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MECHANICAL REFRIGERATION,
WITH DETAILS OF AN AMMONIA COMPRESSION
MACHINE, AND DESCRIPTION OF VARIOUS
METHODS OF REFRIGERATION.

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THE number and importance of Refrigerating Works in Australia have very largely increased since the last paper, by Mr. Sinclair, read some eighteen months ago before this Association. The export of meat, butter, cheese, fruit, &c., continues to increase, and it is only by the use of refrigerating machinery that it is possible that we can convert our surplus into hard cash, and at the same time benefit the starving masses of Europe.

The author has taken the following figures from the "Year Book of Australia":—The fresh meat exports for New South Wales, Victoria, and Queensland for the year 1892-3 were valued at £517,941, and for 1893-4 at £610,808, or an increase of £92,867 for the year. The butter exports for New South Wales and Victoria for the year 1892-3 were 8,855,552 lbs., and for 1893-4 they ran to 17,155,544 lbs., or rather more than 100 per cent. However, from July to December, 1894, Victoria alone exported 20,000,000 lbs. of butter, valued at £800,000, but the returns for New South Wales are not given. The value of butter exported now stands next to wool.

Victoria is very much ahead of us in the quantity of butter exported, owing to the great help given to the industry by the Government.

The author supplied a Refrigerating Plant to a factory in Melbourne where they make 8 tons of butter per day, and he visited another factory where the output is 24 tons per day. Both of these factories are very much larger than anything we have in New South Wales at present.

A rough outline of the cooling work to be done per 24 hours in this particular factory may be interesting. The refrigerating machine was built in Sydney by Messrs. Bennett and Speechley. About 300 cans of cream are brought in from the country each day. They weigh 112lbs. each, and have to be reduced from a temperature of about 80deg. to 56deg., and about 2,000 gallons of water have to be reduced from 80deg. to 50deg. to churn with. The butter is then salted and worked, and finally packed in wooden boxes 12 x 12 x 12 inches, each holding 56lbs. This is done in a room of some 20,000 cubic feet capacity, the temperature of which is maintained at 50deg. There is also a storeroom of some 5,000 cubic feet capacity, in which the butter is kept ready for shipment at a temperature of between 35 and 40 degrees.

The drawing (Plate XVIII.) of a small Combined Ice-making and Refrigerating Plant, which has been at work in Suva, Fiji, for some months, showing good results. There are some original features in the arrangement of this plant, to which the author desires to draw attention. The machinery is arranged at one end of the building, and consists of two duplicate ammonia compressors, driven by a steam engine placed between them. Steam is supplied by an ordinary vertical boiler. The ammonia condenser stands on the first floor, and is of the open air type. As the ammonia is liquified it gravitates down into the bottle shown secured to the wall. The bottle is connected to the expansion valve placed on the first floor, and the return valves are situated directly below them. There are three ice-

tank coils and one cold room coil, each having its own expansion and return valve, so that they can be regulated quite independent of each other. The charging bottle from which the ammonia is drawn is shown standing in one corner. The cold storage room is on the ground floor, and the ice-tank on the first floor. The room is insulated by three air spaces, divided by double tongued and grooved boarding, with felt and felt paper in between the boards. The ice tank is not insulated, and is made of iron plate $\frac{1}{8}$ in. thick; the cold which radiates from it being utilised to cool the room below. On one side there is a radiating coil which is used to supplement the cooling of the air for the storage room. The tank is filled with brine, and the ice is made in moulds, of which there are 55, each holding 30lbs. of ice. A small brine circulating pump is driven from a disc on end of machine shaft.

The ammonia expands directly through the coils and returns again to the compressors. A special feature in the arrangement of this plant is the method of securing a constant circulation of air in the cold room. The hot air rises up one side, and is cooled by contact with the coil placed there, and at once falls and passes under the ice tank, where it is still further cooled, and then returns down the opposite side of the room. The arrows on the drawing show the direction of the air circulation. By having the ice tank placed as shown, the insulating of it is unnecessary, and when the machine is stopped, there is always a large storage of cold to draw upon in the tank until the machine is again started.

The drawing (Plate XIX.) shows an Ammonia Compressor, having a cylinder 9in. bore by 18in. stroke. The inlet valve is fast on the end of the piston rod, and is utilised to drive the piston; consequently the valve must open or close before the piston can move, thus ensuring the highest mechanical efficiency. As the discharge valve covers the whole head of the cylinder, there need be no fear of working too close to it, and so all loss by clearance is avoided, as the piston can be set

to lift the head valve off its seat if necessary. To ensure the cylinder being filled with gas on the suction stroke, a number of grooves are cut in the cylinder bore, which connect the opposite ends when the piston is at the end of its stroke. This enables the machine to be run at a high piston speed without loss of efficiency.

The small Compressor (Plate XX.) has no inlet valve proper, and depends altogether on these parts to fill the cylinder. The piston then acts as the valve. Of course there is a slight loss of power through this form of construction, but simplicity is a first consideration in these small machines, and there are several of them at work giving every satisfaction.

It will be noticed that the head valves of both compressors are recessed. This is done to let the edge of the top ring of the piston pass out of the cylinder bore at end of stroke, and so prevent wearing a ridge; and it does away with the necessity for counter boring, which would mean a loss through clearance space.

The author wishes to particularly draw attention to the construction of the piston rings, as he considers that all metallic rings should be made in this way. The rings are made of cast-iron, and turned a dead fit for the cylinder, only being left large enough to run a diagonal saw-cut through, and the ends are then filled until the ring will just go into the cylinder bore. There is no spring in the ring, which is practically solid. Each ring is held in place by a steady pin let into the body of the piston, and turned a smaller diameter on the projecting part, so that it is impossible for it to work out and score the cylinder. Should the ring wear slack in time, a thin liner is inserted between the ends, so as to increase its diameter, and the liner is held in place by being bent at right angles and slipped over the steady pin. The author has made a number of steam piston rings in this way now, and they have given the greatest satisfaction. They always fit the cylinder, and bear evenly all

round, are easy and cheap to make, and have no tendency to expand and cut the cylinder like a spring ring should the lubrication be neglected. He has also had them running in an ammonia compressor for eighteen months, without the cover being taken off, which is about as severe a test as it is possible to put them to. Any one who adopts this type of piston ring once will never use any other—that is, if he can appreciate a good thing when he gets it.

Plate XXI. shows a small belt-driven refrigerator complete, having the condenser mounted on three wrought iron standards over the compressor. This condenser is of the submerged type. The liquid bottle is secured on one side of machine frame, and the expansion valve is placed on top with a pipe inside carried down to the bottom of the bottle. The castings on suction and delivery have perforated tin strainers in them to keep dirt out of the cylinder.

Plate XXII. shows a 20-ton refrigerator, which consists of two compressors, with steam cylinder placed between. Each compressor has its own separate connections, so that it can be run independent of the others at any time if necessary. A machine of this design is at work in Townsville, North Queensland, making ice and cooling water at the Lion Brewery. It was built by Mort's Dock and Engineering Company, who also built a 40-ton machine of a very similar design for the Fresh Food and Ice Co. There are now 25 of these machines of various sizes at work in the different colonies, and, although built and designed in this country, they can hold their own with any of the imported machines, both in first cost and efficiency.

When discussing Mr. Sinclair's paper, the author stated that it was impossible to produce dry air with a cold air machine; however, he has since discovered how to do so. Some six months ago the Chief Engineer of the P. and O. Co.'s *Rome*, asked his advice about a cargo of cheese which was to be shipped home in one of the cold chambers, as there had been no end of trouble, and several cargoes had been condemned on

arrival in London. Now what is required to carry cheese is a temperature of between 40 and 50 degs., with a dry atmosphere. This it was impossible to get with the ordinary method of circulating the air from the machine through the cheese, and as it was tainted by the cheese it would require to escape, or else it would spoil the meat carried in the other hold. On the author's suggestion this cheese hold was cooled by radiation, the inlet and return trunks being in the top corners on opposite sides of the hold, and were connected by ordinary galvanised down piping. This at once got over the difficulty, as the air passed through the pipes in place of coming in direct contact with the cheese, and so returned again to the machine. Any moisture in the air settled on the pipes in the form of snow, and he also supplied a sketch showing how to arrange a false ceiling under the pipes so as to catch the drips and also cause a circulation of air. Before the agents here could make up their minds about fitting the boat up, they called in the Fresh Food and Ice Company to get their opinion about it, and their engineer's report being in its favour, the hold was fitted up by Mort's Dock and Engineering Company, Ltd. This shipment of cheese brought 54s. per cwt. in London, and a similar cargo carried by the Orient boat which followed a week later brought only 44s. To give you some idea of the value of the suggestion, it may be stated that the difference in price for the *Rome's* cargo was £1,500. Now, if the cold air machine was utilized in this way, that is, to give out cold by radiation, in place of by direct contact, it would at once get over the necessity of freezing the meat cargoes. The great enemies of the chilled system are the owners and builders of cold air machines, and it is an unfortunate thing for Australia that it is so.

You have no doubt seen reports lately about this great thawing process in London, which goes to prove the fallacy of the theory always advanced that freezing meat caused the tissues to burst and so allowed all the juices to run out of it, as by this thawing process the meat comes out all right. This

thawing consists of circulating air which is gradually heated so as to absorb the moisture from the meat as it thaws.

But why should all this drying be required? The author maintains that it is absorbed from the moist air circulated by the cold air machinery on the present system of working, and which also taints the meat with any lubricant used in the expansion cylinder. It is well known how much better meat will keep in a dry atmosphere than in a moist one, irrespective of temperature, and we also know that it costs very much less to maintain a temperature of 35 to 40 deg. than one from 15 to 20 degs.

Under these circumstances it is difficult to understand how our shippers here do not insist upon better methods being adopted than those at present in use. It would appear that there is gross ignorance and neglect displayed in this matter by the engineers who have the fitting up of these boats in the old country, and, as it is of vital importance to Australia that her products be put upon the world's markets to the best advantage, the author trusts that the engineers here will take the matter up and prove what can be done, for by so doing they will benefit themselves as well as their country.

What is required in all cold rooms is an instrument which will record not only the temperature, but also the amount of moisture in the air. And the refrigerating machine or system which will maintain the required amount of moisture, at a constant temperature, best suited for the various classes of goods to be stored, is what is wanted, either on board ship or on land.

The author desires to call attention to a sample of infusorial earth which he has had tested as an insulator against charcoal and crushed pumice, and there is very little difference in the insulating properties of the three materials.

Charcoal weighs 26 lbs. per cubic foot.

Crushed pumice weighs 21 lbs. per cubic foot.

Infusorial earth, crushed, weighs 24 lbs. per cubic foot.

As this sample is taken from a local deposit of considerable extent, he thinks it should not cost any more than the other materials, and it is certainly much cleaner to handle. The following is the Government analysis:—

Moisture, at 100 C. ...	2.69	Combined water	2.79
Silica ...	90.94	Alumina	2.38
Oxide of iron28	Magnesia...	...	Trace
Manganese ...	Trace.	Sodium Chloride37

So far, in his own practice, he has made use of air space for insulating; but if this material can be supplied at a reasonable price he feels sure that there should be a large demand for it, as insulating cannot be made too good, and the less it costs the better, if at the same time it is efficient.

The object of this paper is to cause discussion by the members on the various matters relating to refrigeration, which the author has brought forward for the mutual benefit not only of the members, but also for the community at large; and so he trusts that the subject will be thoroughly well discussed, and lead to good results.

APPENDIX.

SINCE writing the foregoing paper the author has been requested by the Council to enlarge upon the remarks made by him at their last meeting in reference to the methods adopted in fitting up the various ships for the export of Australian produce to the European markets. In doing so, he wished to express his pleasure that this subject is at last exciting the attention which it certainly deserves from our members, and he trusts that it will soon lead to radical improvements on the present method.

To-day's cables announce that the first successful shipment of chilled beef has arrived in England. Now, it is only eighteen months ago that he was laughed at for advocating this system. Also, during the last few weeks, there have been the usual cables stating that fruit and cheese had arrived mouldy, and either been condemned or sold at a loss.

It pays to produce a good article if it can only be put on the market in a good condition; therefore it certainly seems very hard that our producers, after having gone to all the trouble and expense, should run such risks as they do at present of having their whole shipment spoiled by gross ignorance and neglect. At our last meeting the author blamed the shipping companies and their engineers in the old country for all the trouble; but after all, it is a matter which concerns the local engineers very much more than those on the other side. The various colonial Governments have appointed experts to show people how to make cheese and butter and grow fruit. Why should they not go further, and appoint thoroughly capable engineers to see that the holds of the various steamers are fitted up according to the most approved methods for preserving the various goods during the voyage? These engineers could also advise about machinery and methods for local requirements.

To show that it would pay to do so, he would again instance the "*Rome*," to which he referred at our last meeting. Her cargo of cheese was 150 tons, and it brought 10s. per cwt. more than the cargo shipped by the Orient Company's steamer, which followed one week after her. This gives £1,500 more cash to the consignees for this shipment. The author trusts that our local producers will note these figures, and insist that their goods be carried as they ought to be, without this great element of uncertainty which at present exists. If the cargo arrives in good condition, everything is satisfactory; but should it go bad, blame is thrown on the unfortunate grower or producer for green fruit, or bad package, or any other excuse; but the shipping company takes no risk, although in the

majority of cases they are to blame, or rather the machinery and system employed by them.

The author has prepared a drawing (Plate XXIII.), showing a section through a steamer with the holds fitted up for cold storage. The upper hold shows the usual system of arranging the air trunks adopted with the cold air machine. The cold air comes in through one trunk, and after circulating in actual contact with the goods in the hold, returns again to the machine. The lower hold shows the alteration to this system, such as was adopted on the "*Rome*." Here the opposite trunks are connected by iron pipes, through which the cold air passes and returns again to the machine. The cold is given out by radiation, and a circulation of air is obtained by means of the false ceiling below the pipes, which causes the cold air to flow down the low side, owing to its increased density, its place being filled by the warm air which rises in the centre.

Any moisture in the air at once settles on the pipes in the form of snow, and if the hold is kept closed, the air in the hold is very soon dry. Should the machine stop at any time, and the snow on the pipes begin to melt, it is at once carried away on the false ceiling, and so does not fall on the goods.

There is certainly nothing new about this system of air circulation, only it seems so simple that engineers will not believe in its efficiency, and perhaps members will be surprised to hear that only one cold room in Sydney makes use of this system.

If engineers would remember that still air is a bad conductor, and that the cooling surface of the coils will increase or decrease in capacity according to the rate at which the air passes over them, they will then see at least one of the advantages of this system. Thus, suppose the air travels past the coils at 50 feet per minute, it will then take up a certain amount of cold; but if the air travels at twice the speed it will take up very nearly twice the amount of cold in the same time, and so double the capacity of the cooling surface.

The author desires to call attention to a sample of yet another insulating material, and one which he thinks is particularly suited to refrigerator car insulation. This material is made up of certain reeds or grass which grow in the swampy ground near San Francisco, California. The weight of a square foot 1 inch thick is only 4 ounces. Messrs. Parke and Lacy are agents for this, and will be pleased to give any of the members information regarding prices, &c.
