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DESIGN OF TECHNICAL PETROPROTEIN PLANTS IN DEVELOPING COUNTRIES1/

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We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

The present development of the world food market is determined by a rapidly increasing population and greater demand for meat products due to wealth in the rich countries which was led to protein shortage all over the world. On the other hand there are principally sufficient reserves and raw materials on the earth to beat these frightening tendencies.

Experts therefore suggest an enlargement of arable land, higher yields of crop by artificial fertilisers, improved and man-regulated water cycles, cattle and plant selection with higher and faster food production and accelleration of growth by use of growth hormones.

An entirely different path is followed with carbon containing inorganic raw materials for industrial production of single cell protein. Its contribution, quantitatively just a small percentage of food stuffs produced, nevertheless offers an important product of high quality to be added to mass feeding and thus improve its nutritive value.

Furthermore the industrial way of production of SCP in compact plants independent of seasonal and climatic changes with negligible ground demand may prove advantageous compared with conventional food production.

An elegant method of SCP-Production under certain circumstances makes use of hydrocarbons as carbon source. Hydrocarbons can be produced in large quantity and high purity as by-product from gas oil refinery.

In recent years only industrialized countries displayed an intensive activity on this field, not only as development of processes was concerned, but also the choice of production site. Thus petroprotein plants under construction at present are all situated in countries with no serious food problems. This means another set back for developing countries.

One can find much detailed scientific literature on the various aspects of petroprotein, and many of them state identical facts, as far as technology of production and nutritive questions are concerned, despite the fact that so far there exists no real optimation of microorganisms, utilisation of new technology including computer control and a full value product with low nucleic acid content, toxicological safety and a balanced content of essential amino acids, which alltogether would lead to a commercially profitable food additive. Here therefore it is not intended to add another such article but rather to talk about questions and considerations that especially arise with design of petroprotein plants in developing countries.

Three years ago a comprehensive research programme to develop systematcally technical processes for unconventional protein production including microorganism screening, selection, mutation, tests of product quality by analyses and animal feeding, market analyses and processing of raw product, has been set up in the Federal Republic of Germany by the government and a consortium of industrial firms. This period of time appears relatively short compared with the pioneer works of others, on the other hand one was able to start from somewhere with great experiences on the fermentation and microorganism part as well as large scale technical engineering and petrochemistry.

The original euphory about a new and promising solution to fight starvation has at present given way to a cautious optimism.

A developing country interested in SCP-production therefore has to consider carefully if there really exists an actual need in the country for this special food additive. SCP may be employed as valuable animal feed supplement, improving protein and vitamin content of the diet, as substitute of human food in times of crisis and, after refinement even as component of flour, soups, meat extract or beverage concentrate.

It must be clearly pointed out, however, that as for ruminant nutrition SCP turns out to be much to expensive compared with urea as nitrogen source, which leaves us with swine and poultry food component. It is economical to produce SCP on large scale only of these animals are kept in large centralised farms to enable a cheap distribution and mixing with other food components.

Even a country without important farming facilities may profitably produce SCP, as long as there is substrate available and the product can be sold on an export market.

To be furthermore considered there may be prejudices of the population against so called artificial foodstuffs in general and products from mineral oil and microorganisms in special, in this context one thinks of recent developments in Japan.

Finally it should be pointed out that political arguments such as independence of imports or utilisation of waste materials may determine a decision to have a petroprotein plant, even if such a plant cannot produce at an economic level, as long as the raws are in the country.

Supposing some country has made up its mind out of one reason mentioned or another to erect a petroprotein plant, various processes of production with various types of raw materials and strands of microorganisms, are offered, thus the choice of process depends on the specific circumstances of a country with its socioeconomic structure, sources of substrate, stage of industrialisation and education and its geographic conditions and transport systems.

The capacity of a production plant is determined by the demand within the country, export possibilities, by an existing transport- ans distribution network, structure of consumers, substrate availability, capital and considerations of economy.

Production costs cannot be calculated on a global scale but must be adjusted to the special conditions in the developing country.

So far the research group mentioned above has evaluated two basically different models of SCP-Production industry.

On one hand a plant produces more cheaply with growing size. For central Europe capacities necessary for a cost covering run average between 50 000 to/a and 100 000 to/a output SCP. This figure is proved correct bv the size of plants now under construction in Italy, Rumania and Russia, which all range above 100 000 to/a.

Such a plant implies production of 100 000 to 150 000 to/a substrate with it and a demand for animal feed or export of 2000 000 to/a, taking a composition of 5 % SCP per feed. Production cost in Central Europe at the moment may range at 450 US $ per to. See slide

These plants run continuously and more or less fully automatised. Personal necessary for maintenance and control must be qualified. Therefore a large scale petroprotein plant does not create a considerable amount of places of work.

Production failure due to inadequate control and lack of detailed practical experience of personel may cause considerable expenses.

Out of considerations of capacity, economy and distribution results the choice of production site. A large-scale petroprotein plant should be situated adjacent to a refinery or some respective production plant for the fermentation substrate, which saves transportation and storage capacities and can make use of the distribution network for the petrol products.

Furthermore quality of air and climatic influences as well as the considerable cooling demands are to be taken into consideration. In this context microorganism strands generally are recommended which are able to grow at higher temperatures in order to reduce the cooling energy. In case of n-alkanes, however, a calculation and experiments show that loss of substrate with exhaust air and reduced oxygen solubility in the fermentation broth cause higher expenses, which would favour fermentation temperatures of 25°C.

The points mentioned above postulate a construction site by the sea, particularly since corrosion problems in heat exchangers have been technically overcome, by a riverside or in the vicinity of a cheap energy reservoir. Alltogether regions with moderate climate are favourable due to lower cooling cost, easier maintenance of sterility and better storage of end product.

Only mentioned in brief be necessary characteristics of the type of microorganism of choice. Yeasts in particular, generally employed in hydrocarbon fermentation so far have not been optimated as yet as for a higher temperature flexibility, with lower nucleic acid content and a balanced percentage of essential amino acids. It may be mentioned that the research team introduced in the beginning hase succeeded in improving these properties significantly.

Beside a study of large-scale industrial plants investigations with particular respect to developing countries have been part of the research programme to construct relativly small plants, semicontinuously run in a simplified process, easy to control, with a higher personal demand and broader flexibility of substrate employed.

This process is shortly described with an example of a 200 to/a plant: - slide -
After inocculation of the central 100 m^3-fermentor with precultured microorganism the fermentation is carried out batch-wise up to a concentration of 2 % biomass, then the major portion of fermentation broth is concentrated in a one step centrifugal procedure without washing and extraction. The smaller portion remains in the fermentor and the process rebegins. The biomass is further concentrated by evaporation. There is no drying, the biomass is tanked as a paste with 50 % water content and must be consumed quickly.

The idea of these small plant units is to establish a decentralised production capacity situated in each case close to the consumer, so that the expensive drying stage can be ommitted, because in the final food mixture the SCP has to be in wet form. Technical failures of one plant of many does not affect the total output as much as would it be the case with a large scale plant, the product becomes cheaper due to a simpler process and no need for a distribution network. The raw materials can be delivered in combination with petrol distribution via petrol service stations.

As far as fermentation technology is concerned scientists and engineers propagatevarious types of fermentors optimal with oxygen transfer rate, mixing properties, energy demand and efficiency of cooling.

It is clear that there cannot be a generalisation. With closer investigation no fermentor can stand up for all conditions, for example the use of air lift fermentors with n-paraffins incorporates some problems since on the surface a demixing of water and hydrocarbon occurs which impedes growth rate and enlarges loss of substrate with exhaust air.

The research programme therefore has investigated many different types of fermenter, like mechanically agitated reaction vessel with different, even unconventional, stirring devices, air lift fermentors, loop reactors, surface methods, jet propulsion of fermentation liquid, mammoth principle, and tube reactors in order to find for each type optimal dimension and shape and optimal process.

As for n-paraffin and ethanol fermentation in large scale plants these studies have lead to a mechanically agitated reaction vessel with a new type of stirring and with dimensions not reallized anywhere else so far. Gas throughput, mechanical energy, loss of water and substrate, oxygen transfer rate, heat transport, emulgation of four phase system, productivity and maximal biomass concentration have been considered in this context. Water demand and sewage problems have been minimised by a recycling of process liquid. The continuous fermentation process is automatically regulated and adjusted to steady state conditions.

Concentration of biomass produced is carried out continuously in a one step process without washing and extraction for n-paraffin fermentation under special microbiological conditions of metabolism. To mention one of a few characteristics of these conditions the process is carried out under C-limitation.

Traces of substrate in the final product are well below

officially permitted levels, with n-paraffins about 0,01 % in dry product. Concentration of carcinogens and mutagens is extremely low for example 3,4-Benzpyrene
The drying process is carried out under conventional methods.

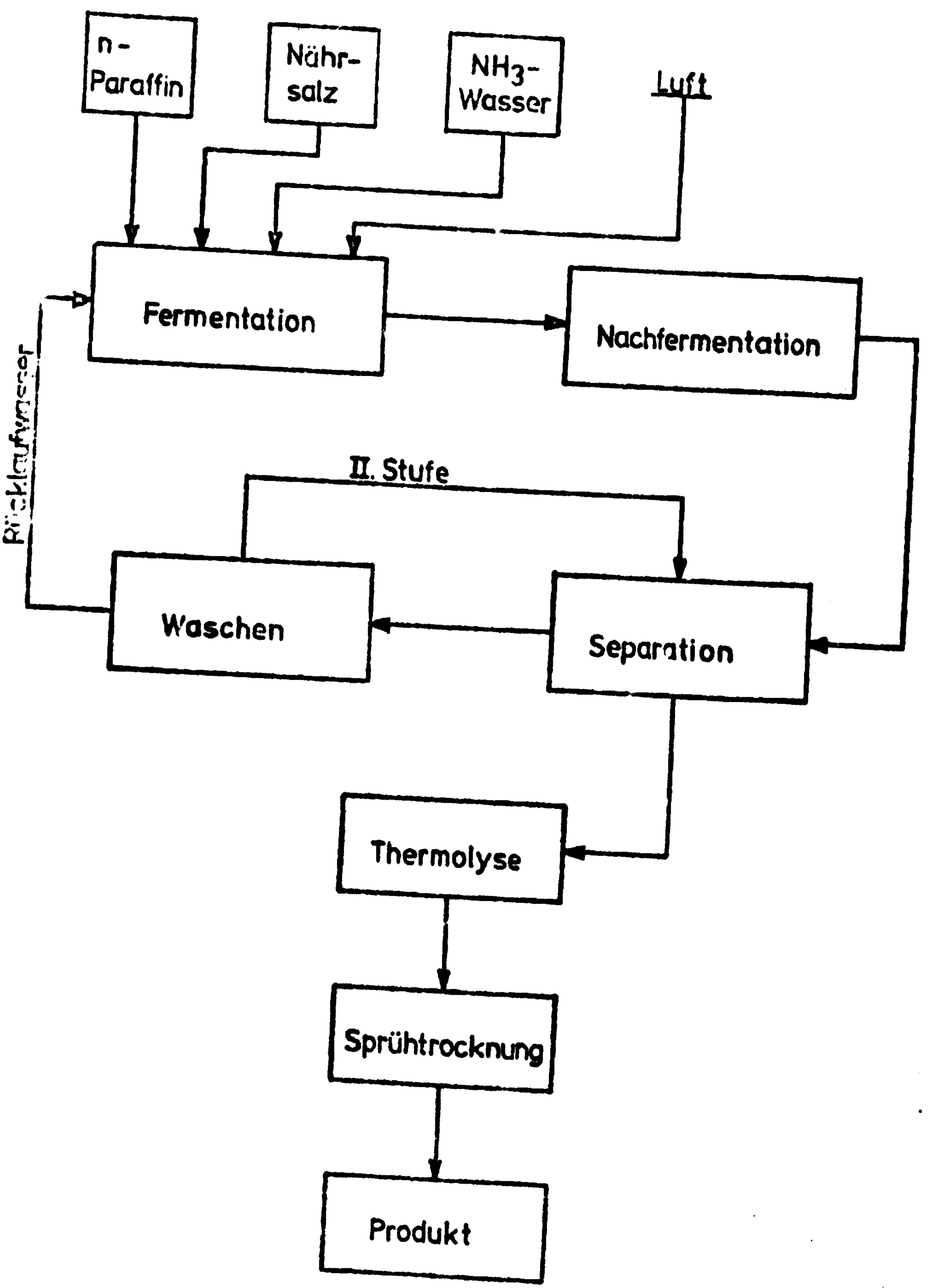
With animal feeding experiments it has been shown, that a final processing of dry product influences positively the acceptability of SCP.

Finally a prospect into future developments:

Hydrocarbons represent by no means an inexhaustible substrate for fermentation. Particularly developing countries should therefore bear in mind if there are possibilities of adjusting a large petroprotein plant to a new raw material, like other synthetic carbon carries or respectively pre-treated waste products.

With correct planning from the beginning such an adjustment can be carried out without expensive changes.

Kurzschema zur K.K.F.



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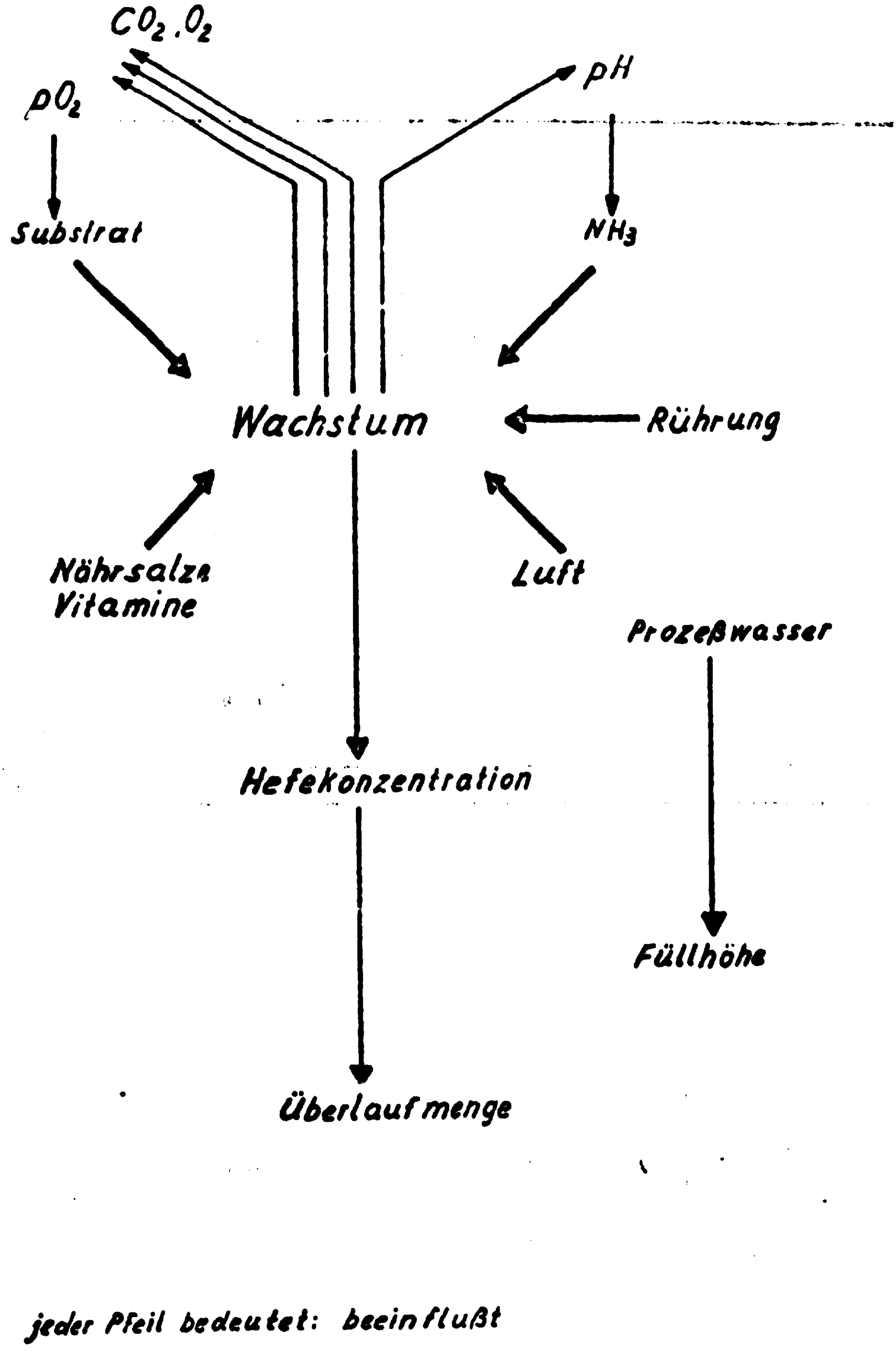
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Nährsalze
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Luft
Prozeßwasser
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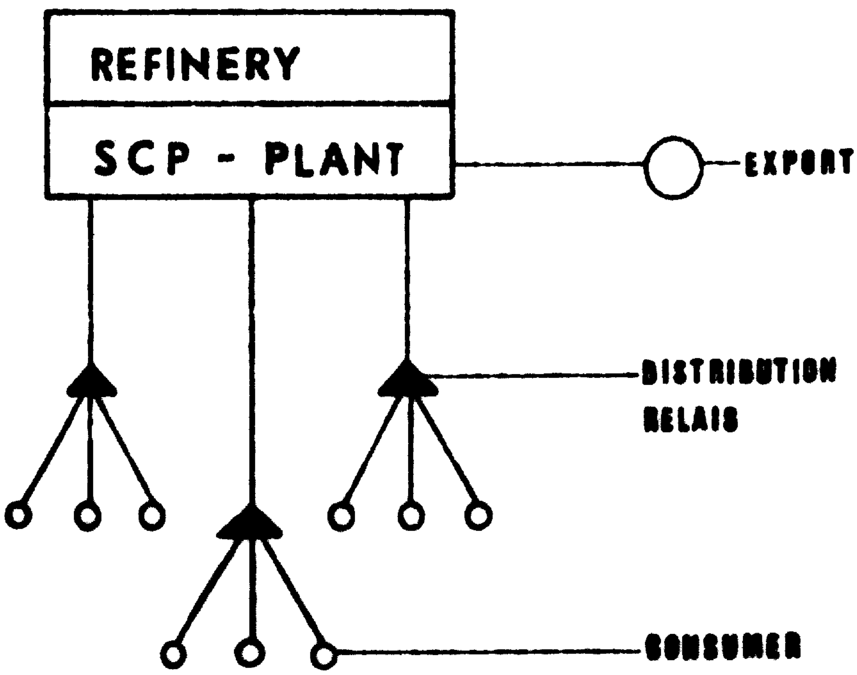
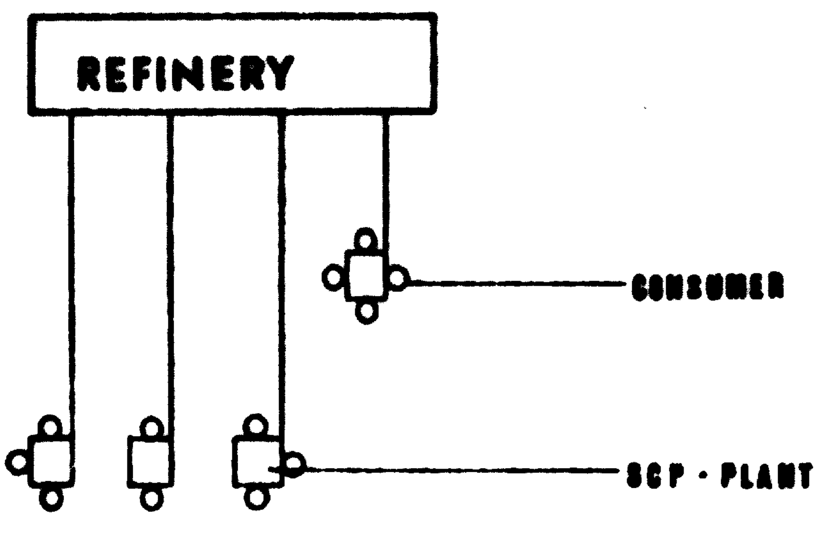
ONE UNIT MODEL



MULTI UNIT MODEL



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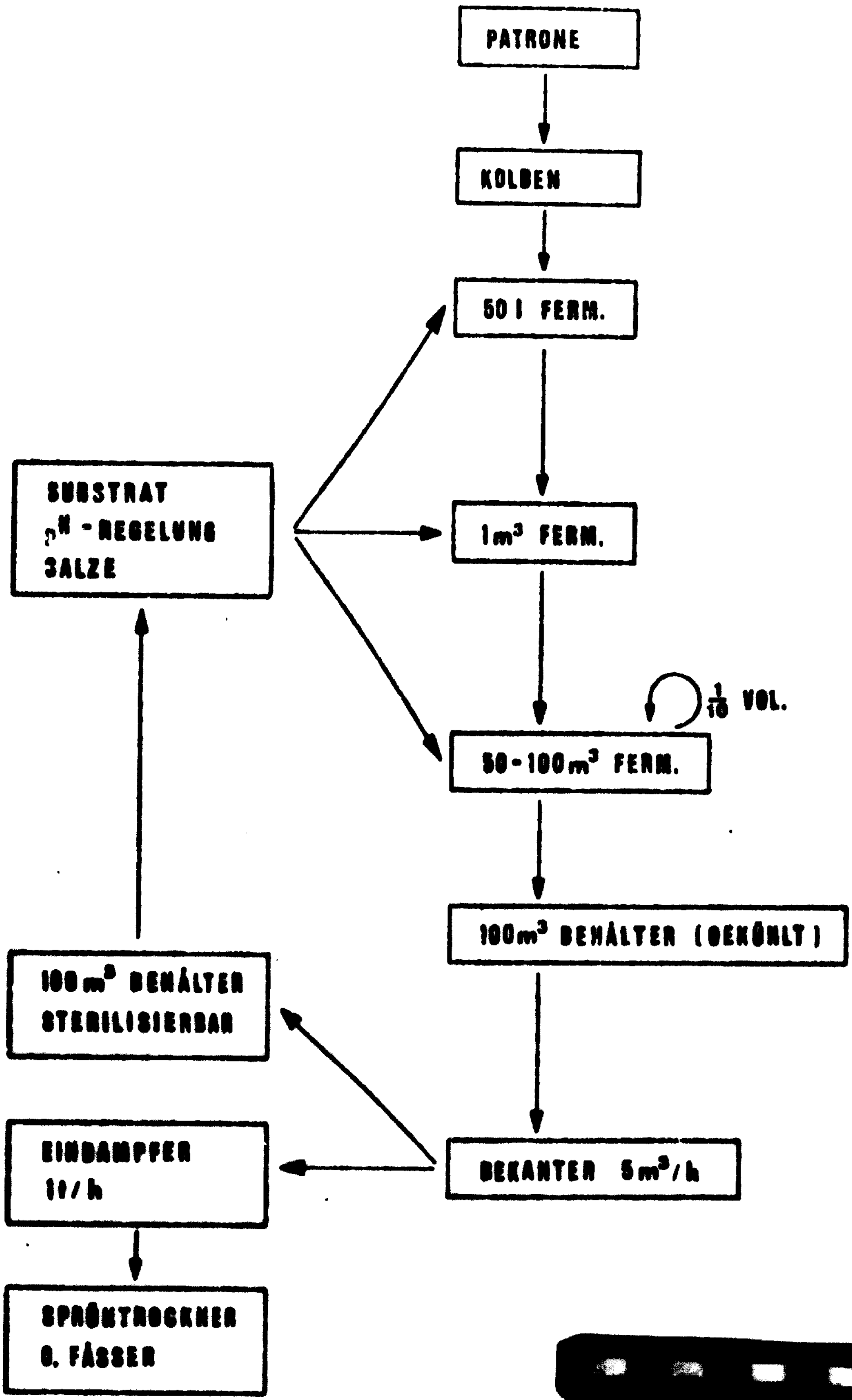
FERMENTATIONSEINFACHANLAGE



SEMI - KONTINUIERLICHE - PRODUKTION

200 t/JAHR BEI 100m³ FERMENTER ≙ 1t/TAG

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