REPUBLICA DE VENEZUELA

MINISTERIO DE OBRAS PUBLICAS

DIRECCION DE OBRAS HIDRAULICAS

CARACAS, VENEZUELA

SISTEMA RIOS BOCONO-TUCUPIDO

SPECIFICATIONS

FOR

HYDRAULIC TURBINES, GOVERNORS,

BUTTERFLY VALVES

SPIRAL CASE EXTENSIONS

AND

DISHED HEADS

FOR THE

BOCONO DAM

R. J. TIPTON ASSOCIATED ENGINEERS, INC.

CONSULTING ENGINEERS

DENVER CARACAS

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SCHEDULE

For convenience of reference, a Schedule of the equipment to be furnished follows. This Schedule corresponds to that contained in the Proposal.

Item No.	Description	Quantity
1	Hydraulic turbines, 28,000-horsepower, 200-rpm, vertical shaft, Francis type	3 each
2	Governors, oil pressure, cabinet actuator type	3 each
3	Butterfly valves and controls	5 each
4	Spiral case extensions with sleeve-type couplings	3 each
5	Dished heads, flanged	2 each
6	Supervision of erection:	
	(a) Services of erection supervisor	150 days
	(b) Services of assistant erection supervisor	150 days

GENERAL CONDITIONS

Location of Project. The Boconó dam site is located in the Republic of Venezuela on the Boconó River at the eastern toe of the foothills of the Andean Range. The site is situated near 70° West Longitude and 9° North Latitude at a site known locally as Peña Larga, in the states of Portuguesa and Barinas, about 50 kilometers Southwest of the City of Guanare.

The elevation at the dam is about 200 meters above sea level. Temperatures are quite uniform. Daily variations range from about 18° Centigrade to 43° Centigrade, with a mean annual average temperature of about 25° Centigrade.

Annual precipitation in the area varies in the vicinity of the project area from about 1,500 millimeters to 2,000 millimeters. The greatest amounts of rainfall usually occur as intense storms of short duration, although continuous rainfall of several days' duration has been experienced. Humidity varies from a minimum of about 30 per cent during the November to April dry season to a maximum of 100 per cent during the May to October rainy season. Monthly averages vary from 62 to 70 per cent.

Description of the Project. The Boconó Dam will be of the concrete gravity type, with a maximum height above foundations of approximately 111 meters. The crest length of the dam will be approximately 560 meters, and the crest will form a roadway across the dam. An elevator will be provided in the dam which will connect to the power plant and the gallery system.

The spillway will be of the overflow type, across the center section of the dam, and will have an over-all width of 126 meters. Spillway discharge will be controlled by seven 13.50 by 11.80-meter radial gates operated by electrically-driven hoists. A bridge will be constructed across the spillway and the gate hoists will be mounted at the bridge deck. The spillway will discharge into a hydraulic jump type stilling basin

at the toe of the dam. The stilling basin will be approximately 115 meters long, at the terminus of which will be constructed a concrete gravity auxiliary dam with a maximum height above the foundation of approximately 24 meters.

A single penstock, approximately 6.5 meters in diameter, will be placed through the dam. It will extend from the intake structure on the upstream face of the dam to, and along, the power plant and will terminate in manifold connections to the hydraulic turbines. Butterfly valves will be installed just upstream from each turbine. Water discharged from the turbines will flow into the stilling basin.

Seven river outlets will be provided through the dam. The flow through each outlet will be controlled by 84-inch diameter jet-flow regulating gates and 84-inch ring-follower guard gates. The outlets will discharge flows down the face of the dam into the stilling basin.

The power plant will be incorporated in, and form a part of, the right, or South, wall of the stilling basin. The power plant structure will be of concrete and will have an over-all length of approximately 132 meters and an over-all width of approximately 24 meters. The control room, offices, machine shop, electrical equipment rooms, and service facilities are located at the downstream end of the power plant. Auxiliary mechanical and hydraulic equipment is located at the opposite end of the power plant and in galleries below the generator floor. The power transformers will be located at the rear of the power plant, and the switchyard will be located on the roof of the power plant.

The total ultimate installed capacity of the Boconó power plant will be 100,000 kilowatts in 5 units of 20,000 kilowatts each. Three units with a total capacity of 60,000 kilowatts will be installed in the initial stage of development. The turbines will be of the vertical shaft, Francis type, rated at 28,000 horsepower, each at 200 revolutions per minute. The alternating current generators will have a normal continuous rating of 22,222 kilovolt-amperes, 3-phase, 60-cycle, 13,800-volt, and 90 per cent power factor.

Generators Nos. 2 and 4 will be connected to their respective 3-phase power transformers through generator voltage circuit breakers, using metal-enclosed insulated phase bus. Generator No. 3 will be connected to its power transformer in a similar manner, except there will be no generator voltage breaker.

The power transformers will be 3-phase, self-cooled units, rated 20,000-kilovolt-amperes, with provision for the future addition of forced-air cooling equipment. The transformers will be connected 13.8-kilovolt delta on the low side and arranged for either 115-kilovolt grounded wye or 230-kilovolt grounded wye connection on the high voltage side. The initial operation will be at 115 kilovolts with provision for changing to 230-kilovolt operation at a future date when the additional generating units are installed.

The switchyard, located on the roof, will have provision for high voltage switching in each feeder line from the power transformers and at each main line termination. The switchyard will also have provision for terminating 4 main transmission lines, 2 Eastward and 2 Westward. Sectionalizing bus switches are provided to insure continuity of power flow in the main lines through the switchyard in the event of generator shutdown. The switchyard will be designed for operation at 230 kilovolts, although initial operation will be at 115 kilovolts.

In addition to the lines serving the main high voltage transmission system, a 4.16-kilovolt line and a 13.8-kilovolt line will be provided to serve local area loads.

Station service power for operation of equipment in the dam and plant auxiliaries will be furnished from two generating units through stepdown transformers to provide 3-phase power at 460 volts. In the event of shutdown of all generators, station service power will be obtained from the transmission system feeding back through the switchyard. A gasoline-driven, 3-phase generator will be provided for emergency station service power. Station lighting current will be supplied from 480 to 115/230-volt, single-phase transformers.

A station auxiliary battery will provide 125-volt, direct-current power for all control circuits and emergency lights within the power plant.

Definition of Terms. Wherever the following terms are used or referred to herein, they shall have the following meanings:

Ministry	-- Ministerio de Obras Públicas of the República de Venezuela.
Engineer	-- The person or firm designated by the Ministerio de Obras Públicas to supervise this Contract.
Bidder	-- A firm invited to submit a proposal for furnishing the equipment described herein.
Contractor	-- The firm awarded the Contract for furnishing the equipment described herein.
Calendar Days	-- Where referring to time periods, shall include Sundays and holidays.

Instruction Plates and Markings. All gauges, meters, and instruments shall have dials or scales calibrated in metric units. All thermometers shall be calibrated in degrees Centigrade. All name plates, instruction plates, warning signs, and any markings whatever on the equipment and its parts and accessories shall be in the Spanish language, using the idioms and word meanings in current use in Venezuela. All Spanish markings to be used, together with their English equivalents, shall be submitted to the Engineer for approval before the equipment is marked or labeled.

Inspection and Tests. The Engineer or his representatives shall be permitted to inspect all equipment during its fabrication and prior to its preparation for shipment; to inspect its packing when ready for shipment; to witness all factory tests of finished products; and to witness any or all tests for which results are required under these Specifications to be approved by the Engineer. The Contractor shall notify the Engineer a reasonable time in advance when and where the equipment or parts will be available for each inspection or test.

Acceptance of equipment, or the waiving of any inspection or test or witness thereof, shall in no way relieve the Contractor of the responsibility of furnishing equipment meeting the requirements of these Specifications.

Preparation for Shipment. The Contractor shall prepare all materials and articles for tropical ocean shipment in such a manner as to protect them from damage in transit, and shall be held responsible for all damage due to improper preparation for shipment.

Double boxing shall be used if required to give extra protection to the equipment against mechanical injury. All parts requiring protection from moisture, including polished parts which rust readily, shall be coated with a rust-preventive compound and double-boxed with tarpaper or sizal kraft paper inserted between layers of boxing. All parts, such as coils, parts containing coils for electrical machines, instruments, relays, meters, etc., requiring the utmost protection against moist atmosphere and termites shall be packed in sheet metal-lined sealed boxes with tarpaper or sizal kraft paper inserted between the metal-lined box and the outer layer of boxing.

Where necessary, heavy parts shall be mounted on skids so that cable slings can be readily attached for handlings. Where it is unsafe to apply external slings to a box, attached slings shall be provided and shall project through the box so that attachment can readily be made. All costs of preparing the equipment for ocean shipment as prescribed herein shall be included in the unit prices bid in the Proposal.

Clearance and Weight Limitations. All equipment to be furnished under these Specifications shall be designed and apportioned in size and weight to permit transporting the equipment from Puerto Cabello to the dam site by truck. No individual part of the equipment shall exceed 50,000 pounds when crated and shall not exceed 2.6 meters in height and 5.4 meters in width, unless factory fabrication of the equipment is clearly impractical without exceeding these limitations.

SPECIAL PROVISIONS

Work to be Done. The Contractor shall furnish all labor, services, materials, plant, and equipment to perform in strict accordance with these Specifications all the work necessary to design and to manufacture the equipment described herein.

The Contractor shall furnish 3 hydraulic turbines, 3 cabinet actuator governors, 5 butterfly valves with controls, 3 spiral case extensions, and 2 flanged dished heads, all complete, including all necessary appurtenances and interconnecting parts and piping for the complete installation. The installation provided shall be such that the face of the upstream flange of the butterfly valve will be located 34' - 6-7/16" from the longitudinal center lines of the units measured along the centerline of each penstock branch. The Contractor shall also furnish the test barrel and dished head for hydrostatic testing of the turbines and the spare parts listed in these Specifications.

The Contractor shall be responsible for the design and integration of the complete installation so that all portions of the unit shall function satisfactorily one with another and all warranties shall apply to the complete installation.

Cooperation with Other Contractors. The Contractor shall exchange with other contractors engaged in the manufacture or erection of related equipment all necessary drawings, dimensions, templates, gauges, and other information required to insure the complete and proper design and manufacture of all connecting or related parts of the turbine, governor, generator, and control equipment. Two copies of all drawings and of all correspondence relating to information and specifications interchanged between contractors shall be sent to the Engineer, and 1 copy shall be sent to the Ministry.

Supervision of Erection. Construction of the Boconó Dam will be carried out by a competent construction contractor under contract with the Ministry. The construction contractor will be required to furnish all materials and labor necessary for the installation of the various items of equipment to be installed in the

power plant and elsewhere. The Contractor supplying the equipment covered by these Specifications will be required to furnish the services of a competent and experienced erection supervisor and one assistant to supervise and be responsible for the erection, starting, and operation of the turbines, governors, and butterfly valves. The erection supervisor and his assistant shall report to Caracas, Venezuela, on the date designated by the Ministry after an advance notice of not less than 60 days, and shall remain until the equipment has been in satisfactory operation for 10 days, unless released earlier by the Ministry.

The erection supervisor shall be qualified and empowered to act as the agent of the Contractor in all matters respecting the erection of the generators. The work and operations of the erection supervisor and his assistant shall be coordinated with the program of construction at the job site as directed by the Engineer.

The amounts bid in the Proposal for furnishing the erection supervisor and his assistant shall be the amount to be paid per calendar day, including Sundays and holidays. The cost of first-class air transportation for the erection supervisor and his assistant from the Contractor's plant to the site and return will be paid directly by the Ministry or reimbursed to the Contractor on a direct cost basis, at the option of the Ministry. The per diem rates shall include the salary, living expenses, and all personal expenses of the erection supervisor and his assistant. The number of days indicated in the Proposal for services of the erection supervisor and his assistant are approximate estimates for comparing Proposals only, and the Contractor shall be entitled to no additional compensation above the unit prices bid therefor by reason of any amount or none of these services being required. The period of time for determining payment shall begin from the time the erection supervisor and his assistant leave the Contractor's plant and shall continue until they return to the plant. All traveling shall be done continuously over the most direct routes.

Data Required of Bidders. Each Bidder shall include in his Bid the following information, which shall be all in metric units except for horsepower which is defined as 550 foot-pounds per second:

(a) General drawings and photographs showing the general construction and approximate dimensions of all the equipment that he proposes to furnish, including outlines of spiral cases, draft tubes, and butterfly valves.

(b) Over-all dimensions and preliminary weights of all principal parts.

(c) Number of shipments to be made, number of pieces in each shipment, and the crated shipping weight of each piece.

(d) Materials specifications of principal parts.

(e) The guaranteed full gate capacity of the turbines when operating under an effective net head of 70.0 meters.

(f) The guaranteed best efficiency and horsepower output of the turbines when operating under an effective net head of 70.0 meters.

(g) Curves showing the expected horsepower output with reference to efficiency and to turbine discharge in cubic meters per second.

(h) Turbine setting in relation to minimum tailwater.

(i) Discharge diameter of runners.

(j) Diameter of turbine head covers.

(k) Total weight of rotating parts of the turbines.

(l) Unbalanced hydraulic thrust of the runner.

(m) WR^2 of the rotating parts of the turbines.

(n) Run-away speed, when operating under an effective net head of 70.0 meters with no load on the generator.

(o) Governor ratings in kilogram-centimeters.

(p) Capacities of the governor sump and pressure tanks.

(q) Capacity, horsepower, and rated oil pressure of the governor oil pumps.

(r) Volume of the servomotor cylinders.

(s) List and description of governor auxiliary devices.

(t) Nominal size of butterfly valves.

(u) Description of butterfly valve operating mechanism.

(v) Horsepower rating of all motors.

Drawings and Data to be Furnished by the Contractor. The Contractor shall, as soon as practicable, but not over 30 calendar days after receipt of notice of award of Contract, submit to the Engineer 4 sets, and to the Ministry 1 set, of general drawings showing the principal dimensions of the turbine spiral case, draft tube, turbine and draft tube setting, pit liner, servomotor cylinders, and all other parts embedded in concrete. These prints will not require approval.

As soon as practicable thereafter, but not over 60 calendar days after receipt of notice of award of Contract, the Contractor shall submit to the Engineer 4 sets, and to the Ministry 2 sets of prints of checked assembly detail drawings, piping diagrams, wiring diagrams, and descriptive information, sufficient to demonstrate fully that the equipment to be furnished will conform to the requirements and intent of these Specifications.

One print each of the drawings will be returned to the Contractor by the Engineer marked either "Approved",

"Approved Except as Noted", or "Returned for Correction". The notations "Approved" or "Approved Except as Noted" shall authorize the Contractor to proceed with the manufacture of the equipment covered by such drawings, subject to the corrections, if any, indicated thereon. When prints of drawings have been returned marked "Returned for Correction", the Contractor shall make the necessary revisions on the Drawings and shall, within 30 days, submit prints for approval in the same manner as before.

Any manufacturing done before approval of the Drawings will be at the Contractor's risk. The Engineer shall have the right to require the Contractor to make any changes in the design which may be necessary, in the opinion of the Engineer, to make the equipment conform to the requirements and intent of these Specifications without additional cost to the Ministry. Approval of the Contractor's drawings shall not be held to relieve the Contractor of any part of his obligation to meet all of the requirements of these Specifications or of the responsibility for the correctness of his Drawings.

When the Contractor has completed the preliminary design of the equipment, but not over 90 calendar days after receipt of notice of award of Contract, he shall furnish the following guaranteed data to the Engineer:

(a) Quantity of lubricating oil and quantity of cooling water, per minute, required by the main guide bearing.

(b) Quantity of lubricating oil required to fill the main guide bearing system.

(c) Quantity of water, per minute, required for lubricating the main shaft stuffing box.

(d) Minimum clearance of water passages through the runner.

(e) Revision, if necessary, of any data furnished with his Bid, including weights, sizes, and shipping dates.

At the time of delivery of the equipment, the Contractor shall furnish to the Engineer 2 complete sets, and to the Ministry 2 complete sets of reproducibles of all final approved drawings corrected as required.

At the same time, the Contractor shall also furnish to the Engineer 4 complete sets of instructions in the Spanish language, and 2 complete sets of instructions in the English language and shall furnish to the Ministry 2 complete sets of instructions in the Spanish language for erection, operation, maintenance, and repair of the equipment, and for identification of parts.

The Contractor shall send a copy of all correspondence pertaining to the Contract or equipment to be furnished to both the Engineer and the Ministry.

Acceptance Tests. After the turbine-generator unit has been installed in the power plant and placed in satisfactory operation, it may be tested by and at the expense of the Ministry to determine the extent to which the Contractor's warranties have been fulfilled. The efficiency tests will be conducted in accordance with the latest Test Code for Hydraulic Prime Movers of the American Society of Mechanical Engineers.

The Contractor will be notified of and will have the right and opportunity to be represented at any acceptance tests which the Ministry may make.

MATERIAL AND WORKMANSHIP

General. All materials shall be new and shall be the best available for the purpose for which used, considering strength, ductility, durability, suitability for the intended service and best engineering practice. Workmanship shall be of the highest grade and in accordance with the best modern standard practice.

Standards and Specifications. All materials, equipment, and fabrication and testing thereof shall conform to the latest applicable standards and specifications contained in the following list or to equivalent applicable standards and specifications established and approved in the country of manufacture of the equipment.

ASTM -- American Society for Testing Materials.

AWS -- American Welding Society

ASA -- American Standards Association

NEMA -- National Electrical Manufacturers Association

API -- American Petroleum Institute

ASME -- American Society of Mechanical Engineers

All threaded parts shall have American National Standard threads.

References to standards and specifications or to equipment and materials of a particular manufacturer shall be considered as followed by the words "or equivalent". The Contractor may propose alternative standards, specifications, materials, or equipment which shall be equal in every respect to that specified. If the Contractor for any reason proposes alternatives to or deviations from the above standards, or desires to use material or equipment not covered by the above standards, the Contractor shall state the exact nature of the change, the reason for making the change, and shall submit complete specifications of the materials and equipment for the approval of the Engineer. The burden of proof of the

comparative quality and suitability of alternatives or deviations shall be upon the Contractor and the decision of the Engineer in the matter of equality will be final.

Working Stresses. Liberal factors of safety shall be used throughout, especially in the design of all parts subject to reversal of stresses or shock. For the rotating parts of the turbine, the maximum unit stress due to runaway speed shall not exceed two thirds of the yield point. When the parts of the equipment subject to maximum water pressure of 140 pounds per square inch are also subject to the maximum stresses resulting from operating conditions, the unit stress in the material used shall not exceed the values in the following table. However, a stress of 2/3 of the yield point will be allowed in the wicket gates, wicket-gate stems, and wicket-gate levers at the breaking point of the shearing pin.

Maximum Allowable Unit Stress in Pounds per Square Inch

Material	Stress in Tension	Stress in Compression
Cast Iron	2,000	10,000
Cast Steel	10,000	10,000
Alloy Cast Steel	20 per cent of the ultimate strength or 33 per cent of the yield point.	20 per cent of the ultimate strength or 33 per cent of the yield point.
Plate Steel for spiral case or other principal parts.	12,000	12,000

For other materials used in the manufacture of the turbines and governors, the maximum stresses due to the most severe operating conditions shall not exceed 1/3 of the yield point nor 1/5 of the ultimate strength of the material. For temporary overloads, unit stresses not exceeding 1/2 of the yield point stress will be permitted.

Steel Castings. All steel castings shall be grade 65-35 carbon-steel castings with a maximum carbon content of 0.30 conforming to ASTM Designation: A27-55. Radiographing or similar tests will not be required. No repairs shall be made to castings without the approval of the Engineer. Welding shall be performed only by properly qualified welders and in accordance with the best welding practice. Cracks and other defects disclosed when the castings are cleaned or during machining operations shall be chipped to sound, clean metal before any repairs are made. If the removal of the metal to uncover a crack or defect reduces the stress-resisting cross section of the casting to such an extent that the computed unit stress in the remaining metal is more than 30 per cent in excess of the allowable stress, the casting may be rejected. Castings requiring welding repairs at any stage of manufacture after the first annealing shall be stress-relieved, unless otherwise permitted by the Engineer.

Thicknesses and other dimensions of the castings as called for on the Contractor's drawings shall not be reduced by shop or foundry practices to the extent that the resulting stress in the metal will exceed the stresses allowed under these Specifications. Castings shall not be warped or otherwise distorted, nor shall their dimensions be oversize to such an extent as to interfere with proper fit with other parts of the apparatus. The structure of the casting shall be homogeneous and free from excessive non-metallic inclusions. An excessive segregation of impurities or alloys at critical points in a casting will be cause for its rejection.

Steel Plates. Steel plates for the spiral cases, pressure tanks, and other principal stress-carrying parts shall be of fire box quality, Grade B, conforming to ASTM Designation: A285-54T. Steel plates for the pit liner, draft tube liner, and other unimportant stress-carrying parts shall conform to ASTM Designation: A283-54.

Electric Welding. Members to be joined by welding shall be cut accurately to size. The edges of the members shall be sheared, flame cut, or machined to suit the required type of welding. The cut surfaces shall expose sound metal, free from injurious defects. The surface of plates to be welded shall be free from rust, grease, and other foreign matter for a distance of at least 1/2 inch back from the edge of the weld.

All welding shall be performed by the electric-arc method, by a process which will exclude the atmosphere from the molten metal, and, where practicable, using automatic machines. After being deposited, welds shall be cleaned of slag and shall show uniform sections, smoothness of weld metal, feather edges without overlap, and freedom from porosity and clinkers. All pinholes, cracks, and other defects shall be repaired by chipping or grinding the defects to sound metal and rewelding. The welding rods used for manual welding shall be of the heavily-coated type and shall be suitable for all position welding.

Tests of Materials. If requested to do so, the Contractor shall furnish the Engineer with a certified copy of reports of tests of all materials used in the manufacture and fabrication of the apparatus. The results of these tests shall be in such form as to show compliance with the applicable specifications for the material tested. All costs of tests and reports shall be borne by the Contractor.

HYDRAULIC TURBINES

Item 1

Type and Description. The 3 turbines to be furnished shall be of the vertical-shaft, single-runner Francis type with steel spiral cases. Rotation shall be counter-clockwise when the turbines are viewed from above. The turbines shall be designed and constructed so that all removable parts, including runner, shaft, guide bearing, guide bearing housing, head cover, gate-operating mechanism and wicket gates can be removed upward through the stator bore of the generator, and so as to allow vertical movement of the shaft and runner when the lifting jacks are being operated. Provision shall be made in the design to allow each turbine shaft and runner to be lowered and supported to clear the generator shaft when the coupling bolts are removed.

Design pressure shall include 25 per cent water pressure increase over maximum static pressure.

The Contractor is invited to suggest any changes in the conduit system and power plant layout, which in view of his experience, he considers desirable.

Head Variations. The gross head on the turbines may vary between 96 and 46 meters. The controlling water surface elevations referred to mean sea level will be approximately:

Headwater Elevations:

Maximum	290.0 meters
Minimum	240.0 meters

Tailwater Elevations:

Normal	194.0 meters
Minimum	192.5 meters

Maximum net design head is 70.5 meters; normal net effective head is 70.0 meters.

The centerline of the turbine distributors will be at elevation 195.5 meters.

The Contractor shall guarantee that the turbines will operate at all gate openings throughout the above ranges without causing detrimental surges or vibrations.

Turbine Rating and Speed. The turbines shall have a capacity or rating of not less than 28,000 horsepower at full gate opening when operating under net effective head of 70.0 meters and a speed of 200 rpm. One horsepower is defined as 550 foot-pounds per second.

The point of best efficiency is desired when operating under a net effective head of 70.0 meters at approximately 24,000 horsepower.

Runners. Each turbine runner shall be of cast steel, made in 1 piece. The runners shall have sufficient strength to support its own weight, plus the weight of the turbine shafts when the latter are disconnected from the generator shafts and the runners are resting on ledges or shoulders in the discharge rings. There shall also be sufficient strength to withstand the stresses caused by conditions at run-away speed under maximum head with no electrical load on the generators.

The runners shall have renewable stainless steel wearing rings and no more than 2 rings shall be provided for each runner, 1 on the runner crown and 1 on the runner band.

All surfaces of each runner which will be in contact with the water shall be smooth and free from hollows, depressions, cracks, or projections that might cause pitting due to cavitation. The Contractor shall warrant the runners against excessive pitting or cavitation for a period of 1 year from the date they are placed in service. Excessive pitting shall be defined as removal of more than 80 pounds of metal from the runner in 8,000 hours of operation.

The runners shall be securely fastened to the shafts with removable flanged bolted connections. The finished runners, with wearing rings attached, shall be carefully statically balanced at the Contractor's shop.

Shafts. The turbine shafts shall be made of forged, open-hearth carbon or alloy steel properly heat-treated. The shafts shall operate at any speed up to full run-away speed without detrimental vibration or distortion.

Each turbine shaft shall be of the proper length to connect with its generator shaft and shall have an integrally-forged flanged half-coupling on its upper end for connection to the coupling on the lower end of each generator shaft. The face of each coupling shall be at an elevation to fit the shaft length furnished by the generator manufacturer, which elevation is to be 202.0. The dimensions of each shaft coupling-half shall in no case be less than required by the American Standards Association Standard B49.1-1947 for "Shaft Coupling, Integrally Forged Flange Type for Hydroelectric Units," or the latest revision thereof.

The shafts shall have removable sleeves where they pass through the packing box in the turbine head covers. The sleeves shall be made of stainless steel, shall be accurately machined and polished, and shall be securely fastened to the shafts. Suitable oil or water deflectors shall be provided between each main guide bearing and the packing box.

The turbine shafts shall be accurately and smoothly machined all over and shall be polished where they pass through the guide bearings. The shafts shall be bored through the axis with a smooth hole, not less than 2 inches in diameter for inspection purposes.

The Contractor, in cooperation with the generator manufacturer, shall space and drill the coupling bolt holes in the forged half coupling of the turbine shaft. Final reaming of the turbine runner and generator-shaft-coupling bolt-holes and fitting of bolts shall be done by the Ministry, at the time the turbine and generator are erected in the power plant and under the supervision of the Contractor's erecting engineer.

The generator manufacturer will furnish all coupling bolts and nuts, as well as removable protective covers for the bolt-heads and nuts on both halves of each coupling.

Guide Bearings. The turbine guide bearings shall be of the babbitt lined, oil-lubricated type, shall be located above the runners, and shall consist of readily removable bearing liners and cast iron bearing supports. The guide bearings shall also be so designed and located with reference to the packing boxes beneath as to permit ready access to the latter for maintenance without removing the guide bearings.

The bearing housings and bushings shall be split vertically in halves to facilitate dismantling, and the bushings shall be securely doweled or keyed to the housings. The bearing bushings, properly proportioned with respect to the shaft diameter, shall be of high grade, properly selected, anti-friction metal, scraped and polished as required for fit around the shafts and suitably grooved for the circulation of oil.

A vapor-pressure dial-type indicating thermometer and a bulb-type thermal relay with sealed mercury contacts shall be furnished for each guide bearing. The bulb for the indicating dial thermometer shall be placed in the oil discharge from the bearing or in the hottest part of the oil bath if the immersed type bearing is provided. The bulb for the thermal relay shall be placed in or adjacent to the bearing metal. The contacts of the thermal relay shall be readily changeable to normally open or normally closed and shall be suitable to operate an alarm on excessive bearing temperature rise.

Each guide bearing shall also be provided with a resistance temperature detector, to be located in or adjacent to the guide bearing metal. The detector shall be located in the area of the bearing where the highest temperatures would be expected.

Lubrication of the turbine guide bearing shall be effected by oil circulated through the bearing by either pressure feed or by the use of an oil reservoir around the bearing. The lubrication system shall be designed so that the temperature of the bearing or oil shall not exceed 49° Centigrade. If lubrication is by pressure feed, 2 independent motor-driven pumps shall be provided for mounting in an alcove in the turbine pit liner. One pump shall be driven by a 60-cycle, 3-phase, 440-volt, full-voltage starting motor. The emergency pump shall be driven by a 125-volt, full-voltage starting, direct-current motor. Oil

cooling, if required, shall be accomplished by means of suitable heat exchangers which shall be provided with the turbine. Maximum temperature of the cooling water will be 26° Centigrade. Electric heaters with thermostatic controls shall be provided for maintaining the oil temperature in the reservoir while the unit is idle if cooling coils are provided. The lubrication system shall have sufficient capacity such that the oil will not be completely circulated in less than 10 minutes and shall be complete, including pumps, strainers, and by-pass. If the pressure feed lubrication system is supplied, the following instruments shall be provided: Cooling water pressure gauge, oil pump discharge pressure gauge, cooler-outlet oil temperature gauge, cooler-inlet water temperature gauge, one automatic control for the emergency pump, and suitable switches for control and alarm circuits to operate on low oil pressure. If the bearing is of the immersed type, a float switch shall be provided instead of the low oil pressure switch. Oil level sight gauges for both oil reservoirs shall also be provided and a water supply pressure switch for each cooling system to operate on low pressure. A 1.5-ampere, 125-volt direct-current mercury contact shall be provided on each switch.

The gauges and temperature controls shall be mounted adjacent to the main guide bearings, at points accessible for inspection and maintenance.

All piping and conduit within the turbine pits shall be furnished by the Contractor and all piping shall be seamless copper tubing with solder-type fittings. All instruments and gauges for each complete turbine bearing lubricating system shall be furnished by the Contractor. All alarms and wiring will be furnished by the Ministry. The design of the main guide bearings shall be such that water will not enter the lubricating systems. All lubricating oil will be furnished by the Ministry and will be identical with that used in the governor oil system.

Stay Rings. The stay rings shall be made of cast steel or welded steel plate and shall be designed to support the weight of the superimposed structure, including the weight of the generators with the spiral cases empty, and designed also to resist the bursting stresses in the spiral cases when subjected to the internal water pressure. If welded stay rings are furnished, all welds shall be stress-relieved. The stay rings shall be sectionalized to correspond with the sections of the spiral cases and shall be shop-welded to the spiral case.

Tapped grout and vent holes shall be provided in the lower flange of each stay ring to facilitate the placing of grout. Provisions shall be made for closing grout and vent holes after concreting.

Spiral Cases. The spiral cases shall be constructed of cast steel with flanged and bolted sectional joints using alloy-steel bolts or welded-plate steel with field-welded joints. The inlet end of the spiral case shall be suitably finished and beveled if a plate steel spiral case is furnished; or if the cast steel spiral case is furnished, the inlet shall be provided with a suitable machined and drilled flange for connecting to the steel spiral case extension.

The spiral case shall be furnished in sections as large as can be conveniently handled, but in no case shall they be furnished in more than 4 sections.

Each spiral case inlet and water passage shall be so designed and constructed so as to produce minimum hydraulic losses and disburbances. The baffle sections of the spiral cases shall be of cast steel or welded plate steel specially designed to eliminate the necessity for forming plates at the junction of the small end of the spiral cases and the inlet sections. Tolerance for match between inside surfaces of the adjacent spiral case sections at joints shall be limited to 1/2 the nominal plate thickness.

A suitable number of supporting brackets for the application of jacks and a corresponding number of jacks and lugs with hold-down turn-buckles shall be provided by the Contractor for supporting and anchoring the spiral cases securely in position while concrete is being placed.

The Contractor shall drill and tap each spiral case for a pressure gauge. Each spiral case shall also be drilled and tapped at points selected by the Engineer and 4 stainless steel piezometers shall be furnished for Winter-Kennedy flow meter taps.

Head Covers, Bottom Rings, and Discharge Rings. The head covers, bottom rings, and discharge rings shall be of cast steel or welded plate steel, amply ribbed and proportioned. The discharge rings may be integral with either or both the stay

rings and bottom rings. A ledge or shoulder shall be provided on each discharge ring for supporting the weight of the turbine runner and shaft when the latter are disconnected from the generator shaft. The space under the head covers shall be adequately drained. The central opening in the head covers shall be large enough to pass the flanges of the main shafts. Provision shall be made in the head covers for checking the upper wearing ring clearances at 4 approximately equally spaced locations on the circumference. The discharge ring shall be provided with a replaceable steel liner.

Packing boxes, designed so that they can be repacked and adjusted without disturbing the guide bearings, shall be provided where the turbine shafts pass through the head covers. The packing boxes shall be provided with non-ferrous lantern rings and connections for water and grease lubrication. A temperature control relay with a 1.5-ampere, 125-volt direct-current mercury contact with its bulb located in each packing box opposite the water connection shall be provided to operate on excessive packing box temperatures.

An air valve shall be provided in each head cover to be operated by the gate-operating mechanism for the admission of air at partial gate opening.

Wearing Rings and Facing Plates. Replaceable wearing rings and distributor facing plates shall be provided at the locations where there are close running clearances between the runners and wicket gates and the stationary parts of the turbines. The upper and lower stationary wearing rings shall be of stainless steel and shall be located to match and shall be non-galling with the rotating wearing rings on the runner. The radial clearances between the rotating and stationary wearing rings shall be as small as practicable. Replaceable distributor facing plates shall be provided above and below the wicket gates and shall be faced with stainless steel. Distributor facing plates may be integral with the upper and lower stationary wearing rings.

Gates and Operating Mechanisms. The turbines shall be provided with a suitable number of movable wicket gates to control the supply of water to the runners. The number of gates and

water passages in the runners shall be coordinated so as to insure that the turbines will operate without excessive vibration. It is essential that the design of the wicket-gate assemblies be such that leakage through the turbines with the gates in the full closed position be limited to the maximum extent possible.

The gates shall be of cast or forged steel with stems integrally cast or forged. Each gate and stem shall be accurately machined and finished, and all gates shall be interchangeable. Three bronze-bushed, grease-lubricated bearings shall be provided for each gate, 1 located in the bottom ring and the other 2 located in the head cover, 1 above and 1 below the packing box. Each stem shall also be provided with a bronze thrust bearing or collar to carry the weight of the gate. Each gate stem shall be stainless-steel coated where it passes through the packing box.

A double shear pin shall be provided between each gate stem and the gate operating ring, which shall be strong enough to withstand the maximum operating forces, but which will break in either the opening or closing direction in case 1 or more of the gates becomes blocked. Stops shall be provided to limit the movement of a loose gate so that it cannot come in contact with a runner nor interfere with operation of adjacent gates.

The operating mechanisms for the wicket gates shall be located above the turbine covers, readily accessible for inspection, maintenance, and adjustment. All parts having relative motion in contact shall be properly equipped with grease-lubricated bronze bushings. Means shall be provided for adjusting the position of any individual gate independently of the others.

A mechanical device, designed to withstand the maximum governor thrust, shall be provided to lock each operating ring in the open or closed position, or to limit the maximum gate opening under high head conditions.

All lubrication points for the gate operating mechanisms in the turbine pits shall be served by manual type forced feed lubrication systems. Each system shall include a manual pumping unit with grease reservoir, tubing, and an adjustable measuring valve for each lubricating point. The arrangement shall be such that no lubricating points can be accidentally neglected, and so that, upon operation of the central pump, each lubricating point will be served with a quantity of grease equal to 1/3 of the clearance volume of the bearing.

Draft Tubes and Liners. The Contractor shall furnish the draft tube design upon which he warrants turbine performance. The concrete portion of each draft tube below the steel liner will be constructed by the Ministry.

The Contractor shall furnish plate-steel draft tube liners not less than 1/2 inch thick to a point at which the draft tube area is not less than twice the runner discharge area. The interior of the draft tube liners shall be smooth, shall have no abrupt changes in direction, and shall be securely attached flush to the discharge rings. The liners shall be reinforced heavily on the outside by means of suitable ribs or structural steel shapes and shall be provided with adequate means for securely anchoring them to the surrounding concrete of the power house substructure. A watertight and airtight man-door, not less than 24 inches square, with a hinged cover opening outward into the access passageway, shall be provided in each draft tube liner to allow access to the underside of the runners. The inside of the doors shall be flush with the inside of the draft tubes. A test cock shall be provided slightly below each man-door.

A sufficient number of leveling screws and hold-down bolts with turn-buckles shall be provided to permit centering, leveling, and securely holding the liners in final position, both vertically and laterally during assembly and placement of concrete.

Turbine Pit Liners. The turbines shall be provided with plate steel pit liners, not less than 1/2 inch thick. The top of the liners shall be flanged at elevation 197, and bolted by flanged connections to the stay rings. The liners may be in sections, bolted together in the field, and shall be provided with anchors for embedding and securely anchoring to the surrounding concrete.

Stairways, Walkways, Floor Plates, and Gratings. The Contractor shall furnish platforms, stairs, handrails, floor plates, and gratings where necessary for the turbine pits. All turbine pit equipment shall be readily removable for dismantling the turbines from above.

Drains. Adequate drainage piping shall be provided for removing any leakage that may occur within the turbine pits. Such leakage water shall be discharged through stay vanes to drainage piping which will be furnished by the Ministry.

Instruments. The Contractor shall furnish the following with each turbine:

(a) A pressure gauge to be mounted in the turbine pit to indicate the pressure in the spiral case.

(b) A gauge indicating both pressure and vacuum, to be mounted in the draft tube access gallery to indicate conditions in the draft tube below the runner.

(c) A gauge indicating both pressure and vacuum, to indicate conditions between the runner crown and the cover plate, to be mounted in the turbine pit.

The cases of all instruments shall be of the flush type with dull black lacquer finish and chromium-plated polished rings. The dial faces shall be not less than 5 inches in diameter; the scales shall have white faces with black markings; and the pointers shall be black, except that the second pointer and markings on dual dials shall be red. Instruments to be mounted in the turbine pits shall be furnished complete with mounting panels or brackets.

All gauges shall read in metric units and in the Spanish language.

All thermometers shall read in degrees Centigrade.

The Contractor shall furnish all piping and fittings between the turbines and the gauges. Materials shall be brass or bronze. Stop-cocks shall be furnished for all lines at the turbines.

Spare Parts and Tools. The Contractor shall furnish the following spare parts:

(a) Two wicket gates, complete with gate stems and stainless steel sleeves.

(b) Two complete sets of shear pins for one gate operating mechanism.

(c) One main shaft guide bearing.

(d) One runner, complete with wearing rings.

(e) One stainless steel sleeve for the main shaft where it passes through the packing box, including necessary keys, screws, etc., for attaching.

(f) One complete set of packing and cup leathers for one entire turbine.

(g) One complete set of wearing rings and wearing plates.

The Contractor shall also furnish the following:

(a) One set of lifting jacks and any other necessary devices for field handling and erection.

(b) One set of case-hardened wrenches and any special tools or equipment that may be required for assembling, installing, maintenance, or dismantling of any part of the turbines.

Shop Erection and Testing. The turbines shall be assembled in the shop and shall be properly matchmarked and doweled to insure correct assembly and alignment in the field, except that where necessary, suitable dowels shall be furnished for insertion after field assembly and drilling. Each shop assembly shall include the turbine casing, cover, turbine pit liner, draft tube liner, stairways, handrails, floor plates, etc., which are to be matchmarked, as well as parts of the mechanism.

Hydrostatic tests will not be required at the Contractor's plant, but the cases will be given a hydrostatic test at a pressure of 10 kilograms per square centimeter after final erection. The Contractor shall furnish the necessary spiral case inlet and stay ring bulkheads for use in the hydrostatic tests.

Painting. All exposed unfinished surfaces of the turbines and accessories shall be cleaned thoroughly and shall be given 1 shop coat of pure red lead and linseed oil paint prior to shipment, except as subsequently provided. All finished surfaces shall be coated with a suitable rust-preventive compound. All surfaces which are to be embedded in concrete shall be cleaned and left unpainted. All unfinished surfaces subject to contact with lubricating oil shall be cleaned and painted with a special oil-resistant paint.

GOVERNORS

Item 2

Type and Description. The three governors to be furnished under these Specifications shall be of the oil pressure, relay valve, cabinet actuator type with electrically-driven speed responsive elements. The governors shall be equipped with the necessary automatic auxiliary devices to permit full automatic operation of the starting, build-up of speed and voltage, synchronizing, pick-up of load to a predetermined manual setting, and stopping of the turbine generating unit.

The governors and the specified auxiliary equipment shall have an established reputation for satisfactory and reliable service. The Contractor shall determine and state the governor capacity to be used.

The speed responsive elements of the governors shall be driven by alternating current motors, which receive their current supply from permanent magnet generators to be furnished by the Contractor. The permanent magnet generators will be mounted on top of the main generator pilot exciter shafts. The generator manufacturer will be responsible for the support of the permanent magnet generators, and for furnishing the connecting shafts and couplings.

The speed responsive elements and the connecting mechanisms shall be sufficiently sensitive and accurate to initiate corrective movement of the turbine gates upon variations of 1/100 of 1 per cent in turbine speed. The speed of the speed-responsive elements shall vary directly as the turbine speed.

Operation of the wicket gates shall be by means of servomotors, to be supplied with oil under pressure from the governor pumping unit. The governors shall be capable of moving the wicket gates through their full travel in either direction in a time of 5 seconds. This time shall be adjustable, however, between limits of 5 to 15 seconds.

Each governor shall be equipped with means for delaying the action of its servomotor, so that proper compensation will be made in gate motion to prevent hunting.

The governors shall be designed to use a type and grade of oil suitable for lubrication of the turbine guide bearings.

All gauges, dials, indicating devices, instructions, and lettering stamped on or fastened to the governors and accessories shall be in the Spanish language, and quantities shall be in metric units.

Controlling and Indicating Devices. Each actuator shall be equipped with the following:

(a) Automatic start-stop mechanism and necessary auxiliary devices.

(b) Gate limit adjustment which can be operated manually at the actuator and also electrically from the main control board by means of a 125-volt, direct-current, reversing motor. A dial shall be provided to show, by means of a red hand, the position of the gate limit setting and a black hand to show the gate position at all times. The gate position and gate limit indicator shall be provided on the actuator and a similar instrument shall be provided for mounting on the main control board.

(c) Manual gate control by means of which the gates may be operated manually at the actuator by means of oil pressure from the governor oil pressure system. The transfer from actuator to hand control and vice-versa shall be accomplished by means of a transfer switch at the actuator with provision for energizing red and green indicating lights for manual and automatic position indication. The indication lights will be furnished by the Ministry, and will be located on the power plant control panel board.

(d) Speed level adjustment which can be operated manually at the actuator and also electrically from the main control board by means of a 125-volt, direct-current, reversing, synchronizing motor. Speed control shall be from 85 per cent of rated speed at no load and zero speed droop to 105 per cent of rated speed at rated load and maximum speed droop. A speed level adjustment indicator shall be provided on the actuator and a similar indicator, except that it shall be electrically operated, shall be provided on the main control board to show the exact setting of the speed level adjustment.

(e) Speed droop adjustment device for controlling the speed droop of the turbine, which can be operated manually at the governor. The degree of speed droop shall be adjustable from 0 to 5 per cent. A graduated dial shall be furnished to show the amount of speed droop for which the unit is adjusted.

(f) Automatic shut-down for closing the turbine gates at normal rate of closure, which also can be operated manually at the actuator and electrically from the main control board. This device will be used for automatically shutting down the turbine upon overspeed, failure of governor oil pressure, excessive temperature of the turbine shaft bearing, or upon operation of any of the automatic protective features in connection with the turbines, generators, and exciters. The solenoid coil shall be designed for continuous service at 125 volts, direct current, and to shut down the unit when de-energized. Two 1.5-ampere, 125-volt direct-current electrically independent mercury contacts shall be provided with the shut-down mechanism. One contact shall be closed when the mechanism is in the shut-down position and the other contact shall be closed when the mechanism is in the reset position.

(g) A combination manual and automatic generator brake valve with intermittent operation for controlling the operation of the generator brakes. The operation of the air valve shall be controlled by a handle with "Manual," "Off," and "Automatic" positions. Automatic operation shall be such that the brakes cannot be applied until the turbine gates are fully closed and the generator disconnected from the bus. When operating automatically, brake application shall be deferred until the generator has decelerated to a predetermined speed adjustable between 50 per cent and 20 per cent of normal speed. A timing device shall cause intermittent brake application with time periods adjustable, until the speed has decreased to a predetermined value. Thereafter, the brakes shall be applied constantly until the unit comes to a standstill. The brakes shall be released automatically after an adjustable period of time sufficient to assure that the unit has been brought to a complete stop. Opening the turbine gates shall instantly release the brakes. All electrical equipment shall be suitable for operation at 125 volts, direct current.

(h) Tachometers to indicate the speed of the turbine. One shall be mounted on the front of the actuator and the other shall be mounted on the main control board.

(i) Pressure gauge mounted on the actuator to show the pressure in the governor oil-pressure system.

(j) Hand pump to provide oil pressure for closing and opening the turbine gates if oil under pressure is not available from the governor oil system.

(k) Overspeed switch mounted on and forming a part of the governor-drive generator with five 1.5-ampere, 125-volt, direct-current electrically independent contacts, each adjustable to open or

close at any turbine speed from 125 per cent of normal to run-away speed, and to reset automatically at 105 per cent of normal speed.

(l) Oil pressure failure switch with 2 independent 1.5-ampere, 125-volt, direct-current mercury contacts which can be adjusted to close or open when the governor oil pressure drops to a predetermined value.

(m) A speed-no-load device for automatically returning the turbine to speed-no-load upon over-speed due to loss of load. The design of this device shall be such that the turbine gates are under control of the speed responsive element after being returned to the speed-no-load position, and shall be such as to permit the safety shut-down to completely close the turbine gates at any time. The speed-no-load solenoid shall be suitable for continuous operation on 125 volts, direct current and shall bring the unit to speed-no-load when de-energized.

(n) An underspeed switch mounted on and forming a part of the governor-drive generator, arranged to operate the automatic generator brake valve circuit when the unit decelerates to a predetermined speed between 50 per cent and 20 per cent of normal speed. Three 1.5-ampere, 125-volt, direct-current electrically independent contacts shall be provided which can be adjusted to open or close on low speed.

(o) A low oil level float switch to operate when the oil level in the pressure tank drops to a low value. Two 1.5-ampere, 125-volt, direct-current electrically independent mercury contacts shall be provided which can be adjusted to open or close on low oil level.

(p) A gate-position switch to operate at any point from zero to 0.3 gate opening. Five 1.5-ampere, 125-volt direct-current electrically independent mercury

contacts shall be provided which can be adjusted to open or close at a predetermined gate position.

(q) A speed-changer switch operated by the speed-changer mechanism to prevent over-running the synchronizing motor.

Governor Oil Pumps. Each governor shall be provided with an electric motor-driven pump of the rotary or screw type, self-priming under the maximum oil pressure, and shall have a capacity per minute of at least 3 times the total oil volume of the servomotor. Each oil pump shall have sufficient capacity for the operation of the unit.

Each pump shall be equipped with a pilot valve, unloader valve, check valve, and safety relief valve, so adjusted that the proper working pressure will be maintained during pumping, and so that excess pressures cannot be created.

The arrangement of the system shall be such that the required air to form the air pressure cushion in the pressure tank will be automatically maintained.

Pressure Tanks. Each pressure tank shall be constructed in accordance with the latest edition of the API-ASME Code for Unfired Pressure Vessels for Petroleum Liquids and Gases, for the maximum working pressure. The tank capacity shall be at least 20 times the capacity of the servomotor.

Each pressure tank shall be equipped with a pressure gauge and with a sight gauge to indicate the oil level in the tank. The oil level gauge glass shall be protected from accidental breakage by means of a suitable guard which shall also serve as a protection against accident to the observer, and shall be provided with hand shut-off valves and automatic means for shutting off air and oil discharge from the pressure tank in the event of breakage of the gauge glass. All connections to the pressure tanks except the air blowoff and the upper gauge glass connection, shall be made below the oil level. The interior surfaces of the pressure tanks shall be sandblasted and coated with a suitable oil-resistant coating to prevent deterioration

of the metal. Each tank shall have connections near the top for manually releasing air or for introducing air from the power plant air system.

Sump Tanks. Each sump tank shall have a capacity of not less than 110 per cent of the total quantity of oil in the entire governor system for one unit. There shall be a suitable, easily removed strainer through which all the oil returned from the servomotors shall pass. Each sump tank shall be provided with an oil-level gauge for indicating the quantity of oil in the tank and shall also have suitable connections for filling and draining. The interior surface of the tanks shall be sand-blasted and coated with an oil-resistant coating to prevent deterioration of the metal. The breather connections on the oil sumps shall be equipped with metallic-type oil vapor filters.

Piping. The Contractor shall furnish all piping and valves between the oil pumps, sump tanks, pressure tanks, regulating valves, and servomotors.

Piping shall be iron-pipe size, seamless black steel pipe, and all pipe larger than 2 inches in diameter shall be provided with extra heavy steel flanged connections. All valves necessary for the operation of the governor system shall be of the rising stem, steel body, bronze-mounted type, except those valves built into and forming an integral part of the governors or pumping units. All necessary studs, bolts, cold-finished nuts, washers, oil-resisting gaskets, packing, etc., required in connection with the field assembly of the governor oil-piping systems shall be furnished by the Contractor. All gaskets shall be made of an oil-resistant material.

Motors, Controls, Wiring. The motors for the pumps shall be 440-volt, three-phase, 60-cycle squirrel cage, induction type motors designed for full voltage starting. The motors shall have ball bearings, closed conduit boxes and have screen guards over the end bell openings. Windings shall have moisture and oil-resistant insulation.

An enclosed motor starter shall be provided on the governor to operate each oil pump motor. It shall be of the full-

voltage magnetic type, with external, manually reset, thermal overload elements. The Contractor shall furnish a control transformer in each motor starter to provide 115-volt single phase power for the control circuits.

The Contractor shall supply pressure switches for starting and stopping the oil pump motors at low and high pressures respectively.

All internal wiring of the governors and pumping units shall be arranged so that external connections are made in terminal boxes suitable for conduit, and shall be otherwise enclosed in raceways or conduit properly supported. Conduit and wiring between the governors and power sources will be furnished by the Ministry.

Design and Finish. The general design of the governor's cabinet, pressure tanks, piping, and other auxiliaries shall have a neat, attractive appearance. Exposed, unfinished surfaces shall be carefully filled and rubbed to smooth surfaces and shall be given a priming coat. Finished surfaces shall be coated with a suitable rust-preventive compound. Surfaces which are to be embedded in concrete shall be cleaned and shall not be painted. Surfaces subject to contact with oil shall be cleaned and coated as specified for the sump and pressure tanks. All exposed handles shall have a polished finish. The cases of all instruments shall be of the flush type with dull black lacquer finish and chromium-plated polished rings. The dial faces shall be not less than 5 inches in diameter. The scales shall have white faces with black markings and the pointers shall be black, except that the second pointer and markings on dual dials shall be red.

Spare Parts and Tools. The Contractor shall furnish the following spare parts:

(a) One complete rod, plunger, and bushing assembly for pilot valve.

(b) One governor head, complete.

(c) One complete compensating mechanism.

(d) One complete rod, plunger, and bushing assembly for distributing valve.

The Contractor shall furnish one complete set of case-hardened wrenches and tools necessary for assembling and dismantling the governors.

Shop Erection and Tests. The governors and auxiliary equipment shall be completely assembled in the Contractor's shop and tested insofar as practicable. The various parts shall be properly matchmarked and doweled to insure correct assembly and alignment in the field. The entire system subject to oil pressure will be tested after erection, to a pressure 50 per cent above the maximum working oil pressure. The governors shall be shipped complete and ready for operation, with the exception of the external piping.

BUTTERFLY VALVES

Item 3

Type and Description. The 5 butterfly valves to be furnished shall be of the horizontal disc type, power operated for installation in each penstock branch. The size of the valves shall be determined by the Contractor to correspond to the spiral case inlet area such that there will be no decrease in velocity of flow between the valve inlets and the spiral case inlets. The valves shall be provided with hydraulic operators. The valves shall be designed for operation at a maximum head of 140 pounds per square inch, and, together with their control systems, shall be designed for opening or closing the valves in approximately 2 to 3 minutes. The turbines will not be operated with the valves in a partially open position. The operating mechanism shall provide for opening the valve with approximately balanced pressures on each face of the disc and for closing the valve against the maximum unbalanced head. A 10-inch by-pass line, including guard and service valve, shall be provided with each unit.

The Contractor shall furnish with the valves, all the necessary gaskets, mounting plates, anchors, and flange bolts, nuts and washers, and a complete set of tools required for installation and maintenance of the valve.

Valve Bodies and Flanges. The valve bodies shall be made of cast steel or rolled and welded steel and shall be constructed with flanges and hubs for shaft bearing housings integral with the valve bodies. The water passages shall have smooth contours and be so apportioned to provide for a smooth flow of water with as little turbulence as possible. The valves shall be designed so that the net water passage area at any point through the valves is not less than the cross-sectional area of the inlet to the turbine spiral case.

Each valve body shall be equipped with supporting brackets which shall rest on a metal base or anchor plate to be furnished with the valve. Provision shall be made for approximately 5 centimeters of axial movement in the mounting.

Valve Shafts. Valve shafts may consist of one piece extending completely through the valve disc or of the stub-type, comprising 2 sections inserted into the valve disc hubs. The valve shafts shall be securely attached to the valve discs by means of dowel pins,

keys, or taper pins. The shafts and connection system shall be suitable for transmitting the full required torque with an adequate factor of safety. All valve shafts shall be of corrosion-resisting steel conforming to ASTM Designation 276-55, Type 302, 304, or 316.

The valve shafts shall be packed to prevent leakage, and the stuffing boxes shall be designed to permit adjustment or replacement of the packing without removing any part of the valves or operating units except the glands. The axis of the valve shafts shall be horizontal and be arranged for connecting the operating units on the right side looking downstream.

Valve Discs. The valve discs shall be of a cast or fabricated design with no external ribs or cavities and having a smooth streamlined shape. Each disc shall be designed to sustain the full differential pressure across the closed valve without exceeding a working stress of 1/5 of the tensile strength of the material used. The discs shall have suitable corrosion-resistant metal seating edges. Adjustable mechanical stops shall be provided to prevent over-travel of the disc in either the open or closed position. The mechanical stops shall be designed to absorb the full operator torque with a minimum factor of safety of 5. The disc trunnions shall be journaled in bronze sleeve bearings with adequate provision for watertight seals and positive lubrication.

Valve Seats. Valve seats shall be designed to provide tight shutoff at the full pressure differential. Provision shall be made for removal and replacement of the valve seats without removal of the valves. The valve seats shall be of bronze, monel, or other corrosion-resistant metals and shall be accurately fitted to the leaf seating edges to minimize leakage.

Operating Units. Each valve shall be furnished with a complete operating hydraulic torque unit. The units shall be mounted directly on the hub of the valve and supported therefrom. Each unit shall be equipped with a device to prevent opening the butterfly valve unless approximately equal pressure exists on each side of the disc.

Each torque-drive unit shall consist of a cylinder and oil-driven piston arranged to rotate the valve disc. The hydraulic system shall be designed to operate at a pressure of not over 1,000 pounds per square inch, and shall include a positive hydraulic or mechanical locking mechanism for holding the leaf securely in the open or closed position.

The hydraulic drive units shall be furnished complete, including all hydraulic pressure equipment, piping, oil tank, pump, control valves, electrical equipment, indicators, and operating controls. All control equipment for each valve shall be contained in a separate drip-proof metal cabinet suitable for floor mounting near the associated butterfly valve. Cabinets shall be equipped with locked access doors with provision for anchoring the bases to the floor. Each cabinet shall contain a pressure tank and a motor-driven oil pump of the rotary, positive displacement type suitable for light hydraulic oil. Provision shall be made for interconnecting the hydraulic systems of each valve to provide for standby operation in the event of failure of one unit. Each unit shall be complete with valves, unloading valve, solenoid-operated directional valve, pressure gauge, switches, motor-starter, pushbutton operating stations, and indicating lights. Limit switches which can be adjusted to stop the operation when its valve reaches the open or closed position shall be provided. A mechanical gate leaf position indicator shall be provided, together with indicating lights for each valve. The latter shall show the position of the valve as follows: 1 red light on when the valve is fully closed; 1 green light on when the valve is fully open; both lights on when the valve is in any intermediate position. Provision shall be made for connecting the remote pushbutton operating station and remote indicating lights for each valve.

The Contractor shall furnish all operating controls for the butterfly valves, including the hydraulic control units; and the push-button control stations and the indicating lights to be installed at or near the valves. The interconnecting electrical circuits between the remote control station and valve operator units will be furnished by the Ministry.

The control units shall be furnished completely connected and wired, ready for installation and interconnection to the valve operating mechanisms, electrical supply circuits, and remote control circuits. Electric power supplied to the control units will be 460 volts, 3-phase, 60-cycle, alternating current. The Contractor shall furnish in the equipment the necessary control transformers for 115-volt single-phase control and indicating circuits.

Shop Assembly and Testing. Each butterfly valve, together with its operating mechanism shall be completely assembled in the shop to insure that all parts are properly fitted. The butterfly valve bodies shall be tested for leaks with water pressure of 220

pounds per square inch while the valves are in the open position. After the pressure test on the valve bodies, if satisfactory, the valves shall be closed and a hydrostatic pressure of 140 pounds per square inch applied to the upstream end of the valves and maintained for 15 minutes after all air has been vented. Under this pressure, the leakage shall not exceed 30 United States gallons per minute. The amount of water escaping past the seals of the leaf trunnions shall be negligible. The record of the actual leakage obtained shall be furnished to the Ministry.

After the pressure tests have been completed, the Contractor shall test the operation by moving the disc of each valve several times through its full arc of travel. During such tests, the discs shall move smoothly and with uniform resistance throughout the full travel. There shall be no evidence of any binding or sticking of parts at any point in the travel cycle, and the operation shall be satisfactory to the Consulting Engineer.

Painting. The exterior exposed surfaces of the valves shall be cleaned thoroughly and shall be given 1 shop coat of pure red lead and linseed oil paint prior to shipment. Water passageways and leaves shall be cleaned by the use of xylol followed by sandblasting or grit-blasting to uniform bright base metal. Any remaining grit or dust shall be removed by brushing, air blowing, or suction. The surfaces shall then be painted with CA-50 cold-applied coal-tar paint with 3 or more coats to obtain a dry film thickness of not less than 20 mils.

All surfaces of the control cabinets which require painting shall be thoroughly cleaned and shall be given 1 shop coat of pure red lead and linseed oil paint prior to shipment.

SPIRAL CASE EXTENSIONS

Item 4

Description. Three spiral case extensions shall be furnished to connect the turbine spiral cases to the butterfly valves as shown on the Drawings. Each spiral case extension shall consist of a steel make-up section approximately 4.50 meters in length and shall be furnished complete with suitable fittings at either end for connection to the butterfly valve and spiral case, a sleeve type coupling, and a man-door. The spiral case extensiones are to be connected to turbine units Nos. 2, 3, and 4. Each section shall consist of a gradually tapered conical section which reduces from the butterfly valve diameter to the spiral case inlet diameter, a short cylindrical section just upstream from the coupling, a sleeve type coupling, and a cylindrical portion downstream from the coupling to connect to the spiral case. The sections shall be furnished approximately 0.25 meters longer than the calculated length and they will be cut to fit in the field.

The Contractor will be allowed to use the dished heads to be furnished under Item 5, but shall provide any additional heads and equipment which may be needed for pressure testing in his shop.

The spiral case extensions together with the couplings and appurtenances shall be designed for the same conditions and requirements as the turbine spiral cases.

Couplings. The sleeve-type couplings shall be designed to permit removal of the butterfly valves and shall be complete with packing seals, bolts, washers, and nuts. The sleeves of the couplings shall be formed accurately to insure that watertight joints can be readily made and shall be similar or equal to the Dresser Manufacturing Company, Style 38, Steel Coupling with the center stop removed.

Man-doors. A 24-inch diameter man-door, equipped with a hinged cover and backout screws shall be furnished and located in each make-up section. Each man-door shall be furnished complete with cover, gasket, bolts, and nuts.

Shop Erection and Testing. The spiral case extensions shall be assembled in the shop with the turbines and shall be properly match-marked and doweled to insure correct assembly and alignment in the field. Each spiral case extensions shall be shop tested at a pressure of 220 pounds per square inch for not less than 2 hours and all leaks shall be stopped.

Painting. All exposed surfaces of the spiral case extensions shall be thoroughly cleaned and given 1 shop coat of pure red lead and linseed oil paint prior to shipment. All finished surfaces shall be coated with a suitable rust-preventive compound.

DISHED HEADS

Item 5

Description. Two flanged dished heads shall be furnished to be used during installation of power plant equipment for pressure testing, and for subsequent installation on the downstream flanges of the butterfly valves for turbines Nos. 1 and 5.

The dished heads shall be designed for the same conditions and requirements as the turbine spiral cases.

Testing. Each dished head shall be shop-tested at a pressure of 220 pounds per square inch for not less than 2 hours. Any leaks which may occur shall be stopped.

Painting. All exposed surfaces of the dished heads shall be thoroughly cleaned and given 1 shop coat of pure red lead and linseed oil paint prior to shipment. All finished surfaces shall be coated with a suitable rust-preventive compound.

DRAWINGS

Drawing List. The following Drawings are made a part of the Specifications:

Drawing No.	Title
E1-1	General Plan
E1-2	General Elevations and Sections
E1-3	Plans, Sections, and Details
E1-4	General Arrangement - Plan at Centerline of Turbines
E1-5	General Arrangement - Electrical Equipment Gallery
E1-6	General Arrangement - Generator Floor
E1-7	General Arrangement - Control Floor
E1-8	General Arrangement - Transverse Sections Through the Units
E1-9	General Arrangement - Longitudinal Section Thru Centerline of Units

The Drawings are intended to show the proposed general arrangement of the power plant. The final design of the power plant will be modified insofar as is practicable to suit the equipment furnished by the Contractor.

N

W 10,200
N 15,800

W 10,400
N 15,400

W 10,600
N 15,400

N 16,000

BOCONO RIVER

Sta L 0+63.00

Sta R 0+63.00

Δ = 20° 30'
R = 470.00
T = 84.990
L = 168.163

Berm

El. 190.0

El. 203.8

1:9

1½:1

Riprap

El. 185.00

Sta S 3+51.30

EL. 204.20

2:1

El. 204.20

El. 183.00

Sta S. 3+18.30

El. 190.00

Backfill

ISLAND

El. 204.00
Sta R 0+87.00
Sta R 1+06.00

Drainage ditch

Wall

AUXILIARY DAM

ENTRANCE YARD

Elevator penthouse

Crest El. 204.00
Sta S. 2+93.50

Outlets

Outlets

El. 220.70

Slope as directed

STILLING POOL

El. 220.60

126.00

HIDROELECTRIC POWER PLANT

El. 204.0

Slope as directed

Radius to axis of dam 470.00

DIVERSION TUNNEL

Block ①

Tunnel plug

175.00

Δ = 51° 00'
R = 175.00
T = 83.471
L = 155.771

Radius to axis of dam

Training wall El. 220.60

Contraction joints

El. 204.0

℄ STILLING POOL

S 75° 00' E

Switchyard protection wall El. 223.60

El. 188.00

Switchyard not shown

Transformer transfer track

Draft tube gates

Sta S 1+89.50

Draft tube gate hoist

Transformer yard

El. 204.0

Backfill

El. 209.00

Backfill

River outlets

Radial gates

SPILLWAY

0.75:1

0.75:1

0.75:1

Slope as directed

PC Sta A 2+76.23

Axis of Dam

Elevator tower

Balcony

Crest of dam El. 291.00

PT Sta A 7+36.16

Berm El. 210.0

Tunnel entrance

El. 200.0

N 16,030.00
W 10,350.00

Berm El. 200.0

El. 189.0

Berm El. 200.0

Intake structures

Spillway bridge

Sta A. 4+32.00

Sta. A. 5+00.00
Sta. S. 1+00.00

N 15,717.00
W 10,631.00

Sta A 5+68.00

0.30:1

Trashrack structure

Fixed wheel gate structure

Slope as directed

P.T.

P.C.

10 0 50M
SCALE

GENERAL PLAN

NOTE

The dimensions and elevations are in meters unless indicated otherwise

REPUBLICA DE VENEZUELA
MINISTERIO DE OBRAS PUBLICAS
DIRECCION DE OBRAS HIDRAULICAS
R. J. TIPTON ASSOCIATED ENGINEERS, INC.

BOCONO - TUCUPIDO RIVERS SYSTEM
BOCONO DAM

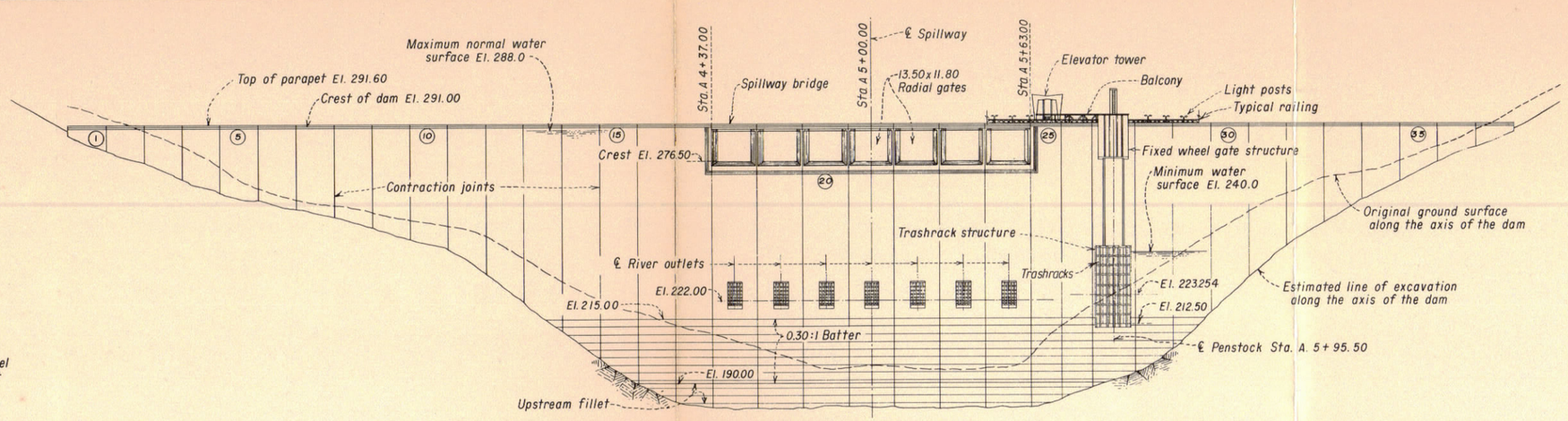
GENERAL PLAN

NO	DESCRIPTION	DATE	BY
REVISION			

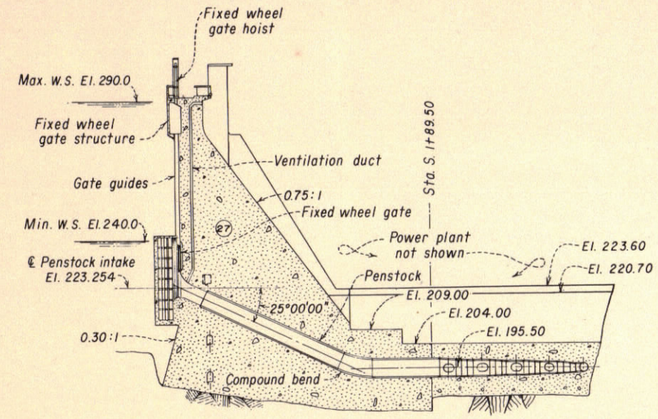
DRAWN G.Z.
TRACED R.S.H.
CHECKED C.W.M. B.F.V.
DENVER, COLORADO JANUARY, 1958

APPROVED R. J. TIPTON ASSOCIATED ENGINEERS, INC.
APPROVED

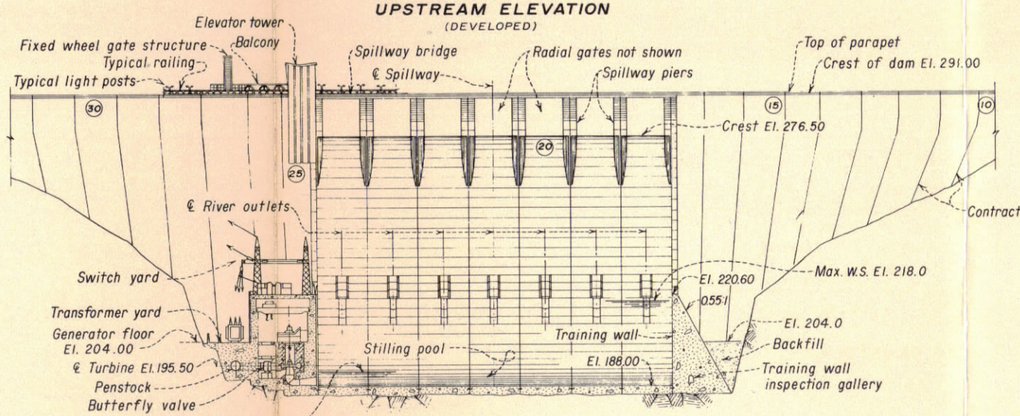
SHEET ..... OF E7 E1-1



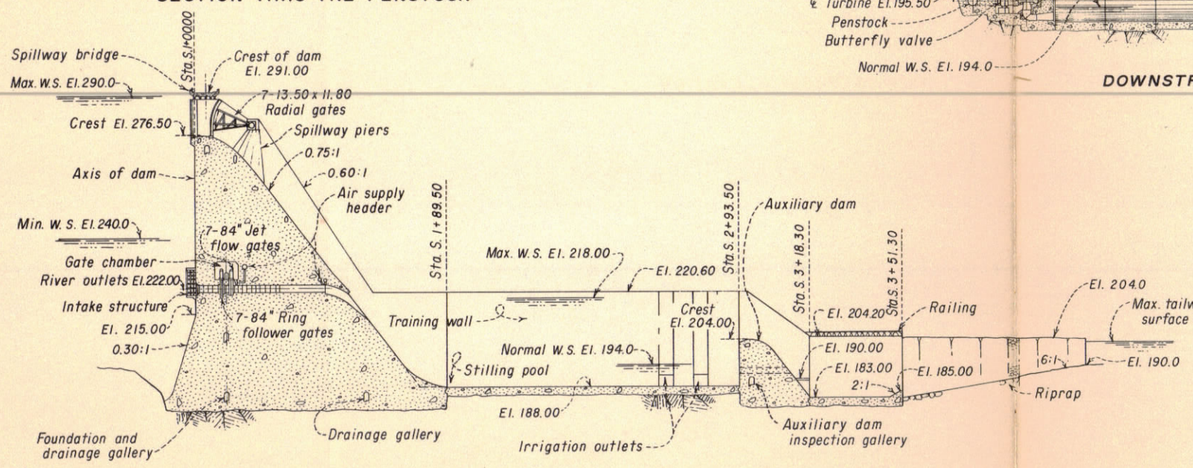
UPSTREAM ELEVATION
(DEVELOPED)



SECTION THRU THE PENSTOCK

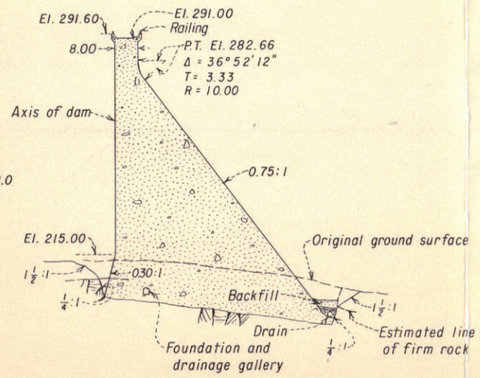


DOWNSTREAM ELEVATION



SPILLWAY SECTION
(DISCHARGE SYSTEM)

SCALE 10 0 50M.



NON-OVERFLOW SECTION

NOTE

The dimensions and elevations are in meters unless indicated otherwise.

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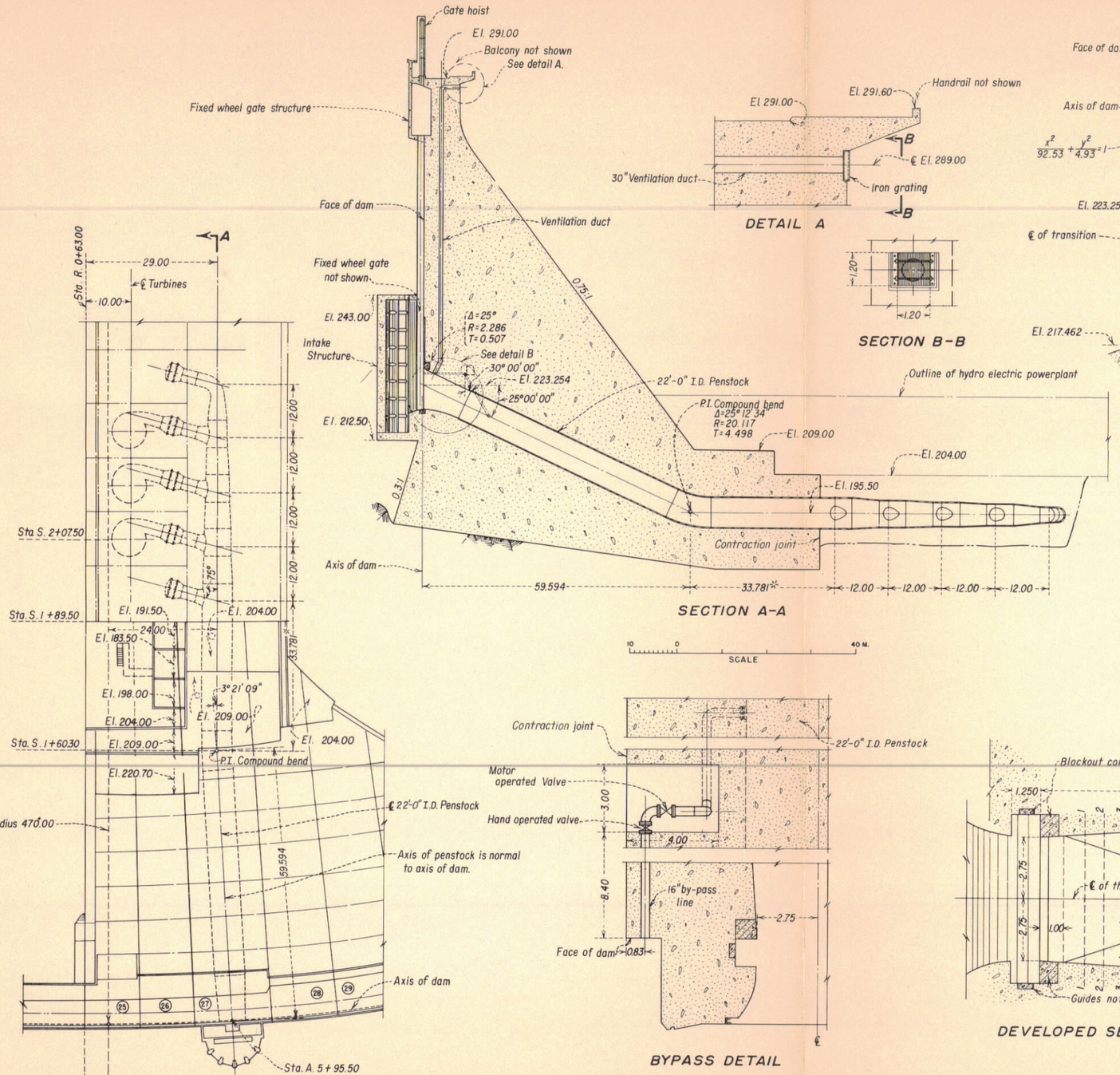
BOCONO-TUCUPIDO RIVERS SYSTEM
BOCONO DAM

GENERAL ELEVATIONS AND SECTIONS

NO	DESCRIPTION	DATE	BY

REVISION

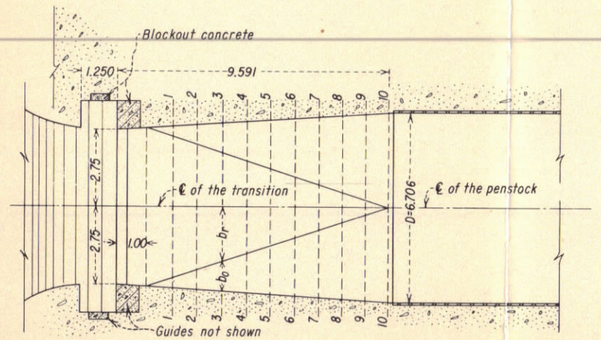
DRAWN G.Z.
TRACED G.R.C.-O.K.W.
CHECKED F.V.W.B.F.K.
APPROVED R. J. TIPTON ASSOCIATED ENGINEERS, INC.
APPROVED
DENVER, COLORADO JANUARY, 1958
SHEET NO. E7 | E1-2



DIMENSIONS FOR THE SECTIONS

	Σ∝	Σ L	a_0	b_0	b_n	b_r
0-0	0°00'00"	0.000	4.513	0.000	2.813	2.813
1-1	2°30'00"	0.909	4.277	0.355	2.870	2.515
2-2	5°00'00"	1.800	4.073	0.703	2.926	2.223
3-3	7°30'00"	2.678	3.897	1.045	2.981	1.936
4-4	10°00'00"	3.543	3.749	1.383	3.036	1.653
5-5	12°30'00"	4.399	3.625	1.716	3.089	1.373
6-6	15°00'00"	5.246	3.526	2.048	3.143	1.095
7-7	17°30'00"	6.088	3.450	2.376	3.196	0.820
8-8	20°00'00"	6.925	3.395	2.702	3.248	0.546
9-9	22°30'00"	7.759	3.364	3.028	3.301	0.273
10-10	25°00'00"	8.591	3.353	3.353	3.353	0.000

BYPASS DETAIL



DEVELOPED SECTION THROUGH TRANSITION

NOTES

The dimensions and elevations are in meters unless indicated otherwise.
The dimensions marked with an asterisk are approximate. Final dimensions shall be furnished later.

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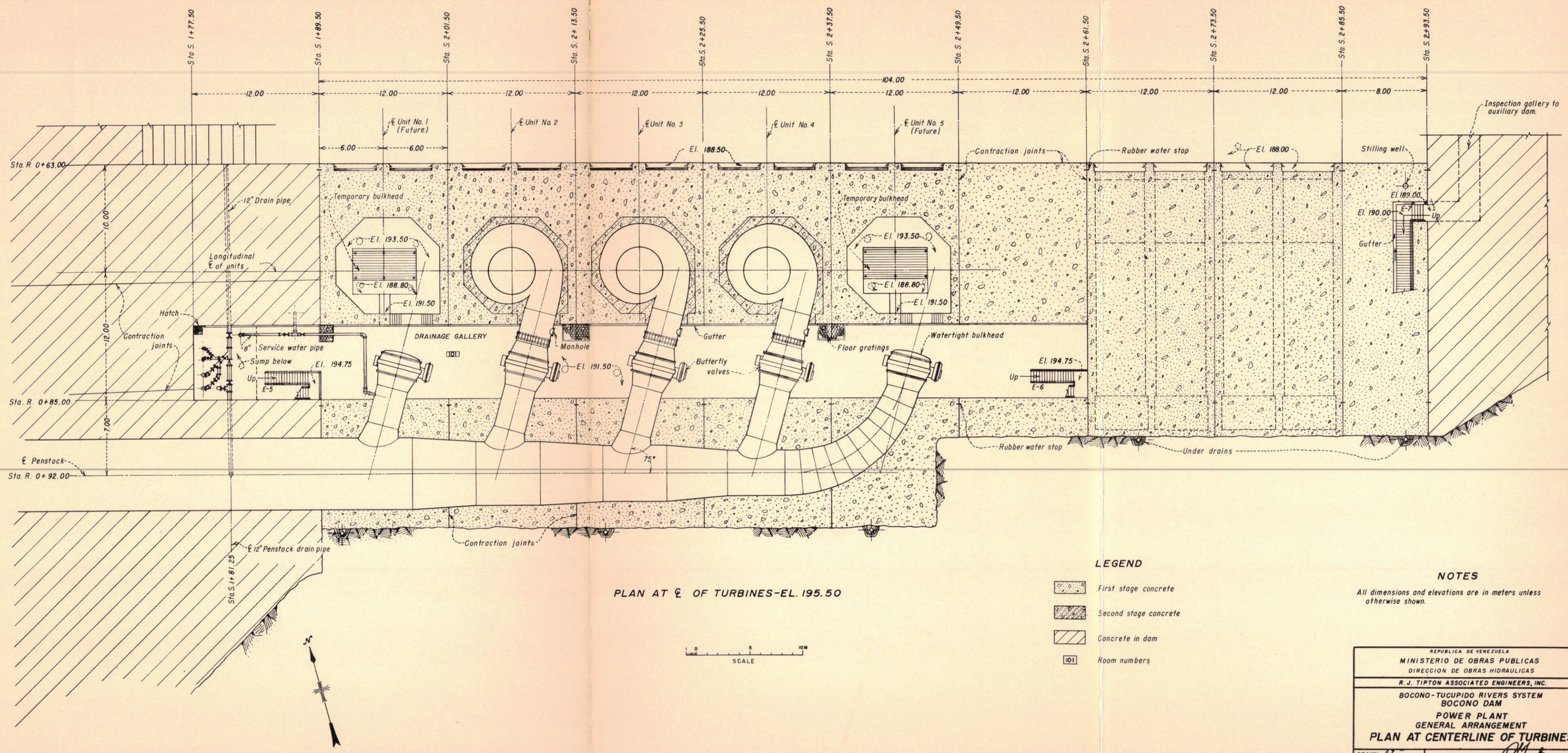
R. J. TIPTON ASSOCIATED ENGINEERS, INC.

BOCONO - TUCUPIDO RIVERS SYSTEM
BOCONO DAM
PENSTOCK

PLANS, SECTIONS AND DETAILS

NO	DESCRIPTION	DATE	BY
REVISION			

DRAWN A.A.K.
TRACED E.J.H.
CHECKED C.W.M. B.F.K.
APPROVED R. J. TIPTON ASSOCIATED ENGINEERS INC.
APPROVED
DENVER, COLORADO JANUARY 1958
SHEET ... OF ... E 7 | E1-3



PLAN AT ℄ OF TURBINES-EL. 195.50

SCALE 1:0 5 10M

LEGEND

- First stage concrete
- Second stage concrete
- Concrete in dam
- 101 Room numbers

NOTES

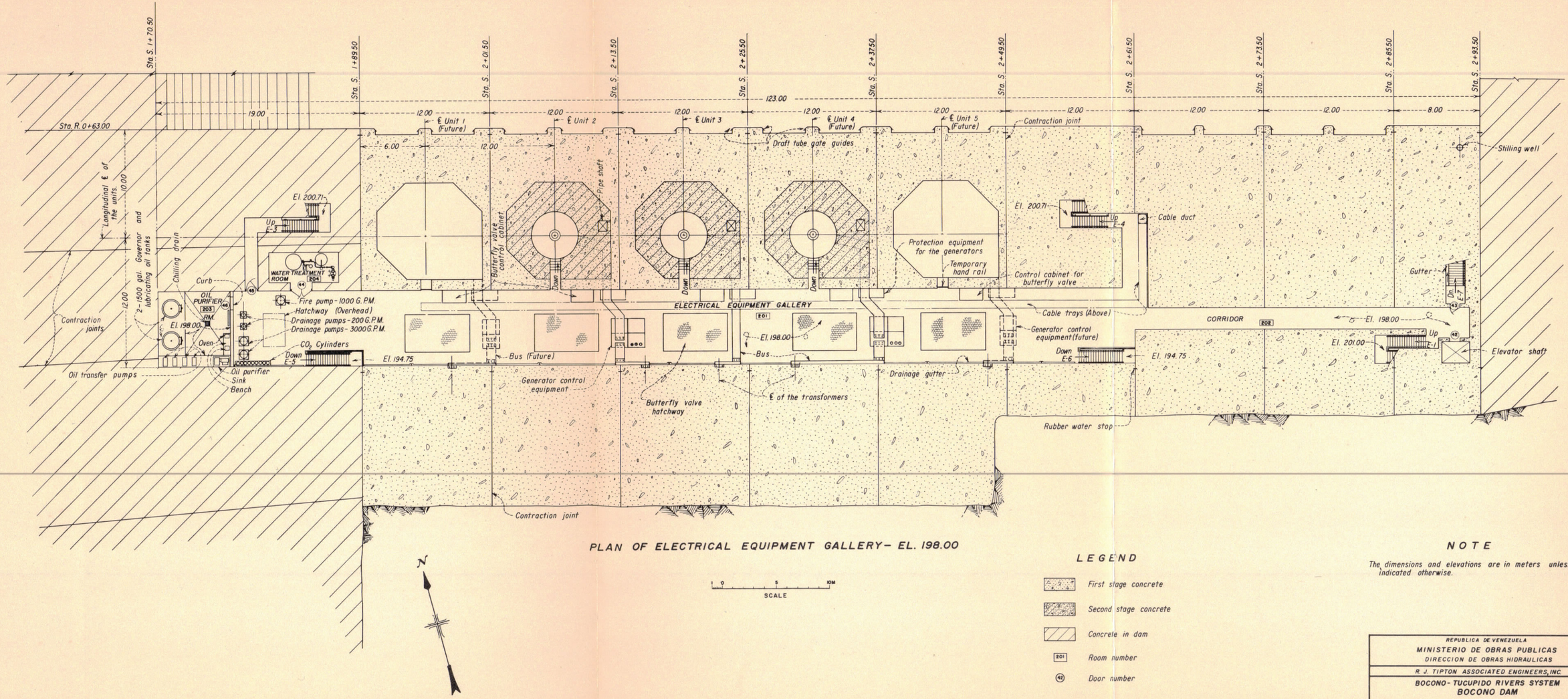
All dimensions and elevations are in meters unless otherwise shown.

REPUBLICA DE VENEZUELA
MINISTERIO DE OBRAS PUBLICAS
DIRECCION DE OBRAS HIDRAULICAS
R.J. TIPTON ASSOCIATED ENGINEERS, INC.

BOCONO-TUCUPIDO RIVERS SYSTEM
BOCONO DAM
POWER PLANT
GENERAL ARRANGEMENT
PLAN AT CENTERLINE OF TURBINES

NO.	DESCRIPTON	DATE	BY
	REVISION		

DRAWN G.Z.
TRACED D.R.S.
CHECKED C.J.R.D.F.V.
APPROVED R.J. TIPTON ASSOCIATED ENGINEERS, INC.
APPROVED
DENVER, COLORADO JANUARY, 1958
SHEET ..... OF E7 E1-4



PLAN OF ELECTRICAL EQUIPMENT GALLERY- EL. 198.00

SCALE 1 0 5 10M

LEGEND

- First stage concrete
- Second stage concrete
- Concrete in dam
- 201 Room number
- (42) Door number

NOTE

The dimensions and elevations are in meters unless indicated otherwise.

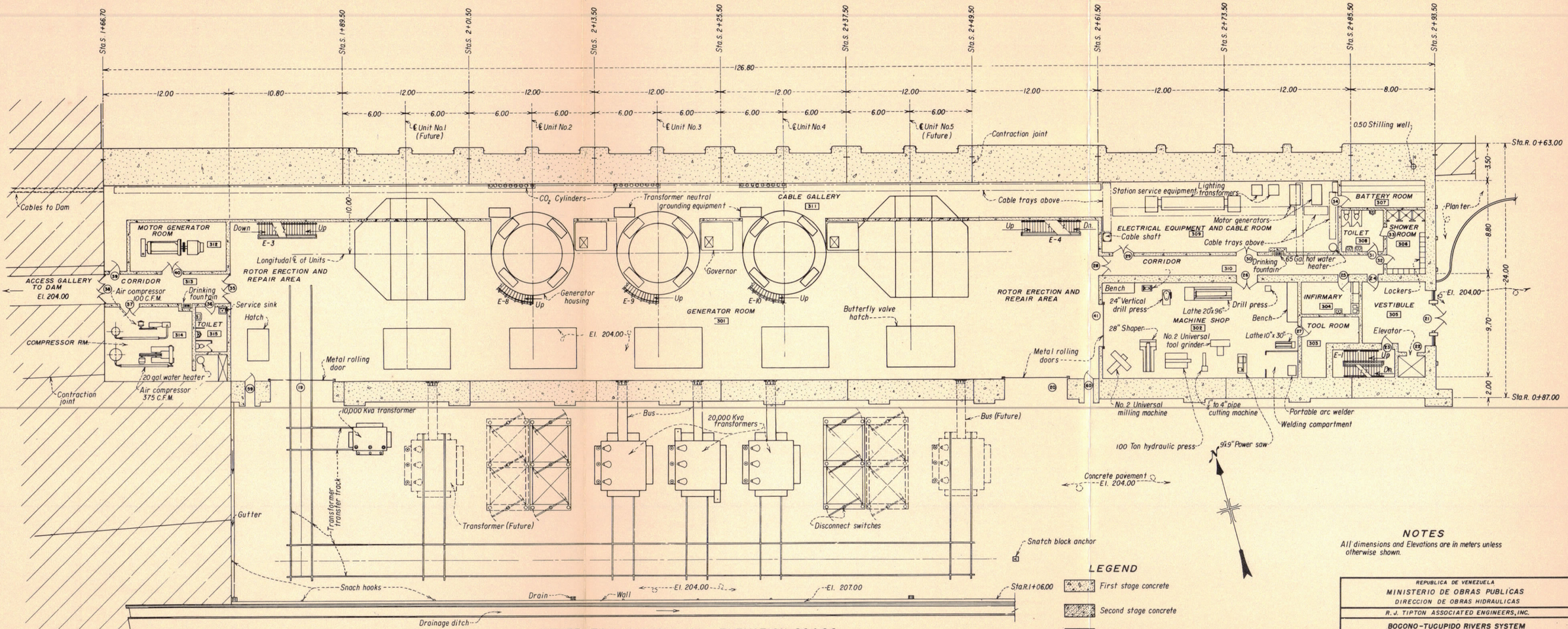
REPUBLICA DE VENEZUELA
MINISTERIO DE OBRAS PUBLICAS
DIRECCION DE OBRAS HIDRAULICAS

R. J. TIPTON ASSOCIATED ENGINEERS, INC.

BOCONO - TUCUPIDO RIVERS SYSTEM
BOCONO DAM
POWER PLANT
GENERAL ARRANGEMENT
ELECTRICAL EQUIPMENT GALLERY

NO.	DESCRIPTION	DATE	BY
	REVISION		

DRAWN G.Z.
TRACED R.G.H.
CHECKED C.J.R.B.F.V.
APPROVED R. J. TIPTON ASSOCIATED ENGINEERS, INC.
APPROVED
DENVER, COLORADO JANUARY, 1958
SHEET ..... OF E7 E1-5



GENERATOR FLOOR PLAN – ELEVATION 204.00

LEGEND

- First stage concrete
- Second stage concrete
- Concrete in the Dam
- 101 Room Numbers
- 5 Door Numbers

NOTES

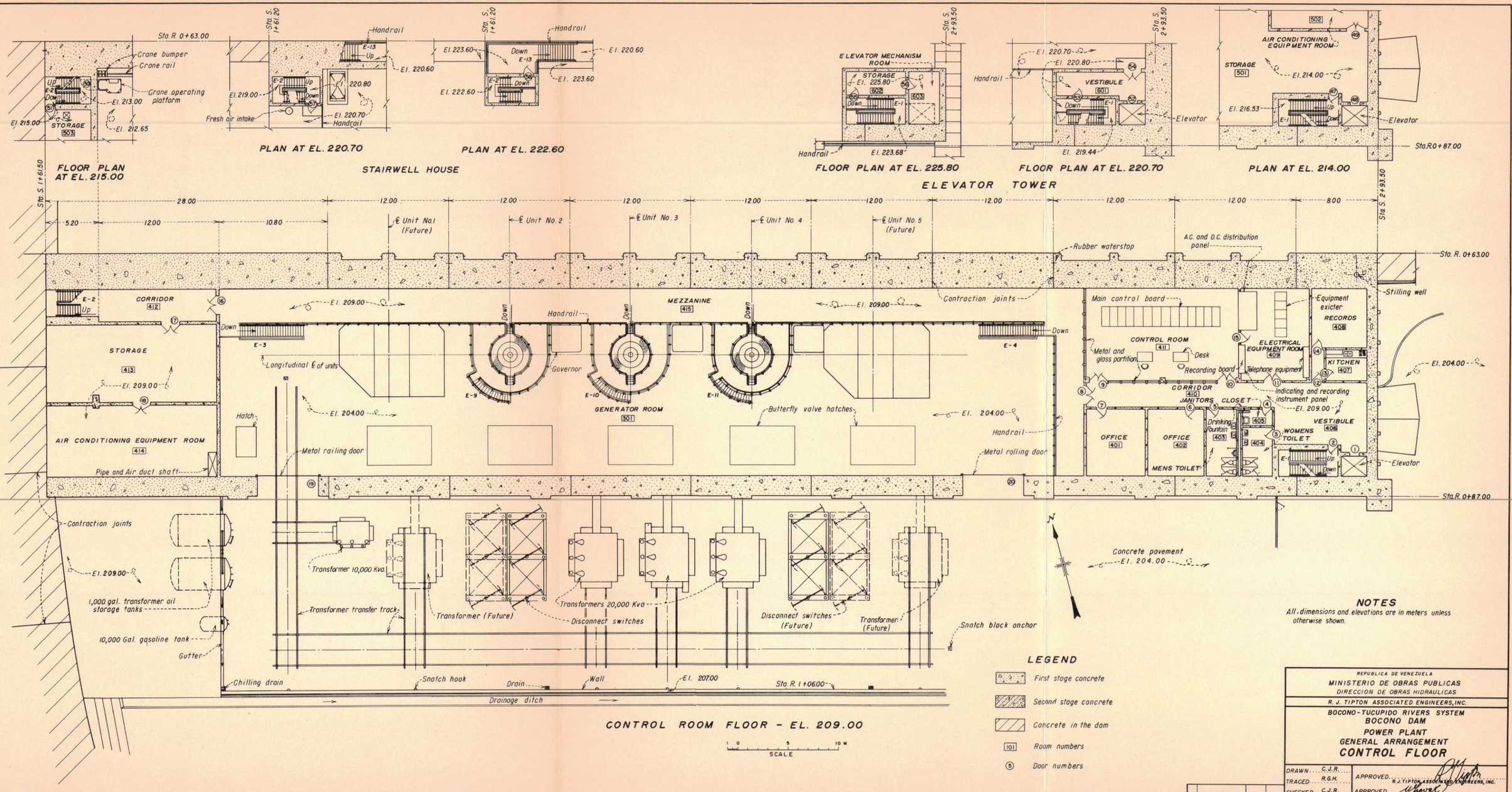
All dimensions and Elevations are in meters unless otherwise shown.

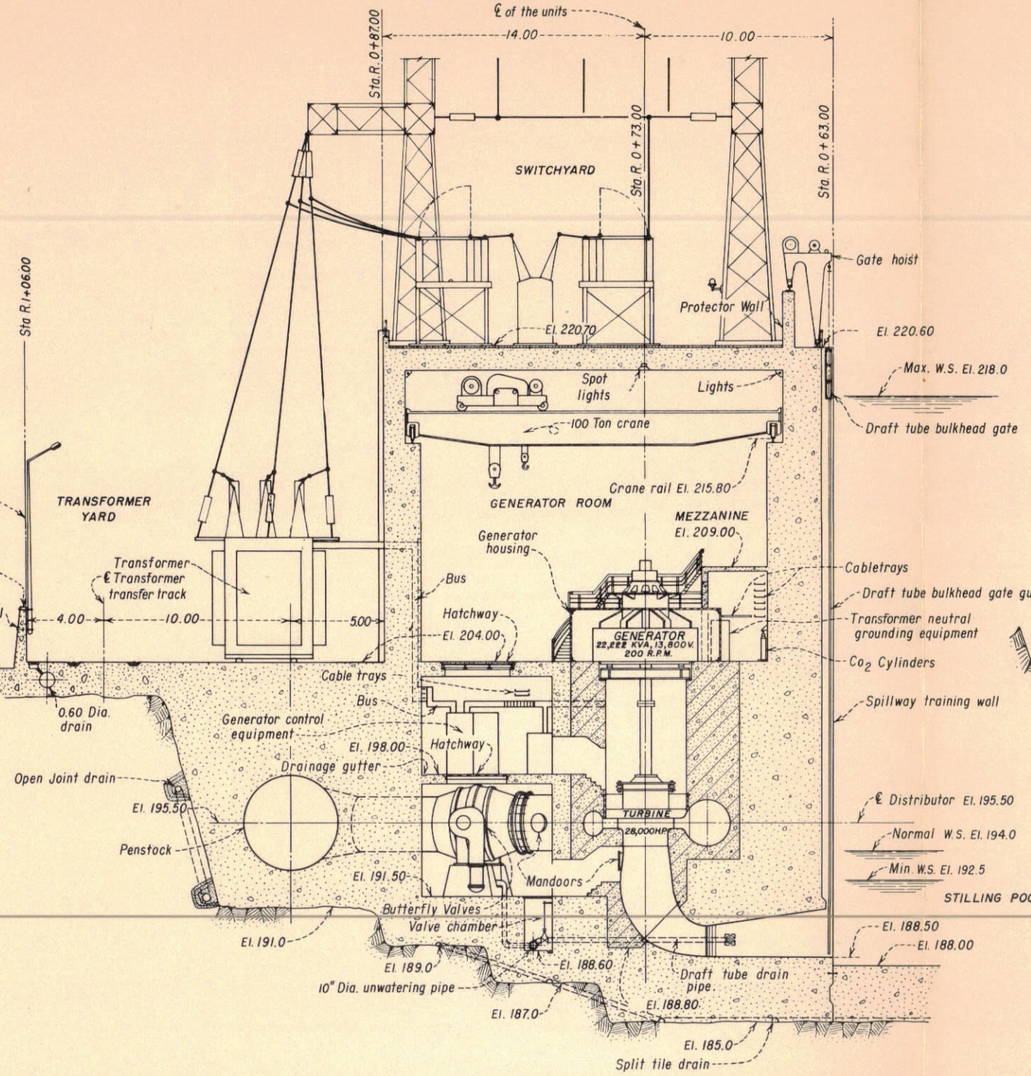
NO.	DESCRIPTION	DATE	BY
REVISION			

REPUBLICA DE VENEZUELA
MINISTERIO DE OBRAS PUBLICAS
DIRECCION DE OBRAS HIDRAULICAS
R. J. TIPTON ASSOCIATED ENGINEERS, INC.

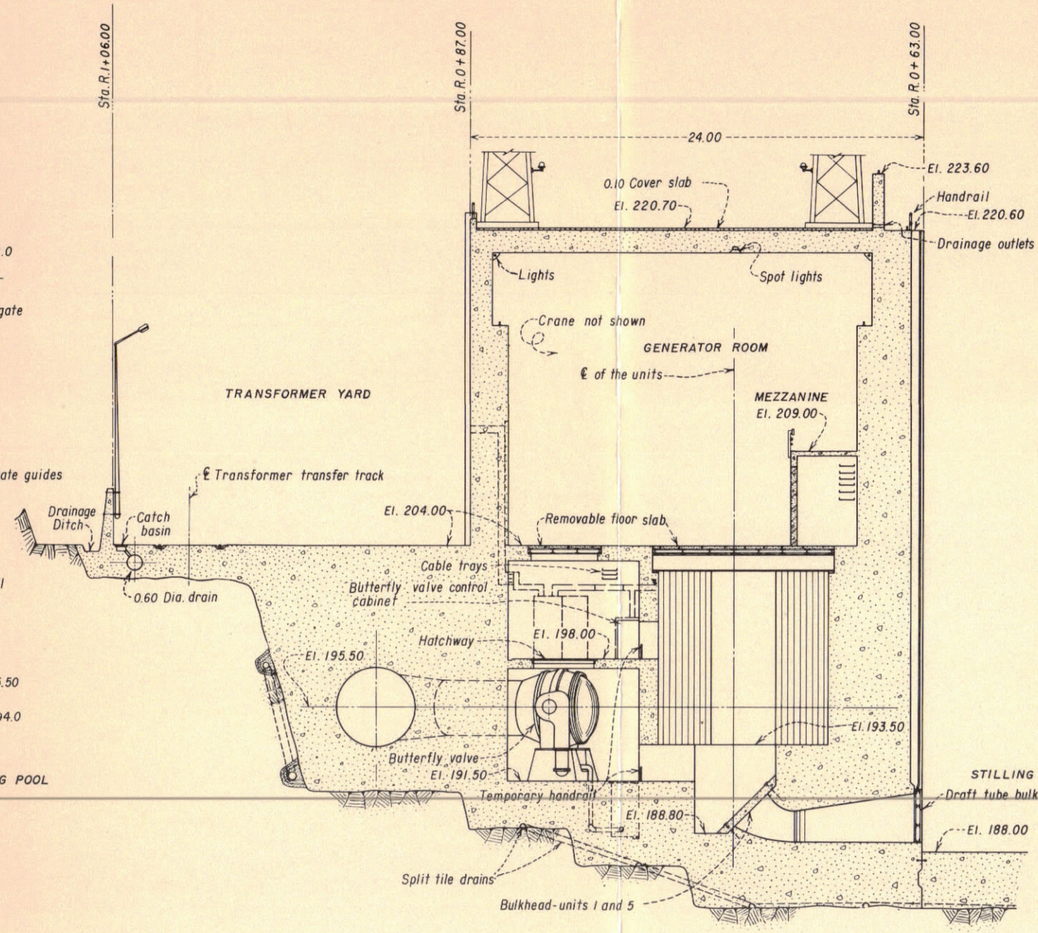
BOCONO-TUCUPIDO RIVERS SYSTEM
BOCONO DAM
POWER PLANT
GENERAL ARRANGEMENT
GENERATOR FLOOR

DRAWN C.V.R.
TRACED E.L.F.
CHECKED J.R. B.F.K.
APPROVED R. J. TIPTON ASSOCIATED ENGINEERS, INC.
APPROVED
DENVER, COLORADO JANUARY, 1958
SHEET NO. E7 EI-6


FLOOR PLAN AT EL. 215.00
PLAN AT EL. 220.70
PLAN AT EL. 222.60
STAIRWELL HOUSE
FLOOR PLAN AT EL. 225.80
FLOOR PLAN AT EL. 220.70
PLAN AT EL. 214.00
ELEVATOR TOWER
CONTROL ROOM FLOOR - EL. 209.00
SCALE
NOTES
All dimensions and elevations are in meters unless otherwise shown.
LEGEND
First stage concrete
Second stage concrete
Concrete in the dam
Room numbers
Door numbers
REVISION
REPUBLICA DE VENEZUELA
MINISTERIO DE OBRAS PUBLICAS
DIRECCION DE OBRAS HIDRAULICAS
R. J. TIPTON ASSOCIATED ENGINEERS, INC.
BOCONO-TUCUPIDO RIVERS SYSTEM
BOCONO DAM
POWER PLANT
GENERAL ARRANGEMENT
CONTROL FLOOR
DRAWN C.J.R.
TRACED R.G.H.
CHECKED C.J.R. R.T.K.
APPROVED
APPROVED
DENVER, COLORADO JANUARY, 1958
SHEET OF
E7
E1-7



TRANSVERSE SECTION ALONG THE CENTER LINE OF THE UNIT



TRANSVERSE SECTION ALONG THE CENTER LINE OF THE FUTURE UNIT

SCALE 1 0 5 10M

NOTE

The dimensions and elevations are in meters unless indicated otherwise.

LEGEND

- First stage concrete
- Second stage concrete
- Concrete in the dam

NO	DESCRIPTION	DATE	BY

REVISION

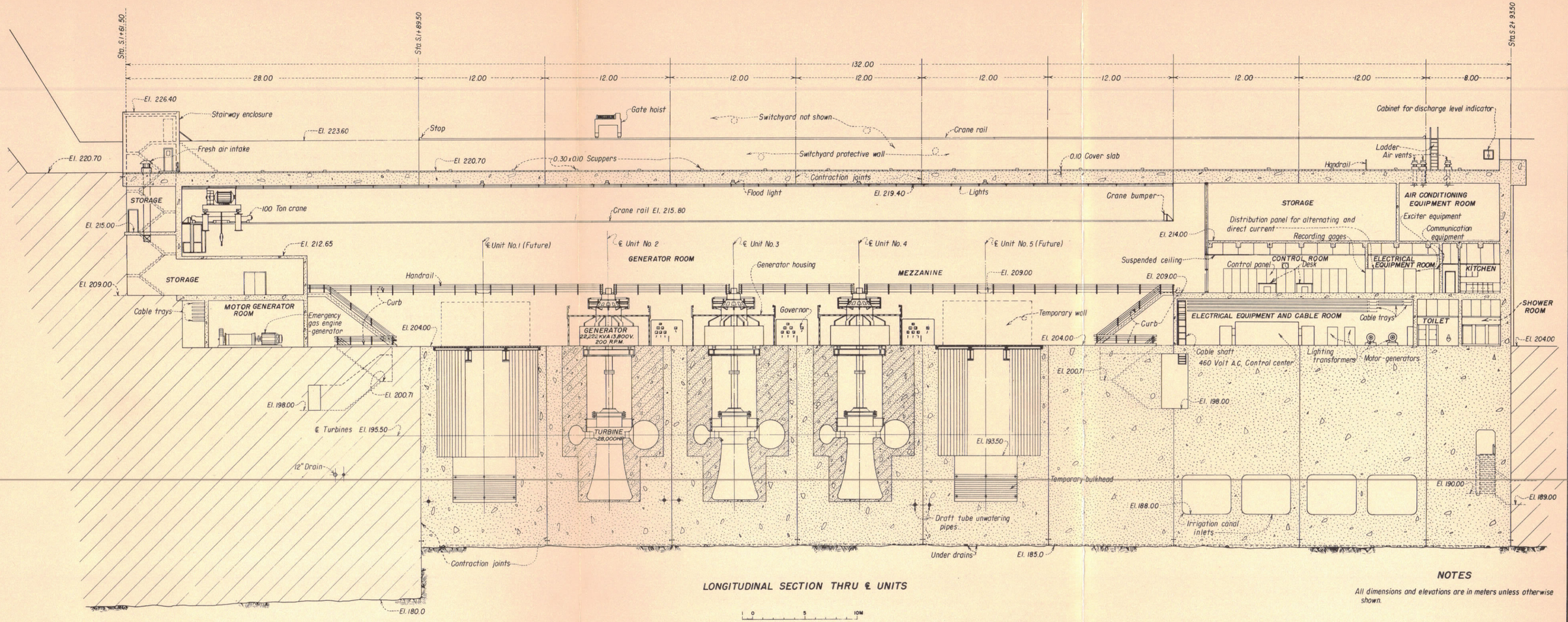
REPUBLICA DE VENEZUELA
MINISTERIO DE OBRAS PUBLICAS
DIRECCION DE OBRAS HIDRAULICAS

R. J. TIPTON ASSOCIATED ENGINEERS, INC.

BOCONO - TUCUPIDO RIVERS SYSTEM
BOCONO DAM
POWER PLANT
GENERAL ARRANGEMENT
TRANSVERSE SECTIONS THROUGH THE UNITS

DRAWN G.Z.
TRACED M.E.K.
CHECKED J.R. B.F.K.
APPROVED R. J. TIPTON ASSOCIATED ENGINEERS, INC.
APPROVED
DENVER, COLORADO JANUARY 1958
SHEET ..... OF .....

E7 | E1-8



LONGITUDINAL SECTION THRU ℄ UNITS

SCALE 0 5 10M

LEGEND

- First stage concrete
- Second stage concrete
- Concrete in dam

NOTES

All dimensions and elevations are in meters unless otherwise shown.

REPUBLICA DE VENEZUELA
MINISTERIO DE OBRAS PUBLICAS
DIRECCION DE OBRAS HIDRAULICAS

R. J. TIPTON ASSOCIATED ENGINEERS, INC.

BOCONO - TUCUPIDO RIVERS SYSTEM
BOCONO DAM.
POWER PLANT
GENERAL ARRANGEMENT
LONGITUDINAL SECTION THRU ℄ OF UNITS

NO.	DESCRIPTION	DATE	BY
	REVISION		

DRAWN G.Z.
TRACED R.S.H.
CHECKED C.J.R. B.F.K.
APPROVED R.J. TIPTON ASSOCIATED ENGINEERS, INC.
APPROVED
DENVER, COLORADO JANUARY 1958
SHEET ..... OF E7 E1-9