tions of the conduit, the contact plow and the manner of supporting the same. The design of the new conduit system, in which the writer had the pleasure of assisting, was carried out at the Paris works of the company. In Fig. 1 is shown a section of the two conduits, one for each track. They are placed on the inner side of the track. The outer track rail is of the ordinary type, while the conduit rail serves as the inner track rail. Here the conduit rail is double and the space between the two rails gives passage to the plow which runs in the conduit. The conduit is formed by placing a series of cast iron supports or frames at regular intervals (see photograph) and bracing them together by side-bars. Between the frames are placed a series of sheet iron forms having the section of the conduit, and beton is filled around them. When the latter is fixed, the forms are drawn out through the slot. The wood paving of the street is then laid over the conduit. Fig. 1 is a section through a manhole, showing the contact bars which carry the current.

Where the road passes the bridge over the Seine, a special form of shallow conduit had to be used as there is not sufficient depth to place the standard form. Here the conduit is formed of cast iron sections about three feet long, reinforced by a web in the center. At the top is a steel plate on either side of the groove, upon which are fixed the conduit rails. The adoption of the shallow conduit made it necessary to elevate the conducting rails for the plow some five inches, and thus the plow had to be raised and lowered by a special device when passing over this point. The method of supporting the plow is one of the problems which needs to be solved in as satisfactory a manner as possible. On the long conduit lines in Europe such as at Berlin, Brussels, and Budapest, it is found that the best method is to keep the plow always attached to the car, and to provide a mechanical device for raising and lowering it when at the terminus of the line, without needing men in the manholes to accomplish this. In the above cities the slot is wide enough to allow the plow to be drawn out at any point of the line, but this gives an excessive width to the slot, and makes the plow of a narrow design which is not desirable. To carry out the present idea the plow has been designed as shown in Fig. 2. It consists of several iron plates bolted together, and supporting a pair of contact shoes by means of levers and springs. The current wire passes down the middle to the contact shoes.

Where the line changes over from conduit to trolley, the following method is used for raising the plow out of the conduit: The space provided underground is large. The slot is made to open and close at this point, and so allow the plow to be lifted out of the conduit. For this purpose, the slot runs between two trap doors supported on a cast iron frame lying flush with the pavement. The traps are opened by means of a mechanical device which the motorman operates by a lever. At the same time the motorman lifts up the plow by the device which is described below.

The method of lifting the plow formed one of the most difficult points in the design of the apparatus, as the following conditions had to be fulfilled: In some of the crossings the central conduit is used, and thus the plow is obliged to shift from the side to the center of the car while still in the conduit. Again, the plow is to be raised out of the conduit or lowered into it. This always takes place in the central conduit. Third, while in the side position, the plow is to be raised or lowered in passing from the standard depth conduit to the shallow conduit which is mentioned above. Fourth, at the places where the plow is lifted or lowered into the conduit, the electric circuits must be automatically established by the same movement which works the plow. These different operations are carried out by the device which is shown in the views A, B, and C of Fig. 3. The plow, P, is made to slide along the rail R by means of its two side arms, and it can thus move to and fro under the car. When in the middle position in the central conduit (A) it can be raised out of the conduit by means of a lifting device which the screw M at the side operates. The handle M lies on the side of the car and is removable. Fig B shows the plow in lateral conduit and under normal working conditions, while Fig. C shows it in the shallow conduit. In this case, when at either side of the car, the plow can be adjusted in height by another lifting device which is observed at N. The operation of the lifting device by the conductor also changes the electric connections by means of a switch which is connected to the former by a lever.

PRODUCER-GAS POWER PLANTS.*

By A. FREDERICK COLLINS.

THE operation of large gas-engine units in competition with those utilizing steam has been made possible by improved methods for economically converting all kinds of fuel, be it anthracite or bituminous coal, coke, lignite, peat, wood, and even rubbish, into a gaseous state.

The apparatus in which this conversion takes place is termed a gas producer, and its relation to the gas engine is equivalent to that of the boiler to the steam engine. The gas-producer plant and the steam boiler require about the same amount of attention, but the former, used in connection with its internal combustion engine, represents a much higher degree of efficiency than the latter, for the heat loss attendant upon the conversion of water into steam is eliminated, as

well as that due to a long, leaky, high-temperature steam line.

Especially is the above true of small gas-engine units, and steam can only approximate the efficiency of gas where very large plants are practicable, as for instance in the operation of steam railways. This may be strikingly illustrated by a comparison of the consumption of fuels between these two types of prime movers. Thus the amount of fuel consumed under a steam boiler for an engine of, say, one hundred horsepower requires, under favorable conditions, from two and one-half to four pounds per horsepower per hour,

the air, when the gas, coming in contact with it, is consequently ignited.

There are several forms of gas-producer systems, and these may be divided into two general classes, namely (a) those known as the *pressure* type and (b) those of the *suction* type. The characteristic difference between these two systems is that in the former air compressed by means of a fan or blower is projected through the bed of burning fuel in the generator, and serves not only as a blast for the fire, but forces the gas from the generator under pressure, and in this state it enters the cylinder of the engine. In this type

FIG. 5.—CROSSLEY GAS PRODUCER COMPLETE.

as against a consumption of one pound of coal per horsepower per hour in a gas producer and engine having an equal output. In practice, however, the actual consumption of a gas plant, constructed in accordance with the most approved designs, is only one-fourth that of a steam plant of similar capacity.

For this very excellent reason, as well as the subsidiary one that the gas producer is far less dangerous than the modern high-pressure steam boiler, the growth of the gas-producer and gas-engine industries has been remarkably active the last few years, and the future is full of promise for the new power regime, as the apparatus for the generation of gas is being constantly improved, and engines are being built in ever-increasing sizes.

In producer-gas power plants the equipments are constructed so that a combustible gas is obtained directly from the coal or other fuel, and this product is then washed to free it from impurities and cooled, when it is ready to be utilized in the cylinder of the gas engine. When this point is reached, air is mixed with it in the proper proportions, when it is compressed in the cylinder and ignited, either by the flame of a gas jet, by the electric spark, or, as in the Diesel engine, by means of a high temperature which is evolved during its cycle of operations by compression of

of gas generator a gas holder is required to receive the gas to be used in the engine.

In the suction type of apparatus, the gas is generated by air, which is drawn or sucked through the fuel, saturator, and scrubber by the suction action of either an auxiliary pump, called an exhauster, or the piston of the engine itself. Since recent gas engineering practice has favored the suction system of producers, it is the purpose of this paper to describe two forms of the latter, the first using a gas holder, and the second operating the engine direct.

In the Loomis-Pettibone gas producer the air is drawn through the producers by the suction of the exhauster, shown in longitudinal section, Fig. 1, in the plan, Fig. 2, and in the photograph, Fig. 3. The air enters through the same doors in the top of the producers where the generator is charged with fuel. When the fresh air and fuel are drawn downward through the deep layers of white-hot fuel, the products of combustion and any distillates, or separated products, pass out through the grate of fire brick at the bottom of the producer.

The temperature of the gas as it comes from the generator is naturally very high, and this is utilized to generate steam in the boiler, through which the gas next passes, and when it issues from this, its tempera-

FIG. 3.—LOOMIS-PETTIBONE PRODUCER-GAS PLANT.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

ture is reduced to about that of ordinary chimney gas; passing from the boiler to the scrubber, consisting of trays filled with coke and sprayed with water, it is cooled to the normal temperature of atmospheric air, when it is finally forced by the exhauster into the gas holder.

The object of the steam boiler, which utilizes the high temperature of the gas that would otherwise be

steel shell, *D*, filled with coke, through which a small quantity of water trickles. This clears the gas of any tarry products that it may contain, and is cooled to atmospheric pressure.

After passing through another scrubber, *E*, having trays filled with sawdust or a similar material, which exposes the gas to a very large surface, and removes the last vestiges of fine ash or other solid matter which

Gasoline, purchased by the barrel, costs about 15 cents per gallon, while coke can be purchased in almost any city or town for \$4 per ton. Using these figures as a basis for comparison, and assuming that the plants are to develop 40 horse-power per hour for ten hours, and that one-eighth gallon of gasoline at 15 cents will produce one horse-power, 400 horse-power would cost \$7.50; whereas one pound of coke will give one horse-power per hour, then at \$4 per ton the cost would be 80 cents per day, or a saving of \$6.70 per day in favor of the gas producer, or an annual saving of over \$2,000.

Thousands of small manufacturers, electric lighting plants, etc., are using the crudest type of slide valve engines, which consume, even at a conservative estimate, from six to eight pounds of coal per horse-power hour; and a gas engine with a suction producer would prove a most remunerative substitute, and one showing a very large return on the investment.

FIG. 4.—AMERICAN CROSSLEY SUCTION GAS PRODUCER.

wasted, is to make water gas. To accomplish this, the feed doors are closed intermittently, as well as the valve, and steam is then admitted under the grate of generator No. 1 (Fig. 2) when it is separated into its constituent elements, forming water gas in its passage through producer No. 2, whence it is conducted by the valve, *A*, to the boiler, the scrubber, and finally to the gas holder. When water gas is again made, the process begins in No. 2, working through No. 1, so that the direction is reversed.

Two gas holders are employed to receive the producer gas and the water gas, the holder for the producer gas giving the necessary elastic storage between the apparatus generating the gas and the engine utilizing it. The second holder, which has only a third of the capacity of the first, is employed for the purpose of receiving and keeping separate the producer gas and the water gas thus intermittently generated. The valves, *X Y Z*, permit the gas to be delivered to either of the holders or escape into the air through the purge pipe.

These plants are operated with either kind of coal or with wood, whichever may be procured the most cheaply in the locality where the plant is set up; and the down draft principle, which is the chief feature of the suction system by which the gases are passed through the bottom of the fire, is highly efficient in producing fixed gases from any and all kinds of fuel.

Another form of suction gas producer, also manufactured by the Power and Mining Machinery Company, is a reproduction of an English system known as the Crossley. In this the gas is drawn through the fuel bed as before, thence through a saturator and a scrubber, and directly into the cylinder of the engine by the suction action of the piston. This arrangement, while available for the largest systems, also provides an economical solution for the problem of generating gas for small plants, for it will be observed that it does not require expensive gas holders, thus reducing appreciably the first cost.

In the American Crossley producer the plant comprises the following principal parts: the producer, the saturator, hydraulic box, coke scrubber, and sawdust scrubber. The producer is made of a cylindrical steel shell lined with fire brick and fitted with a revolving steel grate, all of which is shown in diagram, Fig. 4, and in the photograph, Fig. 5. There is an annular space between the brickwork and the outer shell, through which the air for the combustion of the fuel passes from the saturator to the bottom of the producer; a central collecting bell is suspended from the top, and keeps the fuel at a uniform level.

One or two charging hoppers are provided, either in the center or one on each side of the bell. The fuel is charged through tubes, and the hoppers are emptied alternately. The bottom of the producer is closed by a water seal, so that the cleaning and removal of ashes may take place without interrupting the continuous operation of the plant. The air and steam in passing through the incandescent fuel combine with the carbon in the formation of gas, which leaves the producer, *A*, through the central collecting bell when it passes on to the separator, *B*.

The saturator is a water-jacketed pipe, in which the water is maintained at a constant level. The gas as it passes from the producer is hot, and the saturator not only reduces the temperature, but the entering air in its passage through the producer comes in contact with the heated water, and picks up a certain amount of steam vapor, which on its course through the fire increases the calorific value of the gas there being formed.

Sometimes the saturator is omitted, the steam which this apparatus would supply for gas being produced in an evaporator attached to the top of the producer. In either case the gas is next directed into a hydraulic box, *C*, which acts as a seal, and prevents any gas from backing up into the producer. It is provided with an inclined water trough, which permits the removal of accumulated dust. The gas then enters a cylindrical

may have been carried over the gas, it is now perfectly clean, cool, and dry, and ready for work in the engine. Under some circumstances the sawdust scrubber is not necessary, the gas being sufficiently clear after leaving the coke scrubber for immediate use in the engine.

In starting a plant, a small hand-fan is used to bring the fuel to incandescence; as soon as the gas is sufficiently rich to use in the engine, the operation of the producer becomes automatic. Small engines are usually started by giving the flywheel a turn or two by hand. The larger engines are started either with compressed air or with illuminating gas, and as soon as the engine has made one or two revolutions, it is allowed to take gas from the producer.

These suction gas plants are especially designed to render long and continuous service without repairs or stoppages for any reason. The Crossley type, just described, is built in units from 8 to 300 horse-power, and its simplicity, compactness, and economy are features which are attracting more attention to the gas engine to-day than to any other of the four great powers.

Gas-producer and engine plants are much more common in Europe than in America, in virtue of the fact that the cost of fuel for steam plants is almost prohibitive in many of the countries of the old world.

While large units are not so much in evidence in the United States, there are at the present time innumerable small engines using gasoline or illuminating gas for fuel. Clearly, the small consumer is not aware of the advantages, from an economical standpoint, of the gas producer, but the following comparison will indicate at once the handsome saving that can be effected by installing a suction plant and using anthracite coal, coke, or charcoal.

FIG. 1.—LONGITUDINAL SECTION OF LOOMIS-PETTIBONE PRODUCER.

FIG. 2.—PLAN VIEW OF LOOMIS-PETTIBONE PRODUCER-GAS PLANT.

Improvement in the Treatment of Viscose.—In the treatment of viscose (cellulose rendered soluble by the carbon bisulphide process, that of Cross and Bevan) it is gelatinized in a receiver. After coagulation and cooling, it is now subjected to a modified process by the Société Française de la Viscose, consisting essentially in the simultaneous action of washing with a saline solution, and drying. It is necessary that the drying apparatus should consist of earthen ware on a metal not attacked by polysulphides, such as aluminium. The coagulated viscose is mixed immediately with a solution of sea salt, whether containing lime and magnesia or not, or with a mixture of sea salt and sodium bicarbonate, for example, for 100 kilogrammes of viscose having 10 per cent of cellulose, a solution of 100 liters of water containing 10 per cent of sea salt (sodium chloride) and 10 per cent of sodium bicarbonate. The pasty mass is put in the dryer, which at first expels the mother water. While the apparatus is at work a new saline solution having 50 per cent of sodium chloride is introduced in less or greater quantity. Any saline solution accomplishing the same purpose can of course be substituted for that of the sea salt. The simultaneous action on the mass treated results, it is claimed, in the perfect elimination of by-products, without any harmful effect on the solubility of the cellulose.

A general process for the preparation of hydrosulphites has been inaugurated by M. L. Descamps, which the Revue des Produits Chimiques says consists in causing the sudden action of zinc powder or any very fine and pure reducing powder on a concentrated solution of pure sulphurous acid, perfectly free from any other acid. The sudden elevation of the temperature to a point not too high is favorable for the instantaneousness of the reaction, which is a condition *sine qua non* of success. Another condition is also absolutely necessary; the reaction must be complete; no acid molecule must remain free, or decomposition will take place. The proportions to employ are 670 grammes of the powder per kilogramme of sulphurous acid in solution. The reducing powder should be slightly in excess, so that no particle of the acid may escape the reaction. The operation is economical, and the yield nearly theoretic. The product is stable and may be utilized as it is for the standard reactions, to convert it by precipitation of the base or by double decomposition, into another hydrosulphite.