works yard. The manager will make mistakes unless he always asks himself the question: Will it pay? Does the roposed investment bring the greatest return upon each dollar of capital? Is there not some other way of accomplishing the purpose, which during the assumed life of the apparatus employed, will show a greater net return?

Of less magnitude, but none the less necessary to the smooth running of the plant, are the mechanical engineering problems encountered in selecting the moving machinery required and in maintaining these machines in an efficient condition. For instance, the ratio of the water cylinders to the steam cylinders of the elevator pump should be the inverse of that for the oil unloading pump, if the work in each case is to be done with good efficiency. The engines which drive the blowers for furnishing blast to the generators should be chosen only after giving due consideration to reliability, thermal efficiency, first cost and durability. The volume of business done by some particular gas company may be so small that it cannot afford the best apparatus in the market; the interest item outweighs all others combined, and the mechanical engineer recognizes this and buys a cheap 10-horse power blowing outfit that will last long enough, or until the business has grown large enough to afford something better; but in large stations when the horse-power involved may and often does reach several hundred, the cost for interest and depreciation, even for the best that money can buy, is of less importance, compared with the cost of steam for operation; and the most efficient blowing unit obtainable should be installed, due consideration being given to the questions of durability, possible obsolescence or inadequacy in the near future. This suggests one of the most puzzling problems of the mechanical engineer in the gas works: namely, that of selecting the right sized unit, whether it be an installation of coal gas benches, a water gas set, or a combination of both; whether he should recommend an increase of storage holder capacity or install greater generating capacity, and whether, in case greater holder capacity is decided upon, it should be located near the generating plant or at a distance; in the latter case supplemented with a pumping plant and high pressure mains. It is true that the solution of these questions involves also business judgment, for instance, in making extensions of plant. This can be done in small successive instalments, each sufficing for a short time in the future, as growth of business shall demand; this while conservative and safe, may result in ultimate high total capitalization, due to greater cost of successive small extensions and changes. On the other hand, extensions may be made on a large scale sufficing for a long time at a much lower cost for a given capacity, but this subjects the business to the risk of heavy interest charges if its growth is not rapid, or to heavy replacement costs if improved apparatus be substituted for old. Sound judgment as to business prospects is here required, but after its exercise there is equally important use for the knowledge and judgment of the engineer, even if much that is ordinarily called business judgment is not itself the application of mathematical or of engineering principles.

Having designed and built a gas plant, with constant consideration of the result to be obtained, with an eye to thermal, mechanical and labor efficiencies, with the least expenditure of money compatible with the utmost reliability and fair durability, the mechanical engineering problems of operating must be met. One of the most important of these is the quality of the raw materials. Since it is the business of the mechanical engineer to secure the greatest possible quantity of heat units and light units in the finished product for each dollar expended for raw material, it is important that he does not handicap himself at the start by purchasing inferior raw materials. Although there is a growing tendency towards the purchase of coal on the basis of its heat value, still this practice is not by any means general, and it is customary for the engineer to purchase coal regardless of the percentage of fixed carbon, volatile combustible, ash, sulphur and water. How important a matter this is may be seen by reference to two analyses given below of samples of coke which, when good, is a most excellent gas-making fuel. Two analyses of bituminous steam coal are also given.

	Coke.		Steam Coal.	
	No. 1.	No. 2.	No. 3.	No. 4.
	%	%	%	%
Moisture	15.0	1.5	0.73	12.71
Volatile combustible	5.0	3.0	17.43	28.62
Ash	15.0	5.0	4.63	20.78
Sulphur	1.0	0.5	0.62	3.69
Fixed carbon	64.0	90.0	77.71	34.87
	100.0	100.0	101.12	100.67
B.T.U.	.....	.....	15,178	8,840

The sample No. 1 had been exposed to heavy rains, or it had been flooded when quenched, was badly burnt off in the first place and was the product from a seam of coal containing much ash and sulphur. From a mechanical engineering stand-point only the fixed carbon is of certain value for making carburetted water gas. Consequently the gas manager has actually paid 40 per cent. (0.9 ÷ 0.64 = 1.4) more for his fuel in purchasing sample No. 1 than in purchasing sample No. 2. Although he may not be able to control the dealers in the matter of the analysis of their coal, he is, to some extent, in command of the situation, owing to the fact that he may restrict his purchases to certain coal fields where the quality is good and uniform. He may also insist upon proper methods of quenching, and upon the shipment of the coke in covered cars or failing to be able to keep the coke dry en route, he may find that it will pay to build sufficient storage at the works to permit a partial drying out under cover.

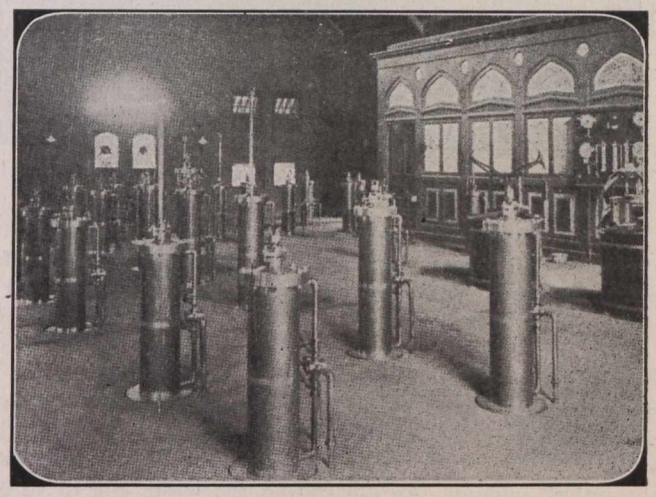

Fig 4.

A labor-saving device—the hydraulic cylinder. By simply turning a small cock, the cylinder shown above will open and close valve gates weighing many hundred pounds.

One of the most troublesome problems to be met with in a gas works is that of labor. It might be said that this is not particularly a mechanical engineering problem, since all