whole pumping system, and causes continual wear-and-tear even where the best material and workmanship have been available for the construction.

Where the head is low—say, not exceeding 50 ft.—the ordinary type of centrifugal pump has met with great success, but it is handicapped by its very low efficiency, such pumps seldom realising much over 50 per cent.

In quite recent years several fast-running plunger pumps, of what may be called the "express" type, have been put on the market, and have certainly achieved remarkable results when compared with the older forms of either direct-acting or geared pumps. Their principal feature is the use of mechanically controlled valves of special construction, permitting a high plunger-velocity; but even they are subject to the usual wear-and-tear of internal parts, such as rams, valves, seatings, and controlling levers, and of the external rod ends and gearing, which is, of course, aggravated when muddy or gritty water has to be dealt with.

In order to avoid the drawbacks to which all plunger pumps are liable, and also to get over the disability of the rotary pump for high lifts, the multiple chamber centrifugal pump—known as the "Mather-Reynolds Patent High-lift Pump"—was introduced some years ago. This was able to discharge water against heads with which the ordinary centrifugal pump could not deal.

The feature of this pump is that it consists of one or more sets of vanes, or impellers, each set running in its own chamber, but upon a common shaft, the delivery-pressure of the liquid varying directly as the number of chambers used. Thus, if an ordinary single pump can deliver water against a head of 30 ft., the addition of another chamber will give a final delivery-head of 60 ft., while four chambers will enable the pump to discharge the same amount of water against a head of 120 ft. With this multiple pump it was found possible to deliver large quantities of water to a height of as much as 150 ft., a result never before attained by a centrifugal pump.

The centrifugal pump has been further developed by Messrs. Sulzer Bros., with whom Messrs. Mather and Platt (Limited) have made arrangements for the adoption of their latest improvements. With these improved pumps water can be delivered against as great a head as 200 ft. with a single chamber, and at a high efficiency, some of the larger sizes of pumps giving out the equivalent of as much as 76 per cent. of the power put into them.

In this improved patented type of circulating pump the water enters the revolving wheel axially, and in the case of single pumps symmetrically on each side of the wheel, so that axial thrust is eliminated; the water then traverses the curved internal passages between the vanes, and is discharged tangentially at the periphery into a stationary guide ring of special construction; this conveys it to the annular chamber in the body of the pump, where the velocity-head imparted to the water by the wheel is converted into pressure-head. From this chamber the water is finally discharged into the pipe-lines, or, if the pump be a multiple one, into the second and subsequent chambers.

A special feature of this pump is the provision of the stationary guide ring mentioned above: this is fixed concentric with the revolving vanes, and, owing to its design, enables the conversion of velocity into pressure head to be carried out in a much more perfect manner than is possible in the case of any other centrifugal pump; thus not only is the possible height of lift very greatly increased, but also the efficiency of the pump is materially improved.

Another point of interest is that in these pumps the water is nowhere forced to undergo a sudden change of direction, or to meet with a sudden difference of cross-section in the passages.

The whole internal design is carried out in suitable curves and channels of gradually increasing area, so that the liquid dealt with is never restricted or opposed in its course through the pump.

It is claimed that this is an advantage of no little value. As to other advantages, when compared with a plunger pump for high lifts, a glance at the two types will make these manifest, as follows: (1.) The centrifugal pump has no moving parts in contact, except the steel spindle revolving in its ample and well-lubricated bearings; wear-and-tear must therefore of necessity be a minimum. (2.) The pump has no need of air-vessels, and since it runs at a high speed of rotation it can be designed so as to occupy a small space. (3.) Heavy foundations are entirely unnecessary; large pumps have been run at full load on wooden balks without any fixing whatever. (4.) Owing to the speed of rotation the pump can be coupled direct to the spindle of an electric motor or steam or water turbine, thus obviating the necessity for the introduction of gearing.

The pumps may, of course, be driven from steam or gas engines or existing shafting by means of belt or ropes; but the ideal source of power is the direct-coupled electric motor.

To convey an idea of the value of this class of pump for mining purposes, the experiences of the owners of a silver-mine in Spain may be briefly recapitulated. The original plant consisted of a Cornish pumping-engine with single-acting plungers 10 in. in diameter by a stroke of 6 ft. 6 in. There were seven plunger-sets and one draw-lift, the total height of the column being 1,200 ft. Owing to the cost of fuel for steaming this pump something more economical was decided on, and a new compound engine for driving and a set of differential pumps, having plungers 15¾ in. and 22 in. diameter by 5 ft. stroke, were ordered. Pending the construction and erection of this plant a steam-pump was placed underground. The results obtained from this, and also from the differential pumps (when installed), were so unsatisfactory, by reason of expensive working and frequent breakages, that both were abandoned and replaced by hydraulic-ram-pumps, the rams at the surface being coupled direct to the tail-rods of new horizontal engines.

This plant fufilled its purpose for a year or two, but, owing to the enormous shock due to the movement of the columns of water at each reversal of the stroke, serious trouble was experienced by the breakage of the hydraulic mains, and the necessity for the adoption of a more satisfactory method of pumping became manifest.

After careful investigation the high-lift centrifugal pump was decided upon. The engines which formerly worked the hydraulic rams now drive dynamos for the generation of electric