The Royal Sanitary Institute

Visit to the Works

of the

SOUTH STAFFORDSHIRE WATERWORKS COMPANY

On Thursday, July 15th, 1937

ROYAL SANITARY INSTITUTE

Health Congress at Birmingham

15th JULY, 1937

DEPART		ARRIVE	
	p.m.		p.m.
BIRMINGHAM	2·15	Maple Brook ...	3·15
Maple Brook ...	3·30	Sandfields (Lichfield) ...	3·45
Sandfields for Tea at the George Hotel, Lichfield at 4·45			
George Hotel ...	5·15	Pipe Hill ...	5·25
Pipe Hill ...	5·40	Sandhills ...	5·50
Sandhills ...	6·5	BIRMINGHAM	6·35

THE ROYAL SANITARY INSTITUTE

VISIT TO THE WORKS

South Staffordshire Waterworks Company

On THURSDAY, JULY 15th, 1937

The South Staffordshire Waterworks Company was established in 1853 and is administered under various Acts of Parliament from 1853 to 1936.

The population supplied is a little over one million, and the Company's area extends over 450 square miles in the Counties of Stafford, Warwick, Worcester, Derby and Leicester.

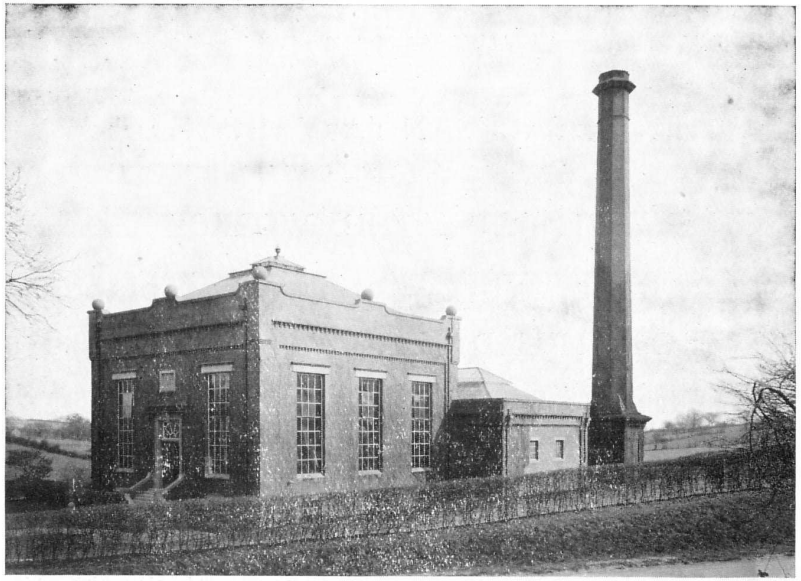
The main supply is from underground sources in the New Red sandstone formation. There is, however, a surface water scheme from a gathering ground 10 square miles in extent.

There are 30 main pumping and re-pumping stations and 27 service reservoirs and water towers situate in various parts of the district.

MAPLE BROOK PUMPING STATION.

This plant consists of two vertical triple expansion surface condensing rotative pumping engines each driving a pair of borehole pumps and a set of three throw ram pumps, together with two Lancashire boilers with superheaters, two feed pumps, lighting set, two steam winches and overhead crane.

The "H. Ashton Hill" engine draws its supplies from boreholes Nos. 1 and 2, which are 36 inches diameter for a depth of 121 feet, 33 inches diameter for a further depth of 185 feet, and 20 inches diameter for a further depth of 364 feet, making a total depth of 670 feet.



MAPLE BROOK.

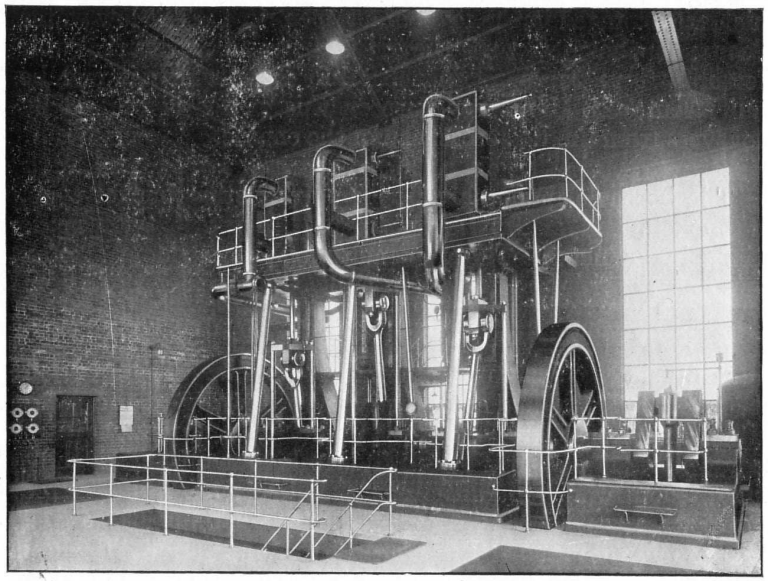
The " H. K. Beale " engine draws its supp lies from boreholes Nos. 3 and 4, which are 36 inches diameter for a depth of 122 feet, 33 inches diameter for a further depth of 199 feet and 20 inches diameter for a further depth of 312 feet, making a total depth of 633 feet.

The " H. Ashton Hill " engine was supplied by Messrs. Galloways Ltd., of Manchester, and the " H. K. Beale " engine by Messrs. Glenfield and Kennedy, of Kilmarnock.

Each engine is of the following dimensions :—

H.P. Cylinder	22in. dia.
I.P. Cylinder	35in. dia.
L.P. Cylinder	55in. dia.
Stroke	4ft.
2 Borehole Pumps each ...	15in. dia. ×5ft. stroke.
3 Force Pump Plungers each...	13½in. ,, ×4ft. ,,

Each engine is capable of pumping two million gallons per 24 hours when running at a speed of 20 revolutions per minute from a maximum depth of 300 feet in the boreholes and against a head of 306 feet on the force pumps, making a total head of 606 feet including friction.



No. 1 ENGINE.

The engines are fitted with Corliss valves and the valve gear is of the Dobson type actuated by eccentrics from the crankshaft. The steam valves are fitted with trip gear and spring-loaded dashpots to accelerate their action.

Between the " H.P." and " I.P." cylinders and the " I.P." and " L.P." cylinders, are fitted re-heating receivers to maintain the steam in dry condition throughout the working cycle. The surface condenser of the " H. Ashton Hill " engine is placed in the force pump suction tank in the basement and the air pump is of the " Edwards " type driven by a separate steam engine.

The surface condenser of the " H. K. Beale " engine is placed in the force pump suction tank outside the building and is designed to prevent sand drawn from the boreholes reaching the force pumps. The borehole pumps discharge into the ends of the suction tank through bell-mouth pipes with the invert above the top of the condenser to ensure it is never uncovered. The water flows from both ends over the condenser placed in the centre of the tank giving a positive circulation and then

discharges over a weir to the suction pipes of the force pump which are arranged in the form of an open ring. The low water velocity in the tank and the final decanting over the weir effectually trap the sand in the tank, from which it can be readily removed. The air pump on this engine is worked by side levers from the I.P. crosshead of the engine.

The borehole pumps are of the single-acting bucket type, the buckets and clacks being of the " Pernis " type made entirely in gunmetal. The steel pump rods have coned cottered joints and the rising mains are of lap-welded steel with riveted flanges and " Vislok " bolts. The force pumps are of the single-acting plunger type, placed directly under the cylinders and driven by side rods from the engine crossheads. This method transmits the power from the cylinders direct on to the rams whilst the crankshaft drives the two borehole pumps and the surplus power is absorbed by the flywheels to maintain a steady turning moment. On " H. Ashton Hill " engine, the force pump valves are fitted with gutta percha beats and the valve boxes are formed round the rams. On the " H. K. Beale " engine, the valve boxes are separate from the ram cases making them more accessible and these are fitted with " Pernis " valves. In the foundations between each pair of boreholes and underneath the engine house floor are placed two steam winches which are used for drawing the buckets and clacks when required.

The two boilers are of the Lancashire type made by Messrs. Galloways Ltd., and are 8 feet diameter by 30 feet long. These are fitted with Sugden's superheaters and the necessary dampers and valves are provided so that either saturated or superheated steam can be used. The working steam pressure is 160 lbs. per square inch, and the temperature at the superheaters is normally about 550° F.

Adjoining the boiler house is a workshop and store for oils and spare parts.

A cottage is provided in the station grounds for the foreman of the station.

The " H. K. Beale " engine and pumps were carried out to the designs and specifications of the Company's Engineer-in-Chief, Mr. Fred. J. Dixon, M.Inst.C.E., M.I.Mech.E.

SANDFIELDS PUMPING STATION.

This pumping station draws its supply from the Company's original impounding reservoirs at Hanch, Stowe, and Minster Pools, and the supply from these reservoirs is supplemented by the bleed from a tunnel $3\frac{1}{2}$ miles long in the New Red sandstone between Hanch reservoir and the pumping station.

The original plant was designed and installed by the originator of the Company, R. McClean, Esq., M.P., who was a well known engineer and railway contractor.

This consisted of three single cylinder, condensing, rotative beam engines driving on to a common crankshaft and nine Lancashire boilers. The engines were made by James Watt at Soho Works, Birmingham, and were brought into commission in October, 1858.

These engines had an interesting history, as they were originally designed for and worked as blowing engines on the South Devon Atmospheric Railway. This method of operation did not prove successful and the engines were purchased by the Company. They were dismantled and removed to Lichfield where they were remodelled for use as pumping engines.

Each engine had a double-acting cylinder 46 inches diameter by 8 feet stroke and from its beam operated a ram and bucket pump. The buckets were $18\frac{1}{4}$ inches diameter and the rams 14 inches diameter by 8 feet stroke. Each set of pumps were fixed in a well 8 feet diameter by 70 feet deep and the combined output of the three engines was 3·43 million gallons per 24 hours. At a later date, the crankshaft was cut through so that two engines were left coupled whilst the third engine worked as a separate unit. This was done to allow more flexibility in the operation of the plant to meet the variations in the pumping requirements.

In 1873, the works were extended to receive a Cornish beam engine constructed by J. Davies, of Tipton. This engine has a steam cylinder 65 inches diameter by 9 feet stroke and drives a bucket pump $25\frac{3}{8}$ inches diameter and a ram 17 $\frac{3}{16}$ inches diameter by 9 feet stroke. The engine has an output of two million gallons per 24 hours and is still retained at the pumping station.

The original boilers were suitable for a pressure of 40 lbs. per square inch. These boilers were condemned and in 1907 four were removed and replaced by three Lancashire boilers each 8 feet diameter by 30 feet long, suitable for a working pressure of 100 lbs. per square inch, but they worked at 40 lbs. to suit the old plant.

During the coal strikes of 1921 and 1926, the remaining condemned boilers were utilised for the storage of oil fuel, and the oil burning equipment is still available to convert one of the high pressure boilers into an oil-fired boiler in case of another coal strike.

In 1922 the Company decided to construct a comprehensive filtration plant for dealing with the water from this Station.

To accomplish this object, it was necessary to lift the water to the surface for treatment and then pump the filtered water to Walsall.

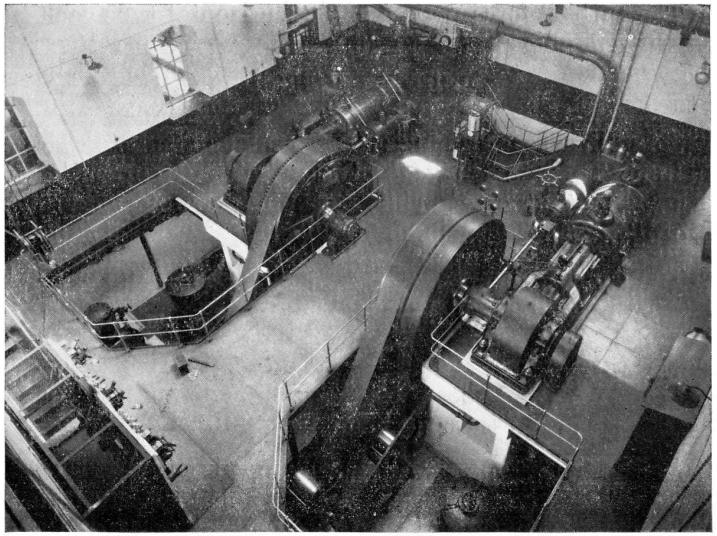
The existing plant delivered the water in one lift to Walsall and the pumps could not be altered to meet the new conditions. Also, the plant was working at a low steam pressure and due to heavy continuous operation over a long period, was not in efficient condition.

It was decided to carry out a scheme of reconstruction of the pumping plant in conjunction with the construction of the filtration plant and the whole of the works now to be described were carried out to the designs and specifications of the Company's Engineer-in-Chief, Mr. Fred. J. Dixon, M.Inst.C.E., M.I.Mech.E.

It was essential that the new pumping plant should be flexible as regards range of output, also the pumps lifting the water to the filtration plant must be suitable for independent range variations to suit the requirements of the filtration plant.

Due to the limited space avilable, general accessibility of the plant was an important factor.

Various types of prime movers and combinations of plant were considered as to their ability to fulfil the above conditions and finally a combination steam-electric drive was adopted.



UNIFLOW ENGINE.

The two main engines are of the horizontal uniflow surface condensing rotative type. Each engine drives its air pump from an extension on the crankshaft operating a bellcrank. There are two belt drives from each engine flywheel, one belt driving a turbine force pump which delivers the filtered water to Walsall reservoir whilst the other belt drives a 90 kw. 220 volt horizontal direct current generator which supplies the power to drive a vertical spindle electrically driven well pump which lifts the water from the well to the filtration plant, and also provides power for auxiliary plant and lighting. Each pumping set has an output of $1\frac{1}{2}$ to 3 million gallons per day of 24 hours. Each engine has a cylinder 29·5 inches diameter by 25·6 inches stroke and develops an indicated horse power of 392 at 158 r.p.m. Oil separators remove the oil from the exhaust steam, which is condensed in a surface condenser of 720 square feet cooling surface and then utilised to feed the boilers.

The well pumps have single impellers of the double inlet type and are driven by vertical spindle direct current shunt wound motors of 80 B.H.P. on a 220 volt supply. The pumps have a speed range of 760 to 840 r.p.m. to give the desired output against a total head of 80 feet.

The turbine force pumps of the horizontal type each have have three double inlet impellers in series with a speed variation of between 870 and 940 r.p.m., and are each capable of delivering $1\frac{1}{2}$ to 3 million gallons per 24 hours against a total head of 320 feet.

In case of emergency, the two units can run together at a maximum output of $4\frac{1}{2}$ million gallons per day, which is the full capacity of the main.

The boilers now work at their designed pressure of 100 lbs. per square inch and superheaters were added. Provision was made in the steam pipe arrangement for working with saturated or superheated steam and a large steam receiver spans the three boilers for use if the beam engine is brought into commission when the steam pressure is reduced to 40 lbs.

At this time, two of the old condemned boilers at the canal end of the boiler house were removed and the space utilised for the construction of an oil store, spares and tools store and a cement testing laboratory.

The auxiliary equipment comprises two electrically driven boiler feed pumps, two electrically driven oil extraction pumps and one electrically driven drainage pump.

To provide power for the overhead electric crane, lighting and power for auxiliary plant when the main engines are standing, a steam driven auxiliary generating set is provided. The engine is rated at 40/50 B.H.P. at 600 r.p.m. and is direct coupled to a 25 kw. 220 volt direct current generator. The main switchboard consists of three generator panels and spaced between them are two feeder panels with isolating switches for the two well pump motors, crane, auxiliary plant in the pumping station and lighting, also lighting and power for the filtration plant, including air compressors, lift, alumina pumps and sludge pumping plant. The panels are provided with meters to measure the power consumption on the various power and lighting circuits.

The quantity of water pumped to the filtration plant is measured over a rectangular weir and recorded and integrated on a flow recorder which electrically records back to an indicator in the engine room the actual rate of flow in thousands of gallons per hour over the weir at any instant, which enables the driver to keep the well pump discharge at the required amount.

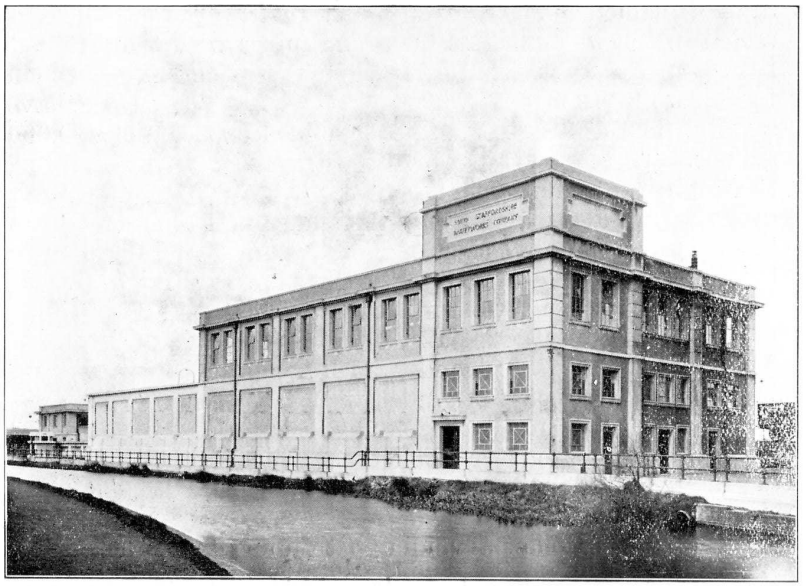
The quantity of water pumped to Walsall reservoir is integrated and recorded by a combined Venturi flow and pressure recorder.

SANDFIELDS FILTRATION PLANT.

Entering the filtration block at the administration end on the ground floor are chlorine and alumina stores, an electrically operated lift, and a heating chamber. On the first floor is the Superintendent's office in which is fitted the apparatus for chlorinating and de-chlorinating, an alumina tank room with tanks in duplicate and a pump room containing the power and lighting distribution panel, two alumina pumps and a washwater pump.

On the second floor are two laboratories and office accommodation for the Company's chemist and staff.

From either first or second floors there is direct access into the filter house containing ten rapid sand filters. From the filter house we come to the upcast shaft up which the raw water is delivered and the reaction and precipitation tanks and then pass on to the washwater and sedimentation tanks and sludge pump and press house.



SANDFIELDS FILTRATION PLANT.

SANDFIELDS FILTRATION.

The process of filtration will now be briefly described. The raw water is delivered from the pumping station through a 24in. diameter main to the upcast shaft. The coagulent is added to the water in this main and mixes with the water as it rises in the upcast shaft and flows along the mixing trough to the two reaction and precipitation tanks. These tanks have a water depth of 19 feet and a combined capacity of 420,000 gallons. These tanks are provided with vertical baffles dividing the tanks into compartments. The raw water flows under and over these baffles precipitating the sludge and then enters the two channels along the sides of the filter house and flows on to the filter beds. The ten filters each have a filtering area of 280 square feet and the total capacity of the filters is four million gallons per day. The filtering medium consists of a 27 inch bed of washed and graded Leighton Buzzard sand supported on 18 inches of graded washed gravel. The filtered water is collected in a trough and discharged at the administration end into the clear water tank, which extends under all the filters, and at this point the chlorine is added. The clear water tank has a central division wall and baffle walls which makes the water follow a winding path up one-half of the tank

and then down the other half to the suction well from which the force pumps draw their supplies. A de-chlorinating agent can be added at this point, if required. The clear water tank has a capacity of 250,000 gallons.

The filters are cleaned by blowing air through the filtering medium which loosens the film of dirt resting on the sand. After shutting off the air, wash water from an overhead tank is passed through the filtering medium and washes the dirt into troughs which discharge into pipes leading to the sedimentation tanks. When the filter bed is clean, the wash water is shut off. After allowing a short interval for settling, the filter is again brought into commission.

The compressed air is provided by duplicate electrically driven compressors in the pumping station basement and the air is stored in a large steel air vessel alongside the engine house. The compressors work under automatic pressure control.

The washwater pump under automatic control feeds the overhead tank over the laboratories and in case this pump fails, the tank can be fed under ball valve control from the Walsall pumping main. If the tank is out of commission, then the water is taken direct from the main through a reducing valve.

After the wash water has settled in the sedimentation tanks, the supernatant water is drawn off through a floating arm and pumped back by a 3 inch centrifugal pump into the reaction tanks. The sludge which has collected in the bottom of the tanks is drawn off by two reciprocating pumps and delivered into the sludge presses against a pressure of 100 lbs. per square inch. The water is squeezed out of the press, leaving the sludge in the form of cakes which are broken up and put on the land.

In describing this filtration plant, it has not been possible, on account of lack of space, to describe the many interesting automatic controls which play such an important part in the correct functioning of this comprehensive scheme nor attempt to deal with the construction of such a complicated reinforced concrete structure.

The pumping plant was provided by Messrs. Sulzer Bros. Ltd., and the filtration plant by The Paterson Engineering Co. Ltd.

PIPE HILL PUMPING STATION.

The pumping plant at this station consists of two horizontal compound tandem surface condensing rotative Pumping Engines. No. 1 engine was supplied by Messrs. Hathorn, Davey and Co. Ltd., of Leeds, and No. 2 by Messrs. Ashton, Frost and Co. Ltd., of Blackburn.

There are four boreholes: Boreholes No. 1 and No. 2 are 30 inches diameter for a depth of 311 feet, and 20 inches diameter for a further depth of 245 feet. Boreholes No. 3 and No. 4 are 30 inches diameter for a depth of 303 feet, 18 inches diameter for a further depth of 215 feet in the case of Borehole No. 3, and 64 feet in the case of Borehole No. 4, and 15 inches diameter for a further depth of 58 feet.

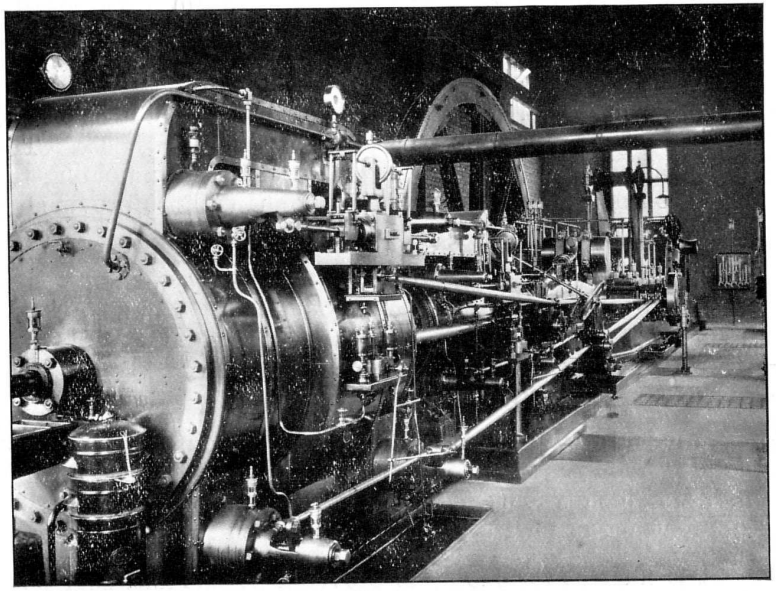
PIPE HILL.

No. 1 engine is capable of pumping two million gallons against a total head of 733 feet including 300 feet in the boreholes, and No. 2 engine will pump two million gallons against a total head of 554 feet including 150 feet in the boreholes.

The jacketted cylinders of No. 1 engine are 32 inches and 62 inches diameter by 5 feet stroke. The borehole pumps are fitted with buckets 15 inches diameter by 5 feet 6 inches stroke. The double-acting force pump piston is $15\frac{3}{4}$ inches diameter by 5 feet stroke. Engine No. 2 has cylinders 26 inches and 49 inches diameter by 5 feet stroke. The borehole pumps and the force pump are the same size as for Engine No. 1.

The borehole pumps are actuated by compensating quadrants and have " Pernis " buckets and clacks. These are more efficient than the double beat type as they have lighter valves of larger area and can run at a higher speed. The borehole pumps of Engine No. 1 are 300 feet below floor level, but the borehole pumps for Engine No. 2 are only 150 feet below floor level.

The pump rods have coned joints each of which is fitted with a single cotter. The rising mains in the boreholes are of lapwelded steel with screwed couplings.



PIPE HILL. VIEW OF No. 2 ENGINE, SHEWING VALVE GEAR.

The discharge from the borehole pumps flows through a channel in the engine foundations to the force pump suction tanks formed in the basement and the surface condensers are placed in these tanks.

The force pumps are each fitted with a number of small valves which are screwed into the valve plates. The valves on No. 1 engine have metal beat faces but those on No. 2 engine are fitted with gutta percha beats.

No. 1 engine is provided with Corliss valves, actuated by " Frickard " gear.

No. 2 engine is provided with Corliss valve gear of the " Dobson " type.

There are three Lancashire type boilers made by Messrs. H. and T. Danks of Netherton, each 8 feet diameter by 30 feet long. The steam pressure is 110 lbs. per square inch.

The engine house is provided with an overhead crane and between the quadrants of each engine is a steam winch for dismantling the borehole pumps or for withdrawing the buckets and clacks.

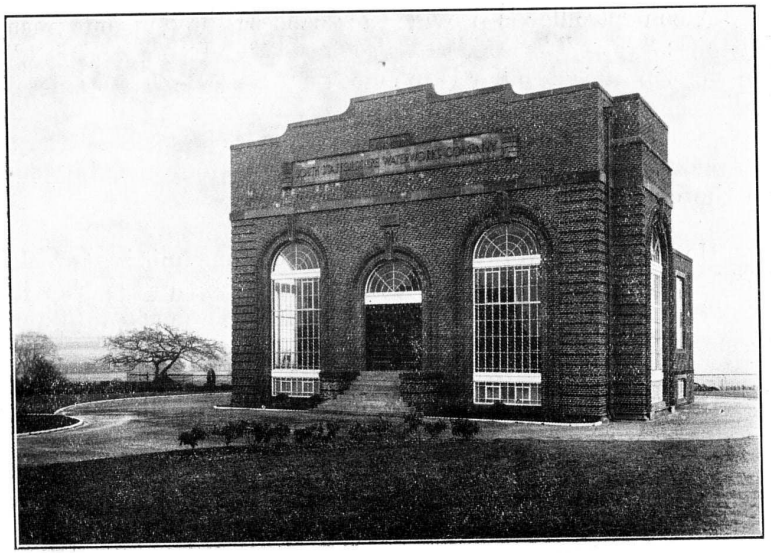
A steam driven generator provides the station lighting and duplicate feed pumps are placed in the boiler house. The workshop and stores are in a separate building adjoining the boiler house, and a cottage for the foreman is also provided in the station grounds.

The coal supplies are discharged on the Company's wharf on the Birmingham Canal Navigation's Wyrley and Essington Branch which runs past the station.

SANDHILLS PUMPING STATION.

The duplicate electrically driven pumping plant was supplied by Messrs. Mather and Platt Ltd., of Manchester, with Messrs. British Thomson Houston Co. Ltd., of Rugby as the Sub-Contractors for the electrical equipment.

The dual power supply is provided by the Lichfield Corporation and is 3 phase, 50 cycles, 11,000 volts, which is transformed down to 400 volts.



The high tension switchgear consists of two incoming feeder panels, meter panel and two outgoing feeder panels, the latter belonging to the Company, and these are connected to the two step-down transformers.

The transformers each have an output of 200 kVA. and are of the oil-immersed self-cooled core type in boiler plate tanks with external cooling tubes.

On the primary side, additional tappings plus or minus $2\frac{1}{2}\%$, 5%, and $7\frac{1}{2}\%$ are provided.

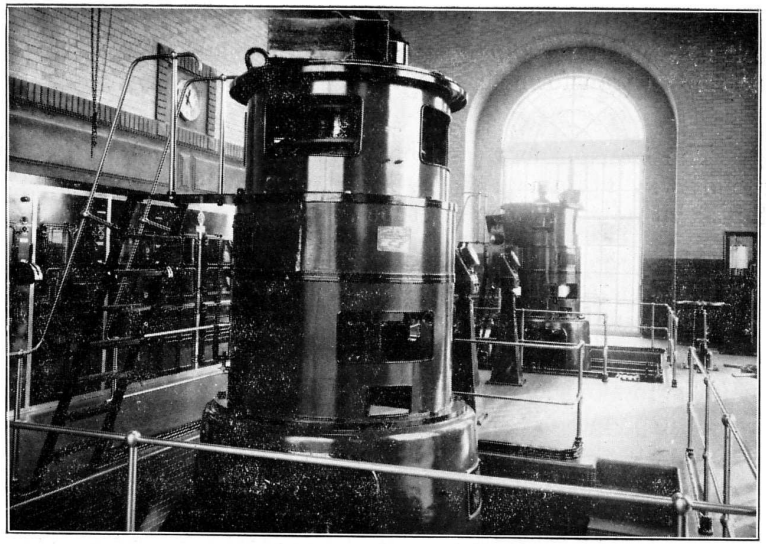
The low tension control gear of the contactor type consists of seven panels of exhibition finish and is made up of two incoming feeder panels, two outgoing pump panels each fitted for remote control, one metering panel, one auxiliary panel, and one earthing panel. By placing these panels under an arch formed in the engine house wall, there is a considerable saving in floor space and they are very accessible.

A control pillar is provided for each set having four push buttons : "Start," " Stop," " Raise Speed," and "Lower Speed." On the top of each pillar is mounted a " Cirscale " tachometer indicating the motor speed. When the power supply is on the L.T. busbars, the appropriate pump switch is closed, after which the pumping unit is entirely controlled by the four push buttons on the control pillar.

Under normal working conditions, only one unit is at work, but in case of emergency the two units are to run together in parallel. Each unit is to be capable of continuously fulfilling either of the following duties :—

A. Delivering a nett quantity of one million gallons per 24 hours with the water level in the borehole 100 feet below pump house floor level and delivering same against a head of 370 feet above floor level including friction to Barr Beacon reservoir.

B. The same duty as "A" but with the water level 250 feet below pump house floor level.



The pump motors are of the vertical spindle drip proof, variable speed, alternating current, commutator type capable of developing continuously 132 B.H.P. at 650 r.p.m. and 200 B.H.P. at 825 r.p.m. The top motor bearings are of the combined radial and thrust type capable of easily sustaining the rotor at all loads, and the bottom bearings are of the radial type.

Each pump consists of a seven-stage centrifugal borehole pump placed approximately 250 feet below floor level and six-stage centrifugal booster pump mounted on the same vertical shaft and placed at basement level, the two pumps working in series.

All the impellers are of bronze of the single inlet type with bronze neckrings and guide passages and cast-iron casings.

The pump shafts are provided with double-coned joints with locknuts and the intermediate shaft bearings are provided with special bronze bushes.

The rising main pipes of steel are fitted with riveted flanges and the intermediate shaft bearings are secured between each pair of flanges.

The shafting rotates in a steel protection tube which is lubricated by means of filtered water taken from the second stage of the booster pump.

The rotating parts of the pumps are carried by a Michell combined thrust and radial bearing, carried in a housing cast in the motor stool. The thrust bearing is provided with an adjustment for locating the impellers in relation to the guide passages.

In addition to the main pump room, there are at the same level, the high tension room, office, lavatory, and workshop. The basement under the pump room is utilised for the cable runs, whilst the basement under the workshop, office, etc., is used for storing oils, spare parts, and tackle required in connection with the plant.

In the station grounds are two cottages occupied by the drivers.

The whole of these Works were carried out to the designs and specifications of the Company's Engineer-in-Chief, Mr. Fred. J. Dixon, M.Inst.C.E., M.I.Mech.E.

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