DISCUSSION.

Mr. James Shirra, in opening the discussion desired to thank the author for bringing this important invention before us, as undoubtedly there was a future before the arrangement, and the sooner Engineers familiarised themselves with this and all other modifications of internal combustion engines, the better for themselves and the world. We seemed to be just waking up to the possibilities of these—the large blast furnace gas engines mentioned, were striking instances of what could be done. He would like to point out though, that they had not come as a bolt from the blue, as it were, but were the outcome of a continuous, if increasingly rapid, evolution along natural lines. The modern gas or oil engine, at least, that most efficient and typical form of it, the Dissel engine, was the legitimate descendant of the Caloric or Hot Air engine of Stirling or Ericssen, which promised so much about the middle of the last century, only the fuel used now was in a liquid or gaseous form, and the combustion and heating of the air took place in the working cylinder itself, so avoiding in a great measure external losses. Dr. Otto, who was mentioned in the paper as the founder of the Gas Motoren Fabrik Deutz, and the inventor of the four-cycle principle, had undoubtedly done much for the progress of the Gas engine, but the credit of inventing or enunciating the principle should be given to Beau de Rochas, who laid down exactly, in 1862, the cycle and procedure that made Otto's engine of 1872, such a success compared with all the gas engines that had gone before it. We knew how old Dr. Faust, at the crisis of his life, when the black poodle appeared, was debating which was the "Urgrund" or primitive cause—the Word, the Mind, the Power, or the Deed, here Otto showed us the power and the deed, but we must credit Beau de Rochas with the word and the idea of an efficient four cycle engine some ten years before Otto materialised them. Now, in the evolution of machines, as in that of living bodies, the progress seemed to be from the simple to the complicated, from the comparatively stable to the eminently unstable in composition, combination and action. Balfour Stewart, writing on "Energy" contrasted such a machine as a steam engine which worked in a stable calculable cycle, with a loaded rifle with a hair trigger at full cock, where the slightest touch from outside might bring about an explosion or sudden transmutation of energy, and the exhibition of various non-calculable phenomena. In a steam engine the object of the designer was systematic action, all the arrangements were of a conservative nature, and the element on instability was avoided as much as possible. In other prime movers the same object must be aimed at, but with gas engines this undesirable element seemed much more in evidence, and must be still more so in those operated by suction gas producers.

Let us take one of our most primitive prime movers, the overshot water wheel. The mill wheel had come to be proverbial for its unceasing monotony of action—we assumed the existence of the driving brook, of which we were told "men may come and men may go, but it goes on for ever", and so did the wheel if suitably placed. But it was too stable for most people; we wanted to be able to bring our power to our work, not vice versa, so we used the stored energy of portable coal in a steam engine. Here we met far more opportunities for instability, possible causes of breakdown, than in the water-wheel, and the direct interposition of human agency was constantly required to keep the machine going. The fires had to be stoked, the water and steam gauges watched, and though automatic stokers and feed regulators might be used, they could not be said to be universally applicable. At least we might say that it took no very high intellect or skill to attend to the supply of these two requisites, while the third great requisite, the supply of the air to the fuel, practically take care of itself. In the gas engine we had the fuel supply, if that was from the town mains or a gas-holder, pretty well taking care of itself also, but the conditions under which it was burnt were much less elastic than in the steam engine, it was less adaptable to varying loads, and the deficiency or excess of fuel, or other modifying factors, were not so evident to the senses of the attendant. No doubt attendants developed a sort of special sense by experience, so that they knew the symptoms of defective working about as well as the engine driver who saw flame issuing from the funnel or the gauge glass full up with water, knew what was the matter with his job; but when in addition to using the gas, it had to be made in a producer, especially a suction producer where we had no reserve to draw on, and which seemed at first sight a very unstable combination, the attendant would need a deeper insight into the unseen than was the lot of ordinary humanity. Hence it was that the attempt was always made with gas engines, petrol motors, and the like, to make them self-regulating; we were constantly told that skilled supervision was not necessary, that any labourer could work them, and that the skilled mechanic would only interfere prejudicially if he had anything to do with them, because every contingency had been foreseen, and the machine was automatic.

In practice we knew how disappointing this assumption was with ordinary oil motors say; and in a suction producer gas engine where the efficient working of each part depended on that of every other part, such automatic regulation must be difficult. It was not impossible, the Author had shown us that, and with progressive engineers difficulties were just things to be overcome, but it was not every one who had the time and the money to devote to experimenting to reproduce the exact conditions and environment of successful working. The apparent elements of instability in such an arrangement as described, apart from the general accidents to which all engines or gas engines were liable, as mechanical injury, bent spindles, defects of igniting or lubricating arrangements, and so on, were the possible variable composition of the gas, the variable temperature of it when taken into the cylinder, the possible presence of tar, dust, or water, in it, and the possible lack of an immediate response to an increased demand for gas. These possible defects had been considered certainly by the makers, and we had plenty of evidence that the machines could be made to work well and economically; but when the inevitable hitch occurred something more expensive than a driver at labourer's wages would be needed to set it right again.

At a trial of ten suction producer engines at the Glasgow Agricultural show in June last, according to "Page's Weekly", two failed at start, one had to be stopped after starting through a failure in the water supply, and while six of them were started and got up to the working load in from 12½ to 17½ minutes, the seventh took 48 minutes to do so. A full report was not yet to hand, but evidently the producer engine-driver would require to have not only a detailed and perfect knowledge of his machine, but nearly every physical law of thermodynamics and chemistry at his fingers' ends, in other words he must be a skilled engineer in the fullest sense of the word. No doubt means would be invented of providing the gas engine and producer with gauges and indicators analogous to such as were needed in a steam plant. Imagine a steam engine without pressure gauges on the boiler or valve casings, without a water-gauge on the boiler, without a fire-door even for viewing or dealing with the burning fuel, with nothing to indicate the super-heat of the steam or the amount of condensing water, if such were used, but all these items attended to automatically, and you would imagine a possible engine perhaps, but a most uncertain and erratic one. Was it too much to ask of science to give us easily read gauges for a gas plant, which would show us the composition of the gas or the working charge at any stroke, its temperature and pressure at any instant, the voltage and flux of current in the electric ignition apparatus when such was used, the condition of and height of water in the scrubber and its seal, and so on,—something that would show the attendant at a glance if anything was abnormal about the working, and obviate the annoying and disheartening trial and error process of finding out the almost inscrutable defects that often vitiate the working of internal combustion engines as we know them.

This would be an elegant field for a happy blending of science with industry; chemistry would need to be made more than ever the handmaid of engineering, and even zoology might be pressed into its service, as was done in Submarine Navigation where white mice were kept as eudiometers or indicators of the purity of the air. These little animals were very sensitive to the presence of that intensely poisonous gas carbon monoxide, and would show by their uneasiness if it was present in the engine room atmosphere. The Author had mentioned the poisonous nature of this producer gas but has scarcely emphasised it enough. He said, Carbon oxide was, next to hydrogen, the principal constituent of generator gas, was not "hydrogen" here a misprint for the inert "nitrogen"? In water gas production, where a blast of steam was blown through the fire, hydrogen was the most important combustible constituent of the gas, and it was much more energetic than carbon monoxide, but its greater specific volume required larger cylinders to develop its energy. Such producers, however, required to be worked intermittently, as the dissociation of the steam lowered the temperature of the generator very much, and the steam must be shut off at intervals to let the coke burn up again, producing CO only during this period. The presence of hydrogen in the gas seemed necessary if it was to be ignited with facility in the cylinder, but it could only be in a small percentage when steam at atmospheric pressure was used; was not the great function of the vapor supply to keep the fire-bars cool and prevent clinkering, as in the wet ashpits of the locomotive boilers which were formerly used in torpedo boats?

The author used metric units largely in his statistics Calories per kilogramme, litres of water. and so on. There was no fault to be found with this, it was rather commendable, for we ought to accustom ourselves to speak and think in the language of scientific civilisation. The metric system ought to be taught in our schools, and while he would highly deprecate its compulsory use by legislative action, he would like to see everyone able to think of dimensions, for instance, as easily in millimetres as in inches, and the fittest system would establish itself as the popular one. But even the metric system had its ambiguities. thus the

Calorie might be big or little, heat required to raise 1 kilogramme water 1deg. C, or 1 gramme water 1deg. C. In the paper the big Calorie was used, coal of 7000 Cals. per kilo, would be also of 7000lb, or 7000 by 1.8 equal 12,600 British thermal units per lb. degrees cent. per lb. The British equivalents of metric quantities were not always correctly given, at least, 6.8 litres. the evaporative value of 1 kilo. of the coal used, equal barely 1½ gallon, not 1.52 as stated. But gallons per kilogramme was a half-caste sort of expression, when we remembered a litre of water weighed just a kilogramme, we get 6.8 kilos. water per kilo. of coal, or 6.8 lbs. water per lb. coal, a statement which would be more readily apprehended by us. even if we had no sympathy with the conservative British workmen sung by Macquorn Rankine long ago:—

"Some talk of millimetres, and some of kilogrammes,
And some of decilitres to measure beer and drams,
But I'm a British workman, too old to go to school,
So I'll eat by the pound, and drink by the quart, and
work by my three-foot rule."

The steam plant the author compared with the producer motor was, on the whole, an economical one, the engine was an extremely economical one, but the poor evaporation co-efficient brought it down enormously, 6.8lb of steam only per lb. of coal; while an 1 h.p. was got from 12.1lb. of steam per hour. He had no doubt some of our members could offer to supply boilers that would give the 12.1lb steam for 1lb coal, and so reduce the coal bill for steam to nearly that of the producer in one act. But there were very few steam engines of 100 I.H.P. would work so economically as this, and the gas plant ought to use much less fuel than the steam; still the steam engine would survive for many a day yet, especially if power users kept on trying to run suction gas plants of 100 I.H.P. with a wages bill of only £130 per annum, or a 32 I.H.P. one on only £45.

Of course, this latter low figure was got by assuming that the attendant's services were needed for only three hours' daily; but let us consider what he had probably to do in those three hours, even on the assumption that the apparatus worked perfectly, and regulated itself. The fire had to be drawn in the evening when the work was finished, the coke quenched, and the unburnt coke put aside for re-use next day—the total quantity was not much to be sure, as only about 2½cwt. was burnt daily on the figures given, but the generator would probably contain a 5cwt. at least, and if only 15 per cent. was allowed for all sources of waste, the stoker would have to be unusually careful in his drawing and cleaning the fires. Next morning, he (see Page 92) had to see to the weighted lever, M., shut off the scrubber, and open the direct draught up the escape pipe, then light the fire and keep gradually filling up with coke, at the same time keeping the fan going to create a draught. This would be 20 minutes of fairly hard work; then he had to attend to his tar extractor, take out the foul set of discs, and put in the clean ones he had ready—cleaning the tar off the former would fill in some of his leisure time during the day. The scrubber would want attention, too, the bottom door must be taken off, and the ash and dust removed from the water in the bottom of it, and from the overflow basin; the coke itself in the scrubber would want renewal once a week, perhaps. He presumed the old scrubber coke could again be used as fuel, but it would be saturated with water and tarry products, and would need to be well mixed with fresh coke when used. Now. when he had everything cleaned out, water turned on, lubricators filled, and the fire being well aglow, a few turns of the fly-wheel completed the operation, and the engine started for the day. The generator, we were told, held sufficient fuel for two hours, but should be attended to every hour, using the poker to avoid caking. Since, with the 30 h.p. engine the consumption of fuel was only about 32lb per hour, he expected we should read here the "supply hopper" instead of the "generator," but seeing that it wanted regular attention every hour, the ash-pit cleaned, etc., as well as considerable attention before and after starting, he did not see how we could avoid debiting the plant with the whole of the attendant's wages, although he might find time during the day to look after some minor jobs besides.

On page 100 we were told that after eight hours run no sediment or deposit that was likely to prove detrimental was found, but what after a week's or a month's run. and were the evaporative qualities of the water jacket not as likely to be impaired by deposit from hard water as a steam boiler's would be?

There could be no doubt as to the fuel economy of producer engines when everything was in order, and worked perfectly. When the fuel bill was high, we did not object to pay more for skilled labor and expensive machinery for our plant, if by so doing we reduced to a greater extent the expense for coal; but when we attempted to reduce all these expenses at once, we usually make a mistake. These remarks on the Author's paper are in no way meant to discourage the use of a great and economical principle, but to point out that the machines made on it have yet to be perfected; that the "automatic" idea, by which intelligent engineering supervision was supposed to be dispensed with was often a delusion, and was always to be looked on with suspicion; and that the way to popularise such machines was not by ignoring their difficulties, and raising unwarranted expectations. but by frankly admitting and facing the difficulties, and specially by providing the plant with indicating apparatus, including some sort of instantaneous pressure and temperature gauges, which, like the steam and vacuum gauges of the steam engine, would show at once, before the engine stopped or breaks down, what was beginning to go wrong.

Mr. A. J. Arnot said he had read the paper with a great deal of interest, and congratulated the author on the manner in which he had placed the various advantages of the suction gas producer before them.

It appeared, however. unfortunate, and somewhat detracting from the value of the paper that actual results were not given, instead of estimates. It was an easy matter to make estimates, but they were not always carried out in practice, as most of the engineers present here would recognise.

The Author had got astray in his reference to calories, as, in dealing with the steam plant he dealt with a coal valued at 13s per ton containing 318 calories per pound. Coal at that price generally averaged in this country 12,000 B.T.U., and as one calorie equalled 3.968 B.T.U., or, roughly, 4, the calories per lb, he (the speaker) presumed, should be 3180, equal to 6,996 calories per kilogramme.

Taking the Author's assumption of 12.1lb. of steam per I.H.P., his estimate of 1.8 lb. of coal to produce that quantity of steam showed an exceptionally low boiler efficiency, equal to 52 per cent. Steam boilers had been known repeatedly to show 80 per cent. efficiency, and any first-class boilermaker would guarantee at the least 75 per cent. He contended, therefore, that the figures given on the estimated steam plant were not reliable. At the same time. although Mr. Forkel had estimated on 12.1 lb. of steam per I.H.P., with a compound condensing engine of 100 h.p., he (the speaker) thought his estimate would only be obtained under test conditions, and not in practice. Of course, with an engine of 500 h.p., that quantity of steam would be near the mark, but a fairly high degree of super-heat would required to be used.

Recognising, however, that suction gas plants had been introduced in several places in the Old Country. and one or two in the Colonies—where purchasers following on the old Latin proverb, Omni ignotum pro magnifico (Everything unknown is thought to be magnificent), have taken the risk of demonstrating to their fellow citizens whether or no this new application of power was a success—it was surely common sense to review the actual results obtained with reference to the cost of maintenance, rather than deal with the uncertain figures of estimates.

Prof. Lewicki, of Dresden, has recently written an elaborate treatise comparing the economy and safety of modern steam boiler plants, with suction generator gas power plants. This gentleman is in an unbiassed position, and had obtained data from a number of suction gas plants and steam plants all of 100 H.P., and showed the actual total cost of working per H.P. per hour in the case of the suction gas installations to be .556 of a penny, and the actual cost of the steam installations to be .492 of a penny.

He gave the following conclusion as the result of his examination:—

> "Modern steam power installations, considered from the points of view mentioned above, are, with regard to the total cost of working. cheaper than suction gas plants."

Another table given by Prof. Lewicki from results obtained with suction gas plants and steam installations each of 100 H.P., showed the total cost of working per effective horse power per hour, with gas instal-