

comparatively large propellers of 20 to 24 in. diameter, mounted on horizontal shafts piercing the tank ends and belt-driven at low speeds served this purpose.

With *horizontal agitators*, proper space must be provided for installing the pulley, drive, inspection and maintenance. *Vertical agitators*, directly connected in a single assembly of motor, frame and propeller, are preferable as they can readily be serviced without any tank disturbances.

Excess horsepower should be avoided in agitators because the hours of usage throughout the year represent considerable power consumption over light and heavy load periods. The whole brine-circulating path must follow good hydraulic practice through elimination of excess friction heads occasioned by changes in volume velocity cross section. Lubricating, oil leakage and thrust bearing difficulties must be prevented in agitators. Means must be provided to prevent whirlpooling and drawing in air which cut down their capacity as well as lowering the brine pH value. For maintaining a 1 F deg temperature difference throughout the tanks, the necessary brine volume circulated is based upon $7\frac{1}{2}$ Btu per (gal) (F deg).

CAN LIFTS AND GRIDS

In loose can tanks, 300 and 400-lb cans are kept in position by wood framework at the top. If the tank does not have coils between the cans, steel guide rods between the cans are necessary to keep them vertical and to support the framework.

Cans are grouped in multiple by means of sections of flat steel from 4 to 8 in. deep and $\frac{1}{4}$ to $\frac{1}{2}$ in. thick. The cans drop into transverse spaces between the long deep sections, then are held in position by square head rivets just over the can bands, or by a lightly riveted flat strip. The spacing of the cans in the grid is such as to provide desired brine flow areas between the cans, seldom exceeding 1 in. in width, except where transverse bars or plates are located between the grid bars to hold a pin for the lifting crane hook. These lifting pins are usually at intervals not more than eight cans wide. In one common design, using a light grid, the ice can bands rest directly upon the grid. The can bands are riveted together in groups and the end can of each group riveted to the transverse bars, also serving as the crane lift pin attachment.

Can grids are preferably hot-dipped galvanized. Their weight is important in preventing the cans from floating and tipping in the brine flow. Grids range in weight from 18 to 50 lb per can, the heavier the better.

Wooden ice can covers rest directly over the grids, eliminating the need for supporting wood framework. The can covers, 2 to 3 in. thick and loosely fitted, are usually in groups of 3 to 6 can coverage. They also provide weight to hold the grids down in the brine.

Grids usually tie cans in groups of from four cans to half or full row tank width. Their use results in considerable labor saving in harvesting and filling. A spare can-grid set serves as a replacement for the group lifted out of the brine, thus quickly restoring the proper tank brine level.

AIR AGITATION AND CORES

Blowing air through cans filled with suitable raw water for freezing is necessary for making clear ice. The purpose of the air is to effect water agitation during freezing, which agitation assists in forming clear, pure water-ice crystals by rejecting the major volumes of the dissolved salts, and even color, into the unfrozen water core. The concentration of salts becomes high in the remaining unfrozen core, consisting of about 3 to 4 gallons. It is usual to pump out the core and replace it with fresh water, preferably cooled.

When *high pressure air* is used for agitation, it is compressed

to about 25 to 30 psig. A minimum of $\frac{1}{2}$ cfm of free air is provided per can, and then cooled by means of water through double-pipe galvanized coolers or spray tanks. The precooled air is in turn further cooled by passing it through ice water, by means of brine coils, or, more frequently, by passage through dehydrators which consist of tanks containing brine-chilled coil surfaces. The water vapor in the air is frozen on these coils, and in due course the precooled air is switched over to another dehydrator shell which has been defrosted by means of three-way valves on the air and brine lines. Condensate in all methods is eventually removed by hand draining or trap. The dehydrator is usually supplied with brine by means of a small circulating pump taking cold brine from and returning it to the ice tank.

The compressed air, after dehydration, is expanded by means of an automatic valve to about 15 to 18 psig, which reduces its relative humidity. The air so treated is conducted by headers extending down the tank sides or centers. Air laterals, usually permanently attached to each grid, are readily connected into the main headers by means of a rubber tube and brass tapered friction fitting and check valve. The supply of air from the grid lateral to the can bottom is accomplished in some instances by means of brass tubing to a fitting entering the can bottom or side, through a tube which is an integral part of the can or is sweated in the can corner terminating at the can bottom, or even extending to the can center by being sweated into a can bottom depression.

Air dehydrated in this manner will not freeze out its moisture content when contacting the brine while some flow is maintained. During the can lowering operation a temporary air blowing attachment must be maintained so that the can water cannot enter the air tubes, which would freeze shut quickly. The amount of air, about $\frac{1}{2}$ cfm per can, is regulated by small orifice fittings in each can supply. These orifices are preferably kept above the brine level to prevent the tendency of ice crystals to close them and also to make them accessible for clearing an occasional stoppage by ice or foreign particles.

In the *medium pressure* system the design is quite similar to the *high pressure* system in all details except that only one uniform pressure is carried in the system, namely 15 to 18 psig. Since this air carries a higher humidity than the expanded cooled air of the *high pressure* system, the air volumes are increased to about $\frac{1}{4}$ cfm per can and the regulating orifices correspondingly made larger.

In the *low pressure* system of agitation, free air is compressed by means of rotary or centrifugal stage blowers to 2 psig, or fractionally higher. One-half cu ft per min of air is provided per can. The air is best taken from a warm engine room of high humidity, particularly in winter and cool months, in order to insure a heat content sufficiently high that it will not readily freeze out when passing through cool laterals and drop pipes in the cans. The blower air should enter through *extensive surface filters*. With this system, the air distribution must be liberally proportioned to insure maintaining not less than two psi uniformly over the tank.

Air is usually supplied to individual cans by means of a removable lateral placed over the cans and lying in depressions provided in the grid transverse members. The air is introduced in the can by means of a 5/16 in. drop tube extending to within 11 to 14 in. of the can bottom, and connected to the lateral with rubber tubing and fittings. Uniform air pressure is essential, and the drop tube must be located in the geometric center of the ice can. A swinging tube along the long axis is satisfactory, provided the open tube end swings through the center and cannot fix itself sideways. A variety of means exists for accomplishing these ends.

For *high and medium pressure systems* standard reciprocating

cating type air compressors are used, as well as wet rotary types. For low pressures, rotary blowers or centrifugal blowers are universally used.

A comparison of horsepower requirements for air agitation by the three methods described, covering a 60 ton, 300 lb, 720 can plant is as follows:

High Pressure: 20 hp air compressor; 1 hp brine pump
Medium Pressure: 15 hp air compressor; 1 hp brine pump
Low Pressure: $7\frac{1}{4}$ hp blower

While the low pressure system has the least horsepower requirements, its refrigerating requirements may be greater because of the added volume of air chilled and blown through the can water. The grid lateral, with the drop tubes attached, is usually lifted out at the time of pumping out the cores, and not replaced when the cores are refilled; this eliminates the need of thawing out the drop tubes if it is not desired that they should become frozen into the block.

Core pumps are preferably of the positive 15 to 30 gpm piston type and not more than one hp. Rotary, self-priming centrifugal, and jet types of pumps are also sometimes used. Core water volumes range between two and three gallons, sometimes greater. Core water is drawn from the cans by means of a 1 in. inside diameter heavy hose and flattened tube. Core washing and filling with fresh water is from another similar hose, with suitable fittings and automatic valves for control. The rate of drawing and refilling cores should be less than one can per minute.

The pumping and filling of cores in rows of 24 and 36 cans will consume from 15 to 20 min, provided that a 15 gpm piston type core pump and a good hand filler is used.

CRANES, DIP TANKS AND ICE DUMPS

Frozen ice cans in small tanks are lifted out by means of a wheeled portable hoist stand straddling the can. An improved method is a light four-wheel single-beam hand-pushed crane with the hand hoist suspended from it. A further improvement is an air lift or electric motor hoist, which can handle up to four cans satisfactorily. With larger tanks of more than 50 ton per day capacity, the powered travel type should be considered.

For can lifts of less than full row grouping, a trolley supported hoist is powered for transverse travel on the bridge beam or truss, making for a three-motored crane. With full row lift, the less costly two-motored crane is required, one for lifting and the other for travel. One-half ton electric hoists with not less than a $\frac{1}{4}$ hp motor are usual for one and two-can lifts. Bridge or travel motors are of $\frac{1}{2}$ to 5 hp rating, depending upon crane weight and capacity. Trolley motors are of 1 to 3 hp capacity and hoist motors rarely exceed $7\frac{1}{2}$ hp.

Hoisting preferably takes place at speeds between 15 and 18 fpm. Bridge speeds are about 75 to 100 fpm and trolley speeds 150 fpm.

The hoisting motor must be provided with a reliable heavy duty brake. Standard designs have been developed.

Cranes are selected for the actual ice load to be lifted plus the weight of cans and grids. The hoisting ropes on a crane are either of the single-rope direct lift or single reeved type. Cans or groups are carried by the crane to the tank dump end where they are usually submerged under water in a dip tank and held until the ice block floats up in the can. Dip tank water is preferably held at not over 70 F in order to avoid ice stressing and cracking or undue melting. Dip tank displacement overflows from liberal weirs near the dip tank top.

After the ice thaws free from the cans they are raised and advanced to a dump. In one type of setup they are reeled into a suitably balanced cradle supported on trunnions. As the crane hooks are disengaged, an hydraulic cylinder for group

lifts tips the dump quickly into position for the ice to slide out. In one- to four-can size dumps, the tipping and upending is usually manual. Quick tilting is necessary to prevent the ice from refreezing to the cans. The pitch for this dump and ice run need not be over 1 in. per ft.

The other common form of dump utilizes the crane for tipping the cans. The can group is rested off balance on a tilting table, and with the crane up against railstops, the can group tips over and is held back by the taut lowering cables. The tendency for some ice-blocks to refreeze to cans warrants use of a two-speed motor for high speed lowering only.

All dumps, when free of ice, are righted again by hand, crane or hydraulic plungers, and again suspended from the crane hoist. In this position a lever-operated valve on an elevated can filler releases water from sectional tanks. Each ice can is filled automatically from 2 in. pipe spouts with the prescribed weight of water.

Can fillers are of open or closed type. Exact measuring of the water into each individual section of the open-type filler is accomplished by the overflow from one section to the next, the first section attached to the water supply line serving to operate a regulating float control valve of the balanced type. The float valve is locked shut upon operation of the can filling lever, and not released until the lever is returned to its original fill position. A long shaft across the filler tank, attached to the lever, operates dump valves on the bottom of each can filler section. This type of can filler calls for frequent adjustments to maintain uniform weights of water in each can.

In order to avoid floats and adjustments the fixed-size closed-tank pressure filler has been adopted. It consists of a series of small closed tanks or one large-diameter single tank, solidly partitioned into individual can selections. While possibly assuring uniform weight per section, since the sections are solidly filled with water under pressure, the valve control mechanism is simple; individual float tank air vents are provided. Through the means of an internal inverted bucket, weight control is permitted. Accessibility for cleaning and valve adjustments is sacrificed, to some degree, making the choice of types of can fillers one of individual preference.

Ice is sometimes dumped directly into the storage room in one to six-can dumps. For larger groups, however, it has proved advisable to dump it against the external storage wall. A transverse chain or drag cable conveyor advances it along the wall at a speed of 5 to 15 fpm to an aperture in the wall, permitting one cake at a time to slip into the storage. In this method large ice-passing doors are unnecessary, considerable storage space is saved, and water is not dragged along with the ice into the storage. Means for timing each block of ice into a scoring machine are now available. Likewise, devices for upending the ice automatically are available.

In some localities it is found advisable to *temper* ice to reduce possible ice cracking or checking owing to low prevailing freezing brine temperatures. *Tempering* is done before the ice enters the dip tank. Ice is suspended or set up near the dip tank for periods of 10 to 20 min before dipping.

Core pumping is a chore frequently abandoned in order to hasten the freezing time. The pumping of cores of 2 and 3 gallon capacity and their refilling with water will usually retard the freezing time up to 1 hr because of ice meltage and the time required to chill down the water. *Usual freezing time* formula for ice cans incorporate this time in the time given as the freezing time.

Scoring ice before or after entering the storage is at the usual rate of $5\frac{1}{2}$ blocks per min.

It is usual in plants of 40 to 70 tons for a single man on each shift to operate the plant, attending to his engine room duties, harvesting ice and scoring it. In plants of 80 to 100