CHAPTER 5

PILOT PROJECT PROPOSALS

5.1 General

Project proposals in this Chapter include the six milk collection and processing programmes described in Chapter 4. The presentation attempts to give technical indicatons concerning equipment of the plants and the size and type of buildings required. In the short description of each of the six groups of plants labour requirements and time schedules are discussed. Since most of the equipment proposed in each of the plants is suitable for all groups, standard equipment specifications have been prepared and are given in section 5.2. The selection of the equipment needed for a particular processing programme and a particular capacity is given in the respective parts of section 5.3. Standardization of equipment may not be of interest to those establishing a single plant but it may help in comparing the various proposals included in this study. It may also help to reduce capital costs in cases where equipment for several pilot plants with various processing programmes is to be purchased. Indicatory cost estimates, based on 1981 prices, are given in section 5.4.

Section 5.3 indicates that milk processing in all types of plants is relatively simple compared to service procurement. It is evident, particularly from the isometric layouts, that the “milk system” is only one of three or four combined “systems”: the “well water system”, the “hot water system” and the “chilled water system”. The refrigerant piping is not shown since the absorption refrigeration system will depend on the design of the selected supplier.

In all groups of plants the same concept for buildings has been assumed. In this, only milk handing is located indoors in the processing building. All services equipment is proposed for outdoor installation on supporting structures adequate for the purpose. Such structures should be a part of the specification for outdoor equipment, whereas the milk handling building could be built of local materials by local companies or craftsmen. In the proposed layouts there are no load bearing floors or walls (except for the ground floor), so that neither special building structures nor construction materials are needed. Usually the most difficult problem in dairy building construction is the finish of walls and floors. Glazed ceramic tiles are an expensive finish for walls. Some resinbased or silicate paints applied to hard wall plaster are a cheaper and acceptable solution, although not as durable as ceramic tiles. Floors are the most difficult problem in milk processing buildings. Hard-burned bricks or tiles jointed with special mortars are the common solution in modern plants. Cast iron tiles are successfully used for floor finish, particularly when cans are in operation. As small building areas are being considered, imported suitable floor finish materials should not increase greatly the overall capital inputs. However, the work must be done by highly specialized craftsmen.

The layouts proposed do not include auxiliary space needed for changing rooms, toilets, stores, offices, mechanical/electric energy procurement area etc. This is subject to local conditions and may be included in the plants of a selected plant on a chosen site only. All pilot project proposals presented in this study could have an indicatory character only since local factors will greatly affect the final shape of the building or buildings and the specification of equipment, particularly regarding non-conventional energy sources. It is, therefore, of paramount importance that no physical action concerning construction be taken until all plans are clarified with the suppliers of equipment and materials who very often undertake the job on a turn-key basis.

5.2 Standard equipment specifications

5.2.1 Milk reception and measuring equipment

Function Milk is supplied by small-scale producers who deliver it in their own vessels in quantities averaging about 5 1 at a time. The milk is poured through a cloth filtre into a standard bucket. A sample is taken from the bucket for quality testing, the bucket is placed on the hook of a spring balance and weighed again after emptying into a milk can or into the milk processing vat. The intake of milk is recorded.

Capacity. The reception capacity depends on the average supply of milk by individual producers and the efficacy of the personnel employed in the reception section. With two buckets and one spring balance the capacity will depend mainly on the weighing and emptying time of the bucket. Assuming about one minute per operation and two hours effective daily reception, the capacity of a reception section with one spring balance and two buckets can be estimated at 300 1/hour or 600 1/day. In plants with higher capacities two lines should be able to receive up to 1 600 1/day since most likely the average supply per producer would increase.

Specification. All components of the equipment should be easy to clean and suitable for operations in. hot, humid climates.

1. One spring balance of 25 kg capacity, weighing accuracy not less than 0.05 kg, legalized in the country of origin.
2. Two stainless steel buckets of 15 1 capacity and of hygienic design, equipped with one handle for placing the bucket on the hook of the spring balance.
3. Two milk cloth filtres composed of a 15 1 conical stainless steel vessel with a 150 mm outlet and a supporting structure suitable for positioning the vessel outlet above the weighing bucket.
4. One platform weighing machine having a capacity of 100 kg may be needed in plants dispatching pasteurized liquid milk in cans.

5.2.2 Milk can

A standard aluminium alloy milk can with mushroom lid, capacity 50 1, to be used for milk transportation. Occasionally the can may also be used as a container in which milk is heat treated.

5.2.3 Milk-in-can heat treatment tank

Function. Milk received from the producer is filtered, measured and collected in a standard 50 1 milk can. The filled can is then placed in a rectangular, insulated water container equipped with a divided lid with openings for the can necks. The neck of the can protrudes above the lid of the tank, so as to permit agitation of milk in the can. The water in the tank is heated or cooled, depending on the milk treatment programme and the equipment of the tank. During the heat treatment process water in the tank is agitated manually.

Capacities. The heat treatment tank should be suitable for simultaneous heat treatment of milk either in two or in five cans. The tank for five cans should be such that the cans can be placed in one line.

Specification. The tank should be made of corrosion-protected mild steel sheets. It should be insulated so as to guarantee a temperature change of the water in the tank of not more than 3°C in 24 hours in an ambient/water temperature difference of 30°C. The outer cover of the insultation should allow the operation of filled milk cans without damage either to the cans or to the tank components. A manual propeller agitator with a vertical shaft and suitable gear should be such that the water in the tank is kept in motion. For heating, the tank must be equipped either with a heat exchange coil in which hot (80°C to 90°C) water circulates by natural conversation and causes the rise of the temperature of the water in the filled tank (without cans) from 30°C to 70°C in not more than one to one and a half hours, with sporadic water agitation lasting altogether not more than half an hour.

For cooling, an ice accumulation coil provide an icebank of not less than 20 kg ice for each milk can to be immersed in the tank is required. The design of the coil needs to be coordinated with the design of the refrigerator.

5.2.4 Manual milk-in-can agitator

The agitator consists of a stainless steel shaft to one end of which a perforated, round plate is welded, the other end being formed into a handle. It should be of standard dairy design.

5.2.5 Milk processing vat

Function. In the insulated, jacketed processing vat, milk delivered by the producers is heat treated by means of hot water, well water, and/or chilled water depending on the requirements of the process. The milk is manually agitated and the heat treatment media are kept in motion by a manually-operated pump. The arrangements of the heat treatment channels, milk agitator and media pump are described in Chapter 4 and shown in Fig. 23. In plants for cheese manufacture the milk agitator should be replaceable by curd cutting and agitating tools, suitable for manual operation through the same gear as the agitator. The reference number for vats equipped for cheese manufacture is marked by the index C. The vat would be equipped with a divided lid, removeable if required.

Capacities. (in litres effective volume): 50, 100, 160, 250, 400, 630, 800, 1 000, 1 600

Description. The inner vessel of the vat, the lid and all agitating tools must be made of stainless steel. All parts of the vat welded to the stainless steel vessel must also be made of stainless steel. Insulation of the vat should guarantee a temperature change of the milk in the vat of not more than 2°C in 24 hours by an ambient/milk temperature difference of 30°C.

The outer cover of the insulation should be corrosion proof. The vat must be equipped with a stainless steel outlet cock of a suitable diameter designed according to standards applied in the dairy industry. A stainless steel connecting piece must be attached to the outlet valve.

5.2.6 Milk quality testing equipment

Function. Milk supplied by the producers must be checked for cleanliness, acidity, specific gravity and fat content. Product testing is limited to temperature measurement in all products, specific gravity in liquid producers and brine in cheese production, acidity in fermented products and finally water content in butter. Microbiological tests must be limited to methylene blue or resazuring tests. Acidity tests of the incoming milk include quick alizarol alcohol test performed on each delivery.

Sampling bottles (40 bottles per 100 1 daily capacity) are used for milk samples taken daily for weekly or fortnightly fat testing. The laboratory must be equipped with facilities for water testing on hardness (soap tests).

Specification. The quality testing equipment includes the laboratory table, stools, shelves, glassware, a manually-operated Gerber centrifuge, water baths equipped with simple liquid fuel heaters, chemicals for one-year operations and all auxiliaries required to perform quality control tests as described above. The testing equipment should be suitable for use without availability of electric power or piped water.

Since no separate room is foreseen for the laboratory equipment the arrangement of the testing table, shelves and sampling cupboards should be such that all equipment and glassware, after completing daily work, can be locked.

5.2.7 Wash trough

Function. Manual washing of cans, bottles and small equipment takes place in wash troughs. The troughs should not only be used for washing under running water by means of suitable brushes but also as containers for detergent solutions in which bottles or parts of equipment are soaked in order to soften the deposits collected on surfaces to be cleaned afterwards.

Capacity. The dimensions of the troughs should suit convenient manual operation and permit full immersion of a 50 1 milk can.

Specification. The wash trough should consist of a rectangular container resting on four legs. All parts should be made of corrosion-protected or non-corrodible materials. Sturdy construction is required as pieces weighing about 10 kg, such as cans, may be washed in the trough. One overflow pipe and one outlet plug should be fitted.

5.2.8 Water container (water tank)

Function. Water containers are required for storing

- well water
- unheated wash water
- heated wash water
- hot water for milk pasteurization

Description. The water containers can be most conveniently installed when designed as closed horizontal cylindrical vessels with standardized inner dimensions. Insulation is required on the hot water container for milk pasteurization and on the hot wash water container. The well water container may not be insulated provided it is protected against direct insolation in plants where well water is used for milk chilling after pasteurization.

Capacities. All requirements for water storing in the plants under consideration can be met by standardizing the dimensions of the tanks so that the containers' total volumes in m^3 are as follows: 0.17, 0.28, 0.42, 0.66, 1.06, 1.70, 2.65, 4.42 and 6.38.

The total volumes of the containers have to exceed the nominal require ment by about 20 percent because the highest water level should be kept at about 0.9 diameter and the king outlet of the tank should be positioned at about the 0.1 diameter level since, except for the hot water container for milk pasteurization, untreated water might be kept in all containers and deposits may tend to collect on the bottom. The working outlet in the hot water container is positioned slightly above the bottom level.

Specification. The water tanks should be made of corrosion-protected or non-corrodible materials, designed as closed horizontal cylinders with suitable supporting legs or plates. The front wall should be either screwed to the cylinder or, in all welded constructions the tank should be equipped with a manhole. Four pipe connections are required in all tanks (inlet, outlet, overflow and drainage) all positioned in the front wall of the tank. The hot water tanks need an additional connection in the rear wall for the circulation inlet from heaters. All tanks should be equipped with water level indicators. The hot water containers and hot wash water containers should be insulated.

5.2.9 Water treatment plant

Function. All plants considered in this study are designed under the assumption that the hygienic standard of water supplied to the plant is acceptable for milk plant operations and household use. Such water may contain minerals tending to create deposits on heat exchange surfaces, particularly at elevated temperatures (water hardness). The function of the water treatment plant is to soften water used as a heating medium in all pasteurization processes.

Capacity. Capacities in the range of 0.1 to 0.3 m^3 per hour are sufficient for softening the daily quantities of make-up water to replace water lost or drained from hot wash water tanks. Daily quantities of water which need softening will amount to 0.05 to 0.5 m^3, depending on the type and capacity of the plant.

Specification. The water treatment plant should be of the ion exchange type, its particulars depending on the composition of minerals contained in the water. It should be suitable for continuous operation under pressure not exceeding 1 m to 2 m water column since it will be fed by gravity. No electric power should be needed to operate the plant.

5.2.10 Milk can roller conveyor

The standard milk can roller conveyor should have rollers fixed on ball bearings, of a length according to the needs of the plant, with can intake and dispatch tables and with or without 90°bends. It should be free-standing.

5.2.11 Well water pump

The pump should be suitable for supplying water from the water source to the well water container in the plant. Since the pump must be selected according to the water procurement conditions at site, no standard specification can be given.

Assuming that the total pumping head will not exceed 20m, the pump should be suitable for manual operation in plants with daily milk throughputs of up to 630 l. In plants of higher capacities the manual power must be replaced by means selected for a particular site.

5.2.12 Pipes and fittings

The interconnection of all machines and equipment with suitable pipes, fittings and supports must be done according to the final layouts and specifications.

Apart from the refrigerant/absorber interconnections in the absorption refrigerator, the majority of pipe work to be done comprises water lines. The water temperature varies from about 0°C for ice water up to 90°C for hot water for pasteurization. The water pressure does not exceed the few metres water column. Galvanized steel or plastic pipes of suitable quality may be used for water lines. There is little pipe work needed for milk transportation, limited to the interconnection of the processing vats and bottle-filling equipment. This part of piping must be made of stainless steel according to dairy standards. For water temperatures below that of the ambient the pipes must be insulated.

5.2.13 Supporting structures for outdoor installations

According to the general concept of the plant designs, only the milk processing part is located in a regular building, whereas service equipment is located outside this building on structures suiting the complex needs of a particular plant. Their specification, design and materials used for their construction must depend on the final specification and the layout of the plant and must create a well-coordinated unit together with the processing building.

Should the equipment be completely imported, the outdoor equipment together with all supporting structures could be supplied in a prefabricated form in transportation containers to simplify the erection of the plants. A properly prepared cost comparison should be the deciding factor in selecting either individual items erected on the site or prefabricated deliveries.

5.2.14 Oil-fired water heater

Function. The water heater is used to increase from about 80°C to about 90°C the temperature of water used as the heating medium in milk pasteurization processes. It becomes operational only when, by afternoon, the temperature of the sun-heated water does not reach the required level.

Capacity. The water heater can have six capacities to meet the heat requirements of the plants proposed: 2.5 kW, 4.0 kW, 6.0 kW, 10.0 kW, 16.0 kW and 25.0 kW. Its daily operation is expected for two to three hours only.

Specification. Water heaters commonly used for space central heating and domestic hot water in countries with moderate or cold climates, are considered suitable for the requirements of the plants under consideration. Oil is suggested as the standard furnace fuel, but gas, coal or wood-fired heaters may be applied if and when they suit better the conditions prevailing at particular sites. The heater must be complete with fuel containers, burners, controls, indicators and alarms, and operational without additional energy supply from outside the heater.

5.2.15 Absorption refrigerator with ice accumulation

Function. In most of the milk collection systems milk must be cooled to about 4°C. Processing of pasteurized liquid milk and manufacture of a number of milk products also require cooling of milk or cream to about 4°C. In order to reduce the temperature of milk to 4°C (usually from about 35°C), water at a temperature of about 1°C is moved over a heat exchange surface separating the water from the milk. The function of the refrigerator is to provide chilled water for milk cooling. Since there can be only a small temperature difference between milk and water particularly at the end of the heat exchange and, since cooling of milk has to be completed within 0.6 to about 1.4 hours (depending on daily quantity), "storage of cold" is required. This is best achieved by freezing a part of the water when there is no milk cooling but the refrigerator is operating. The latent heat of fusion (0.093 kWh/kg) is about 80 times higher than the specific heat of water (0.00116 kWh/kg) and therefore accumulation of cold in icebanks permits reduction of the volume of chilled water containers.

Capacity. There are eight capacities of the absorption refrigerators which can meet the cooling requirements of the proposed plants (expressed in kWh/day): 3, 4, 6, 10, 15, 23, 36 and 58. The same capacities expressed as kilograms of ice accumulated in the icebanks are as follows: 32, 43, 65, 108, 161, 247, 387 and 624.

Specification. Basically intermittent absorption refrigerators with one cycle per day, operating without electric or mechanical energy supply and with desorption temperatures not exceeding 100°C to 120°C are considered for the suggested plants. The concept of pilot plants indicates the experimental character of the enterprise which means that the refrigerator can be operated either with furnace fuel desorption heaters or with solar desorption heaters. The need to make the system work with thermal energy provided either from conventional sources or from solar radiation explains the demands described above. Should application of mechanical or electric energy be necessary, particularly in larger machines to obtain the required process parameters, the power applied should not exceed a fraction of 1/kW per prime mover and the total daily energy requirement for all prime movers should not exceed the capacity of a 200 Ah battery. Should controls require electric power, even in smaller plants, the total requirements should be kept within the limits achieved by a man-driven bicycle-type dynamo of 40 W charging a suitable battery.

The lack of mechanical/electric power in the plants with the exceptions mentioned above, necessitates the consideration of stagnant water condensers with well water temperatures of about 30°C for refrigerant condensation. No limitations are made concerning absorbent/refrigerant mixtures or other details of the absorption refrigerator, provided they can meet the requirements of the plants under consideration.

5.2.16 Solar wash water heating system

Function. In milk collection centres with milk-in-vat cooling of 400 to 1 600 1/day, hot water is needed only for cleaning and disinfection of equipment coming in contact with milk.

The desirable hot wash water temperature is about 60°C of which well water of about 30°C is to be heated in a solar water heating system.

Capacity. There are four capacities of the water heating system which can meet the requirements of all the proposed plants: 3, 5, 7, and 9 kWh/day.

Specification. A solar heating system with flat plate collectors suiting the insolation conditions prevailing at site, with natural convection of water heated from 30°C to 60°C. Water is softened in treatment plants prior to entering the heating system. It is drawn for washing purposes directly from the primary circuit.

If a design with divided primary and secondary circuits is considered advantageous because of reasons of improved economy or operational safety, the supplier should be encouraged to suggest such a solution.

All controls and safety devices must operate on thermal energy provided by the system since no outside energy supply is planned.

5.2.17 Solar water heating system

Function. In all plants in which milk treatment requires raising the temperature of milk, hot water is used as the heating medium.

The heat exchange processes are so designed that the initial inlet temperature of hot water is 90°C and at the end of the process it may drop to 80°C. Hot water creates the primary circuit of the system; milk should be considered as the secondary circuit except for milk-in-can heating in collection centres where there are three circuits, milk being the third. The second circuit consists of the water in the tank in which cans with milk are immersed. Hot water of the primary circuit circulates in a heat exchange coil immersed in the water in the tank.

In all plants requiring hot water for milk heating conventional fuel heaters are installed. The solar water heating system must be considered as an alternative energy source and the conventional heater used only when by sunset the water temperature does not reach the required level of 90°C.

Capacity. There are 16 capacities of the solar water heating system which can meet the requirements of the proposed plants (expressed in kWh/day): 2, 3, 5, 6, 7, 9, 11, 14, 17, 21, 26, 31, 41, 49, 66 and 78.

Specification. A solar heating system with flat plate collectors suiting the insolation conditions prevailing at the site, with natural convection of water heated from 80°C to 90°C. Water is softened in treatment plants prior to entering the heating system.

Water losses during circulation in the heat exchange system in milk processing vats, as well as the need to use a part of this hot water for washing purposes, necessitate the daily addition of make-up water to the primary circuits in all milk-in-vat milk heating systems. Should a design with a separate circuit passing the solar collectors be advantageous, for reasons of improved economy or operational safety, the supplier should be encouraged to suggest suitable solutions.

All controls and safety devices must operate on thermal energy provided by the system itself since no outside energy supply is planned.

5.2.18 Solar desorption heater in absorption refrigerators

Function. In all plants in which milk treatment requires deep cooling to 4°C, chilled water is used as the cooling medium. Absorption refrigerators are designed to accumulate ice on evaporator coils. By melting the ice, heat is removed from water serving as the milk cooling medium. Conventional fuel heaters provide the heat needed for desorption. Solar desorption heaters must be considered as an alternative energy source and the conventional heater is used only when by sunset the pressure in the refrigerant circuits does not reach the required level.

Capacity. There are eight capacities of absorption refrigerators to which the solar desorption heaters need to be adjusted. The capacities are expressed in kilograms of ice accumulated daily on evaporator coils: 32, 43, 65, 108, 161, 247, 387 and 624.

Specification. Solar heating systems with moderately concentrating collectors suitable for application as desorption heaters in absorption refrigerators. The specification of the system depends closely on the design of the absorption refrigerator. The system should be offered together with the absorption refrigerator.

5.2.19 Mechanical/electric power source

Function. Milk processing plants with a capacity of about 1 000 1/day and more require mechanical energy in quantities exceeding rational employment of manual power. Water pumping and milk agitation with heating media circulation are the processes where power requirements are the highest. Circulation of media in the absorption refrigerators and in the solar heaters may be intensified with pumps if ample mechanical energy is available. In addition, mechanization of bottle washing and filling systems could also be introduced.

Capacity. In line with the basic concept of the pilot plants under consideration, electric generators driven by combustion engines should only be installed in exceptional cases. Windmills providing mechanical power directly or generating electric energy, drawn directly or from batteries charged by wind generators, are recommended in areas with sufficient wind energy available.

The capacity of the power station cannot be defined since, depending on local conditions for power generation, the mechanization of the plant may take various forms and levels. The minimum requirements for power are estimated at above 75 W and for daily energy production at above 0.56 kWh.

Specification. A windmill with dynamo, batteries, alternators and all mechanical and electrical applicances suitable to the requirements of the plants and adapted to local wind conditions. Only in specific cases a combustion engine-driven electric generator should be considered as an appropriate solution for the mechanical/electric power supply.

5.2.20 Man-operated electric generator with battery

Function. In specific cases operation of solar water heaters and absorption refrigerators may be facilitated by introducing controls, safety devices and small prime movers requiring small amounts of electric energy. In such cases, if no other solution is available, man-driven electric generators could meet the requirements. This may be particularly useful in plants where all other mechanical energy requirements could be relatively easily covered by manual power and where installation of wind-mills could not be feasible or justified.

Capacity. Considering the limited output of manual power a 40 W generator operated over about five to six hours could generate about 0.25 kWh of electric energy, either in direct supply or through battery charging.

Specification. A bicycle type, man-operated rotating wheel, propelling a 40W dynamo, with a battery of about 50 Ah and all electric installation is required.

5.2.21 Milk reception funnel

Function. In some of the milk plants - in particular in those with milk separation - the milk processing vat may be not accessible from the reception floor. In such instances the received milk can be poured into a reception funnel from which it will flow by gravity into the processing vat.

Description. A stainless steel funnel of about 50 1 volume, with an outlet and connecting pipe to the processing vat, supported on a suitable structure at a convenient working level.

5.2.22 Manually-operated milk separator

A manually-operated milk separator of standard design and capacities of about 160 1/h and 250 1/h milk intake.

5.2.23. Butter churn

Function. To make butter out of cream with about 30 percent fat content, by turning the churn around its horizontal axis.

Description. The butter churn should be suitable for filling with cream from 35 to 55 percent of its total volume. Required total volumes: 100 1 and 200 1. The churn is rotated about a horizontal axis by a crank handle for manual operation. If an electric motor can be provided a belt reduction drive is required.

Internal kneading rollers are not required if a separate kneading machine is provided for further processing of the butter.

5.2.24 Butter container

A stainless steel container of about 50 1 for butter storage in ice water before kneading/packaging. The container should be equipped with a stainless steel lid.

5.2.25 Butter-handling table

A rectangular table with a washable surface of about 1 m^2, with all four legs equipped with wheels. The table is to be used as an auxiliary surface during kneading and packaging.

5.2.26 Butter-kneading machine

A circular manually-operated butter-kneading machine with a rotating kneading table and one roller, capacity up to 15 kg/h.

5.2.27 Butter-packaging machine

A manually-operated butter portioning machine equipped with facilities for manual wrapping of the product in waxed paper or aluminium foil. Capacity up to 15 kg/h in 100 g or 250 g packages.

5.2.28 Curd-handling trolley

The curd-handling trolley is used as auxiliary equipment during the process of filling cheese moulds with curd. It should consist of a sturdy stainless steel tray suitable for containing about 20 cheese moulds and 20 lids and should be positioned on four legs equipped with wheels permitting easy transfer of the filled moulds to the appropriate area of the processing hall.

5.2.29 Cheese moulds

Standard cheese moulds (wooden or of perforated stainless steel sheets or plastic cylinders) suitable for blocks of about 5 kg soft cheese.

5.2.30 Cheese presses

Manually-operated cheese presses with 20 single-arm levers suitable for 20 cheese moulds positioned at a time.

5.2.31 Brine container

A rectangular plastic container with 40 mm outlet with one outlet cock, equipped with a suitable supporting frame protected against corrosion. Capacity about 0.25 m^3.

5.2.32 Rack for cheese moulds

A sturdy rack for cheese moulds to be dried after washing, suitable for up to 60 moulds with lids.

5.2.33 Bottle washing and filling equipment

Function. Pasteurized liquid milk, stirred fermented milk beverages and unstirred fermented milk products are to be packaged in returnable glass bottles of standard volume, varying from 0.25 to 1.0 1. The bottles are collected in crates containing 30 bottles of 0.25 1, 20 bottles of 0.5 1 or 15 bottles of 1.0 1. Preferably only one size of bottles and crates should be handled in one plant.

Empty bottles from crates returned from the market need to be soaked in a hot alkaline solution for at least 20 minutes and afterwards, brushed manually and rinsed. Cleaned bottles should be positioned upside down in cleaned crates and stored until the filling starts.

The product for filling is kept in the processing vat, from which it will flow by gravity to an intermediate container equipped with spring loaded outlet valves, connected to the container by flexible hose-pipes. The volume of the intermediate container and the number of filling valves attached depend on the required filling capacity. Bottles for filling are put on a table above which the intermediate container is positioned.

Capacity. From 100 bottles/day to 1 600 bottles/day with two to ten filling valves.

Description. (a) A complete set of soaking, brushing and rinsing troughs adequately equipped with necessary pipes and fittings, protected against corrosion, suitable for manual washing of bottles and crates.

(b) A complete set of manual bottle filling valves with intermediate containers, pipes, fittings and necessary tools, tables and supporting structures. All parts coming in contact with milk are to be made of stainless steel and flexible hose-pipes out of food-quality rubber or plastic.

5.3 Project proposals

5.3.1 Milk collecting centres with milk heating

The centres are equipped to dispatch hot (60°C) milk in 50 1 cans. The specifications and layouts are based on the assumption that clean cans are supplied by the processing plants. In centres receiving up to 250 1 milk daily, the milk-in-can heating system is proposed. For daily throughputs above 250 1 up to 1 600 1, the milk-in-vat heating system is planned.

The description of milk handling processes, reception techniques, scope of the quality control and of the concept of service procurement can be found in Chapter 4 (“Prospective small-scale systems”) and in section 5.2 (“Standard equipment specifications”).

In Figs. 28 to 33 the general outline of the concepts of the centres is illustrated. In all centres solar water heaters are proposed as an alternative energy source in addition to the conventional heater. No layouts for the solar system could be proposed since they will depend on local conditions at the site.

As can be seen from the figures, hot wash water is planned only for centres equipped with processing vats.

The duration of processes and the labour requirements may be estimated as follows:

- reception	- up to 3 hours	- two men
- milk heating	- up to 1 hour	- one man
- can filling	- up to 1 hour	- one man
- truck loading/unloading	- up to 0.5 hours	- two men
- washing	- up to 1 hour	- one man
- service procurement	- up to 4 hours	- one man

Under the assumption that milk is received in the centre once a day and that it is dispatched immediately after the temperature of the milk has reached 60°C, the work can be completed within one 8-hour shift with only two men employed even in centres handling 1 600 1 per day.

5.3.2 Milk collecting centres with milk cooling

The centres are equipped to dispatch chilled (4°C) milk in 50 1 cans. The specifications and layouts are based on the assumption that clean cans are supplied by the processing plants. In centres receiving up to 250 1 milk daily the milk-in-can cooling system is proposed. For daily throughputs above 250 1 up to 1 600 1 the milk-in-vat cooling system is planned.

The description of milk handling processes, reception rechniques, scope of the quality control and of the concept of service procurement can be found in Chapter 4 ("Prospective small-scale systems") and in section 5.2 ("Standard equipment specification").

In Figs. 34 to 39 the general outline of the concepts of the centres is illustrated. In all centres solar heaters are proposed as an alternative energy source for absorption refrigeration generators in addition to conventional heaters. Hot wash water is planned only for centres equipped with processing vats. Solar collectors are planned as the only energy source for wash water heating.

No layouts for the solar systems could be proposed since they will depend on local conditions at the site.

Table 9. Equipment specification - Milk collecting centres with milk heating

Equipment	**Standard specification reference (in text)**	**Requirement (numbers)**						
		Daily throughput (litres)						
		100	**160**	**250**	**400**	**630**	**1 000**	**1 600**
1. Milk reception and measuring equipment	5.2.1	1	1	1	1	1	2	2
2. Milk can 50 1	5.2.2	2	4	5	8	13	20	32
3. Milk-in-can heat treatment rank with water heating coil - for 2 cans	5.2.3	1	-	-	-	-	-	-
-for 5 cans	5.2.3	-	1	1	-	-	-	-
4. Manual milk-in-can agitator	5.2.4	2	4	5	-	-	-	-
5. Milk processing vat 400 1	5.2.5	-	-	-	1	-	-	-
630 1	5.2.5	-	-	-	-	1	-	-
1 000 1	5.2.5	-	-	-	-	-	1	-
1 600 1	5.2.5	-	-	-	-	-	-	1
6. Quality testing set	5.2.6	1	1	1	1	1	1	1
7. Wash trough	5.2.7	1	1	1	1	1	1	1
8. Well water tank 0.28 m^3	5.2.8	1	-	-	-	-	-	-
0.42 m^3	5.2.8	-	1	1	-	-	-	-
0.66 m^3	5.2.8	-	-	-	1	1	-	-
1.06 m^3	5.2.8	-	-	-	-	-	1	-
1.70 m^3	5.2.8	-	-	-	-	-	-	1
9. Hot wash water tank - 0.17 m^3	5.2.8	1	1	1	1	1	-	-
- 0.28 m^3	5.2.8	-	-	-	-	-	1	1
10. Water treatment plant	5.2.9	1	1	1	1	1	1	1
11. Milk can roller conveyor with one bend - 5 m length	5.2.10	-	-	-	1	1	1	1
12. Manual well water pump	5.2.11	1	1	1	1	1	1	1
13. Pipes and fittings - set	5.2.12	1	1	1	1	1	1	1
14. Supporting and protecting structures								
for outdoor installations - set	5.2.13	1	1	1	1	1	1	1
15. Hot water tank 0.42 m^3	5.2.8	1	-	-	-	-	-	-

0.66 m^3	5.2.8	-	1	-	-	-	-	-
1.06 m^3	5.2.8	-	-	1	-	-	-	-
1.70 m^3	5.2.8	-	-	-	1	-	-	-
2.65 m^3	5.2.8	-	-	-	-	1	-	-
4.42 m^3	5.2.8	-	-	-	-	-	1	-
6.38 m^3	5.2.8	-	-	-	-	-	-	1
16. Oil-fired water heater 2.5 kW	5.2.14	1	-	-	-	-	-	-
4.0 kW	5.2.14	-	1	1	-	-	-	-
6 kW	5.2.14	-	-	-	1	-	-	-
10 kW	5.2.14	-	-	-	-	1	-	-
16 kW	5.2.14	-	-	-	-	-	1	-
25 kW	5.2.14	-	-	-	-	-	-	1
OPTIONAL								
17. Solar water heating system - 5 kWh/day	5.2.17	1	-	-	-	-	-	-
- 7 kWh/day	5.2.17	-	1	-	-	-	-	-
- 11 kWh/day	5.2.17	-	-	1	-	-	-	-
- 17 kWh/day	5.2.17	-	-	-	1	-	-	-
- 20 kWh/day	5.2.17	-	-	-	-	1	-	-
- 41 kWh/day	5.2.17	-	-	-	-	-	1	-
- 66 kWh/day	5.2.17	-	-	-	-	-	-	1

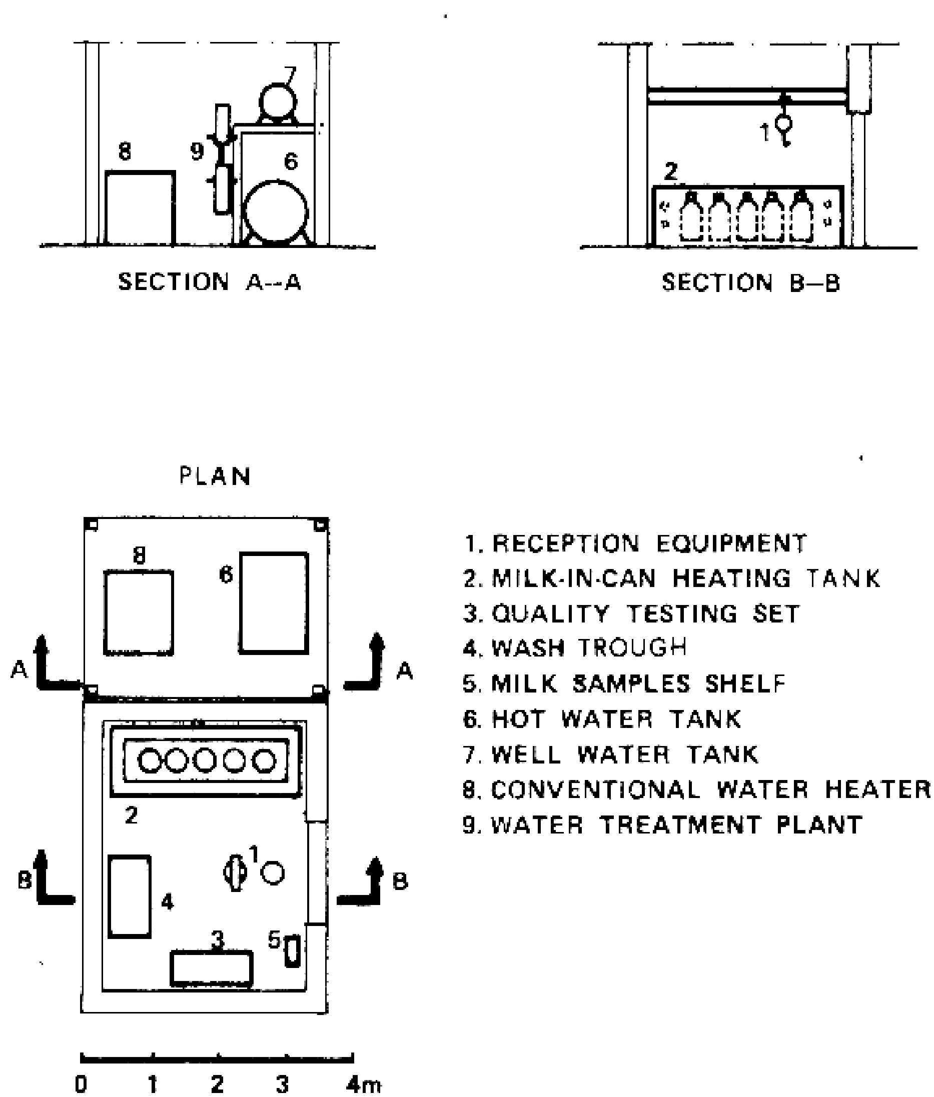


FIG 28. MILK COLLECTION CENTRE 100 l/day TO 250 l/day - MILK-IN-CAN HEATING.

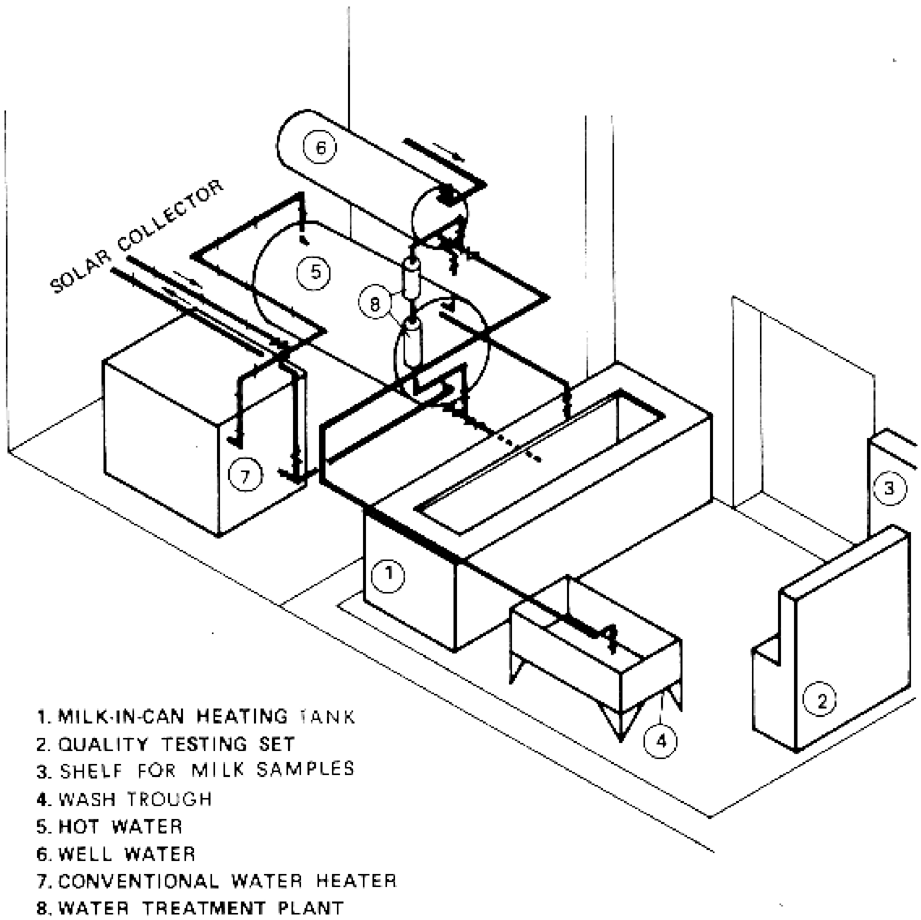


FIG 29. MILK COLLECTION CENTRE 100 l/day TO 250 l/day - MILK-IN-CAN HEATING

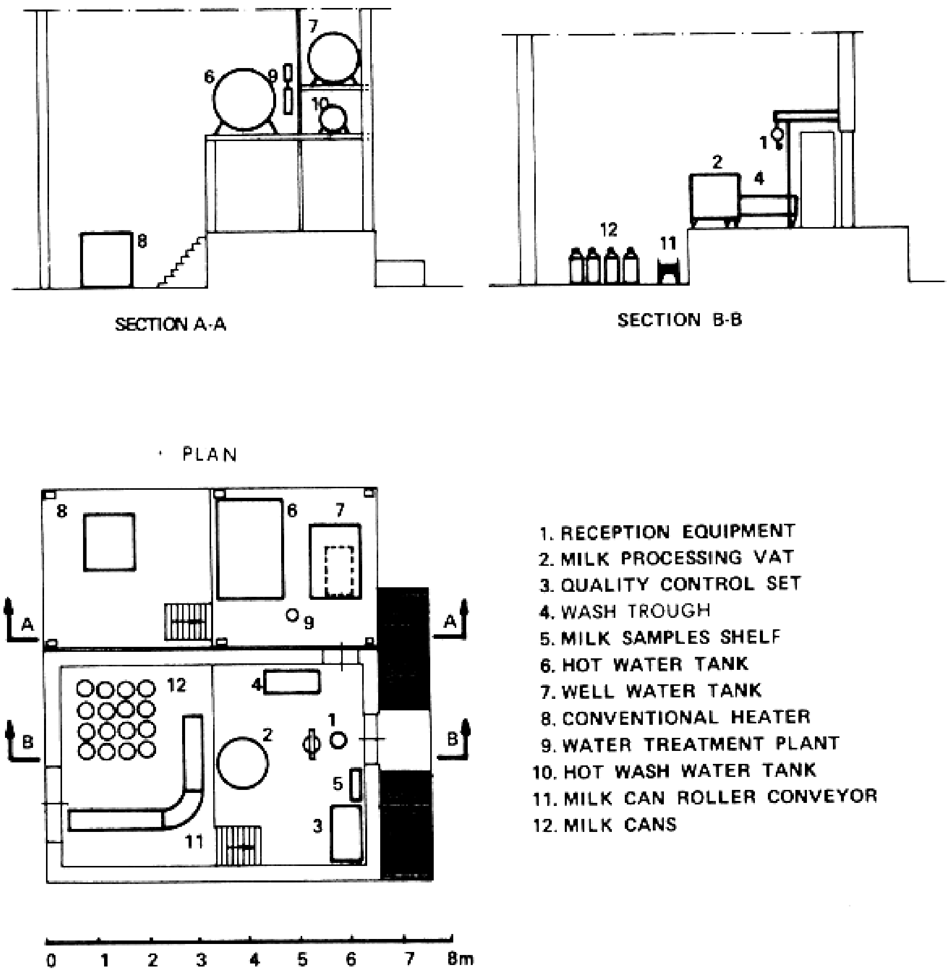


FIG 30. MILK COLLECTION CENTRE 400 l/day TO 630 l/day. MILK-IN-VAT HEATING'.

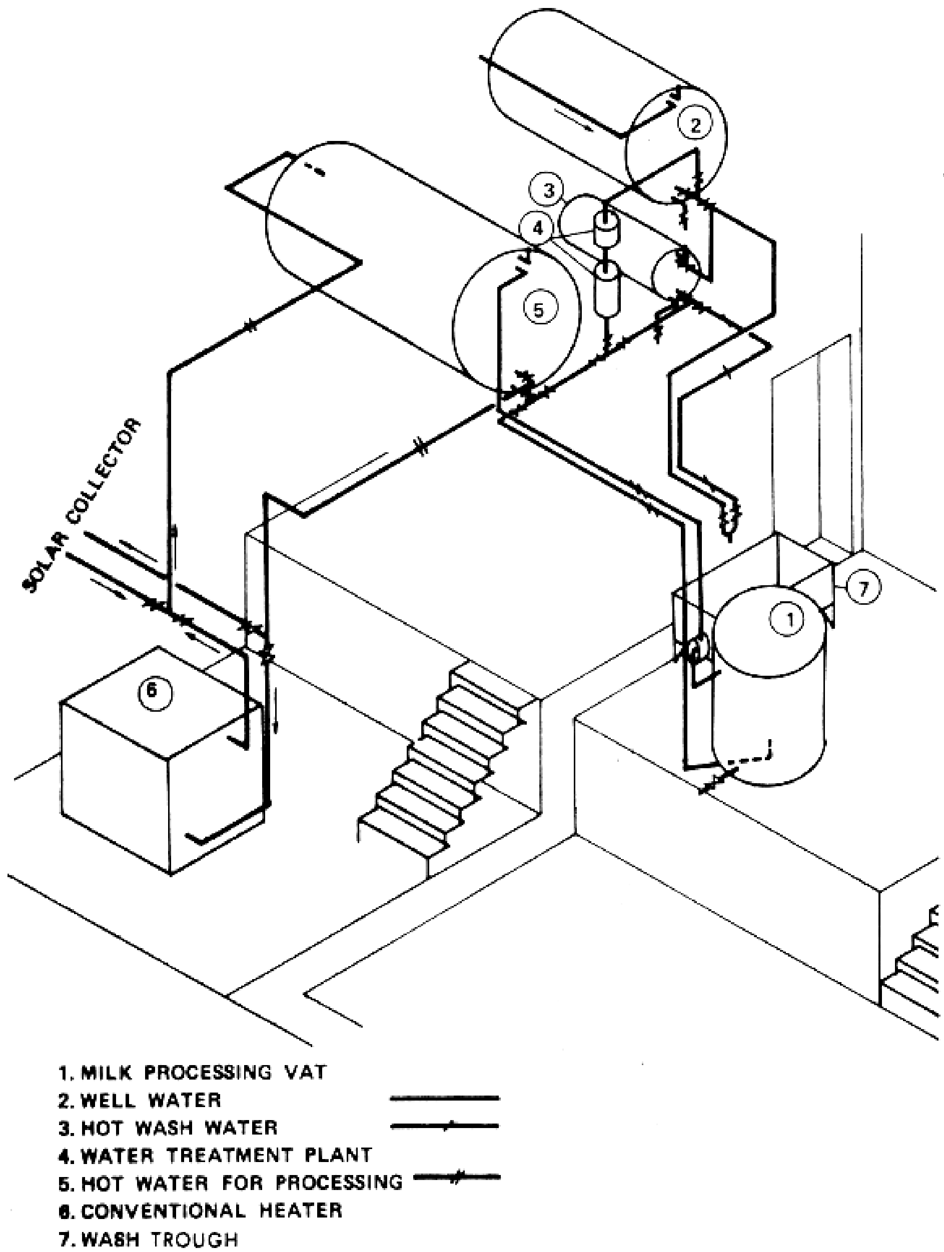


FIG 31. MILK COLLECTION CENTRE 400 l/day TO 630 l/day. MILK-IN-VAT HEATING

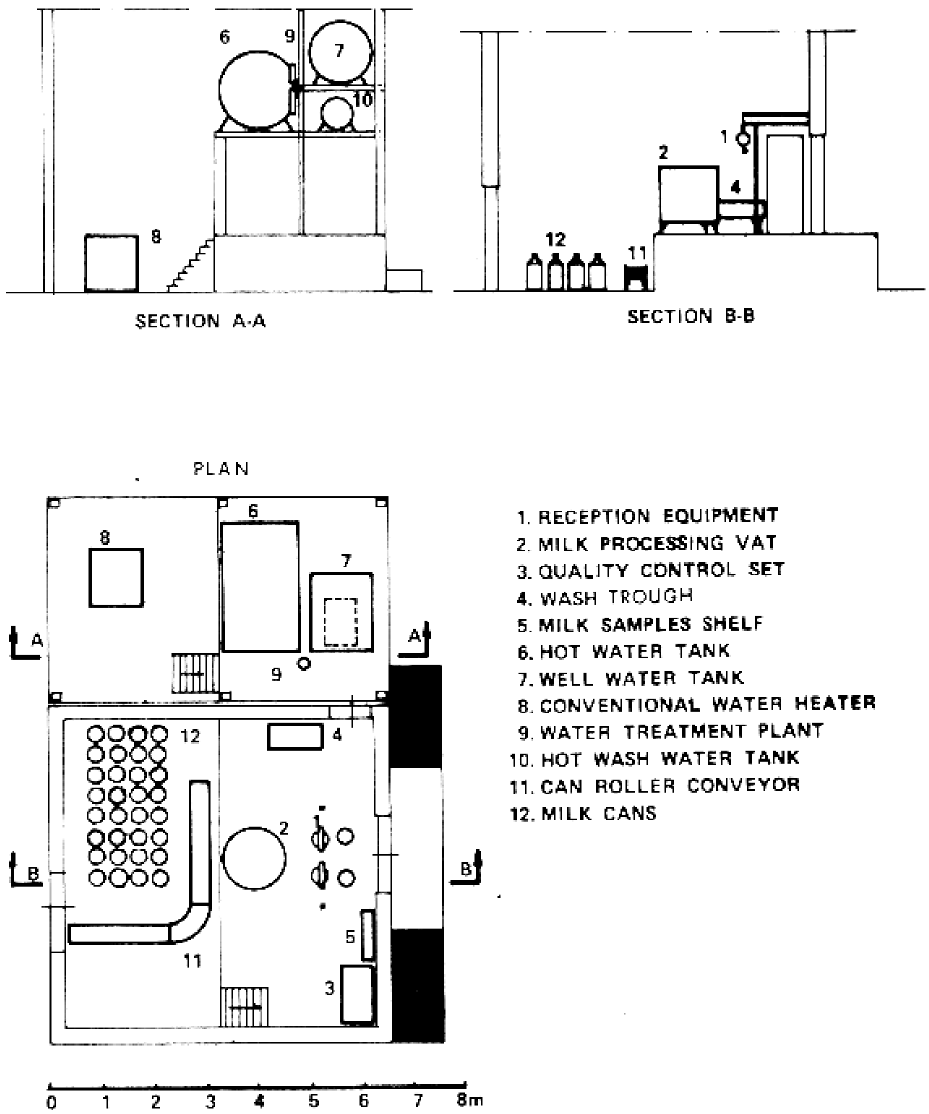


FIG 32. MILK COLLECTION CENTRE 1000 l/day TO 1600 l/day. MILK-IN-VAT HEATING.

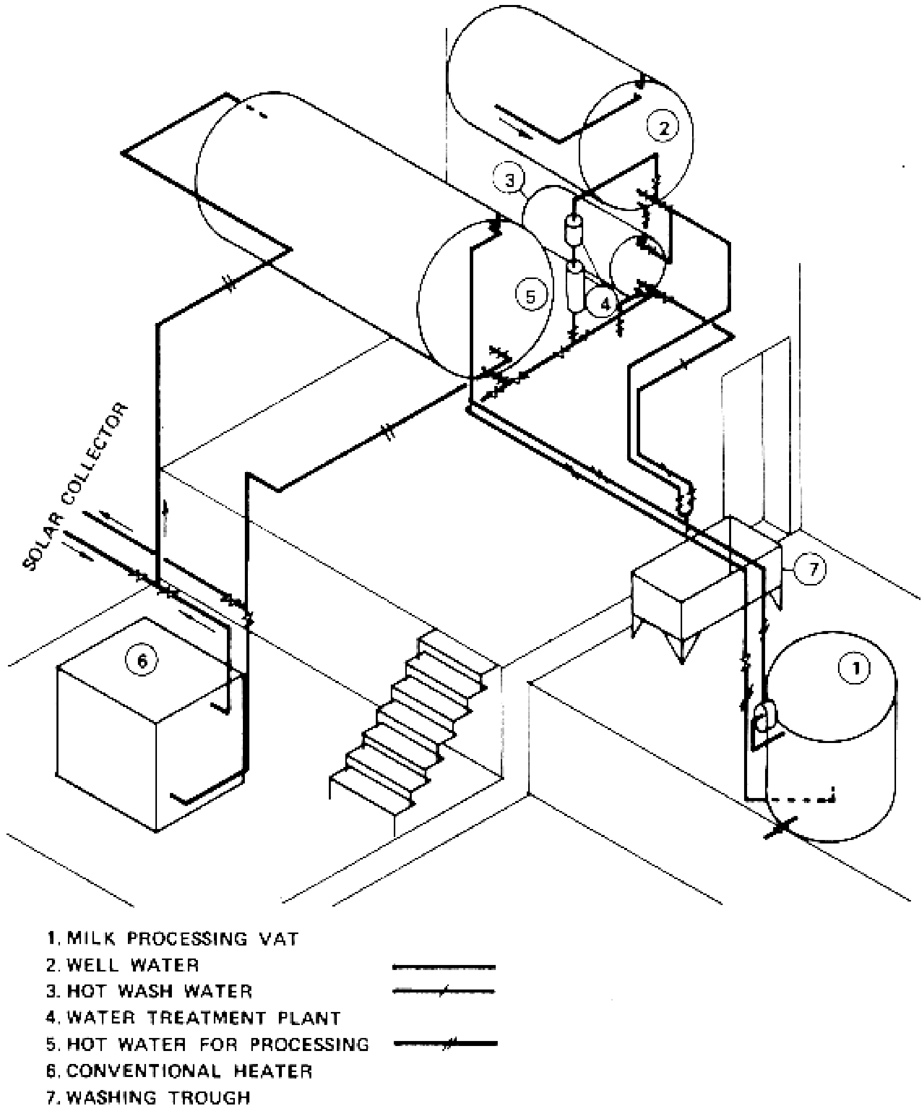


FIG 33. MILK COLLECT ION CENTRE 1000 l/day TO 1600 l/day. MILK-iN-VAT HEATING

The duration of processes and the labour requirements may be estimated as follows:

- reception	- up to 3 hours	- two men
- milk chilling	- up to about 3 hours	- one man
- can filling	- up to 1 hour	- one man
- truck loading/unloading	- up to 0.5 hour	- two men
- washing	- up to 1 hour	- one man
- service procurement	- up to 4 hours	- one man

Assuming that milk is received in the centre once a day and that cans can be dispatched immediately after the temperature of milk has fallen to about 4°C, the work can be completed within one 8-hour shift with only two men employed in centres handling up to 1 000 1 per day. In centres handling 1 600 1 per day the work can be completed in one 8-hour shift under favourable conditions. Ten hours from the starting of reception seems to be a more realistic assumption.

5.3.3 Pasteurized liquid milk processing plants - dispatch in cans

The plants are equipped to process pasteurized liquid milk dispatched at a temperature of approximately

4°C. The milk is transported to the customer in cans containing 50 1 each. Empty cans are washed after return and kept clean until the next filling. Up to a 630 1 daily throughput all milk processing is done in one jacketed vat. In plants of higher capacities the processing needs to be done in two parallel vats of a suitable capacity.

The description of milk handling processes, reception techniques, scope of the quality control and of the concept of service procurement can be round in Chapter 4 ("Prospective small-scale system") and in section 5.2 ("Standard equipment specifications"). Filling of cans up to the 50 l mark is the proposed quantity measuring system. Cans not fully filled should be weighed on a platform weighing machine.

In Figs. 40 to 45 the general outline of the concept of the plants is illustrated. In all centres solar heaters are proposed as alternative energy sources to absorption refrigeration generators and to water systems, in addition to conventional heating systems. No layouts for solar systems are presented since they will depend on local conditions on the site .

Plants of a capacity exceeding about 630 1 daily need to be equipped with a mechanical/electric power source since manual operations of all mechanisms may prove to be impractical due to the relatively high level of total mechanical energy requirement. Wind-powered electric generators are proposed in such instances for all plants located where local weather conditions would make such a solution practical.

In plants of up to 400 1 capacity two men are able to complete milk reception, processing, plant: cleaning, water pumping and service equipment servicing within one 8-hour shift. In plants processing 630 1 per day the labour requirement increases to three men. An additional mechanical/electric power source is required in plants of a capacity exceeding 630 1 up to 1 600 l, and the labour requirerent rises to four men.

Table 10. Equipment specification - Milk co11ecting centres with mi1k coo1ing

Equipment	Standard specification reference (in text)	Requirement (numbers) Daily throughput (litres)						
		100	160	250	400	630	1 000	1 600
1. Milk reception and measuring equipment	5.2.1	1	1	1	1	1	2	2
2. Milk can 50 l	5.2.2	2	4	5	8	13	20	32
3. Milk-in-can heat treatment tank with ice accumulation coil for 2 cans	5.2.3	1	-	-	-	-	-	-
- for 5 cans	5.2.3	-	1	1	-	-	-	-
4. Manual milk-in-can agitator	5.2.4	2	4	5	-	-	-	-
5. Milk processing vat 400 1	5.2.5	-	-	-	1	-	-	-
630 1	5.2.5	-	-	-	-	1	-	-
1 000 1	5.2.5	-	-	-	-	-	1	-
1 600 1	5.2.5	-	-	-	-	-	-	1
6. Quality testing set	5.2.6	1	1	1	1	1	1	1
7. Wash trough	5.2.7	1	1	1	1	1	1	1
8. Well water tank 0.28 m^3	5.2.8	1	-	-	-	-	-	-
0.42 m^3	5.2.8	-	1	1	-	-	-	-
0.66 m^3	5.2.8	-	-	-	1	1	-	-
1.06 m^3	5.2.8	-	-	-	-	-	1	-
1.70 m^3	5.2.8	-	-	-	-	-	-	1
9. Hot wash water tank 0.17 m^3	5.2.8	1	1	1	1	1	-	-
0.28 m^3	5.2.8	-	-	-	-	-	1	1
10. Water treatment plant	5.2.9	1	1	1	1	1	1	1

11. Milk can roller conveyor with one bend -5 m length	5.2.10	-	-	-	1	1	1	1
12. Manual well water pump	5.2.11	1	1	1	1	1	1	1
13. Pipes and fittings - set	5.2.12	1	1	1	1	1	1	1
14. Supporting and protecting structures for outdoor installations - set	5.2.13	1	1	1	1	1	1	1
15. Absorption refrigerator with ice accumulation - 4 kWh/day	5.2.15	1	-	-	-	-	-	-
- 6 kWh/day	5.2.15	-	1	-	-	-	-	-
- 10 kWh/day	5.2.15	-	-	1	-	-	-	-
- 15 kWh/day	5.2.15	-	-	-	1	-	-	-
- 23 kWh/day	5.2.15	-	-	-	-	1	-	-
- 36 kWh/day	5.2.15	-	-	-	-	-	1	-
- 58 kWh/day	5.2.15	-	-	-	-	-	-	1
16. Solar wash water heating system								
- 3 kWh/day	5.2.16	-	-	-	1	-	-	-
- 5 kWh/day	5.2.16	-	-	-	-	1	-	-
- 6 solar wash water heating system								
- 7 kWh/day	5.2.16	-	-	-	-	-	1	-
- 9 kWh/day	5.2.16	-	-	-	-	-	-	1
OPTIONAL								
17. Solar desorption heater in absorption refrigerators for - 4 kWh/day	5.2.18	1	-	-	-	-	-	-
- 6 kWh/day	5.2.18	-	1	-	-	-	-	-
- 10 kWh/day	5.2.18	-	-	1	-	-	-	-
- 15 kWh/day	5.2.18	-	-	-	1	-	-	-
- 23 kWh/day	5.2.18	-	-	-	-	1	-	-
- 36 kWh/day	5.2.18	-	-	-	-	-	1	-
- 58 kWh/day	5.2.18	-	-	-	-	-	-	1
18. Man-operated electric generator with battery - 40 W	5.2.20	1	1	1	1	1	1	1

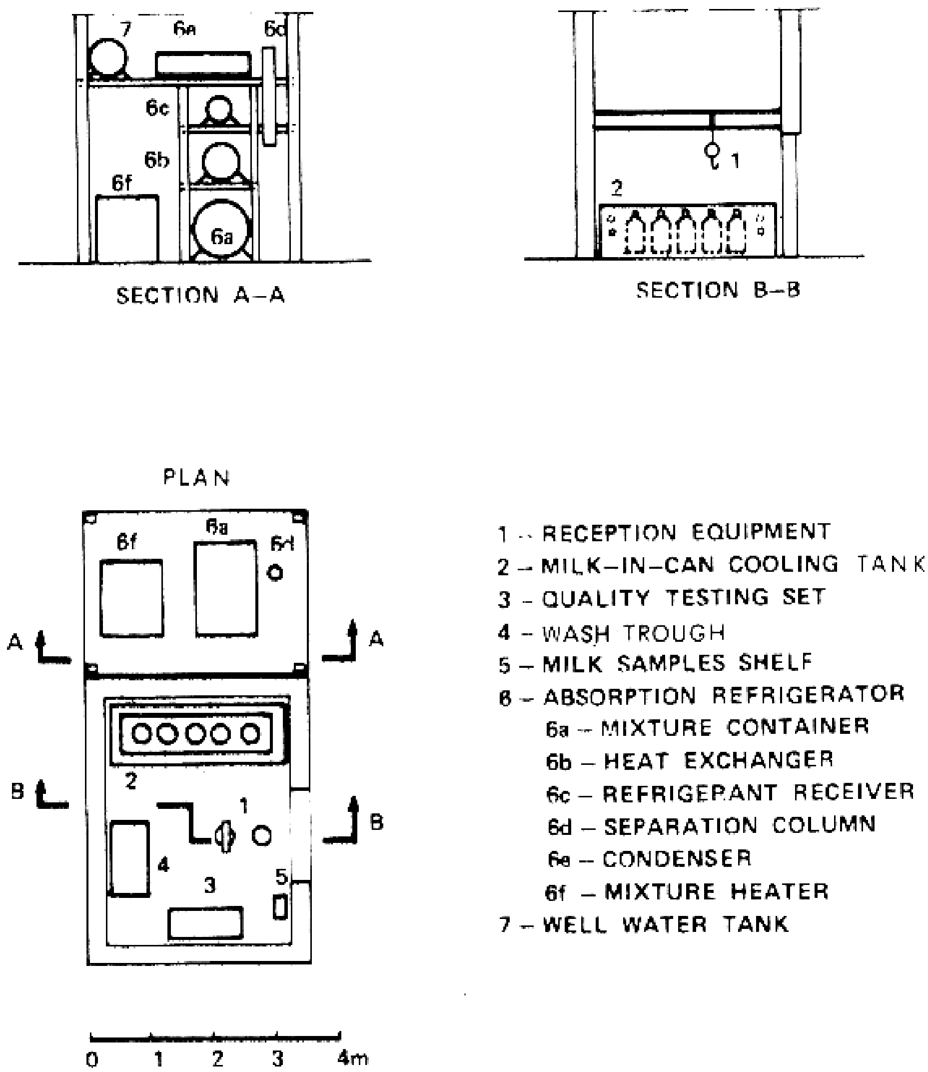


FIG 34. MILK COLLECTION CENTRE 100 l/day TO 250 l/day - MILK-IN-CAN COOLING

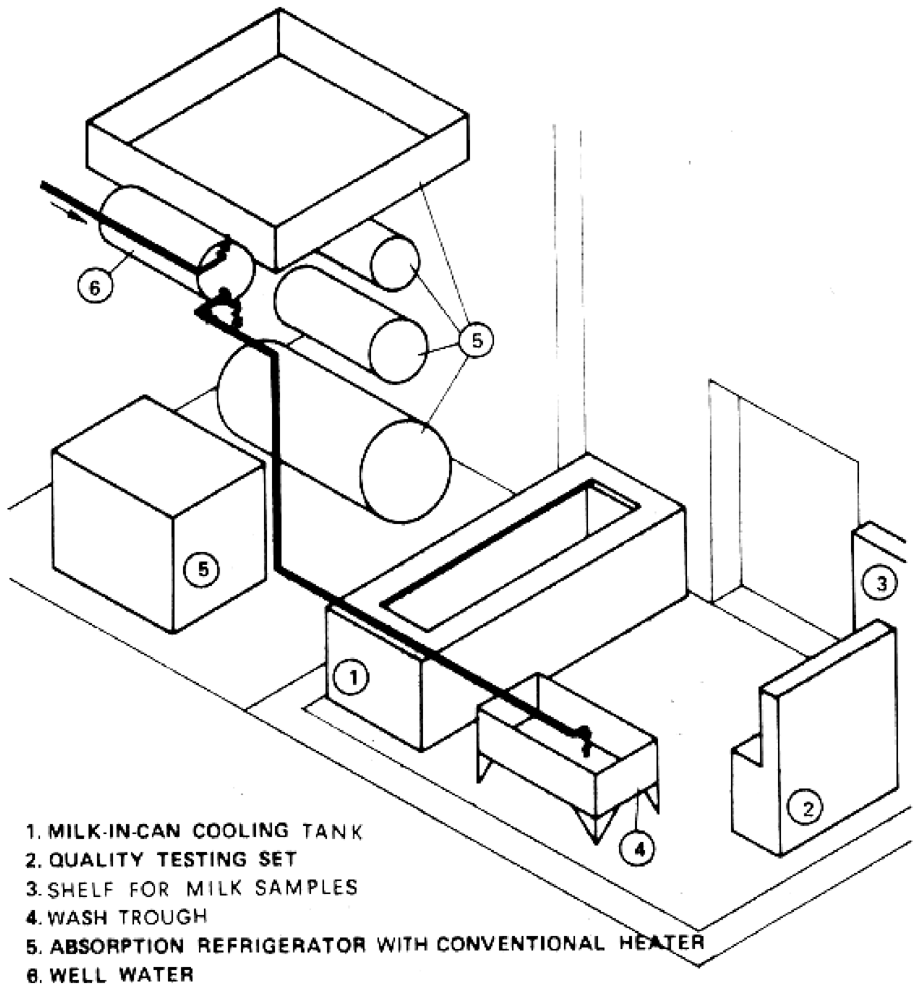


FIG 35. MILK COLLECTION CENTRE 100 l/day TO 250 l/day -MILK-IN-CAN COOLING

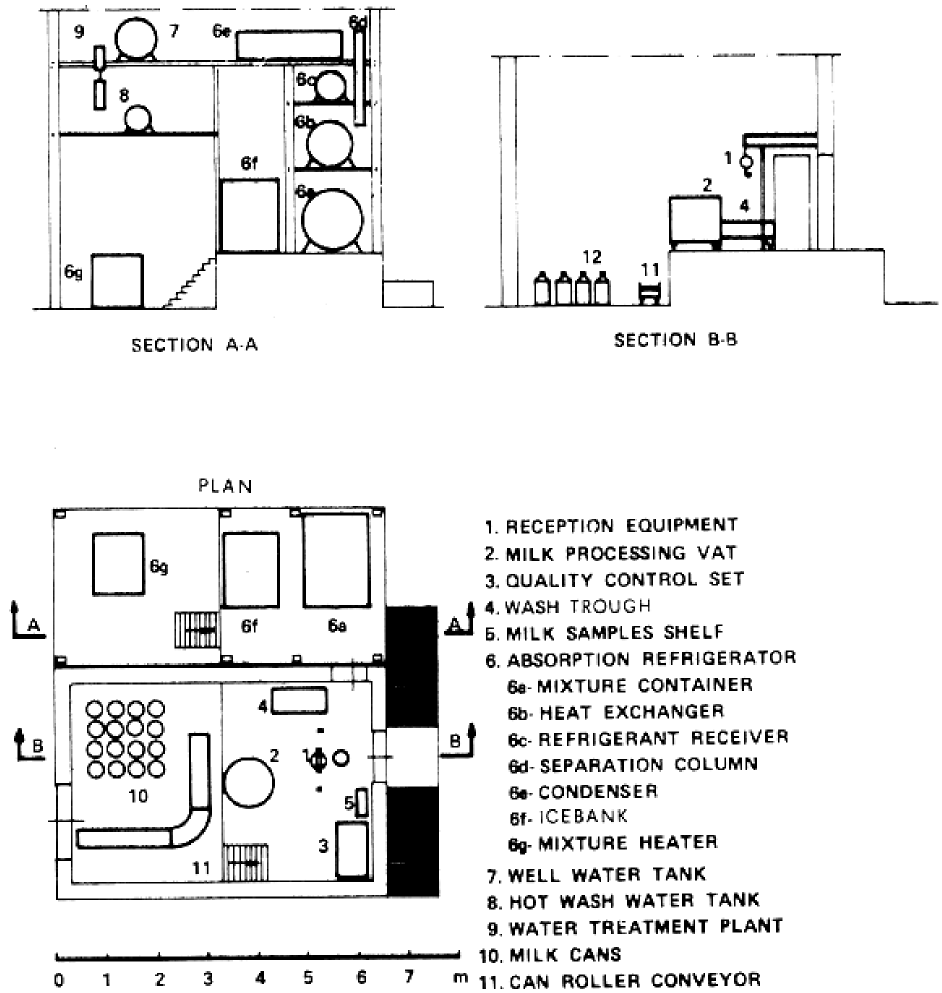


FIG 36. MILK COLLECTION CENTRE 400 l/day TO 630 l/day. MILK-IN-VAT COOLING.

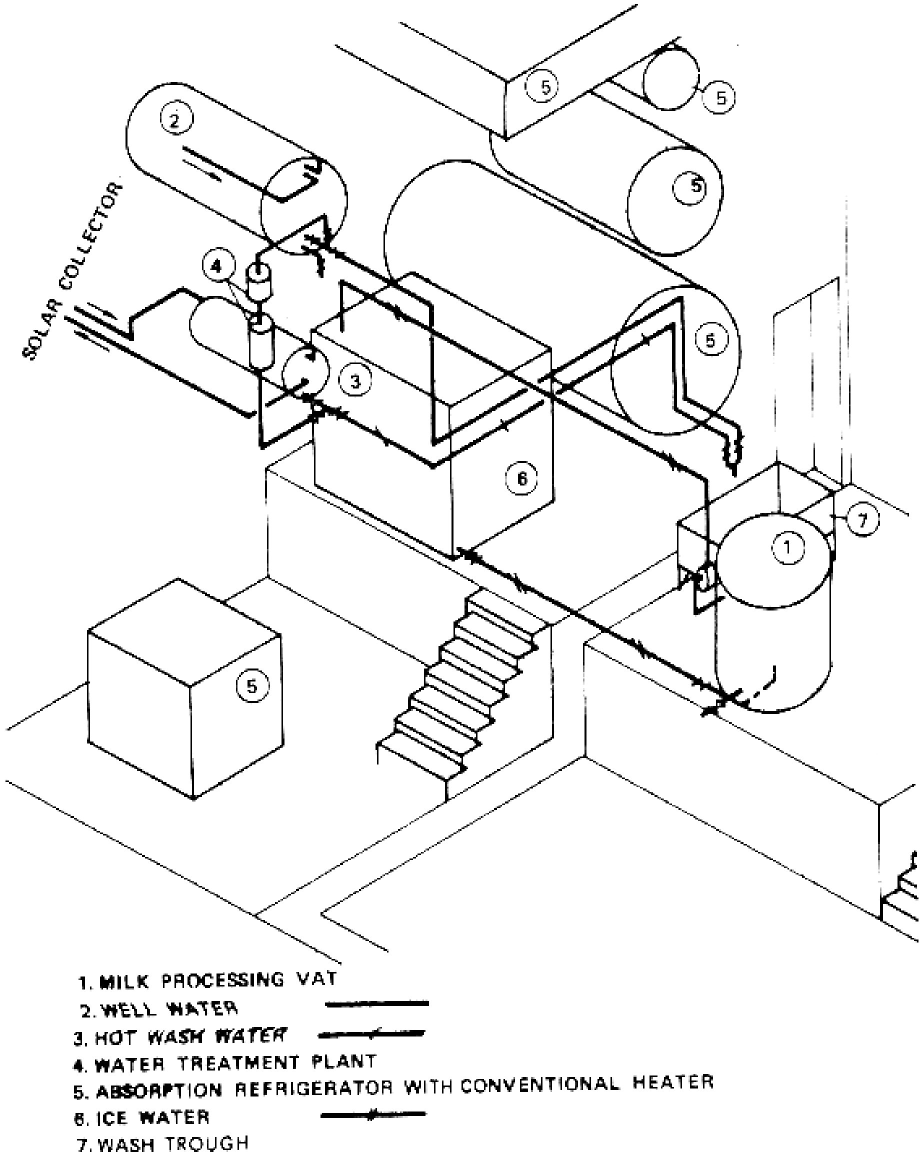


FIG 37. MILK COLLECTION CENTRE 400 l/day TO 630 l/day. MILK-IN-VAT COOLING

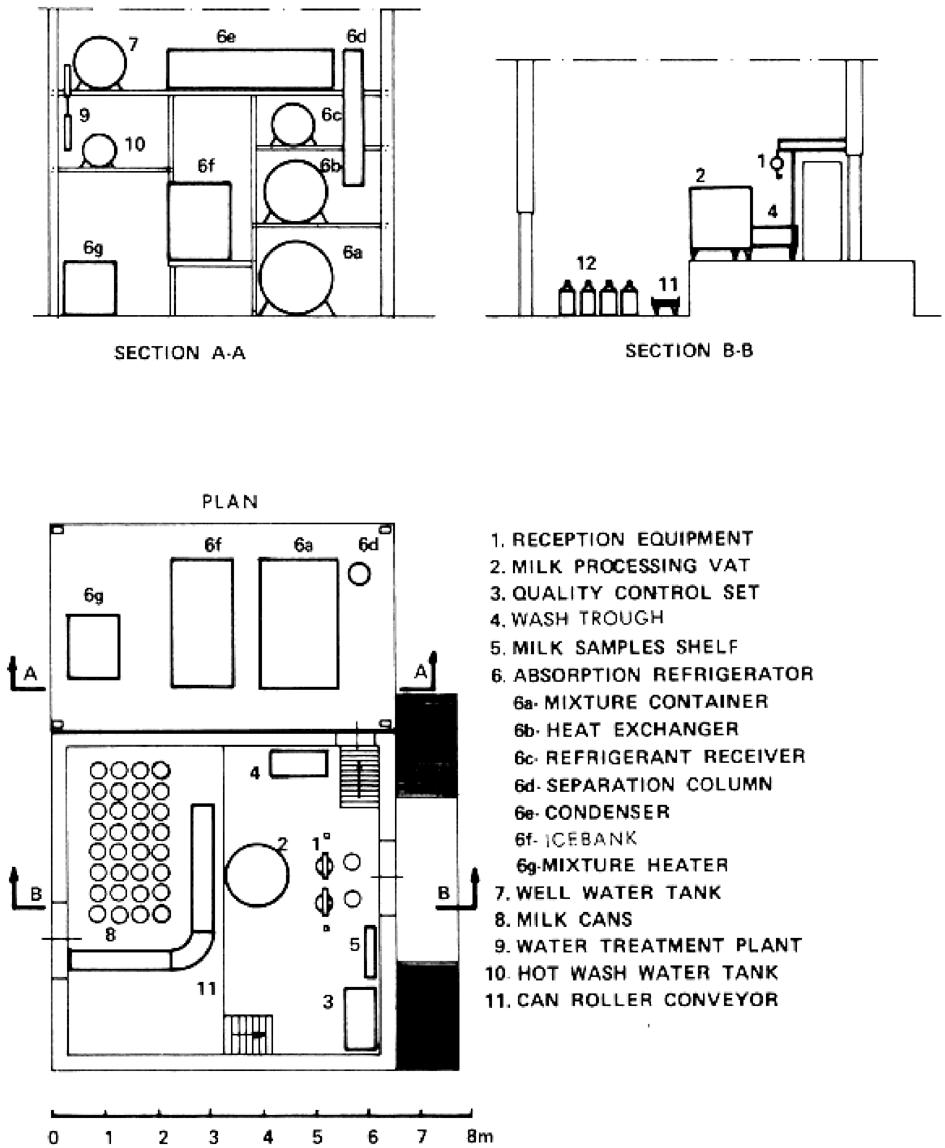


FIG 38. MILK COLLECTION CENTRE 1000 l/day TO 1600 l/day. MILK-IN-VAT COOLING.

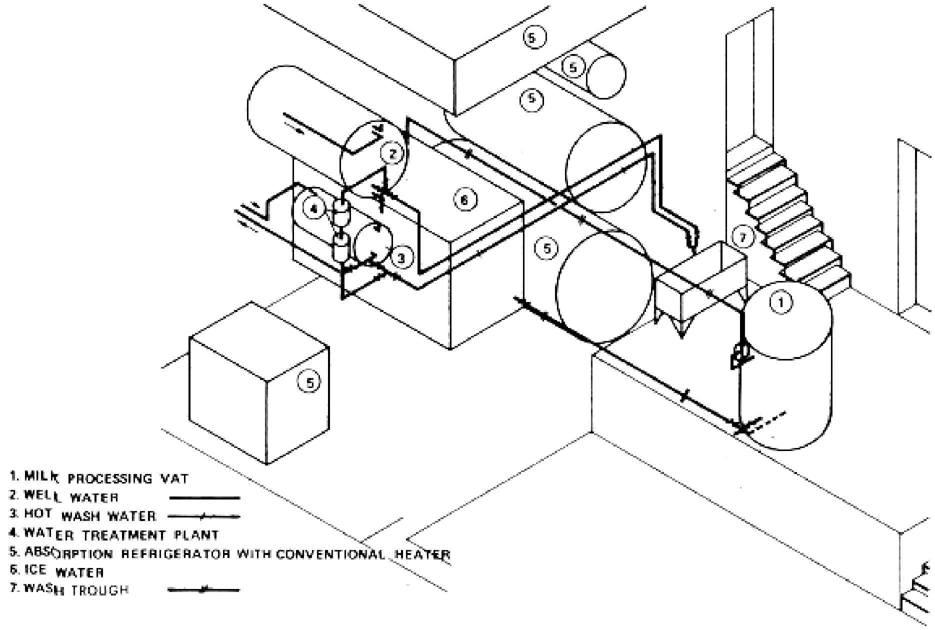


FIG 39. MILK COLLECTION CENTRE 1000 l/day TO 1600 l/day. MILK-IN-VAT COOLING

Table 11. Equipment specification - Pasteurized liquid milk processing - despatch in cans

Equipment	Standard specification reference (in text)	Requirement (numbers) Daily throughput (litres)						
		100	160	250	400	630	1 000	1 600
1. Milk reception and measuring equipment	5.2.1	1	1	1	1	1	2	2
2. Milk can -50 1	5.2.2	2	4	5	8	13	20	32
3. Milk processing vat - 100 l	5.2.5	1	-	-	-	-	-	-
- 160 1	5.2.5	-	1	-	-	-	-	-
- 250 1	5.2.5	-	-	1	-	-	-	-
- 400 1	5.2.5	-	-	-	1	-	1	-
- 630 1	5.2.5	-	-	-	-	1	1	-
- 800 1	5.2.5	-	-	-	-	-	-	2
4. Quality testing set	5.2.6	1	1	1	1	1	1	1
5. Wash trough	5.2.7	1	1	1	1	1	2	2
6. Milk can roller conveyor without bends - 3 m length	5.2.10	1	1	1	-	-	-	-
with one bend - 5 m length	5.2.10	-	-	-	1	1	1	1
7. Well water tank - 1.06 m^3	5.2.8	1	1	1	-	-	-	-
- 1.70 m^3	5.2.8	-	-	-	l	-	-	-
- 2.65 m^3	5.2.8	-	-	-	-	1	1	-
- 4.42 m^3	5.2.8	-	-	-	-	-	-	1
8. Hot water tanks - 0.42 m^3	5.2.8	1	-	-	-	-	-	-
- 0.66 m^3	5.2.8	-	1	-	-	-	-	-
- 1.06 m^3	5.2.8	-	-	1	-	-	-	-
- 1.70 m^3	5.2.8	-	-	-	1	-	-	-
- 2.65 m^3	5.2.8	-	-	-	-	1	-	-

- 4.42 m^3	5.2.8	-	-	-	-	-	1	-
- 6.38 m^3	5.2.8	-	-	-	-	-	-	1
9. Wash water tanks - 0.28 m^3	5.2.8	1	1	-	-	-	-	-
- 0.42 m^3	5.2.8	-	-	1	-	-	-	-
- 0.66 m^3	5.2.8	-	-	-	1	1	-	-
- 1.06 m^3	5.2.8	-	-	-	-	-	1	-
- 1.69 m^3	5.2.8	-	-	-	-	-	-	1
10. Hot wash water tanks - 0.17 m^3	5.2.8	1	1	1	1	-	-	-
- 0.28 m^3	5.2.8	-	-	-	-	1	-	-
- 0.42 m^3	5.2.8	-	-	-	-	-	1	-
- 0.66 m^3	5.2.8	-	-	-	-	-	-	1
11. Water treatment plant	5.2.9	1	1	1	1	1	1	1
12. Well water pump	5.2.11	1	1	1	1	1	1	1
13. Pipes and fittings - set	5.2.12	1	1	1	1	1	1	1
14. Supporting and protecting structures for outdoor installations - set	5.2.13	1	1	1	1	1	1	1
15. Oil-fired water heater - 2.5 kW	5.2.14	1	-	-	-	-	-	-
- 4.0 kW	5.2.14	-	1	1	-	-	-	-
- 6.0 kW	5.2.14	-	-	-	1	-	-	-
- 10.0 kW	5.2.14	-	-	-	-	1	-	-
- 16.0 kW	5.2.14	-	-	-	-	-	1	-
- 25.0 kW	5.2.14	-	-	-	-	-	-	1
16. Absorption refrigerator with ice accumulation - 4 kWh/day	5.2.15	1	-	-	-	-	-	-
- 6 kWh/day	5.2.15	-	1	-	-	-	-	-
- 10 kWh/day	5.2.15	-	-	-	-	-	-	-
- 15 kWh/day	5.2.15	-	-	-	1	-	-	-
- 23 kWh/day	5.2.15	-	-	-	-	1	-	-
- 36 kWh/day	5.2.15	-	-	-	-	-	1	-
- 58 kWh/day	5.2.15	-	-	-	-	-	-	1
17. Mechnical/electric power source capacity 75 W, output 0.56 kWh/day	5.2.19	-	-	-	-	-	1	1
OPTIONAL								
18. Solar water heating system - 5 kWh/day	5.2.17	1	-	-	-	-	-	-
- 7 kWh/day	5.2.17	-	1	-	-	-	-	-
- 11 kWh/day	5.2.17	-	-	1	-	-	-	-
- 17 kWh/day	5.2.17	-	-	-	1	-	-	-
- 26 kWh/day	5.2.17	-	-	-	-	1	-	-
- 41 kWh/day	5.2.17	-	-	-	-	-	1	-
- 66 kWh/day	5.2.17	-	-	-	-	-	-	1
19. Solar desorption heater in absorption refrigerator - 4 kWh/day	5.2.18	1	-	-	-	-	-	-
- 6 kWh/day	5.2.18	-	1	-	-	-	-	-
- 10 kWh/day	5.2.18	-	-	1	-	-	-	-
- 15 kWh/day	5.2.18	-	-	-	1	-	-	-
- 23 kWh/day	5.2.18	-	-	-	-	1	-	-
- 36 kWh/day	5.2.18	-	-	-	-	-	1	-
- 58 kWh/day	5.2.18	-	-	-	-	-	-	1

20. Man-driven electric power source	5.2.20	1	1	1	1	1	-	-

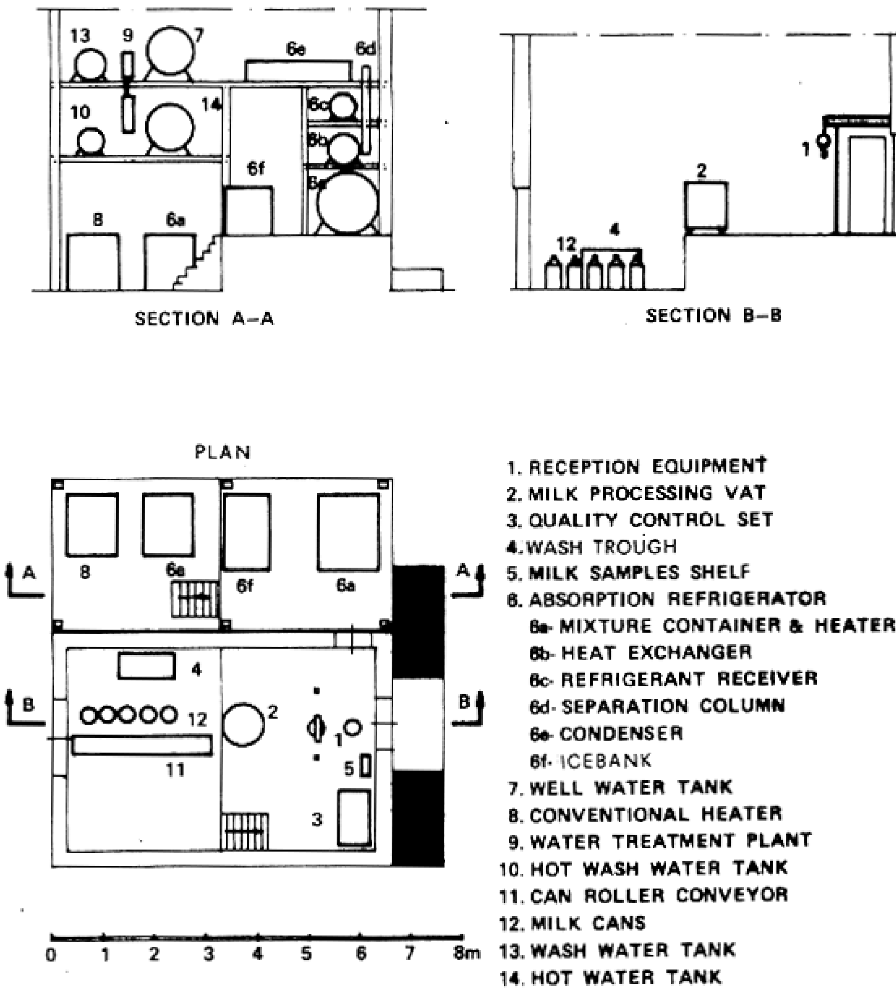


FIG 40. PASTEURIZED LIQUID MILK PROCESSING 100 l/day TO 250 l/day-DISPATCH IN CANS.

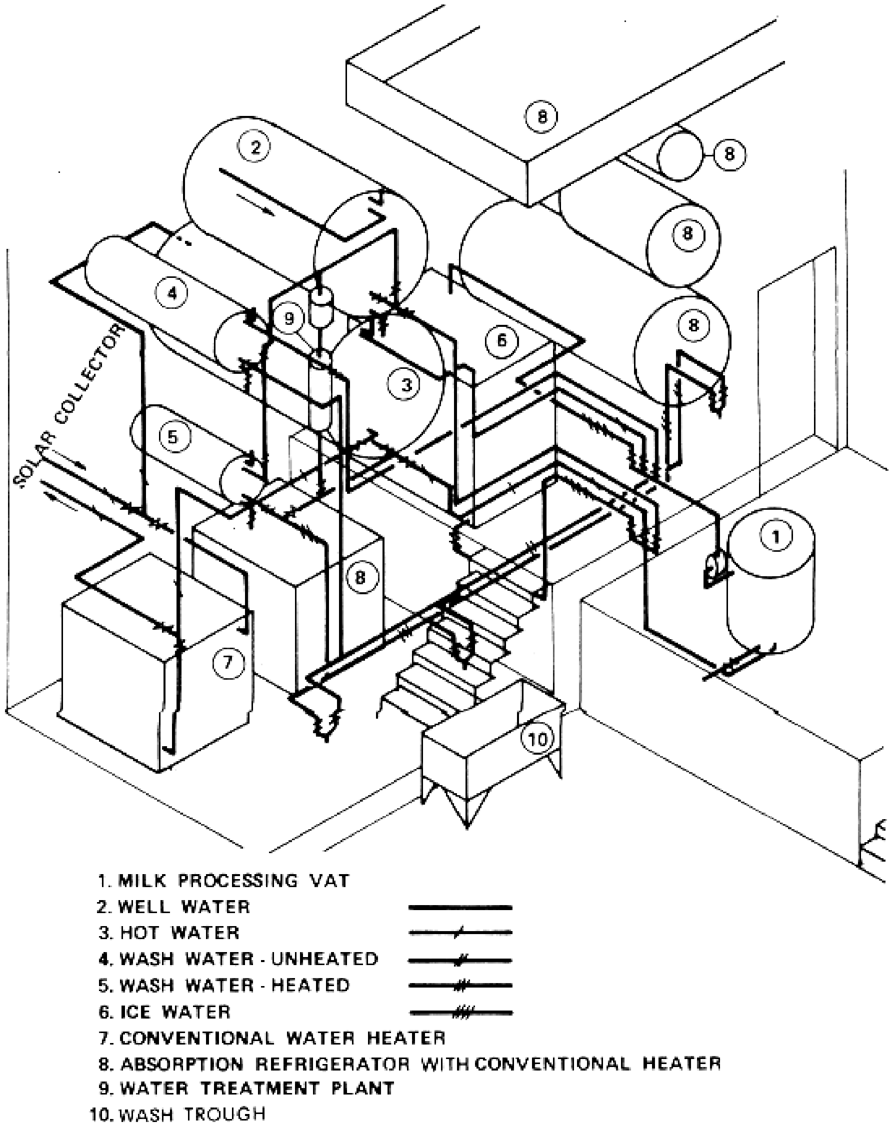


FIG 41. PASTEURIZED LIQUID MILK PROCESSING 100 1/day TO 250 l/day -DISPATCH IN CANS.

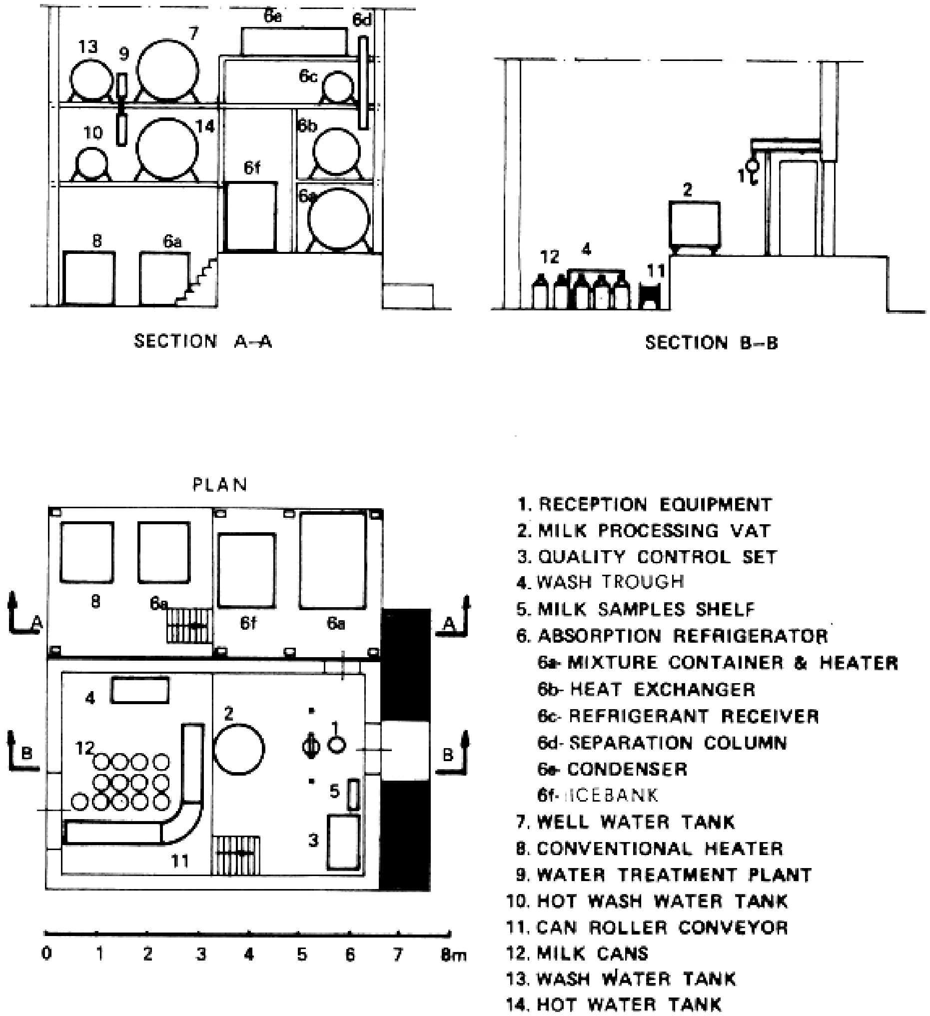
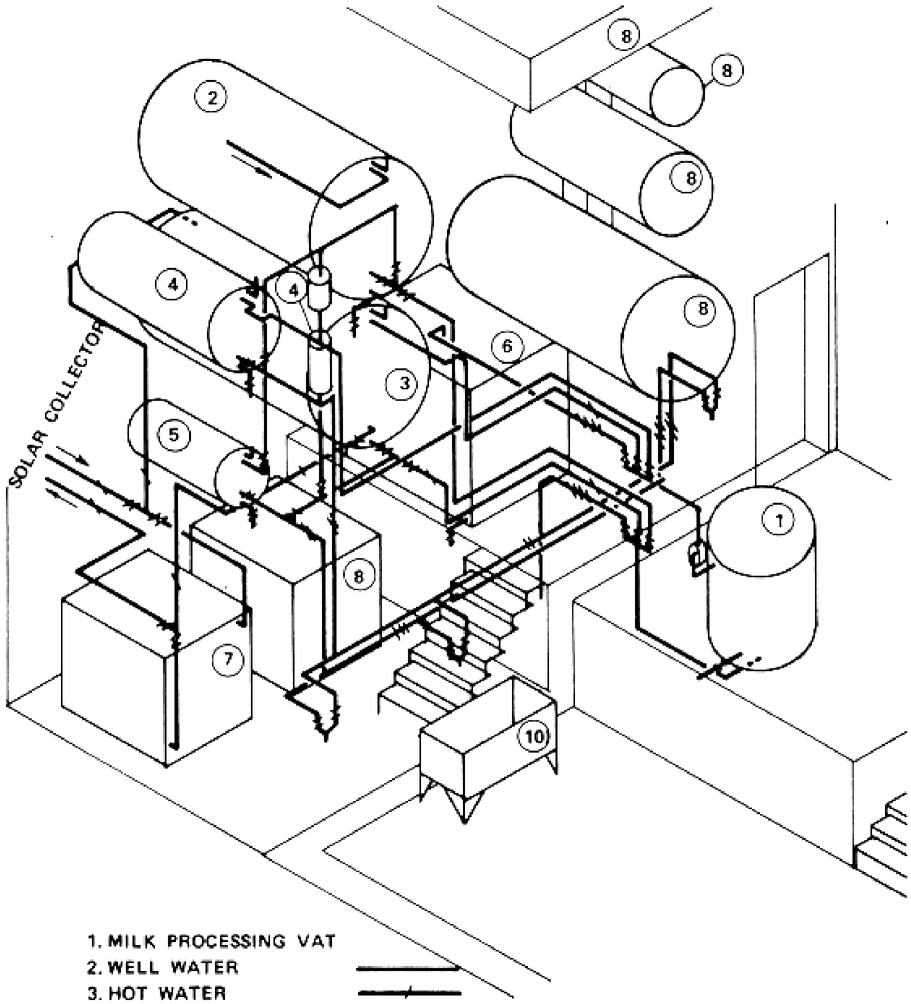


FIG 42. PASTEURIZED LIQUID MILK PROCESSING 400 l/day TO 630 l/day -DISPATCH IN CANS.



1. MILK PROCESSING VAT
2. WELL WATER
3. HOT WATER
4. WASH WATER - UNHEATED
5. WASH WATER - HEATED
6. ICE WATER
7. CONVENTIONAL WATER HEATER
8. ABSORPTION REFRIGERATOR WITH CONVENTIONAL HEATER
9. WATER TREATMENT PLANT
10. WASH TROUGH

FIG 43. PASTEURIZED LIQUID MILK PROCESSING 400 l/day TO 630 l/day -DISPATCH IN CANS.

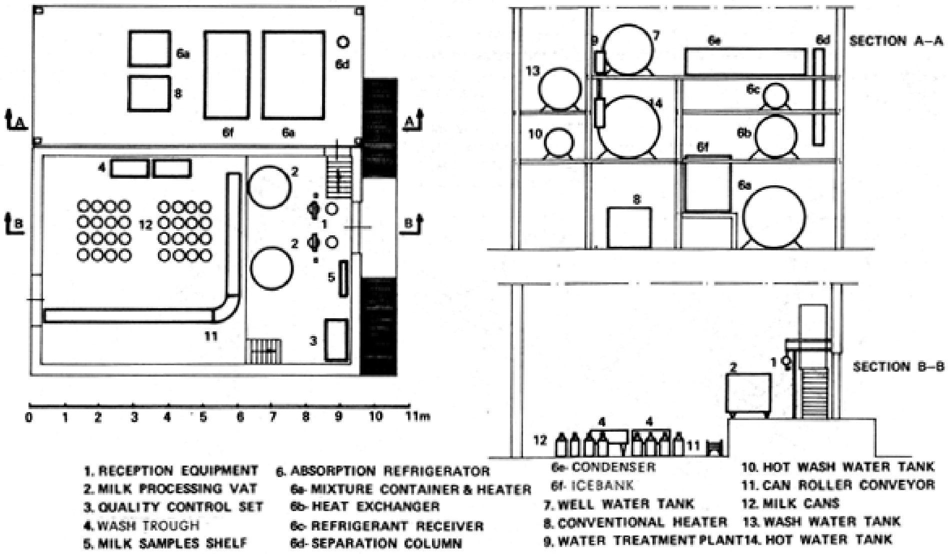


FIG 44. PASTEURIZED LIQUID MILK PROCESSING 1000 l/day TO 1600 l/day - DISPATCH IN CANS.

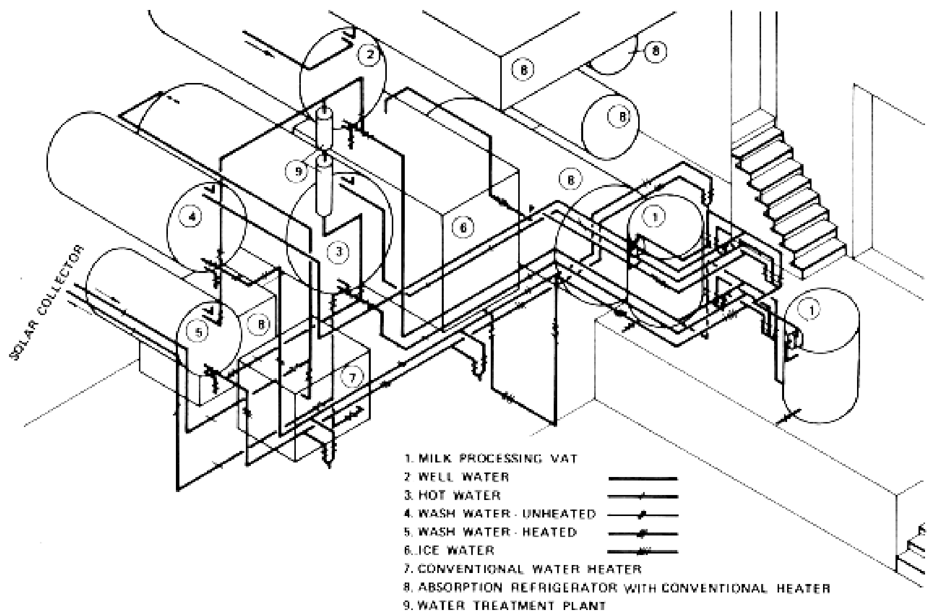


FIG 45 PASTEURIZED LIQUID MILK PROCESSING 1000 l/day TO 1600 l/day - DISPATCH IN CANS

5.3.4 Pasteurized liquid milk processing plants - dispatch in bottles

Milk handling techniques, equipment specifications and layouts for plants processing pasteurized liquid milk dispatched both in cans and in bottles do not differ much except for the packaging hall in which equipment for washing, filling and dispatch of either cans or bottles is installed.

Cold storage of packaged liquid milk, both in cans and in bottles, could be omitted provided packaging is done at the time of dispatch. Under such an assumption the bottle filling capacity must depend on the local marketing and distribution system. It could mean in extreme instances that all milk is bottled within one hour. Manual filling with spring-loaded valves takes about 20 to 25 seconds per one litre bottle. One person is able to fill about 150 l/h, which means that about ten people need to be employed to fill about 1 600 litres in one hour, plus about two persons to crate the bottles and to load the crates on the transport vehicles. Thus the totalstaff of a bottling plant of 1 600 l/day may be three times that in can filling plants. Semi-mechanical bottling machines could be an improvement in the packaging technique but they are no longer available on the standard dairy machinery market.

A general specification for manual bottle washing and filling equipment is given in section 5.2.33. Considering the similarities between the plants processing pasteurized liquid milk and the dependence of the applied packaging techniques on local marketing conditions, neither separate specifications nor layouts are suggested for plants with dispatch in bottles. They must be prepared based on the data presented in section 5.3.3 and 5.2.33 and on the analysis of sales systems most suitable for the local market.

5.3.5 Bottled fermented milk beverages manufactured from pasteurized milk

There can be no standard approach to the manufacture of fermented milk products since the applied technology depends very much on local dietary habits and local marketing conditions. All these products have in common milk pasteurization, chilling to the required fermentation temperature and incubating with selected starters. Starter propagation techniques depend on the kind of microbiological cultures involved but for the majority of products a milk can can be used.

For stirred products, starters are added to the milk in the processing vat. Milk is left to coagulate for two to four hours, after which the curd is stirred and chilled in the processing vat. Filling may being after the product temperature is lowered to about 5°C.

For unstirred products, starters must be added shortly before filling and the setting of the coagulum occurs in the filled bottles separately. As filling is basically slow in the plants under consideration the manufacture of unstirred products requires intermediate containers between the processing vat and the filling valves. Starters are added to the milk in these intermediate containers. Their volumes must not exceed the quantity of the product bottled in about 30 minutes.

The speed of bottle filling will depend on the filling system available and on the volume of the single bottle filled. With hand filling only about 150 one-litre bottles per hour can be filled by one person but in practice only about 200 quarter-litre bottles per hour. There are practical limits to the number of bottles handled manually in one plant. A plant of 1 600 l/day processing capacity which fills fermented milk in quarter-litre bottles must handle 6 400 bottles daily. Manual washing of such a quantity, particularly in hot climates and in bottles neither washed nor rinsed by the customer immediately after emptying, will create unsurmountable problems regarding hygienic conditions of manufacture. It is difficult to set a practical limit to the number of bottles handled in a small-scale plant but 1 500 to 2 000 seems to be the maximum. Regardless of the capacity of the plant manufacturing stirred fermented products, the duration of fermentation i such that bottles can only be filled in the second shift. The filling speed has to be adjusted to the dispatch timing, as already described in section 5.3.4.

Unstirred products require keeping the incubated milk in bottles at fermentation temperature for a few hours. The temperature and timing depend on the product. In traditional artisanal manufacturing systems the ways of adjusting the starter concentration, fermentation temperature and timing are based on centuries-long experience. They do not require modern applicances for adjusting the process parameters. Small-scale plants will have to follow these traditional methods, typical for the area and product concerned. The main difference between the artisanal enterprise and the proposed plants lies in the sales organization.

The artisan's shop is known to the customers and dealers who most often operate within walking distance from the shop. The small-scale plants described in this study may have to transport their product over a relatively long distance to the market.

Without chilling, the growth of microorganisms in the product may make its quality unacceptable to the customer. It may therefore be necessary to chill the product in bottles after fermentation. As filled bottles have to be kept in crates, the volume of the goods for chilling and dispatch will be in the order of 5 m^3 in the largest plants under consideration.

A suitable cold store for chilling the product would require electric fans for circulating the air in order to achieve effective chilling.

Problems involved with extensive installation of electric appliances were listed in section 4.2.1.3 and therefore chilling of the product through immersion in cold water is proposed in this study.

The suggested system is illustrated in Fig. 46: crates with filled bottles are immersed in an insulated trough filled with water up to a level of about 20 mm below the bottle cap. Ice water circulates by thermal convection in a piping system installed along the inner walls of the trough. The crate is immersed at one end of the trough and pushed towards the other end by the next crate entering the trough. In order to reduce friction the crates are positioned on a structure of bars or pipes which are corrosion proof such as plastic or protected against corrosion. The total area occupied by the chilling troughs depends on the type and number of crates. One hundred crates, containing fifteen one-litre bottles of product, totalling about 1 500 l, may require about 25m^2 floor area for troughs.

The milk handling techniques in this group of plants are in general terms very similar to those described in section 5.3.3 and so are the specifications except for those concerning bottle washing and filling which replace the can filling system. Incubation and fermentation do not affect the general layout suggested in section 5.3.3 and the comments in section 5.3.4.

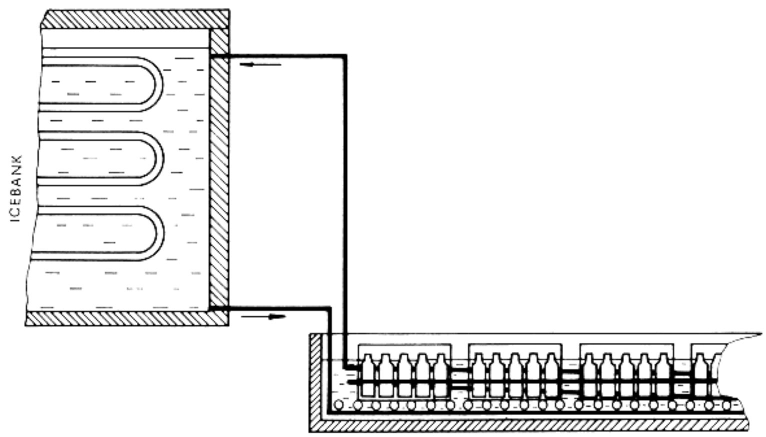


FIG. 46. IN-BOTTLE CHILLING OF UNSTRIRRED FERMENTED MILK PRODUCTS

Neither standard layouts nor standard pilot specifications can be suggested for the bottle filling and chilling part of the plant. They are so much affected by the type of the product and local marketing conditions that realistic proposals cannot be given unless these factors are analysed in detail.

5.3.6 Cheese and butter manufacture

As assumed in section 4.1 out of every 100 kg milk supplied, about 33 kg would be fully separated. The separation would result in about 26 kg skim milk and 7 kg cream with 30 percent fat. Finally, cheese would be manufactured out of 93 kg milk. The expected yields would be about 15 kg cheese, 75 kg whey, 2.0 to 2.2 kg butter and 5 kg buttermilk.

Packaging of cheese in tins containing 5 kg cheese and about 6 kg brine would result in a requirement of three tins per 100 kg milk received. Butter would be manually packaged in 100 g to 250 g packages and kept in iced water in insulated cans. The respective figures related to the particular capacity of the plants may be presented as follows:

Table 12. Cheese and butter manufacture

Daily milk reception	kg	630	1 000	1 600
Milk for separation	kg	210	330	530
Quantity of 30 percent cream	kg	45	70	110
Quantity of butter	kg	13	20	32
Buttermilk as food or feed	kg	30	45	70

Milk for cheese manufacture	kg	585	930	1 490
Quantity of cheese	kg	100	150	240
Whey for feeding	kg	450	700	1 100
Tins containing 5 kg cheese	Nos	20	30	48
Insulated cans for butter storage	Nos	1	2	4

There are several methods of manufacturing cheese sold in brine. The equipment needs to be adjusted to the technology chosen. The technology and equipment depend on the kind of the product desired. Heat treatment prior to renneting could be done in a cylindrical vat and all other processes in rectangular or cylindrical cheese vats. There are also several methods of curd transfer, cutting, whey draining and curd pressing.

The simplest technology specified in this section seems to be the performance of heat treatment, milk clotting, curd cutting, curd drying and whey draining in one cylindrical vat. The curd is then transferred - usually through the outlet cock - to a curd handling table where it is pressed into a block and cut or put into moulds and pressed separately.

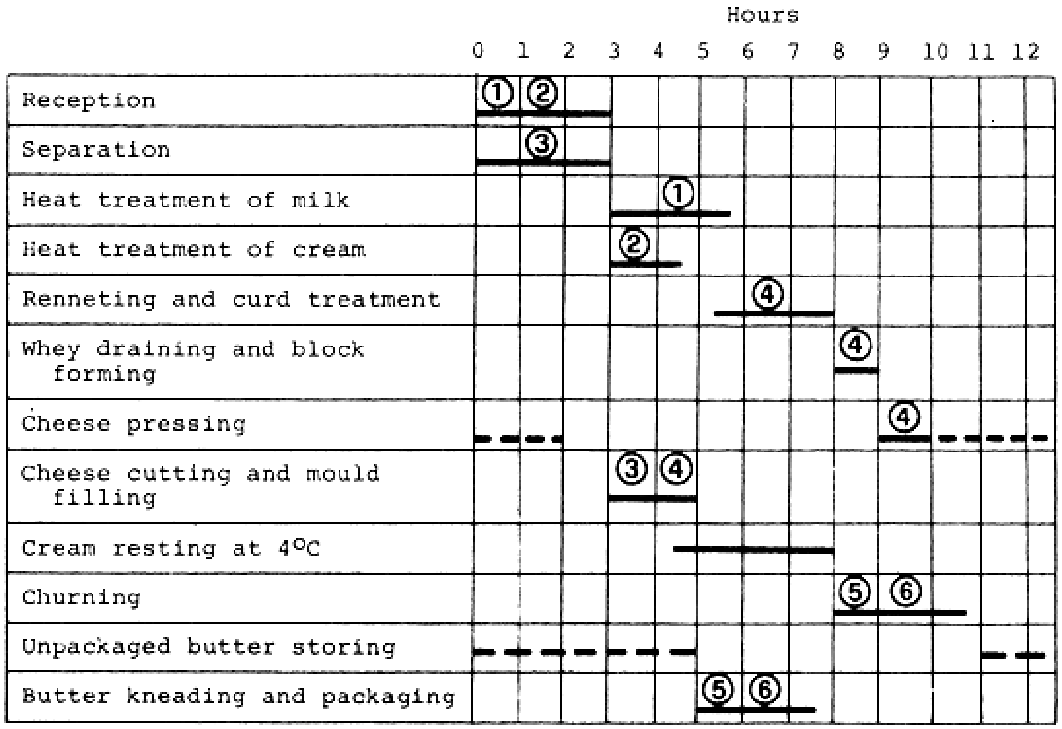
Butter obtained in the manually-operated butter churn requires kneading, to be performed on a manually-operated kneading machine. Prior to kneading, butter should be chilled which may be best achieved by removing it from the butter churn into a stainless steel container and placing the container in the chilled water tank. After about 24 hours the butter should be ready for kneading and packaging. Packaged butter should be placed in ice-water in insulated transport boxes or cans.

Whey and buttermilk are collected in cans and sold or given away as animal feeds.

In Figs. 47 and 48 the general outline of the concept of the plants is illustrated. There is little difference in area requirement for cheese and butter manufacture when total daily intake varies from about 600 to 1 600 1. Therefore, only one preliminary layout for a 1 600 l/day plant is suggested. Staff requirements may also be considered as relatively constant for that range of capacity.

A preliminary time schedule with indications of staff employment (about 6 men for processing only) operating in two shifts may be indicated as follows:

Table 13. Process schedule for butter and cheese

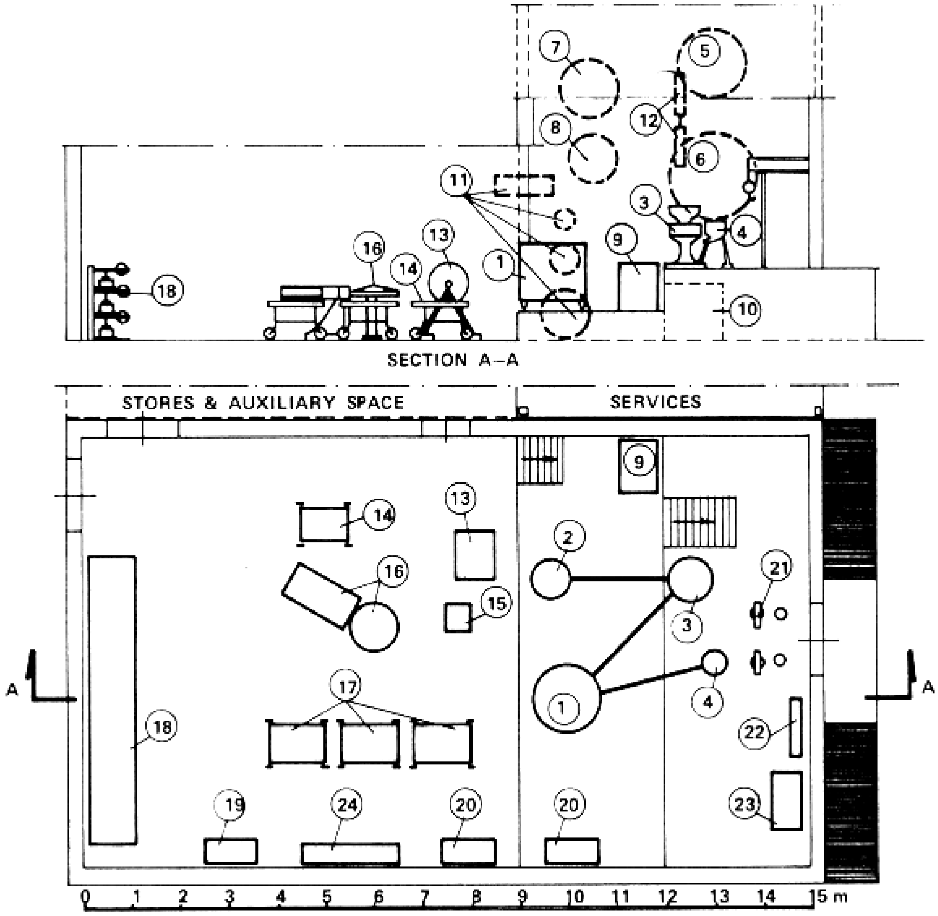


Numbers in circles refer to a given staff member employed at an indicated processing section. Two more men may be required for energy procurement. The total indicated staff of eight people does not include sales, transport and procurement of packaging material.

Table 14. Equipment specification - Cheese and butter manufacture

Equipment	Standard specification reference (in text)	Requirement (number) Daily throughput (litres)		
		630	1 000	1 600
1. Milk reception and measuring equipment	5.2.1	1	1	1
2. Milk can 50 1 insulated	5.2.2	2	4	8
3. Milk processing vat - 50 1	5.2.5	1	-	-
- 100 1	5.2.5	-	1	-
- 160 1	5.2.5	-	-	1
- 630 1	5.2.5.C	1	-	-
- 1 000 1	5.2.5.C	-	1	-
- 1 600 1	5.2.5.C	-	-	1
4. Milk reception funnel	5.2.21	1	1	1
5. Manually-operated milk separator - 160 l/h	5.2.22	1	-	-
- 250 l/h	5.2.22	-	1	1
6. Quality testing set	5.2.6	1	1	1
7. Butter churn - total volume - 100 l	5.2.23	1	-	-
- 200 1	5.2.23	-	1	1
8. Butter container	5.2.24	1	1	1
9. Butter-handling table	5.2.25	1	1	1
10. Butter-kneading machine 50 kg/h	5.2.26	1	1	1
11. Butter manual-packaging machine	5.2.27	1	1	1
12. Curd handling trolley for 100 kg curd	5.2.28	2	2	3

13. Cheese moulds - (5 kg of curd/mould)	5.2.29	50	80	130
14. Cheese presses-mechanical, for 20 moulds	5.2.30	2	3	4
15. Brine container	5.2.30	1	1	1
16. Rack for cheese moulds	5.2.32	1	1	1
17. Wash trough	5.2.7	2	2	2
18. Well water tank - 1.7 m^3	5.2.8	1	-	-
- 2.65 m^3	5.2.8	-	1	-
- 4.42 m^3	5.2.8	-	-	1
19. Hot water tank - 2.65 m^3	5.2.8	1	-	-
- 4.42 m^3	5.2.8	-	1	-
- 6.38 m^3	5.2.8	-	-	1
20. Wash water tank - 1.06 m^3	5.2.8	1	-	-
- 1.70 m^3	5.2.8	-	1	-
- 2.65 m^3	5.2.8	-	-	1
21. Hot wash water tank - 0.28 m^3	5.2.8	1	-	-
- 0.42 m^3	5.2.8	-	1	-
- 0.66 m^3	5.2.8	-	-	1
22. Water treatment plant	5.2.9	1	1	1
23. Well water pump	5.2.11	1	1	1
24. Pipes and fittings - set	5.2.12	1	1	1
25. Supporting and protecting structures for outdoor installations - set	5.2.13	1	1	1
26. Oil-fired water heater - 10 kW	5.2.14	1	-	-
- 16 kW	5.2.14	-	1	-
- 25 kW	5.2.14	-	-	1
27. Absorption refrigerator with ice accumulation - 3 kW/day	5.2.15	1	-	-
- 4 kW/day	5.2.15	-	1	-
- 6 kW/day	5.2.15	-	-	1
28. Mechanical/electric power source	5.2.19	1	1	1
OPTIONAL				
29. Solar water heating system - 33 kWh/day	5.2.17	1	-	-
- 52 kWh/day	5.2.17	-	1	-
- 83 kWh/day	5.2.17	-	-	1
30. Solar desorption heater in absorption refrigerator - 3 kWh/day	5.2.18	1	-	-
- 4 kWh/day	5.2.18	-	1	-
- 6 kWh/day	5.2.18	-	-	1



1. MILK PROCESSING VAT
2. CREAM PROCESSING VAT
3. MILK SEPARATOR
4. MILK RECEPTION FUNNEL
5. WELL WATER TANK
6. HOT WATER TANK
7. WASH WATER TANK
8. HOT WASH WATER TANK
9. ICEBANK
10. CONVENTIONAL WATER HEATER
11. ABSORPTION REFRIGERATOR
12. WATER TREATMENT PLANT
13. BUTTER CHURN
14. BUTTER TABLE
15. BUTTER CONTAINER
16. BUTTER KNEADING AND PACKAGING MACHINES
17. CURD HANDLING TROLLEY
18. CHEESE PRESSES
19. BRINE CONTAINER
20. WASH TROUGH
21. RECEPTION EQUIPMENT
22. MILK SAMPLES SHELF
23. QUALITY CONTROL SET
24. RACK

FIG. 47. CHEESE AND BUTTER MANUFACTURE 630 l/day TO 1600 l/day FRESH MILK INTAKE. - EQUIPMENT SHOWN FOR 1600 l/day.

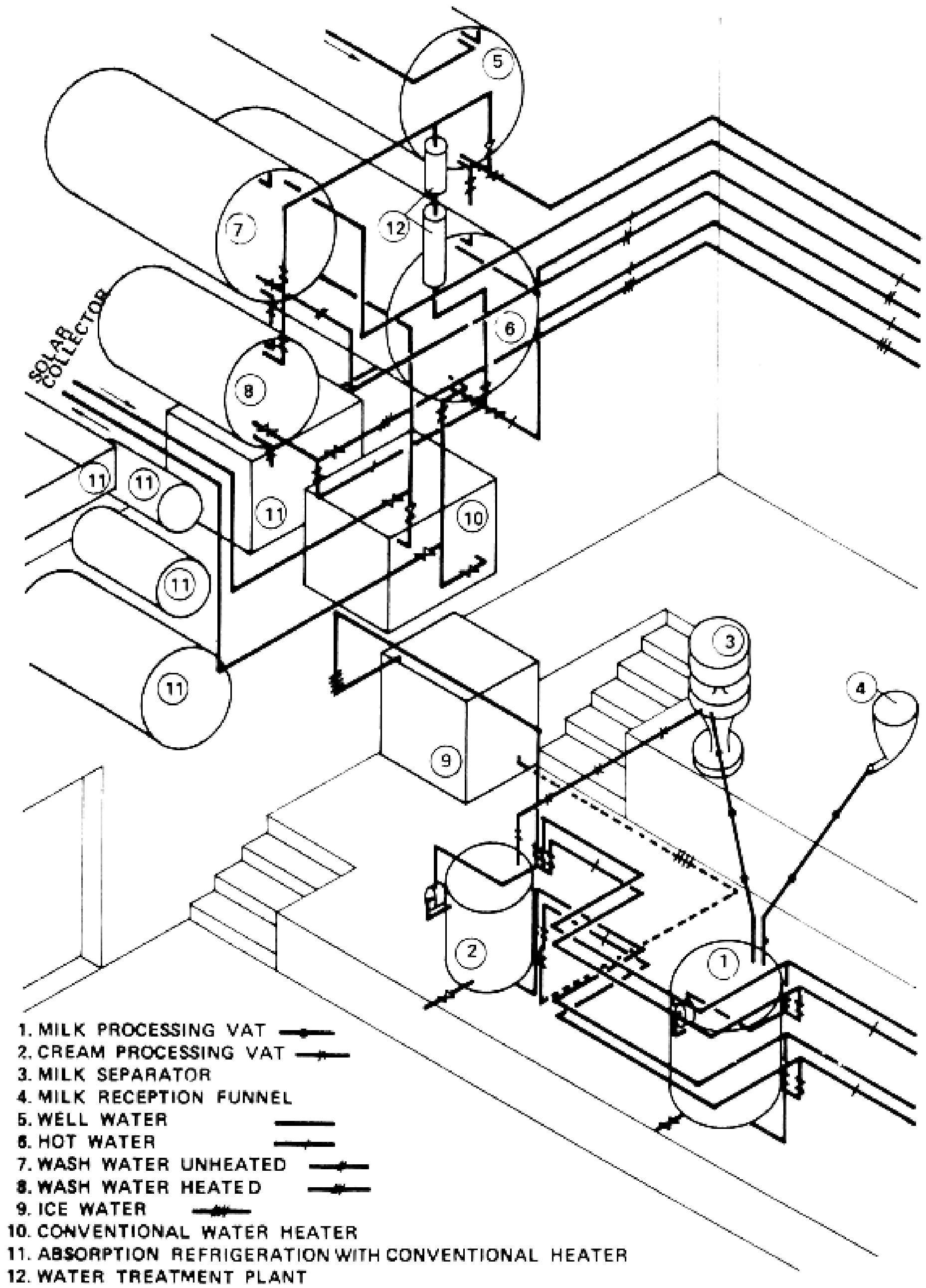


FIG 48. CHEESE AND BUTTER MANUFACTURE 630 l/day TO 1600 l/day FRESH MILK INTAKE.

5.4 Indicatory cost estimates

Figures presented in Table 15 are only an illustration of the order of magnitude of the capital inputs required. Many factors may affect the erection costs of a pilot plant described in this study. They depend mainly on local conditions and therefore an accurate cost estimate cannot be made unless all factors are known and a suitable detailed project is prepared for the selected locality.

Figures in Table 15 and in Figs. 49 and 50 are given separately for plants equipped with or without optionals. Under "optionals" basically equipment for solar energy procurement is specified. Accordingly, projects for plants without "optionals" represent simple small-scale collecting and processing centres adapted to operation without electricity supply from outside and using conventional fuels for their service procurement. Plants with "optionals" are additionally equipped with solar collectors and can procure services either from conventional or from solar heaters. The cost estimates include contingencies calculated as a lump sum which is equal for all capacities within a selected processing programme.

The margin of error in capaital input estimates is wider for plants with lower capacities. It seemed therefore to be appropriate to put in the final cost evaluation a relatively higher figure as contingencies.

As can be seen from the figures, there is little difference in the total costs between the first four capacities (up to 400 l/day) within each of the processing programmes. It is therefore suggested that the capacity of 400 l/day should be chosen as the base for planning the smallest plants.

The pilot character of all projects must be considered by those who would be making the decision concerning respective investments. The capital input should constitute only a part of a more compact project which should include the expertise and technical assistance of carefully selected advisers.

Table 15. Capital input requirements (1981 estimates in "000" US$)

	Capacity l/day	Equipment		Building	Contingencies	Total		US$/1
		without optional	with optional			without optionals	with optionals	without/with optionals
Collection - hot dispatch	100	9	10	6	15	30	31	300/310
	160	10	11	6	15	31	32	194/200
	250	12	13	6	15	33	34	132/136
	400	15	16	12	15	42	43	105/108
	630	16	18	12	15	43	45	68/71
	1 000	24	26	18	15	43	45	57/59
	1 600	28	32	18	15	61	5	38/41
Collection - cold dispatch	100	11	14	6	20	37	40	370/400
	160	13	16	6	20	39	42	243/263
	250	15	20	6	20	41	46	164/184
	400	17	26	12	20	49	58	123/145
	630	19	32	12	20	51	64	81/102
	1 000	23	44	18	20	61	82	61/82
	1 600	29	60	18	20	67	98	42/61
Pasteurized - dispatch in cans	100	14	17	12	25	51	54	510/540
	160	16	20	12	25	53	57	331/356
	250	18	24	12	25	55	61	220/244
	400	24	34	12	25	61	71	153/178
	630	31	45	12	25	68	82	108/130
	1 000	42	60	28	25	95	113	95/113
	1 600	50	84	28	25	103	134	64/86
Pasteurized or fermented - bottled	100	16	19	18	35	69	72	690/720
	160	18	22	18	35	71	75	444/469
	250	20	26	18	35	73	79	292/316
	400	27	36	24	35	86	95	215/238
	630	33	47	24	35	92	106	146/168
	1 000	45	63	36	35	116	134	116/134
	1 600	56	90	36	35	27	161	79/101
Cheese and butter	630	39	43	65	40	144	148	229/233
	1 000	49	54	65	40	154	159	154/159
	1 600	58	66	65	40	163	171	102/107

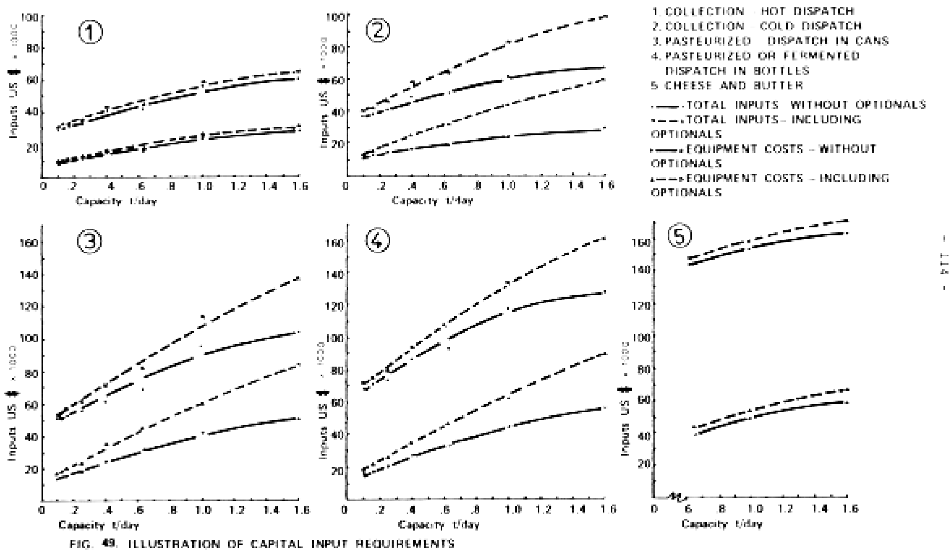


FIG. 49. ILLUSTRATION OF CAPITAL INPUT REQUIREMENTS

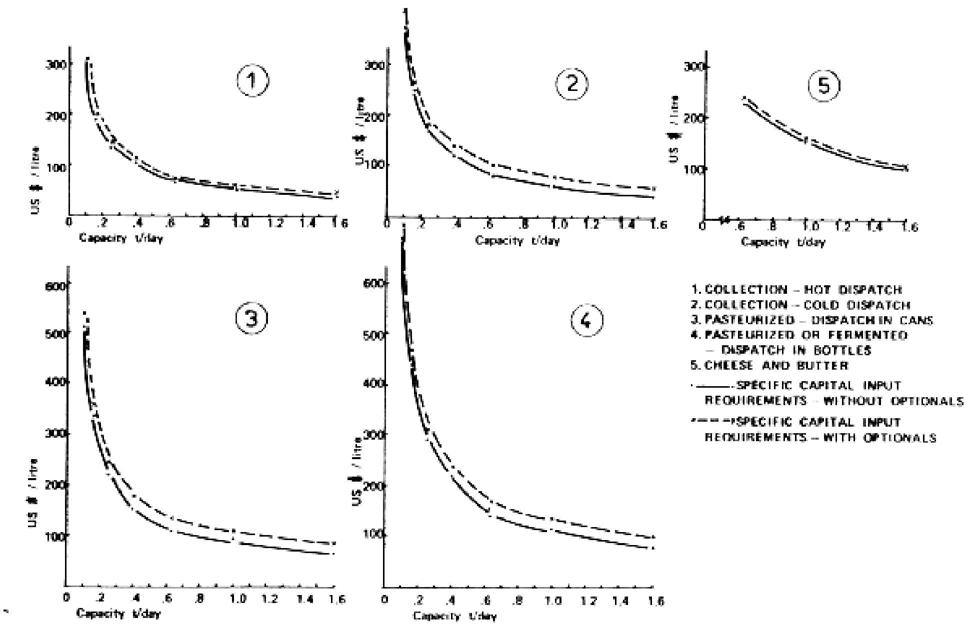


FIG. 50. ILLUSTRATION OF SPECIFIC CAPITAL INPUT REQUIREMENTS