ROTATIVE WATER-PRESSURE ENGINE.

By WASHINGTON JONES, M.E.

The I. P. Morris Company, of this city, have constructed recently, at their Port Richmond Iron Works, a pair of water-pressure rotative engines, from the designs of Messrs. Taws and Hartman, mechanical engineers, and under the supervision of Mr. William Firmstone, President of the Longdale Iron Company, of Virginia; and intended to supply blast for that company's coke furnace at that place. As this is the only engine of the kind used in the United States, or elsewhere, so far as the writer is aware, to produce blast for a furnace, a description may be of interest. The general plan of the engine is not novel, being that in which the two cylinders for air and, in this case, water are in line, and, with a piston-rod common to both, secured at front end into a cross-head moving on guides, and carrying a connecting-rod whose outer end takes hold of a crank-pin fitted into hub of fly-wheel. The engines are coupled by one shaft, with cranks at right angles, and are mounted upon strong bed-girders, which extend from blast cylinder flange, under the water cylinder and beyond, so as to contain the shaft pedestals. The usual guides for cross-heads are bolted on top of these girders, and the whole is securely held down to a masonry foundation. The cylinders have the diameters of 18 ins. for water, and 48 ins. for blast, both of 5 ft. stroke. The pistons are fitted with double metallic rings, set out with springs. The water admission and discharge valves are of the piston type, 18 ins. diameter, and are also fitted with adjustable spring packing. Motion is given to them by the ordinary eccentrics and rods. The water is taken from a dam 65 ft. above the centre of water cylinders, and the available supply in dry seasons amounts to 4 cubic ft., but, ordinarily, to 6 cubic ft. per second. Sufficient of this quantity is conveyed by a riveted lap-jointed plate iron flume of 30 ins. diameter, and which is laid to conform with the general contour of the bank. From its point of attachment, to a wooden trunk of 5 ft. depth by 10 ft. width, it dips, at an angle of 20° , for 70 ft.; thence, by an easy bend, at an angle of $38^{\circ} 30'$, for 53 ft.; then changing, by another easy bend, into a horizontal line, it continues for 34 ft., when its diameter diminishes, in a length of 6 ft., to 24

ins., at which size it runs for 4 ft., and then branches right and left to the side pipes of water cylinders. The main pipe extends on for a short distance, and is then closed by joining an air vessel which is

WATER-PRESSURE ROTATIVE BLAST ENGINE OF THE
LONGDALE IRON CO.

24 ins. diameter and 9 ft. high. Each of the branches is supplied with an air vessel of 10 ins. diameter and 9 ft. high. The exhaust water is discharged immediately downwards through a pipe $14\frac{1}{2}$ ft. long, having its lower end, below the surface, in waste water way, which is 13 ft. below the centre of water cylinders.

The engines made, when first put up, $8\frac{1}{2}$ double strokes per minute, but have been run up to 12 double strokes, without noise or shock. The blast pressure, when blowing into the furnace, was $3\frac{1}{2}$ pounds; sometimes it fell as low as 3 pounds, but only at such times when the throttle-valve in water supply pipe was not fully open. Their steadiness of motion may be attributed to the large areas of water valves and chambers, they being equivalent to that of the water cylinders, and the freedom from shocks is due to the position and ample size of the air vessels, their aggregate capacity being over twice that of the water cylinders, or as 38 to $17\frac{1}{2}$, and also to the large area of the flume pipe, which conveys a sufficiency of water at a low velocity, or $\frac{1.767 \times 5 \times 2 \times 2 \times 8\frac{1}{2}}{4.908 \times 60} = 1.02$ ft. per second.

All the air carried into the cylinders by the water is permitted to escape by means of a bent pipe attached to the highest part of valve casings, and carried downwards into a vessel of water.

The furnace supplied with blast by these engines has a diameter at boshes of 11 ft. and a height of 60 ft., with a closed top, and yields 130 to 150 tons of hot blast coke pig per week.

The accompanying indicator diagrams, taken from water cylinder, show the effect produced by the use of air vessels on the water supply pipe, and of air escape pipes on valve casings. No. 1 was taken from forward end of water cylinder of engine No. 1, at a time when air vessels and air escape pipes were not in action. The number of revolutions were not noted, but they were evidently less than usual as the blast pressure was but 3 pounds per square inch. This was intended as a test to determine the efficiency of the air vessels. At the middle point of the admission line the sudden depression is evidently produced by the opening of valve on engine No. 2 to admit

water to its cylinder just when the piston of No. 1 had attained its greatest velocity, and the greatest supply was demanded; and, following it, an abrupt rise above the mean line due to the impulse of the accelerated motion and the sudden check of water column in supply pipes. This effect is twice repeated before the termination of the stroke, but in lessening degrees, and is caused, as stated, by the oscillations of the water column, and the presence of trapped air in valve casings. The action of engines was not even, and strong shocks

were produced: they were therefore stopped, and the two air vessels upon the valve chests put into use, but air escape pipes and cocks remained closed, and engines again started, with a result as seen in card No. 2, where the unevenness of the admission line is very much softened but still unsatisfactory. The revolutions were $7\frac{1}{2}$ per minute, blast pressure $2\frac{3}{4}$ pounds. All the air vessels were then put into use, air escape cocks opened, and card No. 3 taken, which is quite satisfactory. The engines then had been running four hours, making $8\frac{1}{2}$ revolutions kindly, and producing a blast pressure of $3\frac{1}{2}$ pounds

per square inch. As circumstances required the location of engines to be at their present level of 13 ft. above surface of water in waste way, which diminished the head to that extent, the continuation of the exhaust water pipe below the water, utilizes the negative pressure due to the difference in levels. This will be seen on card No. 3, where the exhaust line falls below the atmospheric line 5.625 pounds.

The gross power of the water expended during one double stroke of the engines, assuming the capacity of the cylinders as the basis for determining its quantity, is equal to

$1.767 \times 5 \times 2 \times 2 \times 78 \times 62.4 = 172,007$ ft. pounds. When

running with the throttle wide open the blast pressure obtained was 4 pounds, corresponding to a power developed of $1809\cdot56 \times 5 \times 2 \times 2 \times 4 = 144,765$ ft. pounds. Consequently, the useful effect of machine is equal to $\frac{144765}{172007} = 84$ per centum.

As 4 pounds of blast are more than is required for the furnace, and as the supply of water is somewhat less than anticipated, the water cylinders were reduced recently by bushings to a diameter of $15\frac{3}{4}$ inches. The engines now run regularly at 12 revolutions per minute, and give a blast pressure of $2\frac{7}{8}$ pounds. The power developed is equal to $1\cdot353 \times 5 \times 2 \times 2 \times 78 \times 62\cdot4 = 131,702$ ft. pounds, and the work done in the blast cylinders is equal to $1809\cdot56 \times 5 \times 2 \times 2 \times 2\frac{7}{8} = 104,050$ ft. pounds. Consequently

the useful effect of the engines is now $= \frac{104050}{131702} = 79$ per centum.

The increased loss of effect, $84 - 79 = 5$ per centum, results from the reduction of capacity of water cylinders or a lessened power, whilst the prejudicial effect of friction of machines, of the water through the flume and the passages, and of the several right-angled bends given to the current before it acts upon the piston, remains practically the same as before the reduction.

Card No. 4 was taken from blast cylinder at the same time No. 3 was taken from water cylinder, and is given here only to show that blast cylinder valves are of ample proportions; and that no undue loss occurs in getting the air into or out of blast cylinders.

Before the adoption of this type of motor was decided on, it was considered by the proprietors, whether to build an overshot wheel, or to put in a turbine, or the proposed plan of the yet untried water pressure rotative engine. Objections existed against the use of the first two, as gearing had to be used to transmit the power to the work. It was therefore determined to try the engines just described, and their performance is so superior to any probable result from an overshot wheel or a turbine as to satisfy those concerned of the soundness of judgment evinced in their adoption.