PRODUCER GAS

Emergency Use for Automotive Purposes.

Issued by authority of the Hon. the Minister of Supply.

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FOREWORD.

In time of national emergency there is always danger of supplies of motor fuel from overseas being seriously interrupted. Such an interruption would gravely affect the commercial and industrial life of the country.

Foreseeing this danger, the Government, before the outbreak of present hostilities, set up a Committee to investigate the use of alternative fuels for motor-vehicles.

All substitutes for motor-spirit were carefully considered, and it was decided that for this Dominion the use of producer gas offered the most practicable solution of the problem.

Shortly after the commencement of the war I appointed a Technical Committee consisting of representatives of the Transport, Public Works, and Scientific and Industrial Research Departments, to investigate in detail the application of producer gas to motor-vehicles.

This brochure briefly reviews the use of producer gas for automotive purposes and describes a plant developed by the Technical Committee to meet emergency conditions.

I earnestly commend this publication to all concerned with the transport industry and hope that advantage will be taken of the information it contains to aid the Government in its efforts to conserve supplies of motor-spirit.

D G Sullivan

Minister of Supply.

The producer (1) consists of a cylindrical shell of mild steel, and is filled with fuel through the door (A) and cleaned through the door (B). Air is drawn in through the tuyere or nozzle (C), which is water-jacketed, and the gas generated is drawn off through pipe (D).

Cooler.

As the temperature of the gas when leaving the producer is very high some method of cooling must be employed. Cooling-pipes (2) are shown in the diagram, but whether or not these alone would provide sufficient cooling without the use of a separate cooler would depend largely upon the length of pipe that can conveniently be fitted to the particular vehicle.

Cleaner.

The gas after leaving the cooler contains a considerable quantity of fine dust, which must be removed, otherwise excessive engine wear and other troubles would result. In order to remove this dust cleaning-equipment (3) is provided, consisting in this case of two units—a cyclone (F) to remove most of the dust followed by a filter (G), which removes the remainder of the finer impurities.

The gas is mixed with air in a simple mixing device attached to the inlet manifold of the engine. To operate the plant the engine is started on petrol, and the suction developed in the inlet manifold is used to draw air through the producer equipment from the air-nozzle or tuyere (C). A small torch is applied at (C), and the flame which is drawn in ignites the fuel in the producer. Gas is quickly generated, and the engine, which has meanwhile been running on petrol, is then changed over to gas. The time involved in this operation varies with different types of producers, but should not be more than a few minutes at the most.

Fuels for Producer-gas Plants.

As raw fuels such as wood and coal usually contain considerable amounts of tarry matter and, in the case of wood, a good deal of moisture in addition, their use is not possible except with specially designed plants. It is important that tar should not be allowed to enter the engine, as this would give rise to serious troubles. For this reason, therefore, the only fuels in general use for automotive producer plants are those which have been treated to remove volatile and tarry matter.

Charcoal, carbonized brown coal (char), and some special types of coke are suitable fuels. It may be mentioned, however, that fuels such as "char" or coke derived from coal may contain considerable quantities of fusible ash, which forms clinker in the producer. This limits the distance that can be run before clinker removal becomes necessary. Charcoal does not suffer from this disadvantage, but is bulkier, and more frequent filling of the producer is required. The use of charcoal, however, gives rise to more dust and increases the difficulty of cleaning the gas. It should be noted that the weight consumed per mile is approximately the same for each fuel. In order to give some idea of the rate of consumption of these fuels in comparison with petrol it may be stated that, roughly, 15 lb. of solid fuel is equivalent to 1 gallon of petrol.

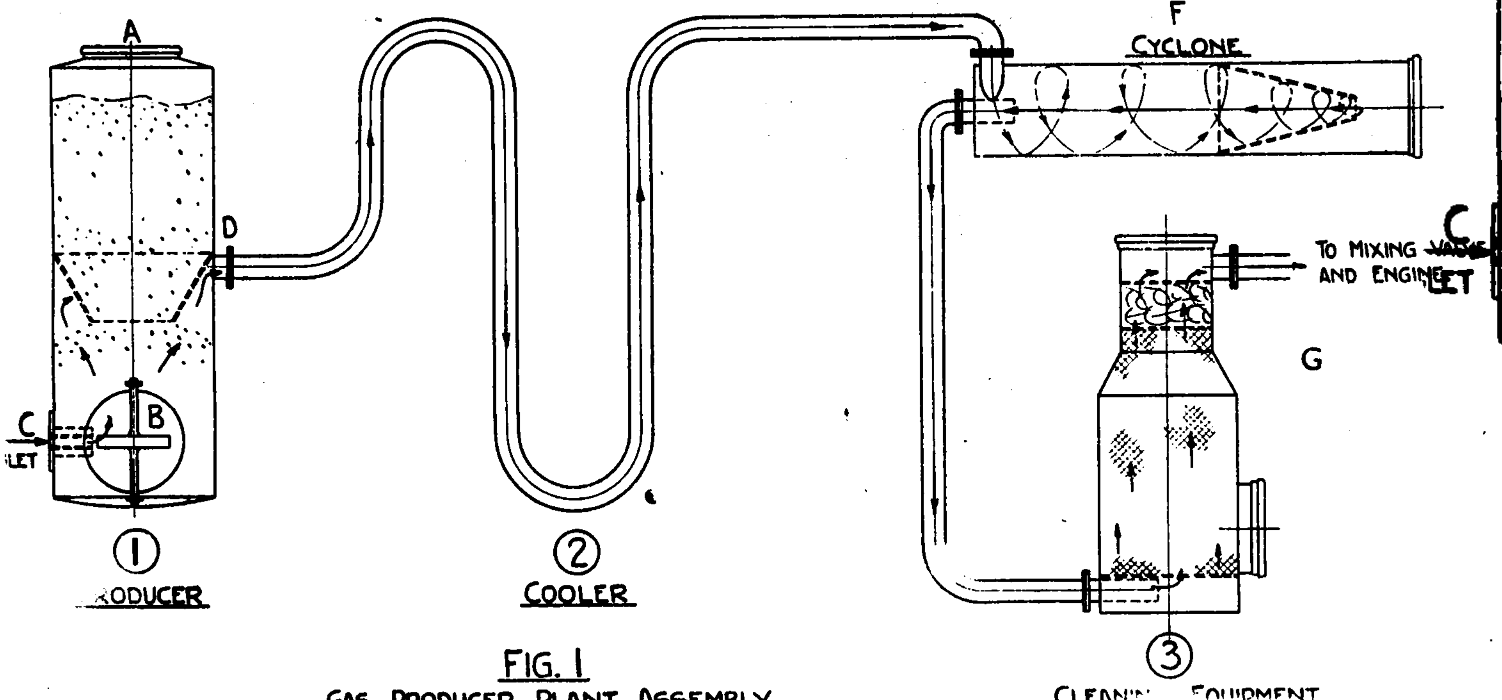


FIG. 1
GAS PRODUCER PLANT ASSEMBLY
(DIAGRAMMATIC ONLY)

General Remarks.

All standard makes of motor-engines have been specially designed to operate on motor-spirit, and for this reason it is to be expected that the same performance would not be obtained when producer gas is used for fuel. The amount of heat which can be liberated by the explosion in the cylinder of a mixture of air and producer gas is considerably less than that produced by the explosion of a mixture of air and petrol vapour.

Indeed, it has been found that a petrol-engine running on producer gas can develop only between 50 per cent. and 60 per cent. of the power which would be obtained by the use of petrol.

It is well known that the efficiency of a motor-engine can be increased by raising the compression, and with producer gas a much higher compression ratio may be used without running the risk of "pinking." If, therefore, the compression ratio of a petrol-engine were to be raised the loss in power normally experienced with producer gas could be reduced. Although the compression ratio of a petrol-engine could be raised to some extent by fitting special cylinder heads or "high top" pistons it is doubtful if the relatively small benefit which could be obtained by these expedients would be worth the cost involved. In addition, there might be certain practical difficulties, and trouble would probably be experienced when attempting to run the engine on petrol. In this connection it may be mentioned that when converting an engine to producer gas it is desirable to retain the petrol carburettor system so that motor-spirit may still be used on occasions such as when starting up, or simultaneously with producer gas to enhance the performance, if desired, when meeting a heavy demand.

Another way in which the power of the engine can be increased is by advancing the ignition timing. With producer gas the ignition timing may be advanced to a greater extent than with petrol, and advantage should be taken of this when running on producer gas, although care should be taken not to overadvance the ignition, as a loss in power will result.

The loss in power experienced with producer gas does not effect the running of a vehicle as seriously as might be anticipated.

To illustrate this point the experience of the Technical Committee while operating the plant, which is fully described in Part II of the brochure, may briefly be outlined.

This plant was fitted to a used Ford 50 cwt. truck, unladen weight 2¾ tons, loaded with steel rails to give a gross laden weight of 5¼ tons.

The table given below summarizes the performances obtained with producer gas and motor-spirit with the vehicle laden and unladen :—

—	Unladen.		Laden.	
	Gas.	Petrol.	Gas.	Petrol.
Time to reach 30 m.p.h. through gears from rest	40 sec.	9·6 sec.	50 sec.	16·5 sec.
Maximum speed on level ..	45 m.p.h.	55 m.p.h.	40 m.p.h.	52 m.p.h.
Average speed for one mile ascending grade 1 in 12·7	12 m.p.h. (3rd and 2nd gears)	27·5 m.p.h. (top gear)	7 m.p.h. (2nd gear)	14·1 m.p.h. (2nd gear)

It will be seen that the use of producer gas does not seriously affect the performance of the vehicle on the level road. With the truck, both laden and unladen, the maximum speed obtained with producer gas is only about 10 miles per hour less than that obtained by the use of motor-spirit. In view of the fact that a speed of 40 miles per hour can be reached on producer gas no inconvenience results since the maximum speed permitted for this class of vehicle is 25 miles per hour.

It is while accelerating or climbing hills, however, that the loss of power becomes noticeable. The figures show that it takes three to four times as long to reach a speed of 30 miles per hour from rest on producer gas as it does with petrol.

During the tests it was found that the average speed over a distance of one mile when ascending a uniform grade of 1 in 12·7 was approximately half that obtained when petrol was used. This relationship existed both with the vehicle laden and unladen. Although it takes longer to negotiate hills with the use of producer gas it should be possible to climb steep hills without trouble. For instance, no difficulty was experienced in climbing a hill of 1 in 5·2 when the vehicle was fully laden.

For satisfactory operation on producer gas, regular servicing of the plant is essential. This entails periodical cleaning of the producer to remove ash or clinker, removal of dust from dust-separators, and attention to the gas-cleaning equipment in order to ensure that dust or other impurities do not reach the engine as increased engine wear may take place or a costly overhaul become necessary. This attention would probably occupy about thirty minutes daily.

The weights of producer-gas plants vary from 2 cwt. to 8 cwt. approximately. The extent to which this factor influences the carrying-capacity of the vehicle will depend upon its type and size.

A convenient method of installing producer equipment is shown in Fig. 2. This arrangement should be applicable to most types of trucks and has the advantage of distributing the additional weight fairly evenly between the two axles. Spa¢e may be provided for the producer and filter either by cutting the platform or moving it back along the chassis. When the equipment cannot be fitted in this way it should be possible to place it at the rear of the vehicle, or perhaps in front, or on a small trailer. If a water-cooled tuyere is fitted and it is not possible to place the producer in such a way as to use the engine-cooling water, then a separate water-tank must be provided.

Disadvantages and Advantages of Producer Gas.

The chief disadvantages of producer gas as compared with petrol may therefore be summarized as follows :—

(1) Loss of approximately half the power :
(2) Cost of plant :
(3) Bulk and weight of equipment :
(4) Time occupied in filling and cleaning.

The principal merit of producer gas lies in the fact that it can utilize fuels of local origin and that it may be readily applied to standard types of petrol vehicles in time of emergency.

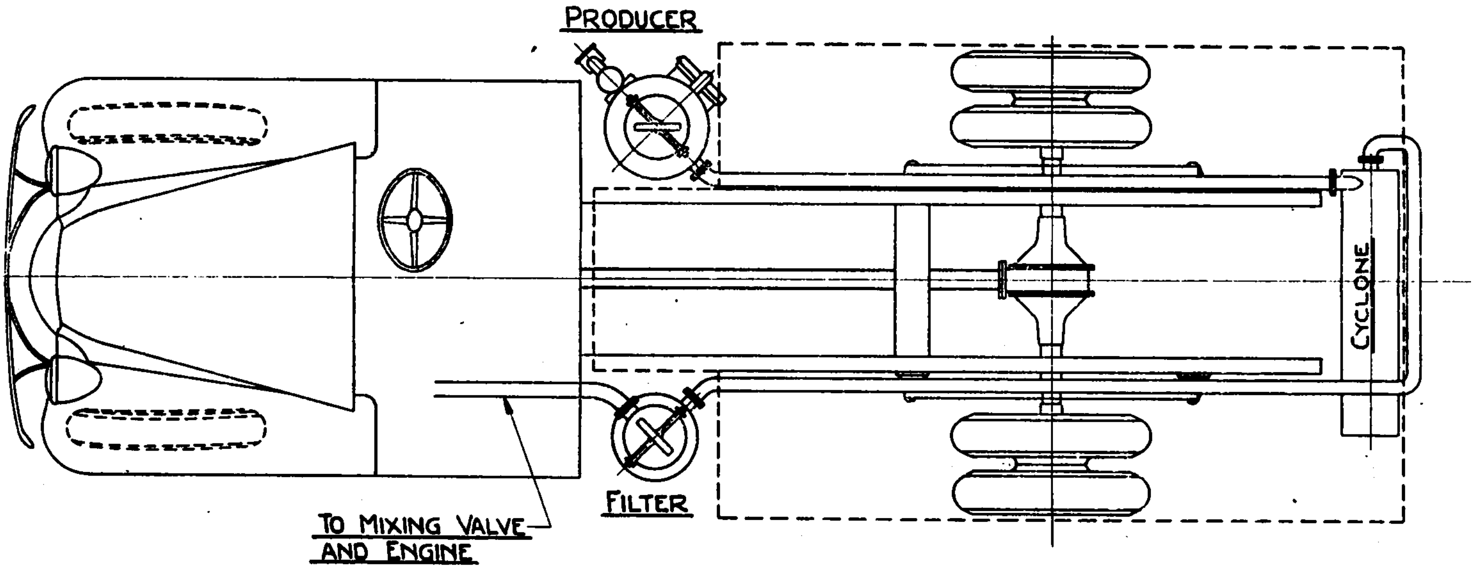


FIG. 2

TYPICAL INSTALLATION OF GAS PRODUCER ON MOTOR VEHICLE
(DIAGRAMMATIC ONLY)

PART II.—THE EMERGENCY PRODUCER.

Before designing an emergency producer plant the Committee obtained all possible information from overseas sources.

It was found that there was a number of different types of plants and a considerable number of varieties of each type. Some of these plants were of elaborate and costly design, while others were relatively simple. It had to be decided, therefore, to what extent the more complicated designs were warranted, having due regard to performance and practical utility.

It was considered that a plant for emergency purposes should possess the following characteristics :—

(1) Capable of being manufactured from materials readily available :
(2) Lowest possible cost compatible with efficiency and workmanship :
(3) Ease of manufacture resulting from simplicity of design and standardization of component parts :
(4) Rapid starting from cold, simplicity of control, flexibility in road operation :
(5) Ability to generate gas of good quality, free from harmful impurities, from fuels commercially available in this country.

It is also desirable that such a plant should be applicable to a wide range of the heavier commercial vehicles, tractors, or stationary engines.

In designing a plant for emergency purposes the Committee has taken into account all the above requirements. It will be appreciated, however, that no one plant could possess every desirable feature. and an element of compromise must always be involved. It is not suggested that more elaborate and costly plants designed specially for one particular purpose would not give equal or perhaps even better results than the one designed for broad application, but after careful consideration the Committee felt that the advantages of having a number of plants for different types of services were outweighed by those resulting from the application of one standardized plant.

The development of the emergency plant involved both bench tests and road tests. For the former a Ford V8 engine coupled to a Heenan and Froude dynamometer was used. The engine was standard in every respect except that provision was made to vary the ignition timing in order to investigate the effects of various spark settings. The use of the dynamometer enabled the engine to be run at a definite power output and also made it possible to determine accurately the horse-power developed under different conditions. Measurements were made of the gas temperature at various points and of the pressure drop across the producer, and the cooling and the cleaning equipment. During test runs frequent instrument readings were taken and samples of producer gas and exhaust gas were analysed on a modified Orsat gas analysis apparatus specially designed for the purpose.

Reliability and fuel consumption tests of up to eight hours' duration were carried out. During these tests the engine was operated practically continuously at full throttle and the load adjusted to give an engine speed of 1,800 revolutions per minute, which is equivalent to a road speed for a truck of about 28 miles per hour. At regular periods throughout the test, horse-power determinations were made and the results compared with those obtained with petrol. Road tests were conducted with a 50 cwt. Ford truck loaded to capacity with steel rails. Reference has already been made to the results of some comparative tests with petrol and producer gas carried out with this vehicle. Before the design of the emergency producer was finalized many test runs were made with various producer fuels. As an indication of the performance obtained with the final design of plant the results of a day's test run may be given.

The above vehicle (lightly laden) was driven from Wellington to Palmerston North via Shannon and back to Wellington by way of the Wairarapa–Rimutaka route. The whole test, inclusive of starting up and refuelling, was carried out by the driver alone. Starting up from cold occupied less than one minute. Five stops were made during the journey for refuelling, which occupied a total time of nineteen minutes, or approximately four minutes for each stop. No further attention was required, and it may be mentioned that no special provision was made to facilitate refuelling. The fuel was carried in large sacks under a tarpaulin, which had to be unroped and refastened each time refuelling was necessary. The fuel used was charcoal prepared from unbarked rimu mill slabs. If hardwood charcoal had been used less frequent refuelling would have been necessary.

For the journey of 216 miles the running time was 6 hours 42 minutes. The petrol cock was kept closed during the whole journey, and no petrol was used except that required for starting up before leaving Wellington. The amount needed for this would be somewhat less than 1 pint. No difficulty was found in restarting on gas only, after the stops made, which included one of half an hour for lunch.

Gas Generator.

The gas generator is shown in section in Fig. 3. It consists of a cylindrical shell (A) 48 in. in height and 18 in. in diameter rolled from a standard 4 ft. sheet of 10-gauge (⅛ in. thick) mild steel. The top and bottom are of the same gauge material and slightly dished for strength. A door (B) 10 in. in diameter is fitted on top for charging the producer, and a similar door (C) is provided on the side near the bottom for cleaning purposes.

It will be noted that the design is such that no refractory lining is necessary and that the fuel is made to serve as a protection for the generator shell against undue heating. Air is introduced through a nozzle or tuyere (D). In some designs of producer the air is drawn through a grate instead of a tuyere, and opinion appears to be divided regarding the merits of these two systems. It is common practice to use a grate in producers used for stationary engines or where the power requirements are not subject to wide fluctuations. Although certain modified forms of grates have given reasonable satisfaction in automotive producers, the Committee considered that the tuyere type was preferable for the purpose in view, even though it possesses the disadvantage of having to be water-cooled.

The tuyere is constructed of mild steel, and no special heat-resisting alloys are required. From the diagram it will be seen that it consists of two concentric pipes with a water-space between provided with water inlet and outlet connections. These may be coupled to the engine cooling system or to a special water-tank according to circumstances.

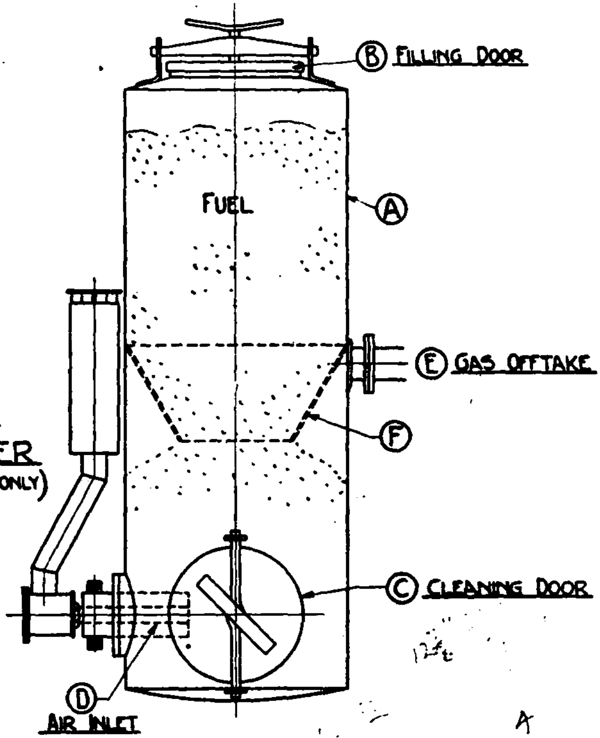


FIG. 3
PRODUCER
(DIAGRAMMATIC ONLY)

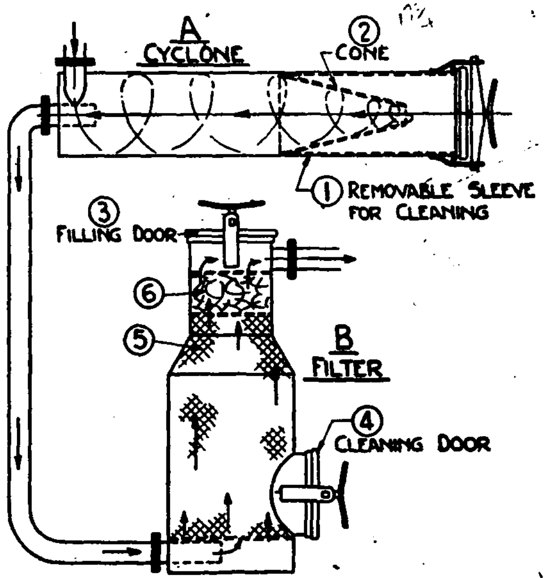


FIG. 4
CLEANING EQUIPMENT
(DIAGRAMMATIC ONLY)

From the point of view of operation the advantages of the tuyere type of air inlet may be summarized as follows :—

(*a*) Rapid starting from cold :

(*b*) As the velocity of the air entering the producer is relatively high even at low engine speeds no difficulty is experienced in idling indefinitely :

(*c*) The high air velocity also permits the rapid formation of gas to meet heavy demands, such as when accelerating or after coasting down hills :

(*d*) The plant may be restarted on producer gas after fairly lengthy periods of idleness without the necessity of using motor-spirit.

The gas is withdrawn from the producer through the pipe " E " (Fig. 3), which enters the generator shell below the conical gas collecting ring (F). This ring is placed in a position above the fire zone and is not therefore affected by heat. This arrangement enables the gas to be withdrawn at low velocity, thus minimizing the entrainment of dust and ensuring a low outlet resistance, which cannot always be obtained when vertical outlet gratings are used. Another advantage is that the gas leaves the producer at a lower temperature than with some other types.

Both charging and cleaning doors are 10 in. in diameter. This size has been adopted for all five doors required for the complete equipment. Door fastenings have also been standardized in the same manner. This results in simplicity and reduces costs of manufacture.

Considerable thought has been given to the design of door, since it is necessary that all joints should be airtight and remain so while the plant is in service. This is especially important in the case of the generator, since air leaks would permit the fuel to burn towards the leak, resulting in dangerous local overheating.

Cooler.

In Fig. 1 the cooler is shown as a length of pipe, as in many cases the pipe used to connect the various pieces of equipment provides sufficient cooling surface. For certain cases, however, where it is not practicable to obtain the necessary cooling in this way, a special cooler (Fig. 6) has been designed suitable for mounting in front of the radiator. Where producer equipment is mounted on trailers or fitted to tractors this cooler is recommended.

Gas-cleaning Equipment.

During the operation of the producer a certain amount of dust derived from the fuel is carried over with the gas. It is important that this dust should be removed before the gas reaches the engine, otherwise excessive engine wear would take place.

Satisfactory equipment for this purpose should possess the following characteristics :—

(1) Ability to remove impurities from the gas :
(2) Low resistance to flow of gas :
(3) Ability to function for reasonably long periods without blocking :
(4) Ability to deal with moist gases :
(5) Low initial and maintenance cost :
(6) Reasonably small weight and bulk.

The difficulty in designing a reasonably small and efficient cleaner lies in the comparatively large volume of gas which has to be handled. For instance, a 30 h.p. truck engine required up to 80 cubic feet of gas per minu which is equivalent to a flow of gas through a 2 in. pipe of over 60 ft.] second.

A portion of the dust which must be removed from this rapid stream c gas is of a very fine nature. This necessitates the use of some filter mediur capable of retaining this fine dust without becoming blocked. Bag filter have been extensively used on the Continent, but these suffer from th disadvantage that they rapidly become blocked through the action o moisture unless the fuel used is perfectly dry. This condition is, howeve difficult to ensure in practice. Some filters have been devised whicl effectively clean the gas, but which offer a high resistance to the flov of gas. It will be appreciated that if the supply of gaseous fuel to th engine is impeded a considerable loss of power will result.

In an effort to overcome these difficulties some rather costly anc complicated types of cleaning equipment have been designed, but from th work of the Committee it would appear that in gen ral such cleaners do no possess any distinct advantage over those of simpler design.

The Committee has devoted much time to this most important problen of dust elimination, and all the various types of gas-cleaning equipmen which have been developed in different parts of the world have been carefull considered.

The gas-cleaning equipment designed by the Committee is shown i Fig. 4. It consists of two portions—a cyclone separator (A) for removin all but the finest dust, which is retained by the filter (B).

If all the dust had to be removed by a single-unit filter system designe to deal satisfactorily with the finest dust it would become choked soone than if most of the coarser dust had been previously removed.

The cyclone consists of a cylinder 4 ft. long and 10 in. in diameter o 16-gauge mild steel sheet. The gas enters tangentially near one end anc leaves by a central pipe at the same end. The other end is fitted with a standard door, which gives access for cleaning. This operation is greatl facilitated by having a removable sleeve (1) into which the conical portio (2) of the cyclone is welded. The dust separated from the gas collects i the sleeve, which can be withdrawn through the door.

Upon investigating the factors which influence the design of cyclon dust separators, the Committee decided on the dimensions shown in th diagram.

These were chosen with regard to:—

(*a*) Efficiency of dust separation under varying gas velocities and particl size of dust:
(*b*) Reasonably low resistance to gas-flow
(*c*) Ease of mounting on vehicle. This cyclone will operate efficientl either vertically or horizontally. It will therefore often be foun that it is convenient to mount this unit horizontally below tl platform at the rear of the vehicle, where it is out of the way ar can be easily serviced:
(*d*) Provision for cooling the gas.

The filter consists of a 16-gauge sheet-steel container of the form a dimensions shown in Fig. 4B. Standard doors (3) and (4) are fitted at t and bottom for filling and cleaning purposes respectively.

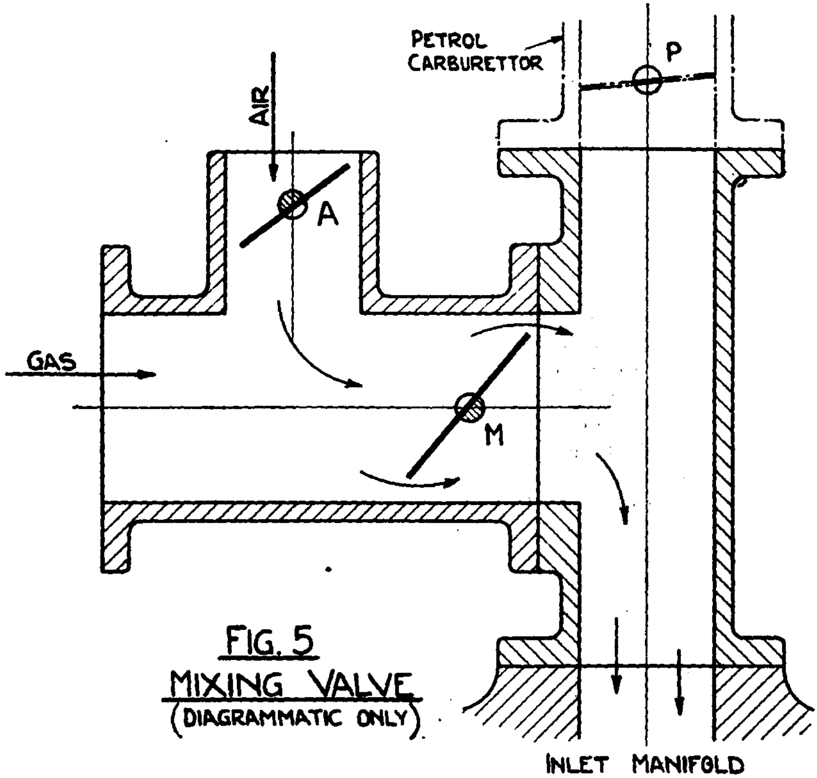


FIG. 5
MIXING VALVE
(DIAGRAMMATIC ONLY)

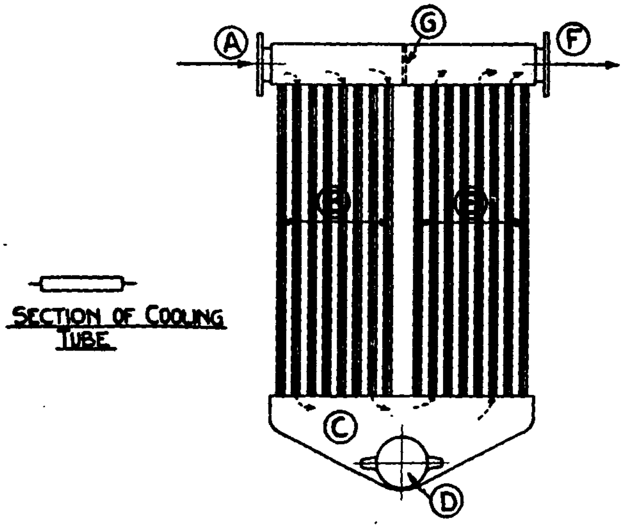


FIG. 6
SPECIAL COOLER

The gas enters the filter near the bottom and passes upwards through a grating, which supports a bed of oiled coke (5). Before the gas leaves the filter it passes through a pad of teased fibre (sisal, flax, or hemp) (6), which acts as a security filter and also indicates by its condition when the coke filter requires attention.

Mixing-valve and Controls.

Before the gas enters the engine manifold it is mixed with approximately its own volume of air. This takes place in a mixing-valve, which is usually interposed between the existing petrol carburettor and the intake manifold. With this arrangement it is a simple matter to bring the carburettor into operation at will, thus allowing the engine to run on either petrol or producer gas or both at the same time.

Owing to the large number of different makes of engines it is not possible to design one mixing-valve to suit every case, but the type illustrated in Fig. 5 should be adaptable to most engines. For the sake of simplicity it has been shown in diagrammatic form only.

The normal accelerator control is disconnected from the petrol throttle valve (P) and attached to the gas mixture throttle valve (M). Both (P) and the air-control valve (A) may be actuated by Bowden wire controls mounted on the dashboard.

When starting up, the valve (M) is closed and the engine started on petrol in the usual way by operating the valve (P). When it is decided to operate on producer gas the valve (M) is slightly opened with the valve (A) closed. Air is thus drawn through the producer, and when the lighting torch is applied to the tuyere the fuel is ignited. The lighting torch consists simply of a few turns of asbestos cord round a stout wire. Before lighting, the torch is dipped in a bottle of kerosene.

As soon as the fuel is alight the air-valve (A) can be opened and (P) closed. The engine is now running on gas, and its speed can be varied by operating valve (M). When the air-valve (A) is adjusted to give the best results it requires little or no further regulation for the varying conditions of road operation.

Special Cooler.

As stated earlier, the connecting pipes and general equipment provide sufficient cooling surface for the gas in most cases. Where the equipment is mounted on trailers or tractors or where the length of the connecting pipes is short a special cooler is desirable. The cooler shown in Fig. 6 has been designed to meet these special conditions. The gas enters at (A) and passes down through the tubes (B) in parallel. Some of the dust carried over by the gas is deposited in the chamber (C) and may be removed through the door (D). The gas then rises through the tubes (E) and leaves at (F). The cooler is divided into two passes or sections by the baffle (G).

Remarks on Construction of Emergency Producers.

Apart from having had in mind the efficiency of the operation of the emergency producer plant, the Committee has had two principal aims in view :—

(*a*) Standardization of components ;
(*b*) Simplicity of construction.

The plant is constructed of mild-steel sheet, and, in the main, two gauges only are used. The dimensions of the equipment were chosen so as to obviate waste of material as far as practicable. The doors on the various components are all of the same pattern and size. This applies also to door joints and fastenings. All pipe couplings and flanges are of standardized design, and provision has been made for the use of pipe rolled from sheet steel in case difficulty should be experienced in obtaining supplies of piping.

Although the equipment has been designed so that the advantages of mass production can be obtained, its construction would offer no difficulty in a small engineering shop. With this in view alternative designs of certain details have been worked out.

Fuels for use in Emergency Producer.

It is desirable that an emergency producer plant should be capable of being operated on a variety of fuels. Much of its value from an emergency aspect would be lost if it were dependent on one source of fuel supply only. The output of "char" and of special coke will always be limited by the capacity of the plants capable of their production, whereas the production of charcoal is not restricted in this way. For this reason, therefore, the emergency plant was designed so that it could be used with charcoal as well as specially prepared fuels from coal.

The special characteristics of these fuels have already been mentioned. The clinker which is formed with fuels derived from the coals available in this Dominion interferes with the operation of the plant and may cause local overheating of the producer shell if allowed to accumulate to too great an extent. This disadvantage does not, however, exist when charcoal is used and this fuel is therefore recommended for use with the emergency producer in preference to others available at the present time.

The advantages of having supplies of suitable fuel derived from the carbonization of coal are such as to encourage further investigation. Work in this direction is being actively pursued, and close contact is being maintained with similar investigational work now being carried out in Great Britain.

The above gives a general description of the emergency plant, but it is hoped that in the near future this brochure will be followed by a service manual giving full details regarding the care and operation of the equipment.

PART III.—TECHNICAL.

For those who may be interested in the more technical aspects of th application of producer gas the following brief technical discussion has bee included :—

Theory of Gas-production.

When the oxygen (O_2) of the air burns with the carbon (C) of the fuel, carbon dioxide (CO_2) is formed. This may be represented by the simple chemical equation—

$$C + O_2 = CO_2 \quad (1)$$

Under the high temperature conditions existing in the producer the carbon dioxide formed may react with more carbon to give carbon monoxide (CO) thus—

$$CO_2 + C = 2CO. \quad (2)$$

However, as air contains approximately 79 per cent. of nitrogen (N_2) the resulting carbon monoxide is diluted with this incombustible gas.

Producer gas should therefore have the following theoretical composition :—

CO	35	per cent. by volume.
N_2	65	,,
	100	

In practice, however, small percentages of both oxygen and carbon dioxide are found in the gas. Hydrogen (H_2) and small amounts of methane (CH_4) are also usually present. The hydrogen is derived from the moisture in the fuel and in the air supplied to the generator. The methane comes from certain chemical constituents of the fuel.

The composition of a typical producer gas is given below :—

CO	30·0	per cent. by volume.
H_2	5·0	,,
CH_4	1·0	,,
CO_2	1·5	,,
O_2	1·0	,,
N_2	61·5	,,
	100·0	

The calorific value of such a gas would be 121 British thermal units per cubic foot. Ordinary coal gas has a calorific value of 450–500 British thermal units per cubic foot.

When CO_2 is formed according to equation (1) heat is given out or the reaction is said to be *exothermic*. On the other hand, the formation of CO as indicated by equation (2) is accompanied by the absorption of heat, and the reaction is termed *endothermic*. The amount of heat given out by the first reaction is in excess of that absorbed by the second reaction, and it is this heat which has to be dissipated by the equipment.

Use of Water in Gas-generation.

With the intention of utilizing as much as possible of this waste heat some designs of producers make provision for the addition of water to the air blast either in the form of steam or as a liquid spray. The water (H_2O) reacts with the carbon of the fuel with the absorbtion of heat, and the net result of this reaction may be indicated in the chemical equation—

$$H_2O + C = CO + H_2 \qquad (3)$$

This effect can be utilized only to a limited extent, because if too much water is added the temperature of the fire zone is reduced to a point at which the production of carbon monoxide is adversely affected. In other words, the production of hydrogen may at times be obtained only at the expense of the production of CO.

After careful consideration the Committee is of the opinion that the extra equipment and complications involved in the use of water to obtain a gas of higher calorific value is not justified by the practical result obtained.

Loss of Power.

Reference has already been made to the fact that a loss of horse-power is experienced when the normal petrol engine is operated on producer gas. Figure 7 shows graphically the relationship between the power developed with petrol and that obtained when producer gas is used on the same engine.

These curves were obtained on a Ford V8 engine coupled to a Heenan and Froude dynamometer. The engine was a 1936 model, and although it had seen considerable service in a road vehicle it was in good mechanical condition. The condition of this engine would therefore be representative of that of the average truck engine which might be required to operate on producer gas.

It will be noted that at 1,000 revolutions per minute the horse-power developed on petrol is 27, compared with 14 on producer gas. In other words, only 50 per cent. of the power developed on petrol is obtained with producer gas. This relationship is maintained up to a speed of 2,500 revolutions per minute approximately, where the power developed on producer gas falls off while that available by the use of petrol continues to increase. At 3,000 revolutions per minute, therefore, it will be seen that the horse-power obtained with petrol is 63, as compared with 28 with producer gas—that is to say, only 45 per cent. of the power is obtained with producer gas. The data on which these curves were based apply only to the particular engine used which had not been modified in any way except by adjustment of ignition timing to improve its performance on producer gas. The extent of the loss in power experienced with producer gas depends upon the type and design of the particular engine. As a matter of interest the torque curves are also given in Fig. 7.

Ignition Setting.

When petrol is used, performance can be improved by advancing the ignition timing up to certain limits. In practice the extent to which this can be done is limited by " pinking." With producer gas, however, pinking cannot occur at the compression ratios employed in petrol-engines. If, when using producer gas, it is desired to improve performance by advancing the spark, care should be exercised to ensure that this is not overdone,

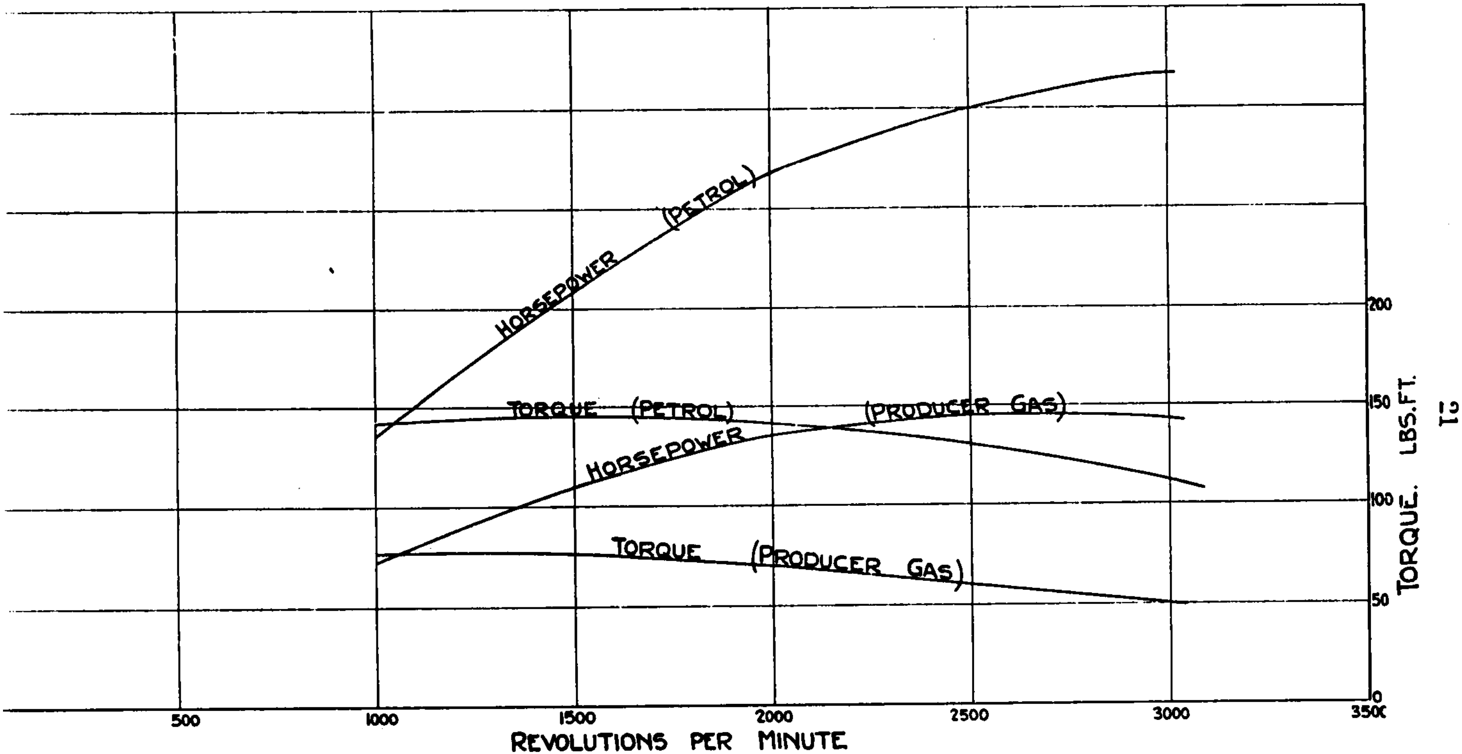


FIG. 7

COMPARISONS OF POWER DEVELOPED WITH PETROL AND PRODUCER GAS

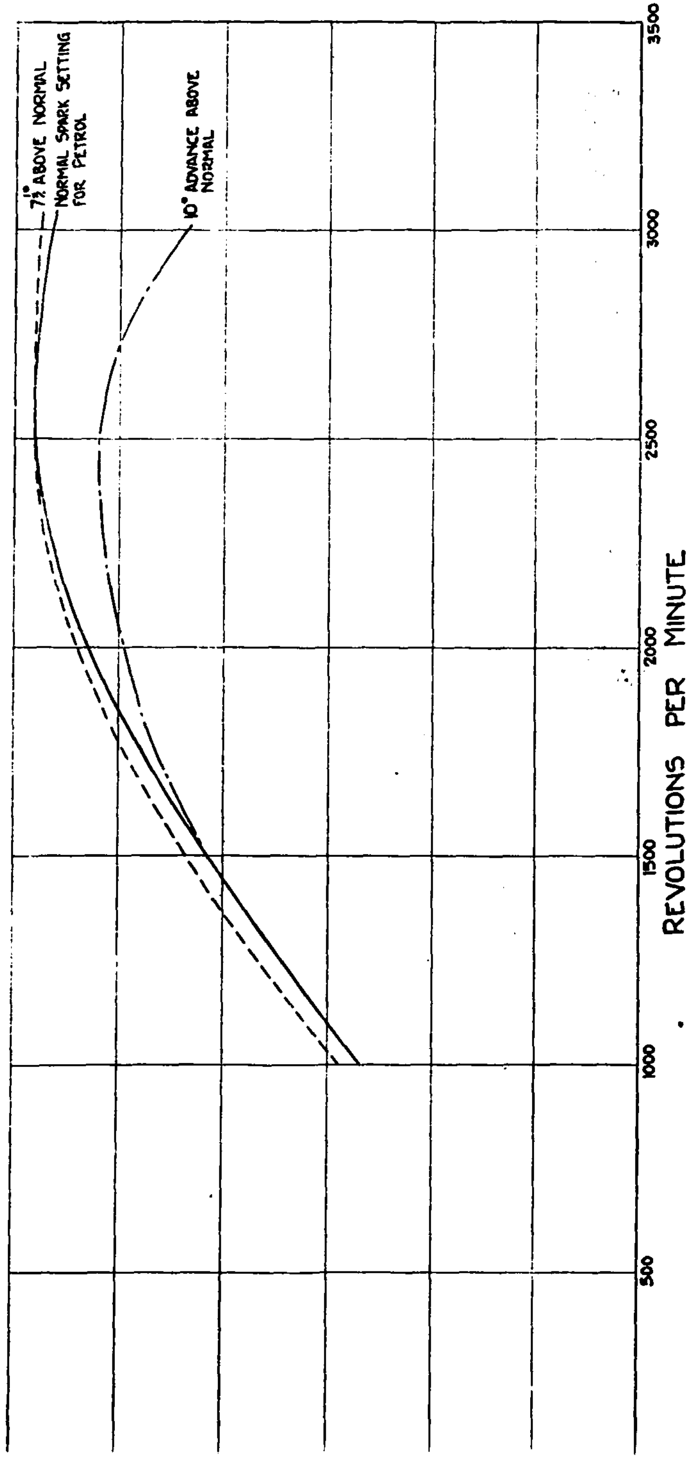


FIG. 8

GRAPH SHOWING POWER DEVELOPED AT VARIOUS SPARK SETTINGS (FORD V.8) otherwise a serious loss of power will be experienced. This is illustrated in Fig. 8, which shows the power developed at different spark settings. It will be seen that by advancing the spark from the normal spark setting for petrol to a maximum of 7½° in advance of the normal position an increase in power can be obtained. If, however, the spark is advanced further, a serious falling off in power results.

The curve for 10° advance above normal is shown to illustrate this point, and it will be observed that the greatest loss occurs at the higher speeds. These curves were obtained from one particular test engine, and definite figures cannot be given for all types of engines.

It is possible that the most satisfactory results with producer gas will be obtained with a spark setting of about 5° to 7½° in advance of the setting normally employed with petrol, but the setting for each individual engine will, of course, be the one which gives the best results in practice.

Effect of Compression Ratio.

The effect of increasing the compression ratio of an engine which is to be operated on producer gas has been discussed earlier. Figure 8 shows the increase in power which can be obtained by raising the compression ratio.

It is also possible to recover much of the power loss by supercharging or blowing.

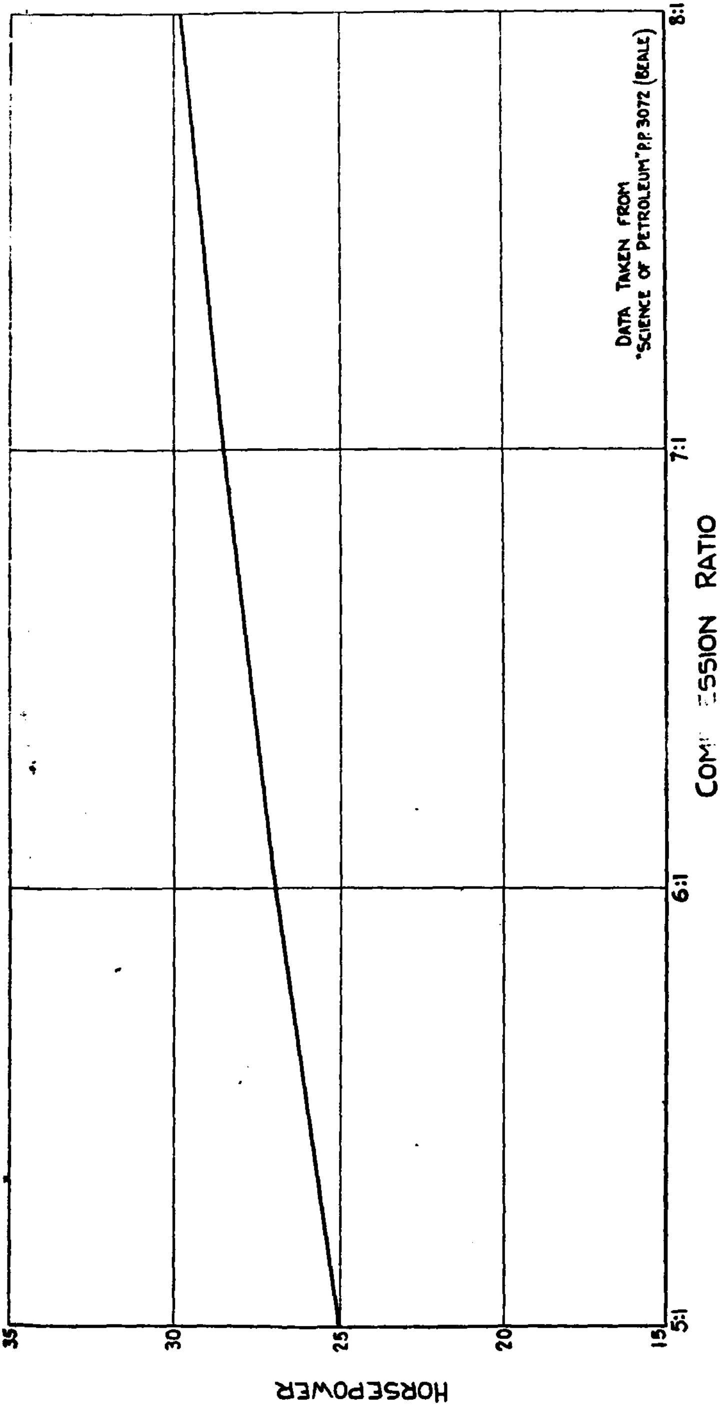
Both these expedients would involve considerable extra cost, especially the fitting of a supercharger, and for emergency purposes these measures are not recommended.

Effect of Temperature of Gas and of Resistance to Gas-flow.

The power developed by the engine depends upon the weight of gas drawn into the cylinders. The volume of gas contained in each charge is fixed by the dimensions of the cylinder and the length of the piston stroke. The weight of gas drawn in therefore depends upon its temperature and pressure. When heated, a gas expands, and therefore the weight of gas which enters the cylinders is reduced.

It will be seen, therefore, that it would be an advantage to cool the gas as much as possible before it reaches the engine, but it must be borne in mind that the gas is mixed with an approximately equal volume of cold air and that there is a tendency for the mixture to become heated as it passes through the induction system. In practice, there are limitations beyond which no advantage is obtained by further cooling the gas.

It is important that the resistance to the flow of gas through the pipe-lines and equipment should be kept low, as high resistance is, in effect, equivalent to throttling back the engine.



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GRAPH SHOWING POWER INCREASE . VARIOUS COMPRESSION RATIOS

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