

Preserved Steam Engine

at

Maple Brook 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

INTRODUCTION

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 In addition to the superb example of a horizontal Company's museum. 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 formed 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 Lichfield and the Black Country, was from two impounding reservoirs, Stowe and Minster Pools, located near Lichfield Cathedral. 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 It was then raised by pumps and pumping station, completed in 1858. 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

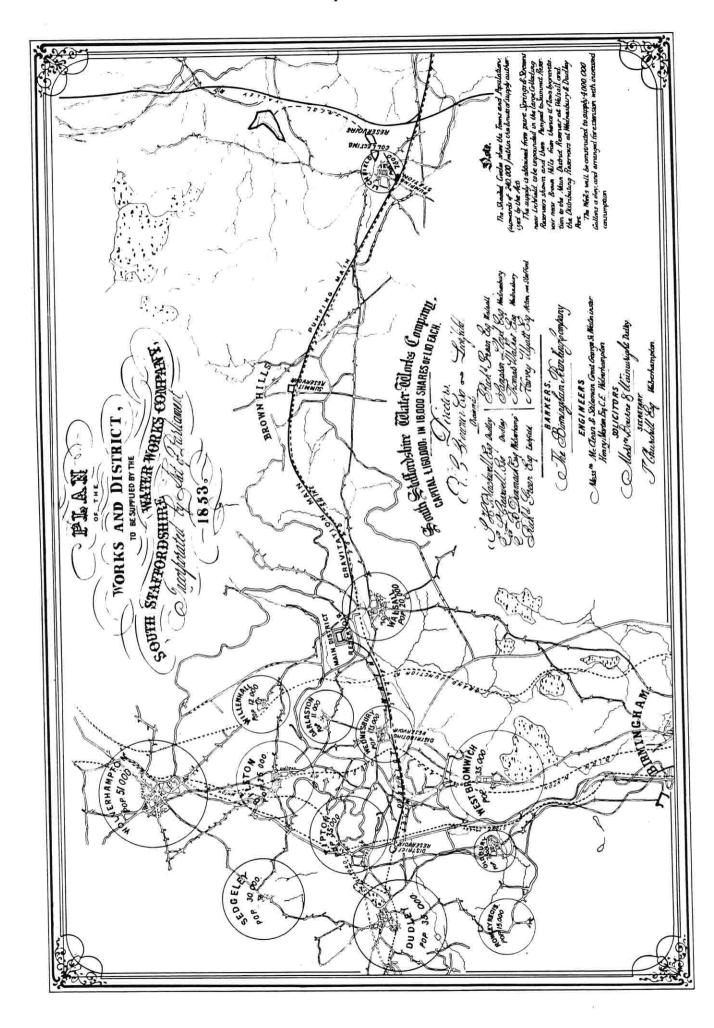
VICTORIÆ REGINÆ.

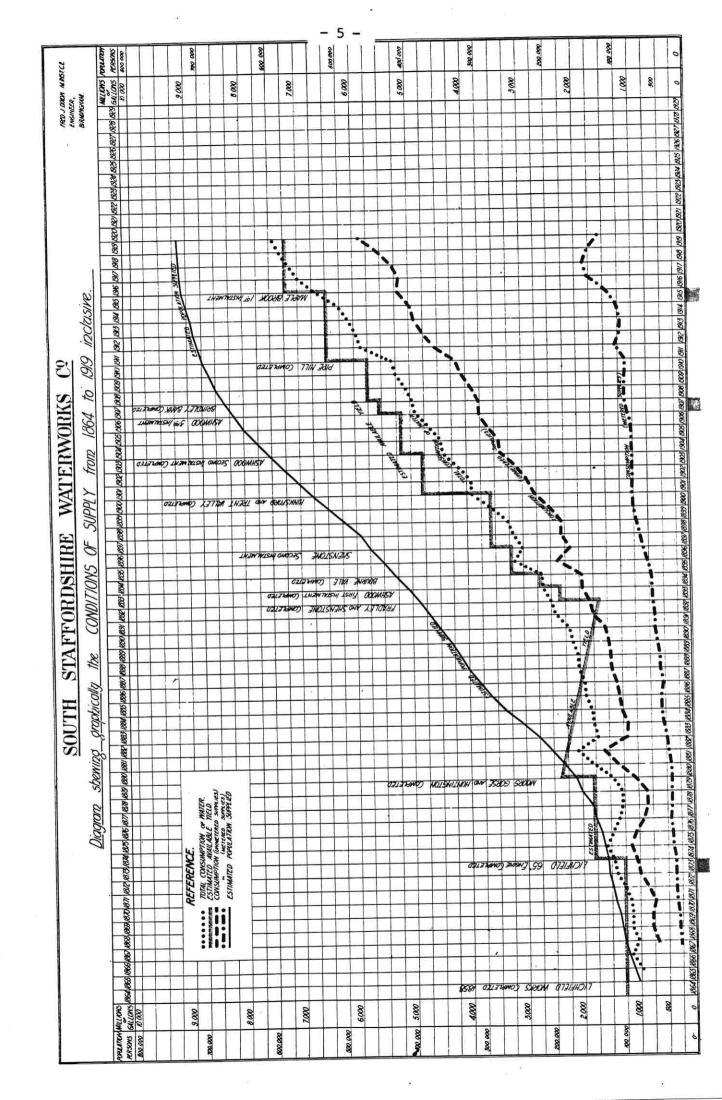
Cap. cxxxiii.

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.]

HEREAS 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 [Local.]





STEAM ENGINES FORMERLY OPERATED BY THE SOUTH STAFFORDSHIRE WATERWORKS COMPANY

PUMPING STATION	ENGINE Nr	TRIAL DATE	PUMP hp	INDICATED hp	MECHANICAL EFFICIENCY %	ENGINE DETAILS
	1	4-5-94	-	69	-	SINGLE ACTING EXPANSION CONDENSING BEAM ENGINE
ASHWOOD	2	18-7-02 20-2-07	256.7 261.7	309 310	82.6 84.4	HORIZONTAL TANDEM COMPOUND EXPANSION SURFACE CONDENSING DIFFERENTIAL ENGINE
		1-4-98	88.9	111.4	79.8	INVERTED COMPOUND EXPANSION SURFACE
BOURNE VALE	1 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
	1		-		-	25" DIAMATER HORIZONTAL SINGLE CYLINDER ROTATIVE ENGINE
CONEYGRE	2	18-1-97	19.9	30.1	66	
CONEIGRE	1	25-4-07	53 "	72	74	HORIZONTAL TANDEM COMPOUND EXPANSION SURFACE CONDENSING ROTATIVE ENGINE
	1	19-2-97	80.7	98.6	81.8	HORIZONTAL TANDEM COMPOUND EXPANSION
FRADLEY	2	5-9-94	64	84	77	SURFACE CONDENSING DIFFERENTIAL ENGINE
		24-6-02	180.5	202.8	89	INVERTED COMPOUND EXPANSION SURFACE
HINKSFORD	1 2	23-6-02	182.5	212.6	85.8	CONDENSING ROTATIVE ENGINE
	-	1881		50		25" DIAMATER DOUBLE ACTING EXPANSION
	2	1881	#	50	=	CONDENSING BEAM ENGINE
HOPWAS		1926	_	_		HORIZONTAL TANDEM COMPOUND ROTATIVE
	3	1920				
HUNTINGTON	1 2	16-11-94 22-11-94	45 45.3	53.6 55.4	83.9	65" DIAMATER SINGLE ACTING EXPANSION CONDENSING BEAM ENGINE
MAPLE BROOK	1 2	1915 1922	_	223	-	INVERTED TRIPLE EXPANSION SURFACE CONDENSING ROTATIVE ENGINE
	-	1922		1229		
VICADO GODGE	1	7-8-94	64	71	90.2	65" DIAMATER SINGLE ACTING EXPANSION CONDENSING BEAM ENGINE
MOORS GORSE	2	3-11-98	117.8	129.4	91.7	CONDENSING BEAM ENGINE
PIPE HILL	1 2	27-10-11	302.7	346.4	87.3 -	HORIZONTAL TANDEM COMPOUND EXPANSION SURFACE CONDENSING ROTATIVE ENGINE
	1 1	19-11-94	103.5	119	87	46" DIAMATER DOUBLE ACTING EXPANSIO CONDENSING BEAM ENGINE
	2	1858	-	12 × 12 × 12 × 12 × 12 × 12 × 12 × 12 ×	-	CONDENSING DEAR ENGLIS
	3	19-11-94	101.5	123.6	83	THE PARTY OF THE P
SANDFIELDS	4	1873	-	190	-	65" DIAMATER SINGLE ACTING EXPANSIO CONDENSING BEAM ENGINE
	1	1922	351	243	69.1	HORIZONTAL SINGLE CYLINDER UNIFLO
	2	1922	387	249	64.3	ENGINE
GUENGMONE	1	7-10-97	133.5	158.3	1	HORIZONTAL TANDEM COMPOUND EXPANSION SURFACE CONDENSING DIFFERENTIAL ENGINEERS
SHENSTONE	2	-		-	39)	
	1	18-6-02	1		73.4	HORIZONTAL TANDEM COMPOUND EXPANSION SURFACE CONDENSING ROTATIVE ENGINEERS
SPRINGSMIRE	2	19-6-02	68.3	91	75	TWO CRANK COMPOUND VERTICAL ENCLOS
	3	16-10-08	147	215.5	68.1	HIGH SPEED ENGINE
	1	14-5-02	129.6	164	79	HORIZONTAL TANDEM TRIPLE EXPANSION
TRENT VALLEY	2	12-8-07	190.1	222.1	85.6	SURFACE CONDENSING DIFFERENTIAL ENGI
	+-:	1871	-	; <u>-</u> ,	-	DOUBLE ACTING EXPANSION CONDENSE BEAM ENGINE
WOOD GREEN	2	3-3-97 1875	83.1	91.2	91.1	65" DIAMATER SINGLE ACTING EXPANSIS
0.10.1	3	19.19	_			INVERTED TRIPLE EXPANSION SURFA

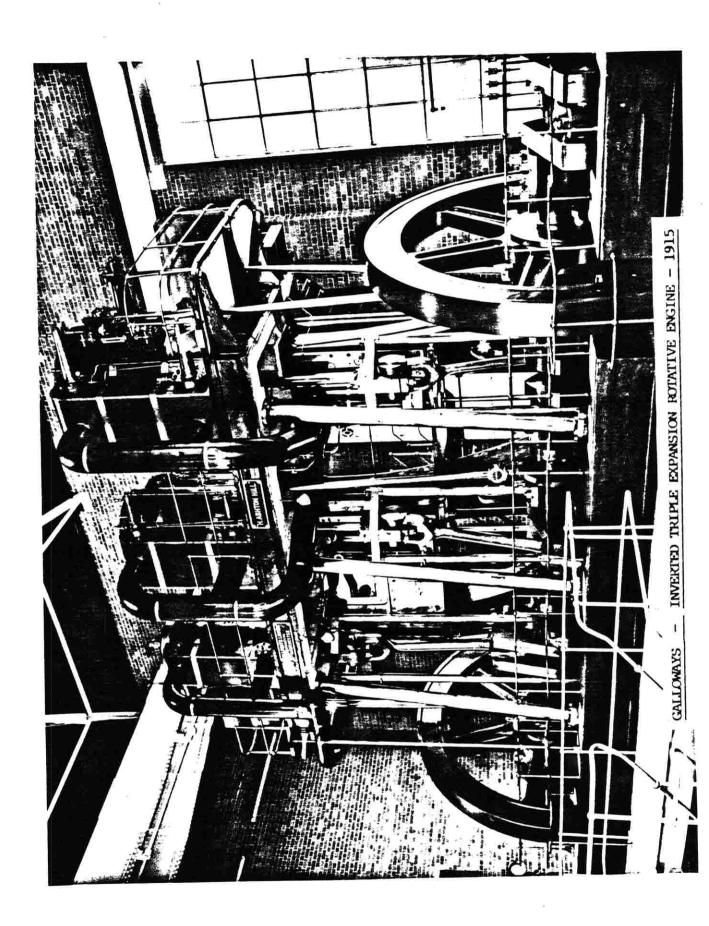
Maple Brook Pumping Station

Chorley Wood
Burntwood
Staffordshire

National Grid Reference SK 061107 Engine House Floor Level 485.91 feet A.O.D.

Major Items of Interest

Pumping Station Engine House	1914
Inverted triple expansion, surface condensing, rotative steam engine. Galloways Ltd. (Manchester)	1915
Steam Winch, D.C. Lighting Engine, Insrumentation	1915
Operational Pumping Plant	1972



MAPLE BROOK PUMPING STATION

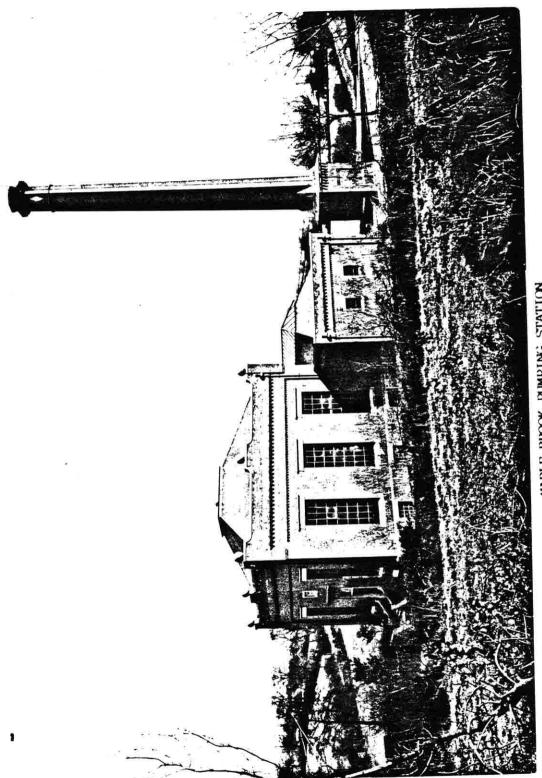
Maple Brook pumping station marks the end of the South Staffordshire Waterworks Company's steam era, it houses the last steam engine to be operated by the Company. The Nr.l engine, now preserved, was commissioned in 1915 and ran for the last time on 5th of April, 1972, when the present day pumping plant was brought into service. It is named after a former Company Engineer in Chief, L. Ashton Hill.

Work commenced on the pumping station in 1909 with the drilling of Nr.1 and Nr.2 boreholes. The engine and boiler houses were built by Messrs. B. Whitehouse & Sons (Birmingham), and were completed in 1914. Originally the engine house was built to accommodate two steam pumping engines, but initially in 1915, only the L. Ashton Hill engine was installed. The Nr.2 engine, which pumped water from Nr.3 and Nr.4 boreholes (drilled 1919-1922), was built by Glenfield & Kenedy (Kilmarnock) and installed at a later date in 1922. The addition of the Nr.2 engine and its associated boreholes and pumping plant completed the original pumping station installation.

The Nr.l engine was built by Galloway Limited (Manchester), and together with its associated boilers and pumping plant cost £16,165. It is an inverted triple, compound expansion, surface condensing, rotative type, with flywheels at each end, between the engine and the borehole pumps. The engine weight including borehole and force pumps was about 320 tons, and the engine required 6 to 10 tons of coal per day to be burned in its boilers. The Nr.2 engine was very similar to the Nr.l engine, one exception being that the air pump was driven by levers from the intermediate pressure cylinder crosshead.

Both of the original engines were capable of developing 225 hp at 20 rpm, whilst pumping 2 million gallons of water per day each, from a maximum depth of 300 feet in the boreholes, and providing a delivery head of 300 feet on the force pumps, making a total lift of 600 feet. The Nr. 1 engine is fitted with Corliss valves, and the valve gear is 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. Detailed information relating to the Nr.1 engine may be found in extracts from the original specification dated January 1912 - Appendix (ii).

Each engine drove two borehole pumps which delivered ground water to a suction tank in the station grounds, three ram pumps pumped water from the suction tank and into the supply main. The borehole pumps were driven from the main crankshaft and were situated at each end of the engine. They were single acting bucket type, the buckets and clacks being of the Pernis type, made entirely in gunmetal. The three force pumps are positioned directly under the steam cylinders, and are driven by side rods from the engine crossheads, and are the single acting plunger type.



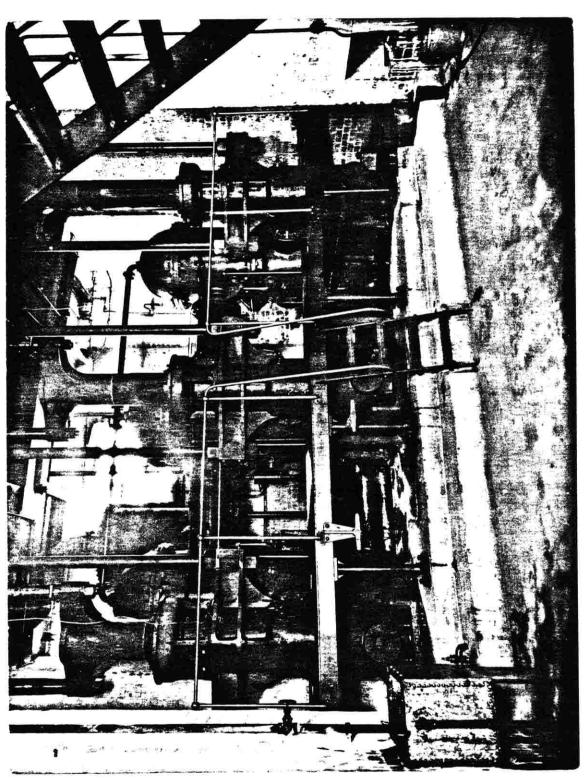
On the left hand side of the engine is a Barring engine, which was engaged with one of the engine's flywheels to turn the engine over until it reached the correct starting position for the initial admission of steam. The L. Ashton Hill engine is turned over periodically by engaging the Barring engine, which is itself now powered by a 5 kW electric motor, this arrangement rotates the engine at 3/4 rpm. In the basement, at the same end of the Nr.l engine as the Barring engine, can be found a separate steam driven Edwards Air Pumps, which was necessary to maintain the vacuum in the steam condenser. In the foundations opposite each borehole and underneath the engine house floor, were two steam powered winches which were used in conjunction with the station crane for removal of the bucket and clacks from the boreholes, one example has been retained.

GALLOWAY STEAM ENGINE DETAILS

Power 22	5 hp		Speed	20 rpm
Size	4	4 feet long x 16 feet w	ide x 24	4 feet high
Flywheels 14	feet diameter	Weigh	nt 16	6 tons each
High pressure	cylinder	22 inches diameter	x 4 1	feet stroke
Intermediate	pressure cylinder	35 inches diameter	x 4	feet stroke
Low pressure	cylinder	55 inches diameter	x 4	feet stroke
2 Borehole pu	ımps each	15 inches diameter	x 5	feet stroke
3 Force pumps	s plungers each	$13^{1}/_{2}$ inches diamet	er x 4	feet stroke

The boiler house originally housed three Lancashire boilers, each 8 feet diameter by 30 feet long. They were built by Galloway Limited, and supplied steam at a pressure of $160~\rm psi$. They were each fitted with Sugden's superheaters, the superheaters raised the temperature of the steam to $550^{\rm o}{\rm F}$, and were fitted with the necessary valves to enable either saturated or superheated steam to be supplied to the engines.

The two boreholes associated with the Nr. 1 engine are 632 feet deep. They are 36" in diameter for the first 123 feet lined with solid tubes, reducing to 33" for a further 183 feet lined with perforated tubes, subsequently reducing to 20" for the remaining 326 feet which is unlined. The borehole pumps discharged water into a cistern which can be seen behind the force pumps, and from which the force pumps took their suction. A surface condenser was positioned in the cistern so that the borehole water was used to condense the spent steam. The pumping system was designed so that the quantity of water delivered by the borehole pumps, was always in excess of that delivered by the force of the pumps. If the water level in the cistern started to fall it gave an indication that the borehole pumps were in need of maintenance.



Also preserved at the site is the pumping station's old dc lighting engine, a double crank single acting 8 hp steam engine, driving a compound wound 5 kW dynamo. It was built by Bumsted and Chandler of Hednesford and provided for a dc electrical load of 100A at 50 V.

Prior to shutting down the Nr. 1 steam engine in 1972 new electrical pumping plant was installed, and now comprises four 7 stage Sulzer submersible borehole pumps driven by Hayward Tyler fixed speed motors developing 80 hp at 1450 rpm. The two booster pumps comprise Sulzer vertical spindle, mixed flow, 4 stage units driven by Laurence Scott & Electromotors Ltd. Variable speed motors. They have a speed range of 1275 rpm to 1580 rpm developing 95 hp and 195 hp respectively, the duty point is 115 hp at 1385 rpm.

The power supply is 11,000 volts, 3 phase, 50 Hz. The two 300 kVA transformers step down the supply to 415 volts, 3 phase, 50 Hz for medium voltage distribution.

MAPLE BROOK PUMPING STATION

SUMMARY OF COSTS 1909 - 1923

LAND:	SITE OF PUMPING STATION	£. s. d.
	Conveyance No. 66 May 1 1908. Freehold Area 2 Acres. SITE FOR ASH TIP.	305. 0. 0.
	Conveyance No. 67 November 21 1921. Freehold Area 3 Acres.	240. 0.0.
	Fencing etc. Law charges.	35. 17. 5. 93. 18. 9. 674. 16. 2.
BOREHOLES:	Boreholes Nos. 1 & 2. Messrs A.C.Potter & Co.	
	Sinking and Testing Pumping. Sundry Charges.	4533. 4. 8. 679. 13. 3.
	Contract signed. Dec 20 1909. Completed. Oct 1912.	
	Boreholes Nos. 3 & 4.	9533. 13. 6.
	Messrs A.C.Potter & Co. Sundry Charges.	97. 6. 2. 14843. 17. 7.
	Contract signed. Sept 27 1919. Completed. March 17 1922.	
PLANT:	No. 1 Engine 3 Boilers & Crane.	
	etc. Messrs Galloway & Co.	16068. 15. 11.
	Sundry Charges. Contract signed. Feb 29 1912	201. 14. 3.
	Completed. May 1915	
	No. 1 Engine commenced Pumping. May/15.	
	No. 2 H.K.Beal Engine. Messrs Glenfield & Kennedy.	37816. 0. 0.
	Sundry Charges.	1954. 13. 6. 56041. 3. 8.
	Contract signed. July 1 1920 Completed. Nov 25 1923	1
	Commenced Pumping Oct 17 1922	
BUILDINGS:	Engine House, Boiler House & Stack Roadways, Gates, Drains and Septic	
	Tank. Messrs. B. Whitehouse & Son.	6804. 0. 11.
	Foremans Cottage	452. 0. 0.
	Site Work, Electric light main connections & Sundry Charges	2251. 18. 6.
	Contract signed. July 25 1912 Completion of final payment	
	Oct 1915.	
	Foundations etc. for H.K.Beale Engine by S.S.W.W.Co Labour & Materials.	1475. 8. 0. 10983. 7. 5
	Commenced Oct 31 1921. Completed. Aug 1922	
	COST OF BUILDINGS ETC.	82543. 4. 10.

MAIN:

18" Cast Iron main, Maple Brook to Scout House Reservoir. Messrs Cochrane & Co. Pipes etc. Glenfield & Kennedy. Valves. Messrs Gro. Law. Main Laying.

9395. 0. 5 250. 0. 0. 2343. 15. 7. 11988. 16. 0.

TOTAL COST OF PUMPING STATION & MAIN

£ 94532. 0. 10.

SOUTH STAFFORDSHIRE WATER WORKS COMPANY.

MAPLE BROOK PUMPING STATION

Contract No. 2.

Specification of Work to be done in the manufacture, delivery, and erection of a

STEAM ENGINE, PUMPS, & BOILERS.

H. ASHTON HILL, M. INST. C.E., ENGINEER.

SOUTH STAFFORDSHIRE WATER WORKS COMPANY.

MAPLE BROOK PUMPING STATION.

Index to Clauses of Specification.

GENERAL CONDITIONS AND STIPULATIONS.

CLAUSE.

1. Interpretation

CLAUSE.

13. TIME OF COMPLETION

14. FOREMAN

1.	1. Three Ministra			8	11.4	FOREMAN			poses
$^{2}.$	CARD III	***	(*,/ * (*		14.	WORKING OF ENGI		***	***
3.	EXTENT OF CONTRACT	***	27/12		15.				
4.	CLASS OF MACHINERY	(6.00x)	*.*.*		16.	ALTERATIONS FROM			***
5.	DESIGN		24.0	1	17.	CONTEMPORARY W			
6.	Drawings	***	Sta	î	18.	The second of th		***	
7.	DESCRIPTION OF ENGINE		3436XE		19.			*(*,*)	***
8.	FUTURE EXTENSIONS	*:*:*	•••		20.	CONTRACT OF THE ACTUAL TO THE		***	
9.	WORK REQUIRED OF ENG	INE	(*(*)*)	11	21.		***	*:*:	***
10.	POWER OF ENGINE	55.0	63.4	23	22.	DELAY	**	200	ee*
11.	DUTY OF ENGINE				23.	PAYMENTS	(2.02)	339.7	*.*
12.	DEFECTIVE MATERIAL OR	Wor	к		24.	CONTINGENCIES .	1200		***
			EN	IGI	NE				
	=		1,000			USE.			
	USE.				42.	PISTON ROD CROS	SHEAT).5	
25.	CTM STARRY III	9990	****		43.	GIRDERS			***
26.	CYLINDER COVERS		318.0		44.	SIDE RODS		444	(202)
27.	PISTONS	***	***		45.	SURFACE CONDENS			
28.	PISTON RODS	***	***	39	770.000	AIR PUMP AND E			1999
29.	PISTON ROD PACKINGS		: *.*:(*)		46.	CRANKSHAFT PLU			
30.	CORLISS VALVES	• • •	***	1	47.				
31.	Corliss Boxes	* * *	1555	100	48.	New York Committee Committ	m. D		
32.	VALVE GEAR	• • •	*(*)	Ĭ.	49.	ENGINE CONNECT			***
33.	EMERGENCY BRAKE	***			50.	OIL SEPARATOR		***	21412
34.	RECEIVERS		5.674		51.	FLY WHEELS		lacador:	*1515
35.	STEAM PIPES FOR MAIN	AND	AUX-		52.	BARRING ENGINE			16.00
	ILIARY ENGINES	100	969000		53.	Non-Conducting	COME	OITIE	N
36.			***		.54.	Lagging			
37.	the tensors and the which	1264	34(400)		55.	PACKING STAGES.			
38.						FRAMES, AND P	LATES	. ETC.	****
39.					56.	TRAVELLING CRA	NE	***	
40.	2 51		BACK		57.	STEAM WINCHES	•••	833	14.404
40.			***		58.	ELECTRIC LIGHT	PLAN	Γ	***
41.	- Dr.								
41.	110103 1101 00100 120			7 * 1	, .				
(Index continued on next page.)									

INDEX TO CLAUSES OF SPECIFICATION.

BOREHOLE PUMPS.

CLAUSE.	CLAUSE.
59. DESCRIPTION	66. BUCKET RODS AND COUPLINGS
60. Working Barrels	67. GUIDES
61. SUCTION VALVE BOXES	68. RISING MAINS
62. BUCKETS AND SUCTION VALVES	69. CAST IRON FLANGED PIPES
63. Buckets	70. Connecting Rods
64. TEMPORARY WORKING BARRELS	71. PUMP ROD CROSSHEADS
65. TEMPORARY BUCKETS AND SUCTION	72. Crosshead Guides and Plates
VALVES	Street William Control
VALVES	
FORCE	PUMPS.
CLAUSE.	CLAUSE.
73. Description	81. Delivery Air Vessel
74. Suction Boxes	82. SLUICE VALVES
75. SUCTION CHAMBERS	83. RELIEF VALVE
76. DELIVERY CHAMBERS	84. Westinghouse Air Compressor
77. PUMP VALVES	85. AIR CHARGER
78. PLUNGERS	86. Suction Pipes
79. JOINTS	87. SUCTION TANK
80. WATER LEVEL INDICATOR	88. Delivery Pipes
CLAUSE. 89. DESCRIPTION 90. CASTINGS GENERALLY	GLAUSE. 91. TESTING 92. PAINTING
ВО	LERS.
CLAUSE.	CLAUSE.
93. DIMENSIONS	107. Planing and Turning
94. CONTRACTOR TO SUPPLY WORKING	108. FITTINGS AND MOUNTINGS
Drawings	109. BOILER FEED PUMPS AND FEED
95. MATERIAL AND TEST OF PLATES	TANK
96. Brands	110. STEAM PIPES TO BOLLER FEED
97. Test Strips	Pumps
98. SHELL	111. FEED PIPING
99. FLUES	112. Blow-off Piping
100. CAULKING	113. Superheater
101. ENDS	114. AUTOMATIC CO, RECORDER
101. ER25	115. FRAME FOR BOILER FRONT
103. FLANGING AND WELDING	116. IRON FRAMES AND FOOTPLATES,
104. MANHOLE	Етс
105. STAND PIPES	117. TESTING, INSPECTION, ETC
106. RIVETTING	§
TOO. ILLITITIO	

MAPLE BROOK 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 Maple Brook, near Lichfield.

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

January, 1912.

Paradise Street,

BIRMINGHAM.

GENERAL CONDITIONS AND STIPULATIONS.

INTERPRETATION.

In this Specification the expression "the Company" shall mean the South Staffordshire Water Works Company; the expression "the Contractor" the person or persons engaged or proposed to be engaged in the work to which this Specification refers, and shall include his or their heirs, executors and administrators; and the expression "the Engineer" shall mean Mr. H. Ashton Hill or other the Engineer for the time being duly authorised by the Company to act as Chief Engineer in the construction of the said works.

SITE.

The site upon which the engine, pumps, boilers, etc., are to be erected is at Maple Brook, in the parish of Burntwood, Edial and Woodhouses, which is about five and a half miles from the passenger and goods station of the London and North Western Railway Company at Lichfield, Trent Valley (main line Rugby to Stafford), and about three miles from the Hammerwich passenger and goods station of the same Railway Company (branch line Walsall to Lichfield).

EXTENT OF CONTRACT.

The contract includes the supply and fixing of all machinery, piping, and ironwork generally within the engine, pump and boiler houses and boreholes which may be fairly implied from either this Specification or the one provided by the Contractor, whether specially mentioned or not.

The foundations, masonry, brickwork, and other builders' work will be executed by the Company.

CLASS OF MACHINERY.

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 and materials throughout to be only of the first class. The foregoing and following general conditions to be embodied in the terms of the Contract.

DESIGN.

The Company will provide general plans and sections showing the complete plant and space available, and the Contractor must adhere to these, but any improvement in the arrangement will be considered. When tendering, any amendment shown to a scale of not less than a quarter of an inch to a foot must accompany a more detailed specification of engine, pumps, boilers, etc., giving proposed sizes of cylinders, pumps, pipes and fittings.

DRAWINGS.

The Contractor whose tender is accepted must submit all the detailed drawings of the engine, pumps, crane, steam winches, 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, boilers, etc., with details of all openings and holes required, so that the buildings can at once be commenced, and to avoid the necessity of any subsequent alterations or pulling down. If any such alterations shall be necessary, they must be carried out at the Contractor's expense. The Engineer to be supplied with a blue sun print of each drawing immediately after approval.

After the engine, pumps, boilers, etc., have been started, the Contractor must provide two complete sets of permanent coloured and mounted detailed drawings for the Company's use, including a general arrangement of all the machinery, including boilers, to a scale of three-eighths of an inch to the foot, showing pipes, fittings, etc.

DESCRIPTION OF ENGINE.

The engine is to be of the inverted triple expansion, surface condensing rotative type, with fly-wheels at each end of engine, having the valves, levers, etc., arranged, so as to be controlled from the centre of the engine house. The columns and plummer blocks to be mounted upon strong bed plates as shown on drawings. The force pumps of the single acting plunger type to be worked by side rods from piston rod crossheads, and the two borehole pumps from each end of the crankshaft.

FUTURE EXTENSIONS.

The buildings will be proportioned so as to allow duplicate machinery to be installed conveniently at some future time. In deciding the sizes of pipes and arrangement of same this must be borne in mind.

WORK REQUIRED OF ENGINE.

The engine is required for pumping water from two boreholes which are lined with steel tubes 30½ inches internal diameter, and spaced 36 feet 6 inches apart; these are 300 feet deep or thereabouts from the engine-house floor, and the pumps are to be put down to this depth. The engine is to be capable of lifting from 300 feet, but allow in ordinary work for a lift of 225 feet in the boreholes and a head of 306 feet or 132½ lbs. pressure in the delivery main, or a total of 531 feet, which includes friction.

POWER OF ENGINE.

The engine and pumps are to be of such size and power as to ensure the delivery, with the engine running at 20 revolutions per minute, of a net quantity, after allowing five per cent. for slip, of Two Million gallons in every twenty-four hours.

DUTY OF ENGINE.

11 The work specified above is to be performed with a steam pressure at the boilers of 160 lbs. per square inch above the atmosphere.

The Contractor must state in the detailed specification the duty he will guarantee (with the water level in the boreholes 225 feet below the Engine House floor, and an average pressure on the delivery main of 132½ lbs. per square inch) on each 1,120 lbs. of water discharged from the air-pump and all drains; the water pumped to be ascertained by the displacement of the pumps multiplied by the number of revolutions. The guaranteed duty must be performed on a six hours' trial, conducted by the Contractor to the satisfaction of the Engineer, the Company providing men, fuel and stores.

DEFECTIVE MATERIAL OR WORK.

If at any time during the construction of the plant, or within six calendar months after its completion, any imperfections shall appear through the introduction of unsound materials or defective workmanship, or if any portion of the plant has been or is being executed contrary to the drawings or specification or instructions given by the Engineer, the Contractor shall, upon notice in writing being served upon him by the Engineer, forthwith reconstruct and make good the same at his own proper cost and charge, the true intent and meaning of this Contract being that the whole of the works are to be satisfactorily and completely finished, and to be perfect in all their parts.

TIME OF COMPLETION.

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

FOREMAN.

To keep a competent foreman in charge of the work during all working hours, who shall be considered the representative of the Contractor during his absence, and to whom the instructions of the Engineer may be given.

The Engineer to have full power to discharge or dismiss from the works the said foreman, or any other workman, for misconduct, incompetency, or otherwise.

WORKING OF ENGINE.

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 this term the Company will provide such additional labour as may be required, together with fuel and stores.

All damage done to the whole plant, or any part of it, during the above-mentioned period of six months, from whatsoever cause, must be made good by the Contractor.

ALTERATIONS FROM PLANS.

The Contractor shall in no case alter or make any difference in the plans first agreed on without the written approval of the Engineer, and no extra charge shall be payable to the Contractor by the 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.

CONTEMPORARY WORKS.

No claim or demand shall be made by the Contractor for any delay, stoppage, or damage caused by workmen employed by the Company, or by any other Contractor who may be engaged on the works.

SUB-CONTRACTS.

No work shall be under-let or let as task work by the Contractor, except the permission of the Engineer, in writing, shall have been previously obtained, naming the party to whom any work may be under-let.

LIABILITIES.

The Contractor shall be held responsible for and in respect of all damage, from whatever cause arising, to persons or property, including public and private roads, by reason of or in the course of the execution of the works, and for the like damage caused by any employee on such works, and also for the like damage in respect of which any damages, claims, or compensation is made against the Company, under or by virtue of the Common Law, "The Employers' Liability Act, 1880," or "The Workman's Compensation Act, 1897," or any statutory modification of or substitution therefor, for the time being in force, and shall indemnify and keep the Company indemnified against all liabilities of what kind soever arising thereunder.

SECURITY.

The Contractor shall be required to give security to the satisfaction of the Company for the due and proper performance of the contract according to the intent and meaning of this specification, and the conditions and stipulations precedent to the same.

PENALTY.

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.

Any delay arising from causes over which the Contractor has no control must be at once notified in writing to the 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.

Payments to be upon the certificate of the Engineer as follows: 50 per cent. of the contract amuont when work to that value has been delivered on the ground; 30 per cent. when the whole of the work included in the contract has been delivered; and 10 per cent. when the engine has been started and kept at work for one month to the satisfaction of the Engineer. The balance to be paid at the end of six months from the satisfactory starting of the whole plant.

CONTINGENCIES.

24 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.

ENGINE.

CYLINDERS.

The H.P., I.P., and L.P. cylinders are to be suitably proportioned to perform the work required of them at a superheated steam pressure of 160 lbs. per square inch and a stroke of four feet. The variation of temperature in each cylinder to be the same and the work to be equally divided 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 to be used as steam jackets. All parts must be quite steam and water-tight when jointed up. Provision to be made for supporting non-conducting composition on all parts necessary. The liners to be bell-mouthed top and bottom, bored true and parallel. All necessary machining for the various covers, pipes, fittings, etc., to be carefully done. Cylinder drains to be led to surface condenser, and connections for indicator pipes to be conveniently placed.

CYLINDER COVERS.

Covers to be provided for tops and bottoms of cylinders, to be of cast-iron, of ample depth, strongly ribbed, machined on faces and edges, and each one to be easily removable. The bottom covers to be arranged for United States metallic packings. They are to be designed to give the minimum of clearance, each to be fitted with a relief valve, and provision made for supporting non-conducting composition. The top covers to be provided with polished cast-iron false covers having the centres filled in with steel chequered plates, and the bottom covers finished with planished sheet steel lagging. Cylinder tallow cups to be provided (see under "Fittings").

PISTONS.

To be of cast-iron, of extra depth, so as to give a large wearing surface, and to be provided with packing rings and springs made by Messrs. Wm. Buckley and Co., Ltd., Sheffield, and suitable for super-heated steam. The rings to be carefully tongued to keep them perfectly steam tight. The junk rings are to be secured with steel screws, screwed into gun metal nuts, in the body of the piston, and to be fitted with copper washers.

PISTON RODS.

To be of hard forged steel, machined all over, coned and shouldered into pistons and secured by deep gun metal nuts, with collars and suitable lockings. The lower ends to be forged T shape for bolting to crossheads, screwed holes to be put in top ends for

lifting with eye bolts.

28

PISTON ROD PACKINGS.

The piston rod of the H.P. cylinder to be fitted with duplex packing and the I.P. with block packing, and the L.P. with atmospheric packing made by the United States Metallic Packing Co., and fixed by their men. Lubricators and drain cocks for the packings to be of gun metal, polished all over, and drain pipes to be of polished copper with neat gun metal supports (see under "Fittings").

CORLISS VALVES.

To be of the most modern design, all working on their lower faces, having small movement, and double ported if necessary. The exhaust valves are to fill up the boxes so as to prevent excessive clearance. The spindles to be of mild steel, and to go right

through the valves, and to be supported in bushes in the back covers. All packing for valve spindles to be of the spherical type. Spherical packing and bearings for bridle spindles to be lubricated (see under "Fittings").

CORLISS BOXES.

The top and bottom boxes to be cast separate, and fitted to the cylinders and made absolutely steam tight. Each box to have a separate inlet and outlet branch, and all flanges to be of extra thickness, truly faced, and well bolted together. The bridles are to be neatly moulded and polished all over, and the covers are to be got up bright on edges and outer faces, and fitted with bronze bearings for ends of spindles. All bushes and collars to have long bearing surfaces. Oil catchers to be fitted where necessary (see under "Fittings").

VALVE GEAR.

To be of the "Dobson" or "Reynolds" type. Steam valves to be actuated direct from the crankshaft by eccentrics and rods and trip gear, with noiseless dash pots to be provided for controlling the opening and closing of same on each cylinder. The exhaust valves to be worked direct from the crankshaft by eccentrics and rods actuating levers, keyed on valve spindles. The gear to be designed, so that the period of admission and compression of steam can be altered and adjusted by hand on each cylinder while the engine is running.

All levers, connecting rods, joints, etc., to be adjustable and of best quality crucible forged steel, the wearing parts to be thoroughly hardened and of large diameter and surface. All necessary brackets, rods, hand-wheels, indices, etc., to be provided for altering and indicating the admission of steam. The whole of the gear, where possible, is to be polished and finished dead bright.

The eccentrics to be of cast iron, and the rods of mild steel, of circular section, with upper half of strap bolted on, the lower half being secured to it by turned steel bolts and lock-nuts. The whole of the rods and straps to be polished dead bright and fitted with bronze liners.

EMERGENCY BRAKE.

Provide a balanced throttle valve in steam main, also a vacuum breaker controlled 33 by the pressure on pumping main. The brake to have a water cylinder lined with gun metal and fitted with a gutta percha packed piston on the end of a vertical bronze rod, working through a stuffing box in top cover; this rod to be fitted with two forged steel washers containing a steel spring of flat section held in compression by two forged steel columns and top crossbar. The top end of bronze spindle to be attached to lever on throttle valve by a steel connecting rod. The brake to be arranged with fulcrum and long detachable lever for working the apparatus by hand. A neat case containing a water sealed valve for destroying the vacuum to be fitted in a tray cast on upper part of cylinder. The whole of the above to be polished where possible and mounted upon the engine bed plate. Connect 11 inch supply pipe from pumping main outside delivery air vessel to water cylinder. The following fittings to be provided and fixed: One 6-inch open-faced dial (to show mechanism) water pressure gauge without flange, of Messrs. Dewrance and Co.'s best make (gauge cock to have polished dark mahogany handle), one 3 inch copper pipe to drain tray and top of cylinder, one phosphor bronze valve on 1½ inch inlet branch, one on vacuum pipe, and one on 3 inch drain pipe. All pipes above floor level to these fittings and to vacuum breaker to be of polished copper and fitted with neatly shaped gun metal unions.

RECEIVERS.

Two steam jacketted re-heaters of large capacity are to be provided and fixed on middle platform behind back standards; these are to be connected to the steam cylinders with mild steel pipes. The re-heaters are to be covered with non-conducting composition and planished steel lagging. All pipes for the jacketting to be of copper. Bosses are to be cast on for attachment of pressure gauges and drain pipes (see under "Fittings").

STEAM PIPES FOR MAIN AND AUXILIARY ENGINES.

All the main steam pipes between boilers and superheaters, and between superheaters and engine, and branch steam pipes to Air, and Westinghouse pumps, steam winches and dynamo engine are to be made by Messrs. Stewarts and Lloyds, Limited, of Birmingham; they are to be of wrought steel, lapwelded, with wrought iron flanges welded on, with fillet at back, faced plain and drilled in accordance with British Standard Table II.

Suitable outlets to be electrically welded to the pipes in the required positions. Steel and copper expansion pipes to be provided where necessary, and ample provision to be made for drainage, and all necessary phosphor bronze drain cocks and wrought iron pipes to be supplied.

Where necessary the steam pipes are to be made to template.

The pipes are to be tested to 320 pounds per square inch by hydraulic pressure, and the test pressure to be clearly stamped on each pipe.

Insert in steam pipe, close to engine stop valve, one wrought steel thermometer pocket, to stand above lagging, with brass thermometer protector, and one special solid glass thermometer, with armour, to read up to 600 degrees Fah. Provide cast iron separator for steam pipes to auxiliary engines and where necessary, wall brackets, pipe hangers, wall base bracket with roller, to approved designs. A float steam trap of Messrs. Dewrance and Co.'s make, No. 3648, complete with testing handle, to be provided for steam pipes in boiler house.

EXHAUST PIPES.

To be led from Corliss boxes on L.P. cylinder to oil separator, and from thence to surface condenser. A cast-iron circular and ornamental base ring to be fixed around pipe at floor level; pipes to be neatly eased in planished sheet steel for the sake of appearance.

FLANGES.

All flanges, together with bolt heads and nuts, throughout the engine, pumps and boilers, to be truly faced and joints made quite steam and water-tight, the holes drilled to templates, and neat washers supplied, the flanges to be in accordance with the latest report issued by the Engineering Standards Committee in "British standard tables of pipe flanges."

BED PLATES.

To be cast in five parts, not less than two feet four inches deep, and framed of metal not less than 1½ inches thick, to be well ribbed, and bossed for all bolts, and to have a moulding running all round the bottom, four inches deep by 1½ inches proud. All necessary faces to be cast on and machined for attachment of crankshaft plummer blocks, massive joggles machined for machined wrought iron fitted taper joggle keys; lugs for pump stays, faces for front columns and back standards, and arrangement made

for heads of holding down bolts to be sunk and covered over with plates. All joints to be machined quite true, and well joggled together with broad keys cut out of the solid, and secured by a large number of bolts not less than 1½ inches diameter. All faces to be marked off and evenly finished after erection. The crank openings in bed plate to be closed in on underside with strong cast iron oil trays bolted on, having loose stuffing boxes with bearings in halves for side rods. For drains to these trays (see under "Fittings"). Where necessary flanges to be cast on for supporting York flags. Foot plates of chequered steel § of an inch thick (Admiralty pattern) to be fastened in recesses on the top of bed plates, and in openings between same. The under side of bed plates to be machined for bedding to main and cross girders. (For Oil Catchers, see under "Fittings.")

ENTABLATURE.

A neatly moulded entablature of cast iron to be fixed on top of columns and back standards. The entablature is not to be less than 18 inches deep by 1½ inches thick, and well ribbed. All joints and faces for steam cylinders, cantilever brackets for carrying the packing stages, etc., to be machined.

FRONT COLUMNS AND BACK STANDARDS.

Provide three parallel columns of polished mild steel, not less than eight inches diameter. Ends to be flanged and bolted to the bed plate, and entablature, with well finished bright bolts and nuts and moulded washers. The three cast iron standards to be of very massive design, with bases splayed and left open so that the interiors of same can be examined and painted. Both upper and lower flanges to be well bracketed, and faces truly machined on surfaces and edges, and keyed into faces on bed plate and entablature by keys cut out of the solid metal. Guide faces to be machined for plates. Savealls to be cast on standards, and polished bronze drain connections and pipes to be fitted to same.

PISTON ROD GUIDE PLATES.

The guide plates to be of cast iron bolted to machined faces on back standards. They must be properly grooved for efficient lubrication and fitted with guide strips of polished forged steel secured by pins with countersunk flush heads.

PISTON ROD CROSSHEADS.

To be of handsome appearance, with ample wearing surfaces, and polished all over. The bearings to be of phosphor bronze in halves, the latter to be held in position by mild steel caps secured by mild steel bolts to the T heads on ends of piston rods. Forged steel distance pieces, shaped to match the connections, to be fixed to crossheads for attachment of side rods. The guide shoes to be of cast iron. (For Lubricators, see under "Engine Connecting Rods.")

GIRDERS.

The two cast-iron girders for supporting the bed plates to be of massive proportions and of even thickness throughout, and of metal not less than 2½ inches thick. Under sides to be cambered and the top faces to be machined (to receive bed plates); also faces for heads of holding down bolts. Cross girders to be provided.

SIDE RODS.

To be of mild steel not less than 5 inches diameter, with large collars at upper ends, and held up to their faces by deep steel nuts and washers. They are to be polished all over and swelled (for re-turning when worn) on the surfaces that work in stuffing box guides.

SURFACE CONDENSER.

To be of the open type, placed in the tank on the suction side of force pumps, consisting of a sufficient number of solid drawn brass tubes, Admiralty mixture (to give the necessary cooling surface), expanded into rolled brass tube plates. A sufficient number of solid drawn brass stay tubes, not less than thick, and brass nuts 1 inch thick, to be provided. The steam to be passed through the tubes. The tube plates are to be bolted into end chambers provided with properly ribbed covers. Fit an injection pipe and gun metal spray, to be controlled by a valve worked from the engine house floor, a neat east iron column for same to be bolted to the floor and to be provided with polished handle and engraved gun metal index plate. Provision for receiving cylinder drains to be made on exhaust pipe. Provide cocks for shutting off drain pipes. Condenser to be designed for a working pressure of 50 lbs. per square inch. (For Cocks see under "Fittings.")

AIR PUMP AND ENGINE.

To be of the steam driven Edwards type, suitable for superheated steam, and all details to be approved by the patentees. It must be strongly built for 160 lbs. working steam pressure, and well finished; fitted with heavy fly-wheels having polished rims. The pump is to run at moderate speed, free from vibration. Cast iron pipes to be supplied to connect pump with condenser, and to carry discharge from air pump through an air vessel with internal pipe to the feed tank in boiler house. A connection with sluice valve to be made on discharge pipe for measuring condensed water for engine test purposes, an emptying valve to be placed on the suction pipe. (For Valves and Lubricators see under "Fittings.")

CRANKSHAFT PLUMMER BLOCKS.

To be of cast iron, with neat polished steel glands. The bearings for shaft journals to be of phosphor bronze in halves, the top half being flat. The length of bearings to be from two to one and a half and one and a quarter times their diameters, according to positions; ends of four blocks only (over boreholes) to be machined for taper joggle keys. All bolts to be of mild steel with polished nuts, the full depth, exclusive of the safety collars. Thick polished steel washers to be fitted under all nuts. Faces to be machined and provided with polished cast bronze savealls, on the sides of plummer blocks which do not overhang the oil trays fixed on under side of bed plates. Brass oil tubes to be fitted in glands and upper half of bronze bearings. (For Lubricators and Savealls, see under "Fittings.")

To be in three lengths, each of the built up type, neatly designed, of best quality mild forged steel. The shafts, cranks and pins to be polished all over; and after all parts have been shrunk together and secured with keys, each length to be put in a lather and journals and crank pins trued up and lapped, or ground dead true. The shaft must not be less than 12 inches diameter in the smallest journal, and increased in diameter for journals each side of fly-wheel. Solid flanges to be forged on for connecting the three lengths together, and fitted with keys cut out of the solid. The flanges are to be securely bolted together with polished steel bolts and nuts.

ENGINE CONNECTING RODS.

To be of mild forged steel of handsome appearance, polished all over. The upper end to have a mild steel gudgeon pin shrunk in, and not less than 8 inches diameter by 10 inches long in journal. The lower end to be fitted with phosphor bronze bearings

in halves held in position with steel caps secured by mild steel bolts having round heads and deep nuts with safety collars and set pins. Polished bronze lubricators of best finish and polished copper pipes with neatly-formed bronze clips to be fitted to each end of rods.

OIL SEPARATOR.

Provide and fix an oil separator of ample capacity, to be placed in the exhaust pipe to surface condenser; together with oil pump and tank, wall brackets and all pipe connections, the complete plant to be constructed by the Baker Oil Separator Co., Limited, Union Works, Saynor Road, Hunslet, Leeds. The oil pump to be driven from the crankshaft of the Edwards Air Pump. The Contractor must give a guarantee that the vacuum will not be affected in the L.P. cylinder. (For Valves, etc., see under "Fittings.")

FLY-WHEELS.

The fly-wheels to be of best quality cast iron, of sufficient size and weight to keep the engine running smoothly under all conditions, to be carefully built up in segments, which are to be truly machined on faces, and securely held together in boss and rim by turned steel dowels and fitted cotters cut off flush. The boss must be bored to a good fit on the shaft and firmly secured by one steel key, and to have two polished steel hoops not less than three inches by two inches in section shrunk on. The arms to be neatly panelled, and wheel to be turned and polished on rim and side fillets, and to be left running perfectly true. No balance to be cored in rim. Teeth for barring purposes to be fitted to one wheel.

BARRING ENGINE.

A steam barring engine of Messrs. Hick, Hargreaves and Co.'s make, of their standard double cylinder pattern, with automatic disengaging gear, and arranged to give downward thrust. The engine to stand on a strong cast iron tray, and a planished steel protector box to be fitted over the geared wheels.

NON-CONDUCTING COMPOSITION.

The steam cylinders, Corliss valve boxes, main steam pipes, reheaters, boilers 53 (including fronts and steam mountings), all steam cylinders of auxiliary engines and their steam pipes, feed delivery pipes to boilers, and all other necessary parts to be covered with Fossil Meal non-conducting composition, the same to contain no less than 70 per cent. of pure earth (Kieselguhr of standard quality) after the binding material has been added to it; the hair used for binding must be of best quality; no fibre will be allowed. A 6 lb. sample ready for use to be submitted for the Engineer's approval. The composition to be obtained of Messrs. Haaeke and Co., Kieselguhr Wharf, Homerton, London, N.E. The thickness of the covering to be as follows: All steam cylinders, steam pipes and valves to be filled in level with the outside diameter of flanges, boiler shells to have 21 inches and the fronts of same to have 41 inches. All steam and other pipe flanges under planished steel to be covered with asbestos millboard & inch thick, and all boxes of galvanised iron to be lined with the same material. The surface of the composition must be left perfectly smooth and true, and where exposed it is to be painted with three coats of paint to be obtained of the Torbay Paint Company, 26, 27, 28 Billiter Street, London, E.C.

1st coat, grey priming.

2nd coat, iron grey egg shell gloss, heat resisting.

3rd coat, No. 72 deep maroon enamel, heat resisting.

Where necessary non-conducting composition must be well secured with thick galvanised iron wire.

LAGGING.

The main steam and exhaust pipes in engine house, cylinders and bottom covers, 54 Corliss boxes, steam pipes to Westinghouse and air-pump engines above floor, steam cylinders of all auxiliary engines and all other parts necessary, to be lagged and neatly finished with planished sheet steel of best quality, not less than 16 B.W.G. in thickness, supported with steel internal joint strips and secured with planished bands having polished gun metal connections and button-headed screws. Sample of sheet steel lagging to be submitted for approval. The H.P., I.P., and L.P. steam cylinders are to be fitted with horizontal bands of polished sheet steel, two to each cylinder. The side of the planished steel lagging next to composition is to receive two coats of best oxide of iron paint before leaving the Contractor's works, all rust being removed before the paint is applied. In the boiler house all the main steam pipe flanges, also flanges of steam pipes to boiler feed pumps, boiler feed pipe flanges, dead weight safety valves, main and Hopkinson-Ferranti stop valves, lever safety valves, manhole covers, are to be covered with detachable boxes of galvanised iron, lined with asbestos millboard 1 inch thick. The boxes are to be fastened with neat detachable bands and clips of galvanized iron, the iron for the boxes is to be 20 B.W.G. before being galvanised.

PACKING STAGES, STAIRS, FLOOR FRAMES, AND PLATES, ETC.

Packing Stages.—A neat packing stage and landing to be provided and fixed around three sides of the entablature, and another with landing about 8 feet below (between back standards). Each to be composed of angle iron frames 2½ inches by 2½ inches by ¾ inch, properly shaped and welded together at corners, and filled in with steel chequered plates having all necessary holes cut in for pipes and rods, etc., to pass through. Neat cantilever brackets and all other supports to be provided for carrying both stages.

Stairs to Packing Stages.—To consist of steel stringers, 4½ inches wide by ½ inch thick, with east iron treads not less than 8½ inches wide of approved pattern.

Stair to Pump Room.—One set of stair to be provided and fixed in the centre of engine house. Stair case to have channel irons not less than 9 inches by 4 inches around ends and sides at floor level to carry York flags and railing. The stair to have steel stringers 8 inches wide by $\frac{5}{8}$ inch thick, fitted with cast iron treads (9 inches wide) and cast iron risers. The stair not to be less than 4 feet wide between the stringers. All stairs to be set at an angle of 45 degrees.

Handrailing.—Double handrailing around packing stages, landings and each side of stairs, the top rail of polished brass 1 inch diameter and not less than $\frac{1}{16}$ inch thick, bottom rail of polished solid steel of the same diameter. Handrailing to be supported by polished steel stanchions tapering from $1\frac{1}{4}$ inches at bottom to 1 inch at top, with approved bases forged on for securing to chequered plates and stringers. Double handrailing around staircase to pump room and each side of stair, the top rail of polished brass $1\frac{1}{4}$ inches diameter and not less than $\frac{1}{16}$ inch thick, bottom rail of polished solid steel of the same diameter. Handrailing to be supported by polished steel stanchions tapering from $1\frac{1}{2}$ inches at bottom to $1\frac{1}{4}$ inches at top, with approved bases forged on for securing to flags, channel iron and stringers. Double handrailing and stanchions to match those on packing stages, to be fitted around engine and borehole pump crank races and fly-wheels.

Floor Frames and Plates.—One cast iron frame to be fitted over the oil separator and covered with chequered plates; two double frames without plates over steam winches (rebated to receive 3 inch York flags); and one frame fitted with plates 4 feet square, for access to pump chamber. For sizes of these frames see Contract Drawing. (For chequered Plates on and between bedplates see under "Bedplates.") All rebates in frames to be machined for plates and internal frames.

Steel Chequered Plates for Packing Stages, Floor Frames, etc., to be of Admiralty pattern, § inch thick, thoroughly levelled and edges planed square, and secured where necessary by countersunk headed screws. Iron plates to be fitted under all joints, which are liable to "ride." Provide lifting holes § inch by § inch in plates where necessary.

Foot Steps.—(Three) mounted on cast iron brackets to be fixed on engine and borehole pump bedplates.

Rolled Steel Floor Joists.—Six inches by 5 inches to be provided and fixed for supporting floor of York flags for half the area of engine house, including engine site.

Ladders.—One steel ladder to be provided and fixed between basement and top of suction tank, one ditto for travelling crane with supports fixed in wall.

TRAVELLING CRANE.

An overhead hand power travelling crane of the most up-to-date type and best workmanship, made by Messrs. R. Gibbins and Co., Birmingham, or other approved maker; to span the engine house and to run the whole length of it; suitable for lifting heaviest part of engine or pumps, and to be worked from floor level by means of endless cotton ropes, running over grooved pulleys. The crane is also to be used in conjunction with the steam winches to lift the borehole rising mains and pump rods, etc.

The lifting gear to be spur geared, and to give two different speeds of lifting for heavy and light loads, fitted with ratchet wheel and catch, the brake to be of the constant thrust type. The barrel to be grooved for wire rope and to be sufficiently long to avoid overlapping.

General Design.—The crane to consist of a travelling bridge moving longitudinally, with a traverser movable across the bridge and carrying the lifting gear.

Longitudinal Motion.—To be communicated to both end-trucks by cross shaft, operated by a hand-rope and rope wheel at each end. The shaft to have extra bracket bearings along the span.

The Bridge.—To consist of rivetted compound girders, stiffened laterally and vertically where necessary, and securely fixed to the end-trucks. The sections employed are to be ample to ensure that the deflection due to lifting the full load shall not exceed one-six-hundredth of the span.

The Traverser to run on four wheels, axles to be of mild steel and framework of mild steel plates. The gear to be so built in framework that all parts are easily accessible and removable.

End Trucks to be of wrought steel, each wheel of same to have two bearings.

Steel Rope.—Provide a suitable length of best flexible steel rope.

Sheave and Hook.—Provide sheave and swivel hook, the latter to be of mild steel, and capable of bearing five times the working load.

Crane Rails.—Crane rails of strong section are to be provided and secured to steel joists, with countersunk headed screws. Stops are to be fitted to the rails to prevent the traveller striking the end walls of building.

Provide a special connection for suspending blocks (specified under "Steam Winches"), and arrange for scotching and strutting the crane when rising mains and rods are being raised or lowered by steam winch.

Painting.—The whole crane and rails to be coated with boiled linseed oil put on hot, after all scale and rust has been removed by scraping and wire brushing.

The Contractor will be allowed the use of the crane to erect the engine, etc., but at the completion of the contract he must leave it in perfect working order.

STEAM WINCHES.

57 Two steam winches, each with double steam cylinders and reversing gear, constructed by Messrs. J. H. Wilson & Co., Ltd., of Dock Road, Seacombe, Birkenhead, to be fitted with powerful band brakes worked by hand wheels and screws, ratchet wheels and pawls, and suitable for drawing rising mains or pump rods (in conjunction with travelling crane) with three and four sheave blocks and steel rope. The lower sheave to have a swivel hook, the latter to be of mild steel, and capable of bearing five times the working load. The winches to be finished in the same high-class manner as the main engine, but not polished. The gearing to have machine-cut teeth, and to work as noiselessly as possible; guards to be of planished sheet steel. Winches to stand in large cast iron trays not less than four inches deep internally, and fitted with drain pipes to basement.

The warping drums of the winches to be capable of being disconnected from the main barrels so that they can be worked alone for the purpose of lifting the borehole suction valves. The barrels to be grooved for wire ropes. The winches to be placed under the engine house floor, and so arranged that they will serve a duplicate engine as well as the one included in the Contract.

Provide wire rope blocks (three and four sheaves), which are to be suspended from a special connection on the overhead crane, also galvanised steel rope for use with the blocks and winches.

Provide a galvanised steel rope & inch diameter for lifting the borehole suction valves; this rope to run over the fourth sheave of the block mentioned above.

ELECTRIC LIGHT PLANT.

Include the sum of £250 (two hundred and fifty pounds) for electric light installation.

BOREHOLE PUMPS.

DESCRIPTION.

To be two in number, of the bucket type, each 5 feet stroke, and suitable for a total lift of 300 feet, at an average bucket speed of 200 feet per minute.

WORKING BARRELS.

To be of cast iron, bored true and parallel and bell-mouthed; screwed for attachment to rising mains, and flanged to receive suction boxes.

SUCTION VALVE BOXES.

To be of cast iron, screwed to receive suction pipes, and fitted with phosphor bronze seats for suction valves.

BUCKETS AND SUCTION VALVES.

Constructed entirely of manganese bronze, to be of the Pernis multi-annular type, as shown on drawing, which can be seen at the office of the Engineer. Each of the buckets to have five valves and the suction valves six. The suction valve seatings are to be suitably weighted by steel rods, and to have gutta-percha rings dovetailed into same. Tackle for lowering the rising mains, rods, and suction valves to be provided by the Contractor, and to become the property of the Company.

BUCKETS.

To be fitted with gutta-percha packing rings, 3 inches deep by 1 inch thick, and to be securely fastened to steel spindles by deep gun metal nuts, locked by steel cotters in the spindles behind them.

TEMPORARY WORKING BARRELS.

Of cast iron or steel to be provided and fixed above the permanent working barrels; these will be used when the engine is first started, to prevent the permanent barrels being scored.

TEMPORARY BUCKETS AND SUCTION VALVES.

Two of each to be provided; these to have the ordinary flap valves and to be fitted with suitable packing.

BUCKETS RODS AND COUPLINGS.

To be of mild steel with sockets forged solid on rods, and to have turned sockets and spigot joints secured with steel cotters; each rod to be 15 feet in length, the spigots and sockets to be tapered.

GUIDES.

To be of cast iron (annular) and secured to rods below each coupling; rods to be swelled to receive same.

RISING MAINS.

The rising mains to be made up of lap welded mild steel tubes 17 inches internal diameter, and in suitable lengths, the upper half of tubes in each lift to be § inch thick, and the lower half ½ inch thick, securely connected together by steel screwed couplings 12 inches in length. Each tube to be turned on both ends, and a gutta-percha joint inserted between each length. The couplings to be a tight fit on the tubes for the whole length of the thread. The rising mains are to be suspended from cast steel flanged sockets. The whole when screwed together must hang perfectly plumb.

The Company will provide and fix at the top of each borehole a cast iron cylinder, 3 feet internal diameter, with top flange 4 feet diameter. On each top flange the Contractor is to bolt a head box of massive proportions, with discharge branch; this box to have an internal flange heavily bracketted, and truly machined on face and spigot for receiving the steel casting from which rising main is suspended, covers containing stuffing boxes with bronze bushes and collars to be bolted to each head box, and so designed to form a collector for all oil drippings from crank pins. Head boxes are to be eccentric with borehole lining tubes if necessary.

Steel castings of ample strength and sound material to be screwed to top of each rising main. They are to be machined on under sides and spigot to fit head boxes. The screwed parts (of extra length) to be a good fit on steel mains, and stout lugs to be cast on for lifting purposes. Provide eight stout pins for breaking joints.

CAST IRON FLANGED PIPES

To be provided for conveying water from head boxes to force pump suction tank.

CONNECTING RODS.

To be the same design as the Engine Connecting Rods and arranged with an efficient system of lubrication for top and bottom ends.

PUMP ROD CROSSHEADS.

To be of forged steel, polished all over, and fitted with phosphor bronze bearings in halves, the latter to be held in position by forged steel caps, and secured by steel bolts having round heads and deep nuts, with safety collars and set pins.

The lower part to be bored taper to receive the pump rods, which are to be secured by strong cotters.

The slippers to be of east iron having large wearing surfaces.

1

CROSSHEAD GUIDES AND PLATES.

The guide plates to be of cast iron grooved for efficient lubrication, and fitted with guide strips of polished forged steel, secured by pins with countersunk flush heads. The whole to be mounted on massive castings, well secured and bolted to the brick piers, and arranged with large oil catchers. (See under "Fittings.")

FORCE PUMPS.

DESCRIPTION.

To be three in number, of the single acting plunger type, with a stroke of four feet, to be placed directly under the steam cylinders, and worked by side rods from a crossbar on piston rod crosshead. Provide bosses for indicator cocks.

SUCTION BOXES.

The three cast iron boxes to be not less than 18 inches deep internally, and each faced for valve plates, suction chambers, holding down bolts and base plates. Fix one 1½ inch phosphor bronze bye-pass with phosphor bronze connections, and one 1 inch phosphor bronze drain cock on each box, both to be flanged and polished, faces to be cast on to receive same. Sockets to be cast on for suction pipes. Each box is to be fitted with a cast gun metal valve plate, in which the suction valves are to be secured with Morse taper. These plates are to be supported by central stude and distance pieces. (See under "Fittings.")

SUCTION CHAMBERS.

Each of the three cast iron chambers above suction boxes to be faced all over top and bottom, and provided with two oval manholes 18 inches by 12 inches, the covers having provisions for lifting. The delivery valves are to be fitted to the tops of each chamber with Morse taper. These tops are to be well supported with brackets. Faces to be east on each box for bye-pass, and on one box, nearest delivery air vessel, for air charger suction pipe.

DELIVERY CHAMBERS.

Each of the three cast iron chambers to be machined on all faces. Access to same to be by oval manholes, 18 inches by 12 inches, two to each chamber, the covers having provision for lifting. Delivery branches of large diameter to be cast on each chamber for passing the water from each pump to delivery air vessel, the tops of branches to be on top line of pumps to prevent air locks. The chambers to be provided with cast iron glands, lined with gun metal, deep stuffing boxes, and extra long gun metal collars to act as guides to plungers. Supports to be cast on for stays to engine bed plate.

Provide one 1½ inch flanged and polished phosphor bronze bye-pass with polished phosphor bronze connections for each chamber. Faces to be cast on to receive same. (See under "Fittings.")

PUMP VALVES.

All suction and delivery valves and seats to be of phosphor bronze of the multiannular type, with phosphor bronze spindles and springs, and conveniently arranged for examination and removal. All wearing and other surfaces to be as large as possible. The design of valves to be the same as those for Borehole Pump buckets. Valve seats to be fitted into plates with Morse tapers, and suitable tools for fixing and withdrawing same to be provided.

Each of the six sets of valves to have a clear area through them of not less than the area of one plunger.

PLUNGERS.

To be three in number, of hard cast iron, with dished ends, and accurately turned on all parts working in stuffing boxes. To have very deep lugs cast on, with upper and lower faces accurately machined for attachment of side rods. They are to be east hollow, but not less than 1½ inches thick, and arranged for receiving lead, to perfectly balance the engine.

JOINTS.

All joints throughout the pump work to have extra deep flanges truly machined and recessed for gutta-percha cord joint rings, and where practicable strongly bracketted, all bolt holes drilled, bolts faced under heads and nuts, and provided with faced washers fitting on faced parts of flanges.

WATER LEVEL INDICATOR.

A water level indicator, of Messrs. Glenfield and Co.'s make, to be provided and fixed, for indicating the depth of water in suction tank. A neat cast iron pedestal containing the working parts and surmounted by a vertical dial with brass face to stand on engine house floor. Float to be of Copper.

DELIVERY AIR VESSEL.

The delivery air vessel to be of the size! shown on blue prints. The body and branches to be constructed entirely of steel plates rivetted together, with butt joints and cover plates, and suitable for the specified working pressure of 132 lbs. per square inch. Machined faces to be provided for Whipperman's Air Charger and pipes, Westinghouse Air Pump pipes, and gun metal gauge fittings (see under "Fittings"). A wrought steel manhole to be rivetted on. A cast iron base plate, 3 inches thick, with machined top, to be supplied, for air vessel to sit on; four holding down bolts to be provided. Connection to be made to pipe for gauging depth of water in boreholes.

SLUICE VALVES.

Two geared sluice valves, with bye-passes complete, one to go between force pumps and delivery air vessel and one between the latter and pumping main, to be obtained of Messrs. Glenfield and Co., of their best heavy pattern, and fitted with index plates. A small cast iron circular frame and chequered plate to be fixed in stone floor over one of the valves.

RELIEF VALVE.

An efficient relief valve to be fixed on the delivery main between force pumps and sluice valve of the double beat valve type, controlled by spiral spring, and so arranged that water escaping therefrom will be conducted to drain.

WESTINGHOUSE AIR COMPRESSOR.

One of the Westinghouse type of ample power and capacity to charge the delivery air vessel when under its full pressure, and to work with 160 lbs. steam pressure (superheated), to be used as an auxiliary air charger and mounted on a neatly moulded cast iron plate, fixed in a convenient position in engine house. The studs for fixing same are to be of steel, screwed into bat bolts in wall and provided with polished bronze cap nuts. The front surface of plate to be covered with planished steel not less than 1 inch thick, with edges machined quite square.

AIR CHARGER.

A Whipperman and Lewis' air charger to be obtained of Gilbert Lewis, engineer Manchester, and fixed on air vessel. Valves to be of Messrs. Dewrance and Co.'s make. Connect air charger to one of the suction chambers of force pump. All connecting pipes to be of steam tubing.

SUCTION PIPES.

A cast iron pipe to be provided for each pump with flange at one end for bolting to suction tank, and spigot at other end for connecting to suction box.

SUCTION TANK.

Provide and fix a cast iron open top tank for receiving the water from the two boreholes. The plates must be of sufficient strength to avoid the use of internal stays. All plate flanges to be truly faced for their full width. The joints to be made with a coating of white and red lead putty. The tank must not be less than 22 feet long by 7 feet wide by 6 feet 6 inches deep. Machinea faces to be provided for attachment of suction pipes to force pumps, also fix supports for pipes from boreholes. A substantial drain cock to be fitted in a convenient position.

The tank plates, after they have been thoroughly freed from rust, are to have one coat of boiled linseed oil put on hot.

DELIVERY PIPES.

Flanged cast iron delivery pipes to be provided between force pumps and delivery air vessel.

FITTINGS.

To be of the best make, turned and polished all over unless they are covered with non-conducting composition.

All Stop and Drain Valves under steam pressure in Engine, Pump and Boiler houses (large or small), to be obtained of Messrs. J. Hopkinson and Co., Ltd., Huddersfield, the bodies to be of phosphor bronze, polished all over and fitted with "Platnam" metal valves and seats. Handwheels to be of gun metal (of approved pattern) polished all over. All flanges of valves to be circular, and to have studs, bolts, and nuts of Delta metal. Valves to be suitable for superheated steam.

All Stop and Drain Valves under water pressure to be obtained of Messrs. Dewrance and Co., 165 Great Dover Street, London, S.E., the bodies to be of phosphor bronze, polished all over and fitted with renewable valves and seats. Handwheels to be of gun metal (of approved pattern) polished all over. All flanges of valves to be circular, and to have study, bolts and nuts of Delta metal.

Governor Valve.—One Hopkinson-Ferranti patent stop valve for 160 lbs. working pressure, Fig. 2025, with Siemens-Martin cast steel body and cover, with solid "Platnam" metal seat and disc; to be worked from floor level through rods and gearing, and to have a highly finished and polished spoked handwheel of about two feet diameter. Valve to be placed in steam pipe to H.P. cylinder and worked from front of engine.

Branch Stop Valve.—One Hopkinson-Ferranti stop valve as above to be fixed in branch steam pipe to engine and worked from packing stage. Rim for hand-wheel to be polished and without milling.

Auxiliary Engine Stop Valves.—Two stop valves to be fixed on branch steam pipes to each auxiliary engine and other long branches, *i.e.*, one close to main steam pipe, and one close to the engine. All valve spindles to be fixed vertically, and if out of reach to have gearing.

Steam Winches.—Stop valves, lubricators, drain cocks, and steam tubing.

Auxiliary Balanced Steam Valve with copper pipes to connect each end of L.P. or I.P. cylinder, to facilitate starting engine.

Drain Valves and Pipes, etc.—Where necessary for steam cylinders, jackets, United States Metallic Packings and other parts, also non-return valves, pipes, handwheels, handles, levers, brackets, pipe supports and rods. Handles and levers to be worked at front of engine, supported by neat brackets. All elbows to be of polished phosphor bronze.

Inspection Boxes.—Two cast iron boxes to be fitted into the entablature, to which all drain pipes are to be led, the covers to be secured by hinged pins and fly nuts. From these boxes copper pipes are to be led to the main exhaust pipe, and stop valves fixed close to the latter.

Gauges.—For steam, vacuum, borehole and water pressure, of Messrs. Dewrance and Co.'s best make, all 10 inches diameter, to have open-faced dials (opening 4 inches diameter) to show mechanism; gauge cocks fitted with dark mahogany handles, and mounted on a neatly moulded cast iron plate with planished sheet steel front, to be

fixed in a convenient position on the engine house wall by bronze cap nuts on steel pins, the latter to be screwed into but bolts, leaded into brickwork. Copper pipes to floor level to be § inch external diameter, of stout gauge, with neat copper scrolls and neatly-finished gun metal unions.

Fix 7-inch diameter gauges of the same pattern on emergency brake, L.P. cylinder jacketting and reheaters, all without flanges at back.

The lettering on all gauges to be approved.

About 300 feet of § inch outside diameter copper pipes (not polished) to be provided for borehole gauge. All joints of same to be brazed.

Borehole gauge pipes to be connected to delivery air vessel,

Copper Pipes.—All pipes, unless otherwise specified, to be of stout copper, well polished and fitted with heavy phosphor bronze circular flanges. Pipes to be carefully led, free from dents, and neatly secured by phosphor bronze clips or brackets. No pipe to be less than ½ inch bore. Flanges to have studs, bolts, and nuts of Delta metal. All flanges, elbows, etc., to be brazed, not soft soldered.

Cylinder Oil Lubricators.—Three in number, to be obtained of the Empire Engineering Co., Salford, Manchester, of their "Feed Well" type, with pressureless sight glass. One with 6 feeds to be fitted to the high pressure cylinder for lubricating the top and bottom of cylinder, and the spherical packings on the four valve spindles, and two with four feeds each, for the spherical packings on the Corliss spindles of intermediate and low pressure cylinders. The above are to be actuated by the Corliss gear.

Mount lubricators on neat brackets or polished steel columns, and provide polished cast iron oil trays under each. Copper connecting pipes to be § inch bore.

Gun Metal Flushing Lubricators of best make with double glands, asbestos packed, to be fitted to each cylinder.

Engine Oil Lubricators of phosphor bronze, to be obtained of Messrs. Hunt and Mitton, Oozells Street North, Birmingham, catalogue No. D 1084, to have external adjustment and to be fixed on outer bearings of all Corliss spindles, all parts of valve gear, United States Metallic Packings, and other bearings and working parts throughout the main and auxiliary engines.

Oil Catchers of polished cast bronze, tinned steel and polished sheet brass to be fitted to all parts required by the Company, including the rods and guides over boreholes.

Those of sheet brass to be of 16 B.W.G. top edges wired, corners neatly mitred, detachable wherever necessary for cleaning purposes, and provided with screwed plugs for draining off oil. All joints to be neatly brazed, not soft soldered.

Steam Traps.—Two of Messrs. Dewrance and Co.'s float type. These are to be of large capacity and fitted with handle for testing.

Bye-Passes.—Six 1½ inch phosphor bronze double gland cocks, of Messrs. Dewrance and Co.'s make, for valve boxes of force pumps, connected up with suitable phosphor bronze elbows. (See under "Force Pumps.")

Air Cocks of phosphor bronze, to be fixed on force pumps where necessary.

Counter.—Patent seven-Tigure counter (Harding's) and gear, the latter to be enclosed in case and provided with lock and seal (as made by Messrs. Thomas Glover and Co., London), to prevent it being tampered with. The counter to be mounted on a massive polished steel stanchion and fixed on engine bed.

Indicator Cocks and Gear.—An indicator of approved make to be provided. Cocks to be of Messrs. J. Hopkinson's make, asbestos packed, with drain cocks attached. The copper indicator pipes on each cylinder to be arranged so that one indicator may be served by either end of cylinder. Provide screwed plugs to enable pipes to be removed when not indicating. A set of neatly made and polished indicator levers, links and quadrants to be provided for each cylinder. Force pumps to be provided with phosphor bronze cocks of Messrs. Dewrance and Co.'s make, also gear for indicating.

Water Gauge of Messrs. Dewrance and Co.'s make, to be provided and fixed, on delivery air vessel and set to 6 feet centres. The cocks to be of bronze (for \(\frac{3}{4} \) inch glass), as bestos packed and with flanged ends.

 Λ polished bronze guard of Messrs. Dewrance and Co.'s make to be fitted to gauge; the guard to be made in halves and bolted together.

Copper Pipes for Air Compressor.—Exhaust 1\frac{1}{4} inch, delivery 1 inch, steam 1 inch (above floor) and drains \frac{1}{2} inch. Compressor to be arranged for charging delivery air vessel when it is under its full load.

Bed Plate Drains.—To be of wrought iron, bolted to faced flanges on trays, and led to drain in basement.

Main Pump Gland Drains.—To be of wrought iron, bolted to faced flanges on plunger stuffing boxes, and led to drain in basement.

Spanners.—A complete set of forged steel, polished all over, and mounted on a neatly moulded cast iron plate, with planished sheet steel front; polished and numbered gun metal pegs to be provided for each spanner. But bolts to be let into wall, and plate secured to same by steel studs fitted with polished gun metal cap nuts.

Holding Down Bolts for Engine and Pumps, and all auxiliary plant, to be of steel, with nuts, cotters and large washer plates, and provision made to prevent bolts turning when screwed up. All nuts and washers to be faced.

Supply and Waste Pipes.—All pipes, supply and waste, to within one foot outside engine, boiler and pump house walls.

CASTINGS GENERALLY.

All steel, iron, phosphor bronze and gun metal castings are to be run solid, free from sand, air holes, and other defects and blemishes, and to be neat, smooth and true.

Test bars, 1 inch square, to be cast on all principal iron castings, and when placed on supports 12 inches apart must sustain without fracture a stress of 2.000 lbs, applied at the centre of span. The bars, carefully labelled, showing from which casting they

have been taken, to be sent to the Engineer for testing. All phosphor bronze and gun metal castings to be equivalent to the following mixture:—

Phosphor Bronze.					Gun Metal.				
Copper				parts	Copper	***	•••	86	parts.
Tin			61	,,	Tin	•••		10	,,
Phosphor		£ £ 5	61		Zine	• (•)•		4	,,
* *******	75 70 70 70 1			,,,				*****	-
			100	,,				100	"

TESTING.

All parts of the engine work subject to internal steam pressure, also all pump work; to be tested by hydraulic pressure to twice the working pressure. All testing to be done in the presence of the Engineer or one of his assistants.

PAINTING.

The painting of engine and pumps will be executed by the Company.

Travelling crane, suction tank, etc., to be coated with boiled linseed oil. (See under "Travelling Crane" and "Suction Tank.")

BOILERS.

SPECIFICATION FOR THREE LANCASHIRE BOILERS.

DIMENSIONS.

The boilers shall be of cylindrical form, 8 feet internal diameter at back end, and 8 feet 3 inches at front end, by 30 feet long, having flues, each 3 feet 2 inches internal diameter.

CONTRACTOR TO SUPPLY WORKING DRAWINGS.

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 two complete sets of permanent coloured and mounted detailed drawings for the Company's use.

MATERIAL AND TESTS OF PLATES, ETC.

95 The best quality of Siemens-Martin mild steel plates to be used.

Shells and Gussets.—To have a tensile strength of 28 to 32 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 per cent. elongation in 10 inches.

Rivets.—To be specially selected rivet steel, the tensile strength of which shall be from 28 to 32 tons per square inch, and the elongation in a length of 10 inches to be not less than 20 per cent. Samples of the rivet steel are to be submitted for bending, breaking and flattening tests.

BRANDS.

Each plate to be branded and numbered, care being taken during construction that the numbers and brands are in a prominent position. The tensile strength and ductility of each plate to be stated on the record of tests furnished to the Engineer.

TEST STRIPS.

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, will be rejected. Plates must be extra large, so that test strips can be cut from them.

Strips from the plates of shell, furnace tubes and angle bars are to be capable of being bent cold to a radius of one-and-a-half times the thickness of the plate without fracture, after having been heated to a cherry red and plunged into water of 80 degrees Fahrenheit. The welding properties of strips taken from the angle bars and furnace plates are also to be ascertained by actual trial, and, generally, the materials are to be capable of withstanding the various tests to the satisfaction of the Engineer.

SHELL.

The shell to consist of five rings of plates, each ring to be in one plate reaching the whole circumference of the boiler, bent cold to a true circle in the rolls, and to be

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 double rivetted (except the end seams securing the end plates to shell, which shall be single rivetted), and the longitudinal seams to be butt-jointed, united by double-cover straps with four and six rows of rivets through outer and inner straps respectively, the straps being 15 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.

The three front rings of plates to be disposed telescopically, so as to give a greater area on front end plate for expansion and contraction.

The butt straps to be cut to the required sizes from plates of the same quality as that specified for the shell, and care must be taken that the straps in the direction of their width shall be lengthwise of the plates they are cut from. The ends of the butt straps where they tuck under the ring seams to be thinned by planing. All the thinning of the plates and butt straps to be done by machinery.

FLUES.

Each boiler to have two flues through it, each 3 feet 2 inches internal diameter, tapering at the last ring but one at the back end to 2 feet 8 inches diameter. The front and back end sections to be made of plates § inch thick, and the remaining sections inch thick; each flue to consist of twelve sections, the longitudinal seams to be solidly welded, flanged at each end by machine at one heat, and the edges of the flanges to be turned perfectly true by special machinery, and flanges accurately drilled to template, and with a solidly welded caulking ring between, rivetted together, forming what is called the "Anti-Collapsive Expansion Joint."

CAULKING.

The seams throughout to be caulked or fullered internally and externally.

ENDS.

The end plates to be \(\frac{3}{4}\) inch thick, each in one solid plate; the back end to be flanged at one heat by special machine, to fit the shell internally and rivetted in, and the front end to be rivetted to a solidly welded steel angle ring rivetted on the shell externally.

The flue holes of the back plate to be flanged inwards and those of the front plate outwards, these holes to be bored out by special machine.

The end plates and the angle ring to be turned prefectly true on all edges.

STAYS.

Each end of boiler to be strengthened 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 two stays at the front end, and three 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. The stays at front end above flues to be of the "Link" type, formed of anchor plates, pressed to shape in hydraulic press; and diagonal bars, the latter being secured in position by means of turned pins.

FLANGING AND WELDING.

These to be done with the special tools and appliances for such purposes, and all plates which have been worked in the fire to be annealed when completed.

MANHOLE.

There shall be rivetted on the top of boiler a strong wrought steel raised oval manhole, 16 inch by 12 inch, of McNeil's make, having a faced joint, the opening for this on shell to be strengthened by means of a doubling plate being placed on the inside, and the front end shall be provided with a wrought steel inverted manhole, to be fitted with a suitable door, complete with bolts, nuts and cramps.

STANDPIPES.

Provide and rivet on the top and bottom of boiler and front end plate, wrought steel weldless standpipes with faced flanges for attachment of all mountings specified. Those on the front end plate must be long enough to project through non-conducting composition. (See under "Non-conducting Composition.")

RIVETTING.

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 removed. Any holes not precisely fair with one another shall be rimered out, no drifting to be resorted to.

PLANING AND TURNING.

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.

Each boiler to be supplied with the following fittings and mountings. These to be fixed by the Contractor, all bolts and nuts, jointing material, etc., to be supplied.

Furnace Fittings.—One complete set of wrought iron furnace frames to project over composition, with polished gun metal beadings all around, fitted with polished cast iron air-regulating fire doors with sliding ventilators of polished gun metal.

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

One complete set of triple fire bars.

One complete set of firing tools for the three boilers.

One pricker bar for each furnace, consisting of two bars bolted to the back of the circular steel furnace frame plates, supporting a movable rod between them.

Two flue doors and frames, with planed joint surfaces. (Drawings for doors and frames to be supplied by the Company.)

Dampers and Frames, etc.—Provide two dampers and frames and a girder over dampers to support pulleys, to be of "H" section, 8 inches by 4 inches, 25 lbs. per foot run, to span the width of boiler house and to be supported by neat cast iron columns and one strong wrought iron stay to wall. Flexible steel ropes, pulleys, wall brackets, and balance weights to be provided. Dampers to be worked by steel ropes

running over pulleys, fixed to the end wall of boiler house. Damper weights to be circular and fitted with neat shackles for connecting to ropes; also india-rubber buffer rings. Tops of frames to be machined, and built in flush with tops of York flags. The ropes to be 1 inch circumference, ungalvanised and constructed of six strands (twelve wires per strand), with seven hemp centres, to be obtained of Messrs. J. and E. Wright, Ltd., Universe Works, Birmingham. Ends of ropes to be fitted with thimbles, and splicing to be executed by Messrs. Wright's men, ungalvanised wire to be used for this purpose.

Provide and fix over Pyrometer blocks on York flags two small circular cast iron frames with steel chequered plate covers (Admiralty pattern) turned on edges.

Provide and fix to flagging around top of boiler 3 inches by 3 inches, ½ inch angle irons to receive non-conducting composition, to be mitred at back end of boiler, and shaped to fit into front covering plate. Flush bat bolts to be firmly fixed in flags, and angles to be secured to same with countersunk headed screws.

Steam Mountings.—Provide and fix patent safety boiler mountings, to be obtained of Messrs. J. Hopkinson and Co., Ltd., Huddersfield, and to be of their own make, and to Specification B. 1909.

All flanges and all preparations for receiving mountings shall be prepared, *i.e.*, drilled and studded, in accordance with the suggestions made by the Engineering Standards Committee in "British Standard Table II. of Pipe Flanges."

One 7 inch patent "Triad" junction valve, Fig. 1004, with Siemens-Martin cast steel body and cover, fitted with "Platnam" metal valve and seat. Rim of hand-wheel to be polished and without milling.

One 7 inch cast iron anti-priming pipe, complete with hangers, fixed underneath junction valve, Fig. 9058.

One class "B" "Duad" safety valve, Fig. 7, for high steam and low water, fitted with "Platnam" metal seat complete, with cast iron plate weights, for a working pressure of 160 lbs. per square inch. To be fitted with a cast iron escape bend, Fig. 286.

Lead drain from same into blow off pipes in front of boilers.

One 2½ inch patent "Ipsed" safety valve with controlled discharge and lock-up weights, Fig. 10, for high steam only, for a working pressure of 160 lbs. per square inch. To be fitted with cast iron escape bend, Fig. 286. Lead drains from same into blow-off pipes in front of boilers.

One 2½ inch blow-off valve, Fig. 2540, bronze, with "Platnam" metal seats and discs, improved locking gland, and patent "Oplok" pinion, also suitable wrought iron box key for same, Fig. 6223 (only one box key to be supplied for three boilers).

One Siemens-Martin cast steel taper elbow blow-off pipe, Fig. 9064, for attaching the blow-off valve to standpipe previously rivetted on to boiler.

Two \(\frac{3}{4}\) inch "Absolute" water gauges, Fig. 6440, fitted with patent safety plugs and shields, Class "B," to 18 inch centres. The drain pipes to be connected to a polished bronze "V" pipe, Fig. 6230. The latter to be connected with a union to a flexible copper pipe six feet in length. Only one to be supplied for the three boilers.

One gun metal water level pointer, Fig. 6250, with etched name plate.

One 10 inch open-faced dial (opening four inches diameter, to show mechanism) steam gauge, graduated to 320 lbs., red figures at 160 lbs., with flanged asbestos packed cock and syphon and inspector's gauge connection, Fig. 4180.

One $2\frac{1}{2}$ inch bore "Accessible" check-feed valve, Fig. 1381, with Siemens-Martin cast steel body and cover, and double guided check valve seat of "Platnam" metal. Also a wrought iron perforated distributor feed pipe, to be in three six feet lengths, two plain and last one perforated, and to be supported in boiler with angle iron brackets, etc.

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

BOILER FEED PUMPS AND FEED TANK.

Supply and fix in boiler house two "Tipton" vertical steam pumps of ample capacity (one to act as duplicate) for 160 lbs. steam working pressure (superheated), made by Messrs. Lee, Howl and Co., Tipton, Staffs. (Catalogue No. 1039), both to be fixed on one large and deep cast iron tray, to catch all grease and drippings. United States Metallic Packings to be fitted to piston rods. Provide gun metal lubricators for steam cylinders, with double glands (asbestos packed). Packing for pump pistons to be specially suitable for hot water. Steam cylinders to be neatly lagged with planished sheet steel. Foundation bolts, nuts and plates to be supplied.

Supply and fix a neatly moulded and panelled cast iron feed tank with machined joints; cover of same to be bolted on. A 6-inch circular inspection cover of steel chequered plate to be provided.

The discharge from air pump, the various traps, and exhaust from feed pumps, to be led into the tank. Internal pipes to be provided.

A polished gun metal water gauge cock to be fixed on side of tank, also a neat polished gun metal bracket to support gauge glass. A horizontal "Simplex" Berryman heater to be fixed in tank, for exhaust steam from auxiliary engines to pass through to waste. Heater to be supplied by Messrs. J. Wright and Co., Tipton, Staffs.

Provide and fix all necessary relief valves, stop valves, and drain pipes, also all pipes from main and auxiliary engines to tank, from tank to feed pumps, and from feed pumps to boilers, to be arranged in such a manner that by a slight modification the water to be pumped into boilers may be conveniently led into tanks and measured when engine tests are required to be made.

All flanges and facings on pumps, tank and pipes to be circular. A 1-inch ball valve, for cold water supply, of approved make, to be fixed on top cover of tank. The Company will make the connection. (For valves, see under "Fittings.")

STEAM PIPES TO BOILER FEED PUMPS.

The steam pipes to boiler feed pumps are to be made by Messrs. Stewarts and Lloyds, Ltd., of Birmingham. They are to be of wrought steel, lapwelded, with wrought iron flanges welded on, with fillet at back faced plain, and drilled in accordance with British Standard Table II. Steel or copper expansion pipes to be provided where necessary, and ample provision to be made for drainage.

Provide wall brackets and pipe hangers to approved designs.

Where required the steam pipes are to be made to template. The pipes are to be tested to 320 lbs. per square inch. by hydraulic pressure, and the test pressure to be clearly stamped on each pipe.

FEED PIPING.

The feed pipes to boilers are to be made by Messrs. Stewarts and Lloyds, Ltd., of Birmingham, and are to be wrought steel with wrought iron stamped flanges, with strengthening boss at back, screwed and expanded on, faced plain and drilled in accordance with British Standard Table II. Suitable outlets to be electrically welded to the pipes in the required positions.

Where necessary, the feed pipes are to be made to template. The pipes are to be tested to 320 pounds per square inch by hydraulic pressure, and the test pressure to be clearly stamped on each pipe.

BLOW-OFF PIPING.

Provide and fix the necessary flanged cast iron blow-off pipes of a suitable size.

All flanges to be faced and drilled in accordance with British Standard Table II. The pipes to be tested hydraulically to 200 lbs. per square inch.

SUPERHEATER.

Provide and fix in the down take at the back end of each boiler a Sugden patent superheater complete, to be obtained of Messrs. T. Sugden, Ltd., 180 Fleet Street, London, E.C.; it must be capable of giving a temperature rise to the steam at the engine stop valve of 150 degrees Fah.

Tubes.—The superheater to consist of solid drawn U-shaped steel tubes, 1½ in. outside diameter, tested by hydraulic pressure to 500 lbs. per square inch, and expanded into mild steel steam boxes.

The following fittings to be supplied with each superheater:-

One Spring Loaded Safety Valve of Messrs. J. Hopkinson and Co.'s make, loaded to lift at 170 lbs. per square inch, with open flow; parts subject to pressure to be of Siemens-Martin cast steel. Valve to be fitted with Hopkinson's "Platnam" metal seat.

One Wrought Steel Thermometer Pocket, with brass thermometer protector.

One Special Solid Glass Thermometer, with armour, to read up to 600 degrees Fah.

Two all polished Bronze Cocks, one for testing and one for draining, with polished handles and connecting nipples.

Inspection and Cleaning Doors.—Doors between the boxes to admit of inspection of the tube joints, and the cleaning of the exterior of the tubes, whilst the superheater is under steam.

Framework.—Heavy flanged and ribbed frame and sole plate, to span the boiler down-take, for finishing off the brickwork and carrying the superheater.

Swivel Balanced Damper for Completely Isolating Superheater.—Cast iron damper, with wrought steel shaft and pillow blocks, levers and counterweights, T supporting beam, cast iron bridge, lever operating and adjusting gear, together with flue cover plate.

Provide and fix in the steam pipes between each boiler and superheater two Hopkinson-Ferranti Patent stop-valves for 160 lbs. working pressure, Fig. 2025, for passing steam in one direction, with Siemens-Martin cast steel bodies and covers, and solid "Platnam" metal seats and discs. One of these valves to be geared. Rims of hand wheels to be polished and without milling.

The superheater to be tested to 320 lbs. per square inch by hydraulic pressure, and the test pressure to be clearly stamped on same.

AUTOMATIC CO. RECORDER.

Provide and fix against the glazed brickwork in the front of the boilers one "Auto" CO₂ Recorder, Model "A," operated by water; to be obtained of the "Auto" Recorder Co., Kent Street Works, Leicester; also provide and fix the following materials in connection with same:—

Two cast iron wall brackets.

Four lengths of 1 inch steam pipe, each about 5 feet long, screwed at one end.

Four cast iron sockets for flues, with holes through which the 1-inch steam pipes can pass freely.

About 70 feet of ½ inch gas pipe, including six bends.

Three gun metal cocks, polished all over bodies and handles.

Two extra filters for cleaning gases; all tools.

FRAME FOR BOILER FRONT.

Provide and fix to each boiler front a well-made, light, cast iron circular frame for supporting and finishing off the non-conducting composition. The segments of the frame to be bolted together by means of lugs cast on the inside of same, and the joint surfaces to be machined; no joints to fall on the vertical or horizontal centre line of boiler. The frame must be secured to the boiler where necessary by small angle brackets and countersunk headed screws. The cast iron frame for supporting the composition round the manhole to be cast in one piece and fixed with set screws. The circular steel plates round the furnaces to be secured with specially made bolts. Circular rings of polished gun metal to be fastened to the steel plates with stout brass screws having countersunk heads, these rings to have the name of the maker of the boiler and year of construction cast on them in raised letters.

A detail drawing of the frames, etc., will be provided by the Company.

Stairs to Tops of Boilers.—Provide stair to match those for packing stages, but handrailing on one side only.

IRON FRAMES AND FOOT PLATES.

Provide cast iron frames and steel plates for blow-off pit and pipe channels to extend the full width of the boiler house, with suitable hand holes for blow-off cocks; the frames to be flanged up six inches against the glazed brickwork at the front of the boilers.

All rebates in cast iron frames to be machined for steel plates, and the top of frames, to receive the paving must be perfectly level.

All steel chequered plates for blow-off pit and pipe channels to be of Admiralty pattern, 3 inch thick, to be thoroughly levelled, edges planed quite square, well bedded down, and made to templates obtained on site.

Plates to have rectangular holes $\frac{7}{8}$ inch by $\frac{3}{8}$ inch cut in same for lifting purposes, and two keys to be provided.

TESTING, INSPECTION, ETC.

The boilers are to be 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 160 lbs. per square inch, and tested by hydraulic pressure to 260 lbs. per square inch, before leaving the maker's works; to be delivered and placed on seats with all mountings and connections complete, as per Specification. Certificate of hydraulic test to be sent to the Engineer. The whole work is to be subject to inspection at any time and by anyone 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 inspections 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 boiled linseed oil put on hot.

The fuel used in the furnaces will be Staffordshire slack.