PRODUCER GAS.*

Fundamentals.

The making of producer gas consists essentially of drawing a limited quantity of air through a bed of red hot fuel (coal, coke, charcoal, wood, &c.).

If a container is filled with charcoal and ignited it can be fanned to a glowing mass by supplying an abundance of air to the fuel. If now the amount of air supplied to the heated bed of charcoal is reduced, there will be a quantity of charcoal at a sufficiently high temperature to combine with oxygen readily, but for which insufficient oxygen is available. The combustion of the carbon, which is the principal element of charcoal, will be incomplete, and a gas, carbon monoxide (CO), will be formed. This gas is capable of burning to carbon dioxide (CO_2) when mixed with more air and again ignited. Consequently, if a gas producer be arranged with a limited supply of air, the hot charcoal will combine with less oxygen than it would in an ordinary open fire thus forming a combustible gas which can be burned elsewhere. Hot carbon possesses another ability; it is able to dissociate the elements of water or steam to give hydrogen and oxygen. The hydrogen remains free, but the oxygen combines with carbon to give carbon monoxide. This reaction is also used in a gas producer.

It is simplest to assume that in a gas producer the first reaction is to form carbon dioxide, which is then reduced to monoxide, but whatever the case may be the results are the same and may be set out as below.

(1) $C + O_2 \rightarrow CO_2$
(2) $CO_2 + C \rightarrow 2CO$
(3) $H_2O + C \rightarrow H_2 + CO$

C	= Carbon
O	= Oxygen
H	= Hydrogen
CO	= Carbon Monoxide
CO_2	= Carbon Dioxide
H_2O	= Water

The first reaction (1) is that which normally takes place in an open fire. The second (2) and third (3) will only take place at a high temperature in the absence of oxygen, and it will be seen that the first and second could be combined as follows without altering the result.

(4) $2C + O_2 \rightarrow 2CO.$

The reaction (4) or (1) and (2) combined, gives off heat (is exothermic) and this heat is used to maintain the temperature of the fuel bed and to bring about the reaction (3) which absorbs heat (is endothermic). A balance must be set up between the heat evolved in reaction (4) and that absorbed in (3) so that the temperature of the fire does not fall, consequently the amount of steam or water admitted to a gas producer must be carefully controlled. For Australian conditions the admission of steam is considered to be very desirable as the hydrogen evolved improves the quality of the producer gas. Further, oxygen obtained from steam is not mixed with nitrogen or other diluents as in the case of atmospheric oxygen used in reaction (1), thus a greater concentration of combustible gases is developed.

* Reprint of Pamphlet No. 4, New South Wales Forestry Commission, Division of Wood Technology.

In brief, the essentials to making producer gas are—A hot bed of fuel in a suitable container and through which a limited amount of air may be drawn together with a controlled supply of water or steam. The result will be the generation of a mixture of gases: Nitrogen, hydrogen, carbon monoxide, and a small percentage of impurities. This is the mixture known as producer gas. Such a gas, when mixed with the right proportion of air, can be exploded in an internal combustion engine in exactly the same way as an air-petrol mixture.

Quite a large number of producers have been evolved in an endeavour to obtain the best possible gas with any particular fuel. The principle is the same in every case. Designers try to procure a gas which burns with great heat (high calorific value) and then to deliver this gas to the engine, free from any tar, soot, dust or other solid matter and cooled to the temperature of the surrounding air, or lower if possible.

Producer Furnaces.

Furnaces have been constructed in a great variety of shapes and sizes. The older types were almost invariably lined with fire-brick or similar material. This lining frequently led to trouble as it was affected by vibration, and it has survived only in stationary plants. In vehicular plants it has been found possible to so arrange the air inlet and the gas outlet in the furnace that the container is protected by an envelope of charcoal which surrounds the fire and through which little or no air passes. The charcoal actually acts as an insulator for its own casing. Special precautions in design have to be made at the point where the air enters the fire, as high temperatures are invariably met at such points.

Furnaces may be divided into three types according to the direction of the draught in them, i.e., down draught, up draught, and cross draught. The first type is not normally used for charcoal plants and needs no particular explanation. In the up draught producers air is admitted at the bottom of the furnace through a grate, and considerable ingenuity has been displayed on the part of designers in making a grate which will withstand the high temperatures at this point. The furnaces are usually surrounded by a false shell which acts as an ash hopper, and the air supplied to the furnace is pre-heated in the space between the furnace and false shell. Steam is also generated in this space from a "drip feed" of water supplied to it. Gas is drawn off at the top of the furnace and passes on to the cleaning process which will be discussed later.

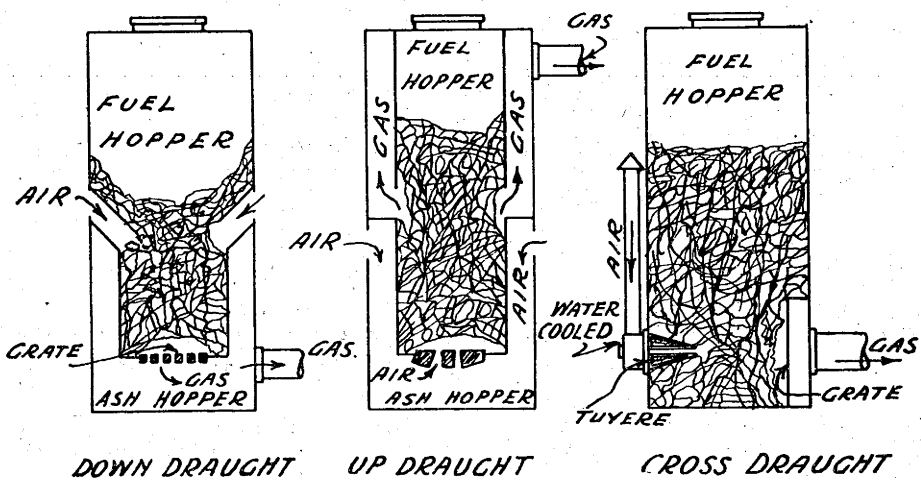
In the maintenance of up draught producers it is necessary to see that air is admitted through only the proper air inlet and that all doors, inspection holes, and filling holes are securely closed and sealed. The grate must be kept free of clinker as this seriously hampers the operation of the producer. Makers usually provide the necessary tools for this work, and it should be attended to at regular intervals depending on the quality of the fuel used.

In the cross draught producers the air is let into the furnace through special openings in the side of the casing. In most cases only one air inlet or tuyere is provided, and in all cases special arrangements have to be made to cool the tuyere. Some makers provide water cooling, either in conjunction with the engine-cooling system or by means of a separate water tank connected to the tuyere and operating on a thermosyphon system. Some tuyeres are cooled by the air supply to the producer, which passes round a tortuous path through the tuyere

on its way into the furnace. Either steam or water is admitted with the air as it enters the furnace, and means of controlling the rate of water supply are provided.

Gas is drawn off to the cleaning system through a grate or grill on the side of the furnace opposite the tuyere, and a second grate or similar device is usually provided below the path of the gas in the furnace for the ash and clinker. As in the case of up draft producers, it is essential to see that air enters the producer only at the correct point or points and that all other openings are sealed. Clinker removal is necessary as in up draught furnaces.

THREE TYPES OF FURNACES SHOWN DIAGRAMMATICALLY.



Cleaning System.

When the gas leaves the furnace it carries with it particles of dust, soot, ashes, fine charcoal, etc., and it is essential that these impurities should not be allowed to reach the engine. The gas must, therefore, pass through a series of scrubbers or cleaners.

Many types of scrubber have been used by different makers, and only the most successful will be described here.

With stationary plants the practice is to use a large cylinder filled with coke or similar material as a scrubber. The gas passes from the producer upwards through the coke with which it mingles intimately and a shower of water is passed downwards through the scrubber. The coke and running water combine to clean and cool the gas very effectively.

For vehicular work the weight of the equipment is of great importance and so the coke and water scrubber has had to be discarded and replaced by dry scrubbers and dust traps. With a number of designs the gas passes straight into the dust trap and there baffles are placed to cause the heavier particles to be deposited. In another type of trap the gas passes through baffles in which the openings are shaped to impart a swirling motion to the gas, and the heavier

particles are separated by centrifugal action to the outer portion of the scrubber. They then fall to the bottom of the vessel where they collect and can be removed at regular intervals.

Filters are also considerably used as gas cleaners. Pads for these filters have been made of many materials such as wood wool, metal wool, sisal, hair felt, etc., and they are usually packed into trays or cages to facilitate cleaning. In some cases the pads are soaked in oil or water, and in others they are dry. The filters must be regularly cleaned and the pads washed so that their effectiveness is not impaired. In many cases the pad material has to be teased from time to time to prevent its becoming so tightly packed as to impede the passage of the gas.

Various oil scrubbers are also used as a final stage, in the cleaning process. In some the gas actually passes through the oil, the inlet being submerged in the liquid. Another type depends on the splashing of the oil on to plates over which the gas passes. The success of such scrubbers depends on the regular changing of the oil and on maintaining the oil at the correct level.

Coolers.

It is of the greatest importance that the gas should be cooled to as low a temperature as possible before entering the engine. Adequate cooling ensures that the gas delivered to the engine is at its maximum density, giving the greatest charge (by weight) for the cylinders. Some makers have provided special coolers for this purpose in the form of radiators or nests of pipes through which the gas passes and so placed that they are cooled by the air as the vehicle moves. A separate cooler is not always necessary if the scrubbers afford ample cooling, but it can usually be classed as highly desirable. Coolers should not require any attention apart from occasional inspection to see that no soot is accumulating.

Fan or Blowers.

With some producer equipments it is usual to supply a fan or blower to be operated by hand in order to heat the furnace before starting. The fans are very similar to those used on the blacksmiths' forges and need no description. Other makers depend on the engine to supply the draught for starting the fire and start the engine on petrol. This method of starting will be dealt with later, but it should be noted here that on every producer which is not equipped with a fan provision should be made for the temporary connection of one for testing purposes. This can be done by fitting a tee-piece in the gas line just before the line reaches the mixing valve (see below). The branch of the tee should be extended to a convenient position and there closed with a blank flange. Such an arrangement would allow a fan to be connected, and in the event of starting difficulties, would enable the gas to be tested and the resistance in the gas line ascertained.

Mixing Valves.

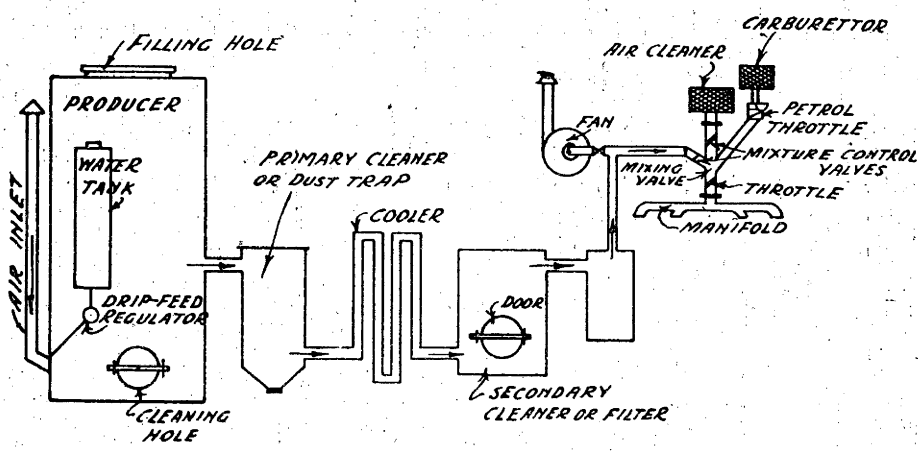
On a producer gas engine the mixing valve takes the place of the carburettor on the petrol engine. In essence, it consists of a "Y" piece with a butterfly valve in each branch and a throttle valve in the stem. The gas line coming from the cleaning system is connected to one branch, and the other branch is coupled to the air cleaner or left open to the air. By varying the position of the two butterfly

valves the ratio of gas to air can be adjusted to the best position at any time, according to the performance of the engine. It is, therefore, usual to couple the two valves together with levers and bring a control into the driver's cabin on a vehicle.

The throttle valve is of the usual type and is connected by levers to the driver's cabin in just the same way as the accelerator is connected to the throttle of the carburettor in the ordinary vehicle.

Where a converted vehicle is to be started on petrol it is also necessary to retain the entire petrol system. This means that an inlet system consisting of the induction pipe, carburettor and mixing valve have to be re-arranged so that either gas or petrol can be admitted as necessary, and although the location of the parts may vary considerably it is the equivalent of adding a third branch to the Y-piece and connecting the carburettor to this branch.

DIAGRAM OF A TYPICAL PRODUCER GAS EQUIPMENT SHOWING SEQUENCE OF OPERATIONS.



Starting up with Blower.

In a producer plant fitted with a blower the starting-up process consists of igniting the fuel bed with a kerosene wick or similar arrangement, and then operating the blower until the producer has reached a temperature high enough to make gas. Care must be taken to see that all the valves at the mixing box are closed, so that the blower does not merely draw air back from the engine. When the gas is ready the mixing valves are set to correct positions and the engine started in exactly the same way as a petrol vehicle.

Starting on Petrol.

On vehicles without a blower the engine is started on petrol, with all mixing valves closed and the producer ignited. With the engine running at a fair speed the gas valve is opened a little to set up a draught in the furnace. The temperature of the furnace rises; gradually gas is produced and the controls are manipulated so that the engine gets more and more gas and less petrol until the

petrol throttle can be closed right off and the vehicle driven on gas. The process of changing from petrol to gas requires a little practice, but after a time it should be found possible to make the change with the vehicle in motion.

Once the vehicle is settled down on gas the petrol is turned off and gas is used entirely. It should be noted that the tap for turning off the petrol should be placed in a convenient position between the petrol pump and the carburettor, and that it is advisable to have the petrol pump overhauled at the time of conversion of the vehicle.

Most users prefer to get their vehicle running on gas before they start the water feed to the producer, and this may be considered good practice, as it facilitates raising the furnace temperature.

Operation.

Once the plant is changed over to producer gas, the driving of the vehicle is in every way similar to that of a petrol vehicle. Plants have been built to give a range up to 200 miles on one filling of fuel, depending on the fuel, but an average figure of 100 miles between fuel recharging is more usual. The plant in most cases has to be stopped for refuelling, and in opening up the hot furnace some care is needed, as the hopper is likely to be filled with gas, which promptly burns. The resulting flames are too short-lived to be dangerous, but can be very unpleasant.

Maintenance.

The routine maintenance of the ordinary petrol vehicle has been reduced to an absolute minimum in recent years. A little more trouble has to be taken in attending to a producer gas vehicle, but this is only to be expected, and the success of any vehicle depends to a large extent on the care exercised by the user. The important points are set out below:—

1. The furnace must be regularly cleaned out to remove all clinker or ash.
2. The scrubbers must be emptied and inspected regularly.
3. Filter pads must be washed as required.
4. Oil scrubbers must be recharged.
5. All joints in the gas line must be kept absolutely air tight, so that air enters the system only at two points, i.e., at the air inlet to the furnace and at the mixing valve. The importance of this point cannot be over-stressed, and supplies of spare jointing material should always be on hand.
6. Supplies of clean water for cooling the tuyere and feeding to the producer must be maintained.
7. The usual maintenance required for a petrol vehicle should be given to a producer gas vehicle.

The time involved in the additional work required to maintain a producer gas vehicle will vary with the fuel quality and the capacity of the scrubbers. A reasonable estimate for a vehicle working a full day would be about ten minutes each day and an extra thirty minutes once a week. These figures should not be exceeded with plants at present available.

Choice of Fuel.

Producer gas users are advised to be careful in the selection of the fuel for their units. The idea that "anything will do" is a misguided one and often leads to trouble. Experiments indicate that any sound timber can be successfully converted into charcoal, but hardwoods are probably the best. The important points are as follows:—.

1. The charcoal should be free from any unburnt portions of wood or bark.
2. The charcoal should be evenly graded with a minimum of fines. (Suggested size, $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. mesh.)
3. A charcoal with good mechanical strength and giving a metallic ring is preferable.
4. The greatest care should be taken to avoid sand or earthy impurities in the fuel, as these impurities form clinker in the furnaces. Clinker presents by far the greatest problem to be overcome in the furnace, and it can be largely avoided by using only fuel free from the above impurities.

Suitability of Vehicles.

Any petrol engine can be converted to run on producer gas. Whether the conversion will be satisfactory or not depends to a large extent on the power reserve of the engine in regard to the work performed on petrol. A definite loss of power is unavoidable, and with engines of low compression ratio, this may be as high as 40 per cent. The loss may be reduced to about 20 per cent. by increasing the compression ratio to 7 to 1, or the power loss can in some cases be completely overcome by boring out the cylinders and fitting larger pistons.

For vehicle work the power loss is often not of vital importance, as modern vehicles have fairly high compression ratios and ample power reserves. The only effects of the conversion are: A reduction in speed on hills, in acceleration, and possibly in absolute maximum speed. It follows that many vehicles could be converted to producer gas without seriously reducing their utility. On account of the necessity of maintaining a high furnace temperature, it may generally be stated that the larger the vehicle and the more uniform the load on the engine the better the results will be, as under these circumstances a more effective current of air passes through the producer.

Ignition System.

The ignition system of petrol vehicles is quite suitable for producer gas, except that arrangements must be made to increase the angle of advance of the spark when running on producer gas. Angles of advance up to 45 deg. before top dead centre have been found satisfactory, but the correct position varies with each engine and must be found by adjustment in each case.

Precautions.

All users of producer gas should remember that the gas contains carbon monoxide, which is highly poisonous and difficult to detect. There is no fear of the gas harming anyone during the normal running of a producer gas vehicle, as there is never a positive pressure in the gas line. Nevertheless, care should be exercised whenever the system is opened up for cleaning of scrubbers, &c., to avoid breathing the gas.

When an equipment is provided with a blower, the greatest care should be exercised to see that the blower is not operated in a closed room or shed, and that wherever it is operated the outlet or exhaust from the fan is not inhaled. The handle of the blower should always be removed so that the uninitiated cannot do any harm either to themselves or others.

COCO-NUT OIL AS LIQUID FUEL.

At the Vunapope Catholic Mission, situated at Kokopo in New Britain, coco-nut oil is being used as a liquid fuel. It is running a 30 h.p. H.M.G. two-stroke semi-diesel engine. The engine runs well and pulls a full load. Combustion appears to be complete, for there is no sign of smoke from the exhaust. The only trouble so far experienced was that after about fourteen hours' running, the fuel pump and injector valves began to stick and had to be taken down and cleaned.

Planters are invited to submit suggestions for the improvement of the GAZETTE.

Appreciation of the GAZETTE *can be shown by lending it to your friends.*

VEGETATIVE PROPAGATION IN TROPICAL PLANTATIONS.*

The Imperial Bureau of Horticulture and Plantation Crops, East Malling, has issued Technical Communication 13 on this subject by G. St. Clair Fielden and R. J. Garner. It deals with the vegetative propagation of some 55 plantation crops, and follows a previous communication (issued in 1936) dealing with the vegetative propagation of some 100 fruit varieties grown in the tropics and sub-tropics. The help of technical experts has been invoked for adequate treatment of such major crops as rubber, coffee, cacao, &c., while the foreign literature has been thoroughly combed for details of propagation of the less familiar, but nevertheless important, crops. One feature of the previous work, which commended it also to workers in temperate regions, is retained and considerably enlarged, namely, the section devoted to methods used in vegetative propagation. The descriptions are supported by simple, clear, line drawings of some seventeen types of graft and seven types of budding commonly used in vegetative propagation. Tropical workers will also be glad of the illustrated detail of the construction of loosely woven potting baskets which have been found so useful a substitute for pots in nursery work in the tropics. For those who wish to study originals, a list of references immediately follows the discussion on the propagation of each particular crop.

* *Nature*, No. 3690, 20th July, 1940.