or failure of the enterprise as a whole. The system of instruction which instils the theory of an operation and at the same time illustrates the theory in practice enables the mechanical engineer to forsee the direction in which success may be attained; and at the same time the practical instruction in the laboratories and shops saves him from the pitfalls in which the pure theorist is certain to flounder with fatal result.

In the treatment of the coal through the various stages of manufacture to the completed product, the gas manager is confronted with problems of efficiency and appropriate design; the phenomena of combustion; the handling of heavy and bulky materials; with chemical reactions of the most complicated nature. In order to insure good service, continuity of the supply of gas both as to quantity and quality, and a stable, profitable business, it is necessary so to design the plant that it possesses entire reliability, and so to operate it that the greatest net profit is obtained. With extravagance in first cost or wasteful operating methods,

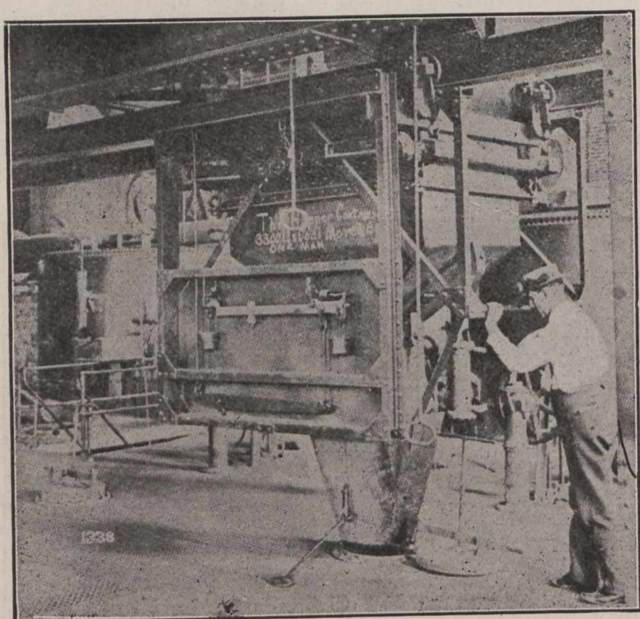

Fig. 3.

In addition to the fuel-weighing machine shown above, the mechanical engineer has applied methods of precision in the measurement of air required for blasting, the steam for producing water-gas and the oil for carburetting the water-gas. His effort has always been in the direction of replacing the old haphazard methods of gas-making with those of scientific accuracy.

whether due to design or bad management, what might have been a highly attractive undertaking in which capital would readily seek investment, soon degenerates into an over-capitalized and unprofitable operation with a reduction, or entire loss, of credit, meeting finally the expensive process of a reorganization. It is therefore at the very outset that mechanical problems are met and must be correctly solved before we may intelligently determine how to build the plant so that the high efficiencies and rigid economies necessary to success may be obtained. It is not alone sufficient to know that a given piece of apparatus will perform its function with the highest efficiency; the questions must be asked: What does this efficiency cost? Will it pay to make the investment? Will it pay, for example, to purchase machinery to unload the coal, and if so, what kind of machinery? What is the cost of operating this machinery, for steam, repairs, deprecation and attendance? Would it not be wiser to avoid locking up so much money in coal-handling machinery, which may be obsolete in a few years, and rather rely upon common labor, which, though costing a little more perhaps, all things considered, does not rust, carries with it no interest charge, and is so flexible that it may be employed in numerous other operations besides the unloading of coal? All the above are mechanical engineering problems.

While the construction of the foundations of the buildings in a gas works and the strength and other characteristics of the materials employed may be properly the business of the civil engineer, and while the chemical reactions involved in the generation and purification of the gas may strictly fall within the province of the chemist, still it will not be denied that the appropriateness of the design of the structures, both as to first cost and the facilities offered for economies in labor, the efficiency with which the chemical reactions are produced, and the thermal and mechanical efficiencies of the apparatus employed, are purely mechanical engineering problems.

One of the first problems of the mechanical engineer in the gas works is the receipt and storage of the coal for gas making and for boiler fuel. He must decide whether the amount of material to be handled will warrant the installation of mechanical unloading devices. Upon his knowledge of the cost of operating and the durability of this class of machinery depends the wisdom of the decision, and without special knowledge of this subject a mistake would probably be made which would materially affect the cost of a unit volume of the product. For example, it would not pay to invest $5,000 in machinery to handle from the car to the bin the 1,000 tons of anthracite coal that will be needed in a carburetted water gas plant supplying a city of 25,000 inhabitants. The steam and labor of attention necessary to operate the machinery will cost 5 cents a ton, and the interest (5 per cent.) and depreciation (10 per cent.) will add 75 cents more. Utilizing a simple hydraulic elevator costing $1,000, a laborer, at 25 cents for his wages, will put up one ton per hour, and the interest and depreciation at 10 per cent. on $1,000 will bring the cost up to 35 cents. If to this we add 5 cents a ton for operating the elevator pump, we find that by the adoption of the second method we have saved 40 cents a ton in handling the coal. But the $5,000-elevator will handle 5,000 tons at the same cost for interest and depreciation as it did the 1,000 tons. Its installation, therefore, in a plant of five times the size of the one first assumed will be justified, for then the comparison would be:—

For the $5,000 elevator:

	Cents.
Interest and depreciation	15
Operating expenses	5
Total cost of coal handling per ton	20

For the $1,000 elevator and common labor:

	Cents.
Interest and depreciation	2
Labor of operating	25
Steam for elevator pump	5
Total cost of coal handling per ton.........	32

The above example will serve to illustrate one phase of mechanical engineering in receiving and storing coal in a gas