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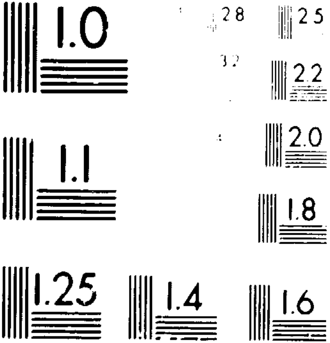

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STUDY ON FOOD PROCESSING TECHNOLOGY AND MACHINERY FOR DEVELOPING COUNTRIES

AND

CATALOGUE OF "ADAPTED" TECHNOLOGIES AND RELATED MACHINERY

WITH

RECOMMANDATIONS FOR MACHINERY MANUFACTURING AND MAINTENANCE

IN

FOUR SUBSECTORS: MEAT, FRUIT AND VEGETABLE, DAIRY, CEREALS

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Final report

September 1983

INDEX

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1 - INTRODUCTION AND SUMMARY

This study deals with technologies and machinery for the food processing in the developing countries.
It includes a catalogue of "adapted" technologies and machinery, selected among the vaste range of internationally available options, in the following subsectors: meat, fruit and vegetable, dairy, cereals.
It defines also the basic terms of reference for the establishment of a food processing machinery manufacturing industry, in the less developed countries.

It is a technical guide, not designed for food processing specialists, but as a consulting support for operators and decision makers, concerned with planning, design and management of the industrial sectors of food processing and machinery manufacturing in the developing countries.

This study can be of great help in establishing basic terms of reference for techno-economical analyses and in trying to "open the technological package", but it cannot be considered as a feasibility study for a food processing industry, since no cost or economical analysis has been performed.
It also provides recommandations and technical elements for performing a machinery complexity analysis and for evaluating needs in terms of production and infrastructure resources, for establishing and developing a food processing machinery manufacturing capability in a less developed socio-economic enviromment.

This study has its roots on the idea that technologies and machinery, to be employed and managed in the less developed countries, should be "adapted", at the maximum extent possible, to the socio-economic conditions of these countries; it tries to give an amswer to the demand for technical information about practical examples of "adapted" technologies and related machinery.

In the past years, many theoretical discussions have been held on what "technological adaptation" is, or should be, and many cases reported on how a wrong technological choice could actually have a disturbing impact on the socio-economic equilibrium of the less developed countries.
So far, practical results have been scarce, and, very often, confined in the field of village-level artisanal techniques.

This study starts from the principle that, if, on one hand, technologies and machinery should be adapted, on the other hand, in a primary sector, as the food processing is, and in a context of very rapidly growing nutritional needs, as the one developing countries show, this sort of "adapted" (sometimes also called, "ap

propriate") technologies cannot give any substantial and economically feasible answer, except in the case of village self-subsistance economy, which is very important and seeking for convenient solutions, but certainly not the only aspetc of the less developed countries technological needs.
Examples are evident; when thinking about unarresting inurbation in huge and rapidly growing towns, or about food-processing needs at district or area level.
These cases heve been, up to the moment, almost ignored in elaborating adapted solutions for the food processing technologies and related machinery.

Without giving any new countribution to the theorctical discussion, this study has the aim to demontrate that a compromise, from pratical and operational points or view, between the need for adaptation and the corresponding mandatory demand, for industrially available and economically feasible technologies and machinery, is possible.
It is a tentative approach towards a practical application of the concept of "intermediate" technology: "something in between the sophisticated technology employed in the industrialized countries and the village-level artisanal technique".

This study tries therefore to discuss and establish the selection criteria, which can help operators and decision makers to make their technological choice, and to demonstrate that, once the "technological package has been opened", among the well-tested and easily available food processing machinery of the international technological market, it is possible, with some technological "downgrading", to select "adapted" machinery, which still retains all the technical and economical advantages of an industrially operating technology.

The technological "downgrading" is a critical revision of the different functions, within a processing technology or line, to identify those technically and/or economically essential in a given socio-economic contest and to delete all the others, induced by a different environment and/or culture (such as, for example, automated and electronic features of a machinery). A critical analysis of the different functions is possible only when a processing technology and/or machinery, too often supposed or offered as a sealed package or a "black box", has been "dismantled".
With the technological "downgrading", the food processing line can preserve all the advantages of a well-tested, easily available and industrially operated machinery, being, at the same time, more "adapted" to a less developed environment.
It is therefore possible to imagine "intermediate technology" plants starting operations in the developing countries, equipped with "modern" food-processing machinery, attentively and critically selected,

out of the "international catalogue".
The size of these plants should certainly be small, but they would retain all the economical and technical features of an "industrially-operated factory.
Of course, the same result can be (and actually has been) obtained by "upgranding" the local techniques: other studies report about the encouraging results attained with this "symmetrical" system.
The catalogue of this study is a first approach in supplying basic and operational technical information about available examples of this type of "adapted " machinery.
Machinery have been selected taking into account the best compromise between "adaptation" and availability on the market; they are therefore to be considered only as typical examples, being any equivalent machinery suitable for the same use.

There is another aspect that this study takes into consideration: the possibility of a local manufacturing of the machinery. The potential capability, for a given machinery, to be manufactured (at least partially) by local manufacturers, is considered as an important criterium for including it in the range of "adapted" items.
In other words, the idea is that, if a given machinery has not an intrinsic potentiality of being produced in the destination country, it cannot be considered as "adapted".
This intrinsic potentiality is primarily connected with the technological complexity of the machinery..
It is obvious that many other non-technological factors have a determining action in starting machinery manufacturing industry (size of the market, general policies, cultural and educational habits, and so on.), but, once started, this industry will never develop, if this is not technologically possible.
Potential manufacturing capability and operational adaptation are so strictly interconnected, that some questions immediately rise .
How can a machinery, which has an instrinsic technological complexity far beyond the manufacturing capability of a certain environment, be supposed to work properly and to produce profit, on the long run, in the same environment?
Is that the case of the so many huge plants, producing at low rates, or not even, because of lack of maintenance?
And what may maintenance be considered, but the first step in acquiring a manufacturing capability?

Starting from these points, this study discusses about a possible path, in three stages, for developing a machinery manufacturing capability, starting from small maintenance workshps.
It also supplies the basic terms of reference for evaluating the index of complexity (IC) of a food processing machinery and, consequently, for measuring its intrinsic "adaptability" to a local manufacturing industry.
The IC is a number, which measures the degree of technological skill, requested to manufacture a capital good, by stating needed production and infrastructural resources. (see ref. n.4)

The calculation of the IC has been made for a typical "adapted" food processing machinery and the list of requested infrastructural and production resources has been automatically pointed out.
The IC calculation has not been used to back up the selection of all the machines for the catalogue, because this was beyond the limits of this study, but the typical "adapted" machine is largely indicative of the whole category.
The catalogue of "adapted" machines has not therefore , as already pointed out, the value of an absolute reference, but, since selection has been made on a practical experience basis, it has only the meaning of a list of "typical examples" of how "adaptation" concepts could be put into practice.
It is also to be pointed out that the selection has been made (because of the limited time available) on a limited sample of options: those produced by the italian manufacturers of food processing machinery.
Any other similar or equivalent machine, produced in other countries and/or by other firmas, is obviously apt for the same use.
Since, as it has already been outlined several times, these machines have "intermediate" technology functional levels, they would more probably be included in the production range of those countries where, for various reasons, technological level of some food processing plant has been kept at a lower stage and where intermediate technologies are still in operation (such as some southern European and southern American countries, and, in general, the most developed among the developing ones).

The level of detail of the technical information given in the catalogue for each machinery, is very general; the catalogue reports only what has been considered the minimum for "getting acquainted" with the machine and its main features.
It has been assumed that the readers will be interested in obtaining further information, from the potential manufacturers, only when the implementation programme for a certain project, in a given country, attains the feasibility study level.
Of course, since it is very general and, for some aspect, inevitably generic, the catalogue does not contains all machinery and equipment needed to operate each technology selected.
The catalogue reports information on only the most relevant items of each technological chain, and cannot be used, as already stated, as a food processing manual.
Processing technology has been "dismantled", and its practical applications described, but minor line components and auxiliary equipment are sistematically ignored.

As introductory notes, a last few words have to be spent in explaining what is behind the choice of the four food processing subsectors (meat, fruit and vegetable, dairy, cereals) and of the products within each Subsector.
The meat subsector has been selected (even if in many less developed countries meat is considered as a luxury food) because of its impor-

tance as a protein supplying food and, consequently, of the general demand for its expansion. Slaughtering is the very primary processing and is done, in almost every country, following local practices, often influenced by cultural and even religious habits.
Nevertheless, it is in the slaughtering phase that the quality of meat to the consumer (fresh or canned) is determined in terms of hygenical conditions.
Many local slaughtering habits should be abandoned, because they cannot guarantee sufficient meat quality standards, but, at the same time, centralized and refrigerated slaughterhouses cannot be proposed in many non-industrialized environnents.
An "intermediate" technology proposal could be very helpful, because meat processing is, in itself, a simple technology.
The same considerations can be made for the secondary meat processing (canned meat, sausages etc.), which can count on a rapidly expanding market.

The fruit and vegetable subsector covers one of the most important group of food products in the less developed countries, for the internal market as well as for export.
If the export market needs are very unlikely to be satisfied by "intermediate" technology plants (the reasons are discussed in the general part of the study), these can give a determining contribution in establishing cooperative or district-level food processing capabilities to reduce the rapid spoiling out of many crops, due to long transport distances and in creating other employment opportunities in the rural areas.
The dairy subsector has been taken into consideration because milk and milk products could have a great potential importance in contributing to less developed countries nutritional balance.
It is, nevertheless, to be pointed out how the milk processing technology is one the most complex of the whole food sector.
Pasteurized milk can be obtained with a relatively simple technology, but has a very short life (2 + 3 days), if kept at low temperature. Technological problem is then shifted to consumer's and distribution chain's equipment, (refrigerated storing) which, in the majority of less developed countries, cannot be afforded.
UHT (ultra high temperature) sterilized milk has a very long shelf life (up to 6 months at ambient temperature), but it is obtained by very complex and sophisticated processing lines, which are, moreover, very difficult, or even impossible, to be dismantled into machines and normally offered as "packages" by the few superspecialized big manufacturers.
The dairy subsector seems then very dubiously to have its "intermediate technology" solution; it has been included because a critical revision and a general survey of the existing technologies has been supposed to be very helpful before taking decisions.
The dairy subsector includes also some dairy products, such as cheese, yoghurt, butter which can, on the contrary, be easily obtained by century-long and well-established simple technologies.

The cereals subsector shows very different aspects, depending on crop considered and on consumption area.
The most important world cereals are obviously wheat, rice and maize.
The importance of wheat (typically a temperate crop) in the nutrition of many LDCs is increasing, but the wheat supply normally depends largely on imports from developed countries.
It is therefore very unlikely to be assumed that the primary processing of wheat (storing and milling) would take place at district level and in intermediate-technology small plants; because also of the strategical importance of the wheat reserves, its primary processing would more probably take place into centralized plants, at country or region level.
This excludes simple technological solutions; huge wheat mills are sophisticated and automatized plants and the relevant very complex machinery is supplied on the international market by few big firms, which normally work on a "turn-key" plant basis.
Only the secondary processing of wheat (bread and pasta making) could find its space in the country, in terms of small intermediatte technology plants.

Rice and maize are, on the contrary, mostly grown and threshed in the LDCs.
In this case, the district-level intermediate processing technology, to develop or to integrate village-level local techniques, can be (and actually is) an economical and feasible solution.
Secondary processing is a family business, strictly interconnected with local habits.
It is worth being said that the output products of the small mills have normally different "quality standards", with respect to the outputs of huge rice mills or "wet" maize processing systems. Rice is whitened and polished and maize flour has no bran and germ; the aspect is more appealing to the developed countries' consumers and the product has a longer shelflife, but the treated cereals loose a certain portion of its nutritional value. Which one has then a "better quality"?
The interdependance between quality standards and technological complexity must be deeply discussed (this has been done in the general part of the study), in order to avoid any erroneous liason between simple technology and poor quality.

The four considered subsectors cover the large majority of food processing needs in the developing countries; only oil and fats processing (the fifth subsector of great importance in the LDCs) has not been included in this report, because of its technological complexity, with more evident interconnections with the chemical industry, while all other processings mostly rely on electro-mechanical and heat technology.
Other specific subsector exist (such as coffe, cocoa, wine and spirits, beer, etc.) but they are of interest in only few developing countries, and are therefore beyond the limits of a general study.

Structure of the study

This study is divided into three sections: a general part, a catalogue and three appendixes.

The general part has two main purposes:

1 - To revise basic concepts and assumptions of the technological "adaptation" to developing countries' conditions, and to establish and discuss criteria, which back up the selection of technologies and machinery for the catalogue.

2 - To analyze basic requirements for starting a food processing machinery manufacturing industry and to suggest possible paths to be followed and industrial equipment to be provided.

Chapter 2 and 3 aim, respectively, to achieve these purposes.

Chapter 2 starts the discussion by pointing out that technologies and related machinery should be selected on the basis of the same criteria and that the "selection for adaptation", perfomed in this study, is only a general qualitative analysis (machinery should be considered as "probably adapted" to the "average" developing country's conditions).
The basic concepts of "adaptation" are put in the form of practical assumptions: an adapted technology "should": I) be capagle of being industrially operated, II) be apt for processing foods intended for domestic market distribution (and not for export), III) have a small or medium-scale capacity, IV) have an intrinsic potentiality of being manufactured (at least partially) in the same country where it is in operation.
The selection criteria are established starting from the critical analysis of the different unctions of a food processing technology (intended to induce physical transformations on food, to package processed food, to handle food during process, to manage energies and processing fluids). Since each of these functions has a different weight in different socio-economic environments, the selection criteria come out from a critical revision of their presence and possible elimination (the "downgrading"), among available options.

Chapter 3 tackles the problems of machinery manufacturing in the less developed countries.
Machinery is here seen as an electro-mechanical capital good and not as a food processing equipment.
This requires the introduction of a more precise mean of complexity analysis, such as the index of complexity (IC), which is a number defining infrastructural and production capabilities, needed to manufacture a given capital good.
This number has been calculated for a "typical-adapted" food processing machinery, as a references standard and as a source of information about infrastructural and production capabilities for potential manufacturers. The correspondance between level of complexity and local manufacturing capability needs is also outlined showing how it has different aspects when considering infrastructure production resources and components to be assembled on the basic machinery.

Finally, chapter 3 deals with the practical application of these concepts: what is actually needed to manufacture an "adapted" food processing machine, in terms of equipment, personnel and management? And which paths should be followed, in starting and first development phases?
Some practical recommandations and suggestions are given: in particular, the primary role of maintenance (in the operating food processing, but also in establishing manufacturing capability) is remembered and enforced.
As a general indication, a possible development pattern, in three stages, is outlined.

The catalogue (chapter 4) is a selection of "adapted" technologies and related machinery.
It is conceived as a technical guide and as a consulting support for decisions and actions in the food processing, but not as a food processing manual: the level of detail is kept very general and only the most relevant machinery, for each technology selected, is described. It can contribute to "open the technological package", but it cannot be used to completely "dismantle" the food processing line, because auxiliary and minor equipment are normally not mentioned.
The selection of technologies has been performed in the four subsectors of meat, fruit and vegetable, milk and cereals processing.

For each subsector, introductory notes (general remarks) outline main aspects of internationally available and tested processing technologies and select the food products, which are supposed to be of interest in the less developed countries.
All technologies, selected for the catalogue, should be considered as "probably adapted" to the "average" developing country's conditions; in some special case, "unadapted" technologies are described for information and operational or complexity problems are warned.
The catalogue can be used as a source of general technical information for the food processing industry and/or for the capital goods manufacturing industry: in both cases, the initial introductory notes give suggestions and limitations.

For each of the products, selected in each subsector, a technology description section outlines the process and its possible alternatives, pointing out the steps where "adaptation" is possible.
Often, a diagramme helps understanding how technology flows and which machinery (or manual) operation is normally employed.
In correspondance to the technology description, a machinery description section supplies the general terms of reference (such as working principle, major components, recommandations for manufacturing, typical examples etc.) of the most relevant machinery and equipment. In many cases, a photograph shows a typical example of the described machinery.
The examples shown have been taken out of the normal production catalogue of some italian manufacturers and should be considered as indicative samples; any other equivalent or similar machinery is obvionsly suitable for the same use.

The three appendixes have been designed as sources of practical information.
Appendix I deals with operational suggestions for energy conservation

and saving in the food processing industry. After having made some general considerations on the characteristics of energies (mainly thermal and electrical) used in the food processing, with some reference data of the USA food industry, the first chapter lists and comments practical energy conservation measures and techniques.
The second chapter deals more specifically with energy conservation and saving for processing the products considered in the four subsectors of the catalogue.

Appendix II tackles the problem of production scale in the food processing industry; without making any economical analysis (possible and significant only at feasibility study level), it nevertheless supplies some practical example of existing or designed small-scale food processing plants with general considerations about capacity and production scale in the "adapted" food processing sector. The considered cases refer to a tomato paste processing plant, to a small integrated cannery and to a cooperative rice milling plant. These plants employ adapted" technologies and, for each of them, the following information are given: type and quantity of raw and finished products, type and quantity of packaging, description of the technology employed, rated throughput and man-power requirements.

Appendix III is a non-exhaustive indicative list of italian manufaturers of food processing machinery in the four considered subsectors. From the production catalogues of some of them, the typical samples of machinery have been selected for the catalogue of this study. Except the case of the major firms of technologies and processing lines supply, all others are medium or small firms, supplying food machinery out of the catalogue or special machinery on order.

2 - SELECTION OF ADAPTED FOOD PROCESSING TECHNOLOGIES AND RELATED MACHINERY

2.1 Review of basic concepts for adaptation of food processing technologies to less-developed countries' conditions

It has been stated that this study has not the aim of resuming a discussion about phylosophical definitions of what is, or should be, an adapted (or appropriate) technology.
Nevertheless, it may be useful to resume very briefly some basic concepts of what is intended for adaptation, in the food processing sector, from a practical, or operational, point of view.
A theoretical definition (such as "the adaptation of technology is a dynamic concept depending on the relation between the techniques and equipment employed and the changing environment within which they must be operated", see ref.6, pag.93) is of scarse help in selecting technologies for a not-better-defined less-developed country. Before discussing this point, some general remarks have to be pointed out.

First of all, food processing technologies have not been changed very much during last years; only machinery has been continuously improved and becomes more and more complex.
These improvements have been rarely dictated by technological changes; in the majority of cases, other functions have been added to machinery features, mainly intended to save labour costs and/or increase capacity. Selecting adapted technologies means therefore selecting those that can be operated with simple machinery, or, in other terms, that technology and machinery have to be selected on the basis of the same criteria.

Secondly, it would be possible to define exactly if a given machinery has a certain degree of complexity, since very accurate studies (see ref. 4.) allow to calculate its "index of complexity"

(even if this would require a very laborious analysis on each single machine), but this would not solve the problem of exactly calculating the second term of the "adaptation equation": the socio-economic conditions: the aim of this study is more limited and is intended to give general practical references of how technologies and machinery could be considered as "probably" adapted, by performing only a qualitative analysis on the basis of some fundamental assumptions.
These concepts will be furtherly discussed at the end of this paragraph; before, it is worthwhile defining these assumptions and their role in the establishment of basic needs , in terms of food processing , in the less developed countries.
Or, in other words, let us define firstly some basic requirements (the assumptions) of a given socio-economic environment (the second term of the " adaptation equation") and then let us check, with a rough, but practical, qualitative analysis, if a given technology and machinery could fit the requirements, that is, if they are "adapted".

First assumption is that an adapted technology should be suitable for fully industrial operations.
In fact, many developing countries are nowadays faced with high rates of increase in population and with strong inurbation processes, that give origin to rapidly expanding basic needs in terms of food quality and quantity.
Some "appropriate" village-level artisanal techniques can probably be the solution for people faced with self-subsistance problems, but cannot certainly solve the problem of providing foods for urban population, or at province or district level.
In this primary sector, only industrially operated plants can provide the necessary quantities, within fixed and tolerable quality standards.
Furthermore, technologies, and related machinery, should be such as to be economically managed in order to assure a certain profit to the factory or to the agroindustry chain.
It could be said that, if a technology is really adapted to social and economical conditions, then it must give,

when adequately managed on the long run, positive economic results.
It goes without saying that economical feasibility has to be carefully studied case by case, taking into account actual factors; but, in principle, an adapted technology plant should have potentiality to solve problems of management, personnel qualification, maintenance, production quality etc., without spoiling out resources, as it happens where unadapted technologies are employed.

Second assumption is that an adapted technology should process foods mainly for domestic market distribution.
It is worth being remembered how destination market requirements may influence technological complexity; one of the most complex steps in food processing system is packaging, which in turn is largely influenced by market habits and requirements.
In a high competition environment, where product marketing plays a very important role, it is obvious that the packaging system has to be very sophisticated and, in some case (as for milk), rigidly determines the overall processing technology complexity.
Furthermore , international quality standards (such as taste, color, etc.), sometimes improperly considered as the best and largely due to western countrie[illegible] nutritional habits, are obtainable, in practice, [illegible] the use of sophisticated technologies and speci[illegible]inery.
This does not imply, of course, that adapt[illegible] technologies would not permit to achieve good quality standards; but, provided that hygienical conditions have to be kept at the best, a certain flexibility exists, in the domestic market , in adapting quality standards, tolerance, packaging etc. to "adapted" market requirements.
In some case, this adaptation may result in increasing nutritional value, and thus "quality" of some items, such as rice, maize or other cereals, requested in the international market with such a refining standard as to have a poorer nutritional value (by removing bran and germ), than the wholemeal obtained with simpler techniques.

Third assumption is that the large majority of adapted technology processing plants would have a small-or medium-scale production capacity.
This characteristic is common to very many plants also in the developed countries, where, except some multinational food giant, a very high percentage of food production is scattered around the country into small or medium-scale plants.
In the less developed countries, the lack of transport facilities, the reduced capacity of refrigerated warehouses and, normally, more severe climate conditions, all suggests to scatter food processing facilities as close as possible to the harvesting areas. This does not mean that each village should have its own small plant but that adapted technology plants might prove to be a better solution at district or province level.
The overall capacity of a food processing plant is one of the most important factors in determining technology and machinery complexity , as well as management and maintenance difficulties.
On the other hand, village-level plants will never justify industrial operations, since processing quantities are largely below industrial minimal value;probably the district or province level is the most equilibrate scale for a fully industrially operated, but adapted, technology.

Fourth assumption is that, if a technology is well adapted to local conditions,in the food processing as well as in other sectors, it could give a great contribution in stimulating local follow-up process of technological improvement, further adaptation etc.
In other words, only a right technological choice can start an "assimilation" process, which can give impulse to an induced local industrialization process, capable of starting maintenance workshops and small manufacturing units, as it will be discussed in para. 3.3

In defining what an adapted technology should be, by investigating ,through the four assumptions outlined above, which would probably be the basic needs, for food processing, of the less developed countries, it is not meant that an adapted technology should have only these characteristics. It is only meant that these aspects are the most relevant for the general purpose of this study; other minor aspects, possibily of great influence in some context and in some country, cannot be taken into consideration, since the selection made has to have only the value of a very general average.

Let us get back now to the problem of a clear definition of what an adapted technology shoul be. In previous studies (see references 1 and 2) and in many other reports on this subject, efforts have been done in defining adapted technologies and in trying to back up definitions with general consideration; the interested reader is sent to these sources ,for further details.

For the purposes of this study, already defined in the introduction as essentially a practical consulting support, only one fundamental aspect of the "adaptation" deserves further discussion: adaptation has its full meaning only when expressed in comparative and quantitative terms.

In other words, adaptation is not a quality: this technology is adapted, the other one does not.

Each technology can only be more or less (in quantitative terms) adapted to a quantified and expressed environment (its comparison term in the "adaptation equation").

Now, could the same technology be qualified as "adapted" for India or for Mali (both classified as less developed countries, on the basis of GNP)

And, moreover, could a given product processing technology (i.e. rice processing) be equally adapted to Pakistan or to Tchad, where rice has such a basically different impact on nutritional habits?

It goes without saying that, in a general study, only a general indicative average can be given."Adapted" technology (and what is more important related machinery, which has to be selected on the basis of equivalent criteria) is here meant as the simplest possible method, obtained by selecting and/or modifying well-tested alternatives, of processing food with currently available

machinery, suitable to be operated in such a way as to fit with the requirements, stated by the assumptions. This is not a theoretical definition but can be used to establish practical experience-based selection criteria for a general (and for same aspect inevitably generic) study.
A last point has still to be raised: not all the selected technologies have the same level of complexity, in absolute quantitative terms (for example, as defined by the index of complexity outlined on para.3.1). The "simplest available method" of industrial processing of pasteurized milk is more complex than the "simplest available method" of industrial processing of rice.
Is then the pasteurized milk processing an "adapted" technology? May be it is adapted (but some doubt is expressed in the corresponding paragraph of the catalogue , see 4.3) to same less developed country's urban area; it is certainly unadapted to whichever rural area where no feasible milk processing system can probably be operated.
Is then the selected rice processing an adapted technology? It is very probably adapted to disctrict-level small processing plants on rice-growing rural areas; it is very probably unadapted,but in the opposite sense, large urban communities in the same country.
When selecting technology and machinery, possible locations have been in fact taken into account: it is more likely that milk processing is located in an urban area and that rice processing is located in rice-growing rural areas.
Does this mean that all technologies, selected and defined as "adapted", can be satisfactorily operated (from technical as well as economical point of view) in whichever area of whichever less developed country? Obviously, only a carefull feasibility study can give an answer; but this is beyond the purposes of this study.
Once defined what a food processing adapted technology should be, let us enter into the discussion on how to select it among existing alternatives.

2.2 Selection criteria for food processing technologies in four subsectors.

During centuries, a so wide range of food processing systems has been developed in so many different countries , that it would be practically impossible to take into consideration all existing alternatives.

Those considered in this study are the food processing systems commonly used in western countries during the last half of this century.

Even if it is so widely differentiated, it can be found that food processing has some common aspect. One common aspect is that, since raw materials are rapidly perishable, food processing consists normally of a sequence of operations, rapidly following each other. Food processing has the form of a processing line, where multiple functions are carried out simultaneously.
These functions have a very different "weight" in processing food , as it will be pointed out below; nevertheless, usual international transfer of technology procedures, such as "turn key", aim to consider food processing system as a "package",where no adjustment is possible. If, on the contrary, a technology has to be adapted, a careful analysis of the different processing functions must be carried out: some function is to be kept fully operating, some other to be "down-graded" or deleted. The "down-grading" of existing technologies is in fact one of the possible ways to obtain an adapted technology; results may also be achieved by "up-grading" local artisanal techniques to industrial operations. Much research is being done on the latter and results are promising and interesting, but, in the present study, adaptation has been carried out by down-grading technologies, currently employed in the developed countries, and by selecting machinery among options already tested and currently avai-

lable in the international market.

The extent of the technological down-grading (and hence the criteria to be applied to machinery selection) has been established on the basis of a general functional analysis , described below, bearing in mind the assumptions, outlined in the previous paragraph.

A food processing line is designed to accomplish the following main functions:

a) operating a physical transformation on food , intended for better, or longer, preservation, for changing its taste, color. state, size , etc.

b) packaging processed food into a container , designed for preservation, marketing, storing etc.

c) handling food, being processed, in order to transport, displace, select, feed, sort, increase capacity etc.

d) supplying, conveying and controlling processing fluids and energies, generated by local utilities or connected with main supplies.

All these functions are often simultaneously accomplished by a processing machine or are strictly interconnected or interrelated.
Nevertheless, when dealing with a technological complexity analysis, these functions should be considered as if they were separately carried out.
In some case, once operational or product quality standards have been fixed, some technological process has no valid and simpler alternative.
This does not mean that adaptation goes together with poor quality , because quality standards very often depends more on operational know-how and management skills than on the processing technology.
But it is evident that, in same case, "higher" quality standards can be attained only by the use of more complex and sophisticated equipment, specially developed to attain "higher" quality.

This point would require a deeper discussion on what food quality is and how should be measured.
Should quality rely on fulfilment of nutritional habits?
It is clear that a trend to standardize "quality" to western standards has induced to improperly consider internationally accepted foods as the best.
Should quality rely on conservation of original nutritional valve?
What then about "modern" cereals processing, where "higher" quality standards of rice, maize, wheat, greatly reduce its original nutritional value? Should quality rely on a more appealing aspect and colour, or on a longer shelf-life , or on any other peculiar characteristic of a special food?
What then about the use of various additives, which certainly improves certain food characteristics, but can hardly be defined as "quality" improvements?
It is evident that the quality of a processed food has so many aspects, depending mostly on nutritional and social habits, that, exception made for measurable hygienical conditions, any definition of "rich or poor" quality has a very relative weight. Hence, in same case, once a "quality standard" (i.e. taste and colour of citrus juice) or a preserving method (i.e. liophilization of fruit or UHT processing of milk) have been fixed , no simpler technological alternatives exist.
In some other case, the same function can be accomplished in a simpler way and complexity depends only on the use of more complex machinery, whose complexity is often caused by other related functions, such as automatization or type of energy supply.
Therefore, making an effort to analyze the four main functions separately, any technological selection must be carried out simultaneously with the corresponding available machinery selection, bearing in mind the previously defined assumptions.

For example if meat processing technology is being discussed, heat treatment for meat preservation and canning can be performed by wood-fired open copper pans, or by double-bottom stainless steel steam-heated pans, or by rotating direct-steam cooking retorts.
Technological step is the same (at least in its general sense of single operation within a process), and can be quoted as very simple (nothing else than meat coo-

king), but grade of complexity of related machinery varies from village-level to complex.
It is clear that, if industrially operated plants are requested (as the first assumption for an "up-to-date" adapted technology), selection will be directed towards the stainless steel double-bottom steam-heated pan,being wood-firing probably unsuitable for industrial operations and steam retort a too complex machinery.

If the four different main functions of a processing line are considered as separate, and related available machinery is taken into account, there is no doubt that, in general, the first function (a) gives few adaptation chances, at technology level: quality standards of the final product must be high, hygienical conditions must be kept at the best.
A slightly wider choice exists among machinery but it should not be forgotten that machinery must be well tested, easily available, suitable to be industrially operated, and hence the choice range narrows.
Even if few adaptations are possible, function "a" can be normally accomplished in a simple way, because of the intrinsic simplicity of the food processing, which has often only improved, without profound changes, systems developed in the past, if we exclude recently developed processes, such as freezing, liofilization,sterilization UHT, etc. (but these processes are certainly out of adaptation limits).

A greater extent of adaptation work can be done on technologies and machinery for function "b".
Also in this case, hygienical conditions and good packaging standards are out of discussion: shelf life and quality of the product strictly depends, in most cases, on container quality. No valid, but simpler, alternatives to the tin can have been yet developed, in spite of the great amount of research made on this field.
Plastic and carton bags are steps higher in the complexity scale, because of forming and filling machines' complexity, while glass containers are costly, and difficult

to handle, items. The highest grade or complexity is then determined, in canning , by the seaming machine. Some adaptation is nevertheless possible, on can size, labelling and raw materials, which should be optimized to actual basic needs of developing countries' markets. Another direction to be followed might be to increase the use of preserving technologies, in which simpler or no packaging, is needed,such as drying, salting or spice curing which have been recently improved to give better results with respect to traditional low-quality foods.

It is on function"c" that the majority of adaptation work can be performed.
If food processes have not been changed very much in the last years, the grade of complexity of processing machinery has increased very rapidly, because of the economically pressing need for automatization of product handling and line operating.
This was intended mainly to save labour costs and/or to increase to overall capacity of the line.
This process has only an economical justification in a very-high-wage environment and in a very competitive market; it made many technically-efficient machinery economically and commercially obsolete in a very short period.
It goes without saying that the socio-economic environment in the less-developed countries is different; low wages and/or basic social needs justify the assumption that an adapted technology should be more labour-intensive and operated in smaller scale plants, scattered in the country at a district or province level.
Huge and automatized plants have already proved to be the wrong solution in many developing countries; the trend towards small-scale plants might be suggested also by the need to start a maintenance and manufacturing capability and to stimulate local tehcnological assimilation and development, as it will be pointed out in the next capter.
The suggested down-grading of existing technologies

may permit the re-employment of a wide range of machinery, considered as economically (but not technically) obsolete in the developed countries. The selected machinery has a low degree of automation: all sorting and grading operations are done manually and many machines are batch-operated.
When the process foresees continuous operations, then product hangling is done with the aid of mechanically driven trasporters (overhead conveyors, bucket or flap elevators, roller transporters, etc.); no electronic device is included.
All machinery selected is then adapted to small and medium scale plants, equipped with low and medium capacity lines, manually or semi-automatically operated.

Finally, let us take into account function "d", which became, in the last years, a determining factor in the economic balance of many food processing technologies, where a high energy consumption (particularly thermal energy) is requested.
In selecting adapted technologies, this problem must be approached by firstly comparing grade of complexity of machinery and auxiliary equipment (utilities) versus energy conservation and saving , in terms of specific energy consumption per unit of finished products.
Generally speaking, an increase in energy utilization efficiency corresponds to an increase in machinery complexity; an example is thermal energy, the most widely employed for food processing.
It is well known that the major portion of energy requirements for food processing is in terms of thermal energy.
The efficiency of thermal energy conversion,in any traditional technique,is very low;any attempt to save thermal energy implies the use of multiple-stage techniques, of heat recuperation exchangers, of better insulating meterials, of precise temperature controlling devices, etc.;all these systems increase technological complexity and are often out of the reach of whichever adapted technology and/or machinery.

Steam is the most widely employed heat supplying fluid and its production and distribution have the same energy conservation and saving aspects: more efficiency in producing steam means use of more complex, well engineered and, normally, larger capacity plants, that are often in contrast with adapted technology choice. The use of poorer fuels or process wastes, such as husks, stones, pellets etc. is possible and economically convenient, but it certainly increases heat generation plant complexity and requires a more efficient and continuous maintenance; otherwise, the higher efficiency in conversion is rapidly spoiled out.
Same aspects are shown by water saving techniques, which are often a determining factor in allowing a processing plant to be established in countries, where water supplies are scarce. Water saving is possible mainly by recycling waste and cooling waters; but this implies the use of more complex equipment ,such as water depuration plants, evaporating towers, flow and temperature controlling devices etc.
Therefore, when dealing with adapted technologies, a careful investigation is to be done, case by case, on techno-economical convenience of complicating machinery and/or equipment for energy saving and conservation. Some highlights of possible alternatives in equipment selection and some introductory notes on energy saving procedures will be given in Appendix 1.

3. - ANALYSIS OF ADAPTED FOOD PROCESSING MACHINERY AND RECOMMANDATIONS FOR MANUFACTURING

3.1 Complexity grade of adapted food processing machinery

In the previous chapter, complexity and adaptation of technologies and machinery have been analyzed and discussed from the point of view of food processing industry operations, in the less developed countries.
If the same machinery is analyzed from the point of view of manufacturing , in the same countries where adapted food processing industry is being operated (and where there is therefore a possible market demand for adapted machinery), do complexity and adaptation criteria show the same aspects, or have to be revised?
In other words, a machinery, "adapted" to food processing industry operational conditions, can be considered as "adapted" also to capital goods manufacturing industry conditions of the same country?
In principle, no direct correspondance exists (the two industries have very different operating and market conditions) but an interrelation comes out from one of the basic assumptions for technological adaptation: if a machinery is adapted, then its technology can be "assimilated" by the environment.
Technological assimilation is the basis for the establishment of a local manufacturing capability, following certain development paths, which will be discussed on para.3.3
Technological assimilation from the point of view of manufacturing, implies that a given socio-economic environment is capable of acquiring infrastructure and production capabilities, needed to produce capital goods up to a certain level of complexity.
A precise definition of infrastructural and production capabilities (and then of level of complexity) is given by the "index of complexity" of a capital goods.

The IC calculation is based on a detailed user's manual (ref.4) available at UNIDO, to which the reader is sent for further details on theoretical bases and detailed procedures.

It is here remembered that the IC is a number which represent the quantity of complexity involved in a given capital good, whose value normally varies from two practically calculated extreme values, ranging from a minimum of 17 up to an absolute maximum of about 600.
The minimum level corresponds to an almost primitive machine, whilst upper levels are found only in the aerospace industry products.
A kind of complexity scale, having six steps,can also be established.
These steps, called N steps, are numbered from N1 to N6 and correspond to complexity grades (IC values),as follows:

N1	- 17	to	30
N2	- 30	to	50
N3	- 50	to	100
N4	-100	to	180
N5	-180	to	320
N6	-320	to	580

To each step, an equivalent range of capital goods complexity can be defined.
Step N1 corresponds to initial development level, at small artisanal or village level operational stage;
Step N2 represents the first technological stage in industrial development ; step N3 covers the majority of capital goods specialities and can be defined as the medium-state development.
Only at step N4 a full industrial development at the heavy industry level, has been attained.
Steps N5 and N6 are linked to very special industrial activities, such as aircraft or aerospace industry, typical of large industrial countries.
There is no doubt that developing countries, at mid term, can accept maximum complexity levels within N3 step,as it has been recommended at the First UNIDO Consultation on the Capital Goods Industry (see ref.5) . In the same document, the agro-food industry capital goods are defined as to have an average complexity level without components of about 65 and a total complexity (with components) of about 95.

The index of complexity procedures have been applied to a typical adapted food processing machine.
It is to be noted that the calculation of the IC for the selected machinery was beyond the purposes of this study, because it could not be used to back up an adapted machinery selection for the processing industry of the less developed countries.

In fact, the IC supplies no information about operational conditions of the machinery , but defines only manufacturing requirements.
Nevertheless, it has been considered that the calculation of IC for a typical machine could be of great help in defining the type of infrastructural and production requirements, with which a food processing machinery manufacturing industry should be equipped.
It has also been encluded , after having analyzed samples adapted machinery, that few differences existed between them, in terms of infrastructural and manufacturing needs; the typical average machine is then really indicative of manufacturing needs for the entire group of adapted machinery, differences being limited to few points,except the cases of milk processing and of multiple-effect concentrators, as it will be mentioned on the catalogue.
The average level of complexity (IC) for a typical adapted machinery results in the range of 40 to 50 without components, and goes up to about 60 to 80 if main components are taken into account. On the average, it can be said that selected adapted machinery remains within the limits of step of complexity N2 (max of 50), suitable to be operated in many less developed countries.
The possibility to be manufactured depens on so many other factors (such as market size and requirements,general policies, financing etc.) that it can only be stated , at the moment, that an adapted machinery could be manufactured from the technical point of view, in many less developed countries(except components to be imported and assembled).

The calculation of the IC of a typical adapted food processing machinery has been performed, taking into account the following production factors (see ref.3 for details):

code	description	technological level
overall factors		

P	- light and standard industry	1
Hs	- from 1.1 to 4.0 hours of know-how per US$1000 of product (estimate)	1 to 2
L	- simple static and dynamic test on components and parts, some fluid-dynamics and thermo-dynamics tests	1 to 2
Hd	- between 50 to 400 direct hours per tonne of product (estimate)	1 to 2
Vt	- from 4 to 50 basic types of machinery produced (high integration of production)	2 to 3
Vm	- from 4 to 15 models for each type of machinery (estimate)	2 to 3
S	- up to 1-3 items produced per month (small factory)	4
M	- machine requires re-assembly of parts in the user's site by the manufacturer and likage to the processing line	3
T	- maximum of 100 persons employed at the manufacturer's plant (small plants)	

<u>Production resources</u>

Ø1	- metal cutting of bars, sheets and profiles, with machines of the advanced universal tupe, high precision working, prevalent manual operation	2
Ø2	- bending, folding, rolling, drawing flanging of metal sheets with the use of advanced universal type machine	2

tools,high precision working to ISO standards (manual operation)

Ø3 -	cold shaping of wire and tubes, by existing conventional technology, manual operation	1
Ø4 -	riveting and threading by conventional machines, manually operated	1
Ø5 -	cold pressing of metal sheets, stamping of special sheets, by machine of advanced universal type, high precision working to ISO standard (manual operation)	2
Ø7 -	welding of all types, by machines of advanced universal type, very high accuracy to ISO standards (with some semi-automatic operation)	2 to 3
Ø8 -	horizontal single-chuck lathes with high accuracy working, manually operated to ISO standards (with some semi-automatic operation)	2 to 3
Ø12-	surface planing and planing - milling machines by existing conventional technology, high precision working to ISO standards	2
Ø14-	milling machines of advanced universal type, high precision working to ISO standards, manual operation	2
015-	table drills of advanced universal type, high precision working to ISO standards, manual operation	2

Ø18 -	grinding and surface finishing and polighing machines, high precision working, manually operated, advanced universal type machines	2
Ø30 -	static and operating geometrical tests, in accordance with international standards	2

Semi-finished products

B.1 -	Basic primary iron casting ,with some piece of standard quality, some use of electric furnace (heavy and high-resistance parts to be imported)	1 to 2
B.2 -	Steel casting of basic carbon steel, in accordance with standards, up to medium-size parts (other raw or semi-finished parts to be imported)	1 to 2
B.7 -	Open die forging of light parts, by conventional equipment with high performance and accuracy (heavy parts to be imported)	1 to 2

Third-party services

B.9 -	Stress relief and annealing of ferrous and non-ferrous materials up to medium-heavy parts, in accordance with specification	2
B.10-	Heat treatments, such as tempering and normalizing in accordance with standards	2
B.11-	Metallic surface deposits, such as zinc, tin lead coating in hot bath, or electro-chemical processes, in	2

accordance with standards

B.12-Manufacture and maintenance of simple tools and medium-complexity metal-cutting and plastic-deformation tools	2
B.13-Manufacturing of dies for cold stamping in fairly well equipped workshops, little own know-how, on third-party specifications	2
B.14-Manufacturing of dies for hot metal working, medium-sized workshops,semi-complex shapes	1 to 2
B.15-Manufacturing of jigs and masks for welding and parts assembling	2
B.17-Médium and medium-heavy boilermaking with complicate spherical shapes; medium-sized workshops handling up to 15 tons	2

With the production factors listed before ,an average adapted machinery can be manufactured, without components; converting the technological levels shown into corresponding values for each factor, the indew of complexity sums up to a minimum of 41.33 and a maximum of 47.81; the rounded average can be assumed at 45.
It can be seen that the typical IC falls into the range N2; this means that, if components are imported and assembled, the basic machine (frame, body, operating parts etc.) can be manufactured (at least from technological point of view) in countries at the second stage in development (see para 3.3).
Considering main components, the following factors should be taken in account:

Basic components

C.1 -	mechanical machine parts and basic ferrous and non-ferrous materials, such as bolts, washers, nuts, pins, springs, pulleys, levers, control knobs etc.	2
C.2 -	medium-sized machine parts, such as connections, clutches, cams, joints, brakes, supports, in many different varieties and variable speed units up to 25 HP, gear boxes, safety devices, ball bearings, etc.	2
C.4 -	hydraulic components up to 70 kg/cm^2, such as pumps, valves, vessels, tanks, automatic actuators, etc., in various types and sizes, some with test certificates, standard types	2 to 3
C.5 -	simple pneumatic components, such as pistons, valves and manifolds, in accordance with standards	2
C.6 -	simple vacuum pumps and vacuum circuit accessories up to 10^{-3} mmHh, quality tested and guaranteed	3
C.7 -	electrical control and monotoring devices, such as knobs, switches, circuit breakers, alarms, light signals, microswitches, meters, control panels etc.	2 to 3
C.8 -	electrical power supply and drive, such as motors up to 30 HP, wiring, conneetors etc.	2
C.14-	low pressure and temperature (up to 150°C) steam systems, non-corrosive, such as valves, manifolds, regulating devices etc., some standard, semi-automatic applications	2 to 3

C.15 - simple instruments for measuring liquids, gases, electricity; limited accuracy, but in accordance with standards 3

C.18 - special non-metallic components, such as rubber rolls, plastic nuts, plexiglass and glass, insulting materials etc. 3

Converting these factors into the corresponding values, the IC for components sums up to about 24, on the average.
The mean total IC (including components) for an average typical food processing adapted machine is about 68.

It can be seen that, if components are taken into account, the total complexity falls within the range N3: a range of development unachievable, at medium term by many of the less-developed countries.
All components are therefore to be imported and assembled; this should be carefully taken into account when establishing maintenance procedures and stocks.
On Tab.1.1, a summary table of IC calculations for a typical machine is shown.
It can be noted that the ratio (about 35%) of components IC (about 24) on the total IC is very high.
This is due to the reason that, in adapted machinery for food processing, major sources of complexity are effectively the components, because basic machine is, in principle, a "container", with a "supporting frame", where food processes take place, connected to different kinds of "actuating and feeding" devices.
A sound change, in this "machine structure", intervenes only when the processing line is automatically and continuously operated; but this is out of the limits of adapted technologies and machinery ,which are almost manually - and batch - operated.

Food processing machinery has , in any case, a limited grade of complexity: as an example the most complex food technologies (with milk processing and food lyophilization) have ICs (without components) of about 82 and a total complexity of about 115 (see ref.5, pag.301,table 7).

TAB. 1.1 - Index of complexity (IC) of a typical adapted food processing machine

PRODUCTION FACTORS

Basic machine

Overall factors (A1)

P	1	1.00
Hs	1÷2	1.00÷2.00
L	1÷2	1.00÷1.68
Hd	1÷2	1.00÷2.00
Vt	2÷3	1.41÷2.00
Vm	2÷3	1.41÷2.00
S	4	2.83
M	3	2.83
	1	1.00

Production resources (A2)

Ø1	2	1.19
Ø2	2	1.19
Ø3	1	1.00
Ø4	1	1.00
Ø5	2	1.19
Ø7	2÷3	1.19÷1.41
Ø8	2÷3	1.19÷1.41
Ø12	2	1.19
Ø14	2	1.19
Ø15	2	1.19
Ø18	2	1.19
Ø30	2	1.00

Semi-finished products (BI)

B.1	1÷ 2	1.00÷ 1.41
B.2	1÷ 2	1.00÷ 1.68
B.7	1÷ 2	1.00÷ 1.41

Thirdy-party services (BII)

B.9	2	1.41
B.10	2	1.41
B.11	2	1.41
B.12	2	1.68
B.13	2	1.41
B.14	1÷2	1.00÷1.68
B.15	2	1.41
B.17	2	1.41

IC for basic machine	min	max
	41.33	47.81

mean value 44.57

Components

C.1	2	1.41
C.2	2	1.68
C.4	2÷ 3	2.00÷4.00
C.5	2	1.68
C.6	3	2.00
C.7	2 ÷ 3	2.00÷4.00
C.8	2	2.00
C.14	2÷3	1.68÷2.83
C.15	3	4.00
C.18	3.	2.83

total IC	min.	max
	62.61	74.24

mean value 68.425

Note: -first code makes reference to the description of production factors in ref. 4

-second number shows technological level of the factor (1 to 6) (two figures means minimal and maximal levels)

-third number gives the IC value for each factor, to be summed up

-see ref.4, (The index of complexity of capital goods: user's manual - F.Vidossich) for details

3.2 Complexity and manufacturing capability needs

Several factors concur in creating favourable conditions for starting a food processing machinery manufacturing industry in a less developed country.

Market demand,general industrial policies,financing sources, social conditions etc. have a great influence in determining how feasible and profitable a capital goods industry could be,but, for the purpose of this study,only technological manufacturing capability factors are taken in account.

Once these factors have been set up, it means that food processing machinery manifacturing is technologically possible.

It will be aim of detailed, case - by - case, feasibility studies to analyze if factors, other than technological, make the food processing industry feasible and profitable and to indicate solving actions.

For example, if, as often occurs, market size and demand are unadequate, a possible response could be the establishment of multi-product plants, where production facilities are integrated with other product of equivalent complexity, such as agricultural machinery and/or agro-industrial products ,which, in general, have many common aspects with food processing machinery.

Other sectors might be : basic chemical machinery, basic pharmaceutical machinery, heat-generation plants, water pollution treatment, refrigeration plants, which include also machinery of equivalent complexity and similar production equipment.

Many considerations have then to be made before starting a food processing machinery, as any other, industry, but, once the decision is taken, the technological factors of production should have

afforded the level which corresponds to the complexity of products to be manufactured.
If this has not occurred, any effort in starting manufacturing activities give rise only to assembly shops or to few highly integrated plants,isolated from the socio-economic contest.
These activities has very few technological interactions with the environment: a very poor, or no, assimilation of manufacturing know-how takes place and, therefore, no further development is stimulated.

Let us then define which is the minimal manufacturing capability level that fits with the starting of an adapted food machinery industry.
Following the guidelines of the index of complexity calculations, manufacturing capability level will be expressed in terms of three type of factors: components (C factors), infrastructure (B factors) and production (A factors).

It has been calculated, in the previous paragraph,that the complexity index (IC) of a typical adapted food processing machine falls within N2 complexity level (up to an IC of 50), if components are not taken into account. With components, the totale IC raises to about 80, then falling into the level N3. Therefore, to start manufacturing the basic machine, it is to be set up an infrastructural (B factors) and production (A factors) capability, compatible with level N2.
To start manufacturing of the total machine, (with components) the N3 level should be attained.

In many less developed countries, it is a fact of life that the overall development is still at N1 level; this is an important embryo, capable of future development, but it does not yet allow starting of a manufacturing activity.

Other less developed countries have yet, on the contrary, reached a full N2 level.
Level N3 represents a typical medium state of development, attained by many of the more advanced developing countries. (a)

The less developed countries, which have attained the N2 complexity level of infrastructure and production capabilities, can then afford manufacturing of adapted food processing basic machines (without components).
Before discussing (in para.3.3) how to attain an industrial development, equivalent to the N2 level, for the case of food machinery industry, and before defining in details (in para 3.4. and 3.5) what to provide , in terms of infrastructure,production equipment and personnel, let us make some final considerations on manufacturing capability factors (C,B and A).

Components bring complexity beyond the N2 level, and have to be imported from more developed countries and assembled, except some very special case of simple "ready-made" items, produced by local third-parties.
Tentatives to integrate components production with machine production have proved to be uneconomical, because this "forces local production before its time"and does not take advantage of international technological market.
On the contrary, the components dependance from

(a) considerations about the levels attained by developing countries have been taken from Table I- Reference standards for the complexity levels- see ref.4- op.cit. - pag.26-27 and pag.147.

more developed countries may be useful in keeping quality level of capital goods bounded to international standards.

The establishment of an industrial infrastructure is one of the primary goals of any industrial development programme, as it will be seen in the next paragraph.
As for components, a high degree of integration of intrastructural capabilities with the machinery production equipment, in the same firm, has proved to be a temporary and inadequate approach to the problem. Integration results, in general, into a slower know-how assimilation, because of the lack of technological relationships between the various techniques, operated in the same plant, and the environment , that, in turn, can result into longer times to pass from one level to the next.
Moreover, integrating infrastructure with manufacturing equipment causes the relevant cost burden to fall on the shoulders of a single sector; it is evident, on the contrary, how infrastructural capability should be established ,to be economically operated, on the basis of the total volume of industries starting operations in the same period. Since it has been calculated that, to attain the full N2 level, about 80 per cent (b) of the total complexity factors should be provided, it is clear how infrastructural capabilities could rely on a very wide range of capital goods industry sectors.

(b) see.ref.4,op.cit.,pag.113.

Production factors are much easier to be established ,since they have a direct relationship only with the sectoral needs in terms of equipment and personnel; a detailed analysis will be done on the next two paragraphs.
Only one point is to be outlined: the manufacturing technology level.
So far, adaptation of technology and machinery has been referred to food processing operational conditions, in the less developed countries.
What about adaptation of manufacturing technology to the same conditions? Should manufacturing technology (and related machinery) be adapted with the same criteria used for food processing technology and machinery adaptation?
Even if the two sectors (food processing and capital goods manufacture) have very few common aspects, nevertheless basic assumptions (see para.2.1) can be considered as still applicable, since they depend more on environmental conditions needs than on sectorial characteristics.
If a functional analysis (see para 2.2) is performed, it yields definitions very similar to those used for food processing operations: the first function of a manufacturing technology is to induce physical transformation (mainly mechanical, in this case), the second one to handle the products during the process.
As in food processing, it is on the second function that the majority of technological adaptation can be performed; this has been done by selecting, in para 3.4, only manual or semi-automatic machinery of traditional type, easily available and well-tested.
This manufacturing machinery is "technologically adapted", to the less developed country conditions; its profitability has to be checked with detailed case - by- case, feasibility studies.

3.3-Establishment of capital goods manufacturing capability in the food processing machinery industry

Many alternative ways may be followed to establish a capital goods production capability. It is obviously a different matter to establish capital goods industrial capabilities in a centrally planned country or in a market economy country.
Nevertheless , if technological self-reliance is the common goal, there are common aspects of the patterns to be followed and there is no doubt, at the moment , that "technological self-reliance is absolutely essential for ensuring successful industrialization "(a).
All attempts to shorten an equilibrate and adequate, but unfortunately long-lasting, process of industrialization have proved to have great shortcomings.
For example,turn-key large projects and advanced technology contracts have proved to have a little technological assimilation potential and industrialization stimulation power.
In other words, no country can jump from level of complexity N1 (which has been practically reached in almost every country) to upper N2 (or lower N3) level, needed to manufacture very simple food-processing machinery, without a continuous step-by- step shifting; and it is worthwhile remembering that any increment requires an exponentially-growing effort (this coming out from the basic hypotheses of complexity index).
Therefore, attempts should be more effectively put in rapidly routing the development stages,than in forcing the environment to jump necessary steps.

(a) see ref.5 - op.cit. pag.239

Although having merely the meaning of a very general indication, a typical pattern in three stages for developing food-processing machinery manufacturing capability may be as follows:

- <u>first stage</u>:-<u>maintenance and repair capability</u>
  - -manufacturing of spare parts and simple components (small workshops)
  - -assembling of machinery
  - -no technological adaptation of imrpvement
  - -basic training on direct skills
- -<u>second stage</u>:<u>manufacturing of machinery and parts under license or other contract agreement</u> (multi-product plants)
  - -technological adaptation and/or improvement
  - -setting-up of infrastructure
  - -training on sales and management
- -<u>third stage</u>: -<u>manufacturing of its own machinery</u>
  - -technological self-reliance and mastery
  - -devolpment of know-how and engineering
  - -higher level training on indirect skills

The establishment of a maintenance and repair capability is the main goal of the first stage.
The role of maintenance and repair capability has not yet been considered in all its importance for the food processing, as for any other ,sector.
It is well known that one of the most important factors (in many cases the determining one), causing operational unprofitability of food processing plants, is the lack of maintenance and that, therefore, many resources are to be put in establishing local maintenance and repair capability in the less developed countries.
But, it is normally underestimated that maintenance

and repair can be a way of entering basic industrial development routes and a very effective opportunity for training skilled labour.
Maintenance and repair is an important "key to open the door" to technological assimilation.
Maintenance procedures should cover not only the urgent needs for trouble-shooting and repairs, when a break-down has occurred, but also general preventive maintenance, which can and should be in operation at the very initial development phase. These maintenance procedures, and particularly trouble-shooting and disassembling , play a very important role in helping to understand working principles and primary structure of the machinery, and hence give contribution to technology assimilation.
A simple, but effective, programme of preventive maintenance, has the value of a complete labour training course, indicating weaker machine parts and how they could be improved.
Furthermore, it creates much more jobs than any other food-processing machinery manufacturing industry, and widely distributed around the country, as food-processing plants are.
If the complexity level of the machinery is within the limits of the previously defined adaptation, it is possible to reach a fully indipendent maintenance and reapair capability, at the first stage in industrial development.
Immediately after, a process of "copying" of simple mechanical components could give start to the development of a manufacturing capability, limited in variety and at artisanal level.
When this copying capability has been developed, a spare-parts manufacturing programme should be established, in accordance with the machinery manufacturer. (The possibility of spare-parts indipendent manufacturing should be included in the contract agreements, when buying machinery in the international market).

It would be preferable that (at least in the market economy countries) maintenance and manufacturing facilities should be located in small workshops, independent from the food processing factory.

This structure , if adequately sustained, may be the embryo of the industrial infrastructure, which is the main goal of the second stage in development and the basic condition for a viable manufacturing capability. Froma a macro-economical (and macro-technological) point of view, it is very unlikely to expect food-processing machinery alone would justify the establishment of infrastructrual (and then manufacturing) capability. Therefore, only a multiple-product manufacturing can be envisaged, at least at this development stage.Furthermore, only the reach of an overall multi-product critical size will allow the firm (not necessarily the plant) to start its own process of know-how and technology improvement.
The manufacturing plants (not necessarily firms), should be as scattered as possible in the territory (compatibly with a profitable management) to diffuse technological skills and know-how.
Since the setting-up of an industrial infrastructure is the main goal of the second stage, it is obviously with-in products with similar infrastructure requirements, that a multiple-product manufacturing is to be searched.
Various contract agreements (license, joint-venture, buy-back etc.) with the machinery supplier may allow manufacturing of parts, sub-assemblies, components or complete machines.
It is important to point out that infrastructure and production capabilities have to proceed and to improve at the same time, as simultaneously as possible; otherwise, there is an excess of technological capacity in the manufacturing plants, which are obliged to import more semi-finished products or,on the con-

trary (but this rarely occurs in the developing countries), the infrastructural investments can hardly be profitable.
The interdependence between infrastructural and specialized programmes is in fact very high at complexity levels N1 and N2, where the main framework of capital goods manufacturing is set up.
Once the overall critical size has been achieved, it is possible that a <u>full technological mastery in food processing machinery</u> (at the adapted technology level, of course) calls for sectoral specialized development programmes.

Starting of a <u>food processing machinery indipendent manufacturing</u> capability is <u>the goal of the third stage</u>. A newly established food-processing machinery industry should start producing machines very similar to those produced by international firms, although at downgraded complexity levels, chosing those which do not require high investments and have the larger possible domestic market, as resulting from demand estimates and initial sales volume calculations.
Machines to get started with might be, for example, those used in canneries and slaughter houses,such as boiler-making, heat exchangers, conveying belts and chains, pasteurizing and cooling pans and retorts,cooking pans, kneading-machines, slaughtering apparatuses etc.
All these actions are in fact very specialized sectoral programmes, even if the industry will continue to operate on a multiple-product basis. This will last until economic studies make advisable to undertake a full level of production in the specific sector, increasing quantities, varieties and models.
A prototype construction section is the core of future development; the prototypes may be machines where improvements are based on previous experience in maintenance and repair, or intended to test new adapted solutions on the basis of local demand, or to apply local artisanal techniques, or to try to "re-produce"mo-

re advanced internationally-available machinery.
A further technological adaptation has to take place in the machine technology, as well as in the manufacturing technology, to make production processes match with new available skills.
This adaptation may be done in agreement with the former machine manufacturer or independently, depending on contract agreements and regulations.
Generally speaking, the more adapted (or down-graded) the machinery, the easier the agreement: many food-processing machinery, considered as obsolete for non-technical reasons in the developed countries, can be manufactured in the developing countries, with few restrictions and lower or no royalties.
Another possible way of adaptation , which is to be considered as a complementary route and not as an alternative, is the "up-grading" of authoctone technology and machinery to reach full industrial operation.
Although this way might simplify some assimilation problem, it will encounter practically the same constraints in establishing a manufacturing capability, since equivalent technological levels imply the same manufacturing complexity, whether it comes from "down-grading" or from "up-grading" patterns.

3.4. Infrastructure and manufacturing equipment

The evalutation of the complexity index (IC) (see para 3.1) has already given an indication about infrastructure and manufacturing equipment, needed to produce a typical "adapted" machine (see para.2.1 for definitions), on which all unrequested function have been "down-graded" or eliminated (see para 2.2)
This infrastructure and manufacturing equipment corresponds to the needs of the third stage in development (see para 3.3); for lower stages,proportionally reduced equipment is needed.
In this paragraph, the list of manufacturing facilities makes reference to IC evaluation procedures and definitions (see ref.4 for more details, pag.38 to 117), for infrastructural facilities (B factors, referred to as "semi-finished products" and "third-party services" on para 3.1) and for manufacturing equipment (A factors, referred to as "production resources" on para 3.1).
It is worthwhile remembering that a general study,such as the present one, can only give general reference data; infrastructure and equipment listed on this paragraph have then the value of typical technical resources to manufacture typical "adapted" food processing machinery.
It is also to be made clear that these resources are intended to produce basic machines, which do not include components (such as electric motors, hydraulic and pneumatic components, etc.) referred to as "basic components" on para.3.1.
All these components should be imported and assembled, because no component manufacturing is possible with this infrastructure and equipment, except special cases to be investigated at feasibility study level.

Before entering the description of technical resources, a few general considerations on food processing machinery manufacturing should be made.
Even if the complexity of a food processing machinery is not very high, this would not mean that a good manufacturing practise is so easy to be attained.
There a factor, that no index of complexity can take into account, strictly connected with the nature of goods to be processed.
It is the "accurate manufacturing", not only in the meaning of a precise execution, which of course is important, but also in the sense of a very careful manufacturing practise, that takes into account apparently negligible details.
For example, if a pipe bead-weld connection has been correstly executed, from the point of view of mechanical strength and pressure withstandind capacity, but has some very small surface cavity or pinhole prorosity, this will result in a difficult washing and possible product spoilage by bacterial contamination.
As a further example, if the seal gasket of a rotating shaft in a kneading machine is not properly mounted and causes a very small leakage, this would not cause any problem to the rotating shaft running , but can contaminate the product and spoil out an entire production cycle.
The proper know-how for food processing machinery manufacturing is based on thousands of these "circumspect" operations, which do not increase the total level of complexity, but imply the employment of very skilled people for production and management.
It is more the case of "care-oriented" mentality, than of pure operational skill.
How to attain such an "accurate manufacturing" skill should primarily entrusted to an accurate training of production and management personnel, as it will be discussed in the next paragraph.

Infrastructure

This infrastructure is to be considered as the minimal basis on which a food processing machinery production could be started.
It is evident that only food processing machinery production would never saturate these infrastructural resources; an integrated development program must take into account the total volume of similar industries, starting operational activity in the same period (see para. 3.2).
To start manufacturing, the basic infrastructure should already be equipped to provide (see para.3.1 for description and ref.4, op.cit. pag.77 to 99 for more details):

- basic primary iron casting (B.1)
- steel casting of basic carbon steel (B.2)
- open-die forging (B.7)
- stress relief, annealing etc. (B.9)
- heat treatments (B.10)
- metallic surface treatments (B.11)
- manufacturing and maintenance of simple tools (B.12)
- manufacturing of dies for cold stamping (B.13)
- manufacturing of dies for hot metal working (B.14)
- manufacturing of jigs and masks (B.15)
- medium and medium-heavy boiler making (B.17)

Some of these infrastructural capabilities (B.12,B.13, B.14, B.15, B.17) could temporarily assumed by manufacturing plant departments, specially equipped for the purpose, but this is to be considered as a temporary remedy.
An integral programm, for establishing indipendent infrastructural capabilities has to be simultaneously initiated, relying mostly on natural trend towards work specialization, and adequately sustained by financing small workshops, operatedfor example by formerly employed workers and artisans.

Other infrastructural resources (B.1,B.2,B.7,B.9,B.10, B.11) requires investments and acquisition of operational know-how, that only food processing machinery manufacturing would never justify, from technical and economical points of view.
These resources should be developed through an integrated industrial infrastructural program.

Once the basic infrastructure has been established and the above listed facilities are fully operating, some other infrastructure facility could be started, in order to progressively reduce the total amount of imported goods, particularly in the field of simple mechanical components and spare parts.
Infrastructural resources to be established in a second phase might be:

- non-ferrous casting (B.3), particularly alluminium or alluminium alloys casting
- die-casting (B.5) of ferrous and non-ferrous materials
- gear and teeth manufacturing (B.19) for simple and conventional universal equipment
- specialized fine machining (B.20)
- cold stamping (B.23)

The latter two cases apply only when the degree of development makes possible to detach some manufacturing capability from the producing plant (where these resources have already been foreseen,see "A" factors).
Other possible infrastructural facilities (not included in the list for IC calculations) that could be usefully employed to reduce imported goods, are:

- electrical switch board assembling
- electrical installations wiring
- electric motor rewinding

Manufacturing equipment

A plant for food processing machinery manufacturing should be equipped with the main equipment described below- (see para 3.1 for detailed description of type of work and ref.4 pag.47 to 76 for more details).
It is to be noted that the following description states the type of equipment to be operated and not the number ,which can be fixed when total plant capacity has been established, on the basis of potential market and feasibility analysis.
Generally speaking, since production rates of food processing machinery will never be very high, it is to be supposed that a single equipment for each type of operation will be sufficient, except in the case of welding.

List of manufacturing equipment

Metal cutting (Ø1):
- -recirpcating saw,
- -circular saws
- -portable shear disk saws
- -3 mts guillotine shears for cutting sheets, up to 8 mms
- -bench shears for cutting profiles

bending,folding,etc.(Ø2):
- -3mts.sheet folding presses
- -2mts. roller presses up to 5 mm.thick
- -roll forming machines

riveting and threading(Ø3):
- -semi-automatic tube threaders
- -column threading drills
- -semi-automatic riveters

cold pressing(Ø4):
- -hydraulic presses, up to 200 tons
- -mechanical presses, up to 80 tons

welding(Ø7) :
- -oxyacetilene welding sets
- -metal-arc welding sets for various

types of steel,mainly stainless steel
- inert-gas shielded arc welding sets,with continuous wire feeding
- spot welders
- high frequency aluminium welders
- various manual turntables and benches
- motor-driven turn tables
- steel truss welding benches

horizontal lathes (Ø8):
- single-chuck horizontal spindle lathes of universal type, manually operated
- copying devices
- set of tools for various steel types
- high-precision small lathes, manually operated

surface planing and planing-milling (Ø12):
- universal rotary table surface grinders
- universal slotting machines

milling machines (Ø14):
- boring mills, max dia. 120 mm.
- universal milling machines.

drilling machines(Ø15):
- precision sensitive drills,max. dia.20 mm
- radial drilling machines,max.dia. 60 mm.
- multiple-spindle drilling machines
- portable electric drills

grinding and surface finishing(Ø18):
- universal grinding machines
- portable polishing machines

- pedal-operated grind-stone machines
- cylinder-grinding machines

auxiliary equipment (no reference to IC):

- 5 tons. bridge cranes
- 10 tons gantry cranes
- benches and turntables for welding
- miscellaneous hand tools
- fork-lift trucks
- tool-sharpening sets
- measuring and quality-control instruments
- benches and instrumentation for electrical testing
- jigs, masks,
- dies for forming,
- hydraulics and pneumatics testing benches

3.5 Personnel and mangement for manufacturing

Personnel qualification profiles can be grouped into three main functions:

- direct production
- supervision and management
- support and service

An increase in manufacturing complexity ,when passing from one development stage to the next (see para.3.3), corresponds to an increase in qualified personnel needs for each function, although in a differentiated way.
At the beginning, more direct production personnel qualification is requested, while ,at a certain development stage, more supervision , management, support and service personnel is needed.
These differentiated needs will be listed below; before, it is worthwhile making some general considerations about personnel training problems,particularly as far as integration between functions is concerned.

The first consideration refers to the difference that exists between level of individual training and level of collective training or know-how.
High individual training standards may quite easily be achieved by sending people, at various levels, to follow specialized courses and "stages" in the more developed countries. It can be achieved that single workers can master techniques or skills to accomplish manufacturing tasks; this is of great importance in the first development stage, where maintenance and repair, as well as "copying" of parts and components, involve individual skills in small workshops.
Only in the very first stage of development,there is a predominance of individual production skills; at the second stage collective skills (or organiza-

tional know-how) begins to be a determining factor in the small-scale plant management. There are obviously increasing difficulties in training people for higher level indirect functions, such as engineers,draughtsmen, technicians, sales responsibles, accountants and managers, but still a good individual level of education and skillness can be achieved.
What is much more difficult, and therefore time-consuming, is to reach a satisfactory level of collective training or, in other words, of organizational knowledge, which allows a plant to be profitably operated. This is the result of a high degree of integration between different skills ,which cannot be obtained by simply summing up individual skills, but requires a long-lasting process of assimilation, as any other "technology".
It could be assumed that the same principles of technological adaptation are applicable also to "soft-ware" techniques or know-how, such as industrial organization, training, engineering, etc. that have to be "redesigned" for less developed environments.

The second consideration refers to an important consequence of these assumptions: if a high degree of integration between different functions is requested,then training programmes should be "tailored" to different stage needs.
It is often observed how intensive and apparently well-designed training courses, held in the developed countries, has the only effect to stimulate emigration. This is particularly evident for higher qualification personnel, which encounter difficulties in finding a job at his own qualification level.
It also happens that direct production personnel,trained at foreign manufacturer's headquarters,finds so deeply different working conditions, when getting back to the country of origin, that learned skills cannot easily be turned into daily working practice.

Integration of skills with the ambient and between them is difficult,because training courses have been held in a so different socio-economic environment ,that only an "individual" assimilation, if any, has been attained.
Training courses should be held, when possible, in a socio-economic environment as similar as possible to the original country's conditions and should be "tailored" in such a way as to stimulate integration between skills and between functions.
This latter aspect should suggest to avoid any "general"supervision and management training courses,and to give preference to "specific" courses; for example managing a small maintenance workshop requires a completely different professional practice and psicological attitude, than managing a manufacturing plant, even if small.
For each function, personnel should be trained at a level which matches with the maximum cultural level of the area where it is going to operate.
An "adapted" training stimulates cultural assimilation and social integration between different functions.

The third consideration refers to a particular aspect of food processing machinery manufacturing. which has already been pointed out: the need for "accurate manufacturing".
It has been said that this is, more than a special skill, a mentality with which daily working practice is performed.
Probably, the only way to attain this mentality is to be progressively aware of the consequences in processing food , of any inaccuracy: machines are still working but processed food quality standards go down or are unacceptable.
It is the continuous interaction between the user and the manufacturer, that originates this "collective skill" for "accurate manufacturing".

Even if, probably, no special training course in "accurate manufacturing" would give good results from a practical point of view, maintenance and repair practice could be of great help.
Direct experience of failures and uncorrect operational modes is a very good training.
Other useful periodical training courses could be organized at food processing machinery users'plants, where correspondance between product quality and manufacturing accuracy can practically be shown.

Taking into account these recommandations, a basic training programme should match with the following needs, at different stages:

first stage:
- basic training of workers and artisans on simple mechanical skills and on assembling/disassembling procedures
- basic training on supervision and management of small workshops

second stage:
- specialized training on mechanical and electro-mechanical skills
- specialized training on assembling skills
- specialized training in semi-finished products manufacturing
- basic training on work organization, small plants management, administrative work, sales management etc.
- basic training for technicians and engineers

third stage:
- specialized training on management and supervision of small plants
- specialized training for engineers and technicians on engineering services, research and development

- specialized training on sales and marketing management

As it can be seen , direct production personnel is fully trained to cover qualification needs during the second stage, when an indipendent manufacturing could not yet be started.
This highly contributes to the creation of infrastructural capabilities during this stage, as a support for starting manufacturing industry, as outlined in para. 3.2.
During the third stage, indirect functions predominate and training of management and engineering skills are a key factor for the establishment of an indipendent manufacturing industry, if market demand is adequate.

The abovesaid training programme should be implemented to cover the following <u>specializations</u>:

<u>first stage</u>:
- welding of all types (steel and stainless steel)
- small-pieces artisanal casting
- simple machining
- metal sheet cutting
- metal sheet folding and forming
- pre-assembling and assembling of electrical , mechanical, hydraulic and pneumatic parts
- trouble-shooting and repairs in electro-mechanical machinery
- maintenance procedures and scheduling
- raw materials and spare-parts stock management

<u>second stage</u>:
- special welding techniques
- non-ferrous metal welding
- medium-pieces forging
- die castings
- mechanical machining (lathes,milling machines, drilling machines,grinding

machines, boring machines)
- cold forming and pressing of metal sheets
- large-pieces sheet folding
- dimensional measurements and quality control procedures
- electrical and electronic components and parts assembling
- hydraulic and pneumatic components and parts assembling
- heat and surface treatments
- utilities and supply maintenance and repairs
- general stock management
- workshop supervision
- production shediling
- production organization and control
- preventive maintenance sheduling
- administrative works and procedures
- sales and technical assistance
- technical staff jobs with intermediate educational level (high and technical schools)
- small firms management
- quality control planning

<u>third stage</u>:

- university-level education for science and management
- engineering specialists in various branches
- system analysts
- food processing technologists

- sales management and planning
- marketing management and planning
- sales agents
- technical assistance scheduling and management
- basic research and development operations

4 - CATALOGUE OF ADAPTED FOOD PROCESSING TECHNOLOGIES AND RELATED MACHINERY

4.1- Meat processing

4.2- Fruit and vegetable processing

4.3- Milk processing

4.4- Cereals processing

IMPORTANT : read the introductory notes before consulting the catalogue.

INTRODUCTORY NOTES TO THE CATALOGUE

Catalogue structure

- The catalogue has four sub-sectors : meat processing, fruit and vegetable processing, milk processing and cereals processing
- In each subsector, the indexing page provides the list of products and/or processes, which are described
- For each product or process, on the general remarks section, the general problems of product/process/sub-sector are discussed, with a survey on the most widely employed technologies; on the technology description section, adapted technologies are selected and described, often with the aid of a flow diagramme; on the machinery description section, general information of the relevant and most significant machinery, for each technology, is given, often with reference to some machinery manufacturing skills.
- Photographs, in some case, show typical examples of the described machines, (note that examples are selected among a limited sample of italian-made products and should be considered only as a typological aid to description, with out any other engagement).

Technology and machinery selection

- All technologies and machinery fits, unless specifically indicated, the selection criteria for adaptation, discussed on chap. 2.
- Technology and machinery descriptions have been kept as separate as possible, but in some case, technological aspects are added to machinery description, and vice-versa, when definition of process is strictly inter - connected with its practical application, and viceversa.

- Adapted technologies are selected among those widely employed, today or in the past, in the western countries; no special local technology has been considered.

- Adaptation is often obtained by "down-grading" more complex technologies (see para. 2.2); no "up-grading" of local techniques has been performed, because of lack of information and experience (other very interesting studies on the latter aspect of adaptation are currently being prepared).

- No quantitative complexity analysis (index of complexity) has been included in the catalogue; the index of complexity (IC) for a typical adapted machine has been calculated, as an example, on chap. 3.1; all machinery selected has IC approximately in the same range.

When using catalogue for food processing industry purposes note that

- This catalogue is not a food processing operation manual, nor a food processing engineering manual, but a consulting guide for selecting most widely employed adapted technologies and most significant related machinery.

- This catalogue is not designed for food processing specialists, but for engineers, technicians, economists, decision makers etc. of the less developed countries to help in taking decisions and actions on adapted technologies and in "opening the technological package" for food processing.

- The degree of technical information is very general, intended to supply overall reference data (working principles, processing alternatives, know-how recommandations etc.)

- No cost evaluation has been performed

- Machinery, common to several processes, is indicated in each process, making reference to the others

- Energy conservation and saving aspects for food processing operations are discussed on appendix I

- Some examples of small-sized food processing plant is given in appendix II; in the catalogue, capacity of processing lines is discussed when this aspect has connection with adaptation criteria

When using catalogue for capital goods manufacturing industry, note that :

- This catalogue supplies only a very rough reference to equipment and skill, needed to manufacture each machine; a much more detailed description of manufacturing equipment, skills, infrastructure etc. is given on chap. 3 for a typical adapted machine

- All basic machinery, selected and described in the catalogue, can be manufactured with the equipment listed on chap. 3, unless specifically indicated

- All components (such ad electric motors, ball bearings, hydraulics, pneumatics, electrical switches, etc.) must be imported, except some very special case of simple items to be produced locally

- All machinery, unless indicated, could be manufactured in the same factory, from a technical point of view (for general policies, market considerations etc. see chap. 3).

4.1 - MEAT PROCESSING

4.1 1 - SLAUGHTERING AND FRESH MEAT PREPARATION

4.1.1.1 General remarks

This is a subsector in which a very limited amount of developing in the processing technology has been carried out, also in many developed countries, where completely manual processes are still in operation.

However, since the process is, in principle, very simple and consists in purely physical (and mostly mechanical) operations, this does not affect very much the final quality of the products, if very stringent hygienical conditions are kept during processing.

As a consequence, meat processing technology can be considered very simple and assimilation is possible in the majority of developing countries, but hygienical condition standards strongly requires the employment of skilled personnel and adequate management.

Slaughtering and fresh meat preparation can be considered as a primary processing, intended for fresh meat market distribution and consumption, or for other meat preservation processing, such as meat canning or sausage making, that are referred to as secondary processing.

This subsector has many interrelations with the animal rearing methods and with the different aspects of meat and meat products marketing.

Dimensioning and location of slaughtering plants, and related economical feasibility analysis are highly affected by animal rearing conditions.

On the other hand, market requirements are the key factors in defining type of packaging and/or wrapping and the use of refrigerated storage and transportation.

These are the only possible complexity sources of the technological process; another source of complexity could be the automatization of internal transports and operations, but this is only required for large plants in high-wage environments.

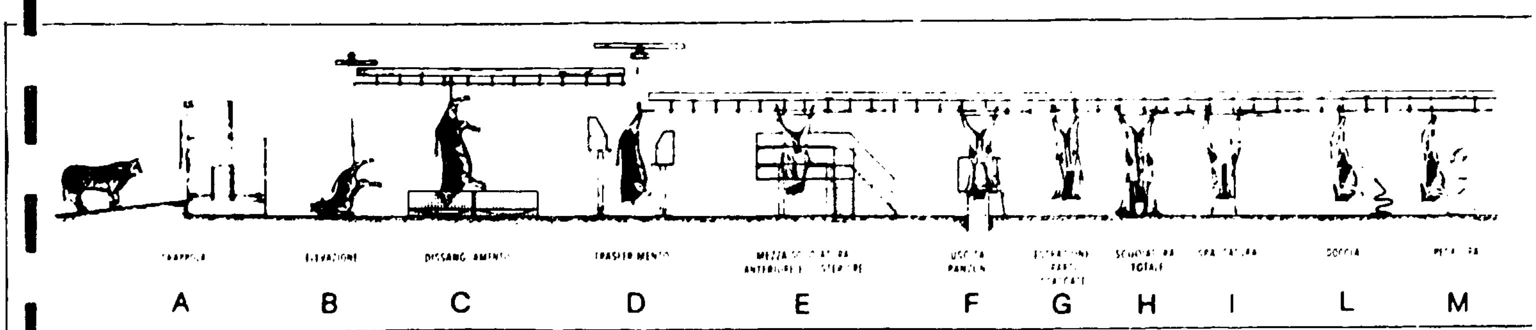


Fig. 4.1.1 - Cattle slaughtering line

4.1.1.2 TECHNOLOGY DESCRIPTION

4.1.1.2.1 Cattle slaughtering

The processing line starts with the animal slaughtering, performed in a special stall (A) called cattle trap, by means of a special pistol; the animal is then elevated by means of a crane in the "death field" (B), to be suspended to the overhead conveyor. This is in use in almost all modern abattoirs, along all the processing line, and is considered the unique basic automation, suggested also in the less developed countries, to maintain good hygienical conditions. Once the carcasse has been suspended, blood is drained and collected in a hopper (C).
The carcasse is then transferred, by means of a crane, to a lower-level conveyor (D) and posterior legs are divaricated, to be easily operated in the manual processing line.
Operations are, in sequence: front and back semi-skinning (E), stomach and offal removal (F), other separable parts removal (G), complete de-skinning (H), splitting into two parts along the spinal column (I).
The carcasses are then carefully washed (L) and final weighing completes the slaughtering process.
The normal production rate of a line, with manual operations, is in the range of 10 to 15 cattle/hour, with skilled personnel and management.
With automatic de-skinning and divarication, line production rate can be increased up to 20 to 30 cattle/hour.
Fully automatic operations can achieve a maximum production rate of 60 animal/hour.
A typical cattle slaughtering line is shown on Fig. 4.1.1.

4.1.1.2.2 Pig slaughtering

The processing line starts with the animal slaughtering, in the swine trap (A), after having stunned the animal with an electric device.
The pig carcasse is then elevated (B), by means of a conveyor ramp, to the overhead conveyor, and blood draining is then performed (C), (sections from A to C can be common to other animal slaughtering).
The carcasse is then lowered (D) to be scalded, depilated and subsequently finished (E), in a special pool.
The subsequent operations are manual, with the carcasse elevated again (F) to the overhead conveyor. In sequence, the following operations are performed: skin finishing (G), evisceration (H), other removable parts extraction (I), splitting into two parts (L), final washing (M). The line

ends with the carcasse weighing (N).
The normal production rate of a manually operated line is in the range of 30 to 50 pig/hour, with skilled personnel and management. By the use of semi-automatic conveyor ramps for elevation and dropping and of semi-automatic scalder transporter, production can be increased to 60 to 100 pig/hour.
Fully automatic lines can achieve a maximum production rate of 200 pig/hour.
A typical pig slaughtering line is shown on Fig. 4.1.2.

4.1.1.2.3 <u>Sheep slaughtering</u>

Sheep slaughtering process is very similar to cattle one. After bleeding, sheep carcasses are transferred to an inflating section, which enables skinning and flaying to be carried out with ease.
The subsequent operations are similar to those described for cattle.
Normal production rates are in the range of 20 to 30 sheep/hour, with manual operations and skilled personnel and management.

4.1.1.2.4 <u>Poultry slaughtering</u>

Poultry is normally slaughtered and processed on the same line; destination market requires a low temperature refrigeration and automatic or semi-automatic wrapping system, to assure good storage and conservation of the product.
The processing lines, available on the market, are automatic or semi-automatic lines, with high degree of complexity, capable of processing up to 400 chicken/hour-man.
If simpler technology is requested, this must be seeked in the type of installations in use some years ago, where many operations were performed manually, capable of processing 100 to 150 chicken/hour-man.
The processing technology includes the following sequence: high-voltage stunning, conveying belts, scalding tanks, plucking machines, evisceration, washing. A final refrigeration at - 5°C is performed by countercurrent chilling in water (or better in high-speed air freezing tunnels, to prevent water contamination by bacteria).

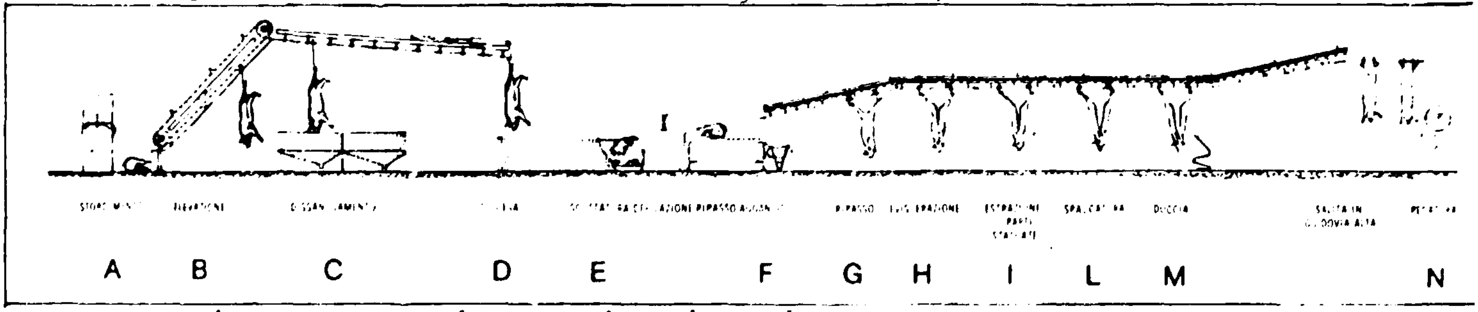


Fig. 4.1.2 - Pig slaughtering line

4.1.1.2.5 Butchery

All operations performed in the butchery halls are manually operated, also in many developed countries. Some tool can be used, such as saws, but in any case this machinery is manually operated.
Cutting and sectioning are the basic processes for fresh meat consumption, or for secondary treatment in meat processing plants.
Butchery can be operated at the end of the slaughtering line, but it is common practice to base the fresh meat market on small to medium-size butcheries, scattered around, to serve villages or town areas.
This is done also because short-period refrigerated meat preservation is easier in large pieces, such as halves or quarts.

4.1.1.2.6 Refrigeration and freezing

A certain amount of refrigeration is needed in the slaughtering process, to improve meat quality and hygienic conditions, as well as slaughterhouse's management.
The slaughterhouse processing chain, after the weighing operation, is physically extended to the cold storage units, whose correct handling is a decisive factor in the plant profitability.
Meat is refrigerated to a minimum temperature of - 5°C, to be then distributed to the market in refrigerated or isothermal trucks.
The use of freezing for long-term preservation is a very good system, probably one of the best way to preserve, keeping the most of nutritional value and product quality.
The equipment normally used is a continuous tunnel with air circulating at a speed of about 4 m/sec at a temperature of - 30°C.
Other methods employ metal plate freezing.
Freezing implies the use of relatively complex machines and, moreover, it requires that the complete market chain, from trucks to retail shops is equipped with very low temperature refrigerators.
This is unlikely to be foreseen in the less developed countries and therefore this technology is to be considered as unadapted.

4.1.1.3 MACHINERY DESCRIPTION

4.1.1.3.1 Overhead conveyor

The overhead conveyor has normally a capacity from 500 Kgs to 1200 Kgs per meter. It is built up of a main frame of steel profiles, which is normally suspended at the plant roof, which must be dimensioned for the exceeding charge. The sliding guide is built by curved or linear steel plate, suspended to the main frame by means of steel arms. The manufacturing is simple and all the assembling is done by welding.

Some complexity arises only in manufacturing two-way switches, (manually operated), where dimensional accuracy is an important factor in determining operational manoevra bility and maintenance.Steel anti-corrosion protection must be very accurate: best way is hot-zinc coating, but also adequate paint coating, with a frequent maintenance, could give good results.

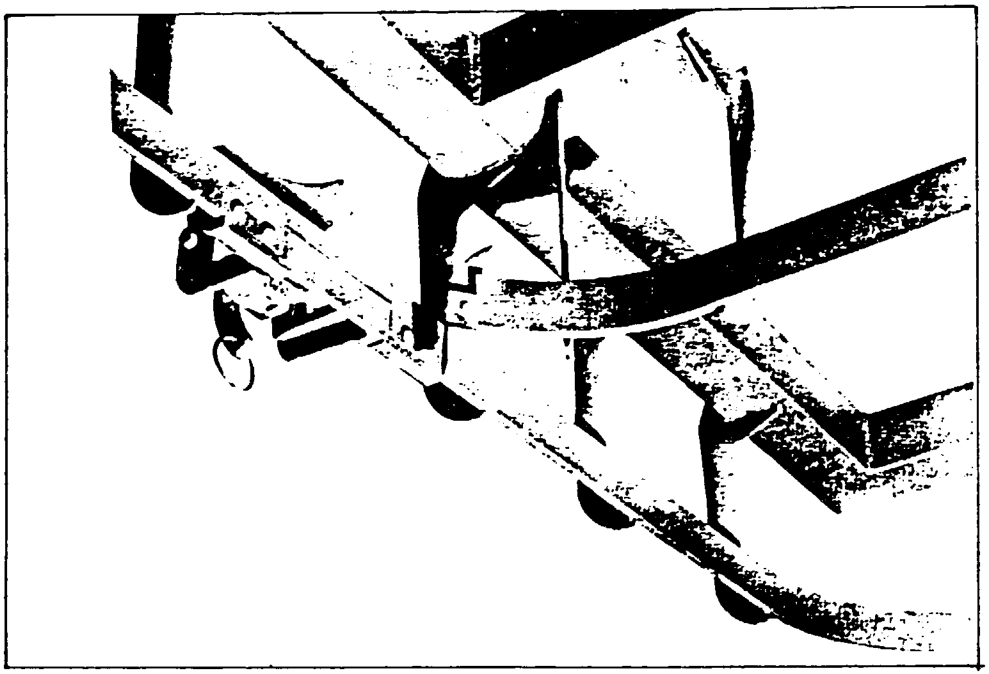


Fig. 4.1.3 - Overhead conveyor (courtesy of V.AR)

4.1.1.3.2 <u>Trap</u>

Cattle slaughtering and swine stunning are performed in a special stall, called swine or cattle trap.
The trap is composed by an access door, a guillotine for door control and a lateral door, manually or pneumatically operated, for stunned animal sorting.
All components should be in stainless steel, for ease of maintenance and corrosion resistance.
The trap is a very simple device, but manufacturing requires skilled stainless steel welding and sheet forming.
As a valid alternative, the trap can be manufactured by steel sheet and, when completed, hot zinc coated. This reduces manufacturing cost and gives good operational results, provided a good zinc coating is performed.

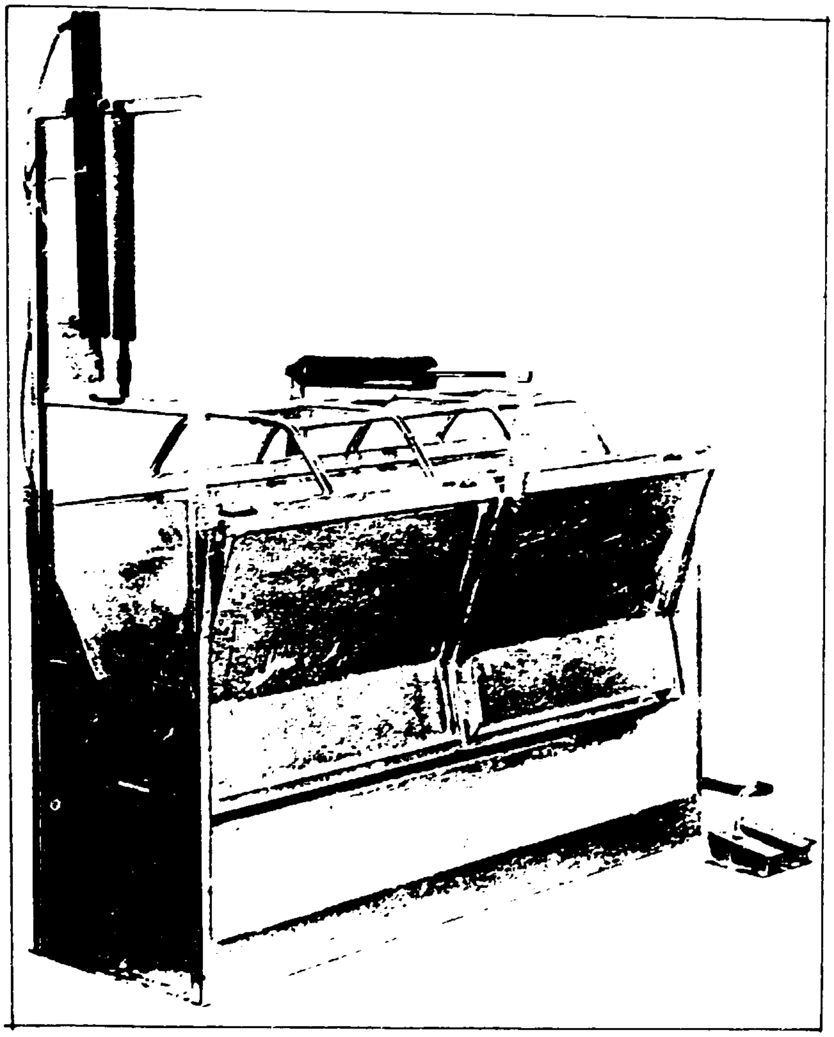


Fig. 4.1.4 - Swine stunning trap (courtesy of VAR)

4.1.1.3.3 "Death field" and transfer crane

The dead cattle must be suspended to the overhead conveyor, at the beginning of slaughtering process.
This is done by a device, consisting of a bridge crane with a steel profile frame, four wheels for crane deplacement, a reduction gear box in cast iron, directly coupled to an electric motor drive and to a rope roller.
Normal capacity is in the range of 1 ton.
This device has normally a remote control, by means of a pushbutton panel, with all electrical connections.
Steel protection is done by hot-zinc coating or paint coating.
Manufacturing of the steel frame requires skilled welders; the crane can be assembled using imported components.

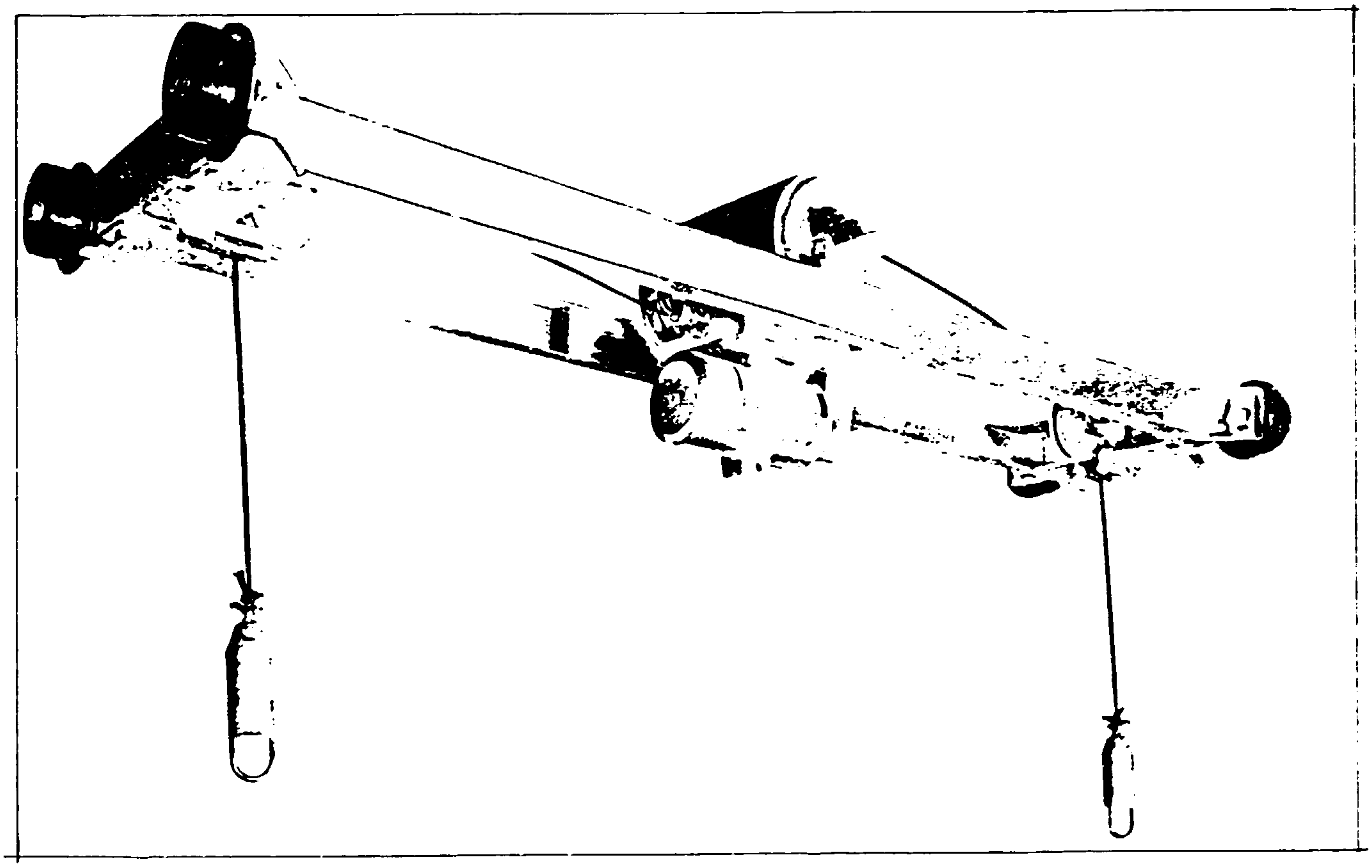


Fig. 4.1.5 - "Death field" crane (courtesy of VAR)

4.1.1.3.4 Service platforms

Along the slaughtering line, certain operations, such as de-skinning and posterior legs devarication, are to be performed with the operator standing on a platform. The platform is built of a supporting frame by welded steel profiles and steps and working area in zinc-plated grating.
Manufacturing requires only skilled welders.
Zinc-plated grating is a higher complexity item, since its manufacturing requires precision steel plate cutting and welding, that can be economically unfeasible.

4.1.1.3.5 Hoppers

Some processing operation, such as blood drainage and stomach removal, requires the use of collecting hoppers. The hopper is normally made out of a supporting stainless frame with stainless steel sheets for the side walls and collecting tank.
Manufacturing is simple and requires only skilled stainless steel welders.

4.1.1.3.6 Scales

Weighing can be performed by scaling devices, mechanically linked with a short section of the overhead conveyor track.
Scaling devices exist in many different versions, from very simple manual scales, to semi-automatic or electronic displaying and computing units.
At low processing rates, a mechanical scale is an adapted tool.

4.1.1.3.7 Ancillary equipment and tools

Along the whole processing lines, each operation requires the use of side platforms, chariots, gliding tables, discharging hoppers, charging platforms, etc.
All these equipments are normally made by stainless steel sheet, with a supporting zinc-coated steel frame.
Manufacturing is very simple; a very careful attention is to be put on steel protection, because of the very hard corrosion environment.
All tools are made by stainless steel.
Pistols, cartridges, electric stunners should be imported.

4.1.1.3.8 Pig scalding tank

The tank is made by a main paint-coated steel profile frame and by thick steel sheet side walls.
Assembling is made by welding parts together.
Inside the tank, a tube nest heat exchanger provides heating (normally by steam) to the scalding water, where pig is laid down by means of a manually or pneumatically operated lowering arm, connected with the aerial conveyor.
Normal dimensions of the scalding tank are 3.00 mts by 1.70 mts by 0.95 mts (height).
The extraction of the scalded pig is done by means of a comb extractor, made of zinc-coated steel, manually or pneumatically operated.
The manufacturing of the scalding tank requires skilled welders and an accurate assembling of the heat exchanger.

4.1.1.3.9 Depilating machine

Pig depilation, after scalding, can be done manually (by special brushes) or using a depilating machine, that can be classified as an intermediate complexity device.
The main frame is made by tubular steel profiles, assembled by welding, with steel sheet side walls.
All steel is hot-zinc coated.
The pig supporting cradle is made by welded tubular steel profiles, suspended to the side walls.
The depilation is done by grasping teeth and rubber brushes, that deplace the pig body, while depilating it.
The brush supporting roller is made by cast iron, with steel driving shaft.
The machine is completed by control and driving mechanisms, such as electric motors, pneumatic actuators, valves, side plastic protections, water feeding pipes, etc.
Finishing is always done manually and is normally performed on a roller table at the output of the depilating machine; this table has a main frame of zinc-coated steel profiles and upper steel rollers with side ball bearings.
Manufacturing of the depilating machine requires accurate steel plate cutting, skilled welders, trained machine tool operators, an accurate mechanical and electrical assembling and cast iron forming.
All electrical and mechanical components, such as motors, controlling devices, pumps, piping and connections, ball bearings etc. are to be imported.

4.1.1.3.10 Utilities

A slaughtering line, as described before, is to be supplied with water, steam and electric power. Manufacturing of the equipment for power and fluids generation and distribution is not foreseenable in many developing countries and be imported. (see Appendix I for more details on energy saving and supplying in food processing operations).

4.1.1.3.11 Poultry processing line

A poultry processing line can be classified as intermediate to complex machinery, whose manufacturing is foreseenable in many developing countries.
Killing is done by mechanically-operated knives that are inserted at the connection of spinal column.
Bleeling is done in stainless steel hoppers, while animal is being transferred to next line stations.
A scalding tank is provided, with hot water, to ease subsequent plucking.
Plucking is done by revolving rubber rolls, with fingers protrudings and is completed, for high quality standards, by a singeing in gas flame chamber.
Evisceration is done manually by special knives, and inspection must be performed on eviscerated part, to check bird for wealthy human consumption.
A final chilled water bath allows birds to be cooled to about 3°C for final wrapping and refrigerated warehouse storing.
These lines process about 300 to 450 chicken/hour and have a high degree of automatization in operations.
High output rates and automatic operation suggest that this line should not be employed as an adapted machine; down-grading of poultry lines is very difficult, because of the high integration between components.
Alternatively, entirely manual butchery tables, except a plucking machine, can assure a very simple processing, at a maximum output rate of 30 to 50 chicken/hour.

4.1.1.3.12 Butchery tables

Preparation of meat for secondary processing or for fresh meat consumption is done by entirely manual operations on butchery tables.
Butchery tables have a zinc-coated steel structure and a stainless steel plane, to keep hygienic conditions to the best.
An improvement is the mechanizazion of the central strip of the table plane, to be used as a conveying belt for meat pieces.

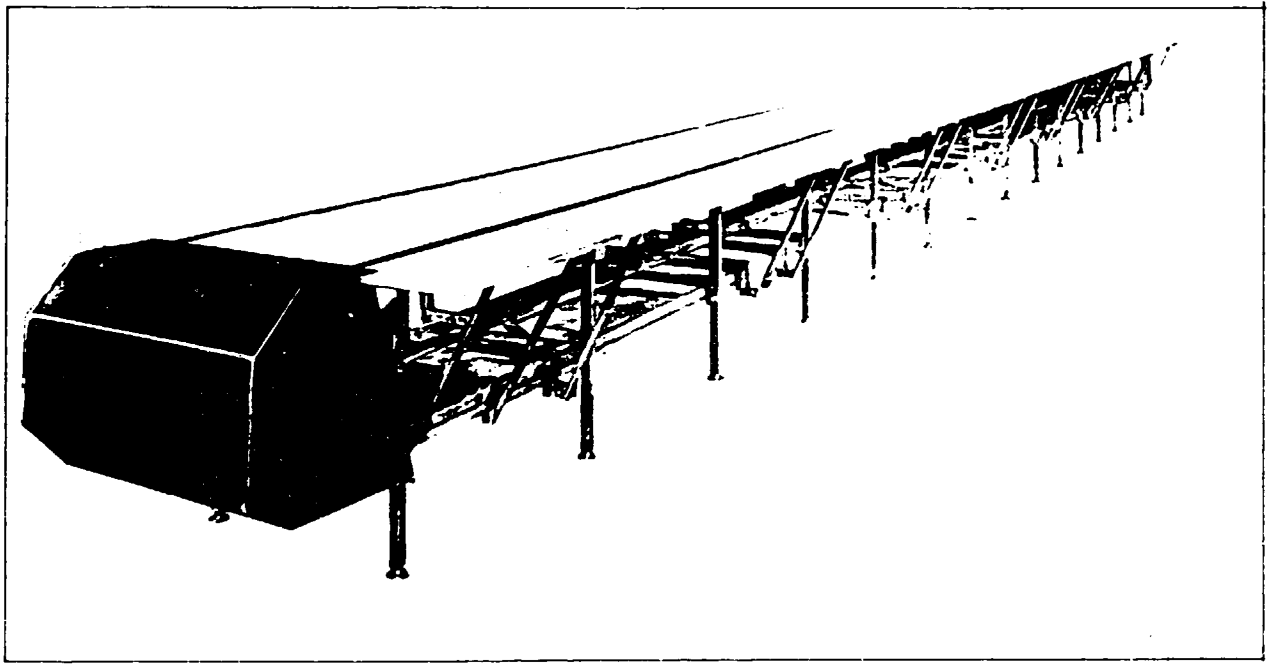


Fig. 4.1.6 - A typical butchery table (courtesy of Var)

4.1.1.3.13 Refrigerated storage

Profitability of a slaughterhouse may be improved by the use of refrigerated storage rooms.
The use of a refrigerated storage gives better quality meats in better hygienic conditions.
However, the design of refrigerated storages requires good engineering capability and high investments, which may be economically justified only after a careful techno-economic feasibility analysis.
A great part of the investment relates to the building costs; building technology for refrigerated stores is

more complex than for usual industrial building of good design and employs insulating materials not easily available in developing countries.
Moreover, machinery for cooling fluids generation and cell heat exchanger are complex items and manufacturing is not foreseenable in many developing countries.
An opportunity for these countries might be the assembly of imported machinery parts and the manufacturing, under licence, of steel frames and distribution piping.
Just for reference, a refrigerated storage unit must be equipped with the following main machinery (freon type):

- n° 2 freon refrigeration compressors, having the nominal refrigerating capacity of the unit
- n° 2 electric motors for compressors driving complete controlling unit for refrigerating system, with pressure and vacuum gages, indicators, electric switches etc.
- n° 1 freon condenser with cylindrical tube nest, water or air cooled
- n° 1 freon separator for liquid freon feeding to pumps
- n° 1 freon pumping station, with two electrically driven centrifugal pumps, equipped with all temperature and pressure controlling devices and valves
- n° 1 evaporating battery in each refrigerated cell, with electrically driven circulation fans, defreezing device, control and safety devices
- complete piping, valves, controlling devices, safety blocks etc. for freon distribution system.

All the abovesaid machinery can be classified as complex or very complex and requires a high degree of engineering and manufacturing capability.

4.1.2 MEAT PRESERVES

4.1.2.1 General remarks

Depending on country nutritional habits and climate, different meat preserving systems have been developed.
The processes suitable to be industrialized are:

- salting
- smoking
- thermal treatments
- sausage making (spice curing)

Salting and smoking have a very limited diffusion and have never reached the full industrial operation, probably because of the changes they induce on aspect, taste and quality of food, thus giving a meat accepted only in limited areas.
Technologies employed for meat salting and/or smoking are normally artisanal and entirely manually operated; it is a subsector where research should be made to improve product quality and to develop fully industrial techniques.
The main advantage of salting and smoking and smoking techniques are the long shelf life and the fact that meat does not require special packaging to be kept in storage.
At the present time, thermal treatments and sausage making are the most widely employed preservation methods.
These methods have a long historical background in many countries and the processes vary very much, following the different nutritional habits, but, generally speaking, the technologies employed are very similar and, except the case of mechanized large factories, the machinery employed can be classified as simple.

4.1.2.2 Technology description

4.1.2.2.1 Canned meats

Meat cutting, deboning and preparation are normally performed manually, as final operations of the slaughtering process, or in the plant reception butchery department, if meat processing is performed in a different plant.
These operations are performed using special manual tools, on specially built butchery tables, and require very skilled personnel.
Meat cooking can be done by laying meat pieces into metallic cages, submersed in hot water.
Water is heated into steel pans, with double walls and

steam circulation.
As an alternative, meat can be cooked by direct steam heating into stainless steel autoclaves.
Meat is laid down into circular metallic containers, stacked in a cage to ease handling.
After cooking, liquid part is discharged into reserve tanks; cooked meat is extracted from autoclaves and con tainers are sent to cooling chain.
Cooling is needed to make meat more compact for later processing.
Cutting into pieces or portions is normally done manually, because a mixing between different parts is normally requested.
Meat is finally put into tin cans and liquid part, jelly or gravy, is added.
A good technique is to fill cans with liquid under vacuum conditions, to obtain a rapid mixing of meat with filling liquid; otherwise, a normal level filler can be used.
Cans are then sealed in the seaming machine, that can be automatically or manually operated.
Sealed cans are sent to the sterilizing tunnel or autoclave, where sterilization process takes place for about 40 minutes.
After sterilization, cans are cooled and labelled, if requested.
Final packing may complete the process.
A typical meat processing technology flow-diagram is shown on Fig. 4.1.7.

FIG. 4.1.7 - TYPICAL MEAT PROCESSING TECHNOLOGY FLOW-DIAGRAMM

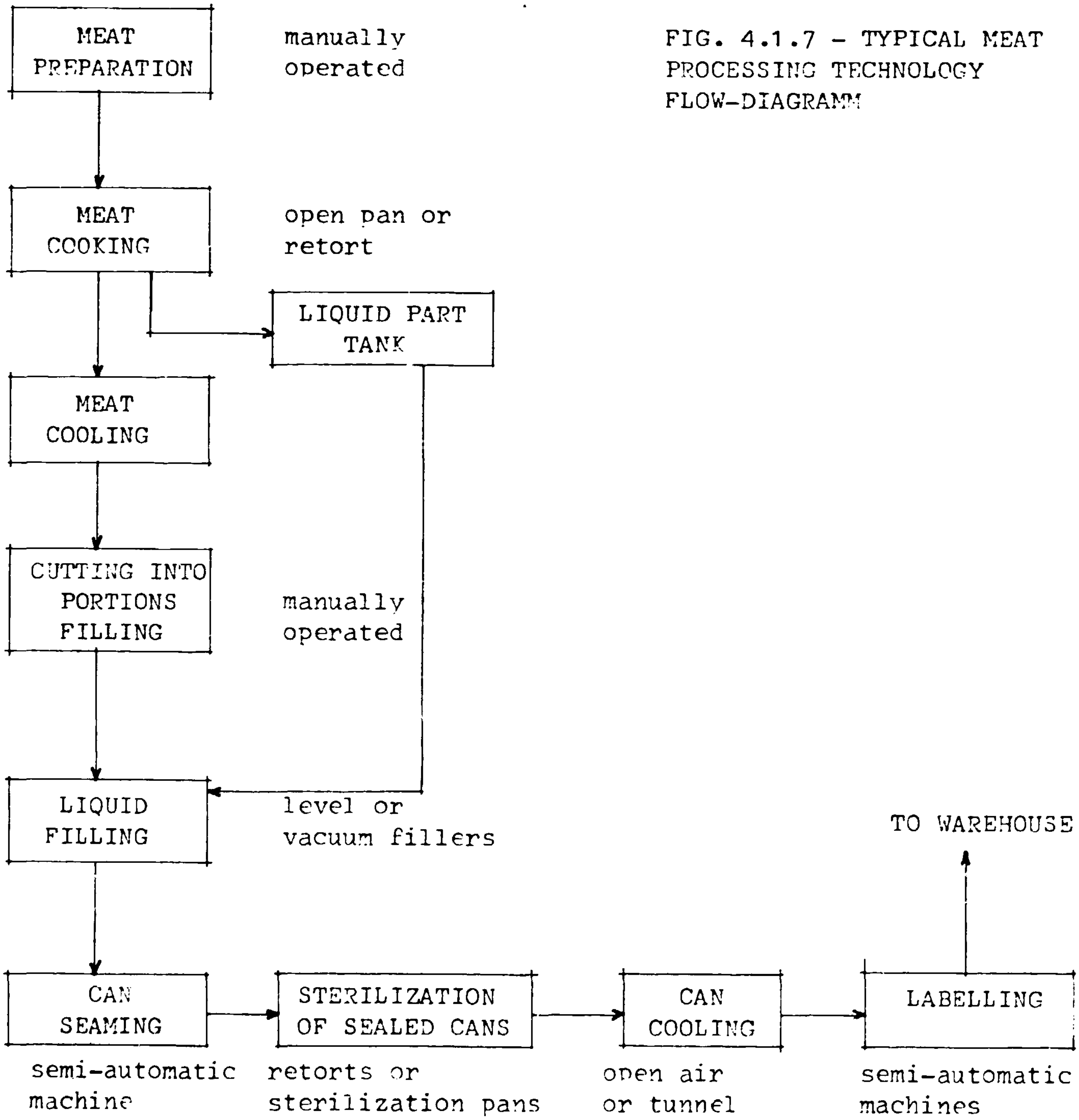
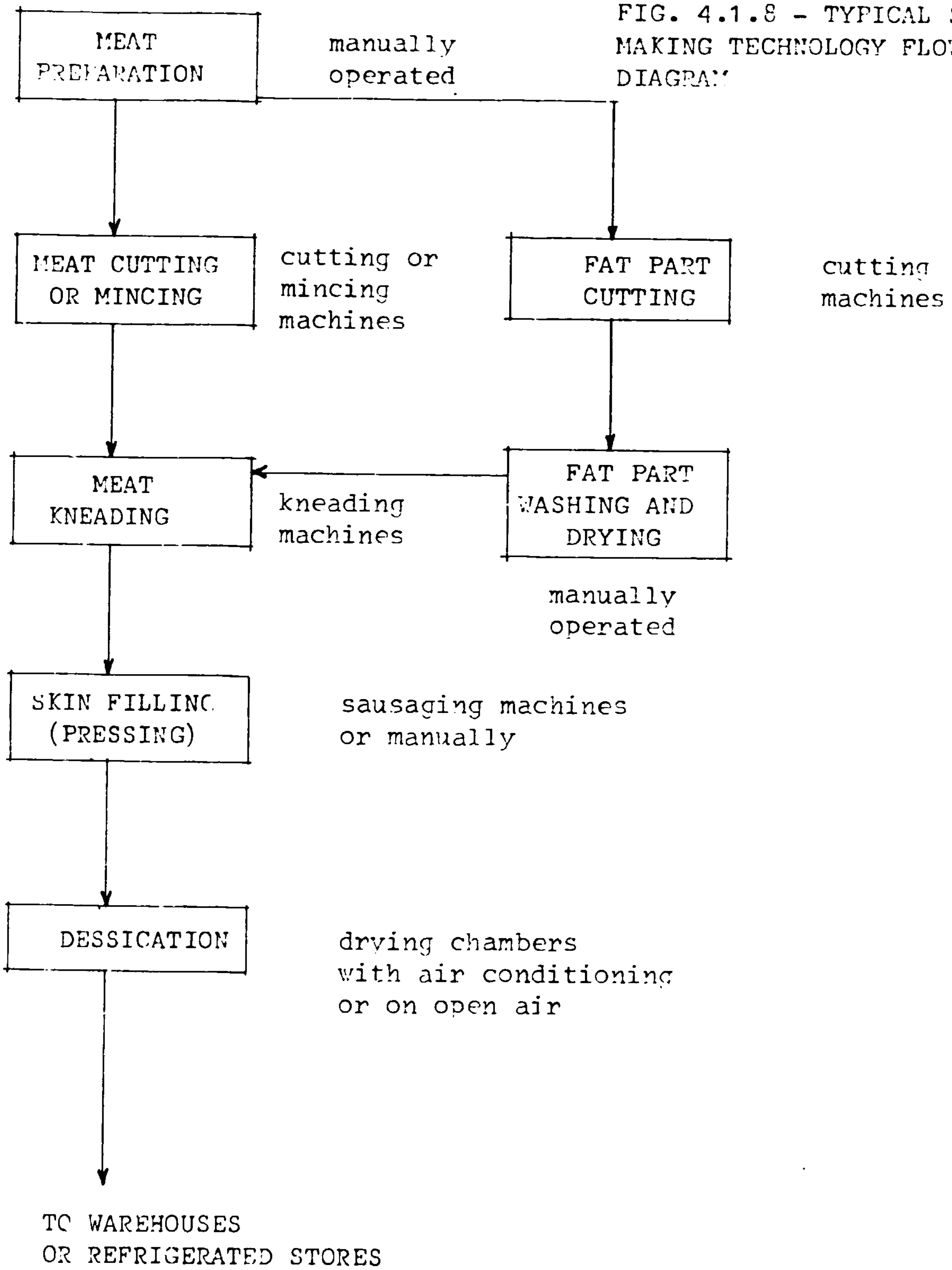


FIG. 4.1.8 - TYPICAL SAUSAGE MAKING TECHNOLOGY FLOW-DIAGRAM



4.1.2.2.2 Sausage making

During centuries, so many types of sausage making techniques have been developed, that a general description is impossible.

As a general rule, sausages can be classified into cooked meat sausages and cured uncooked products.

In both cases, conservation is due to the chemical action of curing ingredients, such as salt, sugar, pepper and aromatic spices in general; an important role is played by innocuous microorganism, specifically cultured for each specific product.

Additives are sometimes employed, such as nitrites, ascorbic acid, phosphates etc.

The most widely employed technology starts from the pork meat as raw material, leading to a final product,packed into natural or artificial skin, called "salami" or equivalent.

This is an uncooked pork meat mix, cured with salt and spices, with a medium shell life, if adequately stored.

Semi-manual technologies, with the use of simple machinery, are widely in operation in many small-scale plants in developed, as in developing, countries.

It is to be pointed out that know-how and skill of the operators is much more important, in obtaining good quality and long-lasting products, than the technology or the machinery used.

A typical technology starts from cutting the pork meat cuts into smaller pieces, using cutting or mincing machines. The fineness depends on the type of product.

Fat parts are also cut into small pieces, and then washed and dried in cutting-drying machines.

Preserving and curing agents are then added; meat and fat parts are then mixed and homogenized by means of kneading machines.

Perfectly mixed mass is then pressed into skin tube bags; this operation can be done at the sausaging machine or by hand, carefully checking that skin is completely and uniformely filled up; skin is then sealed by a rope and sent to the drying chamber.

In the traditional technology dessication and curing should proceed naturally for months, but industrial techniques have obviously shortened this period using conditioned chambers, where temperature and humidity are ciclically varied, to obtain sausage core dessication and curing in about 20 to 30 days.

A typical sausage making technology is shown in the flow-diagram of Fig. 4.1.8.

4.1.2.3 Machinery description

4.1.2.3.1 Cooking pans

For cooking meat, the simplest technology uses open pans with double bottom walls for steam circulation. These pans are basically made by formed sheets of stainless steel, supported by a main frame in tubular steel profiles, or, more often, in cast iron.
The machine, in itself, is very simple; the only possible problem can arise from the fact that bottom walls are to be steam-tight and pressure tested; therefore very skilled welding is to be employed.
Assembling procedure of the machine is very simple and few rotating parts can be manufactured at precision machine tools or imported.
An example of cooking pan is shown on Fig. 4.1.9

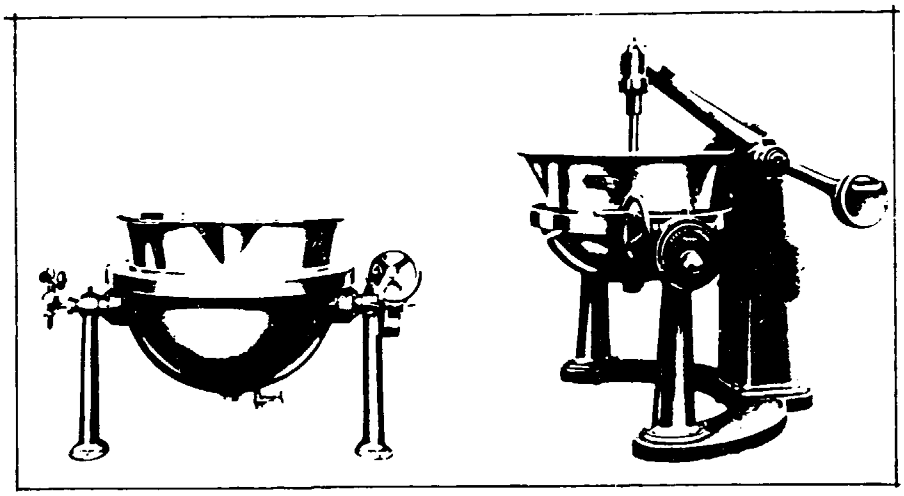


Fig. 4.1.9 - Typical double-bottom steam-heated cooking pans, with and without mixing arm (courtesy of Luciani)

4.1.2.3.2 Liquid filling and seaming machine

Normally, meat canning is performed in a manual way, since the automatic process would imply complex handling machinery. After this operation, filling liquid or gravy is added by means of a dosing and filling machine, which is usually coupled with the seaming head, that seals the can.
A more complex technology implies the use of vacuum automatic filling machine, that gives better results and increases the operating capacity, but is a more complex device.

The dosing-seaming machine is an intermediate complexity device, with some complex driving mechanism, such as the turning seaming head.
The machine body has a main cast iron structure with some steel arm to support operating parts.
All mechanical parts are manufactured by precision machining, with some forged component.
Containers and liquid tanks are stainless steel sheets.
Electrical motor drive and electromechanical control mechanisms complete the machine.
The whole design manufacturing requires very skilled workers and, moreover, a certain amount of engineering and manufacturing know-how.
A machine of this type can handle cans up to one liter, at a rate of 2000 cans/hour.
A simpler solution can be the use of semi-automatic single can seaming machine, whose hourly capacity is determined by the operator (in the range of 200 cans/hour).
These machines are simpler, as far as maintenance and manufacturing are concerned, because the only complex part is the seaming head, driven by a pedal.
Main body structure is a large iron casting.
Other operations needed are precision machining and stainless steel sheet forming.
A typical semi-automatic seaming machine, with a pedal operated can raising, is shown on Fig. 4.1.11.
A filling-seaming machine, with automatically operated seaming heads, is shown on Fig. 4.1.10.

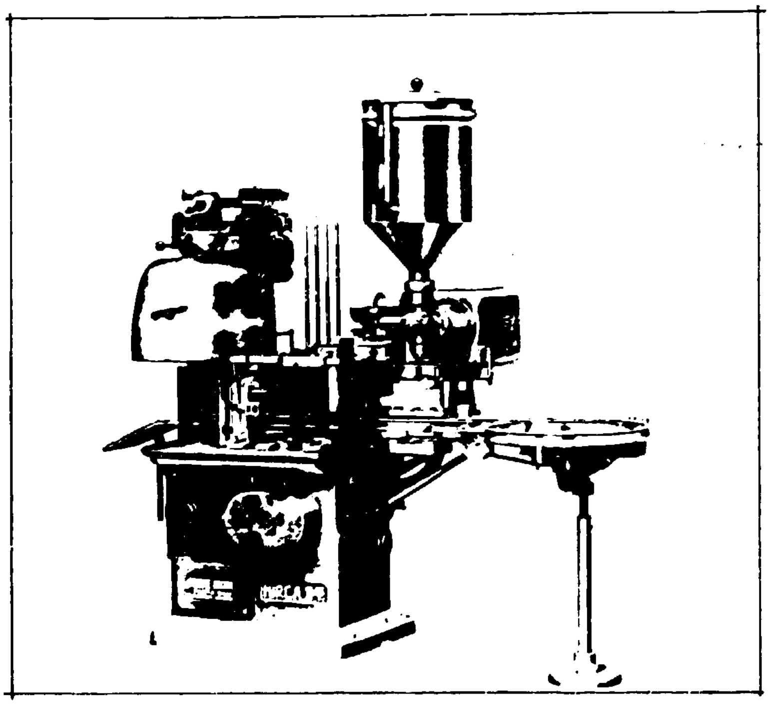


Fig. 4.1.10 - Typical dosing-seaming machine, automatically operated seaming head (courtesy of Luciani)

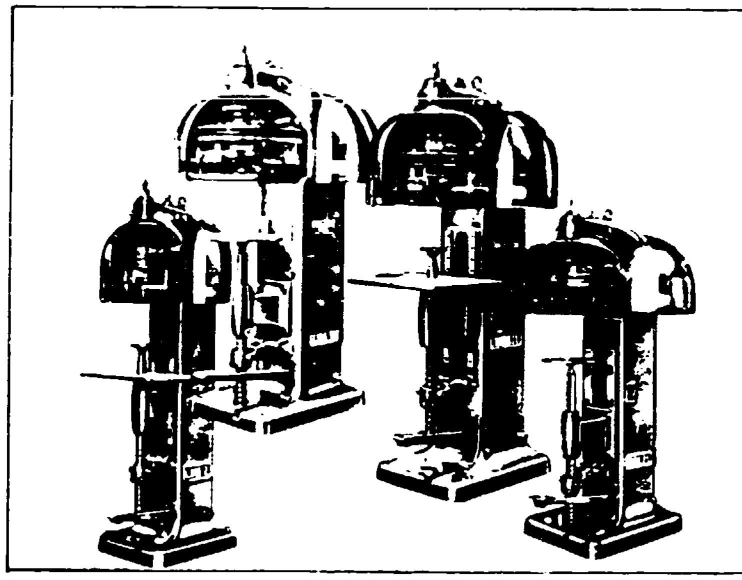


Fig. 4.1.11 - Typical semi-automatic seaming machines, with pedal-operated can raising (courtesy of Luciani)

4.1.2.3.3 Sterilization autoclave

Can sterilization can be performed in continuous tunnels of high capacity, but a simpler system employs batch-operated sterilization autoclaves. Cans are put inside into baskets or circular cages, depending on the type of autoclave (horizontal or vertical).
The heating fluid is steam, so the body must sustain high pressure.
The body is built by a thick metal sheet (normally stainless steel), curved and welded by very skilled certified welders and must be pressure tested.
Piping, valves, outlets etc. must be pressure tested and are welded to the main body; the front or upper door has to have a steam tight sealing.
Temperature control devices, as well as security gages, are of great importance.
The machine, in itself, is not complex, but severe pressure and temperature working conditions suggest the use of very wareful welding and checking procedures.
A typical example of sterilization horizontal and vertical retorts is shown on Fig. 4.1.12

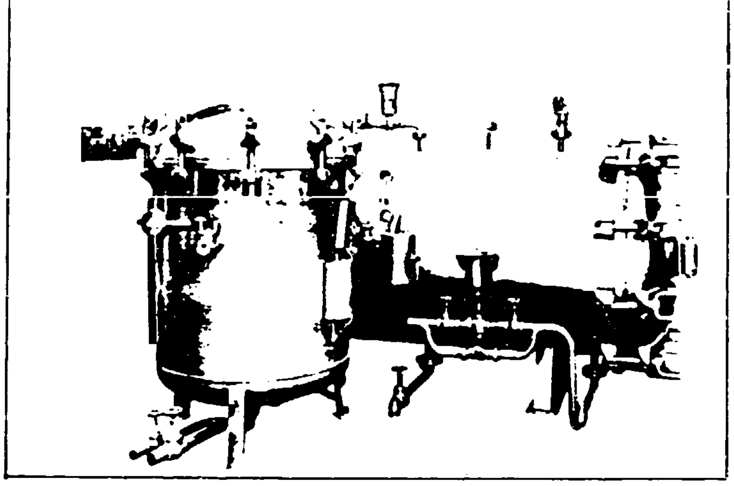


Fig. 4.1.12 - Typical sterilization retorts, vertical and horizontal type (courtesy of Luciani)

4.1.2.3.4 <u>Meat cutter and mincer</u>

Meat cutting for sausage preparation is done into a rotating blade extruder, where meat pieces are forced to pass through by a rotating worm-screw or a blade conveyor.
The machine has a very high power motor drive (about 50 Kw for a capacity of 400 Kgs/hour), because the process has a high mechanical energy consumption.
Machine body is made by stainless or painted steel sheets, with a main steel profile frame, that support electric motor drive, reduction gear box and mechanical transmission.
All internal parts are of stainless steel.
From the manufacturing point of view, all parts are to be precision machined and must be well dimensioned because of the relatively heavy duty.
The machine must be well engineered to allow simple opening and cleaning of all parts which get in touch with meat.
A typical mincing machine is shown on Fig. 4.1.13.

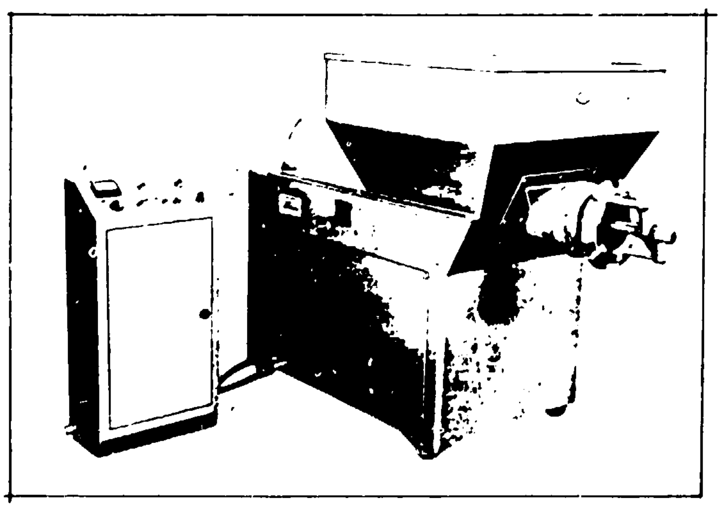


Fig. 4.1.13 - Mincing machine for sausage making (courtesy of VAR)

4.1.2.3.5 Meat kneading machine

This machine has the function of homogeinizing the mass of minced meat with fat part and additives.
The capacity varies from 50 lts. to 300 lts., depending on type of sausage and production scale.
This machine works by rotating blades, that kneads and press the meat mass.
The kneaded meat is taken out at the bottom, by a special door.
Technology is very simple; the machine is made out of a cast iron or welded steel supporting body, with the kneading chest and rotating blades in stainless steel.
Motor drive and reduction gear can be externally mounted, as it is shown on Fig. 4.1.14.

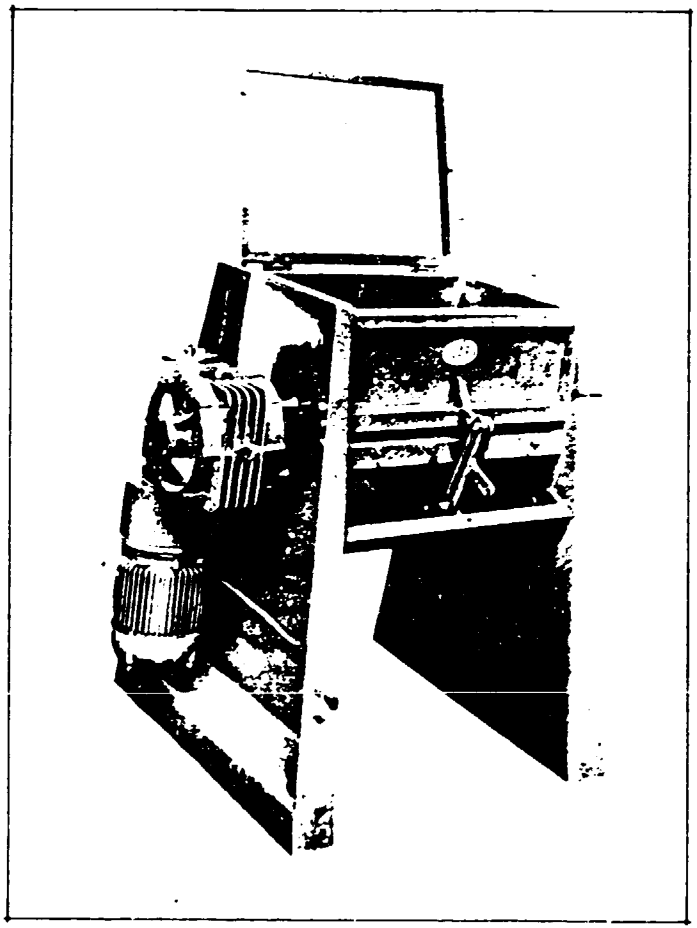


Fig. 4.1.14 - Typical meat kneading machine for sausage making (courtesy of VAR)

4.2 FRUIT AND VEGETABLE PROCESSING

4.2.1 Fruit and vegetable preserves

4.2.1.1 General remarks

4.2.1.2 Technology description

- 4.2.1.2.1 Fresh fruit canning
- 4.2.1.2.2 Fresh vegetable canning
- 4.2.1.2.3 Fruit and vegetable dehydration
- 4.2.1.2.4 Dry vegetable rehydration and canning
- 4.2.1.2.5 Pulps and juices preparation

4.2.1.3 Machinery description

- 4.2.1.3.1 Washing machines
- 4.2.1.3.2 Stoning machines
- 4.2.1.3.3 Peeling-scrubbing machines
- 4.2.1.3.4 Slicing-cutting machines
- 4.2.1.3.5 Crushing-grinding or juice extraction machines
- 4.2.1.3.6 Cooking, blanching, scalding machines
- 4.2.1.3.7 Pulping-refining machines
- 4.2.1.3.8 Deaerating vacuum tanks
- 4.2.1.3.9 Pasteurizing heat exchangers
- 4.2.1.3.10 Can filling machines
- 4.2.1.3.11 Seaming machines
- 4.2.1.3.12 Can sterilization pans and retorts
- 4.2.1.3.13 Cooling tunnels
- 4.2.1.3.14 Labelling machines
- 4.2.1.3.15 Vegetable dehydration ovens
- 4.2.1.3.16 Steam generators
- 4.2.1.3.17 Pumps and piping
- 4.2.1.3.18 Tanks and containers

4.2.2 Concentrates

4.2.2.1 General remarks

4.2.2.2 Technology description

- 4.2.2.2.1 Tomato concentrate
- 4.2.2.2.2 Citrus juice concentrate

4.2.2.3 Machinery description

- 4.2.2.3.1 Flume transport
- 4.2.2.3.2 Washing machines
- 4.2.2.3.3 Chopping machines
- 4.2.2.3.4 Pre-heaters
- 4.2.2.3.5 Refining machines
- 4.2.2.3.6 Vacuum kettle concentrators
- 4.2.2.3.7 Sterilizing heat exchangers
- 4.2.2.3.8 Dosing-filling machines
- 4.2.2.3.9 Seaming machines
- 4.2.2.3.10 Can sterilizing and cooling tunnels
- 4.2.2.3.11 Continuous multiple-effect vacuum concentration plants

4.2.1 FRUIT AND VEGETABLE PRESERVES

4.2.1.1 General remarks

During centuries, in different countries, a very vast range of processing system has been developed, to fulfill local nutritional habits.
Furthermore, this subsector is perhaps the most rich in terms of varieties, both in tropical or temperate areas, whichcan be processed.
Many of these processes have been developed only for a given fruit or vegetable and therefore require the use of very specialized machinery, if handling is done automatically or semi-automatically.
Nevertheless, if adapted technologies are dealt with, and handling and preparation are done mostly by hand or be very simple machines, then the further processing,intended to preserve fruits and vegetables for a long time, has many common aspects and can be performed by the use of some basic and common machinery.
The most widely used preserving system is canning of fresh fruit and vegetable, in natural state or with some syrup or sauce adding.
Another system, widely employed in the past, that could give good results, if adequately industrialized, is fruit and vegetable dehydration.
Since, in the majority of cases, fruit and vegetable are very perishable items, processing has to take place within a very limited amount of time after harvesting; this implies that the processing system can operate at full capacity only for a limited period during the year.
For these reasons, since, as said before, the preserving process has many common aspects, integrated canneries have been developed, where many fruits and vegetables can be processed, in different periods of the year.
These canneries are probably the best economical approach for small production rates (up to a maximum of 1 ton per hour); preparation of raw materials is done by specialized machinery or by hand, and then the preserving process uses the same line.
In describing (in the next paragraphs) the processing technologies for some of the most widely available fruits and vegetables, the possible integration between different processes will be taken into consideration.
An integrated cannery should have the capability of producing also fruit (and vegetable) juices and pulps, in natural state.

Except in the very special case of tomato, which will be considered separately, no concentration is normally needed, for domestic market distribution.
In fact, concentration of fruit juices is a very delicate process and, to achieve good quality results, complex double-effect continuous concentration under vacuum should be used.
Except this case, all other machinery is simple or very simple; complexities are only caused by the need to automatize preparation and handling operations, that begins to be economically convenient only for very high production rates, which are out of the production range of the described and adapted technologies.
In appendix II, technical performance and cost figures of an integrated cannery are evaluated.

4.2.1.2 TECHNOLOGY DESCRIPTION

4.2.1.2.1 Fresh fruit canning

This technological process can be used to prepare for canning any type of fruit, from tropical or temperate climate areas.

In general, fruit has to be discharged from the harvesting container by hand into the first selection line.

The selection is always done by hand; automatic selection can only be operated for certain type of fruit,such as apples or oranges, but machinery is very sophisticated.

After selection, washing is performed, normally in cold water, by means of washing machines; except some special case (such as pineapple and other tropical fruits),these machines can be used for a wide range of fruits.

Many fruits have a stone to be removed; destoning is normally operated in semi-automatic machines, with manual handling.

In some case, blanching is requested, and is done in a blanching machine, which is used also for vegetable processing.

Some fruit requires to be sliced or divided into halves, before canning: this is normally done by semi-automatic slicers, manually operated and filled.

Can filling of fruit is normally done by hand, because of the necessary adjustment of the fruit slices or halves into the can.

Syrup or other preserving liquid is then added, using a volumetric filling machine; overflow or level filler could also be used.

Some fruit requires a pre-heating, which can be performed in a steam tunnel, with cans over a shifting net.

Seaming is done with a non-rotating can semi-automatic seamer, manually filled and operated; sealed cans are then sterilized; this operation can be performed in steam retorts or in open hot-water boilers, depending on the type of fruit to be processed and corresponding acidity level.

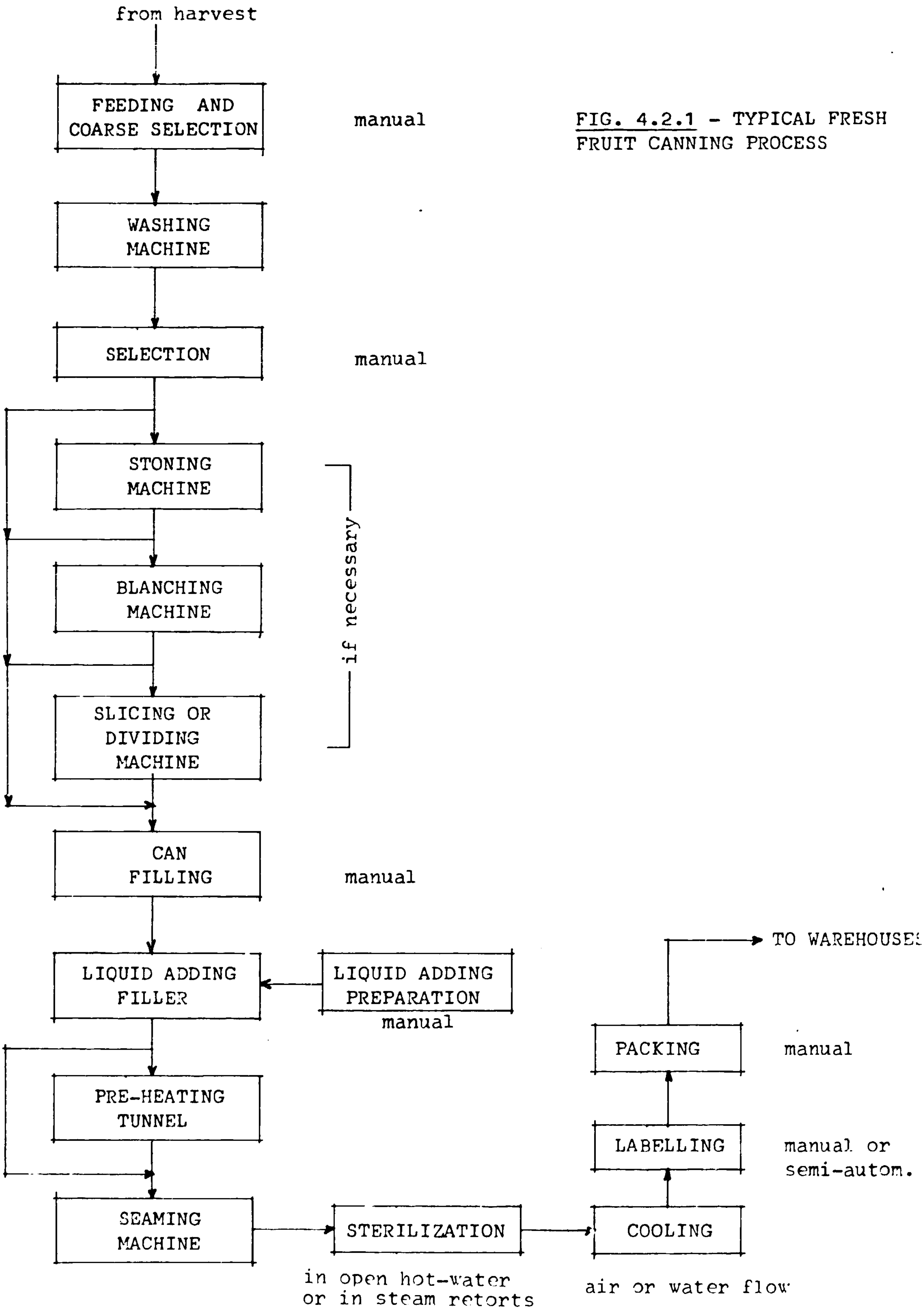
For pH more than 4.6, products are to be sterilized in retorts at temperature of more than 100°C.

Pineapple slices, for example, can be sterilized in an open hot-water boiler. Can cooling can be obtained by simply exposing it to air or using more complex water refrigerating tunnels.

Water flow cooling is obviously more rapid, but can micro pore contamination is possible and water shall be chlorinated.

This operation is not simple and open air cooling is always preferred, for an adapted technology.
Labelling can be obtained with manual or semi-automatic operations.
Final packing of cans is normally manually-operated.
Syrup is prepared by soluting sugar in depurated water and stirring it manually in a stainless steel container.
As it can be seen, adapted fruit canning technology is very simple and can be easily operated with simple and semi-automatic machinery; final product quality and hygienical conditions depend obviously on management and operational know-how.
This technology can be employed up to a maximum capacity of 800+1000 Kgs per hour.
At higher rates, a certain mechanization is to be introduced, thus making machinery technology more complex.
With the exception of some completely automatic fruit selecting and sorting equipment, fruit canning technology is at simple to intermediate complexity level.
A typical fresh fruit canning process is outlined in the flow-diagram of Fig. 4.2.1.

FIG. 4.2.1 - TYPICAL FRESH FRUIT CANNING PROCESS



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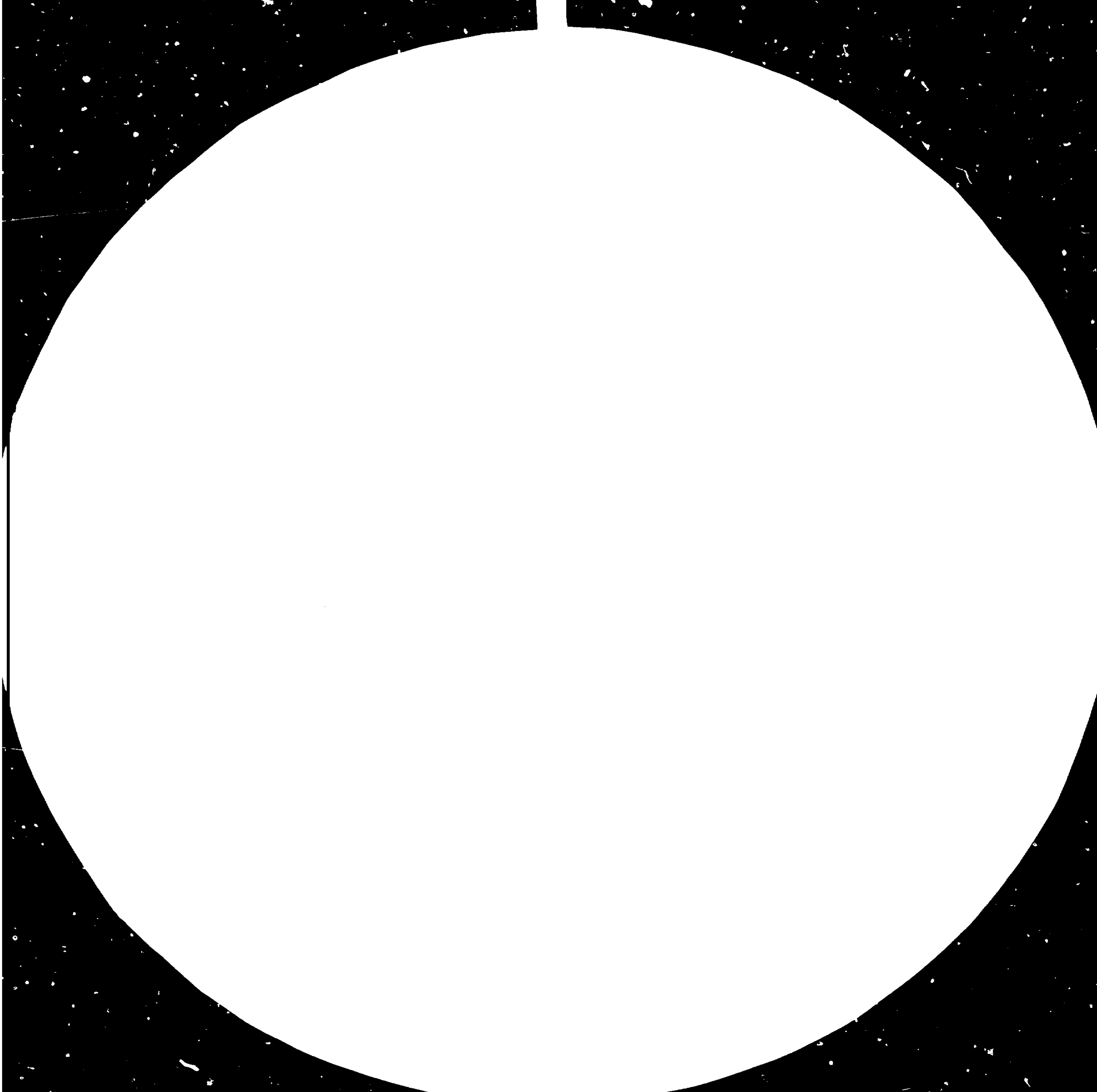
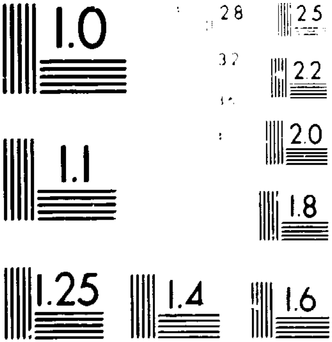




MICROCOPY RESOLUTION TEST CHART

4.2.1.2.2 Fresh vegetable canning

Many vegetables can be canned in natural state, having only been adequately prepared and washed.
Normally, vegetables are washed in rotary or floatation water washers, after a first coarse manual selection.
A second fine manual selection is performed, and the vegetable is normally blanched, or scalded, into a hot-water rotary blancher, or a tunnel steam scalder.
Some vegetable is to be hardly brushed before scalding; this is done into a rotating brush peeler.
As for fruits, vegetable processing line can be easily used for different raw materials in the case of manual or semi-manual operations. When mechanization is requested, very specialized machinery can only perform selection and sorting for the single vegetable, or class, it has been designed for.
Washing and blanching machines can be easily converted for use with different type of vegetables.
A very general flow-diagram of typical fresh vegetable canning process is outlined in Fig. 4.2.2.
As it can be seen, after can filling, which is normally done manually or with a gravity dosing hopper, the process is identical to that for canned fruits.

4.2.1.2.3 Fruit and vegetable dehydration

In the dehydration process, the moisture contents of fruits and vegetables has to be reduced to less than about 15% to allow the product to be easily preserved at normal temperature conditions.
This is a very simple and interesting process, because it has the advantage of requesting no sealed packaging.
The process is similar to that for canning during the preparation phase (washing and selection).
Products are then peeled or scrubbed, depending on item; this is normally done into rotating brush peeler or, in many cases, also manually.
Vegetables and fruits are then sliced or divided into cubes, chips etc., depending on type of product and market requirements.
This is performed in a slicing or cutting machine.
The sliced products are then blanched, to stop enzymatic degradation, in hot water, into stainless steel open boiler.
Dehydration can be obtained by simply laying down slices or cubes over perforated sheet shelves, in a chamber with natural or controlled air ventilation.
This is a very simple, but efficient, technique to obtain controlled dessiccation of the product, but has the main

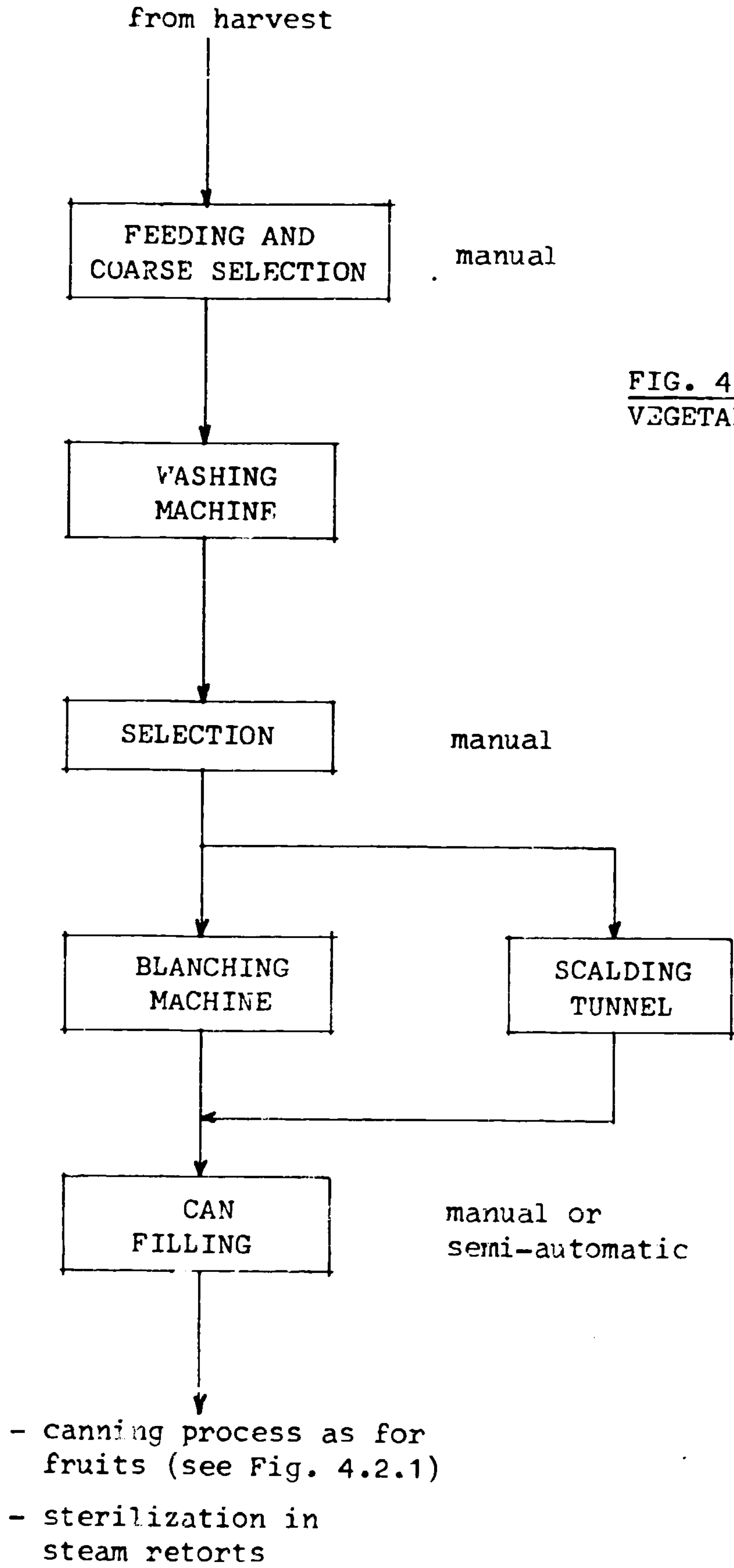


FIG. 4.2.2 - TYPICAL FRESH VEGETALBE CANNING PROCESS

unconvenience of being a long-lasting procedure.
To increase system capacity, and of course machine complexity, a multiple deck rotating belt or chain dryer can be used.
Dessicated products can be packaged into plastic bags, for market distribution.
A general flow-diagram of the dehydration process is given on Fig. 4.2.3.

4.2.1.2.4 Dry vegetable rehydration and canning

In some case, it is convenient to dehydrate big quantities of vegetables, such as beans, peas etc., after the harvesting period, and then, during the year, to process them for canning.
After a manual selection, dry vegetables are submersed in water for the rehydration process; this is done in stainless steel or fiberglass basins or pans.
Rehydrated vegetables are then cooked in open steam-heated pans.
Further processing is identical to that described for fresh vegetables.
Sterilization has to be done in steam retorts, to guarantee good quality products.

4.2.1.2.5 Pulps and juices preparation

Tropical and non-tropical fruits are suitable for this type of processing.
In particular, citrus fruits are normally processed to obtain juice.
A typical technological process to obtain fruit juices (or pulps, or nectares depending on concentration and/or additives) is outlined in Fig. 4.2.4/A.
It is to be noticed that no concentration is foreseen; in fact, to obtain an acceptable quality of concentrated fruit juices, a continuous double-effect concentrator should be used, since a batch-operated simple-effect pan concentration would cause important changes in flavour and taste of the final product, not acceptable in the domestic market and surely out of the international market standards.
The continuous double-effect concentration is a sophisticated technology, which requires costly and complex machinery; for these reasons, no concentration is included in the described technology, which is nevertheless apt to fully match domestic market requirements, in terms of product quality and economic feasibility.

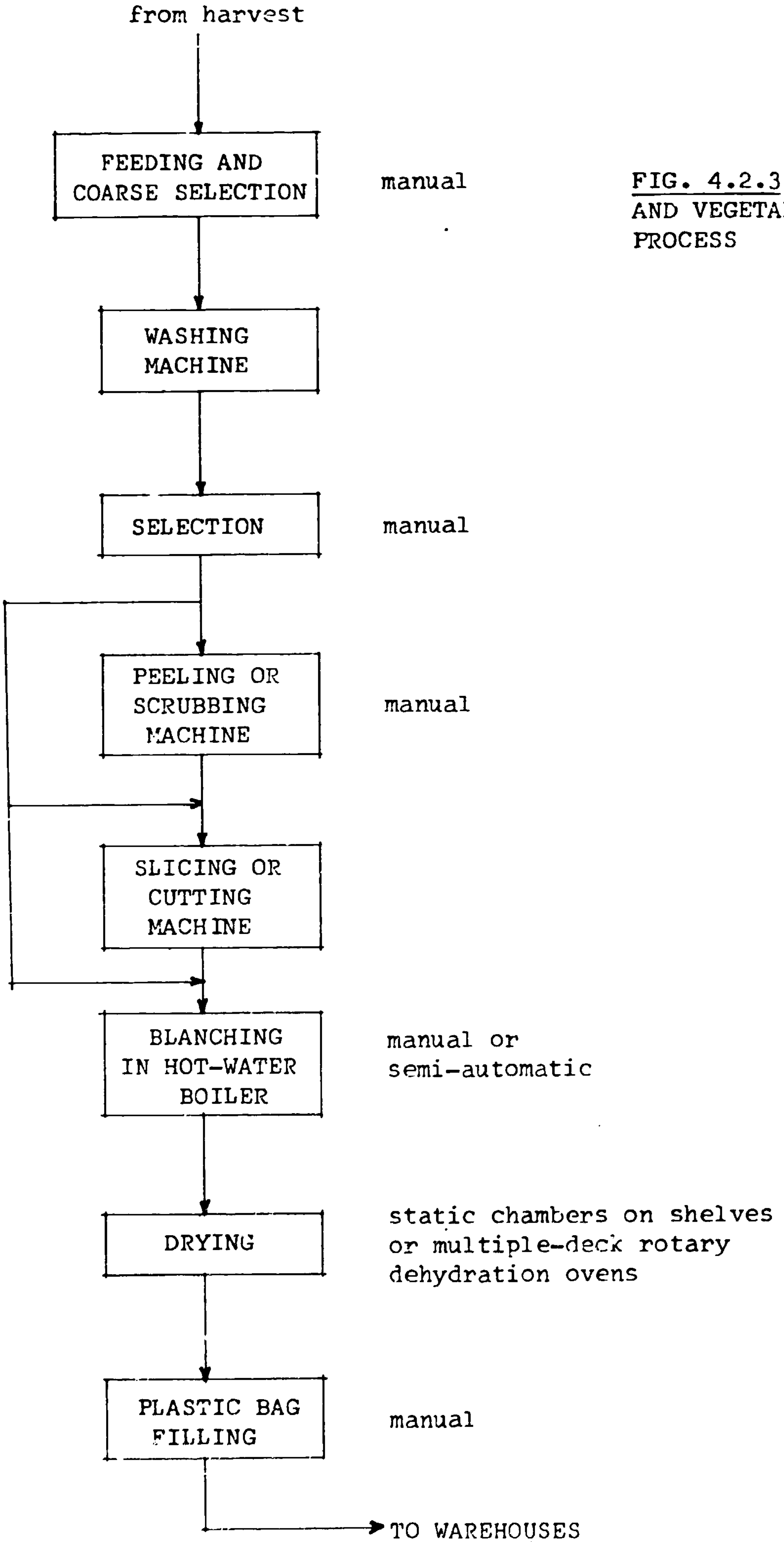
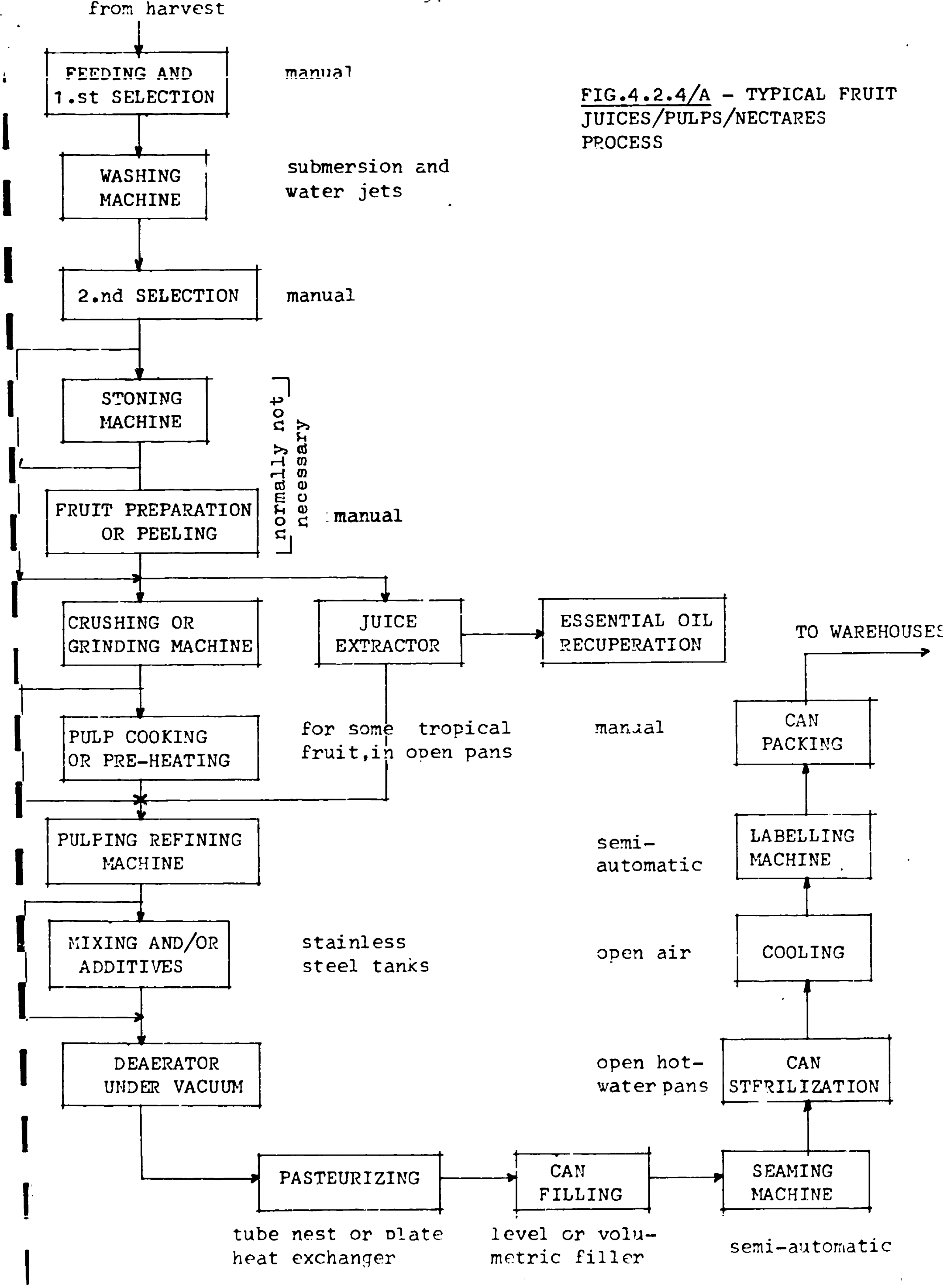


FIG. 4.2.3 - TYPICAL FRUIT AND VEGETABLE DEHYDRATION PROCESS

In case of future development, a concentration plant can always be added to the processing line.
The processing line starts with the manual feeding of fresh fruits, from harvesting area, which should be as close as possible; to prevent spoiled fruits from entering the line, a first coarse selection is done.
All these operations can be done manually.
The fruit is then subject to a deep washing, in a floatation water tank, and to a final washing with high-pressure water jets.
The second manual selection should assure that no damaged fruit is entering further procession.
Stoning, peeling, preparation or other similar operations are normally not made (depending on fruit type), but could be operated manually or by simple stoning and peeling machines. Crushing or grinding machines provide pulp extraction; stone separation is then performed.
In the case of citrus fruit, a juice extractor should be used, with two or four operating heads, with recovery of essential oil, (an important by-product of the citrus juice industry).
Some tropical fruit, such as mango, papaya, guyaba, etc., requires a pre-heating or cooking process, which can be performed on open pans or on a continuous steam cooker.
To obtain a complete separation between juices and fibrous components of the pulps, the juices are to be passed through a pulping-refining machine.
A vacuum tank deaerator completes the juice process, which is then pasteurized into a plate or tube nest heat-exchanger, to prevent microorganismo contamination of the product.
From this point on, the canning line is exactly the same as described for all other canned products, making possible to employ the same processing equipment for different products in different periods of the year.
As it has already been stated, fruit juices normally do not require concentration, at least for domestic market distribution.
Citrus juice can be concentrated, in order to be stored and re-used for beverage making, or to be distributed in the international market.
A typical citrus juice concentration process is outlined on Fig. 4.2.4/B.
After a preparation phase, as described before for any other fruit juice, citrus juice has to be refined in a centrifugal-type refining machine, which provides a centrifugal separation of solid parts.

Essential oils are then separated by a high-speed centrifuge and juice is pumped to the continuous multiple-effect concentration plant.
At the output of the concentration plant, juice is cooled down, to be stored into refrigerated tanks, where, when needed, sugar/acid ratio is corrected.
Juice is then filled manually into drums of 10 to 25 Kgs. capacity, to be stored in refrigerated warehouses.

FIG.4.2.4/A – TYPICAL FRUIT JUICES/PULPS/NECTARES PROCESS



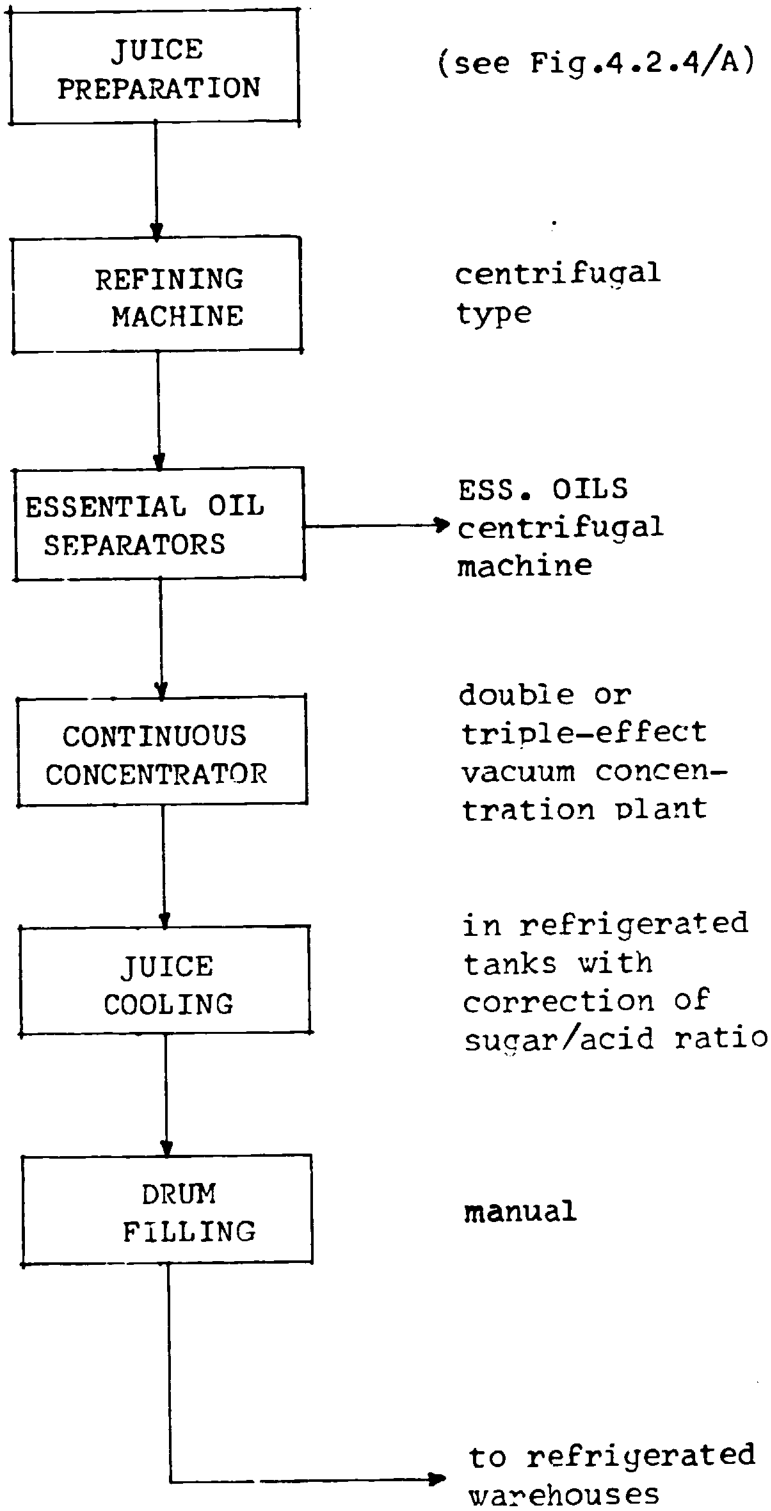


FIG. 4.2.4/B - TYPICAL CITRUS JUICE CONCENTRATION PROCESS

4.2.1.3 MACHINERY DESCRIPTION

4.2.1.3.1 Washing machines

Two basic types of washing machines are normally employed for the majority of fruits and vegetables to be processed: rotary washing machines and water floatation machines.
The first type (see Fig. 4.2.5) is normally used for fruit and tuber vegetables; the second (see Fig. 4.2.6) for delicate fruits.
Leafy vegetables can be also washed in a special tank washer.
Washing normally precedes product selection; in many cases, selection table, where operations are done manually, can be coupled with the washer, by means of an elevator, as shown on Fig. 3.3.7.
With this type of machines, a maximum capacity of 3 to 4 tons per hour can be achieved.
Washing machines are quite simple, being built up of an iron sheet water tank, painted with special food-industry coating, connected with water piping and circulation pumps.
Water floatation is obtained by air, blowed into water by a compressor.
Rotary washer are made of steel bars or profiles, shaped in order to hold fruit or vegetable, they are designed for, without damages.
Rotary bar wheel is supported by self-lubricating ball bearings; driving motor is coupled to the wheel by a gear reduction box.
Washing machines are often provided with output elevator and discharge hopper.
Water sprinkling nozzles are made by plastic or stainless steel.
These machines are simple and manufacturing can be afforded by skilled welders for main frame and tank; some parts are obtained by steel sheet folding and bending.
All mechanical components are to be machined.
Some component, in constant contact with the product, is often made by stainless steel.
Piping is normally zinc coated or painted.

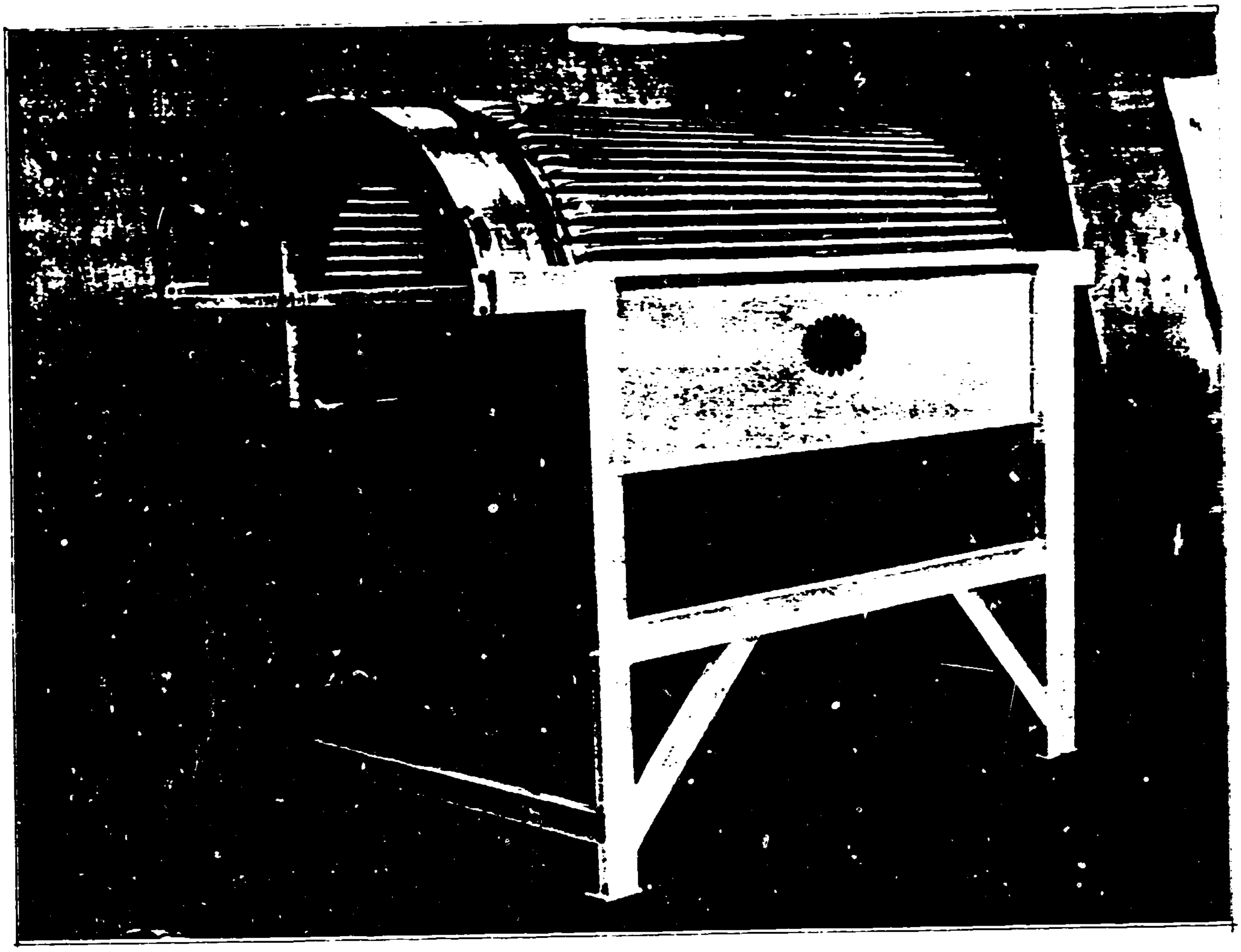


Fig. 4.2.5 - Rotary washing machine for fruit and vegetable (courtesy of Roda)

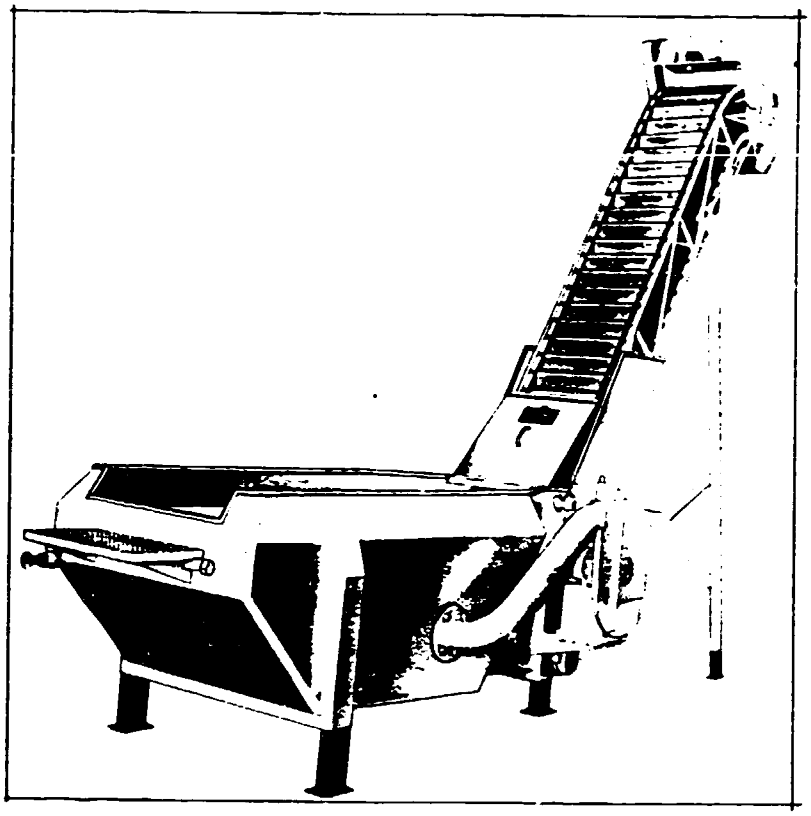


Fig. 4.2.6 - Air-floatation water washing machine with elevator (courtesy of Vettori-Manghi)

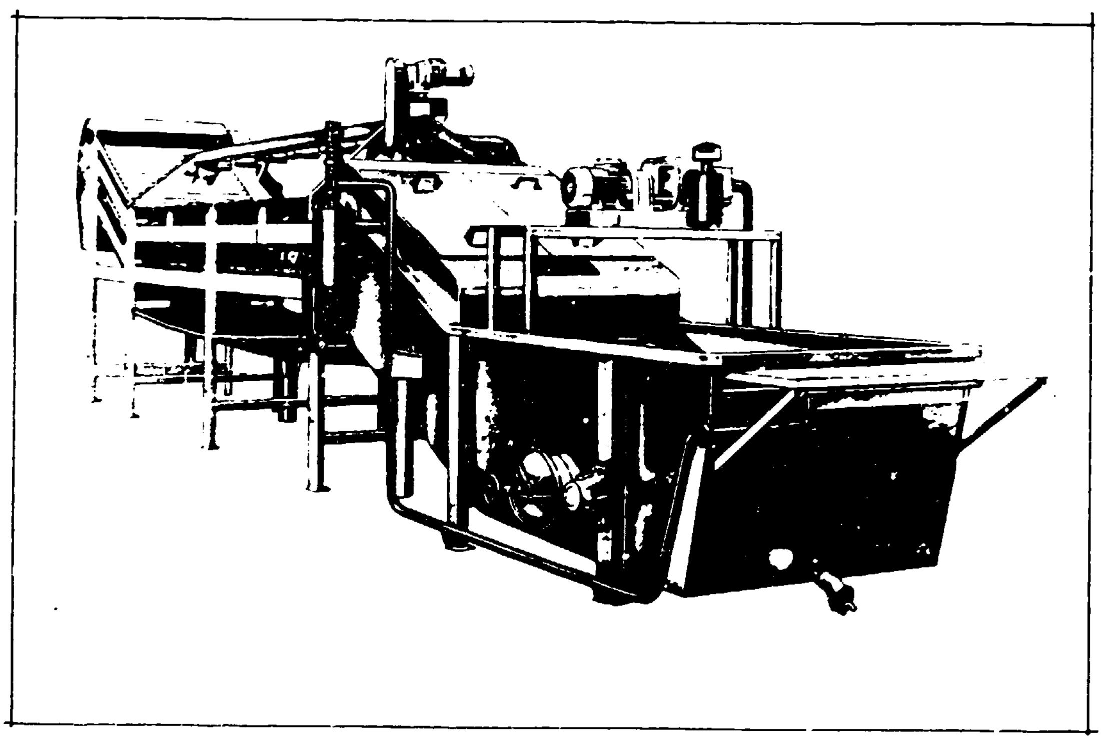


Fig. 4.2.7 - Washing machine coupled with selection bench for fruit and vegetable (courtesy of Vettori Manghi)

4.2.1.3.2 Stoning machines

A very wide variety of stoning machines has been developed, depending on the fruit shape, dimension, type of stone etc.
On a fresh fruit canning line, destoning must be performed without damaging the fruit; in many cases this can be done only by hand or with special semi-manual tools.
On juice extraction lines, destoning is much simpler and is normally obtained by rolling drums, with rubber and/or toothed surfaces, other destoning machine uses centrifugal rotating sieves (see Fig. 4.2.8).
In some case, such as pineapple, special semi-manual machines have been developed, that performs well-defined operations on the fruit (pineapple coring and sizing), with a capacity of up to 10 fruits per minute (see Fig. 4.2.9).
Stoning machines have a main frame of welded steel profiles.
Centrifugal type has rotating paddles in a cylindrical body, with adjustable inclination, cylindrical calibrated holes screen and pulp discharging hopper.
All parts, in contact with the product, are manufactured of stainless steel with polished surface finishing.

4.2.1.3.3 Peeling-scrubbing machines

It could be said that each type of fruit needs its own peeling system; no general rule can therefore be given for peeling machines, even if, with some variation, two main types of peeling machines can be identified: lye machines and mechanical peelers. Lye machines are very delicate in operation and are not so widely used, at least when a mechanical peeling can be achieved.
Mechanical peelers exist in so many forms, depending on type of fruit skin, fruit sizes etc., but, generally speaking, they are intermediate or complex technology items, at least as far as operating heads are concerned.
For tuber vegetable processing, or for citrus juice extraction, a previous scrubbing of the skin surface is needed and brush machines are normally employed to perform this operation.
Brushes are normally made of plastic or rubber materials, rotating on supporting bars.
These machines can be simplified, if handling of the products is done manually.
An example of brush peeler for tuber vegetables is shown on Fig. 4.2.10.

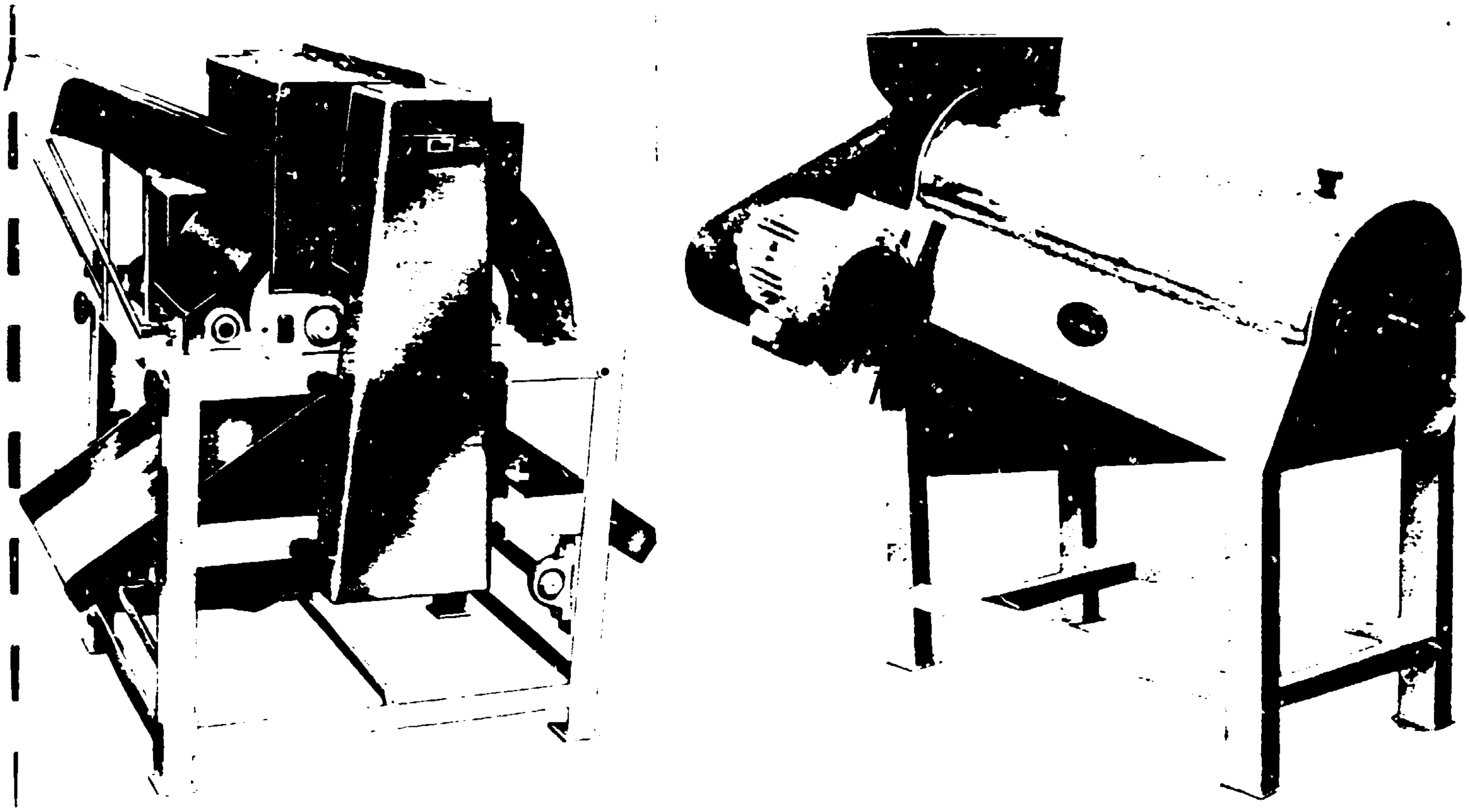


Fig. 4.2.8 - Centrifugal de-stoning machines for fruit pulps and juices (courtesy of FBR and Tavalazzi)

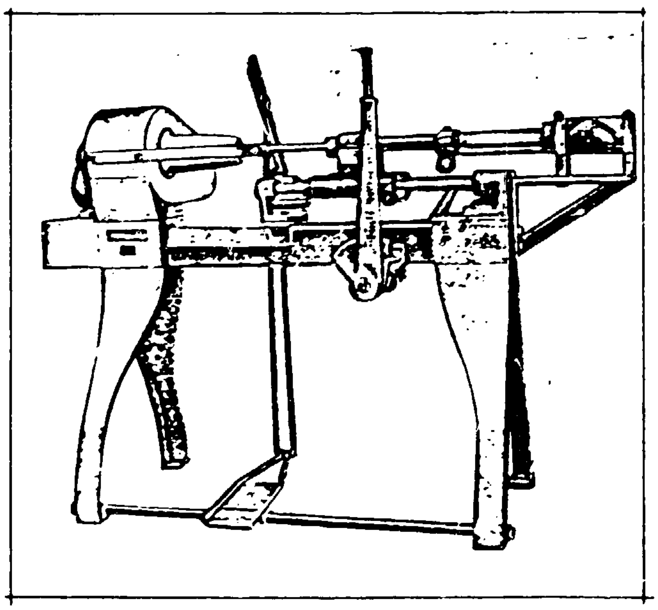


Fig.4.2.9 - Semi-automatic machine for pineapple coring and sizing (courtesy of Mater-plate)

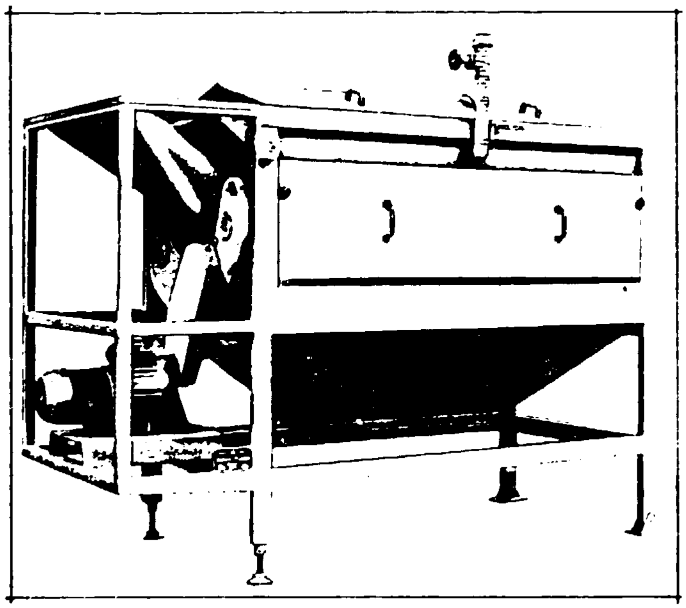


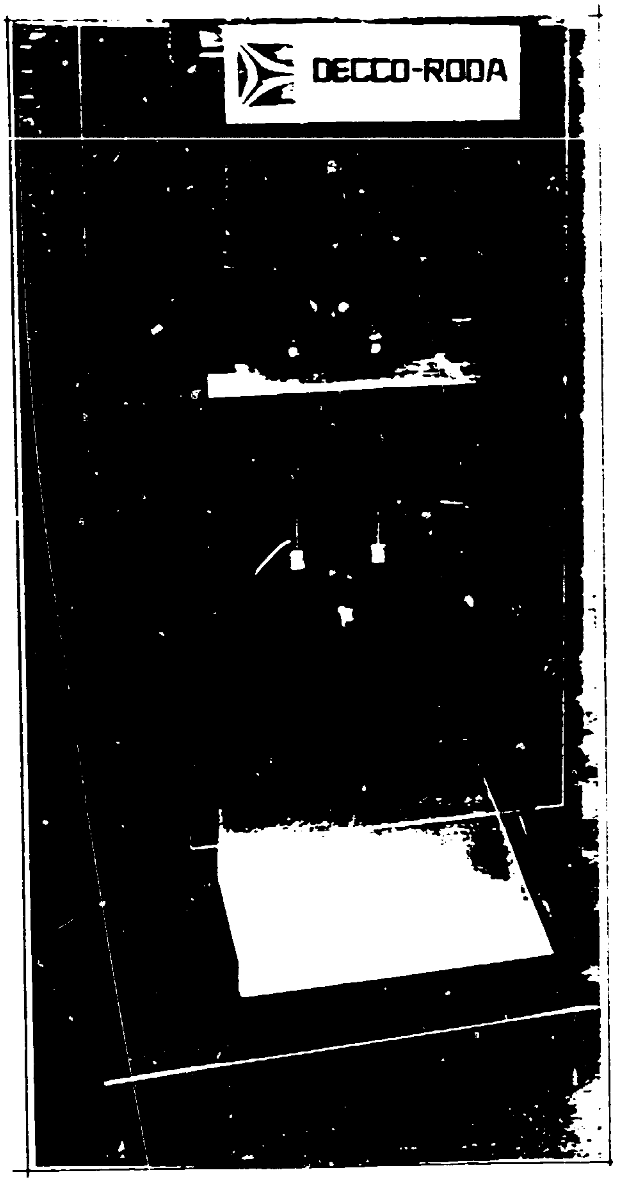
Fig.4.2.10 - Brush peeler for tuber vegetables (courtesy of Vettori-Manghi)

4.2.1.3.4 Slicing-cutting machines

Canned fruit is normally cutted into halves, slices or cubes.
This operation is made by specially designed machines, which, if manually fed, are very simple.
If automatic feeding and output is requested, the machine becomes very complex and unsuitable for adapted technology use.
A manually feeded machine has an iron profile main frame, with cutting section and discharge hopper in stainless steel.

4.2.1.3.5 Crushing-grinding or juice extraction machines

Fruits are to be squeezed or grounded to obtain pulps or nectars; citrus or similar fruits are to be squeezed to obtain the juice.
The fineness of the grinding operation depends on the type of fruit, but normally a pulping and/or refining operation is done.
The grinding operation is normally done by a rotating toothed or comb roller, that breaks the fruit against a counter-rotating roller, which can be toothed or smooth, depending on fruit type, made by sanitary rubber or stainless steel.
All moving parts are made of stainless steel; the juice or pulp hopper can be manufactured by stainless stainless steel or fiberglass sheets.
Main frame is of welded iron bars.
An example of juice extractor is given on Fig. 4.2.11.
Juice extraction can also be obtained by centrifugal machines, of more complex manufacturing, because of high-speed rotating parts.
For citrus fruit, a mechanical squeezer, with 2 or 4 heads, is also used. An example is given on Fig. 4.2.12 (manually operated type).
For fruits without stone, a worm-screw type crusher can also be used.
In all these machines, all parts in contact with the juice must be of stainless steel, to prevent a very rapid corrosion.
All sealing gaskets for rotating shaft must be made of sanitary plastics or rubber.
The refining operation, for citrus juice, can be done, after extraction, in a manual sieve, as shown on Fig. 4.2.13



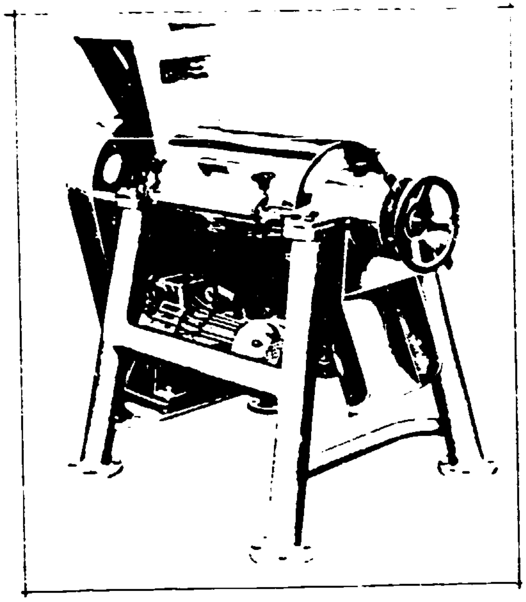


Fig. 4.2.11 -Centrifugal juice extractor (courtesy of Vettori - Manghi)

Fig. 4.2.12 - Two heads mechanical citrus-fruit juice extractor (courtesy of Roda)

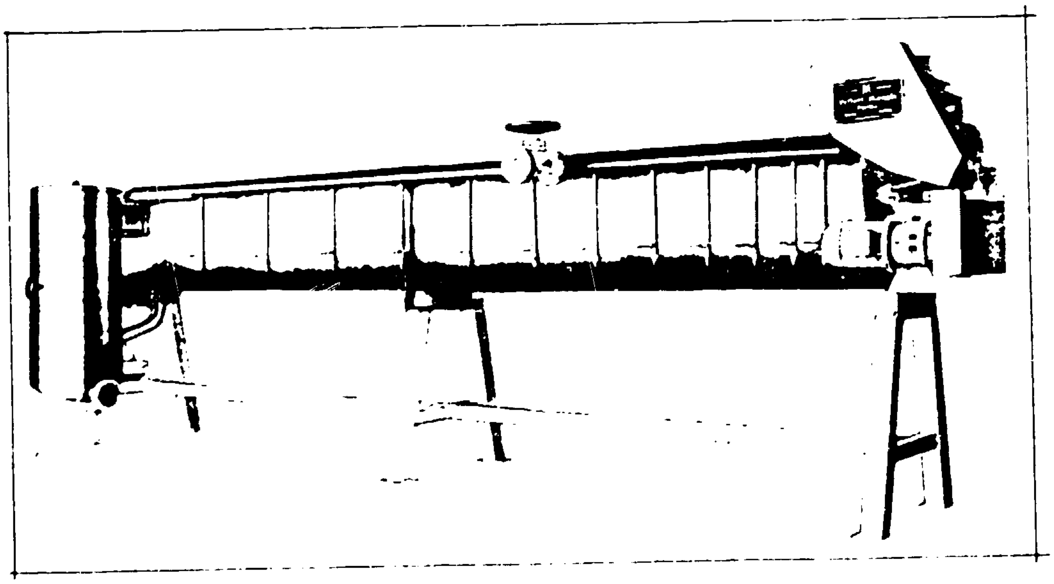
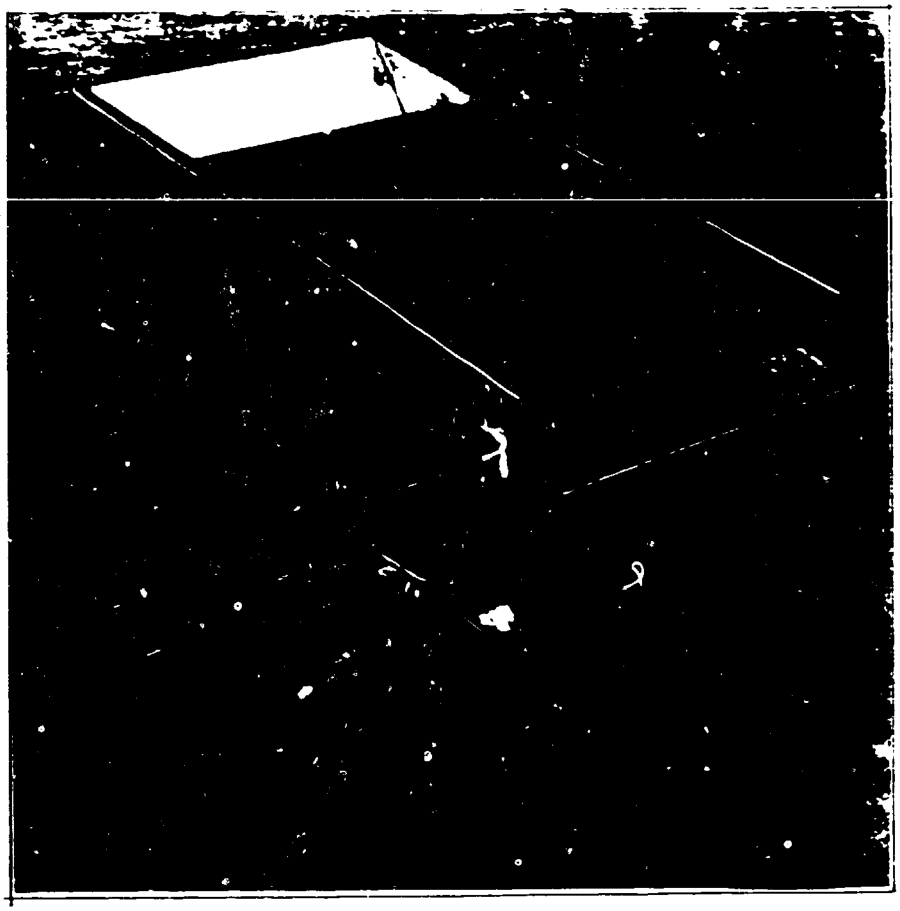
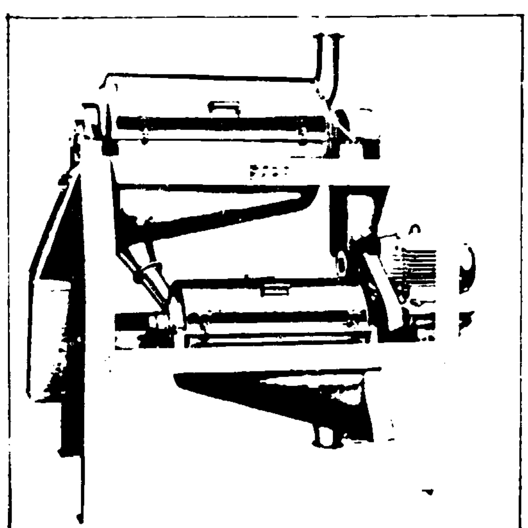


Fig. 4.2.14 - Continuous rotating-blades steam scalding machine (courtesy of Vettori-Manghi)



ig. 4.2.13 - Citrus juice clarification sieve
(courtesy of Roda)



ig. 4.2.15 - Two-stage horizontal
pulping-refining
machine (courtesy
of Vettori-Manghi

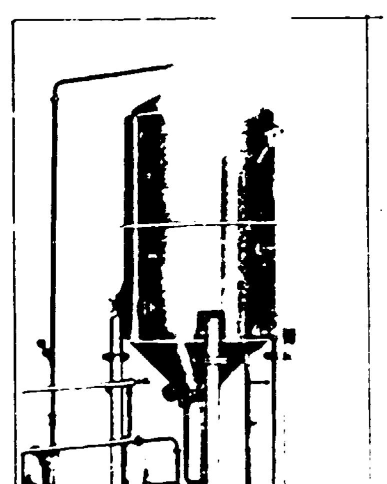


Fig. 4.2.16 - Juice deaerator
with aroma recu
perator (courtesy of Mannini)

4.2.1.3.6 Cooking, blanching, scalding machines

Most vegetables and fruits have to be subjected to thermal treatment, before pulp or juice refining, or before canning, to prevent microorganism or enzyme spoilage, or to maintain natural color.
The cooking and blanching operation consists on keeping fruits and vegetables in a chamber, normally a tunnel, under direct steam, or hot water, action.
Blanching and scalding can be continuously, by means of belts, or rotating blades, or "batch"operated, if pans are used.
A continuous steam scalding machine is shown on Fig.4.2.14.
These machines normally work at low steam pressure (1 Kg/cm2), and their manufacturing must fulfill operational requirements for devices working under pressure conditions.
All parts should be made of stainless steel, except main frame, in painted iron profiles.
The cooking tunnel has to be easily openable, to allow inspection and cleaning.
Sealing is normally made by teflon gaskets.
With a continuous cooker, a capacity of 3 tons/hour is achieved, while, with batch-operated pans, the maximum capacity is in the range of 1 ton/hour.

4.2.1.3.7 Pulping-refining machines

The fibrous part of pulps and juices have to be separated: this is normally done in a pulping-refining machine, which performs also a sufficient homogenization of the product.
In case of very fine nectars, a second pressure homogenization is needed, but the relevant machine is quite complex, being a sifting high-pressure extruder.
Within the range of normal pulps and juices, pulping-refining machine is composed of a rotating shaft, supporting brushing and pressing arms, with radial adjustment, which forces pulps against a cylindrical calibrated hole sieve.
Refined pulp or juice is then collected into a discharge hopper, while unpassed fibrous material is discharged by an end hole.
By adjusting distance between sieve and brushing arms and their inclination, different degrees of refining can be obtained, depending on product to be treated.
All the machine is obviously made of stainless steel; due to high rotating speed, manufacturing requires a very careful machining and finishing of all rotating parts.

Sieves should be easily interchangeable and simple to be cleaned.
Normally, a pulping-refining machine has two cascade stages, with horizontal or vertical rotating shafts.
An example of horizontal two-stage refiner is given on Fig. 4.2.15.

4.2.1.3.8 Deaerating vacuum tanks

The air, absorbed or released by the product during previous operations, must be removed, passing the juice through a calibrated sprayer into a vacuum tank, where air is separated by a vacuum pump, while the product falls in the lower part of the tank, where is pumped out.
The tank must withstand vacuum conditions, and is made of stainless steel sheet, welded and assembled, in order to be vacuum tight; an easy access should be provided, to clean the tank easily.
The vacuum pump is normally liquid-ring centrifugal type; an often needed device is the aroma recuperation condenser, to allow product to get back all aromatic components, carried out by expelled air.
All piping is stainless steel; juice pumps are multi-stage mono type, with sanitary sealing.
Tank manufacturing requires skilled certified welders of stainless steel curved sheets.
An example of medium-capacity vacuum deaerator is given on Fig. 4.2.16.

4.2.1.3.9 Pasteurizing heat exchanger

Inhibition of spoiling microorganism requires a thermal treatment, called pasteurization, where the juices or pulps are continuously and rapidly heated at a given temperature, much below the boiling point.
Pasteurizers are of two basic types: plate-type or tube-nest type.
In the plate pasteurizer the heat exchange between steam or superheated water takes place through plate juice container walls, of special turbulence-inducing design.
In the tube nest type, the product continuously flows in countercurrent with the heating media through a tube nest, and is then circulated to a dwelling section.
In both cases, the machine is completely made of stainless steel, including piping and feeding reservoir.
Manufacturing is not complex in the case of tube nests;

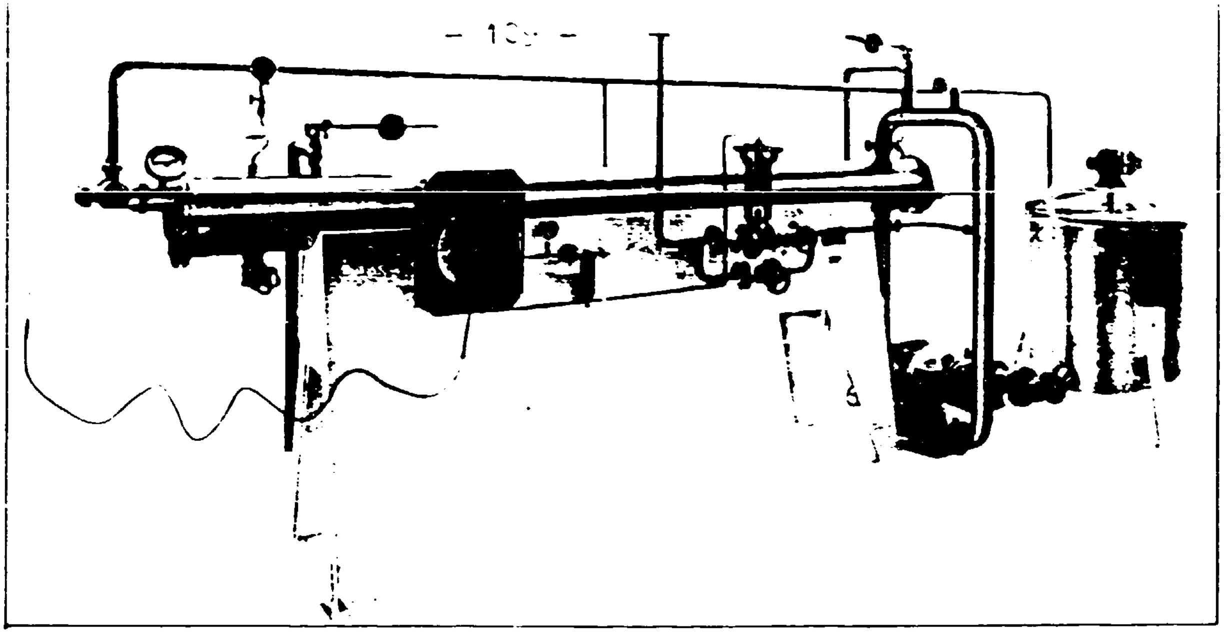


Fig. 4.2.17.A - Tube-nest pasteurizing heat-exchanger (courtesy of FBR)

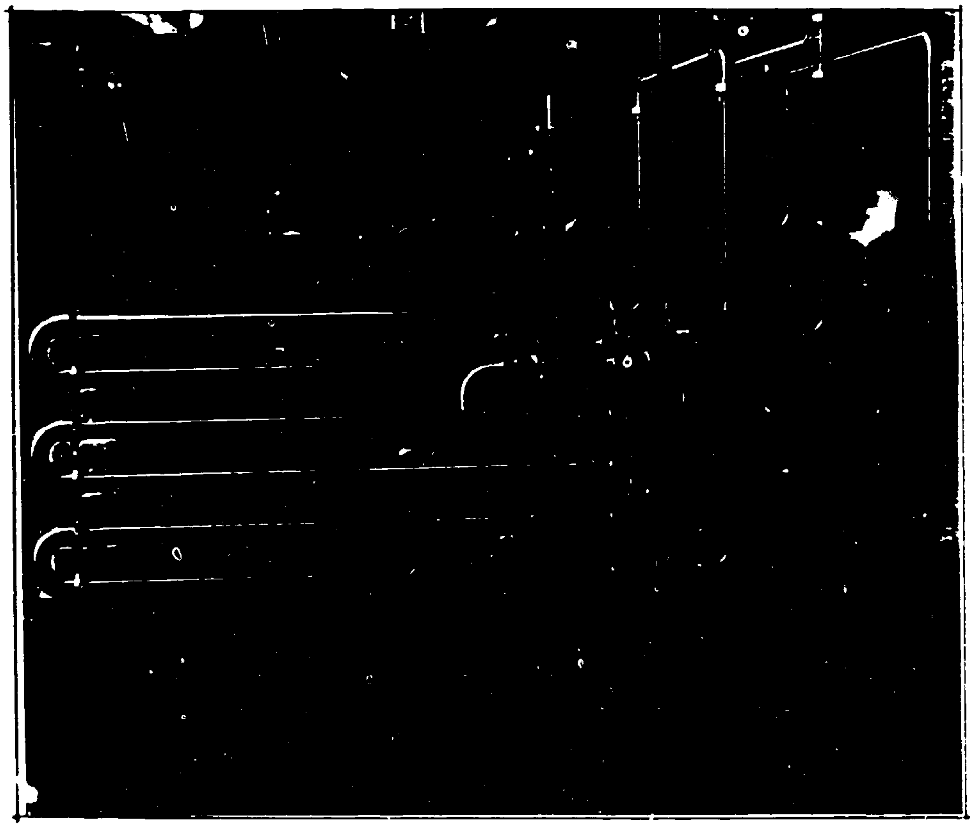


Fig. 4.2.17.B - A plate-type pasteurizing heat exchanger (courtesy of Roda)

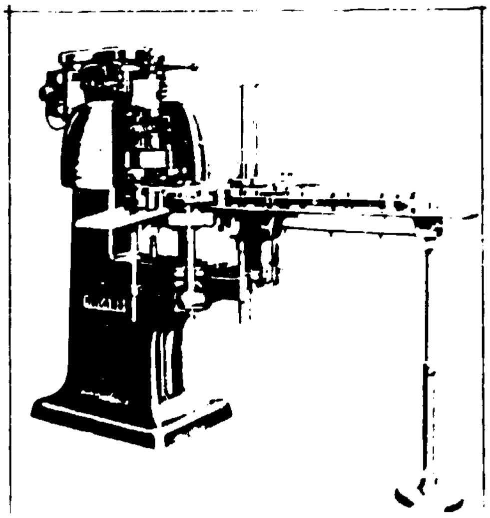


Fig. 4.2.18 - Automatic seaming machine of medium capacity, with feeding belt (steady-can type) (courtesy of Luciani)

welding and finishing of tube nests requires very skilled welders and an accurate tube dimensioning.
Tube nest must be accessible, for maintenance and cleaning.
Circulating pumps are also stainless steel rotor centrifugal type.
The capacity of a small-size pasteurizer is in the range of 1000 Kg/hour, with a steam consumption of about 150 kgs/hour.
An example of small-size tube-nest pasteurizer is given on Fig. 4.2.17.A.
In the case of plate heat exchanger, the manufacturing technology is more complex, since the plates have to be obtained by press forming with high-capacity hydraulic presses, equipped with very complex dies.
An example of plate-type pasteurizer is given on fig. 4.2.17.B

4.2.1.3.10 Can filling machines

4.2.1.3.11 Seaming machines

These machines are the same as described at para.4.1.2.3.2 for other canned products.
The simplest solution for can filling and seaming is to use manual filling for fruit, level filling for syrup or juice and manually operated seaming machine, same as described on para. 4.1.2.3.2.
A step further could be to link a juice or syrup volumetric filler-doser, with a transfer belt that carries cans to an automatic seaming machine, an example of which is given on Fig. 4.2.18.
There is obviously no limit in automatizing the line, because market availability of complete filling-seaming lines is very wide, but this implies the use of complex and very delicate (from maintenance point of view) machinery.
It goes without saying that a vacuum filler, directly coupled with an automatic seamer, allows much better hygienic conditions to be kept and production rates up to 10.000 cans/hour to be obtained.
In any case, these machines are quite complex to be manufactured and assembled, requiring high-precision machining and finishing of various parts with a good level of engineering capability.

4.2.1.3.12 Can sterilization pans and retorts

Depending on the type of fruit to be canned, sterilization is to be made in open hot-water pans or in steam retorts.
The first system is very simple, requiring only stainless

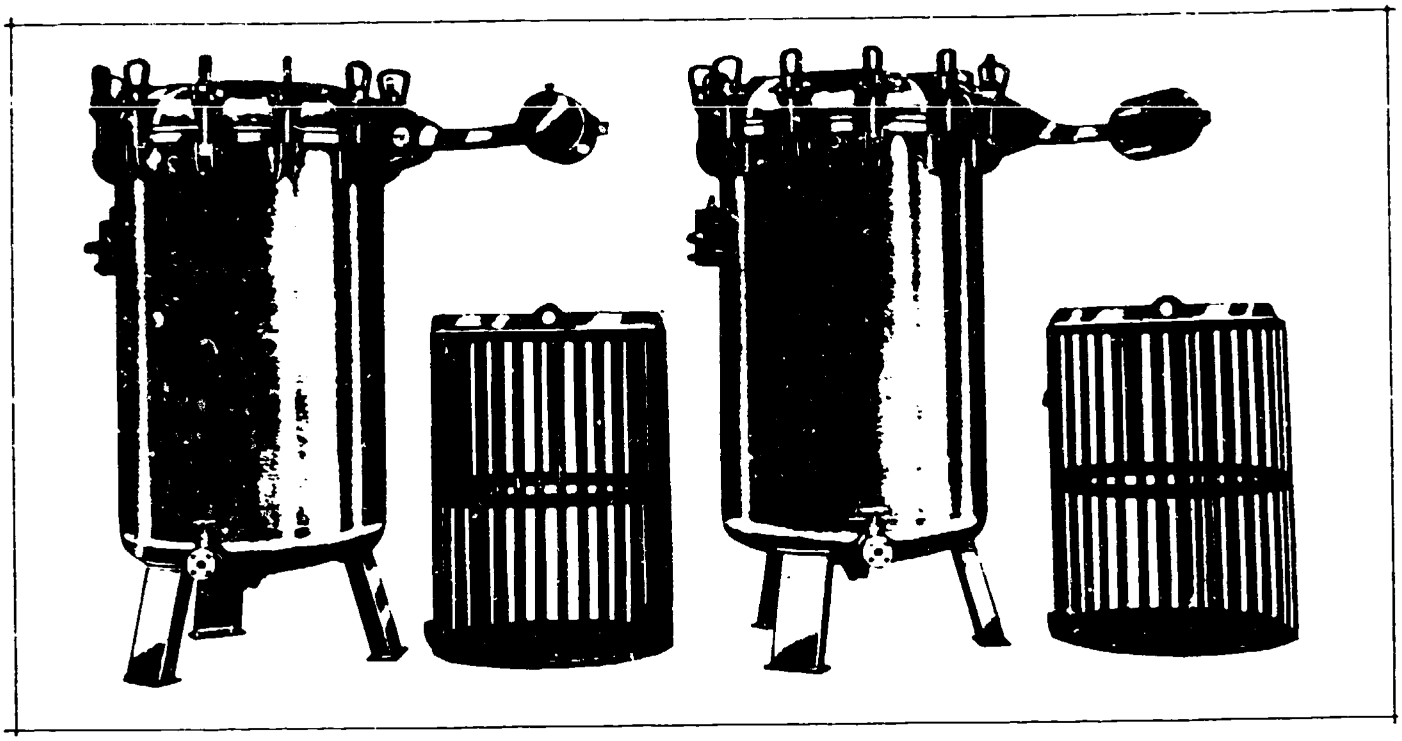


Fig. 4.2.19 - Vertical sterilization retorts (courtesy of Rossi-Catelli)

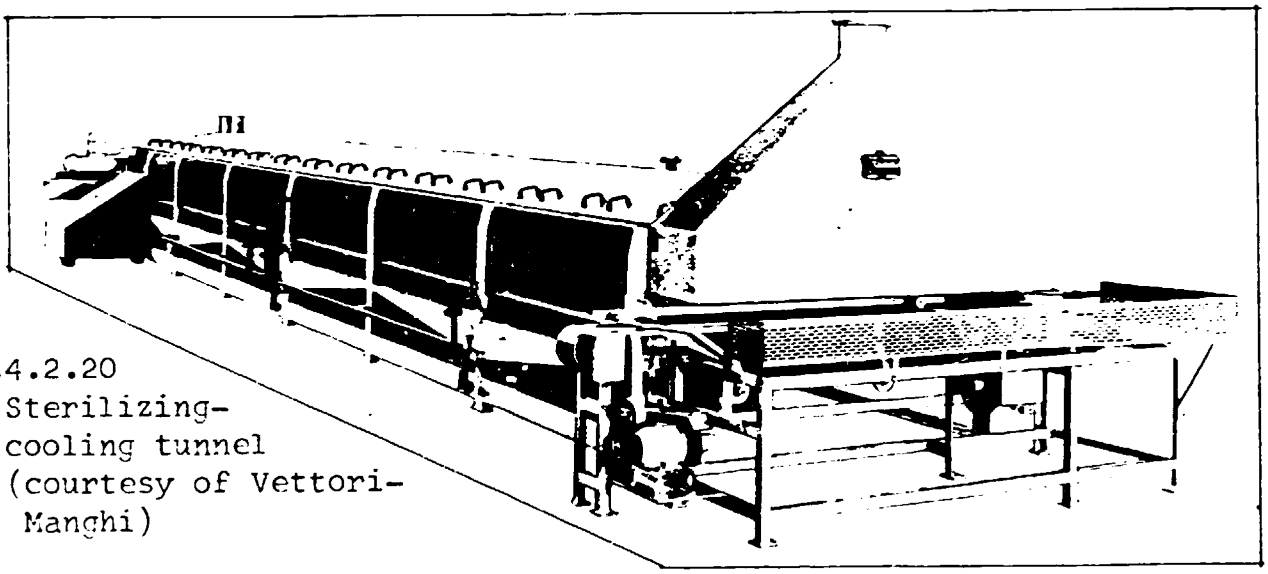


Fig.4.2.20 Sterilizing-cooling tunnel (courtesy of Vettori-Manghi)

Fig. 4.2.21 - Typical stainless steel containers for food products (courtesy of Rossi-Catelli)

steel or zinc-coated hot-water containers (normally steam heated), whose operation and manufacturing is very simple. Sterilization retorts have been described on para 4.1.2.3.3 for meat preserves.
These machines are quite simple and can be of horizontal or vertical type, as it is shown on Fig. 4.2.19.
Manufacturing requires the employment of very skilled certified welders, because these devices operate under high pressure conditions.

4.2.1.3.13 Cooling tunnels

Cooling of seamed cans can be done in open air; this is a very simple method, but requires more space and more time, than any other cooling system.
It has the advantage of clearly showing leaking cans.
Cooling can also be made under cold water flow, in two stages (down to 60 °C and then to 20 °C); this system shortens cooling time, but it has the unconvenience of possible contamination of the products by can micropores; water should be chlorinated.
The majority of fruit juices have a natural pH level lower than 4.6; this means that a retort sterilization is not needed.
In this case a pasteurizing-cooling tunnel is used, where cans are heated up to the pasteurizing temperature and then cooled to ambient temperature.
Pasteurizing-cooling tunnels (an example of which is given on Fig. 4.2.20) are to be used only for high production rates.

4.2.1.3.14 Labelling machines

Dry and cool cans can be labelled at the end of the processing line, or before delivering to the market.
In both cases, simple machines can be employed, with manual feeding and semi-automatic operational cycle.
If automatic can feeding and handling is requested, labelling machines become very complex and costly items.

4.2.1.3.15 Vegetable dehydration ovens

In a dry climate environment, fruits and vegetable dehydration can be obtained in naturally ventilated drying chamber; the product is stacked on perforated metal sheet or wooden bars shelves.

This technology has been employed in many countries for centuries, but if climate conditions are less favourable, an air heater, with forced ventilation, has to be employed.
Air is heated by a steam or a hot water battery, which allows chamber temperature and final product quality to be controlled.
If higher capacities are needed, the dessication time can be shortened, using dehydration ovens. These ovens are small chambers, with painted iron profile frame and steel sheet walls, where air temperature and humidity can be controlled within narrow limits, in order to maintain better dehydration conditions.
These ovens can be equipped with removable product supporting decks or with rotating chains or decks for continuous operation.

4.1.1.3.16 Steam generators

Whenever food processing is performed, a steam generation plant is requested.
Regardless of how complex is technology, steam has to be produced and distributed, because the large majority of food processing technologies are based on thermal treatments, as it has been described in the technology section.
The capacity of the generation plant depends of course on processing line capacity, but a minimum of approximately 1000 to 1500 Kgs of steam per hour is normally requested for a very small cannery.
If concentration is performed, about 3000 Kgs/hour of steam are to be provided for small processing capacity up to 1 ton of product/hour.
These figures are obviously merely indicative and should be calculated for a given processing technology.
Steam generation plants for food processing industry range from integrated compact packages, (about 1000 to 3000 Kgs/hour) to water-tube pressurized steam boilers for production up to 30.000 Kgs/hour. In any case, steam generators are complex machines, working at very high pressure, where control devices must assure operational safety in any condition.
If petrol derivates are not available, other poorer fuels can be used, such as wood sharings, pulverized wood wastes, rice husks, etc.
This practice can be economically convenient, but requires a higher efficiency in maintenance and a more accurate and

continuous tuning-up of burners, which are more complex and delicate than gasoil burners.

4.2.1.3.17 Pumps and piping

Pumps are the most widely employed items in the fruits and vegetables processing, since all processes require to circulate water or liquid products.
In the case of water, no special pumps are required: many models are available on the market, with different characteristics, that cover all possible requirements.
In the case of product circulation, pumps shall have special characteristics and performances.
All pumps shall be of the type specially built for food products, normally with sanitary plastic or stainless steel parts.
Pumps shall guarantee perfect tightness and hygienical conditions; this means that a continuous maintenance programme should be carried out, because a failure at some pumping station normally stops the entire processing cycle.
Water piping is normally made in steel tube, zinc-coated, while piping, where a food product flows, has to be stainless steel tube.
Piping assembly requires very skilled stainless steel welders and experienced piping assemblers.

4.2.1.3.18 Tanks and containers

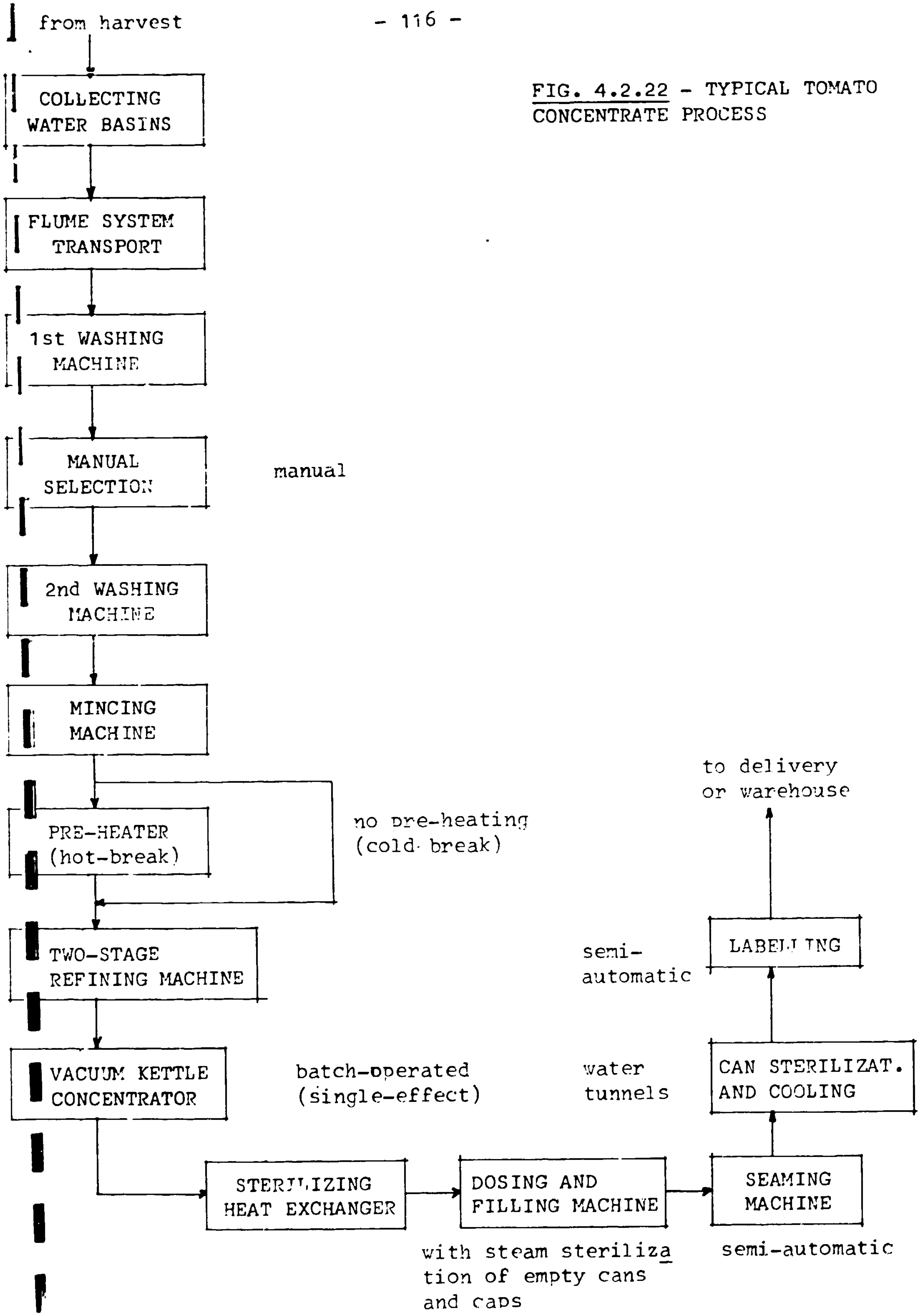
Due to the high number of tanks and containers that are normally employed in a food processing plant, the cost of these items should be considered with attention.
Almost all containers and tanks shall be made of stainless steel, to prevent any contamination, to assure good hygienical conditions and to ease a very frequent cleaning and maintenance.
Storage tanks have a welded iron profile main frame, with stainless steel sheet walls and covers.
Typical storage and transport containers have a welded stainless steel sheet body, with a supporting painted iron frame, normally equipped with rubber wheels, as shown on Fig. 4.2.21.
Other materials that could be employed are copper or aluminium sheets.
Fixed containers can also be made of fiberglass.

4.2.2 CONCENTRATES

4.2.2.1 General remarks

Concentration of fruit juices is a widely diffused method to reduce cater contents of juices.
This can be done in order to reduce weight and volume of juices, during the storage and transport phase, while water contents is given back the juice before consumption.
This is a common procedure for citrus juices, for export to international market, which are concentrated and canned into 5 Kgs. cans, to be employed for beverages or nectares making.
Some other juice is concentrated to respond to market requirements; a typical case is that of tomato, which is commonly concentrated to obtain tomato paste, concentrated juice, ketchup etc., so widely used in many countries.
Concentration under vacuum is not a simple operation and a very wide variety of concentration apparatuses have been developed, more and more sophisticated, to obtain higher quality, better performance and energy cost reduction.
Of course, a continuous triple-or quadruple-effect vacuum concentrating plant is a very complex and huge equipment, but quality results are better and specific consumption lower, than a simple single-effect vacuum kettle.
Vacuum conditions are mandatory, because of the need to concentrate at lowest possible temperature, to keep product characteristics (particularly taste and color) to the best and avoid "overcooking" of juices.
The characteristics of the tomato allows a single-effect vacuum kettle concentration to give good quality results; this means that tomato concentrates can be processed with the employment of relatively simple technology and machinery (batch-operated).
On the contrary, fruit juices (and particularly orange or citrus juices) require, to be concentrated within acceptable taste and color of the final product, the use of a continuous double-effect vacuum concentrator, with a much more complex machinery.
But it is to be pointed out that, for domestic market, there is no need to concentrate citrus juices, which can be canned or bottled in natural state or used, diluted, for making beverages.
On the contrary, even if tomato juice can be consumed in natural state, it is commonly requested on the market in the form of concentrated pastes or sauces.
Using a single-effect kettle concentration plant, require-

FIG. 4.2.22 - TYPICAL TOMATO CONCENTRATE PROCESS



ments of domestic market can be fulfilled and limits of adapted technology not depassed.

4.2.2.2 Technology description

4.2.2.2.1 Tomato concentrate

Tomato concentration technology is very similar to that described for other fruits, with some peculiarity, as shown on flow-chart on Fig. 4.2.22.

The feeding of fresh tomatoes to the processing line is made by the so-called "flume system": tomatoes are discharged into basins, where a water-flow channel (the flume) carries floating tomatoes to the first stage of the processing line.

This system has the main advantage of transporting floating tomatoes without damages and being a kind of pre-washing, that causes bigger impurities to fall down.

Water is recirculated after filtration.

Preparation of product for concentration starts with washing and selecting; a first coarse washing is made in a floatation water tank, from which tomatoes are transferred to a bench, where selecting is made manually and spoiled or damaged fruits are sent to a waste container.

During this phase, a continuous spinning of the fruit is maintained, to ease selection.

A second final washing is performed in a floatation tank, from which tomatoes are transferred, by means of an elevator, into a mincing machine, that provides fruit crushing into pieces.

At this point, two possible ways can be followed; in the so-called hot-break, crushed tomatoes are pumped into a pre-heating tube-nest exchanger, where pulps are heated to about 90 °C for about 2 minutes; this provides an inhibition of certain enzymes and a more viscous and consistent final concentrate.

The cold break method, which is simpler, gives a less viscous product, that eases concentration, and is used for tomato concentrate for consumption as such.

A higher viscosity juices is normally employed for further processing, such as ketchup, sauces etc. Heated pulps are easier to be separated from fibrous parts in the refining machine.

The minced pulp is then pumped to a refining machine,where juice is dinamically sieved by rotating arms, pressing juice against a calibrated-hole sieve, in two stages, to the requested fineness.

The concentration phase is the most delicate of the whole process. To obtain a good quality concentrate, the concentration temperature should be in the range of about 60 to 70 °C, that implies the use of vacuum concentrators. The traditional vacuum single-effect kettle (or pan) is widely used on a batch-operation basis.
Heating is provided by steam.
The concentration phase lasts for a few hours for single-effect concentrator and can be reduced if double-or triple-effect concentrators are used; this also reduces the specific steam consumption per Kg of concentrated product.
It goes without saying that multiple-effect continuous concentration gives better quality products in much less time and big quantities can be processed (up to 500 tons of fresh fruit per day), but the relevant machinery is very complex and sophisticated.
With each single-effect vacuum kettle, a good tomato paste is obtained at a rate of about 10 to 20 tons of fresh fruit per day (three shifts); depending on kettle dimensions.
The concentrated paste is then pumped to a sterilizing tube-nest heat exchanger, as in any other fruit processing, to prevent sour spoilage by attacking microorganisms.
Dosing and can filling is obtained by volume or gravity filler-dosers,which can be coupled manually or mechanically to an automatic or semi-automatic seaming machine.
Several processes can be followed for canned tomato paste after seaming, depending on can sizes and on the overall hygienical conditions that can be kept on the filling-dosing-seaming line.
For manual or semi-automatic filling-dosing-seaming, the surest process is a boiling-water sterilization, followed by an immediate water cooling of filled cans.
Cooling can be done also in open air; this has the unconvenience of a very long (some hours) cooling time and there is a danger of darkening of paste colour, due to higher temperatures for longer time.
A can cooler with nebulized chlorinated water reduces cooling time, but the technology is more complex and there is a danger of water contamination through can micropores, if chlorination is not sufficient.

4.2.2.2.2 <u>Citrus juice concentrate</u>

As it has been already pointed out in para 4.2.2.1, citrus juice concentration is normally needed only in the case of large domestic market or for export to international market.

Fruit juice preparation technology has been described on para. 4.2.1.2.5.
To be concentrated, the juice must be refined and all fibrous contents, as well as essential oil, must be eliminated.
To obtain a satisfactory result, juice clarification (very fine refining operation) must be made by centrifugal filters.
Essential oils separation is also made by centrifugal separators, at very high speed.
Essential oils recovery is an important by-product contribution to economic profitability of the factory.
The clarified juice is then pumped into the concentration plant.
Concentration has to be performed at the lowest possible temperature (normally around 60 + 65 °C) and therefore a vacuum concentrator is requested. Moreover, the concentration period should be as short as possible.
This is easily obtained in the so-called "thin film flash concentrators", which can be considered as the most sophisticated last-generation concentrators.
To save energy and to carry concentration action down to 65-70 Brix degrees, a multiple-effect apparatus has to be used.
This method is based on a continuous flow of juice from the first concentration stage, to the second cascade stage (second-effect) to the third stage (third-effect), in connection with steam flow that runs from one evapotator to the other, up to the final condenser.
Juice heating takes place, in each stage, in a vertical tube nest exchanger; juice then flows into the evaporation kettle, (cyclone), where vapours separation is performed; juice is, at the same time, concentrated and deaerated; a "flash" cooling occurs in the final stage.
Juice is then cooled by refrigerate water into collecting tanks, where acid contents can be corrected by adding sugar.
Juice is manually filled into drums, to be kept in refrigerated warehouses.
Aromas are recovered from vapours by a condenser. The described process is reported only for the sake of completeness, because it is out of the limits of an adapted technology; nevertheless, this is the process to be used to fulfill international quality standards for concentrated citrus juices.

4.2.2.3 MACHINERY DESCRIPTION

4.2.2.3.1 Flume system transport

This system has been developed to transport tomatoes from storage basins, where tomatoes are discharged in bulk from truck, to the processing line without damages, and to make a fruit pre-washing.
The flume system is a channel, where water is kept moving by recirculating pumps.
The channel has a main frame of iron profile and side walls and bottom in painted iron sheets.
As an alternative, fixed installations can be fabricated in masonry or reinforced concrete, till the processing line feeding section, where tomatoes are taken from water by a bucket elevator and sent to the first washing tank.
An example of flume system is given on Fig. 4.2.24.

4.2.2.3.2 Washing machines

These machines are of the same type as described on para. 3.2.1.3.1.
Normally, a floatation machine is employed, with a bucket elevator that connects the machine with the selection bench.
During elevation, tomato are sprayed with clean high-pressure water, for an ultimate rinsing.
At the end of the selection bench, the fruits are automatically sent to the chopping machine.
The washing machine and the selection bench have a main frame in zinc-coated or painted welded iron profiles;walls are of painted iron sheets, while the transporters have buckets and rolls os stainless steel.
An example is given on Fig. 4.2.25.
This machine has a capacity of about 4 tons/hour with a water consumption of about 12 cubic meters/hour.

4.2.2.3.3 Chopping machines

Chopping or mincing of tomato fruit into small pieces is done by rotary comb machines.
Tomatoes are sent by the selection bench elevator to inlet hopper, where fruits are pressed by rotating teeth against stationary comb.
Crushed fruits fall into an output hopper or tank.
The machine is completely built of stainless steel.
Rotating toothed shaft is composed of single machined pieces and is supported by ball bearings.

Stationary comb is a unique machined piece of stainless steel.
The machine can have an external covering of painted steel sheets.
Supporting bench and gear boxes are made of cast or forged iron.
Electric motor is connected by belt drive.
This machine has a capacity from about 6 to 16 tons/hour, depending on rotor size.
An example is shown on Fig. 4.2.26.

4.2.2.3.4 Pre-heaters

In the "hot-break" process, crushed fruits have to be pumped into a tube-nest pre-heater; the heating causes the inhibition of certain enzymes.
In the cold-brek process, pre-heating is not done, and crushed fruits are sent directly to the refiners.
The pre-heaters are stainless-steel linear tube nests,with internal surface mirror-polished, where crushed fruits are pressed through by a volumetric pump.
The two headers are machined from stainless steel pieces and should be easily openable for inspection and cleaning.
The shell is a stainless steel pressure tube, supported by a profile frame.
Manufacturing of this machine requires the employment of very high precision machining, surface finishing and stainless steel welding.
These machines can have a capacity from 3 to 30 tons/hour of tomatoes, heated from 25 °C up to 80 - 90 °C, with a steam consumption in the range of 130 Kgs per ton of tomato.
An example is given on Fig. 4.2.27.

4.2.2.3.5 Refining machines

Crushed tomatoes are passed through a refining sieve, where seeds, skins and fibrous parts are separated from juice.
The refining operation is made in two or three stages by centrifugal refiners, with calibrated cylindrical filters, against which unrefined tomato juice is pressed by high-speed rotating arms.
Filter holes and their distance from arm-end plate scrapers are adjustable, in order to obtain, in each stage, the requested degree of fineness in the juice.

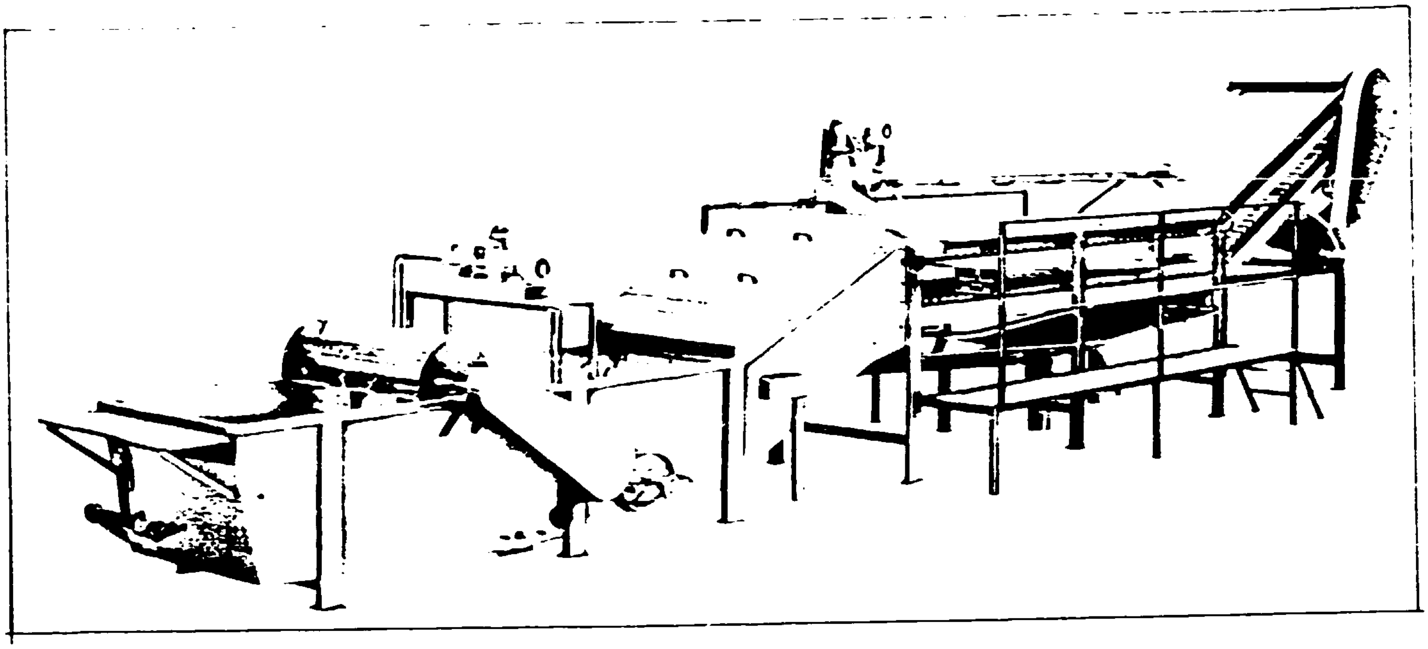


Fig. 4.2.25 - Washing machine, elevator and tomato selection bench (courtesy of Vettori-Manghi)

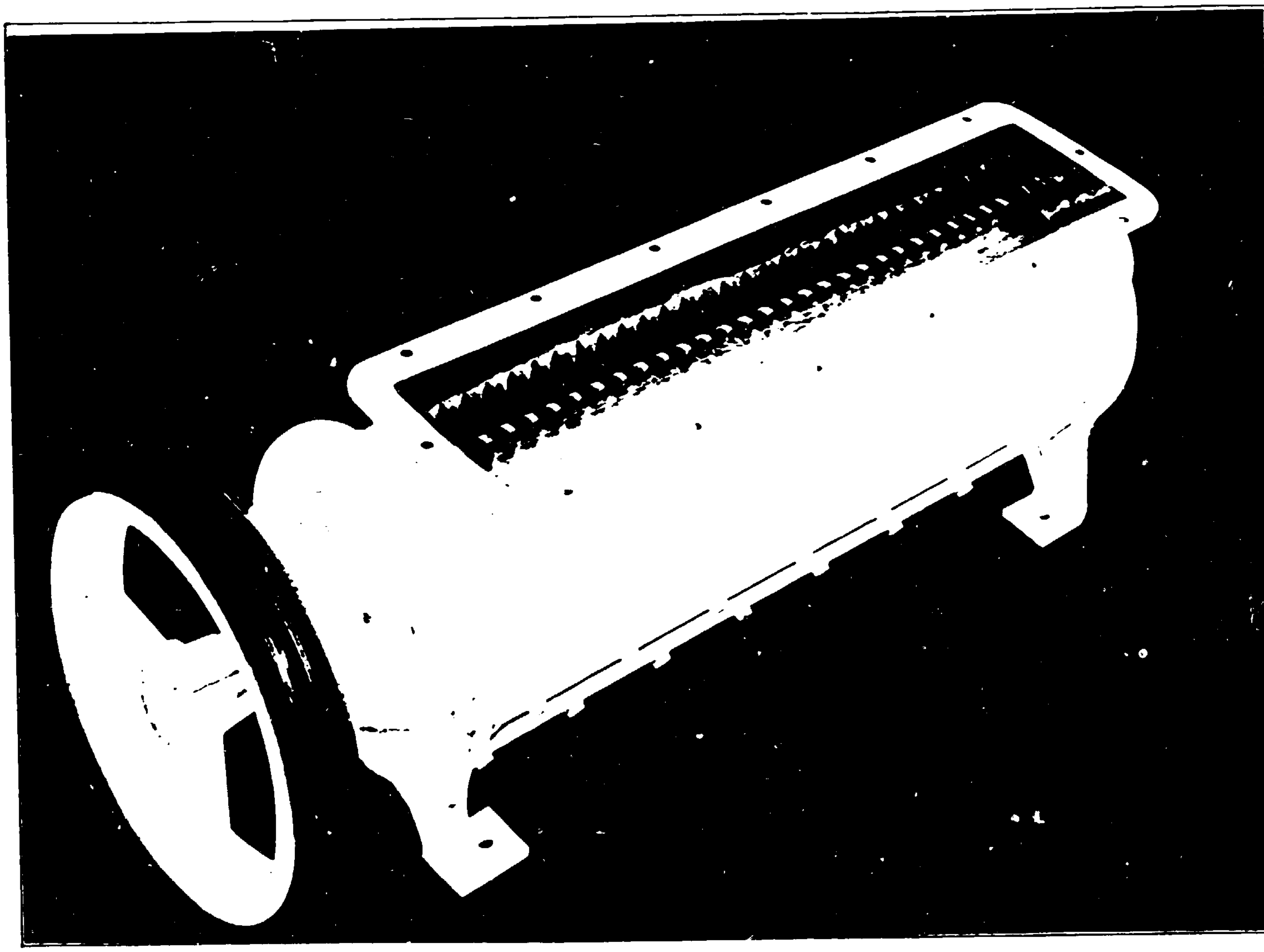


Fig. 4.2.26 - Tomato rotating comb chopper (courtesy of Rossi-Catelli)

Fig. 4.2.24 - An example of tomato "flume"

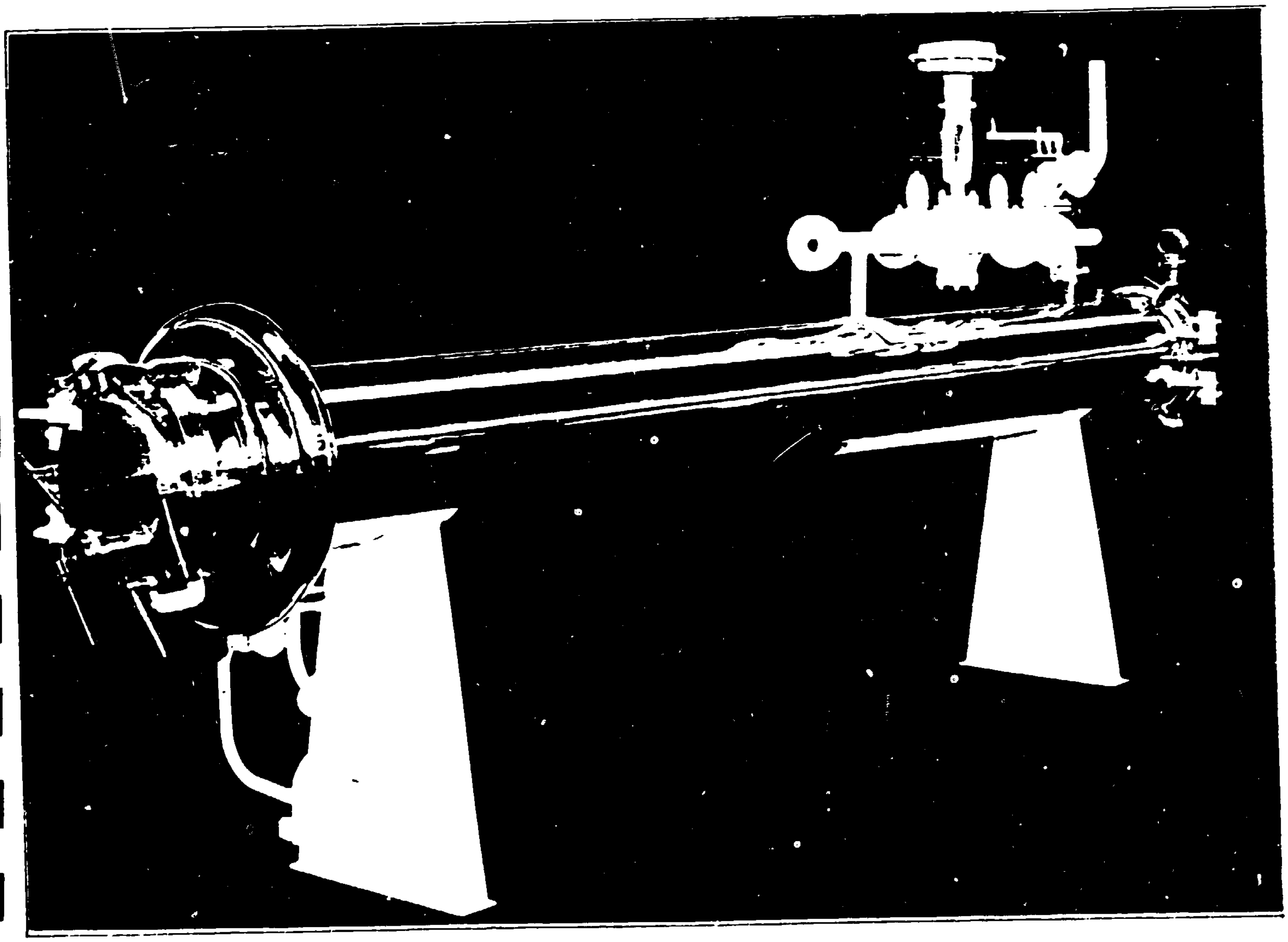


Fig. 4.2.27 - "Hotbreak" tomato preheater
(courtesy of Rossi-Catelli)

These machines can have a vertical or horizontal rotation axe, as it is shown in two examples on Fig. 4.2.28 and 4.2.29.
In the case of vertical axe, wastes fall down directly from rotor core-tube; in horizontal axe case, wastes are pressed by rotating arms to the end of central space through a waste output hopper. In both cases, machines are completely made by stainless steel.
Cylindrical body is machined out of a single piece of stainless steel with supporting head rings, also of stainless steel, where openable front caps are flanged and hinged.
Front caps and rotating arms must be easily dismantled for inspection and cleaning.
Cylindrical filter is a calibrated hole stainless steel thin sheet.
All internal surfaces are to be finished with very high precision and mirror polished.
Manufacturing requires very high precision machining of stainless steel and a very accurate assembling.
Supporting frame is made of painted welded iron profiles.

4.2.2.3.6 Vacuum kettle concentrators

As it has been pointed out in the technology description section, tomato juice characteristics are such that a single-effect vacuum kettle concentrator gives a satisfactory output product.
It is therefore possible to produce tomato paste using a relatively simple machinery, which has been traditionally used, on a batch-operated basis, for many years in the past and is still in operation in some tomato processing factories.
An example is shown on Fig. 4.2.30. The vacuum kettle is composed by a perfectly spherical double bottom, made of an inner part of drawed copper (or welded and machined stainless steel) and an outer skin of stainless steel sheet; kettle heating is made by steam, circulating in the double bottom.
The upper parte is a pressure container flange-mounted on the bottom sphere, made of welded stainless steel thick sheets.
All control and feeding equipment are connected to the upper part; vapours discharge head is connected, by a large stainless steel pipe, to the semi-barometric column condenser, with liquid-ring vacuum pump and centrifugal condensate pump.

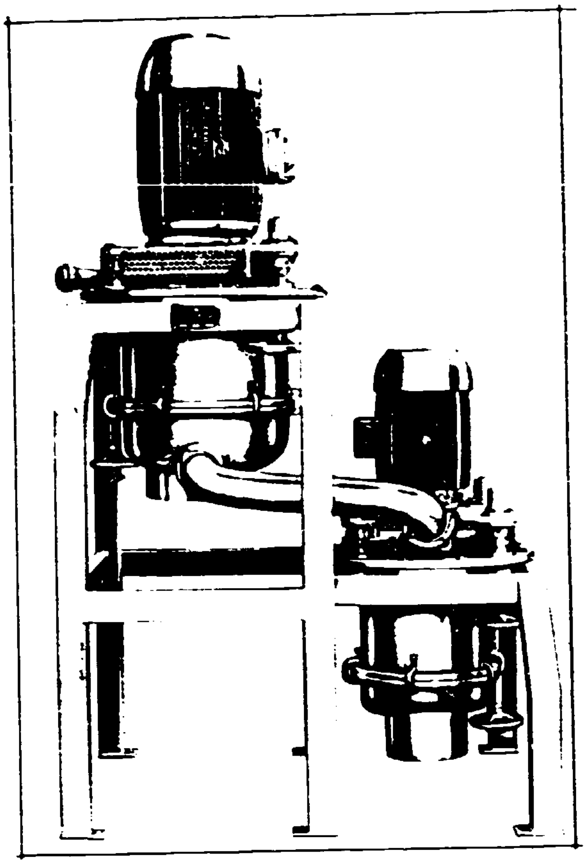


Fig. 4.2.28 - Vertical twostage tomato pulping-refining machine (courtesy of Vettori-Manghi)

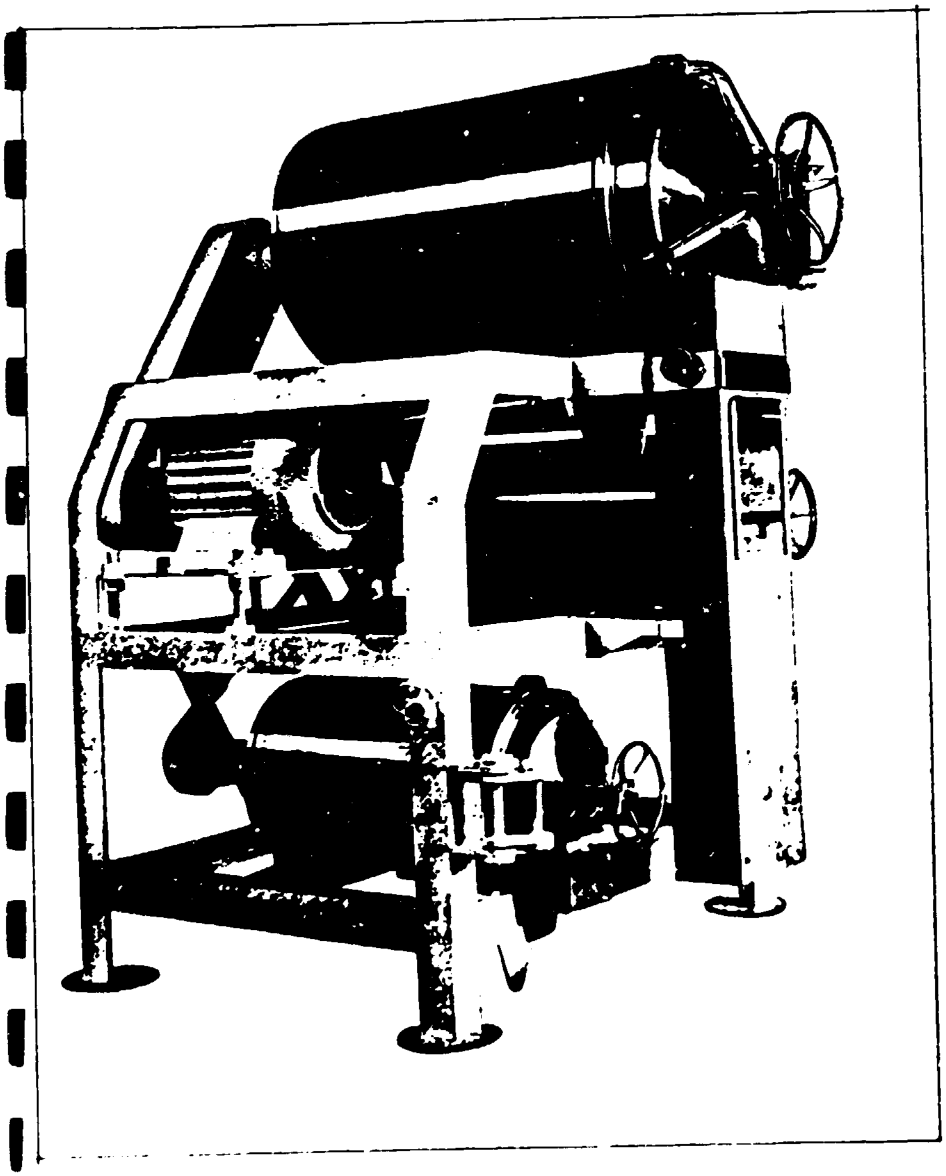


Fig. 4.2.29 Horizontal three-stage tomato pulping-refining (courtesy of Rossi Catelli)

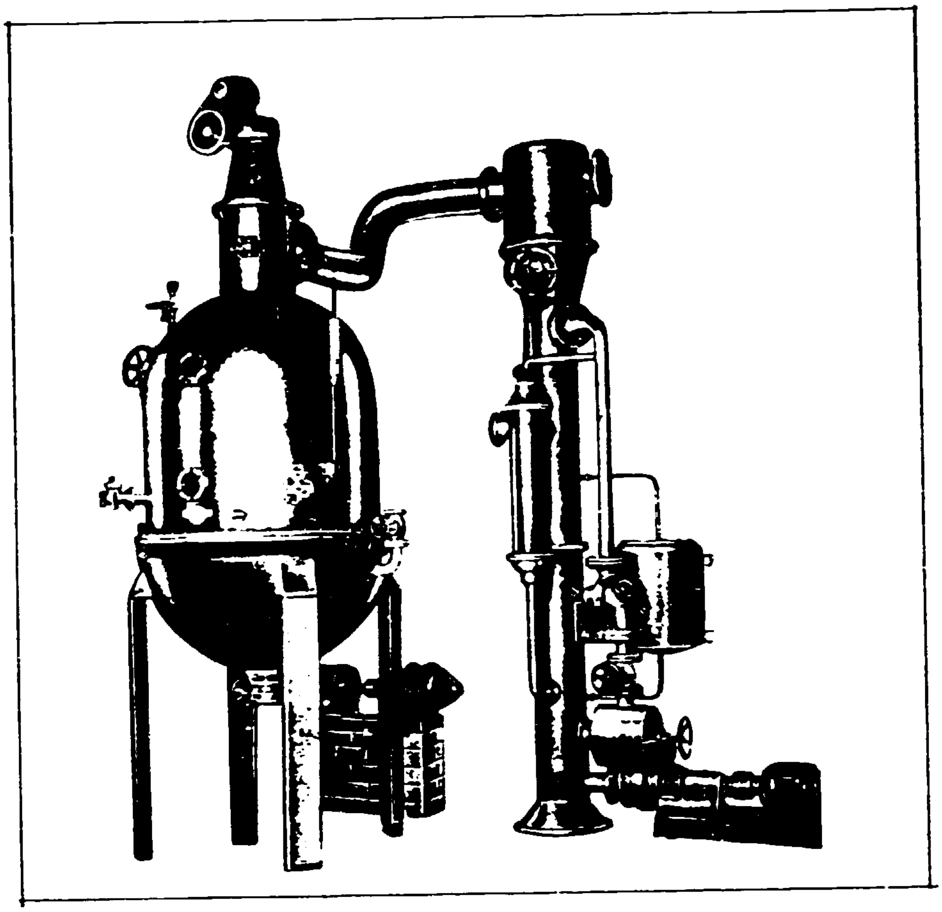


Fig. 4.2.30 - Single-effect vacuum kettle concentrator with semi-barometric steam condenser (courtesy of Rossi-Catelli)

All piping is made of stainless steel tubes.
Inside the kettle, rotating arms are driven by an external motor, to assure product mixing, to avoid overheating and to scrape the spherical bottom for cleaning.
This keeps the copper (or stainless steel) surface perfectly clean and assures maximum heat-trransmission efficiency.
The copper bottom can have the unconvenience of contaminating tomato juice that changes in colour and taste; a stainless steel bottom should be preferred.
This machine can be considered simple, if compared with widely employed continuous multiple-effect concentrators, but ist manufacturing requires huge drawing presses, very skilled and certified stainless steel welders and a high precision machining of auxiliary and control components.
In this type of concentrators, juice is pumped into the kettle, then concentrated and cooled; tomato paste is pumped out at the end of the cycle; this batch-operated cycle has a capacity from 1.5 to 4.5 tons of concentrate at 36% D.R. per day (three shifts), with a steam consumption of 400 to 1000 Kgs/hour and a water flow (for cooling) of 10 to 25 mts/hour (water at 18 °C).

4.2.2.3.7 Sterilizing heat exchangers

The sterilizing heat exchangers are of the same type of those described on para. 4.2.1.3.9, for other fruit juices. The only difference is that, to prevent a sour spoilage, tomato concentrate is to be sterilized immediately after concentration at higher temperatures (over 125 °C).

4.2.2.3.8 Dosing-filling machines

The machines, employed for canned fruits, described on para. 4.2.1.3.10, can be used also for tomato concentrate (juice or paste) dosing and filling of cans.

4.2.2.3.9 Seaming machines

The machines, employed for fruit canning, described on para. 4.2.1.3.11, can be used also for tomato concentrate can seaming.

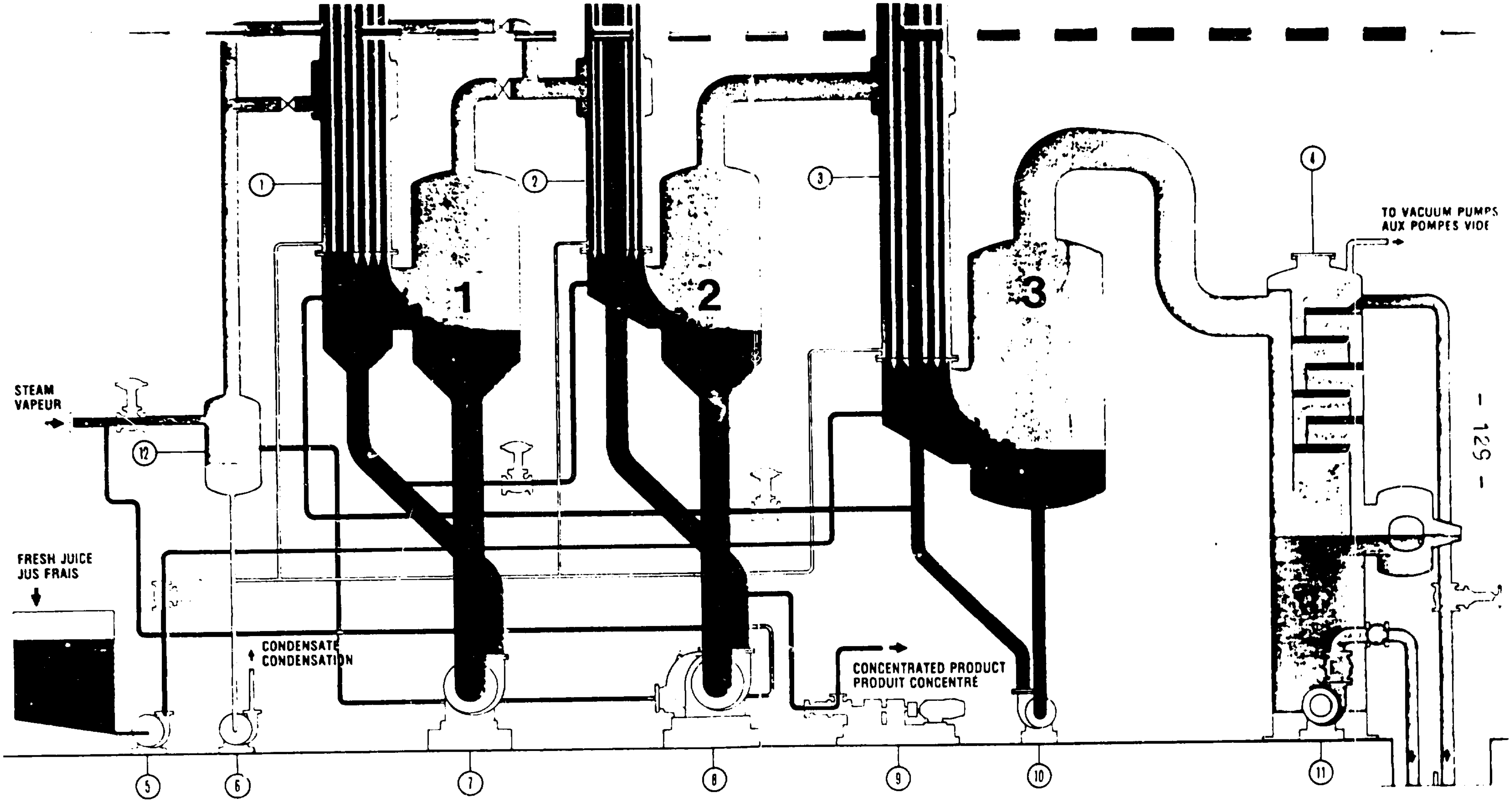
4.2.2.3.10 Can sterilization and cooling tunnels

Immediately after filling and seaming, the can has to be sterilized in boiling water (about 100 °C) to prevent sour

spoilage of paste, contaminated during filling, if this is done, as usually, in a non-sterile environment.
The can contents has then to be cooled down to a temperature of about 35 °C; this is obtained by sprayed water cooling tunnels, where cans are kept spinning, while transferred to the output.
The pasteurizing-cooling tunnel is the same as described on para. 4.2.1.3.13, where a boiling water first section is added.
These operations could also be performed in a simpler way by using boiling-water open pans (same as described on para. 4.2.1.3.12), where, after completion of the pasteurizing time, cold water is being circulated, to rapidly cool cans.
This procedure, being batch-operated, has a small capacity, depending on can and pan sizes, but it is very simple.
In any case, cooling water should be chlorinated.

4.1.2.3.11 Continuous multiple-effect vacuum concentration plant

The plant described herein is out of the limits of adapted technology and is reported only for the sake of completeness, being a process very widely used also in many developing countries. These huge plants are used when a production capacity from 10 tons/hour to 40 tons/hour of fresh fruit is requested.
The concentration may be made on double, triple-or quadruple-effect concentrators.
A functional scheme of a triple-effect continuous concentration plant is given on Fig. 4.2.31, which clearly explains the working principles.
Of course, total heat consumption balance is lower, if a multiple-effect system is used; one Kg of steam evaporates about 1.5 Kgs of water from the juice for a single-effect machine, about 2 Kgs for a double-effect, about 2.6 Kgs or more for a triple-effect, and so on.
Up to six-effect concentration plants are now in operation, for special processes.
An example of multiple-effect continuous concentration plant is given on Fig. 4.2.32.
Multiple-effect concentration can also be obtained by setting up a series of kettles with steam duct connections, as it is shown on Fig. 4.2.33 for a triple-effect tomato concentration plant.



(legend)	STEAM	VAPEUR
(legend)	PRODUCT	PRODUIT
(legend)	WATER	EAU
(legend)	CONDENSATE	CONDENSATION

1 1st Effect tube nest
Faisceau tubulaire 1^er effet

2 2end Effect tube nest
Faisceau tubulaire 2^ème effet

3 3rd Effect tube nest
Faisceau tubulaire 3^ème effet

4 Semi-barometric condenser
Condensateur sémi-barométrique

5 Feeding juice pump
Pompe alimentation jus

6 Condensate extraction pump
Pompe extraction condensation

7 1st Effect circulation pump
Pompe circulation 1^er effet

8 2end Effect circulation pump (finisher)
Pompe circulation 2^ème effet (Finisseur)

9 Concentrate extraction pump
Pompe extraction concentre

10 3rd Effect circulation pump
Pompe circulation 3^ème effet

11 Water extraction pump from condenser
Pompe extraction eau condensateur

12 Steam mixing tank
Cuve de mélange vapeur

Fig. 4.2.31 - Functional scheme of a triple-effect concentration plant

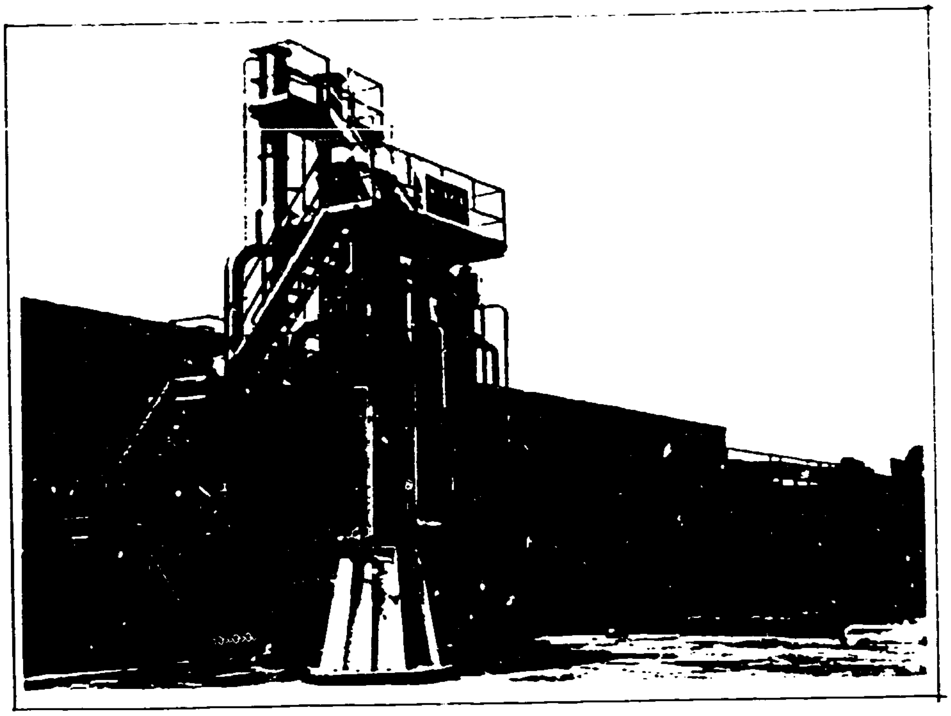


Fig. 4.2.32 - Multiple-effect continuous concentrator for citrus juice, with thin film evaporation finishing (courtesy of Manzini)

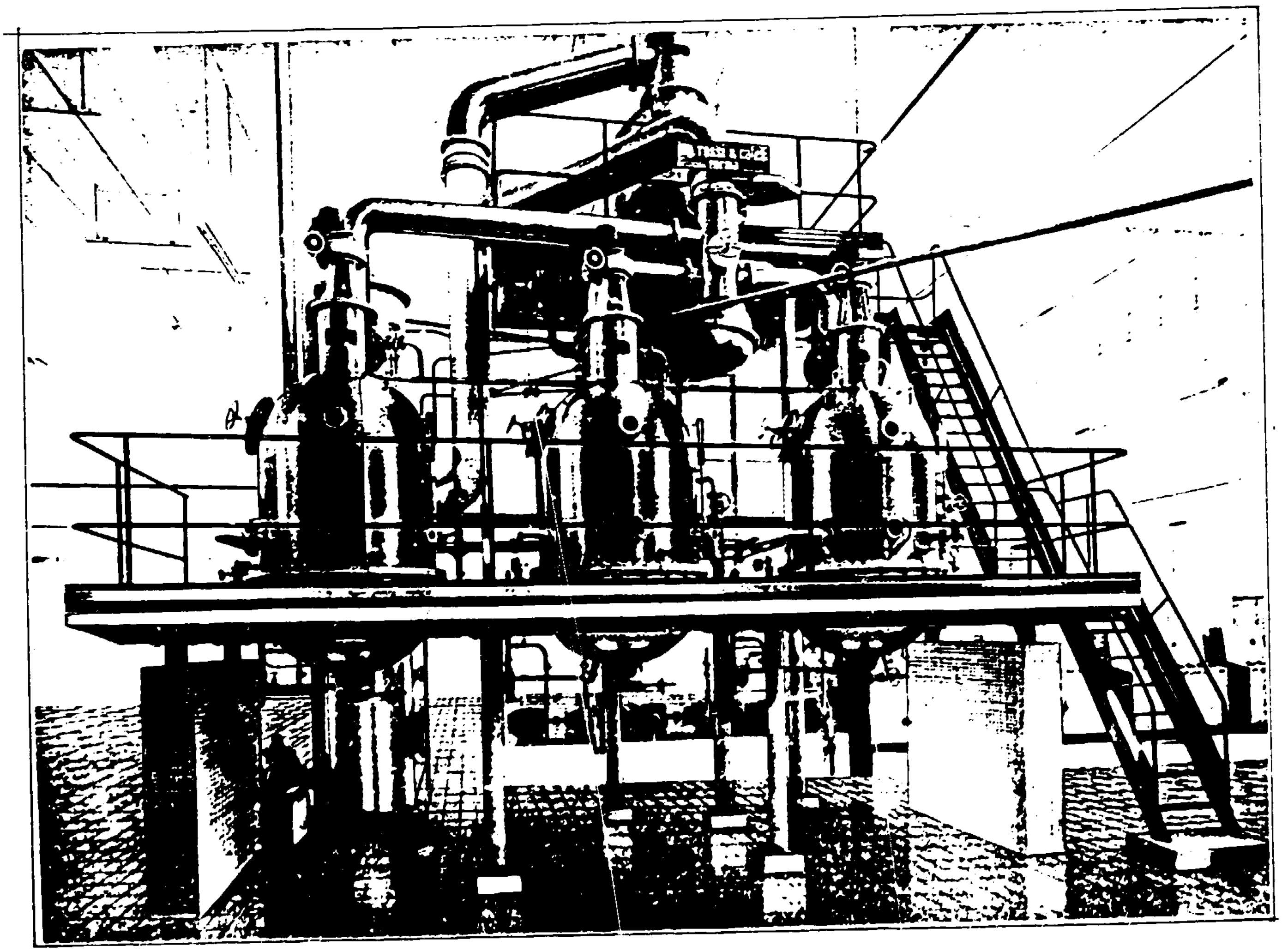


Fig. 4.2.33 - Triple-effect kettle concentration plant (courtesy of Rossi-Catelli)

4.3 - MILK PROCESSING

4.3.1 - Pasteurized and sterilized milk
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4.3.2 - Dairy products
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4.3.1 PASTEURIZED AND STERILIZED MILK

4.3.1.1 General remarks

Fresh milk processing has become, in the last decades, a more and more sophisticated technology, because milk is a rapidly perishable and very delicate product.
To save its characteristics and ist nutritional value,heat treatment must be controlled within very narrow limits, in terms of temperatures, flows, times etc.
This has led to the development of complex and integrated plants, where continuous processes are fully automatized and controlled by sophisticated electronic and mechanical devices.
In the case of milk processing, it is of scarce significance speaking of separate machines, since the whole processing line is highly integrated, from milk reception to packaging section.
In this field, where deeper changes have occurred, glass and plastic bottles have become rapidly obsolete, because of the development of carton forming and filling machines (Tetrapak system or similar products), which are now widely employed in almost every central dairy.
High investments, required to update processing lines, have caused an increase in the average scale of dairy plants; fresh milk market is now dominated by large central dairies.
On the manufacturer's side, research and development had been afforded only by few big firms, which supply complete lines.
Neither "down-grading", non adaptation seems to be possible in the fresh milk processing technologies. Let us get a quick look to technologies currently available.
Milk can reach the consumer in one of the following forms:

- as raw milk, directly from the producing ranch ("from cow to consumer")
- as pasteurized milk from central dairies
- as long-term storage sterilized milk (UHT process)
- as dried and regenerated milk

The first case occurs only in very few developed countries, where specific know-how and environmental conditions make possible to obtain pure and aseptic milk, directly from the producing ranches.
The second case is the most widely diffused; milk is consumed in pasteurized form in all developed countries.
The original technology for milk pasteurizing was simple; milk plants became more and more complex because of the need to have larger capacities, to use more sophisticated

packaging systems, to automatize processes, etc.

Competitive market pressure has forced to consider economically obsolete machinery and equipment, whose output quality was, technically speaking, perfectly acceptable. Re-employment of these equipments might then solve the milk processing adapted technology problem?

Unfortunately, pasteurized milk has a limited life (4 days) if stored at low temperature (0 to 4°C), in refrigerated stores; this calls for quick and effective market distribution facilities and for widely diffused refrigerated storage capacities.

This is obviously out of the reach of the majority of less developed countries.

Pasteurized milk adapted technology can hence be found, but requires a much more developed market structure, than less developed countries can afford.

Long-term storage UHT milk can certainly solve market distribution problems: its life is of more than 4 months at ambient temperature. Unfortunately, UHT processing technology is, by itself, very complex and, furthermore, it has been developed in the last years and machinery has incorporated sophisticated innovations.

No adaptation or "down-grading" is possible, where temperature and time are to be controlled with a tolerance of, respectively, one or two degrees and one second; this excludes any human intervention: line must work in a completely automatic way.

UHT milk can then solve marketing problems, but technology is fully unadapted.

The last case has the same shortcomings of pasteurized milk case; it can solve the problem, frequently occurring in the less developed countries, of a lack in milk producing capacity, but regenerated (or "filled", or "toned") milk shall be pasteurized, calling again for quick distribution and refrigeration facilities.

It is evident that fresh milk processing has some complexity aspect (in the plant technology or in the market infrastructure) and that, therefore, a fully adapted fresh milk processing and distribution chain cannot be conceived.

Nevertheless , in the next paragraphs, for information purposes, available fresh milk processing technologies will be described.

It has been noticed that pasteurization process, followed by glass bottle filling, is, from a purely technological point of view, an adapted and simple technology, if operated at reduced scale.

A glass-bottle daily distribution system, with empty bottle return, has been in operation until a few years ago in the developed countries.
This system has been started long before the wide diffusion of family refrigerators had been completed.
It should be carefully investigated, at single country study level, if, for some urban area, this system might be feasible; this would be a possible solution to fresh milk adapted technology problem.
Completely different aspects are shown by the technologies for processing other dairy products, such as cheese, butter, yoghurt etc.
Those technologies, and related machinery, have been conceived centuries ago and are therefore available in different development phases.
Adapted machinery, for industrial operation of small scale dairy plants, is then easily available and still operating in many developed countries.
It should be carefully investigated, at feasibility study level, if a secondary milk processing dairy (without any fresh milk distribution) could be economically managed.

4.3.1.2 TECHNOLOGY DESCRIPTION

4.3.1.2.1 Milk reception

Milk reception at the dairy is only the last operation of a chain, beginning at the ranch site with milking and then involving short-term storage and transport facilites. From this chain, apart from any other consideration about the farm management, heavily depends the quality of milk to be processed.

Milk reception is operated in two main ways, depending on type of transport: in aluminium cans of 10 to 50 litres, or in bulk tankers.

Obviously, the second system is much easier and effective and is largely employed in the developed countries; but, since adapted technology environment is unlikely to be equipped with road tankers infrastructure, only tank reception technology will be taken into consideration.

At the receiving platform, filled cans are unloaded and transported to weighing scale, which can be manually operated.

After weighing, cans are tipped into the collecting tanks. Tipping can be operated manually or semi-automatically by a lever-operated can tipper.

In another possible reception process, cans are tipped into one or two tanks, where weighing is accomplished and then pumped, through filters, to receiving tanks.

Cans are then sent to the washing machine, which is manually operated through a pedal, which opens a nozzle from which hot water and steam are sprayed into the upside-down can. Cans are then sent back to the loading platform.

Milk is manually or automatically analyzed to determine fat contents and other qualitative data; this is done in order to separate and/or mix different quality milks for standardization.

Aim of the analysis might also be the establishment of milk price, which can vary as a function of fat contents.

Depending on storing time, which in turn depends from dairy size, capacity and management, milk can be refrigerated to 4 to 6 °C in the collecting tanks or, more often, in vertical isothermal tanks.

From storage tanks, milk is then sent, through stainless steel piping and valves, to the processing equipments for pasteurization, UHT sterilization or secondary processing (cheese, butter, yoghurt etc.).

4.3.1.2.2 Pasteurized milk

Aim of the pasteurization is to reduce spoiling micro-organisms action and to kill all possible infecting micro-organisms, in order to guarantee a limited refrigerated-store (0 to 4 °C) life to the product (about 4-5 days) and its completely safe wealth characteristics.
Pasteurization is a heat treatment, accomplished by keeping milk at 63 °C for 30 minutes ("low" pasteurizing procedure, now not widely employed) or at 72°C for 15 seconds.
Different technologies and machineries have been developed, to obtain the requeste temperature and times.
The heating medium is normally steam, operating directly or indirectly through hot water, in order to maintain the minimum possible temperature step (few degrees) between heating medium and milk, to avoid possible heat transfer inconveniences and overheating of the product.
Widely employed in thepast, the parabolic and the drum pasteurizers had the advantage of being very simple machines, easy to be cleaned.
Nowadays, the most widely employed are the tube nest pasteurizers (similar or equal to those employed for other food processes), where hot water is circulating in countercurrent into a jacketed tube of stainless steel.
Another type has tube nest exchanger submersed in the milk inside a pasteurizing tank in stainless steel (to save space).
The most advanced solution relies on plate pasteurizers of very complex technology.
For adapted technology, probably tube-nest pasteurizers could be the best solution, because the same machinery has been employed for other food products and manufacturing technology has been assimilated (with some important notes,as explained in the machinery description section).
Pasteurized milk is then cooled down to about 20 °C,then chilled to about 5 °C and passed to the filling section.
As already pointed out, the widely employed carton forming-filling procedure (Tetrapak or similar) is a very complex technology.
Similar, but a little bit simpler, is the plastic bottle forming-filling procedure (still in use in many large dairies, but becoming obsolescent in many industrialized countries).
Only system, within the limits of adapted technology complexity grade, is the glass-bottle filling, through a level gravity filler (the simplest) or a vacuum filler (more complex, at intermediate technology level).

If filling technology is simpler, glass bottles handling and management is more complex, because requires efficient consumer distribution and empty-return network (on a refrigerated daily delivery base) and accurate bottle control and washing, before filling.
Normally, a good quality product requires homogenization, before pasteurization is effected.
Homogenization is obtained passing milk through a pressure homogenizer; milk is pumped, at very high pressure (150 to 350 Kgs/sq.cm.), into a calibrated valve, where high-speed impact of fat particles, against the valve walls, breaks and homogenizes them, thus making difficult floating of fat particles from milk suspension.
Homogenizers are intermediate complexity machines.
Skimming is requested to standardize milk fat contents to national regulations (normally between 3,6% and 1,8% for "full" milk); skimming can be done by removing the floating cream, before homogenization, to be sent to butter making section.
If a deeper skimming is requested, this can be accomplished by a skimming machine, using calibrated centrifugal action to separate cream from milk, up to the requested concentration.
This machine can also be considered as intermediate in technology.
As it can be seen, it is to be stressed once again that fresh milk processing is very hardly kept within the limits of an adapted technology; this is possible only if non-standardized product (and thus possibly of low-quality, depending on producing ranch management and rearing conditions) can be accepted by the consumer and if the relevant low-range (within city) distribution system is set up.
Whether this is economically and technically feasible or not, it is a question that only accurate case-by-case studies can answer.
A typical milk pasteurizing flow-diagram is shown on Fig. 4.3.1.

4.3.1.2.3 Sterilized milk (UHT)

A recently developed system (UHT= ultra high temperature process) gives a milk which is practically sterile and whose life at ambient temperature, if adequately packaged, is of about 4 months.
This would solve any distribution and consumer's storing problem; unfortunately processing technology is at a very high degree of sophistication, far out the limits of an adapted one.

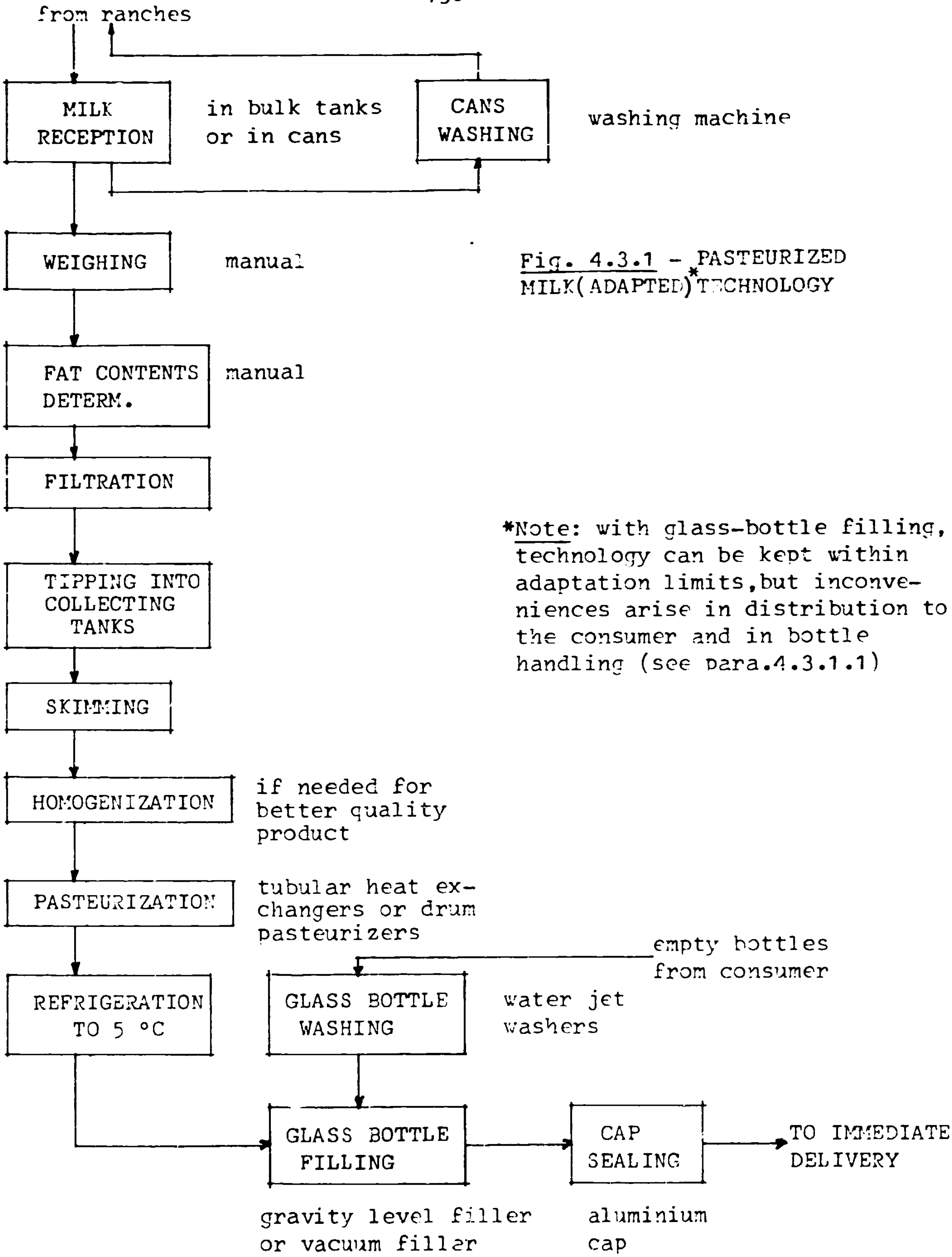


Fig. 4.3.1 - PASTEURIZED MILK (ADAPTED)* TECHNOLOGY

*Note: with glass-bottle filling, technology can be kept within adaptation limits, but inconveniences arise in distribution to the consumer and in bottle handling (see para.4.3.1.1)

The UHT process consists in a "flash" sterilization (i.e.
reduction of thermoresistant spoiling microorganisms to
one spore over a billion, or 9 decimal reductions); per-
formed by heating milk to high temperatures for few seconds
and then cooling it very rapidly.
UHT process can be performed by two basic methods: indirect
or direct heating.
The first method employs tubular or plate exchangers to
firstly heat milk to about 60 to 65 °C and then to about
90 °C to 95 °C, where it remains for 20 to 40 secs.; milk
is then heated to 138 °C to 145 °C, where it remains for
few seconds (2 to 5) and cooled by countercurrent heat re-
cuperators and water chillers down to about 20 °C, in two
or more stages.
The direct method employs steam injection; the first phase
heats milk to about 80 to 85 °C by heat exchangers; then
steam injection causes milk temperature to raise immediate
ly to 140 to 145 °C, where it remains for about 5 seconds;
milk is then "flash cooled" by expansion, in a vacuum
kettle, down to about 80 °C and a final water cooling brings
temperature to 20 °C.
In both cases, filling must be performed by sterile carton
forming-filling machines (type Tetrapak or equivalent).
Homogenization should be performed before entering the ste
rilization line, because it improves heat exchanging be-
haviour of milk as well as its quality.
Homogenization is done by pressure homogenizers.
UHT processing the whole line, including packaging, is an
highly integrated system, which requires an advanced level
of controlling and automation, where no adaptation is
possible, and whose complexity can be defined as very so-
phisticated.
A flow-diagram of a direct steam injection method is shown
in Fig. 4.3.2
A flow-diagram of an indirect plate-exchanger method is
shown in Fig. 4.3.3

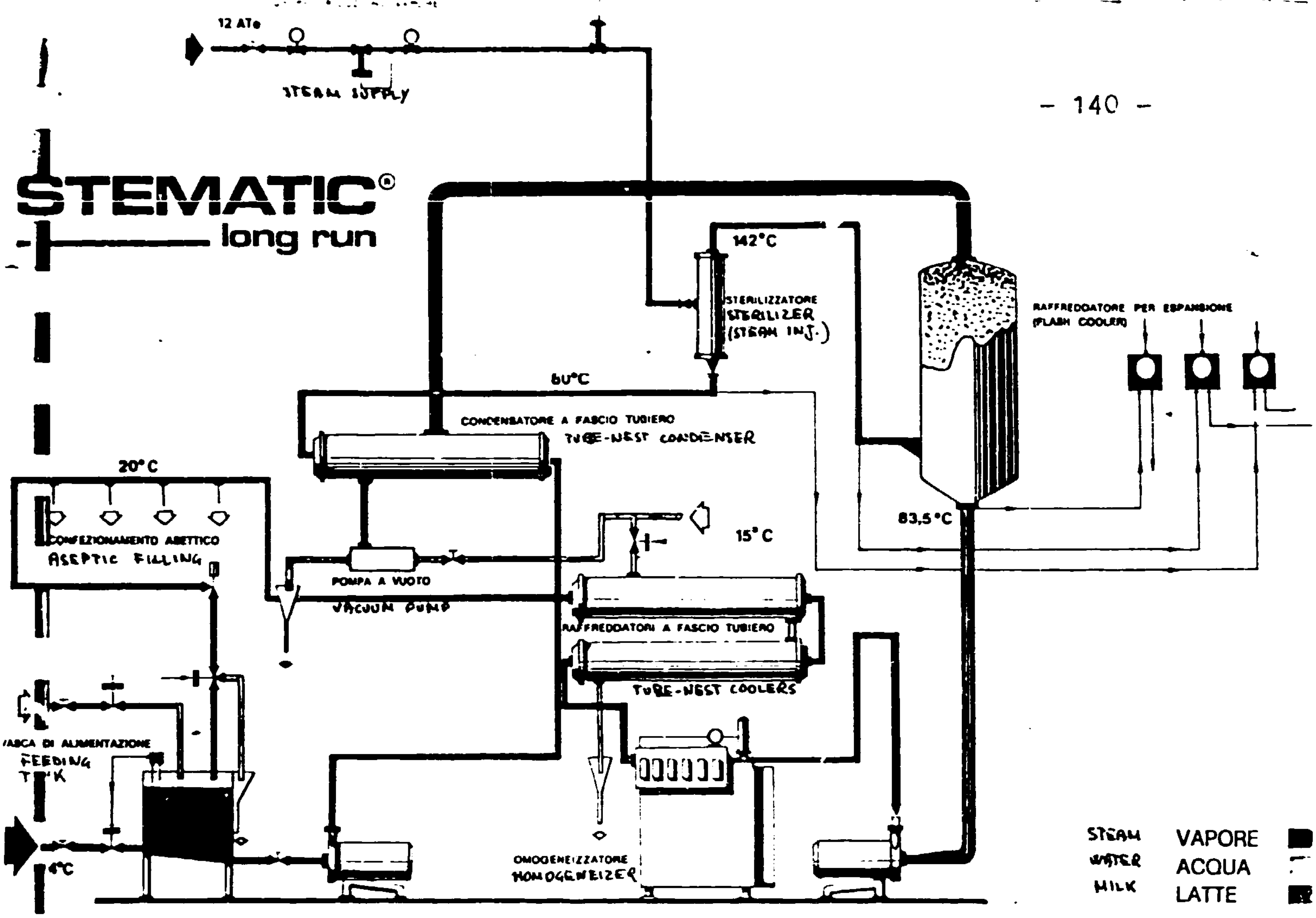


Fig. 4.3.2 - Direct steam injection UHT milk process (courtesy of Rossi-Catelli; Stematic long-run process)

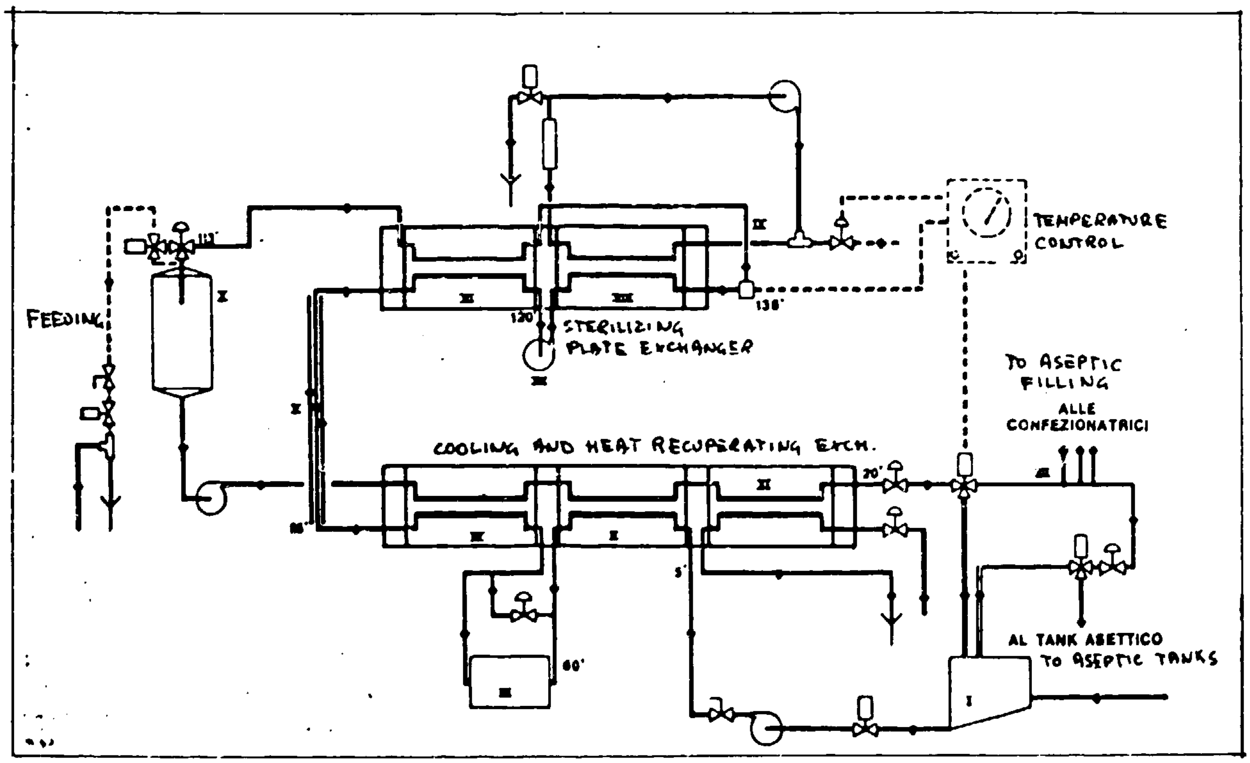


Fig. 4.3.3 - Indirect plate exchanger UHT milk process (courtesy of Sordi; Steriplak S2 process)

4.3.1.3 MACHINERY DESCRIPTION

4.3.1.3.1 Milk reception section

Milk is transported to dairy in cans, made of aluminium, of standard sizes from 10 to 50 litres.
Caps are fixed to the can by a water tight sealing and a pressure device.
Cans are unloaded from ranch trucks manually.
Milk discharge into the weighing tank is done by semi-automatic can tipper, which is made of a steel frame, supporting the filled can, which, operated by a chain or by an hydraulic ram, driven by a motor, turns over filled cans into the weighing tank hopper.
Hopper and weighing tank are made of welded stainless steel sheets, as it is shown on Fig. 4.34
The weighing device can be a manual scale, with direct reading on a panel. Weighing scales are normally in the range from 200 to 1000 Kgs full scale, because several cans are weighed at the same time into the tank.
Milk is then pumped up, through a mechanical filtering device (stainless steel net), to the storing tanks.
These tanks are cylindrical stainless steel sheet containers; surface is accurately polished and finished, to allow easier cleaning.
Legs are also in stainless steel.
Thermometers and level indicators complete tank instrumentation, as it is shown on Fig. 4.35
All piping must be of special stainless steel tube with polished surface; all welding must be very accurate, to avoid any possible roughness and/or porosity, which would not allow rigorous and deep cleaning procedures.
Cleaning is normally done by pumping into the system detergent and disinfecting solutions; this can be done manually, provided a very precise procedure is followed, to reduce possible errors.
Any uncorrect cleaning procedure can spoil out the entire recepted quantity and cause troubles to the whole processing line.
Emptied cans have to be washed and sanitized before withdrawal by farmers; this is accomplished by a pedal-operated hot water and steam nozzle, placed at the center-bottom of a stainless steel vat, where waste water is drained out.
A fresh water sprayer provides rinsing and, finally, a steam jet sterilizes the can.
For higher washing rates, a continuous washing machine should be used; can washers have a washing tunnel, where

Fig. 4.3.4 - Hopper and weighing tank for milk reception (courtesy of Sordi)

eption tanks (courtesy of Sordi)

upside-down cans are washed, in line, by a jet-sprayed detergent solution, after a coarse water pre-washing.
Cans are then transferred, by a chain conveyor, to the hot water rinsing section and to a steam jet sterilizing chamber; a final hot-air blow provides can drying.
Output cans have to be turned over and capped by manual or semi-automatic devices.
The washing machine can be considered at intermediate technology level.

4.3.1.3.2 Milk pasteurizing section

As already stated, pasteurizing is a highly integrated process, where operations are performed in line.
A continuous flow of milk is heated and cooled, following a selected and well determined schedule.
In no point of the line should the product get in touch with atmosphere, where it would be contaminated. All piping should be in polished stainless steel tube.
Pasteurization can be performed by:

- parabolic pasteurizers
- drum pasteurizers
- tubular heat exchanger (jacketed)
- pasteurizing tanks with tube nest heat exchanger
- plate pasteurizers

A parabolic pasteurizer (now rarely employed) is a parabola-shaped drum, rotating on a vertical axis, placed into a parabolic vat. The milk is pumped into the hollow space between the two parabolic vats, whose inner space is steam heated. Milk is then pumped out at the top of the path along the hollow space; by varying rotating speed of the parabolic drum, the pasteurizing time is varied.
A drum pasteurizer is an improvement of the parabolic one and has a cylindrical grooved drum rotating on its vertical axis; its working principle is the same as parabolic pasteurizer.
Both machines are made entirely of cold-formed stainless steel sheets and its manufacturing requires skilled welding and machining of rotating parts.
A tubular heat exchanger is basically working as a jacketed pipe (single or double jacketing) where a fluid is pumped in countercurrent with another fluid (to be heated) flowing in the jacket. Few degrees of temperature difference between the two fluids assure that no product "burning" takes place.
A tubular heat exchanger is a simple machine and its ma-

nufacturing requires stainless steel tube welding and sur face finishing skils; welding must be very accurately finished to avoid any roughness or porosity. An inconvenience of tubular heat exchangers is that they require much space, because dwelling time is to be determined by tube length.
An improvement, to reduce space, is to wind up heating tubes to form a nest and to place them into a stainless steel vat, where milk to be pasteurized is kept circulating.
Vats are stainless steel sheets welded into the shape of a cylindrical tank.
A more sophisticated equipment, the plate pasteurizer, allows heat to be exchanged between the two opposite faces of a cold-formed herring-bone grooved stainless steel sheets, in the form of a rectangular plate.
Many of these plates are pressed together, with a sealing rubber gasket interponed, in order to obtain a "pack" of exchanging elements; at the two ends, a wider chamber allows dwelling of pumped fluids.
Manufacturing of plate exchanger requires a high degree of cold-forming and die-making skill and thick stainless-steel sheet cutting and welding procedures.
Tubular heat exchanger or drum pasteurizers can probably match with adapted technology requirements.
Filling of glass bottles could be done in a very simple manner by using valve-controlled level fillers, which are gravity operated and automatically close filling stem by a conical pressure valve, when bottle has been filled up at the preselected level.
These fillers are very simple and can be semi-automatically operated by hand-supplying of empty bottles.
Better results are obtained by vacuum filling heads; the filling stem has a central hole for vacuum suction of air, whilst a ring peripheral slot allows milk to pour into the bottle; there is no foam formation and aluminium cap is easily sealed.
Bottle washing can be done by hand only for very little capacities; washing machines should be used for normal small-dairy rates of 700 to 1500 bottles per hour. Washing machine is divided in four sections: water pre-washing, hot-water jet sprinkling with detergent solution, water jet double rinsing, steam jet sterilization and hot-air drying.
Washing machines are made of a painted steel or stainless steel tunnel, with a bottle-carrying specially-shaped chain.
Bottle loading and unloading is manually operated; fully automatic bottle handling increases machine complexity.

4.3.1.3.3 UHT milk plant

A UHT milk treatment plant is a highly integrated and fully automatized system, whose degree of technological complexity is probably one of the highest in the food processing sector.
UHT plant can use direct steam injection method or indirect heat-exchanger method.
The first method employs tube nest exchanger to raise milk temperature from 5 °C to about 80 °C; then, steam is injected into the milk flow to raise temperature instantaneously to about 140 °C for a few seconds, since milk is "flash" cooled immediately afterwards by expansion into a cooling tank, where it is at the same time deaerated and dehumidified.
Milk is then pumped into a water cooling unit, that brings temperatures down to 20 °C, for filling into sterile environment.
The second method employs normally plate (or tube nest) exchangers to raise milk temperature, in two hot-water counterflow stages, to about 60 °C and then to about 95 °C, where it remains for 20 to 40 seconds.The final sterilization temperature of about 140 °C is reached in a plate exchanger in counterflow exchange with overheated water.
Milk remains at the sterilization temperature for about 4 seconds and enters a plate exchanger cooler, as heat regeneration with incoming milk, where it is cooled to about 110 °C; milk is then degased in a "thin film" degaser and finally cooled down to 20 °C, by two heat regeneration stages with incoming cold milk and water-
Filling in a sterile environment is made at 20 °C.
Both methods need highly integrated plants, built up in such a way as to save maximum space and to ease cleaning and operational procedures.
All systems are entirely built in stainless steel and lay on various supporting platforms.
An example of direct injection plant is shown on Fig. 4.3.6; indirect heat exchanger plant is shown on Fig.4.3.7.
The production rates of these plants are in the range of 2000 to 24000 litres per hour.
Filling is to be performed in a sterile environment,using sterile containers: one of the most widely employed systems is the carton forming-filling machine, a very complex and sophisticated machine, that sterilizes the container raw material (specially treated thick paper with a plastic film) and continuously shapes a "tube" of carton, filled with sterile milk. The "tube" is then thermically sealed

at the desired interval, then cut into pieces along sealing, reshaped and sorted.
This technology, originated in Sweden, is patented and the very complex machines are normally rented or leased by the manufacturer.

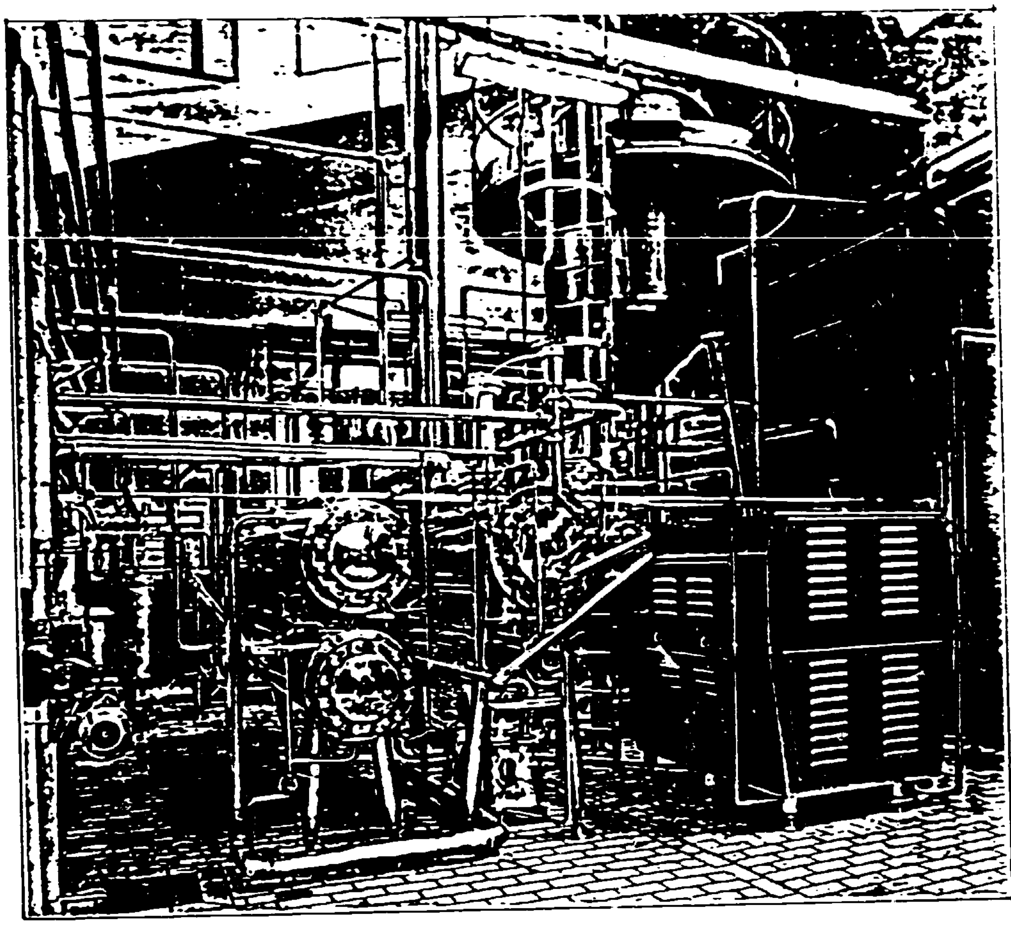


Fig. 4.3.6 - A UHT milk (direct-steam injection method) (Stematic) processing plant (courtesy of Rossi-Catelli)

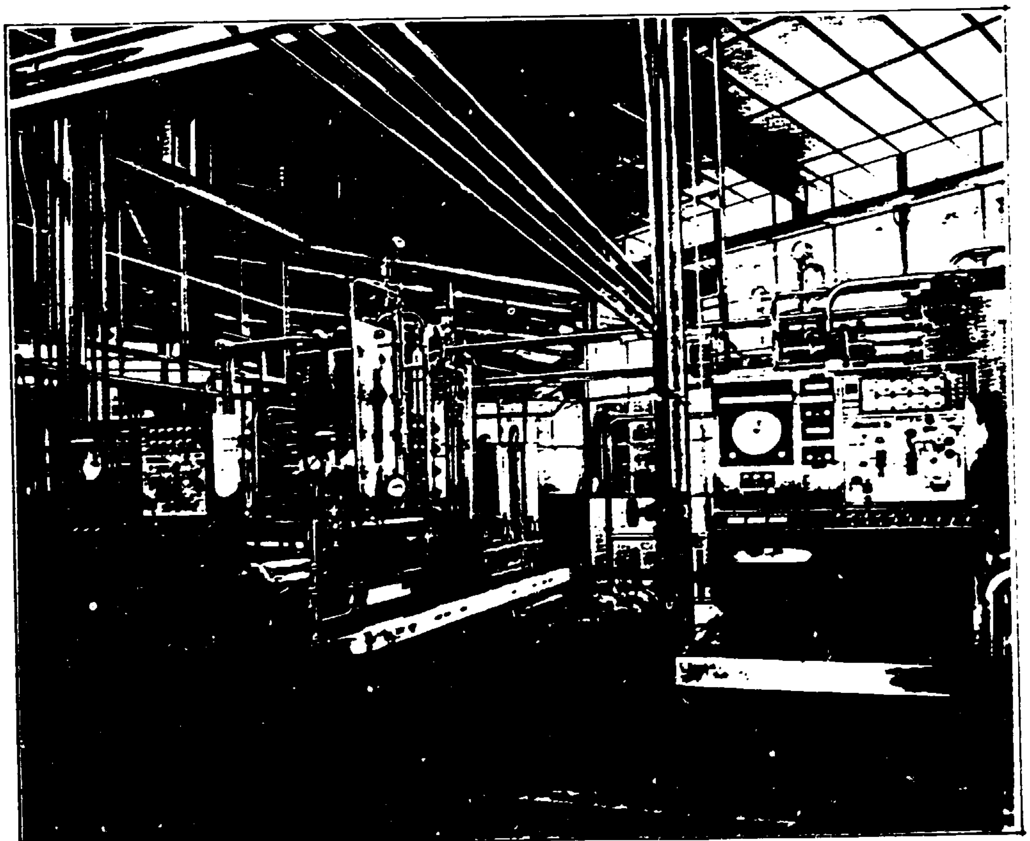


Fig. 4.3.7 - A UHT milk (indirect plate-exchanger method)(SteriplakS2) processing plant (courtesy of Sordi)

4.3.2 DAIRY PRODUCTS

4.3.2.1 General remarks

It is well known that such a large variety of dairy products exist, that it is impossible to take into account all different technologies, strictly connected to local nutritional and cultural habits.
For instance, more than 300 types of cheese are currently manufactured only in the western countries; each product is often made following different processes in different countries.
Only a very general technological advise will then be given, for three of the most widely diffused daily products: cheese, butter and yoghurt.
Between all available technologies, most of which still employing very ancient and simple processes, only small differences exist, but these details are very important in obtaining different product quality, taste, flavour, aspect etc.
Much more important than process followed, it is the operational know-how of operators that determines quality and value of the dairy product.
Technologies, described in the next paragraphs, are then to be considered as representative references; readers are sent to specialist's texts for further details on products, machinery and technology.
It is also to be pointed out that climate and environmental conditions are of great influence on final product quality; it is in fact well known that the majority of cheese products have a quality grading that depends on areas of origin (sometimes on single villages).
Many of these technologies cannot practically be reproduced in a different environment, since they rely on artisanal techniques, developed during centuries, that can only be operated and constantly developed only in a well-defined social and cultural environment.
In this sub-sector, more than in any other, "up-grading" of local techniques should be preferable to any other technology transfer procedure.
As far as machinery is concerned, since manufacturing technologies have been developed many years ago, simple machinery is available and is still in operation in a very wide variety of small and artisanal plants, scattered in the country, near the ranches.
More modern machinery is, in practise, only "up-graded" with respect to anciently developed one, in order to auto

matise operation, to increase capacity or to ease hygienical conditions to be kept.
Sometimes, to obtain peculiar products, manually operated and controlled machines are still to be employed, since automatic operation give only average quality products.
Generally speaking, machinery can be considered as simple or intermediate, if no automatized operations and/or very high capacity are requested.
Almost all technologies available feature batch-operated procedures; continuous processes are available for some product, but imply large capacity and complex machines.

4.3.2.2 TECHNOLOGY DESCRIPTION

4.3.2.2.1 Cheese

A typical cheese-making technology starts with the collection of milk, which is made in the same way as described in para. 4.3.1.2.1, for fresh milk.
In many cases the cheese-making plant is a section of the central dairy; in some other case, small plants manufacture only dairy products, as it is commonly done in some European countries.
Milk has to be accurately analyzed to check if it is of the type needed for cheese being manufactured; particularly, fat content is to be checked.
Milk is then pasteurized; some cheese process requires a non-pasteurized milk and, in general, the need for pasteurization is still being discussed by some cheese-makers.
Pasteurizing, when required, is made at about 70 °C for 15 ÷ 20 seconds.
If pasteurization has been effected, some destroyed lactic microorganism is to be added, being necessary for cheese process.
Milk is then sent into the curdling vat, whose size and shape greatly depends on cheese type and local uses.
A large, so-called universal, curdling vat of oblungal shape can be used, to obtain a great number of cheese types.
In the vat, curd is added and temperature maintained at 20 to 32 °C, for 30 to 120 minutes or more, according to type of milk and cheese type process.
During curdling, milk has to be stirred with special tools and once curd begins to thicken into flakes, curd mass has to be cut into pieces, with special cutting tools, to improve whey separation.
Size of curd pieces, and way of cutting, are typical of each process and are very significant steps in obtaining good quality cheeses.
Some cheese type requires a longer heat treatment for "cooked" curdling, normally done at about 50 °C for a certain time, depending on different cheese processes.
Complete whey draining from curd is performed in a vat or in special moulds, where curd is shaped into the form of final cheese. Sometimes, mould pressing is requested for thicker and harder cheeses.
Shaped cheese is then sent to the final stage, which consists in a brine bath, normally at about 10 to 15 °C, for a time variable from few hours to some week, depending on

cheese type, where rind is formed by osmosis.
Cheese is then sent to warehouses for seasoning, variable from few days to several months.
Some cheeses are intended for fresh consumption and have to be stored into refrigerated warehouses.
Seasoning can be made in cellars or specially conditioned rooms or, for commercial quality products, made by forced drying and wax application.

4 3.2.2.2 Butter

Butter is made by mechanical beating of matured cream into special churns.
Cream, resulting from milk skimming and from centrifugal fat separation of whey, is pasteurized at a temperature of 70 to 75 °C, and then pumped into a fermentation vat, after cooling down to about 10 °C.
Fermentation bacteria are added and cream is "matured" for about 15 hours at about 10 °C.
Matured cream is then put into the beating churns, of various types and shapes, where beating-kneading takes place for about 20 to 30 minutes at 10 °C.
Butter is then shaped and wrapped by manually operated machines and tools.

4 3.2.2.3 Yoghurt

Milk is partially skimmed and pasteurized, as described in the previous paragraphs.
It is then pumped into fermentation tanks, where special curdling lactic ferments are added.
The fermentation process takes place for some hours at low temperature, depending on type of ferments and curdling procedures.
Yoghurt is then packaged into glass or plastic containers, with aluminium cap, thermally sealed, and stored at 0+4 °C.
Good quality yoghurt requires an homogeneization into pressure machines, before curdling.

4.3.2.3 MACHINERY DESCRIPTION

4.3.2.3.1 Pasteurizing heat exchangers

Pasteurizing heat exchangers are of the same type as described at para. 4.3.1.2.2 for milk.

4.3.2.3.2 Curdling vats

A curdling vat is a double-wall stainless steel container, normally of semi-spherical or oblungal form.
In the double-wall hollow space, hot water is circulated, in order to maintain the desired curdling temperature.
Stirring is provided by special tools, which can manually or pneumatically operated; in the latter case, a supporting frame has a guiding rail on which tools are fixed and displaced.
Curd cutting is also performed by special tools (stainless steel grids or nets), supported by the same guiding rail.
Discharge can be performed by raising and inclining the vat, by means of a pneumatically or manually operated leverage.
Curdling vats can be open or closed by stainless-steel cover, depending on type of cheese to be made.
Vat manufacturing requires thick stainless-steel sheet welding and cold-forming.

4.3.2.3.3 Draining and moulding vats

Whey drainage from curd can be performed into special stainless steel vats, where draining is performed by putting curd into perforated containers (at the bottom of draining vats).
Drained curd is then cut and shaped into cheese moulds.
Amount of drainage, cutting procedures, mould shapes etc. are varying very much depending on type of cheese and process (soft or hard cheese).
Moulds are of various materials (stainless steel, copper, wood etc.) depending on type of cheese and local habits.
All operations are manual; vats and mould are very simple and require stainless-steel welding and cold-forming to be manufactured.

4.3.2.3.4 Salting vats

Salting can be made in different ways, depending on type of cheese; normally it is performed by submersing freshly

formed cheese into a brine bath.
The brine bath is a stainless steel vat, where brine is circulated through a heat exchanger, to be constantly kept at the desired low temperature.
Stainless steel must be of very good quality, because of the high corrosive solution.
Manufacturing of brine vats requires stainless steel cold forming and welding.

4.3.2.3.5 Tanks

In the dairy industry, a great importance is given to various tanks, needed to store products or to perform maturation/fermentation processes.
Tanks are of two basic types: single-wall tank and isothermal tank.
Single-wall tanks are made of stainless steel sheet, curved with roller-forming presses and welded into cylindrical shapes, horizontal or vertical.
Main supporting frame is stainless steel as well, because floor cleaning is made with corrosive and/or detergent solutions.
Isothermal tanks are double-wall stainless steel cylinders, with interposed insulating material; milk can be refrigerated by single-tank equipment or by general refrigerating circuit, through tube nest heat exchangers.
Tanks should be provided with easy access for inspection and equipped with inlet and outlet vents for milk, heat exchanging fluid, cleaning etc.
Manufacturing requires stainless steel welding and sheet forming.

4.3.2.3.6 Butter churns

Ancient butter churns, still in use in many small plants, were made of hard wood.
The wood churns were difficult to clean perfectly and are now replaced by stainless steel churus.
Various shapes and sizes have been developed (conical, biconical, off-axis cylindrical etc.), depending on process and local habits. A churus is basically composed of a shaped container, with a small charging door, hermetically sealed when closed, supported by two rotating hinges; container is motor-driven to revolve at low speed.
Manufacturing requires stainless steel welding and machining of mechanical components; supporting frame is of stainless steel profiles.

4.4 - CEREALS PROCESSING

4.4.1 - General remarks

4.4.2 - Rice milling

4.4.2.1 Technology description

4.4.2.2 Machinery description

4.4.2.2.1 Cleaning equipment

4.4.2.2.2 De-hullers

4.4.2.2.3 Whiteners

4.4.2.2.4 Parboiling pans

4.4.3 - Maize milling

4.4.3.1 Technology description

4.4.3.2 Machinery description

4.4.3.2.1 Hammer mills

4.4.3.2.2 Stone mills

4.4.4 - Bread making

4.4.4.1 Technology description

4.4.4.2 Machinery description

4.4.4.2.1 Kneading machines

4.4.4.2.2 Fermentation and proofing rooms

4.4.4.2.3 Ovens

4.4.5 - Pasta making

4.4.5.1 Technology description

4.4.5.2 Machinery description

4.4.5.2.1 Press extruders

4.4.5.2.2 Driers

4.4 CEREALS PROCESSING

4.4.1 General remarks

Main cereals for human consumption are wheat, rice and maize.
The majority of developing countries has no wheat production and must rely on import, accounting for about two-thirds of total imported goods (FAO-Agriculture towards 2000 - 1979).
Wheat is then subjected to primary processing (that intended for grain conservation in silos) in the producing countries and is exported to less developed countries in raw form or as milled flour.
If milling is performed in the destination country, it is likely to be supposed that large mills will supply flour to the entire country or, at least, to a region.
Economical and technical feasibility could suggest to employ more complex equipment for larger capacity plants, whose complexity is higher than that of an adapted technology.
Since it has been assumed that adapted technology and related machinery are more suitable for small-scale plants (even if industrially operated), probably no adapted technology is feasible for large flour mills.
Large-capacity wheat mills are in fact highly integrated and mostly automatized plants, developed and supplied by few manufacturers in the developed countries.
On the other hand, many indigenous techniques have been in use for centuries, as, for example, the classical stone mill, based on friction between granitic cones, but they can hardly be up-graded to industrial operations and remain village-level equipment, to be employed only by local farmers, where cereals are produced.
It is hence likely to assume that wheat flour is produced in centralized mills or imported as such from other countries.
It is the secondary processing of flour (intended for bread or pasta making) which shows more interesting features for adapted technology applications in the less developed countries.
As far as rice and maize are concerned, the case shows completely different aspects, since these two cereals are the basis of human nutrition in many far East and African areas, where they are grown.
In this case, many experiences have shown that small-scale plants for rice and maize milling could be a feasible and

economical solution for district-level adapted technology applications, while large-scale plants have to employ, as for wheat, very complex technologies and machinery.
This chapter will then deal with secondary processing of wheat flour and primary processing of rice and maize, which are supposed to be of greater interest for small-scale adapted technology industrial applications, in the less developed countries.
The most widely diffused secondary processes of wheat flour are bread-making and pasta-making.
Bread has a shelf-life of one day to several days, depending on type of process.
Pasta, being dried, has the advantage of having a shelf-life of several months.
Both are suitable to be operated locally in small-scale local units; bread is still made this way in most industrialized countries, to assure a freshly produced and rapidly distributed product; on the contrary, pasta makers have become larger and larger food producers and sophisticated technology users, even if small units are still operating.

4.4.2 RICE MILLING

4.4.2.1 Technology description

Main stages in rice milling are de-husking and bran removal, also called whitening or pearling.
Paddy (raw rice) is in fact the only cereal that cannot be used as food, or as animal feed, until its husk has been removed.
Dry husk is about 20 percent and the bran is about 10 per cent of total paddy weight. The rest is starch rich kernel.
Since the bran has high protein and oils contents, the brown rice has a higher nutritional value than the whitened rice.
Dried paddy weighing and cleaning must be performed before starting process.
Cleaning can be achieved by gravity to remove stones and heavier materials, by sieving for larger objects and by magnet to remove iron objects.
All these steps can be made with very simple machinery, manually operated.
A possible option in processing rice is to perform "parboiling", an hydrothermal treatment in which paddy is soaked in hot water and then tempered and dried until moisture contents is suitable for further processing.
Parboiling is claimed for better milling yield and for harder grain; furthermore, grain is sterilized and infestation during storage is highly reduced.
Parboiling can be performed with single open pans, husk fired, or by more complex autoclaves.
Drying can be obtained in hot-air stream driers or in vacuum kettles.
Tempering (dwelling time to allow moisture to diffuse to the kernel core) is achieved in a tempering bin.
Dried paddy is then sent to the two-stage milling procedure.
First stage is intended to remove husks and to separate it from brown rice; this is achieved by passing paddy through rotating cylinders, which can be rubber rollers, rotating in opposite directions (which shear the rice grain) or steel roller rotating in a casing (Engelberg huller).
Husk is then separated from brown rice by aspiration.
Paddy, which has not been de-husked, is separated and sent back to be passed again through de-husker.
This separation can be done by gravity sieves.
The brown rice is then passed through the whitening phase, where bran is removed.
Bran removal is achieved by a second pass in the Engelberg

huller, by friction-shearing or in an abrasive cone polisher, which rely on inter-grain friction to remove bran, or in a steel roller huller.
Bran is then separated by aspiration and used, mixed with other components, for animal feeding.
It is to be pointed out that a two-stage mill fives a rice yield of 68-70 percent of paddy and a reasonably white rice, with bran and germ traces; this rice is of more nutritional value than the high polished rice obtained in multi-stage huge rice mills, developed in the industrialized countries.
There is hence no need to insist in whitening and polishing (a further whitening obtained by leather or cotton strip cones), if there is no market requirement for a more sophisticate, but poorer, product.
Whitened rice is then passed to grading by a sieve.
Bagging can be performed by manually-operated bag fillers.
This type of two-stage mill can give a rated capacity ranging from 300 to 3000 Kgs of paddy per hour, depending on machinery type and size.
Paddy drying and winnowing is normally done by the farmer, using solar drying or other autoctone techniques.
A typical adapted technology for rice milling is shown in the flow-diagram on Fig. 4.4.1.

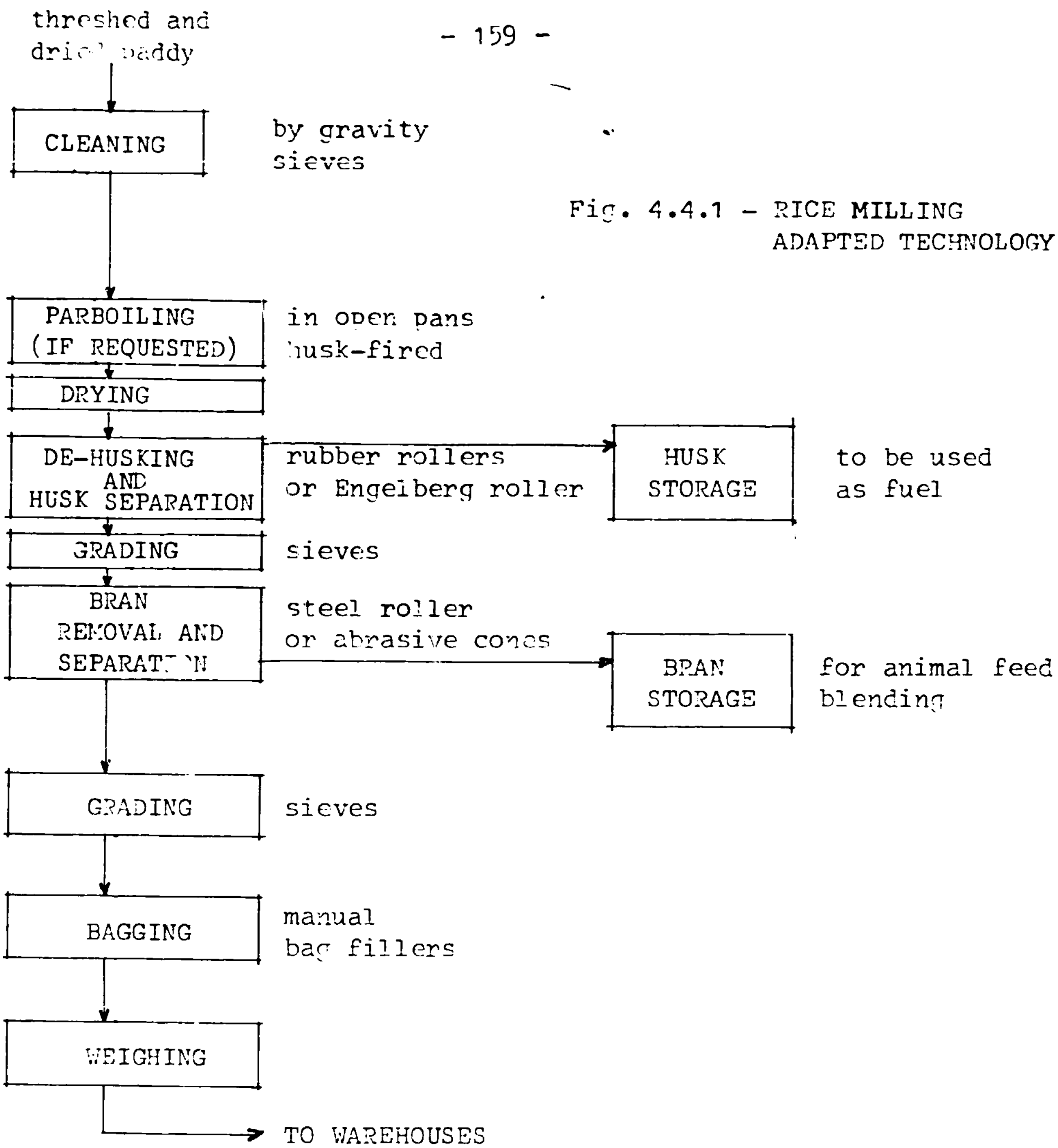


Fig. 4.4.1 – RICE MILLING ADAPTED TECHNOLOGY

4.4.2.2 Machinery description

4.4.2.2.1 Cleaning equipment

Cleaning equipment consists of an intake hopper, which feeds a rotating drum sieve.
The intake hopper is made of steel sheet, welded and painted, and has a steel profile frame, welded and painted.
The down sieve is a perforated cylindrical sheet or net, where paddy passes through; larger objects remain on the cylinder centre and are removed.
Cleaning is completed by a magnet separator, through which the paddy flow is passed to remove metallic objects.
The cleaning equipment is simple; manufacturing requires steel sheet welding, steel frames welding and mechanical components machining.

4.4.2.2.2 De-hullers

The rubber roller de-huller, or sheller, consists of two closely spaced rubber rollers, rotating in opposite directions, and at different speeds.
Rubber rollers are driven by a gear box and supported by ball bearings.
A steel profile or cast iron frame supports moving parts.
Rubber rollers are subjected to considerable wear and have to be frequently changed.
Distance between rollers may be adjusted.
Engelberg de-huller consists of a cast iron or cylindrical fluted roller, revolving on an horizontal axis, inside a sheath casing.
The lower half of the casting is of slotted sheet metal; the flutes move over a stationary blade, where shearing action takes place.
Distance between blade and roller can be adjusted.
Supporting fram is of steel profiles and cast iron.
Manufacturing of de-hullers requires steel profile welding and steel sheet cold forming.
Mechanical components have to be accurately machined.
Large and medium size pieces iron casting is also requested, with some further machining, drilling and/or milling.
In particular, iron casting and machining of rollers, normally in one piece, requires very skilled personnel; better quality is obtained with centrifugal iron casting.
Rubber rolls must be imported; their shelf-life is limited (six months to one year) and therefore spare parts supply is to be attentively managed.

4.4.2.2.3 Whiteners

Rice whitening can be achieved with the same machinery as described in 4.4.2.2.2, when used as second-stage bran removing machine.

This gives a whitened rice with some bran trace.

A more complete bran removal is obtained by abrasive cones.

This machine is basically a cast iron cone, with an abrasive material external coating.

The cone revolves into an aluminium or steel casing,where metal mesh or perforated sheet sections remove bran,while rubber bars retain whitened rice.

Abrasive action of the cone can be adjusted by vertically displacing the cone.

A steel or cast iron frame is the machine body, where the cone is supported by ball bearings and driven by pulleys and shafts.

Cone whiteners can be considered as intermediate technology machines and their manufacturing requires a higher degree of mechanical machining and cast iron forming.

4.4.2.2.4 Parboiling pans

Parboiling, when requested, can be performed in open pans, where paddy is soaked in hot water, heated by husk-fired burners.

Pans are made of hemispherically-shaped steel sheets,welded with a supporting frame of steel profiles.

Parboiling can be done also on double-bottom steam heated pans; in this case husks can be used for firing steam generators.

A more complex technology employs autoclaves, steam heated and pressurized, rotating on an horizontal axis.

Small grain driers are a column, where grain falls in countercurrent with hot air, following a zig-zag path.

Air is heated by an exchanger and propelled by a fan.

A more complex technology employs vacuum driers.

Manufacturing of pans and small driers calls for metal sheet forming and welding and for some machining; their grade of complexity is low.

Larger rice mills use integrated parboiling equipment, with same rotating autoclaves for soaking (steam heated) and drying (vacuum effected); this machinery is very complex and fully automatized.

4.4.3 MAIZE MILLING

4.4.3.1 Technology description

As for other cereals, maize, which in some area, like Africa, is the basis of human diet, if milled as whole meal, including bran and germ, has a higher nutritional value and should be preferred.
On the other hand, sifted maize flour (removing bran and germ) has a smoother texture, a lighter color and a much longer shelf-life.
Larger mills use different multi-stage technologies to obtain a refined maize flour, such as wet milling, which is a sophisticated method, or multi-stage roller mills with automatic sifting and degerming.
A smaller scale adapted technology mill should be located, as for rice, in the growing area and should have a capacity ranging from 30 to 1000 Kgs per hour.
Such features can be achieved by single-pass hammer mills or by motor-driven stone mills.
Grain is cleaned by sifting it for small stone removing and then passed through the intake hopper of the machine.
The output wholemeal is directly bagged manually.
A certain amount of bran and germ removing could be obtained by a coarse sifting of wholemeal.
For higher capacities, ranging from 1000 to 10.000 Kgs per hour, steel roller mills have to be employed.
Grain is sifted by vacuum aspirators to remove stones and by magnet device to remove metallic particles.
A single-pass or a double-pass roller milling is used; a sifting with motor-driven sieves gives coarser particles to be passed again and separate germ.
Bran is removed by aspiration.
Flour is then manually packed or bagged.

4.4.3.2 Machinery description

4.4.3.2.1 Hammer mills

This machine has a very wide operating feature, been able to mill different products.
Hammer mills have a rotating shaft, supported by ball bearings in the casing.
The shaft supports three or four ranges of rotating arms, which in turn support the hammer heads, of various shapes and sizes, depending on type of product to be milled.
Rotating heads break and pulverize raw material against

stator blades, having slots through which the incoming product is forced.

Milled maize is recovered through a receiving hopper, which is equipped with a fine steel or brass screen.

Manufacturing of hammer mills calls for iron casting of rotating arms and machine body, steel welding of sheets and profiles, machining of operating and rotating parts.

4.4.3.2.2 Stone mills

Old mills have been using granite stones, water-powered, for centuries.

Motor-driven stone mills can be considered as an up-dating of this old technology, which has the advantage of a finer adjustment, and thus of a smoother flour output, with respect to the hammer mills.

The stone mills have two stone discs, both rotating, in opposite directions, or one fixed and one rotating.

Clearance between rotating stones can be adjusted, for a single milling fineness regulation.

The stone mills have an external casing and an intake hopper of painted steel sheets and a supporting frame of welded steel profiles.

Driving motor can be electric or diesel engine, with belt-sprocket transmission.

An example of a 500 Kgs/h stone mill is shown on Fig.4.42.

A grinding stone has to be replaced after 300 tons or about 600 hours.

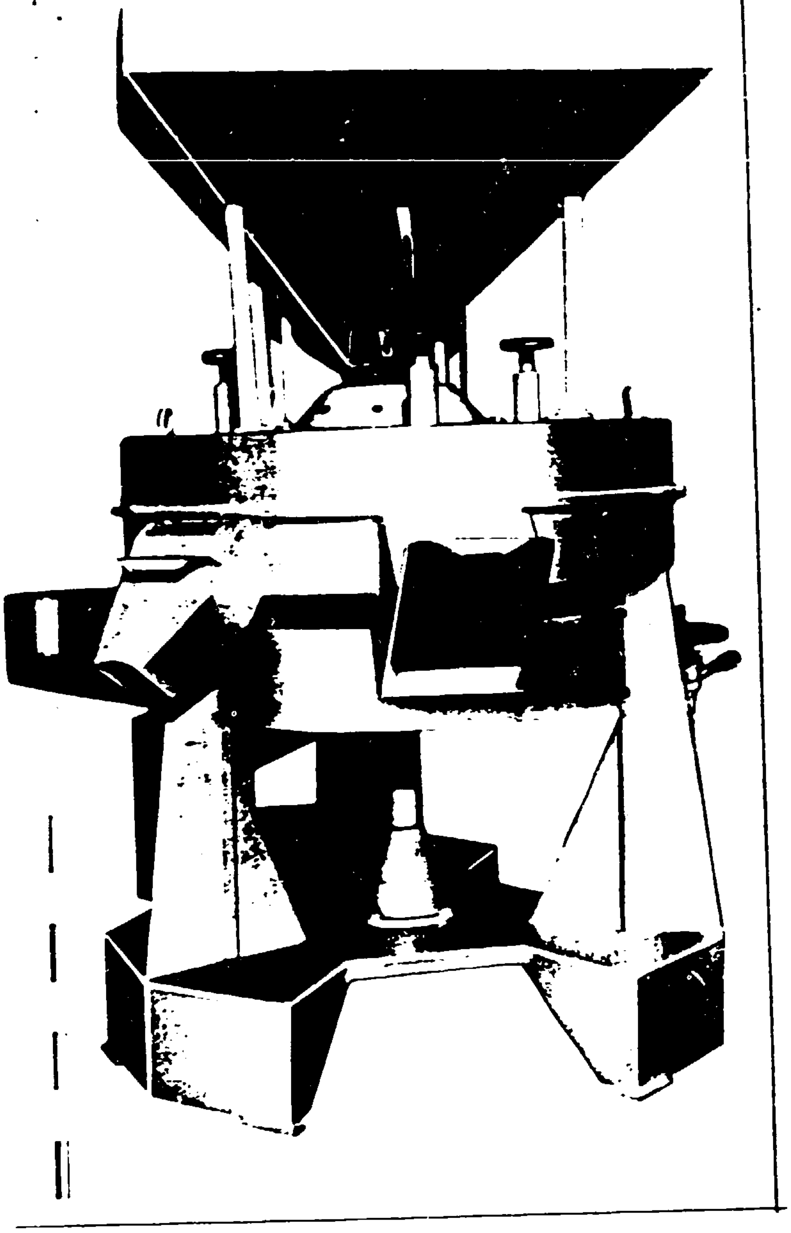


Fig. 4.4.2 - A motor-driven maize stone mill (courtesy of Villani)

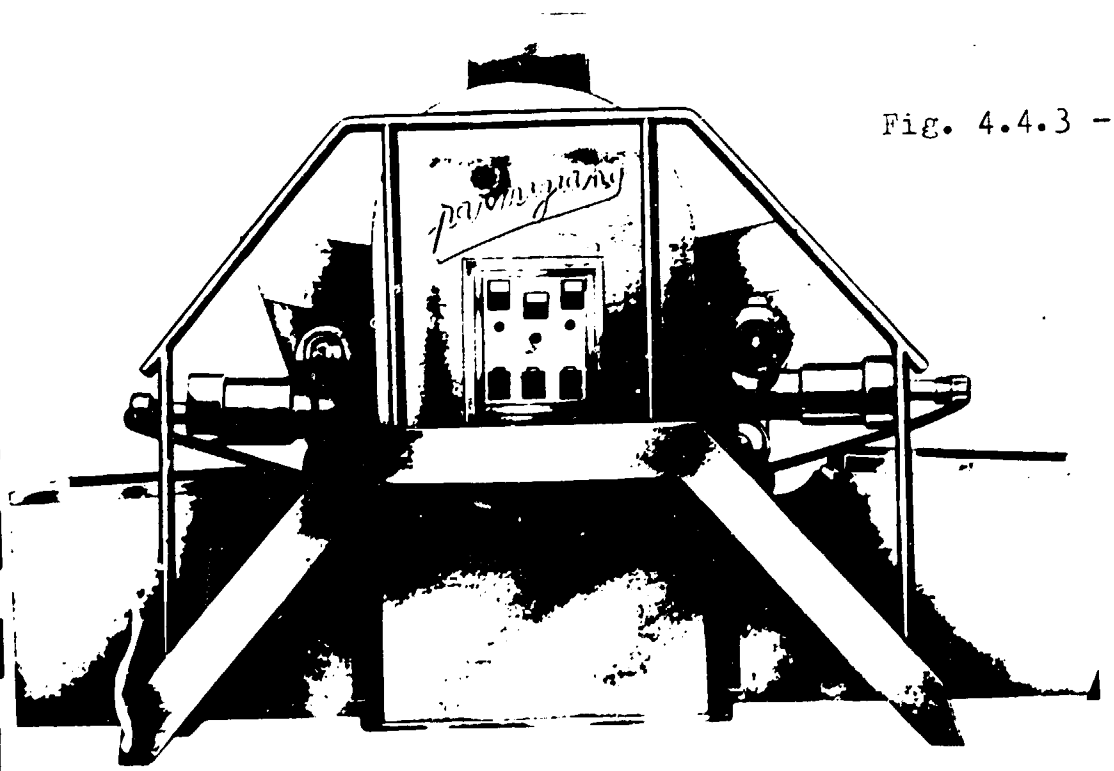


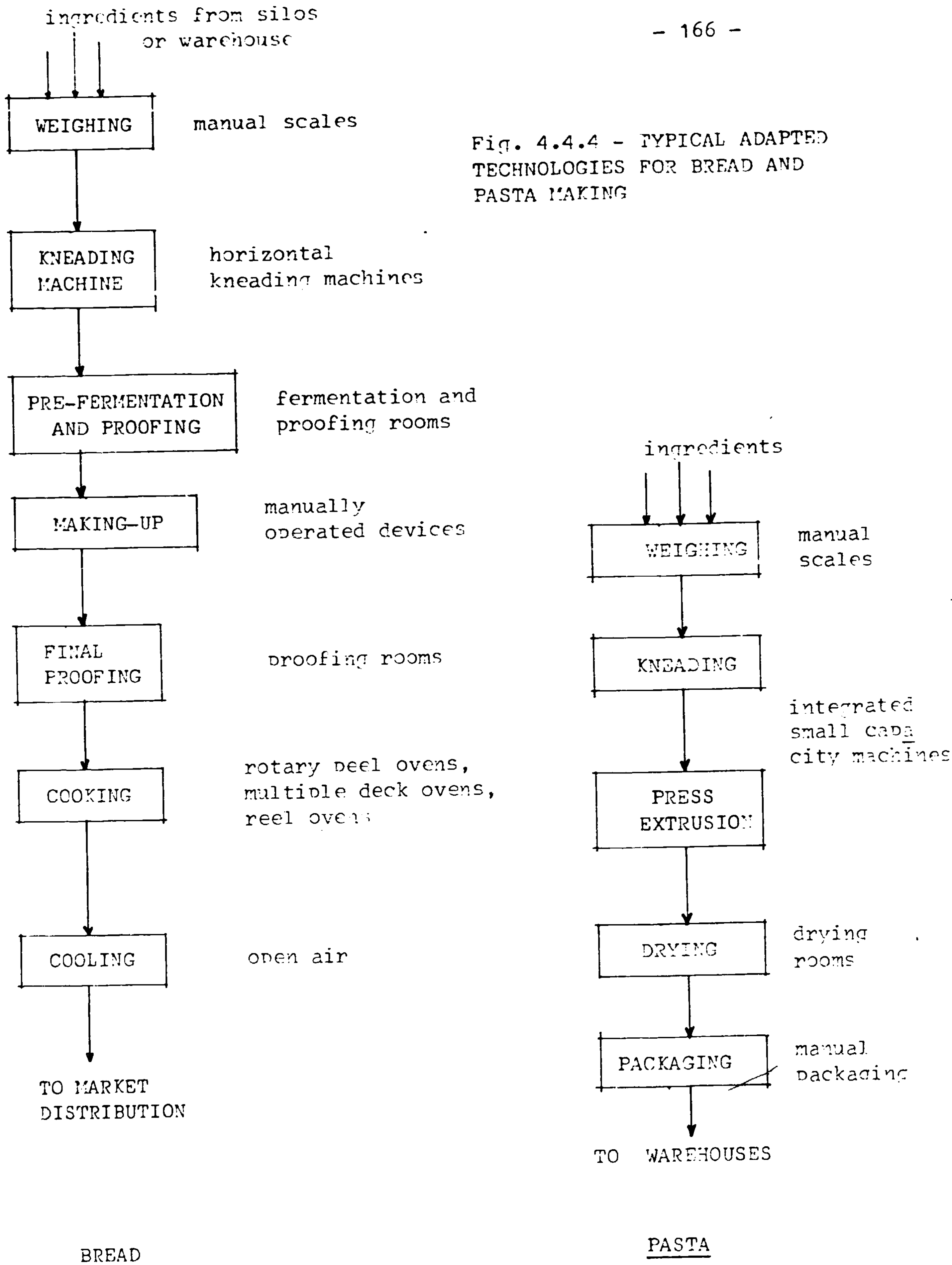
Fig. 4.4.3 - A double-head pasta making machine of 200 Kgs/h capacity (courtesy of La Parmigiana)

4.4.4 BREAD MAKING

4.4.4.1 Technology description

Many different types of bread are currently made and each of them requires a different technology to be produced. The technology described herein has hence the value of an average indicative process, as it is shown on the flow diagram on Fig. 4.4.4.
Wheat flour, yeast, water, salt and, if requested, some additives, are the basic ingredients of bread.
Ingredients are weighed, mixed and kneaded to obtain dough. Pre-mixing of dry ingredients can be requested; kneading is done into horizontal or vertical kneading machines.
Kneaded dough is then shaped in the requested form and size and passed to the fermentation room, where it is kept at about 25 ÷ 30 °C at 75% relative humidity and then to the proofing room, where temperature is raised to 40 ÷ 50°C at 82% r.u. for about 50 minutes to 2 hours, depending on type of bread.
Fermentation and proofing are a key point of the process, since yeast develops its "raising" power and gives bread its characteristics (flavour, softness etc.).
Fermentation and proofing times vary at a great extent; sometimes a pre-fermentation time is requested, following special bread-making processes.
Many types of bread require making-up operations, such as dividing, rolling, rounding, cutting, curling etc. depending on shape and size of the loaf and/or on type of dough and texture to be obtained.
Most types require a final proofing, which is done at various temperatures and humidity grades in final proofing chambers with shaped and made-up dough in the cooking trays, placed in rack shelves.
Cooking is made in different types of ovens, depending on type of bread and oven technology; some type of bread requires a high relative humidity during cooking phase.
Oven temperatures are in the range from 220 to 300 °C.
Oven technologies range from very simple peel oven, to draw-plate or multiple-deck ovens, to rotary peel ovens and reel single-lap or double-lap ovens, up to the most up-to-date technology of tunnel ovens.
With the exception of tunnel ovens, which are very complex and automatized high-capacity machines, all other mentioned types are within the range of adapted technology, with various grades of complexity.
Choice depends on local habits, type of bread and capacity.

Fig. 4.4.4 - TYPICAL ADAPTED TECHNOLOGIES FOR BREAD AND PASTA MAKING



Bread is then cooled in open air or on a cooling room by air ventilation.
Bread normally does not require packaging and is immediately distributed to the market; shelf life varies between one day to several days, according to type and size of loaves.

4.4.4.2 Machinery description

4.4.4.2.1 Kneading machines

Dough kneading machines are normally of the horizontal type; a stainless steel U-shaped container is supported at both ends by steel profiles and can be turned over for dough unloading.
Inside the container, motor-driven kneading arms, supported by a horizontal rotating shaft, of various shapes and length, provides continuous mixing and kneading of bread ingredients, until a compact mass of dough is obtained.
All parts in contact with food have to be manufactured with stainless steel, and have to be easily cleaned and dismantled for inspection.
Kneading machines can be open or closed by a stainless steel cover.
Other types have hemispherical container with arms, rotating on a vertically supported shaft.
Kneading machines are simple to intermediate complexity items, but its manufacturing requires a very accurate machining and finishing of all operating parts and stainless steel thick sheet forming and welding.
Machine casing is of painted steel sheet, while supporting bodies can be of cast iron.

4.4.4.2.2 Fermentation and proofing rooms

Fermentation and proofing rooms have various sizes and shapes; dough can be placed on trays and trays conveyed by serial conveyors or manually positioned on rack shelves.
To save space, fermentation is often made in overhead rooms, where trays are suspended to belts or chains, which convey and stabilize them during the fermentation time.
Proofing rooms are normally connected with the oven, to recuperate heat and steam.
Proofing rooms have a front door, through which racks are loaded and unloaded of dough trays.

Rooms consist of metal sheet double walls, filled with insulating material, supported by a main frame on painted steel profiles.
Heat and humidity are provided by forced air, circulating by means of a fan through a venting hole, connected to a heat source (normally the oven itself).
Manufacturing of fermentation and proofing rooms is relatively simple, but requires skilled thin metal sheet cutting and welding and an accurate assembling.
A typical proofing room is shown in fig. 4.4.5.

4.4.4.2.3 Ovens

A simple peel oven is basically an insulated container (made of earth or refractory bricks), with a front mouth. Wood is fired into the oven, until walls have reached the required temperature and stored enough heat, then bread is introduced and cooked.
This oven is very simple and economic, but unsuitable for industrial operating.
More adapted machines are rotary peel and multiple-deck ovens.
A rotary peel oven is an improvement of old peel oven, achieved by separating fire room from cooking room, thus allowing, by a stack, the evacuation of combustion gases while cooking bread.
A rotating bench takes the place of the oven bottom, where bread trays are continuously displaced by an external drive; in this way, more homogeneous cooking temperature is achieved.
Other improvements are reel ovens, with single or double-lap tray conveyors, where trays are suspended to rotating chain, driven by sprockets.
The total capacity of the oven is increased and the entire volume utilized.
Multiple-deck ovens achieve the same goal by a static system, but require a higher loading and unloading time.
All these types of ovens are still in operation in many developed and developing countries and have proved to give good economical and technical results.
They have an increasing degree of complexity, from the very simple peel oven to more complex double-lap reel ovens.
Manufacturing requires thin steel sheet forming and welding, steel welding, machining and finishing, cast iron forming, and accurate assembling.
A typical rotating rack oven is shown on fig. 4.4.6.

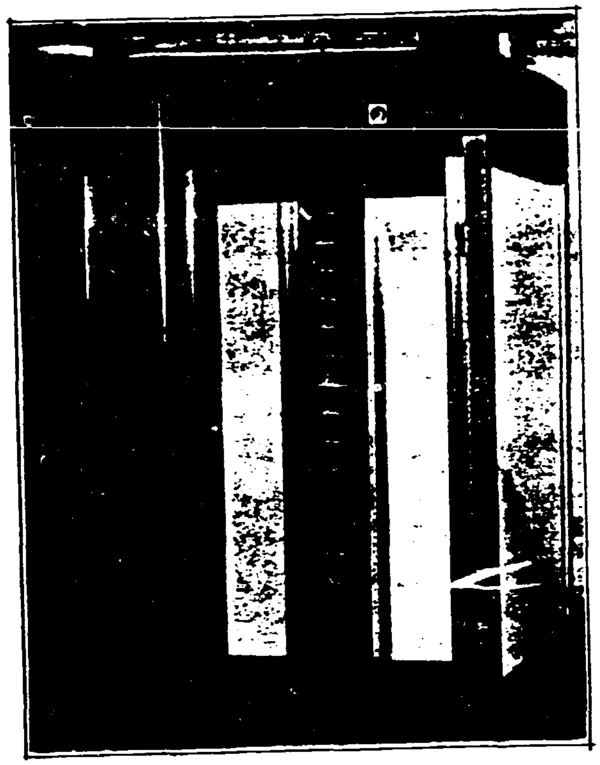


Fig. 4.4.5 - A proofing box, with heat recuperation from oven (courtesy of Polin)

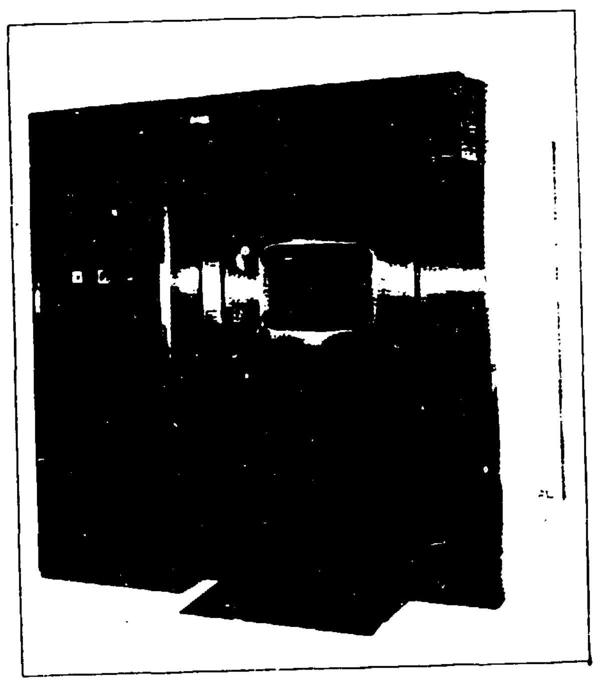


Fig. 4.4.6 - A rotary rack oven (courtesy of Polin)

4.4.5 PASTA MAKING

4.4.5.1 Technology description

Pasta is a dried uncooked wheat flour dough, without yeast, with a shelf life, at ambient temperature, that can reach several months.
The pasta technology originates from some southern European country and uses wheat flour and water as basic ingredients; other ingredients can be added (such as eggs).
Dried pasta is obtained by extruding kneaded dough through a shaped hole, by mechanically pressing it.
Various sizes and shapes of pasta exist, but basic types are long pasta and short pasta.
Long pastas (such as "spaghetti") are long ropes of pasta, which have to be dried by hanging , while short pastas (such as "macaroni") have to be cut in short pieces immediately after extrusion and are dried over a grid.
In the developed countries, very sophisticated technologies have been developed to increase pasta-making capacity and to fully automatized processes, but adapted technology for low output rates is currently available, using simpler machinery, operating also in many developed countries, in small plants.
These machines perform pre-kneading of dough, final kneading, press extrusion and cutting. Pasta is then passed to driers, where fresh air and then hot-air flows dry pasta to requested moisture level.
Long pasta is then cut at desired length and packed into cellophane or plastic bags.
A typical adapted technology for pasta making is shown on Fig. 4.4.4.

4.4.5.1. Machinery description

4.4.5.1.1 Press extruders

Machines, which perform the whole pasta process are adapted, for low output capacity, ranging from 30 Kgs to 300 Kgs of pasta per hour.
For higher capacities, kneading and press extrusion must be separately performed and processing line become more complex.
Integrated pasta presses consist of an intake hopper, where basic ingredients are mixed, after weighing.
A pre-kneading takes place in the intake hopper; when pre-

kneading is completed, hopper is turned over into a second hopper, where final kneading of the dough is performed by rotating arms, driven by an electric motor.
When kneading has been completed, a synchronized feeder supplies dough to the press, which forces dough to be extruded through the shaped hole of the head, which is kept rotating, for certain type of rounded pastas, by the same driving mechanism.
Pasta is then continuously handled to be suspended to hangers for long pastas, or discharged directly on drying chests, for short pastas.
Press extruders are to be considered as intermediate complexity machinery, whose manufacturing requires a good level of skill and know-how.
A press extruder is shown on Fig. 4.4.3.

4.4.5.1.2 Driers

Drying of extruded pasta is normally achieved in two stages; first stage dries pasta by forced ventilation air at ambient temperature; second stage provides final drying by hot air.
Drying times and air temperatures must be accurately controlled to obtain good quality products.
Small drying chambers consist of a metal-sheet walled container or by special rooms, where air is kept circulating by a fan and hot air is provided by hot water or steam heat exchanger on the air flow.
Driers can be used for dehydration of other products.

APPENDIX I

Energy conservation and saving in the food processing industry operations

1 - General considerations on energy saving in the case of adapted food processing technology

2 - Energy conservation and saving aspects for same products in the considered subsectors

1 - General consideration on energy saving in the case of adapted food processing technology

Before discussing how energy saving measures can be applied to the case of adapted technology, a general survey of the main aspects of energy usage in food processing can be useful. (a)

Energy consumption for unit of finished product is not homogeneous,but great differences exist from one product to the other; this depends on the process employed and on the ratio between different types of energies used.
It is well known that almost all food processes use thermal energy, because of the high sensitivity of spoiling microorganisms to heat; it is also known how thermal energy conversion factors, theoretically limited only by the laws of thermodynamics (and theoretical figures are already low), are in practice much lower and energy saving measures difficult.
The ratio between thermal energy and electrical energy (the second ranking energy for food processing) is very high. It is known that,for example, for tomato paste processing, hundred kilocalories consumed for processing roughly correspond to about one hundreth of kilowatthour (giving a ratio of 10.000 to 1) and that in an integrated small cannery, (where canning of different types of fruits is accomplished during various seasons, such as citrus fruits, mango, papaya, guaba etc.) this ratio is in the range of 8000 to 1 - In terms of equivalent energy units (KWhs or BTU) these figures correspond to a ratio between thermal and electrical energy consumptions from about 10 to 1 - to about 7 to 1 - for fruit and vegetable processing.

(a) this chapter is based on "Energy saving techniques for the Food Processing industry" - Noyes Data Corp. N.J. - USA 1977.

For other subsectors, this ratio is different, but thermal energy is,in any case , the most important form of energy to be supplied, and it is therefore that in which maximum effort in energy saving should be put.
Results will obviously be different, depending on process used and on technology level, but generally speaking,as it will be seen, actions for thermal energy saving are difficult and,in the case of adapted technologies, the corresponding possible increase in complexity should be very carefully investigated and compared.

This does not mean that other aspects of energy saving procedures are not to be taken into account: savings in electricity is obviously the second target.

A very general analysis has shown (b) that, taking as a basis specific consumption figures in 1972 for various food products ,differentiated actions could lead to substantial foreseen energy saving for 1980. As it can be seen , in the table below, the target is different for each product, depending mostly on technology used and on the incidence of thermal energy on total energy consumption (only the products of interest for this study are taken into account) :

	1972	1980(target)	% reduction
- meat processing and packaging	2.8	2.5	10.7
- sausages and prepared meats	4.2	3.7	11.3
- fruit and vegetable canning	2.3	2.0	13.0

(b) From "Energy Saving Techniques for the Food Processing industry" op.cit., tab.6-1; data referring to USA food industry.

	1972	1980(target)	% reduction
- fluid milk	0.6	0.5	16.6
- cheese	5.6	5.1	8.9
- rice milling	0.3	0.3	0
- pasta making	1.5	1.4	6.6

(note: specific consumption figures are in thousands of British thermal units - BTu x 10^3 per unit of finished product (pounds) ,except for rice milling ,in which rough rice weight has been considered).

The specific energy consumption reduction is the result of a wide range of energy conservation measures, during a long period.
In the food processing industry, potentially important energy conservation techniques and procedures are as follows (c) :

A - Waste Thermal Energy recovery

1 - use waste heat from plant equipment (cookers, dryers, ovens, compressors, etc.)

2 - recover heat in waste service hot water

3 - recover heating or cooling effect from ventilation exhaust air

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(c) adapted from "Energy Conservation Programme Guide for Industry and Commerce" - NBS handbook - 115 (74-75), as indicated in table 3-1 of "Energy Saving Techniques for the food processing industry"; op.cit. In the above list, measures for air conditioning are not indicated, since of scarce use in less developed countries.

4 - reduce building exhausts

5 - increase regeneration in fluid heat/cooling recovery by increasing heat exchanger size

6 - use low temperature waste effluents to cool input streams (heat recovery tecniques)

7 - use process waste heat for space heating

B - Boiler and Steam Efficiency

1 - minimize boiler blowdown

2 - use better feedwater treatment

3 - recover heat from hot "blowdown"

4 - return more steam condensate to boiler

5 -preheat boiler feed water and combustion air by exhaust gases

6 - use exhaust gases waste heat to produce low pressure steam or hot water

7 - reduce combustion air flow and improve combustion control capability

8 - install and repair steam traps

9 - descale boiler tubes more frequently

10 - insert spinners in boilers to increase heat exchange with water

11 - improve oil atomization using compressed air

12 - better maintenance of burners and injectors

13 - minimize use of low-power operating boilers or stand by boilers

C - <u>Heat Insulation</u>

1 - insulate steam and condensate lines

2 - upgrade insulation of furnaces, boilers, kilns, ovens, cookers and process equipment

3 - insulate walls, ceilings, roofs etc.

D - <u>Dryers, Evaporators and other process equipment</u>

1 - improve evaporators efficiency by using multiple effects

2 - use mechanical vapors recompression in evaporation process

3 - use recirculating air dryers

4 - use mechanical systems to pre-dry products before heat drying

5 - improve maintenance on heat transfer surfaces

6 - eliminate afterburners for pollution control

7 - minimize air intrusion into ovens and use of air fans

8 - match air compressors to actual requirements

9 - use microwave drying and cooking

10 - install agitators and scrapers in vacuum pans of evaporators to improve heat transfer

E - Electrical Energy usage

1 - optimize plant power factors (capacity banks)

2 - optimize motor sizes and pumps to actual requirements

3 - convert light sources to more efficient ones (fluorescent, mercury, sodium etc.)

4 - reduce general lighting, eliminate unnecessary lighting, etc. to minimum necessary for safety

5 - reduce exterior buildings and grounds illumination

6 - replace electric motors with steam turbines and use exhaust steam for process heat

7 - use multiple capacity compressors for refrigeration

F - General Energy Management

1 - re-use process wastes

2 - optimize equipment sizes

3 - use most efficient equipment at its maximum capacity and less efficient ones only when necessary

4 - minimize use of equipment needing stand by operation

5 - shut down or reduce temperature of process equipment when not in use

6 - reduce operating time to strict necessary

7 - use small number of high-output units instead of many less-efficient units

8 - clean or replace filter regularly

9 - convert from batch to continuous operations

10.- convert from indirect to direct firing (ovens)

11 - convert liquid heaters from underfiring to submerston meating

12 - replace steam use by high temperature water, eliminate steam losses

The above listed measures and techniques should be considered as general actions; many other minor and specialized actions could be considered as important, depending on type of process and equipment employed.
All these actions are technologically feasible, but, when dealing with adapted technologies, the relationship between energy saving procedures and increase in complexity or usage of unadapted equipment, should be carefully investigated.
Let us then consider and discuss the above listed actions from the point of view of adapted technologies, for operation in the less developed countries.
The boiler and steam systems are the most obvious energy operations to which energy saving techniques can be applied, since , as it has been said, thermal energy sources are widely requested in almost all food processing plants. The steam generation is susceptible of appreciable energy losses, such as radiation and stack losses, venting of unburned fuel, blowdown energy losses, etc. - The goal is to increase energy conversion (efficiency) to the maximum value possible of about 83 per cent (high industry value) of the fuel-to-steam efficiency; many plants are currently

operating at 75 percent efficiency and then the energy conservation could attain a 32 per cent level.
Such conservation is possible and could be achieved by using, for example, an economizer (an heat exchanger on the boiler stack which removes heat from stack gases, which can preheat feed water and makeup water to compensate incomplete condensate return and "blowdown" procedure) or an air preheater, (which preheat with stack gases the combustion air) or a blowdown stream heat exchanger (which recovers heat from the blowdown hot water).
Boiler efficiency improvement should also rely on a very attentive and continuous maintenance of combustion system and boiler, whose interventions should mainly assure that:

- no more combustion air is used than needed
- burners are always free of soot
- fire-tube and water-tube are free of scale

Other systems employ spinners or turbulators to increase heat transfer efficiency.
Of course, a higher insulation thickness can help in reducing and preventing heat losses.
Finally, the boiler should be used at the nominal rated capacity, since they are normally not designed to operate efficiently at low power levels.

All the abovesaid measures on boiler operations do not normally increase very much the grade of complexity of equipment and are then suitable and suggested to be employed also for adapted technology plants.

As far as waste energy recovery is concerned, many potential sources of energy recovery are present in a food industry, such as, for example, exhaust from dryers, vapors from cooking and processing equipment , cooling exhausts from large motors and compressors, etc.
The reemployment of these energy sources requires a very

accurate study of heat balance between incoming streams (of products or fluids) and waste heat, because there are technical constraints in re-using heat if there is an insufficient temperature difference.
Moreover, this heat recovery equipment, although not very complex in itself, could increase the need for maintenance and specialized operational personnel; except some very special case, such as chocolate making, for example, waste heat recovery techniques have proved to be difficult and should be very carefully economically compared.
In the case of adapted technology, the heat recovery is not suggested, generally speaking , as a convenient method of energy saving , because it can induce technological problems, which, in the context of the less developed countries, can rapidly spoil out all heat recovery advantages.

A proper insulation is a good way of conserving heat susceptible of losses; in the food industry, steam lines, return condensate lines, hot water lines, furnaces, boilers, kilns, cooking equipment and a very wide range of other processing equipment have heat-irradiating surfaces, which should be conveniently insulated; conversely, refrigerating and cooling equipment should be protected against warming.
The only problem, when operating in the less developed countries, is that insulating materials are not easily available and should be imported.
Normally, these materials have a very low unit weight and hence transport and storing costs could be very high; a careful economical feasibility analysis should then be performed, before taking any decision about intensive insulation programs of existing plants; new plants should obviously be designed including as much as possible insulating devices.
Of course, also buildings should be insulated, to mini-

ze the energy used in environmental controls.

A great quantity of thermal energy is consumed in dryers, evaporators and other process equipment.
The efficiency of such moisture - removing apparatuses is normally quite low, unless certain modern techniques are used.
A very good technology in energy saving is the multiple-effect evaporation, a series arrangement of several evaporatos, each called an effect, which use steam to remove moisture by evaporation.
Water vapors are cállected and used , in turn, as steam for the next effect, etc.
The specific heat consumption is reduced almost proportionally with the number of effects, or, in other words, the energy required to evaporate one pound of moisture is to be divided approximately by the number of effects employed.
Modern evaporators use six or even more effects; three or four effects are normally employed for tomato concentrate and citrus juice.
Unfortunately , as it has been outlined in the catalogue (see 4.2) , the multiple-effect continuous concentrators are very complex machines, far beyond an adapted technology level.
Adapted technology should rely on single-effect vacuum kettle concentrator, whose consumption, in terms of steam per unit of output product, is about two times and a half higher than that of an usually employed three-effect concentrator.
This is one of the cases , in which a very efficient energy saving measure cannot be used because of its complexity, if technology has to fit with adaptation criteria.
This is also the case of baking ovens, where thermal efficiency increases, from wood-fired peel ovens to modern mechanised techniques, of about 5 times. (d)
It is clear that, in the first case, only renewable energy sources are employed , while, in the modern techniques, mineral oil is needed, but it is obvious that the increasing needs for higher processed food

(d) G.BARON : "Technology, employment and basic needs in food processing" - case study no.3- pag.89

quantities would rapidly spoil out also "theoretically renewable" sources, such as wood, and furthermore, very difficult industrial operations and maintenance procedures could be envisaged.
One of the feasible examples of alternative energy source for thermal energy production is the husk-fired steam generator for rice parboiling equipment; but, also in this case, an increase in complexity is to be put into account and a very efficient and continuous burner maintenance provided.
The solar dryers are other examples of alternative energy devices for thermal treatment, but, even if promising results have been obtained, they are, at the moment, not suitable for industrial operations.
Intensive researches in this field are in progress, but, generally speaking, for the time being, an increase in a efficiency of heat conversion perunit of output product should rely on more sophisticated processing equipment and therefore on an increase in complexity, which often, in turn, causes adaptation limits to be depassed.
Thermal conversion efficiency improvements should therefore always be checked against the maximum tolerable increase in complexity , for less developed environment operations; otherwise , it is well known that lack of maintenance rapidly spoils out any benefit given by the energy saving.
As far as dryers are concerned, a simple improvement in energy saving could be the employment of mechanical presses , that remove as much water as is possible before evaporation.

Electrical energy saving is very important, even if the total consumption figures are lower than thermal energy, because it is a more expensive and valuable energy source, particularly for the less developed countries.
Electrical motors can have inductive losses in their windings, that a capacitor bank could reduce; the power factor of the motor can raise from 70-80 per cent up to 90-95 per cent.

Such a change also improves electrical use efficiency. As boilers, motors have been designed to operate at maximum efficiency when full loaded; often,to prevent burnouts, over-sized motors are installed, but a proper management for energy saving should match motor loading conditions with rated power needs and install fuses to protect motors against burbouts due to power surges.
A great saving could be achieved in electrical lighting, by reducing excessive or unnecessary lighting. Measures, such as zone lighting,reduced warehouse lighting, conversion from inefficient to more efficient light sources, cleaning and replacing dirty or defective shields, can attain an important and long-lasting electrical energy saving.
All those measures do not increase system complexity, but rely only on an effective maintenance and management practice.
As far as electrical main supplies are concerned, it is to be noted that brownouts, blackouts and voltage lowerings, besides the disastrous effect on food being processed,considerably increase total consumption per unit of finished product, because of the very low total efficiency.
To prevent these effects, the only practicable way, where steady and efficient electrical power distribution system is not guaranteed, is the installation of an emergency generator; it is worthwhile remembering that a generator is a very delicate and complex equipment, whose efficiency grade highly depends on regular and effective preventive maintenance , to avoid malfunctions just in case of necessity.

Finally, it is to be noted that the most effective energy saving measures rely on changes on plant operating practice and maintenance; such conservation techniques are generally of minimal cost, but require very well trained personnel, energy-saving minded.
Boiler maintenance and elimination of idling equipment should be the two main concerns of the plant management

It is to be pointed out that energy can be saved better by people aware of how energy flows and is used in the plant; this means that personnel has to be trained adequately and should have assimilated the main working principles and energy usage procedures of the machinery; it is again a case in which an adapted technological choice is the necessary condition for a good operational practice.
Good housekeeping can be an energy saving measure because many actions , even if each,individually,yields minor returns, all together can sum up important figures.

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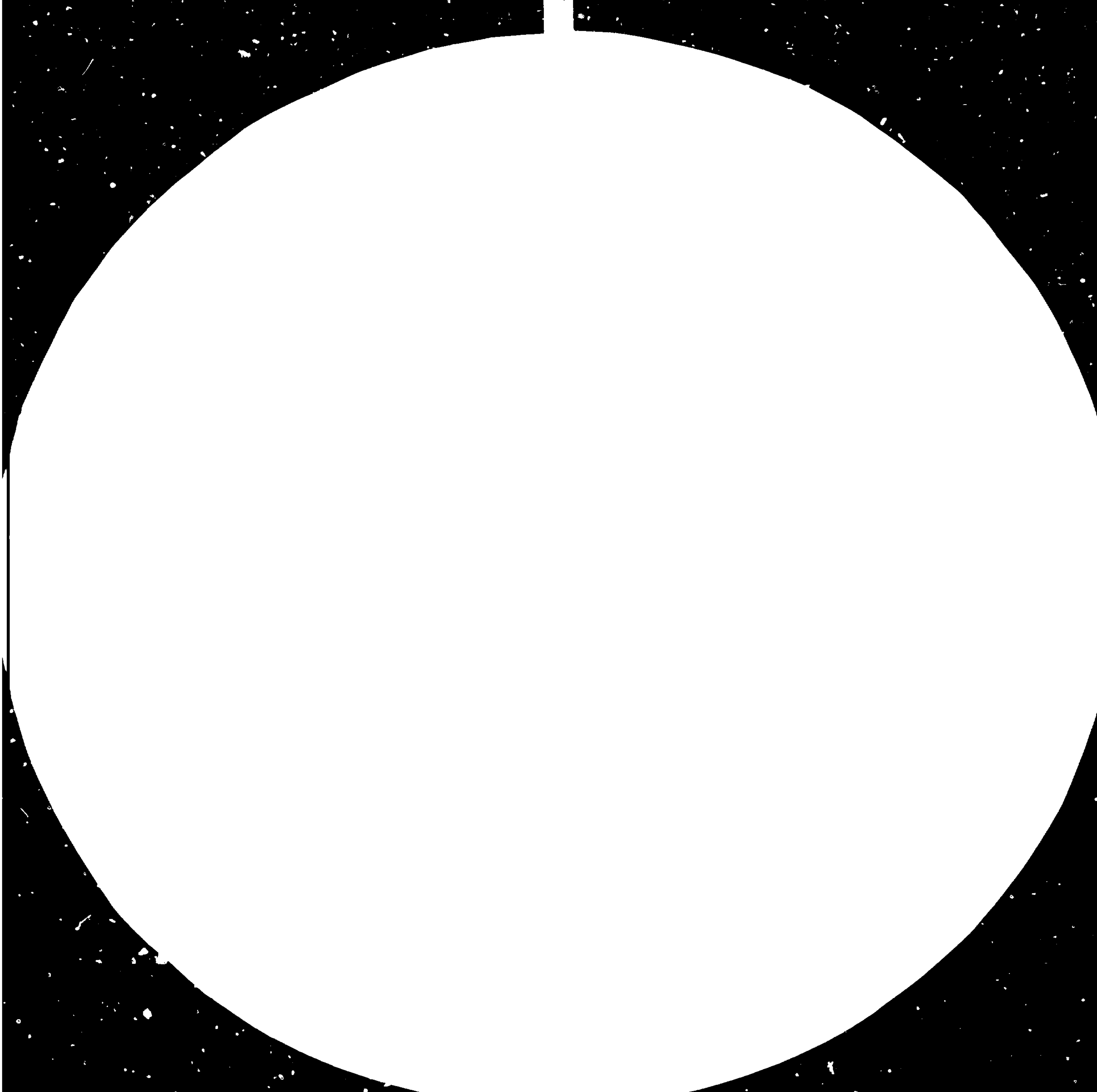

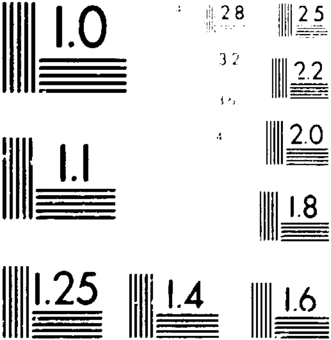

MICROCOPY RESOLUTION TEST CHART

2 - Energy conservation and saving aspects for some products in the considered subsectors

Among the above listed measures and techniques for energy saving, it will be pointed out in this paragraph which of them are of concern for some products in the four subsectors considered on this study, i.e. meat, fruit and vegetable, dairy, cereals processing. It is to be remembered again that the actions, listed below, are only technologically feasible, but their economical feasibility should be checked case-by-case, by calculating internal rate of return of the investment and carefully evaluating possible complexity- implications.

Meat processing

- space heating and refrigerating , by lowering or raising temperatures and improving insulation of buildings and accurately maintaining windows and exhausting holes
- maintenance and operation of combustion controls, optimization of blowdown procedures, repairs of leakage in valves, elimination of standby boilers.
- heat recovery from boilers for condensate return and feed water treatment (no economizer practicable, because watertube boilers are normally employed)
- reduction in the use and heating of hot water
- heat recovery for makeup water
- increases in steam operating pressures and temperatures (causes higher complexity)
- reduction of lighting
- improvement of insulation of refrigerating cells and refrigeration generating and distribution network.
- replacing old units with new efficient ones

- operational control and maintenance of production equipment of high energy consumption , such as ovens, smokehouses, cooking tanks, generators, afterburners etc.
- miscellaneous good house-keeping procedures, such as turning off lights in the refrigeration rooms, monitoring of product temperature requirements, elimination of condensation etc.
- maintenance and repairs of refrigerating compressors and insulating material

Fruit and vegetable processing

- recovery of hot water discharge from peeling and washing machines
- conversion from retorts to continuous cookers (causes higher complexity)
- changing from steam to hot water in blanching
- shortening the cooking time by increasing temperatures
- recover heat from retort cooling water
- recover waste heat from various equipment to heat space
- improve boiler maintenance and blowdown procedures,by using water softeners
- lowering temperatures in the process whenever possible
- repairing immediately steam leaks
- improving insulation in steam and condensate lines
- reducing lighting
- installation of protecting doors in the refrigeration rooms

- improving and controlling operating procedures of motors, lubricating equipment, bearings, capacitors etc.
- employing multiple-effect techniques (causes higher complexity)

Bakery

- improve operating procedures of beaking ovens, by reducing heating-up times and keeping ovens filled with product
- minimizing use of fans of input/output from ovens
- recovery of oven stack exhausting gasses to heat proofing rooms or other equipment
- improve insulation in buildings, ovens, proofing rooms etc.
- improve maintenance whenever possible
- reduce space heating by lowering temperatures, minimizing ventilation,
- improve boiler operating procedures, by minimizing scale build-up and increasing combustion efficiency
- reduce hot water usage
- minimize idling and stand-by times of ovens, boilers, lights and other equipment

Pasta making

- improve boiler operations, as described for other products
- use dryer exhaust for space heating
- use microware dryers (causes higher complexity)
- improve maintenance whenever possible

Cheese making and milk processing

- improve operating procedures of pasteurizing procedures, by using HTST pasteurizing (causes higher complexity)
- improve boiler operations, as for other products
- improve curdling vats insulation
- use HTST (high temperature short time) heat recovery system to heat incoming milk (causes higher complexity)
- recover heat, whenever possible, from output products
- minimize cooling water usage, by heat recuperation
- improve refrigerating and cleaning procedures
- improve insulation of tanks and pipes
- improve maintenance of refrigerating equipment
- reduce lighting

As a summary, it can be stressed once again that energy saving procedures rely mostly on the following three actions, whose results are positively achieved only when a large number of little interventions sums up in a appreciable result:

- improving machinery and equipment design concerning energy utilization (this may cause an increase in complexity and it is therefore to be carefully analyzed)

- <u>improving maintenance and repairs procedures</u>, possibly with a preventive maintenance programme

- <u>improving operating procedures</u> of machinery and equipment, by energy-saving minded and adequately trained personnel.

APPENDIX II

Some examples of production scale in adapted technology food processing

1 - General considerations

2 - Some examples :
- 2.1- Tomato paste processing plant
- 2.2- Small integrated cannery
- 2.3- Rice milling plant

1 - General considerations

It is very often argued that production capacity is the discriminating factor for any technological choice; it is said that high capacity necessarily implies sophisticated technologies, while very low capacities are better performed by simple technologies.
It is evident that more complex technologies (and related machinery) have been developed also in order to increase specific capacity of a given processing line, but this is not the only function which a technological improvement modifies.
In chapter 2 of the general part of this study, a simple functional analysis of food processing technologies and machinery hase shown that at least four functions are modified by an increase of technological complexity : the product quality output, [a] the degree of automatization of the line (and thus the increase in capacity), the packaging system, the energy distribution and consumption aspects [b].
The production capacity is then one of the factors which has an influence on the complexity of a given processing technology or machinery.
Any increase in capacity is strictly connected to a higher automatization of the line, requested because of the non-economical operations of multiple parallel manual lines.
For example, canning and seaming of 100, 1.000 or 10.000 cans/hour determines a technology selection of manually-operated seaming machines for

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a) a discussion about higher or lower "quality" with respect to technology has been held on para. 2.2 of the study.

b) see appendix I

100 cans/hour, semi-automatic or automatic machines for 1.000 cans/hour, fully automatic high-speed machines for 10.000 cans/hour.
It is evident that 10.000 cans/hour could be seamed also with the use of 100 manually-operated machines, with 100 workers, but this would imply an enourmously higher manpower costs plus more space, more maintenance, more management etc.; one hundred manually-operated machines are uneconomical also in a very low wage environment, because they induce other operational costs, other than the already probably unachievable manpower costs.
For a given plant, the capacity of each line determines the choice of the technological complexity of the machine : at increasing capacity, degree of automatization increases to reduce costs and to allow automatic operations, without or with less human intervention.
In the example of the seaming machine, no technogical adaptation is possible when 10.000 cans/hour capacity is requested; in other words, there is a maximum production capacity, for each type of line, machinery, process etc., which can be performed by technologically simple machines; beyond, a higher complexity is requested, because the machine must rely on a certain degree of automatization, to work properly and to be adequately managed.
But, remaining within this maximum limit , it could be argued that 1.000 cans/hour could be obtained for example by three plants producing at a rate of about 300 cans/hour each; in this case, it is likely that three manually-operated seaming machines, in each factory, could be economically managed.
Then, the technological choice depends, within certain limits, from the production scale; if overall plant dimensions are kept within small sizes, it is very often possible to employ low-capacity (and possibly adapted) technologies.
This, of course, implies that the general industrialization policies (for food processing) privilege the district-level small-sized plants operation,

instead of the huge centralized plant.
This is possible, in practice, if decision makers of the less developed countries, responsible for the food processing industry development, are well conscious of the adapted technological choice implications, on production scale as on other socio-economic aspects.
Basic choices, such as decentralizing food processing plants location, producing only for the domestic market, stimulating local maintenance and manufacturing capability, programming an "adapted" personnel training, can practically be sustained, only if an integrated development programme for the food processing industry (and possibly for food processing machinery manufacturing industry) is fully evaluated, from technological and economical points of view.
Technological implications have been discussed in previous studies and summarized on para. 2.1; four basic assumptions define the operating conditions of the adapted food processing industry in the less developed countries.
One of these assumptions is, obviously, that a food processing plant (not necessarily firm) should be kept at a small production scale, because high rates may cause capacity problems for some line and/or isolated machine, exceeding adapted technology level of intervention, as it has been pointed out in the example of the seaming machine.

Economical implications of an adapted technology choice can be evaluated only at project feasibility study level, when the operating conditions of a given project have been defined.
For an economical evaluation of production scale the following aspects should be fully investigated :

- market and demand
- raw materials supplies
- plant location alternatives
- available manpower qualifications
- possible financing sources and conditions

On the basis of the results of these studies, a production scale evaluation can be performed, by computing :

- annual production programme
- annual supply programme
- project engineering (technology, equipment, civil works etc.)
- plant organization (manpower, management etc.)
- investement costs and financing scheme

At this point, annual economic profitability can be checked by computing :

- assumed price of finished products
- revenues
- total costs (wages, overhead costs etc.)
- annual profitabily (after deduction of interest costs)

Usually employed commercial profitability criteria are :

- net present valve
- internal rate of return
- pay-back period

In a production scale economical evaluation, these computations should be repeated until the most convenient scale is found.

In the next chapter, to supply input data for possible economical feasibility analyses, some examples of small-scale food processing plants are given.
Plants of this scale are in operation in some less developed country and the rated throughputs are considered as technically convenient for adapted technology operations.

2 - Some examples

2.1 Tomato paste processing plant *

Raw product : fresh tomatoes
Finished product : tomato paste at 36% solid residue
Packaging : 50 grs. cans
Technology :

The technology employed is basically that, described on para. 4.2.2. of the catalogue.
The cold-break method is employed; main steps are as follows :

- fruit preparation is done in a washing machine and then fruits are inspected as they pass in a conveyor belt; any damaged is removed.
- fruit crushing is accomplished by a rotating comb crusher; the fruit mashed is then pumped to a refining-pulping machine, where sifting of juice is performed.
- juice concentration is performed in a vacuum kettle concentrator in two stages.
- pasteurizator and filling can be performed in a continuous high temperature pasteurizer followed by an immediate can filling or by filling cans, to be pasteurized in a pasteurizing retort; seaming is done by a semi-automatic seaming machine; cans are then cooled in open air and labelled.

The product is usuallly sold in 50 g. sealed cans.
An alternative packaging system can be flexible plastic tubes with a replaceable screw top.

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* from "Inventory of adapted technologies for ACP countries ".
Center for Industrial Development (CID) -Brussels - 1979.

Rated throughput

- 250 Kgs. of fresh tomatoes per hour which corresponds to about 900.000 cans of 50 grs. of tomato paste per year, working 6 days for 26 weeks at single shift (6 months).

Man power

NO.	qualification
1	manager
1	clerk
1	typist
1	shift supervisor
3	process operators
1	quality control
4	general labour
1	driver
13	total staff

2.2 Small integrated cannery *

Raw products: - orange, grapefruit, lemon, lime etc.
- mango, pawpaw, guava, pineapple etc.
- tomato

Finished products : - natural juices or nectars
- concentrates and pastes
- fruits in syrup

Packaging : - 100, 200, 500, 1.000 grs. cans
- 200 lts. barrels

Technology :

Pineapple processing

Ripe pineapple, coming from the collecting stations in bins, arrives to the receiving area to be manually sorted and put on the sizer and corer machine.

This machine performs the following :

- removal of the outer skin
- tops cutting
- core elimination
- pulp extraction from peel for juice preparation.

The obtained cylinders before being transferred to the slicing machine pass through a belt for further inspection and manual elimination of peel residues or other.

The prepared sliced fruit falls on a sorting and packing table where it is manually canned into 1 kg-cans.

Filled cans are then transferred to the syrup filling machine and then to the sealing machine. After sealing, the cans are put into baskets and are conveyed to the pasteurizer and then to the cooler.

Discarded pieces of fruit, from the sizer-corer, from the cylinders inspection table and from the canning section, are collected in containers and sent to the crushing pump which connects to the juice line.

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* developed by Decco-Roda SpA - Bertinoro (Fo)-Italy for less developed countries' operations.

Citrus Line

Citrus fruit is dumped into the tank for the first washing operation. It is then sorted onto a roller type belt and washed again into the brusher-washer. Washed citrus fruits are transferred by means of a belt to the juice-oil extractor.
Extracted juice is sucked by the vacuum refiner and sent to the mixing tanks.
By means of a pump, the pulps are conveyed from the vacuum refiner to the helicoidal press which extracts residual juice.

From the mixing tank the citrus juice is transferred to the deaerator in order to avoid oxydation of the product when canned. The juice, through the tube nest pasteurizer, is conveyed to the canning section for cans of 200 grams.
Filled cans are then cooled by means of the net-type continuous cooler that, in its ending part, will also provide the drying of cans with a fan.
The litographed cans are manually packed into the cartons onto a suitable belt equipped with holding benches.
In case of no-litographed cans, they are conveyed to the labelling machine.

Mango Line

Mango or other similar fruit, when at the right ripeness, is washed and sorted in the same machines of the citrus line.
The product is then sent through the belt and the elevator to the pulper.
The obtained pulp is heated up in the tube nest pre-heater and refined in the finisher.
Mango purée can be processed to obtain fruit nectars by the same line used for citrus juice or concentrate.

Pawpaw Line

Sorted fruit is manually cut in halves in order to remove seeds onto the preparation table and sent to the pulper to be transformed in pulp.
The obtained pulp then undergoes the same process described for mango.

Tomato Line

Tomato is washed and sorted in the machines used also for citrus, and tomato juice is processed in the machines used for mango up to the concentration plant.
In short, tomato will follow this way :

- washing tank
- sorting table
- connecting belt
- elevator
- pulper
- tube nest pre-heater
- finisher
- juice collecting tank

Tomato juice can be sent to the mixing tanks to obtain drinkable tomato juice or directly to the vacuum kettle concentration plant in order to obtain tomato paste or concentrate at needed Brix degree. The concentrate is filled into 200 kg. barrels or into 100 grams cans in the packing line.

Rated throughput

Fruit variety	Days per season	Hours per day	Total working hours	Hourly input (tons)	Input (tons per year)
citrus fruit	120	8	960	3 - 4	2880+3840
mango	40	8	320	1 - 2	320+640
tomato	150	8	1200	1,5 - 3	1800+3600
papawa	120	8	960	1 - 2	960+1920
pineapple	60	8	480	3 - 4	1440+1920

Man power

No.	Qualification
1	Plant superintendent
1	Process foreman
1	Foreman for fruit reception
3	Skilled operators for citrus juice extraction
4	Workers for pineapple cylinders inspection and trimming
6	Can filler operators
1	Syruper and seaming operator
2	Concentration plant and pasteurizer attendant
1	Sugar, mixing, blending attendant
1	Mechanic
1	Electrician
1	Laboratory attendant
1	Warehouse foreman
3	Accounting office and clericals
2	Fork-lift drivers
10	Labourers.
39	Total staff

2.3 Rice-milling plant

Raw product : - paddy rice

Finished product : - white rice with traces of germ and bran

Packaging : - bags

Technology :
The rice mill is a two-stage mill. The first stage, or de-husking, is performed by a rubber roll sheller, for husk removal; husk is then separated by the blower of the sheller. The second stage could be performed by a second passage on the rubber roll hulier for bran removal, or by the use of an Engelberg huller.
The first system is preferable because it yields more head rice and has proved * to be more profitable at district level.

Rated throughput :
A maximun of 750 kgs. per hour of dried paddy, which means a total annual throughput of about 1350 tons, considering a daily production of 4,. tons for 300 working days each year.

Man power

No.	Qualifications
1	- miller
1	- assistant
4	- unskilled
6	Total staff

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* see - "A techno-economic evaluation of rice mills for cooperative and village operations" J. Ramalingam - FAO - Indonesia - 1980

APPENDIX III

List of potential suppliers of food processing machinery

Note : this is a non-exhaustive indicative list of italian manufactures of food processing machinery in the four considered subsectors.

SUPPLIERS OF TECHNOLOGIES AND PROCESSING LINES

- GARIBOLDI snc - via Pienza 20 - 20142 MILANO
  - rice processing
- LUCIANI ORESTE spa - via Bologna 31 - 43100 PARMA
  - meat processing
  - canning equipment
  - fruit and vegetable processing
  - utilities
- MANZINI TITO &F. spa - via Tonale 11 - 43100 PARMA
  - fruit and vegetable processing
  - canning equipment
- RODA spa - P.O. BOX 7- 47032 Bertinoro - FORLI'
  - fruit and vegetable processing
- ROSS ING. & CATELLI snc - via Zarotto 114 - 43100 PARMA
  - fruit and vegetable processing
  - canning equipment
  - dairy processing
- SORDI M. spa - v.le Trento Trieste 37 - 20075 LODI-MI-
  - dairy processing
- VAR spa - via Emilia Ovest, Centro 2000 - MODENA
  - meat processing
  - slaughterhouses
- VETTORI & MANGHI spa - via Spezia 54 - 43100 PARMA
  - fruit and vegetable processing
  - meat processing
- POLIN sas - v.le dell 'Industria 9 - 37100 VERONA
  - bakeries

SUPPLIERS OF FOOD PROCESSING MACHINERY

1 - Meat processing and slaughtering
2 - Fruit and vagetable processing
3 - Dairy processing
4 - Cereals processing
5 - Packaging

- AMB snc Via della Tecnica 19 S. Lazzaro (BO)	1
- ALMA LEVATI srl Torricella Sissa - Parma	1
- AVONI DANTE Via Matteotti 16 - Villanova di CASTENASO (BO)	4
- ARFA snc Via Marconi 3 - Noceto PARMA	3
- BRECO Strada Golese 30 - PARMA	1
- BREVIGLIERI V.le delle Nazioni 36 - MODENA	4
- BRIZZI O. Via Portacastello 3 - BOLOGNA	4
- BOSELLI G. P.zza Partigiani 15 - Noceto PARMA	3
- CGZ ALIMEC srl Via Are 2 - Sala Baganza PARMA	1
- COSTUZ. MECC. ROVANI S.S. 62 KM 161 - Luzzara REGGIO E.	1
- CMP Via della Suora 237 - MODENA	4
- CASEARTECNICA Via Bertini 26 - PARMA	3
- DALL 'ARGINE & GHIRETTI snc Via Nazionale Est 43 - Stradella di COLLECCHIO PARMA	2

- DI NARDO P.
  V.le Storchi 347 - MODENA 1
- DRUSIANI R.
  Via Asiago 14 - Castelfranco Emilia MODENA 1
- FAVA GIORGIO
  Via Cerati 19 - PARMA 1
- FAVA GIANFRANCO
  Alberi di Vigatto PARMA 2
- FBR srl
  Via A. da Brescia 12 - PARMA 2
- FMC - Food Machinery Italy spa
  Via Mantova 127 - PARMA 1 - 2
- FORNI ZENIT srl
  Strada Sant 'Anna 581 - MODENA 4
- FRIGOMECCANICA spa
  Via Provinciale 17 - Sala Baganza PARMA 1
- GHIZZONI DANTE
  Via Matteotti 6 - Felino PARMA 2 - 5
- GHIZZONI ETTORE & FIGLI snc
  Pannocchia PARMA 1 - 2 - 5
- GHERRI GINO snc
  Strada Nuova Naviglio - PARMA 5
- GISTAR snc
  Via di Vittorio - Fornovo di Taro - PARMA 1
- IB di BERTOLI & CORRADINI
  Via San Marco 38 - Guastalla REGGIO E. 1
- IMAS snc
  Via Cheguevara 5 - MODENA 1
- IMA srl
  Via Guerrazzi 5 - REGGIO EMILIA 3
- ING. DARECCHIO
  Via Emilia - Castel Guelfo - PARMA 1 - 2 - 5
- ITALCOSMOS srl
  Via dell 'Artigianato 35 - PIANORO
  BOLOGNA 1
- ING. FERRETTI srl
  Via Pellico 5 - Quattrocastella REGGIO E. 3

- IFM srl
  Via Buozzi 15 - Salsomaggiore PARMA — 1
- LA PARMIGIANA srl
  Via Porro 2/4 - Fidenza PARMA — 4
- LEVATI R. spa
  Via Nazionale Est - Collecchio PARMA — 1 - 2
- LAMPA
  Via Milano 8 - Gatteo FORLI' — 4
- LATINI PIERO
  Via F. Rosselli 23 - Carpi MODENA — 4
- MALAGUTI ANGELO
  Via Corti 45 - MODENA — 4
- MALAGUTI NERIO
  Via Corti 41 - MODENA — 4
- MANZINI GIOVANNI & FIGLI snc
  Strada Madonnina - Madregolo PARMA — 1 - 2 - 3
- MA.PI.BI.
  Alberi di Vigatto PARMA — 2 - 5
- MIGLIAVACCA C. & C.
  Via Alessandria 5 - PARMA — 5
- MOLITECNICA ARDUINI snc
  Via Caduti di Amola - BOLOGNA — 4
- NILMA
  Via Lasagna 5 - PARMA — 2
- NSV snc
  Via Bernini 97 - MODENA — 1
- NUOVA OFF. MECC. F.LLI FILIPPINI
  Corte Tegge - Cavriago REGGIO EMILIA — 3
- OFF. MECC. BARALDI F.
  Via Radici 308 - Formigine MODENA — 2
- OFF. RONCAGLIA spa
  Via Araldi 100 - MODENA — 4
- PANINI srl
  Via Ferrari 49 - Maranello MODENA — 3

- OFF. MECC. ZIVERI Pilastro - Langhirano PARMA	1
- PALTRINIERI E. Via Provinciale 54 - Medolla MODENA	1
- F.LLI PARMEGGIANI snc Via Loda 5 - Castelfranco Emilia MODENA	1
- PELLACINI PIO Via Paisiello 8 - PARMA	2
- PELLACINI SERGIO & FIGLI sas Sala Baganza - PARMA	1 - 2
- RAS snc Albinea REGGIO EMILIA	1
- RIVARA Via Langhirano 210 - PARMA	1
- ROSSI A. & C. Via Trieste 5 - PARMA	5
- ROSSI ING. A. sas Via Moletolo 2 - PARMA	2 - 5
- SAVI ANTONIO spa Via Ravasini 13 - PARMA	2
- SENZANI BREVETTI spa V.le Risorgimento 13 - Faenza FORLI'	4
- SIMPLA snc Via Torrette Cagniona - Savigniano S.R. FORLI'	4
- SIM BIANCA spa Via Marescalca 100 - FERRARA	4
- SM sas Via A. Buozzi 10 - Nonantola MODENA	1
- SM Via Ortles 4 - PARMA	3
- TECNOINOX Via Di Vittorio - San Pancrazio PARMA	3
- TECNOINDUSTRIA snc Via Spezia - Cavalli di Collecchio PARMA	2

- UNION snc Via Colombo 29 - MODENA	1
- VICTUSFORNI srl Via Romagnoli - San Paolo Torrile PARMA	4
- VILLANI MARIO Via VIII Marzo 14 - Collecchio PARMA	4 - 5
- ZACMI Via Mantova 139 - PARMA	2 - 5
- ZAROTTI & C. srl Via Cantelli 5 PARMA	5
- ZILLI & BELLINI srl Via Benedetta 83 - PARMA	2 - 5