if there were no off-setting disadvantages, the use of such appliances would presumably be universal instead of exceptional, and might be applied in Australasia to advantage, where plants were of such magnitude as to warrant the adoption. The cost of an effective and durable mechanical stoking plant limits its application generally, and the uncertainty as to the actual economy had, no doubt, hitherto retarded its general introduction in New South Wales. He (the speaker) certainly did not consider it would produce economy to apply mechanical stokers in every plant, as, no doubt, some small ones might be quite unsuitable for such an arrangement.

Water-tube boilers might be preferable to the ordinary run of boilers in use; at the same time, writers who were supposed to be authorities on the question point to the fact that some of these types gave trouble with regard to want of free circulation, and so permit of steam-plugs being generated in the tubes to such an extent that some of the parts must at times become almost dry. This action may account for the fact that it had been known for the water to have entirely disappeared from the gauge-glasses, probably by the sudden inrush of steam from the tubes at the gauge-glass and of the steam and water drum; and as this action may occur in any of the other elements in the boiler, of course certain risks are produced. He considered, however, the Babcock and Wilcox Stirling and Hornsby are very good boilers, and gave, he thought, what was claimed for them in the way of economy.

The Americans appeared to favour the general idea of heating feed-water by exhaust steam from the auxiliaries of large plants; and, no doubt, this could be done in many cases more economically than by the installation of economisers; and there should not be any difficulty, with proper arrangements, in getting feed-water heated in this way up to temperature ranging from 210 to 220 degrees Fah.

He considered that super-heated steam, intelligently applied, offered an opportunity for a fair saving in the coal bill, and that

with a super-heater placed in the flue, where the gases would strike it after they passed from the boiler, there would be a small gain in boiler efficiency of not more than 2 or 3 per cent. in a boiler worked at ordinary rating. Though a super-heater in the flue might save a few per cent. of heat, it should be remembered that an economiser for heating the feed-water would, no doubt, save more heat at less expense, as the difference in temperature between the gases and steam might be 200 degrees, whilst the difference in temperature between the gases and water might reach 400 degrees, or more, and the resistance of the surface to heat transmission very much less. Therefore, it would almost be safe to say that a given area of economiser heating surface would increase the boiler efficiency four or five times as much as the same area of super-heating surface, besides costing less to instal and less to repair. The losses through radiation, fall of pressure and leaks, in transmission from the boiler to the engine, would increase in direct proportion to the super-heat, and in some cases might reach a very high percentage. Since super-heated steam occupied a greater volume than saturated steam, and moved with greater velocity, the fall in pressure would be greater in the same sized pipe, while, if larger pipes were used, greater losses would occur through radiation. In any case, the pipes close to the engine should be large, or special receivers applied; otherwise the pressure would drop rapidly during admission to the cylinder. In any case, whatever size of pipes were used, the fall of pressure, and consequent loss, would be greater for super-heated steam than for saturated steam of equal weight, and in leakage alone the losses might amount to from 2 to 15 per cent. of the useful steam—assuming a plant to be worked steadily at full capacity—unless a uniformity of the super-heat temperature could be maintained, in which case the leakage losses might not be much greater than for saturated steam. The difficulties at the engine might be overcome by the use of heavier mineral oils for lubrication, with specially-designed valves and metallic packing. The results might then be approxi-

mately —First, a slight gain at the boiler, although less than can be obtained by an increase of boiler heating surface, or by the use of an economiser ; second, an increased loss in the steam pipes, due to radiation, fall of pressure and leaks; third, a gain in economy at the engine ; and it was obvious that the sum total of these results would vary considerably in different plants. Now, if it were possible to place a super-heater in such a position as to make use of the waste gases, giving from 500 to 700 degrees Fah. temperature to the steam, with a small amount of piping, and plant worked steadily all the time, we might get the following result :—

Gain at the Boiler	2	per cent.
,, ,, Engine	10 to 20	,, ,,
Extra loss in Pipes, radiation, say ...	1	,, ,,
,, ,, ,, leaks, say	3	,, ,,
,, ,, ,, fall of pressure, say	$\frac{1}{2}$	,, ,,
Net gain	$7\frac{1}{2}$ to $17\frac{1}{2}$	,, ,,

Such a gain in the coal bill would probably be enough to pay for fixed charge and maintenance of super-heater.

On the other hand, suppose there was double the length or amount of piping, and the plant only averaged one-third as much nett work, we then had—

Gain at the Boiler	2	per cent.
,, ,, Engine	10 to 20	,, ,,
Extra loss, radiation	6	,, ,,
,, ,, leaks	18	,, ,,
,, ,, fall of pressure	$\frac{1}{2}$	,, ,,

Nett loss $2\frac{1}{2}$ to $12\frac{1}{2}$ per cent., in which case, of course, super-heating would not pay.

He was not prepared to advocate any special kind of super-heater, or say where it should be placed for special plants ; but he must say that, if the distance between the boilers and engines was great, and super-heat was produced at the boilers, it would have almost or entirely disappeared by the time it got to the engines, and the only way to overcome this difficulty was

to erect a separate furnace, which would give less power economy and cost more to construct.

The figures he had quoted were taken from some tests made, he understood, in America.

In conclusion, it seemed to him that we were only entering upon the era of steam pressures up to 200 lbs. per square inch, and that super-heating was but dawning upon us ; so that if our economies in the use of steam were to be kept up to date, he thought, as a starting-point, greater attention was required in the prevention of leakage, and means afforded for the entrainment of the water that was drained off from steam separators, re-heaters, receivers, &c., such as are used in large plants, so that this water, which would be perfectly pure, could be returned at a very high temperature to the boiler, and thus add to its life in many ways. Personally, he was of the opinion that a great deal more was to be gained by attention to detail matters of this kind, than by the hasty application of special economy producers. If this was generally adhered to between the boiler and engine, then economy would certainly be realised at the motive power end.

MR. J. SHIRRA said that this Association had always endeavoured to promote economy in the use of steam, and in 1879 offered prizes for competitive papers on the subject. The first prizeman pointed out that commercial economy did not always mean low fuel consumption, and the same was true now.

He instanced Watt's Cornish pumping engine as one by which a high fuel enconomy might be obtained, but it had not been found expedient in practice to work it with the high ratio of expansion necessary to secure this. The success of the triple expansion marine engine could not have been secured without great improvements in detail on the old compound engine, and he mentioned the engines of the Irish mail steamship *Ireland*, built in 1885, as an instance of modern improvements being ignored in order to secure reliable machinery.

He pointed out the great expense of supplying condensing water to our non-condensing engines, and the small benefit compared with risks run from using super-heated steam, which was unsuitable for the ordinary slide-valve engine.

He referred to PROFESSOR KENNEDY'S remarks in this connection at the inaugural address of the City and Guilds Central Technical College (Session 1902-3), and recommended a study of it. (See *Engineering*, 27/3/'03.)

But commercial profit must not be obtained to the detriment of the community, and he thought that the pollution of the air by smoke and the wasteful use of our coal capital were fitting subjects for preventive legislation.

Still, industrial evolution must be gradual; the organisation of our works must change with their environment, for, unless these mutually suit, failure is to be expected. When works are reorganised, it was better to have a new environment for them—a new location.

The chief fault of steam-users and manufacturers was not so much that they did not experiment with possible improvements as that they did not make the best of what they had already, and there should be less dirt, darkness, and discomfort about our engine-rooms and workshops, and more sweetness and light.

MR. A. CHRISTIE said the ground had been pretty well gone over already, so that there was very little for him to say. The great point the author seemed to hit on was our wasteful way of raising and using steam; he seemed to think that all the factories should be driven by triple expansion engines, something after the fashion of a first-class mail steamer. He appeared to forget that nearly all the factories and places where they use steam machinery in Australia were only small, the author himself having stated that there were 183 or 200 steam users in the metropolitan area. Coming to the larger-sized factories, he would refer to the works with which he was connected. There we use compound condensing engines, and, principally, a much-cried-down machine, a high-pressure engine, working at about 60lbs.

of steam. In our works the compound engine was found to be very little better than the high-pressure engine, for the simple reason that, in the first place, our principal power was used for pumping water out of the dock; and, taking all the year round, these engines don't go more than nine hours a week. They do very well at that; we have to keep steam up for 24 hours a day. The principal amount of coal was used in keeping up steam, not in actual pumping, so that the kind of plant advocated by the author would be more expensive, and would require a better man to look after it, with little or no better results.

He pointed out that we ought to be guided by circumstances, and that it might often be found that a high-pressure engine was the most economical financially. As regards the author's scheme for the supply of condensing water, it was doubtful if he had given it much thought. Taking an area having a radius of $3\frac{1}{2}$ miles from the General Post Office, and bearing in mind that the factories are dotted here and there, and some of them are very small, how many miles of pipes and pumping stations would there require to be, and what would be the financial result at the end of the year? Certainly, there would be no 5 % or 7 % left for the investors.

As regards water-tube boilers—that seemed to the author one of the things we ought to use—either a Babcock and Wilcox or a Stirling. His opinion was that for an ordinary amount of work, the colonial boiler was at least as good, if not better. Regarding the efficiency of these tubular boilers, like Babcock and Wilcox, we read all sorts of things in books, and, if we believe all the agents say, they produce more steam than it is possible to obtain from the coal.

A series of tests were made some time ago with Babcock & Wilcox boilers, using New South Wales coal, which gave a very good idea of both the evaporative efficiency of this type of boiler and the heating value of the various samples of coal. The trial extended over six days, the best result obtained being with Brown's Newcastle coal, the result being 9 2 lbs. of water

evaporated from and at 212° Fahr., per lb. of coal, and the lowest with a mixture of Newcastle and Lithgow coal, which was 6.07 lb. water per lb. of coal. During the six days' trial good average samples of both Northern and Southern coal were used, the average result being 7.25 lbs. of water evaporated per lb. of coal.

A few years ago he had made an exhaustive test of the colonial type of boiler, using Southern coal from the Mount Pleasant mine. The result of the test showed that the boiler evaporated 9.75 lbs. of water per lb. of coal. He could not see why steam-users should go to America to obtain boilers when boilers certainly as efficient and cheaper could be, and are, manufactured here.

With regard to the labour-saving machines, he (the speaker) advised their adoption whenever the circumstances warranted the expense. There had been great changes of late years in regard to labour-saving appliances in the machine and tool shops. These were essential in shops where duplicate work was done. In the States there is such a variety of work that special plant is in use, because these tools are only profitable when a large number of the same articles are required; but this condition does not obtain here. Of course, some small machines can be used with advantage, such as for making belts, studs, etc., and these have been used in Eveleigh Works for years, doing excellent work in making stays for locomotive boilers, and similar work. Private firms do not get enough locomotive work to warrant the expense of these special tools. As to pneumatic tools in New South Wales, his own opinion was, that Mr. Vincent had not had much experience of these. In the speaker's opinion, they were not altogether an unmixed blessing. They were expensive to buy, and expensive to keep up, and the most wasteful in power he ever came across. The only thing he could see in favour of these machines was, that they were very handy and portable, and suitable for certain particular purposes; but the chances were, in the end, the cost of work was not much reduced by their use. We had also tried electrically-driven

drills, and for the amount of work that could be done with them, for the power used, they were far superior to pneumatic drills.

There was one point the author did not touch on regarding economical production, and that was the human factor—it was useless having special tools unless we had men to work them properly. The great thing required here was to induce the people to take an interest in their work, but, under existing circumstances, they spent more thought and labour on sport than they devoted to their daily work. This great want of interest was sapping the abilities of the workman.

Mr. R. W. Finlayson said the principal side of the question was the commercial one. The author of the paper had said that he had heard it remarked that "Australians were so slow that they couldn't even catch cold." While in America recently, he found people there who were just as slow as some people here, and in Sydney he was sure there were as clever engineers as in America. In one instance, he had noticed in America, the proprietors of a factory were going to dispose of their old tools, but, at the same time, they were going to sell every one of them, and what struck him particularly was that there were purchasers there who were anxious to instal these old tools in their shops. While there was certainly a generally up-to-date order in America, yet he had seen some very old-fashioned tools, boilers, and engines of the most ancient type there.

Although there was evidence in Sydney of the want of efficiency and being up-to-date, it should not be taken for granted that there were no engineers or employers who would not be only too glad to avail themselves of the services of high-class machinery if the means and conditions of using them were profitable.

Mr. H. Kidd said it was not necessary to go in for condensing engines in order to be up-to-date. For some purposes high-pressure engines gave very satisfactory results. As regards boilers, he thought people who had experience would agree with him that there was no difference between the various classes of

boilers, provided they were working in a satisfactory way. At Fiji they had had a trial of coal, and the lowest figure obtained was 7·5 and the highest 9·5, giving an average of 8½ lbs. of water per 1 lb. of coal. Some years ago they tried the Southern coal, and that went 9.5. This, he concluded, was the best coal. He had obtained the very best results from the colonial type of boilers, and he had tested all kinds.

Mr. Erskine had said that beyond the motive power was the application of it. With his (the speaker's) machinery, from 60 to 80 per cent. of the whole power produced by the engines was absorbed unproductively, leaving only the remaining percentage put to useful, actual work.

With reference to tools, Mr. Christie had covered that ground. One of the most important things was that, when good tools were got, intelligent men must be got with them, and encouragement given to study them and work them successfully.

As to mechanical stokers, he tried the Proctor and Henderson type 15 years ago in connection with the factory in Fiji, also in Pyrmont three years ago, but they would not respond quickly enough.

The conclusion he had come to as regards boiler tests was that, if the coal was properly burned, it did not matter what kind of boiler was used.

Mr. O. W. Brain said that in a number of instances when he had been advocating the adoption of up-to-date appliances, he had been met with the answer that the cost would be out of proportion to all saving.

Everything that one saw in America was not entitled to respect. He had seen machinery of 150,000 horse-power, indicated, consuming 450 tons of coal a day—with coal at 36s. per ton. As regards water-tube boilers, they were being used everywhere in all parts of the Continent; in fact, they had been adopted throughout. It had become the general practice to adopt electrical and up-to-date methods in workshops, and the consequent improvements had been very great.

The President said that, looking at the matter from the standpoint of a mining engineer, he thought Mr. Vincent's paper

had many good grounds for support. There was often a great waste of fuel and steam at collieries; but, although the former could not be excused, the latter might be the result of the adoption of engines that were for certain work, not only convenient, but necessary. For instance, for winding from shallow or even moderately deep mines, in order to obtain speedy winding combined with ease in handling the engines, which had in such cases to be started, stopped, and reversed, say every 30 seconds, the use of high-pressure engines was general. It was only in the case of really deep mines, that compound winding engines could be adopted with any degree of success.

No doubt, there was room for greater economy in the generation and consumption of steam at mines generally, all over the world. This was receiving due consideration in the case of new plants, and he had no doubt that such economies as were applicable to the conditions obtaining in Australia would be adopted in the case of new mines, or even at old ones in cases of renewal of plant.

MR. VINCENT, in replying to the discussion, said that the time at his disposal would not allow him to deal with all the points raised. Whilst appreciating the criticisms, he still maintained that the want of economy was greatly in evidence, and this point had been conceded by most of the members who discussed the paper.

After reading an extract from an address by Dr. Alexander Kennedy, Mr. Vincent pointed to the title of his paper, which dealt with the motive power end, and contended that, no matter what the power was, whether steam, air, gas or electricity, the fact was patent that economy was required, and that economy should be the vital principle in all engineering schemes; that engineers should utilise that machine and that principle which was most economical, whether steam, air, gas, oil or electricity.

THE PRESIDENT said that the thanks of the Association were due to the author for his paper, which had induced a most interesting discussion and had given members much food for thought.