explosion chamber of the engine, and converted into carbonic acid gas. The action of generator gas in the explosion chamber was the same as that of the ordinary city gas, the combustion of which, under normal conditions, as was well known, was complete, but if through some defect the combustion was not complete, and the exhaust was charged with carbonic oxide, it could not be detrimental to health, inasmuch as at a distance of only fifteen feet from the exhaust exit its percentage to the atmosphere would be reduced a thousand fold, and at 150 feet a millionfold, whereas 0.01 per cent. was proved to be non-poisonous.

Exhaust gas had been analysed, with the following result, for a 35 B.H.P., and a 200 B.H.P. Plant respectively:—

35 B.H.P.

Carbonic acid gas ..	9.5 per cent.
Nitrogen	9.5 per cent.
Carbonic oxide ..	0.0 per cent.

200 B.H.P.

Carbonic acid gas ..	15.6 per cent.
Nitrogen	3.5 per cent.
Carbonic oxide	0.0 per cent.

THE ECONOMICAL APPLICATION OF SUCTION PRODUCER GAS.

A great deal had been published about the low cost of power obtainable by the Suction Gas Producer, and the statements combatted by interested people in the steam engine building trade, that it might be interesting if a comparison were made, based on local conditions.

Suction Gas Producers, fed with Anthracite coal, had given the best results in the Old Country; but though it had been found in Queensland, it was away from ordinary means of communication, and for that reason, of no commercial value. It was necessary, therefore, to deal with gas or furnace coke of a calorific value of 297 per lb., such as we had at our disposal here, and the consumption of which was, approximately, 0.93lbs. per H.P. hour. The basis would be 300 working days, of eight hours each, for the year, with a coke price of 15/- per ton.

Taking a 100 H.P. Plant in constant work, we had 8 x 300 x 100— = to 240,000 H.P. hours per year; which, with a coke consumption of 0.93lbs., would amount to 99.2 tons. To this must be added 10 per cent. for losses during meal times, banking up, or withdrawing the fire at night. There was also a proportionate loss when the load varied, so that it was necessary to add 15 per cent., in order to stand on unassailable ground.

99.2 tons, plus 15 per cent., amounted to 114.5 tons, and multiplying this by 15/-, we had the sum of £85 17s 6d, as representing the cost of fuel for the year.

$$\frac{100 \times 8 \times 300 \times 1.15 \times 0.93}{2240} \times 15/- = £85/17/6$$

which represented 240,000 H.P. hours in the year, so that the cost of fuel was 0.085 of a penny per H.P. hour.

$$\frac{£85\ \ 17s.\ \ 6d.}{240{,}000\ \text{H.P. hours.}} = 0.086$$

But there were other charges, such as attendance, lubrication, sinking fund, etc., that would have to be taken into consideration. The price of a 100 H.P. Plant, complete, might be stated to be approximately £1,700; 10 per cent. on this for a sinking fund would be £170.

We had already seen that the producer worked automatically, that it required attention but once every hour for, say, fifteen minutes, in refilling the hopper, and cleaning the fire. Making ample allowance for starting in the morning, and drawing the fire in the evening, for emptying the ash-pan occasionally, it would be found that not more than from three to four hours of the attendant's time would be absorbed. But in order not to be charged with favouring the Suction Gas Producer, we would give our engineering attendant all sorts of other cleaning and adjusting work to do, so as to fill in his time of eight hours per day, and pay him £2/10/- per week, or equal to £130 per year.

The cost of lubrication is somewhat higher than with a steam-engine, in spite of very ingeniously devised automatic lubricators. A 100 H.P. original "Otto" engine required for 240,000 H.P. hours, approximately 111 gallons of oil. Experience had shown that 20 per cent. of its value would cover the oil wasted during the year, and also allow for cotton waste. The price of the best cylinder oil, of high flashing point, was 3/- per gallon. Thus 111 gallons, plus 20 per cent., = 133 gallons.

133 x 3/- = £20.

The entire cost of working a 100 H.P. Plant per year would total up as follows:—

	£	s.	d.
Cost of fuel	85	17	6
Attendance	130	0	0
Lubrication	20	0	0
Sinking Fund	170	0	0
Total	£405	17	6

Working under normal conditions of 240,000 H.P. hours in the year, the cost per H.P. hour would be 0.41 penny.

$$\frac{£405\ 17\ 6}{240{,}000}$$

The water supply for cooling and cleansing might also be briefly reviewed here. The whole plant, inclusive of engine, required about 40 litre of water per H.P. hour, whereof 5.5 gallons went to the engine, and 3.3. gallons to the Producer. But a return service was always provided for a plant of this size, so that the actual consumption was practically limited to the evaporation. Tests had proved that this amounted to about .33 gallons, so that the loss amounted to about 80,000 gallons for the year. 80,000 gallons, at 1/- per 1000, would amount to £4; so that the cost per H.P. hour would be raised by 0.004 penny.

$$\frac{£4 \quad 0 \quad 0}{240{,}000} = 0.004$$

STEAM PLANT. In order to get as good a comparison in the cost of running plants under the two different systems as possible, a compound steam engine, with superheater and condenser, of 100 H.P., is selected to work under the same conditions as the Suction Producer Plant. The heating value of the coal, 318 calories per lb. Such an engine would require 12.1lbs. of steam per indicated H.P. hour, and 1.8lbs. of coal to produce that quantity of steam. But as actual, and not with indicated H.P. is the basis of the calculation, this must be increased to 2.046lbs. of coal. For losses during starting, unfavourable loads, stopping for meal hours, etc., the allowance would be 15 per cent., as with the Suction Producer; but it must be borne in mind that varying loads were very detrimental to the superheater, and that the loss of heat during interruptions was very much greater than with ordinary steam engines; for this reason, an additional 2 per cent. must be added to the losses, thus making it 17 per cent., instead of 15 per cent., to arrive at the true working cost.

The price of coal was about 12/- to 14/- per ton, but on a 13/- basis, the cost of fuel would be £166/8/- for the year.

$$\frac{100 \times 8 \times 300 \times 1.17 \times 2.046}{2240} = 256 \text{ tons @ } 13/- \text{ £}166/8/$$

These figures showed the cost per H.P. hour to be 0.166 of a penny.

$$\frac{\text{£}166 \quad 8 \quad 0}{240{,}000} = 0.166\text{d.}$$

The cost of fuel per H.P. hour in a "Deutz" Suction Gas Producer being 0.085d., thus the latter scored in this item 0.81d. against ue steam engine.

Steam Plant	.. ..	0.166
Suction Plant	..	0.086
		0.80 = ·48 per cent.

The steam engine had been treated very leniently in these calculations, for it was well known that the heat that was lost through negligent attendants, to say nothing of the more or less heavy scale deposits in the boilers. The lubrication of a steam engine was about 15 per cent. less than that required for a gas engine—about 94 gallons for the year—to which 20 per cent. for loss and cotton waste, the same as allowed with the Suction Producer, would make a total of 113 gallons:—

$$94 \times 1.2 \times 3/- = \text{£}16/19/-.$$

A steam engine of this size required the services of a driver and a stoker. So as not to seem to unduly load the expenses, it is assumed that the stoker had sufficient time to spare to perform other duties, and for this reason only charge half his wages.

	£	s.	d.
Driver's wages, at £2/10/- per week	130	0	0
Stoker's wages (½), at £2/5/- ,, ,,	58	10	0
	£188	10	0

SINKING FUND. The price of a steam plant, with superheater as described, would be approximately £1800; 10 per cent. on this sum would be £180. The entire cost of working the 100 H.P. steam plant per year would be as follows:—

	£	s.	d.
Cost of fuel	166	8	0
Attendance	188	10	0
Lubrication	16	19	0
Sinking Fund	180	0	0
	£551	17	0

Equal to a cost per H.P. hour of 0.55 pence.

$$\frac{£551\ 17\ 0}{240{,}000} = 0.55$$

The consumption of water must, however, be taken into consideration, as in the case of the Gas Producer.

It was well known that with such a plant as that under consideration now, one kilo (2.2lb.) of coal of 7000 calories would convert 6.8 litre (1.52 gallons) of water into steam.

We had already seen that we required 256 tons of coal per year. I kilo would convert 6.8 litre of water into steam.

260,650 x 6.8 = 1,772,420 litre, or equivalent to 293,870 gallons, at 1/- per 1000 gallons, the cost of the water would amount to £19/14/- for the year.

The Author desired to point out, that the water required for the condenser had not been allowed for, nor had the difference in the cost of the buildings (owing to the expensive chimney stack) been charged against the steam plant.

It might be of interest to know that New South Wales coke had been used in the "Deutz" Suction Producer, with highly satisfactory results. A 25 H.P. Plant was employed for the purpose, and registered 32 H.P. during a continuous run of eight hours. The consumption of coke being 1.08lbs. per H.P. hour, as compared with 30 H.P., and a consumption of 1.2lbs. of German coke, under exactly similar conditions.

An analysis of N.S.W. coke showed the following results:—

Carbon	82.6 per cent.
Volatile Matter	4.2 per cent.
Ashes	9.6 per cent.
Moisture	3.6 per cent.
	100 per cent.

The coke used was about one inch mesh, and a thorough examination of the plant, after the eight hour run, showed no sediments or deposits that were likely to prove detrimental. This was certainly very gratifying, from an Australian standpoint.

A comparison of the working expenses of a smaller Suction Gas Producer Plant, of, say,, 25 H.P. "Otto" engine of the same capacity, but driven by our city gas, might be interesting.

The consumption in the Suction Producer was 1.08lb. of coke, with 15 per cent. added for losses, would amount to 33.2 tons for the year.

$$\frac{25 \times 8 \times 300 \times 1.15 \times 1.08 \times 15/-}{2240} = £24/18/-.$$

	£	s.	d.
Attendance, about 3 hours per day ..	45	0	0
Lubrication, about 41.5 gallons ..	6	4	6
Cost of Plant, about £520. Sinking Fund, at 10 per cent.	52	0	0
	£128	2	6

This was equal to 0.51 of a penny per H.P. hour.

CITY GAS. A good gas engine, of 25 H.P., would consume from 18 cbf. to 20 cbf. per H.P. hour, so that the consumption for the year would be approximately 25 x 8 x 300 x 19 = 1,140,000, which, at the present price of gas, viz., 4/-, less 20 per cent., gave a total cost of £182/8/-. Attendance of one hour per day would amount to £15 per annum. Allowing for lubrication, same as the Producer engine, viz., £13/10/.

SINKING FUND. The cost of the engine, complete, would be approximately, £320; ten per cent. on this sum would be £32. The entire cost of working this engine per year would total up somewhat as follows:—

	£	s.	d.
Cost of gas	182	8	0
Attendance	15	0	0
Lubrication	6	4	6
Sinking Fund	32	0	0
	£235	12	6

This was equal to 0.97d. per H.P. hour.

$$\frac{£235\ 12\ 6}{60,000} = 0.94$$

The consumption of water was not allowed for in the cost, so summarised, the results were as follows:—

	£	s.	d.
The cost of working a 100 H.P. Steam Engine	551	17	0
Cost of working a 100 H.P. Suction Producer	405	17	6
A minus in favour of the Suction Producer of 35 per cent.	£145	19	6

With the 25 H.P. Suction Producer, the cost of working was:—

	£	s.	d.
	128	2	6
Cost of working same engine by city gas ..	235	12	6
A minus in favour of the Suction Producer ..	£107	10	0

It had been demonstrated, beyond all doubt, that engines of more than 10 H.P. can be more profitably worked by Suction Gas than by the ordinary city service. Below that size, the convenience of city gas will outweigh any pecuniary advantage.

OTHER FUELS. The Gas Motoren Fabrik "Deutz" had constructed a generator for the production of power gas from brown coal—a very interesting subject for our Melbourne manufacturers—but the field was too large to be dealt with at present. He would therefore content himself by giving a few outlines.

It consisted of a twin generator, lined with fire-brick, and open at the top; air was introduced through a grating, as well as at the top, so that there were practically two zones of gas formation, and the engine drew its supply from about half-way up the generator.

The greatest difficulty in gas generation from brown coal had been the extraction of tar, and this has been completely solved by "Deutz," for repeated investigations have proved that the gas left the generator free from tar, and all that was required was the arresting of dust and other solids, which was done by washing, and by passing it through a scrubber.

Brown coal, with a maximum of 20 per cent. moisture, could be used.

He would be very pleased to read a paper on this subject at some future time, if considered of sufficient interest to the members.

The ideal of constructing engineers of Suction Producers had been, and was now, the direct generation of gas from low-grade bituminous coal.

The "Deutz" Motor Works were experimenting with twin generators, somewhat on a similar principle to those used for brown coal, and the results, so far, were very encouraging, but they were, nevertheless, still in the experimental stages, and, therfore, could not be discussed seriously as yet.

OTHER FUELS. Driving gas engines was not the only use that Producer gas could be put to, for it was being very advantageously used for drying ovens, smelting furnaces, etc. To use the gas for these purposes, it was, however, necessary to introduce an attachment—provided with an exhaust fan—to the scrubber, by means of which the gas was obtained by suction, and conveyed to one of the usual inverted bell gasometers, from whence it was taken according to requirements. A pressure of 6in. Mercury Column, to which has to be added the resistance of the generator, the scrubber, and the pipe service, amounting to about 8in., so that, altogether, 14in. (Mercury) was required.

A number of these installations had shown a saving of as much as 50 per cent., as compared with city gas, used for the same purpose.

The Suction Gas Producer had undergone its evolution, starting with Benier's modest efforts, until it had reached its present unassailable position; and although we, as engineers, all honored the men who had laboured so well to bring this cheap source of power to its present state of perfection, we all, he was sure, hoped that at no distant date we would see realised our ideal of drawing a cheap gas supply direct from a low-grade and inexpensive bituminous coal. The realisation of such a dream would give the use of gas engines an impetus that could not be measured as yet, but it would certainly mean a fatal check to the use of the steam engine.

But the development of the Suction Gas Producer could never have been achieved to the same extent, had the construction of powerful gas engines not advanced at the same time, and for that reason, he did not think it advisable to close his paper without touching on this subject.

The "Deutz" Works had developed the "Otto" engines, until they now produced them of as high as 6000 H.P. By ingenious changes in the combustion chamber, they had increased the compression without overheating, and bringing about premature ignition. They had also succeeded, by means of compulsion valves, controlled by governor, to secure the requisite admixture for all loads. Through suitable connections, they mastered the expansion tension without sacrificing the solidity of the engines. By closing the cylinder, and constructing a double-action they had increased the power of the engines enormously, without increasing the weight, proportionately. In short, they had developed the "Otto" to its present proud position.

The double-action engines had the advantage of greater uniformity in velocity, and were up to 1300 H.P. The twin system of the double-action engines was employed from 400 H.P. to 2600 H.P. A Tandem system had also been adopted, and engines of from 3000 H.P. to 6000 H.P. were built on the Twin-Tandem principle. This latter size had, so far, only been used in utilising the powers produced by the gases of blast furnaces.

It might be interesting to mention a few figures in connection with blast furnaces gas, that used to run to waste, and was still not utilised in many places. In the treatment of every ton of pig-iron in the blast furnace, 87,500 cbf. of furnace gas, of about 20 cal. per cbf., was produced during the process.

In a steam engine, this amount of heat would produce 300 H.P. hours; whereas it would yield 1000 H.P. hours in a gas engine.

To illustrate the enormous power contained in blast furnaces, he might mention that in Germany, 8,000,000 tons of pig-iron produced during the year, yielded, as a by-product, about 1,000,000 H.P. hours of gas, after allowing for all losses.