Pumping Water from Mines.—There are two kinds of pumps used in this work, viz.:
1. The Lifting Sett, with the engine at the surface.
2. The Forcing Sett, with the engine either at the surface or underground.

The Lifting Sett.—This consists of windbore, clack-piece with clack or valve, working barrel, bucket and bucket-piece, pumps, or stocks, and rods or spears (see figs. 196 to 199).

The windbore (a in fig. 196) is a cast-iron pipe closed at the bottom end, with its circumference perforated with snore holes for the admission of water for a distance of 3 feet to 4 feet up. It is usually made egg-ended, and is placed in the sump at the bottom of the sett.

The clack-piece, b, is a specially made cast-iron pipe in which the clack or valve is seated; it is made with a door—secured by bolts—through which the clack may be changed.
The clack, $c$, is made of brass or iron, jacketed with leather or gutta-percha, and having the ordinary butterfly valves of wrought-iron plates and leather. In some cases the leather wears quickly and requires frequent changing. Other forms of valves have been tried, viz., the single beat or mitre valve, the india-rubber disc valve, and the Cornish double-beat or equilibrium valve.

The working barrel, $d$, in which the bucket works up and down, is usually bolted to the top of the clack-piece. It is made of cast-iron, and is sometimes lined with brass or gun-metal to increase its durability and reduce friction. Its length depends upon the length of the stroke given to the bucket.

The bucket, $e$, consists of an iron shell and hoop, around
which is placed an india-rubber or gutta-percha jacket to fit the working barrel. The valves or falls are similar to those of the clack, and consist of iron plates grathed or faced with leather, working on a hinge in the centre and at the top of the bucket. The jacket surrounding the bucket and the falls are subject to much wear and tear; the length of time they last depends upon the state of the working barrel, the water, and the speed or number of strokes per minute.

The bucket-piece, \( f \), is fixed at the top of the working barrel, and is fitted with a door called the bucket-door, by which access is gained to the bucket.

*Pumps or Stocks, \( g \).*—These are placed upon the bucket-piece and carried up to the surface. They are generally 9 feet in length, and in all cases should be about 1 inch larger in diameter than the working barrel. They are made with thick flanges, strengthened with brackets, and with an iron belt 3 feet from each end. The joints have spigots about an inch long, and are also properly faced; upon the facings are placed wrought-iron rings \( \frac{1}{4} \) inch thick, wrapped in flannel and steeped in tar; and the whole joint is secured with bolts. At the top of the pumps a "delivery-box" or "collar launder" is fixed, from which the stream of water is delivered.

*Spears, \( h \).*—These are wood rods which are carried down inside the pumps from the surface to the working barrel, connecting the engine with the bucket. They are generally made of pitch-pine, in pieces of from 30 feet to 45 feet in length, the sectional size being according to the diameter of the sett and the depth. The different spears are joined together by means of wrought-iron plates. The ends of the spears are made to fit closely together, and the plates are secured on opposite sides by bolts passing through the wood. Wood cleats are fastened to the spears at intervals to prevent the bolt-heads wearing against the sides of the pumps when working.

**Pit Work Arrangements.**—The lifting sett is fixed into the shaft by commencing with the windbore. This may be placed upon the bottom of the sump, or on a
platform of strong balks or iron girders in the sump. The other pieces and the pumps, as already enumerated, are added above in succession until the surface is reached, care being taken to keep the whole truly vertical. The height from the water in the sump to the bucket, or the suction as it is termed, should not exceed 25 feet. To keep the lifting sett steady and in its vertical position, buntons are fixed across the shaft, and cross pieces of timber termed collarings or horse-trees are secured to these against the pumps (fig. 200). Scaffolds should be placed at the clack and bucket doors for the workmen to stand upon when renewing the clack and bucket.

That part of the sett below the bucket is termed the suction, and above is termed the lift. The height of a lift may be anything up to 50 or 60 fathoms. In some cases a lifting sett is used to a depth of 70 fathoms, but this is unusual. When the shaft reaches this or a greater depth it is customary to have two or more lifts, or lifting and forcing setts combined. The height of the lift is limited by the weight, that is, of the water in the pumps, the spears, and the bucket. In a lifting sett an endeavour is usually made to counterbalance the spears.

**Action of the Lifting Sett.**—The action of the pump depends upon atmospheric pressure. Theoretically, reckoning an atmospheric pressure of 15 lbs. per square inch, water will rise in a perfect vacuum to a height of 34 feet. But in ordinary working pumps, owing to the imperfect vacuum obtained in practice, it will not rise more than 28 ft., and, to work well, the height of the suction should not exceed at the most 25 ft.

When the bucket makes its upstroke, its “falls” are closed by the pressure of the air above them, and a partial vacuum is thus formed. Consequently the atmospheric pressure on the surface of the water in the sump forces a
column of water up through the clack, the falls of which open upwards into the working barrel. When the bucket makes its downstroke, the falls of the clack close and prevent the escape of the water, which thus passes through the falls which are opened by the pressure of the water below them. When the bucket takes its next upstroke it lifts this water with it, and a vacuum again being formed below, another column of water follows the bucket in its ascent. When the pumps have been filled to the top in this manner, every upstroke of the bucket gives a delivery of water at the surface, the quantity depending upon the length of the stroke and the size of the pump. In the action of the lifting pump there is thus a process of “suction” depending upon atmospheric pressure, and of “lifting” depending upon the strength of engine.

Sinking Shafts.—Water in sinking shafts is generally dealt with by a lifting sett which is lowered as the sinking progresses. After a certain depth has been attained, a forcing or plunger sett is put in, to which the lifting sett pumps.