THE SOUTH STAFFORDSHIRE WATER COMPANY

Preserved Steam Engine

at

Brindley Bank Museum & Pumping Station

Viewing by appointment

The South Staffordshire Waterworks Company, Green Lane, Walsall WS2 7PD.

Telephone: Walsall (0922) 38282. Telex 336358

THE SOUTH STAFFORDSHIRE WATERWORKS COMPANY

PRESERVED STEAM ENGINES

TECHNICAL SERVICES DEPARTMENT
ELECTRICAL/MECHANICAL SECTION

APRIL 1987

M.E.J. LEES B.Sc. (Hons)

INTRODUCTION

The South Staffordshire Waterworks Company

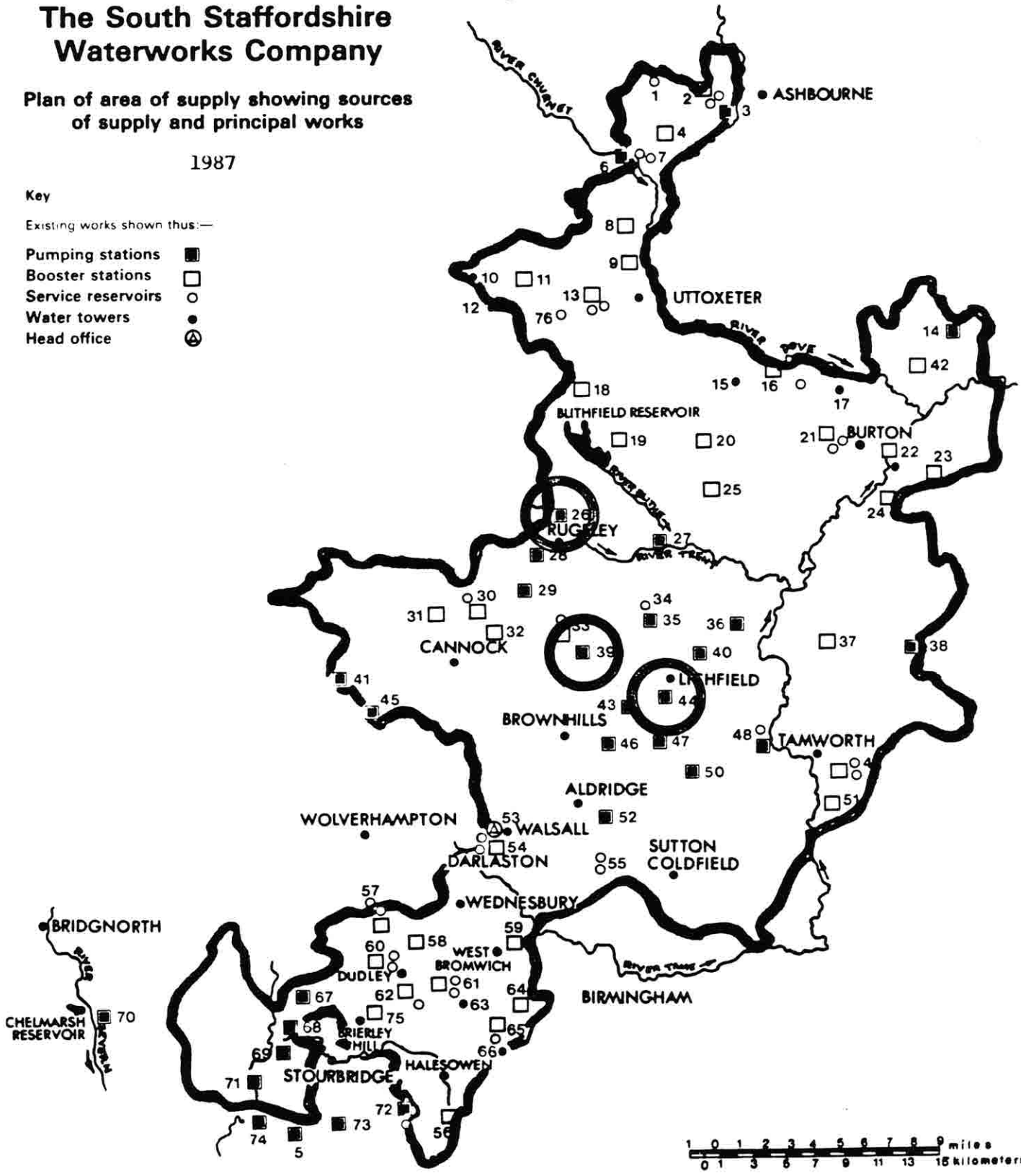
Plan of area of supply showing sources of supply and principal works

1987

Key

Existing works shown thus:—

Pumping stations	■
Booster stations	□
Service reservoirs	○
Water towers	●
Head office	Ⓐ



Based upon the ordnance survey map with the sanction of the Controller of H.M. Stationery Office

INDEX OF PRINCIPAL WORKS

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2 STANTON
3 MAYFIELD
4 ELLASTONE
5 CHURCHILL
6 CRUMPWOOD
7 PRESTWOOD
8 CROXDEN
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10 MORRILOW HEATH
11 DODS LEIGH
12 OVERPARK
13 BRAMSHALL
14 FINDERN
15 HANBURY
16 TUTBURY
17 ROLLESTON
18 KINGSTON
19 HEATLEY GREEN
20 NEWBOROUGH
21 OUTWOODS
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23 BRETBY
24 SAXON ST
25 YOXALL
26 BRINDLEY BANK
27 NETHERTOWN
28 SLITTING MILL
29 MOORS GORSE
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31 LIME PIT LANE
32 WIMBLEBURY
33 GENTLESHAW
34 HANCH
35 SELDY MILL
36 FRADLEY
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39 MAPLE BROOK
40 TRENT VALLEY
41 SOMERFORD
42 BURNASTON
43 PIPE HILL
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47 SHENSTONE
48 HOPWAS
49 GLASCOTE
50 LITTLE HAY
51 TWO GATES
52 BOURNE VALE
53 HEAD OFFICE
54 WALSALL
55 BARR BEACON
56 ROMSLEY
57 SEDGLEY BEACON
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59 WEST BROMWICH
60 SHAVERS END
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62 SPRINGSMIRE
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68 ASHWOOD
69 PRESTWOOD
70 HAMPTON LOADE
71 KINVER
72 HAYLEY GREEN
73 HAGLEY
74 COOKLEY
75 CHAPEL STREET
76 HOLLY GRANGE

PRESERVATION OF OUR INDUSTRIAL HERITAGE

The South Staffordshire Waterworks Company has an excellent record in maintaining its historical buildings, and preserving our industrial heritage. At a number of the Company's operational pumping stations the original buildings, which previously housed steam engine powered pumping plant, have been retained. Three former steam pumping stations have been chosen by the Company for preservation namely, Brindley Bank; which also houses a museum, Maple Brook and Sandfields. At each of these old pumping stations the original steam pumping engines have been preserved in their original settings. The pumping station buildings, which are all excellent examples of the architecture of their period, house three different types of steam engine previously operated by the Company. Brindley Bank, which is an example of a Victorian pumping station, has been established as the Company's museum. In addition to the superb example of a horizontal compound rotative steam pumping engine, the museum has a collection of historical photographs, documents, artefacts and numerous examples of pumping plant machinery. Maple Brook pumping station houses a magnificient example of an inverted triple expansion rotative steam engine, and a splendid example of a cornish beam engine is preserved at the Sandfields site. It is noteworthy that the three preserved pumping stations are all fully operational, with modern pumping plant installed alongside the preserved machinery. Together these preserved pumping stations illustrate the Company's use of steam powered plant over a period lasting nearly 115 years (1858 - 1972).

EARLY HISTORY OF SOUTH STAFFORDSHIRE WATERWORKS COMPANY

The South Staffordshire Waterworks Company was incorporated by Act of Parliament in 1853, and was opened by the first Earl of Dudley; who also turned the first sod for the Company's original works at Lichfield on 22 February 1856. The Company was established to meet the need for a pure and plentiful supply of water in the Black Country area. At that time the Black Country was a densely populated mining and iron working area, which had undergone a period of unprecedented growth. There were abundant natural resources of water, but these had been grossly polluted by neglect, through lack of an organised system of public water supply. The quality of life was very poor, cholera claimed many lives, some churchyards were reportedly overflowing with bodies, and the average life expectancy was only 23 years. The original South Staffordshire Waterworks Company supply to Walsall and the Black Country, was from two impounding reservoirs, Stowe and Minster Pools, located near Lichfield Cathedral. Water gravitated from these two pools, in an addit tunnelled under the City of Lichfield, discharging into a pilot well at Sandfields, the Company's first pumping station, completed in 1858. It was then raised by pumps and delivered to Summit reservoir at Brownhills and thence to the Moat, a reservoir at Walsall, in a 22 inch and 24 inch diameter cast iron, pumping and graviating main, following the route of the Lichfield to Walsall and Dudley railway line. From Walsall it was boosted around the Black Country by individual pumping stations. The original Company offices were situated at Lichfield railway station in 1853.

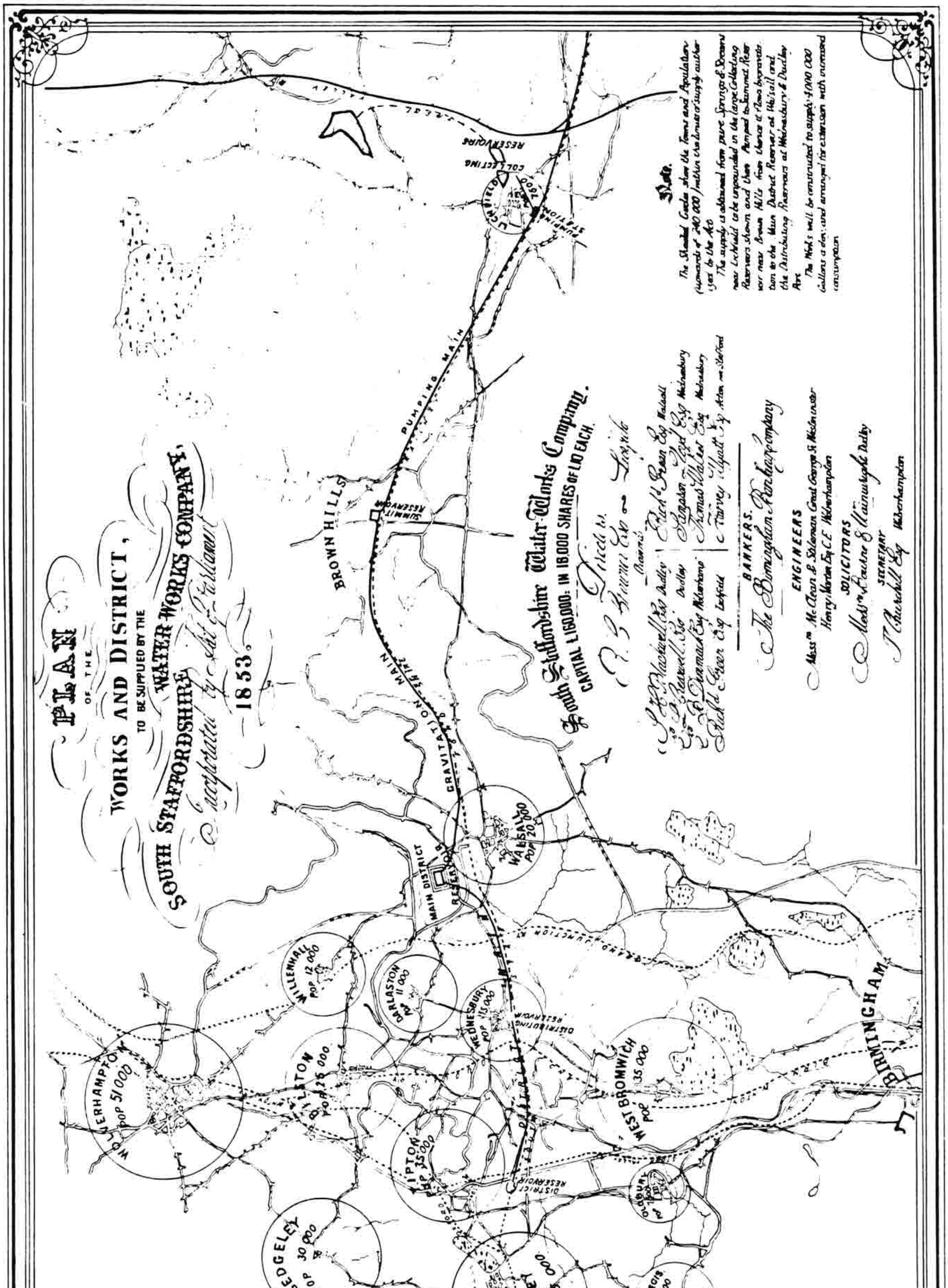
ANNO DECIMO SEXTO & DECIMO SEPTIMO

VICTORIÆ REGINÆ.

Cap. cxxxiii.

An Act for supplying with Water the Inhabitants of *Walsall*, *Dudley*, and other Places in the Southern Parts of the County of *Stafford*, and in certain Parts of the County of *Worcester* adjacent thereto. [4th *August* 1853.]

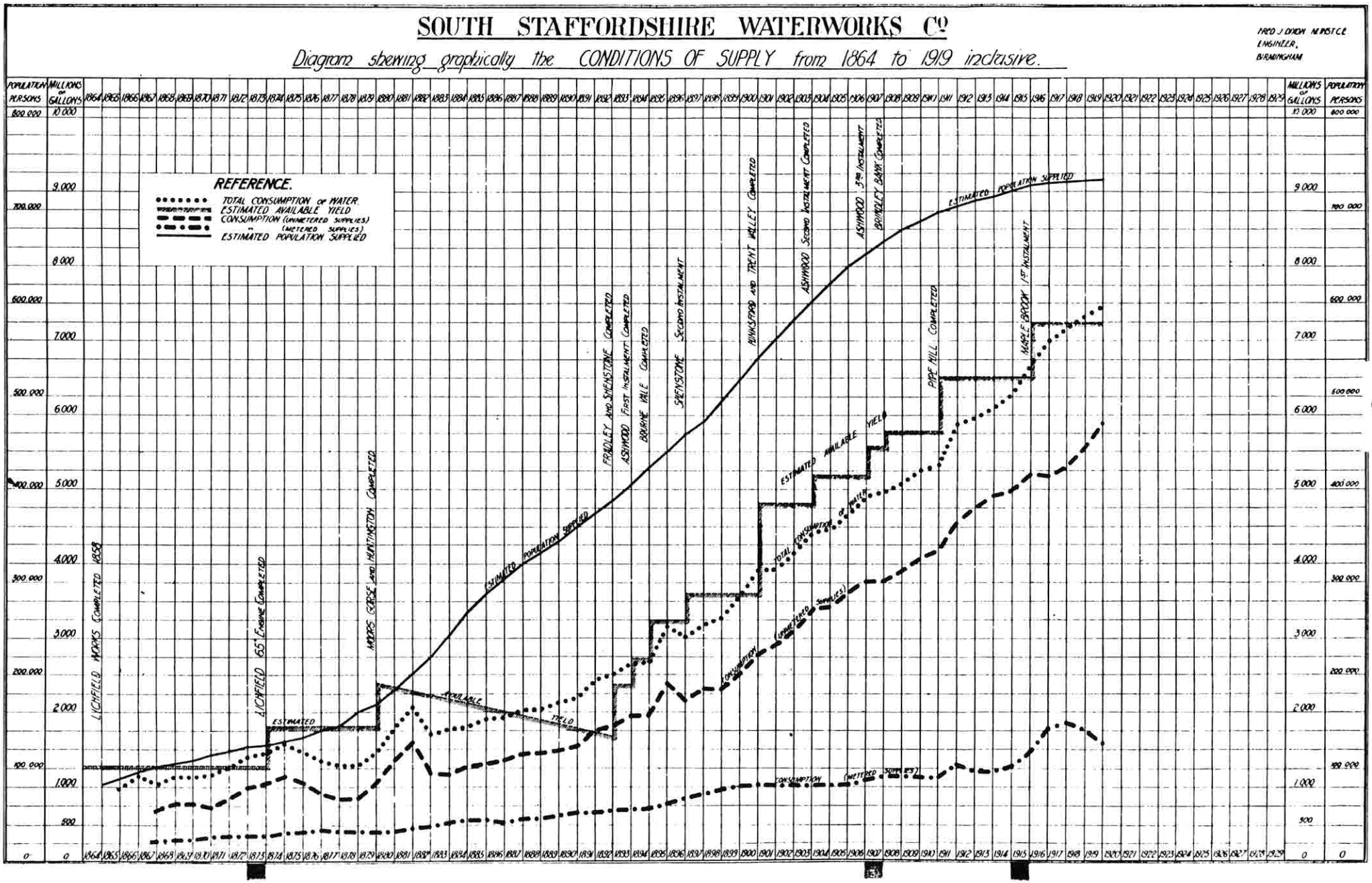
WHEREAS the Inhabitants of the City of *Lichfield*, and of the Boroughs, Parishes, or Places of *Walsall*, *Wednesbury*, *Bilston*, *Darlaston*, *Willenhall*, *Sedgley*, *Tipton*, *West Bromwich*, and *Rowley Regis*, in the County of *Stafford*, and *Dudley* and *Oldbury* in the County of *Worcester*, are not at present sufficiently supplied with Water for domestic, manufacturing, trading, and sanitary Purposes, and it would be of great Advantage to the Inhabitants of such Places if a more ample Supply of pure and wholesome Water were provided: And whereas such a Supply of Water may be obtained from certain Brooks or Streams flowing through the Parishes and Townships herein-after mentioned, and the Construction of Reservoirs and Aqueducts for collecting, impounding, and distributing such Water would be of great public Advantage: And whereas the Parties herein-after named, together with others, are willing to carry the said Undertaking into effect, if authorized by Parliament


PLAN
OF THE
WORKS AND DISTRICT,
TO BE SUPPLIED BY THE
SOUTH STAFFORDSHIRE WATER WORKS COMPANY,
Incorporated by Act of Parliament
1853.
WOLVERHAMPTON POP 51 000
SEDGELEY POP 30 000
BILSTON POP 25 000
WILLENHALL POP 12 000
DARLASTON POP 11 000
TIPTON POP 35 000
WEDNESBURY POP 15 000
DUDLEY POP 35 000
WALSALL POP 20 000
WEST BROMWICH POP 35 000
OLDBURY POP 7 500
ROWLEY REGIS POP 15 000
BIRMINGHAM
BROWN HILLS
MAIN DISTRICT RESERVOIR
SUMMIT RESERVOIR
DISTRICT RESERVOIR
DISTRIBUTING RESERVOIR
GRAVITATION MAIN
PUMPING MAIN
LICHFIELD
PUMPING STATION
COLLECTING RESERVOIRS
South Staffordshire Water-Works Company.
CAPITAL £160,000: IN 16,000 SHARES OF £10 EACH.
Directors.
BANKERS.
The Birmingham Banking Company
ENGINEERS
SOLICITORS
SECRETARY
Note.
The Shaded Circles shew the Towns and Population (upwards of 240 000) within the limits of supply authorised by the Act.
The supply is obtained from pure Springs & Streams near Lichfield to be impounded in the large Collecting Reservoirs shown and then Pumped to Summit Reservoir near Brown Hills from thence it flows by gravitation to the Main District Reservoir at Walsall and the Distributing Reservoirs at Wednesbury & Dudley Port.
The Works will be constructed to supply 4 000 000 Gallons a day; and arranged for extension with increased consumption.

SOUTH STAFFORDSHIRE WATERWORKS Co

Diagram shewing graphically the CONDITIONS OF SUPPLY from 1864 to 1919 inclusive.

FRED J DIXON M.INST.C.E.
ENGINEER,
BIRMINGHAM



STEAM ENGINES FORMERLY OPERATED BY THE SOUTH STAFFORDSHIRE WATERWORKS COMPANY

PUMPING STATION	ENGINE Nr	TRIAL DATE	PUMP hp	INDICATED hp	MECHANICAL EFFICIENCY %	ENGINE DETAILS
ASHWOOD	1	4-5-94	-	69	-	SINGLE ACTING EXPANSION CONDENSING BEAM ENGINE
	2	18-7-02	256.7	309	82.6	HORIZONTAL TANDEM COMPOUND EXPANSION
	3	20-2-07	261.7	310	84.4	SURFACE CONDENSING DIFFERENTIAL ENGINE
BOURNE VALE	1	1-4-98	88.9	111.4	79.8	INVERTED COMPOUND EXPANSION SURFACE
	2	8-5-98	143.9	160.5	89.7	CONDENSING ROTATIVE ENGINE
BRINDLEY BANK	1	31-10-07	155	187	83	HORIZONTAL TANDEM COMPOUND EXPANSION SURFACE CONDENSING ROTATIVE ENGINE
CONEYGRE	1	-	-	-	-	26" DIAMATER HORIZONTAL SINGLE CYLINDER ROTATIVE ENGINE
	2	18-1-97	19.9	30.1	66	
	1	25-4-07	53.3	72	74	HORIZONTAL TANDEM COMPOUND EXPANSION SURFACE CONDENSING ROTATIVE ENGINE
FRADLEY	1	19-2-97	80.7	98.6	81.8	HORIZONTAL TANDEM COMPOUND EXPANSION
	2	5-9-94	64	84	77	SURFACE CONDENSING DIFFERENTIAL ENGINE
HINKSFORD	1	24-6-02	180.5	202.8	89	INVERTED COMPOUND EXPANSION SURFACE
	2	23-6-02	182.5	212.6	85.8	CONDENSING ROTATIVE ENGINE
HOPWAS	1	1881	-	50	-	25" DIAMATER DOUBLE ACTING EXPANSION CONDENSING BEAM ENGINE
	2	1881	-	50	-	
	3	1926	-	-	-	HORIZONTAL TANDEM COMPOUND ROTATIVE ENGINE
HUNTINGTON	1	16-11-94	45	53.6	83.9	66" DIAMATER SINGLE ACTING EXPANSION
	2	22-11-94	45.3	55.4	81.7	CONDENSING BEAM ENGINE
MAPLE BROOK	1	1915	-	223	-	INVERTED TRIPLE EXPANSION SURFACE
	2	1922	-	223	-	CONDENSING ROTATIVE ENGINE
MOORS GORSE	1	7-8-94	64	71	90.2	65" DIAMATER SINGLE ACTING EXPANSION
	2	3-11-98	117.8	129.4	91.7	CONDENSING BEAM ENGINE
PIPE HILL	1	27-10-11	302.7	346.4	87.3	HORIZONTAL TANDEM COMPOUND EXPANSION
	2	-	-	-	-	SURFACE CONDENSING ROTATIVE ENGINE
SANDFIELDS	1	19-11-94	103.5	119	87	46" DIAMATER DOUBLE ACTING EXPANSION CONDENSING BEAM ENGINE
	2	1858	-	-	-	
	3	19-11-94	101.5	123.6	83	
	4	1873	-	190	-	66" DIAMATER SINGLE ACTING EXPANSION CONDENSING BEAM ENGINE
	1	1922	351	243	69.1	HORIZONTAL SINGLE CYLINDER UNIFLOW
	2	1922	387	249	64.3	ENGINE
SHENSTONE	1	7-10-97	133.5	158.3	84.3	HORIZONTAL TANDEM COMPOUND EXPANSION
	2	-	-	-	-	SURFACE CONDENSING DIFFERENTIAL ENGINE
SPRINGSMIRE	1	18-6-02	67.2	91.7	73.4	HORIZONTAL TANDEM COMPOUND EXPANSION
	2	19-6-02	68.3	91	75	SURFACE CONDENSING ROTATIVE ENGINE
	3	16-10-08	147	215.5	68.1	TWO CRANK COMPOUND VERTICAL ENCLOSED HIGH SPEED ENGINE
TRENT VALLEY	1	14-5-02	129.6	164	79	HORIZONTAL TANDEM TRIPLE EXPANSION
	2	12-8-07	190.1	222.1	85.6	SURFACE CONDENSING DIFFERENTIAL ENGINE
WOOD GREEN	1	1871	-	-	-	DOUBLE ACTING EXPANSION CONDENSING BEAM ENGINE
	2	3-3-97	83.1	91.2	91.1	66" DIAMATER SINGLE ACTING EXPANSION
	3	1875	-	-	-	CONDENSING BEAM ENGINE
	4	4-4-13	288.7	306.5	94.2	INVERTED TRIPLE EXPANSION SURFACE CONDENSING ROTATIVE ENGINE

Brindley Bank Museum & Pumping Station

Wolsely Road
Rugeley
Staffordshire

National Grid Reference SK 038194

Engine House Floor Level 253.99 feet A.O.D.

Major Items of Interest

Victorian Pumping Station Engine House	1905
Horizontal, tandem, compound, surface condensing, rotative, steam engine. Hathorn Davey & Co. (Leeds)	1907
Mechanical Sand Filters	1914
Operational Pumping Plant	1969
Company Museum	1974

BRINDLEY BANK MUSEUM & PUMPING STATION

Work commenced on the pumping station in 1902, with the drilling of two boreholes. The boreholes and buildings were completed in 1904 and 1907 respectively, and the pumping station brought into service after commissioning of the steam engine, now preserved, had been completed in January, 1907. Later in 1914, six mechanical sand filters were added to complete the original pumping station works. The original plant was operated by the Company until 1969, when the rising mains, borehole pump components and the steam raising plant were removed, and the present day electric pumping plant installed.

The contractor the the two boreholes was Messrs. Timmins (Runcorn) and the pumping station buildings were constructed by Thomas Lowe & Sons Ltd (Burton On Trent). Messrs Hathorn Davey & Company (Leeds) supplied the steam engine pumping plant and the two boilers. The boilers were constructed locally at Netherton by Messrs H. & T. Danks, and the filtration plant was supplied by Messrs Mather & Platt Ltd (Manchester).

The original steam pumping plant comprised a horizontal tandem, compound, surface condensing, rotative pumping engine, driving two borehole bucket pumps off large bell cranks at the flywheel end of the engine, and a double acting piston type force pump at the other end. The steam engine was capable of running at a speed of 18 rpm and developing 223 hp. This power was sufficient to lift water from a depth of 300 feet in the boreholes, and produce a delivery head of 500 feet on the force pumps, making a total pump lift of 800 feet. Its daily output was approximately 1 million gallons per day whilst running at 14 rpm, and its two boilers consumed 3 tons of coal per day.

The steam engine is fitted with a barring engine which used to be engaged with the engine's flywheel to rotate the engine to the starting position, for the initial admission of steam. A steam powered winch is also mounted at the flywheel end of the engine, this was used in conjunction with the station crane for the removal of the borehole pump components for maintenance and repair. The engine, pumping plant and two boilers originally cost £8478.

Detailed information relating to the Hathorn Davey steam engine may be found in extracts from the original specification, dated May 1904 - Appendix (iii). A copy of a pumping trial, carried out out in October 1907 has been included refer Appendix (ii).

HATHORN DAVEY & Co. STEAM ENGINE DETAILS

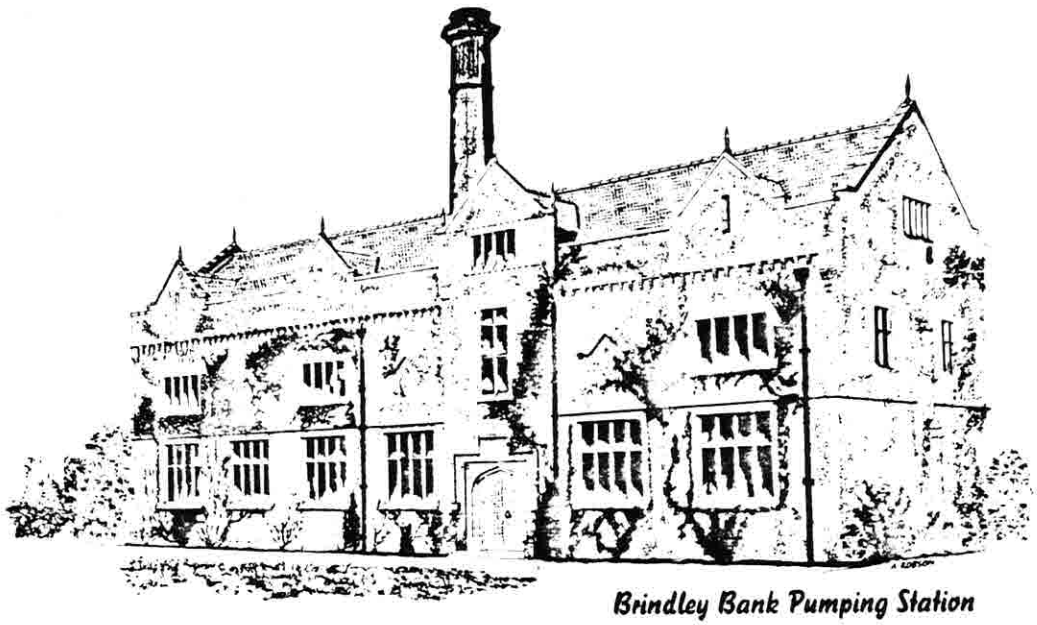
Power	223 hp	Speed rpm	18 revs/min
Size	90 feet 6 inches long x 12 feet wide		
Flywheel 24 feet diameter		Weight	22 tons
High pressure cylinder	28 inches diameter x 5 feet stroke		
Low pressure cylinder	54 inches diameter x 5 feet stroke		
Borehole pumps	12 inches diameter x 5 feet 6 inches stokes		
Force Pump	$12\frac{3}{4}$ inches diameter x 5 feet stroke		

The steam raising plant comprised two Lancashire boilers each 7 feet 6 inches diameter by 30 feet long, they once steamed the engine at a daily working pressure of 100 psi. Part of the old boiler house has been converted into a waterworks museum. The early history of the South Staffordshire Waterworks Company is portrayed by contemporary newspaper articles, reports, maps, drawings and photographs. The museum was formed in 1974, it houses a collection of old waterworks plant and machinery, formerly operated by the Company. This machinery was removed from a number of the Company's pumping stations during the conversion from steam to electric power, a list of the museum items may be found in Appendix (iv). The display of documents and exhibits illustrate the history and technology employed by the Company from 1853 onwards, it also includes copies of documents relating to cholera epidemics in Dudley in the 1850's. Details of early supply schemes, drawings of engines and pumps and items of pumping, monitoring and recording equipment may be viewed.

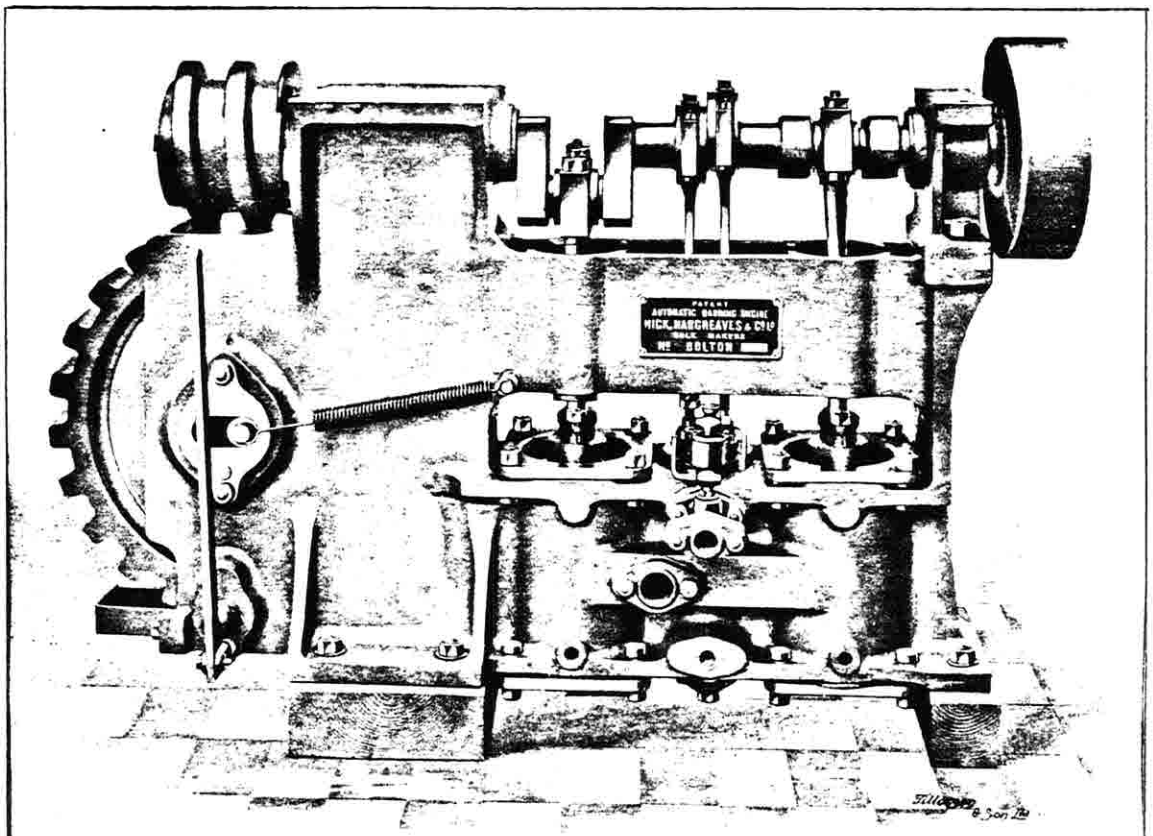
The two boreholes are 511 feet and 514 feet deep reaching the Keuper and Bunter sandstone geological formations, and are 20 feet apart. The terms 'Keuper' and 'Bunter' refer to the period in which geological formations were laid down. Keuper formations are about 190 million years old, whilst Bunter formations are about 200 - 225 million years old. Keuper formations consist of permeable red and white sandstones, Bunter formations consist of coarse textured sandstone and pebbles. Both boreholes are lined with 36 inch solid lining tubes to a depth of 35 feet, and thence one is unlined 30 inch diameter to a depth of 305 feet, and the other is unlined 36 inch diameter to a depth of 119 feet, and 30 inch diameter between 119 feet and 305 feet. Below 305 feet depth both boreholes are 18 inch diameter unlined. The borehole standing water level is 12 feet below Engine House Floor level.

The borehole water was originally passed through the six mechanical filters (in parallel), to remove iron oxide contamination. Each filter has a flow rate capacity of 120,000 gallons per day. Numbers 2, 4 and 6 are fully operational and are used regularly as part of the present day treatment process. The filters contain Leighton Buzzard sand, which is periodically cleaned by means of agitation with mechanical rakes, and backwashing. The rakes are driven by flat belts from line shafting running along one of the pumping station walls. The line shafting is itself powered by a flat belt driven by a water turbine, which derives its power from pressurised water bled from the booster pump delivery.

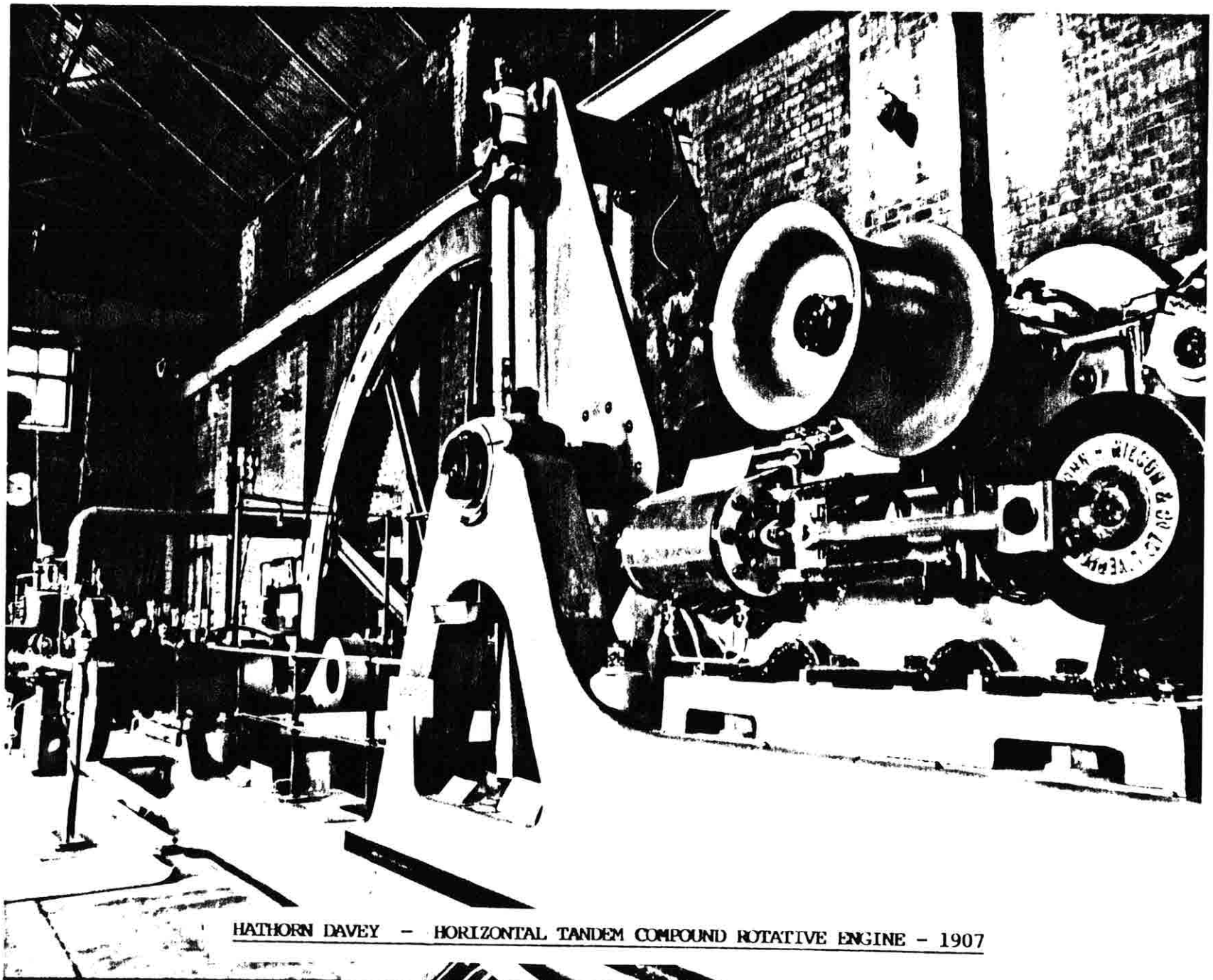
The pumping station was electrified in 1969 at a total cost of £23,000. The two boreholes now contain Sulzer 8 stage submersible pumps driven by 50 hp. (1400 rpm) Hayward Tyler submersible motors, which pump the water through the mechanical filters to an 8000 gallon suction tank. Two Sulzer 6 stage vertical spindle booster pumps, driven by Lawrence Scott and Electromotors Ltd. 9/49 hp. (900/1600 rpm) variable speed motors, take water from the suction tank, and pump the water at 0.48 million gallons per day against a head of 250 feet to supply the Rugeley district. Sterilisation is carried out by the injection of chlorine into the pipework feeding the suction tank and fluoride is added to the water supply after the booster pumps.



Brindley Bank Pumping Station



BARRING ENGINE ARRANGED TO GIVE DOWNWARD THRUST.



HATHORN DAVEY - HORIZONTAL TANDEM COMPOUND ROTATIVE ENGINE - 1907

PATENT STEAM BARRING ENGINE

WITH AUTOMATIC DISENGAGEMENT.

A BARRING ENGINE is a small steam engine for moving a large one, and is now considered a necessary adjunct to every mill or electric power engine of considerable size, being found of great value for the following purposes :—

(1). Moving the engine round slowly before starting, allowing all parts to be uniformly warmed up, thus avoiding straining from unequal expansion.

(2). Moving the engine for setting valves, examining pistons and air pumps, and other similar purposes.

(3). Putting on or repairing driving belts or ropes out of working hours.

The engine described in this circular is claimed to be the most convenient one in the market, and the only one which is entirely automatic as regards disengagement, and absolutely free from a dangerous liability to jam when the main engine moves. It is also both sightly and compact. In addition to supplying one of these engines with practically every main engine turned out by them for some years past, Messrs. Hick, Hargreaves & Co. have supplied large numbers to other engine builders for application to engines of their make. The details of these Barring Engines have recently been overhauled and standardized, a special improvement being that they are now made with duplicate carrying brackets, so as to be suited for erection in either of the two positions shown in the illustrations given herewith, giving, when placed with the cylinders below, a downward thrust, and with the cylinders above, an upward one. The only parts of the engine requiring to be varied, to suit the two positions, are the oil dish under the worm or wheel respectively, and the various lubricators and oil holes. To enable these engines to be sold at a reasonable price, they are built in quantity for stock, only requiring completion as regards lubricators, worm and wheel and bed plate, and they can usually be supplied in about two weeks from date of order.

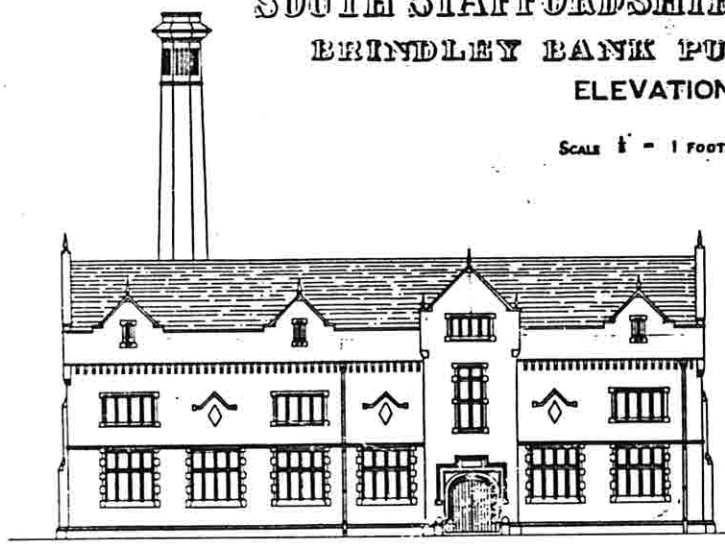
PRINCIPLE of ACTION.—The Barring Engine being started by turning on steam, the worm and worm-wheel at first revolve without the latter engaging with the teeth in the fly wheel. On pressing the lever shown in the illustration, the side of the worm wheel away from the worm is held by friction, and the worm pushes the worm wheel into contact with the teeth of the fly wheel, when it at once commences to drive the latter, the driving force, coupled with the thrust of the worm, keeping it in gear so long as the Barring Engine is the driver. The moment the main engine becomes the driver, the worm wheel turns on the worm as a fulcrum, and moves out of gear, two light springs, shown in the illustrations, retaining it in this position. It will be noticed that quite apart from the action of these springs, it is impossible for the worm to engage with the teeth of the moving fly wheel, as the moment the worm wheel came in contact with the latter it would be pushed back again. In practice the ordinary method is to turn the main engine slowly by means of the Barring Engine for warming up, and when starting-time comes, to give the main engine steam before stopping the Barring Engine. The latter, after being thrown out of gear in the manner described above, does not run at an excessive speed, owing to the steam ports in the cylinders being purposely made of too contracted an area to allow of this.

SOUTH STAFFORDSHIRE WATERWORKS Cº

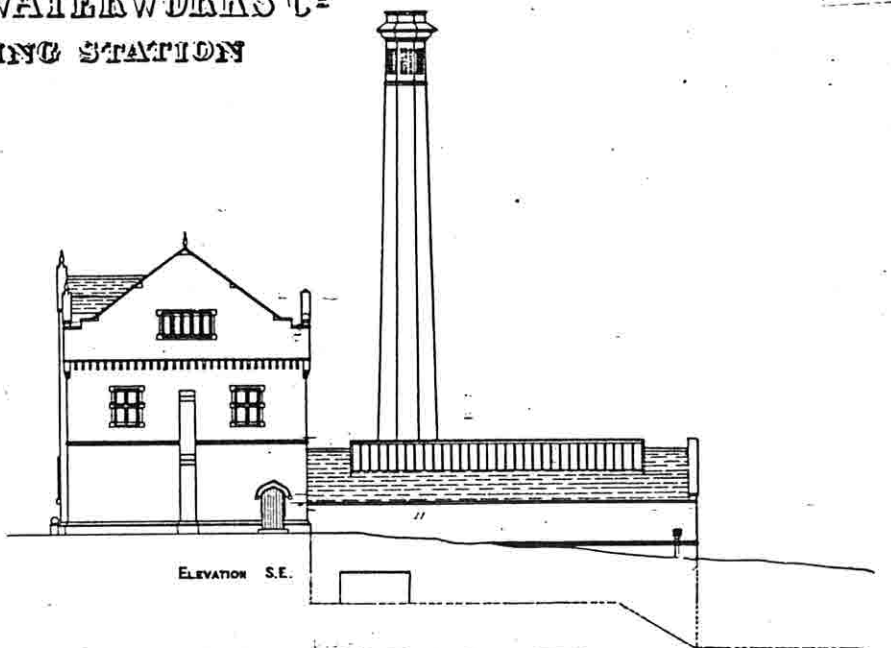
BRINDLEY BANK PUMPING STATION

ELEVATIONS

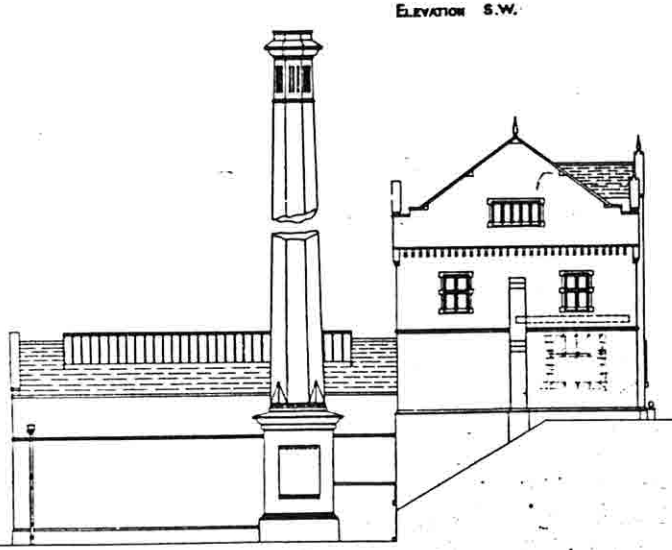
SCALE 1' = 1 FOOT.



ELEVATION S.W.



ELEVATION S.E.



ELEVATION N.W.

ELEVATION N.E.

C.E.D. 201/414.A.

-7-

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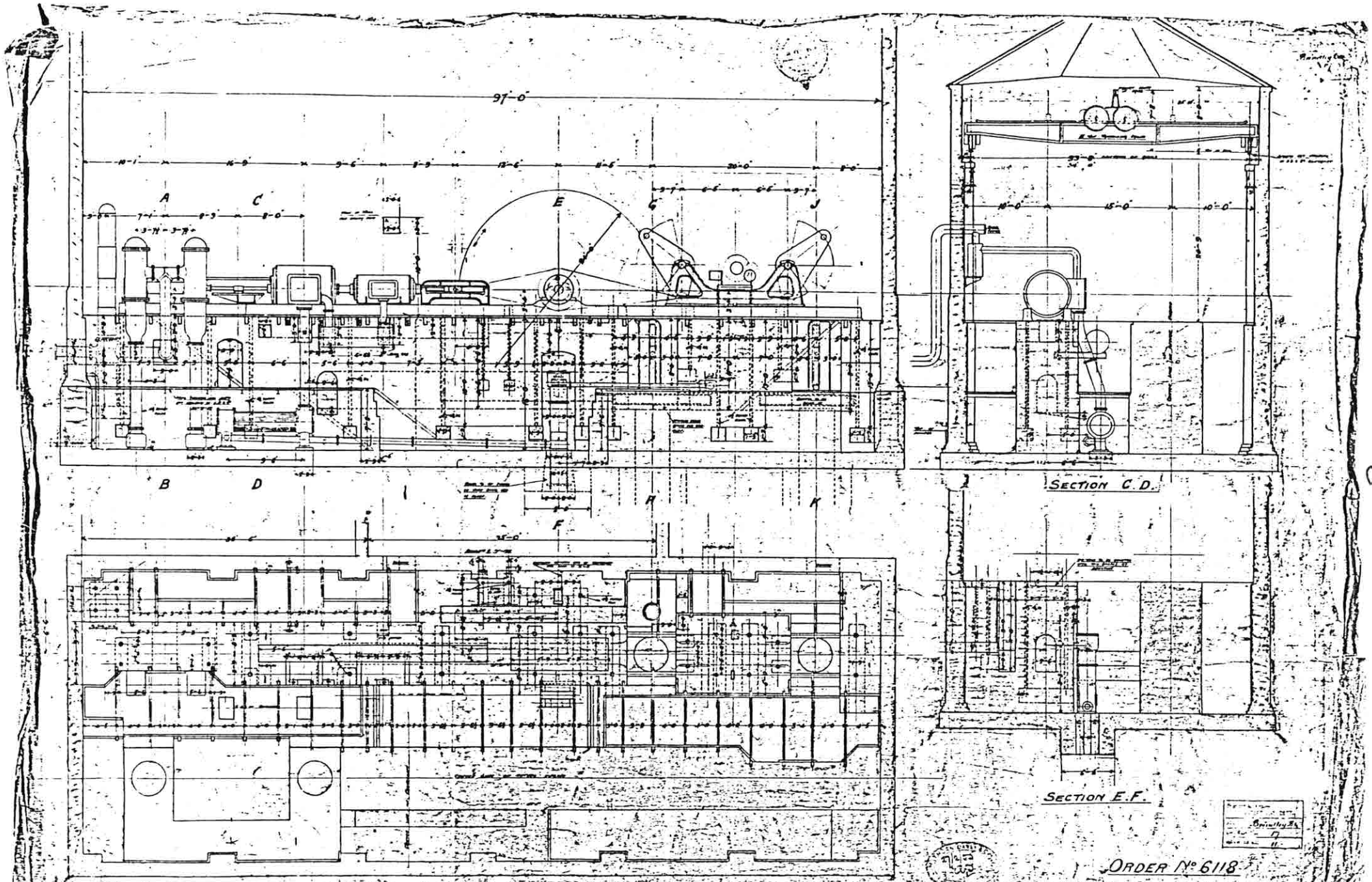


ORDER Nº 6118

BRINDLEY BANK PUMPING STATION

C.E.D. 201/401A

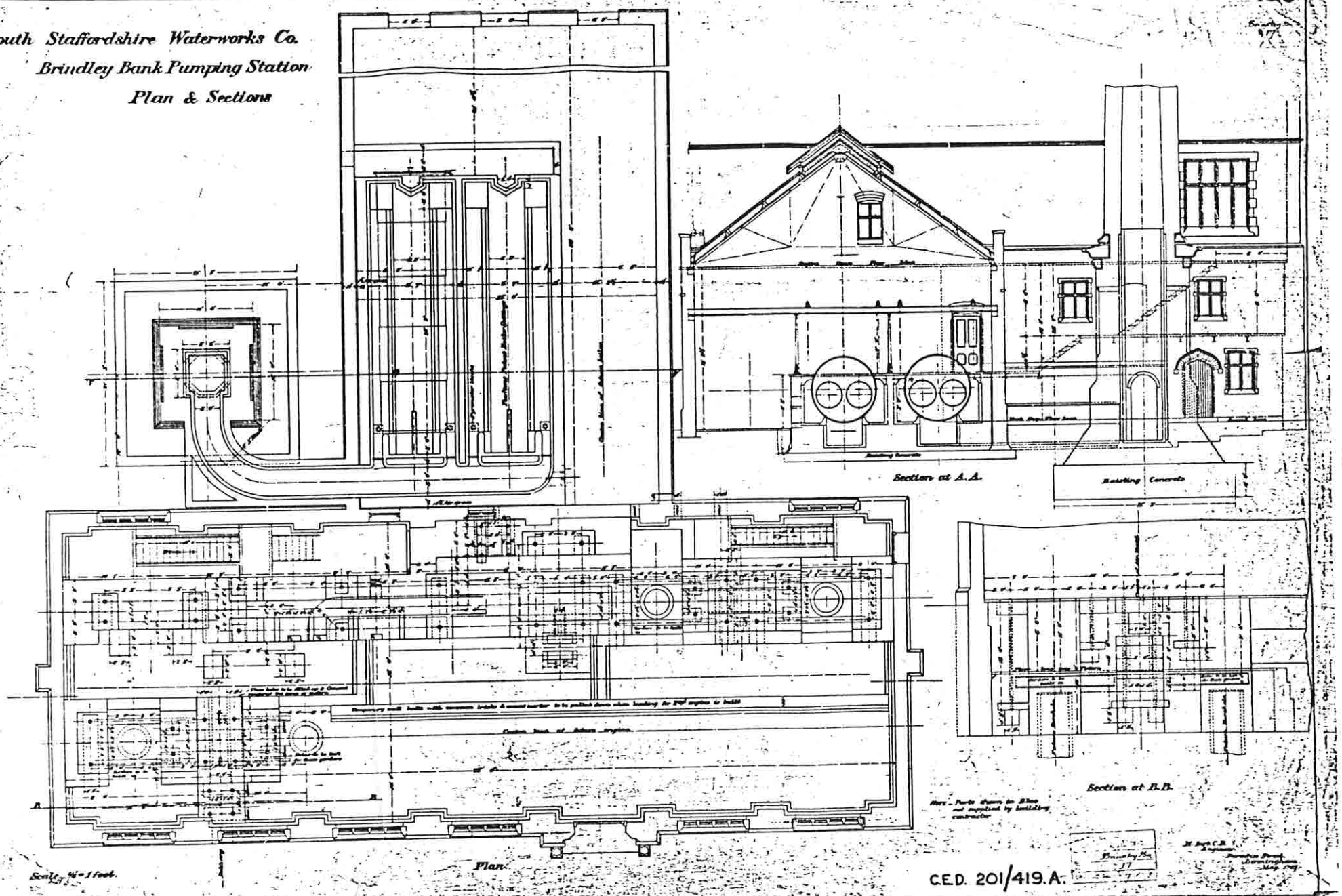
DRAWING Nº 4035

FOUNDATION PLAN

South Staffordshire Waterworks Co.

Brindley Bank Pumping Station

Plan & Sections



C.E.D. 201/419.A.

-9-

APPENDIX (i)

BRINDLEY BANK PUMPING STATION

SUMMARY OF COSTS 1902 - 1914

		£. s. d.	£. s. d.
LAND:	SITE OF PUMPING STATION Agreement No.64.August 1902. Perpetual lease.Area 3a.1r.17½p. at rental of £36.per annum. Possession rights.	520. 0. 0.	
	Law charges.	517. 10. 9.	1037. 10. 9.
BOREHOLES:	Nos. 1 & 2 Boreholes by E. Timmins & Sons Ltd.	2334. 18. 4.	
	Test Pumping	367. 17. 5.	2702. 15. 9.
	Contract signed. Dec. 1st. 1902 Completed. Dec. 22nd. 1904		
PLANT:	No. 1 Engine horizontal compound & Pumps 2 Lancashire Boilers & Overhead Crane.		8478. 18. 9.
	Contract signed. Aug. 25th 1904 Completed. January 1908 Pumping Commenced January 1907		
BUILDINGS:	Engine House, Boiler House & Stack by Messrs. Thos. Lowe & Sons Ltd.	5740. 0. 0.	
	Foremans Cottage	410. 0. 0.	
	Sundry Charges	76. 3. 4.	
	Contract signed. June 29th 1905 Completed. October 1907		
CANAL WHARF:	Payment to the North Stafford Railway Company.	105. 13. 6.	
TRAMWAYS:	Messrs. Koppel	56. 7. 10.	
FENCING, GATES ETC:	Messrs. Hill & Smith and sundries	240. 14. 11.	
	Site work and sundry charges	937. 9. 9.	7566. 9. 4.
	COST OF BUILDINGS ETC.		19785. 14. 7.
MAIN:	18" Cast Iron main Brindley Bank to Moors Gorse. Stanton Ironworks for pipes, laying by George Law & Son and sundry charges.		10449. 18. 3.
	TOTAL COST OF PUMPING STATION & MAIN		£ 30235. 12. 10.
PRESSURE FILTERS:	Installation of 6 pressure filters capacity 750,000 gallons per 24 hours by Messrs. Mather & Platt. May 1914 including reconstruction costs.		£ 3110. 19. 1.

For Enclosure to
H. Ashton Hill Esq.

The South Staffordshire Water Works Co

Brindley Bank Pumping Station

Test of No 1 Engine

Trial made Oct 31st/07

Type of Engine :– Horizontal Compound Tandem Surface Condensing Rotative Pumping Engine.

Dimensions of Engine :– Cylinders 28" and 54" diam x 5'–0" stroke.
Double Acting Force Pump 12¾"diam x 5'–0" stroke.
Two Bucket Pumps each 12" diam x 5'–6" stroke.

Service :– The engine is required for pumping water from two boreholes 20 feet apart which will be 300 feet from the surface. The pumps are to be put down to this depth and the engine to be capable of lifting from 300 feet but allow in ordinary work for a lift of 250 feet in the boreholes and a head of 550 feet or 238 lbs pressure in the delivery main or a total lift of 800 feet including friction. The engine and pumps to be of such size and power as to ensure the delivery with the engine running at 14 revolutions per minute of a net quantity after allowing 5% for slip of not less than 1 million gallons of water in every 24 hours into the delivery main.

Duty :– We guarantee a duty of not less than 100,000,000 foot lbs with a lift of 250 feet in the boreholes on each 1120 lbs of steam discharged from the air pumps and jackets. The water pumped to be ascertained by the displacement of the pumps multiplied by the number of revolutions. The guaranteed duty to be performed on a trial of 24 hours duration.

Particulars of the Trial	12 hour Test
Steam Pressure at Engine	98 lbs □"
Steam Pressure in Receiver Jacket	98 lbs □"
Steam Pressure in L.P. Jacket	30 lbs □"
Vacuum in Condenser	27.8
Total number of revolutions in 12 hours	9314
Number of revolutions per minute	12.93
Point of cut off in H.P. Cylinder	.25
Point of cut off in L.P. Cylinder	.4
Indicated Horse Power in H.P. Cylinder	86
Indicated Horse Power in L.P. Cylinder	100.82
Total Indicated Horse Power of Engine	186.82
Actual lift of Borehole Pumps in feet	234.55
Horse Power of Borehole Pumps	49.57
Delivery Pressure of Force Pumps in lbs per square inch	221.34
Horse Power of Force pumps	105.28
Total Horse Power of Pumps	154.85
Mechanical Efficiency of Engine and Pumps $\frac{\text{P.H.P.}}{\text{I.H.P.}}$	82.88%
Total number of gallons pumped in 12 hours	488,146.7
Number of gallons pumped per hour	40,678.89
Air Pump discharge in 12 hours	27860 lbs
Temperature of Air Pump Discharge	107°F
Cylinder Jacket Drains in 12 hours	3624 lbs
Temperature of Cylinder Jacket Drains	170°F
Receiver Jacket Drains in 12 hours	1108 lbs
Temperature of Receiver Jacket Drains	
Seperator Drains in 12 hours	252 lbs
Total steam consumption in 12 hours	32,592 lbs
Jacket steam per cent of total steam	14.51%
Steam used per hour	2,716 lbs
Coal burnt in 12 hours	5712 lbs
Coal burnt per hour	476 lbs
Water evaporated per lb of coal	5.7 lbs
Steam used per Indicated Horse Power per hour	14.53 lbs
Steam used per Pump Horse Power per hour	17.53 lbs
Coal used per Indicated Horse Power per hour	2.54 lbs
Coal used per Pump Horse Power per hour	3.07 lbs
Duty of 1120 lbs of steam	126,500,000 ft lbs

RECONSTRUCTION

SOUTH STAFFORDSHIRE WATER WORKS COMPANY.

BRINDLEY BANK PUMPING STATION,

Near RUGELEY.

Specification of Work to be done in the manufacture, delivery, and erection of a Steam Engine, Pumps, and Boilers.

H. ASHTON HILL, M. Inst. C.E.,
Engineer.

The Water Works,
Paradise Street, Birmingham,
May, 1904.

BIRMINGHAM:
Hudson & Son, Printers, Edmund Street & Livery Street.

SOUTH STAFFORDSHIRE WATER WORKS COMPANY.

General Conditions and Stipulations

OF

ENGINE, PUMPS, & BOILERS FOR BRINDLEY BANK.

HEADINGS TO CLAUSES.

SPECIFICATION FOR ENGINE AND PUMPS.

HEADINGS TO CLAUSES.

1. CYLINDERS.
2. CYLINDER COVERS.
3. PISTONS.
4. PISTON ROD.
5. PISTON ROD PACKINGS.
6. VALVES.
7. VALVE GEAR.
8. STEAM CHEST COVERS.
9. STEAM PIPES.
10. NON-CONDUCTING COMPOSITION.
11. LAGGING.
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13. MAIN CROSSHEAD.
14. CONDENSER.
15. AIR PUMP.
16. CRANK SHAFT PEDESTALS.
17. CRANK SHAFT.
18. SEPARATOR.
19. FLYWHEEL.
20. BOREHOLE PUMPS.
21. SUCTION PIPES AND RISING MAINS.
22. PUMP CONNECTING RODS.
23. PUMP CROSSHEADS.
24. PUMP GIRDERS AND PLUMMER BLOCKS.
25. COMPENSATING LEVERS.
26. CONNECTING RODS.
27. FORCE PUMP.
28. AIR VESSEL.
29. TESTING.
30. DONKEY FEED PUMP AND CISTERN.
31. MAIN BRAKE.
32. TRAVELLING CRANE.
33. STEAM WINCH.
34. RELIEF VALVE.
35. STAIRS AND LADDERS.
36. FLOOR BEAMS AND CHEQUERED PLATES.
37. HAND-RAILING AND STANCHIONS.
38. SPARES.
39. FITTINGS.
40. EXPANSION PIPES.
41. PAINTING.

SPECIFICATION FOR BOILERS.

HEADINGS TO CLAUSES.

1 DIMENSIONS.

2 CONTRACTOR TO SUPPLY WORKING DRAWINGS.

3 MATERIAL AND TEST OF PLATES.

4 TEST STRIPS.

5 SHELLS.

6 FLUES.

7 ENDS.

8 MANHOLES.

9 STAND PIPES.

10 FOOT PLATES.

11 FEED PIPES.

12 RIVETTING.

13 PLANING AND TURNING.

14 FITTINGS AND MOUNTINGS.

15 GENERAL.

BRINDLEY BANK ENGINE, PUMPS AND BOILERS.

Specification of Work to be done, and Materials used in making, erecting, and setting to work an Engine, Pumps, and Boilers, for the South Staffordshire Water Works Company, at Brindley Bank, near Rugeley.

H. ASHTON HILL, M.Inst.C.E.,
Paradise Street, Birmingham,
Engineer.

General Conditions and Stipulations.

TENDERS.

1 The Directors of this Company invite Tenders for the construction, erection, and setting to work and keeping at work in thorough order and repair, for six months after completion of contract, an Engine, with Pumps, Air Vessel and Boilers complete.

SITE.

2 The site upon which the Engine, Pumps, Boilers, etc., are to be erected is at Brindley Bank, about one-and-a-half miles, along the Stafford Road, from the Passenger and Goods Station of the London and North Western Railway Company at Rugeley, Trent Valley (main line Liverpool and London).

The Trent and Mersey Canal passes the site.

CLASS OF MACHINERY.

3 The whole of the Machinery and parts thereof must be of the newest and most approved patterns, such parts being polished as is usual with highly finished Waterworks Pumping Machinery. All parts not polished to be finished in a workmanlike and careful manner. The workmanship throughout to be only of the first class. The foregoing and following general conditions to be embodied in the terms of the contract.

DESIGN.

4 Tenders must be accompanied by designs to a scale of not less than a quarter of an inch to a foot, together with a more detailed specification of Engine, Boilers, etc., with sizes of Cylinders, Pumps, Pipes and Fittings.

DRAWINGS.

5 The Contractor whose Tender is accepted must submit all the detail drawings of the Engine, Pumps, Steam Winch, Crane. Boilers, etc., for the Engineer's approval before proceeding with the work, and also drawings, showing particulars of the foundations required for the Engine, Pumps, etc., with details of all openings and holes required, so that the buildings can at once be commenced, and so as to render unnecessary any subsequent alterations or pulling down; any such alteration to be carried out at the Contractor's expense.

After the Engine, Pumps, Boilers, etc., have been started the Contractor must provide a complete set of coloured mounted drawings for the Company's use, including a general arrangement of all the machinery, to a scale of not less than a quarter of an inch to the foot, showing Pipes, Fittings, etc.

DESCRIPTION OF ENGINE.

6 The Engine is to be of the horizontal, tandem, compound, surface-condensing, rotative type. The double-acting Force Pump is to be situated behind the L.P. cylinder; the L.P. cylinder behind the H.P. cylinder; the crank shaft carrying the flywheel between the borehole pumps and the H.P. cylinder, and the two single-acting borehole pumps to be worked by means of rocking compensating levers actuated through a connecting rod, either (1) by the engine crank, (2) by the engine connecting rod (the head being specially lengthened for the purpose), or (3) by other approved method.

The flywheel is to be on the wall, or left-hand side of the engine looking from the cylinders, the H.P. cylinder valve chest, condenser, air pump, etc., to be on the right-hand side.

The water from the boreholes will pass through a culvert in the middle of the engine foundations to the condenser cistern, near the force pump.

Each borehole pump and rising main is to be suspended from the surface on a vertical cast-iron cylinder, already fixed, which is 3 feet internal diameter, and has a top flange of 4 feet diameter; the engine-house floor level is to be 10 feet above this top flange.

The boreholes are to be roofed over in the same building with the engine.

CASTINGS GENERALLY.

7 The iron and gun-metal castings are to be run solid, free from sand, air holes, and other defects and blemishes, and to be neat, clean, smooth, and true.

WORK REQUIRED OF ENGINE.

8 The Engine is required for pumping water from two boreholes 20 feet apart, which will be 300 feet or thereabouts from the surface of the ground. The pumps are to be put down to this depth, and the engine to be capable of lifting from 300 feet, but allow in ordinary work for a lift of 250 feet in the boreholes, and a head of 550 feet, or 238lbs. pressure, in the delivery main; or a total of 800 feet, including friction.

POWER OF ENGINE.

9 The Engine and Pumps are to be of such size and power as to ensure the delivery, with the engine running at 14 revolutions per minute, of a net quantity after allowing 5% for slip, of not less than 1,000,000 gallons in every 24 hours into the delivery main; the Engine, however, is to be capable of running smoothly at 18 revolutions per minute, and pumping a correspondingly larger quantity of water.

DUTY OF ENGINE.

10 The work specified above is to be performed with a steam pressure at the boilers of 100lbs. per square inch above the atmosphere.

The Contractor must state in the detailed specification the duty he will guarantee with a lift of 250 feet in the boreholes on each 1,120lbs. of water discharged from the air-pumps and jackets; the water pumped to be ascertained by the displacement of the pumps multiplied by the number of strokes. The guaranteed duty must be performed on a 24 hours' trial, conducted by the Contractor, to the satisfaction of the Engineer, the Water Works Company providing fuel and finding men to work the Engine.

EXTENT OF CONTRACT.

11 The Contract to include all machinery, piping, and ironwork generally within the Engine and Boiler Houses andwithin the Boreholes. The foundations, masonry, brickwork, and other builders' work will be done by the Company.

FUTURE EXTENSIONS.

12 The Buildings will be so proportioned as to allow a second Engine and Pumps (to be used as a stand-by) to be put in conveniently and without unnecessary alterations at some future time in parallel with the first Engine. This second Engine will have its flywheel on the wall side and its H.P. cylinder, valve chest, condenser and air-pump in the middle of the house, like the first Engine ; its borehole pumps will be at the opposite or force pump end of the first Engine.

TIME FOR COMPLETION.

13 The Contractor must specify the earliest date at which he can deliver, erect, and start the Engine.

WORKING OF ENGINE.

14 The Contractor shall, at his own expense, provide and pay an experienced man to take charge of, and work the Engine, Pumps, and Boilers for a term of six months after the same shall have been set to work to the satisfaction of the Engineer, but during such term the Company will provide such additional labour as may be required, together with fuel and stores. All damage done to Engine, Pumps, and Boilers during that period, from whatsoever cause, must be made good by the Contractor.

ALTERATIONS FROM PLANS.

15 The Contractor shall in no case alter or make any difference in the plans first agreed on without the approval of the Water Works Engineer made in writing, and no extra charge shall be payable to the Contractor by the Water Works Company unless the Contractor can produce vouchers signed by the Engineer and dated at the time the order was given, and stating the amount agreed to be paid.

PENALTY.

16 The Contractor whose tender is accepted must distinctly understand that a penalty of £10 (ten pounds) per day will be strictly enforced for every day taken in completing the work beyond the time for which the contract is accepted.

DELAY.

17 Any delay arising from causes over which the Contractor has no control must be at once notified in writing to the Company's Engineer, and continued each week so long as the delay continues ; and upon satisfactory enquiry, such time lost shall be added to the time stated for the completion of the Contract.

PAYMENTS.

18 Payments to be upon the certificate of the Water Works Company's Engineer as follows :—Fifty per cent. of the Contract amount when work to that value has been delivered on the ground ; thirty per cent. more when the whole of the work included in

the Contract has been delivered ; and ten per cent. when the Engine has been started and kept at work for one month to the satisfaction of the Water Works Company's Engineer. The balance to be paid at the end of six months from the satisfactory starting of the Engine and Pumps.

CONTINGENCIES.

19 Provide the sum of £500 (five hundred pounds) to be used only on extras ordered by the Engineer, which will be used or deducted at the Engineer's discretion.

SPECIFICATION FOR ENGINE AND PUMPS.

CYLINDERS

1 The H.P. and L.P Cylinders are to be suitably proportioned to perform the work required of them at the steam pressure and piston speed specified, having regard to the desirability of keeping the variation of temperature in each cylinder the same, and of dividing the work equally between them.

They are to be cast of hard, close-grained cylinder metal, and each fitted with a hard cast-iron liner, free from all defects. The spaces between liners and cylinder bodies are to be used as steam jackets, and must be steam tight when jointed up.

The boring is to be true and parallel, the liner bell-mouthed, and the necessary machining for the various covers, pipes, fittings, etc., to be done. Cylinder drains to be led to condenser, jacket drains into feed tank, and connections for indicator cocks to be conveniently placed. Lagging to be of planished steel.

CYLINDER COVERS.

2 To be of cast-iron, steam jacketted, strongly ribbed, machined on faces and edges, and bored to receive United States patent metallic packings. They are to be designed to give the minimum amount of clearance, and the back L.P. cylinder cover is to be prepared to receive force pump stay. To be lagged with planished steel and finished bright.

PISTONS.

3 To be of cast-iron, cast light and extra deep, so as to give a large wearing surface, and to be provided with Mather & Platt's packing rings and springs, the rings to be carefully tongued to keep them perfectly steam tight.

The junk rings are to be secured with steel screws, screwing into gun-metal bushes in the body of the piston, copper washers to be supplied.

PISTON ROD.

4 To be of mild forged steel, machined all over, in two parts, joined together with a suitable coupling and cotters between the force pump and L.P. cylinder, and properly secured in its pistons and crosshead by deep nuts and suitable lockings.

PISTON ROD PACKINGS.

5 The piston rod at the H.P. and L.P. cylinders to be packed with United States patent metallic packing.

VALVES.

6 To be of the slide type, each cylinder to be fitted with separate Meyer's expansion valves, working on the back of the main valves. A hand-wheel to be provided at each cylinder for regulating the cut-off while the Engine is in motion, and an index to be fitted working along a graduated scale so that the exact point of cut-off can be readily seen. The valves to be designed for a wide variation in cut-off.

VALVE GEAR.

7 The slide valves are to be actuated by eccentrics from the crank shaft. All working parts to have large and ample surfaces, and all joint pins to be carefully case-hardened. The valve spindles to work in ordinary stuffing boxes, with gun-metal glands and bushes.

All parts in prominent positions to be bright.

STEAM CHEST COVERS.

8 To be of cast-iron, strongly ribbed and machined on faces and edges. To be lagged with planished sheet steel, and to be supplied with suitable eye bolts for lifting.

STEAM PIPES.

9 Provide the necessary steam pipes to connect Engine to the Boilers. These pipes to be large enough to supply steam for two engines working together, and to be so designed as to drain themselves well and avoid liability to water hammering. Flanges to be turned and bolt holes drilled to template.

NON-CONDUCTING COMPOSITION.

10 Steam pipes, cylinders, steam chests, boilers, and feed pipes to be covered with Bell's asbestos—best quality—non-conducting composition two inches thick, to be obtained from Messrs. Bell & Co., 19 Summer Row, Birmingham, and to be laid by their workmen. The Boilers only to be finished off with Bell's special "Set Hard." The surface of the composition on the boilers, steam and feed pipes to be perfectly smooth, and to be painted three coats in marone enamel.

LAGGING.

11 In the Boiler house all the pipe flanges are to be covered with boxes of planished steel or galvanized iron, lined with asbestos. The steam pipes in Engine house, cylinders, and steam chests to be neatly lagged with planished sheet steel, secured with planished bands and screws.

BED PLATES.

12 The cylinders and force pump to be mounted on strong cast-iron Bed Plates, cast in convenient lengths, machined, and securely bolted together. A sufficient number of turned bolts and keys to be provided. To be planed to receive cylinders, force pump, shoe guide, etc.

MAIN CROSSHEAD.

13 To be of handsome appearance. Shoe guide to have ample working surface and provision to compensate for wear; to be properly bedded in slides.

CONDENSER.

14 To be of the open surface type, consisting of a sufficient number of solid-drawn brass tubes, to give the necessary cooling surface, expanded into rolled brass tube plates; the latter to be bolted to cast-iron end boxes provided with properly ribbed covers having means for lifting. Fit an injection pipe and spray nozzle to be controlled by a valve worked from the platform immediately above the Condenser.

The Condenser will sit in a brick cistern into which the water, coming from the boreholes through the culvert, will flow, and from which the force pumps will draw.

Provision for receiving cylinder drains to be made on the exhaust pipe.

Provide a cock for shutting off drain pipes close to Condenser.

Condenser to be tested to 20 lbs. per square inch.

AIR PUMP.

15 To be single acting and of ample capacity, and to be worked by a special crank at the end of eccentric shaft.

The working barrel to be of cast-iron, machined to receive valves, fitted with gun-metal liner, bored true and parallel and bell mouthed; bucket, valve seatings, and guards to be of gun-metal. The bucket-rod, studs, and nuts to be of Muntz metal. The bucket is to be packed with gasket, and the groove for this purpose to be extra wide. The bucket-rod is to be properly guided, and the connecting rod is to have suitable arrangement for compensating for wear at both ends. The valves of the bucket to be of the disc type of best rubber. Provide necessary fittings.

Pipes to be supplied to carry the discharge from the Air Pump to two open filters (supplied by the Water Works Company) outside the buildings, and also pipes from these filters to the feed tank in the boiler house. Provide valves or other arrangement so that the discharge may be passed through either of the filters while the other is being cleaned.

CRANK SHAFT PEDESTALS.

16 Crank Pedestals, of cast-iron, to be fitted with gun-metal steps adjustable in a horizontal and vertical direction. Outer pedestal to have bottom step of gun-metal, and to be supported on a substantial cast-iron sole-plate firmly bolted to foundations. Pedestals for eccentric shaft to be provided with suitable means for taking up wear.

CRANK SHAFT

17 To be of mild forged steel, machined all over, with well-designed steel crank polished on face and edges. A separate small shaft, worked from main crank, will carry the eccentrics and drive the Air Pump.

SEPARATOR.

18 A Holden and Brookes' Steam Separator, with water pocket and protected water gauge, to be provided of sufficient size, and fixed as close to the H.P. cylinder as possible. The separated water to be led away through a steam trap into the feed tank in the boiler house. An extra stop valve of Hopkinson's own make to be fixed on the branch steam pipe between the separator and boilers.

FLYWHEEL.

19 To be of cast-iron, of sufficient size and weight to keep the engine running smoothly at 14 to 18 revolutions per minute; carefully built up in suitable segments, and securely bolted or dowelled together. Boss, rim, and edges to be turned, and finished bright.

Holes for "barring" to be cast in the rim; a bracket and bar for turning the engine to be supplied.

BOREHOLE PUMPS.

20 To be two in number, of the bucket type, each 5 feet 6 inches stroke, and suitable for a total lift of 300 feet, at an average bucket speed of 154 feet per minute, and a maximum speed of 198 feet per minute.

THE WORKING BARRELS to be of cast-iron, bored true and parallel, and bell-mouthed. To be suitably machined and prepared for suction valves, and to be screwed for the steel suction and delivery pipes.

BUCKETS to be of cast-iron, extra deep, each fitted with a gutta-percha packing ring 3 inches deep by 1½ inches thick, and to be securely fastened to steel spindles by deep gun-metal nuts, locked by steel cotters in the spindles behind them.

BUCKET VALVES AND CLACKS to be of the multiple valve type, with gutta-percha beats of a design approved by the Engineer; clacks to be suitably weighted, and arrangements made for lifting.

BUCKET RODS AND COUPLINGS to be of mild steel, rods to be turned down at both ends for couplings, and each to be 15 feet in length. Couplings to be secured to rods by cotters. A special link for lifting to be supplied.

GUIDES. Suitable cast-iron annular guides to be provided and secured to rods above each coupling ; rods to be swelled to receive the guides.

SUCTION PIPES AND RISING MAINS.

21 Each column to be made up of lap-welded mild steel tubes ½ an inch thick, and in 15 feet lengths, securely connected together by steel screwed couplings, provided with locking screws. Each tube to be turned on both ends, and a gutta-percha joint to be inserted between each length before connecting-up.

A cast-iron flange, well ribbed, is to be screwed to the top of each column, and the whole column supported, on adjustable steel set screws, by a special casting in halves and bolted together, which will sit on the top of a cast-iron cylinder, referred to previously. These castings to have stuffing boxes, without glands, to prevent leakage round the rising main-pipes, and one of the two is to have a branch cast on the side for overflow connection into the borehole.

CAST-IRON GUIDES, for the pump crossheads to work in, and with holes near the bottom for the water to pass through, are to be mounted on the above-mentioned special castings ; these guides to be fastened together by a stay through the foundations, to ensure rigidity.

PUMP CONNECTING RODS.

22 To be of mild forged steel, finished bright all over, and fitted with suitable adjustments at both ends. Wearing surfaces to be of ample area.

PUMP CROSSHEADS.

23 The borehole pump rods are to be secured to suitable crossheads, which will work inside the guides at the top of each borehole, the slide blocks of which cross-heads to be provided with means for taking up wear.

PUMP GIRDERS AND PLUMMER BLOCKS.

24 For carrying compensating levers and winch to be of cast-iron, of massive design, planed to receive plummer blocks, and to be securely bolted to the foundations raised above the engine house floor to support them.

PLUMMER BLOCKS to be of cast-iron, fitted with strong gun-metal steps of large bearing surfaces, and securely bolted to girders.

COMPENSATING LEVERS.

25 To be two in number, each built up of mild steel plates, secured to cast-iron blocks, having mild steel gudgeons and pins. The arm connecting to the borehole rods to be 6 feet 3 inches radius, and the arm connecting to the engine crank to be 5 feet radius, the obtuse angle between the two arms to be such as to give a stroke of 5 feet 6 inches in the borehole pumps with an engine stroke of 5 feet.

CONNECTING RODS.

26 To be of mild forged steel, polished all over, and provision for compensating for wear to be made at both ends. The connecting rod between the engine and compensating levers is to be forked so as to pass the borehole pump rods.

FORCE PUMP.

27 To be of the double-acting piston type, with a 5 feet stroke. The SUCTION PIPES are to be of ample size, each fitted with a cast-iron STRAINER, having an area through the holes of not less than three times the area of the pipe. Provide DELIVERY PIPES from the pump to the air vessel and from the air vessel to one foot outside the building. All bends to be of a large radius.

WORKING BARREL to be of cast-iron, bored true and parallel, faced to receive covers, machined on feet and branches, and fitted with a bell-mouthed gun-metal liner. Bosses for indicator cocks and air valves to be cast on each end of the barrel. The force pump is to be kept rigid by securing it to the L.P. cylinder with steel stays.

PISTON. To be of cast-iron, extra deep, made in halves, and fitted with strong gutta-percha cup rings and gun-metal mid feather. Four holes to be bored through each half of the piston to allow the water pressure to expand the cup rings.

PISTON ROD to be of mild forged steel, machined all over, and properly secured in piston.

The nut for securing piston to be of gun-metal, and is to be prevented from slackening by a tapered cotter through the rod behind it.

PUMP COVERS to be of cast-iron, machined on faces and edges. The front cover to be bored and fitted with cast-iron gland, bushed with gun-metal, and gun-metal neck bush. The pumpwork flanges to be faced and recessed for gutta-percha hydraulic jointing, and wherever practicable strongly bracketted.

CLACK BOXES AND VALVES. Valves to have gutta-percha beats and to be of the multiple type of a design to be approved by the Engineer and to be conveniently arranged for examination and renewal. An air cushion or vessel is to be provided connected to the under side of the suction valves and a non-return valve fitted in the suction pipes just over the strainers.

AIR VESSEL.

28 An air vessel for the delivery main to be provided, not less than twelve times the capacity of the pump, of steel plates, rivetted together, and suitable for the specified pressure, viz., 550 feet of water. The height of the vessel above the top of inlet and exit branches not to be less than twelve feet. To be tested to twice the working pressure.

TESTING.

29 The H.P. steam jackets to be tested by hydraulic pressure to 150 lbs. per square inch, and the pump work to be tested by hydraulic pressure to three times the working pressure. All the testing to be done in the presence of the Engineer or his Assistant.

DONKEY FEED PUMP AND CISTERN.

30 Supply and fix in boiler house a Cameron Single Ram Feed Pump, made by Messrs. J. Cameron, Ltd., Salford ; size of ram = 3 in., stroke 3 in. Also a cast-iron Feed Cistern, into which the discharges from the various traps and the exhaust from the Donkey Pump are to be led ; fix the tank above the floor so that the water may be delivered into the pump by gravity. A tray to be fixed under the pump to catch all grease and drippings.

Means for measuring the water pumped into the boilers to be arranged for so that tests can be made without undue inconvenience.

MAIN BRAKE.

31 Provide throttle valve in *main* steam pipe actuated by a ram controlled by the pressure on pumping main. Connect 1½ inch supply pipe from main outside air vessel to ram, and provide ¾ inch drain pipe. Delivery and drain pipes to ram, above the engine house floor, to be of polished copper. Provide pressure gauge and polished brass wheel valves.

TRAVELLING CRANE.

32 A 15-ton Overhead Travelling Crane of Messrs. R. Gibbins', Birmingham, or other approved make, with steel wire lifting rope and grooved barrel for same, 35 feet span, to run the whole length of the engine house and to be worked from the floor. Provide steel rails for same, special connection for suspending blocks specified below, and means for scotching, and strutting if necessary, when rods are being raised by winch.

STEAM WINCH.

33 One Steam Winch, with reversing gear of superior make by Messrs. J. Wilson, Liverpool, or other approved maker; to be fitted with powerful band brake, and to be suitable for drawing rising mains and pump rods, with two and three sheave blocks; to be fixed between the compensating levers. Steam and exhaust pipes to be supplied complete.

Provide wire rope blocks (two and three sheaves) for lifting rising main or pump rods, which will be suspended from a special connection on the overhead crane; and steel rope for use with the blocks and winch.

The barrel of the winch to be grooved for the wire rope.

Provide separate snatch block and steel rope for lifting the borehole suction valves.

RELIEF VALVE.

34 An efficient Relief Valve to be fixed on the delivery main between pump and sluice valve.

STAIRS AND LADDERS.

35 Wrought-iron Stairs sloping at a suitable angle, and Ladders, to be fixed in the following positions:—

ENGINE HOUSE.—*Stairs* from engine floor to landing over condenser cistern, from landing to bottom of air pump chamber, from engine floor to platform round compensating levers, and from engine floor to top of boiler flues. *Ladders* from landing over cistern to bottom of cistern, and from engine floor to overhead crane.

BOILER HOUSE.—*Stairs* from top of flues to firing floor. Total height from engine house floor to boiler house firing floor will be about 20 feet.

FLOOR BEAMS AND CHEQUERED PLATES.

36 ENGINE HOUSE.—Rolled Joists of a strong section to be provided for supporting floor of York flags. Manholes to be provided where necessary, and suitable finishings to be supplied to all openings. Wrought-iron Chequered Plates and Cast-iron Frames to be fitted above air pump and condenser, and around force pump valve boxes, Chequered Plates between engine bed-plates, low pressure cylinder and force pump, and under the latter. Engine house floor to be level with top of force pump bed-plate.

A narrow Platform of angle-iron and cast-iron perforated plates of neat pattern, supported on cast-iron brackets bolted to the foundation, to be fixed round the compensating levers for convenience in getting at the bearings and steam winch.

BOILER HOUSE.—Chequered Plates and Frames to cover all pipe channels, so that pipes can be easily examined.

Gangways over boilers to be provided for working the stop valves, consisting of wrought-iron chequered plates, angle-iron frames, and suitable supports.

All chequered plates in engine and boiler house to be machined on edges to fit frames.

HANDRAILING AND STANCHIONS.

37 ENGINE HOUSE.—Provide polished brass Handrailing and polished wrought-iron Stanchions round flywheel, for all stairs, and wherever necessary round openings in floor.

BOILER HOUSE.—Wrought-iron polished Hand-railing and Stanchions to be provided for stairs and for one side of gangways over boilers.

SPARES.

38 To include two Borehole Pump Buckets and Valves.

Two Clacks and Valves.

One complete set of Suction and Delivery Force Pump Valves.

One Force Pump Piston.

All the above to be fitted up ready for immediate use.

FITTINGS

39 To be of the best make, to be turned and polished wherever possible, all valves except main stop valve to have polished gun-metal hand wheels, and to include :—

Gun-metal fitted MAIN STOP VALVE.

DRAIN VALVES and pipes for cylinders.

JACKETTING Valves and pipes.

Provide STEAM TRAPS, of Schäffer and Budenburg's make, for steam jacketting and separator.

GUN-METAL INDICATING COCKS AND GEAR. The copper indicator pipes on each cylinder to be arranged so that one indicator may be served by either end of the cylinder by simply turning a cock.

Patent 7 FIGURE COUNTER (Harding's) and gear ; the latter to be enclosed in case and provided with lock and seal, as made by Messrs. Thomas Glover & Co., London, to prevent it being tampered with.

BOREHOLE GAUGE, with pipe connection to air vessel. All pipes above floor line to be polished solid-drawn copper, and pipes led down the borehole to be the same, but not polished. The lettering on the gauge to be approved.

Steam pressure, vacuum, water pressure and borehole GAUGES to be of the open face type, showing the works, all 10 inch diameter, of Messrs. Schäffer & Budenburg's make, and mounted on a well-constructed neat mahogany board, French polished, fixed in a convenient position in the engine house.

STOP VALVE, LUBRICATORS, drain cocks for steam winch.

Winn's best sight feed LUBRICATOR, to hold one pint of oil, with three sight feeds, mounted on turned and polished wrought-iron column ; also tallow cups.

LUBRICATORS for metallic packings.

VISIBLE FEED OIL BOXES with External Adjustment to be fitted to bearings and working parts, where required, of a neat design. Stauffer's Lubricators with polished gun-metal boxes to be fitted to bearings directly over bore holes.

All small COPPER PIPES to gauges, etc., in engine house to be carefully led, free from dents, polished, and neatly secured by small brass clips.

Supply a No. 3 Well's patent WASTE OIL FILTER.

A 6 INCH CAST IRON SLUICE VALVE to be controlled from engine house floor to be fixed on a branch on the delivery main between the sluice valve and the force pump, for use when starting the Engine. The water to be led back into condenser cistern.

POLISHED BRASS OIL CATCHERS detachable everywhere for cleaning purposes, with screwed plugs for draining oil off.

Four Gun-metal BYE-PASSES and Three AIR COCKS on force pump, also two INDICATOR COCKS, one at each end of the force pump barrel.

Whipperman and Lewis' PATENT AIR CHARGER on air vessel; gun-metal WATER GAUGE FITTINGS, and polished brass sheath, with slit in same, to protect water gauge glass.

A complete set of polished forged STEEL SPANNERS, mounted upon spanner plate, to be fixed on engine house wall.

HOLDING DOWN BOLTS and cast-iron washers.

SLIPPER GUIDE between L.P. cylinder and force pump.

EXTRA STOP VALVES on branch steam pipes to auxiliary Engine, etc., close to main steam pipes as well as close to the engine.

WASTE PIPES to be led to outside of building.

Provide GUN-METAL VALVES between H.P. and L.P. jacketting, and fix 7 INCH GAUGE on L.P. jacket.

Cast-iron SLUICE VALVE to be provided between force pump and air vessel.

Gun-metal AUXILIARY STEAM VALVE on L.P. cylinder.

OVERFLOW PIPE into boreholes fitted with bonnet of copper wire.

Patent WESTINGHOUSE AIR COMPRESSOR, size 8 inches by 4 inches, to be used as an auxiliary air charger, mounted on neat polished mahogany board, fixed to engine house wall.

COPPER PIPES for Westinghouse Air Compressor: Steam 1 inch bore, exhaust $1\frac{1}{4}$ inch bore, delivery 1 inch, and drain pipes $\frac{1}{2}$ inch bore. These pipes and all other copper pipes in engine-house to have well rounded bends, to be free from dents or bruises, and to be polished. Brass flanges to be turned and polished.

EXPANSION PIPES.

40 A Copper EXPANSION PIPE of approved design to be fitted on steam pipes between boilers and engine, and also one between boilers.

PAINTING.

41 The engine, travelling crane, steam crab, pump work, etc., to have one first coat of Calley and Wolston's Torbay paint, No. 7 machinery grey, before leaving the manufacturers' works, and on completion of erection they are furthermore to have two coats of Calley and Wolston's Torbay paint (colour to be approved by the Engineer), neatly finished and lined, and to have one final coat of best varnish. The paint and varnish herein specified to be obtained of the Torbay Paint Company, 26, 27, and 28 Billiter Street, London, E.C.

The whole of the pump trees, inside and outside (except the inside of working barrels), to be coated with a composition prepared according to Dr. Angus Smith's patent process: the coating to be applied at proper heat after dressing, and before oxidation has commenced.

SPECIFICATION.

TWO LANCASHIRE BOILERS.

DIMENSIONS.

1 The Boilers shall be of cylindrical form, 7 feet 6 inches diameter by 30 feet long, having internal flues, 3 feet diameter.

CONTRACTOR TO SUPPLY WORKING DRAWINGS.

2 The Contractor shall, as early as possible after the acceptance of his tender, prepare complete working drawings of the Boilers, in accordance with accompanying specification, and shall submit such drawings for the approval of the Engineer.

After Boilers have been erected on site, the Contractor shall provide a complete set of coloured mounted working drawings for the Company's use.

MATERIAL AND TEST OF PLATES.

3 To be of the best Martin-Siemen's mild steel boiler plates.

SHELLS AND GUSSETS :—

To have a tensile strength of 26 to 30 tons per square inch, with 20 per cent. elongation in 10 inches.

ENDS AND FLUES :—

To have a tensile strength of 24 to 28 tons per square inch, with 20 to 25 per cent. elongation in 10 inches.

TEST STRIPS.

4 Test strips shall be cut from every plate used for the boilers and tested. The result of such tests shall be sent to the Engineer from time to time before the plates are used. Plates outside the limiting tensile strengths aforesaid, or showing the slightest indications of lamination, shall be rejected.

SHELLS.

5 The shells to consist of not more than five rings of plates in each, each ring to consist of one plate reaching the whole circumference of the boiler, and to be made from plates $\frac{11}{16}$ inch thick. The edges of the plates to be planed and the rivet holes to be drilled in position after the plates are bent to form, the circular seams to be lapped and single-rivetted, and the longitudinal seams to butt together and to be united by double-cover straps and four rows of rivets; the outside straps to be $\frac{11}{16}$ inch thick, and the edges planed down at each end to go under the plates; the inside straps to be $\frac{1}{2}$ inch thick. The longitudinal seams not to be in line, but to break joint, and so arranged that they do not come in contact with seating blocks.

FLUES.

6 Each boiler to have two flues through it, each 3 feet internal diameter, tapering at the last ring but one at the back end to 2 feet 6 inches diameter, and to be made from plates $\frac{7}{16}$ inch thick, except first and last, which shall be $\frac{1}{2}$ inch thick; each flue to consist of eleven sections, and the longitudinal seams to be solidly welded, and the transverse joints to be formed by flanging the plates by machine at one heat, and to have a solid welded caulking ring between each joint, forming what is called the "Anti-Collapsive Expansion Joint"; each flange to be accurately drilled to template, and the edges turned perfectly true by special machinery.

ENDS.

7 The end plates to be $\frac{5}{8}$ inch thick, each in one solid plate, the back end to be attached by flanging the plate to fit the shell internally (this plate to be flanged at one heat by special machine), and the front end to be attached by a solid welded steel angle ring, placed externally on the shell; the end plates and the angle rings to be turned perfectly true on all edges, and the flue holes to be flanged outwards for connecting flues.

Each end of boilers shall be firmly secured by means of gusset stays, these to consist of double steel angles and web plate, each boiler to have five stays at each end above the flues, and to have two stays at front end, and three stays at the back end underneath the flues. These stays to be placed in such a position as to equalise the strain as much as possible.

MANHOLES.

8 There shall be rivetted on top of boilers strong wrought-steel raised oval manholes 16 inch by 12 inch of McNeil's make, having faced joints, the openings for these on shell to be strengthened by means of a doubling plate being placed on the inside, and front ends shall be provided with wrought-steel inverted manholes, each to be provided with suitable doors fitted complete, with necessary bolts, nuts, and cramps.

STANDPIPES.

9 Provide and rivet on the necessary wrought steel standpipes with faced flanges for attachment of the mountings specified.

FOOT PLATES.

10 Provide wrought-iron chequered plates and cast-iron frames for blow-off pit, with suitable handholes for blow-off cocks; plates to be machined on edges to fit frames, and frames to be flanged up about 6 inches against the glazed brickwork at the front of the boilers.

FEED PIPES.

11 Provide and fix necessary feed piping from the feed tank to donkey pump, and from donkey pump to boilers. All flanges to be faced and a RELIEF VALVE to be provided and fixed between the boilers and the delivery valve of the pump.

RIVETTING.

12 The whole of the rivetting, including shell, flues, and ends wherever practicable, to be done by special hydraulic machinery, and where not possible pneumatic machinery is to be used, all rivet holes shall be slightly countersunk both inside and outside and all burrs taken off. Any holes not precisely fair with one another shall be rimered out, no drifting being resorted to.

PLANING AND TURNING.

13 The edges of all plates are to be planed and those of all the angle rings are to be turned off, the whole of the work to be neatly finished.

FITTINGS AND MOUNTINGS.

14 Each boiler to be supplied with the following fittings and mountings, which are to have all flanges faced, and bolt holes drilled ready for attachment, and also all bolts, nuts, and jointing material for same.

FURNACE FITTINGS :—

One complete set of wrought-iron furnace frames, with polished brass beadings round, fitted with polished cast-iron air-regulating fire doors with sliding ventilators.

Two dead plates, bridge frames, bearers, chairs, and screw bolts.

One complete set of triple fire bars.

One complete set of firing tools.

Two flue doors and frames.

Two dampers and frames, girder to span boiler house, steel ropes, pulleys, brackets, and balance weights ; dampers to be worked from the front of boilers.

STEAM MOUNTINGS :—

Provide and fix Hopkinson's patent safety boiler mountings, to be Hopkinson's own make and to Specification A 1903.

Flanges and all preparations for receiving mountings shall be made to Hopkinson's standards.

One Fig. 1000 patent "Triad" junction valve.

One cast-iron anti-priming pipe fixed underneath steam junction valve.

One Fig. 7 patent "Duad" safety valve for high steam and low water, with plate-weights complete.

One Fig. 20 3 inch patent dead weight safety valve for high steam only.

One 2½ inch Fig. 2540 patent parallel slide blow-off valve, all bronze, with locking gland and suitable wrought-iron box key for same (only one box key to be supplied for the two boilers). Also a suitable cast-steel taper elbow pipe to be provided for attaching the valve to the standpipe previously rivetted on to the boiler.

One 2½ inch Fig. 1320 patent accessible check feed valve. Also a wrought-iron perforated distributor feed-pipe, to be in three 6 feet lengths, two plain and last one perforated, and to be supported in boiler with angle iron brackets, &c.

Two ¾ inch Fig. 6440 patent "Absolute" water gauges, with Hopkinson's patent safety shields, A to 18 inch centres, fitted with polished copper drain pipes, the ends of which are to project through wrought-iron foot plates in front of boiler.

One brass engraved working level pointer.

One Fig. 4010 own make steam gauge, dial 10 inch diameter, graduated to 200 lbs., with red mark at 100 lbs., with flanged asbestos packed cock and syphon, to be specially designed for attachment of test gauge.

Two fusible plugs, which will be provided by the Company, to be fitted in furnace crowns.

GENERAL.

15 The boilers are to be of the very best material for the purpose, and workmanship throughout of a first-class nature. The boilers are to be constructed for a daily working pressure of 100 lbs. per square inch, and tested by hydraulic pressure to 180 lbs. per square inch before leaving maker's works ; to be delivered and placed on seats with all mountings and connections complete as per Specification. The whole work is to be subject to inspection at any time and by any one appointed by the Engineer, to whose entire satisfaction the work is to be done ; and, further, the boilers and mountings shall be made in all respects to the satisfaction of the Scottish Boiler Insurance Company, Brazenose Street, Manchester, who shall inspect, make, or cause to be made, full tests and inspection of plates, rivets, drilling, hydraulic or any other tests that may be considered necessary from time to time during the construction of the boilers and at completion, such inspections and tests to be at the Contractor's cost, after which the work must be thoroughly freed from rust and painted with one coat of best red oxide paint.

LIST OF MUSEUM PIECES AT BRINDLY BANK PUMPING STATION

NR.

1. Assorted spanners. Moors Gorse Pumping Station 1879 - 1955.

2. Winch used to install and remove Borehole Pump. Moors Gorse Pumping Station 1879 - 1955.

3. Pump bucket and valve from the beam engine driven well pump. James Watt and Co. late Boulton - Watt & Co. Moors Gorse 1879 - 1955.

4. Fishing tackle used for retrieving pump parts and rods from the borehole and for installing the foot valve. Used at Maple Brook Pumping Station 1915 - 1971.

5. Borehole pump bucket and clack valve which was driven by the marine type triple expansion steam engine. Glenfield & Kennedy. Maple Brook Pumping Station 1921 - 1971.

6. Borehole pump buckets which were driven by the marine type triple expansion steam engine. Glenfield & Kennedy. Maple Brook Pumping Station 1921 - 1971.

7. Borehole pump bucket and clack valve which was driven by the tandem compound steam engine. Hathorn Davey. Pipe Hill Pumping Station 1910 - 1970.

8. Footvalves from the borehole pumps. Glenfield & Kennedy. Maple Brook Pumping Station 1921 - 1971.

9. Borehole pump bucket rod and guidewheel. Glenfield & Kennedy. Maple Brook Pumping Station 1921 - 1971.

10. Dead weights for holding down borehole pump footvale (non-return valve). Glenfield & Kennedy. Maple Brook Pumping Station 1921 - 1971.

11. Fire doors, gauges and fittings from steam boilers.

12. Winch used to install and remove borehole pump. Hathorn Davey. Pipe Hill Pumping Station 1910 - 1970.

13. Barring engine used for rotating flywheel on tandem compound steam engine. Hathorn Davey. Pipe Hill Pumping Station 1910 - 1970.

14. Boiler feed pump used for replenishing water in the boilers. Cameron. Brindley Bank Pumping Station 1907 - 1969.

15. Boiler feed pump used for replenishing water in the boilers. Lee Howle. Maple Brook Pumping Station 1921 - 1971.

16. Regulator for adjusting the steam admission cut off. Hathorn Davey tandem compound pumping engine. Pipe Hill Pumping Station 1910 - 1970.

NR.

17. Main brake. The large steam pumping engines were not governed. If the delivery main burst, the engine would accelerate dangerously. If the hydraulic pressure applied to this device dropped significantly it would immediately close the steam regulative valve. Glenfield & Kennedy. Maple Brook Pumping Station 1921 - 1971.

18. Steam driven bilge pump used for pumping water from the sump to waste. Worthing Simpson. Maple Brook Pumping Station 1915 - 1972.

19. Remote water level indicator. Glenfield & Kennedy. Sandfields.

20. Water level indicator. George Kent.

21. Chlorine dosing machine and recorder. Paterson. Ashwood Pumping Station.

22. Main flow meter. British Piotmeter Co. Pipe Hill Pumping Station. 1910 - 1970.

23. Three phase 4 h.p. 400 volt rotor resistance pump motor starter. Brookhirst. Gentleshaw Booster 1931.

24. 80 h.p. 460 V d.c. pump motor starter and shunt field regulator. Mather and Platt. Springsmire Pumping Station 1928 - 1972.

25. Automatic voltage regulator. Brown Boveri. Sandfields Pumping Station 1922 - 1966.

26. Two phase supply cable. Smith and Bellhouse. Wood Green.

27. Oil lubricators.

28. Revolution counter and control pushbuttons. B.T.H. Sandhills Pumping Station.

29. Cistern water level indicator. Glenfield and Kennedy. Pipe Hill Pumping Station 1910 - 1970.

30. Chlorine metering unit. Wallace and Tiernan. Maple Brook Pumping Station.

31. Oil filter used to remove sediment from dirty oil. Maple Brook Pumping Station 1921 - 1971.

32. Mobile chlorine equipment used to introduce chlorine into the water supply. Wallace and Tiernan. Sandfields Laboratory.

33. Apparatus for recording carbon dioxide content of boiler flue gas. Hays Automatic Co. Pipe Hill Pumping Station.

34. Crossley Gas engines driving triple throw well pumps originally installed to supply water to Sir Owsald Moseley's estate.

35. Main pressure recorder - maker unknown.

36. Remote tank and reservoir water level recorder (transmitter on left). Glenfield and Kennedy. Sedgley tanks and old reservoir.

NR.

37. Remote reservoir water level recorder. Transmitter on the right. Glenfield and Kennedy. Barr Beacon Reservoir Nr. 1.

38. Venturi water flow meter. George Kent. Rugeley Reservoir.

39. Remote reservoir water level recorder. Blakeborough Ltd. Mayfield Reservoir.

40. Venturi water flow meter and pressure recorder. George Kent. Kinver Old Pumping Station.

41. Station output Venturi water flow meter. George Kent. Sandfields Pumping Station.

42. Supernatent water flow recorder and integrator used to record the amount of water passing over a vee-notch. Palatine. Sandfields Treatment Works 1923.

43. Water tower level transmitter and receiver with alarm contracts. Evershed Midworth Telemeter System. Warley Tower to Langley P.S.

44. Flowmeter remote repeater. George Kent. Springsmire P.S.

45. Chlorine gas control and metering unit. Paterson.

46. Instrument for checking the performance of a steam engine. The diagram shows the variation in steam pressure during the working cycle. Crosby.

47. Meter for measuring carbon dioxide content of flue gas. Cambridge Instrument Co.

48. Water tank level indicator. Glenfield & Kennedy.

49. Remote reservoir water level indicator with high and low level alarm contacts. Gent and Co. Prestwood Reservoir level at Crumpwood Pumping Station. 1924.

50. Water tank level indicator.

51. Water tank level indicator with overflow alarm contacts. George Kent Ltd.

52. Steam engine stroke counter. Ashton Frost Ltd. Pipe Hill Pumping Station 1910.

53. Register of rainfall 1890 - 1903.

54. Particulars of Pumping Stations 1902.

55. Houses laid on and cut off 1913 - 1925.

56. Stock book 1914 - 1916.

57. This wooden pipe originated in the Sutton Coldfield area. The S.S.W.W. Co. never used wooden pipes. The first mains to be laid were of cast iron.

NR.

58. Wooden socket used for connecting lengths of wooden pipe.

59. Pressure gauge. Turbine plant, Wood Green. Glenfield & Kennedy.

60. Steam pressure gauge. Slade Heath Pumping Station.

61. This wheel barrow was made by a Mr. Elliot of Wolverhampton and was used during the ceremony of turning the first sod, to inaugurate the works at Minster Pool, Lichfield on 22.2.1856. The Right Honourable Lord Ward carried out the ceremony and "amid the echoing cheers of the assembled multitude, placed it (the sod) in the wheelbarrow."
(There was also a spade made by a Mr. Linden of Birmingham which unfortunately is not in the possession of the S.S.W.W.Co.)

62. Lancashire boiler steam pressure safety valve. Maple Brook 1921 - 1971.

63. Chemical injector for boiler water treatment. Maple Brook 1921 - 1971.

64. Steam operated air compressor for replenishing air in surge vessel. Maple Brook 1921 - 1971 - Wipperman & Lewis type. Frant Pearn & Co., Manchester.

65. Integrator for water flow meter - Lea Recorder Co. Ltd.

66. Integrator for water flow meter - Electroflo Meter Co. Ltd.