is likely to occur. Plunger pumps are not suitable for changing well conditions and should be specified only on thoroughly proven data.

The turbine pump has the same limitations as the plunger pump with an important addition. The efficiency and capacity of a turbine are only at a maximum for a very short range of head fluctuation and fall off very rapidly as the head increases. It is absolutely essential that a pump of this class be designed for a definite and known water level, and a change in this level frequently requires the reconstruction of the entire pump. There are some forms of rotary propeller pump which do not have this objection as they are built in sections and can be extended within the limits of strength and of motive power.

The number of units in the proposed plant and the emergency reserve, in the form of water storage or connection with neighboring supplies, may have an important bearing on the problem. With a number of units and sufficient reserve, the hazard due to breaking pump rods is materially reduced and such an accident can usually be repaired in a few hours. With the danger of interrupting the service, this contingency resolves itself into a matter of cost of maintenance. With only one unit, however, the importance of continuous service greatly enhances the value of the reliability of the air lift.

The skill, experience and responsibility of the erection contractor is of great importance, especially where anything but air lift is considered. If possible, a pump should be erected by its makers, or by their trained representatives, and the responsibility of the contractor and pump maker and their policy in dealing with customers' complaints should be carefully investigated. It is often better to have a fairly good well pump made by a concern which stands back of it, than a better pump which does not value the satisfaction of its customers enough to help them overcome the difficulties that are so often encountered in well work.

The erection of a well pump is of almost equal importance with its design, and must be carefully considered in selecting the type of machinery to be used. Many a good pump has been unsatisfactory because of improper installation or of unsuitable well conditions which should have been detected and reported by a competent erector.

The character of the attendance a plant will receive may vitally affect the selection of the type of pumping machinery. Few accidents can happen to an air lift which will not be immediately detected and remedied, although the efficiency may fall off very materially under unskilled or careless management. The other types of plants are more delicate and require constant and intelligent supervision.

The causes of trouble with well pumps are many and sometimes obscure. Probably the most common ones are crooked wells, sand in the water, too low a water level, or, as it is often stated, a lack of water, too high speed, and incorrect alignment.

The crooked well is the bane of the pump man's existence, and unfortunately is exceedingly common. It is difficult to drill a straight well where the rock strata are not homogeneous and horizontal, and the difficulty of measuring the well, coupled with the lack of competent construction supervision, has been largely responsible for the acceptance of so many crooked wells throughout the country.

A long line of rods or a shaft rotating at high speed cannot be expected to work around a corner without giving trouble, and, even where a pump is set on an incline to conform to a straight but inclined well, the unbalanced condition of the loaded parts is likely to give trouble. It is a perfectly safe rule never to install a plunger or rotary pump except where the rods or shaft can be made perfectly straight, and even inclined wells should be avoided as far as possible.

If the water level in a well drops to the barrel or pump, the machine will take air instead of water. This causes severe shock and is a frequent cause of pump trouble.

Plunger pumps should never be run at a greater speed than 90 or 100 ft. of plunger travel per minute, and the higher the lift and the larger the pump, the slower should be the speed. For ordinary crank motion pumps, operating with lifts of 50 and greater, 75 ft. per minute plunger speed is to be preferred.

Improper alignment of a well pump is a very common cause of trouble and no pains should be spared to avoid this condition. It takes an expert erector skilled in this class of work to produce the best results, and this is particularly true when a slight crook in the well or a general slope to the bore require that the pump be set on an incline in order to avoid undue stresses on the rods or shaft. Facing a pump in a different direction, and inclining it slightly from the horizontal, will sometimes make a pump work more easily and eliminate much of the trouble from breakdown. Proper alignment of motor or engine is essential, particularly in direct connected or geared units, as the vibration set up by a poorly aligned gear or shaft greatly increases the stresses in the machine.

It is useless to spend time and money in determining the well conditions and obtaining the right machine, and then to trust the installation work to any practical mechanic who may be the lowest bidder for the work. One would not think of trusting the adjustment of a six cylinder automobile motor to a foundryman, yet many well pumps are installed by men with as little special knowledge of their work as a founder might be expected to have of the gas engine. Unskilled erectors are responsible for many well pump troubles, and the greater the lift or the more unsatisfactory the well conditions, the greater becomes the importance of the skilled erector.

Unfortunately for the engineer, it is often a difficult matter to determine accurately the data necessary for the proper selection of well pumping machinery. Where the digging of the well is included in the work, or where there are sufficient reserve units to permit the dismantling of the well for testing and examination, the difficulties are not great, though the tests are rather expensive. But where the well is in constant use, it is generally very difficult to gain access to the water level and the condition of the well must be judged from the history of its construction and the operation of the existing pumping machinery. All wells are straight, according to the reports of the men who drilled them, but continual breakdowns, that cannot be explained by the lack of water or by too light rods or shafts, are generally indicative of a crooked well or improper erection, and should be viewed with concern.

Well pumping installations are found most frequently in the smaller towns and villages, where the engineer, if there was one, was generally limited to the absolute minimum of expenditure required to furnish a plant that would deliver water. This explains in part why it is so rare in such plants to find provision for measuring the water levels or the pump discharge. Apparatus which will show the water level in a well is simple and costs but a few dollars, and its presence adds materially to the safety of the plant and the ease with which its efficiency may be watched. Water levels, particularly in well populated