reliable method of transport for our perishable cargoes, and there was strong evidence that this Association had rendered good service in taking up the subject.

Mr. NORMAN SELFE said that the subject for discussion appeared to centre on the following points:—First, the large proportion of destruction and waste which attended the shipment of Australian food products to England; secondly, the absence of practical control by Australians over the arrangements made on the cold storage ships which were owned in England; and thirdly, the much greater and longer experience which Australia had had with freezing machinery than England had, and which should justify Australian shippers in taking advantage of knowledge thus gained in the colonies, and insisting on their valuable produce being treated in a more scientific and less wasteful way than now obtained.

Taking the last point first necessitated a short history of mechanical refrigeration.

Until the middle of the present century, only two practical methods might be said to have been known for producing ice artificially, one being by evaporation from water set in shallow trays, as adopted in India, and the other by the use of chemical or frigorific mixtures, such as were described in popular science books, of which nitrate of ammonia with water, and ice or snow with common salt, are perhaps the best known. Since that time, however, great numbers of persons have worked in the field of artificial cold, the labour of many having been thrown away, owing to the imperfect knowledge of the laws of thermo-dynamics which prevailed until recent years. Among the practical pioneer inventors of cold air machines, the names of Windhausen in Germany, Giffard in France, and Gorrie in America, were familiar; and Professor Twining, of New Haven, Conn., was known to have experimented with ether in a compression machine at Cleveland, Ohio, about the years 1855 to 1857; but it did not seem to be generally known and accepted that an Australian inventor, Dr. James Harrison, of Geelong,

Victoria, was one of the first workers in this field, and absolutely the first person to make a commercial success of artificial refrigeration, and put a real practical and scientific ice-making machine on the market. Dr. Harrison commenced in 1855, but, owing to difficulties connected with the workmanship of his machine, was much delayed for the first year or two. On the 3rd of August, 1859, however, Mr. Harrison ordered two machines to be constructed by Messrs. P. N. Russell and Co., of Sydney, at that time the leading engineers in Australia. These machines were on the "table engine" type, and geared direct to a steam "table" engine. The plan (Plate XXIV.) exhibited was the original drawing of these machines, which worked perfectly, and gave every satisfaction. The speaker, who was at the time Messrs. Russell's chief draughtsman, afterwards designed the "horizontal" type machine shown by Plate XXV., which was reproduced from a tracing from the original drawing. Two machines were made from this pattern in July, 1860, which were found to be even more successful than the "table" type, and they worked well for many years in Victoria. In 1861 the speaker designed the large double-cylindered compressor (Plate XXVI.), and this very machine would be found illustrated in the London *Engineer* of that period; but to show how little of artificial refrigeration was known, or even believed in, at that time in England, the following passage is taken from the London *Builder* and the *Engineer* for April 25th, 1862:—"Nature is the only successful manufacturer of ice; we can only make it in small quantities. and only of an inferior quality." Yet at that very same time good artificial ice was being made and sold both in Sydney and Melbourne; the importation of ice from Boston, Mass., became a thing of the past; and the great ice house which was used to store American ice on the Circular Quay furnished materials for a bonfire (from a supposed incendiary), which might be said to have celebrated the victory of artificial over natural ice for ever, as far as New South Wales was concerned. In the "Blue

Book" issued by the Hercules Ice Machine Company of Chicago, on page 17, would be found a confirmation of the fact that Harrison's machine was the first one to be applied to manufacturing purposes, in the year 1861.

Messrs. Siebe and Gorman, of London, took up the manufacture of Dr. Harrison's machines in England, and other English firms later on. Australia, in the meantime, was making progress. Messrs. Siebe, of London, sent out an "Ether" ice plant to the Garden Palace Exhibition here in 1879, years after our original ether machines had been supplanted by aqua-ammonia plants for the supply of Sydney. The Carré ammonia absorption system was first introduced into New South Wales by Messrs. Dawson and Nicolle. From 1861 to 1870 the late Mr. T. S. Mort, in conjunction with Mr. Nicolle, took out patents and experimented with improvements on absorption machines. The old ether machine was removed from the back of the Royal Hotel, and the ice works at Paddington (established by Mr. E. D. Nicolle) supplied ice made by the absorption process for many years. Several German absorption machines were subsequently imported and set to work for ice-making, the remaining ether machines being principally confined to breweries. Messrs. Mort and Nicolle, besides working on Carré's process, also tried a system of air compression, and Mr. Mort fitted up the converted steamship "*Northam*" with a nitrate of ammonia machine. Although there were many failures, great experience was gained, and many cobwebs swept away; and Mr. Mort, by his patriotic expenditure of a quarter of a million of money, and by the earnest way in which he worked to solve the great problem of how to ship our food products successfully to Europe by cold storage, laid the country under such a debt of gratitude which led to the erection of the bronze statue at the Exchange. The speaker had the advantage, as scientific engineer to Mort's Dock Company, of profiting by all these experiments, extending over a great many years, and numbers of other persons obtained great

experience in artificial refrigeration. Messrs. Mort and Nicolle used a large pump in one of their machines (Patent No. 216 of 1869) to promote the evaporation of ammonia from the liquor, but they never made a compressor for anhydrous ammonia, and in the preamble to Patent No. 216 they refer to the "formidable difficulties" in the way of dealing with anhydrous ammonia as an agent for artificial refrigeration, stating that "for commercial purposes it may be said to have practically failed." He (the speaker), however, was so impressed with the properties of anhydrous ammonia that he designed machinery for its use, and obtained the first patent issued in New South Wales for refrigerating machinery, using a compressor for that material. (See Letters of Registration for a "Colonial Ice Machine," No. 887, now expired, and public property). This invention set forth a number of features which were still made use of in the leading ammonia machines, subsequent improvements being merely in details. One feature of Patent No. 887 was the connection of the piston rod end of the compressor cylinder direct with the suction branch, in order to relieve the piston rod packing from pressure. The Fresh Food and Ice Company paid him a royalty for the use of this device in two of their machines, which were still working, and it was adopted also in a number of other machines made and used by another company in the colony, and it was still used in many colonial and imported machines. Another feature was the cooling of air by passing it over the metallic surfaces of the refrigerator. This had lately been re-introduced under the Linde system. Compound compressors and the use of a refrigerating machine in a railway train were also parts of the invention.

The next cycle in refrigerating machinery covers the cold air system, for which early patents were taken by colonial inventors. On the 8th October, 1880, he arranged with the Treasury Department of New South Wales for the supply of a Bell-Coleman machine for Glebe Island, and in 1881 he designed a small machine for bacon-curing for Messrs. Hicks Bros., of

Shellharbour, specially arranged to be worked without skilled labour, and with the minimum of condensing water. This machine had for fourteen years been supplying air at 60 degrees below zero, and had so far made the fortune of the proprietors that they were now supplementing it with an ammonia machine as more economical of fuel. Other cold air machines had been made under his directions, and by several engineering firms in the city.

Numbers of patents had been, and still continue to be, taken out in New South Wales for ammonia compressors and refrigerating machinery. Mr. W. G. Lock, some years ago engineer of the Fresh Food and Ice Co., designed two compound compressors and patented some of their details. They were made in 1884 and 1886 by Mort's Dock Co., Balmain. It was fashionable among refrigerating engineers at present to make fun of compound compressors for ammonia, just as it was years ago the correct thing in some quarters to undervalue compound steam engines and to deride the idea of compound air compressors, such as he illustrated in a paper read before this Association on the 11th March, 1886; but compound engines had now extended to quadruple expansion, and nobody laughed at them, and the number of persons who understood the practical advantages of compound compression for ammonia was daily increasing. The York Company in America, Messrs. Humble and Nicholson in Victoria, and Messrs. Chapman in Sydney made compound ammonia compressors, and at least half-a-dozen other firms of engineers in Sydney made ordinary ammonia compressors for refrigeration, that invented by Mr. Auldjo being at least as effective as the best ones imported. It was beyond the scope of these remarks to go into the relative merits of the various machines now in use. Enough had been said to show that an enormous mass of experience had been accumulated in the colony in connection with the construction and application of refrigerating machinery. The mechanical details of the

many machines now in use in New South Wales might, however, very profitably be considered by this Association at another meeting.

After the experience that had been gained with the air machines of Bell-Coleman, Haslem, Hall, Lightfoot, Giffard, and colonial builders, it was not probable that more of that class would be made here, because second-hand ones could be bought cheaply when they were replaced by others of a more economical type. There were, no doubt, Haslem machines still doing fair work in the city, if the boiler power required was not taken into account, but from a progressive colonial standpoint cold air machines now belonged to a past age, and were as dead as Julius Cæsar. Two of them put into the Hotel Australia for temporary service under his direction, and designed in detail by Mr. Auldjo, when he was at Mort's Dock, were now in course of removal, and could be purchased very cheaply. Notwithstanding this, our English friends and shipowners must still have a good opinion of them, for, in spite of the fact that other machines would do the same work with less than a quarter the consumption of fuel, occupy less space in the ship, and take a great deal better care of the food shipments, English vessels were still being equipped with cold air plants. On the continent of Europe the great rival of ammonia was sulphurous acid. M. Raoul Pictet patented his machine for the use of sulphurous acid in New South Wales, in 1881, and although it had been greatly used in America as well as on the continent of Europe, he was not aware that one had ever been at work in this colony, although he had seen two of them running in Melbourne. The only serious rival to ammonia for refrigeration now seemed to be carbonic anhydride. An eminent an experienced firm in the manufacture of cold air machines, Messrs. Hall of Dartford, had fitted a great many ships with them and several were at work in the colony. Without discussing the relative methods of ammonia and carbonic anhydride, we could say with safety that they both abstracted a

given quantity of heat with only a fraction of the fuel expenditure that was required under the compressed air system. Although Messrs. Hall of Dartford have in the past made some of the largest cold air refrigerators that have been fitted to vessels, it was not understood that they now recommended them, but rather that they preferred the carbonic anhydride plant. This firm, in fitting up their carbonic anhydride machines, appeared to arrange for the chambers being cooled by brine circulation; this, of course, was not so simple as putting the expansion coils in the chambers, as was feasible and a common practice with some ammonia plants. It did not require engineers to see that there was a great contrast between the simple system under which the contents of a cold store parts with its heat direct to the refrigerator coils set in store itself, which was ventilated by a natural circulation of air; and the other and more artificial system under which the ammonia cooled the refrigerator pipes in another chamber, these pipes cooled a quantity of brine which was kept mechanically in circulation, this brine cooled a number of discs of iron which were driven by a separate steam engine, these discs cooled a current of air, and this air propelled by machine driven fans cooled the chamber. In the latter case there were four transferences of heat instead of one; much supplementary power was of course required, much greater complication of machinery was necessary, and greater first cost and maintainance. To return to colonial experience, besides numerous smaller company's works, the Fresh Food and Ice Company of Sydney had since they put in their compound compressors (before referred to) erected two De La Vergne machines, one of which was made in Sydney, and also one of Mr. Auldjo's machines, they had refrigerated hundreds of thousands of sheep for export, made thousands of tons of butter, and in innumerable ways realised the dream of their founder, Mr. T. S. Mort; and, summing up what had been said, it would be seen that for nearly thirty-five years' experience in the

refrigeration of food, products had been accumulating in Sydney. Unfortunately for all concerned, this experience had never been recorded as fast as it was gained, partly perhaps because there was no such periodical as "Ice and Refrigerator" to take note of it, and partly because its importance was never realised; and when we enquired if all those years of experience had been made use of in the transporting of our food products to Europe, and asked if the best systems possible had been adopted in fitting up vessels to secure uniform success and produce the best results for the colonial exporters? the answer seemed to be "No"—Australian experience had practically been ignored in the matter. It was a fact that we were continually seeing statements in press telegrams that this ship's cheese or that ship's apples had turned out badly, that beef was "sodden" or mutton "blue mouldy," and we scarcely paused to consider how many hundreds of thousands of pounds worth of food had already been wasted in a similar way, to lessen the returns to the Australian producer. It was also a fact that questions were continually being raised as to the effect of cold on the fibre of flesh and fruit, and statements made that their texture and flavour were destroyed because they had been frozen, when simply some essential conditions had been neglected. The conditions necessary to ensure proper chilling, safe transmission, and thawing without destruction had been discussed for years; and they should have been put beyond the scale of controversy years ago, and definitely laid down. Ship owners should have been required to satisfy competent inspectors that the necessary conditions were fulfilled before shippers entrusted them with their precious and perishable cargo. The time ought also to have arrived for shippers to be under less obligation to steamship owners than now appeared to be the case when cold storage or refrigeration during transit was required. When we considered the preciousness of the cargo, and the infinitude of pains and trouble which were necessary to produce the best quality of beef, mutton, butter, cheese, apples,

&c., &c., one was struck at the crudeness of the preparations that were often made to preserve (?) or spoil (?) them during a voyage.

It appeared to be a fact that food which did not require for its preservation temperatures below 40 Fah. or at the lowest 33 or 34 deg. was often placed in the holds of vessels and subjected to cold air blasts as low as 60 deg. below zero, that was 100 deg. lower than was necessary. The best cold air machines could deliver at minus 80 deg. when working on frozen meat, but, by putting off the expansion, the engineers in charge could raise the delivery a little, say to 60 deg.; but it was even then 80 deg. cooler than required for some food. Of course all the moisture was supposed to be deposited in the snow box, perhaps theoretically it should be so, but some must be carried on mechanically as sleet by the blast of air; the consequence was that when the ship was opened up all was not satisfactory.

A large fruit shipper from Hobart, Mr. Shoobridge, went expressly to London to see his produce arrive, and graphically described the result to him (the speaker), saying, "That near the air inlets were all frozen up with icicles, while other parts lower down were blue mouldy." Exhaust fans to draw carbonic acid from the bottom of these produce ships which have their chambers cooled by passing a stream of intensely cold air over the top of the cargo, have recently been applied; this modifies the harm done, but was a crude makeshift at best. And yet, with all these crude appliances, let us see what proportion of the total returns the producer got as compared with the ship.

The proceedings of the Intercolonial Fruit Conference at Hobart last month were the latest to hand; there it was stated by a very large shipper that, assuming the 150,000 cases of fruit which Hobart had shipped to London this season would bring an average of 10s. a case, the money would be proportioned thus—