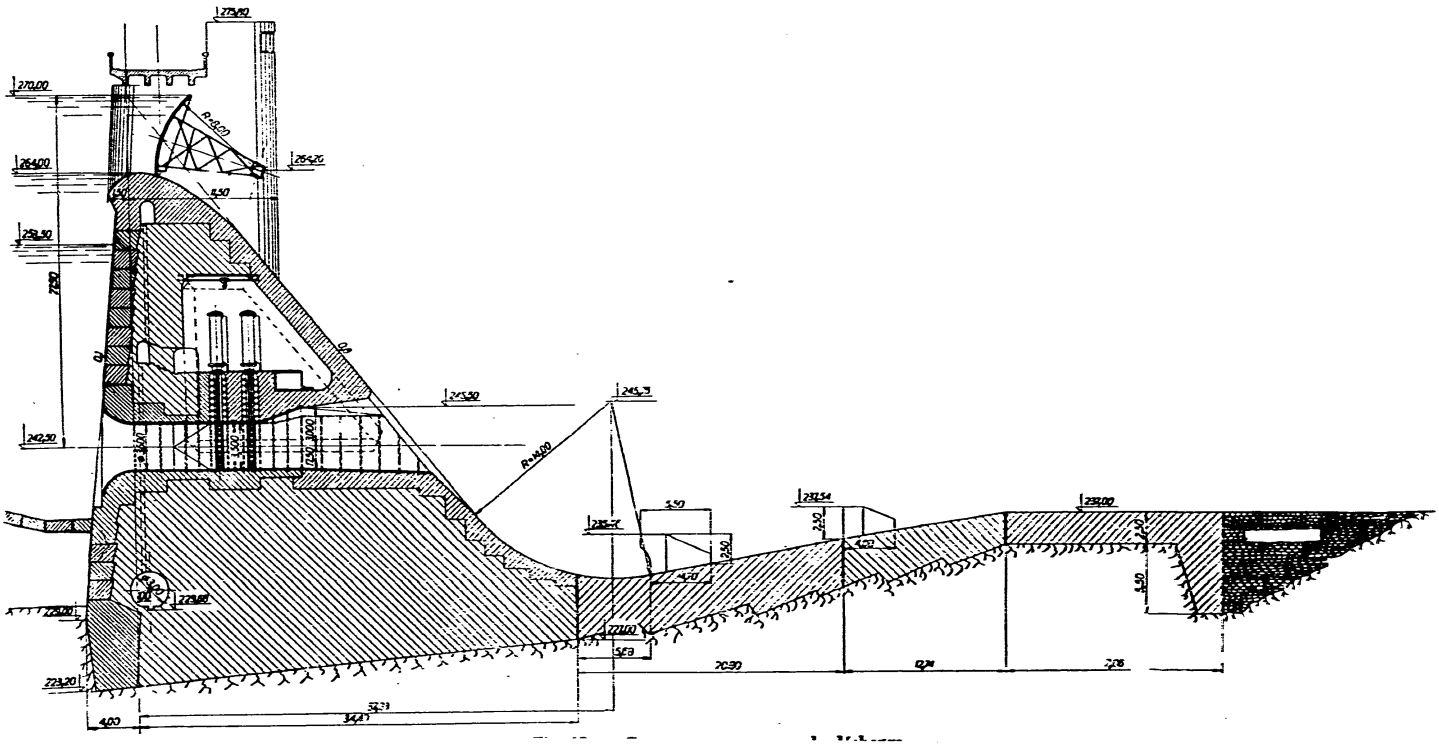
ROZNOW HYDROELECTRIC POWER PLANT, Poland, General Layout of the Construction Works.
Source : Ingénieurs, Arts et Métiers, Paris, April, 1939, p. 91



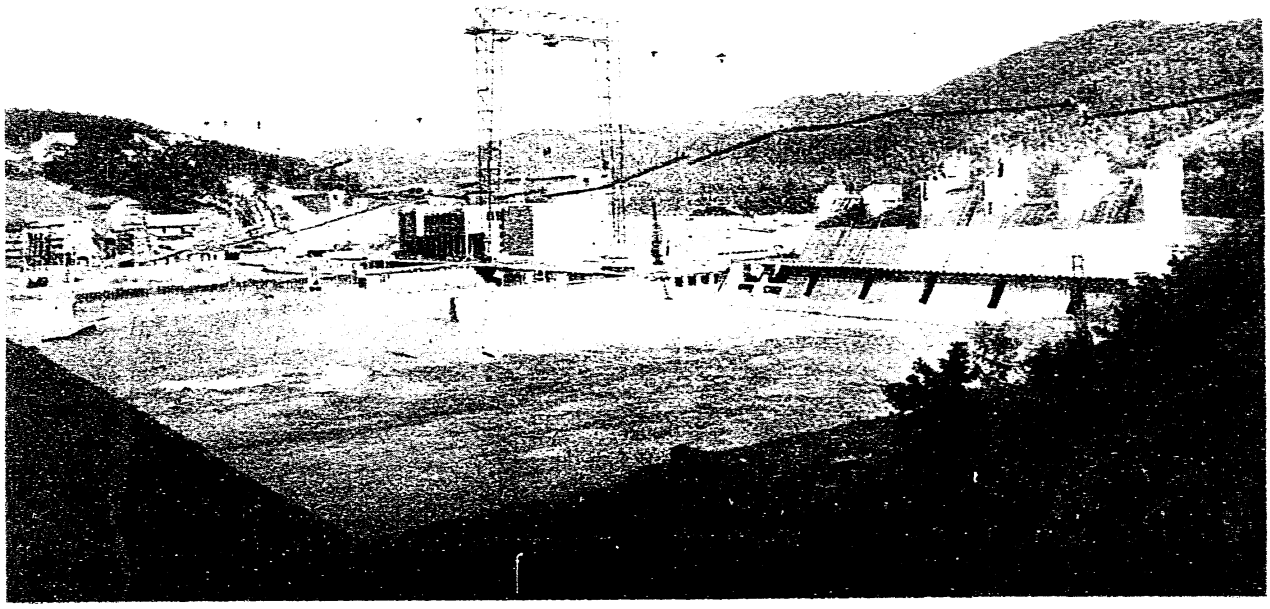
ROZNOW HYDROELECTRIC POWER PLANT, Poland. Layout of the Power Development.
Source : Deutsche Wasserwirtschaft, Munich, May 1941, No. 5, p. 262



ROZNOW HYDROELECTRIC POWER PLANT, Poland. Cross Section of the Dam and Subsoil. Source: Deutsche Wasserwirtschaft, Munich, 1941, No. 5, p. 263



ROZNOW HYDROELECTRIC POWER PLANT, Poland. Crossection of the Spillway.
Source: Travaux (Paris). Nov.,1939,p.436



[illegible] Hydroelectric Power Plant, Poland, Dam and Powerhouse under Construction, Tailwater View. Source: Deutsche Wasserwirtschaft, Munich, [illegible]

ROZNOW HYDROELECTRIC POWER PLANT, Poland. Panoramic View of the Reservoir. Source: Travaux (Paris). Oct.,1939, p.393

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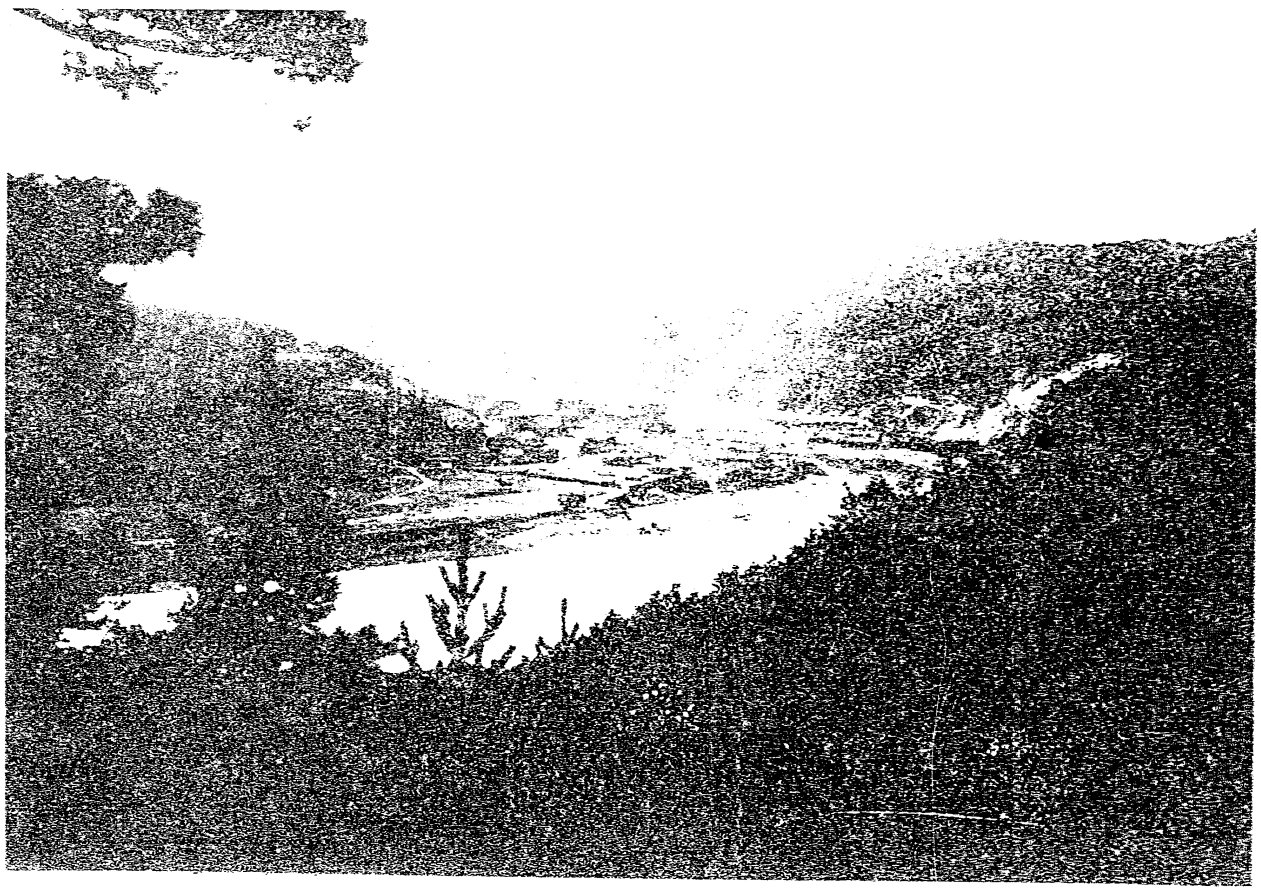
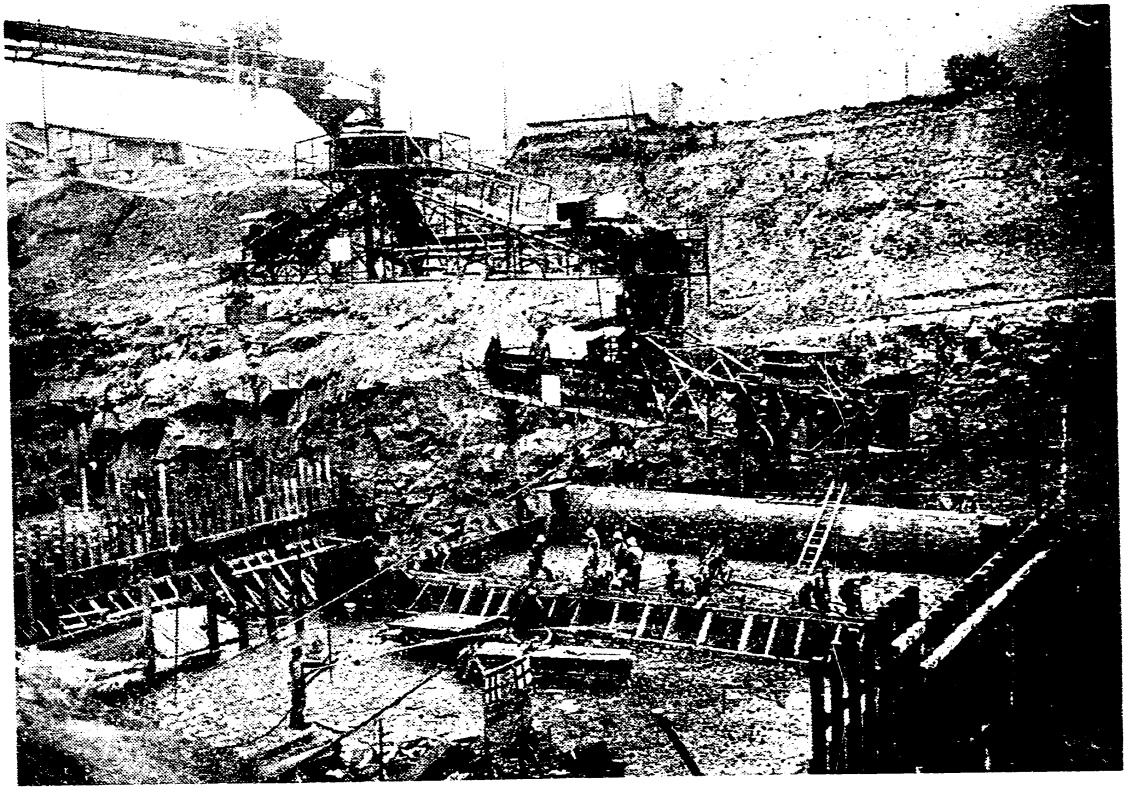


ROZNOW HYDROELECTRIC POWER PLANT, Poland. General View of the Roznow Valley. Source: Travaux (Paris). Oct.,1939. p.395



ROZNOW HYDROELECTRIC POWER PLANT, Poland. Laying Reinforcing Bars and Placing Concrete in Foundations. Source: Travaux, (Paris). Oct.,1939, p.396

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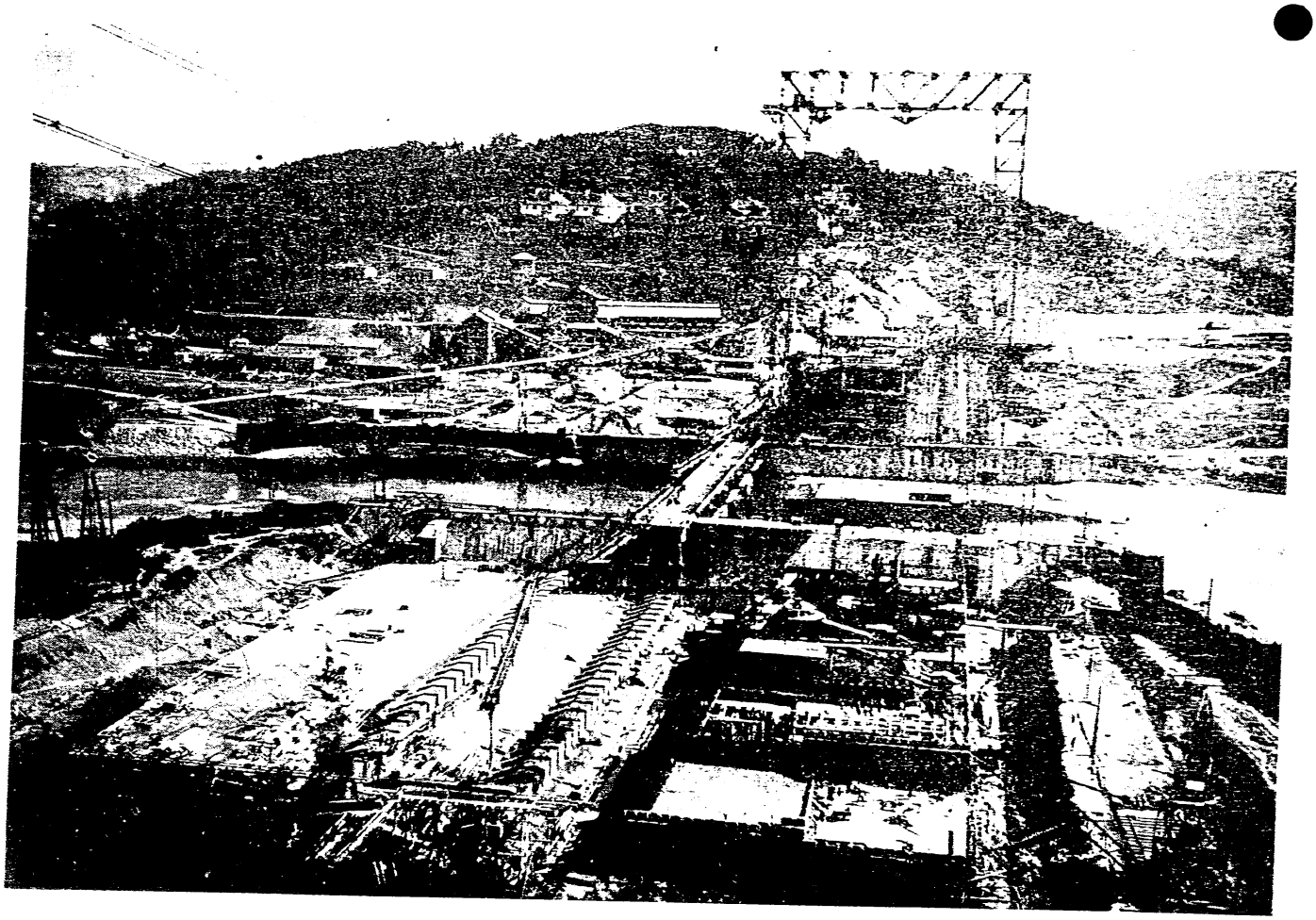
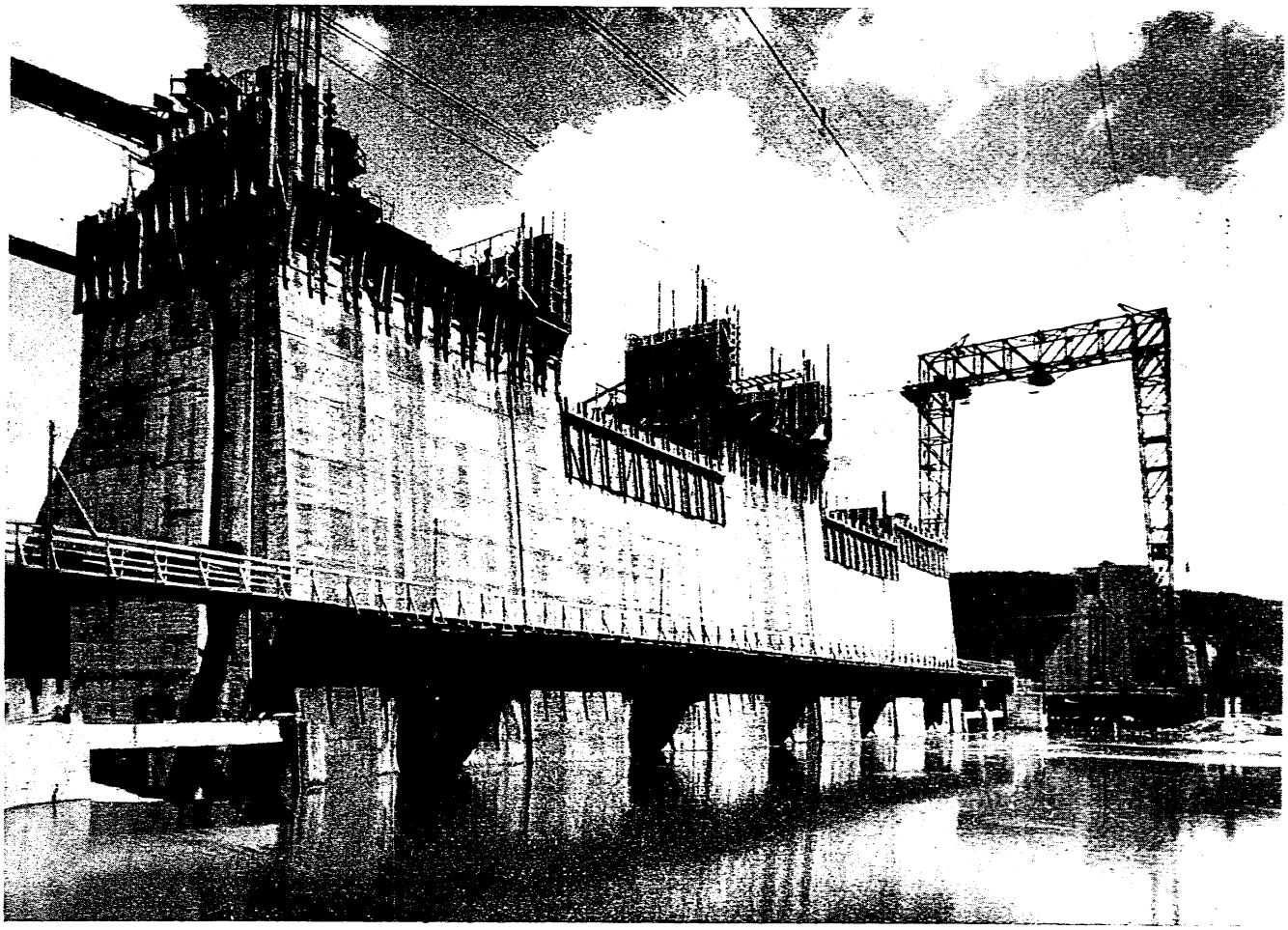
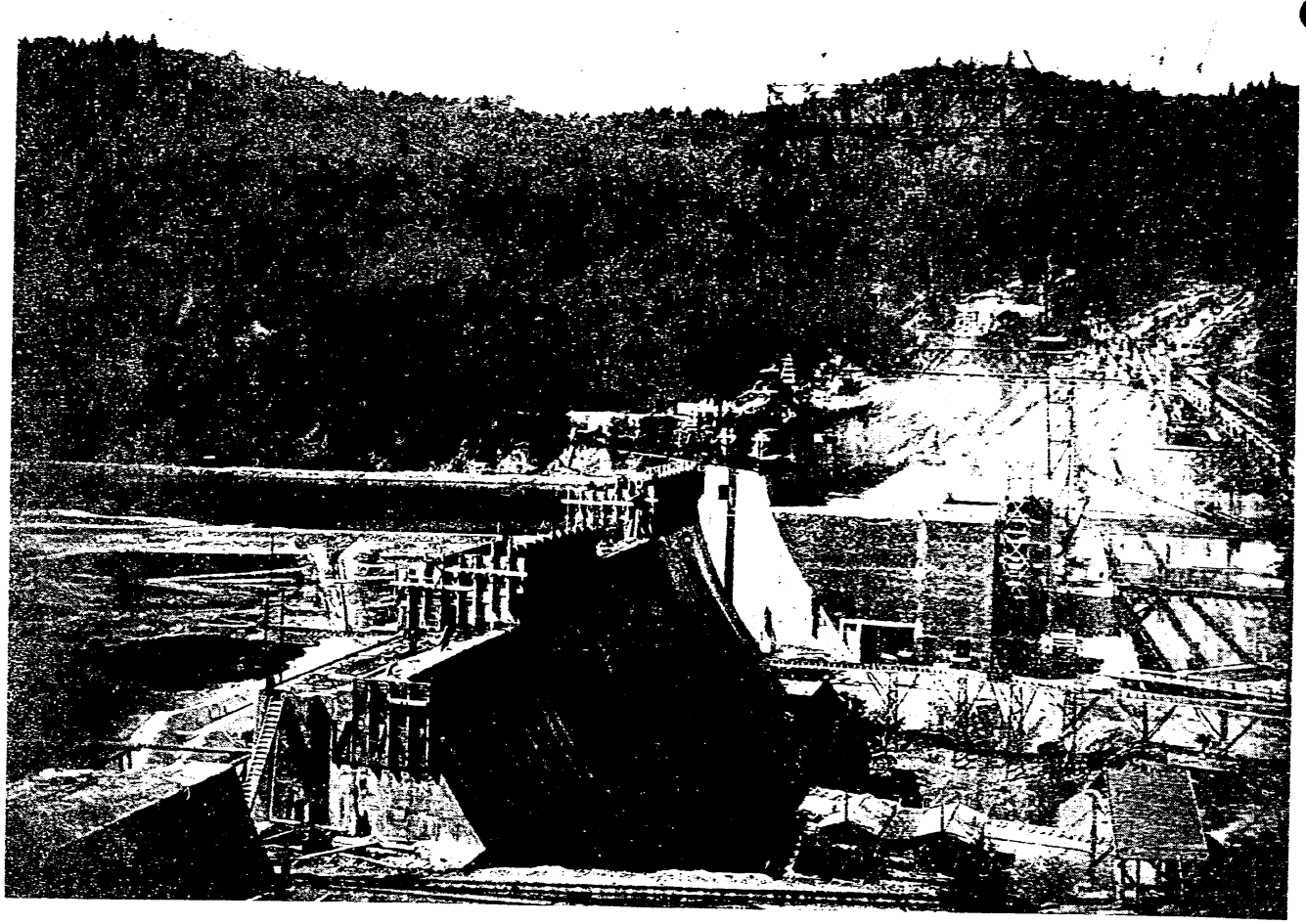


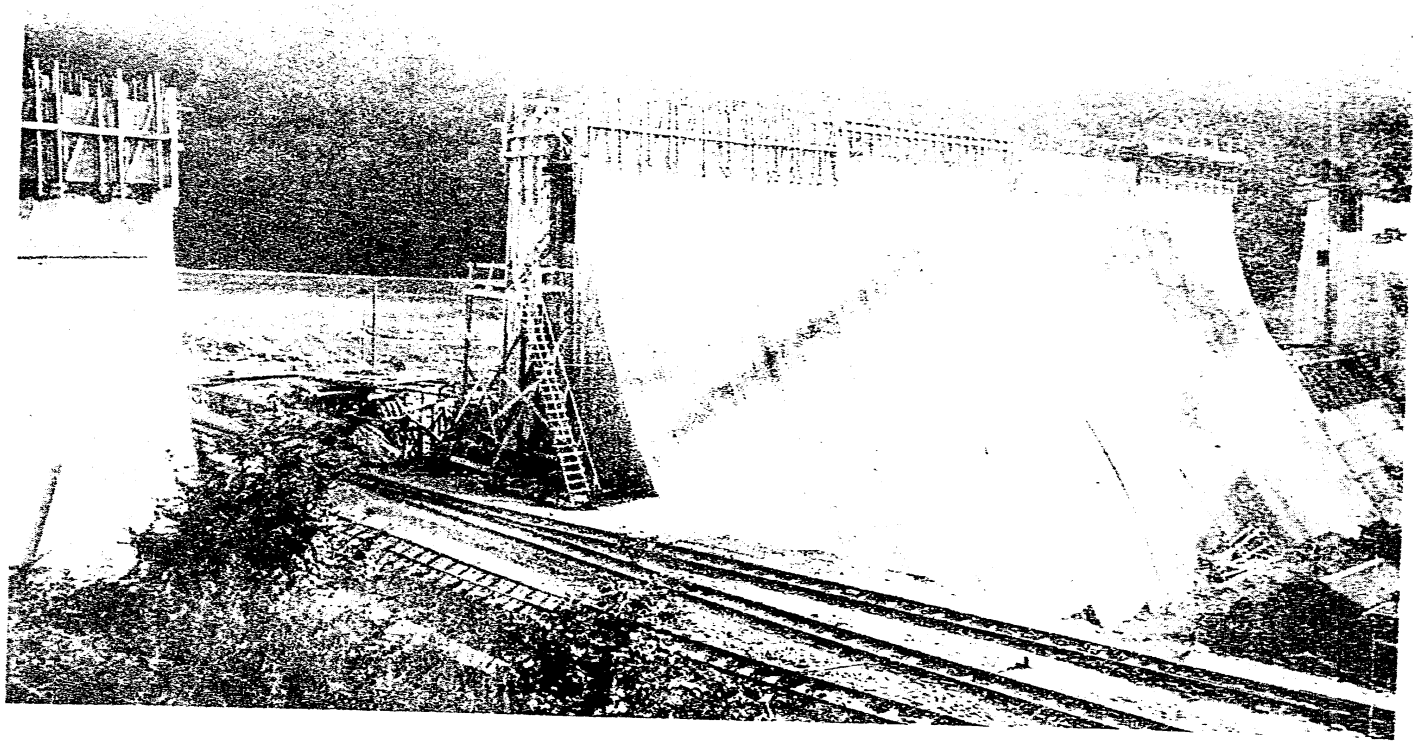
ROZNOW HYDROELECTRIC POWER PLANT, Poland. Construction seen from the left bank. Source: Travaux (Paris). Oct.,1939, p.397



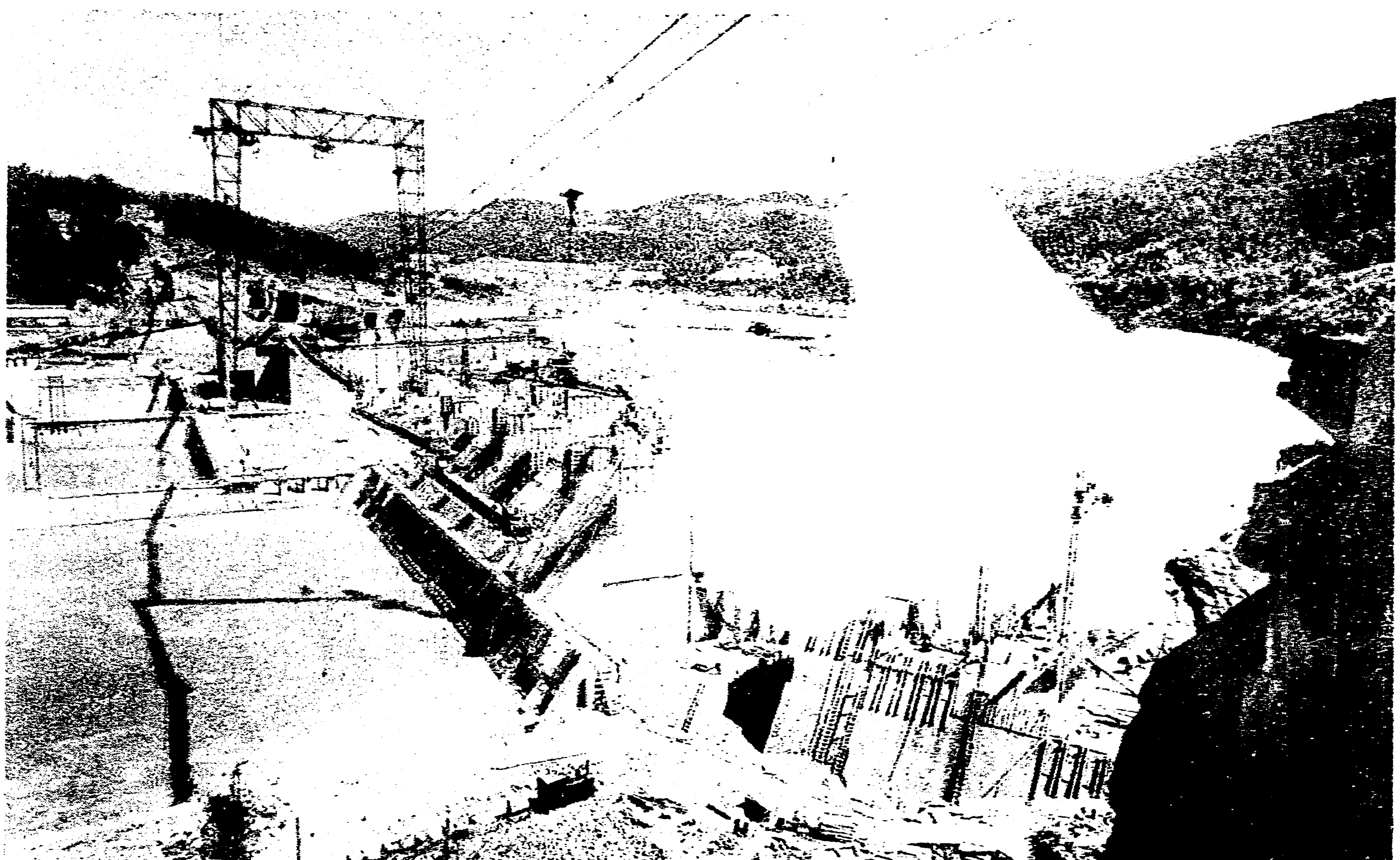
ROZNOW HYDROELECTRIC POWER PLANT, Poland. Spillway Dam with Bottom Discharge Sluices, Tailrace view. Source: Deutsche Wasserwirtschaft, Munich, 1941, p.



ROZNOW HYDROELECTRIC POWER PLANT, Poland. The Dam and the Power-house Seen from the Right Bank. Source: Travaux (Paris). Oct., 1939, p. 398



[illegible] the other hand, Soviet Industry (Paris), January [illegible], p. [illegible].



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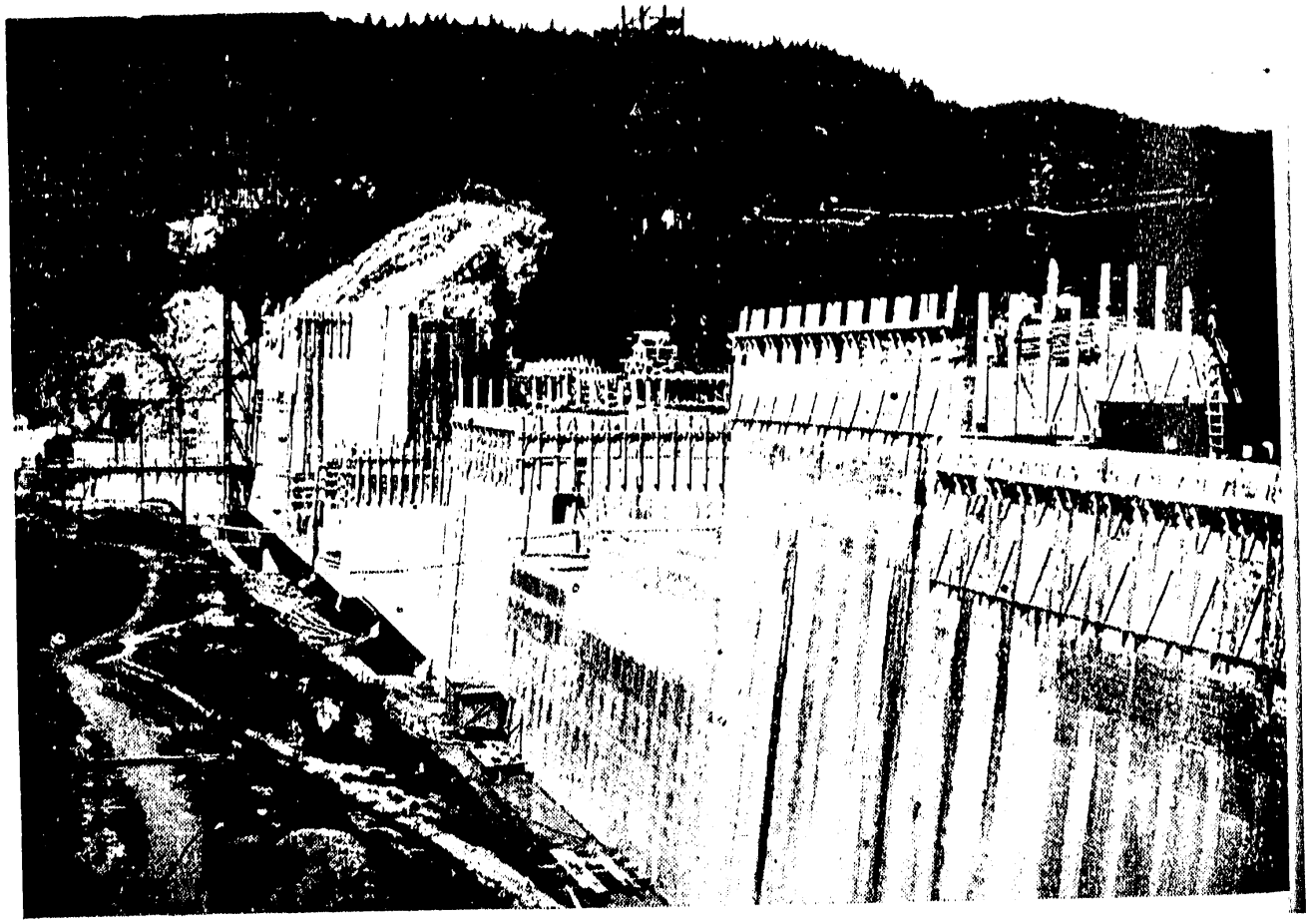
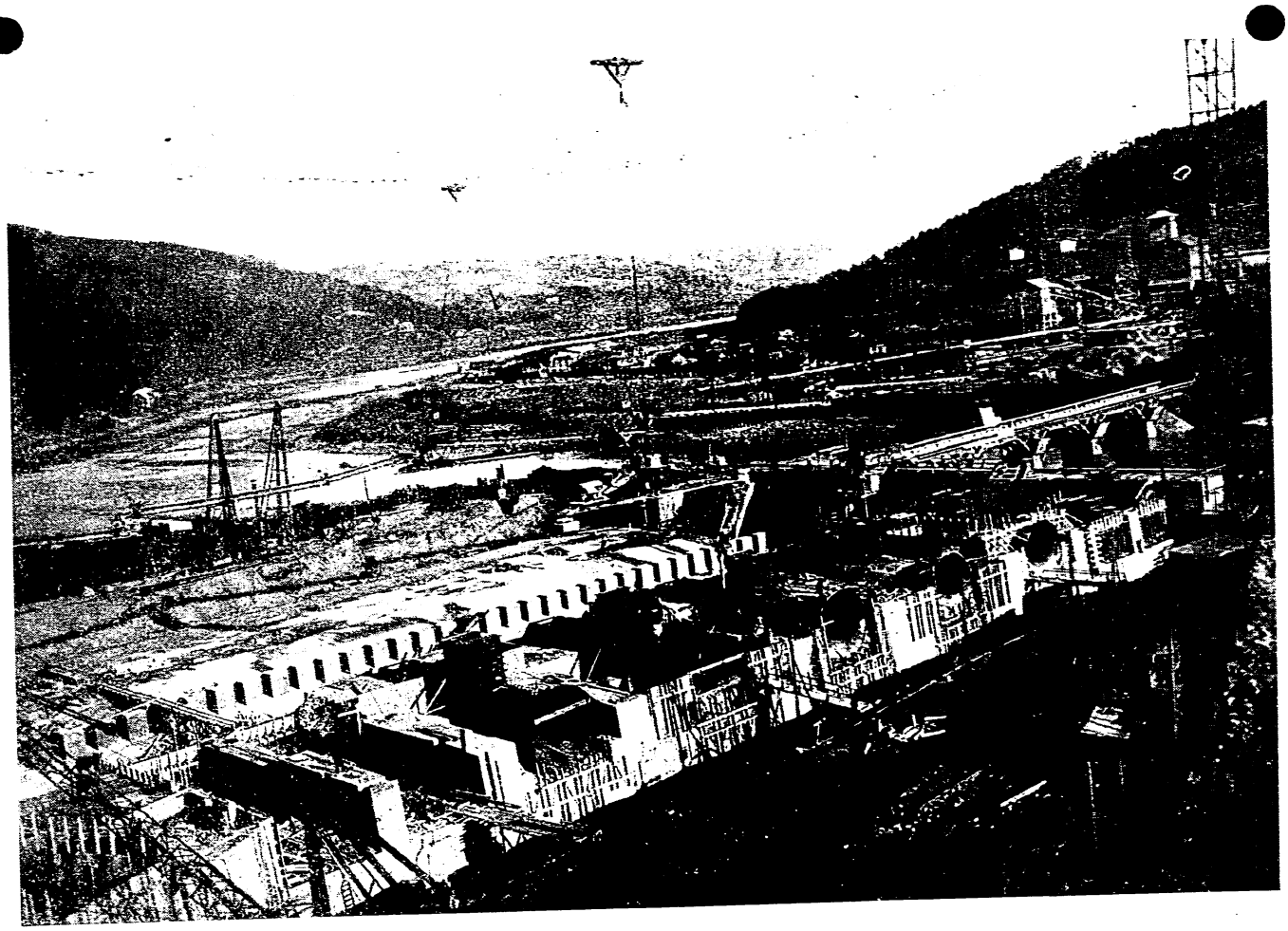
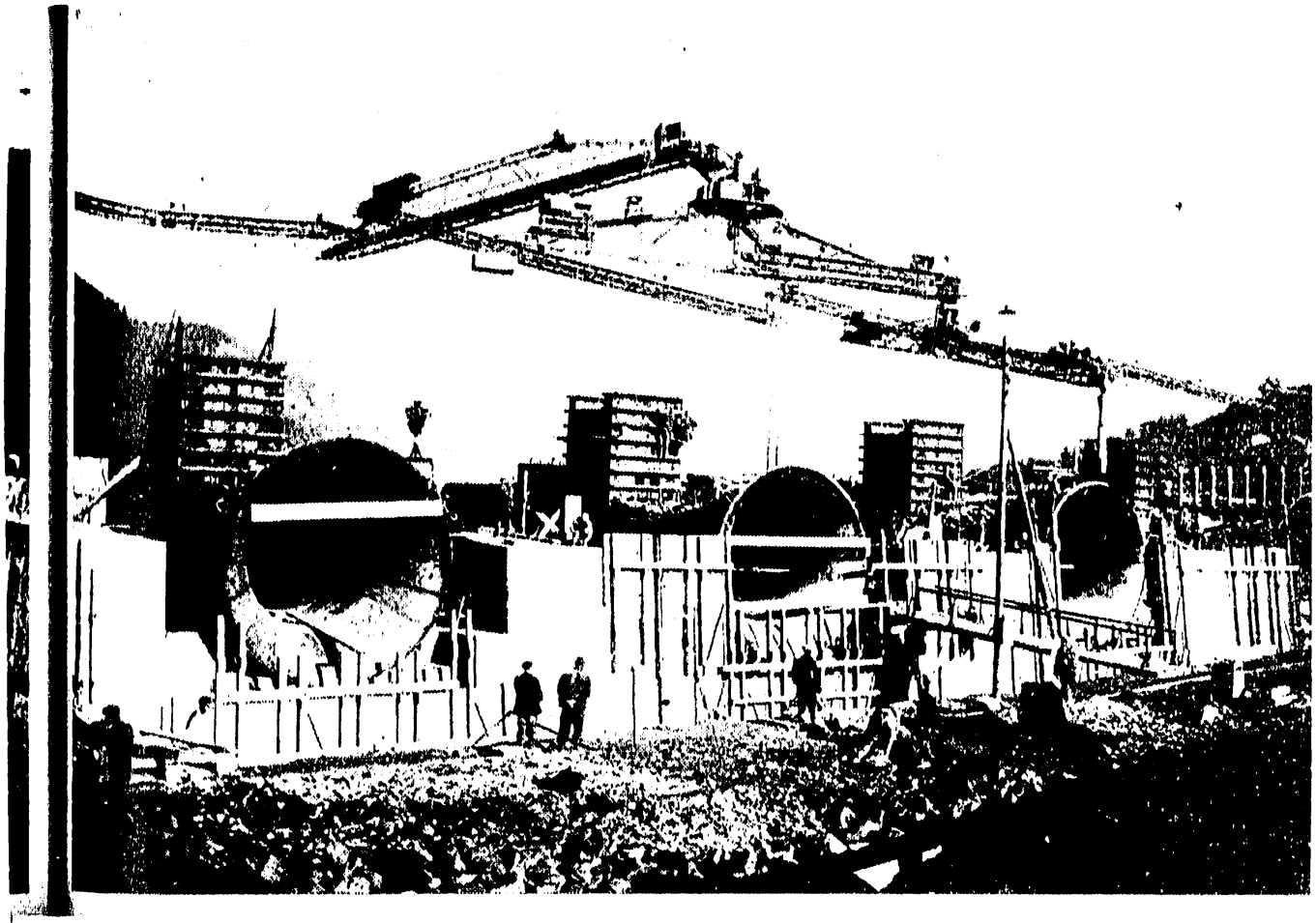


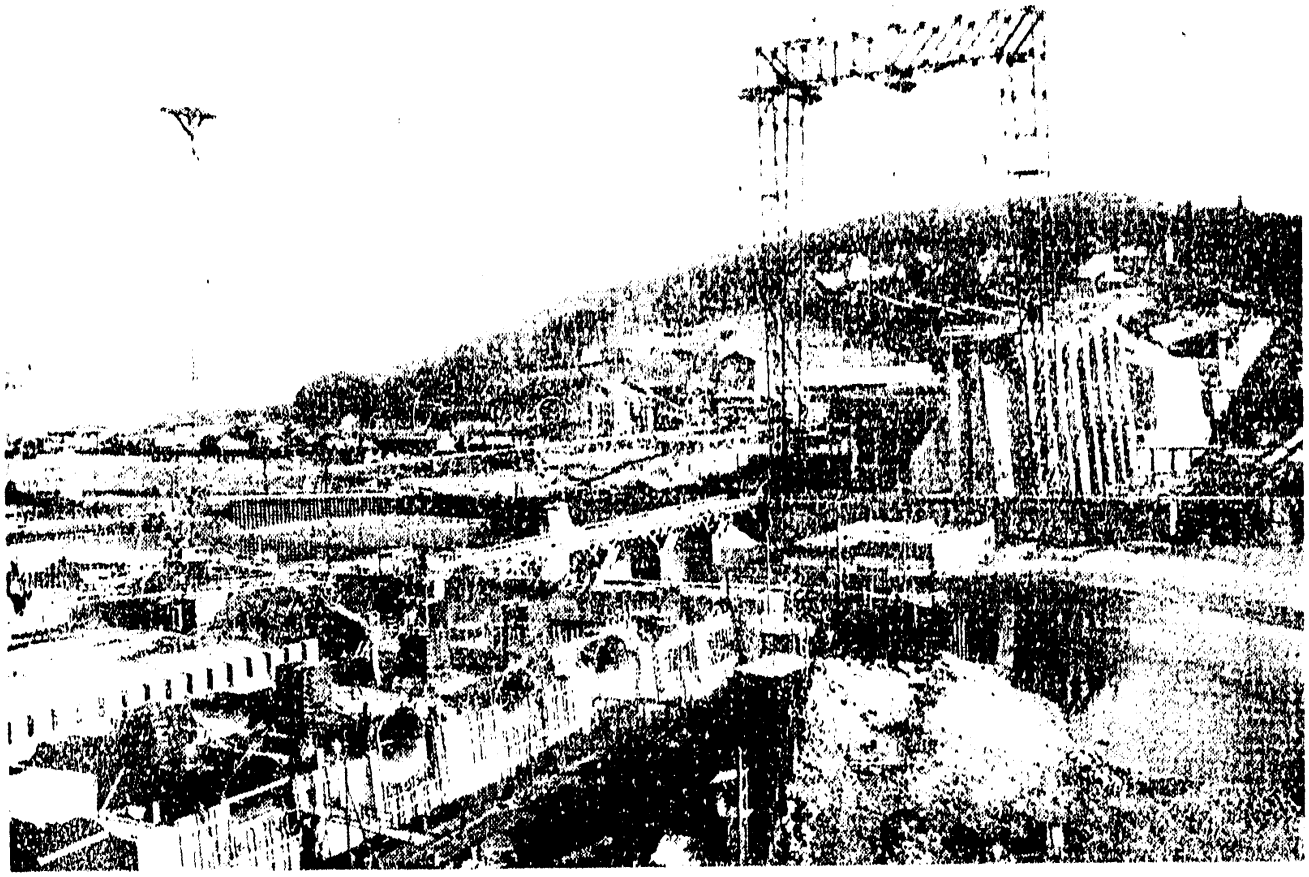
ROZNOW HYDROELECTRIC POWER PLANT, Poland. Construction Seen from the Right Bank. Source: Przeglad Elektrotechniczny, Warsaw, 1939, p. 410



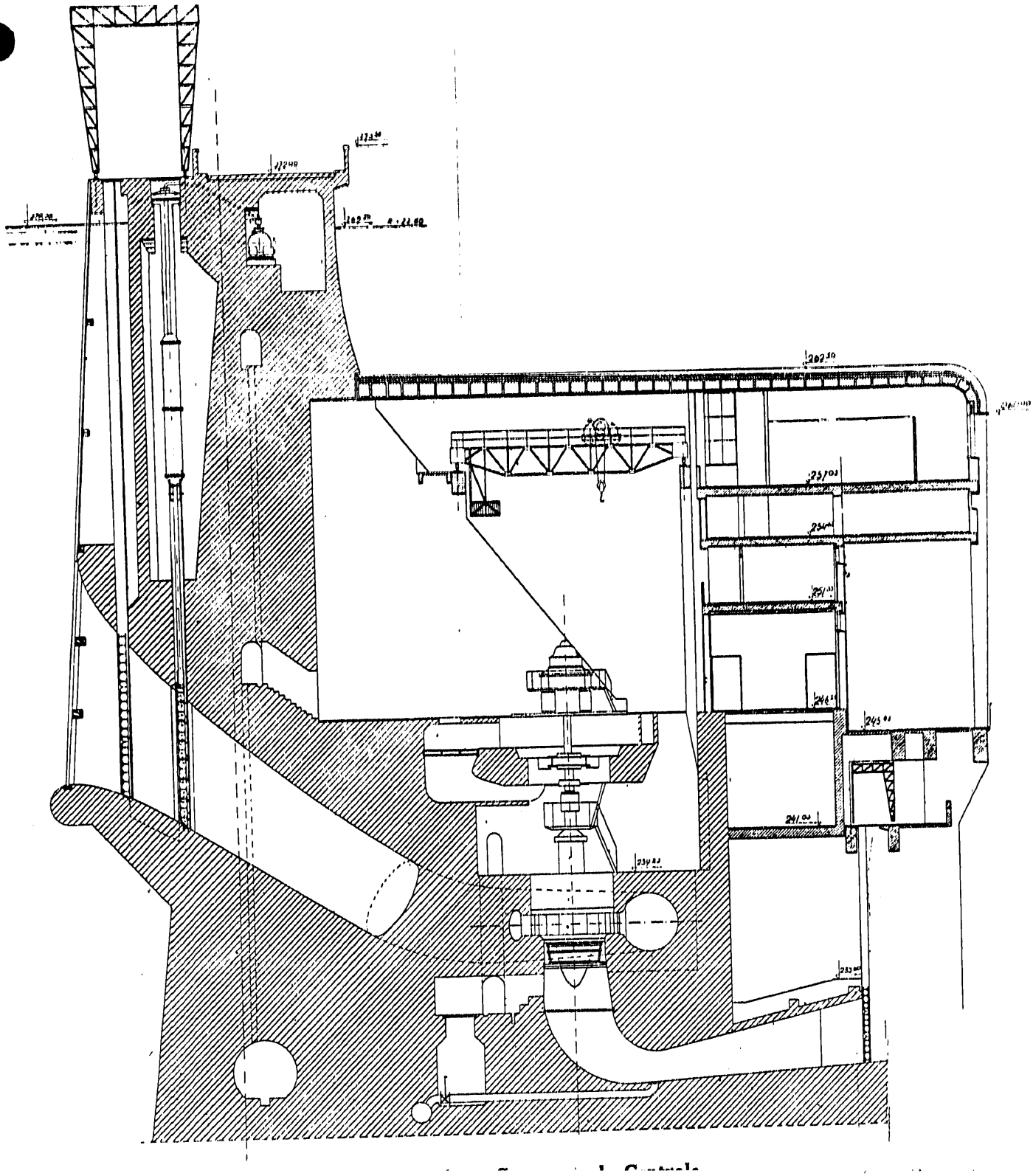
ROZNOW HYDROELECTRIC POWER PLANT, Poland. Bottom Discharge Sluices.
Source : Travaux (Paris). Oct., 1939, p.399



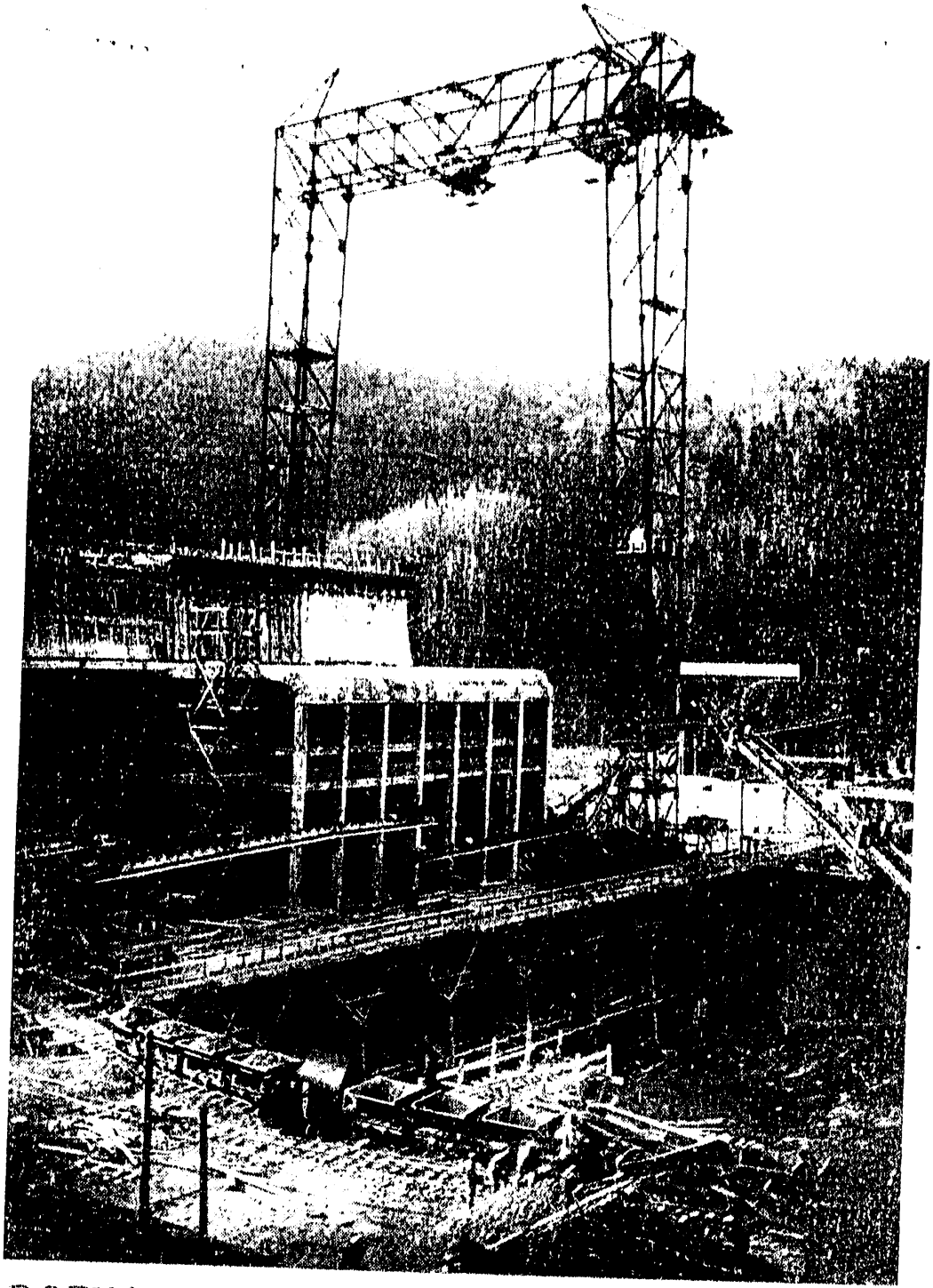
ROZNOW HYDROELECTRIC POWER PLANT, Poland. Bottom Discharge Sluices. Source: Przeglad Elektrotechniczny, Warsaw, June 7, 1939, p. 411



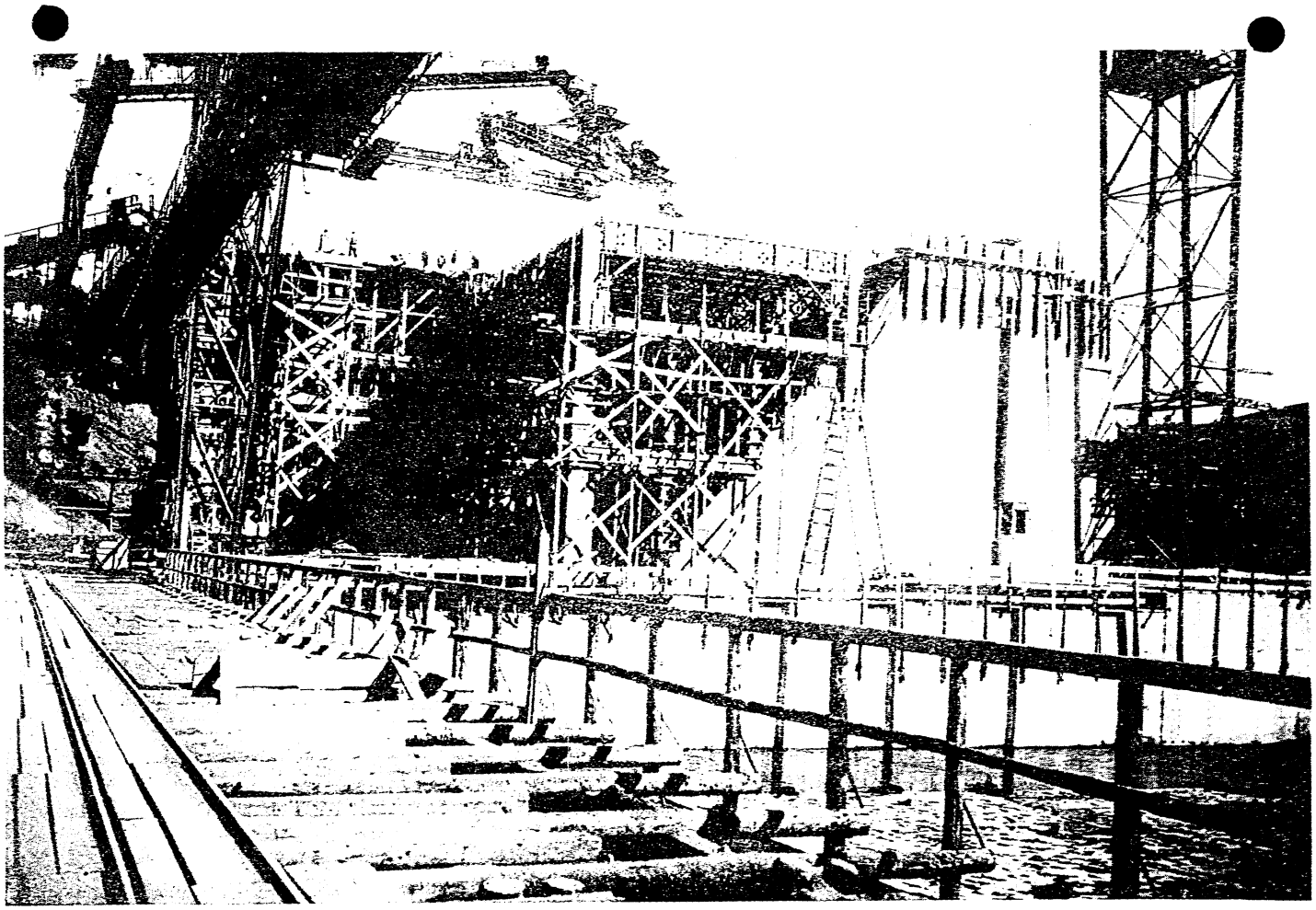
ROZNOW HYDROELECTRIC POWER PLANT, Poland. Construction Seen from the Left Bank. Source: Przeglad Elektrotechniczny, Warsaw, 1939, p.409



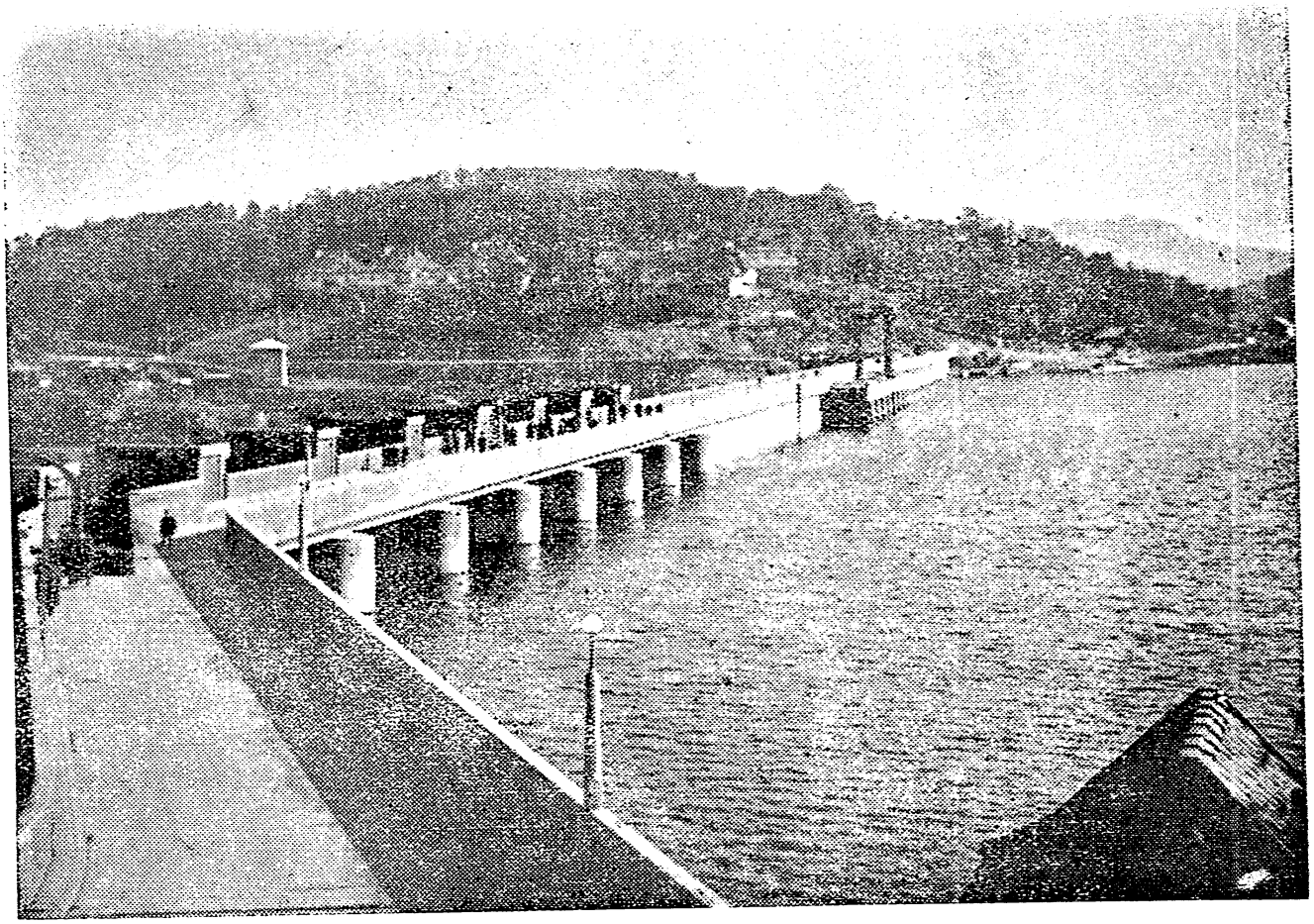
ROZNOW HYDROELECTRIC POWER PLANT, Poland. Crossection of the Powerhouse. Source: Travaux(Paris). Nov.1939, p.437



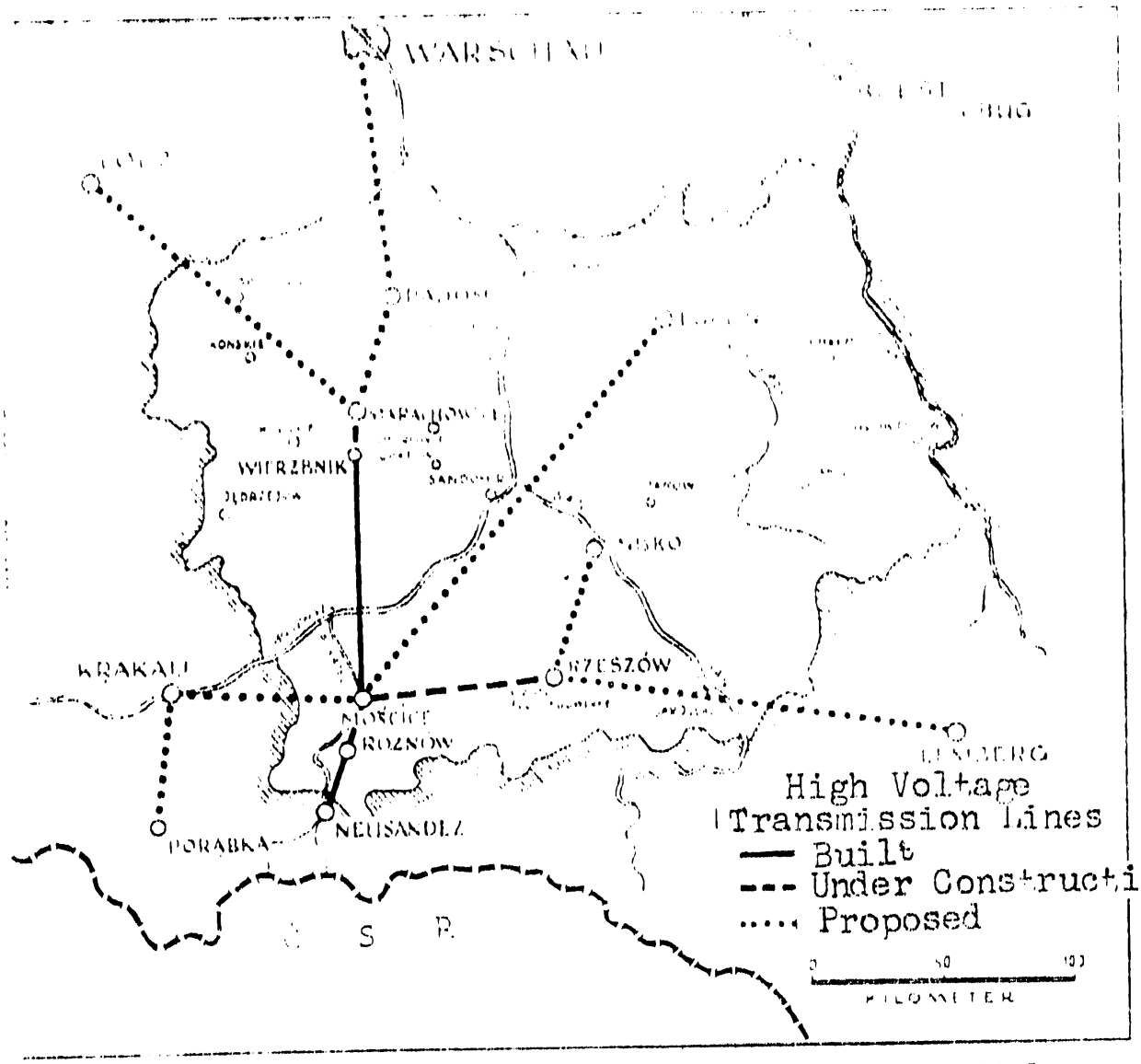
ROZNOW HYDROELECTRIC POWER PLANT, Poland. Downstream View of the Powerhouse. Source: Przeglad Elektrotechniczny, Warsaw, 1939, p. 409



ROZNOW HYDROELECTRIC POWER PLANT, Poland. Powerhouse under Construction.
Source : Travaux (Paris). Nov.,1939,p.437



ROZNOW DAM, POLAND. View of Dam from Reservoir Side. Source: Technik (Bratislava), 1949, No. 2-6, p.63



PORABKA, ROZNOW, AND CZCHOW DAMS, POLAND. High Voltage Transmission Lines in the Central Industrial Region of Poland, as of end of 1937. Source: Ostland Institute, (Danzig),"C.O.P. Das Zentrale Polnische Industrierevier." 1938, p. 25