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NOTES ON HYDRAULIC POWER SUPPLY IN
SYDNEY.

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THE author proposes to consider briefly, in the first place, the remarkable progress and development that has been made in Hydraulic Power Supply on the Co-operative System during the last few years.

The first meeting of this Association at which he had the honor of being present was in September, 1889, on the occasion of Mr. Selfe's very able Paper on "The Operation of Power Companies, and Power Transmission by Compressed Air." On that occasion the System of Power Transmission by Compressed Air had a worthy champion in Mr. Selfe, and at a later stage he (the author) might have to refer to statements then made in reference to the cost of Hydraulic Power Supply in Sydney.

Public Power Supply on the High Pressure Hydraulic System was successfully established in Hull in 1875, on a comparatively small scale, the Installation consisting of two pairs of Pumping Engines of 60 horse-power each, two Lancashire Boilers 22 ft. 6 in. long and 6 ft. 6 in. diameter, one Accumulator with 20 in. Ram and 20 ft. stroke, with storage and filtering tanks complete. Additions have since been made, adding to the output capacity of this station. The works have been in continuous and successful operation up to the present time. Then we have the London Company, inaugurated in 1882, with works in operation in 1884, delivering 218,000 gallons per week to 96 machines. In the London Company's Report for the year ending December 31st, 1893, we have the enormous development in their operations represented by a total output of over

7,000,000 gallons per week, supplied to work a total of 2,025 machines, producing a revenue of £51,445 per annum. Liverpool was the next city to adopt the System in 1886, Melbourne in 1888, Sydney in 1890. The Birmingham Corporation recently commenced to supply power on their own account. Works have also been erected in Manchester and Glasgow by the respective Corporations.

The Melbourne Company commenced to supply power in July, 1889, with about 12 machines connected; now they are supplying Power to 413 machines, consuming 1,500,000 gallons per week, with a total length of 18 miles of mains in use.

The Sydney Hydraulic Power Company commenced to supply power in January, 1891, to eight machines, and now are supplying power to over 200 machines. The steady growth in the Company's operations, and its appreciation by the public, is evidenced by the following particulars:—

Water delivered to mains	Dec. 1891,	240,000	galls	per wk.
„	„	„	„	1892, 570,000 „ „
„	„	„	„	1893, 721,000 „ „

The output at date is 740,000 gallons per week, showing a continued steady increase.

PIER STREET PUMPING STATION.

The Power Company's Central Pumping Station, situated in Pier Street, Darling Harbour, is a substantial brick building, arranged as shown on Plate II., containing Engine-room, Boiler House, Accumulator Tower, Coal Store, and commodious yard space for the storage of pipes, &c.

The Engine House contains three sets of High Pressure Expansive Steam Pumping Engines of "Armstrong's" Horizontal type (Plate III.). Two pairs of the Engines have steam cylinders 24 in. diameter by 30 in. strokes, and one pair with cylinders 16 in. diameter by 24 in. stroke. At a working pressure of 100 lbs. per square inch at the Boilers, each pair of the large Engines is capable of delivering 475 gallons per minute

to the accumulators at a pressure of 750 lbs. per square inch when running at 50 revolutions per minute.

The smaller set of Engines has cylinders 16 in. diameter, with a stroke of 24 in., and is equal to delivering 200 gallons per minute under the same conditions when running at 60 revolutions per minute, the piston speed being 250 and 240 feet per minute respectively, the Engines being equal to an output of 1,200 gallons per minute.

Each set of Engines is complete in itself, with two high pressure steam cylinders and two double-acting force pumps fixed on a massive cast-iron bed-plate; the cranks are shrunk and keyed on to a shaft common to both sides of the Engine; the fly-wheels for the 24 in. cylinder Engines are 11 feet in diameter, weighing each 95 cwt., and for the 16 in. cylinder Engine, 9 feet diameter, and weighs 70 cwt. The steam cylinders have a main slide, and also expansion slide working on the back of same, arranged to cut-off at any point between $\frac{1}{3}$ of the piston stroke and the cut-off of the main valve, The expansion valves are capable of being adjusted while the Engines are running.

The pump cylinders of the 24 in. cylinder Engines are $7\frac{1}{2}$ in. diameter, and fitted with solid gun-metal rams $7\frac{1}{2}$ in. diameter in piston part and $5\frac{3}{8}$ in. in body part. For the 16 in. Engines the rams are 5 in. diameter in piston and $3\frac{3}{8}$ in. diameter in body part. The suction valves are 7 in. diameter, and the retention valves 6 in. diameter for the 24 in. Engines, and 5 in. and 4 in. respectively for the smaller set of Engines.

The water delivered from the main pumps passes into the Accumulators (Plate IV.), the rams of which are 20 in. in diameter, and have a stroke of 22 feet; they are each loaded with 100 tons of ballast (Nepean gravel), contained in a wrought iron cylindrical casing suspended from a crosshead on the top of ram. The area of each ram is 314 square inches, and the pressure being 750 lbs. on the square inch, the total load is 235,500 lbs., or nearly 105 tons, the extra five tons being

supplied by the weight of ram and casing. One of the Accumulators is loaded a little heavier than the other, so that they rise successively; the more heavily weighted being the controlling Accumulator, actuates a throttle valve on the main steam pipes, and when it has reached nearly the limit of its stroke, shuts off the steam and slows down or stops the engines automatically. Although one Accumulator is always in advance of the other, the difference of load is so small that the pressure is maintained in the mains with very great regularity.

In the arrangement of the Steam, Feed and Hydraulic Pipes at the Works, a thorough system of duplication has been carried out. From the Boilers to the Pumping Engines two distinct lines of steam pipes are provided, so that any boiler can be isolated for examination or repairs, and any section of the system of steam pipes can be closed, if necessary, for re-making joints or other repairs without any inconvenience whatever. The same system of duplication has been carried out in the arrangement of feed pipes. The Pressure Pipes from pumps to accumulators have been arranged in a similar manner. Two separate pipes are provided with stop valves (Plate V.), arranged so that any engine can be shut off without any interruption to the supply. Should a pressure pipe break, the section can be isolated at once, the water being sent through the duplicate main, and repairs effected without stoppage. This matter of duplication has been carefully planned and carried out, in order to minimise the risk of interruption of supply,—a most important consideration where hundreds of elevators and hoists rely on one source for their motive power.

BOILERS.

The Boilers (Plate VI.) are four in number, of the double flue Lancashire type, and are made of steel plates and angles throughout. The Boilers are 7 feet in diameter by 25 feet in length, each being fitted with one 4 in. Hopkinson's dead weight Pyramid safety valve and one $3\frac{1}{2}$ in. double lever safety valve.

The Boilers are fired by Vicar's mechanical stokers, with moveable fire bars. The stokers can be adjusted both in the hopper feed and in the travel of fire bars to meet the irregular demands for steam which the installation has to supply. These stokers convert the fire grates of the Boilers into a kind of gas furnace ; all smoke is consumed. The mechanical stokers have been an unqualified success. The coal used is screened small, and excellent working results have been obtained.

During the coal strike about two years ago the Melbourne Power Company were compelled to resort to the use of coal slack and breeze, which, with similar mechanical stokers, gave satisfactory results, though at that time they were short of boiler power. The combustion is perfect, the residue from furnaces being thoroughly burnt out. If the advantages of the mechanical stokers were better known they would be more generally adopted.

MAINS AND CONNECTIONS.

The system of mains for the reticulation of the city is shown on Plate VII. Two mains leave the pumping station in Pier Street, running in the same line until Sussex Street is reached in Liverpool Street. At this point the mains diverge, one following Sussex Street to Market Street. At Market Street a circuit is formed by connecting the Sussex Street main with the main in Pitt Street, through Market Street. Six inch mains are continued through Pitt and George Streets, connecting again at Bridge Street. From Market Street a six inch main is continued through Kent Street to Miller's Point, continuing along Windmill Street with the intention of joining the Pitt Street main at Circular Quay. Smaller circuits of four inch and three inch mains have been laid around many of the city blocks, connecting at two points with the trunk mains.

Stop Valves (Plate VIII., Fig. 1) are provided on the main at about 300 yards apart, and also at the junction of all sub-mains, so that any section can be isolated, if necessary. Should a fracture of the main occur, the stoppage is limited to the time

occupied in shutting down the valves at each end of the section on which the break takes place. There have only been two breaks on the mains since the Company commenced to supply power, one occurring at night on a branch main, causing no stoppage; the second break brought down the accumulators. In 15 minutes the section was cut off and pressure restored throughout the system. The time occupied in reinstating a broken pipe is about four hours. All pipes, bends and tees are of standard lengths, and tested when manufactured to 2,500 lbs. per square inch. After being laid a further test of 1,500 lbs. is made to test the joints (Plate VIII., Fig. 2) before filling in the trench in which the pipes are laid.

Air cocks are fixed at all high points in the mains, through which the air is displaced in charging them. Tee pieces for 2 in., 3 in. and 4 in. branches are placed at convenient points on the line of mains, from which service pipes can be carried to the consumers' premises when required. In making a connection to the consumers' premises a stop valve is provided on the main at a point near the building, also a back pressure or non-return valve is fixed near the machine. Should a pipe or main break, the non-return valve is closed by the pressure on the top side of the valve, and the water is thus prevented from leaving the cylinder, and the car or load from rapid descent.

Owing to the nature of the Sydney streets the mains have been laid underneath the footways. This has many advantages. Being near the building line a shorter and cheaper connection can be effected, and obviates any necessity for disturbing the wood blocking in the streets, and the consequent expensive reinstatement. Repairs are also much easier carried out.

The total length of pressure mains laid up to date is 21,120 yards, equal to 12 miles, and about 2,640 yards of return mains on the watershed to the works where the water would return by gravitation, without exerting a back pressure on the consumers' machinery. After the water supply from Waterloo was decided on, any further extension of return mains was discon-

tinued. The author omitted to mention that the mains also extend on the Pyrmont side of Darling Harbour to Pyrmont Bridge Road. Power is being supplied to 19 cranes, and also to the wool stores of Messrs. Goldsbrough & Co. and Messrs. F. L. Barker & Co.

WATER SUPPLY TO PUMPING STATION.

The water for the power supply is obtained from two sources. Operations at first were commenced with a connection from the city water supply, a six inch connection being laid to the storage tanks at the works; but an initial cost of 1s. 6d. per thousand gallons, and even at the reduced rate of 1s. per thousand, was a serious drawback in supplying the power at a reasonably cheap rate to large consumers; the Company therefore took steps to secure, if possible, a cheaper water supply. With this in view, 10 acres of land lying between Mount Rennie and Waterloo, at the foot of the sand hills, was secured on a long lease. A storage dam was excavated of 750,000 gallons capacity, which has since been increased to about 1,000,000 gallons. A small pumping station was erected and equipped with one set of Worthington's Pumping Engines (compound condensing), equal to raising 25,000 gallons per hour, together with the necessary boiler power. The Waterloo station is connected to Pier Street by $2\frac{1}{3}$ miles of 9 in. and 6 in. mains, $1\frac{1}{3}$ mile from Waterloo station being 9 in. in diameter—this is the rising portion of the main, and brings the water over the highest point in Redfern, after which the water reaches the Central pumping station by gravitation through one mile of 6 in. mains. The water is delivered to large storage tanks at the pumping station, the tanks forming roof over engine house, and measure 50 feet by 40 feet, by 8 feet deep—equal to 100,000 gallons. The tank is divided into two compartments, the water being delivered and allowed to settle in the first, after which it overflows to the second section of the tank; the water then is supplied to the pumping engines, the supply pipes to pumps being in duplicate.

The Hydraulic Power water is sold to consumers by meter, the charges being based on a sliding scale, commencing with a minimum charge of £3 per quarter, for which sum 5,000 gallons is supplied. Where the consumption reaches 275,000 gallons per quarter the charge is 5s. per thousand gallons, and where the consumption reaches 300,000 gallons a special rate is given. Water is now being supplied in Sydney to large consumers at 4s. 2d. per thousand gallons.

The principal use of the power is for intermittent work in cases where direct pressure can be employed, as, for instance, passenger lifts, warehouse hoists, cranes, presses, &c. For such purposes hydraulic power has long been recognised as being the best and most trustworthy. It is not, therefore, surprising to find that the Hydraulic Power Companies in Sydney and elsewhere have secured so large a share of the lifting work.

In all cities where public hydraulic supply has been introduced it has proved more convenient and satisfactory than any private system of power supply, and the sliding scale of charges adopted has brought it within the reach of both large and small consumers, with advantage to both.

Circumstances differ so widely that it is not perhaps possible to make any general statement as to the economy of hydraulic power over older systems, but in many cases the owners of low pressure lifting plants have found the saving sufficient to pay the cost of the new high pressure hydraulic machinery, substituted for steam or other plants, in three or four years.

In Sydney the use of private installations of power-producing plant has, in many instances, been discontinued. To the author's knowledge not less than twenty-five gas engines, representing 175 h.p., have been supplanted by the public power supply. The 175 h.p. quoted was used for the running of thirty-eight lifts, or an average of 4.6 horse-power each.

Taking, say, 200 lifts, the number now connected to the supply mains, and allowing 4.6 horse-power for each, the total

required would be 920 horse-power, whereas the horse-power indicated at the works is about 105 during the busiest hours of the day—this illustrates the economy derived from averaging the requirements of individual consumers. The result of working a large number of machines from one central station reduces the consumption of each to a common average, though a considerable variation in the demand for power exists at different hours of the day. Assuming that the 200 machines at present running consume, say, four horse-power each, 800 horse-power would be required, but in actual work we find that the average maximum demand is one-half horse-power per machine, as indicated at the station, the maximum output being from 12,000 to 13,000 gallons per hour.

The machinery connected to the system comprises the following:—

Passenger and Goods Lifts	...	...	149
Whip Hoists	...	...	22
Dumping Presses	...	...	7
Cranes	...	...	20
Motors	...	...	3
		Total	201

One of the most important points in the distribution of the power is the necessity of the perfectly sound condition and integrity of the mains, the velocity of water at 700 lbs. pressure through a free orifice being 320 feet per second; thus a very small hole is only required to pass a great body of water.

Any abnormal increase in the output is evident during the night if due to leakage, as the demand during about four hours is very low. The number of gallons (Plate IX.) delivered to the mains is indicated by the counters fitted to each engine. Should any unaccounted for increase occur, each section of the main is cut off during the night, each valve being closed at intervals of fifteen minutes, readings of the counters being

taken at the same time at the station, when the section on which the leak occurs is cut off; the revolutions of the engine at once indicate the leak, which, after being located to a particular section, is soon discovered.

The sudden increase shown in the diagram (Plate X.) shows the existence of a leak in February, 1893; this was due to a leak in Pitt Street, owing to a defect developing in one of the pipes in the spigot or male flange, the leak was located as described before. The hole was about $\frac{1}{4}$ in. diameter, passing nearly 40,000 gallons in 24 hours. After the leak was known to be on this particular section some difficulty was experienced in locating the exact position, owing to water passing immediately into an old brick drain, part of the old drainage system, thus leaving the trench perfectly dry on both sides of the leak to within a few inches of the escape.

The meters used for measuring the power to consumers are of various types, viz., Parkinson's Meter, Siemen's, Kent's Positive Meter, and Tylor's Turbine Meter. The water has hitherto, in nearly all cases, been measured on the exhaust side of the machines. High pressure meters of the Kent's Positive type and Tylor's turbine system have been introduced with good results. These meters, in construction, are identical with the low pressure type, the casing only being strengthened to withstand the high pressure. Another class consists of Piston Meters, as the Schonheyder; in these the water passing through a cylinder or cylinders actuates a piston, which in turn is geared to an index, and records the volume that passes. The Parkinson (Plate XI.) type of meter is based on the principle that is employed for gas meters, the water being admitted on one side of a drum, which is divided into compartments. The drum is caused to rotate by the entry of the water. The quantity of water that each compartment contains being known, the volume that is passed by each revolution is recorded on the dial. Kent's Positive Meters (Plate XII.) have also been used on the high pressure side of the machine with very satisfactory

results. The efficiency of the meters and condition of the mains is tested or checked by counters on the pumping engines, which readings being multiplied by a constant representing the capacity of the pumps per revolution, less the five per cent. allowed for slip.

A great advance has been made during the last few years in the class of lifts and hoists used in conjunction with hydraulic power, and Sydney is in no way behind in this respect, in fact the author has no hesitation in saying that we have in this city some examples of hydraulic lifts not equalled in any part of the world, notably the Direct-acting Hydraulic Passenger Lifts at the Hotel Australia, the Government Lands and Works Offices, the Mutual Life Association, and the latest installation at Messrs. Anthony Hordern and Sons' new premises, all of which have been designed by Mr. Norman Selfe, the inventor and patentee. We have also some very complete and perfect examples of the Suspended Hydraulic Lift, as supplied and erected by the Waygood Elevator Company, and other makers. For economy of water for work done the suspended elevator, if properly balanced, stands first. The balancing of the lifts is carried out even to compensating for the weight of ropes when the lift is at the bottom limit of travel. The author has not seen this applied in Sydney, but it is in general use in Melbourne, where the buildings are much higher, and the weight of lifting ropes correspondingly greater. All these improvements have added to the efficiency of the modern elevator. Evidently we have not yet reached anything near perfection, for we have now running in Sydney a multiple power lift known as Carey's Patent, introduced by the Waygood Company, for which excellent results are claimed. Three cylinders are placed side by side, with rams to each of equal diameter; the rams are inverted and fixed to one common crosshead; the three powers are controlled by an automatic valve which adjusts itself to the load placed in the car. Should the load be under the limit of first power the pressure is admitted to the centre cylinder, the

outer cylinders being filled from an overhead tank to which the exhaust water is delivered. If the second power is required the pressure water is admitted automatically to the two outside cylinders, and water from tank to centre cylinder. Should the third or full power be required, pressure is admitted to all three cylinders. The automatic working valve is controlled by a governor arrangement, which prevents the valve moving further over than the power required. The dream of all lift makers is the ideal lift that will consume water in proportion to load raised.

The machinery to which the power water is supplied is of as great importance to an economical and satisfactory result as the distributing plant; but this fact does not receive the attention it deserves. Regulations are issued by Power Companies defining the conditions to be observed by manufacturers in fitting up machinery for connection to the system. These regulations are given in order to secure safety and efficient registration of the quantity of power used; but the score of economy and efficiency of the machines is left to be settled between the makers and the consumers.

Outside of the operations of the Power Company we have in New South Wales several extensive installations of hydraulic power on the high pressure system, the most important being at Newcastle, where the system has been adopted for the shipment of coal, the capacity of the pumping station being nearly equal to that of the Power Company described before. In Sydney we have the installation at the Hotel Australia, also at Messrs. A. Hordern and Sons, Lamb's Wharf, Miller's Point, the Pastoralists' Association, North Sydney, and the Australian Gaslight Company, where the coal is discharged from the colliers by quick-running Hydraulic Portable Cranes, which can be moved to suit the hold of the vessel; two large hydraulic lifts are also in use for raising the coke, etc., from works to Kent Street level. All these installations are worthy of note.

One fact forcibly presents itself to anyone who has given any attention to hydraulic appliances, viz., the absence of public wharf cranes in Sydney for the discharging of heavy weights, such as locomotive boilers and other heavy material. In Melbourne the Harbour Trust have erected several cranes, one equal to raise 25 tons. The cranes are connected and worked when required by the Power Company at a charge per hour when in use. The Harbour Trust have thus all the advantages of the cranes for heavy lifts, without the standing charges which would attend any pumping station under their own control.
