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Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
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SUCRO-BASED CHEMICALS

ST/PHI/81/T01 /11-59

Republic of Philippines

Report on: Two months visit made to the *
Industrial Technology Development Institute in Philippines
From October 7 to December 5, 1988

Prepared for the Government of Philippines
by the United Nations Industrial Development Organization
acting as executing agency for the United Nations Development Programme

Based on the work of Mr. Jiri Kominek,
Consultant for Design of Citric Acid

Backstopping Officer: R.O. Williams, Chemical Industries Branch

United Nations Industrial Development Organization
Vienna

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T A B L E O F C O N T E N T S

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General Information

1. General Project Title	Sucro based Chemicals
1.1 Specific Project Title	Integrated Citric Acid Project
2. Project Location	Industrial Technology Development Institute (formerly National Institute of Science and Technology), Pedro Gil st., Ermita and Bicutan, Taguig, M. Manila, Philippines.
3. Project Coordinator	Dr. Lydia M. JOSON
4. Project Leader	Mrs. Natividad D. PALO
5.1 Recovery of Citric Acid	Mr. Ervin CASARENO
5.2 Design and Engineering	Mr. Romeo CABACANG

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Organic Acids Fermentation Staff:

Mrs. Natividad D. Palo	leader	pharmacologist
Mrs. Cynthia M. Madrid		chemist
Mrs. Rosemary M. Gutierrez		biologist
Mrs. Blanquita B. de Guzman		biologist
Mr. Romeo Cabacang		chemist
Mr. Erwin Casareno		chemist
Mr. Francis Perlta		chemist
Mr. Melchor Valdecanas		mach. eng.
Mr. Vic. Custodio		not. grad.

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INTRODUCTION

This is a report on my two months visit to the Industrial Technology Development Institute (abbr. IIDI, formerly National Institute of Science and Technology) in Bicutan, Taguig Metro Manila, Philippines between October 8th and December 5th, 1989.

According to the job description I had to assist at the operation of the citric acid pilot plant and recommend modification of the operation, the scale-up of the pilot-plant into commercial scale, the design of a large plant and in the preparation of the feasibility study.
Delay of putting into operation of the pilot plant by about one year (see Appendix A), has led to a significant delay of the Citric Acid Programme. My first rough impression was that it is necessary to complete the plant and some of the most urgent requirements are to supply the plant with electricity, steam, and water that must be guaranteed. After cleaning of the reactors a water run is necessary.
During the water run all intruments should be tested (temperature regulation, pH, pO_2, the aeration and the tightness of the plant). If the plant is checked in this way, pH and pO_2-probes should be removed and the fermentors are pickled (passivated) by a mineral acid. After approx. 24 hours the process is finished, the plant can be rinsed out, and when the rest of the acid is removed, the fermentation can start.

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At the time of my arrival almost none of these requirements were fulfilled. Nevertheless, after about one month, the pilot-plant was put into operation provisionally, but the cooling supply did not work and the fermentation temperature sank to 20 - 25 °C (the correct temperature is 30 - 33° C).
The evaporation of water in a tower fermentor without agitator (h i g h aeration rates are necessary) is very high and it is necessary to introduce heat into the fermentation (bubble column effect; in a stirred fermentor, heat is introduced into the liquid through the agitator).
The programme (see Appendix C) was not realized according to the schedule.
I hope that the putting into operation of the pilot-plant as a UNIDO-supported project was not the culmination of the project, but instead, a conditio sine qua non, or in other words, the beginning of the last stage of the project i.e. a regular run and production of citric acid on small scale to estimate the data for a scale-up of the pilot plant to commercial scale. Otherwise - I am afraid - it would be a misinvestment.

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The building

Approximately half of 350 m2 of the ground floor is reserved for the citric acid pilot plant. In the same room an air supply, cooling water supply, and the control panel are located.
The steam generator is in an adjoining room. The building has two floors. The second floor through a plant can be enlarged for further development is not yet finished. The exhaust air of the fermentation is blown into the room, the waste water goes into a small purification plant. On the ground floor is a chemical laboratory. This laboratory lodges three small (14 litres each) fermentors, laminar flow box, shaker, incubator, drier and refrigerator. There is hardly enough space for the staff and to work.

Water, electricity, steam, and air

In opposition to my last information (see my report from May 7th, 1987) that the tap water temperature is lower then 24oC and therefore this water is suitable for cooling of the fermentor, the tap water temperature is higher than 30°C. In addition the tap water is only disposable for a short time daily. For this reason a cooling supply is necessary. This device exists, but it depends on the electricity. The main supplies in Bicutan, however, (not only in Bicutan, but also in M.M.) are not reliable.
Short and sometimes long breaks disturb the labor. The fermentation requires continuous air supply and it is the same as with cooling water: without electricity,air is not available. An emergency generator is absolutely necessary.

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The Pilot Plant

Present state

The pilot plant is mounted in four frame constructions of painted steel in cube form.
Two bubble column fermentors have a gross volume of 200 litres each. The fermentors are slim, the diameter to the hight ratio 1 : 6 is according to my recommendation (13 in. diameter to 79 in. cylindric height). The cooling supply is integrated, the steam (electric) generator is outside the plant. The instrumentation of both fermentors is not complete, some sensors are not mounted, but the instruments, transmitter, indicator and recorder are integrated in four control panels and located behind the partition wall with a process diagramme and a switchboard. At present the fermentation air is delivered from three overburdened piston compressors; the air is full of oil. This will not be the case with e.g. a screw compressor or roots blower. Moreover both air filters are too small.

In detail

Indeed the pilot plant is not ready, the air supply is wanting, the air distributor is not complete and not adjusted, the $K_L a$-values of both fermenters are not known. Yet all these things are closely connected: in the first place there is a complete air distributor. Sketch No. 1 shows the present state. The covered plate of the distributor is fixed by only two screws. This is wrong and an unsuitable simplification of the construction; the plain is given by three points and a parallel slit between ground and covered plate is necessary for a fine distribution of the air. Necessary distance-plates are missing. The position of the air distributor in the fermentor is unvariably fixed. Also the best position is unknown

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(pO_2-measurement), the air distributor must thus be adjustable. If the pO_2-probe will be at hand, the optimal aeration can be found (the maximal deflexion of the pointer of the pO_2-monitor) according to air supply. In my opinion two (or three) small air compressors would be better than only one unit: In case of a power failure the aeration rate can be reduced and only one compressor (or two) can be provided with electricity of the emergency generator. This generator is not yet installed. Each black out is a menace for the fermentation.

The air filters are too small and difficult to handle. The stuffed filters have either too high resistance or they are not efficient enough. The self stuffed filter is a special unit consisting of a cylindrical vessel, dished head and bottom, air distributor and air collector. The filter must be easy to remove and to clean. A stuffing material fibre glass wool from FIBREGLASS LTD., type Superfine A 50 (for example) is suitable. Cotton wool should be avoided as a stuffing material, since it is not as sufficient as glass fibre owing to its greater fibre diameter and it is more easily wetted than glass fibre. A wide range of air filters of glass fibre and ceramic candle construction is commercially available. Well known firms are e.g. DONMICK HUNTER LTD. in England, ULTRAFILTER GMBH in the German Federal Republic, Millipore,Pal a.s.o.

The product of the firm ULTRAFILTER (see sketch No. 2) has the following dimensions: for appr. 120 m3/hour at 3 bar (the filter is laid out for a pressure of 7 bar, the calculatory factor is 0,5)120 mm is the diameter, length 140 mm, total height 238 mm and the connection fitting 3/4 in. resp. 1 in. The pressure difference of a clean filter cartridge is appr. 0,1 - 0,2 bar. Maximal working temperature is 200°C.

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The cartridge filters are to be sterilized by autoclaving or in-line-steaming. A prefilter is recommended. The self-stuffed one is cheaper, the efficiency depends on the stuffing.

- The defoaming supply is missing. At present the antifoaming oil must be added by hand from the top of the fermentor. At the beginning of the fermentation foam is dangerous:
the spores and later the young mycelium can float into the foam and starve. After the addition of antifoam oil it may happen that the spores or the mycelium adher to the wall of the fermenter and get lost for the fermentation.
- The losses of water by evaporation during the fermentation are not compensated. The aeration rate in the small fermentor is higher than in the big fermentor. According to this fact the losses in the small fermentor are very high. The thickening of the fermentation liquor is unphysiological for the micro-organism and therefore not desireable.
Not necessary but useful is a washing device for the cleaning of the sight glass in the fermentor wall. Sterile water or steam will do, supposed the suitable pipe is available (Sketch No. 3).
The welding seams inside the fermenter are not polished.
The rest of cinder is undesireable

Recommendation

Air distributor

Two screws are present. It is necessary to supply two additional screws and four distance plates (see sketch No.1).
I recommend the use of stretch screwing for the air distributor.

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Air filter

It would be better to make both filters bigger and easier to remove.

The check valve in the line mostly brings contamination, but does not work. The air pipes are of stainless steel. If the fermentor stays without aeration, the mash can rise and fill the pipe. If the filter is mounted high enough it remains dry.
The air filters have to be mounted higher than the head of the fermentor (see also sketch No. 3).
Instead of the check valve a condensate drainage is better and more useful.

Air compressors

An air compressor (approximately 120 m3/hour) requires a motor of about 7 to 8 kW. In my opinion this can only be a three-phase-current motor. In this case a three-phase-current emergency generator is required. A small compressor that needs small motors may be built as one-phase-current engine. In such a case a one-phase-current generator is sufficient, but instead of one compressor three compressors and three motors are necessary.

Defoaming supply

A small peristaltic pump (approx. 5 ml/h oil) and electric-level sensor and indicator are necessary.

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Compensation of water losses

A peristaltic pump and a timer are sufficient. Approx. 0,5 - 1,0 litres/hour are needed. The timer must be adjustable for intervals and switch-times.

Sight glasses washing device

This point doesn't need further explanations. (See sketch No. 4)

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Personnel

The citric acid-staff is overburdened if the citric acid pilot plant is fully working. It always has to care for two domains: the fermentation and the isolation and recovery of citric acid. And all this in three shifts by work round the clock. In addition at least for the first shift an analyst is necessary. Yet in my opinion an analyst would be necessary throughout the duration of the project, the fermentation, the molasses preparation and the spore propagation. It would also be an immense aid to have an excellent permanent analysis at hand. The personnel drop out, e.g. on account of pregnancy - the biologists ans analysts are women - is unavoidable. It is one of the causes of delay of the citric acid project.

PILOT PLANT SCHEDULE

FERMENTATION	LIMING	ACIDULATION	DECOLORIZATION DEIONIZER	EVAPORATION	CRYSTALLIZATION
1 st 26 October	27 October	27 October		28 October	29 October
2 nd 3 November	3 November	3 November	3 November	4 November	5 November
3 rd 15 November	14 November	14 November	14 November	15 November	15 November
4 th 23 November	21 November	21 November	21 November	22 November	23 November
5 th 30 November	28 November	28 November	28 November	29 November	30 November
6 December	Analysis of results				

APPENDIX A

WORK PLAN
COMPLETION OF THE PILOT PLANT
(20-27 OCTOBER 1988)

ACTIVITIES	THURSDAY	FRIDAY	SATURDAY	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
1. Electrical Installation								
a. Load/Remote Switch	MELCHOR/MIKE							
b. Pilot Lamp		MELCHOR & MIKE						
2. Fermentor & Accessories								
a. Temperature Sensor			ROMY /MELCHOR					
b. D.O. Sensor			ROMY &MELCHOR					
c. CO2 & O2 Sensor					ROMY/EFREN			
3. Compressor								
a. Electrical			MELCHOR/EFREN					
b. Piping	ROMY & RAYMUND							
c. Motor Drive Arc			MELCHOR/EFREN					
4. Piping Installation								
a. Water tank	ROMY & DESUYO							
b. Column		ROMY/DESUYO						
c. Steam Insulation			ROMY/ERWIN/NARCISO					
5. Panel Board								
a. Mimic board				NARCISO/RAYMUND				
b. Carpentry/Painting					HEROY			
6. Wet Run							ROMY	
7. Standby Generator						MELCHOR		
8. Painting of Pilot Plant							ROMY/VIC/ERWIN	
9. Sign Board							NARCISO	

APPENDIX B

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WORKING PROGRAMME 1987

THE SCHEDULE

MONTHS :

1. Improvement of fermentation technology
   a) strain improvement — 1 - 3, 4 - 6, 7 - 9, 10 - 12
   b) optimization of parameters for the production of citric acid
   c) recovery and purification of citric acid

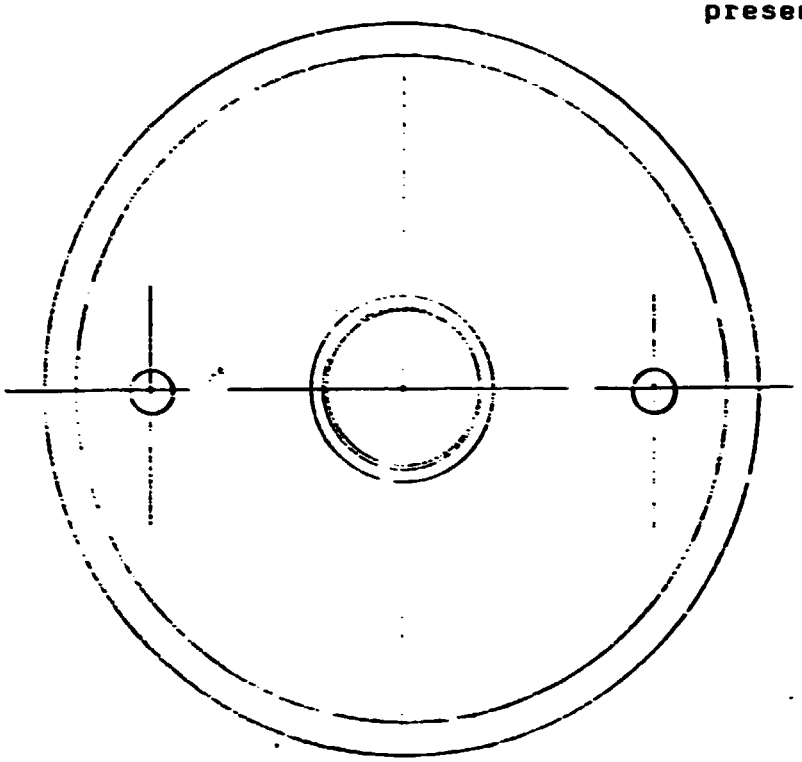
2. Pilot plant production
   a) fabrication of local equipment
   b) installation of equipment
   c) preliminary run
   d) operating

3. Training of engineers and technologists in design, construction and operating of Citric Acid — 1 - 3, 4 - 6, 7

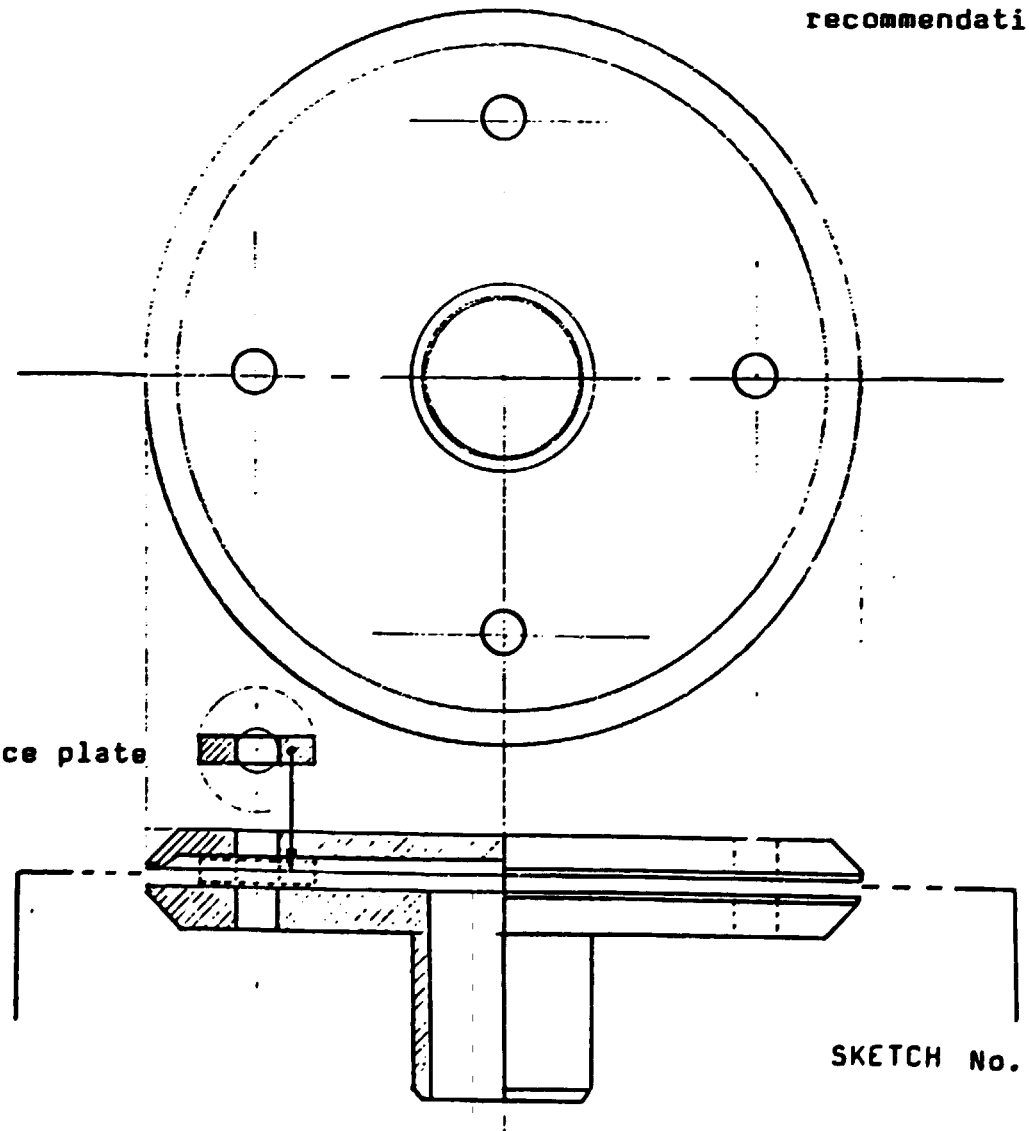
4. Consultant coming
   a) J. Kominek — 2 - 3
   b) A. Gelineo — 2 - 3
   c) M. Röhr

5. Construction of the Pilot Plant building — 1 - 4

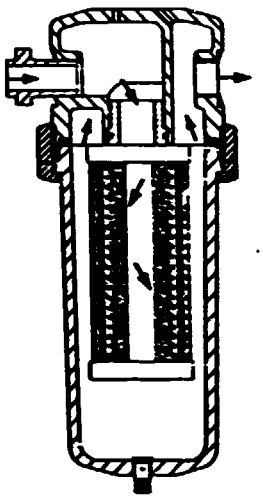
present state



recommendation

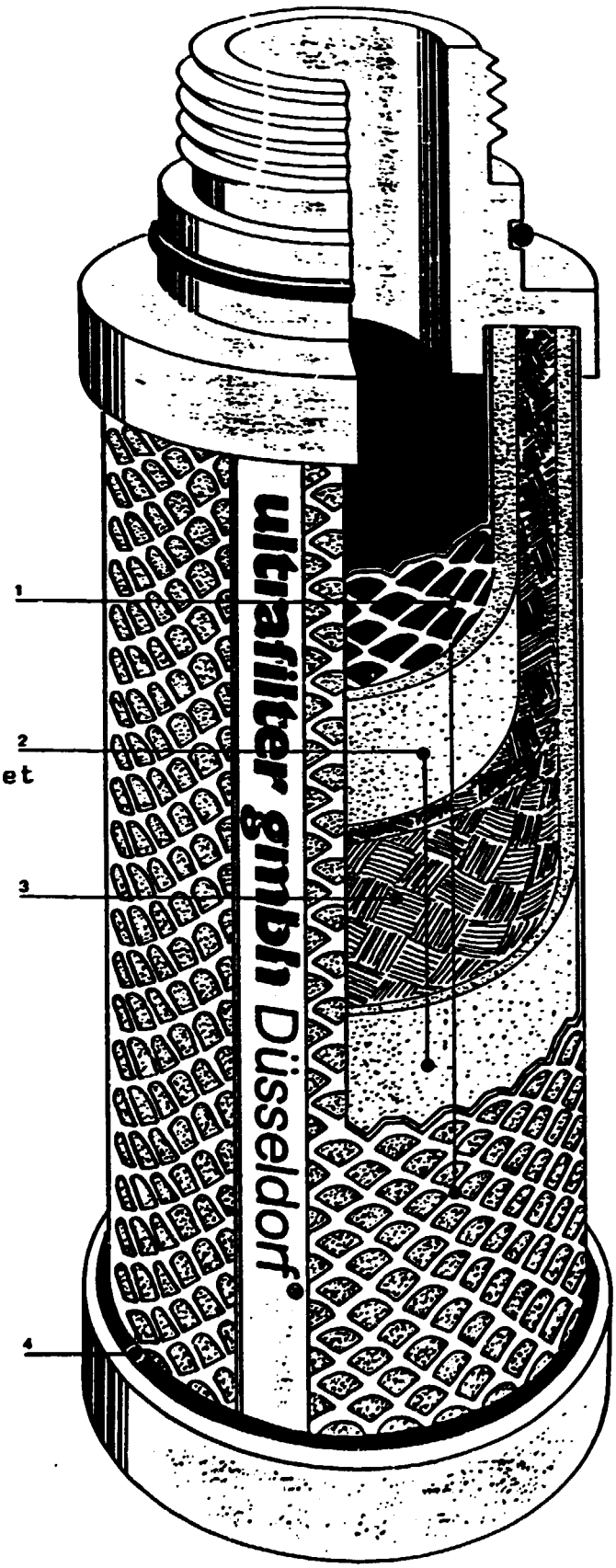


SKETCH No. 1



complete filter

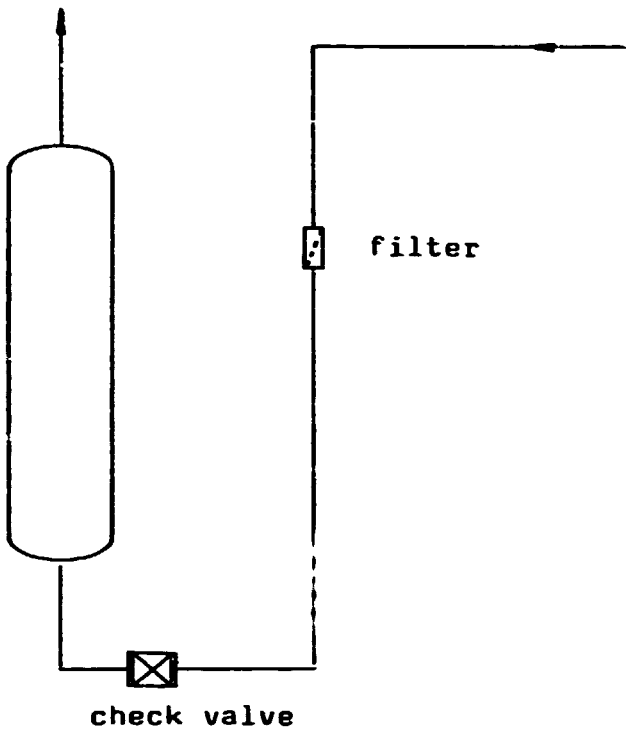
1 stainless supporting jacket
2 prefilter
3 micro-fibre-fleece-filter
4 silicon sealing



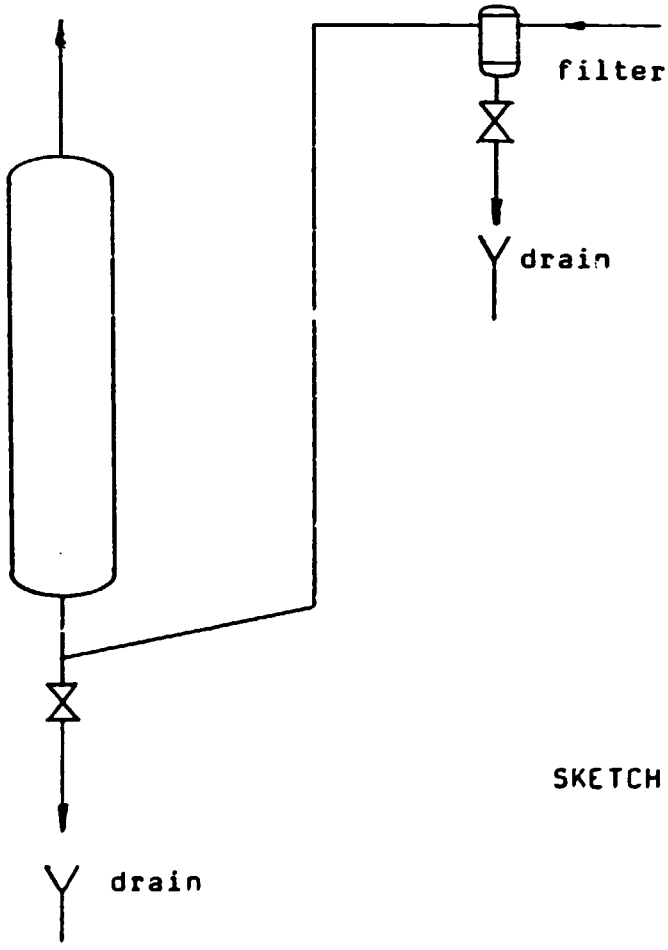
cartridge

SKETCH No. 2

present state



recommendation



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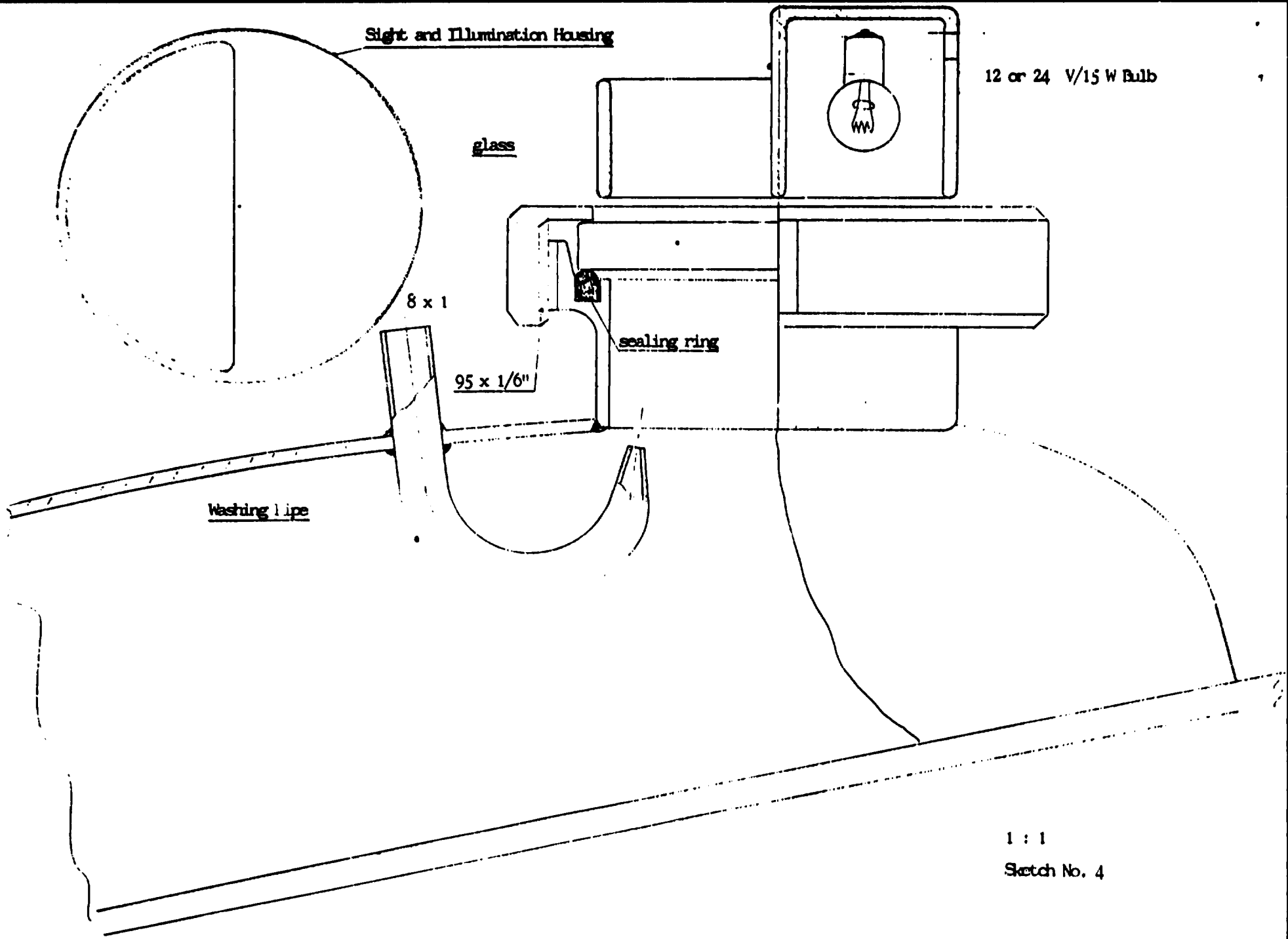
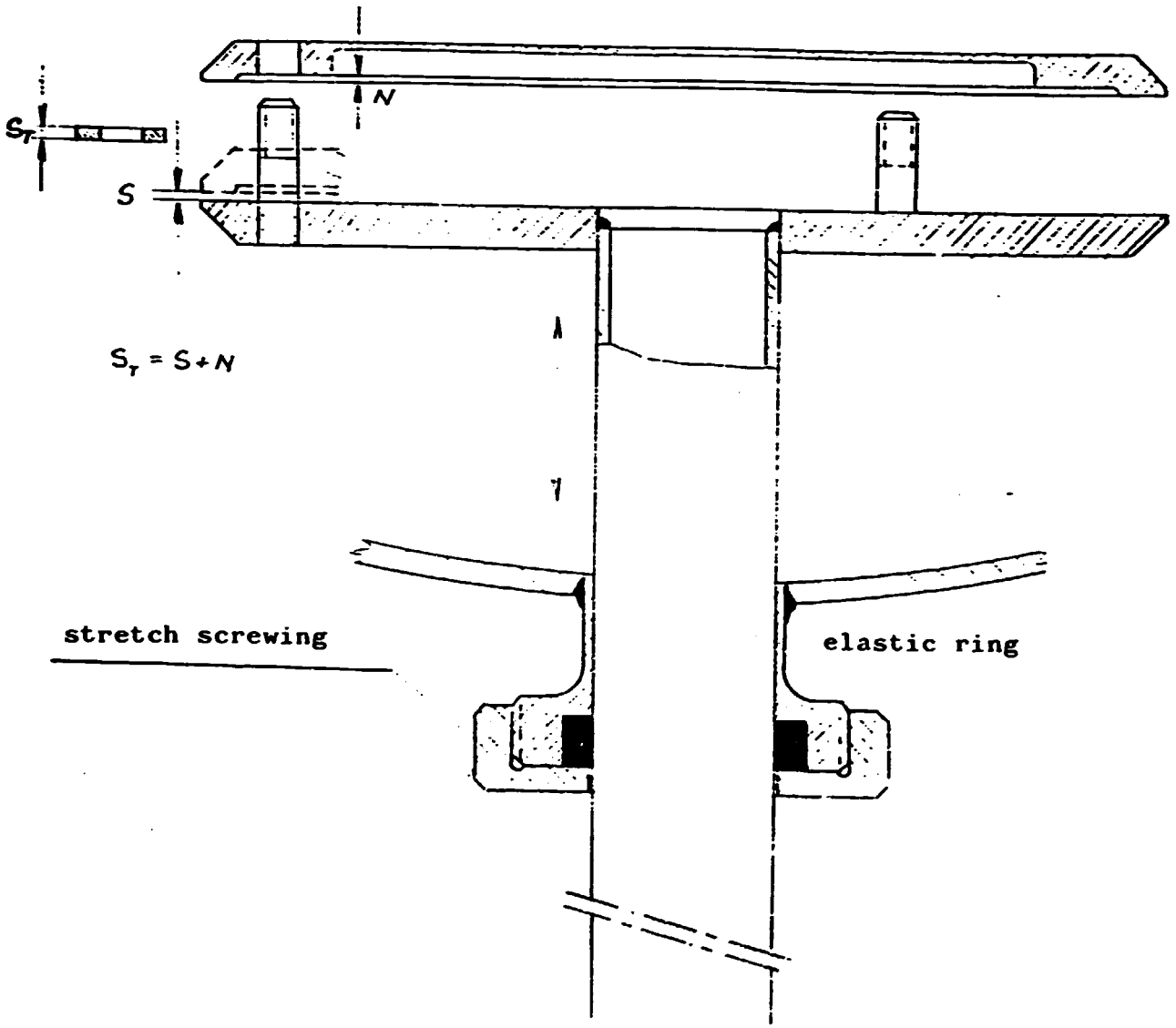

Sight and Illumination Housing
glass
12 or 24 V/15 W Bulb
8 x 1
sealing ring
95 x 1/6"
Washing lipe
1 : 1
Sketch No. 4

JK, 6.2.1999



Sketch No. 5

Koj 6.2.'89