

Equipment  
Used  
in the Milk  
Industry

by J. P. Zolotin

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THE MINISTRY OF THE MEAT AND MILK INDUSTRY  
OF THE ESTONIAN S.S.R.

EQUIPMENT USED  
IN THE MILK INDUSTRY  
by J. P. ZOLOTIN

THE INTERNATIONAL SEMINAR  
FOR THE FELLOWSHIP GROUP OF THE U N O  
ON THE MILK INDUSTRY IN THE ESTONIAN S.S.R.

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## I. MILK TRANSPORTATION FACILITIES, STORAGE EQUIPMENT AND CONVEYANCE BY PIPE-LINE

### 1. Milk Transportation Facilities

Specialized transportation facilities are used to convey milk and dairy products from dairy farms to dairies, such as: milk-tank trucks, rail-bound tank cars, river transport facilities and refrigerator trucks.

Sometimes milk in cans is conveyed by means of platform lorries.

Because of reduced milk losses, decreased labour expenditure and minimum deterioration in the quality of milk, the bulk delivery of bulk milk in tanks is by far more expedient as compared with the transportation of milk in cans.

In comparison with milk cans, the contacting area of tanks per litre of milk is three to five times less. Hence, the temperature increment of milk in tanks is three or four times less than is the case with milk in cans (about 1.5 - 2° C in ten hours.)

Most widely used road transport facilities for milk delivery in the U.S.S.R. are: 800-litre tanks mounted on lorries "ГАЗ -51", 2,800-litre tank trucks "ЗИЛ-150" and "МАЗ -200" type tank trucks of 5,250 litres holding capacity.

In addition to these, there are ЦАП-22 -type milk trucks mounted on four-wheel trailers, their holding capacity being 2,200 litres.

All the tanks mentioned above have two independently operated sections of equal holding capacity.

The tanks are filled up either by means of centrifugal pumps, or the tanks are worked under vacuum. To empty the tanks the milk is drawn off or pumps provided at the receiving department of the dairy are used.

To create vacuum in tanks mounted on ЗМЛ-150 and ГАЗ-51-type trucks the suction manifolds of their engines are used.

With МАЗ-200-type tank trucks, vacuum is created by means of the brake compressor.

Trailer-mounted tanks are not provided with special vacuum-generating means.

All truck-mounted tanks are made of 6-8 mm sheet aluminium. To keep out the heat, the tank walls are insulated with cork or "mipora".

Four-axle tank cars are used in transportation of milk by railway. These tanks have a holding capacity of 25,200 litres and are divided into three sections of 8,400 litre capacity each. 8-10 mm stainless steel is used in the tank shells. For insulation, mipora, 200 mm thick, is used.

Transportation by railway tank cars ensures good-quality milk, since there are practically no changes in the temperature of the latter. According to the data of local and transportation tests, with the ambient temperature and that of the milk contained in a hermetically sealed tank differing by 30°C, the change of temperature observed was 2°C in 24 hours.

Centrifugal pumps provided at the loading and discharge platforms serve to fill and empty the tanks.

М-21-Т-type river launches are used to convey milk by water. One 7-ton milk tank is installed in the front part and a 13-ton tank in the after part of the launch. 8 mm sheet aluminium is used in the tanks which have thermal insulation of 25 mm thickness. The launch is equipped with 2 centrifugal pumps, one (capacity 10,000 litre/h) for loading and discharging the tanks, the other being used for flushing the latter.

## 2. Storage Tanks for Milk and Milk Products

Tanks are used both for short-time and prolonged storage of milk. No changes will be noticed in the quality of milk after 24-hour storage in these tanks.

There are two types of tanks in use in the U.S.S.R.: horizontal-

ally-mounted cylindrical tanks, holding capacity 2,000; 4,000; 6,000 and 10,000 litres, and upright cylindrical tanks of 2,000-litre capacity.

The material used in these tanks is stainless steel or aluminium.

For thermal insulation the tanks are covered with cork or mipora encased in a protective sheathing. Every tank is equipped with a propeller agitator operated by an electric motor through a reducer. Each tank is also fitted with: inspection hole, cover, outlet valve, level indicator, thermometer, filler pipe and test cock.

Up-to-date tanks are equipped with electrically operated remote level indicators and built-in sprayers for in-place cleaning of the tank. Commercially manufactured are milk storage tanks, and such for cooling and storage.

In the latter case ice-cooled water is circulated in the space within the double walls of the tank.

#### Time Required for Unloading Tanks

Tanks can be unloaded by gravity flow and by means of air pressure.

The time required for discharging is determined as follows:

Discharge by gravity flow  
(seconds):

$$\tau = \frac{2V}{\mu f \sqrt{2gH}}$$

where

- V - quantity of fluid in tank, cu.m;
- $\mu$  - factor for rate of flow 0.8-0.85;
- f - cross-sectional area of outlet aperture, sq. m;
- g - acceleration by gravity,  $m/s^2$ ;
- H - maximum fluid level in tank, m.

Discharge under air pressure :

$$\tau = \frac{2v}{\mu f \sqrt{2g(H + \frac{P_e}{\gamma})}} \text{ seconds;}$$

where  $P_{\text{excess}}$  air pressure in tank above fluid level, kg/sq.m.

$\gamma$  - density of air, cu.m./kg;

Horizontally-mounted tank: Discharge by gravity flow:

$$\tau = \frac{1.7V}{\mu f \sqrt{2gH}} ;$$

Discharge under air pressure:

$$\tau = \frac{1.7V}{\mu f \sqrt{2g(H + \frac{P_{\text{excess}}}{\gamma})}} ;$$

Changes in the Temperature  
of Milk Caused by the Sur-  
rounding Medium

Temperature rise due to surrounding medium :

$$\lg \frac{t_o - t_{in}}{t_o - t_{final}} = \frac{0.4343FKZ}{MC} ;$$

Temperature drop due to surrounding medium :

$$\lg \frac{t_{in} - t_o}{t_{final} - t_o} = \frac{0.4343FKZ}{MC} ;$$

Designation in the formulae:

$t_o$  - environmental temperature;

$t_{in}$  - initial temperature of milk;

$t_{final}$  - final temperature of milk;

$F$  - surface area of tank, sq. m;

$K$  - coefficient of thermal transmission kcal/ sq.m/h  
degrees  $C^{\circ}$ ;

$Z$  - duration of temperature change, hours;

M - quantity of milk, kg ;

C - specific heat ,  $\frac{\text{kcal}}{\text{kg deg}}$  ;

### 3. Pumps and Pipe-Lines

The pipe-lines and pumps serve to convey low- and high-viscous milk products.

Pipe lines are made up of pipes, shaped and connecting members, and fittings.

The material used in pipes is stainless steel, copper, aluminium, glass and plastics.

If copper piping is used, it must be tinned.

Metal pipes are manufactured in lengths of from 2.5 to 3 m and 25; 35; 50 and 76 mm. diameter; wall thickness from 1 to 2 mm. Pipe sockets complete with nipples, branches, rubber gaskets and captive nuts, are used in interconnecting the separate pipes.

Glass pipes are supplied in lengths from 1.5 to 3 m, their diameter ranging from 37 to 100 mm.

According to their operating pressure, glass pipes are subdivided, as follows:

1. CTB - not to be operated under pressure ;
2. CT-4 - for operating pressure up to 4 atmospheres;
3. CT-8 - for operating pressure up to 8 atmospheres.

Glass pipes can be used with temperatures ranging from minus 30 to plus 150°C. Sudden drop in temperature should not exceed 60 to 70°C.

To interconnect glass pipes, either flange and bolt connections, or only flanges are used.

Glass piping has certain advantages over metal pipe lines. Since they are transparent, their state of cleanliness is readily checked; besides they are corrosion-proof.

To determine the inner diameter of pipes, the following equation is used:

$$d = \sqrt{\frac{4V}{3600\pi v}}$$

where  $V$  - quantity of fluid delivered, cu.m/s;  
 $v$  - flow rate of fluid, m/s.

The adopted rate of flow of milk products in the pipe-line is within the limits:

milk - 0.5 - 1.5 m/s;  
cream - 0.5 m/s;  
whey - 1-2 m/s;  
butter-milk - 1-2 m/s;  
condensed milk - 0.5 m/s.

Both pumps and pumpless systems are employed to force the milk product through the pipe-lines.

The dairy enterprises in the U.S.S.R make use of centrifugal self-priming, gear, rotary-, and plunger-type pumps.

Centrifugal pumps are used mainly to pump milk and low-viscosity milk products, such as: skim milk, butter milk and whey. Because of their ruggedness, simple design, ease of assembly and dismantling, these pumps are extensively used. Before being started, the pumps are primed with the liquid to be pumped.

The pump comprises a body and an electrically-driven impeller. The liquid to be pumped flows by centrifugal force into the pressure piping.

The rated head of a centrifugal pump is determined by the formula

$$H_R = \frac{\pi D^2 n^2}{g} \text{ metres;}$$

where

$D$  - diameter of impeller, m;  
 $n$  - r.p.s. of impeller;  
 $g$  - acceleration due to gravity,  $m/s^2$

Centrifugal pump delivery is 1,000, 5,000, 10,000, 13,000, 25,000, 50,000 litres per hour.

Self-priming pumps are employed for pumping milk, whey and butter-milk.

The self-priming pump uses a straight-blade-type rotor eccentrically - mounted in the pump body. The pump must be primed once before the first start.

Gear pumps are supplied with external and internal toothings.

Gear pumps find application in pumping whole and skim milk, butter-milk, whey, cream, condensed milk and ice-cream mixtures.

The gear pump operates on the principle of carrying between the gear-teeth the milk product from the inlet side to the discharge side of the pump.

Rotary pumps are employed to transfer milk, butter milk, condensed milk and cream.

The pump comprises the following main parts: body, rotor and blades mounted in radial slots of the rotor.

Plunger-type pumps are used in cases where higher pressure is required, as in homogenizers and nozzle-sprayer driers.

The pump is made up of a cast iron base, cylinder block, pump chamber, suction and pressure valves, crank mechanisms, and plungers.

The power required for all pumps is found as follows:

$$N = \frac{V \gamma (H + h)}{102 \eta_m} ;$$

where

- V - quantity of liquid delivered, in cu.m/s;
- $\gamma$  - density of liquid in kg/ cu.m;
- H - delivery head, in m;
- h - head required to overcome resistance of pipe-line and transient speed to the fluid, m;
- $\eta_m$  - mechanical efficiency of pump

#### 4. Systems Not Using Pumps

In vacuum-compression systems pumps are not used to impart movement to fluids. The fluid is forced along the pipe-line by the difference of pressure, created by compressed air at the pressure side, or by vacuum in the tank into which the fluid passes. Pressure is built up by means of air compressors, while vacuum pumps are used to create vacuum.

## II. EQUIPMENT FOR THERMAL PROCESSING OF MILK AND MILK PRODUCTS

To destroy microorganisms in milk and milk products various methods of processing are used.

The most extensively used method in the U.S.S.R. and in many other countries as well, is thermal processing of dairy products. There are two kinds of thermal processing - pasteurization and sterilization.

With pasteurization the vegetative forms of pathogenic and non-pathogenic microorganisms only are destroyed, while by sterilization not only the vegetative forms, but also spores of microorganisms are killed. Each of those processes includes subsequent cooling down of the product.

### 1. Pasteurization Equipment

Pasteurization is carried out in definite interdependence of temperature and time, as evolved by the Soviet scientist Kuk.

$$\ln Z = 36.84 - 0.48 t$$

where

Z - duration of the pasteurizing process, in seconds;  
t - temperature of pasteurizing, in deg. C;

A criterion of the completion of the process is what Kuk calls "Pasteur's criterion"

$$Pa = \frac{\theta}{z} = 1;$$

where

$\theta$  - holding time;  
z - required and adequate time of pasteurization.

The definite combination of time and temperature is determined by the method of pasteurization.

Three methods of pasteurization are employed in the dairy industry of the U.S.S.R.

1. Holding pasteurization - at temperatures of 63 to 65°C, holding time 30 minutes.
2. High-temperature pasteurization at temperatures within 71 to 76°C, holding time 20-30 s.
3. Flash-pasteurization - at temperatures of 85 to 95°C without holding time.

Special processing equipment is used for each method of pasteurization.

Special vessels are employed for holding pasteurization. Two of the models used in pasteurization are the BIII-300, of 300 litre capacity, and the BIII-600 with a capacity of 600 litres. These vessels, cylindrical in shape, are made of stainless steel.

The internal tanks of the vessels are enclosed in water jackets into which live steam is introduced. For purposes of mixing the product and accelerating the heating process, the vessels incorporate propeller agitators. Vessels for holding pasteurization are used mainly for dietary products and ice-cream mixes.

Drinking-milk is subjected to high-temperature short-time pasteurization which takes place in plate pasteurizing-cooling units where the process is automatically controlled and regulated. In the U.S.S.R. the following models are manufactured: Models OIV-3m, OIV-5m, OIV-10m - with an output of 3,000 litres/h; 5,000 litres/h and 10,000 litres/h respectively.

The basic parts of the automated unit are:

1. Float balance tank.

Designed to ensure stable performance of the centrifugal pump.

Mounted inside the balance tank is a ball float level controller.

2. Centrifugal pump - for pumping the milk across the plate pasteurizer to the centrifugal milk clarifier.

3. The flow controller.

It serves to equalize the hydraulic resistance which is liable to change during operation, thus ensuring stable performance of the centrifugal pump.

#### 4. Plate pasteurizer.

Its function is to heat the milk to the required temperature of pasteurization and subsequently cooling it.

The plate pasteurizer is made up of the following sections:

- a) Regeneration section;
- b) Heating section;
- c) Water cooling section;
- d) Brine cooling section;
- e) Holding section.

In modern plate pasteurizers the principle of heat regeneration is extensively used. The inflowing milk is heated to regeneration temperature by the hot milk passing out of the heating section. Thus, part of the heat expended for warming the milk is reused in the apparatus.

The ratio of the quantity of returned heat to the total heat expenditure is called regeneration efficiency.

$$E = \frac{Q_p}{Q_H} = \frac{MC (t_p - t_H)}{MC (t_H - t_H)} = \frac{t_p - t_H}{t_H - t_H};$$

where

- $Q_p$  - heat returned to the apparatus kcal/h ;
- $Q_H$  - heat expended on pasteurization kcal/h ;
- $M$  - capacity of pasteurizer l/h ;
- $C$  - specific heat of milk kcal/kg deg ;
- $t_p$  - regeneration temperature ;
- $t_H$  - initial temperature of the milk ;
- $t_H$  - pasteurization temperature .

The economical performance of a pasteurizer unit is determined by its regeneration efficiency. At present-day conditions the regeneration efficiency amounts to  $E=0.85$ , i.e. 85% of the heat is returned to the apparatus.

#### 5. Centrifugal clarifier

Impure milk promotes the formation of milk stone on the surfaces of the heat-exchanging plates.

In the U.S.S.R. OMB-3-type centrifugal clarifiers are used. Maximum clarification effect is attained at 40 °C. Therefore the regeneration section is subdivided into two subsections with a clarifier mounted in between the latter.

#### 6. Holder section.

Its function is to maintain the temperature of the milk during holding time to complete the pasteurization process.

## 2. Principle of Operation of the Pasteurizing Unit

The cold raw milk at an initial temperature  $t_1 = 5-7^{\circ}\text{C}$  flows into the float balance tank from where it is forced out by means of a centrifugal pump through the flow control valve into the first subsection of the regeneration section. Heated to a temperature of  $40^{\circ}\text{C}$ , the milk passes into the clarifier and then into the second subsection of the regeneration section where it is heated to regeneration temperature  $t_r$ . The regeneration temperature level depends upon the value of regeneration efficiency.

On leaving the regeneration section, the milk enters the heating section, where it is heated to pasteurization temperature  $t_p = 74^{\circ}\text{C}$ .

In the heating section hot water is used to transmit heat to the milk. The hot water system includes a centrifugal pump, an intermediate tank and a steam mixer.

In the holding section the milk is maintained at pasteurization temperature after which it returns to the regeneration section where the outgoing hot milk imparts its heat to the incoming cold milk.

Then the milk flows into the cooling section where it is subjected to cold water cooling, and from there into the brine water section for cooling down to the final temperature  $t_f$ .

### 3. System of Automatic Regulating and Control of the Pasteurizing Process

The function of this system is to regulate the pasteurization and cooling temperatures; to control the pasteurizing temperature and to return the insufficiently heated milk for re-pasteurization.

The system of automatic-regulating and control of the pasteurizing process includes an electrically operated flow diversion valve, a sensing element (resistance thermometer), an electronic bridge, and a steam control valve.

One sensing element is mounted in the pasteurized hot milk piping, back of the holding section, and another in the hot water line leading from the steam mixer.

The sensing elements are interconnected with bridges which transmit signals to the respective executive mechanisms.

If the temperature drops below the preset value for pasteurization, the sensing element, reacting to the difference in temperature (temperature differential) transmits a signal (pulse) to the electronic bridge where the signal is converted into a command signal. Actuated by the command signal the executive mechanism causes the steam valve to open and operates the flow diversion valve.

Resulting therefrom, an increased quantity of steam passes into the mixer. By operating the flow diversion valve the insufficiently pasteurized milk is returned to the pasteurizer.

The basic part of the pasteurizing-cooling unit is the plate pasteurizer. The latter is built up of a set of heat exchanger plates, base plate, pressure plate, intermediate plates and screw press. The punched heat exchanger plates having corrugated surfaces are made of stainless steel, grade 1x 8H9T.

The corrugated surfaces of the plates make for increased heat transfer and turbulence at low flow rates of the milk in the passages of the pasteurizer. Each section of the unit consists of a definite number of plates mounted in groups to ensure the required rate of flow of the milk. The milk flows in parallel passages of the groups traversing the whole section.

The total area of thermal transmission of the section is determined by the basic equation of heat transfer.

$$F = \frac{MC (t_2 - t_1)}{\Delta t_{\text{mean}} \cdot K} \text{ sq.m;}$$

where

- M - through-put capacity of the unit;
- C - heat capacity of milk;
- $t_2$  - final temperature of milk, at the outlet of the section;
- $t_1$  - initial temperature of milk entering the section;
- $\Delta t_{\text{mean}}$  - mean logarithmic temperature differential between heat exchanging liquids;
- K - coefficient of thermal transmission.

The energy loss of the liquid flowing through the passages of the section is determined as follows.

$$\Delta H = 1\xi \frac{v^2}{2g} ; \quad \xi = 8200 \text{ Re}^{-0.55} ;$$

- where i - number of groups in the section;
- $\xi$  - coefficient of resistance of one group;
- v - flow rate of the liquid in the group, 0.2-0.4 m/s;
- Re - Reynolds' number;
- g - acceleration by gravity.

The determination of energy losses is essential when selecting an appropriate centrifugal pump.

Condensed milk is processed by the flash pasteurization method in tubular preheaters (tube pasteurizer unit).

Two models, the ПТВ-5 and the ПТВ-10 with an output capacity of 5,000 litres/h and 10,000 litres/h respectively, are manufactured in the U.S.S.R.

The unit includes a tube pasteurizer, a gear-type pump for the milk, a water pump, a boiler, condensing vessel, measuring and control instruments.

The tubular preheater unit consists of two sections, a lower one, where the milk is heated by hot water, and an upper section using steam for heating.

If the temperature decreases below the preset value, the resistance thermometer mounted in the milk line back of the heating section, through the automatic electronic bridge actuates the executive mechanism (flow diversion valve).

The insufficiently pasteurized milk is returned into an intermediate reservoir for repeated pasteurization.

The steam control valve opens simultaneously causing an increased inflow of steam into the pasteurizer.

With the temperature rising above the preset value, a self-acting valve is operated to cut off the outflow of the milk and the steam valve closes.

#### 4. Pasteurization by Steam Injection

In pasteurizer units of this type, steam is injected into the product to be pasteurized. Simultaneously with pasteurization off-flavours are partially eliminated.

The milk or cream is fed into the distributing chamber of the steam injection tank where it is atomized.

The steam introduced into the tank commingles with the product and condensates while the product is heated and mixes with the condensate. Next, the product passing into the partial vacuum evaporator, where a subatmospheric pressure of 0.5 to 0.67 atm. is maintained. Part of the moisture having evaporated, the product flows into the high-vacuum evaporator having a subatmospheric pressure of 0.07 to 0.1 atm. After evaporation of all moisture the product regains its initial consistency.

Vacuum is created by a mixing condenser.

The subatmospheric pressure in the steam-injection chamber equals 0.65-0.8 atm. The vacreators (vacuum pasteurizers) have an output of up to 6,000 litres/h.

Being of rugged design without moving parts, they are easy to handle. But they have certain deficiencies such as: excessive water expenditure for steam condensation; purified steam only must be used.

## 5. Sterilizer Units

The efficiency of sterilization can be characterized by the sterilization effect expressed by the logarithmic relation between initial and final bacterial concentration.

$$S = \lg \frac{C_i}{C_f}$$

If  $S = 7$ ;  $C_i = 100,000 (10^5)$  per 1 litre, then  
 $\lg C_f = \lg C_i - S = 5 - 7 = -2$ ,

whence  $C_f = 0.01$ . Consequently, for a given  $S$ , the concentration of spores of  $10^5$  per 1 litre is reduced to 0.01 per 1 litre, or 1 spore per 100 litres.

As with pasteurization, there are several methods of sterilization, but the method most extensively used is thermal sterilization.

All sterilizer units used in sterilizing milk can be subdivided into two basic groups: 1) Units for sterilization in containers (bottles, tetrapack, etc.) and 2) Units for flow sterilization.

The first group is subdivided into discontinuous and continuous sterilization units.

The second group includes surface type sterilizers (plate- and tubular sterilizers) and steam injection sterilizers.

## 6. Units for Sterilization in Containers

Discontinuous sterilizers are used to sterilize milk in containers. They are thick-walled steel cylinders having a welded bottom and an end cover secured to the body flange by means of screw clamps.

The product is loaded into the unit using carts. Having hermetically closed the sterilizer, the latter is filled with water to  $\frac{1}{4}$  of its volume, then steam is introduced. Air is forced

out of the sterilizer and the steam pressure increased gradually. The preset sterilization conditions are determined by the steam pressure in the unit and the holding time of the product. On finishing sterilization, the steam inflow is cut off. Compressed air at 1.3 - 1.4 atm. pressure is introduced and subsequently cold water is fed.

With the temperature decreasing to  $90^{\circ}\text{C}$ , the pressure in the unit is gradually lowered. Cooling down the product to  $20^{\circ}\text{C}$  takes from 15 to 20 min.

There are continuous sterilizers of the tower and the tunnel type.

A tower-type sterilizer has 4 vertical wells where successively the bottled milk is heated, sterilized and cooled. Mounted inside the tower is a vertical conveyor fitted with trays having bottle sockets. The bottled milk placed on the conveyor trays travels upward, negotiating an upper sprocket, then down until it is immersed in hot water, the temperature of which at the bottom of the well is  $110^{\circ}\text{C}$ .

From the first well the bottled milk passes into a second well where the temperature is maintained at  $110^{\circ}\text{C}$ . The steam pressure in this well is about 0.45 atm. corresponding to the height of the water column in the first well; the water column serving as hydraulic lock.

Then passing through the next wells, the milk is gradually cooled down to a temperature of from 20 to  $25^{\circ}\text{C}$ .

In tunnel-type sterilizers the bottled milk on carts passes through a horizontal tunnel where it is heated to sterilization temperature and then cooled down.

## 7. Continuous Flow Sterilization in Surface-type Units

There are two types of units for continuous flow sterilization in use, the plate and the tubular sterilizer. Either one or the other constitutes the basic part of a self-acting plant comprising float balance tank, centrifugal pump, homogenizer, deaerator operated under vacuum, pumps and the system of automatic control

and monitoring of the sterilization process. The operating principle of a plant fitted with a plate sterilizer is as follows:

After entering a balanced tank equipped with a ball float level controller, the milk is pumped under adjustable pressure into the preheater section where it is heated to a temperature of from 60 to 65 °C and then homogenized. Having been homogenized in the first subsection of the regeneration section, the temperature of the milk is raised to 80 or 85 °C. Next, the milk is passed into a deaerator operated under vacuum where the milk is deaerated. Deaeration helps to reduce the intensity of precipitation of milk stone on heat exchanger plate surfaces in the sterilizer section. Then, by means of a centrifugal pump the milk is pumped into the second subsection of the regeneration section and heated to regeneration temperature of about 125 °C. Next, on passing through the sterilization section the milk is sterilized at a temperature ranging from 135-140 °C; and subsequently, in the regeneration section, cooled down to a temperature within the limits 70 to 75 °C, at which it is bottled.

The plant is fitted with auxiliary coolers. In principle, the layout of a tubular pasteurizer unit does not differ from that described above. The only difference consists in that a tubular-type pasteurizer is employed.

There are certain difficulties in manufacturing such units, since the regeneration section is made up of pipe-in-pipe mounted coils.

### 8. Equipment for Cooling Milk and Milk Products

In the U.S.S.R. special milk cooling and storage plants are manufactured for use on dairy farms. Such a cooling plant incorporates a vat of 1,000 litres capacity and a freon compressor unit. Thus, immediately after milking, the milk can be cooled and stored at a low temperature until the time of delivery to the dairy plant. The vat of the cooling plant being rectangular in shape is made of stainless steel and mounted in a heat-insulated casing. Fitted in the lower part of the cooling plant casing is a spiral pipe, and

in the upper part a perforated annular tube. Water is filled into the casing in an amount sufficient to cover the coil pipe of the evaporator.

A water pump mounted on the casing serves to pump water drawn from the cooling pipe into the perforated annular tube. Water emerging from perforations of the tube sluices down the shell of the vat thus cooling the latter and then flows into the coil tube evaporator. The cooling plant is fitted with a freon compressor  $\Phi$ -56 and an air-cooled condensor having a refrigeration capacity of 3,000 kcal/hour.

The vat is provided with a milk mixing device, and is closed by means of a top cover carrying milk filters for removing impurities, and a thermometer. The compressor is started and stopped automatically.

Industrially manufactured in the U.S.S.R. for milk and cream cooling purposes at dairy enterprises are plate-type and surface spray coolers. Plate-type coolers having two sections, a water cooling and a brine cooling section, are manufactured with capacities of 3,000; 5,000; 10,000 and 25,000 litres/h.

The refrigeration temperature is automatically controlled. All automatic controls are mounted on a separate control panel.

Surface spray coolers for milk and cream are used at small dairy plants only. They are being replaced by enclosed plate-type coolers.

Other coolers industrially manufactured in the U.S.S.R. are the flat tube coolers, the single-section type with a capacity ranging from 200 - 500 litres/h and the two-sectioned type with capacities from 750- 1,000 and 2,000 litres/h.

Installed in the cooler are two vertical steel collectors with stainless steel tubes mounted horizontally in them. The column is capped by means of a cover having a baffle plate. Such arrangement promotes the flow of coolant inside the tubes.

In the upper part above the tubes is a perforated receiver which directs the flow of the products to be cooled along the outer surfaces of the tubes. Located at the lower part is a collector with an outlet pipe to receive the cooled product.

#### IV. EQUIPMENT FOR PRODUCING BUTTER AND CHEESE

##### 1. Equipment for Processing Butter

At the present time churns and butter workers are used for the production of butter.

A method is proposed for churning cream with a fat content of 25-35% which has previously undergone physical ripening. This method is based on the obtention of butter from churns.

For processing butter by the churning method, periodic and continuous action churns are used.

A method of obtaining high-fat cream with a fat content equal to the standard content in butter, and of transforming this high-fat cream into butter by mechanical processing, cooling and crystallisation of milk fat in a special butter worker, has been worked out. This method is based on the obtention of butter in butter-making machines.

For processing butter by this method, line production of butter with a capacity of 300-400 and 600 kg, of butter per hour has been developed.

The processing of butter on continuous lines in the U.S.S.R. is the most common. In particular, in Byelorussia 80% of the total processed butter is processed on continuous lines.

The production of butter in butter churns is limited in character at the present time in the U.S.S.R.

In processing butter by this method, for carrying on the process of physical ripening of cream, cream ripening vats with oscillating tube agitators with a working capacity of 400-800-1,200 and 2,000 litres are manufactured in the U.S.S.R.

At the present time in the U.S.S.R. only periodic action churns with horizontal cylindrical barrel, capacity 1000/400; 2000/800; and 3000/1200 litres are manufactured.

Churns with a capacity of 1000/400 litres, mark M-1000 have a cylindrical wooden barrel with two pairs of Scotch hands and two-speed gear box with a churning speed of 35 r.p.m. and processing speed of 1.84 r.p.m.

Churns with a capacity of 2000/800 and 3000/1200 litres, mark MM-2000 and MM-3000 are manufactured with cylindrical of stainless steel and a single-speed gear box.

A continuous butter line is manufactured in the U.S.S.R. with a productivity of 600 kg of butter per hour and is complete with the following equipment:

1. Tank for receiving raw cream, capacity 2,500 l; 1
2. Pasteurizer, tube, 2-section, model ПТ-2; 1
3. Accumulator tank for pasteurized cream, mark  
ОВЦ , capacity 250 l; 1
4. Separators for high-fat cream, model ОСД-500,  
productivity 500 kg/hour high-fat cream; 3
5. Milk pump for raw cream, model МЦН-10; 1
6. Pump for butter-milk, model ОЦН-5; 1
7. Standardized vats for high-fat cream, model  
ВМ-300 with agitator; 3
8. Pump for high-fat cream HP-2; 1
9. Butter-making machine, 3-cylinder, model ТОМ; 1
10. Control desk; 1
11. Weighing table; 1
12. Scales for weighing butter, capacity 50 kg; 2
13. Set of milk tubes with interlocking and communi-  
cating armature; 1
14. Instruments and accessories . 1

The process of obtaining butter on continuous production lines consists in the following:

Fresh, good-quality cream containing 30-40% fat is subjected to pasteurization on a tube or centrifugal pasteurizer to a temperature of 85-90°C. Hot pasteurized cream is sent into the accumulator tank mounted over the separators for high-fat cream.

Cream arrives at the separators by gravity from the accumulator tank. Therefore two separators are usually working, and the third is being cleaned and rinsed.

Separating is done at the pasteurization temperature. The fat content in high-fat cream is maintained within the limits of 84-85%.

The butter-milk obtained is of the order of 0.5% fat, is poured into the funnel of the pump and passes along the pipe-line for further processing into other products, or is cooled and sold in natural form.

High-fat cream passes by gravity into standardization vats by turns. Here their fat content is determined, the required quantity of butter-milk for obtaining butter of standard fat and moisture content is determined and added.

Standardization vats have agitators for mixing cream, for the purpose of evenly distributing the added butter-milk and preventing settling of the fat. Vats also have a cooling jacket. Cooling in vats is necessary for processing cultured butter.

Standardized high-fat cream is forced by a rotary pump into the first section of the three-section butter-making machine and passes successively through the others.

In the first section high-fat cream is simply cooled. In the second section the cooling process continues, accompanied by intensive crystallisation of milk fat and structure formation. In the third section the process of crystallisation of milk fat and the formation of butter is completed. The ready butter comes out of the third section of the butter-making machine through an outlet tube provided with control cocks and thermometer, and is fed into boxes set on weighing platforms.

Butter arrives in a thin flowing condition and quickly hardens in the container.

Boxes containing butter are then sent to the butter storage room.

The continuous butter line includes the continuous churn. In this line, a 3-cylinder machine is used. Lines with a productivity of 300 kg/hour have a 2-cylinder butter-making machine.

## 2. Principle of Mechanism of Butter-making Machine

In the butter-making machine there takes place rapid cooling and crystallisation of milk fat of high-fat cream, during intensive mechanical action, as a result of which the structure of the cream is transformed into the structure of butter.

Fat is cooled and crystallised in cylinders of the butter-making machine, in which the drum-ejector rotates. The cylinders are disposed one over the other and are connected in series.

The churn is manufactured in two sections (model ДОМ) and three sections (model ТОМ).

Each section of the butter making machine has a steel cylinder with a jacket and bottom disposed horizontally. In the jacket there circulates a coolant - water or brine.

The end of the shaft passes through the bottom and the stuffing box on it.

On the shaft is fixed a drum ejector which is a hollow welded cylinder made of stainless steel. On the cylinder, along the longitudinal axis, two steel knives are hingedly fixed. The knives are designed to remove the hardened butter from the cooled surface of the cylinder and for vigorous mechanical action on the product. The drum ejector together with knives turns within the cylinder with a speed of 150 r.p.m. The knives are pressed to the wall of the cylinder, both under the action of centrifugal force, and because of the counter-pressure of the product. Each cylinder is hermetically closed with a steel lid and rubber gasket.

The drum ejector is actuated from an electric motor through a texrope and chain drive.

High-fat cream with a temperature of about  $60^{\circ}\text{C}$  is pumped into the lower section of the butter-making machine and passes under pressure along the ring space between the wall of the cooled cylinder and the rotating drum ejector, cooling to a temperature of the order of  $20-22^{\circ}\text{C}$ . Further, high-fat cream passes along a branch pipe mounted in the lid of the cylinder, into the second section, where it follows a similar path and is cooled to a lower temperature, and the fat is crystallised.

Butter leaves the second section at a temperature of  $11-13^{\circ}\text{C}$  and passes into the third section, where the crystallisation of fat and structure formation take place. The butter leaves the third cylinder at a temperature of the order of  $12-16^{\circ}\text{C}$  in a fluid state and passes into a container for packing. Temperatures of the product in each cylinder are regulated by changing the quantitative.

feed of coolant into the cylinder jacket of the churn by means of a valve.

Water, as a rule, passes into the jacket of the lower cylinder, and it is then cooled with brine. In two-section butter-making machines two cylinders are effective for cooling with brine.

The starting equipment of the motors and temperature control instruments in different parts of the process are concentrated on the control desk.

The use of a continuous production line for making butter makes it possible to increase the amount of butter processed by 2-3 times for the same production area, to increase the productivity of labour and to reduce the costs of production by comparison with processing butter in churns.

### 3. Equipment for Producing Cheese

In the U.S.S.R. in the post-war period, the technique of cheese-making has developed comparatively rapidly. This is due to the concentration of cheese production in larger factories and the higher general technical level of industry.

With the improvement in conditions of obtaining and storing milk on farms, and also the conditions of its transport of factories, there appeared the possibility of building enterprises with a capacity of producing milk into cheese of 50 and more tons per shift.

At such enterprises, in spite of the specific character of cheese-making, the wide mechanization of production processes is economically justified. Therefore, together with the improvement in earlier designs of equipment for the production of cheese, there appeared two types of cheese production, apparatus for moulding and pressing cheese, and also special machines used for processing cheese in cheese cellars - cheese washing machines, electroparaffining, etc.

In this lecture it is useful to consider equipment for souring milk and processing the cheese curd, and also for moulding and pressing cheese, used in large cheese-making factories and manufactured in the U.S.S.R.

The souring of milk and processing of the curd is done in cheese-making vats equipped with mechanical agitators, or in vertical boilers of periodic action cheese makers.

Cheese-making vats in the U.S.S.R. are manufactured with a working capacity of 1,000 and 2,000 litres.

The cheese-making vat is rectangular in shape with rounded corners. At the ends of the vat are mounted two uprights on which two metallic channel bars are fixed over the vat, along its axis. Along these bars the drive mechanism of the agitator moves as along rails. Suspended working parts of the agitator (knives, etc.) have a complex motion: rotation - about the axis of the shaft and reciprocating motion - along the vat together with the drive mechanism.

The inner tank of the cheese vat is welded of stainless steel contained in a shell of ordinary steel with sheathing.

Water and steam can be fed into the space between the inner tank and the casing.

In recently manufactured vats a drive mechanism is mounted with stepless speed changer on a texrope transmission. The stepless changer consists of two pairs of half pulleys, one of which can move along a shaft. The diameter of the channel groove of the texrope belt on the first and second pulleys changes then, and because of this the number of r.p.m. on the shaft can be regulated smoothly, in the limits from 6 to 25 r.p.m.

In cheese-making vats turned out previously, the drive mechanism of the agitator with gear box had 5 speeds of the working shaft - 6.5; 9.04; 13.62; 18.36 and 24.87 r.p.m. Recently the cheese-making industry has been converted to periodic type cheese makers.

The machine construction industry of the U.S.S.R. turns out cheese makers having boilers with a capacity of 2,000-3,000 and 5,000 litres.

The periodic action cheese maker model ЧИД-2 consists of three vertical cheese boilers with cylindrical working tank having a conical bottom. Each working tank has a capacity of 2,000 litres and is made of stainless steel and contained in a steel casing having heat insulation and outer sheathing.

Over each cheese boiler a drive mechanism of the agitator shaft with stepless speed changer is mounted on a bracket.

The drive mechanism imparts rotation to the shafts of the agitator of the planetary type, on which a suspended working instrument is fixed. The number of r.p.m. of the agitator can be regulated smoothly within the range of from 4.7 to 38.6 r.p.m.

In the centre of the conical bottom there is a drain tube with a cock to which the drain channel is fixed for draining off the cheese grain into a movable moulding apparatus.

Cheese boilers (3 in a set) are mounted on a platform, calculating that the moulding apparatus is inserted under the boiler.

The moulding apparatus consists of a steel frame on four wheels with a rectangular vat mounted on a frame.

The apparatus is equipped with a set of metal press plates, a model for cutting the curd, a filter, and swivel pipe for draining off the whey. The geometric volume of the vat of the moulding apparatus is 1000 litres.

In the set with the cheese maker there are 10 pneumatic presses with an air compressor.

The pneumatic presses manufactured in the U.S.S.R. are designed for squeezing out whey and pressing the curd in moulds for the production of Holland, Kostroma, Soviet and other types of hard cheeses.

The press is vertical, 4-layer, 2-section. Each section has its pneumatic cylinder with a reducer and an air cock, which makes it possible to press the curd in each section independently.

The press consists of shelves, two pneumatic cylinders, and control cocks.

The base of the shelves and the upper beam are connected together with four uprights which are also guides for the displacement of the pressing tables.

The press ensures easy stepless regulation of pressing force, facilitates the work of the operator and the removal of the product from a unit of the production platform is accelerated.

In the U.S.S.R. hydraulic presses for pressing the curd and presses of the lever-screw type are also produced.

For the paraffining of cheese, movable paraffin treaters with electric heaters are manufactured. The paraffin treater is a rectangular steel vat insulated with a layer of asbestos and covered with a casing. The vat is mounted on three wheels, In the bottom of the vat a protruding tube with cock is mounted for draining off remnants of the paraffin.

In the lower part of the vat 6 steel tubes are welded, in which electric heating sockets in the form of ceramic tubes with spiral of nichrome wire are mounted.

For automatic temperature control of the paraffin, a heat relay is mounted, which switches off the electric heaters when the paraffin has reached a temperature of  $150^{\circ}\text{C}$ , and then switches on when the temperature has fallen to  $145^{\circ}\text{C}$ .

The cheese is lowered into the paraffin and lifted out by means of a lever slide block mechanism fixed above the vat.

In the paraffin treater, all types of cheeses except Swiss and Holland round cheese can be paraffined. The productivity of the paraffin treater is equivalent to the work of 100-120 unit/hour. The power of one electric heater socket is 800 watts.

For rinsing cheese in the ripening process, cheese rinsing machines with rotating cylindrical rubber brushes and cheese rinsing machines with flat capron brushes moving with a reciprocating motion are manufactured in the U.S.S.R. The latter machines are designed for rinsing bar-shaped cheeses. On these machines the rinsing of cheeses is done with brushes while the head of cheese is constantly sprinkled with water. The productivity of cheese-rinsing machines can be as high as 600 unit hour.

#### IV. EQUIPMENT FOR MECHANIZED PROCESSING MILK AND DAIRY PRODUCTS

##### 1. Purpose and Classification of Separators

Separators are used in the dairy industry for purposes of separating cream from the milk and to clarify the latter. Separators are employed also in homogenizing and standardizing the milk, and to produce high-quality cream.

Consequently, the various types of separators employed in the dairy industry are subdivided into units for cream separation.

## 2. Fundamentals of the Theory of Separation

The theory of separation was first developed by the Soviet scientist Bremer in 1928.

Milk is an emulsion which means that fat globules are dispersed in liquid medium.

The size of these fat globules ranges within the limits from 0.5 to 10  $\mu$  .

The majority of the fat globules, i.e. up to 60 per cent, are of 3-4  $\mu$  in diameter. The specific weight or density of the fat globules is less than that of the surrounding medium in which they are dispersed.

Therefore, being in the field of gravitational forces they rise to the surface. The velocity of rising has been determined by the English scientist Stokes

$$V = \frac{1}{18} d^2 g \frac{\rho_1 - \rho_2}{\mu}$$

where

- d - diameter of particle;
- g - acceleration of gravity;
- $\rho_1$  - density of medium;
- $\rho_2$  - density of particles;
- $\mu$  - factor of dynamic viscosity;

The velocity at which the particles subjected to centrifugal forces rise can be expressed as follow:

$$v = \frac{1}{18} d^2 a \frac{\rho_1 - \rho_2}{\mu} = \frac{1}{18} d^2 \omega^2 R \frac{\rho_1 - \rho_2}{\mu}$$

where

- a - radial acceleration;
- $\omega$  - angular velocity of drum,  $\omega = 2\pi$  ;
- R - radius of dislocation of the particle.

During rotation of the separator drum, the fat globules by

centrifugal force are separated from the stream of milk flowing between the separator disks. The fat globules flowing at the velocity of Stokes toward the axis of rotation, on reaching the surface of the disk, create a stream of flow along this surface toward the centre of the drum. Such a flow of concentrated fat globules, called cream, is continuously being drawn off by means of a special discharge device.

Skim milk flowing towards the peripheral wall of the drum passes out through an outlet. The fat globule in the interdisk space moving at a flow rate  $v_1$  traverses the distance  $S$  from the feeder to the edge of the disk in a direction toward the periphery.

In addition, moving in a radial direction at the velocity of Stokes,  $v_2$ , the fat globule covers the distance  $S$  between two adjacent plates.

Time required to traverse the distance  $S$ :

$$t_1 = \frac{S}{v_1} ;$$

Time required to cover the distance  $s$  :

$$t_2 = \frac{s}{v_2} ;$$

In order that the fat globules precipitate on the surface of the plate located below, the following conditions must be satisfied:

$$t_1 > t_2 , \text{ or } \frac{S}{v_1} \geq \frac{s}{v_2} ;$$

The fundamentals of the separation theory are based on this ratio.

On introducing the values of the parameters included in the ratio, the formula for determining the output capacity of the separator was obtained.

The most convenient formula for design calculations was evolved by the Soviet scientist Lukyanov

$$M = 4.8 \beta n^2 z \operatorname{tg} \alpha (R_0^3 - R_M^3) d^2 t \text{ litres/h;}$$

where

- $\beta$  - efficiency of separators;
- $n$  - r.p.s of separator drum;
- $\alpha$  - angle of tilt of disk in relation to horizontal plane;
- $R_S$  - large radius of disk, in cm;
- $R_M$  - small radius of disk, in cm;
- $d$  - diameter of fat globule, in cm;
- $t$  - separation temperature.

### 3. Cream Separators

According to the methods employed in feeding the milk and discharging the separation products, cream separators are subdivided into:

1. Open-type separators, where milk feeding and discharging of the product is done in uncovered conditions.
2. Semi-enclosed separators, where the milk is introduced into open feeders, while the separation products are removed in enclosed conditions.
3. Enclosed separators. In this case the milk is fed and the separated products are removed in enclosed conditions, i.e. the ambient air is shut out.

In the U.S.S.R. open-type separators are manufactured with an output capacity of 1,000 litres/h and are used to produce cream of high fat content.

Semi-enclosed separators have production capacities of 2,000; 3,000; 5,000 and 10,000 litres /h/. Separators with production capacity of or above 600 litres per hour are electrically driven.

The basic parts of a cream separator are:

1. Base
2. Drive unit
3. Drum
4. Feed and discharge device
5. Electric motor.

The cast iron base is meant to carry the various parts of the separator. The drive unit comprises a vertical shaft rotatively mounted in two bearings, screw gear, horizontal shaft and friction clutch.

The upper bearing of the vertical shaft is secured by means of radially-mounted springs to reduce vibrations caused by an improperly balanced separator drum. The friction clutch is mounted between the electric motor and the screw gear of the drive. Its function is smooth acceleration of the drum.

The separator drum consists of body, cover, captive nuts and a set of disks. The latter divide the inner cavity of the drum into narrow sections to reduce the flow range of the fat globules. Four holes are provided in every disk. With the set of disks positioned, these holes form four vertical passages to introduce the milk into the spaces between disks.

The discharge device is made up of pressure chambers and pressure disks.

Skim milk and cream pass from the drum into the pressure chambers, which revolve with the drum. Both skim milk and cream acquire a definite angular velocity and inside the ring of liquid, pressure is built up which is determined by the equation:

$$P = \frac{\omega^2}{2g} (r_1^2 - r_2^2);$$

where

- $\omega$  - angular velocity;
- $g$  - acceleration of gravity;
- $r_1$  - radius of point considered;
- $r_2$  - radius of free surface of liquid.

The pressure disks for the separation products are stationary. Guide vanes are fitted on the pressure disks to enhance the flow conditions of the liquid.

The quantitative ratio of the outflowing fractions and consequently the fat content in the cream is controlled by valves mounted in the discharge lines of both cream and skim milk.

Further, a pressure gauge is fitted in the skim milk discharge line, and a cream gauge - in the cream discharge line.

Separators manufactured in the U.S.S.R. enable a degree of separation ranging from 0.02 to 0.03 per cent of fat in skim milk.

The quality of milk separation depends on a number of factors.

All factors affecting the degree of separation can be divided into two groups: 1. constructional, and 2. operational factors.

Included in the first group are: calculation accuracy, manufacturing quality of separator parts in general, the drum in particular, state of balance of the drum.

Operational factors are: rotative speed of drum, expenditure of liquid, separation temperature and balance conditions of the drum.

When operating the separators the drum should be run at rated velocity and the milk fed in quantities prescribed. Separation temperature should be limited to 40°C.

#### 4. Centrifugal Milk Clarifiers

In cream separators the skim milk and the cream are separated. In addition there to the milk is being partially clarified, and therefore, the drum of such separators incorporates a special chamber, the dirt chamber.

Centrifugal milk clarifiers are designed for removing mechanical impurities from the milk only. Hence, the drum of a centrifugal milk clarifier differs in design from that of a cream separator.

The drums of both the milk clarifier and the cream separator are equipped with a set of cone-shaped disks each. The longer radius of the disks of the first-named is shorter than that of the cream separators resulting in a bigger dirt chamber.

There is also a difference in interdisk spacings which range from 0.35 to 0.4 mm with cream separators against 2 to 4 mm with clarifiers. Since there are no holes in the clarifier disks, the milk emerges from the interdisk spaces at the outer edges of the disks, flowing towards the axis of rotation of the drum. By centrifugal force dirt particles are flung out of the flowing milk stream because their density is greater than that of the milk. In general, milk clarifiers and cream separators are alike in design.

The separators-clarifiers manufactured in the U.S.S.R. have output capacities of 5,000 and 10,000 litres per hour.

## 5. Separators for Processing Cream of High Fat Content

The separators for obtaining cream with high fat content, made in the U.S.S.R. are open-type units model ОЦД with an output of 350 kg per hour.

Cream with 35 to 40% fat is the initial product for separation.

The upper part of the separator base being bowl-shaped houses the drum and supports the top bearing of the spindle. Located on its machined end face is a vessel to ensure the removal of greatly viscous cream having a high fat content. The lower part incorporates the horizontal drive shaft and electric motor, drum speed counter, a tachometer and the bottom bearing of the spindle. The separator drum includes a disk carrier, a set of disks and a cover. The cast vessel, made of aluminium alloy, grade A-2 consists of 2 receivers, a lower one for butter-milk and an upper one for the cream of high fat content. Mounted on the upper receiver is a float chamber complete with float and control cock. The separator is individually driven by an electric motor.

The rotative motion of the motor shaft is transmitted to the drum by means of helical gearing and spindle.

The top bearing of the spindle is held in place by horizontal and vertical damping springs.

Through a tube the initial cream enters the float chamber where it is kept at constant level. From the float chamber the cream is passed into the separator drum. Due to centrifugal force separation takes place yielding butter-milk and cream with 82-84 per cent fat. Centrifugal pumps remove the butter-milk and the cream enters the cooler - butter churn.

Adjusting screws on the butter-milk outlet and a cock for feeding cream into the drum serve to control the fat content of the final cream.

Clarifiers are semi-enclosed separators intended for milk homogenization. An additional function of the clarifier is the purification of milk.

The clarificator drums are of special design. In the set of disks where the milk is introduced, only large fat globules are separated. The milk and small fat globules leave the drum, while the cream and large fat-globules are fed into the homogenization chamber. Here the cream is forced through the annular passage of the homogenizing disk and the large fat particles break up. The cream is then passed into the tube of the plate carrier, where mixing with the inflowing milk it is returned to the set of disks.

For milk standardization separator-standardizers are used. They are conventional cream separators. Having been separated, the cream and skim milk pass through valves mounted at the respective outlets and mix in definite proportion, thin particles commingling in the flowing stream.

Since the drums of any type of separator have a great mass and revolve at high angular velocities, the energy expenditure in operating separators is great.

The formula below is used to find the power requirement of a separator. The power required for a separator with pressure disk is found by the formula below, the result being reasonably accurate:

$$N = \frac{1.5 \beta (R+H) R^3 n^3}{1.36 \times 10^6} \text{ kW}$$

where

- $\beta$  - factor of power expended to overcome friction;  
between liquid and pressure disks (the value taken  
is 1.1 to 1.5);
- $R$  - outer radius of drum, in cm;
- $n$  - r.p.s;
- $H$  - height of drum to halfway the conical cover, in cm.

According to Lukyanov the power expended for separate stages of operation are:

1. To impart kinetic energy to the drum during  
acceleration ..... 30%
2. To overcome friction of the starting mechanism .... 40%
3. Friction of driven unit ..... 20%
4. Air friction of drum ..... 10%

During operation:

Friction of drive unit .....	25%
Air friction of drum .....	50%
To impart kinetic energy to the liquid .....	25%

## 6. Homogenizers

Valve-type homogenizers are extensively used for the homogenization of milk, cream, ice-cream mixes and other dairy products.

These homogenizers are of high efficiency. For instance, in homogenizing whole milk the fat particles of average size from 3.5 to 4  $\mu$  are reduced to within 0.7 to 0.9  $\mu$ .

The homogenizer unit comprises two main parts, the plunger pump, and the homogenizer head.

Operation of the latter is as follows:

Pressure built up in the canal of the homogenizer head forcing the liquid to open a spring-loaded valve, causes rapid flow of the liquid through a narrow gap between the valve head and the seat. The clearance does not exceed 0.1 mm and the milk is forced through the gap at a flow rate of from 150 to 200 m/s. As a result of mechanical action in the valve zone the fat globules are reduced in size.

A plunger-type pump is employed to build up pressure in the homogenizer head. The pump is fitted with three plungers which makes for uniform delivery.

Changes in the pressure of homogenization are effected by means of a set screw to adjust the degree of compression of the valve spring.

Widely used in the U.S.S.R. are model OIB homogenizer units, their throughput capacity being 1,200 litres per hour.

The supporting column of the homogenizer is of cast iron. Incorporated in its bottom end is an electric motor, capacity 11.8 kW, which serves to rotate a belt-driven crank shaft. The latter, by means of connecting rods operates the pump plungers.

A pressure gauge and a safety device are provided on the homogenizer unit.

## V. EQUIPMENT FOR THE PRODUCTION OF TINNED MILK

### 1. Equipment Used in the Production of Condensed Milk

The U.S.S.R. produces a variety of tinned milk products, such as: condensed sweetened whole milk, condensed milk flavoured with cocoa, condensed milk flavoured with coffee, condensed sweetened cream, evaporated skim milk, sweetened and evaporated sterilized milk unsweetened. These are produced using special processing equipment.

#### Evaporator Units Operating at Atmospheric Pressure

Open-type evaporator units constitute vats or vessels, either steam-jacketed, or having internally mounted heaters (coil pipes, tubular heaters). Some of the units are equipped with mixers. The present day application of open-type evaporators is limited only to processing sugar syrups for use in the production of condensed sweetened milk.

#### Vacuum Evaporators not Using Secondary Steam

Vacuum evaporators of this type find application in the production of condensed sweetened milk and other condensed milk products. These units incorporate a vacuum apparatus with an internally mounted calorizer.

A steam separator is housed in the upper part on the apparatus. Condensation of secondary steam is effected in a condenser, the condensate being removed by means of a piston-type vacuum pump.

An evaporator of this type expends 1 kg of live steam per 1 kg of moisture, which is not economical. This drawback has been eliminated in vacuum-evaporator units where secondary steam is utilized too.

There are two methods of utilizing secondary steam: 1. By compression in a compressor unit the secondary steam acquires the properties of heating steam. 2. Secondary steam for heating is used in the next section where the boiling temperature of the product is lower.

## 2. Principle of Steam Compression

Steam injection compressors of steam-jet injectors mainly are used to compress the secondary steam.

Live steam ( $D_o$ ) is introduced into the injector, and part of the secondary steam ( $D_b$ ) is extracted from the apparatus.

By mixing live and secondary steam in the compressor, heating steam ( $D_r$ ) is obtained which is passed into the calorizer.

$$D_r = D_b + D_o \quad (1)$$

The ratio  $\beta = \frac{D_b}{D_o}$  (2) is called the factor of injection.

Herefrom it follows that

$$D_b = \beta D_o \quad (3)$$

Inserting the equation (3) into the equation (1) we obtain the following expression:

$$D_o = \frac{D_r}{1 + \beta}$$

hence it follows that by increasing the factor of injection, the expenditure of live steam decreases.

## 3. Continuous Vacuum-Evaporator Units Utilizing Secondary Steam

The unit is made up of the following basic parts:

Calorizer, steam separator, condenser, plunger-type vacuum pump, steam ejectors, steam injector and a two-sectioned preheater.

The heater constitutes a cylindrical shell having a convex cover suspended on hinges. Internally mounted are two headers, vertically dividing the heater shell into three sections. Rolled into the headers are circulation pipes of 36 mm dia. and two recirculation pipes 100 mm in diameter. The branch pipes weld-mounted on the boiler shell are heating steam inlet, condensate discharge, secondary steam inlet, milk feed, and thermometer fitting. An outlet pipe for condensed milk and a test cock are provided on the shell bottom. Partitions divide the heater into two parts, the

right-hand part serving for preliminary milk condensation and the left-hand part for final condensation.

The steam separator is used to separate the steam from the milk. It is a closed-type cylindrical vessel with a deflector mounted inside on a support.

A steam dome, a glass-covered port and an air cock are provided on the top cover of the body.

The body bottom is fitted with pipe unions for the recirculation pipe and the discharge pipe. Mounted in the lateral surface of the steam separator is an inspection window and a cover. The unit is equipped with a surface condenser comprising a cylinder having pipes rolled into the headers. Emerging from the steam separator, the secondary steam flows through the first preheater, then through the large-diameter pipe and finally into the interpipe space of the condenser. Steam condensation takes place, the condensate drawn off through the outlet holes at the bottom, is directed to the pump.

The cooling water enters the condenser through apertures in the lower cover and passes out through holes in the upper cover.

Plunger pumps are used for pumping both condensate and condensed milk.

The function of the steam ejectors is to remove air by suction from the vacuum-apparatus. Three pumps are included in the unit.

Two pumps operate in series during milk condensation. The third pump is actuated as soon as the vacuum apparatus is started so as to rapidly create vacuum.

The air emerging from the condenser flows into the first ejector where it is compressed by steam action. Then, air and steam pass into the second ejector. Here compression takes place again, this time by live steam. The resultant mix is issued into the interpipe space of the second preheater of milk, where steam condensation takes place.

The steam jet compressor is intended for compression of secondary steam.

The secondary steam of 0.2 atm. pressure and 60° C temperature is compressed by live steam at a pressure of 5 to 9 atm. and temperature ranging from 151 to 175° C. The pressure and temperature of the

resultant mixture of secondary and live steam is 0.4 atm. and 75° C respectively. The mix flows into the calorizer of the vacuum apparatus.

The specific expenditure of live steam is 0.5 to 0.6 kg per 1 kg of evaporated moisture.

#### 4. Multistage Vacuum-Evaporator Units

The principle of operation of multistage vacuum evaporators is as follows:

The secondary steam condensed in the first stage passes into the calorizer of the second stage, while the secondary steam from the second stage is introduced into the calorizer of the third stage and so forth. Specific expenditure of steam in multistage units amounts from 0.4 to 0.5 kg per kg evaporated moisture. Used in the dairy industry, as a rule, are two-stage vacuum-evaporators with steam compressors.

The unit comprises two stages having inclined calorizers, two-sectioned preheater-pasteurizers, steam ejectors, surface condenser, self-evaporator, steam compressor (injector) and intermediate reservoirs.

The milk condensation process takes place in the following way. By means of a centrifugal pump, raw milk is transferred into the preheater-pasteurizer, where it is heated to 110° C. The heated milk passes into the self-evaporizer, where part of the moisture evaporates due to superheating the milk. Emerging from the self-evaporizer the milk flows into the calorizer of the first stage. Simultaneously live steam is fed into the steam compressor. In the first calorizer the milk starts boiling at a temperature not above 65° C. Some of the secondary steam from the first stage passes into the calorizer of the second stage and some into the steam compressor.

In the second stage the milk starts boiling at a temperature ranging from 45 to 50° C.

The secondary steam flows from the second stage into the condenser, while the condensed milk is pumped into the cooling unit.

## 5. Vacuum Coolers

In order to eliminate the presence of large sugar crystals in the condensed milk, the latter is cooled at definite conditions after having been condensed. The dairy industry makes use of vacuum coolers, where the product is cooled by self-evaporation, and of coolers using combination cooling, i.e. cooling is effected by self-evaporation combined with cooling agents. Horizontal vacuum coolers are of the latter type. The condensed product issuing from the vacuum apparatus is sucked into a preliminarily evacuated crystallizer. As soon as the latter is filled with the product, ejectors are started, the pressure is reduced, resulting in additional cooling of the product. Cooling is intensified by actuating mixers in pipes into which cold water is fed.

Provided on the cooling unit are measuring instruments for checking the process. 45 to 50 minutes is required to cool the product to 30-32°C.

The product is held at this temperature for 45 minutes. The second stage of cooling to a temperature of 27.5°C requires 10 to 15 minutes, the holding time being 45 minutes. The finished product is cooled down to 20-21°C which takes 20 minutes.

## VI. EQUIPMENT FOR PRODUCING DRY MILK PRODUCTS

### Roller Driers

Roller driers find application mainly for drying skim milk, butter-milk and whey. Open-type as well as vacuum roller driers are used in the dairy industry. The solubility of products dried in open-type driers does not exceed 80-85%, in case of vacuum roller driers it is 96-97%.

In principle, there is no difference in design between the open-type and the vacuum roller drier. The following basic parts make up the drier: the rollers of cast iron having polished surfaces, two steel knives for removing the dried product from roller surfaces, device for spraying the milk in a thin layer, drive unit,

discharge worm, condenser, vacuum pump, drying chamber of the vacuum roller unit.

The drying temperature in vacuum roller driers is within 60 to 70°C.

### S p r a y i n g   D r i e r   U n i t s

The best industrial method for drying fluid milk products is the spraying method. The solubility of the product dried in spraying-drier units is 99.99%. The driers used in spray-drying the product can be subdivided into nozzle sprayer and disk driers.

The first group uses a plunger pump to force the product into spraying nozzles installed inside the drying tower. In driers of the second group, the product is fed into a rapidly revolving disk, mounted inside the drying tower. The sprayed product is dried by hot air produced in air heaters and introduced into the drying tower by means of blowers. By action of the hot air the moisture in the drops of the product evaporates and the dried milk particles precipitate onto the bottom of the drying tower.

Spraying-nozzle driers consist of: drying tower, spraying device, filters, air heaters, air blowers and air ducts.

The drying tower is a cylindrical chamber made of stainless steel. Its shell is insulated with glass wool. Sheet steel 1 mm thick, is used in the tower as an external protective casing.

The air introduced into the tower is purified by means of viscin filters. The filter consists of a set of perforated metal disks covered with viscin oil. Bag filters or cyclones are used to remove dried particles of milk from the air which passes out of the drying tower. Because of their simplicity of design, ease of handling, and filtering efficiency cyclones are most widely used.

Centrifugal force is made use of in cyclones. The flow of air carrying particles of the dried product is forced into the cyclone chamber where it acquires rotary motion. Due to centrifugal force the dried particles are flung towards the walls of the cyclone. Acted upon by force of gravity, they drop to the bottom part. The purified air is discharged into the atmosphere through an exhaust pipe.

For pre-heating the air, plate-type air heaters are used. In one section of the plate-type air-heater the air is first heated by the condensate, then by secondary steam and in the third section by live steam.

Multi-sectioned air heaters permit the air temperature to be raised from 10° to 140-160° C.

The fan blowers used in drying towers are of the centrifugal type.

### S p r a y i n g   D i s k   D r i e r s

The basic parts of the spraying disk driers are similar to those used in spraying nozzle driers. They differ only in that rapidly revolving disks are used to spray the product.

The disk should revolve at a speed sufficient to impart to the milk particles a circumferential speed of 100-160 m/s when they take off the disk. The disk is driven by an electric motor or a turbine. The range of flight of the particles depending on the rotative speed of the disk is determined by the inner diameter of the drying tower.

$$S = \frac{8}{3} \cdot \frac{r}{\phi} \cdot \frac{\gamma_1}{\gamma_2} \cdot \ln \frac{v_1}{v_2} ;$$

where

- S - range of flight of particle ;
- r - radius of particle ;
- φ - resistance factor ;
- γ<sub>1</sub> - density of liquid ;
- γ<sub>2</sub> - density of air ;
- v<sub>1</sub> - initial flow rate of particle ;
- v<sub>2</sub> - final flow rate of particle ;

The size of particles issued from a spraying disk are determined by

$$d = 98.5 \frac{1}{m} \sqrt{\frac{a}{R\gamma_m}}$$

where a - r.p.m. of disk.

$a$  - surface tension of liquid ;

$R$  - disk radius ;

$\gamma_m$  - density of liquid .

The resistance factor is determined in dependence of the flow conditions of the particle.

Laminar flow conditions:

$$Re \leq 2 ;$$

$$\varphi = \frac{24}{Re}$$

Transient flow conditions  $Re < 1000 ;$

$$\varphi = \frac{18.5}{Re^{0.6}}$$

Turbulent flow conditions:

$$Re \geq 1000 ;$$

$$\varphi = 0.44$$

## VII. EQUIPMENT FOR PRODUCING ICE-CREAM

The production of ice-cream in the U.S.S.R. is concentrated in urban dairies and in large industrial centres - in ice-cream factories.

Butter-making and cheese-making factories located mainly in small settlements process ice-cream in small packages. The preparation of the mixture for ice-cream is carried out mainly in the above-described vats type ВДП. Homogenization of the mixture is done on homogenizers of the plunger, single-step type. The freezing of the mixture at urban dairies and ice-cream factories is done in periodic and continuous freezers.

Machine construction enterprises of the U.S.S.R. produce a series of periodic and continuous action freezers, both with brine cooling and with direct ammonia evaporation.

Of the group of periodic action freezers four marks are manufactured: ОФН, ОФА, ОФД and ХЭФ, and of continuous action freezers, two models - ОФЭ and ОФН.

In periodic action freezers a portion of the mixture is cooled, whipped, and frozen in 8-15 minutes, and is loaded by gravity.

Freezer cylinders in which the mixture is frozen and whipped are rigidly fixed in a horizontal position and provided with jackets in which brine circulates, or the coolant - ammonia or freon - is directly evaporated.

The cylinder is fixed on a cast iron massive bed in which the drive mechanism and the electric motor are disposed.

The drive mechanism consists of two chain and one gear drive and actuates two shafts: one hollow and one solid, disposed one in another and turning in opposite directions. From the hollow shaft a knife frame rotates through a cam connection, and from the solid shaft the agitator is moved. In the lid of the cylinder there is a loading funnel and a drain cock.

The prepared and cooled mixture is sent from the tank or the vat to the measuring tank of the freezer, whence a portion of the mixture is poured into the cylinder of the freezer through a funnel and is processed. The whipped and frozen mixture in a liquid state is passed through a cock into barrels, whence it is sent for packing.

In freezers with brine cooling, calcium chloride brine at a temperature of the order of  $-18$  to  $-20^{\circ}\text{C}$  is usually used.

In periodic action freezers with ammonia cooling, there takes place direct evaporation of the ammonia in the cylinder jacket, therefore for greater strength the jacket is welded to the cylinder.

The ammonia cooling route is as follows: from the refrigerating plant liquid ammonia flows along the pipe through a shut-off valve, filter, and float regulator into the accumulator, which serves also as a liquid separator. From the accumulator liquid ammonia passes along the pipeline into the cylinder jacket from below, passing through an oil separator. Since the accumulator is disposed above the cylinder and the level of the ammonia in it is maintained at  $1/3$  of the height, the cylinder jacket is filled full of ammonia, which boils because of the heat obtained from the mix-

ture being processed. The ammonia vapour passes out through a pipe and closing cock into the accumulator, whence through a filter and throttle valve it passes again into the compressor of the refrigeration plant.

The throttle valve maintains constant pressure in the accumulator within the limits of 1.1 - 1.3 atm., which corresponds to the evaporating temperature of the ammonia from - 32 to - 28°C.

Periodic action freezers ensure the working of air into the product due to its inleakage through the loading funnel in the process of freezing the mixture.

In continuous action freezers enrichment of the product by air is done through inleakage through the second stage product pump which, having double productivity takes the mixture from the I stage pump and air from the atmosphere.

In continuous action freezers the agitator rotates in one direction with a large number of r.p.m. of the order of 540.

The single cylinder continuous action freezer operates in the following way: from the receiving tank of the freezer the prepared and cooled mixture is pumped by the first stage pump into the second stage pump.

The design of these pumps is the same, but the revolutions per minute of the second stage pump, and consequently its productivity, are twice as great as in the first stage pump. Therefore in the second stage pump air is sucked in together with the mixture through the air valve mounted on the tubing. From the pump, the mixture with the air coarsely dispersed in it reaches the cylinder for freezing. Here freezing of the mixture takes place, and the frozen layer on the cooled cylinder is constantly removed by the agitator knives. The whipped frozen mixture still in an unhardened state comes out through a branch pipe in the front wall of the cylinder, and is sent for packing.

Ammonia flow of coolant in the continuous single-cylinder freezer is similar to the flow in the model OΦA periodic action freezer.

The freezer is activated from an electric motor. Through the speed box, the speed changer and chain drive, motion is transmitted to the agitator shaft and to the pumps.

For preparing and packing small ice-cream bricks, a brine-cooled eskimo generator is used. The main product prepared in eskimo generators is eskimo pies. Different types of brick ice-cream are also made. The final packing of the ice cream is done in chambers maintained at a temperature of the order of  $-20$  to  $-25^{\circ}$  C.

For the preparation of brick ice cream on wafers in the U.S.S.R., automatic production lines are used for packing bricks weighing 100 gr., placing them on wafers, and wrapping with parchment. The line consists of an automatic machine for producing bricks of ice-cream on wafers, mark OAM, with a productivity of 250 kg/hour and continuous action quick-freezing apparatus model OCB.

The OAM automatic machine is a one-position machine with volume batching of ice cream, prepared on a continuous action freezer. The automatic machine is actuated from an electric motor with a power of 1.0 kW.

The work of all units is accomplished with the help of a cam mechanism mounted on the lower plate of the bed. In the centre of the machine a chamber batcher is mounted. The prepared wafers are placed in piles in two plate holders. The ice cream is wrapped in parchment 204mm wide. The ice cream from the freezer model OAM reaches the bunker, whence the hollow of the batcher is filled, forming a rectangular block. The width and height of this block correspond to the dimensions of the brick. The third dimension is determined by the stroke of the plunger and can be regulated depending on the whipping of the ice cream. The torn off piece of packing parchment reaches the movable platform and at the same time the lower wafer is placed on the platform from the magazine.

After the block has been removed from the batcher, the gate valve overlaps the output opening and cuts off the brick, which is laid on the wafer. One wafer is taken from the pile and laid on top of the brick. The brick with two wafers and a sheet of parchment wrapping is ejected by a punch and die, and the box is formed. Under the die claws are disposed which bend the edge of the parchment and close the box. The wrapped brick is expelled by a pushing device onto control scales, and from them onto the loading conveyor. Here they are grouped into 8 in a row, after which they are fed by

pusher into the swinging trays of the hardening conveyor of the quick freeze apparatus.

The quick freeze apparatus OCB consists of a chamber, a sliding chain of the hardening conveyor with trays, an evaporator, ventilators, and unloading conveyor. In the evaporator ammonia boils at a temperature of about  $37^{\circ}\text{C}$ , and in the chamber a temperature of the order of  $-30^{\circ}$  to  $32^{\circ}\text{C}$  is maintained, with intense air circulation.

During passage of the bricks along the chamber, they are completely hardened.

## VIII. EQUIPMENT FOR WASHING CONTAINERS AND PACKING MILK AND MILK PRODUCTS

### 1. Equipment for Washing Churns

Churns at enterprises of the milk industry are washed in special churn washers. In the U.S.S.R. churn washers of the rotary and tunnel types are manufactured.

Churn washers of the rotary type are manufactured with a productivity of 180 and 360 churns per hour, and of the tunnel type with a productivity of 200 and 400 churns per hour.

In the rotary churn washer, when the rotary device makes a complete revolution, the churn is washed on the inside and on the outside and is rinsed with cold water, an alkali solution and hot water are injected and the churn is steamed.

The rotary machine consists of a welded frame, tanks for rinsing liquid, devices for rinsing - nozzle, rotary device, pump for alkali solution, pump for hot water, valve control board, protective sheath and drive mechanism.

The machine washes by the dynamic impact of a stream of rinsing liquid (alkali solution, hot water) from nozzles, which hit the inner and outer surfaces of the churns set on the rotary device and together with it have a jerky rotary motion. Sterilization of the churns after washing takes place in the last stage of washing by means of live steam.

In tunnel churn washers analogous operations of washing by jets churns on a constantly moving conveyor along the tunnel of the machine are carried out. In addition, the remnants of milk remaining in the churn are collected on the loading sector of the conveyor.

## 2. Equipment for Washing Glass Bottles

The washing of glass milk bottles is done on special **bottle washers** built into an automatic line for washing bottles, filling them with milk and capping.

Bottle washing machines for washing bottles manufactured in the U.S.S.R. belong to the brushless type, ensuring washing of the bottles and spraying them with detergent and rinsing liquids.

At the present time the industry of the U.S.S.R. manufactures bottle-washing, filling and capping lines with a productivity of 2,000, 6,000 and 12,000 bottles/hour.

The bottle-washing machine manufactured in the Soviet Union mark OMF-2 has a productivity of 2,000 bottles/hour and is designed for washing bottles with a capacity of 0,25-0.5 and 1,0 litres.

In the lower part of the body of the machine water and alkali washing vat is disposed, and over them - the apparatus for spraying the bottles with an alkali solution and water.

A chain conveyor is built into the body of the machine. On its chains bottle carriers are fixed with 8 nests in each. Periodic motion of the conveyor with bottles is done by a crank lever mechanism.

The machine operates as follows: dirty bottles with neck forward are loaded by hand in the grooves of the receiving table. When the table rotates, bottles jump into the nests of the carriers and then conveyors move successively through both washing vats and the injecting system, and are sprinkled with warm and cool water.

In the first vat the bottles are heated for 2 minutes 53 seconds and are washed in water at a temperature of 35-40°C.

In the second vat, bottles are washed in a 2% alkali solution at 65-70°C for 3 minutes 50 seconds.

When they come out of the vat, the bottles are sprayed inside

and outside four times for 1 minute 55 seconds with 1.5% alkali solution at a temperature of 65-70°C.

After this, for 31 seconds the inside is injected and the outer surface of the bottles is sprinkled with water at a temperature of 45-50°C. Then for 10.4 seconds water at a temperature of 25°C is twice injected into the churns and for 20.8 seconds the outside is sprinkled with water.

Clean bottles are automatically unloaded from the machines and sent on a conveyor to the filling machine.

The arrangement of bottle washing machines with a capacity of 6,000 and 12,000 bottles/hour is similar to that of machines with a productivity of 2,000 bottles/hour, and they differ only in their larger size and automatic loading of the machine with bottles.

Machines with a productivity of 6,000 and 12,000 bottles/hour are provided with automatic devices for taking the bottles from boxes and for placing filled bottles in boxes.

### 3. Equipment for Filling Glass Bottles with Milk

For filling glass bottles with milk, a special automatic machine for filling and capping is used which is built into the washing and filling line.

The machine construction plants of the Soviet Union manufacture automatic filling and capping machines with a productivity of 2,000 and 6,000 bottles/hour.

The automatic machine consists of a filling machine, a press for preparing aluminium caps, and a capping machine, mounted in one aggregate, and linked by a platform conveyor with the bottle washing machine.

The filling machine of the rotary type is designed for filling glass bottles of a capacity of 0.25, 0.5 and 1.0 litres with milk. Milk is poured to the proper level under a vacuum created by a special centrifugal vacuum pump. The machine has a closed rotating tank for milk, on the bottom of which filling instruments are mounted. Clean empty bottles from the bottle washing machine reach the closed platform conveyor of the aggregate, passing round the

capping rotary device. By means of a sprocket gear they are placed exactly under the filling head and move with it in a circle. The filling heads are then lowered onto the neck of the bottles, closing them hermetically, part of the air is removed, and they are successively filled with milk. The filling heads are lifted to an upper position and the necks of the bottles are released.

Then the filled bottles pass on a platform conveyor to the rotary capping machine for capping with aluminium caps.

The caps are stamped on a press consisting of a plate with a stamp crank mechanism and a holder of the foil. The press is mounted on a column next to the rotary capping device.

In stamping the cap, all data characterizing the product in conformity with the State standard (ГОСТ) are stamped on it at the same time. The finished cap is blown by air into a slanted flow which performs at the same time the functions of a magazine. The bottle passing under the magazine raises a catch holding the cap with its neck and caps itself.

The bottle with cap then passes under the rotary device of the capping machine. In the upper part of the rotary device there are packing heads which when the rotary device turns along a contour are lowered and tighten the cap on the neck of the bottle with the help of a rubber cap ring. The closed bottles reach the packing table where they are packed in boxes.

#### 4. Equipment for Packing Milk Products

Among the pieces of equipment for packing milk products the following are of considerable interest. They are widely used in milk factories and manufactured in series in the U.S.S.R.

Automatic machines for packing curd cheeses, model O3K, similar automatic machines for packing processed (rindless) cheeses, model O3A and automatic machines for packing curd, model O3B.

The automatic machine model O3K is designed for packing curd in the preparation of different types of curd cheeses 100 grams in weight with an accuracy of  $\pm 4$  g. The automatic machine packs the curd in parchment.

The automatic machine consists of the following principal parts: bed with drive shaft, batcher, mechanism for feeding parchment and making boxes, moulding table, apparatus for delivering lids and placing them on the boxes, conveyor of finished packed product and electric motor.

The principal link connecting all the devices is a round, periodically rotating table with 10 nests evenly disposed about its circumference at an angle of  $36^{\circ}$  C.

The drive of the automatic device is from an electric motor through a two-speed gear box and belt transmitter. The table, receiving motion from a maltese cross, turns periodically with stoppages necessary for completing one or another technological operation.

The process of operating on the automatic machine takes place in the following sequence: a parchment band from a roller with the label information on it is automatically fed under a stamp for cutting out the card of the body of the box. By means of a claw with the vacuum pump the card is fed under a punch, located over the table. The punch is lowered, forms a box from the card, and places it in the nest of the table. During this movement of the table, the box passes under the spout of the batcher and is filled with curd cheese loaded in a bunker. Further, in the swivelling of the table the filled box approaches the device for putting on the parchment lid. Here the lid is cut from a second band of parchment and by means of a claw with vacuum suction is transferred and placed on the curd mass in the box, and the brick is slightly pressed. In routine motion of the table, the box with protruding edges of parchment passes under the closing mechanism where the edge is turned by special claws and closed. In regular motion of the table, the finished cheese is squeezed out of the nest and by means of a moving claw is fed to a conveyor for the ready product.

The automatic machine has two working speeds making it possible to make 42 or 48 cheeses per minute.

An absolutely analogous arrangement and principle of operation is that of the automatic machine for packing and closing processed (rindless) cheeses 100 grams in weight, model O3A.

The main difference between the automatic machines O3A and O3K consists in the fact that the former packs and closes the processed cheese in packets manufactured of a roll of foil on which paper labels are glued.

For packing processed (rindless) cheeses in the U.S.S.R., besides automatic packing of cheese in 100 g packets, automatic machines for packing cheese in segments weighing 30 g are manufactured.

This automatic machine is turned out under the model O3A-30.

The automatic machine for packing curd in boxes weighing 500 g, model O3B, is similar in its construction to the above described automatic machine, model O3K.

The difference consists in the fact that in the automatic machine O3B the packing is done in boxes made on an automatic machine of rolled compact paraffined paper ( $165 \text{ g/m}^2$ ) and a white paraffined carton 1 mm thick is used as a cover. The transfer of the card of paraffined paper to the machine forming the box here is done by vacuum suction, and with the help of tongs.

For melting paraffin at the folds and for giving elasticity to the paraffined paper, the punch mechanism shaping the box is heated by built-in electric heaters. On the operation of closing the boxes containing curd, it is pressed consecutively on the conveyor from three sides. Here also paraffin is melted and the edges of the paper are pressed one to the other. Further, the box containing curd moves through three cooling points, to which water passes and reaches the output tray.

This presentation includes far from all the technological equipment used in enterprises of the milk industry of the U.S.S.R. and manufactured by the industry of the U.S.S.R. for food processing industries. We indicate here only the main types of machines and apparatus used in the most important sectors of technological processing of milk products.

In the current year, enterprises manufacturing food-processing machinery in the U.S.S.R. have produced serially over 140 types of machines and apparatus for the equipment of the milk industry.

In addition, the serial production of about 42 types of new modern machines is coming into being. 31 of them are automation lines and high-productivity automatic machines.

## C o n t e n t s

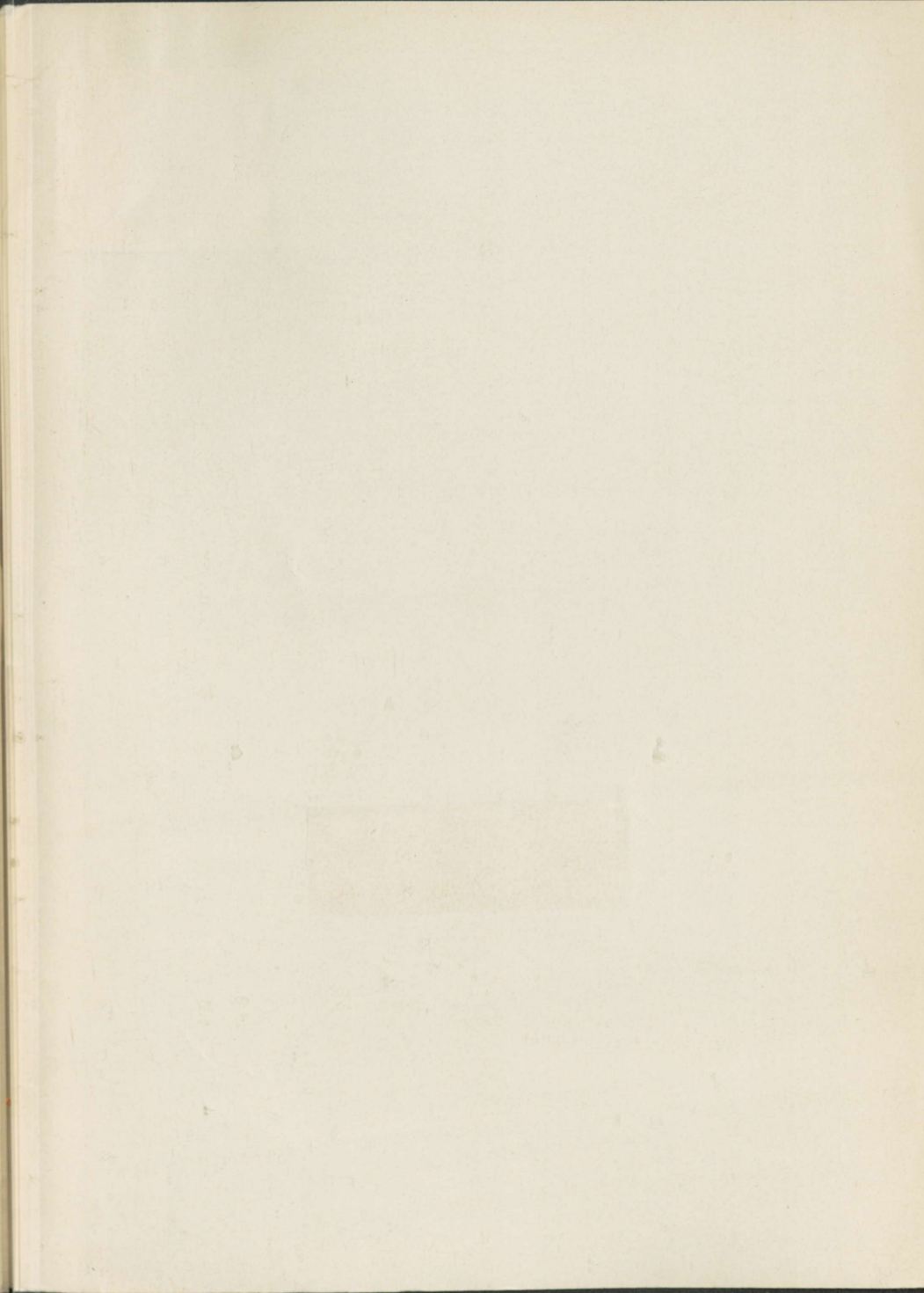
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