tages over the fast gig elevator. While a freight elevator is not so fast, one man can handle the whole operation of elevating, stacking and unstacking. Such an elevator can be relied upon to handle 50 tons per 8 hr man day.

The doors into ice storages should be as few and as small as possible. One entrance door from the platform of 42 in. width is advisable; it should be kept locked except when machinery is being passed through. One ice-passing door for a 50 to 60 ton daily capacity plant is usually adequate. An 18 × 48 in. vestibule type door is becoming general. Light hollow core plywood doors appear successful in use.

ICE UTILITIES

The modern character of the ice business involves other ice operations aside from the manufacture of block ice. *Scoring, cubing, sizing*, and packaging machines for automatic vending stations are developments which are extending rapidly and are worthy of careful consideration. Such operations require enlargement of usual day storages.

The definite trend of ice sales today is in small sizes, both cubes and sized ice. Sized ice is particularly suitable for vegetable preservation by direct contact. In many localities 50 to 60 percent of ice sales is in cubes and sized ice. The trend is definitely to the packaging of this ice in *wet strength* paper bags besides other containers of canvas, barrels, wooden tubs and boxes. Paper containers have capacities of 4, 7½, 10, 30 and 50 lb. The smaller sizes are used in automatic coin vending machines, located in refrigerated boxes at the plant or remote points.

Dairies are adopting canvas ⅜ in. cotton mesh bags of 20 lb crushed ice capacity for cooling by drippage stacked milk cases in trucks. The bags are laundered regularly.

This trend for packaged ice calls for considerable additional day storage by 100 to 200 percent.

The transportation of paper bagged ice for distribution to the trade and automatic vending stations is best served in refrigerated trucks. The trucks are refrigerated by means of ice, ice and salt and with mechanical refrigeration units.

Scoring machines which mark the ice block with 1 to 1½ in. deep saw cuts for exact weights of 25, 50 and 100 lb are offered in a variety of designs. In general they can score about 5 blocks per min. In the typical day storage these machines have the disadvantage of occupying too much space and entailing problems of snow removal.

The desirable location for a scoring machine appears to be in the ice tank room close to the ice dump, with an ice chain conveyor feeding the machine, from whence the ice slides into the storage. However, one difficulty with this location is the rusting of the machines.

ICE CUBE MANUFACTURE

The use of solid, clear ice cubes, particularly for beverage purposes, has developed into an extensive business.

Cubes prepared from block ice are sawed out of the whole by a variety of semi-automatic and full automatic machines which handle ice block weights of 25, 50, 75, 100, 300 and 400 lb. These machines consist of one or two sets of power operated circular gang saws operating in two planes successively and a third large power saw for cutting the indented cubes free of the block ice. In all instances the ice cake is fed to, and directed through, the saws. In the larger cube units, 10½ to 300 lb blocks per hour are processed. Cube dimensions are a full 1⅜ in. along the edges. Snow and end piece losses of the processing are about 30 percent. This refrigeration wastage is recovered in part by the use of this waste ice for ammonia or water sub-cooling purposes. Cubes are delivered to their ultimate destination principally in wet strength sealed paper bags of 4 to 50 lb capacity. Delivery is also made in canvas bushel containers or wooden boxes (50 or 100 lbs contents) and in wooden barrels.

Sizing machines, which have come into increasing general use, consist of an ice crusher delivering ice into an overhead rotating screen, which screens the broken pieces into bins containing desired sizes. Means are now available for weighing and filling paper bags and other ice containers with sized ice and cubes.

Packaged ice is ice cut into 25 and 50 lb pieces by saw or electric resistance hot wires, and then automatically wrapped and sealed in suitable paper wrapping. Packages must be kept refrigerated and dry while delivered to automatic vending machines over a scattered territory. These boxes or stations must be kept refrigerated continuously, for any dampness of the package renders the vending apparatus inoperative.

Vegetable icing is accomplished by *portable slingers*, which are combination units of a block ice crusher, blower and a crude centrifugal pump that hurls this ice through a 4 in., 30 ft long, rubber or metal hose and sprays this ice over vegetable products loaded in railroad cars and in trucks.

CHAPTER 67

SKATING RINKS

Applications; Studios, Ice Reviews, Portable Rinks; Refrigeration Requirements; Type of Enclosure; Selection of Equipment; Skating Surface Temperature, Temperature Control, Rink Piping, Brine Heating for De-icing, Cold Brine Accumulators; General Rink Floor Design; Building of Ice Surface; Fog and Drip; Variable Design Factors; Plastic Rink Piping; Portable Refrigerating Units

ANY artificially frozen sheet of ice is referred to in this chapter as a *skating rink*, whether located outdoors or enclosed in a building. This artificial freezing is usually accomplished by using ammonia, Refrigerant 12, 22, or 114 as the primary refrigerant, and calcium chloride as the secondary refrigerant. Glycol and methanol have also been used as secondary refrigerants particularly in curling rinks.

Although a considerable number of direct-expansion ammonia and a few direct-expansion Refrigerant 12 rinks have been installed and have operated more or less satisfactorily, the accepted and best proven practice is to use brine as the freezing medium. The ASA B9.1 and the Canadian B52.1 Refrigeration Safety Codes now prohibit the use of direct-expansion ammonia as the freezing medium in rink piping in buildings of public occupancy. However, the restrictions against the use of direct expansion ammonia in open air rinks have been removed by some local authorities. A large number of rinks have, consequently, been (and are being) installed for use of ammonia because of lower first cost and much lower operating cost due to 40 percent smaller connected motor horsepower.

APPLICATIONS

Most rinks are used for a variety of sports, but some are constructed for a specific purpose only, and therefore are of definite dimensions. The usual size of rinks for the following sports are:

Hockey. Minimum size of ice sheet required is 80 × 180 ft. A good size is 85 × 185 ft, but the ideal size is 85 × 200 ft.

Curling. The regulation size of each curling sheet is 14 × 138 ft to the *hack*, and 146 ft total ice sheet length.

Figure skating. These rinks are designed to accommodate the desired number of *patches*, each approximately 16 ft in diameter.

Public skating. Public skating rinks are sized to suit the locality. In general 30 sq ft is allowed for each person actually skating.

Public Auditoriums and Coliseums

In the United States, Canada, and elsewhere, ice floors installed in public auditoriums, field houses, etc., are used alternately for ice sports, ice shows and carnivals, public and private figure skating as well as for exhibits, rodeos, boxing, circuses, dancing, conventions, tennis meets, etc. When required, ice can be frozen within 12 to 16 hr.

STUDIOS, ICE REVIEWS, PORTABLE RINKS

Refrigeration Requirements

The amount of refrigeration required varies with several factors such as application (hockey, public skating, etc.); light or heavy service; length of the desired ice season; type of enclosure; latitude in which the rink is located. Sun effect, rain, snow and wind must be considered for outdoor rinks.

It is usual practice in the refrigeration industry to provide one ton of ice machine capacity to freeze and maintain a certain number of square feet of rink surface. These values vary over a fairly wide range, depending on all the factors involved. For the general range of application, the following square feet per ton apply:

Hockey rinks	250 to 335
Hockey rinks (indoor) with light public skating	250 to 350
Heavy public *skating*	200 to 300
Curling rinks	300 to 450
All-year figure skating	200 to 300
Sport *arenas* (indoor)	125 to 150
Open air rinks	90 to 350

The higher values of square feet per ton (minimum tonnage) are based on an average maximum 45 F wet-bulb temperature indoors during the day, and no more than 1½ in. thick ice over pipes embedded in concrete for rinks of average usage in the Great Lakes area.

Ice skating has moved into the Southern States where the ice may be used during periods of high ambient temperatures. The arena should then be air conditioned, which is now common practice, and suitable allowance should be made for the higher ambient temperatures.

Koeninger in 1934 in Germany carried out extensive tests in open air skating rinks on the effect of air motion, air temperature, relative humidity and transmission of heat through the ground on the capacity of the refrigerating system. Two representative curves are reproduced here.

Fig. 1 shows the relationship between air velocity and film coefficient (conductance) for dry air in the lower part of the graph. The upper part gives the total heat load based on ambient air temperature and 85 percent rh and an ice temperature of 28½ F.

Fig. 2 allows the computation of the additional heat load due to relative humidities from 60 to 90 percent in terms of percent of the previously computed dry air heat load.

The heat loads so computed are in Btu per hour per square foot and, when multiplied by the total surface area, represent the total heat load in Btu per hour required to maintain the ice sheet under design conditions. The actual compressor displacement and brake horsepower required will depend on the brine temperature.

The heat gain through the uninsulated floor amounts to approximately 5 to 6 percent of the total heat gain of the system when it is first placed in operation, but as the mass under the piping is reduced in temperature, this gain is gradually reduced until it becomes negligible.

It is extremely difficult to arrive at the actual refrigeration capacity for a skating rink on a purely theoretical basis, due