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Guidelines for investors when establishing a sugar industry in developing countries.

UNIT OPERATIONS AND UNIT PROCESSES FOR BEET AND CANE SUGAR PRODUCTION. 1/

by

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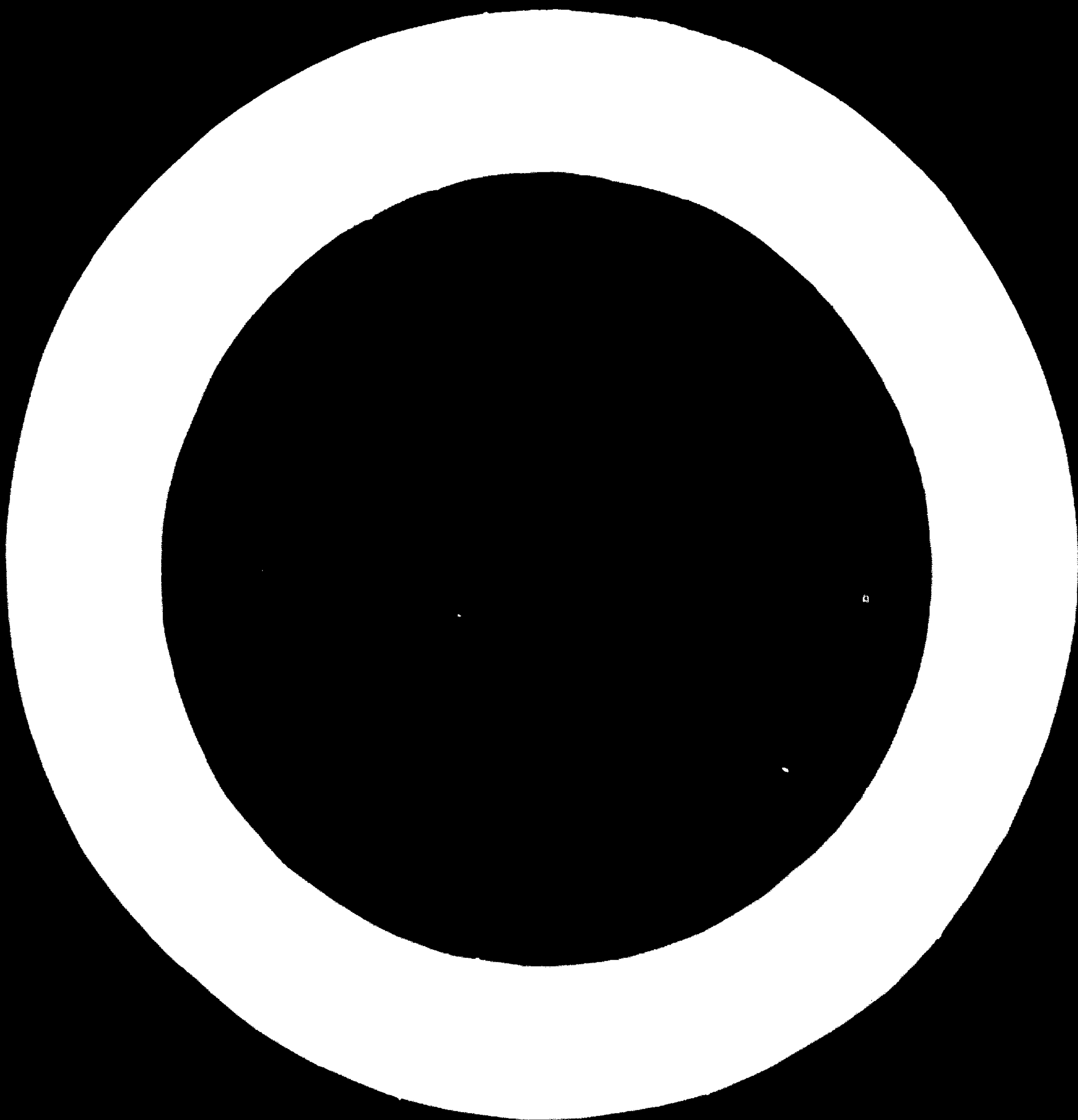

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Introduction

Already during the early Middle Ages sugar made from cane had been imported in Europe and one and a half century ago sugar beets also were processed to sugar. According to this long history and to the different development in many countries there were different kinds of processes used to produce sugar. So, it is not possible to state that there should be only one line of process used for manufacturing sugar from beets or from cane.

This study will try and find a solution to this problem in showing the best way to process beets and cane in the most technically advanced form to a final product suitable for local purposes or export. The climatic conditions with their influence on harvesting time, the local availability of labour and especially raw materials for the chemical process have to be borne in mind. So it should be fixed which special process has to be used under what special conditions.

I. Flow sheets of sugar production

A. Cane sugar production

The attached flow sheets for sugar production, Annex Figure II, 1-6, show schemes for two kinds of extracting the juice and 3 kinds of juice purification systems. The boiling schemes, Annex Figure III, 1-3, show three different types for the production of raw sugar by the defecation process, refined sugar by the remelting sulfitation process and white sugar by the carbonatation process.

If defecation has to be used, it will only be for the production of raw sugar and a clairce purification as shown in the sulfitation boiling scheme for the refined sugar production has to be added.

B. Beet sugar production

The sugar production flow sheet, Annex Figure V, is based on a continuous diffusion system combined with the Braunschweig purification process. The material balance will not have to be changed very substantially if other purification systems are used.

The boiling schemes, Annex Figure IV, 1-3, can also be used for beet sugar processing, for they are based on the quantity of sugar coming to the sugar house and the purity of the thick juice.

II. Unit operations and processes

A. Cane sugar

A 1. Cane preparation

Already the harvesting methods are very different for part of the cane is burnt, that means that in the area where the cane has to be cut all the dried leaves are destroyed by fire. In other parts of the cane area, the trash is removed by hand. In many countries mechanical harvesting is very much advanced, while in some parts the cane is still cut by hand and bundled.
For future projects cane burning and mechanical harvesting should be practiced.
The transportation of cane is usually done either by narrow gauge railway Diesel trains in countries where the route-systems are not developed sufficiently, or by trucks and trailors where the road systems are in an advanced state.
The investment for the railway system is lower if it should be necessary not only to buy the trucks and trailors but also to construct the roads. If mechanical ploughing, seeding and harvesting is employed and if the cane plantations have to be newly arranged, the road, truck and trailor system should be preferred.
The cane delivered to the factory has to be weighed if small farmers are the suppliers who are paid by the quantity of cane delivered.
If the cane comes from plantations belonging to the factory, the railway cars or trucks and trailors are only weighed and the weights added daily to know the total incoming quantity.

This results in the fact that weighing scales have to be provided. Experience has shown that the period passing from the time of cutting the cane to its entering the process should not exceed 18 hours. The storage capacity of the factory should not be higher than is necessary to outlast the nights and some holidays, when cane cannot be delivered. If there is a breakdown in the factory not allowing to process any cane for a longer period, cane cutting has to be stopped and the time should be used for repairs, boiling out the evaporators and cleaning the factory.

For unloading the cars, trucks and trailors a dumping system can be used, or some other transport vehicle has to be provided with special cane chains slung around the total load. In this latter case, a tower crane or an overhead travelling crane running on rails have to be installed. The cane is discharged onto a cane feed table or directly to the cane carrier. If the plant has a very high processing capacity, several milling or milling/ diffusion trains have to be installed and each train has to be equipped with a cane table and unloading cranes.

Where mechanically harvested cane has to be processed a cane washer has to be installed for the mechanical loading of the cane in the fields, which results in a considerable amount of mud and stones which have to be eliminated before milling.

A 2. Juice extraction

In more than ninety percent of the existing cane sugar mills the juice is extracted by milling trains. The cane stalks are cut to pieces by cane levellers and knives; sometimes cane crushers and shredders are installed, too. The milling train is composed of several (4 to 6) three-roller mills interconnected by intermediate carriers. As the largest amount of juice is extracted by the first mill, imbibition water is added to the bagasse before the last mill, and the water pressed out by that mill has to be recirculated according to a maceration system to the last but one mill and so on to the first mill, wherefrom it is pumped via a cush-cush separator as mixed juice to the factory. The rollers of the mills have to have different groovings from the beginning of the train through to its end, Messchaert grooves have to be provided. The speed of the mills has to be variable according to the quality of the cane to be treated. The mills are driven via reduction gearings either by steam turbines or electric motors, the latter possibility not being very common, for the regulation through steam drives is smoother, and in many factories the turbo-generators in the power plant do not produce sufficient electrical power. The extracted bagasse must have a dry substance content of at least 50 %, if it shall be used as fuel in the boiler plant. The cush cush[+] can be screened by standard screens and an elevator or by an arch screen, which is more efficient, and it is transported by the bagasse carrier to the boilers.

[+] or bagacillo

The efficiency of a milling train is fixed by the extraction,

i.e. $\frac{\text{sucrose in mixed juice \% o.c.}}{\text{sucrose input \% o.c.}}$

the sucrose content and the dry matter content of the final bagasse.

Within the last decade the extraction of juice by a diffusion process became more and more important. There are two possibilities: either the so-called 45 % diffusion or the 100 % diffusion. That means that, in the first case, a diffusion system is combined with milling by installing one mill before the diffuser, which extracts 55 % of the total juice quantity, while another 45 % are extracted by diffusion. If there is no mill before the diffuser, but only a normal cane preparation by cane knives and a shredder, then this is called a 100 % diffusion system. Now there are some 30 to 40 cane diffusers installed in the world, but none is using the second type. The different diffusion systems as, for instance, Egyptian BMA, de Smet, Saturn, Silver are quite different from a mechanical point of view. The advantages of these systems are in that the extraction, which generally is approx. 93 - 95 % for mills with a sucrose content of 2.6 %+, has between 96 - 98 % with a sucrose content of 1.6 % resulting in a higher sugar yield in the bag. The capital investment for mills is substantially higher than for a diffuser where the lay-out of the factory, due to a higher quantity of raw juice, what means more evaporation and more sugar in the sugar house, asks for more investment inside the factory.

+ in the bagasse

For future tenders 45 % diffusion systems should be considered, and the extraction as well as the sucrose and dry substance content of the final bagasse should be limited.
It is not possible to fix the scope of supply for different diffusion plants once for all, for experience has shown that different requirements in different countries cannot, for the time being, be ironed out.

A.3 Juice purification

As shown in Annex Figure II, 1-6, there are three main purification systems used in the cane sugar industry. In order that the appropriate one can be selected for a tender, one has to settle beforehand what kind of final product shall be produced, namely

raw sugar,
plantation white sugar,
white crystal sugar,
or refined sugar.

Table (1) shows the different features of the purification systems. If, in a certain country, there is no lime rock available to burn the necessary quantities used for the carbonatation process to produce a good white crystal sugar with a 99.7 % sucrose content, the choice has to fall upon a plant combining a defecation or sulfitation plant and a refinery. But it would be more advisable to work on the responsible promoters to produce white sugar with a 99.7 % sucrose content after the sulfitation process only. If the sugar is to be used for home consumption, the difference is not likely to be quite important, but the capital investment would be lower by some 17 to 20 %.
Provided there are no strong objections against it, such as a lack of lime stone, it is recommended to use the double carbonatation and double sulfitation process.

A.4 Evaporation and sugar boiling

Most of the cane sugar factories in the world are using for evaporation a 4-effect evaporation station with standard Roberts evaporators. As the vapours have to be utilised for heating purposes to heat the preheaters before the purification, before the filtration and sulfitation and those before the evaporation and also to heat the vacuum pans for boiling, the total heating surface[+] required has to be calculated with a factor of 1.1 to 1.3 depending on the size of the factory, i.e. processing 2,000 tons of cane per day necessitates a 2,600 m^2 heating surface.
About 40 - 42 % of this total heating surface are required for the 1st effect, 25 % for the 2nd effect, 18 % for the 3rd and 16 - 18 % for the 4th effect. Up to this day, there is not an internationally accepted process, as the decalcification process in the beet sugar industry to prevent scaling in the evaporator tubes, so normally at two-week intervals, the tubes have to be cleaned by boiling them out with solutions of HCl and NaOH. So, all the equipment in a cane factory has to be designed for a working time of 22 hours per day, that means a plant for a 2,000 ton/day cane processing capacity has to handle some 92 tons/hour.

Condensate removal and vapour condensation will be discussed in Chapter VI.A.

If the concentration of the thick juice reaches 60 to 65 % of dry substance, the evaporation is considered sufficient.

[+] of the evaporation

Normally, the heating tubes in preheaters and evaporators are made of brass or copper, stainless steel is not quite common yet as the price is too high. The heating tubes normally have a diameter of 44.5 mm.

The sugar house boiling schemes, as shown in Annex Figure III, 1-3, only apply to the production of raw sugar, by using the defecation process, production of refined sugar via raw sugar with the sulfitation process combined with remelting and production of raw and white sugar with the carbonatation process. The schemes per Annex Figure IV, 1-3, may not only be used in beet sugar factories, but only in manufacturing white crystal sugar from cane sugar thick juice with the carbonatation process if the purity of the thick juice is high enough.

The vacuum pans used in the cane sugar industry are of the same type as in the beet industry, the tubes of brass or copper. The heating surface is calculated by applying the following factors:

refined sugar	- 5.20	multiplied	by	tons	of	massecuite
white "	- 5.00	"	"	"	"	"
raw "	- 5.00	"	"	"	"	"
B-product "	- 4.75	"	"	"	"	"
C-product "	- 4.50	"	"	"	"	"

If the vacuum pans are equipped with agitators, the corresponding figures are 5.0, 4.5, 4.5, 4.0 and 3.8.

All the pans have to be heated by the vapours of the 1st effect of the evaporator. The vapours should be condensed by individual jet condensers.

The capacity of the crystallizers has to be higher by 10 % than the respective vacuum capacity and is used only to feed the centrifugals with a uniform flow of massecuite. Exceptions are the crystallizers for C-product which have to be provided with a cooling and, at its end, a heating installation. Their capacity should guarantee a retention time of approx. 24 hours.
All those products, which will be sold directly, are to be cured in automatic or semi-automatic batch-type centrifugals. The other intermediate products such as B-, C-affination and C-product can be cured in continuous centrifugals. The speed of the centrifugals should range from 1,000 to 1,200 rpm for massecuites with a higher purity such as refined, white, A- and B-sugar, and from 1,400 to 1,500 rpm for lower-purity products such as raw sugar affination, B- and C-product affination and C-product massecuites.
The centrifugal mixers for these products have to be equipped with a heating device. Individual electrical heating for continuous centrifugals as preferred in Mauritius, Reunion and South Africa is considered too expensive.
Before stipulating a tender it should be clarified if the factory is situated for instance in an area of earthquakes or tornados, so that only a one-floor factory can be constructed. In that case the crystallizers, which are generally installed below the vacuum pans and above the centrifugal stage to let the massecuites flow under their own gravity from one station to another, have to be installed on the ground floor, and this necessitates massecuite pumps to pump the massecuites to the corresponding mixers of the centrifugals.

Formerly the sugar was dried in special installations at the end of the grasshopper conveyors below the centrifugals or by letting the sugar drizzle down a cascade tower against an air stream, but now a granulator has to be installed both for drying and cooling the sugar.
Sugar weighing and bagging or bulk transport facilities to the storehouse have to be provided.

A.5 Auxiliary processes

More than 99 % of all existing cane sugar factories are using as fuel the bagasse of the mills, the rest uses the bagasse to make paper or soft cardboard. The bagasse should have a dry substance of 50 % o.b.+ and the calorific value of one kg is 3,950 - 4,000 kcal. The steam consumption differs according to the installed juice extraction and juice purification system, Figure 1. The boilers should always be of the high-pressure type so that the turbo generators, which are necessary to produce the required electric power, can be used for steam reduction. Three boilers always should be installed, one of them being employed as a stand-by unit with half the necessary capacity.

As was mentioned before the electric power should be supplied by turbo-generators. The connected kW should be calculated with a factor of 0.9 - 1.1, multiplied by the daily cane crushing capacity. Smaller factories should be equipped with two turbo-generators of the total capacity (one of them serving as a stand-by unit); in bigger factories with a crushing capacity exceeding 2,000 t/d three equal generators, two units giving the total output required and one standby unit have to be provided.

In factories with a crushing capacity of more than 3,000 tons per day transformers should be employed for the different sections of the factory in order to avoid losses. An emergency distribution system supplied by emergency Diesel generators should be provided. This network is to guarantee that all the equipment, e.g. the crystallizers, some pumps and part of the lighting will work also during breakdowns.

+ o.b. = on bagasse

The lime preparation plant in defecation and carbonatation factories is an important part which has to be provided. In defecation plants the necessary quantity of lime is very low, and for factories up to capacities of approx. 4,000 tons of cane per day it is not feasible to install a lime kiln, since the smallest one produces about 5 tons of CaO per day. In that case, it should be possible to buy fresh burnt lime from local sources to run the plant. If the capacity is higher, or in carbonatation plants, it is always necessary to provide a lime kiln.+ Generally, coke is used as fuel for the lime kiln, but for some years past it is also possible to use mazout and natural gas, so it all depends on the local conditions.

In a lime slaking drum the milk of lime has to be produced from the burnt lime stone. The concentration is to range between 15 and 18 Beaumé. The collecting tank should be equipped with agitators and the retention time should be 3 to 4 hours to let the milk of lime mature.

For sulfitation and double carbonatation and double sulfitation plants a sulphur furnace is the most common installation. Most of the existing factories are working with sulphur pan furnaces and very often encounter difficulties if the crude sulphur is not refined and so burning is obstructed by ashes and minerals covering the surface. Therefore the lime should be incinerated for rotary sulphur furnaces, which are capable of burning also natural sulphur instead of refined sulphur. The possibility of using bottled SO_2 gas or sulphuric acid is always more expensive.

+ for the production of CaO and CO_2

In cane sugar factories with a daily crushing capacity exceeding 2,000 tons of cane, depending on the fibre content of the cane, yield a surplus of bagasse which should be baled in bagasse presses. The bagasse conveyor feeding the boilers should be extended so that it goes outside the boiler house and serves the presses.

The total additional fresh water requirements of a factory if the flash water is cooled and recirculated and again used as injection water for the condensers amounts to approx. 250 % o.c. To cover this quantity it is necessary to have wells or a river, and a pumping station to supply the factory. If river water is used in tropical areas where sometimes only muddy water is available, settling ponds have to be built between the river pumping station and the mill with a second pumping station.

At present it is not possible to propose an internationally accepted process for the desugarisation or demineralisation of final molasses, which may be added at a later date. At the moment the final molasses are exported as so-called blackstrap molasses or, if the distance to a harbour is too far, mixed with the irrigation water or, mixed with bagasse, used as cattle feed as for instance in Louisiana/USA.

III. B. Beet sugar

1. Beet preparation

Along with the change in beet transportation to the factory, which is presently done either by trucks or tractors and trailors, the beet yard of the sugar factories has changed entirely. In most factories there are now, besides the old flumes, very modern beet silos or platforms. The beets supplied to the factory are weighed, and the samples for determining the dirt tare of each lot and the percentage of sugar in the beets are then taken in a special sampling installation. The farmers are paid for the beets in accordance with the figures established in this installation. From here the vehicles are driven to the unloading equipment, where the beets are unloaded either by water-jet spray nozzles (called Elfa unloading) or by dumping the loaded trailors. Mostly the wet-unloaded beets are fed directly to the process and the dry-unloaded beets are stored in silos or on platforms in huge piles up to 7 meters in height. These piles are provided with an aeration and temperature control system. Depending on the outside temperature during the nights when the temperature is lower, the beets are cooled down to 5 - 7 °C.

The afore-mentioned system asks for installing scales, a sampling station, dry and wet unloading equipment and beet silos or platforms with aeration, temperature control and fluming facilities for emptying the platforms. The capacity should be in accordance with the quantity of beets entering the factory every day, and the silos may have a storage capacity for 30 to 60 days.

Stone and leaf catchers have to be installed in the flume between the beet yard and the factory, and a regulating wheel at the entrance of the factory.

Up to now it depends where the beet washing machine is installed that for lifting the beets will be used a beet lifting wheel (ground floor situation) or a beet pump (upper floor). For future projects the beet lifting wheel and the washer should not be kept inside the factory, but incorporated in a separate building at the end of the beet yard so that this unavoidably dirty place is outside the actual sugar factory. From there the washed beets can be conveyed to the factory by a belt conveyor. If the difference in elevation and distance of the outlet of the washers and the upper part of the beet bin above the slicing machines inside the factory is too large, a beet pump and a water separator above the bin should be provided.

B. 2. Juice extraction

The beet slicers should be installed at an appropriate level to charge the diffusion plant by a belt conveyor with built-in scale. The bin above the slicers should have a beet capacity sufficient for 20 to 30 minutes processing. One or all slicers should be capable of being regulated by the foreman of the diffusion plant.

The internationally accepted systems of diffusion are those with forced feed of cossettes and juice as RT and de Smet, and those without forced feed as BMA, BW and DdS. RT, de Smet and DdS are of the horizontal trough+ type, and BMA and BW are of the vertical tower type. The determining criterions for these systems are the following:

a) They should operate with all kinds of cossettes, cut by Koenigsfelder knives, side-cut knives and straight-cut knives.

b) The heating time should be as short as possible to shorten the time required to heat up from 25 to 50 °C, during which bacteriological fermentation might occur.

c) Direct heating should not be applied.

d) The time required to pass the cossettes should not exceed 80 to 90 minutes to avoid leaching of the non-sugars.

e) There should be no contact between the mixture of cossettes/juice and air, as this would increase the danger of corrosion.

+ or drum

f) The equipment for acidifying the fresh water by SO_2 gas has to be provided to guarantee a pH-value of 5.8 continuously.

g) All the press water has to be recirculated.

The draught should be approx. 120 kg o.b. and the sugar losses 0.2 kg o.b. These figures vary according to the sugar and marc content of the beets.

In some countries or in certain years the beets do not show their normal shape but have many tails breaking off during transport and washing. The percentage of these tails may at times be very high, i.e. up to 7 - 10 %. So, a tail catcher should be in the wash water coming from the washing machine to eliminate these tails. They should be washed, crushed and added to the cossettes ahead of the belt scale.

B. 3. Juice purification

Since there are many different systems of continuous purification, the basic conditions generally accepted for efficient purification should be established:

a) Calcification shall be carried out in a soft way without any pH shocks.

b) As far as possible, invert sugar shall be destroyed.

c) The addition of CaO which should amount to a maximum of 85 % of the non-sugar content, shall be kept as low as possible.

d) The purification effect in percent on input non-sugars shall be as high as possible.

e) The thin juice shall be thermostable to avoid colorisation of the thick juice.

f) The rate of sedimentation should be as high as possible, and the coefficient of filtration as low as possible.

g) Alterated beets should also be treated without reducing the processing capacity.

Well-known purification systems are:

the Brieghel-Müller system for preliming with conventional main liming and carbonatations I and II with recirculation of the sludge of the decantation after the carbonatation I;

the purification system of the Braunschweig Sugar Institute with precarbonatation, intermediate liming, partial recirculation of this juice to the precarbonatation, main liming, carbonatation I, decantation with recirculation of the sludge before precarbonatation and filtration, carbonatation II;

the purification system of Novy Saad Sugar Institute with liming-precarbonatation, decantation and sludge filtration, main liming, carbonatation I, carbonatation II, decantation with recirculation of sludge to liming-carbonatation.

Just these three systems shall be dealt with - despite the fact that there are many other slightly different systems.

Many factories employ an additional sulfitation without or with filtration, and some of them use also decalcification.

This decalcification is performed by pumping the thin juice through ion-exchangers to reduce the lime salts, which produce incrustations in the evaporator tubes asking for boiling out the station to avoid a reduction in processing capacity. The resins are normally regenerated with NaCl; according to a new process of the Hungarian Sugar Institute, this can also be done by recirculating the thick juice (Zsigmond/Gryllus process). If decalcification by resins is employed, no sulfitation unit should be installed ahead of it.

3. 4. Evaporation and sugar boiling

Most of the factories are using quadruple-effect evaporation systems with Roberts evaporators. But an increasing number of factories change the last effect by using a falling-film evaporator, which requires 50 % less heating surface and avoids colorisation of the already highly concentrated juice. An additional circulation pump has to be provided. in order that, in the event of changes in the juice flow through the evaporator, this effect can always be supplied with a sufficient amount of juice.

In beet sugar factories the factor for calculating the heating surface of the evaporation station is 2.3 to 2.4, i.e. a plant with a daily processing capacity of 2,000 tons of beets should have a 4,600 m^2 heating surface.

The normal layout of the individual stages is approx. 25 % for the first, 42 % for the second, 25 % for the third and 8 % for the last effect.

The heating tubes are seamless steel tubes and have an outside diameter of 30 or 35 mm.

Depending on the quality of the thick juice which should have a concentration of 65 % dry substance, it might be advantageous at times during the campaign to sulfitate the juice before finally filtering it. This filtration, just like the filtration after thin juice sulfitation, is carried out by precoating with kieselguhr and carbon. The residues are pumped back to the decantation unit after carbonatation I. The filtered thick juice is conveyed to the sugar house.

As is shown in the boiling schemes, Annex Figure IV, 1-3, the method depends on the product to be produced. Normally, the white sugar scheme is used; only where part of the sugar has to be sold as cube or liquid sugar it is advantageous to boil after the scheme for white and refined sugar. In developing countries refined sugar will be produced only under special circumstances.

The vacuum pans are of the same type as for the cane sugar industry; it is more common, however, to equip them with agitators to prevent conglomerates.

In that case, the heating surface as mentioned in Chapter III.A.4. should be calculated by applying a factor of 5.0 for refined sugar, 4.5 for white sugar, 4.0 for B-product and 3.8 for C-product. For the crystallisers and the centrifugals as well as for sugar drying, weighing and bagging the same conditions as described in that chapter shall apply.

B. 5. Auxiliary processes

The steam requirements of a sugar factory producing white crystal sugar should be 40 to 50 kg o.b., depending on the sugar content of the beets and the draught at the diffusion plant. Coal, mazout or natural gas can be used as fuels, and the layout of the boilers and the necessary equipment to feed the boilers have to be selected accordingly.

The connected kW at the turbo-generators should be calculated with a factor 1.5, multiplied by the daily capacity of the factory in t/h up to 1,500 tons beets/day, beyond this figure with a factor of 1.2 - not considering any stand-by equipment.

Section III.5.A. also applies to the units to be provided, as well as to the electric power distribution system.

The CaO+ required for purification, which amounts to some 2 % o.b., is to be produced in a lime kiln. As the lime rock to be burned never is clean, 4 % o.b. of limestone have to be burnt. All other conditions are the same as in the cane sugar industry, also the sulphur installation.

Depending on the extent of recirculation of flume and flash water, the daily amount of fresh water to be added may be 70 - 300 % o.b. The necessary feed water for the boilers has to be the condensate from the first and partly the second evaporator effect. All the other condensates are used as warm water for processing purposes.

For the flume water a decantation pond has to be provided, and a small amount of milk of lime should be added to prevent acidification. The flash water should be cooled either in a spray pond or in a cooling tower.

+ and CO_2

The filter cake has to be stored in a settling pond, where farmers can take it from after the campaign and use it as a fertilizer.

The mud of the flume water decantation containing small parts of beets, which will ferment and thus give an unpleasant odour, must be pumped far away from housing areas or cleaned by a biological process.

One of the most important by-products of the beet sugar industry are the leached cossettes or pulp, which can be used as cattle feed. If fed as a fresh product or used for siloing the pulp is pressed only in vertical presses to a dry substance content of approx. 16 to 17 %; but if it shall be dried, it will be pressed to a dry substance content of 20 - 21 % to economize fuel consumption. Between 1 and 2 % of molasses o.b. can be mixed with the pulp before drying, thus improving the feeding value of the fodder. The pulp can either be bagged or stored in bulk. For some years past, the dried pulp is pelletized to reduce the volume. In this case, the water content of the fresh dried pulp should be approx. 13 % instead of 10 % if they are not pelletized and stored in bulk.

The pulp is dried in rotary drums which are heated by exhaust gas from combustion chambers using coal, mazout or natural gas as fuel. Sometimes exhaust gas from the boilers is used, but then the drying drums can only be used during the campaign. If a country should be in short supply of animal feed, the same drums can also be used to dry the beet leaves by installing an additional preparing installation reducing the leaves to small pieces. This installation produces the waste product chlorophyll water, which ferments easily and has to be treated like the flume water.

The molasses can further be utilised by installing a desugarizing plant operating, for example, on the Steffen process, which nowadays works continuously. That means not only mounting the machinery for the process but to install a pulverizing plant for burnt lime, changes in and extensions to the purification, the evaporation and the sugar house. The waste water has to be treated carefully.

As an alternative to this process, a demineralising plant for molasses can be provided, also working continuously with a special system of anion and cation exchangers. The regeneration of the ion exchangers is carried out by NH_3 and HNO_3 so that, as a by-product, a fertilizer is produced, thus increasing the feasibility of the plant besides the higher output of sugar, for 80 - 90 % of the sugar from the molasses can be yielded by recirculating the demineralized juice or concentrated for liquid sugar.

III. Security and sanitary problems

The major part of the precautionary measures has to be provided by the supplier of the machinery. This means that all of the rotating parts have to be covered by guards against touches by the labourer. Any tank used for high-pressure water or steam, or any equipment requiring special material or manufacturing, should be tested by the national security authorities of the supplier, and a test certificate has to be furnished along with the pressure tank or other equipment. It is also very important that all areas where it is possible to get an electric shock, e.g. high-tension distribution systems, be incorporated in separate rooms, and that bills or posters indicating the danger be shown. Only the responsible electrician should be allowed to inspect or repair this equipment.

All people working under dangerous conditions should be instructed before starting their work and be provided with protection clothes, helmets, goggles or gloves. In the factory one of the technically skilled employees has to be appointed safety officer, and thus must be known to every worker. He has to be informed about any repair to be made and should regularly inspect all protection devices, that all bills and posters indicating special dangers are shown visibly, that people wear their protection helmets when working under crane loads, that any openings or holes in the floors are covered with suitable material or surrounded by hand rails. He also should instruct people on safety problems.

Lavatories should be reasonably spread over the whole factory site so that the distance between the working place and the lavatory does not exceed 50 meters, and they should be equipped with hand washing basins. For controlling purposes, the labourers should enter or leave the factory site through one single gate; near that place should be the sanitary conveniences equipped with a locker room with separate lockers for every worker and a washing room with showers. A drinking water distribution system has to be installdd so that nobody is compelled to leave his working place.

Beside the laboratory there should be a special room comprising all the equipment for first aid, and it is quite common to have one of the chemists or laboratory assistants trained in first aid. A contract should be made with a local hospital that an ambulance car and medical services will be available as quick as possible. If, as is usual in the cane sugar industry, the factory site is far away from a place or town, a separate small hospital with a permanently engaged nurse should be built. The number of people depending on this place is rather high, as there is not only the crew of the factory but also the agricultural labourers with their families.

IV. Main materials for processing

The materials required for processing cane and beets are shown in Tables 2 and 3. The figures are approximate ones and, as far as possible, shown in proportion to the weight of cane or beets processed. If not used or added permanently, e.g. materials for boiling out the evaporation station, these materials are stated in porportion to a 1,000 m^2 heating surface. In any case, the supplier of the factory has to fix in the tender the amount of materials and the technical guarantees he is ready to grant.

V. Heat balance for sugar factories

The thermo-diagrams given in Annex VI, 1-3 show the heat balances for a defecation, a sulfitation and a carbonatation plant for cane sugar production. Diagram VI.4 shows a balance for a beet sugar factory producing white crystal sugar. The main point in any heat economy is to completely utilize the existing vapours and to use the least possible direct steam from the boilers or exhaust steam from the turbo-generators. The steam consumption of the plant should form part of the technical guarantee by the supplier.

VI . Quality control

A laboratory with complete instrumentation to conduct the controls and the analyses of the raw, intermediate and final products is the basis of an efficient operation of any factory. The analytical methods are laid down for the cane sugar industry in the book "System of cane sugar control", for refining sugar in the book "Analytical methods used in sugar refining", and for the beet sugar industry in Chapter III. - Sugar factory control - of the Zuckertechniker-Handbuch. In addition to those instructions, the Icumsa reports of the proceedings 1954, 1958, 1962, 1966 and 1970 should be known to the responsible chemist.

Besides these chemical controls the factory should, as far as possible, include controlling, measuring and regulating instruments to allow the workman operating the station to immediately influence the process according to circumstances.

In the beet sugar industry the automatic control of the processes by given data is much more advanced than in the cane industry. Some factories are equipped already with central controlling and regulating rooms where just a few people are supervising the whole process. The expenditure for this equipment is very high, so it is always necessary to fix in a tender the degree of automation required.

VII . Feasibility study

The feasibility study for a sugar project has to be divided in several parts. The first task is to clarify with the customer or the competent department of a government the different points of a questionnaire. In addition to the questionnaires attached with Tables 4 and 5 showing some questions to be answered in connection with the technical lay-out of the factory, the agricultural possibilities have to be cleared. It is necessary to know the total acreage available for the cultivation of the raw product, either cane or beets, and what part of it can be harvested per year. Will it be cultivated by small farmers or on large plantations, is cultivation done manually or mechanically, what is the labour cost, the cost for fertilizer and for irrigation. In case of irrigation: is the factory required to provide the electric power to run the pumping station, or will Diesel drives have to be provided. Knowing these details, it may be possible to calculate a price per ton of cane or beets.

The best system of transport and the respective costs have to be fixed, which results in the price per ton of raw product at the factory yard.

With the filled-in questionnaires it should be possible to determine the process and calculate the capital cost. It depends on the kind of sugar to be produced and if it shall be used for local consumption or export where to locate the factory, namely in the centre of the cultivation area or at a place where there are suitable roads or a railway station, so that the costs for shipping the final product to the main distribution center or to a harbour can be calculated. Also, the costs for materials required for the process such as lime stone, sulphur, fuel oil, chemicals, bags, etc. have to be calculated, including transport to the factory site.

When the process has been determined, the labour cost to run the factory during the campaign and the off-season has to be figured up, the expenditure for administrating, purchase of cane or beets and accounting, and the sales of sugar and molasses or dried pulp etc. have to be found out. A special list of all the employees and labourers with their respective salaries has to be made up.

The only part that can be paid on long-term conditions is the delivery of the mechanical equipment cif a port of the respective country. The supplier also has to fix the necessary expenses for supervising the erection by his own people, the erection work proper, however, to be carried out by local contractors, the civil engineering, road construction, inland transport have to be paid after their completion. In addition to this it is necessary in most countries to pay the small farmers in advance for their subsequent deliveries of cane or beets, sometimes only for the fertilizer and the machinery. The first income of the factory can be received only after selling of sugar, pulps and molasses.

On the basis of the a.m. points it should be possible to elaborate a general feasibility study with cash flow, but this paper can only give a few hints as to work it out. The above statements also apply to working out the details for a tender.

An invitation to quote for the delivery of the machinery and equipment necessary for a sugar factory should contain a special chapter dealing with all the information given by the client, the conditions of the country, the duration of the campaigns, the kind of the project, the raw materials available, and the scope of delivery and services required.

A second chapter should refer to the terms of payment, the financial terms, the schedule for the execution of the work, beginning with the date when the offers have to be submitted, decision is made to starting up the factory. If a consulting engineer or engineering firm is engaged the responsibility of that firm has to be clearly stated.

The third chapter should cover all the financial conditions, terms of payment, etc. asked for, the responsibilities the client is ready to assume and those the supplier or contractor has to take.

In the fourth chapter the technical guarantees have to be stipulated, or the supplier should be asked for his technical guarantees and conditions. The technical warranties will be for 2 years or 2 campaigns of factory operation. The procedure to be applied to prove these guarantees as well as the supplier's experts to attend the test runs should be mentioned.

The next chapter should give a general idea of the machinery to be offered by the contractor, without binding him too much on specific processes that might be on licence of one special manufacturer.

The last chapter should give plans of the proposed factory site with roads, rivers and elevations. Meteriological data about rainfall, wind and temperature should be included, as well as analyses of fuel, lime stone, etc., and the proposed means of delivering these materials to the factory should be stated.

Some information about the transport systems for beet or cane sugar, pulp and molasses should be added.

The a.m. points of a tender should be applicable to any sugar project and may be fixed in a standard form; but this should be reserved to a special study, since its length does not allow to make it part of these guidelines.

VIII. Specification of materials and spare parts

Most of the machinery can be made in mild steel, but those parts being in permanent contact with juice of a very low pH and with basic and acid solutions should be made of alloy steel. Because of the corrosion problems the US sugar industry changed over from the standard mild-steel troughs of the DDS diffuser to alloy steel, and some factories in Europe are plating the baffles of the BW and BMA tower diffusers. This is required only if the pH value in the diffuser does not remain permanently at 5.8. The screens for raw juice in the cane diffuser, cush-cush+ separators, pulp catchers and those of centrifugals and the baskets of continuous centrifugals should always be made of alloyed material. Instead of alloy steel mild steel with an acid-resistant coat of special synthetic material or paint can be used for tanks. The piping for acid or basic solutions as gases should also be made of alloyed material or of cast iron, for instance for SO_2 gas. For pumps the following materials (Designation of material DIN 17 006) should be used; the materials being given for the casing, the impeller and the shaft in succession:

GG 25 / 4340 / 1191 open pumps

pumps for flume- and muddy water, fresh water, sludge and diluted mud, muddy juice of the carbonatation I and II, precoating, residues, milk of lime, unfiltered clairce.

channel-wheel pumps.

Mixtures of juice and cossettes, circulation juice, filtered clear juice of carbonatation I and II, filtered clairce.

+ or bagacillo

GG 25 / G Sn Bz 10 / 1191
raw and mixed juice.

GG 25 / 4027 / 1191 thick juice
GG 25 / GG 25 / 1191
clear thin juice, sulfitated thin juice, diluted B-product condensate, injection water.

GG 25 / GG 25 / 4021
drinking water, fresh water, sweetening-off water, cooling water for crystallizers, wash water for centrifugals, warm processing water.

4408 / 4408 / 1191
press water, acidified fresh water for diffusion.

GS - C 25 / GG 25 / 7218
feed water for boilers.

In every sugar factory the provided pumps should have stand-by pumps. If there are two media of the same kind to be pumped, e.g. muddy juice or clear juice of the first or second carbonatation, these pumps require only one stand-by pump. Not only the pumps should have their stand-by units, but also the filters, centrifugals, etc., beside the boilers and turbo-generators.

Spare parts for the factory, which must always be supplied, should comprise a sufficient quantity that might be necessary to replace the parts damaged by attrition or wear and tear within two years time. These parts cannot be fixed beforehand as the specification has to be made by the supplier when the final scope of supply is fixed and order placed with the subcontractors. The expenditure for these spare parts is usually determined by taking 3 % of the fob value of the total supply of machinery and equipment as a basis.

FLOW SHEET FOR A BEET SUGAR FACTORY

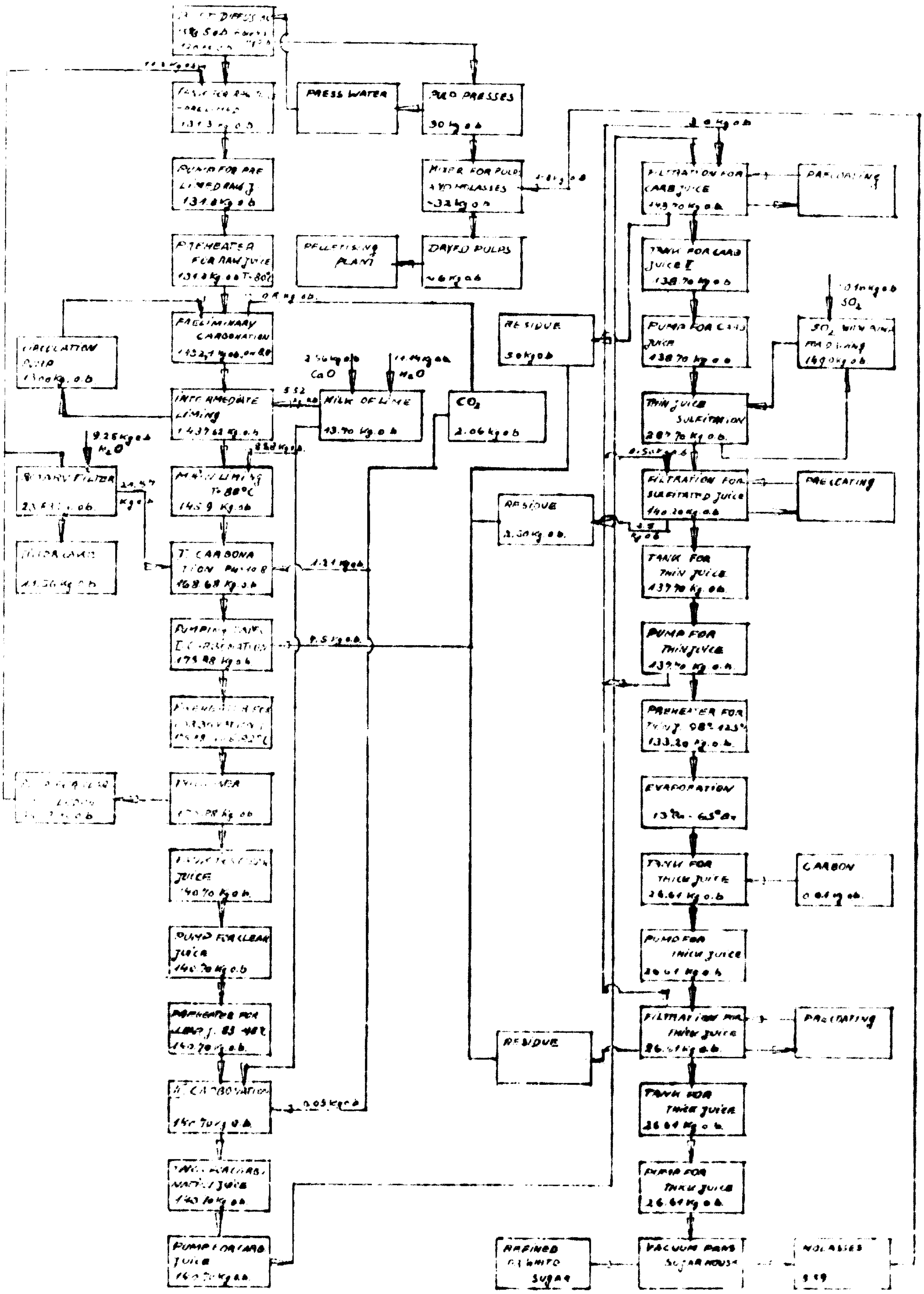
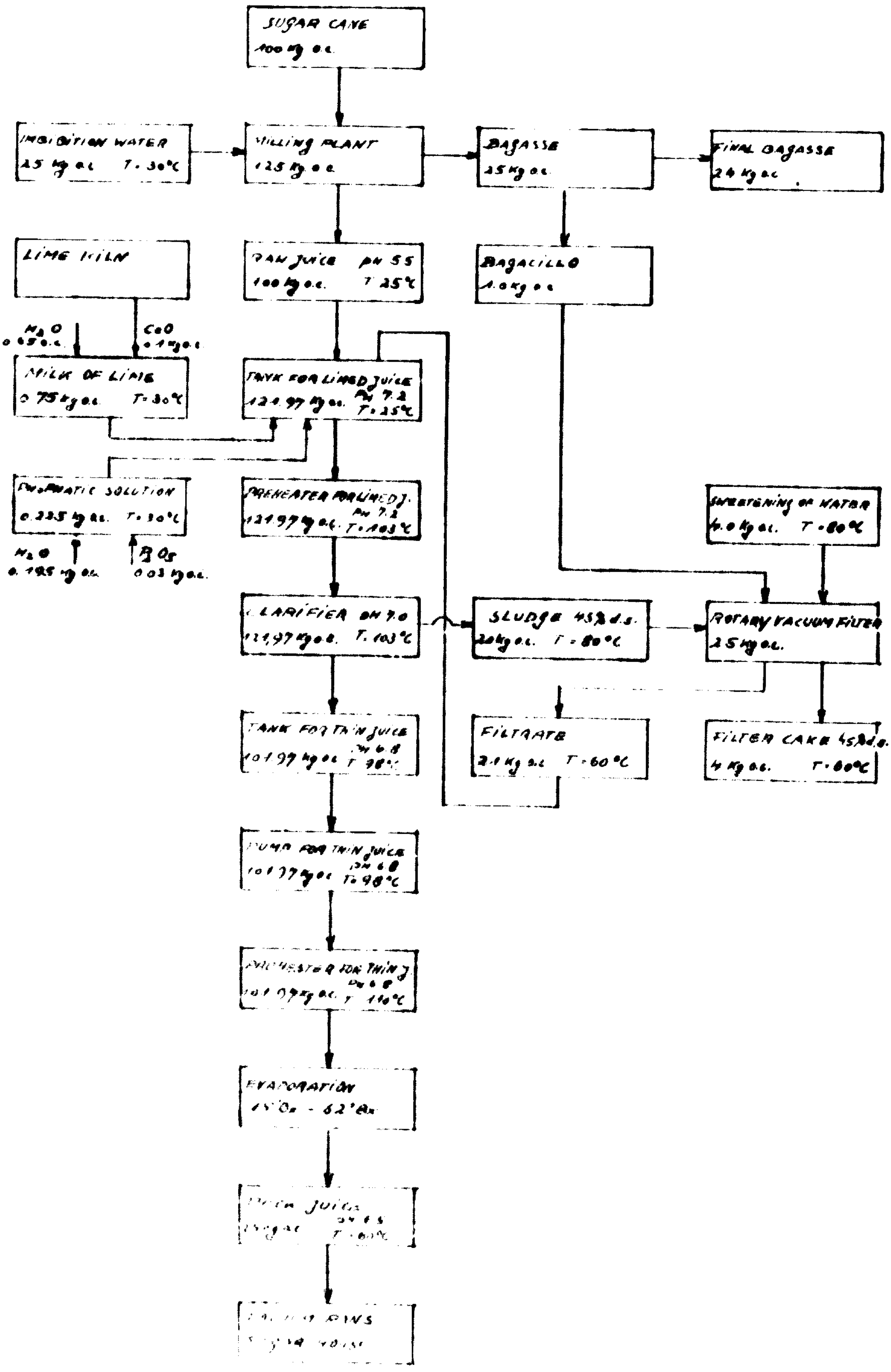


Figure II. 1

FLOW SHEET FOR MILLING AND DEFECATION PROCESS. [CANE]



FLOW SHEET FOR MILLING / DIFFUSION AND DEFECATION PROCESS (CASE I)

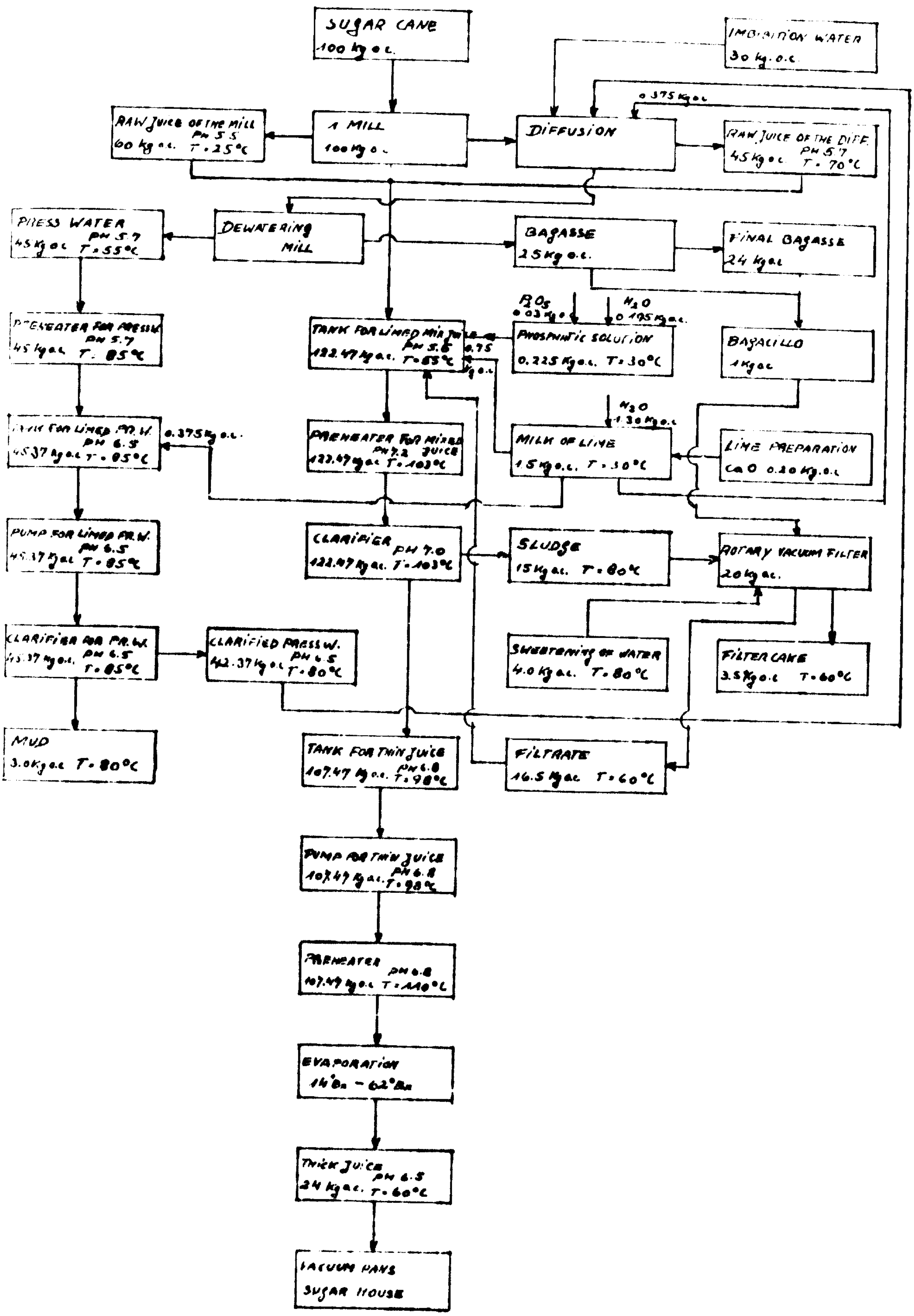
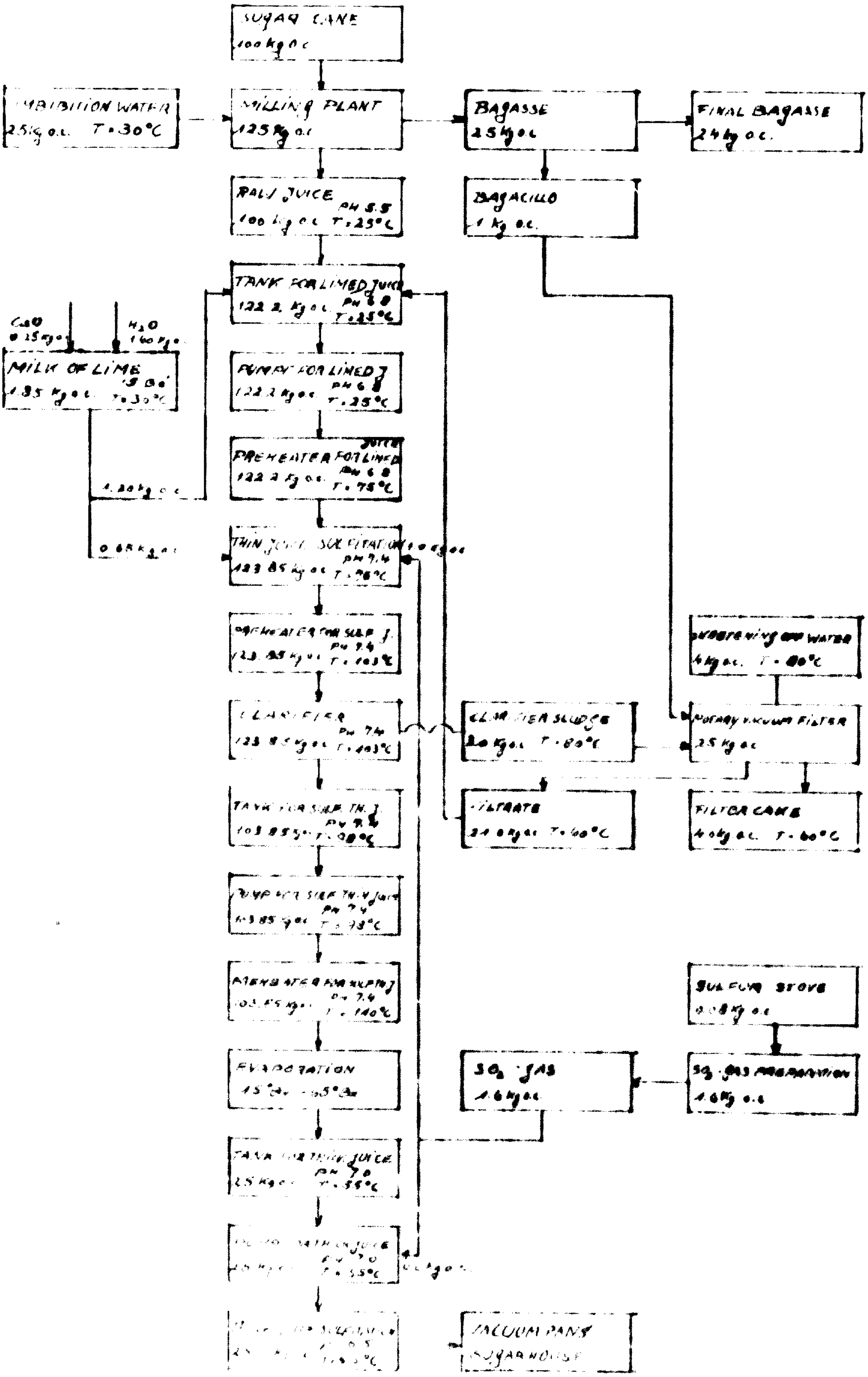


Figure II 3

FLOW SHEET FOR MILLING AND SULFITATION PROCESS (CANE)



FLOW SHEET FOR MILLING, DIFFUSION AND DOUBLE SUL[illegible]ON PROCESS (CANE)

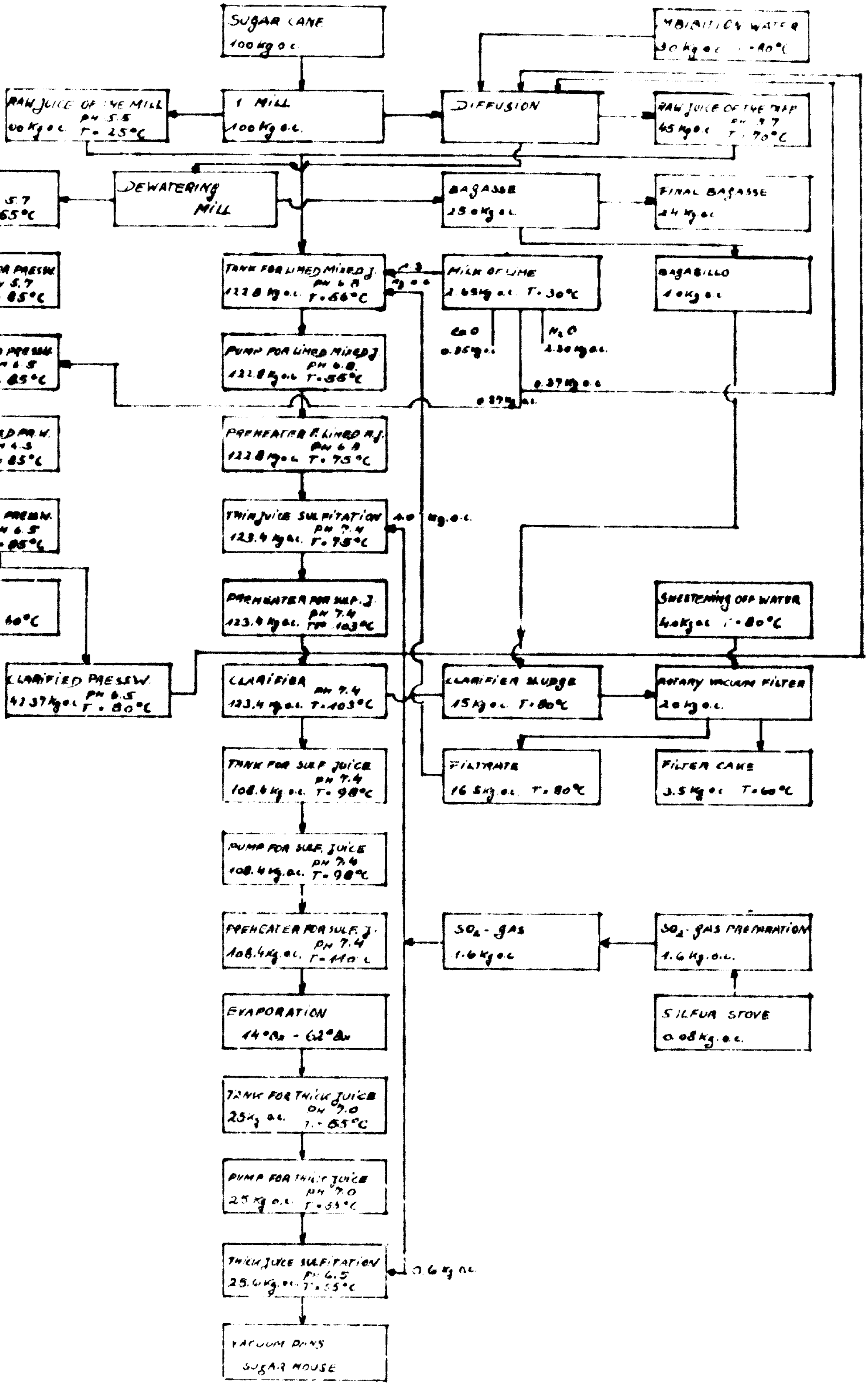


Figure 5

FLOW SHEET FOR MILLING AN DOUBLE CARBONATATION AND DOUBLE SULFITATION PROCESS

[CANE]

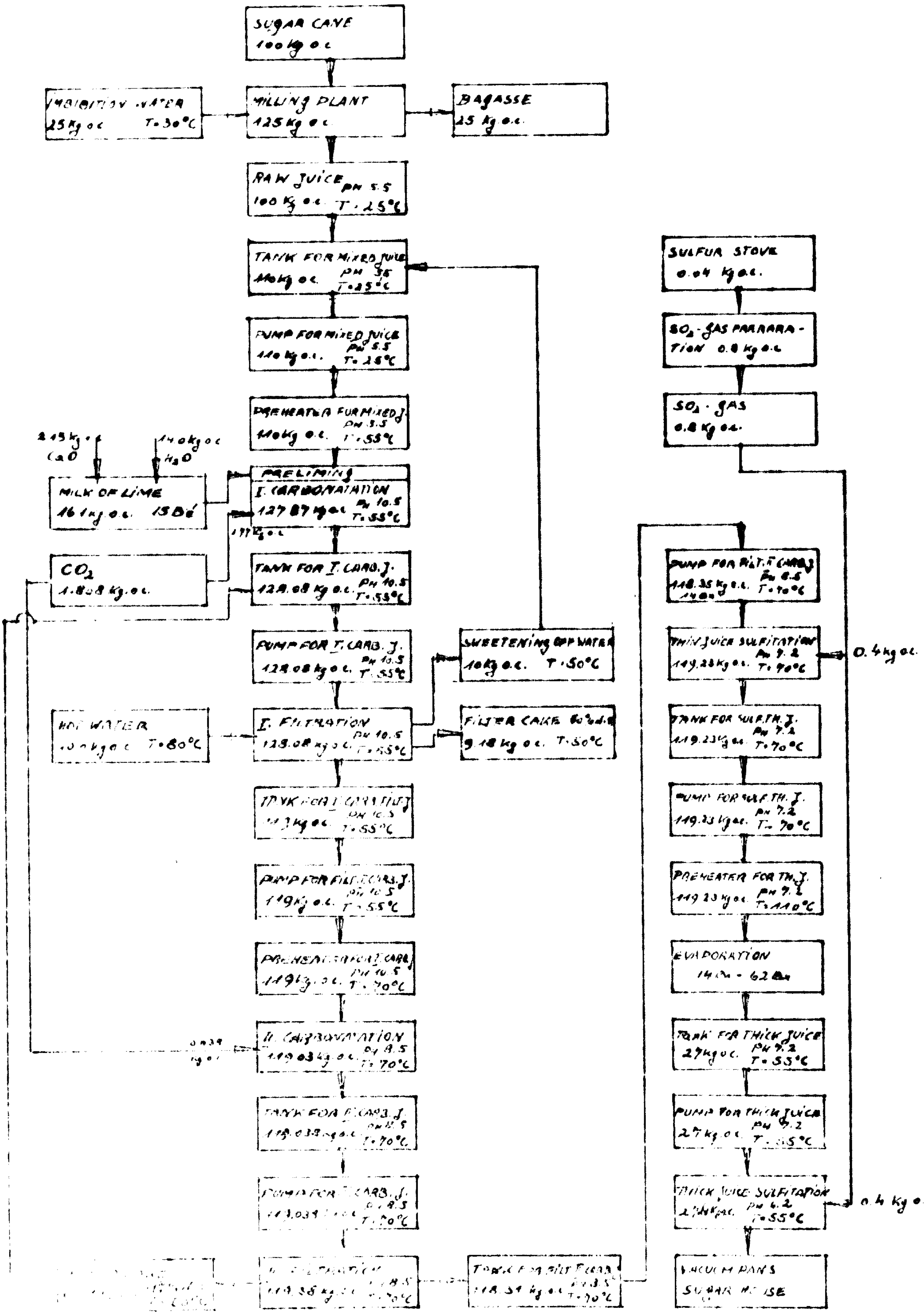


Figure 6

FLOW SHEET FOR MILLING/DIFFUSION AND DOUBLE CARBONATATION [illegible] PROCESS
[CANE]

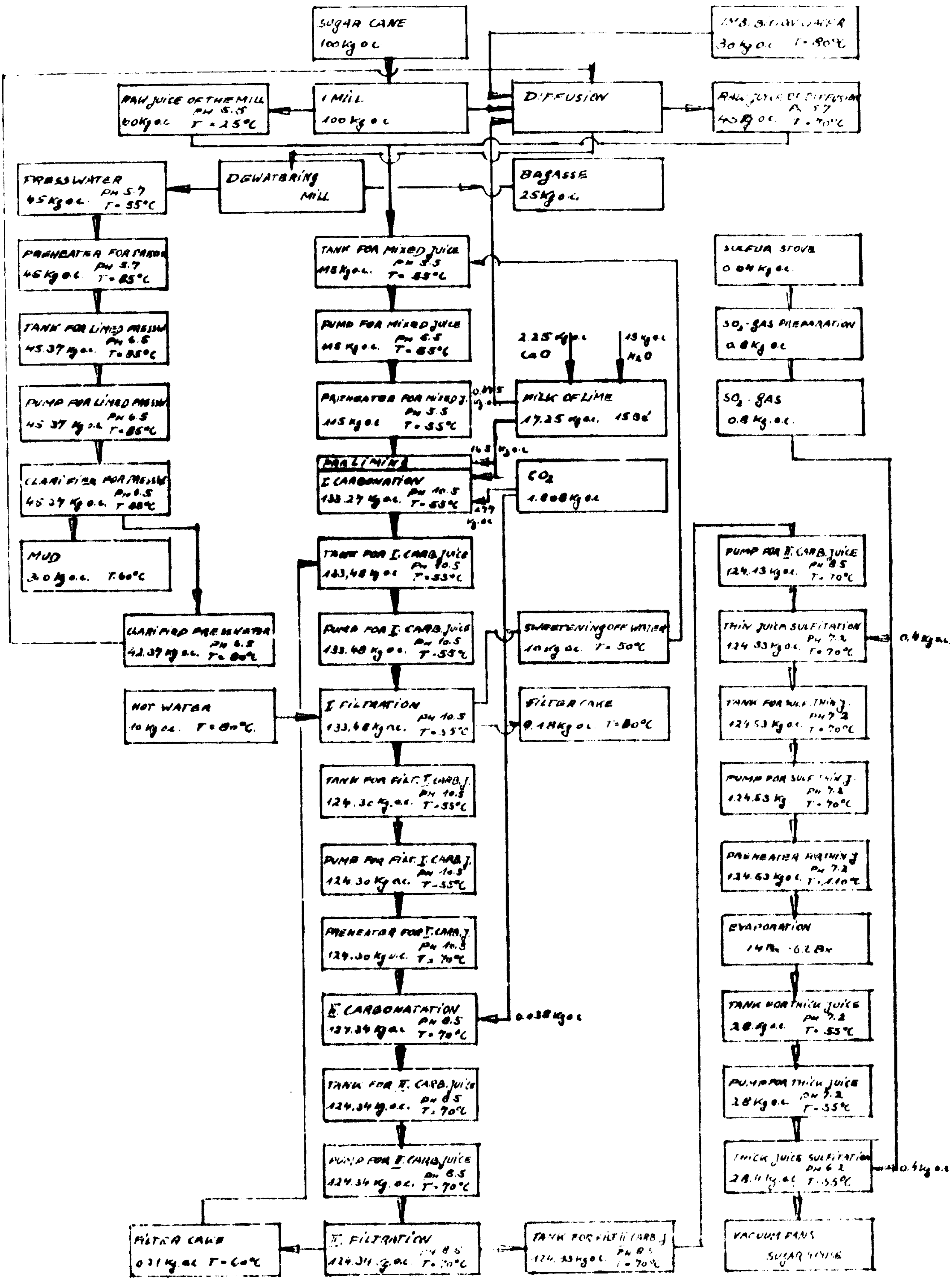


Figure III 1

BOILING SCHEME FOR PRODUCTION OF RAW SUGAR BY DEFECATION PROCESS [CANE]

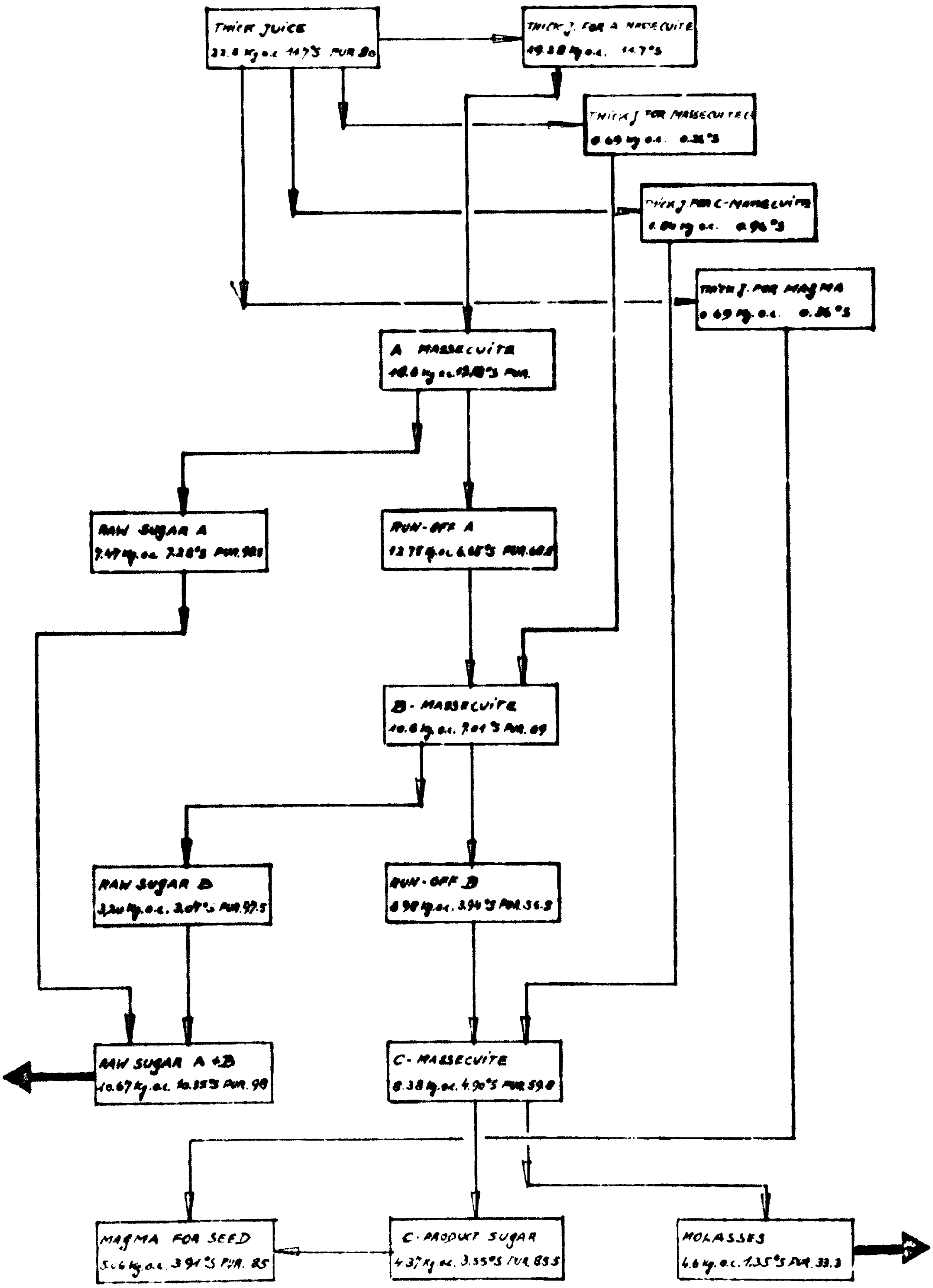
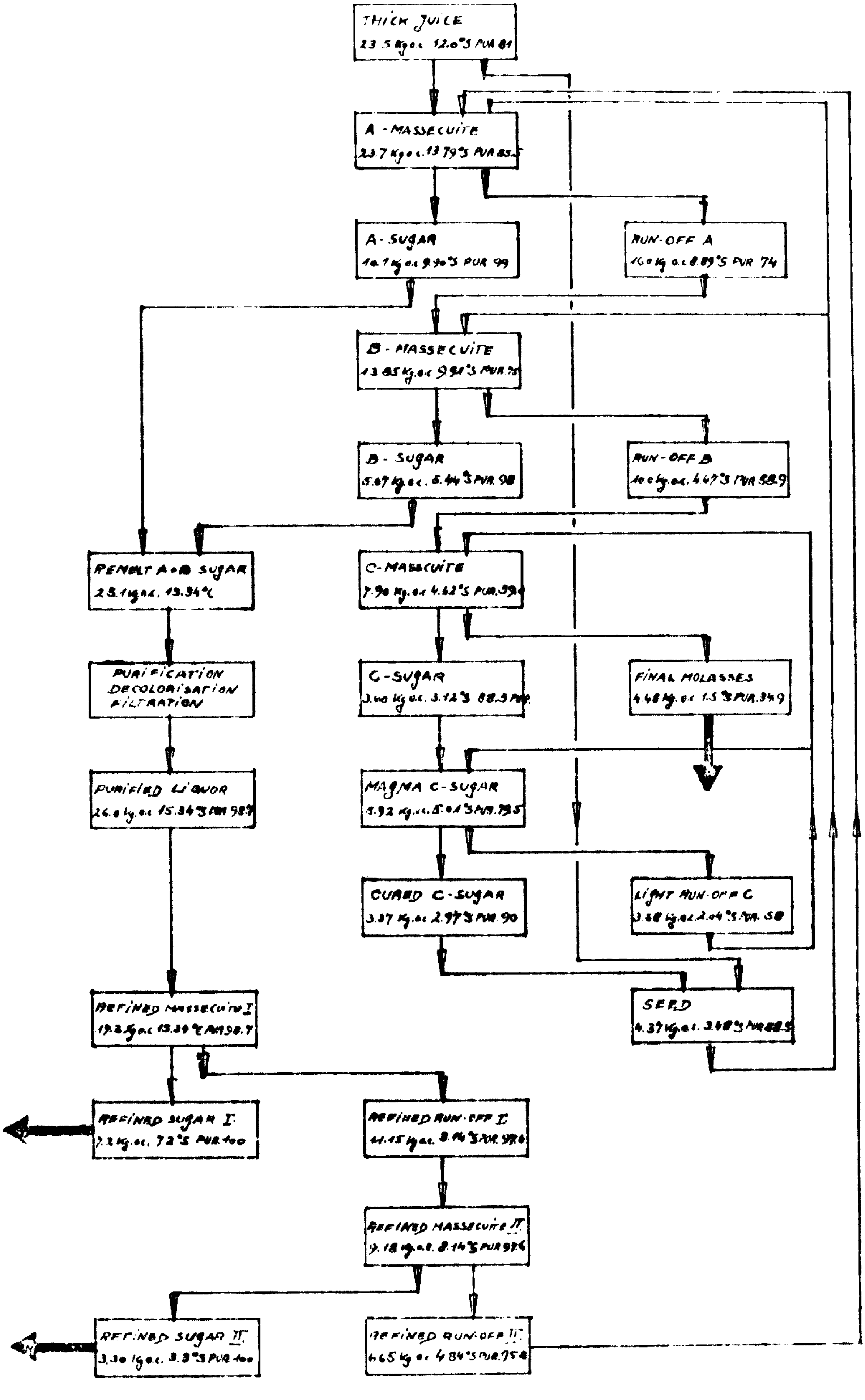


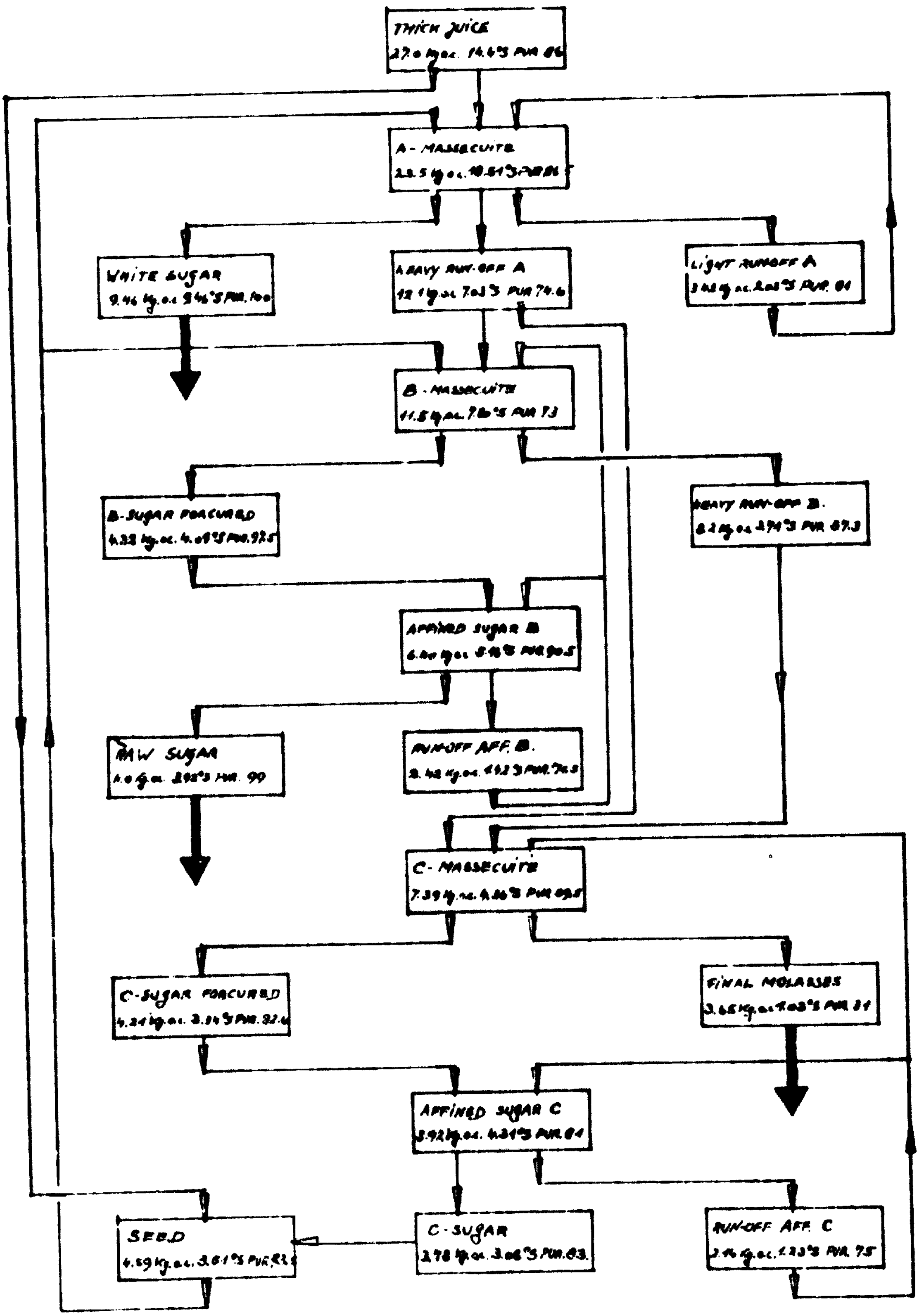
Figure III 2

BOILING SCHEME FOR PRODUCTION OF RAW SUGAR BY SULFITATION AND REFINING BY REMELTING PROCESS

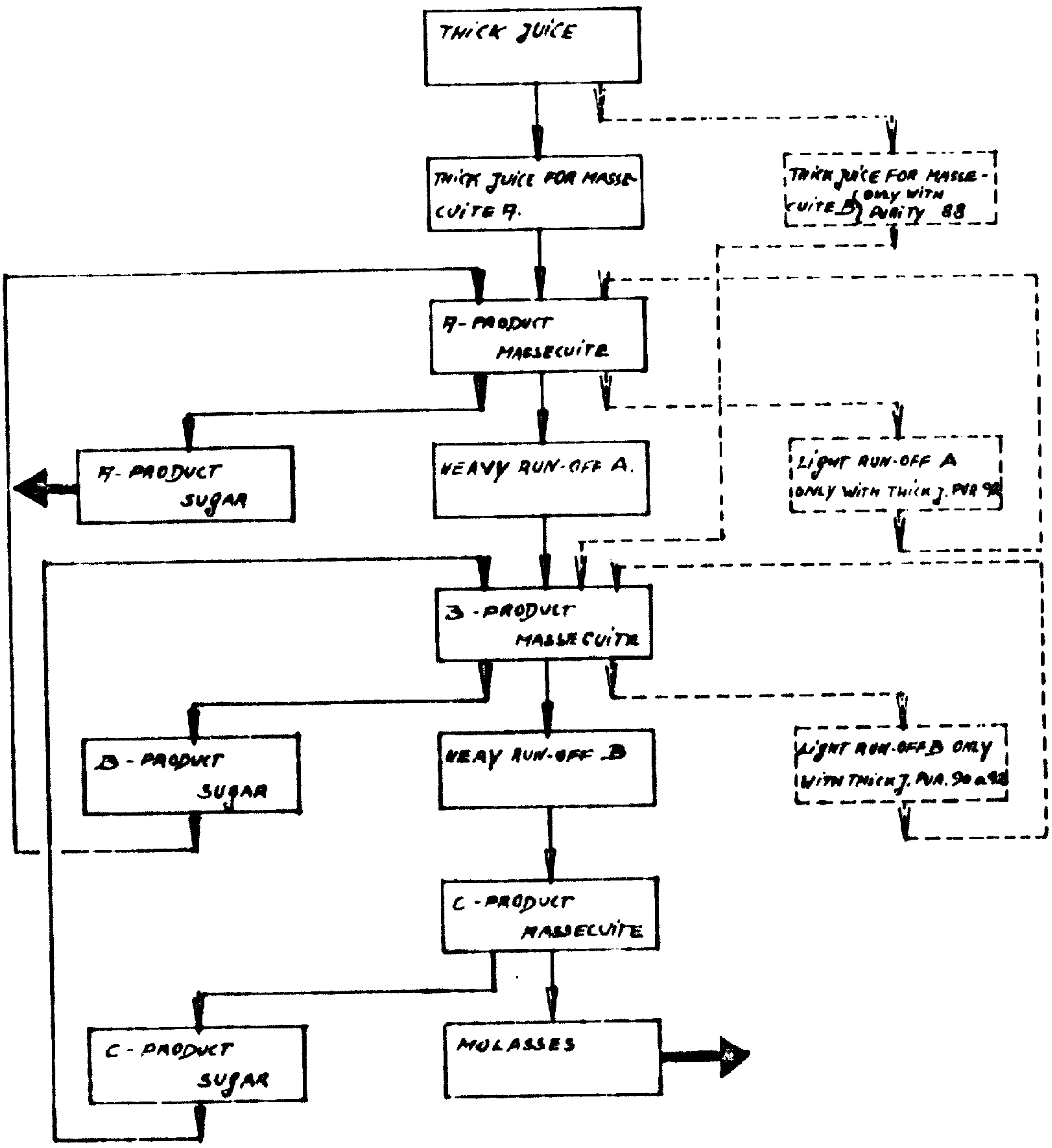
(CANE)



BOILING SCHEME FOR PRODUCTION OF RAW AN WHITE SUGAR BY CARBONATION PROCESS [CA..E]

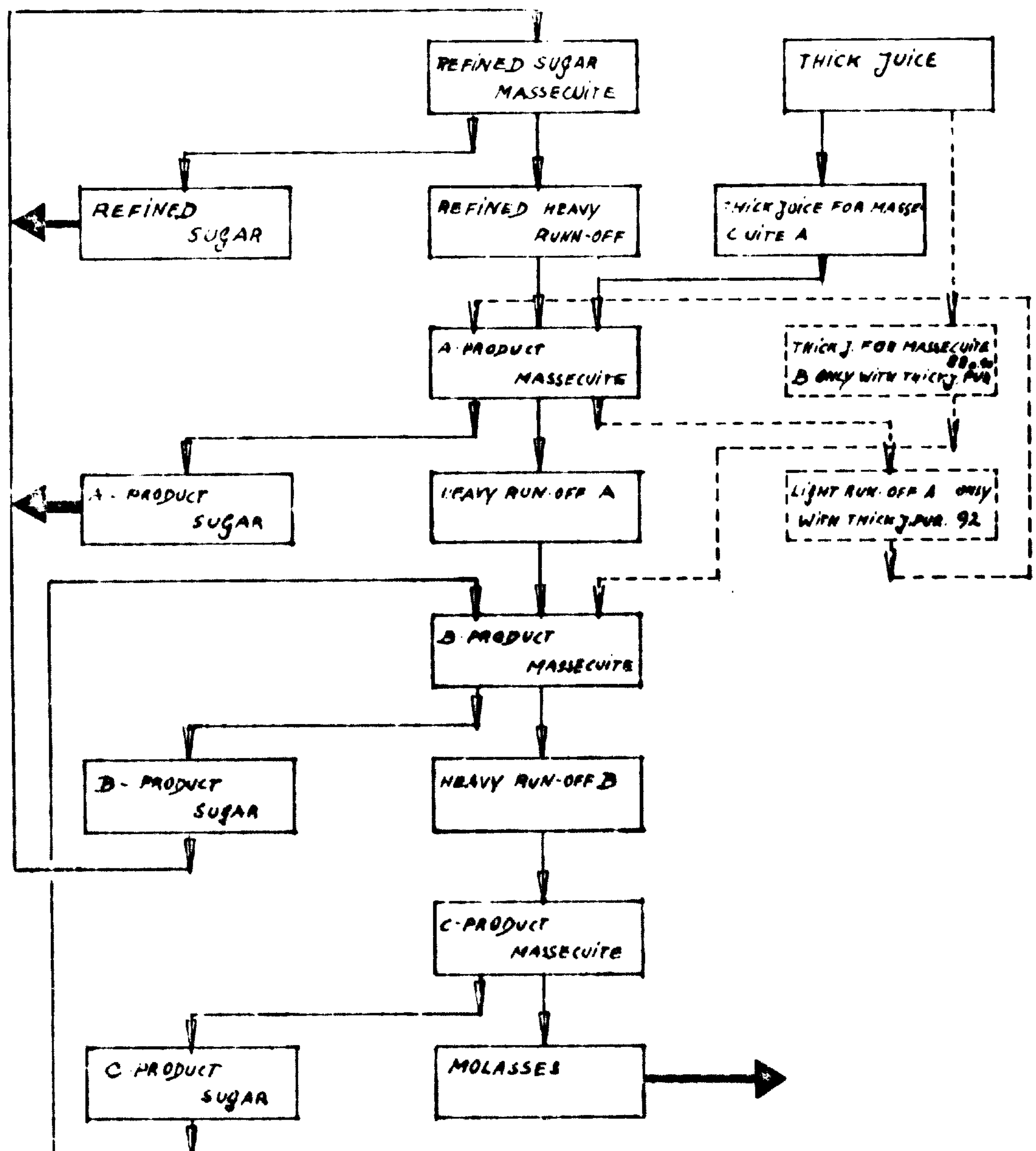


BOILING SCHEME FOR PRODUCTION OF WHITE SUGAR (BEET)



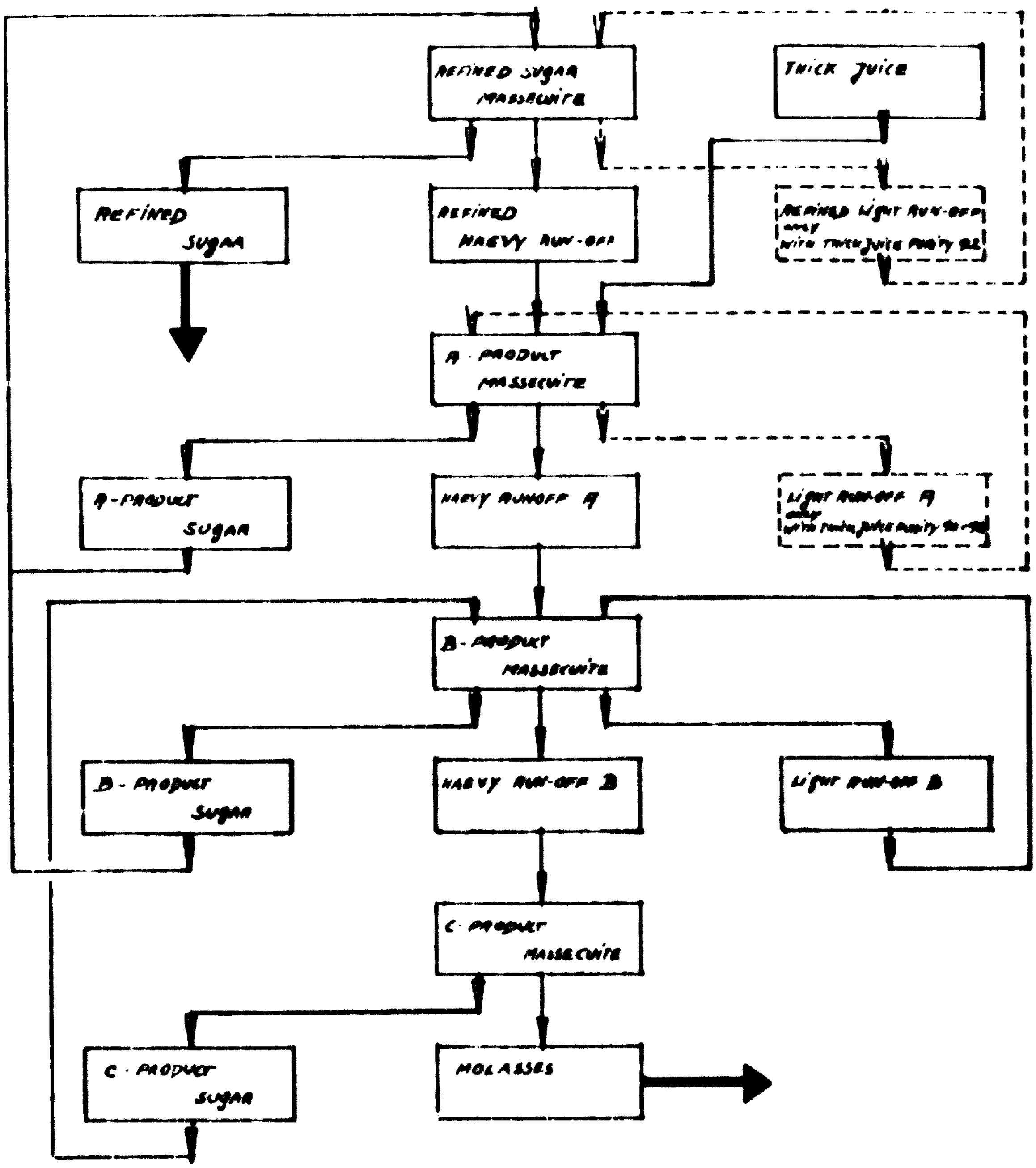
	Kg o.b	°S o.b	PUR.	Kg o.b	°S o.b.	PUR.	Kg o.b	°S o.b.	PUR.
THICK JUICE	26.52	14.0	88.0	30.30	16.0	88.0	34.06	18.0	88.0
WHITE SUGAR	11.14	11.14	100.0	12.73	12.73	100.0	14.32	14.32	100.0
MOLASSES	5.61	2.86	60.0	6.42	3.27	60.0	7.22	3.68	60.0
THICK JUICE	25.93	14.0	90.0	29.63	16.0	90.0	33.33	18.0	90.0
WHITE SUGAR	11.67	11.67	100.0	13.33	13.33	100.0	15.00	15.00	100.0
MOLASSES	4.58	2.33	60.0	5.23	2.67	60.0	5.88	3.00	60.0
THICK JUICE	25.37	14.0	92.0	28.96	16.0	92.0	32.62	18.0	92.0
WHITE SUGAR	12.17	12.17	100.0	13.91	13.91	100.0	15.65	15.65	100.0
MOLASSES	3.58	1.83	60.0	4.09	2.09	60.0	4.60	2.35	60.0

BOILING SCHEME FOR PRODUCTION OF REFINED AND WHITE SUGAR [BEET]



	Kg.o.b.	°S o.b.	PUR.	Kg.o.b.	°S o.b.	PUR.	Kg.o.b.	°S o.b.	PUR.
THICK JUICE	26.52	14.0	88.0	30.30	16.0	88.0	34.08	18.0	88.0
REFINED SUGAR	4.18	4.18	100.0	4.78	4.78	100.0	5.38	5.38	100.0
WHITE SUGAR	6.96	6.96	100.0	7.95	7.95	100.0	8.94	8.94	100.0
MOLASSES	5.64	2.86	60.0	6.42	3.27	60.0	7.22	3.68	60.0
THICK JUICE	25.93	14.0	90.0	29.63	16.0	90.0	33.33	18.0	90.0
REFINED SUGAR	3.40	3.40	100.0	3.89	3.89	100.0	4.38	4.38	100.0
WHITE SUGAR	8.26	8.26	100.0	9.44	9.44	100.0	10.62	10.62	100.0
MOLASSES	4.59	2.33	60.0	5.23	2.67	60.0	5.88	3.00	60.0
THICK JUICE	25.37	14.0	92.0	28.96	16.0	92.0	32.62	18.0	92.0
REFINED SUGAR	2.67	2.67	100.0	3.05	3.05	100.0	3.43	3.43	100.0
WHITE SUGAR	9.54	9.51	100.0	10.86	10.86	100.0	12.22	12.22	100.0
MOLASSES	3.58	1.83	60.0	4.09	2.09	60.0	4.60	2.35	60.0

BOILING SCHEME FOR PRODUCTION OF REFINED SUGAR [BEET]



	Kg o.b.	°S o.b.	PUR.	Kg o.b.	°S o.b.	PUR.	Kg o.b.	°S o.b.	PUR.
THICK JUICE	26.52	14.0	88.0	30.30	16.0	88.0	36.08	18.0	88.0
REFINED SUGAR	11.14	11.14	100.0	12.73	12.73	100.0	14.32	14.32	100.0
MOLASSES	5.61	2.86	60.0	6.42	3.27	60.0	7.22	3.68	60.0
THICK JUICE	25.93	14.0	90.0	29.63	16.0	90.0	33.33	18.0	90.0
REFINED SUGAR	11.67	11.67	100.0	13.33	13.33	100.0	15.00	15.00	100.0
MOLASSES	4.58	2.33	60.0	5.23	2.67	60.0	5.88	3.00	60.0
THICK JUICE	25.37	14.0	92.0	28.96	16.0	92.0	32.62	18.0	92.0
REFINED SUGAR	12.17	12.17	100.0	13.91	13.91	100.0	15.65	15.65	100.0
MOLASSES	3.58	1.83	60.0	4.09	2.09	60.0	4.60	2.35	60.0

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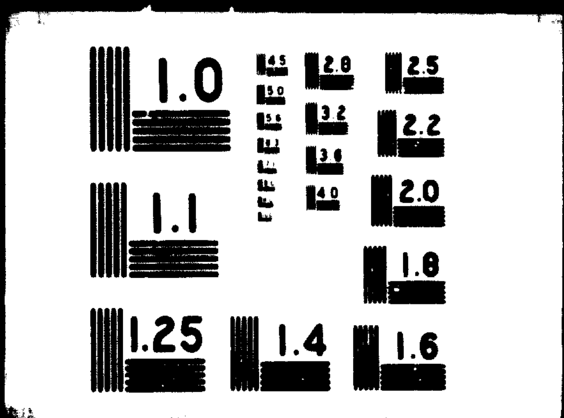
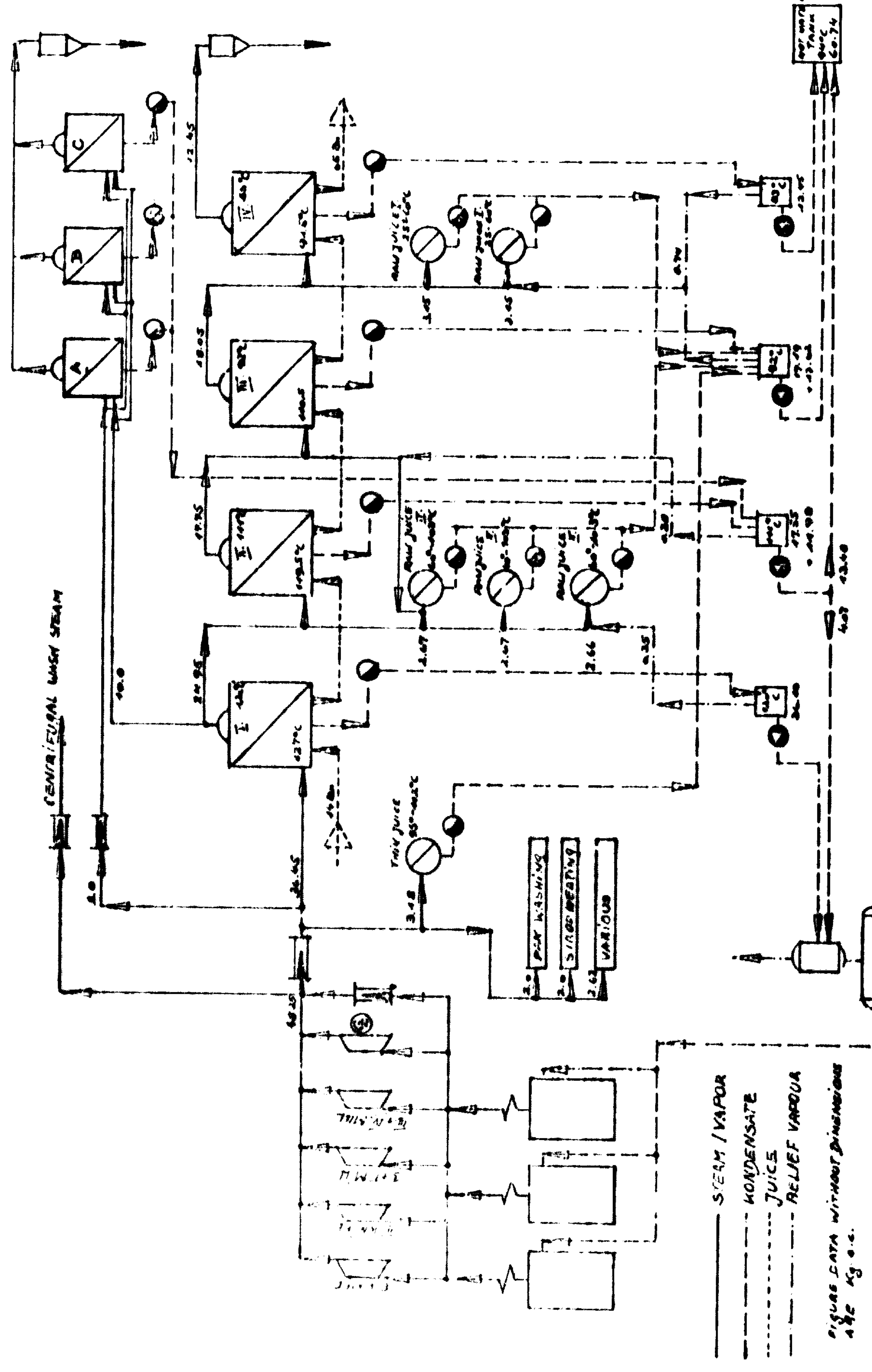
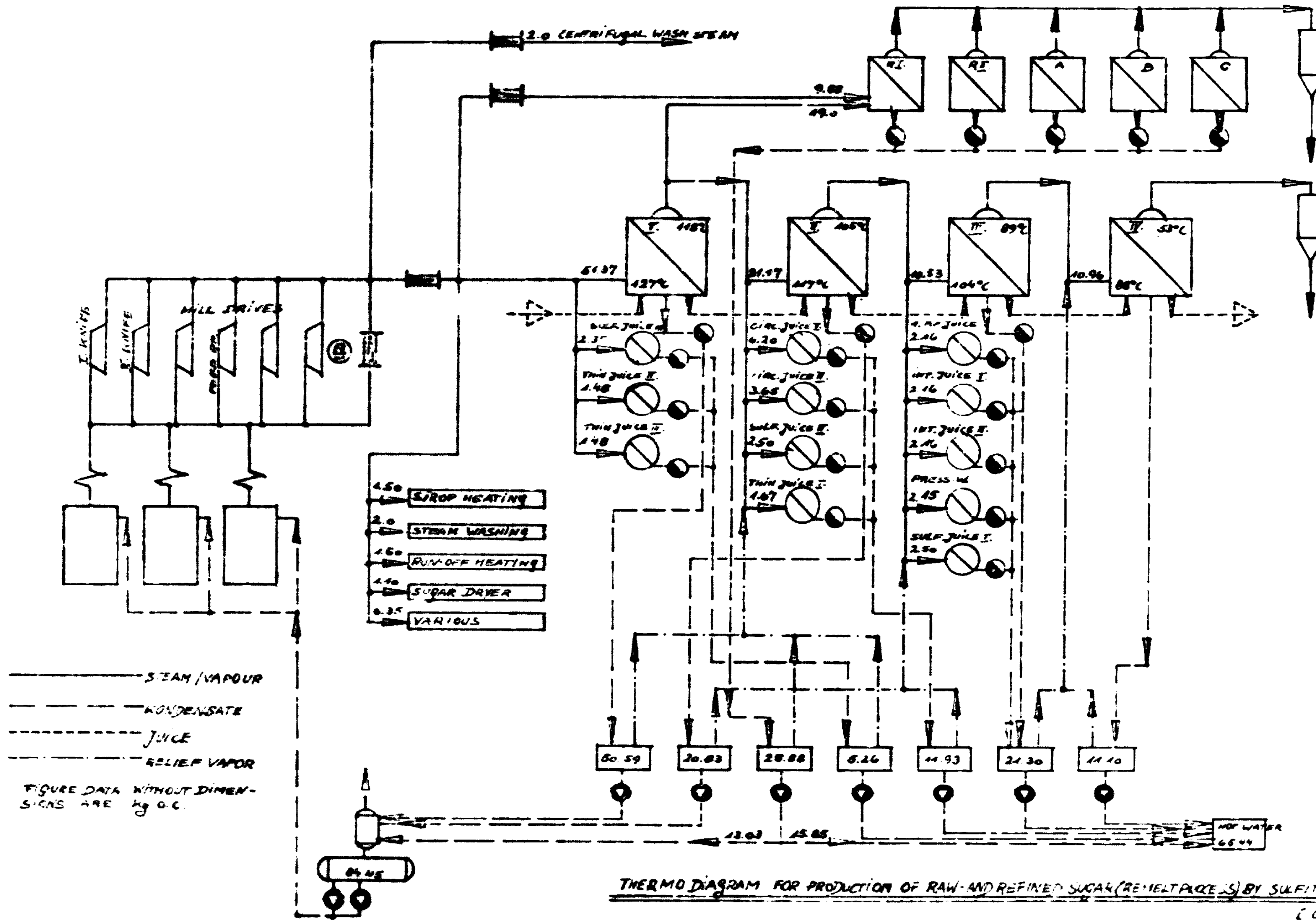


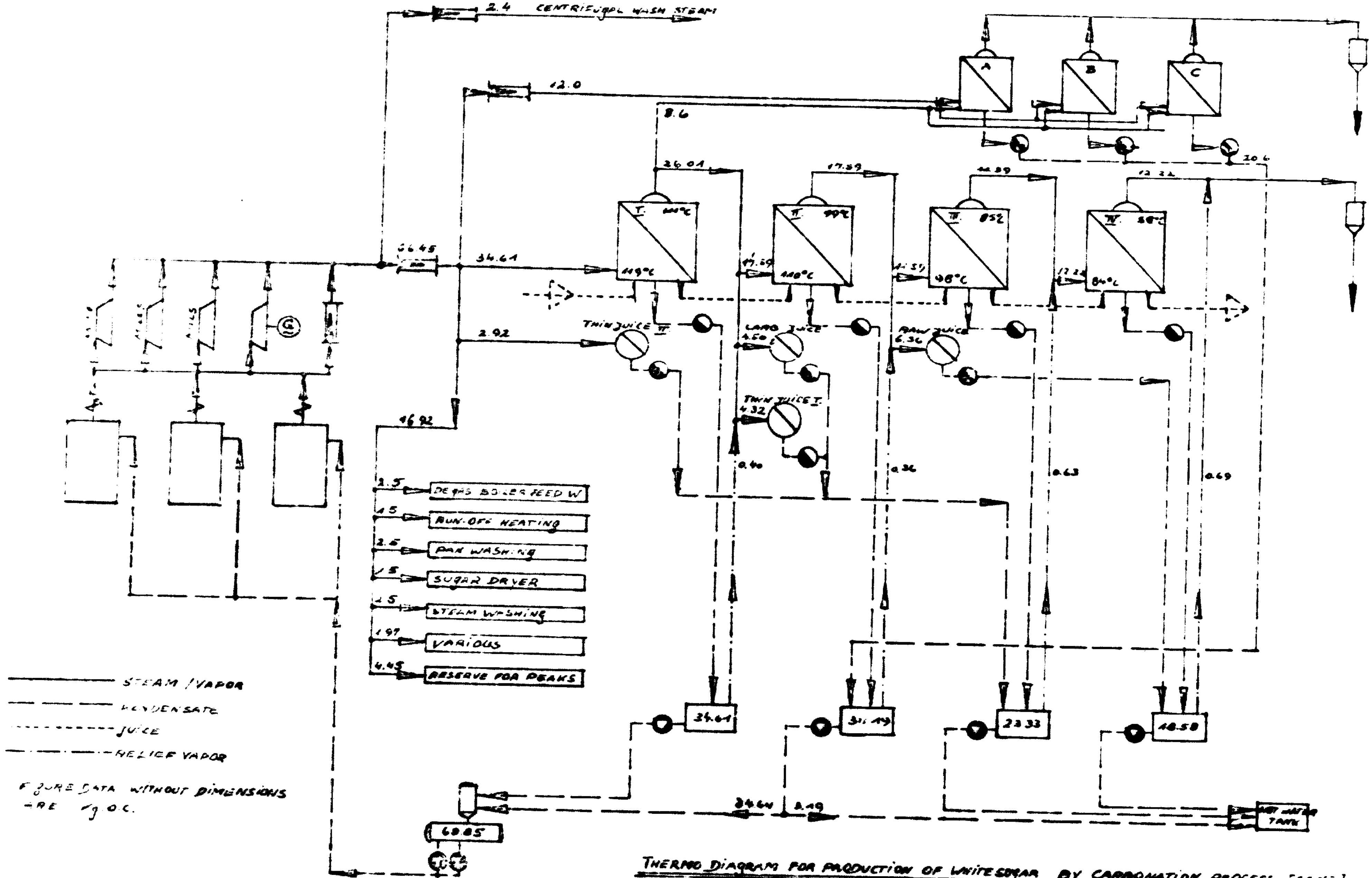
Figure V. 1.



THERMO DIAGRAM FOR PRODUCTION OF RAW SUGAR BY DEFECATION PROCESS
[CANE]



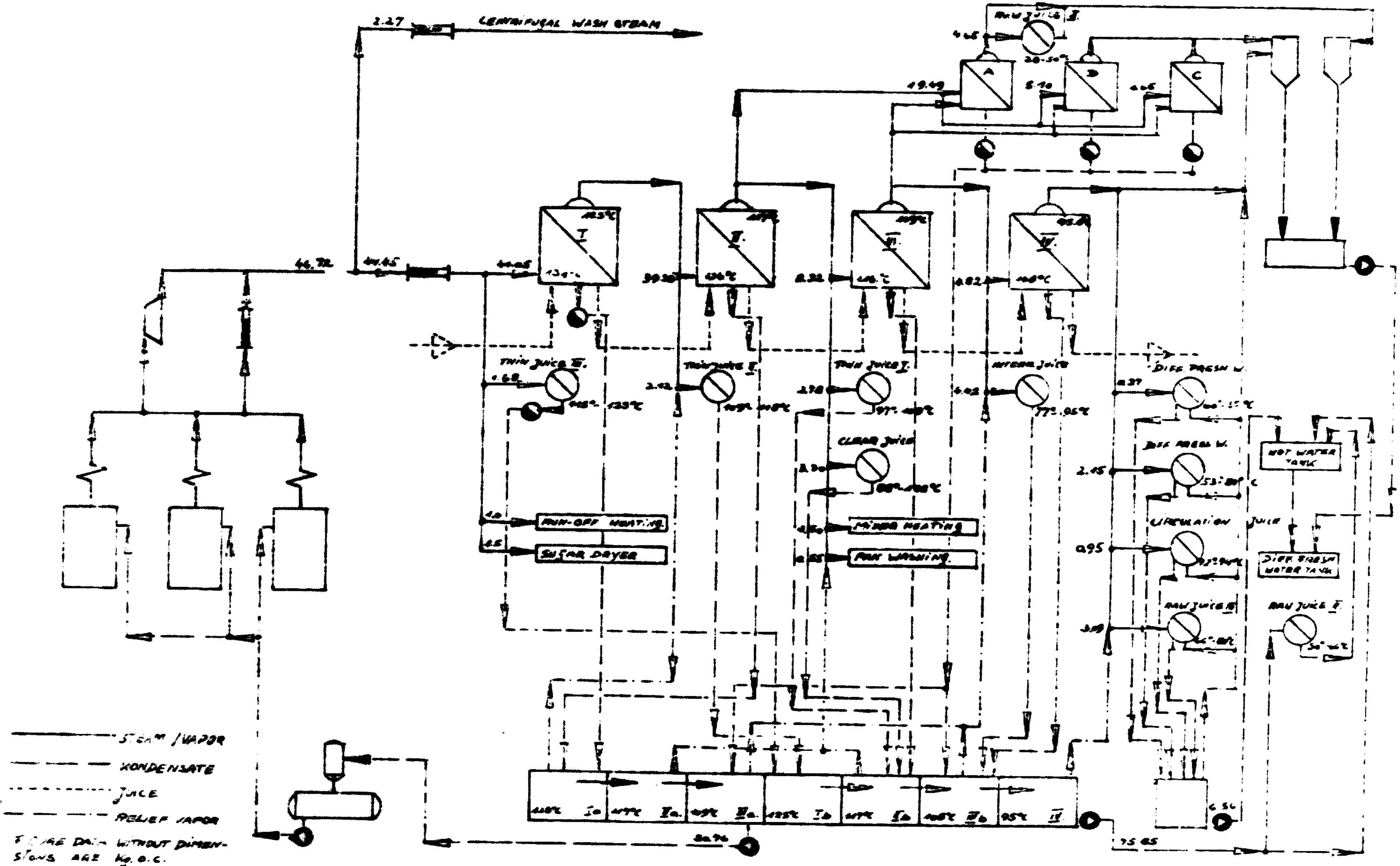
THERMO DIAGRAM FOR PRODUCTION OF RAW- AND REFINED SUGAR (REMELT PROCESS) BY SULFITATION PROCESS
(CANE)



THERMO DIAGRAM FOR PRODUCTION OF WHITE SUGAR BY CARBONATION PROCESS [CANE]

Figure V.3

Figure V.4



THERMO DIAGRAM FOR PRODUCTION OF WHITE SUGAR IN A BEET SUGAR FACTORY.

Table 1. **Comparision of the different purification processes in the cane sugar industry**

	diffusion preswater	defecation	sulfitation	carbonation	defecation/remelting
1. CaO-consumption kg.o.c.	o,o5	o,o6 - o,lo	o,18 - o,24	1,2 - 1,8	o,lo - o,2o
2. sulfur-consumption kg.o.c.			o,o8	o,o3	-
3. CO_2-consumption m^3/tc.				6o	15
4. purification system		liming clarifier rotary filter	liming sulfitation clarifier rotary filter	liming carbonation filterpresses sulfitation	liming clarifier rotary filter claircе carbon filter presses precoatingfilters
5. steam consumption kg.o.c.	milling plant	52	56	6o	7o
6.	mill/45 % diff.	63	67	71	8o
7. sugar quality		raw sugar pol. 97,2°S	plantation white sugar pol. 99,5 °S	white cristal sugar pol. 99,7 °S	raw sugar /refined sugar pol.97,2° S pol.99,9°S
8. pol. final bagasse	milling plant	2,6 °S	2,6°S	2,6°S	2,6 °S
9.	mill/45 % diff.	1,6 °S	1,6 °S	1,6°S	1,6 °S
1o. raw juice draft kg.o.c.	milling plant	1oo	1oo	1oo	1oo
11.	mill/45 % diff.	1o5	1o5	1o5	1o5
12. number of boilings corresponding purity of the raw juice		2 - 3	3	3	5 - 6
13. estimated investment costs of equipment		1oo %	112 %	122 %	135 %

Table 2. Materials necessary for cane sugar factories

	Defacation	Sulfication	Carbonati
1) Burnt, pulverized limestone (CaO)	o,1o kg.o.c.	o,25 kg.o.c.	2,3 kg.o
1 a) Limestone ($CaCO_3$)	-	-	4,6 kg.o
Coke	-	-	o,5 kg.o
2) Phosphoric acid (P_2O_5)	o,3o kg.o.c.	o,3o kg.o.c.	-
3) Sulphur (S)	-	o,o8 kg.o.c.	o,o4 kg.
4) Formaldehyd (HCHO) per 1oo days campaign	3oo 1	3oo 1	3oo 1
5) Floculation aid (Separan)	o.ooo1 - o.ooo5 kg.o.c.	o.ooo1 - o.ooo5 kg.o.c.	o.ooo1 - o.ooo5
6) Soda (NaOH) } 7) Hydrochloric acid (HCl) }	for cleaning by boiling out the evaporation station depending on size of evaporation andkind of incrustation.		

Quantities of other materials according to ley-out of supplier.

Table 3. Materials necessary for beet sugar factories.

				kg o.b.
1)	Chlorine gas (Cl_2)	for flume water after dekantation if recirculation is provided		o,oo8
2)	Sulphur	crystalline	Diffusion fresh water	o,oo8
			Sulfitation	o,oo8
	or	as SO_2-Gas	Diffusion fresh water	o,o16
			Sulfitation	o,o16
3)	Formaldehyde	for diffusion		o,o2 - o,o5
4)	Anti-foam agent			
		extraction (low quality)		o,ol
		purification (good quality)		o,oo5
5)	Diatomaceous earth	Dicalite	clear juice I. Carb.	o,oo6
		Speed plus	clear juice II.Carb.	o,oo3
		Hyflo-Super-Cel	muddy juice II.Carb.	o,oo3
			clairce	o,oo5
6)	Decolorizing carbon		clairce	o,oo5
7)	Soda	5 % solution		o,ol

Quanties of other materials . according to consumption told by supplier.

fuel for boilers depending of heating value of fuel,
steam consumption of factory,
efficiency of boilers.

oil and greases for first filling of turbo-generators,
gearings,
transformers.

for lubrication quality and quantity specification of maker.

Lime stone	size 12o - 18o mm according contents of $CaCO_3$	4 - 4,5
coke	caloric value 7.ooo kcal/kg size 4o - 6o mm.	o,4

Table 4.

QUESTIONNAIRE FOR CANE SUGAR FACTORIES

1) Cane

a) Is the cane culture new or has it been started longer before?

b) Is the cane irrigated artificially?

c) Yield of cane t/ha?

d) Is the cane burnt, shopped and delivered bundled or bulk?

e) Sugar content of the cane on the average?

f) Fibre content?

g) Purity of the juice?

h) Time of harvesting from .... till ....?

2) Transport of the cane

a) Is the cane harvested by hand or by machines?

b) Stucture of the soil (sand, loam, clay, many stones?)

c) Transport to the factory

.... % by cart

.... % by truck and trailer (tipper sideways or backwards?)

.... % by railway car

d) Dirt content on the average?

e) Unloading by hand or mechanically?

f) Storage on the yard?

g) Dimensions and weight of the carts, cars, trucks and trailers?

3) Climatic conditions

a) Rainfall during the time of harvesting? ....mm ......days
b) Temperatures during the time of harvesting max., normal?
c) Direction of the wind and wind velocity?
d) Danger of earth-quake? .... strength?
e) Danger of inundation?
f) Ground water level?
g) Ground pressure?
h) Highest air temperature during campaign?
i) Highest water temperature during campaign?

4) Water conditions

a) Is water available in a sufficient quantity or is it rare?
b) Water from a river or from a well?
c) Degree of hardness, cleanness, analysis?
d) May the sewage be drained unclarified, is it to be clarified or is it to be taken back into the circulation?
e) Distance of the water from the factory (meter)?
f) Height of the factory above sea-level?
g) Difference of heights between factory and taking of water?
h) Has a cooling pond/cooling tower to be provided?

5) Products

a) Is raw sugar to be produced?
b) Is white sugar to be produced?
c) Is refined sugar to be produced? Quantity %
d) Is cube or loaf sugar to be produced? Quantity %

e) Is a special purification process required, defecation, sulfitation or carbonation?

f) Has the surplus bagasse to be pressed?

g) Is the sugar being stored bulk in silos?

h) Is the sugar sacked in jute bags or in paper bags?

i) For how many days production is the sugar warehouse storage to be layed out?

k) Mechanical transport to and in the warehouse?

l) For how many days production are the tanks to molasses to be layed out?

6) Factory equipment

a) How many tons of cane have to be processed per day?

b) Is a later enlargement planned?

c) Is a very modern plant to be constructed (with high wages) or is hand work cheap?

d) Is sufficient good burnt lime, sulphur or lime stone and coke available, analysis?

e) Is it possible to heat for starting up with wood, coal, brown coal, earth-gas or oil? Calorific value, humidity, size of pieces?

f) Is foreign current at hand (voltage, frequency) or is own power to be produced also during the dead season?

g) In which way is the heating material transported to the factory?

h) Is the molasses to be stored in tanks?

i) Is the defecation scum to be removed mechanically or pumped away?

k) Are spare parts to be provided for a normal or for a longer period?

l) Are simple apparatures to be manufactured by supplier's instructions in the country of errection?

m) Are the buildings to be built in steel scaffold construction (faster setup) or solid built with bricks or made of concrete?

n) Shall the steel construction for the buildings and for the platforms and ceilings be provided?

o) Are there special regulations for the construction of boiler-plants and pipelines in the country of errection?

p) Is a one-floor or a several-floor factory to be errected?

7) General

a) Are sufficient trained operators for the factory available in the country of errection?

b) Which starting-time is planned?

c) Traffic connection tc the next big town or port?

d) Language to be used for execution of project?

QUESTIONNAIRE FOR BEET SUGAR FACTORIES

1) Beet

a) Is the beet culture new or has it been started longer before?

b) Are the beets irrigated artificially?

c) Yield of beets t/ha?

d) Size or weight of beets on the average?

e) Sugar content of beets on the average?

f) Marc content?

g) Purity of the juice?

h) Time of harvesting from .... till ....?

2) Transport of beets

a) Are the beets harvested by hand or by machines?

b) Stucture of the soil (sand, loam, clay, many stones?)

c) Transport to the factory

.... % by cart

.... % by truck and trailer (tipper sideways or backwards?)

.... % by railway car

d) Dirt content on the average?

e) Unloading by hand or mechanically, wet or dry?

f) Storage on the floor or in silos?

g) Dimensions and weight of the carts, cars, trucks and trailers?

3) Climatic conditions

a) Rainfall during the time of harvesting? ....mm ......days

b) Temperatures during the time of harvesting max., normal?

c) Direction of the wind and wind velocity?

d) Danger of earth-quake? .... strength?

e) Danger of inundation?

f) Ground water level?

g) Ground pressure?

h) Highest air temperature during campaign?

i) Highest water temperature during campaign?

4) Water conditions

a) Is water available in a sufficient quantity or is it rare?

b) Water from a river or from a well?

c) Degree of hardness, cleanness, analysis?

d) May the sewage be drained unclarified, is it to be clarified or is it to be taken back into the circulation?

e) Distance of the water from the factory (meter)?

f) Height of the factory above sea-level?

g) Difference of heights between factory and taking of water?

h) Has a cooling pond/cooling tower to be provided?

5) Products

a) Is raw sugar to be produced?

b) Is white sugar to be produced?

c) Is refined sugar to be produced? Quantity %

d) Is cube or loaf sugar to be produced? Quantity %

e) Is dried beet pulp (eventuel molassed) to be produced or only pressed pulp?

f) Are dired beet leaves to be gained for animal food?

g) Is the sugar being stored bulk in silos?

h) Is the sugar sacked in jute bags or in paper bags?

i) For how many days production is the sugar warehouse storage to be layed out?

k) Mechanical transport to and in the warehouse?

l) How much dried pulp is to be stored?

1) bulk;

2) sacked;

3) pressed in pellets?

6) <u>Factory equipment</u>

a) How many tons of beets have to be processed per day?

b) Is a later enlargement planned?

c) Is a very modern plant to be constructed (with high wages) or is hand work cheap?

d) Is sufficient good lime stone and coke available, analysis?

e) Is it possible to heat with coal, brown coal, earth-gas or oil? Calorifc value, humidity, size of pieces?

f) Is foreign current at hand (voltage, frequency) or is own power to be produced also during the dead season?

g) In which way is the heating material transported to the factory?

h) Is the molasses to be stored in tanks?

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