In 

...
IN response to an invitation from the President of this Institute, I have compiled a few notes, necessarily at this date of an incomplete nature, respecting the pumping machinery which my firm is now erecting for raising the Melbourne sewage at Spottiswoode. In the first instance designs, accompanied by tender and guarantees, were invited by the Melbourne Board of Works, and some thirty tenders were received, including various types of rotative and direct-acting engines and some half-dozen types of boilers. My firm submitted one rotative and two direct-acting engine designs, and Lancashire, Marine, or Water-tube Boilers. One tender as selected by the Board, comprises the following which I shall subsequently treat in detail:—Four triple expansion, surface condensing, vertical, duplex, compensated, direct-acting, steam pumps, each developing 310 I.h.p. at a piston speed not exceeding 100 st. per min.,; six marine type return tube boilers, each capable of delivering one engine 2-88\" and 4-72\" and 4-32\" sluice valves and several hundred feet of 88\", 72\", and 32\" steel delivery mains. Two travelling cranes, each of 56\' span to lift 12 tons safely. The engines, with the exception of some details modified to suit the special requirements are similar to those raising water at the West Middlesex Companies intake from the Thames at Hampton Court. Each engine has two sets of triple cylinders 16\", 26\" and 44\" diameter by 36\" stroke, so arranged see fig. (1.), that the high and intermediate cylinders take the up stroke while the low take the down stroke and vice versa. Each pump has a central valve box 7\" diameter and 9\" high, containing 224 double valves, and is supported at the four corners by four plunger cases containing four single-acting 32\" plungers so arranged that one in each pair takes the up stroke, while the other takes the down and vice versa. The arrangement constitutes in a modified form an ordinary triple expansion duplex pump. Such a pump however would not meet the requirements of the Board's specification, which demanded a duty of not less than 95 millions with fuel guaranteed for only 11,000 heat units per pound, 61 lbs. being allowed per cubic feet of sewage. To effect this duty the engines are provided with a compensation gear which constitutes the chief peculiarity of this plant, and is shown on figure 1. It consists of two pairs of auxiliary hydraulic plungers working in oscillating cylinders and so connected to the main engine by means of an oscillating beam, as to oppose it in the first half of the stroke and assist it in the second half. On figure 3, separate indicator diagrams from the three cylinders are given. On fig. 4, the forward thrust curve of these is shown combined to form one curve and reduced to the low pressure cylinder area; on this figure also the pump resistance curve which is a horizontal straight line is also shown. Now it is evident that, for the pump to work at all under such conditions, and to get the best efficiency the steam curve must be reduced to a straight, or an approximately straight, line. Figures 1 to 4 show how these hydraulic piston effect this. They are driven home during the former and return during the latter half of the stroke, and give the curve shown, the first half of which is below the zero line, and therefore negative. By combining this with the steam curve we get the resultant curve, which is practically a straight line. Thus these compensators take the place of a crank and connecting rod, cross-head guides, and fly-wheel, and shaft and bearings. As regards the efficiency of such an arrangement it may be summed up by saying that it renders as an high efficiency as a first-class rotative engine, and is very much cheaper. Direct-acting compensated engines are at present working in England and America giving 14\(\frac{1}{2}\) millions duty with good anthracite fuel. Had time permitted some interesting material might be found in comparing the various accepted methods of compensating direct-acting engines, and investigating which it would be found that the method shown to be the best known in general practice, although others may in some cases be superior with picked conditions of suction and delivery head, steam pressure and speed.
same time I do not for a moment imply that this gear is perfect, and there is still
a good opening for something better, for it is too costly; it is inapplicable to high
rates of expansion unless compound or triple cylinders are employed. It will not
compensate a reasonable degree of compression, and it causes considerable loss in
friction. With reference to the valve gear of these engines, each cylinder has four
Corliss valves arranged on the Wheelock principle, or that while each engine works
its own cut-off valves the main valves of the engine are worked by the other, thus
ensuring a uniform speed and uniform cut-off. The steam distribution of each
engine is quite distinct, uniting into a single exhaust pipe which leads to a surface
condenser, through the brass tubes of which the sewage passes. The water and
vapour are drawn off by independent duplex air pumps discharging into concrete
hot wells, whence the feed pumps draw and discharge through the economiser
tubes to the boilers. The main pumps are of distinctly novel design. The four
plunger centres form the corners of an eight-foot square. The plungers are of cast
iron, each working through two gun-metal bushes 6 in. wide, and separated by an
annular space also 6 in. wide. No packing of any kind is used, but these annular
spaces are connected by pipes with the pump suction pipe, which draws off any
water pressing through the lower rings. The central valve-case is circular through-
out, thus reducing its weight to a minimum for the strength required. It is so con-
structed as to form in one piece suction, force, and delivery chambers, and suction
and delivery air vessels in addition to accommodating 56 double gun-metal valves
each 11 in. diameter. There are no foot valves on the suction pipes, but the pump
may be connected by turning a cock with independent air pumps above, which being
about 40 feet above the sewage in the wells charge the pumps without risk of
adding sewage to the feed water. The boilers are in a measure of a novel type:
They are designed to give an evaporation of 10 lbs. of water for 1 lb of New
South Wales coal from and at 212 °F. They have therefore a very large heating
surface, namely, 66 times the grate area. Each boiler will evaporate 9000 lbs. of
water per hour, and will consume 23 lbs. of coal per foot of grate area per hour,
or 3 lbs. per foot of heating surface. Each has two corrugated shells leading
into one combustion flue of the Galloway type containing 15 conical tubes and
2 pockets. The gases then return through 106 tubes extending the whole
length of the boiler and return again over the top of the boiler and round the
steam drum to the main flue whence they proceed either direct to the stack or
through the economiser to the stack. The boiler shells are 8 ft 6 in. diameter by
16 ft long built in three rings of 13/16 steel plates treble rivetted longitudinally and
double rivetted transversely with 1 in. rivet. The four transverse seams were
drilled simultaneously by a special multiple drill. The rivets were closed under a
hydraulic pressure of from 70 to 80 tons, and the joints caulked with pneumatic
caulkers giving some few thousands blows per minute. The economiser is of the
Green's vertical tube type. It contains 709 tubes 9 ft long placed in rows in the
main flue from the boiler to the stack. The tubes are of cast iron with conical
ends pressed into cast iron end boxes, and fitted with automatic soot scrapers,
which are actuated by a separate engine and reversed by three mitre wheels with
clutches and a tumbler. The top and bottom boxes are connected by pipes and
the feed water on its way from the pumps to the boiler, enters by the lower
corner of the battery and discharges by the opposite upper corner and is thence
distributed to the boilers. The efficiency of these economisers varies largely
according to circumstances, and roughly speaking is inversely as that of the
boilers. In this case in all probability the efficiency will be low, due to the large
heating surface on the boiler. We next come to the delivery mains and valves.
As shown on figure 7 these are very large and consist of about 145 of 58 in., 150 of
72 in., and 125 of 32 in. steel pipes, including some awkward bends and junctions.
Also a receiver 15 ft diameter and 24 ft long. All these were designed for a test
pressure of 600 of water. In the case of the bends and junctions each plate
was drawn accurately to scale and cut to the dimensions given, thus ensuring
good work and saving time. These mains were all of 3 in. steel plates double
rivetted. The receiver, 15 ft and 24 ft, could not be transported complete by road
or rail, so was fitted together at the Works, taken down and re-built
and rivetted in place at Spottiswoode. This receiver is in four rings of
3 in. steel plates double rivetted with 1 in. rivets. The ends are made in eight
radii as are the
A 300
2-88
in g


radial segments with a central disc and stayed with eight 2½ roadstays. There are two 58½° branches on one side and three 72° branches on the other. A 3½° circular manhole on top and a 12½ sludge pipe on the bottom. The valves 2-88° and 4-72° are built of steel plates on a cast iron frame. They have each two semicircular doors with metal seats, which are raised by gun-metal screws in gun-metal nuts, and driven through worm gearing by coupled engines fitted with Joy's reversing gear and fixed to the valve covers. The 1-32° valves are of cast iron throughout, but in place of screws and worm-gearing, etc., they are raised by the sewage pressure acting on a gun-metal plunger attached to the valve door and actuated by a small three-way cock. The travelling cranes—one in each engine-house—are built of 3½m. steel plates, 56ft. span and 4½ feet deep in centre. They are fitted with one vertical and two horizontal motion gears for handling the heaviest single pieces of the engines, namely, 11 tons, with a factor of safety of 5.

The foregoing concludes the principal parts of the present installation at Spottiswoode. With regard to the steam and feed pipe arrangements, and also the boiler flues, these have been designed to suit future extensions as required, and are so arranged that when the plant is complete any one or all of the boilers can be connected with any one, or all, of the engines. The waste gases can be passed through any one or all of the economisers to one of both stacks. The feed water can be drawn from any or all of the air pumps by any or all of the feed pumps (each capable of supplying six boilers), and passed through any or all of the economisers to any or all of the boilers. The steam and feed pipes are fitted with valves at every junction, thus facilitating repairs by cutting out of circuit the faulty portion without interfering with the working of any portion of the machinery. In conclusion some interesting points may be mentioned touching the erection of this plant which involved the transport and lifting of some heavy weights, aggregating some 50½ tons. The main pump valve case, which with four plunger cases weighed 24½ tons, was, perhaps, the most difficult task. These were connected by lead joints to the plunger cases, and being of necessity most accurately set, these joints could not be made in the artificial light and cramped space of the pump wells. So the complete pump was lined off and joints run above ground, and the whole 34½ tons lowered by temporary appliances to a depth of 4½-6 feet—a feat which was happily unattended by any hitch. The six boilers, each weighing nearly 2½ tons, were conveyed in tracks from the main line by a temporary siding and deposited close to the boiler-house door, and thence rolled into place. The steam drums bang detached to allow of this, and also to clear the arches from Castlemaine. The large valves weighing 12½ tons, the steel mains, right Low Pressure Cylinders each weighing 5½ tons, the pump and plunger cases, and the rest of the machinery were conveyed in tracks right into the engine-house, under the travellers and accurately in position. In setting the engine bed plates, the foundation stones were dressed and tried till brought to a perfect bearing all over, then ½ sheet lead inserted and the 3½ holding down bolts drawn up tight. In the contract repetition has been a feature including such figures as the following—Corless valves, valve boxes, bonnets, T headed spindles, and levers, 100 of each. 224 gunmetal pump valves each with two doors, 365-3½" boiler tubes or 10,000', 46½-4½" condenser tubes or 8,300', 580° of pump 4½ diameter, 16-32° plungers 4½ long, 24 steam cylinders all jackets on barrels and covers. Seventeen auxiliary engines, including air pumps, air compressors, feed pumps, valve motors and economiser engine. About 900 cocks and valves. About 2,500' of steam pipes. About 800' of feed pipes. About 16½ tons of rivets, 15½ tons of bolts and studs, about 450 tons of steel, about 380 tons of cast iron, about 17½ tons of gunmetal, about 165,000 bricks, and a number of other items, including about 920 tons of material, and last but not least, about 150 sheets of detail drawings. Hoping my remarks may have supplied some interesting information to the members present, and that at some future date I may have the honor of supplementing them with a subsequent paper giving results of trials and performance of the plant generally. I conclude by thanking you for your courteous attention to my paper.
Library Digitised Collections

Author/s:
Thompson, D.

Title:
Melbourne sewage pumping engines

Date:
1900

Persistent Link:
http://hdl.handle.net/11343/24247

File Description:
Melbourne sewage pumping engines