is the ejector nozzle system. Basically this system consists of a supply header fitted with conical ejector nozzles designed to have a tip velocity of 2000 to 5000 fpm with a static pressure behind the nozzle ranging as high as 12 in. of water. Nozzles so arranged will induce a flow of air about three times that actually supplied by the nozzles. This ratio gives the best economical balance between air quantity supplied and fan horsepower. By the use of an ejector system it can be noted that the primary and induced air streams mix over the product and space between the top tray, and sufficient ceiling height must be allowed for this mixing. This mixing rapidly decreases the necessary differential between the air supply temperature and the actual room temperature. The high air flow thus created decreases the temperature drop across the product. Since the temperature drop is proportional to the heat pick-up, a greater air flow will therefore have a lower temperature drop, with the result that the spread between the air temperature entering and leaving the product zone is reduced, which promotes uniformity of drying.

When drying is completed, it is necessary to cool the product rapidly to facilitate unloading. This quick cooling is provided for by a second outdoor air intake which bypasses the heating coil or the air-conditioning unit. At the same time this bypass intake is put into operation, drop dampers are opened in the bottom of the ejector header and this air then also bypasses the ejector nozzles and tends to flush out the heat in the room. The use of an exhaust fan is recommended to rapidly remove the heated air, which at this time rises to the ceiling.

The equipment recommended for this type of operation consists of a fan and heating coil located outside the hot room. No electric motor should be in room due to the hazard of sparking. This unit is provided with outdoor air intakes, ejector headers, return air dampers, and dampers for the outdoor air intake. Most operators prefer to use a recording controller to maintain an accurate record of each batch. This controller simply regulates the flow of steam to the heating coil to maintain the desired room temperature. It is advisable to provide gradual switches to control the position of the outdoor and return air dampers since on a rise in humidity more outdoor air should be taken, and conversely with a drop in humidity more return air should be taken. This function can be provided automatically by a humidity control, but this is seldon used. An end position can be included on the gradual switch for the cooling down period so that when the outdoor air damper is opened wide, the exhaust fan is started.

COLD ROOMS

Many products in the confectionary industry require chilling and drying but cannot withstand high temperatures as indicated in the section Hot Rooms. Typical products in this category are marshmallows, certain types of bar centers, and cast cream centers. In this type of work it is necessary to maintain drying conditions of about 75 F and 45 percent rh. The drying period of this type of product will vary from 24–48 hr. Basically, the system recommended is the ejector type used also for the hot rooms, the difference being that cooling coils are provided in the unit. The load must be carefully calculated in order to determine the sensible and latent heat quantities from which the actual air quantity can be determined, together with air supply temperature, and refrigerant temperature. When properly balanced, the control of relative humidity becomes an inherent part of the design of the system. The control system recommended is basically the same as for the hot room except that the recording regulator in this system must control the admission of steam to the heating coil in winter or regulate the flow of refrigerant to the cooling coil in summer. The flushing dampers and cooling down cycle are unnecessary in this type of operation. There is one precaution which must be observed in the equipment for the cold room in connection with the starch or sugar dust that is picked up in the return air stream. During the cooling cycle, the cooling coil is normally condensing moisture, and the accumulation of starch or sugar dust will rapidly form a paste on the cooling coil, reducing its capacity and causing frequent maintenance and cleaning of the equipment. It is recommended that filters should always be used for the outdoor and return air entering the cooling coil.

COOLING TUNNELS

There are various cooling requirements in the candy plant which can best be handled in a cooling tunnel. Typical of this work is the process of cooling coated centers after leaving the enrober, cooling of cast chocolate bars, and the cooling of hard candy. These operations are usually set up for a high rate of production and a continuous flow of product. The product is normally conveyed on belts either through the enrober or the casting machine and then through a cooling chamber.

Basically, a cooling tunnel consists of an insulated box placed around the conveyor in such a way that the product travels through it in a continuous flow. Cold air is supplied to this enclosure to cool the product. To secure maximum heat transfer between the air and product it is desirable to employ the counterflow principle whereby the air is introduced at the product leaving end of the tunnel and withdrawn at the product entering end of the tunnel so that the direction of the air flow is opposite to the direction of the material flow. In general, air supply temperatures of 35 to 45 F have been found satisfactory for most of this type of work, with air velocities up to 2500 fpm. This high velocity improves the heat transfer and creates a turbulent condition in the air flow which further improves heat transfer efficiency.

The actual size of the tunnel is determined from the size of the conveyor belt and the air quantity. The air quantity is dependent on the heat load and the rate of cooling desired. The rise in air temperature through the tunnel should be limited to 15–20 F deg maximum. One air-conditioning unit generally is used for each tunnel. This unit normally consists of a fan and coil together with the necessary duct connections to and from the unit. Good practice requires an outdoor air intake since there are many times when the cooling can be accomplished with outdoor air without operating the refrigeration plant. The tunnel should be made as tight as possible, and the entrances and exits for the candy should be reduced to a minimum to limit air loss from the tunnel or air infiltration into the tunnel. In some cases it has been found advisable to use a flexible canvas curtain to accomplish this purpose. Some loss is unavoidable, and it is therefore the general practice to take a small amount of outdoor air, or air from the adjoining spaces, in order to provide a slight excess pressure in the tunnel.

For chocolate enrobing work, the condition of the air is the paramount factor in securing the best possible luster on the chocolate together with an even coating. The best results are obtained with rather slow cooling, but this requires either a low production rate or excessively long tunnels, with the result that the final design is a compromise. It is essential that the chocolate be at the proper condition at the time it is poured over the centers, since improper temperature at this point will result in blushing or loss of luster. This, however, is a function of the enrober machine and its operation. If the centers are too cold or too hot, the finished product will have a poor appearance. No amount of correction in the tunnel will compensate for this.

A variation of the standard single-pass counterflow

tunnel has been used for enrober work. The tunnel is divided horisontally by an uninsulated sheet metal partition. The belt carrying the candy rides directly on this partition and the return belt is brought back through the lower space below the partition. The cold air is supplied to the lower chamber near the enrober, progresses to the opposite end of the tunnel, is transferred to the top chamber, progresses back to a point near the enrober, and then is returned to the cooling equipment. This tunnel has several important advantages: (1) it chills the return belt so that this belt in turn can act in the manner of a bottomer slab to give a quick setting of the base of the coated piece, and (2) the uninsulated partition with the coldest air below assists in this bottoming operation. In this manner the air supply has already absorbed some of its heat load by the time it is actually introduced to the product cooling zone. This effectively approaches the advantage of slow cooling but keeps the tunnel at a minimum length.

COATING KETTLES OR PANS

The application of air conditioning to revolving coating kettles or pans has proven to be very satisfactory. Originally these pans were merely provided with a supply of rather warm air, ranging from 80 to 125 F. This air was then exhausted from the kettle to the room, creating a severe nuisance from the standpoint of sugar dust being blown out of the kettle. In addition, a portion of the energy required to produce rotation of the kettle is converted to heat in the centers being coated, with the result that expansion may tend to produce cracking or checking. For this reason, it is general practice to apply a portion of the coating, withdraw the product for a seasoning period ranging up to 24 hr, and then return the material to the kettles for additional coating.

Installations have been made using a conditioned supply of air to the kettles and providing positive exhaust from the kettles. In this way a large portion of the sugar dust problem is overcome. The wet- and dry-bulb temperature of the air supplied to the kettles is closely controlled so that the rate of evaporation and the drying of the coating can be controlled to give uniformity with a high production rate and a reduced labor cost. Evaporation of the moisture in the coating material tends to take place at the wet-bulb temperature of the air supplied to the kettle. A large portion of the heat of rotation entering the product is absorbed, and overheating of the centers is not experienced, thus eliminating the need for a seasoning period and permitting continuous operation. With air conditioning applied to coating kettles, the number of rejects caused by splitting, cracking, uneven coating or doubles can be reduced considerably. Recovery of sugar dust is accomplished by means of a cyclone-type dust collecting device.

PACKING ROOMS

There are a number of rooms or departments in every candy plant in which air conditioning is essential to production or can be shown to be a good investment. The average manufacturer spends considerable time and effort in the correct design and application of packing and packaging materials for his product since it is recognized that this one item very materially affects the keeping quality of the goods. More nearly moisture-proof containers, insulating value for protection against regain of moisture to the product under abnormally high humidity conditions and protection against freezing or extreme heat is highly desirable. Often the manufacturer overlooks the fact that the air in his packing room is the air which actually surrounds the product when placed in one of these moisture-proof containers. The control of this air is essential if the whole theory of proper packing is to be made valid. For instance, product packed in a room having conditions of 85 F dry-bulb and 60 percent rh, which may easily be encountered in a normal summer, would have air surrounding the product at a 69 F dew point. If this sealed package were then subjected to temperatures below 69 F, the air in the package would tend to become super-saturated and moisture would condense on the surfaces of the container and the product. If this product at a later time were then subjected to a higher temperature the moisture would re-evaporate; but in this process, chocolates would lose their luster, and marshmallows would develop a sticky or grained surface, depending on the formula used. Therefore, the control of the air conditions in the packing room is essential. In actual practice, conditions of 65 F dry-bulb and 55 percent rh have been found to be about the maximum practicable. An improvement will be obtained if the relative humidity can be reduced several points. In the case of hard candy which is intensely hygroscopic, the relative humidity should be reduced to 35–45 percent at 60–65 F.

STORAGE

Every manufacturer is anxious to have his products reach the ultimate consumer in the same fine quality that they leave his plant. If the products could be sold to the ultimate consumer immediately after finishing, there would be no problem in this regard. However, it is usually necessary, particularly with seasonal items, to provide storage facilities to even out the production requirement in the factory. Therefore, it becomes necessary to air condition the storage spaces to keep the products in prime condition. It has been found that most types of finished goods except nuts and chocolates will keep for a considerable length of time if stored in room conditions not to exceed 70 F dry-bulb with 40–50 percent rh. In the case of the storage of nuts, the dry-bulb temperature is normally held between 30–35 F with 75 percent rh. These conditions prevent excessive dehydration of the nuts and retard any mold growth, tending to keep any insect eggs dormant.

The conditioning of the storage room is a relatively easy matter, it being the usual practice to use the unitary type equipment known as cold diffusers, which are fan and coil units connected to an external source of refrigeration. The number and size is determined by load requirements and air distribution. These units are fitted with directional flow outlets and no additional ductwork is necessary. The population load in these rooms is very low so drafts are not objectionable, it only being necessary to provide air supply to all parts of the room. It is necessary to allow sufficient space between the top of the loaded product and the ceiling in order to provide a plenum for the distribution of the conditioned air. If the product is to be withdrawn during hot humid summer conditions, tempering should be provided adjacent to the shipping dock where the goods removed from storage can remain for about 24 hr before shipment. This space should be maintained at approximately the outdoor dry-bulb temperature and a rather low relative humidity to permit the product to warm to the outdoor temperature without sweating. This can be accomplished by introducing a small quantity of outdoor air through one of the units serving the storage room, and allowing this air to be relieved through the tempering space to maintain the required conditions.

Candies are frozen to extend the shelf life of those which tend to become stale and rancid when held for only a few weeks at room temperatures. This is particularly true with butter creams and those containing coconut and nuts. Preservation by freezing enables manufacturers to make candies during seasons when sales are slack, to be sold during busy seasons or for special days such as Thanksgiving, Christmas,