temperature and a rink surface averaging one inch thick, a thermostat bulb temperature is satisfactory at 26 F for hockey, 27 F for figure skating; and 28 F for public skating.

Temperature Control

Modern refrigerating equipment in a skating rink, as now installed, is usually completely automatic. The starting and stopping of the compressor motors and auxiliaries is governed by a thermostat located either in the brine line or in the ice surface. The thermostat should have no more than a 2 F deg (plus or minus one degree) differential, and be of a type that is easily adjustable to compensate for rink usage and ice thickness.

In multi-compressor installations a two-step thermostat is used with a time lag between steps. Motorized controls are used for more than two compressors.

Rink Piping

Many methods have been used to convey the freezing medium in an ice surface, and a number of patents have been granted, but all of them eventually have been abandoned. Today, standard mild steel or wrought iron pipe is used as well as polyethylene and API plastic pipe. The size of the pipe depends on the length of run of pipe. Small rinks can use ¾ in. pipe. Larger rinks use 1 in. and 1¼ in. pipe. For medium service 1¼ in. pipe may be used in hairpin loops on rinks up to 185 ft long, or a total run up to 370 ft. The length of the single feed is determined by the quantity of brine to be pumped through each circuit to maintain the recommended brine temperature range and the permissible brine pressure drop. The usual pressure drop through the rink piping is 6 to 8 psi with brine flow velocities in the range of 130 to 150 fpm.

When 1¼-in. piping is used it should not be placed on more than 4½ in. centers as a decrease in freezing rate between piping becomes noticeable. The actual piping centers are determined from the refrigeration load, although when using 1¼ in. pipe, 4 in. centers are usually sufficiently close. On heavy duty or long rinks about 200 ft long, it may be desirable to place feed and return headers at opposite ends of the rink, or hairpin coils may be arranged to run the width of the rink with brine headers extending down one side.

Present practice is to weld all piping and headers, eliminating all threaded joints wherever possible. Welding may be by arc or oxyacetylene method, but care should be taken to use the correct welding rod.

Recently, in some curling rink installations, aluminum tubing has been used successfully with circulated glycol brine. Aluminum tubing must not come in contact with materials which may set up corrosion in the aluminum.

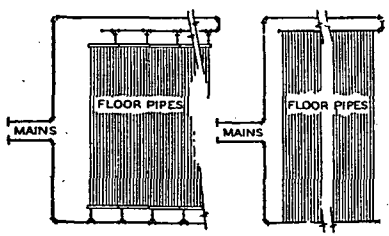

Fig. 4 .... Balanced Flow System of Distribution

Piping supports. When rink surface is of the open type with sand fill under and between the piping, the piping can rest upon pressure creosoted sleepers.

Use of pipe separators or pipe rests having a steel rod for supporting the piping is preferable to laying the piping directly on the creosoted sleepers because they minimize corrosion at the point of contact of pipe to sleeper.

If the rink surface is of the permanent floor type, a chair type support resting on steel plates or creosoted sleepers is often used. T-iron supports are not recommended.

Brine headers. Many systems of brine distribution used in the past proved failures because designers attempted to distribute the brine by a system of branch feeds, expansion loops, and valves, and because the numerous threaded connections on valves, tees, elbows, air vents, etc. failed through early corrosion. Uniform brine distribution was often upset due to the use of brine circulating pumps of too small capacity.

Good design requires a balanced system of feed and return headers, designed and sized for low velocity and copious brine flow. This makes it unnecessary to control brine distribution with valve adjustment because an even brine flow through all rink pipes is always assured. The return brine header should be placed higher than the feed header, with one or two air vents to keep the rink piping free of air.

The balanced flow diagram (Fig. 4) is one of several good designs. With this flow system there is less restriction to brine flow at any point and the distribution is uniform regardless of the quantity of brine circulated. The loss in brine pressure is less, and the friction head generally is lower. However, it is sometimes desirable to have valves for installation and operation. Should it be impracticable to have the return brine header higher than the feed header, an air evacuating system may be required.

To allow for contraction and expansion due to variation in seasonal temperatures, precaution should be taken to allow for the free movement of the rink piping as well as the brine headers.

Brine. To minimize corrosion of the $CaCl_2$ brine, the system must be kept free of air. The brine should be tested for pH, so that the recommended value of 6.8 to 7.2 can always be maintained.

Expansion Tank

A closed system of brine distribution should always be used. A balance or expansion tank should be installed and should be sized for brine volume in system and temperature rise of brine.

Brine Heating for De-icing

For auditorium sports arenas, provision must be made for de-icing the rink surface in less than 4 hr. In practice, the floor is heated to about 50 F so that the ice can be peeled off by breaking the bond between floor and ice, and can be broken and removed with power tractors.

A standard all-steel steam water heater can be used with passes so arranged that all the brine can be pumped through the heater, with the brine flowing in the tubes and the steam in the shell.

Approximately 350 Btu per hr heating capacity per sq ft of rink surface is recommended for heating the brine in the cooling system in order to warm the floor and break the ice bond.

Cold Brine Accumulators

In sport arena rinks designed for frequent de-icing, ice may be required every other day, and ½ in. ice or more must

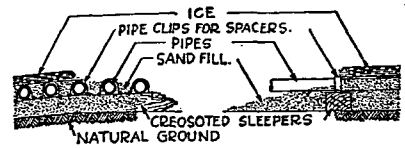

Fig. 5 .... Open or Sand Fill Floor

be frozen in 12 hr to allow for the ice to temper before skating on following day. In such cases, it is advisable to provide a cold brine accumulator to keep the size of the refrigerating equipment and connected horsepower within reasonable limits. This accumulator is a brine storage tank bypassed from the heating cycle so that, when refrigeration on the ice surface is not required, a large volume of brine may be cooled to approximately −25 F and be ready to be pumped into the rink piping as soon as it is needed.

The cold brine accumulator should store sufficient brine to cool the entire brine volume in the cooling system from 65 to 0 F. This cold brine tank usually holds more than three times the volume of the cooling system's brine charge.

GENERAL RINK FLOOR DESIGN

(There are several patented floor and brine flow designs which cannot be evaluated without consideration of cost.)

Generally, there are four types of rink surface floors:

1. *Open or sand fill type* (Fig. 5).
2. Permanent general purpose type with piping imbedded in concrete (Fig. 6).
3. All purpose type with piping embedded in concrete with floor slab insulated (Fig. 7).
4. All purpose floors supported on piers or walls (Fig. 8).

The open type sand fill floor is the least expensive type of rink floor. The cooling pipes rest on wood sleepers over a bed of sand, crushed stone, or other fill. The clean washed sand is filled in and around the cooling pipes. Curling rink floors are usually constructed in this manner, as well as hockey and skating rinks where first cost is a factor, and the building is not intended to be used for other purposes. Clay or cinders should never be used in the bed or for fill around the pipes.

To obtain a better return on investment, most rinks now have a permanent general purpose concrete floor so that the floor may be used for other purposes when the skating season is over, such as for exhibitions, meetings, circuses, roller skating, dancing, boxing, tennis, and other events. Rinks with such type floors have been used for all-year skating.

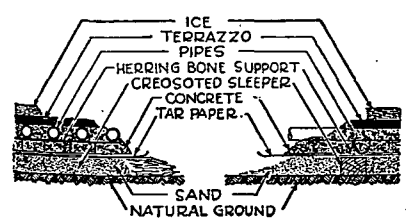

Fig. 6 .... Permanent or General Purpose Floor

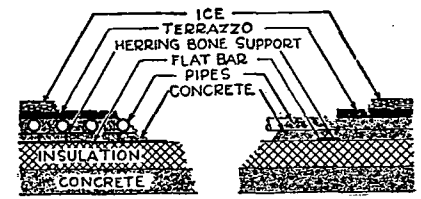

Fig. 7 .... All Purpose Floor

Generally the concrete floor is topped with terrazzo, but, because of the lower first cost, the road type asphalt floor has occasionally been used with indifferent success and is not recommended.

Recently several rinks have been installed using what is called a *bituminous concrete* floor. This is similar to the material used for black-top road construction. This material is poured into place hot at approximately 300 F and then rolled level. While the conductivity is less than Portland cement type concrete, the reduction in heat transfer has not been reported a serious handicap providing the thickness of asphalt is not over ¾ in. This material should not be confused with a similar material used for tennis courts which has been reported entirely unsatisfactory.

Rinks in sports arenas, as well as all purpose rinks, are usually constructed in large cities where hockey is played on certain days of the week. When the game is finished, the ice is removed and the floor made ready for other sports and entertainment. The ice floor must be of such construction that it will stand the frequent change from hot to cold, and the refrigerating machinery must be of sufficient capacity to freeze a ½ in. thick sheet of ice in 12 hr. This type of floor it almost always insulated.

Many patents have been granted for permanent floor construction. Some have stood the test of time, others have not been successful. They have been built on top of wood insulation; on wood floors; in steel pans; and made of composite steel double walls supported on channels with brine circulated between the two sheets of steel, the channel forming the passages. Others had brine sprayed againt steel pan to form the ice surface; square tubes were also used instead of round pipes; extra heavy pipe instead of standard weight; wrought iron instead of mild steel pipe; and a cinder base instead of crushed stone or gravel fill.

The permanent general purpose rink floor constructed in

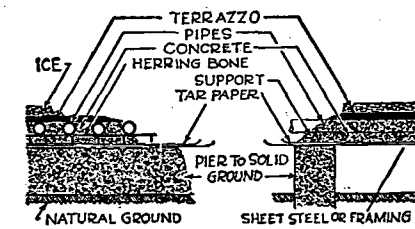

Fig. 8 .... Permanent or All Purpose Floor on Piers