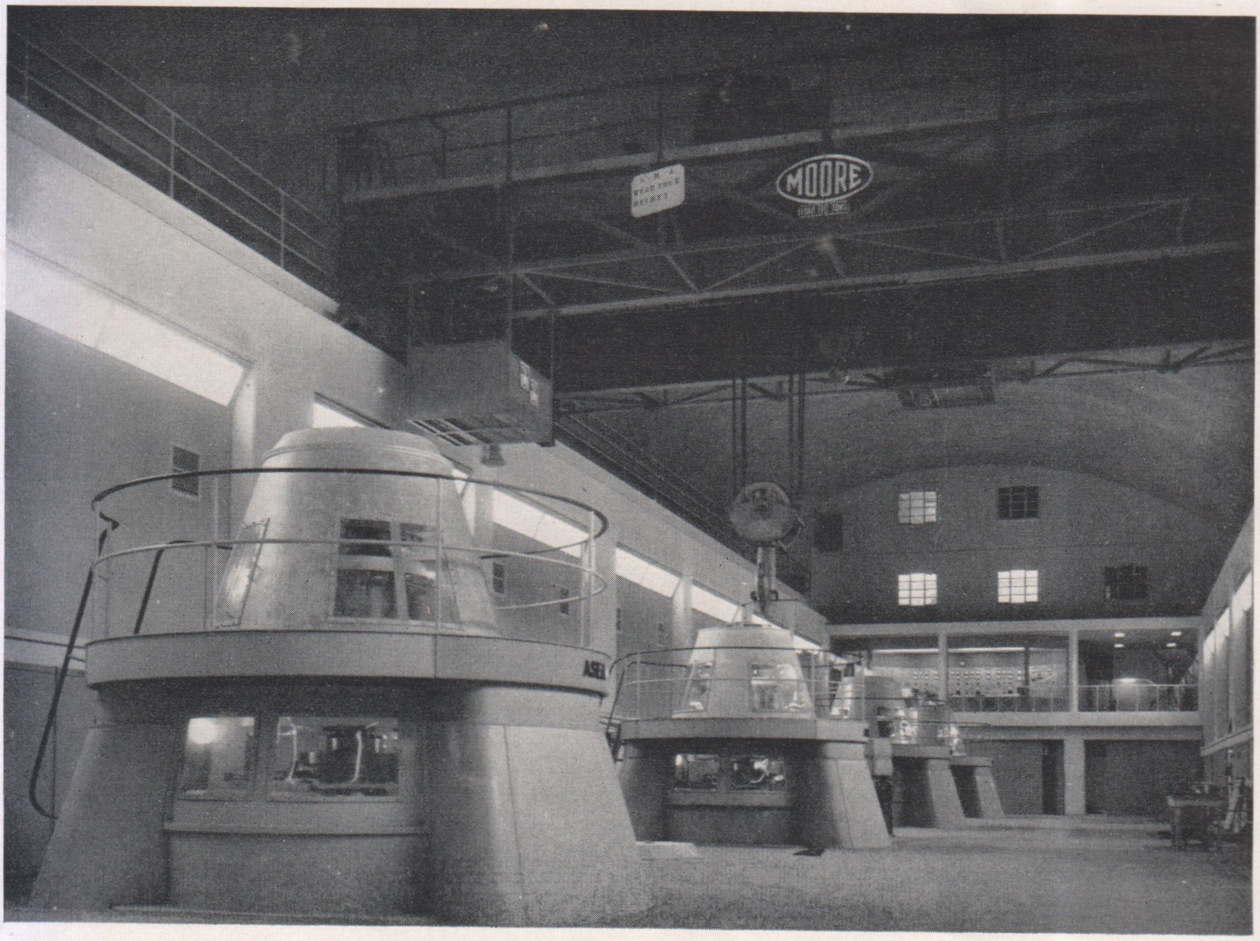

Fig. 10. The Tumut I power station showing the control room in the background

The Tumut I Project

An account is given of the design and construction of the Tumut I project, which forms the second stage in the Snowy Mountains scheme and was brought into operation in October, 1959

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PART TWO

FROM the dam to the shafts leading to the power station, the water is carried by a 21-ft. diameter fully lined tunnel 8,200 ft. long. This tunnel was driven using a track-mounted jumbo carrying 12 Gardner Denver drifters. The face, 24 ft. in diameter, was drilled with approximately 70 holes 12 ft. deep and loaded with 450–600 lb. of AN 60 Polar gelignite.

General progress was good, no major trouble being experienced, the tunnel being 25% supported with steel sets. The excavation commenced on January 17, 1955, and was completed 18 months later with an average rate of progress of 108 ft. per week.

The concrete lining was completed in 16 months using concrete dry-batched on the surface, transported in waterproof cars to two 1-cu. yard automatic Armstrong Holland double-drum mixers which produced concrete for two $1\frac{1}{8}$-cu. yard Pressweld pneumatic placers set up for continuous operation. This concrete plant was mounted on a mobile bridge 600 ft. long which travelled on rails on the tunnel invert. Where steel reinforcing was necessary the invert was placed first, the steel rings of reinforcing being fabricated in three pieces and joined together with screwed couplings to form a ring. Telescoping steel arch forms were positioned by a rail-mounted traveller with hydraulic booms. The maximum placing rate was 60 cu. yards per hour.

Over that section of the tunnel where the groundwater table was higher than the static pressure in the

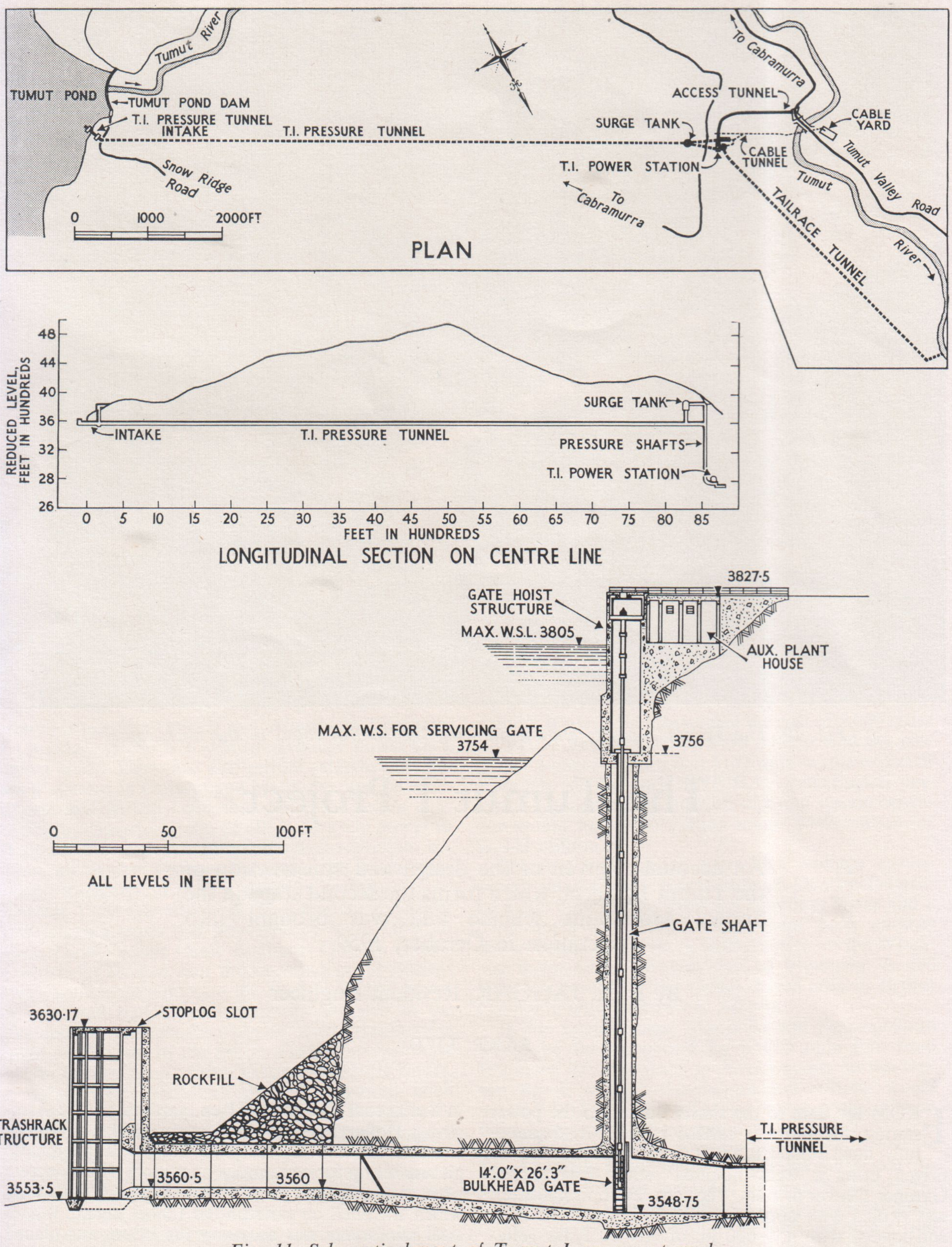

Fig. 11. Schematic layout of Tumut I pressure tunnel

tunnel due to the Tumut Pond dam level, flap valves were provided to permit the flow of ground-water into the tunnel. Some water was encountered and did hinder construction at two points along the tunnel. The maximum rate of pumping was 4,000,000 gallons per day.

At the downstream end of the pressure tunnel twin 18 ft. diameter shafts rise 270 ft. to a surge chamber 50 ft. in diameter and 130 ft. high.

Tumut I Power Station

The machine hall was excavated in three stages:

first the roof, which included the concreting of supporting ribs, followed by the removal of all material above the assembly-bay level, and finally the excavation of the turbine pits. The French group of contractors used Atlas airleg drilling equipment, Eimco 105 and Eimco 21 shovels for mucking and model C. & D. Tournarockers for haulage. After taking a pilot tunnel along the crown of the roof, the excavation was widened progressively from one end to the full face 25 ft. below the crown. By this method the roof was supported entirely by rock bolts for a distance of 115 ft., after which it became necessary to use light steel supports in conjunction with the bolts for the remaining 190 ft. of roof, which was opened by drives along the abutments and crown with a connecting slot to form the space for the supporting ribs. Excavation to the main floor level was done by stripping to a central longitudinal trench. The turbine pits were excavated by ramping down on a 16% grade for the main part, the ramp being removed by stripping, and loading into 4½-cu. yard dumper trays which were lifted by a mobile crane. The transformer hall, with a roof span identical to the machine hall, was excavated by stripping to a central pilot tunnel in two stages. The centre 40-ft. width was opened along the full length followed by widening on either side to the full 77 ft. The entire excavation was supported with rock bolts 7–10 ft. long at 3–5-ft. centres. A feature of the excavation was the close drilling and light charging of the holes on finished excavation surfaces. A total of 66,000 cu. yards solid was excavated from the machine and transformer halls between December 1955 and August 1957.

During excavation the behaviour of the rock while decompressing, was observed by several forms of measurement. First, rock-noise equipment was used to locate trouble spots; secondly, tilting clinometers measuring to 2 seconds of arc were embedded in the concrete abutments to the roof, and also a number were fixed to the walls of the excavation to determine movement. Points were established in the machine hall, which were related by triangulation to a fixed line, with the object of determining the absolute movement. To determine relative movements, the width of the machine hall between concrete abutments was measured. The measurements, when correlated, gave a reasonable picture of the behaviour of the excavation, and proved of great assistance during construction.

The first stage of concreting began in the turbine pits on September 28, 1957, and two years later the last two machines were undergoing commissioning tests. Concreting in the four machine bays totalled 11,300 cu. yards and installation of the first scrollcase commenced on May 12, 1958, after 7,350 cu. yards had been placed. The total quantity of concrete in the machine hall was 18,226 cu. yards and 3,350 cu. yards in the transformer hall. After excavation was completed in September 1957, all concrete in the machine hall and the transformer hall was completed in 17 months with a maximum placing rate of 585 cu. yards per week in the machine hall and 390 cu. yards per week for the transformer hall, the concrete plant producing a maximum of 1,060 cu. yards per week.

To provide routine and emergency access to the station, a lift shaft links the control building with the road 1,181 ft. above. This shaft was excavated in conjunction with the pressure shafts from three construction adits at approximately 300-ft. intervals. With the exception of about 50 ft. at the surface, all shafts were raised. The maximum excavation rate was 14 ft. per day from one heading. The lift shaft was lined with precast concrete pipes 10 ft. in diameter, 4½ in. thick and 5 ft. long. These pipes were placed one on top of the other, and supported each 20 ft. with an 18-in. concrete collar placed between the rock and the pipe. The remaining section was backfilled with 3-in. stone, and with small pipes through the collars a continuous drain was created, which at the power station level is tapped off to form the domestic water supply. Bond blocks were cast in the pipes to provide fixing for the lift guides and for cable support.

Supply of the precast concrete liners finally chosen for shaft lining was subcontracted to Humes Limited by the contractor. The liners were manufactured at Humes aqueduct pipe works at Queanbeyan, N.S.W., and were steam cured for the first day after casting to achieve the required strength of 2,500 lb. per sq. in. at 7 days. One liner was cast per day.

Two pressure shafts were steel lined from the turbine to just below the level of the pressure tunnel, and concrete lined above this point to the surface. The steel pipes were 18 ft. long and 12 ft. in diameter and manufactured from a special low-temperature Australian steel to Lloyd's P403 specification. In the straight section of the shaft the pipes were welded together with an automatic submerged-arc welding machine. The French contractors sublet this work to the Australian firm, Humes Limited. At the shaft head the contractor installed a 35-ton winch to handle the pipes, which were suspended from a "galloway" stage hanging on two ropes from the double-drum winch.

Fig. 12. Machine hall roof showing connecting tunnel portal to transformer hall, looking from the access tunnel to the control building end

Between these two ropes a man car was operated. The welding was done from a three-tier platform on a hollow central column. The platform was moved by attaching it to the galloway stage, the shaft services passing through the hollow column of the platform. Hanging below this platform a similar three-tier platform was suspended to carry the equipment and personnel for the Prepakt grouting of the space between the rock and steel liner. The cycle of operation for construction was fabrication of pipes and transport to site, sandblast and paint inside with hot applied enamel, position in shaft and weld, place crushed aggregate between rock and pipe, and inject Prepakt grout. Grouting had to follow immediately behind, as access would otherwise have been impossible without a second winch between the welding platform and the grouting platform. The maximum rate of production reached one complete cycle each day. This was only achieved in the top third of the shaft and the average was four pipes a week.

To serve as operational access and also as an emergency exit a 1,178 ft. fully automatic lift was installed. The contractor let this work by subcontract to Arnold Engineering and Lifts Pty. Ltd., of Sydney, N.S.W. The lift has a capacity of 6,800 lb., at a speed of 250 ft. per minute and is automatic over four floors but can be manually operated from within the car so that stops can be made anywhere in the shaft. Some difficulties were experienced during installation mainly due to the very high humidity, with dripping water and a heavy draught from the machine hall up the lift shaft. The draught was in fact controlled by baffles, but the regulation of the air flow in order to improve working conditions in the shaft was a feature of the installation works in the shaft.

Fig. 13. Excavation for Tumut I power station

To operate the lift automatically, 39 control circuits were required, necessitating a control cable arrangement. This was first attempted with four cables fixed at the midpoint in the shaft and hanging freely in a loop with a 32-in. bight and fixed at the other end to the cage. These cables were 700 ft. long and probably the longest trailing lift cables in the world. The method proved a failure as the cables would not remain in a simple loop but twisted into a figure-of-eight, possibly due in part to the effects of the draught, which can have a horizontal component at certain sections, but mainly to inherent twist in the cables or to twists imposed on the cable during installation. With the cables falling into a figure-of-eight, damage was done as the cables tangled with the counterweight guides and were torn free. The contractor took this matter up with Arnold Engineering and Lifts Pty. Ltd., who made worldwide enquiries without finding any information that was based on experience and could help with the problem. Finally, research was carried out by cable makers of Australia with a final design incorporating all four cables in one forming a thin elliptical belt-shaped cable. It is not known at present whether this cable will be successful as the cable is still under manufacture.

The tailrace tunnel, 4,500 ft. long, was excavated full face, 688 sq. ft. in area, in 14 months. The drilling was from a rail-mounted jumbo fitted with airleg jackhammers drilling 110 holes 8 ft. deep. The mucking was done with an Eimco 105 overhead shovel into Model D Tournarockers. Steel tunnel supports were used for 50% of the tunnel, the remainder being supported by grouted rockbolts and chain wire mesh. The last 1,000 ft. of the tunnel near the power station was enlarged to 35 ft. to form a surge chamber. The total excavation was 121,000 cu. yards solid; 980,000 lb. of 8 in. × 6 in. R.S.J. steel supports and 11,000 ft. of 7 ft. and 10 ft. long rockbolts were used.

Of the 4,500 ft. of the tailrace tunnel, 1,625 ft. is fully concrete-lined and 820 ft. in the steel-supported section was concreted up to the springing line of the arch, the timber lagging on the steel sets being spiked together to prevent movement. All the lagging was hardwood. The concrete lining embedded the steel supports with a minimum cover on the steel of 5 in.

Operation

Maximum energy output from the water available, and therefore maximum economy, can only be achieved if the operating head is retained as high as possible without spillage of water. The operational controls provided, together with river gaugings and daily weather forecasting, will enable the storage and release of water to be planned. During periods of low flow, water will be drawn from lake Eucumbene, and as Tumut Pond must necessarily be at the same level as lake Eucumbene, this determines the available head at the power station. At other times, however, when there is sufficient water in the Tumut and Tooma rivers, the storage at Tumut Pond will be held as high as possible to ensure maximum head on the power station.

The station is designed to be fully automatic under remote control, and all units are capable of being operated as synchronous condensers.

Equipment

All equipment was erected and installed by Authority forces and this work was completed in 18 months from the placing of the first draft-tube liner to completion of the fourth machine. To assist the installation, the station cranes were erected before any equipment was delivered to the station. Two cranes were erected, each of 110 tons capacity, and these could be linked together with a beam in order to lift the rotor—a weight of 210 tons.

The English Electric Co. Ltd. supplied the four Francis turbines, which were rated at 110,500 h.p. under a net head of 960 ft. This company also supplied the four spherical-type straight-flow valves, which are operated by a penstock-pressure-water servomotor. The generators, rated at 80 MW at 0·95 power factor, 12·5 kV and 375 r.p.m., together with automatic starting, voltage and synchronising controls, were supplied by A.S.E.A., of Sweden.

Seven A.C.E.C. single-phase transformers (manufactured in Belgium) consisting of two primary and one secondary winding, rated at 28/28/56 MVA, are connected in two banks of three, one being spare, and step up the generated voltage of 12·5 kV to a transmission voltage of 330 kV. The busbars from the generators to the transformers are carried in individual ducts for each generator, and consist of double-channel aluminium busbars with flexible connections at each change in direction to allow for expansion. The switchgear consists of 12·5 kV Brown Boveri air-blast circuit breakers. Seven Pirelli General 330

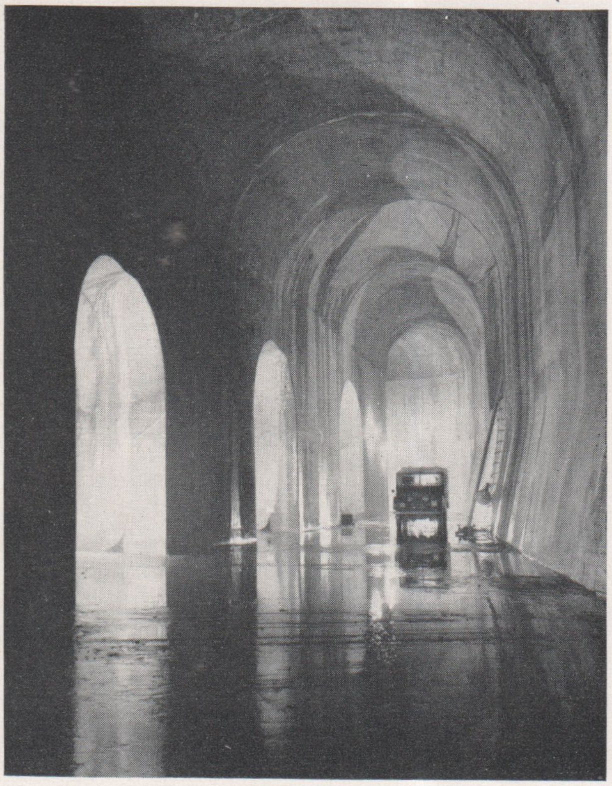

Fig. 15. The manifold section of the tailrace tunnel

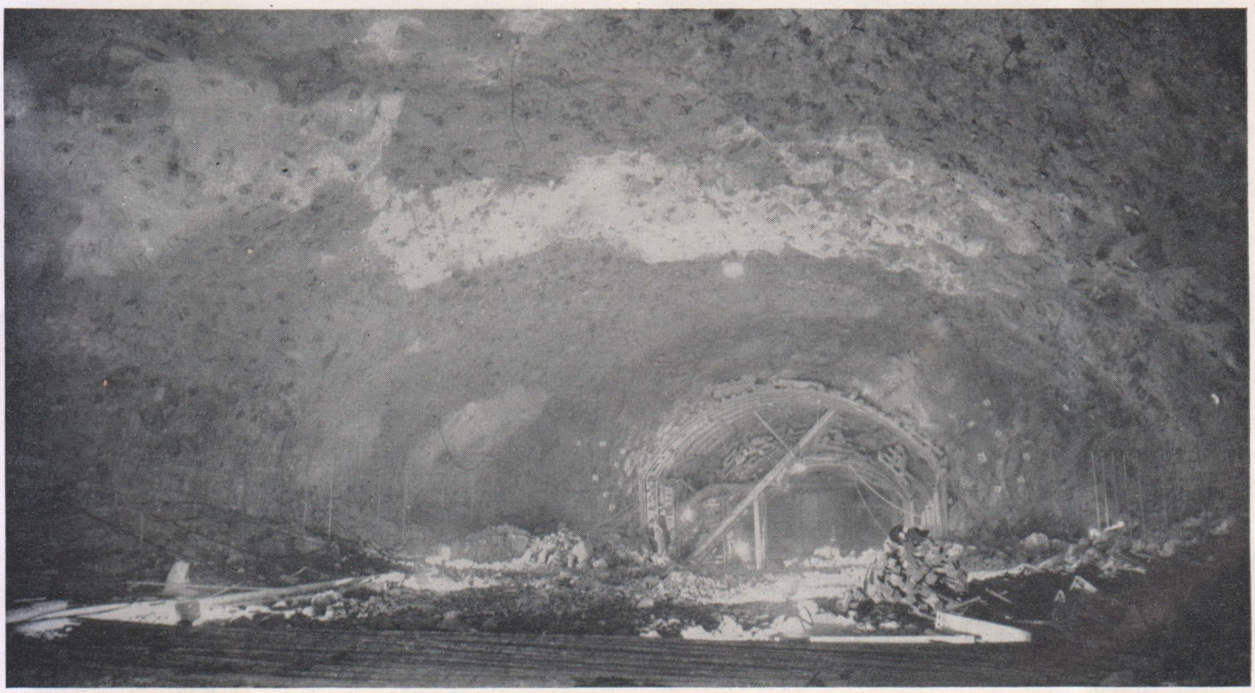

Fig. 14. Excavation for transformer hall showing complete rock bolt support

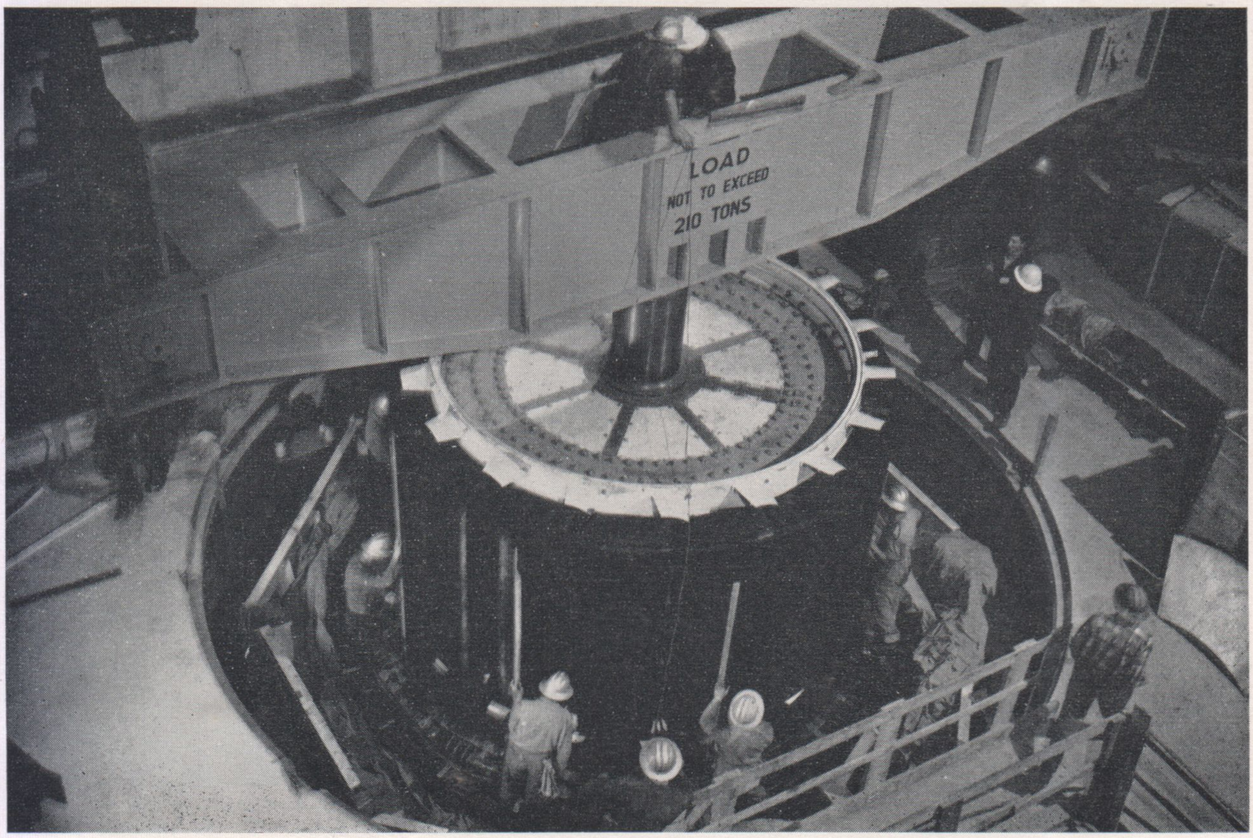

Fig. 16. Lowering the rotor for No. 3 generator

kV single-core oil-filled impregnated-paper-insulated reinforced lead-alloy-sheathed cables conduct the power to the outside cable yard.

Station common services are supplied through two 12·5/11/0·415 kV transformers from the local 11 kV supply with provision to take power from generators 1 and 3. Generator auxiliaries are supplied through 110 kVA transformers connected to the generator terminals.

Ventilation supply for the power station is through the cable tunnel, and exhaust is through the access tunnel and lift shaft. The air is dehumidified by finned cooling coils and heated by recirculating part of the supply through the transformer hall. Drainage water, where possible, is fed by gravity into the tail-race tunnel. Two 800 g.p.m. pumps handle water coming into the power station at lower levels. For protection against flooding, three 5,000 g.p.m. submersible pumps, supplied with power directly from the lift house, are installed. In addition, two jet pumps, operated in parallel by water from the pressure shafts, have been installed.

The transmitted power at 330 kV is carried by high-tensile aluminium-alloy (Silmalec) conductor. In areas subject to heavy icing, one conductor per phase, 1·77 in. in diameter, is used. Elsewhere two conductors per phase, 1·053 in. in diameter, with spacers every 300 ft., have been used. Transport of heavy equipment was made by a Mighty Antar.

The Authority's transmission system comprises interconnections between several collecting stations within the area, and lines from individual power stations to these collecting stations. In general the system voltage is 330 kV but 132 kV is used where the amount of power involved does not warrant the use of the higher voltage. Transmission at 330 kV from the collecting stations to the load centres of New South Wales and Victoria is the responsibility of the respective States.

Conclusion

Just downstream from the tailwater outlet at Tumut I, the water is diverted by a dam and tunnel to Tumut II power station where work is now well under way by the civil contractors, Kaiser-Perini-Morrison-Raymond, having commenced in June 1958. This underground station, similar to Tumut I, will have a capacity of 280 MW from four 70 MW machines, and the first two units are expected to produce power early in 1962. Water from Tumut II power station will pass in succession through three reservoirs. Power stations will be built below the dams bringing the total generating capacity in the Snowy-Tumut development to 1,070 MW. However, the construction of the lower Tumut works will not immedately follow the upper Tumut projects, as the next phase of the works will be the Snowy-Murray, involving approximately 25 miles of tunnel, two major power stations, several dams, and a generating capacity of 1,200 MW. Work on this phase is expected to start late in 1960 with a gradual progression to achieve the production of power in the Murray Valley by the winter of 1966.

The Geon Story. A brochure issued by British Geon Limited, Devonshire House, Piccadilly, London, W.1, is a guide to PVC plastics and deals with Geon as a primary product, as packaging material, as a covering for chemical piping and so on, but so far as readers of this journal are concerned its main interest probably lies in its applications to the electrical industry. The brochure is very handsomely produced.