Corrosion Prevention in Cane Sugar Production

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CORROSION PREVENTION IN CANE SUGAR PRODUCTION

Background

Cane sugar is normally produced from sugar canes that, after the initial shredding and crushing operations, pass through special rolling mills. The juice pressed out in this way is subsequently refined and, after going through a number of processes, is concentrated prior to heating until the sugar crystals form. (Enclosure 1.)

The rolling mills were, by tradition, equipped with plain bearings lubricated with highly viscous oils of varying quality and performance. However, high friction/energy consumption and poor reliability have led to a switch to spherical roller bearings since the mid-1970s.

The primary benefit to be gained by using roller bearings is the energy saving involved - between 20 and 25% may be considered to be a realistic assessment. Sugar mills consume a great deal of energy. The cane waste (bagasse) is used as fuel but the application of roller bearings can even make the sugar mills more than self-sufficient and enable them, to some extent, to sell any surplus electric power to other consumers. This is a factor to be taken into account in an industry that is currently plagued by recession and reduced profitability.

The highly corrosive juice extracted from the sugar cane has posed particular problems when it has leaked into the bearings.

Used grease was found on analysis to have a sugar juice content of 10 to 15% and bearings that had been lubricated by greases normally having extremely efficient corrosion-inhibiting properties were found to be extensively damaged by deep-seated rust.

Even the lubricating properties of these greases were far from satisfactory, since their base oil viscosities were about 15 to 35% of that actually required to ensure acceptable separation of bearing rollers and raceways.

Introduction

In the spring of 1983, SKF initiated a development project, together with the Cuban authorities, aimed at demonstrating the reliability and energy-saving features of rolling bearing applications, as opposed to the traditional engineering practice lent lubricant. Starvation conditions had been experienced during earlier trials with lubricating greases and incipient surface distress had resulted from the absence of a cohesive lubricant film.

SKF Göteborg decided to try using gear oils to ensure that the bearings were well lubricated throughout their working life.

The difficulties encountered in finding lubricating oils suitable for the bearings in sugar mills led to a separate project in the search for a lubricant with

* sufficiently high viscosity
* excellent resistance to the corrosive action of sugar juice

The lubricant - project part I

The mean diameter of the roller bearings used in sugar mills ranges from 600 to 1000 mm and these bearings rotate at about 5 r/min.

Consequently, the lubricant to be employed must have a kinematic viscosity of around 500 mm^2/s at 60°C - the normal running temperature of the bearings.

However, there were very few gear oils of this viscosity available.

In the early summer of 1984, extensive testing of bearings with the gear oils specified in Table 1 was carried out in the laboratories at SKF Göteborg.

Table 1

Oil	Viscosity, mm^2/s			Product Description
	40°C	60°C	100°C	
A	850	260	46	Cylinder oil, compounded
B	1000	450	125	Polyglycol, S/P additives
C	1500	600	165	-ditto-
D	1000	280	52	Gear oil with S/P additives and solid lubricants
E	1450	390	62	-ditto-
F	3230	750	102	-ditto-

It was evident from the examination of the tested bearings that the higher the viscosity of the oil, the better the condition of the bearings, as a result of the superior formation of the lubricant film. (Enclosure 2a-c).

The best results were obtained with Molub Alloy Gear Oil 876 Light from the Imperial Oil & Grease Company, USA. (Enclosure 2c, oil F).

The corrosion preventive additive - project part II

On account of extremely corrosive properties of the sugar juice, a highly active system of additives, with either neutralizing or polar effect, was required.

Fresh juice may have a pH ≈ 5 but this may drop quickly to pH ≈ 3 after about an hour at 25°C on account of the presence of a great number of micro-organisms which convert the saccarose into organic acids. This acidification rapidly leads to superficial corrosion (etching) of bearing components.

The procedure normally adopted to achieve effective rust inhibition, involving the addition of leades additives, proved to be quite useless. This meant that lubricants that would normally be able to cope with salt water cannot provide the rolling bearings with adequate protection against corrosion. (Enclosure 3).

Moreover, sugar mills come under the category of food manufacturers and this means that the use of lubricants containing toxic substances, such as lead additives, sodium nitrite, etc. cannot be permitted.

After about four months spent on the investigation of the rust inhibiting properties of a great number of lubricating oils, an additive which had not been used before in the lubrication of rolling bearings was tried out.

This products is normally employed as a preservative for bearings, machinery, etc. in store and has a vapour-phase action, though it even serves as a load-carrying additive for lubricating oils. The active substances are said to be a mixture of amino-carboxylates in mineral oil.

The additive is produced by the Sealed Air Corporation, Cortec Division, Minnesota, USA, and goes by the name of Cortec VCI 369 (Volatile Corrosion Inhibitor). When tested in the SKF Emcor Rig, together with a gear oil contaminated by up to 25% sugar juice, it proved very effective. (Enclosure 3).

Prallel testing, with up to 10% Cortec VCI 369 added to the gear oil selected for the Cuban project, with regard to welding load in the 4-ball rig and stability of the solid lubricants, did not produce any negative effects.

The toxicity of the additive is also considered to be low since the United States Department of Agriculture (USDA) approves the use of Cortec VPI products in food manufacture provided that there is no direct contact with the food product.

The design of a sugar mill is such, however, that the risk of contamination of the sugar juice is slight. On the contrary, it is the sugar juice that may contaminate the lubricant.

On the other hand, Cortec VCI 369 proved to be virtually ineffective when added to lithium-base lubricating greases.

There is no explanation for this as yet. The VCI 369 may have a bad difficulty in penetrating the soap structure or, in reaction to this or other additives, has become inactive. (Enclosure 4).

Operational Experience from Cuba

The trial sugar mill at the Panchito Gomez Toro Plan was ready to operate in time for the fall 1983 - spring 1984 cane harvest.

The special sphered seals were lubricated with a fairly ordinary lithium-base grease of local manufacture and served solely to stop the ingress of the sugar juice.

Despite all the preacutions that had been taken, it was still necessary to be able to check whether any juice had got in to the bearings, as this would be proof that the seals had worn.

However, the method of analysis had to be simple and reliable.

The equipment most suited to this purpose is made by Labofina SA and goes by the name of FINA Aquatester. (Enclosure 5).

Analysis by this method is simple. A small amount of oil (20 ml) is diluted with an anhydrous solvent and is mixed with a reagent, whereupon, if water is present in the sample, hydrogen gas forms.

This analysis is completed in a couple of minutes.

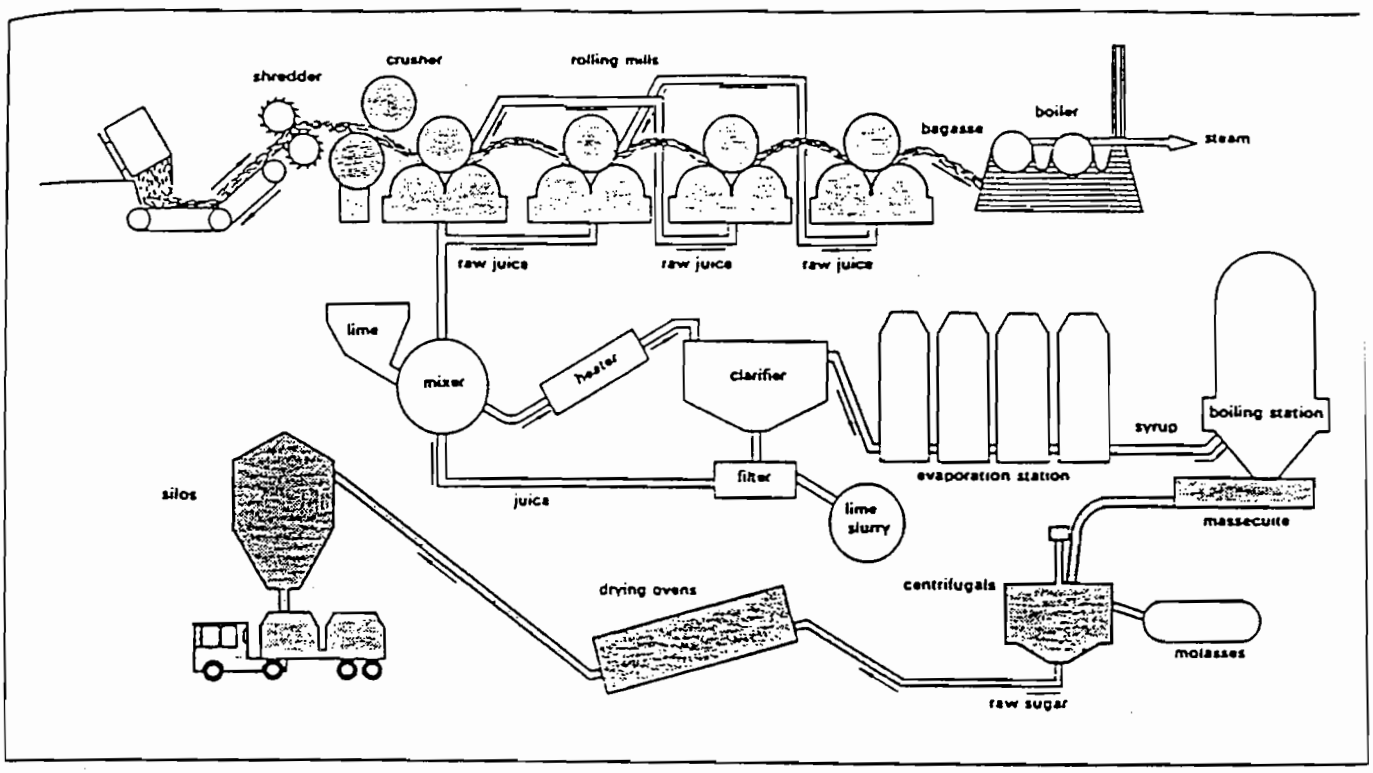
The original water content remained at 0.03% throughout the season.

Conclusion

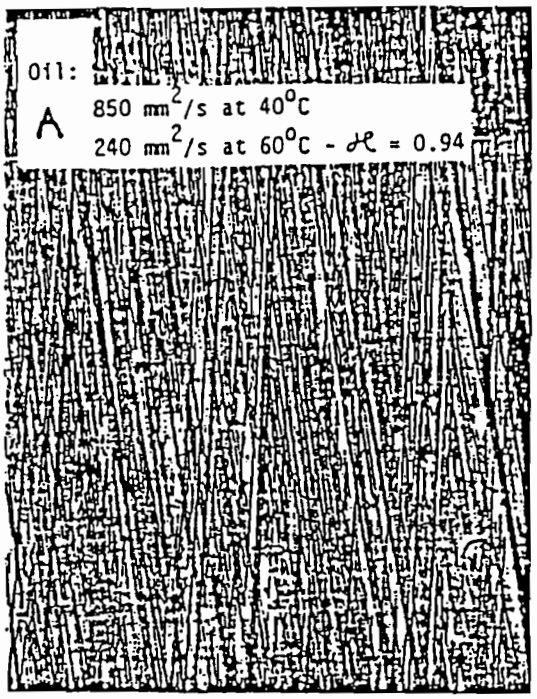
It is evident, from detailed analysis and examination of roller bearings, seals, used lubricant and additives, that perfect hydrodynamic lubrication of the bearings has been obtained with the Molub Alloy Gear Oil 876 Light. All rolling element and raceway surfaces were in excellent condition.

On a basis of the experience gained to date (1985), oil lubrication of spherical roller bearings should be employed in the case of future conversions of existing sugar mills, or of new mills designed to operate with such bearings. Optimal lubrication is achieved in this way and risk of starvation conditions, as experienced with lubricating greases, is eliminated.

The oil used should contain an effective corrosion inhibitor. This is especially important during longer periods of stand still and mothballing of the bearings between seasons. The oil can be made even better in this respect by the addition of a vapour-phase inhibitor such as Cortec VCI 369.



Enclosure 1: Diagramm of sugar processing



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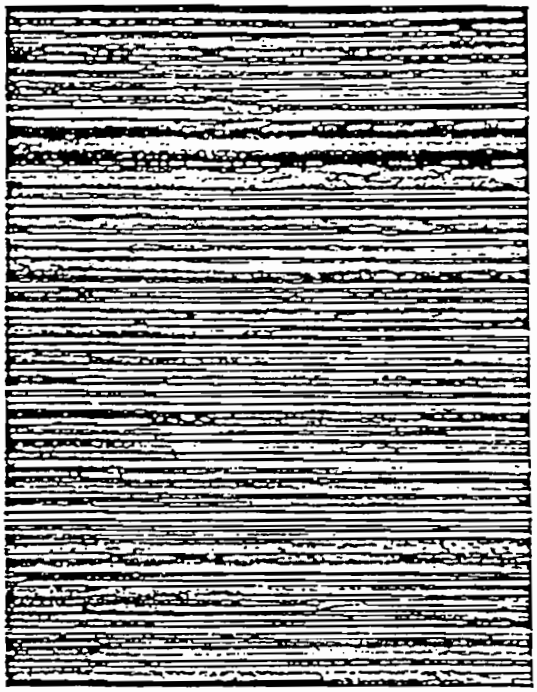

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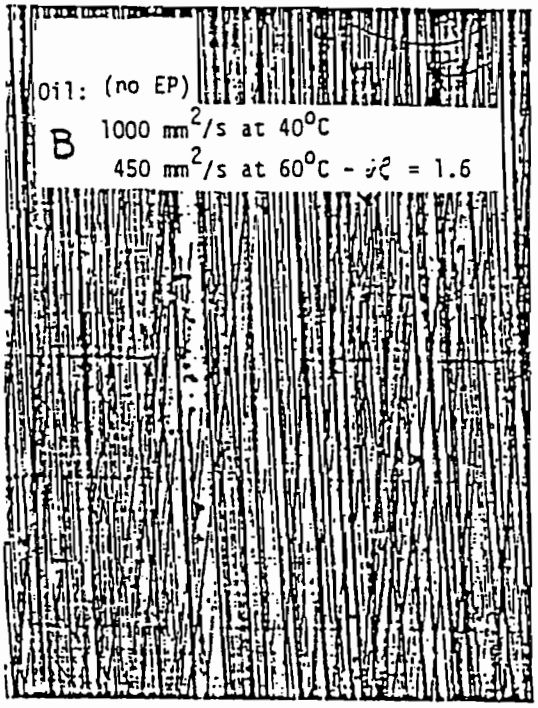

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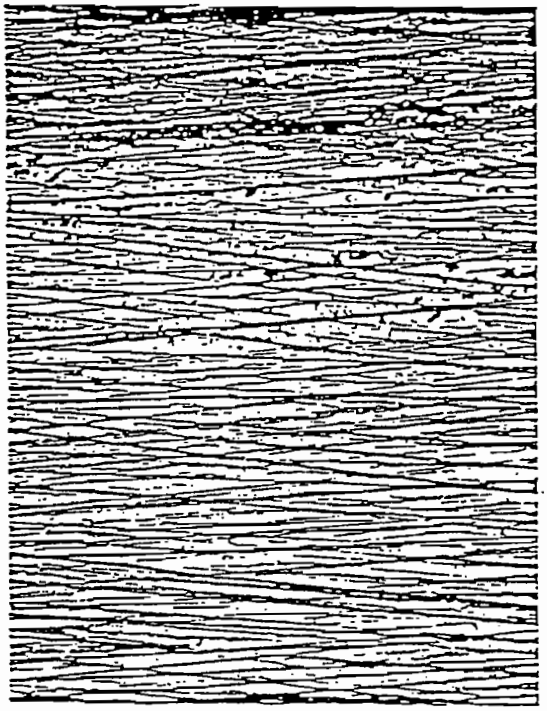

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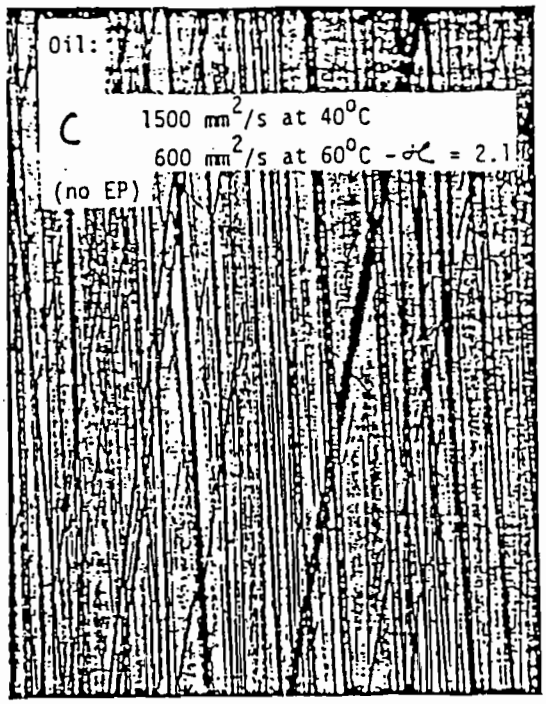
Enclosure 2a



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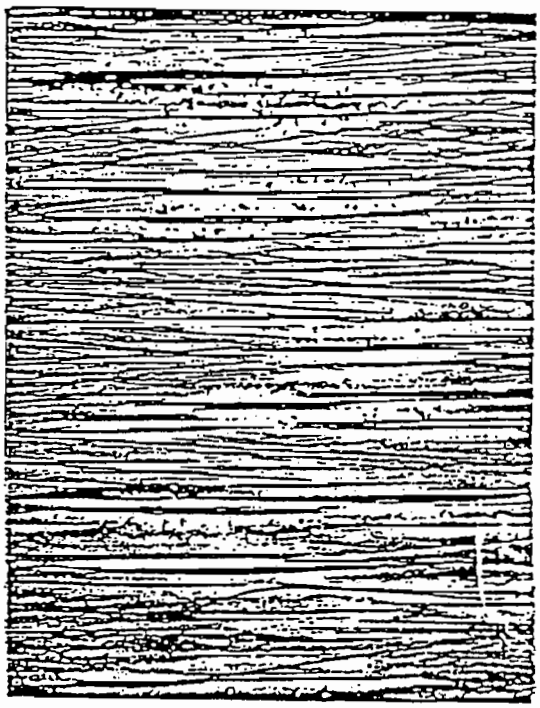

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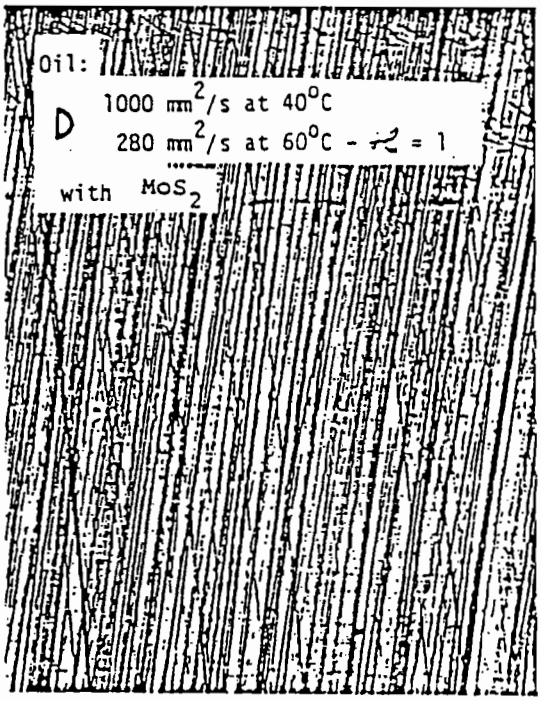

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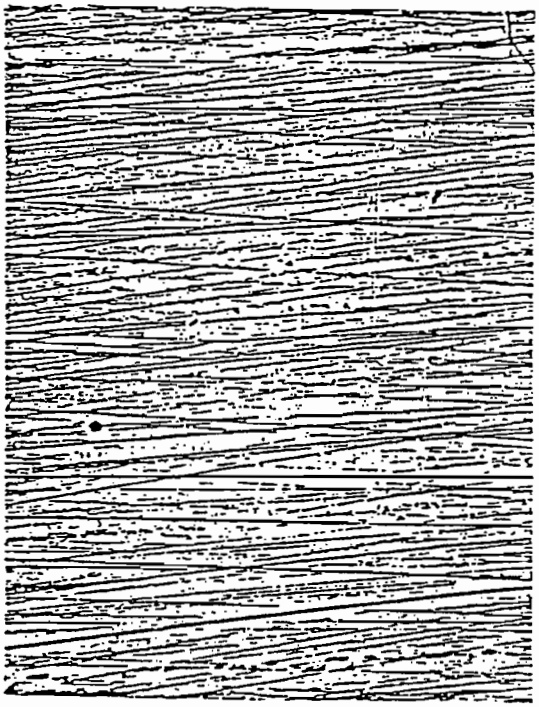

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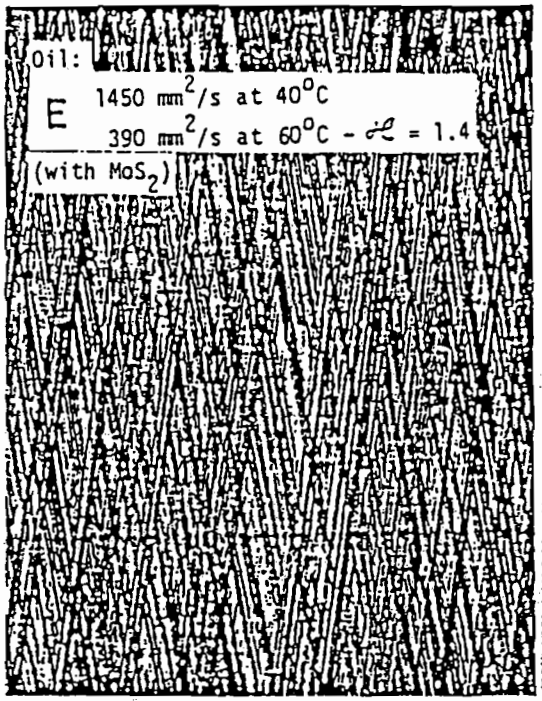
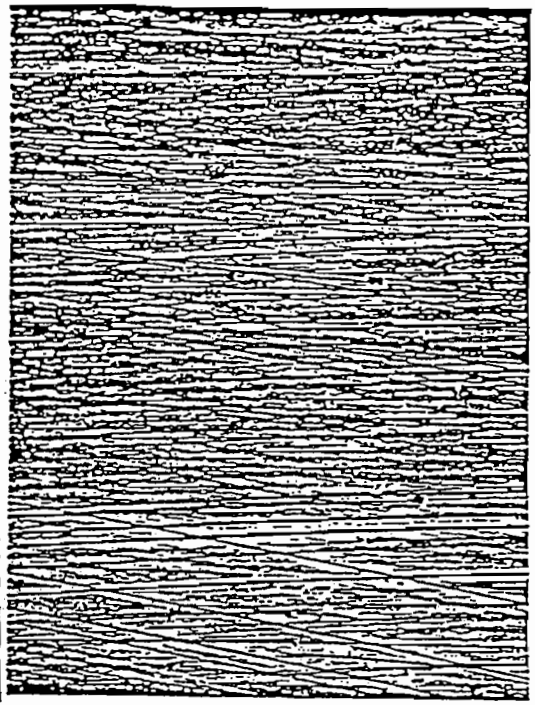
Enclosure 2b





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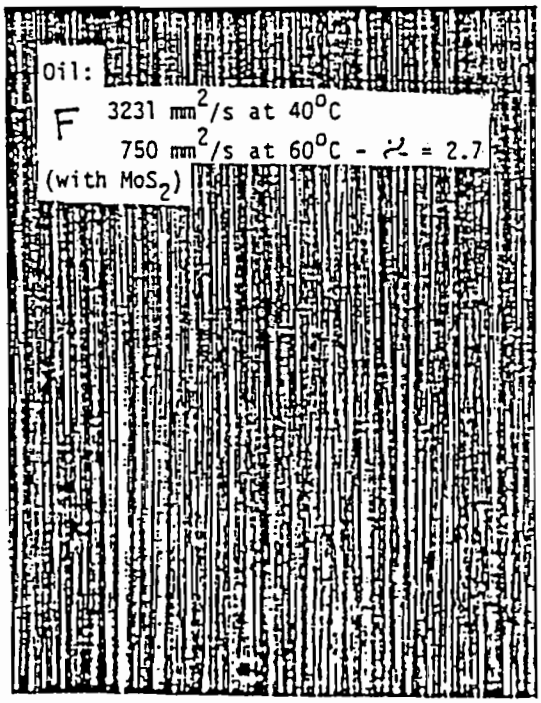

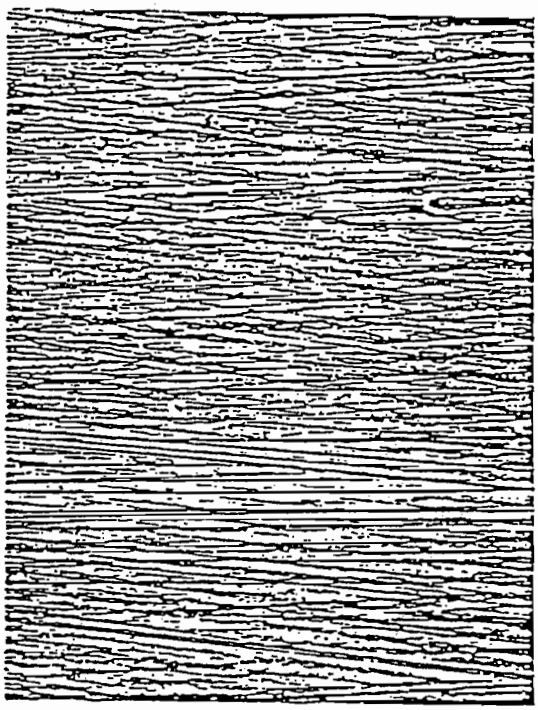

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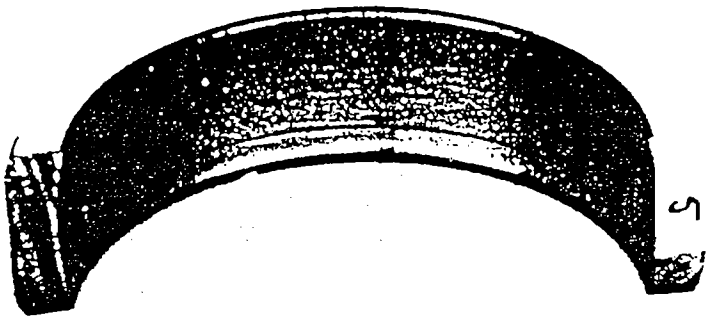
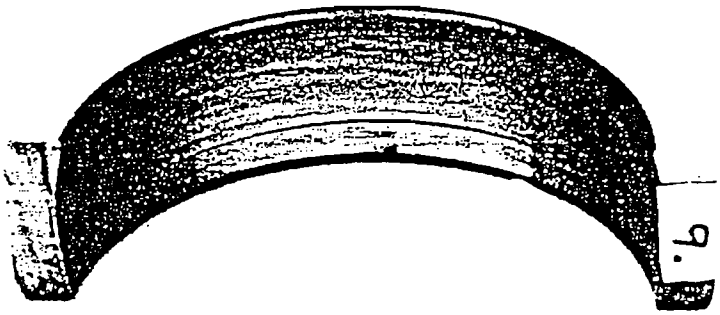
Enclosure 2c



5 % Sugar juice

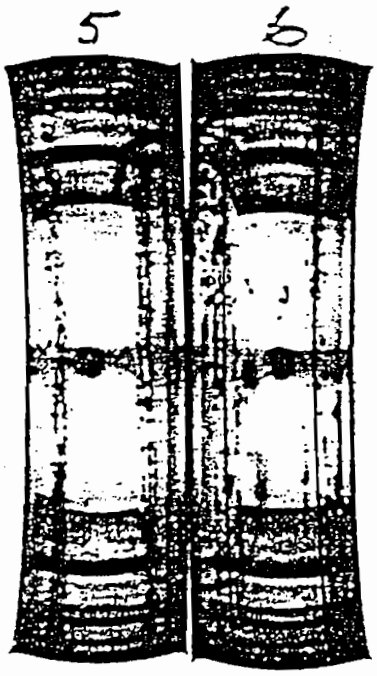
25 % Sugar juice



5% Sugar juice/ 5% Cortec VCI 369

25% Sugar juice/ 5% Cortec VCI 369

Enclosure 3



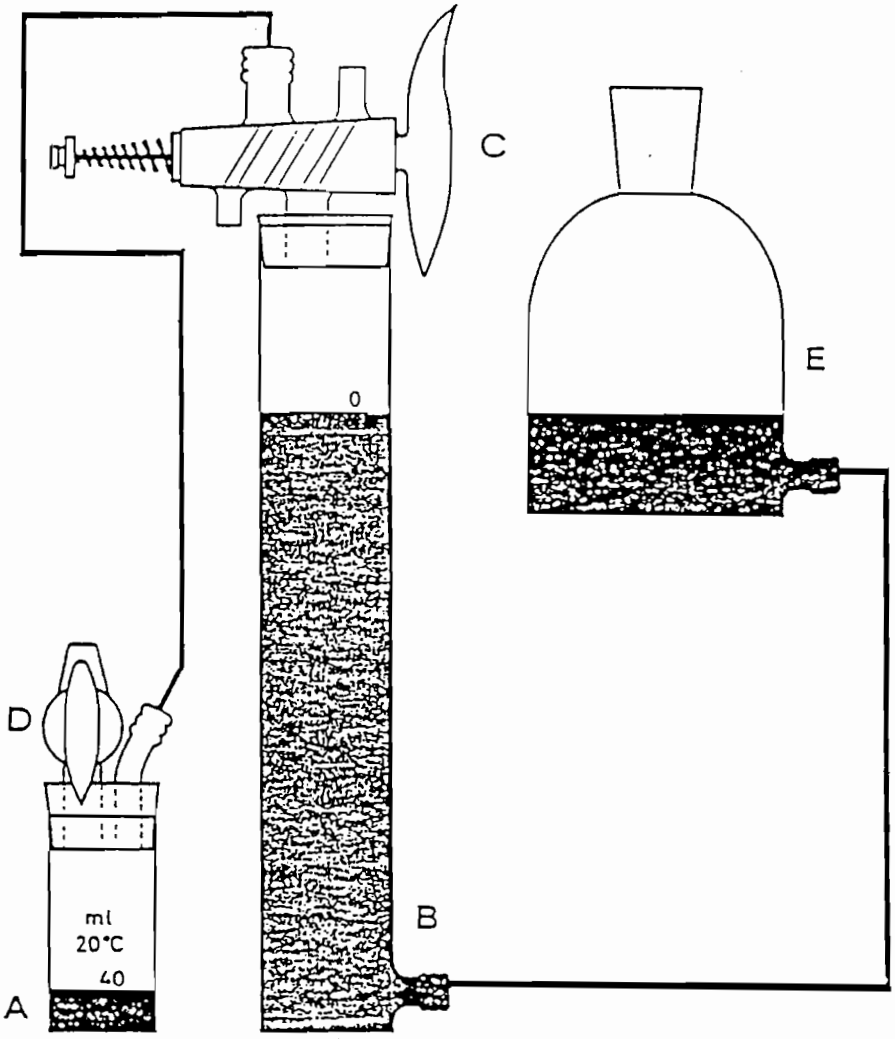
Enclosure 4

Grease A

Emcor Distilled water

Grease A + 5% Cortec VCI 369

Emcor Distilled water



Enclosure 5