fig. 208. The change valve G (fig. 206) is worked by a tappet arrange-
ment similar to that already described for the dip-engines.

The effect of fluctuations of velocity in the driving column from an
accumulator is similar to that in a column with a natural head; and
the effect of enlarging the ram of the accumulator is to reduce the velocity
of the moving weight, in the same way as the velocity of the water is
reduced by enlarging the pipe in the other case. Hence it is highly
important that when an accumulator is used it should be very large,
thereby making its pulsations very slow.

As an example of the practical application of water-pressure machinery
to the working of a metalliferous mine in a hilly district, the author has
prepared figs. 209 to 215, which represent the machinery designed by
him for the A. D. Lead Mine, near Richmond, Yorkshire.

It will be seen from fig. 209 that there is a reservoir situated on the
hillside above the mine, at an elevation of about 500 ft. above the adit
level. Pipes are led from this reservoir down the hillside for a distance
of 1800 ft., and are then taken 240 ft. down a vertical shaft to the
interior of the mine, at the inner end of the adit level. At this point a
large chamber is excavated, to contain the pumping and winding engines.

The pumping-engine (figs. 210, 211, and 212) consists of two vertical
hydraulic cylinders A A, each having a power ram 12 in. in diameter with a
7-ft. stroke. The rams are connected together by a chain passing over
an overhead chain-pulley P (fig. 211), so that one ram makes its up stroke
whilst the other is descending. A rod 3 in. in diameter, fixed to the ram,
passes down through a stuffing-box in the bottom of the hydraulic cylinder,
and is attached to the pump-rod. The pumps are each 13 in. in diameter,
and of course have the same stroke as the hydraulic rams. On each
hydraulic cylinder is placed a valve-box B, shown in section in fig. 212,
with valves similar to those already described in connection with the other
hydraulic engines; both valve-boxes are connected with a single change-
valve C. The pumps (fig. 210) are of the ordinary bucket type, provided
with clack pieces, door pieces, and wind bores, such as are generally used
for sinking purposes. The pumps will be used in deepening the shaft,
and the hydraulic engines are proportioned for raising, at 6½ strokes
per minute, 500 gallons of water from a depth of 360 ft. to the adit
level, the depth being about 120 ft. At the full depth, with 534 ft.
head on the rams, the useful effect will be represented by

\[
\frac{13^2}{12^2 - 3^2} \times \frac{360}{534} = 84 \text{ per cent.}
\]

The winding-engine (figs. 213 and 214) consists of a pair of double-
acting hydraulic cylinders, coupled to right-angled cranks on the driving
shaft, which latter is geared to the winding drum by a spur pinion, the
general arrangement of the engine being very similar to that of a steam
winding-engine. The gearing has a proportion of 1 to 6, and the winding
drum is 6 ft. in diameter. The weight to be raised is 2 tons of ore at a
General Arrangement at A D Mine.

Scale, vertical & horizontal. 800 feet to the inch.
time. The cylinders are 5½ in. in diameter, have a 16-in. stroke, and run at 19½ rev. per minute, giving a speed of 60 ft. per minute to the rope. The admission and eduction valves are somewhat similar in construction to those already described, but are driven by means of eccentrics, having a link-reversing motion, and are put in equilibrium by the some-
Pump Pumping Engine at A D Mine

Section of Hydraulic Cylinder and Valves
Scale \( \frac{1}{16} \text{ in.} \)

Fig. 212.
Winding Engine at A D Mine.

Side Elevation. Scale \( \frac{1}{48} \)^th

Fig. 213

Plan

Fig. 214.

Scale \( \frac{1}{48} \)^th

Longitudinal Section of Cylinder and Valve

Fig. 215.

Scale \( \frac{1}{12} \) th

Figs. 213, 214, and 215.
what novel arrangement shown in fig. 215. The two mushroom admission valves EE are on the same spindle, on which are also fixed two pistons GG, each equal in diameter to the annular eduction valves JJ. These pistons work in cylinders KK, placed beyond the engine ports, and forming continuations of the valve-box. By following out the motion of the valves, as given by the eccentric, it will be seen that the eccentric has only to overcome the resistance due to friction, because in all positions the valves are balanced as regards pressures. This the author considers an important improvement in this type of hydraulic valve, as it enables very large valves to be used, and thus prevents any loss from throttling. It also enables the reversing to be done by means of a link motion, and gives easy and complete control over the engine.

Having described some examples of water-pressure engines of general application, the author proceeds to describe two engines specially designed for particular cases.

In fig. 216 is shown a peculiar application of a hydraulic pumping-engine, and one which the author has had occasion to adopt in several instances for mining operations. At the Hutton Henry Colliery, near Wingate, Durham, a certain quantity of water comes out of the strata at an intermediate point A, in a shaft where it is not convenient to place a pump except at the bottom. The water issuing at A has therefore to be taken down to the bottom before being forced to the surface. It is taken down from the point A in a down suction-pipe CC to the hydraulic pump B, and is delivered through the delivery pipe DD to the surface; so that the work done by the pump is that due to the difference between 866 ft. head in the delivery pipe and 502 ft. in the down suction-pipe, or to 364 ft. only. The power cylinder, 6 1/2 in. in diameter, with a 1 ft. 3 in. stroke, is actuated by means of a driving column from the point E, having an effective pressure of 260 ft. head. The power cylinder and pump, fig. 217, are both single-acting; but the pump is a piston-pump of a peculiar construction. The pressure of the down suction column is constantly in the annular space between the piston-rod, 1 3/8 in. in diameter, and the inside of the pump barrel, 4 in. in diameter. During the forward or delivery stroke of the pump, the pressure behind the annular area of the pump piston assists the plunger of the power cylinder; and the return stroke is produced entirely by the pressure from the down suction column being brought to bear on the full front area of the pump piston, the effective pressure for the return stroke being therefore that due to the difference between the full front area of the pump piston and the annular area of its back face, or, in other words, to the area of the piston-rod. The useful effect is \( \left( \frac{4}{6.125} \right)^2 \times \frac{364}{260} = 60 \) per cent. The engine is designed to work at 10 1/2 double strokes, and to raise 7 gallons per minute. It should be added that the driving water is water which would run down to the bottom of this shaft in any case, and is simply utilised for pumping.