July 9th, 1914

A MODERN PUMPING PLANT.

(By Mr. F. SAUNDERS).

This paper was intended to give a brief description of a PUMPING PLANT, recently erected at Walka Pumping Station, West Maitland, in the Newcastle District, for the Hunter District Water Supply & Sewerage Board.

Before, however, dealing with this plant, it would probably be of interest to give some particulars of the pumping plant, which had done service for the past 27 years, and, in fact, was operating at the present time.

The scheme of water supply was originally designed by the late W. Clarke, M.I.C.E., in the year 1857, and it provided for the requirements of the City of Newcastle and suburbs and the municipalities and townships on the southern side of the lower Hunter River, from the sea coast to West Maitland. Its construction, with some modification in the details, was commenced by the Government in the year 1879.

Toward the end of 1885, an urgent demand for water arose in the Newcastle District, caused by a prolonged drought, and, the main pipe lines being completed, a temporary pumping plant was erected at the intake of the Hunter River. The water was in this way first delivered into Newcastle on the 23rd November, 1885. The temporary plant was kept almost consantly at work until January, 1887, when it was superseded by the present permanent pumping engines.

The Hunter District Water Supply & Sewerage Board was formed and took control of the waterworks, from 1st July, 1892.

The pumping engines were situated above flood level on a hillside about 44 chains back from the right bank of the river.

The old pumping plant consisted of three independent Woolf compound beam pumping engines, one surface and two jet condensing, each engine being approximately 150 H.P., and two horizontal compound duplex direct acting steam pumps. Two of the beam engines were designed to force water to the summit reservoirs; each worked two main pumps of the bucket and plunger type; one pump, having 19in. bucket and 14⅜in. plunger, was at the crank end of the beam, and the other, having 15in. bucket and 10½in. plunger, was at the cylinder end of the beam. The third beam engine was designed to raise water from the river or storage reservoir to the settling tank, or to raise water from the river to the storage reservoir, as required. It worked three main pumps, two, having 21½in. buckets and 15in. plungers, were placed one on each side of the beam centre; the third pump was double acting, and had a pump barrel 24in. dia., and was worked from a supplementary beam linked to a crosshead on the pump rod of the pump on the engine side of the main beam centre. This pump was used to pump the water from the Hunter River to the storage reservoir. Each engine averaged 13 to 16 revs. per minute, and all the pumps had a uniform stroke of 4ft. 6in.

There was also a compound surface condensing duplex pump, with 12in. and 18in. cylinders, 10in. plungers and 12in. stroke, which was installed to pump water to the East Maitland Reservoir, and so relieve the high lift pumps of this duty. Its capacity was 500 galls. per minute.

There was a second set of compound duplex pumps 10in. x 16in. x 14in. x 10in. non-condensing, which was installed as a temporary plant to pump from the storage reservoir to the settling tank only.

There were two suction pipes leading to the river, each 44 chains in length, one being 18in. in dia., and made of cast iron, and the other 20¾in. dia., riveted steel plate. The boiler house originally contained 5-50 H.P. lancashire boilers, each with a working pressure of 60lbs. to the sq. inch.

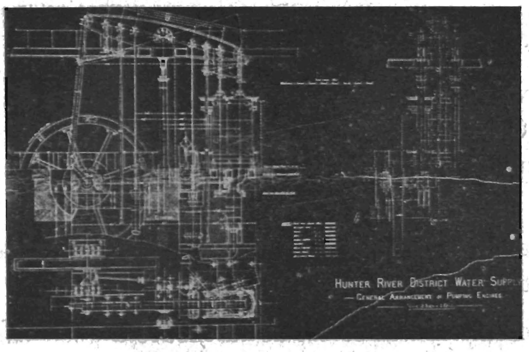

Plate No. 1.

PLATE No. 1: Showed the general arrangement of one of the pumping sets referred to. Whilst this plant represented a design that could well be considered to have long since been out of date, it was hardly necessary to state that after 27 years' continuous duty, these engines gave faithful service at a minimum cost of up-keep, so far as the engines themselves were concerned The pumps had a capacity of from 70 to 120,000 galls. per hour.

The valves of these engines were of the double beat type, kept more or less in equilibrium, and were lifted by cams. The high pressure steam valves were further balanced by dashpots.

There were four independent valves to each cylinder, one each for the top steam and top exhaust, and one each for the bottom steam and bottom exhaust.

To start up the engine, the cut-off was thrown out of action, so that the cams did not engage with the valve slides, the valves being actuated by hand levers. Once the engine was running satisfactorily, the cut-off was adjusted to give the speed desired. This arrangement permitted of the engine being reversed slightly, so as to bring it into position to ensure enough steam being received to get it going over the centre. It took two men to start up, one on the high pressure levers, and one on the low.

The valves gave a perfect cut-off, quite equal to that of the Corliss type, the cut-off line on the high pressure card was as sharp as would be represented on an ideal indicator card.

The engines required a good deal of humoring to get the best working results.

If the cut-off was so set as to ensure a good card being obtained, the engine became very rough and noisy, due to the fact that it took the steam immediately on the top of the stroke, and before the plunger had got to its work on the column of water, the result being a heavy jar when the plunger picked up the load.

The best working results were obtained by giving the steam a little late, so that the pump plunger was taking up the load at practically the same time that the piston received its steam.

Owing to the engines being jet condensing, it was difficult to ascertain accurately what the exact steam consumption per pump H.P. per hour was, but it may be accepted that 30 lbs. was very near the mark, when the engines were in good order.

As some mention had been made of high and low duty pumping sets, it would perhaps be as well to briefly explain the general arrangement of the Walka Pumping Station.

As already stated, the water supply was drawn from the Hunter River through two suction mains, some 44 chains in length. This water was taken care of by one of the low duty pumps, which delivered it through an aeration fountain into filter beds, where it was settled and clarified, and then run into what was known as the filtered water reservoir. The high duty pumps took their supply from the latter reservoir and lifted it into the service reservoir some six or seven miles distant, for distribution through the various mains.

In addition to the filter beds and filtered water reservoir, there was also an additional reservoir, which was used for the storage of bulk water, so to speak, pumped direct from the Hunter River, and used in case at any time the supply direct from the river could not be utilized.

As was only to be expected, this type of plant was not very economical, the approximate coal consumption being 1.4 tons per 1,000,0000 galls. lifted 100ft., as against .5 ton for the same duty with the new plant described.

In round figures, the saving gained by the installation of the new plant would represent about £900 (NINE HUNDRED POUNDS) per annum for coal.

Dealing now with the plant, which formed the subject of this paper: It had a capacity of 2,500 British Imperial galls. of water per minute, against a total static head of 264ft. through 9,800 yds. of riveted steel delivery main, 20¾in. internal dia., and suction main 18in. dia., 62 yds. long, making a total lift—including friction—of 336ft.

The plant was designed and manufactured by Messrs. Hathorn, Davey & Co., Ltd., Leeds, England, and consisted of what was known as the INVERTED VERTICAL

CORLISS TREBLE EXPANSION SURFACE CONDENSING ROTATIVE TYPE, similar to the set of pumping engines supplied by the same firm to the Rand Water Board, Johannesburg, South Africa, which established a world's record for steam economy some six years ago.

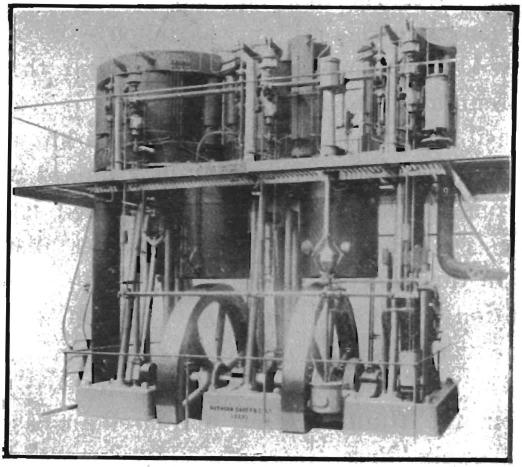

Plate No. 2.

PLATE No. 2: Gave a good idea of the type of plant referred to; but this showed the steam portion of the plant only, the pump cases and valve boxes being fixed at a lower level.

The dimensions of the engines were as follows:—

H.P. Cylinder 16in. dia.
I.P. „ 28in. „
L.P. „ 44in. „ , with a fixed stroke of 3ft.

The valves were of the Corliss type, the steam valves being so constructed that they also acted as relief valves The valves were made of cast iron fitted with steel spindles, and the bottom valves were provided with steel springs for holding them to their faces; the valve spindles were fitted with self-adjusting metallic packings. The valves were actuated by a special valve gear of the maker's own design. The high pressure steam valves were controlled by a sensitive governor, having a range of cut-off from 0 to 1.7 of the stroke, and were so arranged that the maximum speed of the engine could be carried and set by hand from 20 to 40 revs. of the engine, whilst the engine was in motion.

The intermediate and low pressure cylinders were provided with indexes and regulating wheels for hand adjustment, which could be varied whilst the engine was in motion from .2 to .6 of the stroke.

The governor and valve gear were driven by a positive motion through cut gearing, which was enclosed in dust-proof oil retaining cases, and a dashpot was provided, with an adjustable valve to prevent hunting.

A neat design of trip gear was fitted to these engines, to stop them by means of shutting off steam and breaking the vacuum, either in case of complete loss of load or in case of increase of load above a fixed point, caused by the dropping of a sluice valve or other means.

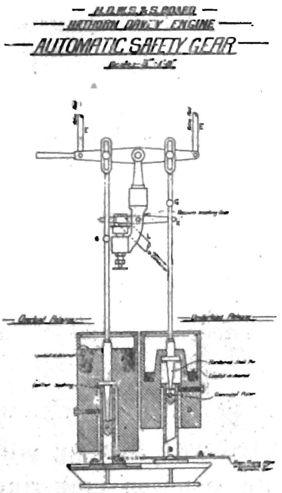

Plate No. 3.

PLATE No. 3: Gave details of this safety automatic trip gear. As already mentioned, the action of this gear was twofold; the steam was shut off the engine, and, at the same time air was admitted to the condenser, thus breaking the vacuum. Under these conditions the engine could be stopped almost instantaneously. The action was as follows:—The pipe ''A'' was connected to the rising main and admitted water to the cylinders ''B'' under the loose piston ''C.'' Should the load on the engine suddenly drop, the pressure from the pipe ''A'' lifted the pistons to the top of the cylinder, the piston carried with it the accumulator ''D,'' which was prevented going too far by the stop pin coming into contact with the flange of the cylinder ''B.'' The accumulator was connected to the eccentric valve rods ''E'' by means of the slotted rods ''F,'' which carry the stops ''G.'' If the pressure in the main was suddenly lowered below that for which the underload accumulator was set, the accumulator would immediately drop, and, so soon as it had travelled a certain distance, a slotted link would come into contact with pin ''H,'' shutting off the steam by means of the valve eccentric rod ''F,'' and, at the same instant, the stop ''G'' came into contact with the lever ''K,'' which admitted air to the condenser through pipe ''L,'' and effectually broke the vacuum. The same action applied to the overload release, except in the opposite direction.

The piston rods were fitted with floating self-adjusting metallic packing in accessible cases; the pistons so set and machined that they approached covers within a quarter of an inch in order to reduce the clearance to a minimum; these were also fitted with floating self-adjusting metallic packings, held with cast iron junk rings, fitted with steel screws and brass washers.

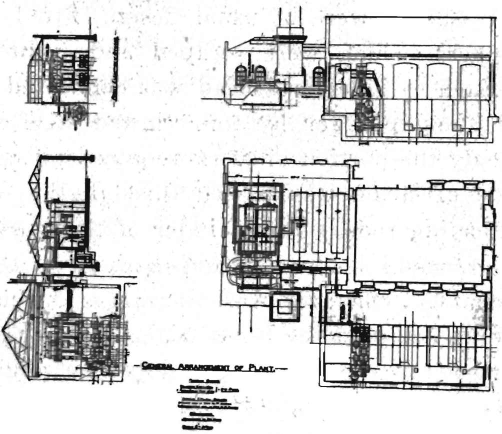

Plate No. 4.

PLATE No. 4: Showed the general arrangement of the pumping engines, from which it would be noted that steam receivers of large capacity were placed between the high pressure and intermediate pressure cylinders, and one between the intermediate and low pressure cylinders. These steam receivers were jacketed with boiler pressure steam; the low pressure cylinders being also jacketed with steam at a reduced pressure. In addition to this, the cylinder covers were jacketed with the steam, which entered their respective cylinders, and the recivers were so placed that the water drained from the cylinders into them and was re-evaporated. They were so made internally that the steam was compelled to circulate past the jacketed surfaces, and ensured the whole of the steam being thoroughly dried.

It would be observed that the cylinders were carried on a strong cast iron entablature and then secured to separate heavy cast iron standards of box section, which, in turn, were bolted to the entablature and bedplate, and machined to carry the crosshead slippers; the latter had cast iron cover bars and oil catchers. The front part of the entablature was supported on three turned wrought steel columns, secured top and bottom by steel bolts.

The crossheads were of usual design, fitted with cast iron slippers, which were scraped and bedded to the slides. Each cylinder crosshead was connected to its respective pump plunger by four turned steel side rods, so that only the portion of work required to equalize the expansion of steam was passed through the crankshaft and connecting rods, the remainder of the work done on the piston would be transmitted directly to the pumps. The mechanical efficiency was, therefore, extremely high, the average being on the Rand trials, 94.6 per cent. The steam efficiency was also high, since the engine, being fitted with flywheels, and the stroke being constant, it was therefore possible to run with a much less clearance than can be done with a direct-acting engine.

The crankshaft was made in two separate pieces, fitted with a drag crank in the centre; the latter was provided with gunmetal adjustable sliding pieces, so that it had freedom of vertical movement, with the object of preventing the setting up of friction due to any settlement which might take place in the foundations. This was a system which the makers had adopted for a great number of years, and had always found it most satisfactory. The high and low pressure engines operated on overhung crank pins, and, whilst some engineers might look upon this as a source of weakness, it was not really so if the crank was suitably proportioned; in fact, was the plan most commonly adopted in mill engines, in which the whole of the work was actually put through the crankshaft and crankpin. Bearing in mind that the work put through the crankshaft was merely that required to equalize the expansion of the different cylinders and to drive the valve gear, the load on the crank pin was not at all heavy, figuring out in this instance at 250 lbs. to the sq. inch, and on the main bearings only 100 lbs. to the sq. inch.

There were two flywheels, each 9ft. in dia., of heavy design, cast in halves, machined, cottered and dowelled together; one of them had a barring rack cast in.

The bedplate was of box section, machined to take the crankshaft bearings, standards and columns, the bearings being formed of heavy cast iron bushes, lined with anti-friction metal.

To enable the engineer to get at the valve gear, a staging was provided, carried on rolled steel joists, the flooring being of the open-bar type, as used in marine practice, constructed in that way, so as to let as much light through as possible; this platform was accessible from the engine house floor by means of a wrought iron ladder.

The surface condenser (of the enclosed type) cylindrical in form, fitted with tubes of solid drawn brass 1in. in dia., furnished with gunmetal tube plates, was placed on the suction main of the pumps, sufficient surface being provided in this condenser to be ample for a maximum summer temperature of circulating water of 85 deg. Fahrenheit.

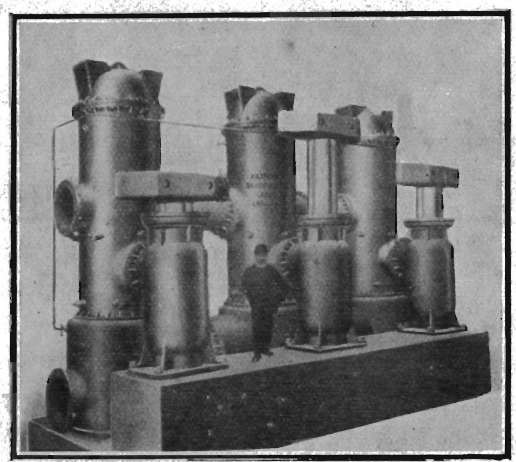

Plate No. 5.

It would be noted from the general arrangement that the whole of the water, on its way to the pumps, passed through the condenser, and no difficulty was experienced in maintaining a good vacuum.

The air pump was of the vertical single-acting type, with a dia. of 11in. x 3ft. stroke, and was fixed to the side of one of the main pumps and worked from the ram head of the same. This pump was fitted with a bucket of cast iron extra deep, and had gunmetal spring rings, Muntz metal rod, etc., with valves of the Kinghorn type of sheet metal working in bronze grids.

The three main pumps were of the vertical single-acting ram type, similar to that shown in plate No. 5, with rams made of cast iron, and had a dia. of 15in. with a stroke of 3ft.

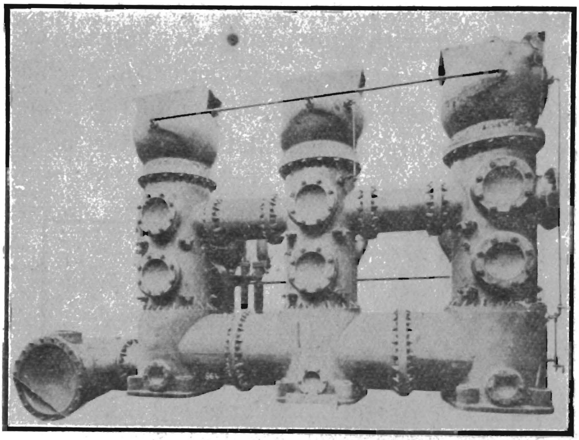

Plate No. 6.

At the time this plant was being considered, the Engineers responsible for its selection were of the opinion that rams made of phosphor bronze or good gunmetal would be more suitable, and, whilst the makers were prepared to meet their wishes in this respect, they strongly recommended that cast iron be adopted for the purpose, as they had found, after many years of extended experience, that this metal had proved itself as being thoroughly satisfactory for the purpose, renewals being practically nil.

The ram cases or pump barrels were also of cast iron of cylindrical shape, provided with the necessary branches and flanges. The stuffing boxes were water-sealed, fitted with cast iron glands, bushed with bronze and bronze neck rings.

PLATE No. 6: Was an illustration of the clack boxes, which were also of cylindrical form, each in three parts. The top part of the clack box formed an air vessel, the middle part carried the valve seatings and valves, and the bottom part was fitted with an internal pipe, which formed a vacuum vessel.

There were 19 suction and 19 delivery valves, or 38 valves in all for each plunger.

The combined capacity of the delivery air vessels was 20 times the displacement of one plunger, which, with a three-throw pump of this character was sufficient to ensure practically absolute steadiness in the delivery main—a fact which was established at the time of the official tests being conducted.

The suction air vessel consisted of three bases with pipe branches, which formed a larger dia. pipe common to the three pump valve boxes, and into which dipped three bell-mouth pipes, one from each set of suction valves. The capacity of the air spaces in these bases was ten times the displacement of one plunger. The bases had also a large water capacity, and, therefore, formed a reservoir to equalise the rate of flow in the suction pipes, whilst the air, which was contained between the dip pipes and the outer wall of the suction chamber, formed an elastic cushion, ensuring the immediate following up of