DISCUSSION.

Mr. Russell Sinclair (President), in opening the discussion, said he highly appreciated the value of the paper the author had contributed to our transactions, and was sure that the Association, as a body, were greatly indebted to him for the time and trouble he had given in its preparation. The wonderful development in the turbine of recent years and the extraordinarily rapid extension of its use has, as pointed out by the author, been more rapid than any previous departure in engineering. The introduction of the compound engine was not as rapid, nor was that of the triple expansion engine, and he thought we may safely take it that the use of the turbine will become as general as the use of these types of reciprocating engines became, so that a paper throwing so much light on the subject as the one under discussion does, is of great value to us as engineers, who are anxious to learn all we can, and make ourselves familiar with a type of machinery we shall be brought daily more and more in contact with.

He could not presume to criticise the paper, but he would be glad of further information. On page 103, the author states that advantages to be derived by superheat were limited by the superheater, and in actual practice 250° was not likely to be improved on. He would like to ask if it is not rather the capability of metals to withstand the temperature of superheat rather than the superheater which will limit the advantages; his view was that it is the metals of the turbine which have to withstand the erosive action of the superheated steam which would sooner show deterioration than the structure of the superheater, which could be constructed to withstand the steam pressure under a greater superheat.

The author mentions that saturated steam as it passes through the blades becomes mixed with condensed water, this having an erosive effect on the blades, but experience in ordinary engineering has been that high temperatures have also this effect on metals, and he should think that the limit to the advantages of superheating will be the attainment of that degree of superheat which will give dry steam during the greater portion of its passage through the various vanes without injury to the metal. It would be most interesting if the author could state in his reply whether any difficulties have come under his notice of blades becoming eroded in actual practice so as to interfere with the efficiency of the turbine, and if so, what is the usual remedy, it does not seem to be a very simple matter to effect repairs.

Another point is whether the stationary vanes and the sides of casing are affected or not, if they are, does it materially affect the clearances and consequently the efficiency of the turbine. He had heard it rumored that, there was a gradual process of erosion of the inside wall of the casing going on, which had the effect of a gradual but serious loss of efficiency and increase of consumption in steam and fuel.

What to him appears the most remarkable property of the turbine, is its capability of utilizing the energy in low pressure steam expanding to a high vacuum, but to obtain this high vacuum the author does not make it quite clear what is the nett gain when describing the augmentor jet. He explained that the steam consumption of the jet was 1 per cent. of the total steam, but a nett. reduction of 8 per cent. was obtained with similar quantity of circulating water, but on page 106 he mentions that the quantity of circulating water must of necessity be greater than with the lower vacuum of 26ins. He would ask the author to explain the statement that the ratio of circulating water to the steam condensed was about 50 to 55 per cent., and the total power generated was about 2 per cent. Does this mean a nett. gain of 2 per cent., or does it mean 2 per cent. of the total used as required for the air and circulating pumps? With ordinary reciprocating engines it was usual to allow about 30lbs. circulating water per lb. of steam condensed. If the author's figures mean that 50 per cent. more is required for the higher vacuum, it equals 45lbs. The work absorbed in circulating this increased quantity must represent a very large amount of power.

The author mentions very briefly towards the end of his paper a possible development of the combination of a low pressure turbine with a reciprocating engine. He might say that by last mail a clipping from a Glasgow newspaper reached him which states :—"At the Royal Institution, London, last night, the Hon. C. A. Parsons caused some surprise by announcing that a combination of the reciprocating engine and the steam turbine would shortly be tried in a cargo boat of moderate speed. The reciprocating engine would use the steam down to the atmoshperic pressure, and the turbine would use the expansion down to the condenser. There would be a saving he estimated in the cost of coal of from 15 to 20 per cent."

In concluding, the author adds that tramp steamers so fitted would have the advantage of having more than one propeller, does this indicate that the design will be three screws, the centre one turbine driven, with twin sets of reciprocating engines, or the wing screw turbine driven with the centre reciprocating, either way it would appear to have the disadvantage of great first cost, which, for tramp steamers, is not desirable.

Mr. Scoular said the author had dealt with the subject in a fair way with regard to the principles of this machine, but on one or two points he (the speaker) did not hold the same opinion, and seeing that only one class of turbine formed the main subject of the paper. The Parsons' turbine has no doubt created a revolution in mechanical engineering, as far as the application of steam is concerned; still it would have been very much better had comparison been made of the various types of turbines that are now being used throughout the world, giving data of trials, steam pressures, speeds, and methods of determining nozzle and blade angles, etc. The blade angle appears to have been fixed at 25 degrees for the Parsons turbine, but there is nothing to show, either mechanically or scientifically, how this has been determined, therefore we, as engineers, are unable to grasp both the mechanical and scientific side of the question, and it appears doubtful if this angle is correct for more than one particular size of turbine. It would be interesting to know what the total frictional loss would be, after the steam had passed through, one step of moving, and fixed blades including the loss at nozzles, when set to correspond with the angle given.

Reference had been made to a certain class of turbine that wonld only develop 300 H.P,, but (speaking from memory) he thought they were made in America of a similar design up to, and over 3000 H.P.

It would have been interesting if the author had dealt with and described some of the difficulties that the Parsons' Company had to overcome during the experimental stages with their machines, for as an engineering body we came together for the purpose of mutual benefit, interchange of ideas and experiences, therefore, a description of what transpired during the experimental stages, would have placed us on the same level as himself, and no doubt given food for expansion of the mind to many of us.

The author appears to consider the increased amount of water for condensation purposes at 50 to 55 per cent., and in connection with this point it may be mentioned that prior to the first turbine being installed at Ultimo, arrangements were made for a main circulating water pipe of a size suitable for vertical engines of the same I.H.P. as those then in position, but when tenders were accepted for a turbine of the same rated power as one of these engines, it was found necessary to increase the main pipe from 20ins. to 24ins. diameter to meet the reqnirements, but as this pipe large enough to work two additional sets of the same power as the one now installed, so far as experience goes one would hesitate to say that 50 to 55 per cent. more water is being used for the present turbine, though it is generally admitted that a greater proportion of circulating water is required to produce a higher vacuum and get the most economical results with machines of this type.

The turbine has come to stay and it is to be hoped that at some future date a subject of such importance as this one, will be dealt with by the author or some of the members in such a way as to define the scientific as well as the practical points in connection with a machine which is now coming rapidly to the front in the field of steam engineering.

Mr. Cook (visitor), considered one of the great advantages claimed for the turbine over the reciprocating engines is that it takes less space as compared with the horizontal type reciprocating engines. Parsons' type steam turbines required only one-third of the floor space. With vertical reciprocating engines the proportion is one-half. There is nothing said about the amount of space taken by the condenser. He understood that if steam expanded so enormously as with the turbine, it called for a very much larger condenser. Therefore, in comparing the space taken up, he thought that the space taken by the condenser should also be taken into account. That is one of the questions he desired to ask. There is one advantage about the turbine, low pressure, that in mining machinery in particular, where the work is discontinuous the exhaust steam is wasted, therefore there would be considerable lost power. This exhaust steam might be used with a low pressure turbine.

Mr. W. H. Grieve, in reply, apologised for not being present at the discussion, being out of the State at the time, and was not able to check the proof of his paper, and unfortunately, numerous errors have crept in as a result.

In answer to Mr. Sinclair, in reference to his (the author's) remarks on superheating, page 103, as Mr. Sinclair implies, the limit to advantages due to superheating is due to the inabilities of the metals employed to stand excessive temperatures. We generally find an excessive drop in temperature from the superheater to turbine stop valve, even in very short lengths of steam piping, and on that account the superheater tubes have to withstand a much higher temperature than has the turbine. Taking steam at 200lbs. pressure and 250° Fahr. superheat, or a temperature of about 640° Fahr., it is known that the strength of steel diminishes by about 10,000lbs. per 100° Fahr., and as the temperature in superheater may very possibly be nearer 750° Fahr., it will thus be seen that the tensile strength of the steel has suffered considerably.

The steam velocities are very low in the high pressure portion of the Parsons' Turbine, and no erosive or other damaging effect has been observed upon blades dealing with very high temperatures, in fact, in all cases even with super-saturated steam, the blades become covered with a very thin deposit from the steam. In the low pressure part of the turbine, if the steam be initially super-saturated, due to long steam pipes, the leading edges of low pressure blades are subject to a perpetual bombardment, as some one termed it, of water molecules, which bombardment has the effect of microscopically pitting this edge of blade, but could not possibly affect the economy of the plant.

The largest turbine plant at present in Australia was tested after two years exceedingly hard duty, with lengthy steam pipes and saturated steam, the consumption resulting, being the same as when machine was first installed.

The blades subject to this pitting action would have a life of 50 years or thereabout, when by an inexpensive operation, they could be replaced in a few days. With dry steam this action ceases completely. The stationary vanes are quite unaffected. The inside walls of cylinder do not suffer in the least if reasonably dry or superheated steam be supplied, and the foregoing test of a large plant gives evidence as to the maintenance of the initial economy in the Parsons' type of turbine.

One of the most misleading errors in the paper is on page 106, in reference to amount of cooling water required in terms of amount of steam condensed, to produce high vacua. What he said was:—"The ratio of circulating water to the amount of steam condensed was about from 50 to 55 to 1," and not per cent. as printed, and the next paragraph should have read as follows:—"And the percentage to total power generated used with motor driven air and circulating pumps, worked out at about 2%." This, he thought, will explain Mr. Sinclair's question, but to give actual test figures to his reference of 8% gain by adopting the Vacuum Augmentor as on page 105. This test was taken at Sheffield upon a 1500 K.W. Turbo Alternator.

The temperature of cooling water in this case was as high as 85° Fah. and the ratio to steam condensed about 30 times the steam consumption at full load, therefore the vacuum was comparatively low, but the augmentation and overall resulting gain in efficiency in steam consumption is clearly demonstrated.

The steam pressure was 115lbs., superheat 150° Fah., and the loading on machine 1050 K.Ws. in both of the following cases when without the augmentor the vacuum at turbo exhaust registered 25·18ins. and a steam consumption of 20·7lbs. per K.W. hour. After fitting this auxiliary a vacuum of 27·12ins. was maintained with the same quantity and temperature of cooling water, and a speed of air pumps, the steam consumption being reduced to 18·66lb. per K.W. hour, which consumption includes the steam used by the augmentor steam jet, or a total nett. reduction of 10 per cent. due to machine not being fully loaded at time of test, and which gain was reduced to eight per cent. at full load.

The increase in quantity of cooling water necessary for these high vacua, taking Mr. Sinclair's figure at 30 to 1 for reciprocating engines, and 50 to 1 for for turbine gives one the impression that the cost of pumping the additional water must amount to a very large part of the saving due to decreased temperature at turbine exhaust, but in nearly all cases the height to which cooling water has to be raised is small, and taking the average cost of condensing with such vacua, of a large number of stations compares very favourably indeed with those used in stations where reciprocating engine and relatively low vacua are required, and the 2 per cent. mentioned by him (the author) represents the expenditure of power in complete condensing plant as a percentage of total power generated.

In reference to the probable method of combining the reciprocating engine with the turbine for slow speed steamers. This combination must, of course vary with H.P. and speed required, but in large steamers the three propellers will most probably be adopted, the centre propeller being driven by the low pressure turbine. The cost of such an arrangement, would he believed, compare very favourably with the twin screw reciprocating engines, and the expected saving due to this additional expansion of the steam would in a very short time make amends for any additional initial costs, if such a difference really existed.

In reply to Mr. Scoular he desired to say that his paper was entitled "The Parsons' Steam Turbine." Personally, he should be pleased to hear a paper read on the other types, but as his paper was more of a practical nature he had confined his remarks to the type he had had experience with. In reference to his remarks as to angle of Parsons' blades, Mr. Scoular would, he thought, admit that we still have only a hazy idea as to the theory of water flow, which being the case the flow of steam presents enormous difficulties to the mathematician. Certainly there are numerous technical books at present whose authors claim a purely theoretical treatment of the flow of steam in the various turbines. Granting these deductions be correct, he yet can see no reason for having doubts and which Mr. Scoular evidently entertains, that the most economical angle is that which Parsons have adopted, which is the result of long practical experiences and expensive tests.

Mr. Scoular uses the words " size of turbine," by which he (the author), presumes power of turbine is what he implies. The power of turbine does not in the least affect the angle of individual blades, the common ideal of each blade being the same, namely, to extract the highest percentage of kinetic energy from the steam, in which operation they succeed in withdrawing about 70%. It therefore follows that the only effect power of turbine has upon the blades with equal steam conditions, is in the length and number, which length provides the annulus for the extra steam passage in the case of higher powers.

He did not know of De Laval turbines over 300 H.P., and was inclined to think Mr. Scoular was mistaken in the type of turbine when stating powers of 3000 H.P. His reply to Mr. Sinclair regarding the clerical error of inserting "per cent" in place of "to one," will explain Mr. Scoular's misinterpretation of his meaning.

Mr. Cook mentioned that the space taken up by the condenser should be included in floor space necessary for any plant, with which he agrees, but the difference of the two systems, turbine and reciprocating engines, lies in the fact that the condenser is usually placed immediately under the turbine, and thus does not take additional floor space, so that the ratios mentioned by Mr. Cook, namely, one-third and one-half are very close to the comparative spaces of the turbine and reciprocating systems. As mentioned in the paper, there are a large number of Parsons' turbines operating with exhaust steam, which steam previously exhausted to atmosphere, with a resulting saving in many cases of 300 K.W. additional power from the steam.