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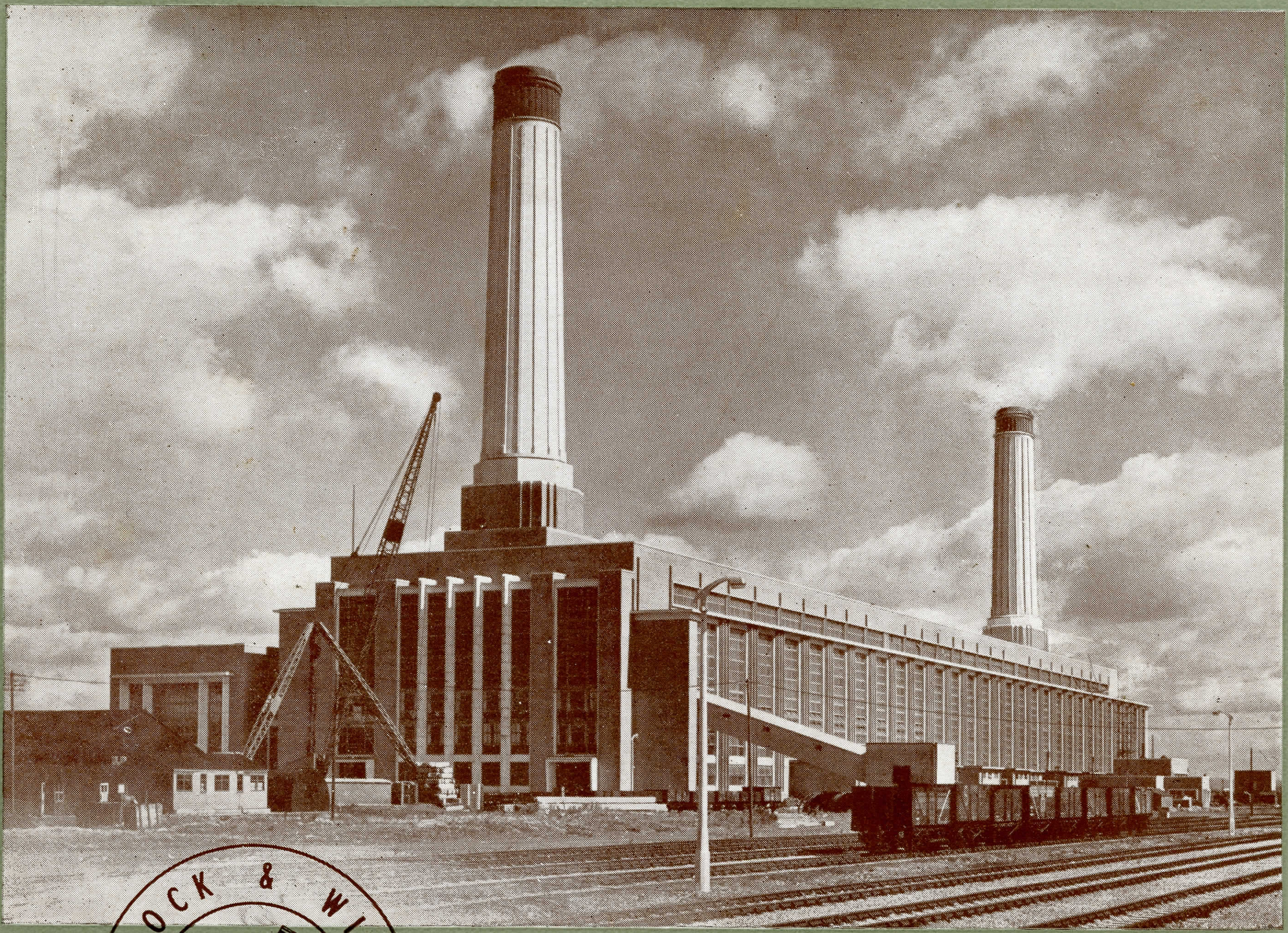

Uskmouth

GENERATING STATION

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November, 1953

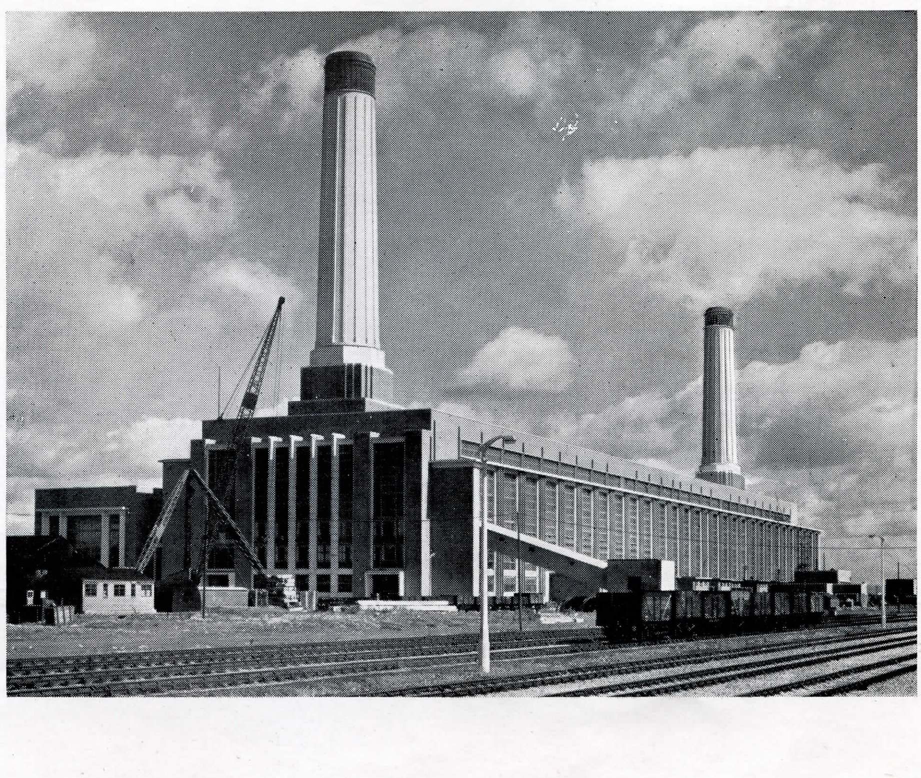
THE LARGEST SINGLE CONTRACT EVER PLACED IN GREAT BRITAIN FOR STEAM RAISING PLANT

Uskmouth GENERATING STATION

THE 360 MW Uskmouth " A " generating station of the British Electricity Authority, was officially opened by the Mayor of Newport (Mon.) on October 7th, with the first two turbo-generators supplying 120 MW to the Grid. When completed, the station will have cost some £20 million, and will be the largest generating station constructed in one continuous operation in this country. A further station, Uskmouth " B "—at present in the project stage—will, when constructed and completed upon an immediately adjacent site, make the combined stations the largest power generating unit in Europe. The site upon which the station is constructed covers in all approximately 600 acres, it is flanked by the River Usk and the Severn Estuary, and is some three miles by road from Newport. The site has excellent access to railborne coal supplies, to adequate supplies of circulating water, and there are good facilities for ash disposal.

The commissioning of the first two 60 MW sets in the station marks an important stage in the task of making South Wales self-sufficient in electrical power. Shortage of power in the area is mainly a result of post-war industrial development; as before 1939 it was, on the whole, principally an exporting area for electricity. By 1948, however, electricity was being imported at peak load periods, and by the middle of last year these imports represented about one-third of the peak load. The South Wales Area Board heads the list of area boards in the country for the number of units it sold per head of the population each year. Last year the figure was 1,600 kWh per head of the population, the average for the country being 1,088 kWh. Since the end of the war the demands for electricity in South Wales had increased by 80 per cent. Industry takes about half of the electricity produced by the generating stations in this country in general, but in South Wales it takes about 75 per cent. of the total.

Plans for Uskmouth generating station were first discussed by Newport Corporation in 1946, and in September of that year the Central Electricity Board gave their approval. Development of the project before nationalisation of the electricity supply industry in April, 1948, was in the hands of Mr. T. H. Wood, M.I.Mech.E., A.M.I.E.E., then borough electrical engineer and manager to Newport Corporation, who had been appointed consulting engineer for the station. Messrs. L. G. Mouchel and Partners Ltd., and Sir William Halcrow and Partners were appointed civil engineering consultants for the station proper, and the river intake works respectively, and Mr. Johnson Blackett, F.R.I.B.A., the Newport borough architect, was made consulting architect. After nationalisation, the scheme passed under the control



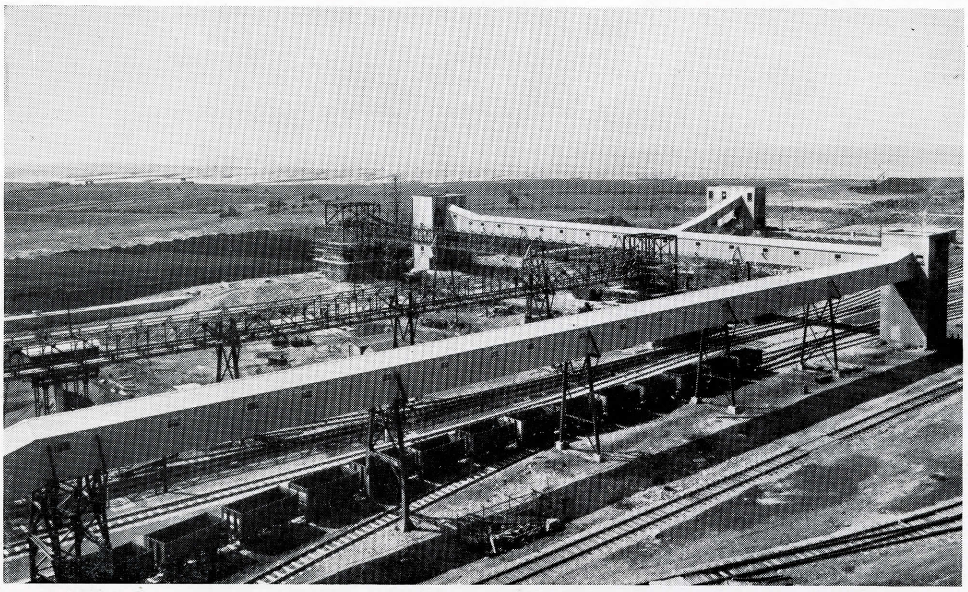
Exterior view of the station, showing the two 300-ft. high chimneys, and also one of the coal conveyors entering the main building at low level.

of the South Wales Division of the B.E.A. On being appointed chief generation engineer (construction) of the South Wales Division, Mr. T. H. Wood continued his association with the construction of Uskmouth power station under Mr. H. V. Pugh, M.I.Mech.E., M.I.E.E., the first controller of the division. In October, 1951, Mr. Pugh was appointed controller of the London Division, and was succeeded by Mr. H. J. Bennett, A.M.I.E.E.

Before work began, the site was rough grazing land, lying from 4 ft. to 6 ft. below maximum high-tide level and, though protected by earth banks, it was subject to occasional flooding.

Preliminary filling for the extensive rail sidings and for the access road to the station began in April, 1948, and during the following twelve months some 430,000 tons of quarry waste and mine slag were brought to the site to form protection banks above high-tide level.

What is believed to be the largest caisson ever sunk under compressed air was sunk on the foreshore at Uskmouth to ensure a supply of water for cooling purposes at the lowest tide levels. The caisson steelwork, an all-welded structure, forming the caisson shoe and working chambers, was divided into three compartments of equal size by the provision of two internal transverse bulkheads accommodating spine trusses into which were framed roof girders over the working chambers. Because of the weakness of the foreshore, the steel shoe of the caisson had to be assembled on made-up ground away from the river bank. The shoe, weighing approximately 580 tons, was erected on ball-carriages, behind the river bank and was rolled out on two tracks along the line of the bulkheads to a position above high-tide level, and immediately above its final site. From this position, it was lowered by hydraulic jacks to a prepared and level hard-core bed on the foreshore.



The Babcock & Wilcox coal-handling plant is in two sections, each being capable of delivering 300 tons per hour to any one of the twelve boiler bunkers.

The strata formation consists of a 12 ft. deposit of soft peaty clay, hardened by drying, and overlaying a 20 ft. thickness of soft clay. Below this, there is a bed of sand mingled with silt and clay, from 5 to 20 ft. thick above a layer of stiff clay and small stones. The hard base below this consists of sand, gravel and boulders at a mean depth of 70 ft. below ground level. The total number of piles for the foundations of the main station was 6,778, of an average length of 55 ft. Basement-level piling was completed by August, 1950, and the high-level piling external to the retaining walls by April, 1951, including a further 450 piles 75 ft. in length supporting the separate switch-house which is located to the north of the main station buildings.

In March, 1950, work commenced on the reinforced concrete circulating-water ducting between the pumping station and the main building, and between the latter and the outfall point, some 3,000 ft. upstream. The greater part of this ducting is of circular section, with a diameter of 8 ft., whilst those portions which run beneath the main building are of square section, measuring internally 8 ft. 0 in. × 8 ft. 0 in. The total length of ducting is approximately $1\frac{1}{2}$ miles.

The main buildings are steel-framed with brick cladding, the roofs which cover an area of approximately six acres, being formed with pre-cast concrete slabs overlaid with cement screed, granulated cork and asphalt. Two 300-ft. high reinforced concrete chimneys, constructed by Tileman & Co. Ltd., London, are located one at each end of the boiler house. The total length of the main building is 896 ft. and the width 270 ft. Between the N.W. face of the main building and the river bank is a separate building housing the 132 kV air-blast switchgear and the control room. This building was specially designed to withstand the shock associated with the operation of air-blast switchgear.

Coal-Handling Plant

The coal-handling plant, which was designed and supplied by Babcock & Wilcox Ltd., has several interesting features. Designed to deal with 600 tons per hour, it provides complete duplication of storage and handling capacity. Railborne coal arrives at a comprehensive system of sidings designed to give the maximum possible flexibility in working, and to provide adequate standage for full and empty wagons. The arrangement of the plant will be followed from the adjacent diagram. Loaded wagons are dealt with by four wagon tipplers of the Babcock side-tipping type. These are arranged in pairs, each pair tipping into a central underground hopper arranged between them. From these hoppers the coal passes, via a vibratory feeder, to belt conveyors 1A and 7A ; No. 1A serving tipplers 1 and 2 and No. 7A tipplers 3 and 4. Commencing underground, these conveyors emerge between the tracks and elevate the coal to junction towers approximately 500 ft. from the tipplers. The coal is then delivered to two further conveyors, Nos. 2A and 8A, which cross the tracks in overhead gantries at a height of some 35 ft., and deliver the coal to radial conveyors 3A and 9A for delivery to storage ; or bypass these, and deliver direct to the re-claiming hopper. Coal for storage is delivered "over end" by the radial conveyors, which have an angular movement of some 120 deg. and form the initial piles for distribution over the storage area, which covers an area of 11 acres, and has a capacity of 108,000 tons with a storage depth of 10 ft. The underground reclaiming hopper is fitted with special grids to take bulldozer tracks, and the coal is fed via vibratory feeders to belt conveyors No. 4A and 10A which transfer the coal parallel with the railway tracks for a distance of some 400 ft., to crusher houses in which the coal, after passing under a suspended magnet to remove tramp iron, is delivered to a " Flextooth " crusher where it is reduced to a size capable of passing through a 1 in. ring. Twin crushers are provided in each house, with arrangements for bypassing either, if required. From the crushers, or bypass chutes, the coal falls on to one of two 60 in. vibrating screens, for removal of non-magnetic rubbish. It is then transferred to conveyors 5A and 11A which re-cross beneath the railway tracks, and rise to deliver the coal at each end of the boiler house. The coal is delivered from conveyors 5A and 11A at a height of some 94 ft. above basement level, to two further belt conveyors Nos. 6A and 12A which run side by side along the entire length of the boiler house (about 860 ft.). Each conveyor is provided with an automatic tripper which travels from one bunker to another and controls the point of unloading. Conveyors 5A and 11A are of particular interest not only because of their length (some 700 ft. between centres) but because they represent the first application of the " Taylor " tandem drive. This device, utilising a separate motor, with hydraulic coupling, on each of the two driving pulleys, secures the advantages of the large angle of lap obtainable with a normal geared tandem drive, but eliminates the troubles such as pulley build-up, and belt slip which tend to affect the geared drive. For weighing the coal there are seven patent automatic and unchokable coal weighers supplied by Richard Simon & Sons Ltd. Each weigher is capable of weighing 5 cwt. per discharge. Four of the machines are of the Simon standard type, and the other three are supplied complete with travelling carriages so that the weighers may be moved from boiler to boiler.

The coal-handling plant at Uskmouth provides a good example of a modern layout which incorporates features to mitigate the somewhat unsightly appearance of gantries, by using more attractive materials for clothing the gantries. In addition, particular care has been taken in the layout design to keep the heights of gantries as low as possible, so as not to break the skyline of the attractive power station building. The neat appearance of the low-entry conveyors into the building is clearly seen in our exterior view of the station.

Boiler Plant

The steam generating plant will eventually comprise twelve pulverised-fuel-fired Babcock & Wilcox boilers of the High Head type, each having an evaporative capacity (M.C.R.) of 360,000 lb./hr., with steam conditions of 950 lb./sq. in. and 925 deg. F. Incidentally, the contract placed with Babcock & Wilcox Ltd., for the Uskmouth steam raising plant, including the boilers, pulverising mills, coal and ash-handling plant, and the overhead travelling cranes of capacities up to 175 tons,

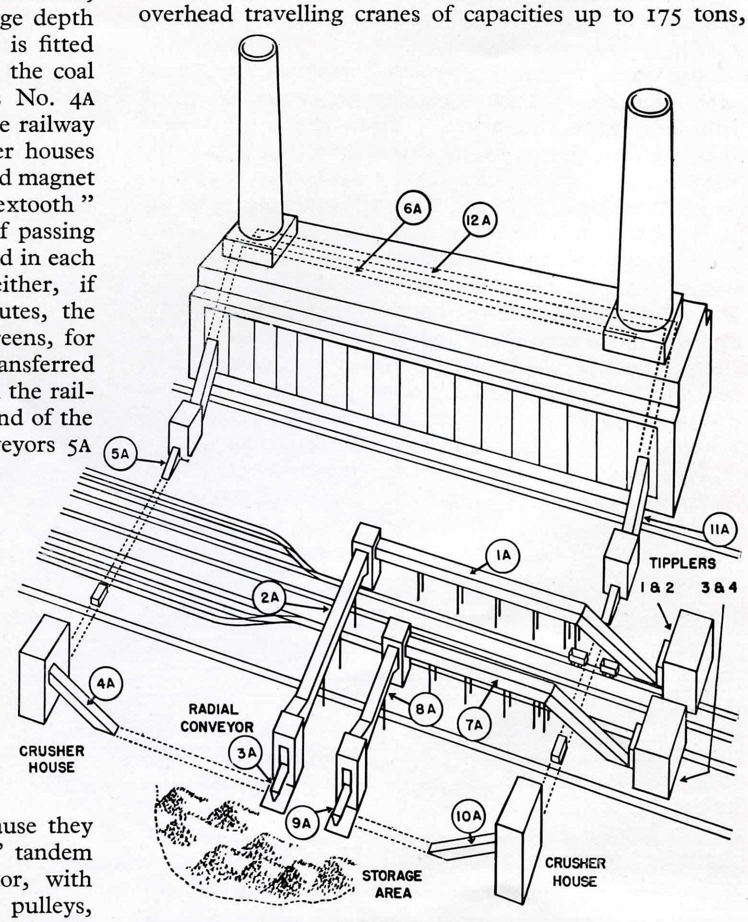


Diagram showing layout of the duplicate coal-handling plant.

represents the largest single contract ever placed in Great Britain for such plant. The boilers are connected in pairs to steam receivers which are themselves interconnected, for range operation. A branch main leads to an auxiliary steam range supplying the central evaporating plant, deaerators, steam-driven feed pumps, ejectors and space-heating system. The water-cooled furnaces, each of which has a volume of 26,500 cu. ft. and a heating surface of 4,625 sq. ft., are of Bailey wall construction. They are designed for burning in pulverised form, South Wales coal with a minimum volatile content of

11 per cent. and a maximum ash content of 20 per cent. The boiler house bunkers are of reinforced concrete, and each bunker has a capacity of 700 tons. Coal is fed under gravity from the bunkers into the pulverising mills, of which there are three per boiler. These mills are of the Babcock & Wilcox " E " type, and each mill has a maximum capacity of 8 tons/hr.

Air pressure for each of the pulverised fuel mills is maintained by a Keith Blackman turbo-blower. These are 20 in. " Type 8 " three-stage units of cast-iron construction. The impellers for these blowers were specially designed; made in aluminium with backward curved blades, they are lightweight and have power limiting characteristics. The drive for each blower consists of a 5 h.p. totally-enclosed, surface-cooled motor, also of Keith Blackman design and manufacture. Mounted together with the filter unit on the bedplate, the motor drives the impeller at 2,900 r.p.m. to deliver 200 cu. ft. of air per min. at a pressure of 40 in. w.g. and at a temperature of 80 deg. F.

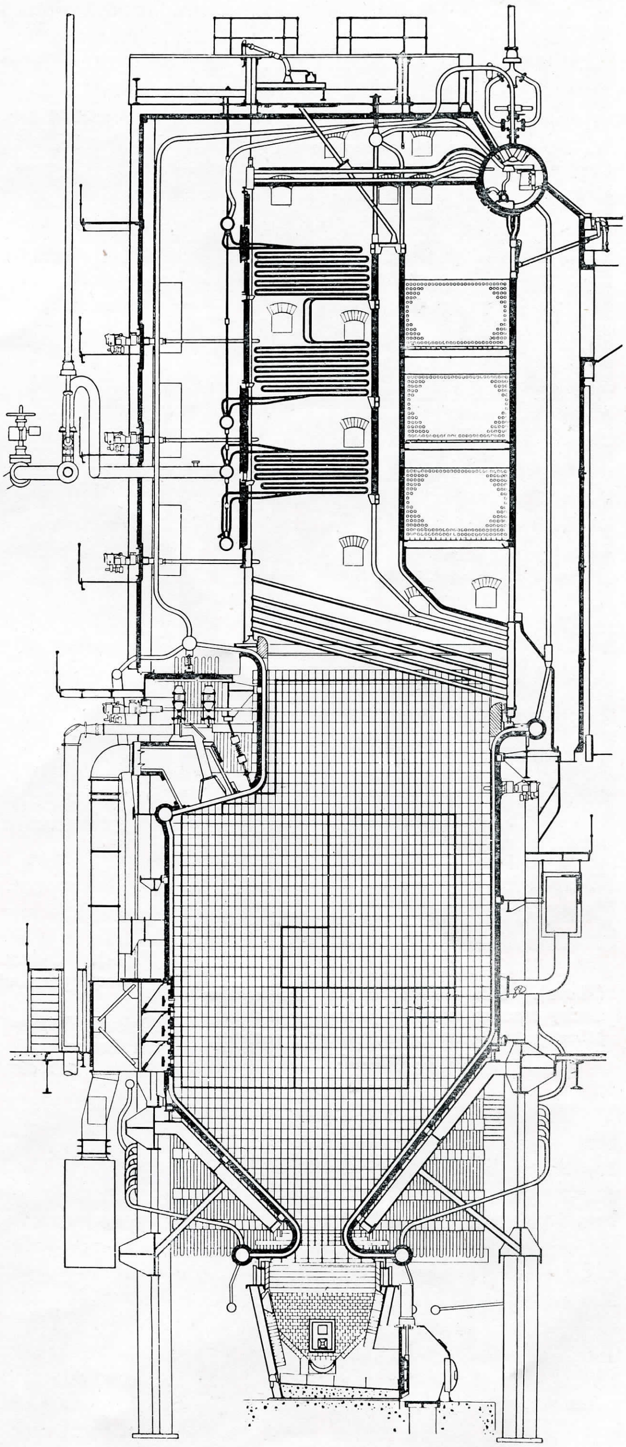
The burners, of which there are twelve per boiler, are of the vertical intertube type, located near the top of the furnace and firing downwards. Each boiler is fitted with four retractable pressure-atomising oil burners for lighting-up purposes. These automatically enter through furnace ports when oil pressure is applied, and are ignited by a spark from a high-tension transformer, being extinguished and retracted when the oil pressure is turned off.

The superheaters are Babcock multi-loop type with surface-type attemperators between primary and secondary stages, for control of final steam temperature. The heating surface of the primary section is 10,800 sq. ft. and that of the secondary section 3,960 sq. ft. There are two surface-type attemperators per boiler, each with a heating surface of 241 sq. ft. Gas by-passing arrangements are also provided. The economiser is of the Babcock integral multi-loop type with two parallel tube banks of three sections transversely across the boiler; the total economiser heating surface being 21,100 sq. ft. The feed water temperature at the economiser inlet is 386 deg. F., and at the outlet, 535 deg. F. The gas temperatures at the economiser inlet and outlet are 1,055 deg. F. and 535 deg. F. respectively.

Over the area of the boiler side walls by the economiser tube banks, steel doors of angle and plate construction are hinged off the main boiler framing. These doors were supplied by M. H. Detrick Co. Ltd., and they are lined with 3 in. thickness of block insulation and 3 in. thickness of refractory tile. The method of support utilised was Detrick " Thinsulite " construction and comprises small clip castings inserted in recesses in the tiles and threaded on to a bar casting which was secured to the door frame.

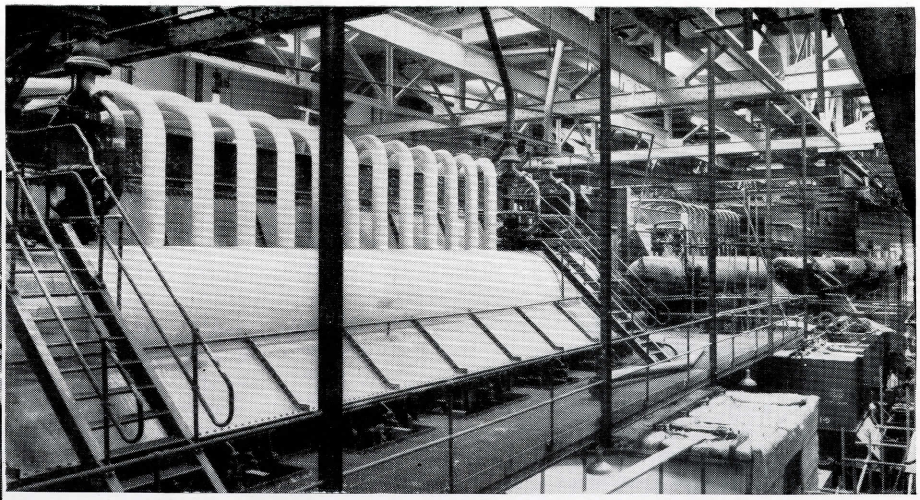
Incidentally, the large inlet openings to the chimneys and the concrete lintels forming these openings are protected on the underside by Detrick arch suspension construction slung from steel framing. On the inside face of the lintel is arranged a curtain wall which is about 10 ft. high and is sealed into the chimney lining above the lintel. This wall is supported on lightweight castings hooked on to horizontal bar castings which are secured to vertical stanchions carried on the arch steelwork.

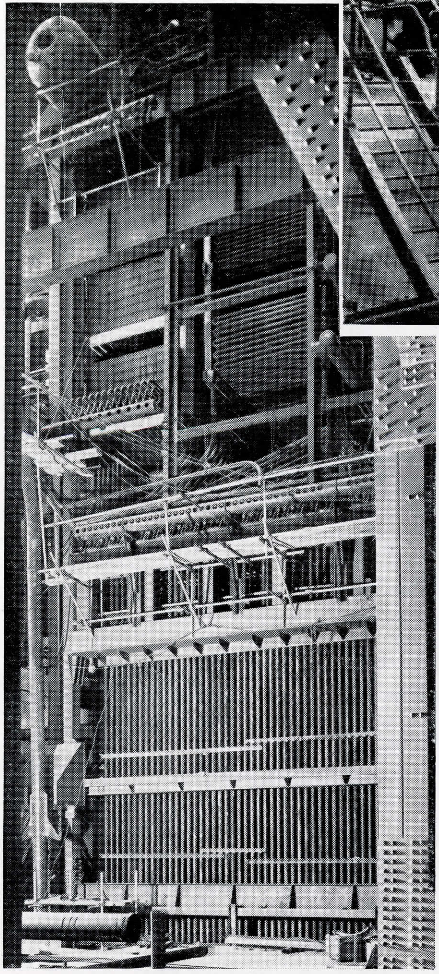
There are 27 sootblowers provided for each boiler unit, of which 23, located in the furnace and superheater, are of the Babcock pilot-valve retractable single-nozzle type; the remaining four, located in the air-heater, being Babcock blowers with Howden elements. Automatic sequence control, of the Babcock-Lockheed hydraulically-operated type, is arranged to give fully automatic control of the full range, or with pre-selected suppression of any individual blowers from the cycle, or the individual

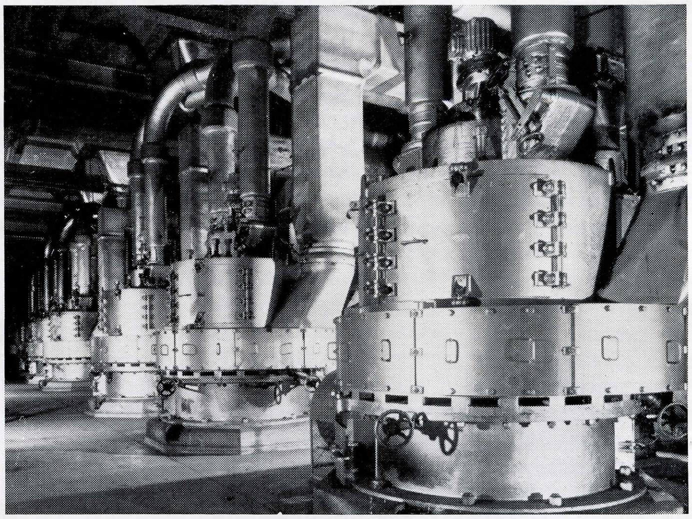


Cross-sectional outline arrangement of one of the twelve Babcock & Wilcox pulverised-fuel-fired 360,000 lb./hr. " High Head " boilers which will ultimately be installed.

(Right). *View of boilers at drum level, taken during erection.*





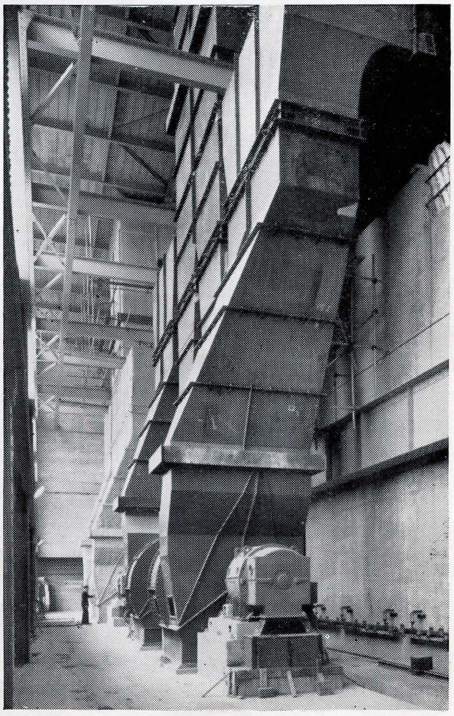


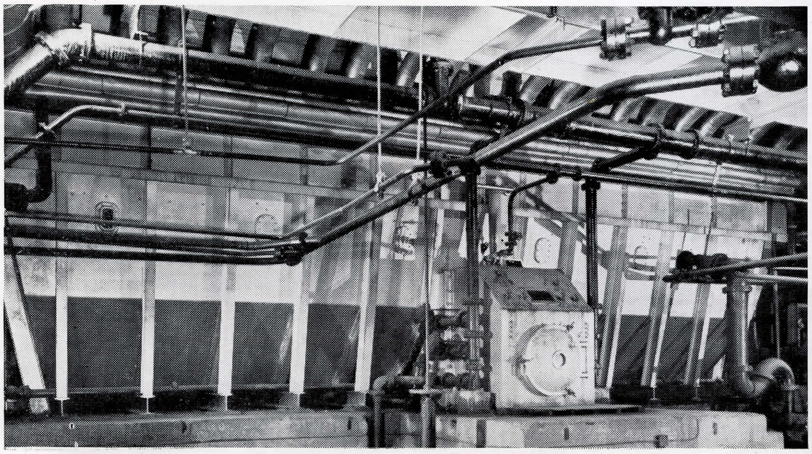
(Left). *Babcock & Wilcox 'E' type coal-pulverising mills, of which there are three per boiler.*

(Above). *Side view of one of the boilers during erection, showing furnace wall tubes, primary and secondary superheater sections, and economiser.*

(Right). *Induced-draught fans and ducting for boilers Nos. 1 & 2.*

(Below). *Water-filled ash hopper for the Babcock & Wilcox 'Hydrojet' ash disposal plant.*





operation of any selected blower. If, during the general operation, any blower fails to complete its operation within a given time, blowing ceases and an alarm sounds. Manual operation can also be carried out, if desired.

The boiler mountings, valves, etc., were for the most part manufactured and supplied by Hopkinsons Limited, and they comprise parallel-slide valves, Hopkinson-Ferranti valves, including items with electric valve controls for the main and bypass valves, contactor panels for electrically-controlled valves, push-button control panels, control cubicles, torsion-bar safety valves, water level indicators, pressure gauges, pressure gauge valve controls, etc.

Additional mountings and fittings were supplied by Dewrance & Co. Ltd., including high-pressure feed valves of the "pressure-held" cover type, various valves for auxiliary equipment, etc.

Draught Plant

Each boiler is provided with two induced-draught and two forced-draught fans supplied by James Howden & Co. Ltd. The i.d. fans are of Howden Turbovane single-box radial tipped bladed type, driven by G.E.C. 356 h.p. variable speed d.c. motors. Each fan is capable of an output of 103,500 cu. ft./min. at a pressure of 13 in. w.g. and temperature of 280 deg. F., the fan speed being 780 r.p.m. The f.d. units are of Howden "B" design-4, single-box backward-bladed type, driven by G.E.C. 146 h.p. variable speed d.c. motors, and each fan is capable of an output of 67,000 cu. ft./min. at a pressure of 8.5 in. w.g. and temperature of 90 deg. F. when running at a speed of 780 r.p.m. In addition, there are three primary air fans per boiler, also of Howden manufacture, and of that firm's 'P' single-inlet box, backward-bladed type, driven by G.E.C. 90 h.p. constant speed a.c. motors, and capable of an output of 13,500 cu. ft./min. at a pressure of 23.5 in. w.g. and temperature of 450 deg. F., the fan speed being 1,450 r.p.m.

Two "size 20" Howden-Ljungstrom air preheaters are provided for each boiler; each unit has an effective heating surface of 25,950 sq. ft. and is driven by a G.E.C. totally enclosed squirrel-cage motor developing 3 h.p. at 960 r.p.m. through a double worm reduction gear giving a rotor speed of 2.5 r.p.m. Air bypass ducts are incorporated in the casings of the air-heaters for control of the minimum element temperature at reduced loads, the control dampers of these ducts being remotely operated. De-dusting of the boiler flue gases is carried out in two stages, the first comprising two Howden Centicell collectors, and the second, one electrostatic precipitator per boiler. Both stages are positioned in the flue gas circuit after the air preheaters. Each of the two Howden Centicell collectors per boiler comprises 600 small dust-separating cells operating in parallel, and each collector is provided with one dust hopper which is sub-divided into two sections by a division plate in order to deter inter-cell flow. The pressure drop at M.C.R. is 2.4 in. w.g. across the Howden Centicell collectors.

For isolating purposes in the main flues three "Flu-Tite" dampers supplied by the Thames "Flu-Tite" Engineering Co. Ltd., have been fitted. These dampers are 20 ft. 0 in. wide × 16 ft. 0 in. deep, each damper unit consisting of two component parts with separate curtains each approximately 10 ft. 0 in. wide × 16 ft. 0 in. deep. These dampers are hand operated through reduction gear boxes and are of the "W" type suitable for isolating draught in either direction.

The electrostatic precipitators, which were supplied by the Sturtevant Engineering Co. Ltd., each handle 168,000 c.f.m. at 285 deg. F. at M.C.R. loading, and remove approximately 6 tons of dust per boiler in each 24 hours when operating at the design conditions. Each precipitator is housed in a reinforced concrete casing located inside the boiler house, and is under suction of the induced-draught fans. After leaving the centrifugal dust collectors, the gas to be cleaned is passed vertically upwards through banks of earthed hexagonal steel tubes which form the system of receiving electrodes located in the main body of the precipitator. Down the centre of each tube is suspended an electrode wire charged with a potential of 45,000 to 50,000 V from the negative terminal of the high-tension transforming and rectifying equipment. The high potential difference between the two electrode systems sets up a corona discharge, the ion flow of which, when acting upon a dust and its carrying gas, drives the dust to the earthed receiving electrodes thereby removing the solids from the gas stream. The precipitated dust on the electrodes, removed by electrically operated rapping gear which is fully automatic and easily adjustable, collects in hoppers under the main body of the precipitators. A transformer and mechanical rectifier with the necessary control gear, supply the high voltage required and, in normal operation, there is one high-tension set to each precipitator. The high-tension sets however, being interconnected in pairs, allow for one set to supply the precipitators for two boilers should a high-tension set be out of service for maintenance.

Ash-Handling Plant

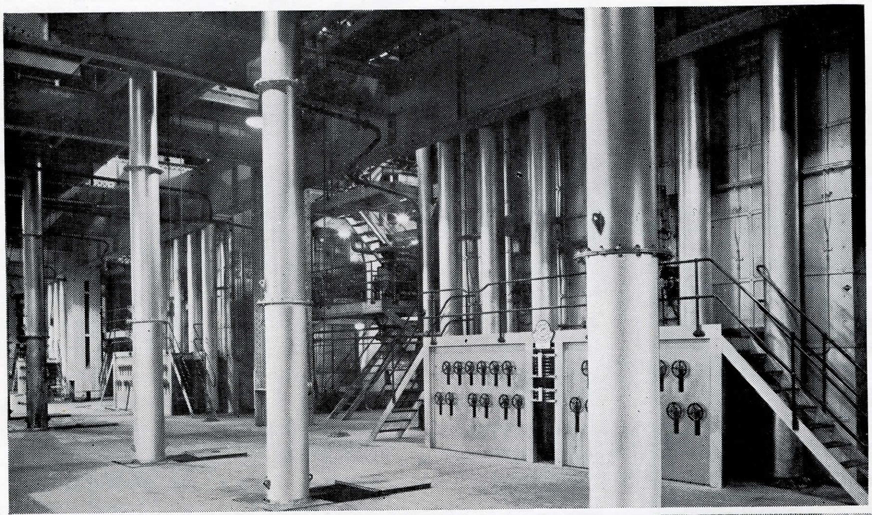
The ash-handling plant is of the Babcock "Hydrojet" system, arranged to handle the ash from all twelve boilers. With coal of maximum ash content, the total "make" of ash to be disposed of would amount to approximately 100 tons per hour. The boiler ash hoppers are of the Babcock type "A" water-filled pattern which have a capacity of 30 tons and are periodically emptied via a power-operated door by high-pressure water jets. The ash is conveyed by a "Hydrojet" high-pressure sluiceway to ash crushers which discharge into a transfer sump, the mixture then being pumped to ash ponds by "Hydroseal" ash pumps. At present, only the first-stage ash pumps are used, since the ash is being pumped to ponds at a point just beyond the coal store. For the further ponds to be used in future (up to 1½ miles from the station), a booster pump will be used in tandem. There are three ash crushers, three first-stage ash pumps and three second-stage booster pumps. In addition, there are pumps for supplying water for high-pressure sluicing, hopper cooling water, sealing water, and high-pressure water for operating the power-operated ash-hopper gates. All these pumps are duplicated. Dust and fly-ash from the boiler passes, the collector hoppers and the electrostatic precipitators, is extracted by feeder ejectors or "Windswept" dust valves and "Hydro-vactor" ejectors which utilise a high-pressure water jet to produce the vacuum. The dust-water mixture is discharged into a gravity sluice leading to the ash sump for disposal to the filling ground along with the ash.

Feed Water System

The feed suction and delivery mains are common to all sets, with suitable valves in the line to separate the various sections. Eight electrically-driven multi-stage boiler feed pumps are provided, and in addition there are two steam turbo-driven pumps which come into operation automatically in the event of failure of electrical supply causing a drop in pressure in the feed line. The electrically-driven pumps were supplied by Mather & Platt Ltd., each pump being capable of delivering 700,000 lb./hr. of feed water at a discharge pressure of 1,165 lb./sq. in., a temperature of 210 deg. F. when running at 3,000 r.p.m. These pumps are driven by 1,550 b.h.p. motors of G.E.C. manufacture. Other centrifugal pumps supplied by Mather & Platt Ltd., are for general service, including sealing water, town's water boosters, bearing cooling-water returns, etc. The steam turbine-driven boiler feed pumps were supplied by G. & J. Weir Ltd., complete with non-return discharge valves and automatic starting equipment. Each pump is designed for a capacity of 700,000 lb./hr. at a discharge pressure of 1,165 lb./sq. in. when supplied with steam at 900 lb./sq. in. and 900 deg. F. From the feed pumps, water can be delivered either direct to the economiser check valves or via the Cope's feed regulating valves (manufactured by Cope's Regulators Ltd.); a topping-up connection being provided on the Cope's feed line. Feed water make-up, amounting to approximately 4 per cent. of the total steam consumption, is obtained from the town's water supply via the softening and evaporating plants.

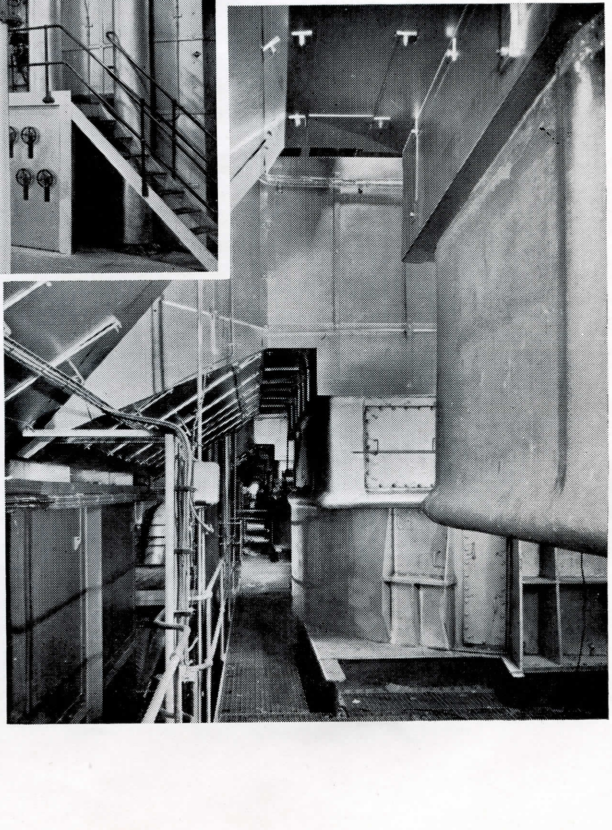
To prevent scale formation in the evaporators, the make-up water is first treated in Neckar base-exchange softening plants. The installation comprises two triple-unit base-exchange plants, each unit being rated at 5,000 galls. per hour with a capacity of 80,000 galls. between salt charges, based on an inlet hardness of 114 parts per million. The final feed to the boilers is conditioned with caustic soda and sodium sulphite, the dosing being effected by means of Kent pH controller recorders, which were also in the supply of the Neckar Water Softener Company Ltd.

All the steam and feed piping, and the six steam receivers in the station were supplied by Aiton & Co. Ltd., to the order of Babcock & Wilcox Ltd. The high-pressure steam piping, including 10 in., 9 in., and 5 in. bore mains, is designed for a pressure of 1,030 lb/sq. in. and a temperature of 925 deg. F. This piping and also the 30 in. bore steam receivers are made from chrome/molybdenum steel. Aiton patent Corwell joints are used throughout for both the main and the auxiliary steam pipework, and Aiton 'Uniload' supports are installed to accommodate the vertical movement due to thermal expansion of the 10 in. bore steam mains. The high-pressure, carbon-steel feed piping is designed for a pressure of 1,280 lb./sq. in., and the mains are of 10 in.

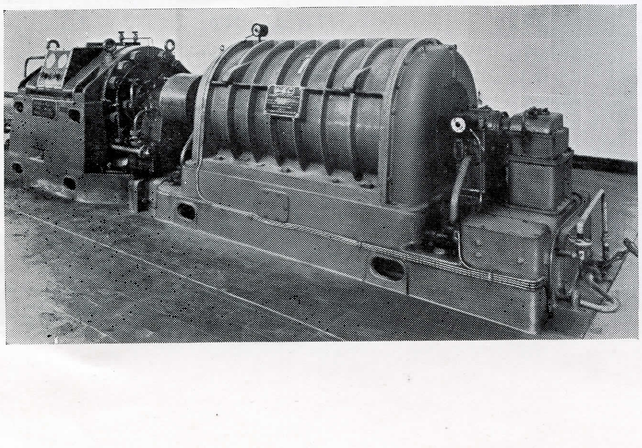


(Left). Front view of one of the boilers, showing (in foreground) pipes through which coal is fed under gravity to p.f. mills.

(Below). Howden-Ljungstrom air-preheaters and ducting at rear of boilers, insulated with Versil glass silk.



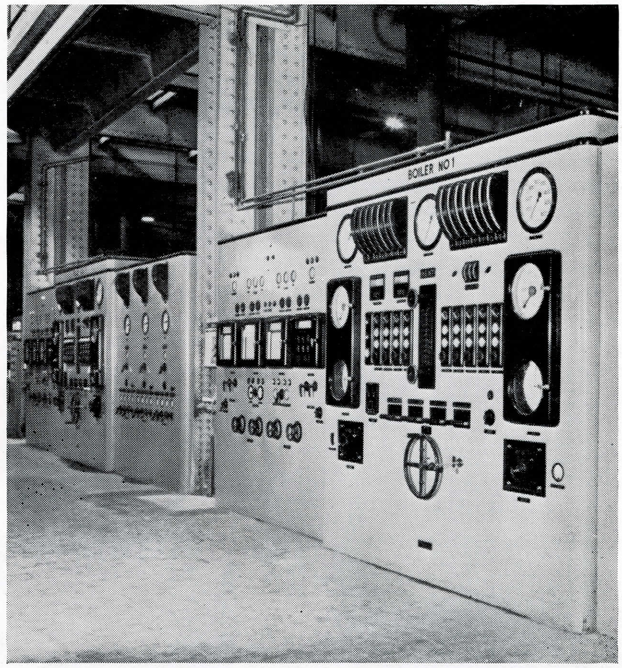
(Below). One of the Mather & Platt boiler feed pumps, driven by a G.E.C., 1,550 h.p. squirrel cage motor.



and 8 in. bore, with 6 in. bore connections to the boilers. Again, Corwell joints are used for all intermediate joints and connections to valves, etc. The piping for the complete blowdown and drain system was also supplied by Aiton & Co. Ltd. An extensive low-pressure system for supplying the station with town's water has also been supplied, the main piping being of cast-iron. The thermal insulation of the boilers and of the main pipework was the responsibility of the Darlington Insulation Co. Ltd., using Darlington 85 per cent. magnesia and Dextramite high temperature insulation. The insulation of the air heaters, gas and air ducting, casings, etc., for all the boilers and also for some of the piping was carried out by Versil Limited, Liversedge, Yorks, using a new mechanically designed method of construction using Versil glass silk. The air heater insulation is finished with hard setting composition, with open mesh canvas trowelled in. The hot air ducting is finished by a new method using Kimoloboard fixed with channel banding and metal corner pieces.

Boiler Control Equipment

The automatic combustion control equipment, and the majority of the instruments for the boiler plant were supplied by George Kent Ltd. Each boiler has its own instrument and control panel which carries the necessary indicators and controllers. On all boiler installations, one of the most important variables to be controlled is the combustion of the fuel. Normally, empirical values for the ash content of the fuel being used have to be assumed in controlling combustion. On this installation, errors which arise from this assumption are averted by using the new Kent oxygen analyser to determine the oxygen content of the flue gases and to control automatically the total air flow to the furnace so that the desired amount of excess air is kept constant under all fuel conditions. The oxygen control signal is superimposed on the fuel/air ratio controller, and thus increases or decreases, as the analyser demands, the amount of air fed to the furnace to allow for any change in the quality of the fuel. By this means the combustion efficiency is maintained at its optimum value, effecting maximum fuel economy. Since the fuel consumption of the twelve boilers in the station will be over 20,000 tons per week, even a small increase in the combustion efficiency will result in quite a large saving in fuel costs. Another special feature of the control scheme employed is the method of controlling the temperature of the superheated steam. This is effected by using two controllers in cascade. One controller is fitted to the instrument measuring the final steam temperature at the outlet of the secondary superheater. This controller operates in cascade with a second controller fitted to an instrument measuring the temperature at the inlet to the secondary superheater, setting this controller's desired value in order to effect control of the final steam temperature. This second controller regulates the amount of attemperation, which is carried out by means of the desuperheater situated between the primary and secondary superheater sections. Controlling the degree of superheat within fine limits allows the turbines to be run safely at their maximum efficiency, without any fear of the temperature rising to a value that would endanger the plant. The "nerve centre" of the plant is the central control room in which are Kent panels on which are mounted instruments enabling the supervisory staff to distribute the loading on the boilers. The boilers will normally be run in ranges of four, and the control room staff can distribute the load among the boilers to suit the demand even when the plant is under complete automatic control. If, during operation, the master pressure controller requires occasional service attention, the respective range can be manually controlled as required, or each boiler can be individually controlled from the central control room. Provision is, of course, also made for each boiler to be



The 'Kent' control panels for boilers Nos. 1 and 2.

manually controlled from its own individual panel located on the firing floor. All the controllers used are of the Kent Mark 20 range, in which all parts are interchangeable, making maintenance and spares replacement a comparatively simple matter. Instruments supplied by other manufacturers, and mounted upon the boiler control panels include "Igema" distance water-level indicators by James Gordon & Co. Ltd., Cambridge Instrument Co.'s temperature indicators, and Negretti & Zambra's temperature indicators for temperatures of the pulverising mills.

Generating Plant

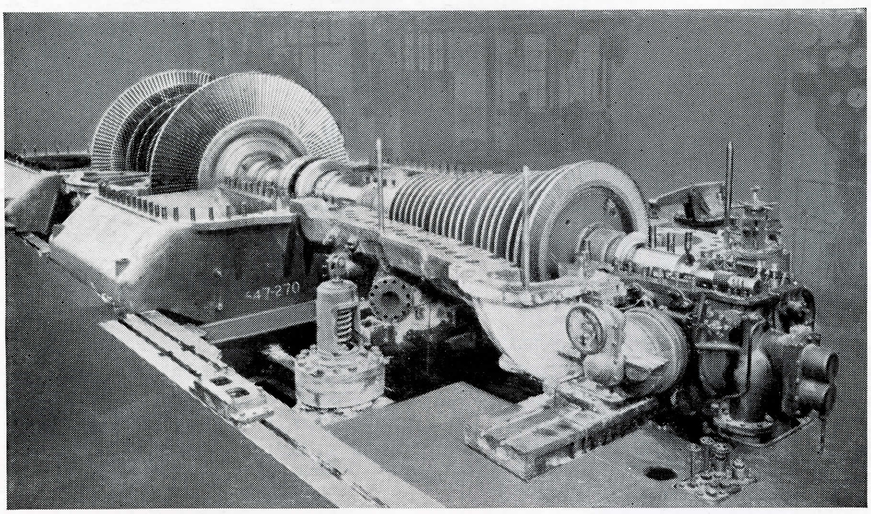
The General Electric Co. Ltd., was the main electrical contractor responsible for the turbine and electrical equipment for the whole of the station with the exception of the 132 kV switchgear. The contract covered the design, manufacture and erection of the six 60 MW hydrogen-cooled turbo-alternators, six 70 MVA, 11.8 kV/140.7 kV generator-transformers, 46 auxiliary transformers totalling 88 MVA, no less than 500 motors aggregating some 50,000 h.p. for boiler house and station auxiliaries, 32 grid-controlled rectifiers totalling 17,000 kW and over 100 switchboards for 3,300 volt and 415 volt service.

Each of the six steam turbines is designed for a M.C.E.R. of 60 MW when running at a speed of 3,000 r.p.m. Normal steam conditions at inlet are 900 lb./sq. in., 900 deg. F. and the normal vacuum at 60 MW load with circulating water at 56 deg. F. is 28.9 in. (30 in. bar). Feed heating is effected in five stages to a final temperature of 385 deg. F. at 60 MW. The turbine has two cylinders with twenty stages in the high-pressure casing, and six stages on each side of the double-flow low-pressure casing. The steam inlet to the H.P. casing is adjacent to one of the L.P. exhaust casings, so that the steam flows towards the front pedestal, thence through two overhead pipes to the centre of the L.P. exhaust casings where the flow divides towards the two exhausts—an arrangement which simplifies thermal expansion problems.

The turbine and alternator rotors are rigidly coupled together and only one thrust bearing is provided. It is located adjacent to the journal bearing at the steam inlet end of the H.P. rotor almost in the vertical plane of the traverse keys which secure the L.P. exhaust casing to the foundation girders at this point. Thus the thrust bearing is virtually fixed and both the H.P. and L.P. casings and their respective rotors can expand freely and independently in opposite longitudinal directions, thus maintaining approximately constant blade clearances. The moving blades are milled out of solid bars, molybdenum stainless iron being used in the high temperature zones and rustless steel elsewhere. The blading is designed for impulse conditions at the inner diameter of the blading annulus, the degree of reaction increasing towards the outer diameter. The shaft glands, balance piston, and interstage packings are of the steel vernier labyrinth type. Oil for the bearings, governor relay and the hydrogen seals is supplied by the main oil pump, an automatic auxiliary oil pump being provided for emergency service. A seal oil pump maintains oil supply to the hydrogen seal when the set is shut down. Throttle governing is used from no load to full load, the four governing throttle valves being arranged to operate in parallel to give the M.C.E.R. at full load. The throttle valves are built into the H.P. casing around which they are arranged symmetrically to ensure uniform distribution of steam which is supplied through loop pipes connected to the two emergency stop valves mounted on foundation girders.

Superimposed on the speed governor system are two devices for enforcing a gradual load reduction in the event of either a falling vacuum or a reduction in boiler pressure. In addition, the trip gear ensures an immediate and total shut down in the event of emergencies such as overspeed, oil pressure failure, vacuum failure, thrust failure and certain faults on the generation side. The condensing plant for each turbine was supplied by Hick Hargreaves & Co. Ltd., and consists of twin condensers with a total surface of 47,000 sq. ft. designed for 28.9 in. vacuum when supplied with 40,000 gals./min. of water at 56 deg. F. Hick Hargreaves also supplied 5-stage feed heating plant including shunt deaerators and low level d.c. heaters, and triple-effect recompression evaporating plant for each set.

The circulating water required for cooling purposes is drawn from the River Usk by means of the circulating pumps located in a pump house, the sub-structure of which is the 40,000 ton caisson referred to earlier in this description, and which had to be constructed because the large rise and fall of the tide at times approximates 43 ft. Thus the pumps had to be located at a depth which ensures that they are below the level of the lowest tide. Water is taken from the pump house along two reinforced concrete ducts to the centre of the turbine house where the ducts branch into two sections, one section dealing with the condensers of the first three turbines and the other with the second three. The discharge is taken through two more ducts running parallel with, but at a lower level than the condenser inlet ducts to a point approximately 3,000 ft. higher up the river than the inlet point. The main contractors for the whole of the circulating water pump house equipment were Gwynnes Pumps Ltd., London, whose supply included eight 45-in. 148-in. vertical spindle double entry centrifugal pumps each designed for a maximum duty of 52,500 g.p.m. against a total head of 60 ft. at 395 r.p.m. and by speed control a minimum duty of 35,000 g.p.m. against a total head of 18 ft. at 248 r.p.m. The pumps are driven through approximately 60 ft. of $7\frac{1}{2}$ in. diameter vertical shafting, the weight of the shafting impeller being taken by a Michel thrust bearing incorporated in the motor stool at motor floor level. Gwynnes Pumps Ltd. also supplied various auxiliary pumps including four 5 in. vertical spindle slurry pumps, four 2 in. vertical spindle seepage pumps and six 4 in. horizontal split casing rubber lined pumps for delivery of wash water to the main band screens. Each pump is driven by a 1,100 h.p. vertical spindle d.c. motor of G.E.C. manufacture. As the speeds of the pumps have to be adjusted according to the state of the tide and the load on the station, power for each motor is obtained from a grid-controlled rectifier rated at 884 kW, 750 V. The main



View showing one of the 60 MW turbines under construction at the G.E.C.-Fraser and Chalmers works.

pump suction and discharge valves are hydraulically operated, are of Glenfield and Kennedy's manufacture, and comprise eight 55-in. Gwynne/Glenfield self-closing discharge and sluice valves, and eight 48-in. suction sluice valves. The oil for operating the valves is at a pressure of 500 lb./sq. in. and is provided by duplicate sets of power equipment, which are located in the centre of the pump house, and is taken to the valves by two long mains so arranged that the oil always flows from the main at the higher pressure. The screening plant comprises eighteen 60 in. width central-flow band-type screens of F. W. Brackett & Co.'s manufacture, each capable of screening $1\frac{1}{2}$ million gals. of water per hour under normal conditions, with a minimum immersion of approximately 13 ft.

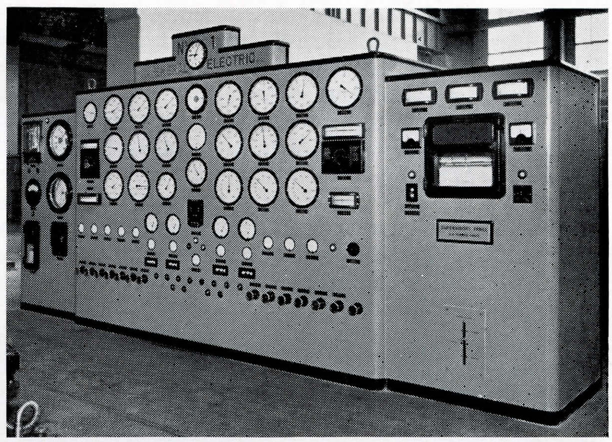
Alternators

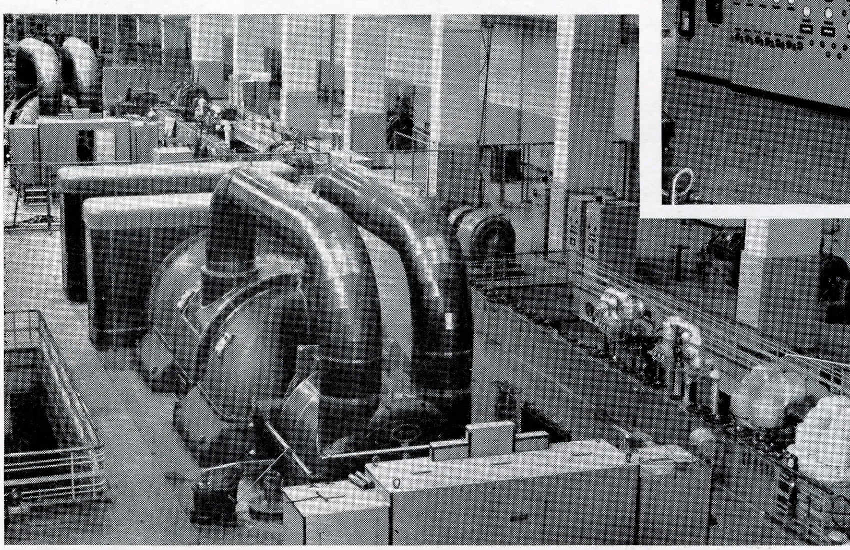
The G.E.C. hydrogen-cooled alternators generate at 11.8 kV, 50 c/s. The main feature of interest in the design is the use of hydrogen as the cooling medium. For these machines the pressure within the stator is of the order of $\frac{1}{2}$ lb./sq. in. above atmosphere.

The hydrogen gas cooling system is self-contained with the hydrogen circulation confined within the alternator, thereby eliminating any external ducting. Fans mounted at each end of the rotor shaft force the hydrogen through the stator core, winding and rotor. The warm hydrogen then passes through the four coolers which are built into housings located at the ends of the stator. Town's water is used in the coolers, and is passed through heat-exchangers where it is cooled by river water before being recirculated in a closed circuit. The pressure and purity of the hydrogen within the machine are automatically controlled and measured, and a comprehensive system of alarms gives warning of low purity, high or low pressure and the presence of water in the alternator casing. Thermocouples are provided to give temperatures of the gas seal rings, of the "cold" gas, of the town's water inlet to the coolers, of the river water inlet to the heat exchangers, as well as of the metal at various points in the stator. In order to maintain a high degree of purity of hydrogen within the machine, and to economise in the consumption of hydrogen, a gas seal is provided between the rotating shaft and the stationary stator casing. A collar forming part of the shaft is provided on the hydrogen side of each of the main bearings. Each alternator is excited by a separately driven 196 kW exciter set which embodies a flywheel whereby full output is maintained for a short predetermined time in the event of a reduction in the voltage or a temporary interruption of the a.c. supply to the squirrel-cage driving motor.

(Right). Turbine control board with the supervisory control panel on the right.

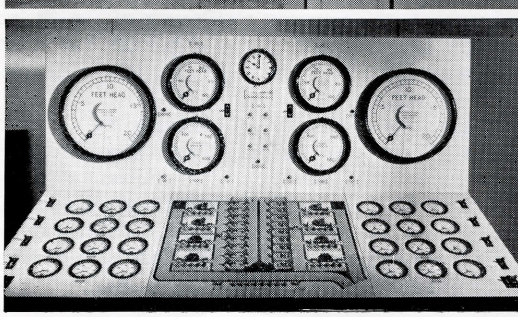
(Below). Turbine room showing two of the G.E.C. hydrogen-cooled sets.

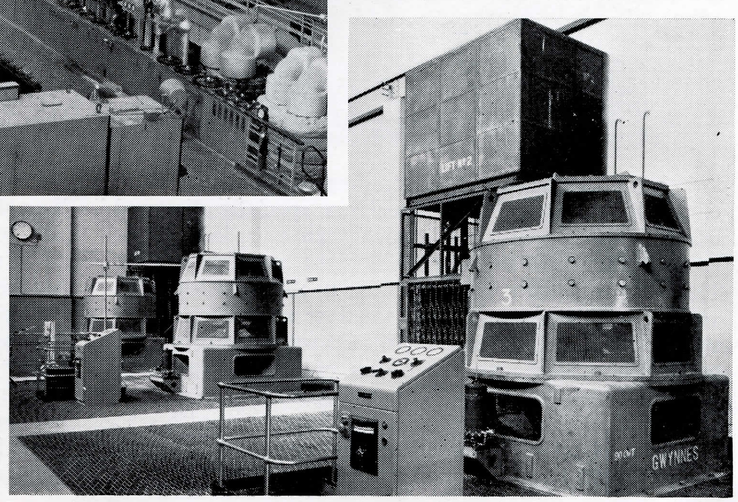




(Below left). Control desk in No. 1 circulating water pump house.

(Below). 1,100 h.p. G.E.C. motors driving the Gwynnes circulating-water pumps in No. 1 pump house.





Main Switchgear

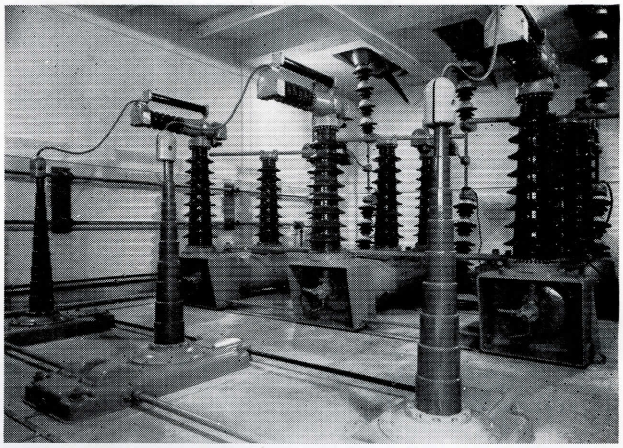
There is no switchgear on the 11.8 kV side, each generator being connected to an 11.8/132 kV transformer, and thence to the main 132 kV switchgear which was supplied by Metropolitan-Vickers Electrical Co. Ltd., and which comprises 21 air-blast circuit-breakers and 56 isolators, together with instrument transformers and associated apparatus such as compressor plant and control boards. For service at 132 kV, the main switchgear would normally be of the outdoor type, but in view of the heavy mists that are prevalent in the coastal district where the station is situated, it was decided to house the gear in a special building. A conventional duplicate-busbar switching system has been adopted. A bus-section switch is provided in the main bars ; the reverse bars are normally sectionalised, but a reactor, controlled on each side by a circuit-break and busbar selector switches, can be inserted either across the section in the main bars, or across the gap in the reverse bars. The layout of the switchgear on three floors of the switch-house is somewhat unusual. The circuit-breakers and circuit isolators are mounted on the first floor of the switch-house, with partition walls between circuits.

The control room houses the main control board, the control desk for the six generators, the operator's desk, and the control boards for the station auxiliaries. The circuit-breakers are the company's well-known air-blast type GA6S2, but in this instance they are modified for mounting directly on the floor instead of on a support. This type of circuit-breaker has a rated breaking-capacity of 3,500 MVA at 132 kV ; the total-break-time, measured from receipt of tripping impulse to final interruption, is approximately 3 cycles. There are two breaks per phase, each break being shunted by a Metrosil non-linear resistor. The compressor equipment for the compressed air to open the sequence switch is designed to supply compressed air at a pressure of 320 lb./sq. in. The isolators are specially designed to enable the two terminals in each phase to be in different rooms. For this to be possible, the rotating contact blade has to be of a design similar to that of a bushing, so as to be able to pass through the floor or wall separating the two rooms. Current-transformers are of the ring type, and are threaded over the cables or over the rotating blades of the isolators. The voltage-transformers are single-phase oil-immersed units with ratio 76,200/63.5 V.

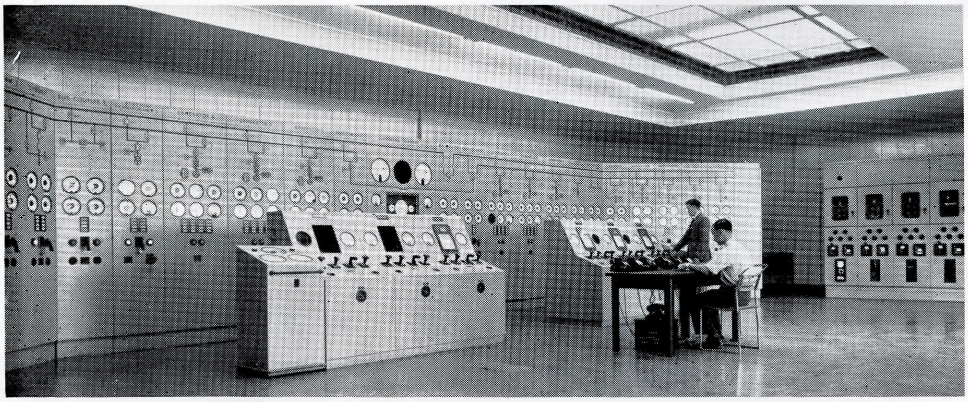
Power supplies for the station auxiliaries are derived from two 132/3.3 kV station transformers and from six 11.8/3.3 kV unit transformers. Supplies for the coal and ash handling plant and other common services are fed from the station transformer and its switchboard, and supplies for individual turbine and boiler plant auxiliaries are taken from the corresponding unit transformer and its switchboard. For starting-up and standby purposes, there are connections between the station switchboard and each unit switchboard. The variable voltage d.c. supply required for operating the circulating water pumps and the boiler fans is obtained from grid controlled mercury arc rectifying plant supplied with a.c. at 3,300 V from either the station or unit transformers. Sixteen transformers of G.E.C. manufacture supply current at 415 V for the lower voltage auxiliary plant.

Air for operating the circuit-breakers is obtained via a duplicate copper bus main from the compressor room located on the ground floor and in the centre portion of the building. The compressor room contains four air compressors, two common air receivers divided into banks of four units, and a compressor control cubicle. The air pressure at the common receivers is reduced from 600 lb./sq. in. before entering the duplicate bus main so as to give a pressure of 320 lb./sq. in. at the circuit-breaker unit receivers.

Connection to the 132,000 V grid is made by six lines feeding out to Gloucester, Cardiff, Upper Boat, Lydney, and two to Llantarnam, with tee connections off these lines to Newport. The terminal towers are adjacent to the building and connection from the switchgear to these is made by 132,000 V cables terminated in sealing ends installed in a compound.



(Above). Metropolitan-Vickers 132 kV air-blast circuit breakers.



(Left). View in station main control room.

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