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05417

Distr.
LIMITED

ID/WG.171/14
5 April 1974

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

International Consultation on
Agro-Industrial Development

Belgrade, Yugoslavia, 13-18 May 1974

FRESH MILK PRESERVATION TECHNIQUES 1/

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id.74-2195

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INTRODUCTION

In the following paper are presented the most common processes for pasteurization sterilization in continuous flow and aseptic filling. The different plants on the market are presented, unfortunately incompletely as it has not been possible to obtain material from all manufacturers. The references (1, 2, 3) have, however, been of great help in making the paper as complete as possible.

The most realistic process under the given circumstances is today UHT-treatment combined with aseptic filling. Therefore, most attention has been paid to this process. Further, flexible packages are in this case most interesting and aseptic filling in glass and tins is not considered.

Acknowledgement

The author is very grateful to the following companies which have kindly submitted background material thereby making this investigation possible.

E. Ahlborn AG, W. Germany
Alfa-Laval AB, Sweden
Cherry-Burrell Corp., USA
Stork-Amsterdam, Holland
Svenska Elopak AB, Sweden
Tetra Pak International AB, Sweden
Thimonnier SA, France

DEFINITIONS

Sterilization in general is a process by which complete destruction of all microorganisms and their sporer is achieved. Consequently, absolute sterility means complete absence of any form of viable organisms or spores. However, the canning industry has long since introduced the term commercial sterility which means that the product is not complete sterile but is free from microorganisms that can develop under the conditions normally present when the product is handled and stored.

Another term is ultra-high temperature treated milk (UHT milk) which means a sterilized milk heated for approximately one or more seconds at a temperature of at least 1[illegible]°C in a continuous flow heat treatment and packaged under aseptic conditions. According to (1) the UHT milk "must keep for a prolonged period of time without deterioration; it must be free from toxins and from organisms which would be harmful to the consumer's health; and finally it must be free from organisms which are able to grow in milk and thus contribute to its deterioration".

Pasteurization means heat treatment to 70-80°C involving the killing of toxic microorganisms and virus but not of spores.

TECHNICAL SYSTEMS

Heat treatment

The heat treatment necessary to achieve the specified degree of bacteriological reduction may be done either before the product is filled in its package or when it is packaged. In the first case the product is normally heat treated in continuous flow through a heat exchanger. In the second case the untreated product is filled into the consumer package and this package is then pasteurized or sterilized in for instance an autoclave.

Heat treatment before filling may be done according to the following technical alternatives:

Batchwise. The bulk of milk is collected in an open tank with a jacket. The milk stays in this tank during all the pasteurization. The jacket is first supplied with steam for as long a time as is needed for the milk to reach the pasteurization temperature. The steam is turned off and the milk is left for a certain time - holding time. Then cooling water is applied to the jacket and the milk is cooled down and is then ready for eventual filling.

The method has a lot of disadvantages:
non-hygienic, unequal treatment of the milk (milk in close contact with the tank wall will be very superheated compared to

milk in the center of the tank), the process is tedious and uneconomical. Today, this method is almost out of use and is only of historical interest.

Continuous flow through a heat exchanger (indirect heating)

The liquid is pumped through a set of heat exchangers according to the flow sheet below. In the first heat exchanger the liquid is preheated to a pre-chosen temperature by means of already pasteurized (sterilized) liquid. It is then passed into a second heat exchanger where it is heated to the final temperature by means of hot water or vapour (steam). From this point the liquid is passed through the first mentioned heat exchanger again, thereby giving up part of its heat and in this way heating the untreated liquid. In a third heat exchanger cooling water, ice water or brine cools the liquid to an appropriate temperature for filling (figure 1).

Accessories:

Balance tank; in front of the inlet milk pump is fitted a small tank in which the level is controlled. To this tank flow is diverted during diversion flow (see below) and cleaning.

Inlet milk pump; hygienic centrifugal or positive pump.

Flow controller, fitted after the inlet milk pump (in case of centrifugal pump) in order to keep a constant flow.

Holding tube; this tube is sized to contain a certain liquid volume. This volume in combination with the flow set by the flow controller gives the liquid a constant, specified holding time at the pasteurization or sterilization temperature.

Diversion valve; this valve is guided by a thermometer in the holding tube. If the temperature is below the specified value the liquid is diverted to the balance tank.

Heat exchangers available

Plate heat exchangers, most common, possible to open up for cleaning and inspection, flexible, extendable, compact.

Tubular heat exchangers; triple-tube units, no gaskets (figure 2).

Scraped surface heat exchangers are only used for very viscous products and are therefore of less interest in this case.

Steam injection and steam infusion (direct heating)

As an alternative to indirect heating (plate or tubular heat exchanger) plants are also available with the last part of the heating section performed as a mixer for steam and product. The steam is condensed into the product thus giving a very short heating-up time. Two methods are available: steam injection (steam is injected in a turbulent flow of product) and steam infusion (milk is sprayed into a steam chamber). These methods involve dilution of the product (by the steam condensate) and therefore this water has to be removed. This is done by boiling the liquid in a vacuum chamber and in this way rapid cooling is also achieved.

Electrical methods

It would also be possible to heat the product by means of conductance or dielectric heating. So far, however, practical processes are not available.

Heat treatment of liquid filled in packages. Due to necessary mechanical strength these methods are only applicable to glass bottles and tins. The heat treatment can be done according to various methods.

Batch sterilizers consist of a tank with a lid both resistant to internal steam pressure. The tank is filled with the containers to be sterilized, the lid is mounted and steam is applied to the tank for a certain time. For cooling the containers may be sprayed with water either in the tank or outside. The method is tedious and has a long heating up time giving normally serious heat denaturation to the product. To improve the heating up, apparatuses are available where the containers are agitated during heating thus increasing heat penetration.

Continuous autoclaves normally involve the following stages: sterilization at increased steam pressure, cooling at increased pressure and cooling at atmospheric pressure. The containers are fed continuously through the cylindrical machines in a spiral flow. Inlet and outlet are provided with locks.

Hydrostatic sterilizers involve continuous sterilization of the containers in a steam dome. The containers are passed through the machine by means of a chain. Inlet and outlet to the dome is via water locks.

Tunnel pasteurisers and sterilizers. In these machines the containers are fed through the different zones of the machine on a band. Heating and cooling takes place mainly by means of forced air. Steam may be injected for heating and water sprayed for cooling.

Packing

The following types of containers and packages are available on the market:

glass bottles

glass jars

tins

cartons made from laminated paper and plastic film prefabricated

gable-top

formed in line

sachets or pouches made from laminated plastic film

SUMMARY OF HEAT TREATMENT SYSTEMS

	Pasteurization	Sterilization in container	Continuous flow sterilization (UHT)
Heat treatment before filling			
batchwise	Out of date	-	-
continuous flow			
plate heat exchangers	Most common	Used for pre-treatment	Common
tubular heat exchangers	Common	Used for pre-treatment	Common
direct heating	Possible, used in spec. cases		Common
Heat treatment after filling			
batchwise autocl.	-	Used	-
continuous autocl.	-	Used	-
hydrostatic steriliser	-	Common	-
tunnel pasteur./steriliser	Used	Used	-

SUMMARY OF PACKING SYSTEMS

	Pasteurisation	Sterilization in container	Continuous flow sterilization
Glass bottles	Common	Common	Not solved
Tins	Not used	Common	Used
Pre-fabricated cartons	Common	-	Common
Formed in line cartons	Common	-	Common
Sachets and pouches	Common	-	Newly developed

AVAILABLE PASTEURIZATION PROCESSES

Most heat treatment plants on the market include plate heat exchangers, but some manufacturers have triple tube heat exchangers on their programmes. In both cases the flow sheet is roughly in accordance with figure 1.

Some leading manufacturers of plate heat exchanger plants are listed below:

E. Ahlborn AG, W. Germany
Alfa-Laval AB, Sweden
APV Co., England
Breil & Martel, France
Cherry-Burrell Corp., USA
Cream Package Division, St. Regis, USA
DDSM, Denmark
G. Frau, Italy
Paasch & Silkeborg, Denmark
Schmidt-Bretten, W. Germany
M. Sordi, Italy
Volma, Holland

Regarding filling plants only paper and plastic containers are considered as glass bottles are not a realistic alternative.

Some manufacturers of filling plants for (a) pre-fabricated cartons (b) cartons formed in line and (c) sachets or pouches are listed below:

(a) Ex-Cell-O Corp., USA
Tetra Pak International AB, Sweden

(b) Zelf-pack GmbH, W. Germany
Tetra Pak International AB, Sweden
Supack GmbH, W. Germany

(c) Thimonnier S.A., France
Prepac, France

AVAILABLE PROCESSES FOR CONTINUOUS STERILIZATION (UHT) AND ASEPTIC FILLING

The following plants differ very much and therefore a short description of the different systems is given in the annexes. Reference is also made to the leaflets supplied by the manufacturers, some of whom are listed below:

STERILIZATION PROCESSES

Direct heating

Ahlborn DHS (E. Ahlborn AG, W. Germany)
Alfa-Laval VTIS (Alfa-Laval AB, Sweden)
APV Uperizer (APV Co., England)
Breil & Martel Thermovac (Breil & Martel, France)
Cherry-Burrell No-Bac Aro-Vac Flash Cooler with UHT-HTR (Cherry-Burrell Corp., USA)
Laguilharre (Ets. Laguilharre, France)
Paasch & Silkeborg Palarisator (Paasch & Silkeborg, Denmark)
Rosci & Catelli (Italy)

Indirect heating-plate heat exchangers

Ahlborn IHS
Alfa-Laval Thermodule
APV Ultramatic
Sordi Steriplate (M. Sordi, Italy)

Indirect heating-tubular heat exchangers

Cherry-Burrell Unitherm
Stork Sterideal (Stork-Amsterdam B.V., Holland)

ASEPTIC FILLERS

Pre-fabricated cartons

Pure Pak by Ex-Cell-O Corp., USA

Cartons formed in line

Self-pack GmbH, W. Germany
Tetra Pak (Tetra Pak International AB, Sweden)
Tetra Brik
Zupack GmbH, W. Germany

Sacnets or pouches

Thimonnier S.A., France

Prepac, France

Interconnection of the sterilizer with the filler(s)

If one sterilizing plant is to be connected with one aseptic filler the installation is quite simple. The capacities of the two machines has, of course, to be matched; in fact the sterilizer capacity has to be a little higher than that of the filler. The surplus milk is returned to the entrance of the sterilizer. This arrangement is simple but not flexible. If one of the machines stops for any reason the other machine has to be stopped too, or other precautions have to be taken. If such an interruption takes place and it is only for a short period of time, it is of great advantage if the other machine can be kept sterile meanwhile. If this is not possible, the complete plant has to be shut down and before starting up again, the plant has to be presterilized. Several hours may be lost in this way.

The direct connection of the two machines also in same cases demands a certain skill by the operator. This is when using filling machine forming the packages in-line. In this case the shifting of rolls of package material may be complicated and stressing.

A more flexible way of connecting a sterilizer with one or more fillers is by interposing an aseptic balance tank. In this way the sterilizer and the filler(s) can be operated entirely separated.

CHARACTERISTICS OF THE PASTEURIZATION PROCESS

The cost figures given below are not enough for a complete economical evaluation. For equipment capital costs are given, but freight and custom are to be added. For filling equipment costs of paper is given. Further requirements with regard to steam, power, water etc. are listed. (When not mentioned the following costs of facilities are used.

steam	0.025 Sv.crown/kg	
power	0.122 "	/kwh
water	2.10 "	/m^3)

A rough estimation of installation and service costs is made, but it should be mentioned that these can differ very much with make and local conditions.

The data are only examples. Only few manufacturers have delivered the basic material for this evaluation and therefore, of course, discrepancies are possible. All figures are in Swedish crowns (for recalculation has been used 1 US dollar = 4.75 Sv. crowns and 1 DM = 1.75 Sv. crowns). All prices are from January 1, 1974.

For full cost calculation also the following may be considered: building, transport and handling equipment, laboratory equipment, labour etc. For a complete survey regarding costs for sterilized milk is referred to A. Neitzke: "Marketing aspects - marketing aspects" (1)

Capacity of pasteurizers

An upper limit for capacities is difficult to fix as several manufacturers of plate heat exchangers today have very big units on their programme, and it is always possible to combine two or more units in one processing plant. In this way very big capacities can be reached. However, a practical upper limit with all heat exchanger functions (heater, regenerative, coolers) in one frame may be about 22,000 l/h.

A pasteurization plant mostly involves one or more centrifugal machines and the capacity therefore has to be chosen with regard to these machines. Before filling the milk is normally cooled down and stored; therefore the capacity of the filler does not necessarily influence the capacity of the pasteurizer.

Pasteurizer investment cost

The diagram (figure 3) gives the total investment cost (including heat exchanger, inlet tank and pump, flow controller, temperature control with recorder, diversion system, hot water heating system and piping). Prices are given at manufacturers harbour, custom and freight are not included.

For installation, depending on conditions, 1-2 % of the investment may be added. However, travelling expences etc. for fitter are not included. When calculating annual costs should be added maintenance costs (repair, spare parts) averaging to 2 % of the investment sum, per year.

Pasteurizer: Consumption of steam, power and water

Consumption per 1000 kg of milk:

steam (min. ca 3 b)	ca 17	kg
power	0.3 - 1.2	kWh
cooling water (+1.5°C)	ca 1500	l

Steam and cooling water consumption are also presented in diagrams figures 4 and 5.

The installed electrical power is almost constant 6-7 kW for the different sizes of plant.

The figures given are mean values. During start-up higher values are reached for a short period of time.

For cleaning and pre-sterilising of the pasteurizer one needs power, steam, water and chemicals amounting to Sw.Cr. 0.35-0.45 per 1000 kg of milk. The time required for these operations is altogether approximately 1 h daily.

Capacity of filling equipment

In the following only paper packages are considered. The figures are typical examples of capacity limits for some different types of fillers.

Type of package	Size of package	Capacity
Sachet or pouche	0.2 - 1.[illegible] l	1800 - 3600 l/h
Tetrahedral	0.15 - [illegible] l	675 - 3600 l/h
Rectangular	[illegible] - [illegible] l	870 - 15000 l/h

Filling costs

It is not possible to present an investment sum as for pasteurizers because the filling equipment is normally marketed on other terms. This equipment is often rented, at least to a certain extent. In the diagram, figure 6, is therefore calculated rough "hardware" costs per 1000 packages (including amortization/rents [illegible] paper) for a plant producing approximately 10 million packages per year.

Filling equipment: Consumption of power, water etc.

Consumption per 1000 packages:

	Tetrahedral	Rectangular
Power, kWh	ca 1	ca 2
Air, Nm^3	ca 1.7	10 - 15
Cooling water, l	-	50 - 200
Gas, kg	-	ca 0.6 (only gable top)

CHARACTERISTICS OF THE UHT AND ASEPTIC FILLING PROCESS

Capacity of sterilizers

	4000 l/h	8000 l/h	12000 l/h
Direct heating			
Ahlborn DHS		x	
Alfa-Laval VTIS	x	x	x
APV Uperizer	x	x	
Cherry-Burrell	115 - 18900 l/h (30 - 5000 GPM)		
Paasch & Silkeborg Palarisator	x	x	x
Rossi & Catelli	x	x	x
Indirect heating			
Ahlborn IHS		x	
Alfa-Laval Thermodule	x	x	x
APV Ultramatic	x	x	
Cherry-Burrell Unitherm	75 - 9000 l/h (20 - 2400 GPM)		
Sordi Steriplate	x	x	
Stork Sterideal	x	x	

Sterilizer investment cost

Unfortunately, very few figures are available and the diagram figure 7 only considers two manufacturers of sterilizers for direct heating and one of sterilizers for indirect heating. The amounts cover the complete plants which are pre-erected and tested by the manufacturer before delivery. Prices are given at manufacturers place, custom and freight are not included.

As the plants normally are pre-erected and tested before delivery the installation cost is very low.

Sterilizer: Consumption of steam, power and water

Consumption per 1000 kg/h of milk:

Direct heating

steam (min. ca 7 b)	110 - 225 kg
power	9 - 15 kWh
cooling water	1100 -4500 l

Indirect heating	
steam	30 - 110 kg
power	10 - 15 kWh
cooling water	85 - 3000 l

The consumption figures are also given in diagrams, figures 8, 9 and 10.

The data given are mean values. During start-up for a shorter period higher values can be reached.

Certain facilities are also needed during pre-sterilisation of the plant before running and for cleaning after shut-down. These different amounts vary from one type of steriliser to another and are certainly also dependent on raw milk quality and length of the running period. In one type of plant (direct heating) these operations require 2 h daily. Costs for power, steam, water and chemicals are approximately one Sw. Cr. per 1000 kg of milk (8 hours of operation daily).

The direct heating methods involve mixing of steam into the product. In some countries this is not permitted by law. However, more and more countries are permitting this type of process if the steam fulfils certain quality demands. If the existing steam boiler is producing a steam quality which is not acceptable for mixing with milk, different steam-purifying systems are available on the market. The manufacturers of sterilisers normally have equipment for these purposes to incorporate in their plant.

<u>Capacity of aseptic filling equipment</u>

Type of package	Size of package	Capacity
Sachet or pouche	0.2 - 1.2 l	400 - 3600 l/h
Tetrahedral	0.008 - 1.0 l	72 - 3600 l/h
Rectangular	0.15 - 1.0 l	540 - 3600 l/h

<u>Filling costs</u>

Like pasteurized milk fillers aseptic fillers are marketed at special terms. The diagram fig. 11 therefore covers paper costs plus machine costs (amortization respectively rents) per 1000 packages when the plant produces approximately 10 million packages per year. Unfortunately, no costs for the sachet or pouche type packages are available.

__Filling equipment: Consumption of power, water etc.__

Consumption per 1000 packages:

	Tetrahedral	Rectangular
Power, kWh	ca 4	1 - 10
Air, Nm^3	ca 0.2	8 - 25
Cooling water, l	-	100 - 250
Gas, kg	-	ca 1 (only gable top)

__Building requirements__

For UHT processing and aseptic filling some special building facilities are recommended, above those which are usual for normal milk processing.

Regarding filling room an overpressure installation of filtered air is recommended. Further humidity and temperature must be regulatable so that condensate on equipment, walls and the ceiling is prevented.

Paper or blank storage room has also to be air-conditioned in order to keep temperature and humidity within specified limits. It must be big enough to cover at least as many weeks production as the delivery time for the package material entails.

For For storing of processed and filled milk a certain space should be set apart. For control the production should be kept three days before distribution. Eventually this storing can be done during distribution, for instance in sub-dealers localities, but essential in this case is that all milk is under control for three days after processing.

For more detailed recommendations filler manufacturers should be consulted.

__Laboratory__

In addition to normal milk tests facilities should be available to check raw milk quality (stability according to alcohol test). Further control of keeping quality and turbidity test according to IDF recommendations should be done. It could also be the duty of the laboratory to be responsible for some kind of a code or dating system which is invaluable as a means of tracing production faults.

General viewpoints

No doubt the UHT process and the aseptic filling are still more complicated than the pasteurization process with regard to operation, laboratory control and service. Staff education and training are therefore of great importance. Most plants are automated which makes them still more complicated and close service facilities must be considered.

RAW MILK AND PRODUCT

Raw milk quality

To get a high quality product it is important to have a raw milk with high bacteriological quality and good chemical-physical stability. Further, the stability very much affects the running time of the heat treatment plant. Normally the direct heating methods are a little less sensitive to raw milk stability than the indirect heating methods. Heat stability of the raw milk is checked by means of the alcohol test and raw milk which does not resist an alcohol concentration of about 75 per cent is not recommended for treatment.

Regarding bacteriological quality a higher number of microorganisms is normally accepted in raw milk to be sterilized than in milk to be pasteurized. This could be a dangerous recommendation with regard to UHT-treatment as a higher number of microorganisms may cause enzymatic changes influencing the heat stability. Therefore, in accordance with (1) it should be recommended that raw milk for UHT-treatment should at least satisfy the requirements to be met by milk which is to be pasteurized.

Whether the milk is to be pasteurized or sterilized the raw milk quality is of greatest importance. By careful handling of the milk all the way from the cow up to the dairy in most cases the raw milk quality may be improved. It is therefore mostly worthwhile for the dairy to instruct and control the farmers and others on how to handle the raw milk in the right way.

Product shelf life and distribution

Pasteurized milk has a limited shelf life which is dependent on the temperature. At room temperature the product deteriorates quickly (within a few hours) and it has therefore to be distributed and stored at a low temperature (below +4/+6°C). Also at this temperature storing time is limited, max. 8-10 days. If pasteurized milk is to be used in warm countries either it has to be consumed immediately or a so called "cooled chain" must be available. This means for instance small local pasteurization units close to the consumers or distribution in cooled trucks direct to centers where the milk can be consumed directly. Normally, complete "cooled chains" are not to be considered and therefore UHT-milk is a most interesting alternative.

The shelf life of UHT-milk at room temperature is not limited for bacteriological reasons but due to enzymatic and chemical-physical changes. The maximum storing time is dependent on temperature and the consumers attitude to these changes. In different countries this shelf life varies between 6 weeks and 6 months. The package material also influences the shelf life; the product can stand a longer storing time if the package material contains an aluminium film.

The type of distribution with regard to the mechanical stability of the package also has to be considered.

Nutritive value

Investigations have shown that UHT processing, either by means of direct or indirect methods, is comparable to pasteurization with regard to losses in nutritive value (1).

Acceptability

UHT-milk has a taste slightly different from that of pasteurised milk. If the consumer is affected by this depends either on how sensitive the consumer is or how the milk is consumed. In countries with high pasteurised milk consumption there have been difficulties in introducing UHT-milk (USA, Scandinavia). In countries with consumers used to in-bottle-sterilized milk and in countries not used to milk at all UHT-treated products have been easier to introduce (Great Britain, Italy, Spain). Even if the milk is consumed directly the difference in taste has more influence than if the milk is used in cooking.

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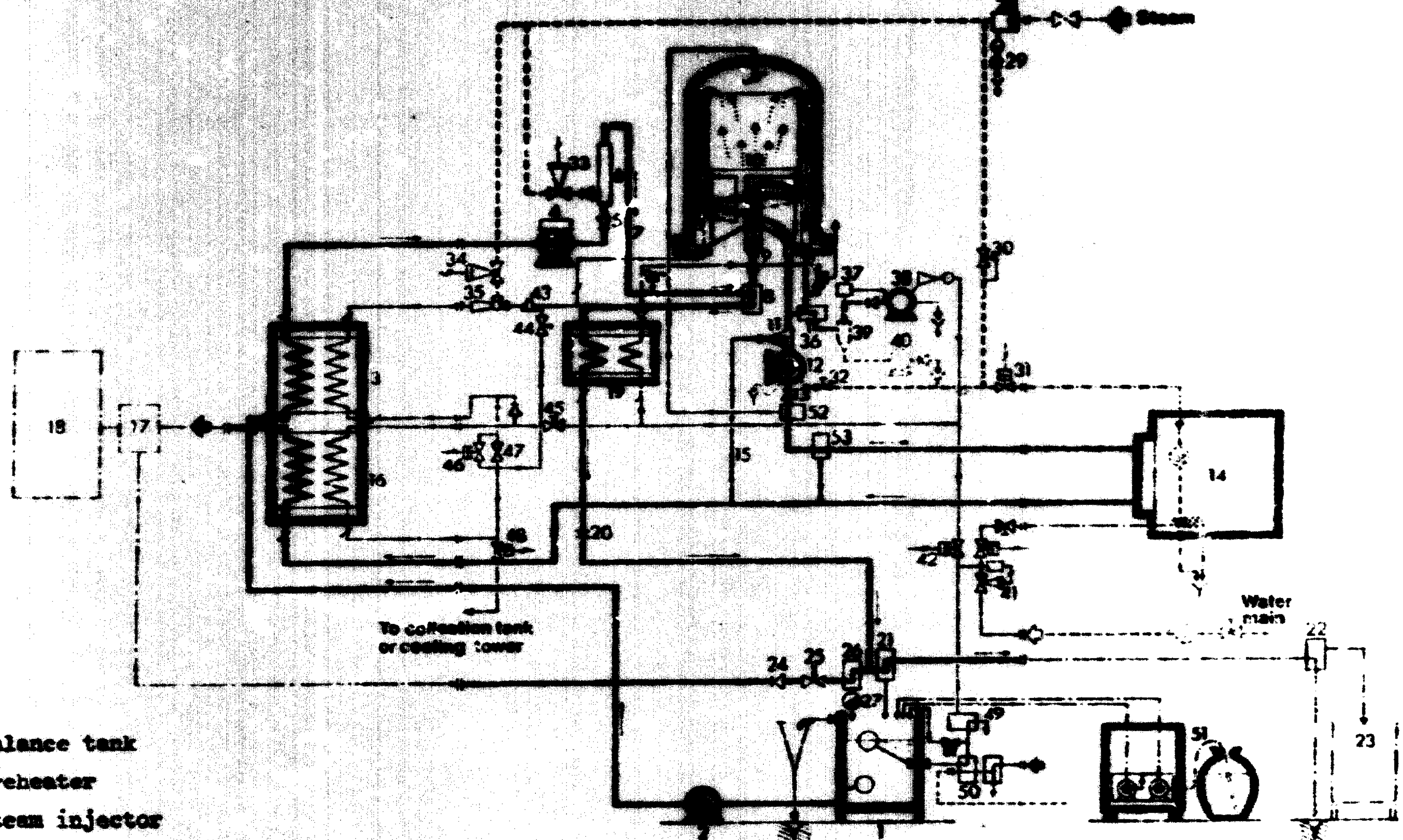
2. Modern sterilization methods for milk processing. Food Industry Studies No. 4. United Nations.

3. David S. Hsu: Ultra-high-temperature processing and aseptic packaging of dairy products. Damana Tech Inc, New York 1970.

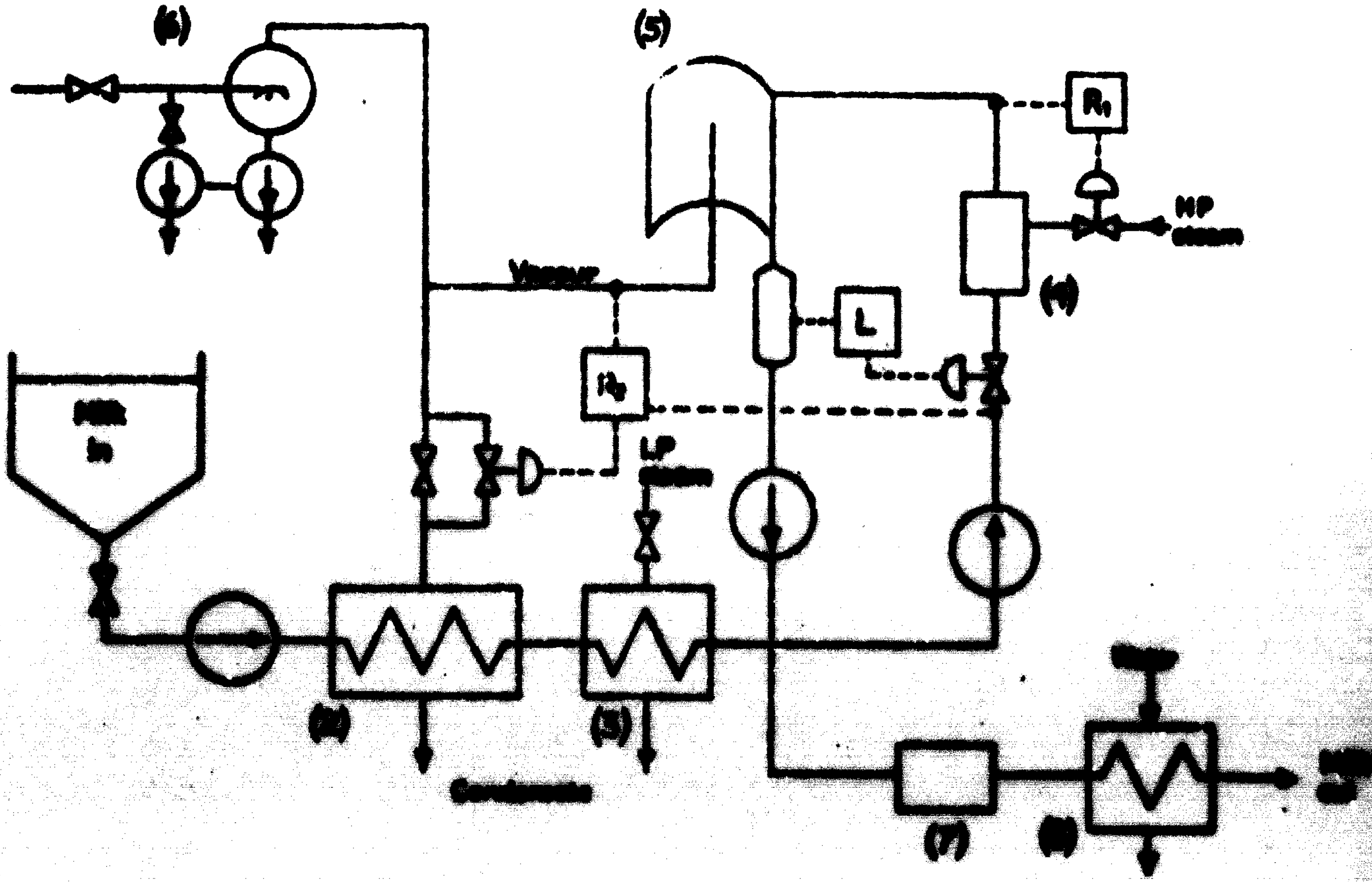
ANNEX: SHORT DESCRIPTION OF SOME UNT PLANTS

[illegible] (VTIS)



1. Balance tank
3. Preheater
6. Steam injector
8. Flow diversion valve
10. Vacuum vessel
14. Aseptic homogenizer
16. Aseptic cooler
18. Aseptic filling or aseptic tank
19. Flow diversion cooler

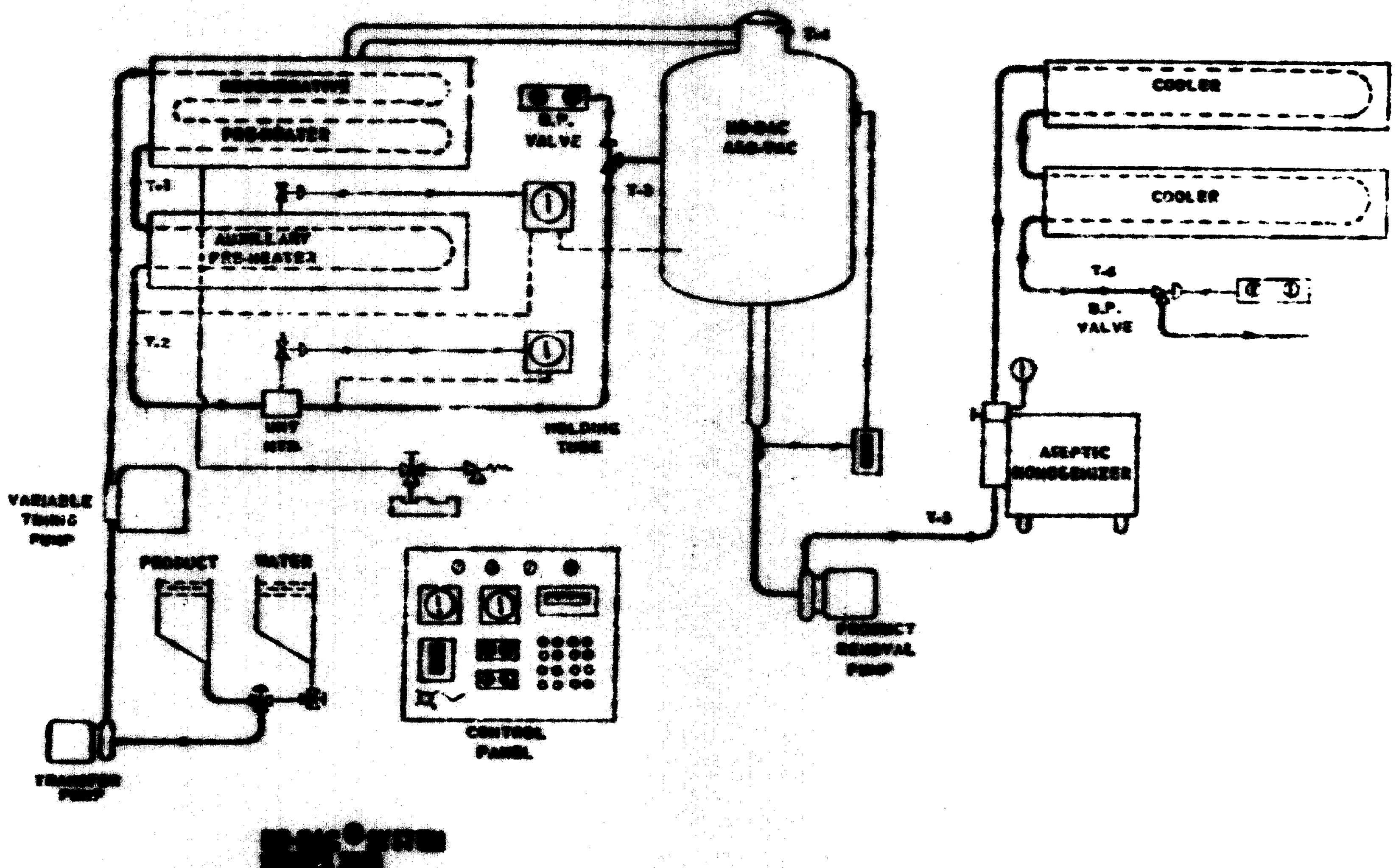
APV Uperizer



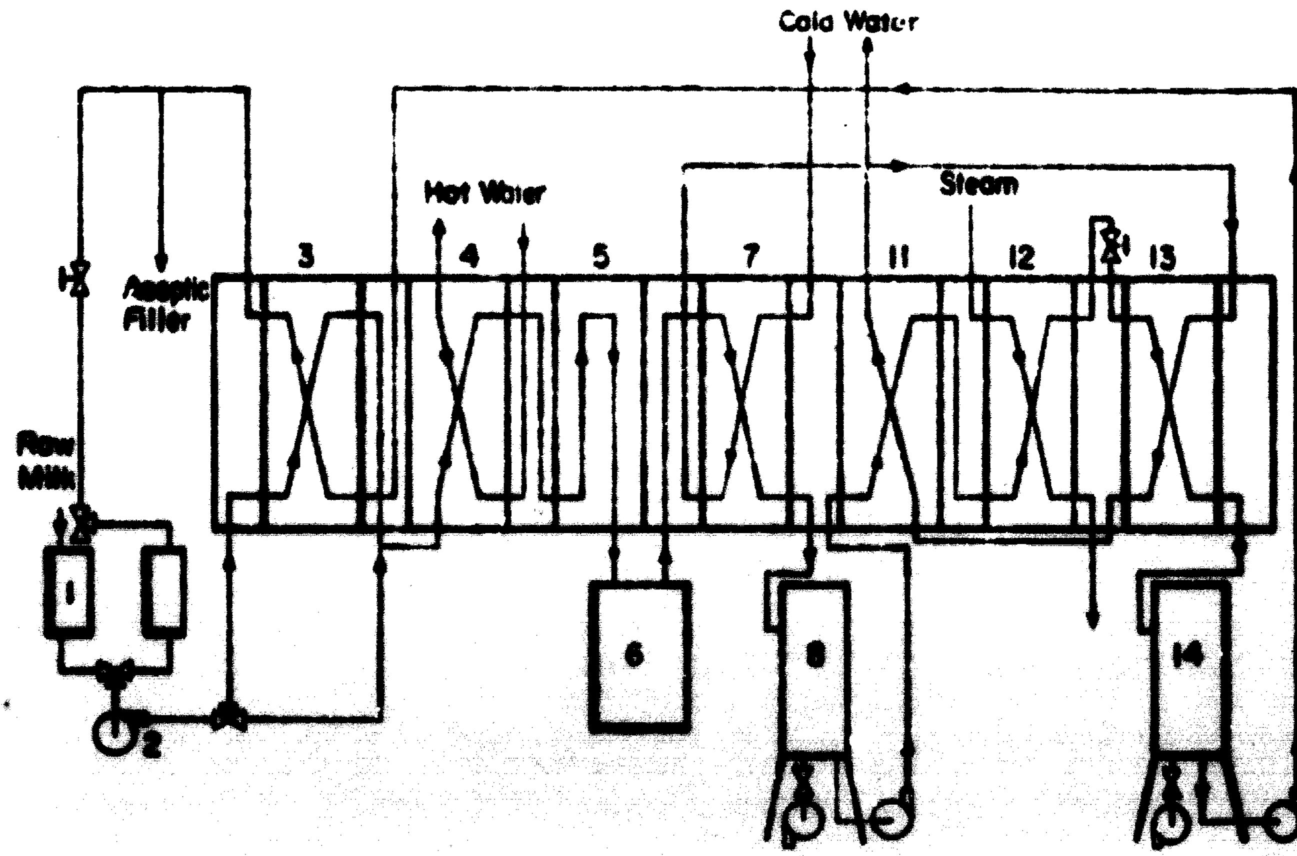
1. Raw milk tank
2. Preheater
3. Preheater
4. Steam injection head
5. Expansion chamber
6. Water condenser and ejection pumps
7. Aseptic homogeniser
8. Tubular water cooler

R1. Temperature controller
R2. Ratio controller
L. Level controller

Cherry-Burrell No-Bac Aro-Vac Flash Cooler with UHT-HTR

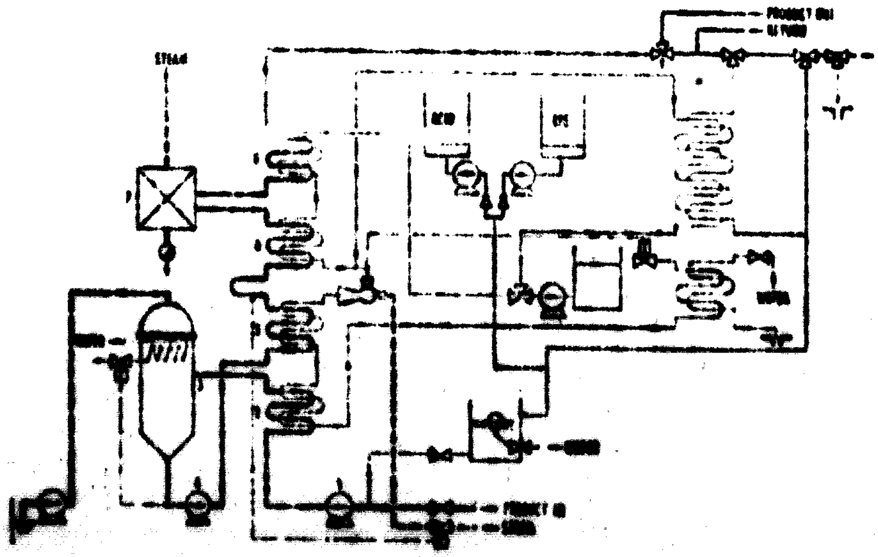


Ahlborn Indirect Heating Sterilizer (IHS)



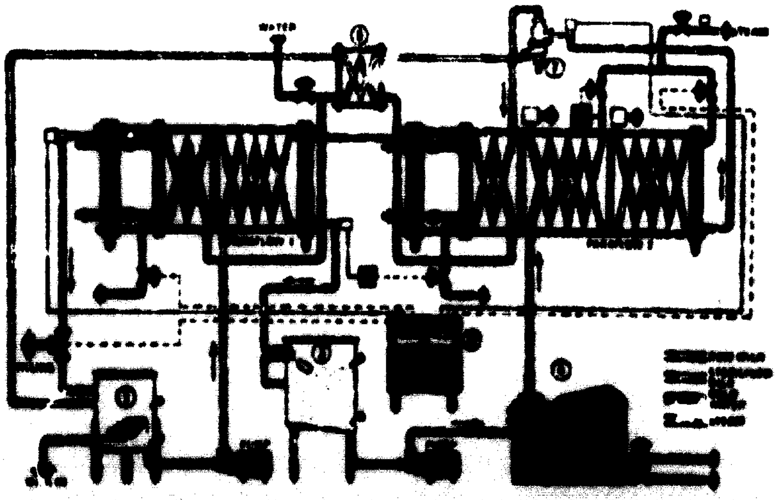
1. Raw milk tank
2. Pump
3. Regenerative section
4. Heating section
5. Plate holding section
6. Homogenizer
7. Main water cooler
8. Vacuum chamber
11. Hot water heating section
12. Steam heating section
13. Cooler
14. Vacuum chamber

Alfa-Laval Indirect Heating Sterilizer (Thermodule)



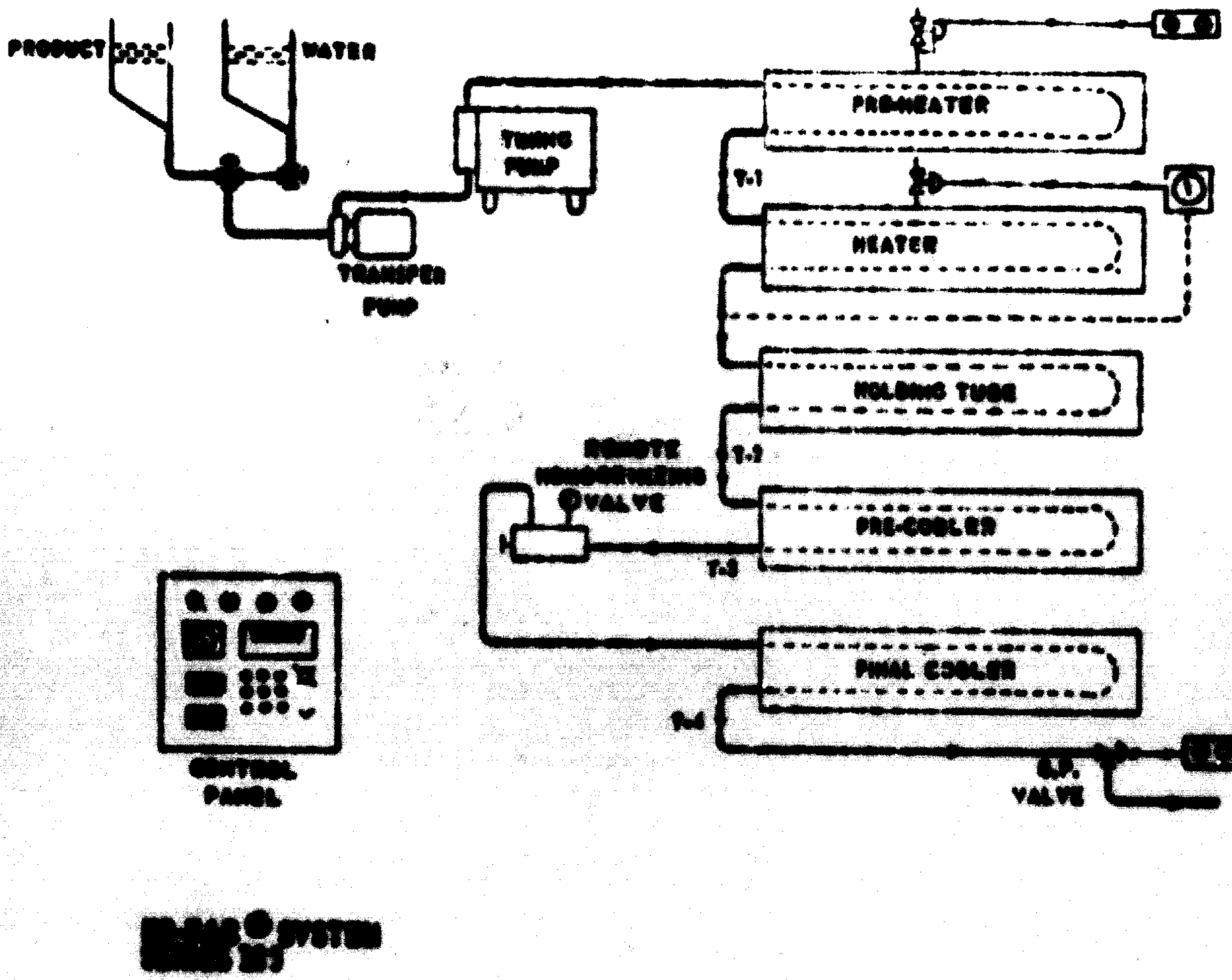
1. Centrifugal pump
2. Preheater
3. De-aerating chamber
4. Centrifugal pump
5. Final heater
6. Aseptic cooler
7. Aseptic homogenizer
8. Aseptic final cooler
9. Flow-diversion valve

APV Ultramatic Sterilizer

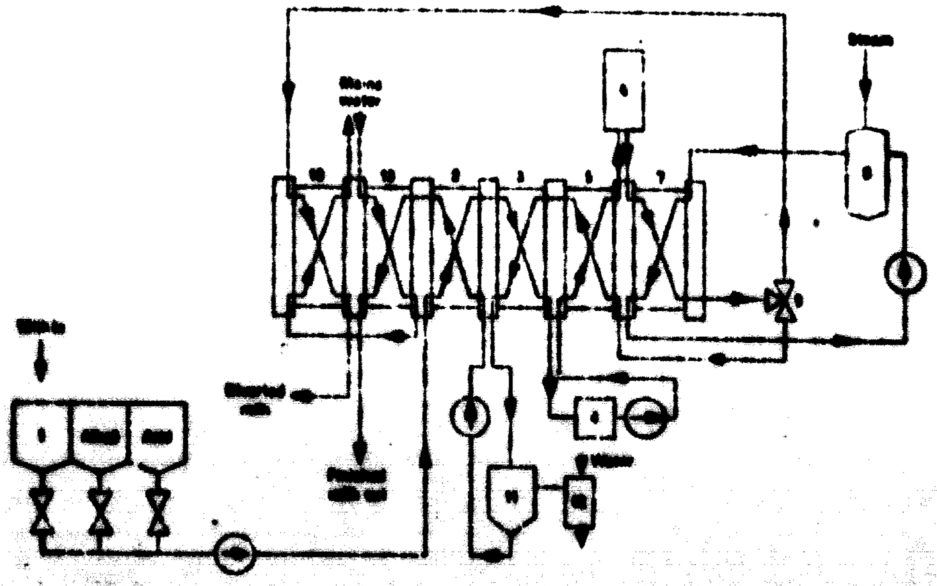


1. Balance tank
2. First regenerative section
3. Holding vessel
4. Homogenizer
5. Second regenerative section
6. Final heating section
7. Flow diversion valve
8. Water cooling section
9. Water cooling section
10. Final cooling section

Cherry-Bur-ell Indirect Tubular Aseptic Proces.ing System (Unitherm)

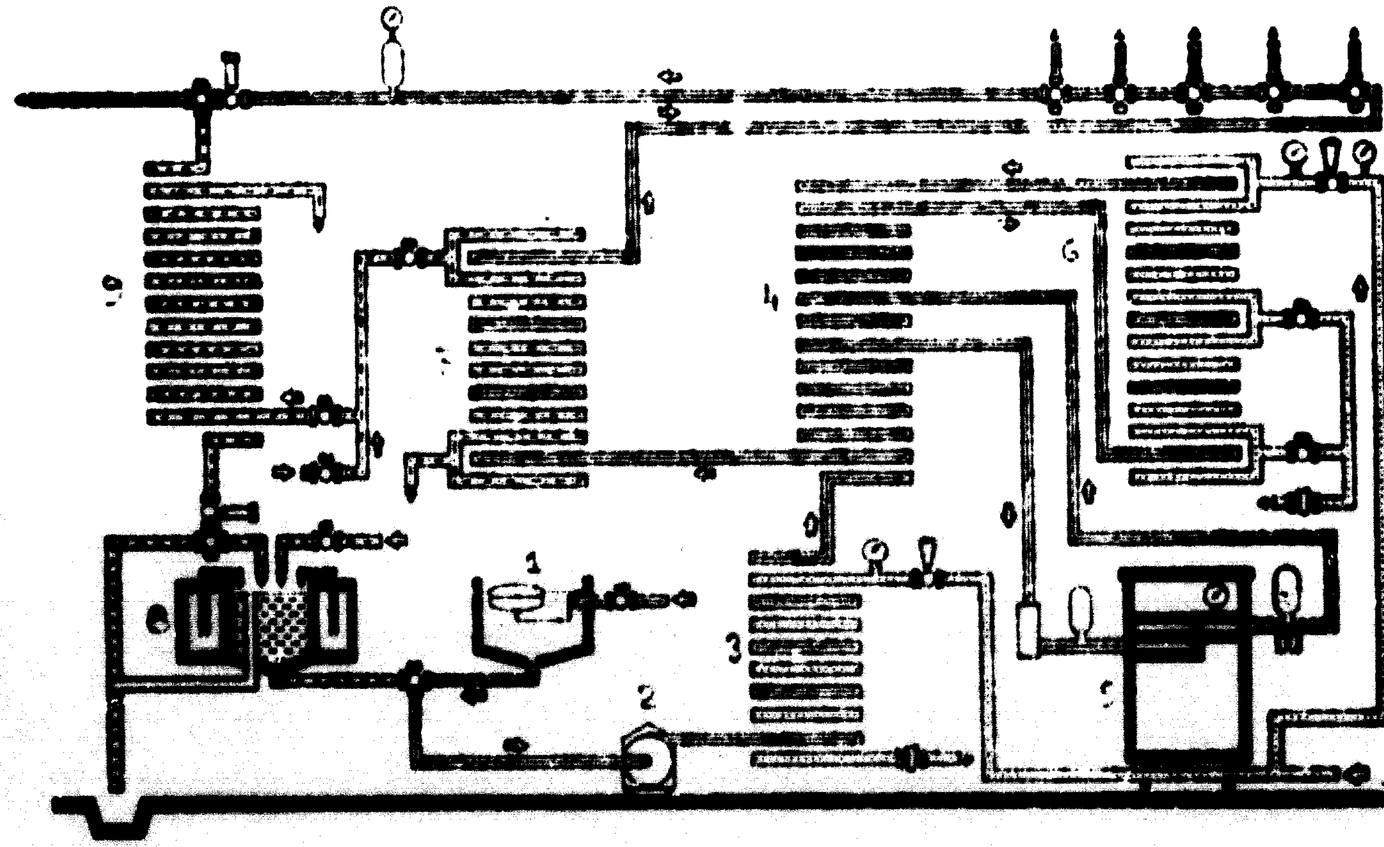


Sordi Steriplate



1. Raw-milk tank
2. First regenerative section
3. Second regenerative section
4. Homogeniser
5. Third regenerative section
6. Tubular holding section
7. Final heating section
8. Heat exchanger
9. Flow diversion valve
10. Water-cooling section
11. Vacuum de-aerator
12. Water ejector
13. Water-cooling section

Stork Sterideal



1. Float controlled balance tank
2. Centrifugal pump
3. Circuit sterilizer
4. Recuperative preheating/cooling section
5. Homogenizer
6. Sterilizing section
7. Cooling section
8. Cleaning section
9. Return cooler

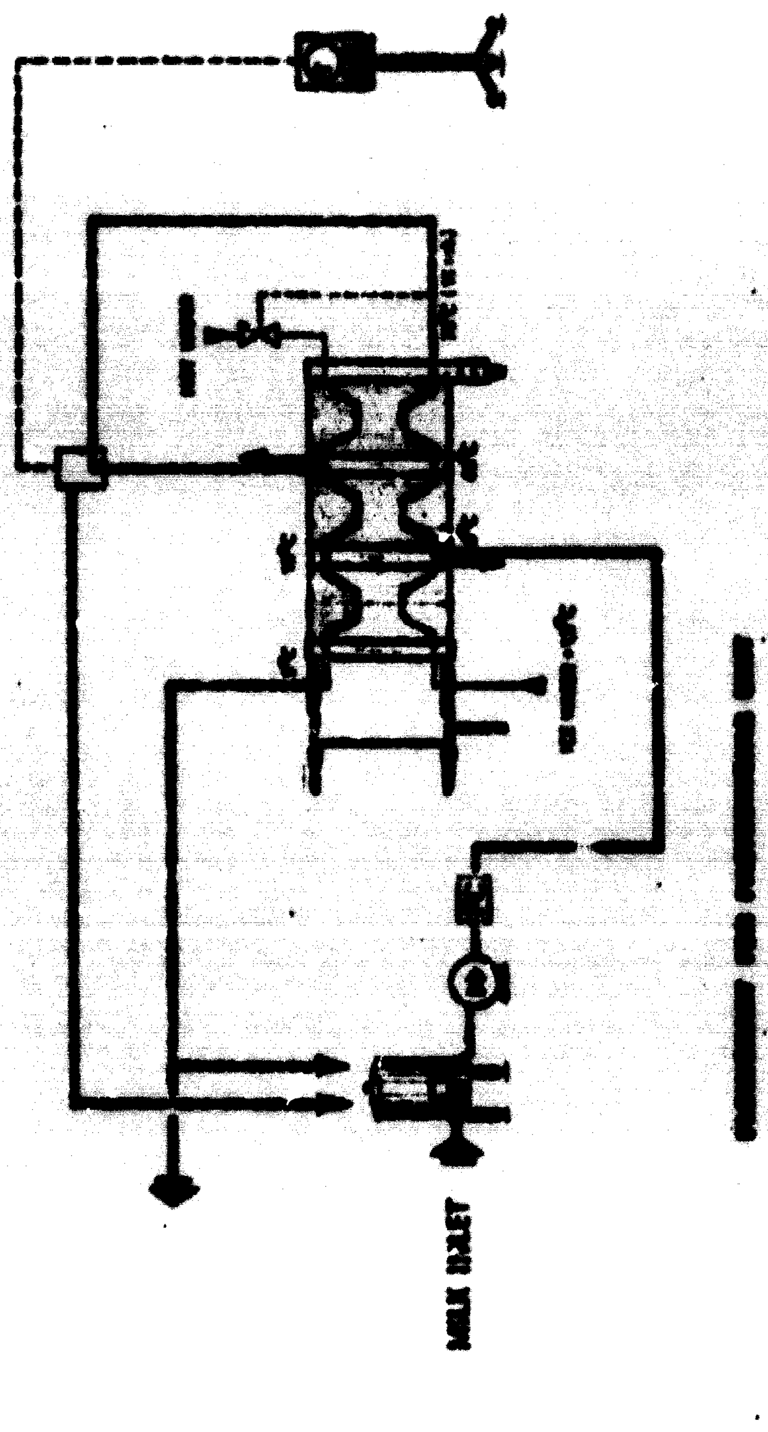


Fig. 1

Figure 2. Triple tube heat exchanger

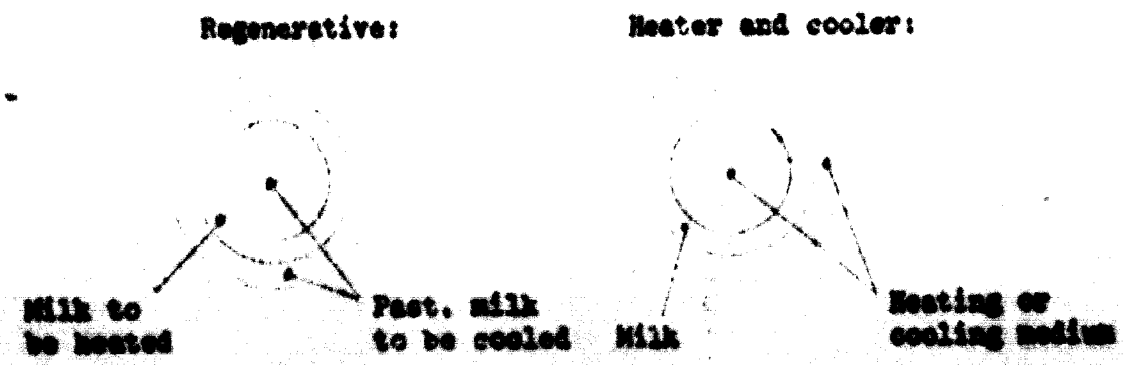


Figure 3.

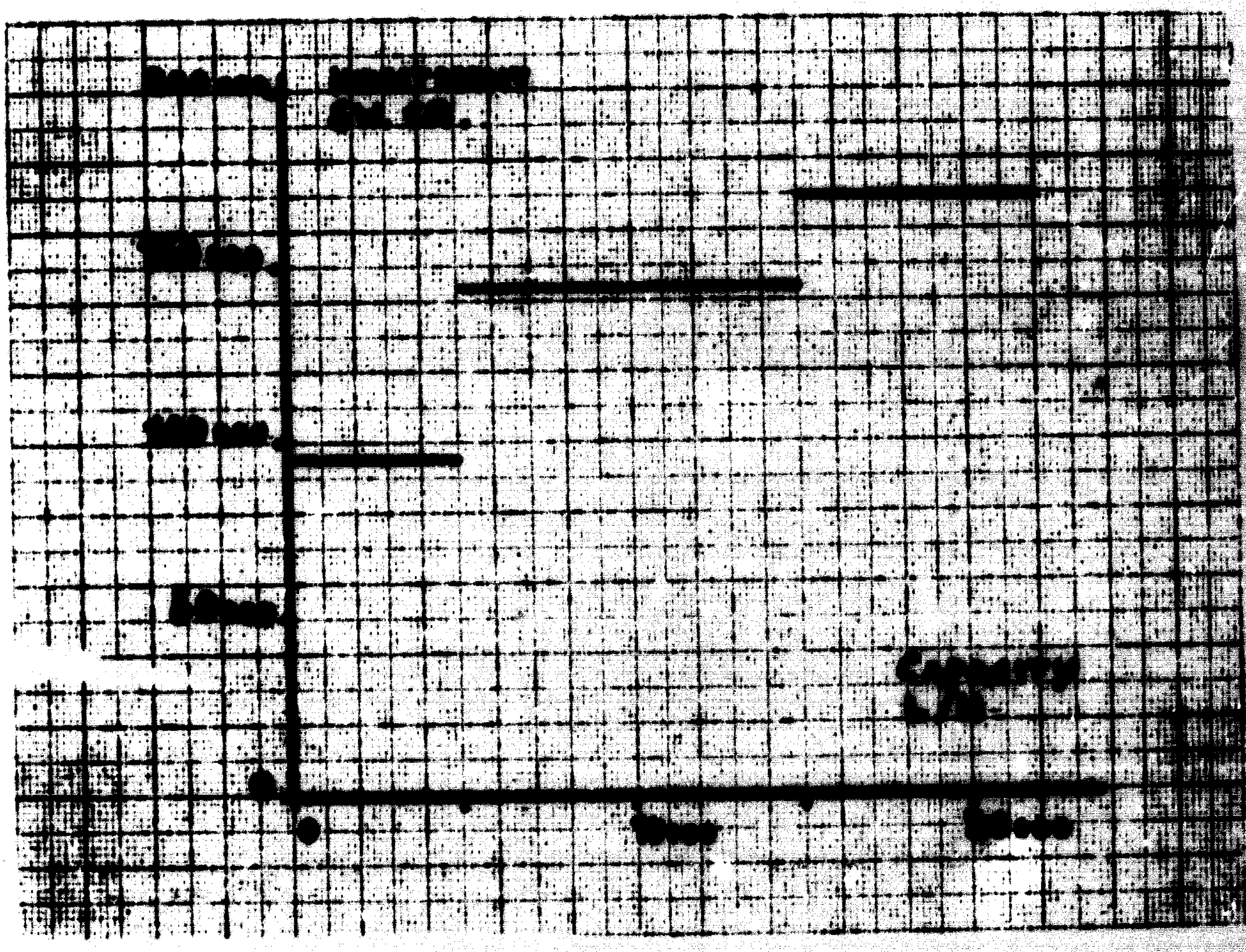


Figure 4.

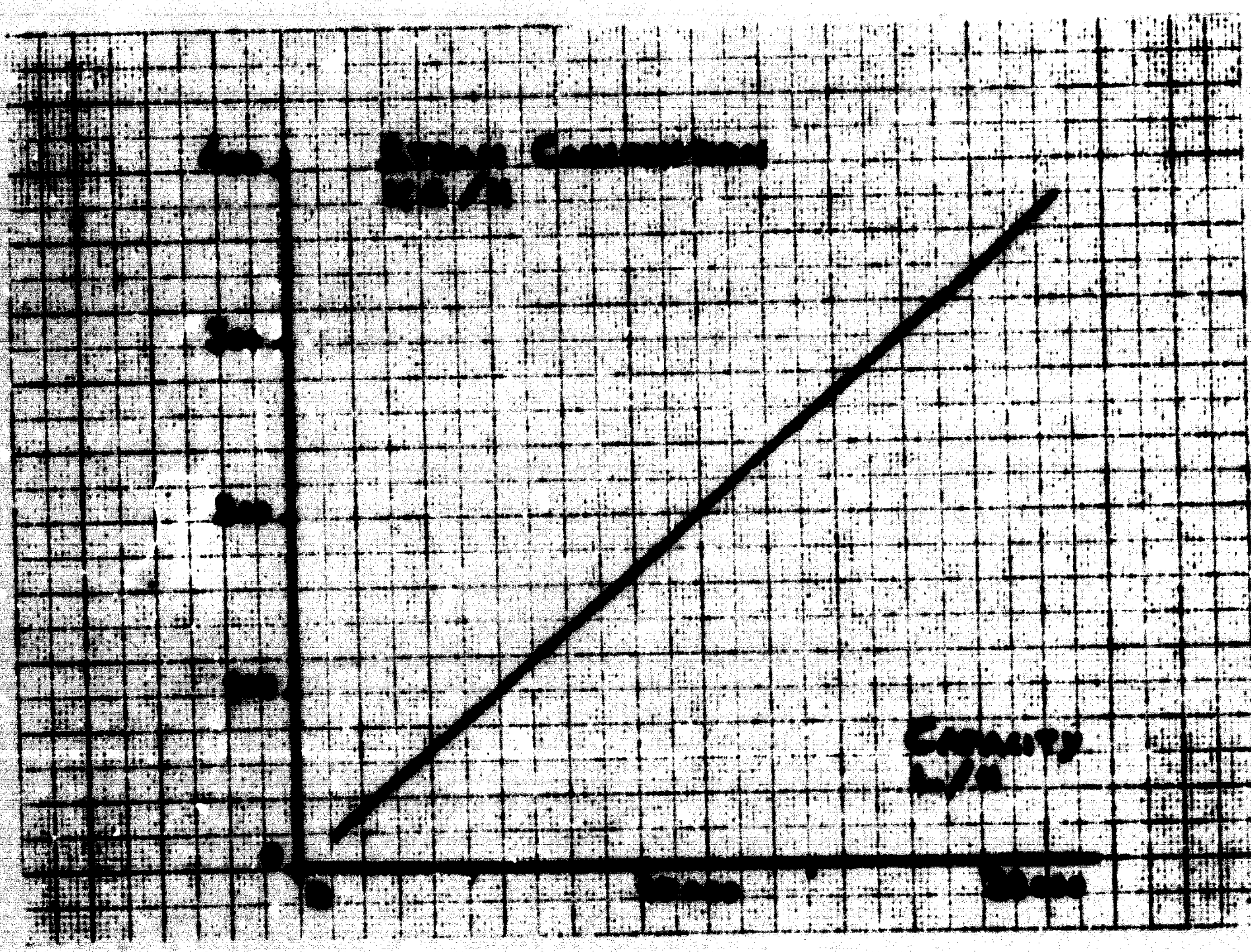


Figure 5.

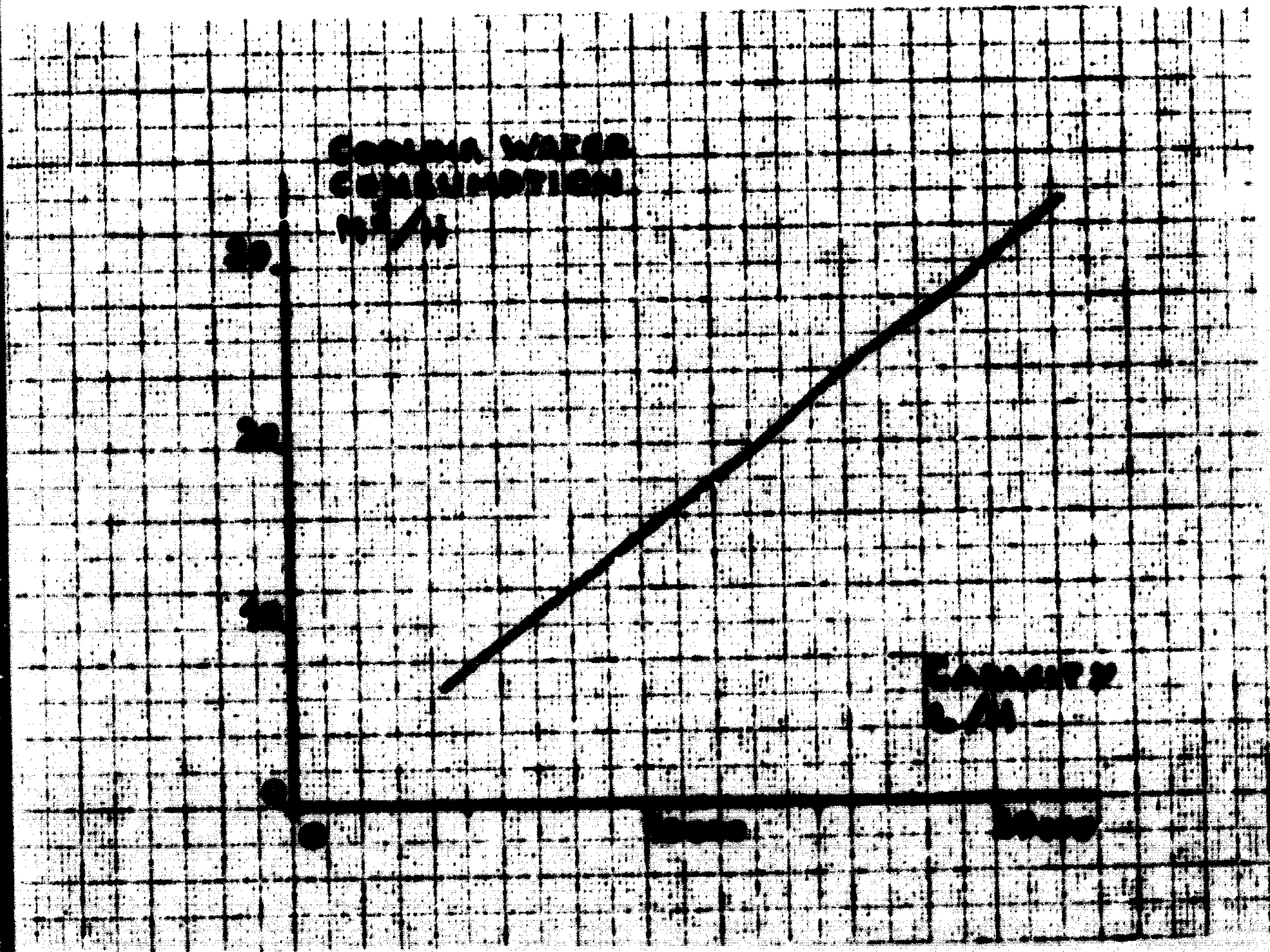


Figure 6.

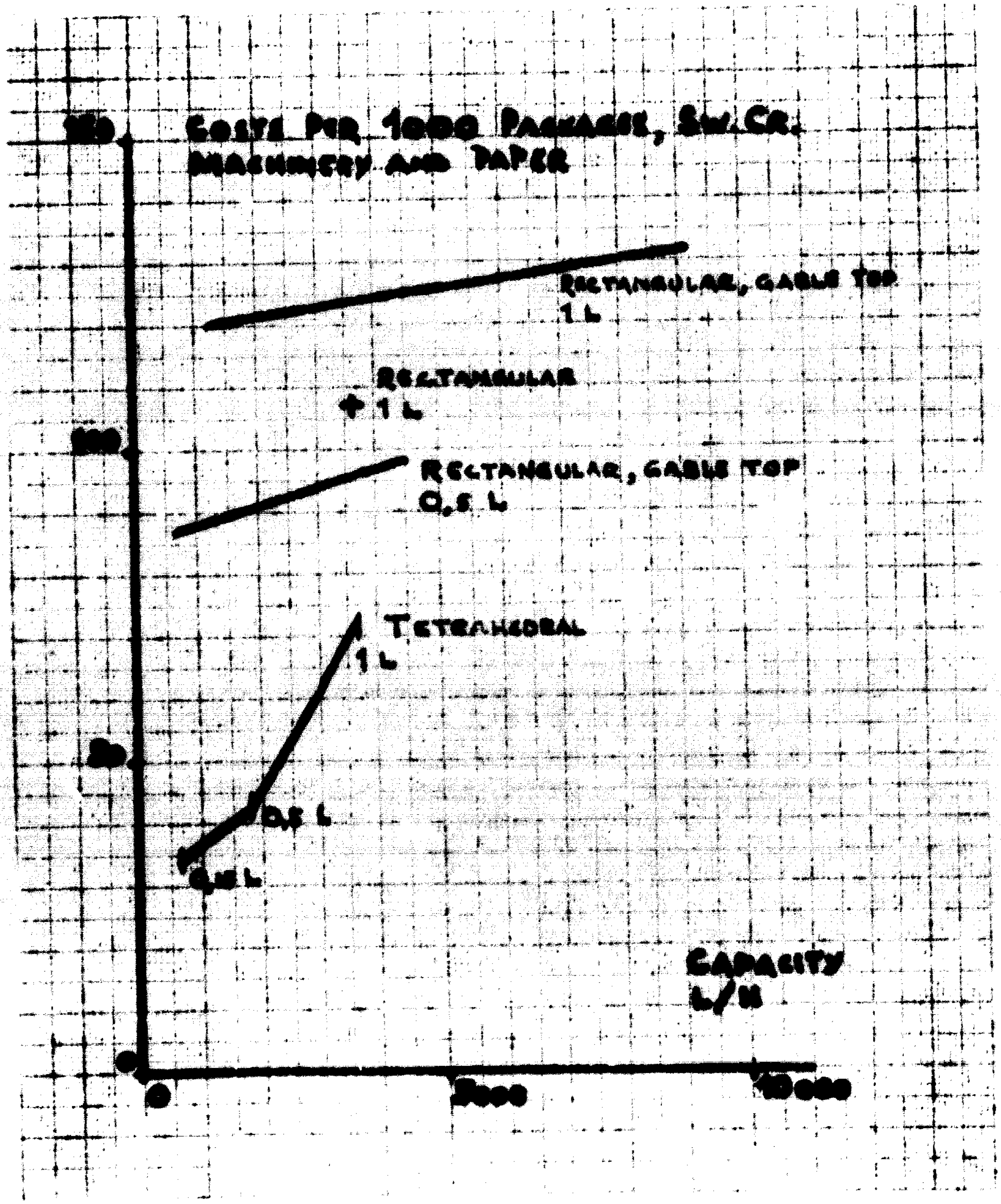

COSTS PER 1000 PACKAGES, SW.CR.
MACHINERY AND PAPER
RECTANGULAR, GABLE TOP
1 L
RECTANGULAR
1 L
RECTANGULAR, GABLE TOP
0,5 L
TETRAHEDRAL
1 L
0,5 L
0,5 L
CAPACITY
L/H
0
5000
10000

Figure 7.

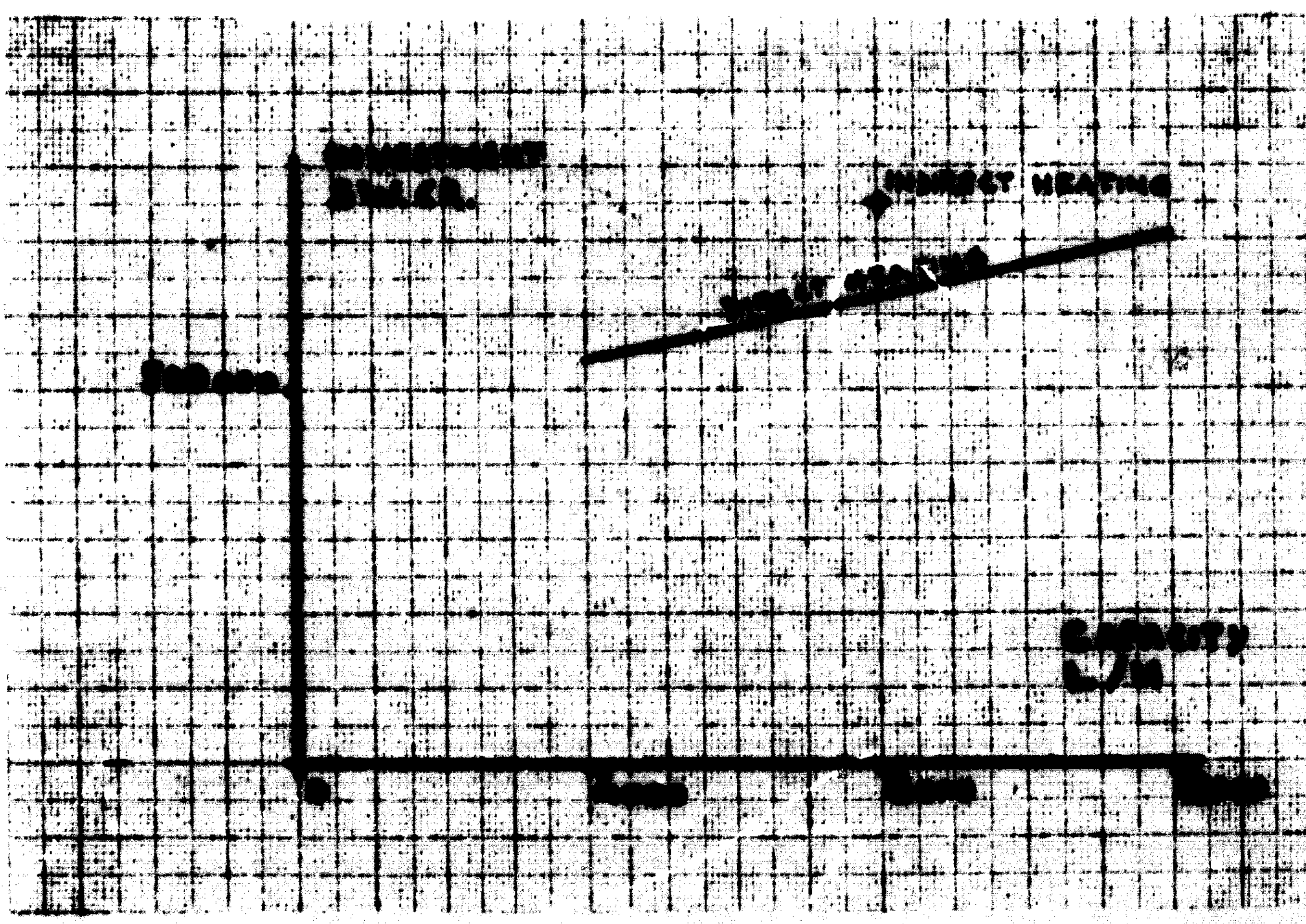
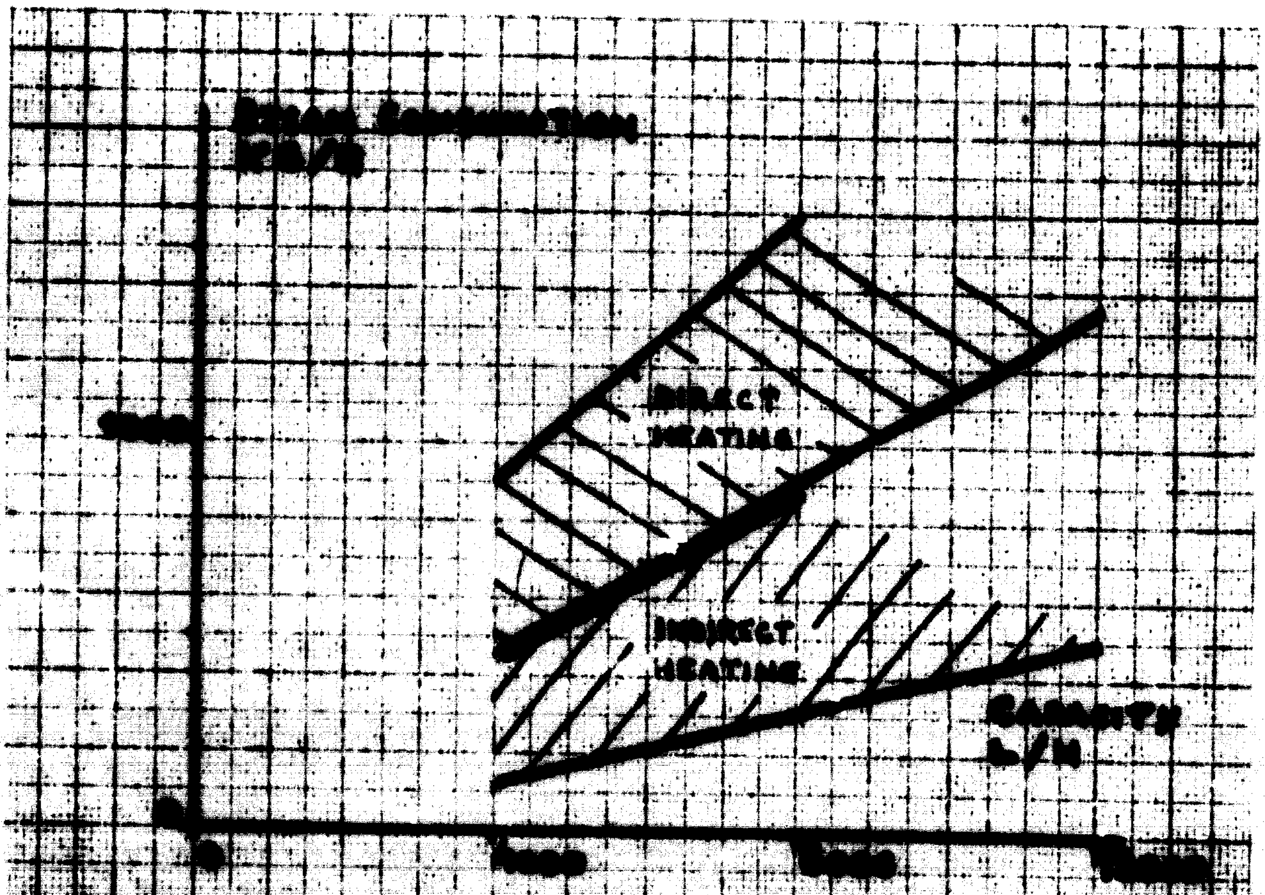


Figure 8.



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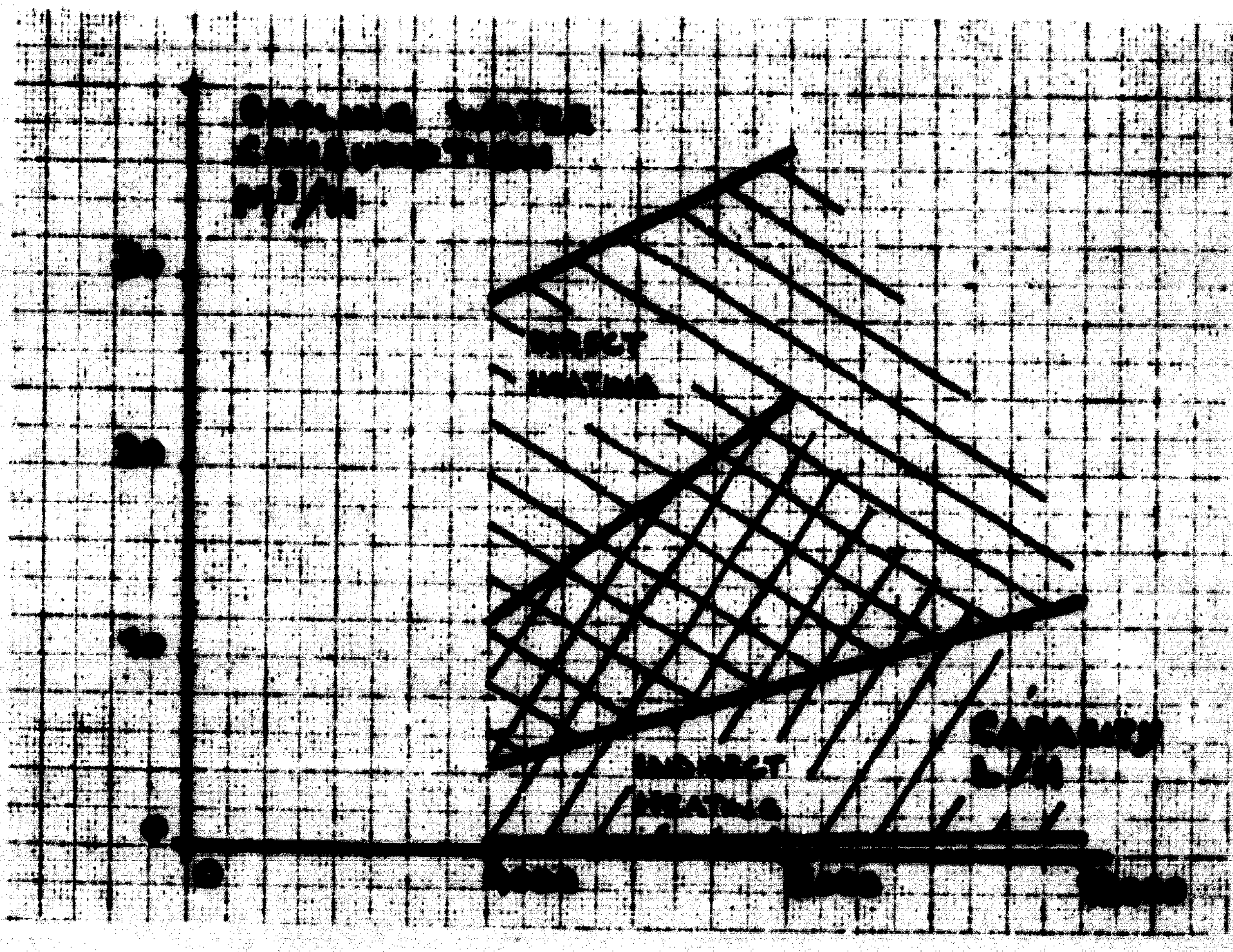


Figure 10.

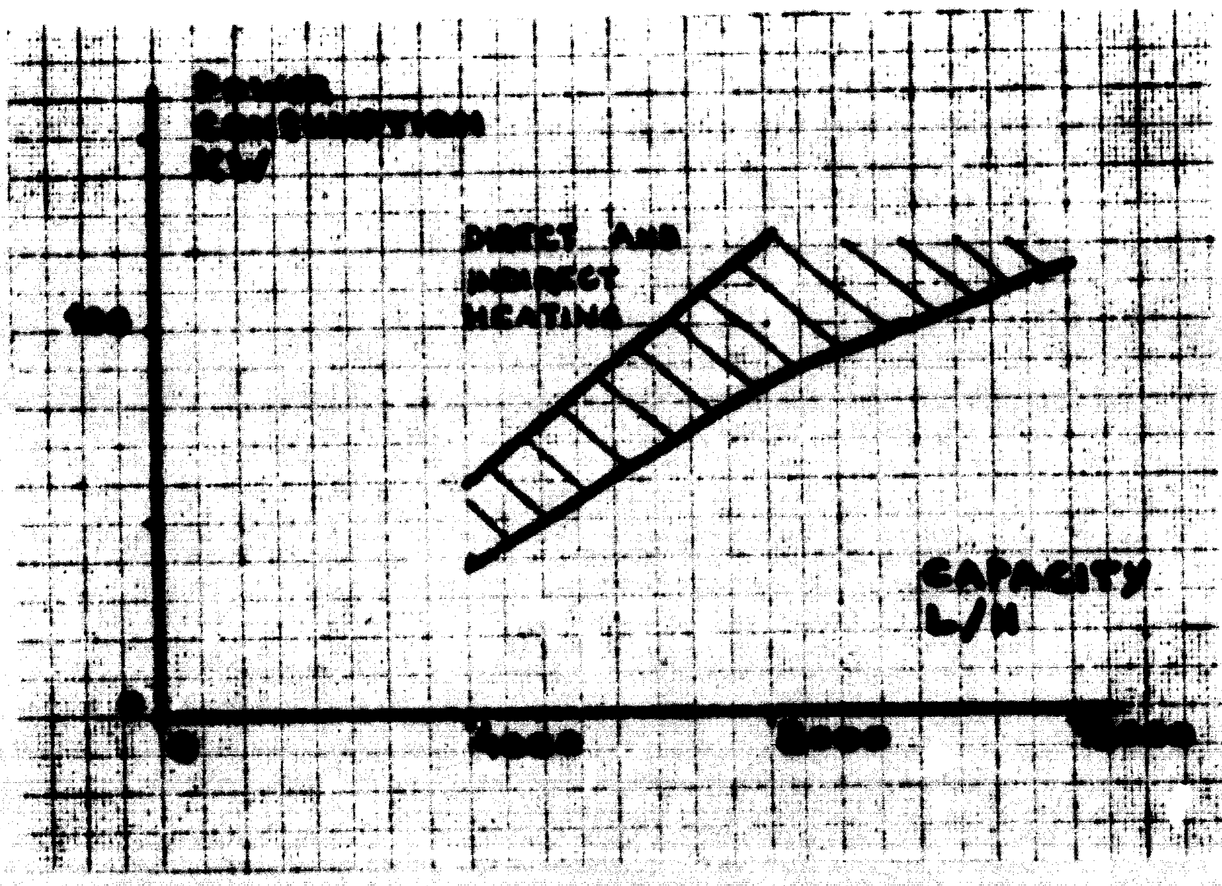
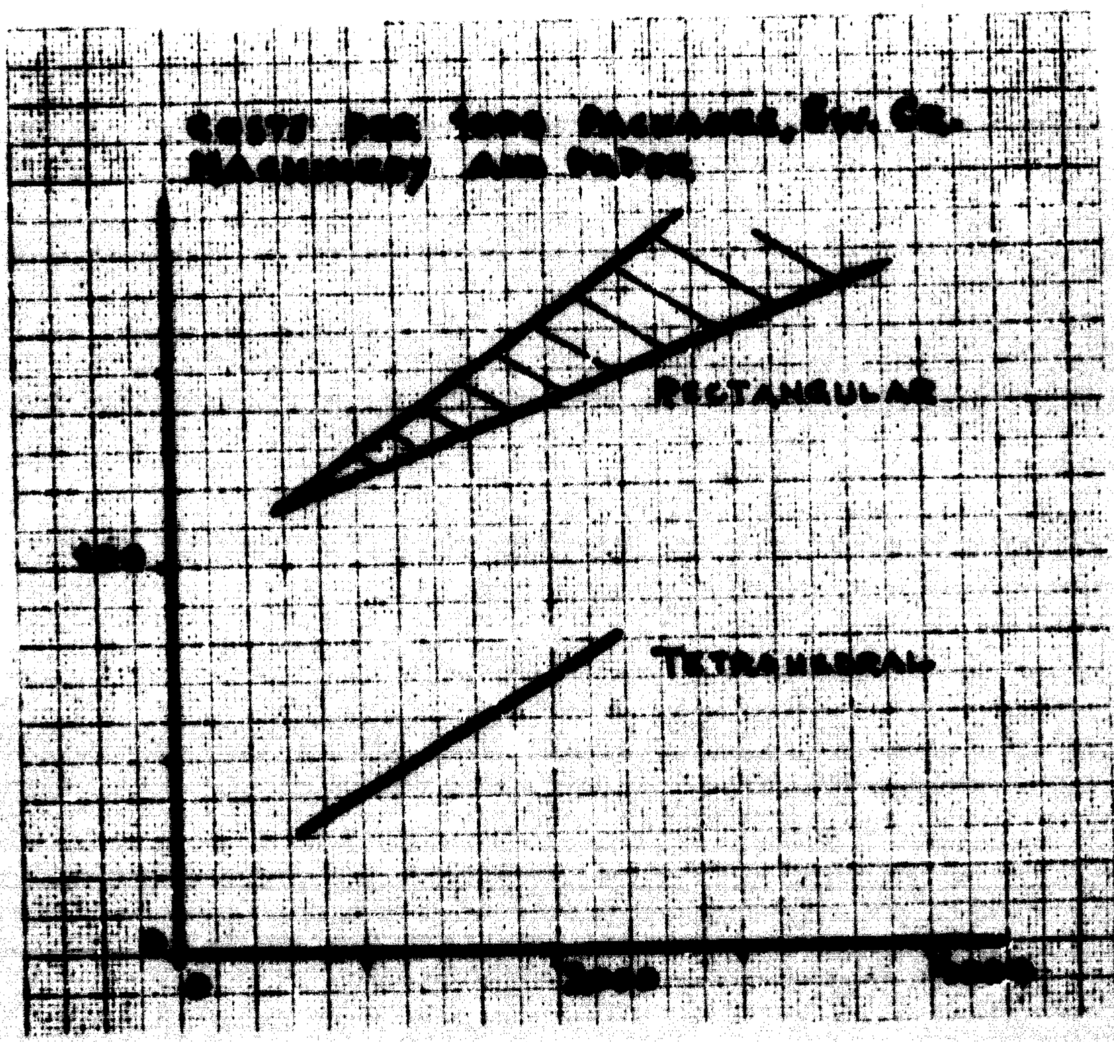


Figure 11.



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