on roof tops at sundown, figure 1-1. The night breezes evaporated the moisture which seeped through the jars, making the water inside the jars cooler. The Greeks and Romans had snow brought down from mountain tops to cone-shaped pits which were lined with straw and branches and then covered with a thatched roof.

As civilization advanced, people learned how to cool beverages and foods for enjoyment. This knowledge increased the use of ice and snow.

B. EARLY EXPERIMENTS WITH FOOD PRESERVATION

Some of the earliest recorded experiments with food preservation date back to 1626 when Francis Bacon attempted to preserve a chicken by stuffing it with snow. In 1683, Anton van Leeuwenhoek opened up a whole new scientific world. This Dutchman invented a microscope and discovered that a clear crystal of water contains millions of living organisms. Today, these are known as microbes.

Scientists studied these microbes and found that rapid multiplication took place in warm, moist conditions such as provided in food materials. This multiplication of microbes was soon recognized as the major cause of food spoilage. By contrast, the same types of microbes in temperatures of 50°F or less did not multiply at all.

Through these scientific studies, it became apparent that fresh foods could be safely preserved in temperatures of 50°F or less. It was now possible to preserve food by drying, smoking, spicing, salting or cooling.

Since little was known about how to create temperatures low enough to freeze water into ice, ice was transported from its source by Clipper ships to the principal cities of the world, figure 1-2.

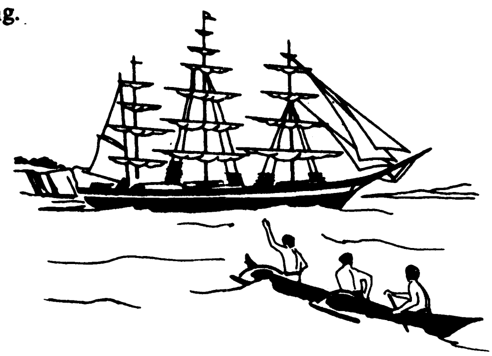

Fig. 1-2 Transporting ice by Clipper ship

EXPERIMENTERS OF ICE-MAKING MACHINES

One of the first patents (1834) for a practical ice-making machine was granted to Jacob Perkins, an American engineer living in London. These machines were used successfully in meat-packing plants. Within the next fifty years ice-makers were produced in the United States, France and Germany, figure 1-3. In this period about 3,000 patents on refrigeration systems had been applied for in the United States.

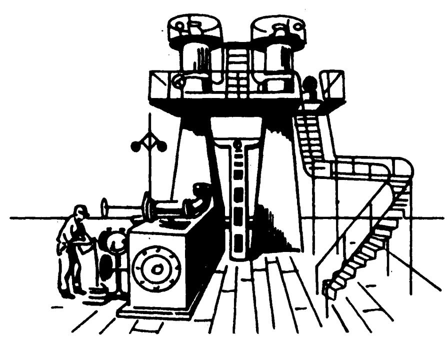

Fig. 1-3 Early artificial ice-making machine

While progress was made in producing ice by artificial means, nearly everyone favored natural ice, believing that artificial ice was unhealthful. Eventually, this superstition was overcome because: (1) artificial ice

In the pharmaceutical field, refrigerating units are used to store, process and test penicillin, aureomycin, and many other chemical and biological materials.

Refrigeration, as a quick cooling process, speeds production, cuts moisture losses in foods and reduces mold. The large frozen food industries, and others engaged in the preparation, marketing and purchasing of foods all depend on refrigeration.

Important studies of the exact nature of electron movement are now being undertaken through a process which demands that the material being studied be subjected to the lowest possible temperature, a temperature at which electron movement slows down to the point where it may be observed.

Steels that must be aged to retain shape and dimensional accuracy are now refrigerated under new and rapid deep-freezing treatments. In other ways, aluminum is kept from aging too rapidly.

In these and other industrial applications, refrigeration units capable of reducing temperatures to as low as −150°F are used in metalworking plants, tool shops and in metallurgical laboratories for heat-treating and hardening operations, figure 1-6.

The list of applications is without end for the principle of refrigeration has progressed as far since the crude experiment of Francis Bacon as the principle of heat in several thousand years.

As scientists, technicians and craftspersons experiment at still lower and colder temperatures approaching −273°C (−460°F), the new science of *cryogenics* (refrigerants) will reveal materials in a state that is neither a solid, liquid or a gas.

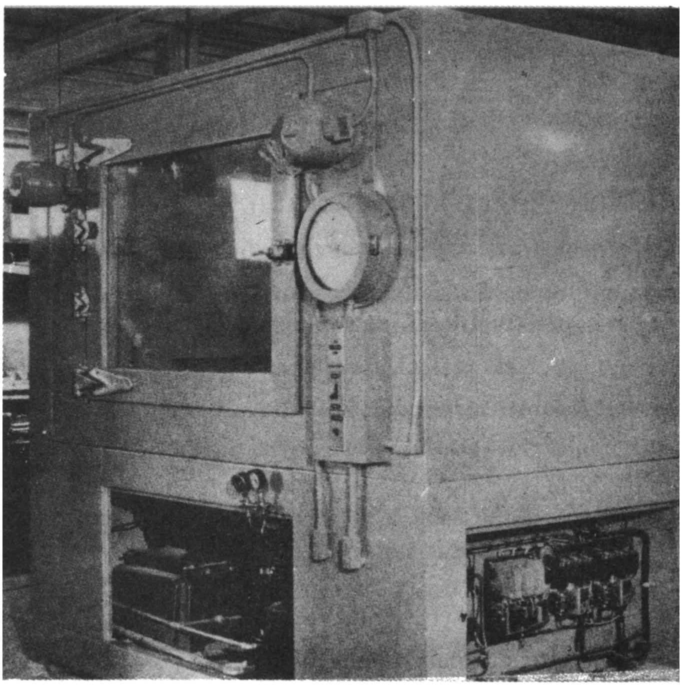

Fig. 1-6 Industrial refrigeration unit capable of −150° F temperature
(Courtesy of York Corporation)

All matter, regardless of its state, is composed of small parts (particles) called *molecules.* What happens to the speed, freedom (or position) and number of these molecules determines: (1) the state of the material, (2) its temperature, and (3) its effect upon other parts or mechanisms of which it may be a part.

THE STRUCTURE OF MATTER

Each molecule of matter is actually the smallest particle of a material which retains all the properties of the original material. For example, if a grain of salt were divided in two, and each subsequent particle again divided (and the process were continued as finely as possible) the smallest stable particle having all the properties of salt would be a molecule of salt. The word *stable* means that a molecule is satisfied to remain as it is.

As fine as the molecule may seem to be from this description each molecule is in itself made up of even smaller particles of matter. These particles are known as atoms. An *atom* is the smallest particle of matter having the properties of the material of which it is composed. By contrast, the atoms within a molecule are not always stable. Instead, atoms have a tendency to join up with atoms of other substances forming new and different molecules and substances.

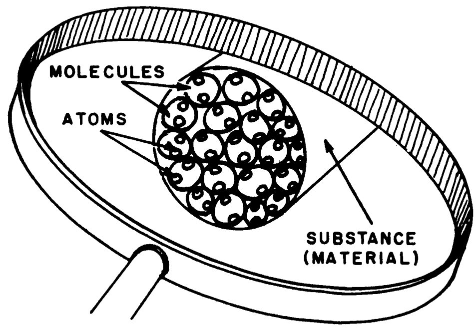

Fig. 3-2 The structure of matter

ARRANGEMENT AND MOVEMENT OF MOLECULES

The molecules in a given material are all alike. Different materials have different molecules. The characteristics and properties of different materials depend upon the nature and arrangement of the molecules, figure 3-3. While millions upon millions of molecules form a material, the behavior of each molecule depends largely upon the material (substance) of which the molecule is composed.

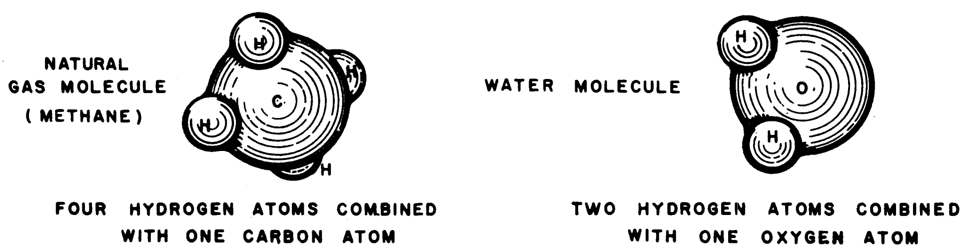

Fig. 3-3 Molecules

cooling capacity for this unit which, when it drops back, has a range from 28,000 to 30,000 Btuh.

In order to avoid *top freezing*, excessive trailer breathing, and cycling between low cooling and low heating, one manufacturer has a cylinder-unloading feature option. When less cooling is required, four of the six compressor cylinders stop pumping refrigerant gas and the cooling capacity is reduced to a 10,000-14,000 Btuh range. This range is close to the load requirement in the previous example. Also, there is a rise in evaporator coil temperature, tending to reduce both top freezing and excessive dehydration of the cargo. Cylinder unloading also reduces the diesel load, requiring less fuel.

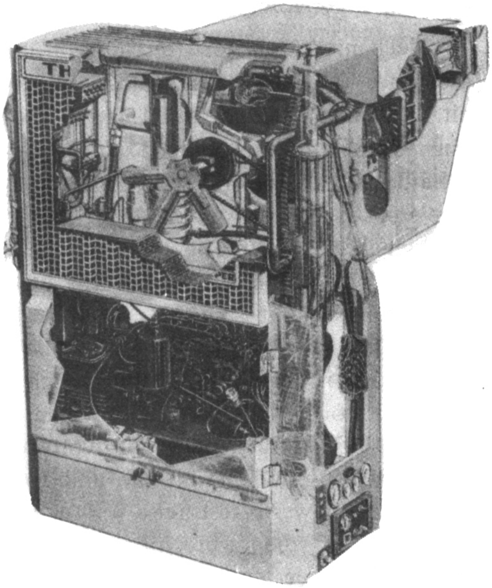

Fig. 24-9 Cutaway showing mechanical components of a large nosemount unit *(Courtesy of Thermo King Corp.)*

Figure 24-9 shows the mechanical components for one of the large nosemount units. The diesel is coupled directly to the six cylinder compressor. The compressor is fitted with two-ring pistons which reduce blow-by and high oil circulation, especially under operating conditions requiring very low pressure on the suction stroke.

Additional refrigeration components are mounted in the upper half of the housing directly over the engine and compressor. The evaporator extends through the mounting port into the cargo compartment. A portion of the condenser is shown in front of the tubular radiator that serves the diesel engine.

Automatic evaporator coil defrosting is initiated by sensing the pressure drop across the coil with a differential air switch. Manual defrosting may be started by

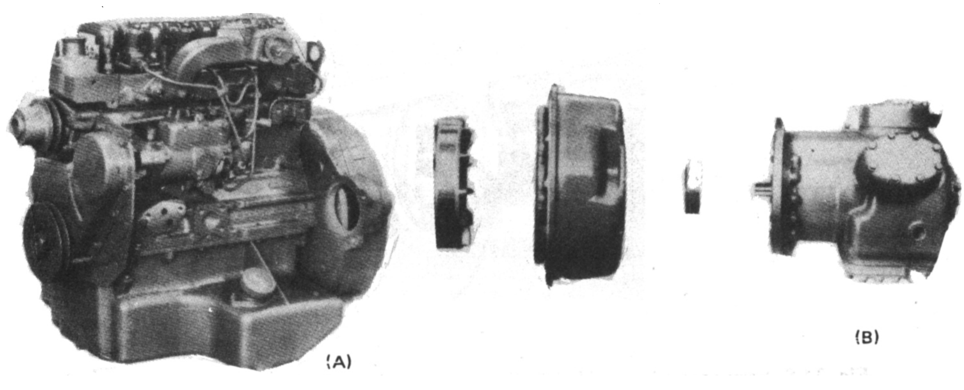

Fig. 24-10 Rotating permanent magnet-type generator *(Courtesy Carrier Transicold Co.)*