to be a very uneconomical installation, yet, to all outward appearances, the conditions in the second well were the same as those in the first, and the results almost beyond comparison.

It is in this second well that experience would have been necessary to have properly piped it up had the city decided to use it. However, they had plenty of other water available, so the well was abandoned. But an air lift could have been installed in it in such manner that, figuring from the current input at the motor of the compressor to the water discharged in the reservoir, it would have shown 30% efficiency. This could have been obtained by installing a 3-in. air lift and taking 50% submergence, or, in other words, by placing the lift as far below the working head of the well as we were going to lift the water. This would have yielded one gallon of water for 0.63 of a cubic foot of air at 67 lbs. pressure.

Misleading Results

Of course, the starting pressure in this well would have been greater than that of the other wells of the system, yet this could have been offset by the use of an auxiliary air line to lift the head of the well. Had the original installation in this well been let stand, anyone wishing to speak disparagingly of air lift pumping could have in all honesty cited it as an expensive mode of pumping water. On the other hand, some manufacturer wishing to extol the virtues of his pumps, might have honestly printed a glowing advertisement of the results obtained in the well first described. Both would be equally misleading. The first is a result from what might be termed a freak well, while the installation of a 6-in. pump in the second well would be improper for the best results obtainable by the air lift system. I only cite these two wells to illustrate my point that each well forms an individual problem and that the same installation in all wells would fail to pump them properly just as would the same medicine fail to cure all men suffering from disease.

One reason why the air lift pump proves valuable in many parts of the state of Iowa, or for that matter in any other part of the country where the water contains as much iron and sulphur as it does in this locality: When a well is pumped by air, the water undergoes a complete aeration, for the air and water are mixed under pressure and this tends to throw off the sulphur gas and precipitates a great deal of the iron. One of the principles on which the iron-breaker works is aeration.

Also, many of the wells in this part of the state pump a great deal of sand, and as the air lift has no moving parts in the well, grit has no effect upon it. Any number of wells may be pumped from a central plant and there is no limit to the quantity of water that can be handled, and with a properly designed system, the extra cost of pumping wells located a mile from the power plant is not material. It has been stated that an air lift system requires little or no attention aside from keeping the compressor in proper running order. While this is practically true, and cited as one of its many advantages, yet sometimes it works to a disadvantage, because it will continue yielding water for years without giving any trouble, yet there are times when the system becomes unbalanced and the working heads of the wells recede (which changes the percentage of submergence), thereby reducing the yield of the well and increasing the amount of air required.

If the wells were checked up once or twice a year, and changes made to meet the new conditions, a great deal might be saved in operating cost. Sometimes very little things cause quite a great loss in economy. Not so long ago, I was called to a plant where a battery of five wells was being pumped from one compressor. The compressor at its maximum speed was barely large enough to pump the amount of water required. The operator told me that when the plant was first installed it gave excellent results. But there had been a decided falling off in the yield of the wells. The system was well designed and should have given good results. Upon investigation I found that two of the wells were much weaker than the other three and that they operated at about 15 lbs. less pressure than the other wells. When the engineer had balanced the system, he had set the regulating valve at the well head of these two weaker wells so as to admit only enough air to pump the water that they would economically yield, and, of course, had left the valves wider open on the strong wells.

When starting the system, the operator discovered that many times these two weak wells did not come in. Their static head being the same as the stronger wells, and therefore being supplied with much less air, did not start so easily. In order to overcome this he had very thoughtlessly taken a wrench and opened the valves of these two weaker wells. Any force follows the line of least resistance and the larger part of the volume of air rushed into the weaker wells, where it could not lift the amount of water that it could have done in the stronger wells. Therefore the system was out of balance and giving poor results, through no fault of the air lift or the man who installed it. When air lift systems are excessively costly to operate, I think it might safely be concluded that there is a good cause, and that the chances are that the trouble might be easily removed.

A great many mistakes are made when installing air lifts, especially by novices in the business, in reference to the size of the pump to be used to deliver economically a certain volume of water. In order to make that as plain as possible, I will give a concrete example:—

For instance, if we wanted to lift 150 g.p.m. from a well with a working head 80 ft. below the surface, the most economical pump to be installed would be a 3½-in. lift at 65% submergence. Under these conditions this pump should yield one gallon of water for every 0.3 cu. ft. of air at 67 lbs. pressure. As you can easily figure, the pump would be located 229 ft. from the surface. Now, suppose instead of being able to get 65% submergence, we can only get 40% submergence. In order to deliver 150 gals. per minute under these conditions a 4½-in. pump should be used, and one could expect a gallon of water for every 0.59 cu. ft. of air at 25 lbs. pressure.

By a little figuring one can ascertain that it required one and one-tenth more horse-power to raise the water in the second instance than it did in the first, and I gave it, hoping to be able to show that even though conditions be vastly different in various wells, a properly designed air lift can be made to yield good results. But, of course, there are places and conditions under which some other type of pump should be used.

As you can note from this example, as the submergence decreases, the size of the discharge line should increase. But this is only a general rule, and the conditions in the well to be pumped entirely govern the ratio of the change to be made.

Variable Discharge Lines

Of late years some firms have been advocating a variable discharge line. I mean by that, some firms wish to start with a smaller pipe and expand toward the point of discharge, the theory being that by allowing the compressed air more space in which to expand, it will lend more of its energy toward lifting water. On the other hand, some firms advocate turning this type of installation upside down, as it were; that is, they reduce the line toward the point of discharge, the theory being the same as the reason for choking the muzzle of a rifle in order to keep all the gases behind the bullet until it leaves the barrel.

Of the two systems, so far as observation has gone, the latter is to be preferred. I have seen it produce excellent results under some conditions; that is, by getting more water by greater economy than would be possible to get from a uniform discharge line made of our standard pipe sizes. I suspect that the friends of the expanded discharge line system will challenge this statement and point to some installations which they claim to be very successful. I have seen one or two of these, but they have been invariably installed in excellent wells that yielded large quantities of water very economically, not because of the system of expanding the discharge line, but in spite of it. However, improvements are being made in the system of piping, and each year shows more practical results than the preceding one.