

Making Ice With Heat

Refrigeration Without Power for Home Use

By Frank C. Perkins

A UNIQUE and interesting type of automatic iceless refrigerator of English design for use in residences and hotels, is shown in the accompanying diagrams, Figs. 3, 4 and 5 and in illustration Fig. 1, the former showing the details of construction and method of operation in using electricity, gas or oil for supplying the necessary heat.

A jungle type of ice maker pictured in Fig. 2, has

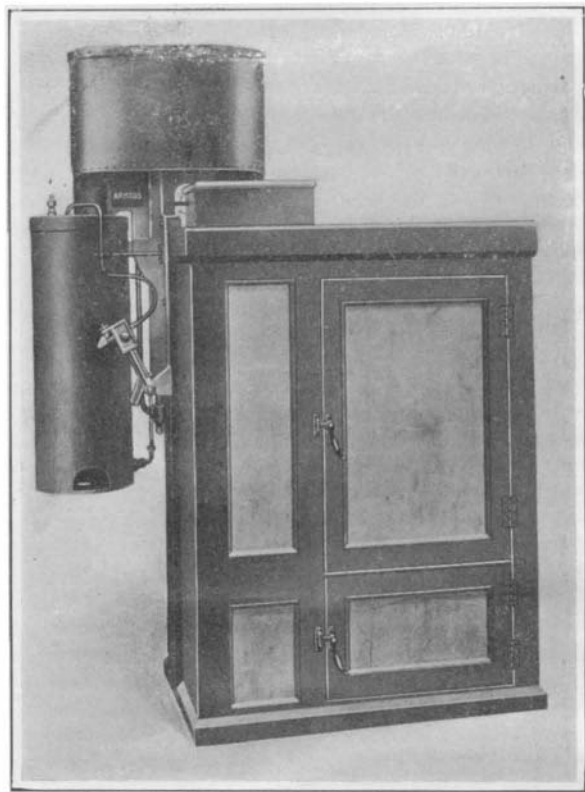


Fig. 1.—Iceless Portable Refrigerator for the Home.

been designed especially for the use of tropical expeditions. It makes 7 to 10 pounds of ice in two to three hours and is operated by an oil burner or wood fire, and is portable and absolutely "fool-proof."

The apparatus during its heat stage has an oil burner under the generator, while during the cooling stage, the burner is removed and a cooling tank and insulated ice mold are in position. One type of this apparatus has an insulated brine tank for ice making. Its capacity is from 1 to 1½ hundredweight per twenty-four hours according to external conditions, gas or electricity supplying the heat.

The illustration Fig. 1 shows the vertical type of self-contained semi-automatic refrigerator and cabinet for country houses. The cooling power of the apparatus is equal to that of about 2 hundredweight of ice per twenty-four hours. The paneled tank cabinet measures approximately four feet by three feet and five feet high and it is lined with marble and fitted with marble shelves and solid nickel ice mold. The walls are insulated and about six inches thick and the available capacity is about 23 cubic feet. An automatic switch cuts off the current instead of a gas valve where electric current is used.

One of the large self-contained English refrigerating equipment is provided with a small room having a cool-

ing power equal to that of about five hundredweights of ice per twenty-four hours. The dimensions of the apparatus are 4 feet by 3 feet 8 inches by 3 feet 2 inches high, and the room measures 5 feet by 4 feet by 6 feet high over all.

Where hotels have their own electric light plant either electricity or steam can be used for supplying the necessary heat for operating this refrigerator.

There is no doubt that a refrigerator which would require no ice, salt, chemicals, skilled attention, repairs, renewals or recharging would be a boon to the housewife and to the hotel manager. There is no question but that a simple appliance for artificially producing cold for a variety of purposes is a growing necessity. There are many refrigerating machines on the market, and for use in very large cold storage or ice-making installations, where skilled engineers are always in attendance, these machines have been found eminently suitable; but where such skilled attention is not available, they are certain to get out of order sooner or later. For this reason, and because they all require some form of motive power, they have not found great favor with those requiring cold only on a moderate or small scale. It is for this class of users that the new iceless refrigerator was specially designed.

The refrigerator is constructed in various sizes for making from a few pounds of ice up to one ton per day, or for cooling from 1 to 10,000 cubic feet of storage space without motive power and without skilled attention. It is operated by the direct application of heat from any available source, such as gas, steam, oil, wood, coal or electricity. Such is the simplicity of the principle that no running machinery, glands, or regulating valves are employed and as there are no moving parts to wear or get out of order, no repairs are required.

The apparatus is noiseless and vibrationless. It is constructed to maintain any required temperature, down to many degrees below freezing point, according to requirements specified when the apparatus is ordered. It can be adapted for any purpose requiring low temperatures and among the common uses to which it is put are, the cooling of safes, rooms and stores and cold storage for freezing meat, poultry, game and fish; also for making ices or ice cream and water cooling. The equipment is of great value in cooling milk, cream, butter and other perishable provisions, as well as for drying air by freezing out the moisture.

The refrigerator is operated on what is commonly known as the "Ammonia Absorption" principle, and differs from all others in the fact that it is hermetically sealed.

Diagram Fig. 3 shows that the essential parts of the machine comprise a combined absorber and generator (or still), a condenser, and a receiver. The generator A, which contains a strong mixture of ammonia and water, is heated by a gas burner B, electric heating wires on bottom of generator or other suitable means. The ammonia is thereby distilled and passing through the pipe C, which is surrounded by water in the tank T, it is cooled and condensed. The resulting liquid (pure anhydrous ammonia) runs by gravity into the receiver R. This process is continued until all the available ammonia has been distilled and collected in the receiver. At this state there is left in the generator a hot and very weak liquor (practically pure water). The gen-

erator is then cooled by admitting cold water to the jacket J. This creates a partial vacuum, causing the anhydrous ammonia to evaporate very rapidly. At the same time the weak liquor is cooled and becomes

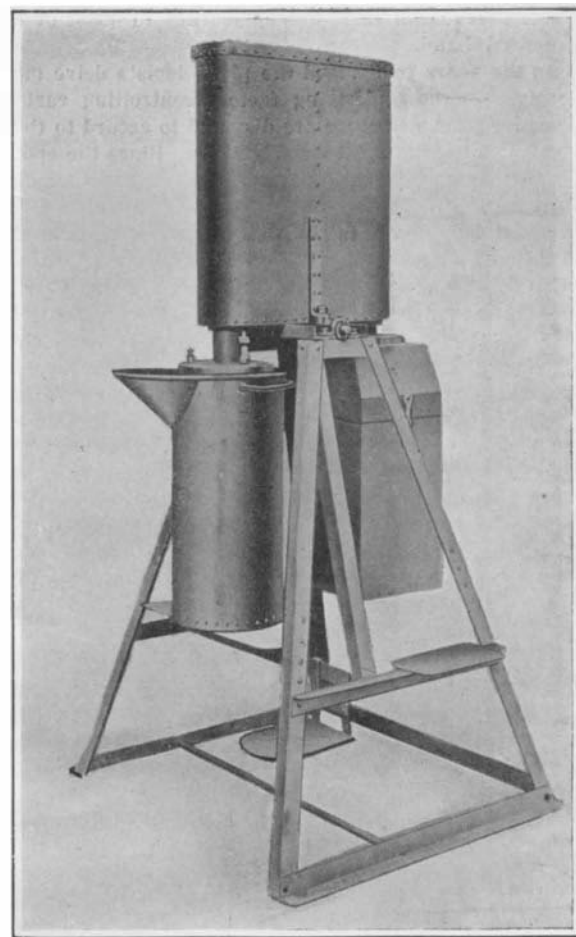


Fig. 2.—A Simple Portable Absorption Ice-making Machine for Tropical Expeditions.

"greedy" for ammonia. It therefore absorbs the vapor resulting from the evaporation of the liquid in the receiver as quickly as it is formed.

The evaporation of the ammonia in the receiver continues until the whole of the liquid has evaporated and been re-absorbed by the liquor in the absorber (the vessel which previously acted as the generator). The liquid in evaporating takes up a large amount of latent heat and consequently the receiver becomes intensely cold and cools all surrounding objects.

When all the liquid has evaporated from the receiver the same state of affairs exists in the apparatus as before the heating was begun. The process can therefore be started again and the same cycle of operations can be repeated an unlimited number of times. The ammonia is not altered or weakened by the process and as there is no possibility of escape, the same charge of liquor will last indefinitely.

To increase the evaporation surface and hasten the evaporation, the receiver often has a coil of pipe connected with it. In many cases this coil is immersed in a tank of brine or other non-freezing solution as noted in diagram Fig. 4. This brine acts as a store for a large quantity of cold and maintains a uniform temperature during times when the apparatus is not being worked.

From these drawings it will be seen that the machine is operated by alternately heating and cooling the vessel A (Fig. 4) which acts alternately as a generator and an absorber. There is an automatic electric

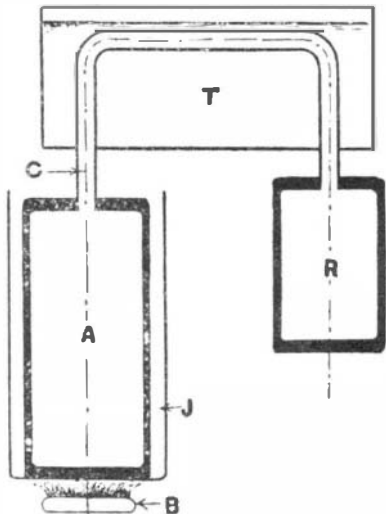


Fig. 3

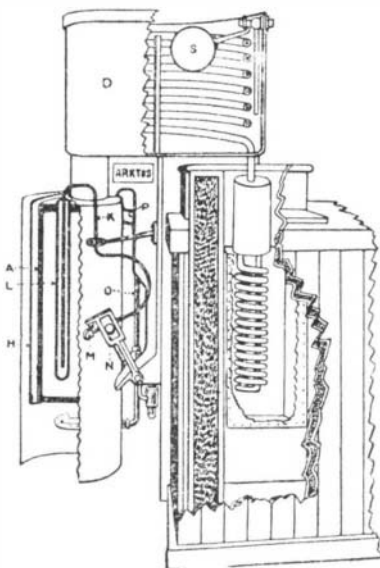


Fig. 4

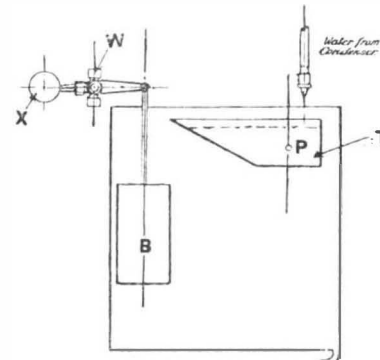


Fig. 5

Principle of Operation and Details of Construction of the Iceless Refrigerator.

switch or gas valve device for turning off the heat and admitting water to the cooling jacket. The tube *K* is filled with water and sealed. The curved portion is flattened. The straight end of it dips into the well *L*, which is surrounded by the liquid in *A*. As the temperature of the latter rises, the water in the tube *K*, becomes heated and expands. Owing to this expansion the curved part of the tube tends to straighten out more and more as the temperature rises. At the end of the tube is a catch *M*, against which rests the weighted lever *N*. The catch is so adjusted that at the required temperature the lever is released and falls.

The lever is connected with the electric switch or gas tap and a three-way water cock, and when it falls, it either breaks the electric circuit or turns out the gas, leaving only a small pilot light burning, and admits water through pipe *O*, from the tank *D* to the jacket *H*. The water fills the jacket and overflows through the spout *P*, and is either carried away to waste or collected in a tank for future use. The lever of the water in *D* is maintained by the ball-cock *S*, connected to the water supply.

When the semi-automatic machine is employed the apparatus is re-started by raising the lever *N*, which turns on the gas or electric current and cuts off the water supply from tank *D*, to jacket *H*, and drains the last. There is no communication between the well *L*, and the generator *A*. When other sources of heat than gas are used, the arrangement is modified but is substantially the same. The machine is semi-automatic and the heating has to be started by hand each time.

A completely automatic device is shown in diagram Fig. 5. This refrigerator will go on working without attention so long as the water is running. Part of the water overflowing from the condenser is allowed to run into the tipping tank *T*, pivoted at *P*. When this tank receives a certain volume, it overbalances and pours its contents into the bucket *B*, which drops and operates the water and gas cock *W* or electric switch.

The tipping tank when empty immediately returns to its normal position. In the bucket *B*, is a small hole so that while the tipping tank is refilling, the bucket empties itself and the counterweight *X* raises it into position again. The electric switch or gas cock is fitted with a ratchet and pawl device so that the rising of the bucket does not affect the cock or switch. One

stroke of the bucket turns the gas or electric current off and the water on, and the next turns the gas or electric current on and the water off, and the gas relights from a small by-pass.

The flow of water into the tipping tank is so adjusted that the tank fills up to the necessary level to overbalance it in the same length of time as is required for heating or cooling the generator. This automatic gear can be placed in any convenient position.

The water required for operating the machine is not contaminated in any way but is slightly warmed; therefore in cases where the cost of water is an item for consideration, it can be collected in a tank and used for other purposes after having passed through the machine. Where boilers are installed, this water can be used economically as feed water the refrigerator acting as a feed water heater. If desired, the same quantity of water can be used over and over again for this apparatus.

The cost of operating the machine is very low. The actual working cost largely depends, of course, on the source of heat available. For small apparatus, gas is the most frequently used, it will therefore be well to give an example of the cost of operation by this means.

A small iceless refrigerator providing cooling power equal to that of a hundredweight of ice, consumes about 250 cubic feet of gas. Thus, where gas costs two shillings and six-pence (62 cents) per 1,000 cubic feet, a small machine provides cooling power at a cost equivalent to buying ice at 15 cents per hundredweight delivered.

The larger the refrigerator the more economical is the working. Where steam at a pressure of not less than 50 pounds per square inch is available, the cost of working the machine is so trifling as to be almost negligible. With an efficient boiler, cold equivalent to the melting of half a ton of ice can be produced per hundredweight of coal consumed.

In any room cooled by this machine, the air is kept perfectly dry and the damp mustiness which is inseparable from ice-cooled chambers is entirely avoided. It is this dampness which causes meat and other articles of food to deteriorate, lose their flavor and become unfit for use in a very short time.

In case the machine is required for ice making only, it is fitted to an insulated tank containing some non-

freezing solution such as strong brine. The machine keeps this 10 deg. to 20 deg. Fahr. below freezing point and in it are placed cans with the water to be frozen.

Blocks of ice can be made of any desired shape or size, and if distilled water is used, perfectly clear ice can be produced. If the water is not distilled, minute bubbles of air contained in the water are frozen into the ice and give it a white, opaque appearance.

For use in making ice cream, an ordinary ice cream freezer is immersed in an insulated tank containing brine which is kept at 10 deg. to 15 deg. Fahr. below freezing point by means of this machine.

It is of great value for use in the dairy, as, to keep milk perfectly fresh it should be cooled to between 35 deg. and 40 deg. Fahr. either immediately that it comes from the farm or after pasteurization. Artificial cooling is absolutely necessary in order to prevent milk from turning sour in hot weather.

For this purpose the machine is of the greatest possible importance. In most cases the milk is first passed over a cooler or "refrigerator" through which cold water is allowed to run. This reduces the temperature to between 60 deg. and 70 deg. Fahr. The milk is then passed over another refrigerator, through which brine at 20 deg. to 30 deg. Fahr. is circulated, reducing the temperature of the milk to about 35 deg. Fahr.

The brine is stored in an insulated tank and is kept cool by the machine. It is circulated through the refrigerator by means of a small pump. Where a plentiful supply of water is not available the whole of the cooling can be done with the brine. In many cases it is desirable to store the cooled milk in a cold room and when this is required the installation is so arranged that the brine tank is situated in the storage room and keeps it at a low temperature.

The most economical method of operating the machine is by a steam coil, and as most dairies are fitted with steam boilers, the installation of the machine provides means of cooling milk efficiently, cheaply and in by far the most simple and cleanly manner.

Air can be dried by being passed over a cold surface which causes the moisture to condense. Thus, if damp air is drawn or forced over a coil of refrigerating pipe, the moisture is deposited on the pipe and either drips off into a suitable receptacle or forms a layer of frost on the pipe, leaving the air perfectly dry.

On the Devitrification of Silica Glass*

By Heat and by Radium Rays.

By Sir William Crookes, O.M., For.Sec.R.S.

THE use of apparatus blown and worked from melted quartz is now almost universal in chemical laboratories, especially where temperatures are required above the heat at which glass softens.

When working at fairly high temperatures I was inconvenienced by the leakage of air through silica glass.¹ The apparatus (Fig. 1) was in the form of a perfectly clear and transparent tube, 1 centimeter diameter and 20 centimeters long, with a bulb $2\frac{1}{2}$ centimeters diameter blown on the end. The other end of the silica tube was drawn out for connecting with the pump and sealing. It was exhausted to a high vacuum and heated to near redness along its whole length to remove any gas that might be condensed on the walls—it was then sealed off.

The tube was placed bulb uppermost in an electric resistance furnace in such a position that the bulb would be at the point of greatest heat, the lower part of the tube remaining comparatively cool; it was kept at a temperature of 1,300 degrees for twenty hours, at the end of which time the silica tube was removed from the furnace. The long continued high temperature caused the bulb and the upper part of the tube to devitrify, and become white and translucent like frosted glass. The sealed-off end was carefully opened, and it was apparent that the inrush of air was by no means so strong as it

* A paper read before the Royal Society, March 7, 1912, and published in *The Chemical News*.

¹ Jaquerod and Perrot have shown that fused silica is permeable to helium and hydrogen at a low red heat. (*Comptes Rendus*, cxxxix., 789, Nov., 1904; and cxliv., 135, Jan., 1907).

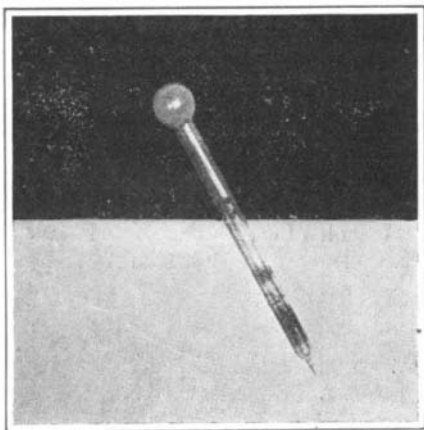


Fig. 1.—Silica Glass Tube which Showed Leakage on Heating.

would have been had the vacuum been as perfect as it was when the tube was sealed up.

This looked as if there had been a considerable amount of leakage through the devitrified bulb, and I tried a test

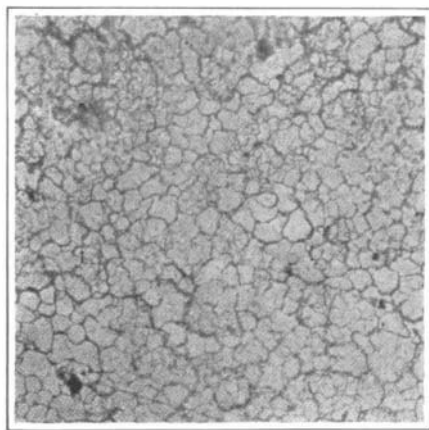


Fig. 2.—Devitrification of Silica Glass Produced by Heat (Microphotograph).

experiment. The tube was again attached to the Sprengel pump, and exhausted to as high a point as possible. During the progress of exhaustion, when the pump was rattling with the characteristic sound of a high vacuum, a large and powerful Bunsen flame was used to heat the bulb. Not the least difference in the sound could be distinguished. When the vacuum was at its highest the tube was sealed off, it was put into the electric furnace, and kept at a temperature of 1,300 degrees for eleven hours. After cooling the end of the tube was broken off under mercury. The mercury rose, but did not fill the bulb. The amount that entered was measured, and found to be 17.75 centimeters. Afterward the tube and bulb were completely filled with mercury, the whole again measured, and the capacity of tube and bulb was found to be 19.25 centimeters, showing that 1.5 centimeters of gas, or 7.79 per cent of the tube's capacity, had leaked through the devitrified silica in eleven hours at 1,300 degrees.

To ascertain if air would leak through the devitrified silica at the ordinary temperature a fac-simile of tube and bulb was made in glass, and the two tubes were simultaneously exhausted on the pump. They were both heated, allowed to cool, and sealed off at the same time. The silica and glass tubes were put in the balance case and kept there for some time. When they were both at uniform temperature the silica tube was weighed. The tube and weights not being moved in the meantime,

weighings were taken hourly, the balance being untouched during the intervals. In eighteen hours the weight increased 0.048 grain.

After the silica and glass tubes had been at rest for some days they were opened simultaneously under mercury. The glass tube filled at once, only a microscopic bubble of air remained at the top. The silica tube, on the contrary, only partially filled, and on measuring the mercury that entered it amounted to 10.15 centimeters, the capacity of the tube being 19 centimeters. Therefore in a few days air to the amount of 46.58 per cent of the total capacity of the apparatus had leaked in.

A micro-photograph was taken of the surface of the devitrified silica bulb (Fig. 2). It showed a surface cracked all over into the appearance of cells, and on closer examination many of the cells showed decided hexagonal outline.

I observed a similar appearance a few years ago when a silica dish, originally clear and transparent as glass, was used for evaporating down about 100 milligrammes of pure radium bromide. Patches appeared on the bottom having a dull roughened appearance, and on examination under the microscope the appearance was very similar to the surface of the devitrified silica bulb just described (Fig. 3). The appearances are so alike that it is legitimate to assume that the same cause had been at work, and that devitrification of the surface is produced both by exposure to a very high and long continued temperature and to the contact with a radium salt at a temperature of boiling water. I have not seen this effect on the surface of glass or silica bottles in which radium salts have been kept in the cold for some years.

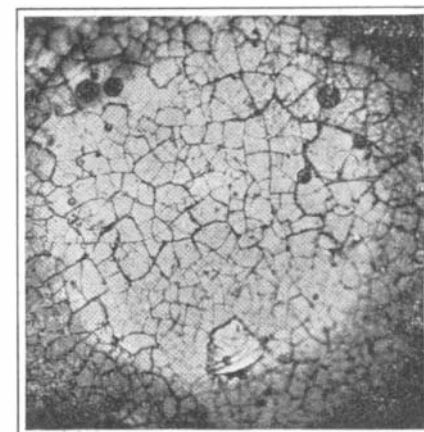


Fig. 3.—Devitrification of Silica Glass Produced by Radium at Boiling Temperature.