

gine is employed the cost of fuel on a well-designed plant is small.

Of course, it is impossible to forecast exactly what supply will be obtained from a tube well, and perhaps the old sunk well was convenient, as it was easy to drive from the bottom of it either for prospecting or increasing the yield, but for moderate supplies the bored well appears to be the cheaper project. An instance of the uncertainty is shown in the case of two 13-in. wells within 100 yards of each other. One borehole yields 4,000 gallons for an hour or so, when the yield gradually falls to 2,000 gallons and remains constant at that point. The other borehole yields 27,000 gallons continuously. In this case the air-compressor is high speed driven by an electric motor taking 40 k.w. when lifting 27,000 gallons per hour, 96 ft. to the surface. In one case, where a gas-producer plant and engine drives a compound equipment consisting of an air-lift pump, which raises the water 120 ft. to the surface, and of a plunger pump, which drives the water to a reservoir at a head of 180 ft., the cost of fuel used when raising 11,500,000 gallons of water has been under £27, or .55d. per 1,000 gallons. On the same site a three-throw deep-well pump driven by an engine using town gas pumped 17,000,000 gallons at a cost for fuel of 1.26d. per 1,000 gallons pumped. The town gas was charged at 3s. 3d. per 1,000 cubic feet. At another place an air-lift pump driven by a motor taking 68.5 k.w. is lifting 17,300 gallons per hour 262 ft.

Water softening is much too large a subject to be handled in one paragraph, as the various systems would have to be dealt with in detail. One system was described by Mr. Lassen before this association in 1905, and it is only my desire now to remind members that it is not economical to feed impure water into a boiler. If the water is of a scale-forming nature, the loss in heat is very serious owing to the deposit of scale on the tubes or plates. If only sludge or a concentrated solution of salts is formed, the loss in blowing down is also great, although in these latter cases the cost of labor in cleaning is less than when hard scale has to be removed. One of the simplest and most efficient forms of purifier is the open heater. Many varieties are on the market, differing rather in the application than in principle. When such a type can be used, it is certainly preferable to a system which turns the pump-room into a whitewash factory, with an uncertain outlet for the by-products. I believe one of the strongest arguments in favor of our present London water supply is the low death rate which is quoted to show its special suitability to our uses. We have only to return home from a visit to districts more favorably situated to realize how hard our lives are, and to wish that more consideration was paid to those who use soap or evaporate the water and less to those who die!

FUEL.

The great rise in the price of coal has necessitated the consideration of the more economical use of it and of the possibility of using cheaper qualities. Many users who previously burned "large" have found relief in the use of "small" or "nuts," not only in connection with mechanical stokers, but

also for hand-fired boilers. Where the draught is poor or the grates small, necessitating a large combustion per square foot, a grade of fuel which will permit an ample amount of air to pass through it is essential. There are several forms of firebar designed to burn small coal, but a bar of the usual shape with small air-spaces will serve very well with a normal draught if the stoker can only be persuaded to keep his fires thin. Thin firing is especially important with small Welsh of the drier kinds, as if a mistake is then made and the fire worked too thick, the application of the pricker only results in making matters worse, and the fire is quickly poked out. Steam jets under the grates form a simple, though rather noisy, means of assisting the draught, but unless the nozzles are carefully watched the proportion of steam-blown under the grates to that evaporated by the boiler assumes most uneconomical dimensions, 12 to 15 per cent. being by no means unusual. The jets are also apt to cause local heating and damage to the boiler plates and fire-bars.

Where the draught can be assisted by a fan, it will be found much more economical than the steam jet method. Forced draught has an advantage as regards the size of the fan required, as the air blown under the grates alone has to be handled, while an induced-draught fan has to handle the same weight of air, in addition to the gases of combustion, at a higher temperature, and consequently increased volume. The induced-draught system is generally preferred where the chimney draught only has to be assisted occasionally, such as on peak loads, and it has the advantage that the ashpan then need no alteration, but may be left open, and there is no chance of flames being blown out of the fire-door. It has a disadvantage, however, when dry Welsh coal is being burned, as grit is more likely to be ejected from the chimney. The regulation of the draught by the dampers has not received the attention it deserves. Automatic regulators have been placed on the market, but the sale of them must have been small, as they are rarely met with. To get the best results when hand-firing, the air admission, and also the chimney dampers, need careful manipulation, and this is a strong point in favor of mechanical stoking, as then the ideal conditions of long runs without opening the doors may be realized.

Gas analysis has of late years received attention, though for many years it was ignored alike by experts when testing steam boilers and by the users of boilers; it is only of late years that the percentage of CO₂ in the flue gases has been recorded on boiler tests. Thousands of tons of coal are wasted yearly by the neglect of the subject. The average amount of CO₂ in the gases may be taken at about 7 per cent., which means a loss of 26 per cent. In the calorific value of the fuel. Greater care would increase the percentage of CO₂ to, say, 12 per cent., which means a loss of 15 per cent. only, and would represent a saving of 10 per cent., which would quickly pay for the apparatus involved. The benefit of recording the CO₂ in the flue gases was first realized in Germany, whence the earlier types of instruments were developed. Since their introduction into this country,

many of the faults in the earlier types have been eliminated, and some of those now on the market merit a much larger recognition than has yet been accorded to them. In many German works it has long been the custom to pay the stokers a premium on the amount of CO₂ recorded, with beneficial results. A sight hole to enable a stoker to see the combustion without opening the fire-door is a very useful adjunct to a furnace, as an intelligent stoker soon notes what color indicates that the boiler is doing its best, and learns how to regulate his operations to obtain that color. When boilers are set in battery the whole can only be placed in the front, but the best place is at the side behind the bridge.

Purchase of fuel by analysis is very important, but when we consider the ease with which coal merchants can sell their stock, it is not surprising that they do not generally view the system with favor, and resent the incorporation of such clauses in their contracts. More united effort will be needed to get them educated up to this equitable method of buying fuel. Experience gained by several years trial has proved to me that sampling and analysis may be done quite commercially under a contract which states the amount of volatile hydrocarbons and ash allowable, with a penalty if the amount of ash is exceeded. Air leakage through boiler settings is a common cause of low efficiency, not only in the case of water-tube boilers, but also in shell boilers of every type, excepting the wet-back marine. Asbestos rope is a most useful draught stopper when either built in between the brickwork and the boiler, or caulked lightly in afterwards. It is sufficiently elastic to allow the boiler to expand when hot without moving the brickwork. Cracks in walls should be promptly stopped. In some cases where the ashpan is fitted with doors, the stokers are apt to regulate the draught by them, and to leave the full chimney suction on the boiler and setting. It is better practice to regulate by the outlet damper.

Mechanical stokers have, unfortunately, too often been recommended like patent medicines, but the purchasers have found that stokers doing excellent service under certain boilers are useless under others. Of late years much more thought and skill has been applied to the problem, with a resultant gain to all concerned. Even now, due to competition, the makers' estimates are apt to be too sanguine, and best results not only in economy of fuel, but particularly as regards repairs, may often be obtained when working the machines below their rated capacity. When selecting a stoker more care than is sometimes displayed should be taken in choosing a type which will burn different classes, and certainly different sizes, of fuel. For instance, if a stoker is arranged to burn only clean nuts, as the market sometimes calls for more nuts than are made, the price is inflated. Smaller grades are tried, but the waste, due to riddling through the grates, is then excessive, and the lesser evil is to continue burning nuts, as the design of stoker has debared the use of the cheaper fuel. Where only one or two boilers are in use no saving in labor can be made by the adoption of mechanical stokers, as the man who is necessary to tend the stokers might as well do the firing himself. A saving may, however, sometimes be effected on the class of fuel used, but