DISCUSSION.

Mr. L. C. Auldjo, in opening the discussion, wished to thank the author for the very able manner in which he had dealt with this very interesting subject. It was one which but comparatively few of the members had had an opportunity of studying practically, and of which very little reliable data had been published.

He (the speaker) was much interested in the subject, and was in a position to speak from actual experience of both the Dry Cold Air and Ammonia systems, and he quite agreed with the author that the former would soon be a thing of the past, although it had done some very good work in the past. Why it should ever have the prefix "dry" was somewhat incomprehensible, as the air circulated by these machines was always more or less charged with moisture when the temperature was above 32° Fah., and was only comparatively dry when below this temperature. This was the reason why fruit and other articles, when exported, on reaching their destination, were found to be in a damaged or unsaleable condition, and the cause was usually attributed to over-ripeness, bad packing, or any other reason but the right one. All that was required to make fruit-exporting a success, was that the cold chambers should be supplied with *dry* air.

There was no doubt that meat could be kept for eight or ten weeks, or even longer, at a temperature of from 35° to 40° Fah. if in a dry atmosphere, and was in a better condition than if frozen. The freezing of meat was only justified by the one reason, that it could be stowed in very much less compass than if only chilled, as by the latter method space was required to allow the air to circulate round the carcasses, but this course

would eventually be universally adopted, and the sooner such was the case the better for the colonies.

It was now almost generally agreed that ammonia was the most efficient refrigerating agent known at the present time. It had been in use many years for this purpose, but had not been so successful as it should have been, in consequence of the defective material and workmanship of the machines not being able to keep it under proper control. These difficulties had of late years been gradually overcome.

Before dealing with merits of the Linde system, he wished to point out what to him appeared an error in the paper where the author stated that—" The higher the suction pressure that can be obtained, the less will be the driving pressure required, and the greater the efficiency of the machine. He (the speaker) considered that " proportionately for the work done " should be inserted after the word " required," as it was known by those conversant with the subject that more steam was required to do the work as the suction pressure increased, and was due to the machine having to handle more gas. If an indicator diagram were taken when the back pressure was at atmospheric pressure, and another when the back pressure was 15lb. above, it would be found that 100 per cent. more gas was passing through for an extra expense of 40 per cent. more power.

He was very pleased at having an opportunity of examining the Linde plant in operation at the Woolloomooloo Fish Markets, which was of high-class material and workmanship, and also a proof of the extreme care that Professor Linde had exercised in the designing of even the most insignificant details, all of which no doubt contributed to having made this system such a success.

The author had briefly referred to the brine-circulating and direct expansion systems, both of which were in general operation in America, in which country refrigerating machinery had attained considerable importance; he (the speaker) favoured the latter system where it could be utilised, and would give his reasons for so doing.

In the direct expansion system, the compressors are single acting, and usually arranged in pairs, with the steam cylinder between them, and several of his own design, on this principle, were now working very successfully.

The weak point in any ammonia compression pump was the gland, as this was the only place from which the gas could escape. If the pump was single acting, the gland had only to deal with the suction or return pressure, which ranged from 5 to 30lbs. per square inch, and an ordinary stuffing box and gland, made rather deeper than for a steam cylinder, was found to be sufficient to prevent leakage.

The suction valve was attached to the piston rod, and was utilised to drive the piston, thus ensuring prompt opening and closing at the end of the stroke ; the discharge valve covered the one end of the pump, and was lifted from its seat by the piston at the end of each discharge stroke, and replaced as the piston returned. By this means the piston worked with practically no clearance, and the full volume of gas was discharged at each stroke. The strains and wear in this type of machine being all in the one direction, it was a simple matter to regulate the lift of the head valve, and the only lubrication required was carried into the pump by the piston rod. Another point was that in the event of one of the compressors breaking down, it could be repaired while the other one was working, a feature which all engineers would appreciate.

The Linde Compressor being double-acting, the piston rod gland had to deal with the full condenser pressure of from 150 to 180 lbs. per square inch, and an ordinary stuffing box was not equal to preventing the gas from leaking, therefore a double stuffing box, with a space between the two, into which oil was constantly pumped, was required. The pressure on this oil must be greater than the condenser pressure, so that there was a leakage of oil inwards in place of gas outwards, and that a large quantity of oil must find its way into the pump was self-evident, for when the piston was on its suction stroke the pres-

sure in the pump fell to from 20 to 25lbs. per square inch, and considerable ingenuity had been displayed in the device for removing it, and after being rectified it was used over again, but these operations must result in the lossof a cert ain quantity of ammonia.

Further, the compresors being double acting, piston clearances were a necessity, and this reduced the efficiency of the machine, increased the risk of knocking the pump covers out, and, for safety, the piston speed must be lower than in the single acting machines.

Regarding the wet or dry system of working, the Americans invariably adopted the former, with a water jacket for keeping the pumps cool, and, from his own experience, he had always obtained the best results when the gas returned to the machine in a dry state.

In a recent translation by Denton, of Ledoux's work on ice-making machines, a comparison is given of the Linde wet and American dry systems, showing 1 per cent. in favour of the latter. This was not much, certainly, but a dry compressor, if thought desirable, could be worked on the wet system by flashing more gas into the coils, thus allowing it to return cold to the pump.

The coolers or condensers in all systems were very much alike, and from them the ammonia was flashed or expanded into the room coils when used on the direct expansion system. These coils could be arranged to suit particular requirements, but were usually placed under the ceiling or down the sides of the room to be cooled.

The air circulation was natural, and was obtained by having a false ceiling under the coils and a partial partition down one or both sides of the room, by which means the warm air rose up the one side and the cold descended on the other side, thus creating a most perfect and constant circulation. Too much circulation was as bad as too little, and he had seen meat, after having remained in a room from five to six weeks, present quite

a shrivelled-up appearance, in consequence of too much circulation. The false ceiling was arranged in sections to check the circulation of the air, also to enable the coils being examined or repaired without difficulty, and to catch any drip of snow that might fall from them when thawing off, a gutter with drain pipe and syphon being provided to carry off the water. A room arranged on this principle was as dry as any room worked on the Linde system, and water thrown on the floor would, in a very short time, be taken up and deposited on the coils, also when meat was taken from such a room into the warm atmosphere of a butcher's shop it maintained its dry and firm condition,

Exception had been taken by some persons to the snow which accumulated on the coils, but there was no difficulty in thawing this off by flashing hot gas through the pipes by means of a specially arranged valve. Personally he did not consider this necessary, as the snow was valuable reserve and would do useful work in cooling the room; it was only in very exceptional cases that it became necessary to thaw it off.

As a proof of the value of the snow on the coils, he knew of a room where the machine was stopped for 18 hours, during which time the temperature only rose from 34° Fah. to 42° Fah., a loss of only 4°; the insulation of the room in this case was not elaborate, as it only consisted of a 9 inch brick wall, 3 inch air-space, and a double thickness of $\frac{3}{4}$ inch tongued and grooved boards, with felt and paper between.

One of the strongest arguments advanced for the Linde and brine systems was the fact of having so much cold stored up in the brine tanks, but he considered this statement somewhat doubtful, and to explain his meaning he would cite, as an example, the Woolloomooloo Fish Markets; the machine in this case was only worked during the day, and after being stopped the fans were allowed to run for a further three hours, which he considered would exhaust all the cold stored in the brine tanks. In reference to this matter, he would like to know how long the

machine had to be in operation on starting up before the temperature of the brine was sufficiently reduced to allow of the fans being started, and air circulated between the discs.

By the direct system if the machine were stopped the accumulation of snow on the coils would prevent the temperature of the room from rising. In the brine system any moisture contained in the air was deposited on the discs and carried into the brine, consequently reducing its density, thus necessitating special arrangements and consumption of steam to evaporate this water and bring the brine up to its original density.

One of the features of the Linde system was the arrangement of revolving discs that lifted up the cold brine, and thus cooled and dried the air which was forced past them by the fans. He had had no opportunity of testing the dryness of the air supplied by this system, but he had no hesitation in saying that it would be found to contain more moisture than the air cooled by the direct expansion system with natural circulation.

He would like to know what percentage of salt was carried along with the air forced through by the fans in the Linde system, and what effect it had on delicate articles stored in the rooms.

Forced draught in the cold chambers he considered was a mistake, as it was almost impossible to divert the current in such a manner that every portion of the room received its fair share. Another objection with Linde system was the complication of blowers, brine-tanks, &c., which became necessary if there were several rooms each stored with different goods, such as meat, fish, fruit, &c., as the air to each room had to be supplied from an independent source, otherwise it would carry a flavour from one class of goods to another, and thus render them unsaleable.

On the question of efficiency, American manufacturers allowed, for the same power, that one-third more space was cooled by the direct expansion than by the brine system, or an advantage in favour of the former of 25 per cent.

He would like to know what the comparative loss was in the Linde, as the following items had to be considered: Power consumed in driving blowers, discs, and oil pump; consumption of steam in evaporating water from the brine, maintenance of extra plant, also the cost of maintenance of the coils in the brine tanks, which had a life of only from three to four years.

The various points of the Linde process, as compared with the direct expansion system, could be summed up follows:—

1st. First cost of plant much higher.
2nd. Much greater complication of parts.
3rd. Working expenses much greater.
4th. Much larger space required for plant.
5th. The life of the plant was shorter.
6th. The efficiency was at least 25 per cent. less.
7th. The goods stored were not turned out in such good condition as by the direct expansion system.

The only objection which could be brought against the direct expansion system was the risk of leakage from the coils in the storage rooms and the consequent spoiling of the goods; but this was altogether a question of design, workmanship, and material. The ordinary pressure on the coils was from 20 to 30 lbs. per square inch, and should the full condenser pressure ever be put on them, it would only be from 130 to 150 lbs. per square inch, there being practically no wear on them if once made thoroughly tight; the liability to leakage was almost nil. Should, however, a leak at any time occur, it was very easily detected by the smell; but should a leak occur in a brine tank coil, where the chances of leakage were very much greater, owing to the corrosive action of the brine, the whole of the ammonia charge might be lost before it was detected.

Mr. McAdam (a visitor) said he had now had about ten months' experience with theLinde plant at the stores of Messrs. Geddes and Co., and it was undoubtedly the best machine he had yet seen, and, so far, had not given the slightest trouble.

He had seen one of Mr. Auldjo's machines at Ultimo, and it appeared to work very well.

Mr. W. D. Cruickshank said, that so far as he could judge very few of the engineers of Sydney had had that practical experience of refrigerating machinery which would enable them to speak with authority on this important subject. Whatever their opinion might be as to the respective merits of the various systems, it was satisfactory to find that it had been taken up by the leading engineers, and this was a guarantee that it would be handled with intelligence and carried forward to a successful issue. It was a national misfortune that some of our great resources, of which we had boasted so long, had been placed in the hands of people who knew little or nothing about them. This applied, among things, to mining, land, and as some of them knew only too well, to financial matters.

It augured well for the future of the colony that such an important subject as the trade of chilled meat and other products was being dealt with by men of intellect and experience.

Mr. F. A. Franklin mentioned that he had taken out Letters Patent for an apparatus for cooling railway carriages, and he thought it would prove of practical value, as an invention closely allied to his own had been lately tested in India with great success.

Mr. A. D. Nelson informed Mr. Franklin that he would be very pleased to show his (the speaker's) designs for refrigerating appliances suitable for railway carriages, and that but a few days back he had discussed the question of its introduction with the Assistant Traffic Manager of Government Railways. He, with others, held several patents for this invention, but so far, although he spent a considerable amount of time and money on it without any success financially.,

Mr. J. Wildridge considered the question of refrigerating machinery one of paramount importance to the Colony of New South Wales, and he hoped to have the pleasure of hearing other papers read on this interesting subject.

At present we were only in our infancy in this matter. We owned 60,000,000 sheep and 1,0000,000 head of cattle, yet out of this vast number we only exported 331,000 last year. For the same period New Zealand exported 2,000,000 carcasses, and the Argentine Republic 1,250,000 carcasses. The frozen meat trade had lifted New Zealand out of the depths of financial trouble, and, if New South Wales would turn her attention to the same source of wealth the result was beyond question.

It remained with the engineers of the colony to take this question of refrigeration up in earnest and carry it forward upon successful lines.

Mr. Sinclair, in reply to the discussion, said it was disappointing to find only one member of the association who had spoken on the subject from a technical point of view. In writing the paper he had kept purposely away from anything like a one-sided description of a particular machine, and had hoped that this would have led to a freer discussion. However, as the discussion was apparently to be narrowed down to a comparison between two machines, he would, therefore, only have one member's remarks to reply to.

Mr. Auldjo had said that meat would keep from eight to ten weeks in a dry atmosphere, and the speaker would like to know whether Mr. Auldjo had ever tried that at a temperature above 32° Fah., as he (the speaker) took it this was the temperature required. He had carried out several experiments, and had data of others, and had no longer record than for seven weeks, although he quite believed it would keep longer if due attention was paid to the circulation of the air.

It was also mentioned that the air circulation could be too strong, and that, with the ordinary brine pipe system, meat would keep as well as in a system with an efficient air circulation. This statement was entirely erroneous and hardly needed an explanation, as most members would know that air of itself was one of the most sluggish things to deal with, and unless some methods were adopted for keeping it moving, the air in

corners and other places would hardly move at all. Anyone could test this for himself in a closed room, by carefully watching the direction of the air currents. As further proof that Mr, Auldjo was entirely wrong in the matter, it must be mentioned that the Fresh Food and Ice Company, where they had the brine pipe and direct expansion systems in the rooms, had lately fitted a fan which circulated the air back and forward in the rooms so as to overcome the evil effects of its sluggishness, and, as a matter of fact, it would be quite impossible to keep meat for any length of time at a higher temperature than 32° Fah., unless there was a strong circulation of air. In experiments which were conducted with the Haslam, De La Vergne, and Linde systems, the latter with the air circulation—a quantity of fresh meat was put into rooms operated on by each machine, in which the temperature was below 32°Fah., and a tainted carcass of meat was also put in among the fresh meat, and the rooms then closed up. After the machines had been allowed to run from 3 to 4 days, the rooms were opened, and it was found that with the Haslam the whole of the meat had become tainted; in the De La Vergne case some was good and some was tainted; and in the Linde room, with the air circulation, there was no taint discoverable except in the one tainted carcass which had been put in, and that this particular carcass had not during the interval got any the worse, showing that there must be a great benefit in the circulation of the air.

The cooling portion of the machine was not the whole feature of the Linde system, nor were the methods of air cooling at J. H. Geddes and Co. or the Fish Markets the only ones adopted by the Linde Company, for in designing an installation on the Linde system they were not bound down to these particular methods, but might utilise the brine pipes and direct expansion systems; in fact, as mentioned in the paper, each had its own peculiar advantages.

It had also been stated in the criticism that "there was no advantage in the storage of cold in the brine tanks, and that

there was loss in running the fan engines after the main engine had stopped for an hour or two, because the machine would have to cool down the brine next morning." Here, again, Mr. Auldjo was entirely wrong, as he overlooked the fact that the machine was designed, as all good machines should be, a little larger than was actually necessary for the work to be done, and during the day the machine was able to reduce the temperature of the brine somewhat below what was actually required for the cooling in the rooms. On stopping the machine at night the fan engines were kept running for an hour or so, until the temperature of the brine might rise to that which was suitable for the cooling to be done in the rooms, so that the machine started away doing efficient work at once. There was thus no loss, but rather an undoubted advantage, which could not be obtained with the direct expansion system.

It was, of course, absurd to talk about the air being so strong as to shrivel up the meat, as no man in charge of a room would allow this to take place. In arranging the shoot for the circulation of air in Linde rooms, a sufficient number of these with sliding doors were constructed in such a manner that the engineer in charge could work them in such a manner that the air would not impinge directly on the carcasses, but be diverted among and through the carcasses hanging up.

It was also claimed that a mistake had been made in writing the paper, by stating the higher the suction pressure the greater the efficiency. Mr. Auldjo surely had omitted to take into account the fact that the higher the suction pressure the greater the density of the gas, and consequently the greater quantity of ammonia which was circulated, thus increasing the work to be done by the machine more than the actual pressure of the gas, and called for more work. This, it was thought, did not require an explanation to technical people.

It would appear that Mr. Auldjo had failed to understand the action of the Linde compressor, because he was entirely in error in referring to the oil arrangements at the gland. The oil

pump as fitted on the gland of a Linde Compressor did not work under pressure, nor was the oil pumped into the stuffing-box. The oil which might pass into a Linde compressor was almost infinitesimal, and the fitting of an oil rectifier was simply the carrying out of a precaution which all good makers would adopt. Most members would understand it was almost impossible to prevent some oil being carried into the cylinder on the piston rod. Even in a steam engine under a high pressure and temperature some oil got inside, and in the case of the Linde compressor, to prevent any evil effects from this quantity, the oil cock and rectifier were fitted on the larger machines. The gland was so constructed that there were two glands. Oil was pumped into the outside gland, being pumped simply into it at the top and falling into a catch to be re-pumped over again. There was then the main gland with about four inches of special packing next to a lantern, which was in direct communication with the suction pipes of the refrigerator, then another set of packing, so that practically no oil could get into the compressor; in fact, so small was the amount used in a 50-ton machine that about a pint would be all that would be required per week. There was no necessity for oil, as the saturated gas employed in the compressor more than sufficiently lubricated it.

It was also mentioned that the air would get charged with salt and be carried into the rooms from off the brine. This was absurd, and Mr Auldjo, who made the statement towards the end of his remarks, did so inconsistently with the beginning of his remarks, where he mentioned, with correctness, that air was practically dry at a freezing temperature, so that he had already answered his own criticism, because the air in passing over the discs of the Linde refrigerator, became reduced down to such a temperature that it would contain less moisture than it had when first coming in contact with the discs, so that in leaving the discs it must have deposited moisture, and not taken it up as he seemed to think it would. In fact, in no case had there been any trace of salt carried over from the discs.

The lifetime of the machines was difficult to arrive at, for although some had been at work for over 14 years they showed no signs of giving out, and the efficiency of a Linde machine could be shown to be greater than any other, as mentioned in the end of the paper, actual work being done of refrigerating equal to 150 tons of ice made per 24 hours, on a consumption of 5 tons of coal, was an efficiency which equalled anything which had yet been done in refrigerating.

In concluding, he wished to say that he would be pleased if those, who are interested in the manufacture of refrigerating machines, would come forward and read a paper before the Engineering Association, describing them, and he would do his best to discuss them in a fair manner.