EL TABBIN POWER STATION

By

I. GÁBOR
Mech. Eng. B. Sc.

and

S. MÉSZNER
Mech. Eng. B. Sc.

Early in 1955 the Egyptian Ministry of Public Works proceeded to a public adjudication covering the construction of a new power station for Cairo City Electricity and Gas Administration, to be built near the small village of El Tabbin to the south of Cairo.

In the course of a keen international competition with the participation of several leading firms of the world, the order was finally awarded to KOMPLEX Hungarian Trading Company for Factory Equipment representi ng the Hungarian industry including the old established firms of world fame GANZ & Co., LÁNG WORKS, and so on. The decision of the Egyptian Government was based on the fact that the Hungarian offer was found to be the most advantageous in every respect. Besides, an industrial power plant of very similar characteristics to those of El Tabbin has been completed in Hungary shortly before the adjudication and was already working satisfactorily at that time. This fact proved to be important, because, as may be seen further on, the construction of El Tabbin Power Station required some very special experience. A considerable part of the work, in fact, the whole building work and a large part of the erection, was to be carried out by indigeneous means, entrusted to the Egyptian firm The Industrial and Engineering Enterprises Co.

At the end of 1956 the smooth course of construction was seriously hampered by the regrettable Suez crisis and the well-known events in Hungary. Nevertheless the first unit of the Power Station was commissioned in May, 1958, well ahead of the nearby Steelworks the blast furnace gases of which it is designed to utilise.

Now, after having successfully commissioned the second unit of the Power Station let us record the main features of this notable engineering feat.

General

The site chosen for El Tabbin Power Station lies on the eastern bank of the River Nile some 25 kilometres (abt. 16 miles) to the south of Cairo. The biggest bridge of Africa, the Helwan Bridge, was also built by KOMPLEX a small distance to the north of the Power Station. Thus, this thriving industrial area of the new Egypt already contains two major achievements of the Hungarian industry.

A few hundred yards to the east of the Power Station lies the first modern steelwork of Egypt. El Tabbin Power Station was specially built to meet the electrical power demand of the steelwork by providing an absolutely reliable power source independent from the Cairo H. T. Grid. On the other hand the Power Station is fuelled by the furnace gas and the waste coke breeze, by-products of the steelwork. Besides providing a safe and independent power source for the steelwork, it produces a considerable amount of cheap electrical energy for public utility purposes out of otherwise valueless by-products.

Layout

Fig. 1 represents the general layout of El Tabbin Power Station. While the Pumping Station (25) lies directly on the bank of the Nile, the Power Station proper is divided from the river by a stretch of cultivated land and El Khashab Canal with the main road along it. To the east of the Power Station begins the desert. The Staff Colony lies to the north of the Power Station with due regard to the prevailing northern winds.

The machine-room and the boiler house with the incoming gas pipe line run in east—westernly direction. The switchgear building

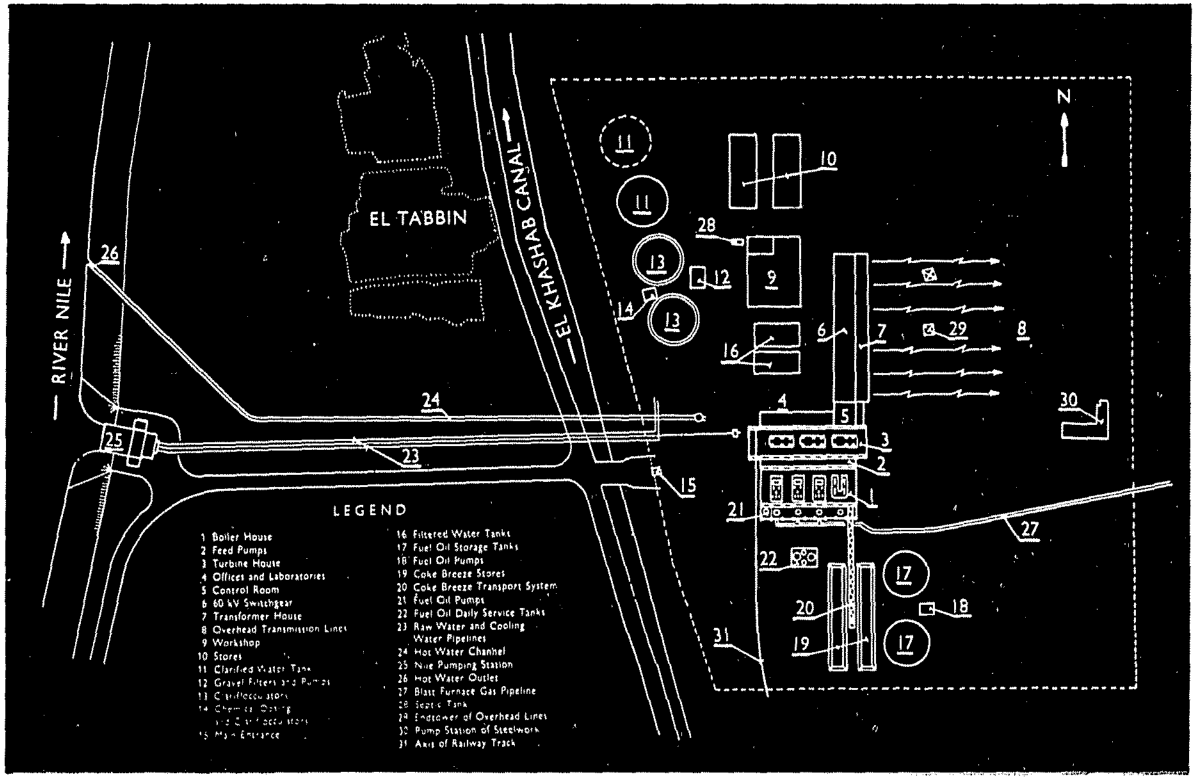

Fig. 1. Combined gas and fuel oil boiler

running north—south is joined to the north-eastern corner of the main building with the control room. The masut tanks as well as the coke storage area are arranged on the southern side near the boiler house while the water treatment plant including water tanks-supplying the steelwork as well-together with the stores are sited in the north-eastern corner of the Stations grounds. All outgoing H. T. feeders are perpendicular to the switchgear building and start in eastern direction. The main entrance is on the western side and connects the Power Station to the main road through a small bridge across the El Khashab Canal.

Mechanical and electrical equipment boilers

The Power Station contains three combined gas and fuel oil fired boilers and a fourth gas and coke breeze boiler. Apart from the difference in fuel and its constructional consequences all four boilers are identical as to main thermal characteristics which are the following :

	(metric units)
Maximum continuous rating	50 t/h
Rated pressure	42 kg/cm²
Steam pressure at superheater outlet	37 kg/cm²
Steam temperature at superheater outlet	450° C

Main data of fuels utilized :

Furnace gas	calorific value	
	value	900 Kcal/Nm³
	ash content	0.04—0.05 g/Nm³
	specific weight	1.27 kg/Nm³
Fuel oil	calorific value	9400 Kcal/kg
	viscosity Redwood No. 1. at 37.5° C	3 500 sec
	flash point	75° C
	specific weight at 15.5° C	0 94
	sulphur content	5%
	asphalt content	10%
	water content	1%
Coke breeze	calorific value	6000 Kcal/kg
	carbon content	84—87%
	ash content	8—10%
	humidity	2—3%
	volatiles	0.5—1%
	impurities: P and S	

It is intended to run the Power Station eventually on furnace gas alone as far as possible. Oil firing is only required as a provision for the periods of shutting down the Steelworks for possible irregularities of the gas supply. Coke breeze will only be available until the ore dressing plant of the Steelworks is not yet installed, after which the coke breeze will be utilized in this plant and the fourth boiler will be reconstructed to fire gas and fuel oil in the same way as the other boilers.

Combined gas and fuel oil boilers

The first three boilers are of the water tube type with natural water circulation. A sectional drawing is shown on Fig. 2.

The whole steam generating system is suspended from a steel frame, thus allowing free expansion downwards. There is a single drum with 1600 mm outer diameter, electrically welded, with concave hammered ends. Boiler tubes are expanded into the drum, otherwise the whole tube system including headers is electrically welded throughout. All weld seams are radiographed.

There are eight gas and eight oil burners installed in couples in the corners of the firing chamber. All burners are made of special cast steel alloys and are readily accessible for cleaning or replacement. Special measures ensure the perfect pulverization of the injected oil, and the perfect mixing of the gas with air.

The superheater coils are divided into two units located behind the firing chamber, with a steam cooler (desuperheater) inserted between thet wo units limiting the superheated steam temperature to 450° C at loads between 30 and 55 t/h. The coils consist of seamless steel tubes made of a special alloy with high Cu and Mo content, welded to the headers.

The economiser is placed in the second flue and also divided in two parts. To avoid corrosion the lower part can be by-passed at low loads.

The air preheater is made of identical cast iron elements, installed in two groups.

The draft required is ensured by the usual forced and induced draft fans, dimensioned with a power reserve of 10%.

For cleaning the flues remote-controlled soot blowers are installed, six on each wall of the firing chamber and sixteen at the air preheaters.

Each boiler has an individual steel stack of 42 m (abt. 138 feet) anchored to the building. A steam ejector is mounted in the stack capable of increasing the natural draft to such an extent which is sufficient to generate 7.5 t/h of steam without any fans.

Boiler control and safety measures

The operation of the boilers is fully automatized. Besides the usual control of the water level, steam temperature and draft, the quantity of fuel oil injected is automatically regulated in function of the prevailing turbine load and of the available gas quantity. Further, the air quantity is also regulated according to the actual ratio of fuel oil and gas as well as in function of the prevailing turbine load. Consequently, between practical limits, the suitable balance between steam consumption and generated heat is always maintained continuously and automatically, at the same time ensuring the firing of the maximum possible quantity of gas with the minimum required oil quantity. Let it be noted that the maximum continuous rating of the combined boilers can be increased to 55 t/h by firing fuel oil only.

The use of blast furnace gas requires special precaution as it is highly explosive, poisonous, and has no smell at all. Accordingly the main gas pipe line is welded throughout and carefully pressure tested. Flanged joints are only applied at the fittings and inspection holes, gate valves are fitted with electrical drives beside the manual ones. The individual boiler feeders contain a safety check valve with water seal automatically controlled by both the gas pressure and the induced draft. This valve closes automatically if the gas pressure sinks below 60—70 mm W. G. thus preventing the formation of an explosive air-gas mixture in case of sudden disturbances. Further, there is a metallic screen in front of the gas burners to prevent backfiring. All gas ducts are connected to explosion doors located above the building roof and there is a safety valve with water seal of a special construction to let sudden pressure waves blow off through a special duct leading above the roof. Finally provision is made to evacuate all gas ducts by means of blowing out with steam.

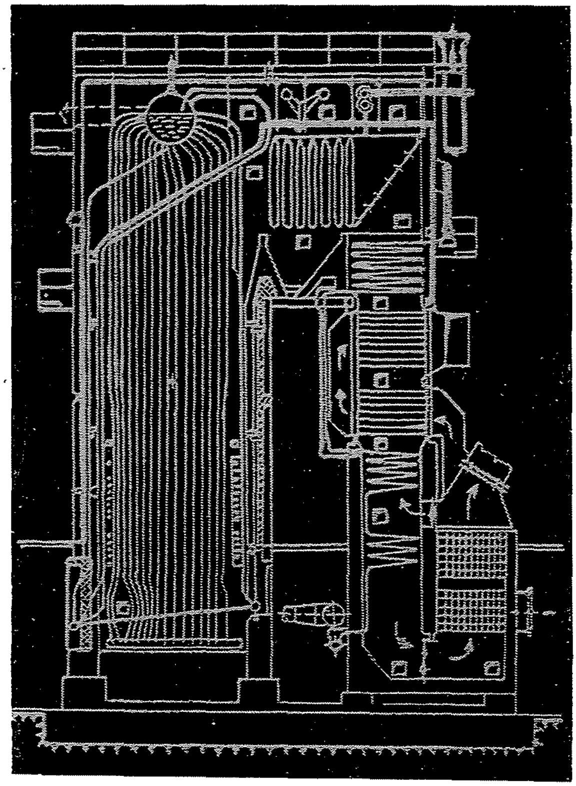

Fig 2

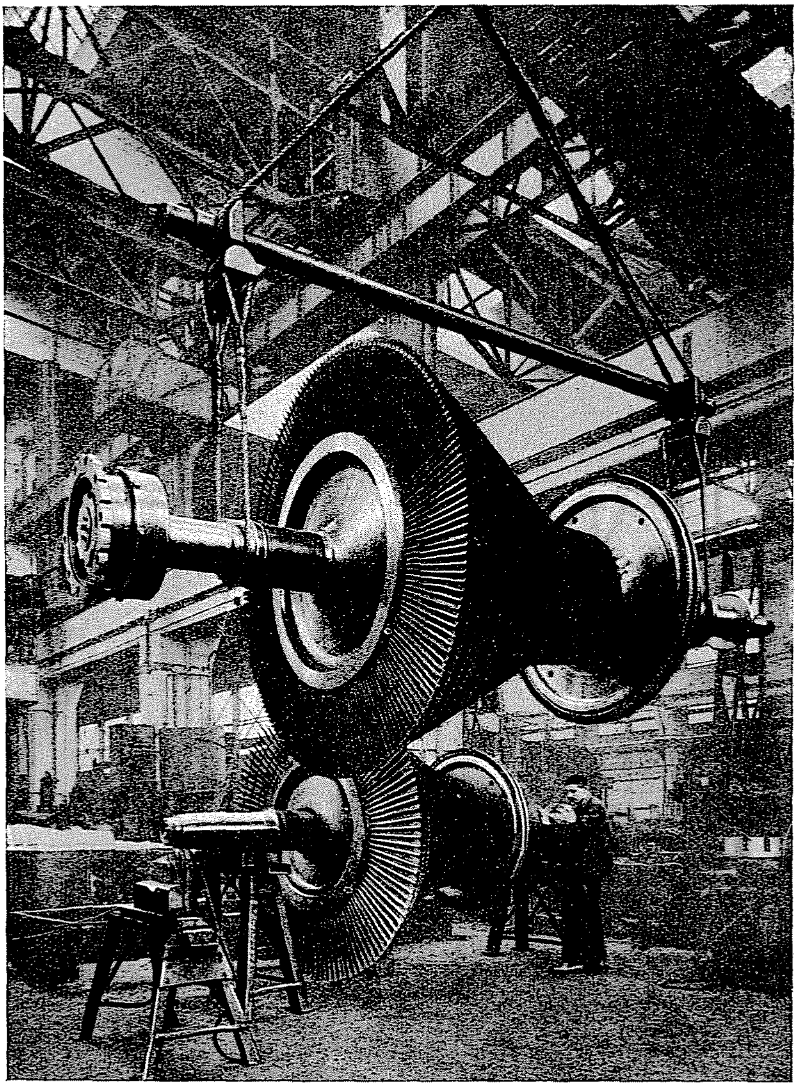

Fig. 3. Turbine rotor

All measuring and control apparatus including warning devices are centralized on the individual boiler panels. The good working order of hydraulic safety devices and water seals may be ascertained at any time even during operation.

Combined gas and coke breeze fired boiler

Owing to the rather unusual combination of blast furnace gas and coke breeze the constructional details of this boiler deserve an article for themselves.

Let us mention first that the maximum continuous rating of 50 t/h is only attainable by firing 3 t/h of coke breeze together with a suitable amount of gas. The steam generation with coke breeze only is not more than 30 t/h, with furnace gas only not more than 26 t/h.

Coke breeze is fired on a subdivided twin travelling grate of 32.5 m² effective grate area divided into 29 separate zones. The draft through each zone can be regulated independently. The travelling velocity of the grate can be regulated by a Ward-Leonard group. The coke supply is controlled by a ring gate and a layer thickness regulator. Two gas burners are installed in corners of the firing chamber and some more in the igniting arch. Starting light oil burners are also installed.

After removal of the travelling grate this boiler can be reconstructed and after some comparatively small modifications it will be capable of firing fuel oil and/or blast furnace gas exactly like the first three boilers.

Steam turbines and their ancillary equipment. Main steam range

The main steam range consists of a double pipe system enabling any turbine to be connected to any of the four boilers separately.

Steam turbines. (Made by Láng Works)

The 3 steam turbines are of the single flow reaction type with two Curtiss wheels (see Figures 3 and 4) and with the following main characteristics :

Maximum continuous rating as measured on the shaft coupling	15 MW
Steam inlet pressure	36 Ata
Steam inlet temperature ...	435° C
Cooling water temperature .	27° C
Speed	3000 r. p. m.
Economical rating	12 MW

There are three unregulated bleeding points for feed water preheating. The maximum continuous rating can be attained, however, without preheat as well.

The turbine rotor consists of forged steel discs welded together on their peripheries. The last discs and the shafts are forged of a single piece. The Curtiss wheel and the balancing piston are pressed on to the shaft and fixed by welding. The blades of the first Curtiss row are milled from the solid, the other blades are made of drawn profiles. The finished rotor is carefully balanced both statically and dynamically.

The high pressure casing is made of cast steel, the low pressure casing of cast iron. The stator is divided in a horizontal and a vertical plane. Parts in direct contact with live steam (valve casings, nozzles) are made as separate pieces of cast steel alloy with high Mo content and welded on to the casing. Labyrinth type glands with steam seals are being used.

The high pressure side bearing is a combined radial and axial bearing with white metal lining and Mitchell blocks. The other, radial bearing is common for turbine and alternator.

The main shaft coupling of the turbo group is of the star type, a special construction allowing some flexibility.

Pressure oil for lubrication and control purposes is supplied by a gear pump driven by the turbine shaft. There is a separate turbo-pump to provide oil during starting and stopping periods.

There are four main inlet valves controlled hydraulically by the mechanical speed governor. Speed can be adjusted by hand or by remote control within ±6% (no load). The maximum remaining speed variation—in case of a sudden cut-out of the full load—is 4%. There are two independent emergency governors acting through oil pressure on the two stop valves in case of a speed rise of 8% resp. 10%. To protect the turbine there are two automatic pressure limiting devices and one vacuum limiting device throttling resp. cutting out the live steam supply in case of emergencies.

The turbine is provided with the usual accessories.

Condensing plant

The surface condensers are of the usual horizontal type for fresh water cooling. The water tubes are made of Admirality brass and are divided into two groups with separate water chambers allowing cleaning of any group without interruption of service. The condenser is provided with the usual appliances.

Feed system

The feed system contains the usual pumps, feed water heaters, drain coolers etc. The temperature of the deaerated water stored in the feed tanks amounts to 150° C. Each unit has its own evaporator capable of evaporating a make-up amounting to 6% at half load, although the total water loss does not exceed 2%. There are altogether six feed pumps of the centrifugal multi-stage type, including two turbine driven pumps.

The duty of the water treatment plant consists of supplying:

1600 m^3/h clarified water, out of which
1500 m^3/h to the Steelworks,

100 m^3/h filtered water, out of which
25 m^3/h to be sterilised and
15 m^3/h to be softened.

Clarification occurs in 3200 m^3 claritloc-culators System BAMAG. Then the water supply of the Power Station is being passed

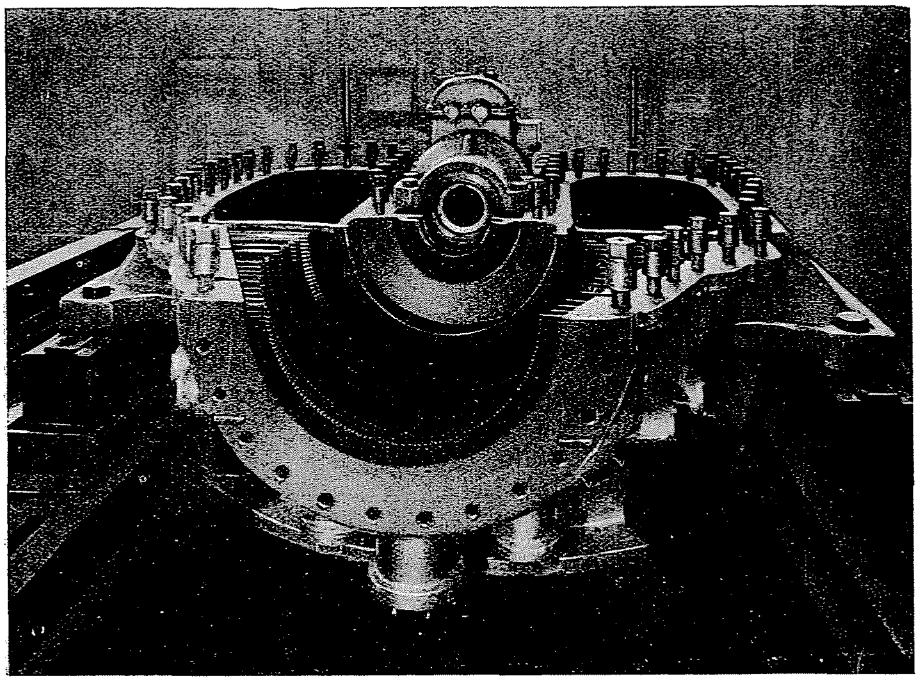

Fig. 4. Turbine stator

through gravel filters into elevated filtered water tanks. Drinking water is sterilized through chlorination, while softening is effected through Permutite type ion exchangers.

Water treatment plant

The whole water requirement of the power station and of the Steelworks is covered by a common pumping station containing four cooling water pumps of 4500 m^3/h capacity each directly feeding the condensers and various coolers of the power plant through an underground double pipe line, and of four raw water pumps of 900 m^3/h each also working on an underground double pipe line leading to the water treatment plant. The intake chambers contain the usual gates, coarse screens and rotating screens with cleaning devices, etc.

Electrical equipment. Connexion

The alternators are directly connected to three step-up transformers delivering the energy generated at 63 kV to the Cairo Grid resp. to the Steelworks, this being the delivery voltage stipulated by the customer. The indoor type H. T. switchgear comprises double busbars and the required cells for altogether six outgoing lines, for the transversal and longitudinal couplings, measuring transformers, and so on. Circuit breakers are of the small oil volume (Delle) type with a breaking capacity of 1500 MVA. The station auxiliaries are fed at 3 kV resp. at 380 V. The 3 kV equipment contains three metal-clad distributors fed from the alternator terminals through stepdown transformers and two further distributors as reserve, fed by the 63 kV busbars through station transformers. All these metal-clad distributors are equipped with single busbars and contain cubicles of the unit construction with withdrawable expansion type circuit breakers. Individual consumers over 100 kW are connected to these 3 kV distributors. The 380 V system comprises three main metal-clad distributors equipped with automatic air break switches. Individual consumers of a power demand between 30 and 100 kW are directly connected to these distributors, while smaller consumers are provided for by cast iron subdistributors installed at appropriate locations throughout the Station, suitably interconnected to provide troublefree service. There are special feeders and subdistributors provided for lighting and for the Staff Colony.

Turbo-alternators.
(Made by Ganz & Co.)

The main technical characteristics of the turbo-alternators are the following:

Maximum continuous rating	20 MVA
Rated Voltage	10.5 kV ± 5%
Frequency	50 cycles p. s.
Power Factor	0.75
Efficiency at full load	97.4%
Speed	3000 r. p. m.
Main exciter	130 V, 950 A
Pilot exciter	220 V, 5 A

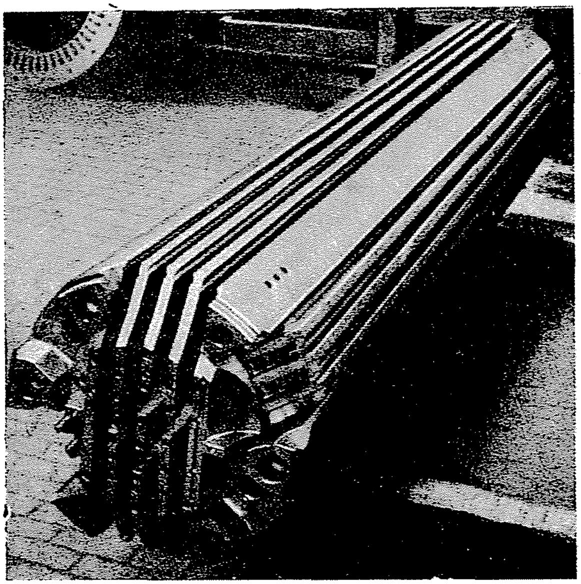

Fig. 5. Alternator rotor partially wound

The exciters are directly coupled to the main shaft. All three machines are provided with normal air cooling in closed circuit. The relatively high efficiency is mainly due to the careful design using high grade materials.

The special "Cross Wound" rotor system of Ganz & Co is worth mentioning, this being the most salient and exclusive feature of the alternators. In this system the inductor is a forged piece carrying two fitted and bolted shaft ends forged separately. Winding is made before fitting the shaft ends, in milled longitudinal slots with parallel walls. There are two parallel slot systems crossed at the ends of the rotor blocks at a certain angle by means of an interposed steel piece. (Fig. 5.) The coils themselves are flat-wound of high tensile strength hard electrolytic copper strips. The rotors are truly and effectively "armoured" against any hazards and their perfect reliability was proved any number of times. As a matter of fact, GANZ & Co. have been manufacturing two-pole turboalternators for over fifty years according to the parallel slot system.

Transformers

There are altogether 13 transformers of five types delivered for El Tabbin, all of GANZ make. They are of the oil immersed type with natural or forced air cooling. Windings consist of high conductivity copper, the specific loss of the core material is less than 1 W/kg. All this together with the careful design and manufacture resulted in relatively very high efficiencies.

Control and protection

The measuring and control apparatus of the 63 kV system, of the alternators and of the most important 3 kV feeders is centralized in the Control Room, together with the protective relays and alarms. Auxiliary power is supplied by two Ni-Ca type batteries of accumulators provided with an automatically regulated charging equipment consisting of a selenium rectifier and a motor-generator set. The D. C. network is unearthed.

The protective system had been designed in conformity with the customers wishes. 63 kV feeders are equipped with distance and overcurrent protection, transformers are provided with overcurrent, gas and reverse power relays, alternators with overcurrent, differential, reverse power and overvoltage protection. The 63 kV busbars are included in the reach of the minimum impedance relays of the alternators and the distance relays of the 63 kV feeders owing to the careful setting of impedance values and time lags. A differential protection of these bus bars was not applicable owing to the necessarily great differences between current tranformer ratios and the undesirability of switching over the secondary circuits of current transformers, necessary in case of asynchronous running of the two bus bars.

To increase the safety of service 3 kV and 380 V feeders will be automatically switched over to a reserve power source in case of a breakdown of the actual feeding. Accordingly there is no undervoltage protection for such equipment (feed pumps, etc) the service continuity of which must be ensured in any case. Less important consumers will, however, be switched off in case of a voltage breakdown thus to reduce the current surge due to switching over.

Building works

The execution of the building presented some difficulties owing to the instability of soil and the high ground water level reaching during flood time the actual ground level. The difficulties were overcome by the use of a number of concrete piles. There are abt. 1000 piles of abt. 40 cm (abt. 16″) diameter and 10 m length (abt. 35 feet) supporting the main building alone. Otherwise the buildings are frameworks of reinforced concrete cast at site in wooden moulds and filled in by brick walls.