COLLECTION, TRANSPORT AND DISTRIBUTION OF MILK

MILK COLLECTION CENTRES

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Satisfactory supply of a dairy factory depends upon how the quality of the milk can be maintained until its arrival at the factory. One solution to this complex problem is the establishment of collection centres in the milk collection area, although, as will be seen later, this method is subject to certain conditions which make it unsuitable for adoption in every case.

Before the various types of collection centre are described, it may be useful to indicate their purpose, from the point of view both of easing collection and of preserving quality.

The Collection of Milk

The simplest and most usual way of collecting milk is from door to door; the van stops at each farm, is loaded with a number of full cans, and deposits a similar number of empty cans which have been cleaned and sterilized by the dairy. This method is only moderately efficient, since it is slow because of the numerous stops; the value of the vehicles depreciates relatively fast, as they are used on all types of road, some of which may be badly maintained; and the transport capacity of the lorries is used uneconomically, because the cans are rarely all completely filled. Under these conditions the collection of milk is inevitably expensive.

Nevertheless, however uneconomic this method may be it is often the only practicable one, notably in wooded country where there are several small isolated farms. It may also be used—less inconveniently—in more prosperous districts where the production from each farm is several hundred litres a day, although bulk collection in tankers might be a better solution.

On the other hand, this method of collection is not justified in districts with small farms grouped in villages. Here, the formation of a milk collection centre to which the farmers bring their morning and evening milk by their own means greatly facilitates collection because the van is able to pick

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up the total production of one village or district with a single stop. The gain in time allows longer pick-up routes to be scheduled. Further, if the milks are mixed at the collecting centre after reception the maximum transport capacity of the lorries can be utilized; this method, however, implies the washing of cans at the farm or at the centre, and is not without risk from the bacteriological point of view.

However the transport between producer and manufacturing dairy may be organized, the setting-up of milk collection centres unquestionably appears to be an advance.

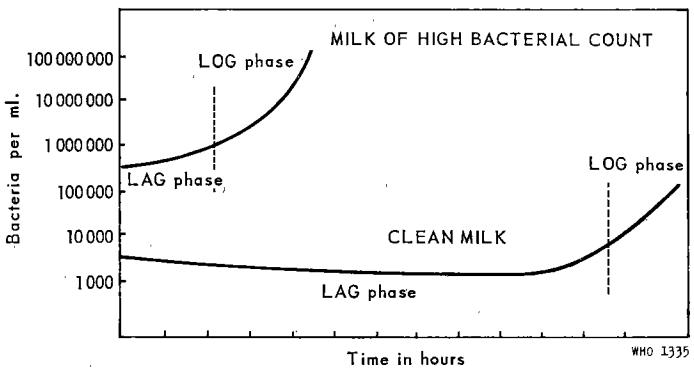
The Preservation of Milk Quality

The constant aim of a dairy factory is to receive raw milk which is both clean and sanitary—a complex question from the biological point of view, and one with practical difficulties. Preserving the quality of raw milk is in fact a problem of asepsis on the farm, and the solution rests in hygienic milking, and the cooling and holding of milk at a temperature sufficiently low to retard the multiplication of bacteria gaining entry at milking.

The hygiene of milking, although not treated in this chapter, is without doubt the essential factor. Temperature conditions during the interval before collection are nevertheless also extremely important, and it is in this respect that the collection centre can be particularly useful.

FIG. 1

GROWTH OF BACTERIAL POPULATION IN MILK HELD AT ROOM TEMPERATURE



Milking takes place twice a day, at about 6 a.m. and 6 p.m., and cans are collected once a day during the course of the morning. The age of milk on arrival at the factory is thus 3 - 4 hours for morning milk and 15 - 16 hours for evening milk. During this time the bacteria multiply. Fig. 1 shows, diagrammatically, the growth of the bacterial population in milk held at room temperature.

During the first hours after milking the multiplication of bacteria is slow; this is the " lag " phase, the duration of which is extremely variable and depends essentially on the initial contamination and, to a lesser extent, on the composition of the milk—which varies according to the season, the feeding and the breed of cows. This period of relative stability is succeeded by the " log " phase during which the bacteria multiply very quickly, causing an irremediable deterioration in milk quality.

It is during the lag phase that precautions must be taken to preserve milk quality, because any intervention after this period when bacteria are in the log phase is of very slight, almost negligible, effect.

The duration of the lag phase varies; it may be as much as 10-15 hours for very clean milk containing 1000 bacteria/ml and held at a temperature of 20°C; while it falls to 2-3 hours or less for milk containing several thousand bacteria/ml held under the same conditions. In practice, it is during the two hours after milking that means of arresting bacterial growth must be applied. Bacterial growth being a function of temperature, the simplest means of checking it is to cool the milk. An empirical rule, taking the preceding statements into account, is to establish cooling conditions, namely, (*a*) lowering of the average temperature of the milk to below +10°C in the two hours following milking; (*b*) maintenance of the milk at this temperature and, if possible, at a lower temperature, until collection.

Unless a plentiful supply of chilled water is available, neither of these conditions can be fulfilled without mechanical refrigeration. Milk coolers using mechanical compressors are expensive and do not easily pay their way on small farms. Where local conditions allow for the formation of a milk collection centre equipped for cooling and holding of milk the milk quality will be improved, and full use may be made of the relatively expensive refrigeration equipment. The milk collection centre should thus represent one of the links in the refrigeration system—a very important link since it occurs at the beginning of the system immediately after production.

The Milk Collection Centre

If used with the appropriate precautions the milk collection centre is a definite advance in local dairy economy, but its formation must be governed by the characteristics of the milk-producing district which it serves.

Installation of collection centres

In principle, the setting-up of a collection centre should be envisaged only for districts where several hundred litres of milk are produced daily by the small farmers grouped around the village. The producers deliver their milk by their own means to the centre from a very short radius—200-300 metres, for example—so that a heavy burden of transportation is

not imposed on them; for greater distances the cans are brought in by van or cart. This simple scheme holds good in districts where the co-operative tradition exists, or where the individualism of the farmer has been obliged to give way to communal methods of organization if full value for his products is to be obtained; it involves goodwill and extra effort. Experience has shown, however, that this method of organization is easily assimilated into local tradition wherever there is the initiative to start it.

More recently, some attempts have been made to extend this scheme to districts where farms are more dispersed, by choosing grassland regions where milking is carried out in the field. The freshly obtained milk is taken not to the farm but straight to the collection centre. The distances travelled to deliver the milk are longer, the radius from the centre being as much as 2-3 km. When these centres are constructed in pre-eminently dairying regions, and drain a relatively large area, their reception capacity becomes much greater, reaching several thousand litres of milk per day.

The promoters of this extension justify it by the fact that once transport of milk is inevitable, it may as well be taken to a collecting point.

The collection of milk from mountain pastures by cable railway or by pipeline leading to a centre in the valley fills a similar need for rapid and convenient collection of milk which is not readily accessible.

These few examples show the limits of application of this method of collecting milk—good in principle, valuable, but dependent upon the prevailing physical, agricultural and human circumstances.

Construction of a collection centre

Milk collection centres may be established either in specially constructed buildings or in rented premises. They generally comprise two rooms, one of which is used for reception and weighing of milk and the other for refrigeration; these two operations may be carried out in one room if the layout does not allow for two, although it is preferable to have separate rooms (see Fig. 2; see also Fig. 4 in the chapter by Mann, page 658). A platform is frequently provided for loading and unloading of milk cans.

The surface area necessary for the installation of a collection centre being relatively small (2-4 square metres per 100 litres of milk—roughly 1-2 sq. ft per gallon, depending upon the reception capacity), many are integrated with buildings housing other communal or agricultural activities. Thus, for example, collective deep-freeze lockers are often installed in the same building as the milk collection centre, with the advantages of somewhat reducing the costs of installation (engineering, water and electricity services, etc.) and offering greater convenience to the users.

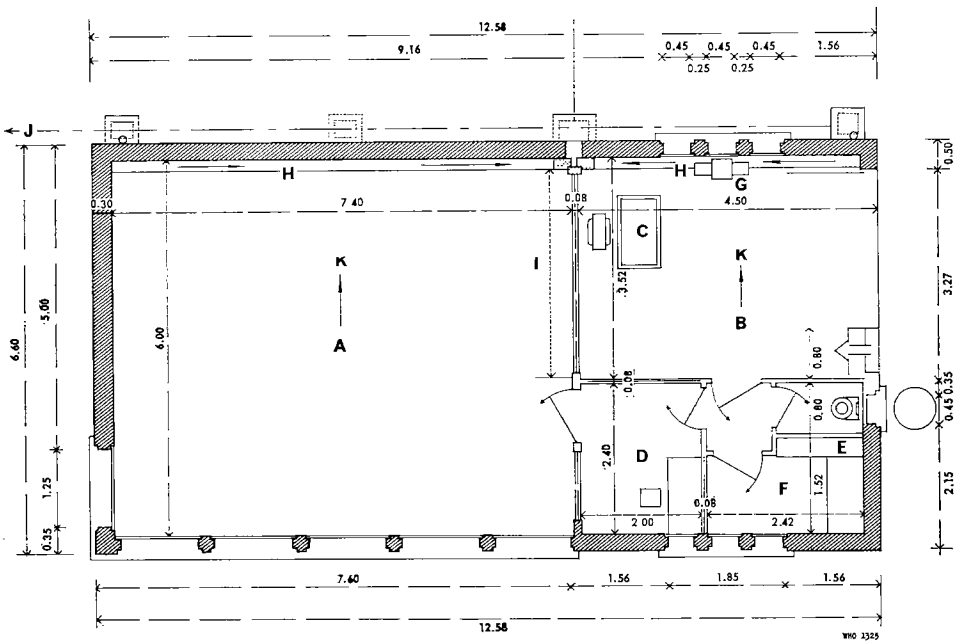
The centre must have access to potable water, electricity and drainage.

Its rooms should always be kept extremely clean to reduce to the minimum the risks of contamination of milk when transferred from one vessel

to another. The floors, and the walls up to a certain height, should be freely washable so that this may be done after the reception of each milking. Since lactic acid attacks cement, the floor should be tiled and sloping slightly towards a drain with a trap, so that water used for washing down the premises can drain off; similarly the walls should be either of porcelain tiles

FIG. 2

PLAN OF A MILK COLLECTION CENTRE OF 800 LITRES PER DAY CAPACITY



A = Refrigeration
B = Reception platform
C = Weighing of milk
D = Office
E = Window
F = Lavatory
G = Can washing
H = Gutter
I = Movable glass partition
J = Towards pavement
K = Gradient 1 %

The surface area measures approximately 40×20 ft (37×18 m).

or treated with a washable paint up to a height of 2 m (6 ft). All corners at the junction of floors, walls and ceilings should be rounded off.

The inevitable humidity, which favours the development of moulds, makes it desirable to incorporate an anti-mould product such as an organoborate in the ceilings and the upper, unwashable, parts of the walls.

The rooms should be well lit and ventilated; the proportion of glassed surface to floor surface should be about one-fifth, and the windows should be of the tip-up openable type.

Although the cooling of the milk is naturally carried out in appropriate refrigerating equipment, it is still desirable to keep the rooms themselves as cool as possible. Doors and windows should therefore face north, and if the work-rooms have a roof which tends to become overheated in summer some form of insulation should be improvised—for example, by covering the upper surface with a cheap material such as squares of pressed straw, rolls of glass fibre, etc.

Interior equipment

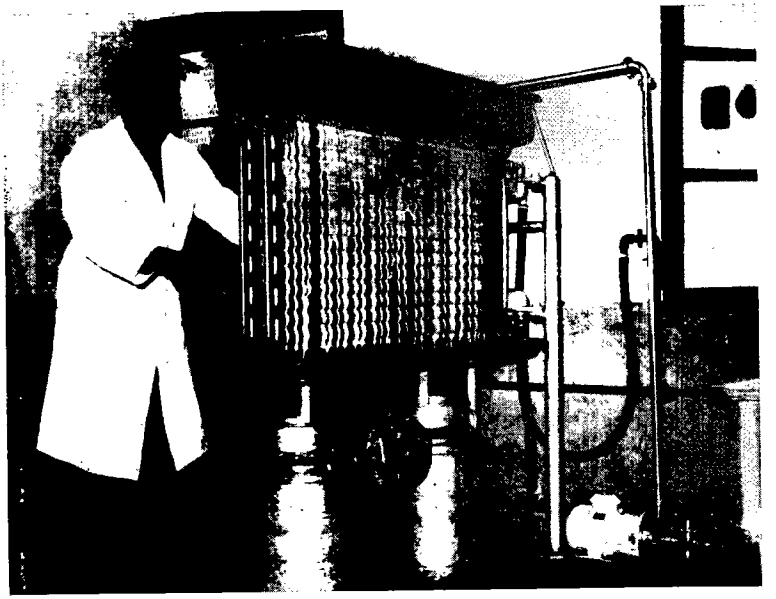
The interior equipment of a milk collection centre depends on the method of collection practised: in cans or in bulk.

Collection in cans. The producers bring in their milk in pails or cans. Two methods of procedure may be used: (1) The individual milks remain in the producers' cans, and the centre confines itself to centralizing and cooling them, its functional equipment being limited to a milk cooler. Keeping of accounts for milk delivered by the producer continues to take place at the reception platform of the dairy, and similarly the cans are washed and sterilized at the factory—a guarantee of their bacteriological hygiene which is not without value. On the other hand, collection is less economic, since not all the cans will be completely full. (2) The milks are mixed at the collection centre. The procedures necessary at the centre are in this case as follows: weighing, filtering and transfer of milk to the collection churns; refrigeration; keeping of accounts for the milk of each producer. To this may be added the washing and disinfection of cans used for transport between the farm and the collection centre. The responsibility of washing cans may be left to the producers, a solution which is simple and probably the best provided it is efficiently carried out. This unfortunately not always being the case, some centres undertake to wash the producers' cans themselves. Equipment for this type of centre comprises a weighing machine for milk; a cooler; a desk at which farmers' production records can be kept; and washing equipment (hot water, troughs and drains) for the producer's cans. Whatever the circumstances, this equipment is not elaborate, and is suitable for centres handling little more than 1000 litres per day.

Bulk collection in tankers. For larger quantities of milk, handling in cans is slow and laborious, and is giving way to bulk collection.

The equipment of the centre then comprises: reception and milk-weighing apparatus; a milk cooler which brings the milk down to +4°C within a few minutes; insulated tanks for storage of cooled milk; pumps and a circulation system for the transfer of milk; a hot water supply and detergent-disinfectant solutions for cleaning the apparatus and producers' cans. This equipment, which is considerably more complex than that used for collection of milk in cans, is suitable for centres collecting several thousand litres of milk daily. Space is naturally always reserved for refrigeration equipment.

FIG. 3
SURFACE COOLER



In large collection centres (taking over 1500 litres per day) the milk is poured into a tank from which it is pumped on to a more powerful surface cooler capable of cooling 1000-1500 litres per hour.

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Milk cooling equipment

The methods and the type of equipment used for cooling milk depend upon the size of the collection centre. When this is small and milk is collected in cans it is cooled by one of the following procedures:

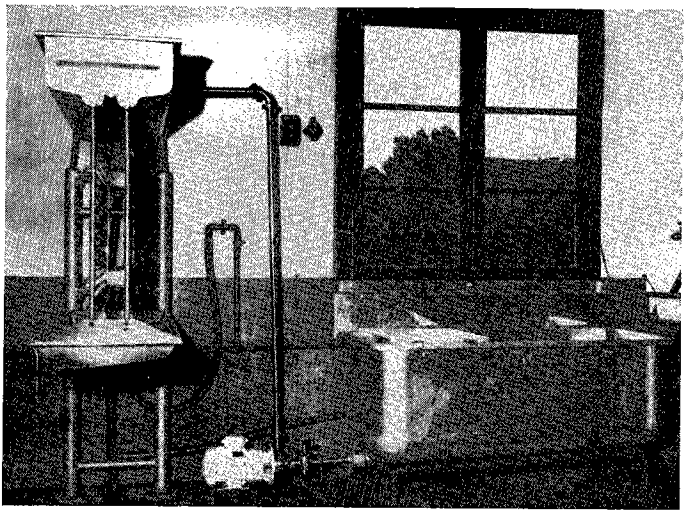
(1) By passing the milk over a surface cooler using a liquid refrigerant (see Fig. 3). Cooling is rapid, occurring in a few minutes, and corresponds to the time taken for the milk to run through the apparatus; the milk is collected in cans and stored in a cool place or preferably in a tank of cold or chilled water.

This is a rapid and efficient method, but it imposes certain conditions on the user. Since the milk passes over a surface cooler, exposed to the air, there is a risk of its contamination by dust in the atmosphere and by the surface of the cooler itself unless this has been extremely carefully cleaned. Such coolers are consequently often encased in a light housing—for example, of sheets of transparent plastic—to protect them from the air. Moreover, the cooler itself must be cleaned after each run—a task which is unnecessary with other methods.

(2) By immersion of the cans in a tank of cold water (in the mountain districts) or chilled water (see Fig. 4).

FIG. 4

DUAL-TYPE SURFACE COOLER



This cooler deals with 1000 litres of milk per hour; a single-type cooler cools 500 litres per hour, and a triple-type, 1500 litres per hour. The consumption of well water is between two and two-and-a-half times the volume of the cooled milk.

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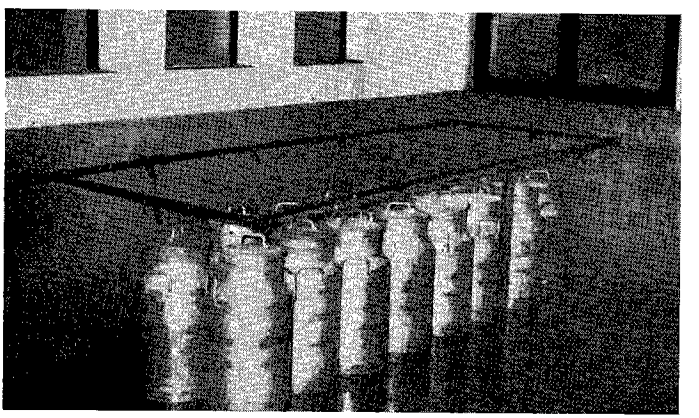
FIG. 5

SPRAYING APPARATUS FOR 16 CANS



The fine pulverization of the water allows advantage to be taken of the cooling effect produced by evaporation; water consumption is thus very low (2 litres of water for 1 litre of milk during the 12 night-time hours).

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(3) By spraying of cold water (in mountain districts) or chilled water on the outside of the cans (see Fig. 5).

These last two methods give a slower initial cooling of milk than the surface cooling method (1½-2 hours are necessary to lower the temperature of the cans by 20°C and therefore to bring it to below +10°C), but their use is simpler and avoids the risk of secondary contamination of milk—which, in effect, does not leave the can until it reaches the dairy, thus avoiding all contact with atmospheric dusts or other agents during actual cooling.

The refrigerant is almost exclusively water—ordinary water if it is cool enough and in sufficient supply, or chilled water produced by an ice-bank type of cooler.

Many centres, including the older ones, use whatever water supply is available for the cooling of milk, but unless the flow and temperature are very suitable and a very cool water (less than +10°C) is plentiful, this traditionally rural but inadequate method is being progressively abandoned for the more efficient chilled-water installations.

Most installations now use mechanical refrigeration with an electricity consumption of the order of 2 watt-hours to lower the temperature of 1 litre of milk by 1°C.

The coolers used are sturdy pieces of equipment with dimensions similar to small standard models for individual needs; functioning is completely automatic and no specialized personnel are necessary.

The refrigeration equipment of collecting centres receiving several thousand litres of milk per day from tankers is entirely different, the problem here being on an industrial scale, and requiring coolers of the type used in dairies.

Apparatus capable of cooling several thousand litres per hour to a temperature of approximately −4°C is utilized to supply surface coolers, or tubular or plate heat-exchangers in which milk circulates in the opposite direction to chilled water, or is cooled by direct expansion of a liquid refrigerant. Passage through the heat exchanger takes only a few minutes; the cooled milk on leaving is directed into insulated tanks of stainless steel, where it is stored while awaiting collection.

The apparatus used, without being complicated, nevertheless requires strict supervision.

It could be greatly simplified in future by adopting refrigerator tanks in which the milk can be both cooled and stored. This type of equipment, in which cold is produced by direct expansion of the refrigerant in the lining at the bottom of the tank, functions very simply and safely; it can cool the supply from one milking to +10°C in less than one hour, and to +4°C in less than two hours.

Whether conventional milk cooling equipment or refrigerator tanks are used, however, it is imperative that they should be meticulously cleaned with

water and detergent if a high bacteriological standard is to be maintained for the milk.

The operation of collection centres

The collection centres are generally set up and managed by local farmers' societies, which arrange the loans and subsidies.

A responsible person is appointed to administer the centre, to ensure the daily reception and dispatch of milk, to maintain the hygiene of the equipment, to undertake other small maintenance jobs, and to arrange for periodic detailed technical checks.

He is also responsible for keeping the books of the centre and, should the occasion arise, the delivery records of the producers.

These tasks take little time in the small centre, only 2-3 hours per day; in larger centres a permanent staff is required, possibly two men employed full-time.

The management costs of a collection centre may be broken down into: amortization of loans; rent, if the site is rented; salaries of personnel; cost of water, electricity and various services; and annual maintenance expenses. They are covered by a premium per litre of milk collected, paid by the factories supplied, to cover the management costs as such, and to repay the producers for the effort of delivering their milk to the centre.

This scheme of management costs is in fact rather theoretical, because the collection centre is formed as a result of local initiative and is consequently planned with the maximum of precautions to ensure its success and profitability. Frequently certain expenses appear in the accounts only as hypothetical amounts because of subsidies from local authorities, farmers' societies, or individuals interested in the success of the enterprise. It is hardly possible in these conditions to judge of the profitability of the collection centre; the usual methods of determining the producer-cost per litre of milk do not reflect the real price, which is considerably less, and varies in different cases; such figures are rarely divulged to investigators.

However, the three examples which follow, concerning small collection centres in the Dijon Basin, France, give some idea of management costs. Since the centres were established to ensure the cooling and holding of milk between milking and collection, the accounts cover a period of only five months per year, from May to October.

TANAY CENTRE

	Old francs
Capacity: 560 litres per day	
Immersion cooler (chilled water)	
Cost of building construction	800 000
Cost of interior equipment	900 000
During 5 months of the year, 84 000 litres of milk were collected and cooled.	

Annual operating costs	*Old francs*
Amortization of building over 30 years at 5 % . .	66 500
Amortization of equipment over 10 years at 5 % .	135 000
Maintenance and labour charges	28 500
Water, electricity	23 500
	253 500

Cost per litre of milk

$$\frac{253\,500}{84\,000} = 3 \text{ fr. per litre}$$

REMILLY EN MONTAGNE CENTRE

Capacity: 400 litres per day
Immersion cooler (chilled water)

Cost of fitting up existing premises	120 000
Cost of interior equipment	650 000

During 5 months of the year, 60 000 litres of milk were collected and cooled.

Annual operating costs

Amortization of building over 30 years at 5 % . .	10 000
Amortization of equipment over 10 years at 5 % .	97 500
Maintenance and labour charges	35 000
Water, electricity	15 500
Rent of premises	5 000
	163 000

Cost per litre of milk

$$\frac{163\,000}{60\,000} = 2.7 \text{ fr.}$$

BLIGNY-LE-SEC CENTRE

Capacity: 400 litres per day
Spray-type chilled-water cooler

Cost of fitting up existing premises	120 000
Cost of interior equipment	650 000

During 5 months of the year, 60 000 litres of milk were collected and cooled.

Annual operating costs

Amortization of building over 30 years at 5 % . .	10 000
Amortization of equipment over 10 years at 5 % .	97 500
Rent of premises	5 000
Water, electricity	13 500
	161 000

Cost per litre of milk

$$\frac{161\,000}{60\,000} = 2.6 \text{ fr.}$$

The merits of collection centres are considerable from all aspects. Apart from their technical and economic advantages, early refrigeration at the centre avoids the use of individual cooling equipment, which is widely dispersed, heterogeneous, and often improperly managed by the producers if left to themselves. Moreover, improvement in the quality of raw milk encouraged by the collection centres has some effect on the slow process of improving the value of agricultural products—a process from which the producer is the first to benefit.

SELECT BIBLIOGRAPHY

Anquez, M. (1955) Cooling of milk at production. *Rev. gén. Froid,* March
Anquez, M. (1959) Cooling of milk at the farm. *Génie rur.*, June
Budge, J. J. (1953) Bulk milk handling in the USA. *Refrig. J.*, December
Koall, H. E. (1956) Production and conservation of milk in the small farm. *Die Kälte,* August
LaBlanchy, A. (1954) Cooling of milk at the farm. *Rev. prat. Froid,* April
Lung, O. (1955) Refrigeration of milk at the place of collection. *Die Kälte,* May
LeRoy, C. (1955) Bulk milk collection. *Génie rur.*, December
Meriaux, D. (1954) The improvement of milk quality in the Dijon milk shed. *Génie rur.* February
Mocquot, G. (1959) In: *Proceedings of the Seminar on the Improvement of Milk Quality,* Loches, October
Petitjean, M. (1956) Refrigeration of milk on the Côte-d'Or. *Génie rur.*, September
Woodruff, A. C. (1952) Bulk milk collecting. *Refrig. Engng,* December
Périgaud, J. (1953) Cooling of milk at the farm. *Rev. gén. Froid,* August