

# Production of Low Temperature and Refrigeration—II\*

## The First International Congress of Refrigerative Industries

By L. Marchis

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COLD-STORAGE rooms can be cooled by different methods. In the abattoirs one of the most common methods is to direct dry cold air into the preserving rooms. This air is brought down to a low temperature and sufficiently dried out either by passing over a cold saline solution (spray refrigerator) or by circulation in contact with a coil acting as refrigerant (dry refrigerator). The choice of the type of refrigerator, as M. Barrier has said, is a question of circumstances. Even in the case of meat preservation it makes a difference whether the meat is frozen, that is to say, immunized, or whether it is merely refrigerated (brought to a temperature between zero and 4 deg. C.), where it is more particularly subject to the action of harmful germs. It also makes a difference whether it is a military storehouse, where the meat is only taken out for immediate consumption and the refrigerating chambers are closed up to the time the food is removed, or whether it is a commercial storehouse, where the meat is taken in or brought out daily and is more or less exposed to the air, and where the frequent entries of the workmen carry in noxious gases and impurities. In this latter case the spray evaporator appears preferable on account of the purification and asepsis of the air of the chambers. In the first case, however, the dry evaporator, on account of its greater simplicity and the lowering of the concentration of the brine, presents some real advantages.

It is not sufficient only to produce cold; the cold must be conserved. For this reason the insulation from heat should be considered a question of the first importance in the construction of a cold store. The proper conservation of the contents demands that the temperature of the storage chambers should be as constant as possible. The question of insulating materials, therefore, has been a subject of particular attention by the congress.

A good heat insulator should fulfill the following conditions:

(1) It should be a very poor conductor of heat. If a very thin layer of the insulator is sufficient to obtain proper insulation, the result is both economy of space and economy of the insulating material.

(2) It should have a low specific gravity. This condition is important in insulation installment aboard ship. Its importance is not less, however, in cold-storage warehouses, because of the reduction of cost in transporting it to the work and the possibility of economy in the cost of construction by making possible the construction of very lightly built buildings.

(3) The insulator should be free from odor, and not subject to decomposition, even when moist. This condition is all important in the construction of cold-storage houses designed for the preservation of food stuffs. These absorb very easily bad odors arising from the fermentation of insulating material and become unfit for consumption. For this reason such substances as rice husks, cut straw, oat husks, or cork mixtures made with fermentable substances, such as casein, should be rejected.

(4) The insulating material should absorb to as great a degree as possible the bad odors which are set free in refrigerating chambers and render them less harmful. From this point of view peat or turf sometimes is of great service.

(5) The insulating material should not be hygroscopic. It should not absorb and retain moisture, which is capable of causing it to lose its poor conducting qualities. This is the case with mineral wool, a sort of fibrous glass made out of the slag of blast furnaces.

(6) When by reason of circumstances, such as the breaking of a water tube, etc., an insulating material is wet it should be able to dry out easily and regain its property of poor conduction.

(7) The insulating substances should not be attractive to parasites, mice, rats, etc., nor afford a good culture ground for microbes.

(8) The insulation material should be incombustible, or at least should not propagate combustion started at any point of the mass. A certain number of cork mixtures possess this property; for example, the mixture of cork and pitch. M. Brüll has shown to the congress several different types of entirely fire-proof cork mixtures.

(9) When once placed in the packing which makes up the insulating mat, either inside or outside of the

wall, the insulating material should not settle and thus produce continuous voids in the insulation. The different wood carbons included under the term charcoal are liable to this disadvantage, when they are used without special precautions.

(10) The insulating materials should not attack the wood, iron, or masonry which comes in contact with them.

(11) The insulating materials should be very easy to work and to apply to the walls of the storage chambers and should possess a certain resistance to bending or crushing.

(12) The insulation should not lose its qualities with time.

It is difficult enough to find an insulation that combines all these qualities. Cork either in granular form or agglomerated, however, is at present the most employed. M. Pasquay has informed the congress that silk waste protected by an impermeable envelope forms an excellent insulation.

The knowledge of the co-efficient of conduction of insulators is of great importance with regard to the thickness which the protecting linings must be to bring down the loss of cold within a certain limit. Different methods have been proposed for determining this. In one of these, the two faces of a plate of the substance are maintained constantly at different temperatures and the quantity of heat passing through the plate in a certain time determined. This may be accurately measured by weighing the amount of ice melted. This is the principle of the well-known physical method called the wall method. It may perhaps be remarked that those who have used this method have not taken precautions against the loss of heat at the edges of the experimental plates. They have not made use of the method of using a guard ring in the form originated by M. Berget.

The other methods for measuring the conductivity are based on Forbes' method. This consists of heating one of the extremities of a long slender bar of the material to be tested. When the system has attained an equilibrium the temperature is taken at different points along the bar, and by the formulæ of Fourier the coefficient of conductivity can be calculated, if that of emission is known. This latter may be that of a coating or a very thin layer of metal, with which the bar has been previously provided.

A variation of the Forbes method is that of the sectional bar of Lodge. This bar is composed of three sections; the first and the third are of a metal the conductivity of which is known. The second is made up of the material to be tested. The end of the first section is heated and the progression of temperature when equilibrium is established is measured. The general formula for uniform movement of heat in an elongated bar makes possible the calculation of the conductivity of the material composing the second section.

It is this method that M. Desvignes has used in determining the conductivity of several insulating substances. He has worked out the technique so that it can be easily employed in the refrigerating industry.

Some of the results obtained by this method are as follows:

### Coefficient of Conductibility.

	Calories for Meter-Degree- Hour.
Cork .....	0.05 to 0.014
Granular cork .....	.068
Cork with casein binder.....	.069
Cork with odorless pitch binder.....	.087
Cork with sodium silicate binder.....	.067
Cork mixed with infusorial earth and calcined .....	.089

As M. Desvignes has remarked, it would perhaps be imprudent to take these figures as a basis for the calculation of loss in a cold-storage plant. The specimens which were used in the tests were picked and were perfectly dry. The given coefficients should be increased not less than 20 per cent. In the application to certain materials some account should be taken of the method of joining. Thus in a partition of cork bricks pointed by cement mortar, where the joints represent in very careful work about 15 per cent of the total volume, the coefficient of conductivity of the brick itself, referred to the total surface of the partition, should be almost doubled. These considerations will show what a difficult question even the approximate calculation of the heating effect due to the walls of the refrigerator may be. The second

section has withheld opinion on this question, therefore, and adopted the following resolutions:

(1) That study and research shall be undertaken in the technical schools and laboratories to determine, either by known apparatus or that which shall be subsequently devised, the specific constants of the different insulators which are practically utilizable in the refrigerating industry.

(2) That the characteristic properties and constants to be determined, by account being taken in each case of the degree of humidity, in the following:

The density to be employed.  
The coefficient of conductivity.  
The resistance to flexure.  
The resistance to crushing.  
The power of expelling water.  
The power of absorbing odors.  
The incombustibility.

These constants should be determined under conditions of temperature and thickness of material applicable to the refrigerating industry.

(3) That the second section shall call especial attention to the study of the conductivity as a function of temperature, thickness, degree of humidity, and of other causes capable of influencing the conductivity; for example, the state of division of the material necessary to assure a certain insulation.

(4) That the section requests that the International Bureau of the Refrigeration Congresses, the organization of which has been planned, shall constitute an international commission charged with taking up the study of methods of testing, and co-ordinating, with a view to establishing methods and obtaining comparable results, any researches which are made, in which otherwise the investigators would have their usual latitude.

(5) That it shall be of interest to submit the question of securing uniformity of such methods to the next congress if the researches concerned are sufficiently advanced.

Official instruction up to the present time has been somewhat neglectful of the refrigerating industry. The present-day developments of this industry render more and more necessary the education of engineers who are specialists in this line. For this reason the second section has also enacted the following resolutions:

(1) That theoretical and professional instruction, applied to different present-day phases of the industry of refrigeration, and with a view to new applications, shall be inaugurated in the laboratories and higher technical schools of all countries, this course of instruction to be followed by detailed practical study of important refrigerating establishments and rational experimentation with the machinery there used, under the direction of specialists.

(2) That in order that the necessary scientific equipment and experimental material and the cost of the experiments may be provided for, this instruction should be subsidized by the governments, municipalities, chambers of commerce, industrial societies, agricultural syndicates, and all other individually or collectively interested in the refrigeration industry.

(3) That the general work and the results of researches carried out in these laboratories and schools, as well as those of associations of engineers and manufacturers who are working in refrigeration, should be submitted to the permanent International Bureau and co-ordinated by it, in order that it may publish periodically a bibliographical index, and may compare the results and derive all the useful indications and conclusions possible from them for presentation to the next Congress of Refrigeration for its examination.

### III. THE CONSERVATION OF PERISHABLE ARTICLES.

We have now found out how to produce and maintain a low temperature in cold stores. It remains now to study the methods of construction and use of the cold storage rooms, and the rules permitting of the conservation of different sorts of articles. These questions have been the subject of numerous reports and discussions which it would take too much time to digest here. I will, therefore, only indicate some of the most important conclusions on these questions.

The cold air of rooms in a cold storage house should circulate as little as possible from one chamber to another, in order that the odors of certain preserved products may not affect others. In particular, if the refrigeration of the cold store is accomplished

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by means of air coolers it is absolutely necessary to have a special air cooler for each series of chambers designed to contain a particular product.

The articles to be preserved should not pass suddenly from the ordinary temperature to the temperature of the storage rooms, or vice versa; in other words, the refrigeration should be progressive. Thus, in abattoirs the warm meat coming from the slaughter rooms is transported by means of an overhead rail into a cold anteroom kept at a temperature of 7 deg. to 8 deg. C. There it undergoes for about twenty-four hours a preliminary cooling, at the termination of which it is carried into the rooms where the air is maintained at a temperature of 0 deg. to 4 deg. C. and a humidity lower than 75 per cent. Salting and treatment of the intestines, the hides, etc., should be carried on in rooms entirely separate from the foregoing, which should be confined solely to the preservation of fresh meat.

The question of the preservation of horticultural products is one of the most difficult in the application of cold to food stuffs. The preservation of apples and pears has been studied in detail in the United States by Mr. G. H. Powell. He has placed results before the congress which demonstrate with the greatest clearness the effect of placing in the refrigerating chamber freshly picked fruits in comparison with those that have been exposed to the air several days after picking. It is necessary to place the sound fruit in the cold fruit chamber soon after it is gathered. Other circumstances also influence its keeping qualities. It is much better if the fruit comes from older trees; it also appears that sandy soils are not favorable to preservation.

Fruits with a thick skin keep much better than those with an easily ruptured covering. The peach, in particular, is one of the most difficult of fruits to preserve. M. Loiseau, horticulturalist at Montreuil, however, has succeeded in keeping this delicate fruit more than a month. According to him, it is especially necessary to maintain the temperature as constant as possible, varying not more than from 0 deg. to 1 deg. C.

Among the recent applications of low temperatures which have been pointed out may be mentioned the use of artificial cold in the manufacture of paraffin and viscose.

Crude petroleum generally contains from 5 to 6 per cent of paraffin in solution. To obtain this paraffin, the petroleum is distilled until it contains from 10 to 25 per cent of paraffin. Then by lowering the temperature of this liquid (paraffin oil) to a degree which varies according to the quality from +16 deg. to -18 deg. C., paraffin is obtained which separates from the oil in the form of crystals which can be separated from the oil by filtration under pressure. The application of refrigerating machines to this purpose makes possible the treatment at one time of large quantities of petroleum. As an example the works of Pardubitz in Bohemia are equipped with machines of a capacity of a million frigories, and pro-

duce annually about four million (kilograms) of paraffin.

The artificial silk called viscose is made by drawing through very fine openings a thick solution of cellulose obtained with alkaline or sulpho-alkaline solvents (caustic soda and carbon disulphide). To accomplish this successfully the solution must be allowed to stand in vessels cooled artificially to +2 deg. C. for a month or two before spinning. The solution is then sufficiently pure to be decanted and spun with success.

#### IV. TRANSPORTATION WITH REFRIGERATION.

The question of transportation of products under refrigerating conditions is one which has justly been a subject of careful consideration by transportation companies both on land and sea.

The refrigerator cars or trains are of several types.

(1) The refrigerator train, consisting of a group of cars, one of which has no capacity for storage, but contains a complete refrigeration plant which feeds the other cars, with which it is connected by suitable piping.

The impossibility of breaking up such a train by uncoupling the cars from each other limits the practical application of these trains, however, except in a few instances. This system was experimented with in 1905 in the transportation of Russian butter from Siberia (from Kourgane to Riga at a mean speed of 15 to 16 kilometers per hour). The cost of the refrigeration, the temperature of the butter being maintained at a mean of 5.5 deg. C., was as high as 0.117 franc per kilogram of butter per day, exclusive of the cost of the refrigerator plant.

In this category must be classified the Russian refrigerator car of the Silitch system. It is mounted on four sets of wheels on boggy trucks and is of the following dimensions: Length, 8 meters; width, 3 meters; height, 2.65 meters; capacity, 120 cubic meters. It is divided into six compartments: Two in the center contain the refrigerating apparatus, while the other four may be charged with goods to be refrigerated.

(2) The lack of elasticity of the refrigerator trains has been remedied by the use of refrigerator or insulated cars. The operation of these cars necessitates, at the starting point, an insulation composed of a refrigerating machine and an apparatus which forces a blast of cold air into the body of the car before and after charging. When the interior temperature of the car has been reduced to the requisite degree, the cold air is shut off and the car hermetically sealed. In Springfield, Mo., there is an installation of this kind capable of cooling 40 cars of bananas at one time to 15 deg. C.

With this type of cars may be compared those where the low temperature is obtained by the previous cooling of brine contained in coils about the roof or walls of the car. The thermo-regulator car of the Mak-soutoff system belongs to this type. The saline solution, which cools the air to about 5 deg. C., must be cooled every two days, necessitating refrigerating stations every five or six hundred kilometers.

(3) Besides the tributary cars of the refrigerator trains and those depending on an installation at the point of departure, there are the self-cooling cars; that is to say, cars themselves containing cold-producing agents. These are the most universally used, both in Europe and America.

These may be divided into two great classes: Cars cooled by ice and cars cooled by evaporation of a liquefied gas.

In the ice-cooled cars the low temperature is obtained by means of ice disposed in compartments along the roof, as exemplified in the cars of the Société des Magasins et Transports frigorifiques de France, or along the walls of the car, as exemplified in the American cars and cars of the Moscow-Kazan Railroad. The plan of closing the body of the car completely from the outside air has been generally abandoned. The ice-cooled cars now in use are usually provided with an arrangement which draws in air from the outside and sends it, after cooling it by contact with the ice, to renew the air in the car. The free space remaining for this disposition of the merchandise is about 30 to 40 cubic feet, allowing the introduction of a load of from six to ten tons, according to the nature of the products. By an ice consumption of an average of 400 kilograms per day a temperature varying between 8 deg. and 4 deg. C. is obtained. The degree of humidity is high, however.

The cars cooled by evaporation of a liquid gas (in this case ammonia) carry on the outside two cylindrical tanks of liquid ammonia. This fluid is sent by regulating cocks into coils placed at the two ends of the car on the inside. The ammonia evaporates and absorbs heat, the ammonia gas produced dissolving in water in a tank placed under the car. One car of this variety was experimented with in 1905 in the transportation of butter from Siberia. The cost of refrigeration for butter maintained at a temperature of from 4 deg. to 5 deg. C. was as high as 0.068 franc per kilogram of butter per day.

In the ice-cooled cars of various types experimented with by the same Russian commission the total cost of refrigeration, including all expenses (ice consumption and charging, installation of ice houses, and operation of cars), amounted to 0.009 franc per kilogram of butter.

As the short summary I have just made shows, the First International Congress of Refrigeration has examined with care most of the scientific and technical problems which exist in the refrigerating industry. If it has solved any of these problems it has indicated in the form of resolutions a very great number of others which up to the present have been only incompletely worked out. The next international congress, which will be held in Vienna in 1910, will not be inferior to that at Paris, and will bring us, let it be hoped, in the scientific phase, to some accurate knowledge of the properties of bodies at low temperatures, and in the industrial phase to a uniformity of units of measure and methods of testing machines and insulating material.

### Mica Production in India

By E. HARRAN

INDIA is, at the present time, the source of a little over half the world's supply of mica. During the five years, 1904 to 1908, inclusive, the quantity exported rose from 1,825 hundredweights to 41,256 hundredweights, and the value from \$415,915 to \$1,237,680.

Although a mica-producing country itself, the United States is India's best customer; and of the total quantity of mica produced in the Orient, seventy-five per cent goes to Great Britain, which is the center of distribution for the States and Germany, the latter country taking the next largest quantity after the former.

The mica raised in India is the variety known as "mucovite," and is found in large pegmatite veins traversing mica schists in various parts of the peninsula, principally the east and south. The two principal centers of production are the Nellore district in the Madras presidency and a tract of land about twelve miles broad and sixty miles long which stretches across the junction of the Gaya, Hazaribagh, and Monghyr districts in Bengal. In the latter of the two areas mentioned the mica industry is a very old-established one, and can be traced back for several centuries. In the former, however, the mining of the mineral was only started very recently, consequent on the discovery of rich deposits by prospectors employed by European capital. In this district the deposits occur in pegmatite veins in granite, in micaceous gneiss, in hornblende, and mica schists. The strata vary from a few inches to several hundred feet in thickness. These pegmatite veins (or "dikes" as they are sometimes called) consist of three essential minerals—quartz, felspar, and mica—in varying proportions. In appearance they bear a resemblance to coarse granite, and the best mica is usually found in those veins in which the constituent minerals have crystallized in large

masses. Where felspar and quartz are present in small masses, the accompanying mica is usually of little value.

The mica found adjacent to the surface is almost always soft and cracked, quite useless for commercial purposes other than manufacture into the substance known as "micanitte." Clearer and better colored mica is reached lower down in the solid ground; and as the tunnel reaches greater depths, where the rock formation is harder and more uniform, the mineral extracted improves in quality. It is stated that in the United States no more than five per cent of the total yield of the mica mines is sheet mica. In India, however, it is calculated that an average of ten per cent can be cut into plates, the balance being either wasted or converted, in part, into micanitte. General experience shows that the mica mostly demanded from India by America is of the green and ruby colored varieties in sheets of three square inches and upward. India actually produces the mineral in green, ruby, yellow, white, and amber colors. These are divided into clear and spotted or stained varieties, the clear ruby and clear green being the most valuable, fetching as they do, at present, prices between \$7,200 and \$9,720 a ton. Of the common varieties, all sized sheets are readily obtainable at prices ranging from 18 cents a pound for 2 by 3 inches to \$1.71 and 12 cents a pound for the larger sheets. The presence of any metallic insertions in the mineral renders it useless for insulating electrical purposes (for which the bulk of it is required) generally. For these specific purposes the sheets must be flexible, free from cracks, capable of withstanding high pressure, and non-conducting. The Indian mines produce mica, conforming to this last specification, in large quantities.

The mica mines in Bengal are still worked in a very primitive way, in fact, in exactly the same method as they were worked centuries ago, when the principal use the mineral was put to was to fill the apertures of

windows for which we now use glass. The mica which generally occurs at the exposed outcrop, on the hill face, of a pegmatite vein, is followed from "book" to "book" by underhand stopping, which results in the production of holes, some of which are now five hundred feet deep. The resultant material excavated, consisting of mica, earth, rock, etc., is brought to the surface by a string of native coolies, being passed in cane baskets from one to another up rudely constructed bamboo ladders. During the rainy season work is completely stopped for some three months, say June, July, and August. At other times, when rain has occurred during the night, the start of work in the morning is delayed for an hour or more while the resultant accumulation of water is being baled out by hand. In Nellore and Mysore in South India, mining operations are carried out in a much more up-to-date manner, as a result of their more recent origin and the attention that European capitalists are directing to them.

### "Dessau" Gas for Balloons

It is but a short time since publicity was first given to the invention of a new method of producing a gas specially adapted for filling balloons. The process was developed at the Deutsche Continental Gas Gesellschaft of Dessau, and the name "Dessau" Gas has accordingly been applied to the product. A report on some of the more recent developments in the new method is given by A. Sander in "Die Umschau." The process consists in subjecting ordinary illuminating gas to a high temperature, whereby the hydrocarbons present are for the most part split up into hydrogen and carbon. The reaction is one of that important class known to the chemist as "contact actions," that is to say, it is greatly assisted by the presence of solid material offering a large surface to the heated gas.

Accordingly in carrying out the process the gas