meet this expenditure. In this manner it is possible to figure out a rate at which the undertaking will be self-supporting. With small plants the biggest items of expenditure are usually the fuel bill and wages. In order to keep these to a minimum it is necessary that the most efficient and reliable plant be installed combined with simplicity in operation.

Steam, Gas and Oil Engines.—The steam engine in favor to-day for small central station work is the vertical compound high-speed engine, fitted with piston valve, automatic governor and having forced lubrication throughout. This type has proved itself very suitable in so far as reliability and speed regulation are concerned. The operation of the same is simplicity in itself. There are, however, other items to contend with in a steam installation just as important as the engine itself. One of these I have previously mentioned, namely, pure water supply. In connection with this, all are familiar with the difficulties attending an impure or shortage of supply. These call for proper and costly treatment on the one hand, and an unreliable service is the result on the other hand, attended with loss of revenue from the sale of energy. There are also injectors, pumps and boilers, which are often more troublesome than the actual prime mover itself. The whole of these difficulties may not be met with, but there is one difficulty attending all small steam installations and, to my mind, a very important one, that is *the stand-by losses.* These ought to be given due consideration when it is intended to install a generating plant. Take the case of a plant running only ten hours out of the twenty-four; for the other fourteen hours there is quite an appreciable loss for which there is absolutely no return, besides there is also the cost of labor looking after the boiler equipment during the non-working hours. Taking this loss of fuel, in addition to the actual fuel consumed during the generating period and with a load factor of 15 per cent., the consumption of coal will be approximately six to seven pounds per unit generated at the switch-board. Taking this lower consumption and coal at the price of $7 per ton, this is a generating cost of 2.1 cents per unit.

Of the gas engine plants the suction gas producer equipment seems to hold the field. These plants are proving themselves more and more reliable and are very suitable for small stations. They are, however, less reliable, although more economical than the steam engine. The greatest difficulty in connection with these plants is usually met with in the gas producers, and in spite of the statements to the contrary, it requires an experienced man to care for the producers, to obtain the best results and keep the plant in first-rate condition. The principal troubles are the keeping of the combustion zone within the proper limits, the removal of ashes and clinkers, and the effects of impurities in the gas. This first trouble is usually caused by the fuel not being kept consolidated during operation. The second due to improper regulation of steam which causes high combustion temperatures, if there is sufficient steam with consequent fusing of incombustible matter. When the ashes and clinker are being removed, and especially in the smaller sizes of producer, little or no provision is made to exclude the air from entering, thus causing an irregularity in the quality of the gas produced. This, you can understand, will naturally affect the running of the engine.

Let us consider the cycle of operation in the engine. During the first stroke, a mixture of air and gas is drawn into the cylinder. On the second stroke this mixture is compressed. At the end of the compression stroke the mixture is ignited by means of an electric spark from a magneto or some such apparatus, thus we have explosion and subsequent expansion during the third stroke. During the fourth or exhaust stroke the products of combustion are set free to the atmosphere. This completes the cycle of operation. The combustion of the gases is accompanied by the formation of a carbon deposit in the cylinder and it sometimes happens even though due precautions are taken, that this carbon, which is at a high temperature, is sufficient to prematurely ignite the fresh mixture during the next cycle of operation. This premature ignition sets up undue strains in the mechanical parts of the engine, which are liable to cause trouble. It is thus found necessary to withdraw the piston in this type of engine at approximate intervals of three months, in order that the carbon deposit does not interfere with the working of the engine. There are also the stand-by losses to be considered, but these are not of the same magnitude as with a steam equipment. In a suction gas plant of the same capacity as that quoted in connection with the steam plant, and under the same conditions, the consumption of coal would be approximately four pounds per kw. generated at the switch-board. Taking coal at $8 per ton, this would mean a cost of approximately 1.6 cents per unit.

In considering the oil-burning engines, I might just mention that it has been a recognized fact both theoretically and practically, that the higher the compression in the internal combustion engine the more efficient would it become. One reason for the keeping of this compression at a moderately low figure has been due to the excessive temperature caused by the compression and the likelihood of this high temperature igniting an explosive mixture such as is compressed in the ordinary gas engine. This difficulty, however, has been overcome in one type of internal combustion engine which is considered one of the foremost prime movers on the market to-day, that is the Diesel crude oil engine. The cycle of operation may be described as follows: During the first or suction stroke, air only is drawn into the cylinder. On the second stroke this air is compressed, and at the end of the compression stroke the fuel oil is sprayed in finely divided particles into the cylinder. The air temperature, being high, as the result of compression, the finely divided oil burns as it enters the cylinder. This spraying of oil is continued during a considerable portion of the outward stroke, and during the remainder of this the third stroke, the products of combustion and the surplus air expand. During the fourth or exhaust stroke the products of combustion are driven off to the atmosphere. This completes the cycle. It will thus be noticed that air only is compressed and not a mixture of air and combustible vapor or gas: consequently, whatever the pressure of compression and whatever the temperature, premature ignition cannot occur, there being no fuel to ignite. Therefore the greatest economical advantages of high compression can be utilized. There is, however, the disadvantages of high compression, which are all more or less of a mechanical nature, but these difficulties of a recent development are being largely eliminated. The Diesel engine, like all other prime movers, is not immune from trouble. It may be the sticking of a fuel valve, the hanging up of a compressor valve, or a leaky exhaust valve. All of these defects may be of little or no importance, and may cause a shut-down of only a few minutes, yet there is that interruption in the service which always means a loss of revenue. To my mind the only great disadvantage in connection with the Diesel oil engine is a possible short-