fitted with these turbines. The total indicated horse power already complete and under construction in Britain and U.S.A. being up to the present 1,020,000.

The steam generation system in the Cunarders does not show any radical departure, as the boilers adopted are cylindrical Scotch type, there being 23 double ended 17ft. dia. x 21ft. long, and two single-ended. The steam pressure is 180lbs. at the boilers, 160lbs. at the turbines. Air is supplied on Howden's Forced Draft System.

The adherence to the type of cylindrical boiler in place of water tube boilers will in the opinion of many naval engineers and architects be amply justified, as the reliability of a well constructed cylindrical boiler has been thoroughly proved and demonstrated.

The question of the water tube boiler as against the cylindrical boiler is being steadily forced on the attention of engineers. However, for naval purposes, it would appear to be decided in favour of the water tube, the success which has been obtained in recently-built vessels of this class with boilers of that type being pronounced. But for ordinary merchant vessels a great deal more demonstration must still be done and experience gained before the well-proved older type will be laid aside. There is, however, the one point of advantage in water tube boilers, namely, the saving in total weight, with steam up, which will always be in its favour, and which will act as a persistent incentive to continued development.

Quite recently here in Sydney a fair sized merchant steamer had a double-ended cylindrical boiler removed and replaced with two water tube boilers, and so far I am given to understand the results are satisfatory, and we may hope to have some data of the results at a later period. These should be especially interesting, as they will give an actual comparison between the performance of both types in the one boat.

It is doubtful whether the progress which refrigerating machinery has made during recent years has been as marked as in most other contemporary branches of engineering. The developments have rather been in the extension of its application to general purposes. In this direction the rapidity of progress in the last few years has been very great, especially in the United States and Europe, and the value of mechanical refrigeration for the purpose of preservation of food products, both in process of manufacture and transit is being more and more recognised.

Thirteen years ago I had the honour of reading a paper on the subject to this Association. The classification of the principal refrigerating media then described has practically not altered. Cold Air Machines, in which air only is the refrigerating medium, are practically now not used, except in some special cases as on board steamers, where the advantage of not relying on what may be termed a chemical agent, is allowed to over weigh the greater cost of fuel. A few of the principal lines of steamers still adhere to this type of machine.

The systems principally in use at present are:—Anhydrous Ammonia Compression, Carbonic Anhydride Compression, Sulphur Dioxide Compression, Ammonia Absorption Compression.

The first mentioned has retained its position of being most universally adopted, for the reasons that it will liquify at the moderate pressures of from 150 to 200, while the latent heat of vaporisation is high, namely, 590 average, according to temperature. This presents no great mechanical difficulties to handle, only accuracy in manufacture and care in operation. The ammonia compression machines have developed on two marked lines, namely, the operation of the machine on the "*wet gas*," and on the "*dry gas*" systems. Each have their adherents, and the friendly rivalry between has done much to assist improvement.

Ammonia compression machines have been improved to such an extent that with the combination of high class steam engines, a result equal to the production of 20 tons of ice per ton of coal can be regularly assured, while with the use of triple expansion engines and a moderate amount of superheat, as high as 25 tons of ice per ton of fuel has been realised. These are, of course, results from fairly large plants.

It has been recorded in more than one instance also that with gas engines, and using producer gas, a result equal to a production of from 28 to 32½ tons of ice per ton of coal was obtained.

The use of machines working with carbonic anhydride has been greatly extended in recent years in spite of the very high pressures they must work with, reaching as high as 1000 to 1100lbs. in the condenser. This has been made possible by improved methods of manufacture, especially in the methods of gland and piston packing, the old type leather packing having been replaced by metallic packings. The one advantage which this type possesses is the absence of odours when leakage occurs. This has led to their large adoption for ship work, as they can be placed in the main engine room, allowing of better attention from the staff. The power required is, however, greater than with ammonia.

Machines using sulphur dioxide are still made by a few firms, but their use is not greatly extending, the lower condensing pressure does not counterbalance the lower latent heat of the liquid and consequent larger and more bulky compressors.

Ammonia absorption machines practically died out some years ago, but recently have been revived by a well known engineering firm in England having adopted the system. As this system dispenses with moving machinery, it has certain advantages, and it may be its use will be extended if only the great tendency to deterioration through corrosion due to contact of iron and steel surfaces with warm aqua ammonia can be got over.

The possibility of the adptation of the rotary or turbine principle to the compression of a gas for the purpose of refrigeration has attracted the attention of Refrigerating Engineers recently, but it is difficult to see how this can be utilised, as the highest pressure so far obtained by a turbo blower has been 60lbs. per square inch with air, which is too low for any of the liquifiable gases . There are possibilities of development however in this direction by the use of some of the heavier gases.

That the development of refrigerating machinery is bound up with the advancement of our own Commonwealth is shown by the amount of export of frozen produce sent away. During last year, for example, there was shipped from Australia—65,650 tons frozen beef, mutton, lamb, etc., value, £1,529,000; 4800 tons of frozen rabbits and hares, value, £490,000; 33,837 tons of frozen butter, value, £3,240,000. Total, 104,287 tons frozen produce of a total value of £5,259,000. All of this was dealt with by refrigerating machinery in Australia before being shipped, or to put it another way, none of this business could have been developed without the aid of the Mechanical Engineer and his work in producing mechanical refrigeration.

In addition to dealing with frozen produce the business of fruit carrying in refrigerated steamers is now being greatly developed, not only from Australia, but the West Indies and other countries, and it is of interest to note that according to Lloyd's latest Bulletin it is stated that there are now over 108 steamers whose refrigerating plants are certified to by Lloyds, these vessels having a total capacity of carrying at one time 10,000,000 carcases of mutton, though this business dates from 1880 only, hardly 27 years ago.

The uses of Mechanical Refrigeration are widening every day. In addition to dealing with frozen produce, fruit, etc., its use is now being daily extended in the manufacture of ice, butchers' requirements, cooling of water for breweries, dairies, in the manufacture of oil and paraffin, chocolate and confectionery, the safe storage of valuable furs to preserve them from the ravages of moths, and attempts have been made to store grain and cereals at a low temperature to prevent damage by weevils—in fact, refrigeration may be said to be now a necessity.

Two special applications are worth noticing. The sinking of shafts through water-soaked soil by the aid of freezing processes has for some time been a well recognised proceedure. In a recent instance in Germany it is reported that a shaft had to be carried to a depth of over 600 feet through soil of this nature, the method adopted being that about 30 bores were made in a circle of 39 feet, and in the centre four bores were made. Into the outer circle of holes freezing tubes were placed to a depth of 330 feet, and shorter ones in the centre holes, thus freezing the ground to a depth of about 300 feet. After the excavation was started the freezing tubes were gradually sunk, and when the shaft had reached the 300 feet depth the ground below was frozen to the required depth. The walls of the shaft were fixed as the work progressed by injecting cement concrete.

A recent development of this process of refrigeration is reported to be under test in America by the Pennsylvania Railroad Company, for the purpose of boring tunnels under river beds when the top of the tunnel comes so close to the bottom of the river as to make the ordinary compressed air system too risky. The process is to make first a small bore tunnel, using compressed air, within this small tunnel a large number of freezing tubes are placed and cold brine circulated through these, this being kept up for several months until all round the small tunnel a core of frozen sand and mud is formed, gradually increasing in diameter to the necessary radial distance to permit of the freezing being stopped and the excavation of the tunnel to the full size proceeded with.

Another development of Refrigeration has been its recent application to Blast Furnaces for reducing the amount of moisture contained in the air which supplies the furnaces. In practice it has become possible to maintain uniform conditions of ore and fuel, but there has always been an element of uncertainty in the atmospheric conditions, owing to varying degrees of humidity, the water contents of the air drawn in by the blowing engines varying from 20 per cent. to 100 per cent. per day, in other words, varying from 1.83 grains of water per cubic feet of air to 5.94 grains.

It is to obviate the deterioration which takes place in the grade of iron produced by the entrance of water into the furnace that the use of Mechanical Refrigeration to dry the air has been adopted. The first plant to be set up being in the United States at the Isabella Furnaces of the Carnegie Steel Co., and it shows the boldness in erecting large plants at great cost that can be faced by engineers where a manufacturer has a great and constant trade to cater for, when it is considered that two machines, each of a capacity equal to 225 tons refrigeration per day, the cost of which must have run into many thousands of pounds, were installed practically as an experiment.

The process consists of the air being cooled by being passed over a system of brine pipe batteries before being drawn into the blowing engine. The brine is maintained at a temperature of about 5 degrees F. The engines are provided with speed regulators and the plant split up into units, so that a constant temperature of the air leaving the cooler is maintained, while all its moisture contents down to the point of saturation due to the low temperature are deposited on the brine pipes; this leaves the density of the air constant, therefore the weight of oxygen blown into the furnace is constant. It is reported that where previous to the application of refrigeration the output was 358 tons of iron, with a consumption of 2147lbs. of coke per ton, after the air was cooled and dried the output increased to 452 tons, with a consumption of 1729lbs. of coke per ton.

These results have been so far considered satisfactory, that a large installation is now being fitted to two furnaces in Cardiff, England. If this test also proves successful it will open up a large field for refrigeration in iron and steel producing countries.

While speaking of refrigeration, reference may be made to the use of liquid air as a possible source of power, which was recently put forward. Unfortunately for those who have spent time or wasted money on any scheme for this purpose, there appears to be no practicability of utilizing liquid air for any commercial purpose other than that of producing oxygen and nitrogen, as it has been demonstrated that when liquid air is drawn from its producer and employed as a substitute for any known method of developing power, or extracting heat, it is theoretically ten times as expensive, and more so in practice.

For example, a temperature of zero is as low as is required for almost any commercial purpose, therefore it would be quite unreasonable to employ liquid air, as to obtain the latter we must descend to a temperature of—312 degrees Fahr.

The same reasoning applies to its use for motor purposes. Certainly when liquid air is allowed to evaporate in a closed vessel considerable volumes of gases under high tension are obtained, which could be used for driving a motor engine, but when we consider that the mechanical work capable of being recovered from liquid air is only a small fraction of the work necessarily done to liquify the air, we can see that its adoption in a commercial sense would not be warranted.

Quite recently, however, a commercially successful development has taken place in the production of oxygen and nitrogen. Liquid air being first produced, and then an interchange of specific heat and latent heat between the liquid air and the air compressed in an earlier stage of the apparatus takes place, by means of which the air becomes condensed whilst the liquid is partially vaporised. This sets up the necessary conditions for separating oxygen and hydrogen by a process of distillation, and these gases may be collected in suitable vessels.

This development is of interest to mechanical engineers in several ways, the most important being the Oxy. Acetylene system of welding, which has lately began to be used with considerable success in Great Britain. The apparatus consists of a blow pipe, which is supplied with oxygen gas and acetylene gas under pressure, in the proportion of 1.7 volumes of oxygen to 1 volume of acetylene. The flame produced has at its apex a temperature of 6300 degrees F.

By the use of this apparatus it is said any unskilled workman can become proficient with very little practice, and almost any kind of welding in iron, steel or copper can be cheaply accomplished. With a blow pipe using 12 cubic feet oxygen and 7 cubic feet acetylene per hour, 20 feet run of plates $\frac{1}{8}$th thick can be welded per hour. With a blow pipe using 60 cubic feet oxygen and 35 cubic feet acetylene, 6 feet run of $\frac{1}{2}$ inch thick plates have been welded per hour.

Tests of strength show that the weld is equal to the solid plate, and bars of Staffordshire iron have tested over 29 tons per square inch at the joint.

As the great initial cost of a plant for electric welding has to a certain extent retarded its development, the development of the oxygen acetylene system is of interest to us, as the first cost of such an apparatus is small compared to the electric plant.

As of interest in connection with a subject to which we devoted a discussion at our last meeting, viz., the corrosion of steel and iron, and as having some bearing on what was the general opinion then stated, that steel does corrode more rapidly than iron, and that, if the latter could be obtained at as low a cost as steel, and of good quality, its use would be greatly extended for many purposes where a structure is exposed to corrosion; I would refer to the construction and setting to work of the Roe Mechanical Puddling Machine for the production of iron at the Pottstown Iron Works, U.S.A., as described by Mr. Roe in a paper read to the Iron and Steel Institute. The machine handles $2\frac{1}{2}$ tons at one heat, turning out 30 tons of blooms in 12 hours with the labour of one puddler and two helpers.

The machine is a large rectangular furnace set on trunnions, and made to oscillate so that the molten mass rushes backwards and forwards, the impact on the ends doing the puddling.

If the practical working of this machine results in the production of a high grade iron of even grain, and as those who are calculated to know, say it will do, and at a cost to compare with steel, mechanical engineers, naval architects and those responsible for the construction and upkeep of vessels will have every reason to be thankful, and will watch the developments with interest.

There is one item which calls for more attention from us as Mechanical Engineers than has yet been given to it, more especially as there is a very persistent and determined association constantly working to push this matter forward, it is the question of the adoption of the metric system of measurement.

It can be hardly denied that as mechanical science advances and interchange of manufactures between the nations becomes more and more general, the question of the adoption of one general system of measurement has become more pressing, and it is being forced on our consideration, whether we like it or not, that we must decide as to which system, the English or the Metric, is to be the recognised standard.

The fact that for some years past permission to use the Metric System has been legal in Britain and America that nearly all large concerns, which issue catalogues, have made a feature of inserting in the printed matter, a table for the conversion of English into metric measurement, and that recently several large and important manufacturers in Great Britain have discontinued the British and decided to adopt the Metric, goes to show that the question is rapidly being removed from a matter of academic to one of practical business interest.

Another sign is that as you are aware the last Colonial Conference adopted a resolution in favour of the Metric system, and probably the one just about to meet in London will reaffirm this, and it appears to me that through the lack of interest of those most directly concerned generally, the position will be that we shall gradually drift into compulsory adoption of the metric system.

Whether this is a consummation to be desired or otherwise is open to a very interesting discussion, but whichever way, it is a matter which should be prepared for, as if we are to have metric measurement then we should be teaching the system to our students and apprentices, as it is not reasonable to expect mechanics trained in the use of one unit with its divisions, to be equally capable of working with an entirely different system on short notice.

Personally, I should regret the passing of the English unit of foot and inch with the divisions of halfs, quarters, eighths, etc., as they are very convenient for shop work, but without doubt the use of a decimal system is more suitable for the finer and more accurate work now required in mechanical practice, since the advent of high-class machine tools and standardisation of parts and gauges.

It appears to me the real question is whether the English unit of one foot decimalised or the French unit of one meter, which equals 3.28 feet, is to be the universal unit of length.

I have only noted a few of the lines of development taking place in mechanical engineering. I would not be justified in taking up your time in further descriptions, as you are all equally able to read them up, but sufficient has been mentioned to emphasise the great progress being made, and to lead to the consideration of the question as to how we are preparing to keep ahead of these developments, thus maintaining the place which rightly we ought to hold in the community of nations as regards engineering capacity. It will be better for us that rather than depend on the arrival from other countries of already trained engineers, that we should see that our own rising generation of mechanical engineers are given suitable opportunities of obtaining the training, knowledge, and experience they require, because they start with the advantage of a knowledge of local conditions, the want of which is a great handicap to anyone who has been trained in another country, and however expert the latter may be, he must both unlearn a great deal and re-learn more to bring himself into complete accord with conditions governing engineering in Australia.

In a country where owing to limited population the number and size of engineering workshops are also necessarily comparatively limited, there must always be a difficulty in finding places for all those who are desirous of learning by apprenticeship to become engineers. This is one phase of the matter which must to a large extent be left to be worked out by other laws than academic discussion, but it appeals to me as a pity that the opportunities for obtaining a training should be so limited that in most workshops there are far more applications than it is possible to grant, and in view of this that there should be in some quarters a tendency shown to endeavour to limit the number which may be employed to a small proportion of the trained men. To my mind it is a pity that all of those who desire cannot be given a chance to learn, as the more trained men we have the more will the country develop, as their brains and experience will be set to find ways and means of extending our engineering enterprises.

It is this limitation of opportunities which to a great extent accounts for the overcrowding of our Technical Colleges, and there is a danger of the Technical College being looked to as a possible substitute for the apprenticeship. I am, however, glad to be able to say that from information obtained by a recent visit to our principal Technical College in Ultimo, that this is strongly opposed and guarded against by those at the head of the teaching staff, who appear to fully recognise that a technical training should either be only a preliminary to, or go in conjunction with actual workshop experience, and for this reason have limited the period of attendance to three years.

Technical College training is now recognised as absolutely essential for the proper training of young engineers. It should therefore be the duty of those at the head of affairs who control such matters to see that there is sufficient opportunities given so that no one who is desirous of learning and prepared to give the necessary attendance should be debarred from doing so.

Unfortunately it only requires a visit to our Technical Colleges to see how short we are of that. The classes are more than fully attended, and numbers have to wait and lose the best period of their life in waiting. This is not as it should be, additional accommodation should be provided without delay, and no money could be better invested by any Government.

As it is, the work being done is of a very excellent nature, and the methods of teaching almost without question, but, it does not go far enough. The facilities provided for the teaching of the elementary branches are excellent and effective, but all engineers as they progress in their studies or experience, must to a greater or less extent determine what branch of the profession they will follow, and more facilities should be provided for this. It is of course a mistake for young engineers to specialise at too early a stage, but sooner or later each student must determine on some special line, if he really intends to be something more than an ordinary mechanic, and to encourage this, the technical college should be provided with much more advanced appliances, such as electrical machinery of the latest type, air compressing apparatus, gas engines and producers, refrigerating machinery, etc., so that insight to the knowledge of the application of elementary principles, to the finished and complete process can be obtained.

We, on our part as an Association, hope to do a little by our student grade of membership, and by the special meetings of students, which it is hoped to hold this session, at which students will be encouraged to take part in a discussion. The Council, by offering two prizes for papers by students, also hope to encourage the closer study of engineering questions.

The interest of members in Technical College work will also, I hope, be maintained, by paying a visit of the Association to the Ultimo College, which is promised us later on in the session.