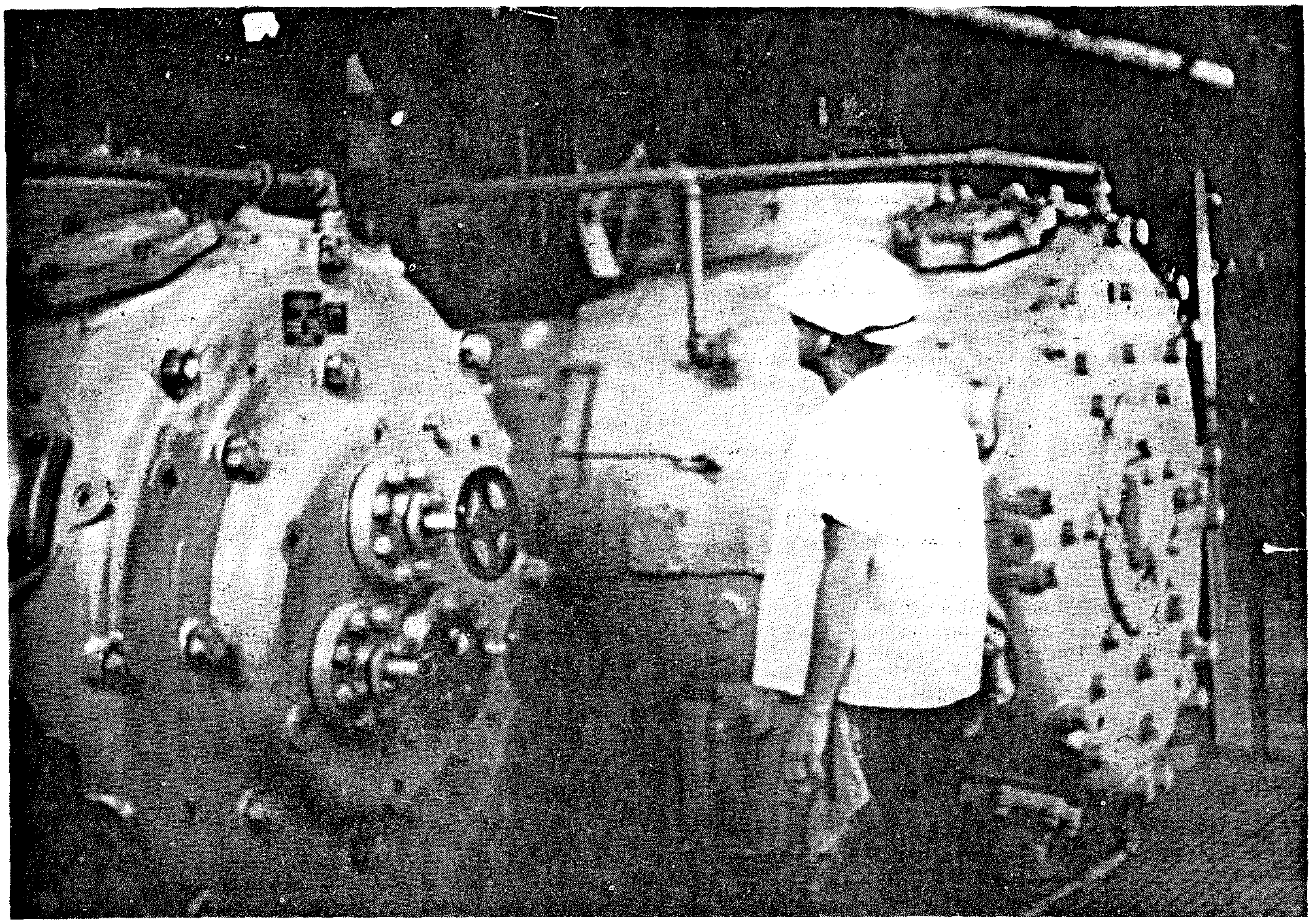

Figure 1. Air compressors for secondary reformer.

Safer Preheat Air for Ammonia Plants

Use of glass fiber mist eliminator and synthetic lubricant proves successful; care must be exercised in thoroughly cleaning compressor when switching from petroleum to synthetic lubricants.

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THE COMPRESSION AND PREHEATING of air for the secondary reformers in ammonia plants are potentially dangerous operations. This is particularly true when lubricated reciprocating compressors are utilized, as is the case in older ammonia plants (before centrifugal compressors) and in new smaller ammonia plants.

During the last two years, steps have been taken at Monsanto Co.'s Muscatine, Iowa, plant by which these operations have been made safer. The air compressors, installed when the plant was built at Muscatine in 1962, were lubricated with petroleum oil. The air was compressed to 225 lb./sq. in. gauge and about 250°F after the third stage of compression. Then the air was introduced into the secondary reformer. The compressors are shown in Figure 1.

In early 1965, the possibility of preheating the air from the compressors to temperatures well over 600°F was considered as a means of increasing reforming capacity. Several courses of action were considered in making this change.

Some wrong approaches

The first approach which was considered and quickly discarded was simply to add a heater. This approach would have been extremely hazardous. The petroleum oil lubricant for the compressor had a flash point of about 400°F and a fire point of 525°F. The air leaving the compressor and entering the heater would have contained oil, and a fire or explosion would have been likely.

Also, our operating experience with the petroleum lubricated compressors showed that sizable quantities of carbon were accumulating in the compressors and their accessories. A fire or explosion even before the heater appeared probable if operations were continued with such deposits present.

It was then suggested that the oil be removed by installing a highly efficient mist eliminator in the air stream at 250°F and 225 lb./sq. in.

gauge before the new heater and after the existing petroleum oil lubricated compressors. However, the vapor pressure of petroleum oil lubricants was checked, and it was found that most of the oil in the air at 250°F would be present as vapor and not mist. Therefore, even if a highly efficient mist eliminator were installed, a considerable amount of lube oil would pass into the heater. Fires or an explosion would be likely.

Safer, but expensive

In a third approach the following train of equipment was considered:

1. Existing oil-lube compressors
2. New after-cooler to lower air temperature to 100°F where the petroleum oil would have a low vapor pressure
3. New high efficiency fiber mist eliminator
4. New activated carbon adsorbers to remove oil vapor
5. New heater to raise 100°F air to preheat temperature

Following this approach essentially all of the petroleum oil could have been removed from the air prior to the heater. However, a fire or explosion could still occur in the compressors or their accessories, since sizable quantities of carbon from the petroleum oil had been found in the existing compressor system.

This approach was expensive in respect to both initial equipment costs and operating costs. Air would have to be cooled only to be reheated. Activated carbon would have to be replenished, and adsorbers would have to be carefully maintained. If the maintenance of the adsorbers were neglected, oil vapor would enter the heater, and a fire or explosion might occur.

What was finally done

The fourth approach considered and the one used was as follows:

1. A fire-resistant low vapor pressure synthetic lubricant was used for the compressors' cylinders. (Minor modifications were made on the compressors.)
2. A glass fiber mist eliminator was installed to handle the air at 250°F and 225 lb./sq. in. gauge.
3. A new heater was installed.

A phosphate ester type synthetic lubricant was selected for the compressors. This lubricant is reported to have a vapor pressure of about 1.0×10^{-5} mm. Hg at 250°F. It has an auto ignition temperature of 1,150°F and passes hot manifold tests at 1,300°F. Calculations indicated that the amount of this fluid which might be present as a vapor at 250°F would be extremely small.

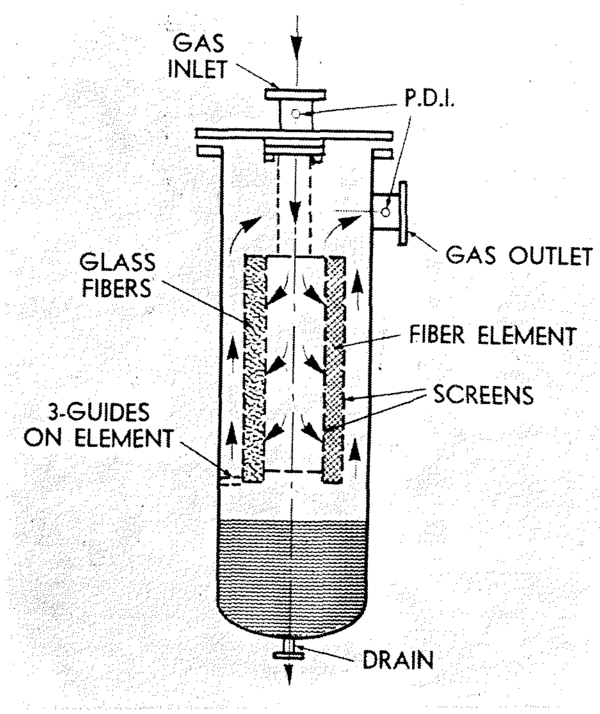
Oil scraper rings were installed on the compressors' rods to prevent a build-up of synthetic lubricant in the crankcase oil. The crankcases of the compressors had been painted with a paint which would have been attacked if the concentration of the synthetic lubricant in the oil had reached 4%.

The mist eliminator installed

The type of fiber mist eliminator which was installed is shown in Figure 2. The mist eliminator was designed to remove essentially 100% of all mist particles larger than 3 microns in size and 99% of all remaining mist particles 3 microns and smaller than 3 microns in size (*1, 2, 3, 4*). It was designed to have a pressure drop of 1 lb./sq. in. or less.

As shown in Figure 2, the air enters at the top, flowing into the core of the element, passes through the glass fiber bed, passes up the annulus between the element and the tank, and then leaves through the tank nozzle on the side near the top. The mist collected on the surface of the fibers drains through the fiber bed and down the outside surface of the element. The liquid drips from the bottom of the element to the tank sump, from which it is manually blown down.

The element is constructed of special glass fiber and carbon steel and is 18 in. in diameter by 96 in. long.



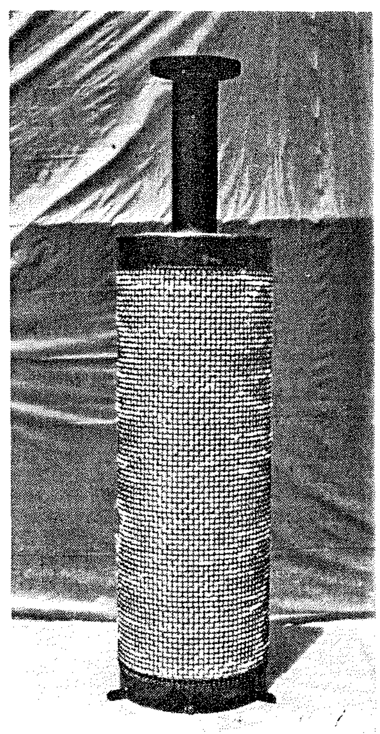


Figure 2. Fiber mist eliminator.

It is installed in a 24-in. O.D. tank which is 10 ft.-9 in. high. A similar element is shown in Figure 3.

The fiber mist eliminator installation in the plant is shown in Figure 4. The mist eliminator tank and piping were insulated to reduce heat losses and reduce fuel requirements for the preheater. Also, since the metal surfaces were hot, the insulation protects personnel working in the area from possible burns. The preheater installation is shown in Figure 5.

Startup precautions

Since the existing compressor system contained petroleum oil and carbon deposits which could not be easily removed beforehand, it was decided that the new heater for preheat air would not be brought up to temperature initially. After the fiber mist eliminator was installed, the compressors were modified and lubrication with the fire-resistant synthetic lubricant was started.

Samples of the drainage from the fiber mist eliminator were taken and sent to the laboratory for analyses. Each sample was analyzed for percentage hydrocarbon and the flash point. The first drainage after startup analyzed 95% hydrocarbon contamination and 5% synthetic lubricant. It took 6 months' operation before the hydrocarbon contamination level fell to 20%. During this time period the preheat air temperature to the secondary reformer was held below the flash point of the drainage from the mist eliminator.

Operating experience

The new system has been in operation over a year. Maintenance experience with the compressors lubricated with the synthetic lubricant has been excellent. The last analysis of the crankcase oil showed that it contained 0.15% synthetic lubricant or very little buildup for almost a year's operation.

The fiber mist eliminator has operated continuously without maintenance, and the pressure drop has remained low even in handling viscous mixtures of synthetic lubricant and carbon deposits. The drainage from the mist eliminator has been blown to waste except when samples have been taken.

The synthetic lubricant is collected at several points in the compressor system. Therefore, the drainage from the fiber mist eliminator represents only a part of the total lubricant recovered. Samples

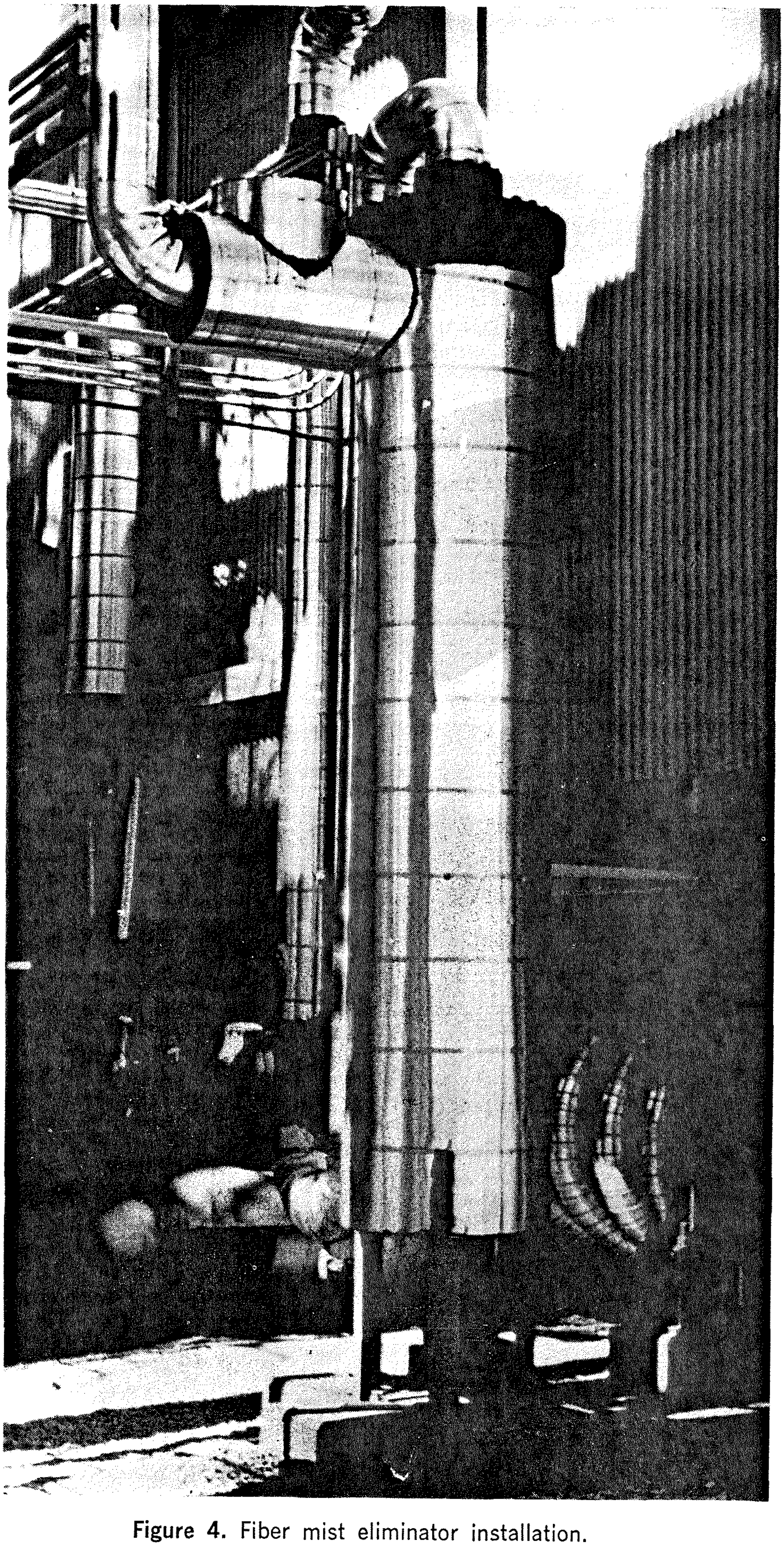
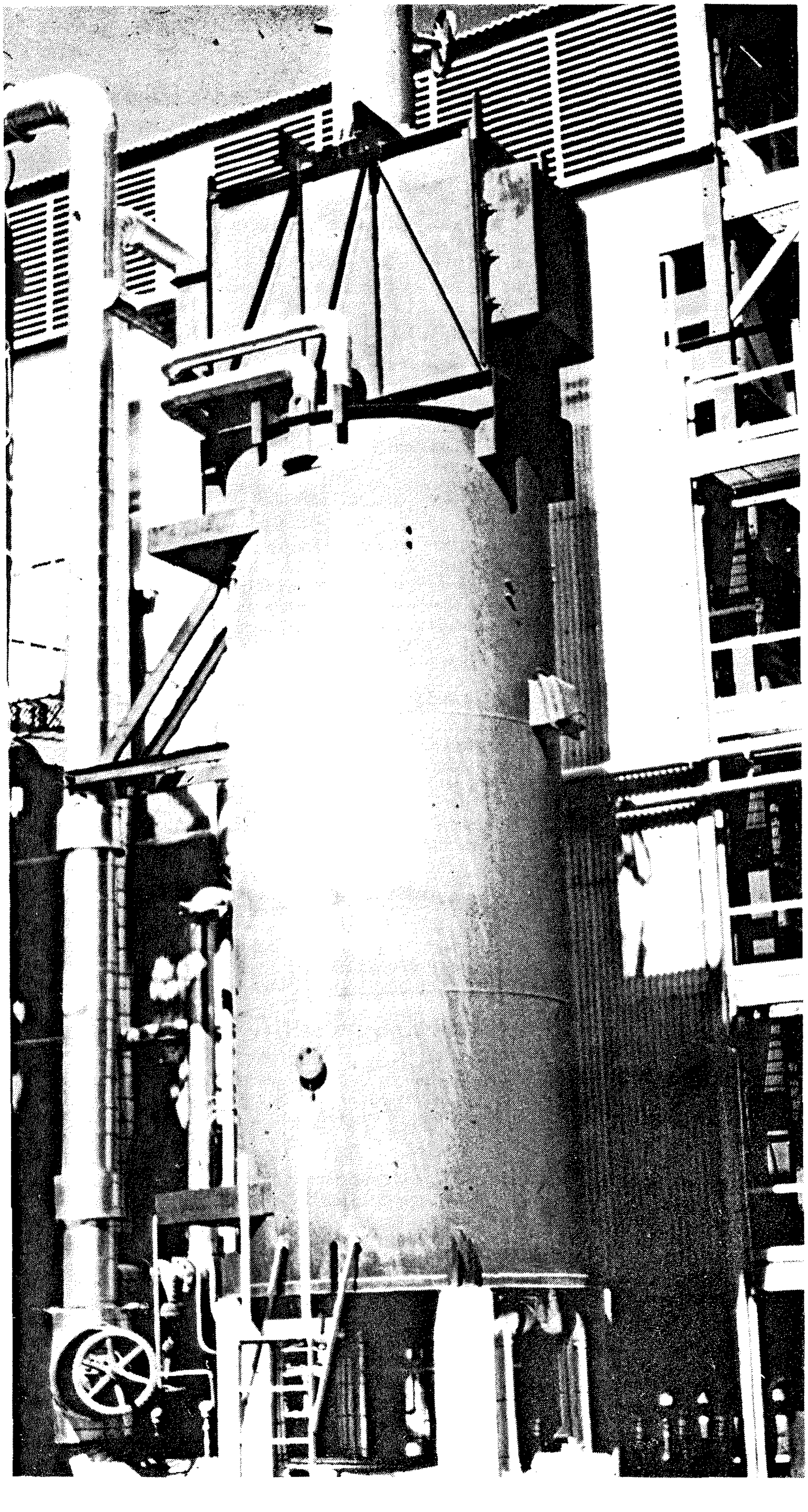


Figure 4. Fiber mist eliminator installation.



of the drainage from the fiber unit showed that 170 ml./day are collected on the average.

It should be noted that the length of time required to remove hydrocarbons from a compressor system, after a switch-over to a synthetic lubricant is made, will vary from one installation to the next. The use of a synthetic lubricant is not absolutely safe when a compressor system is badly contaminated with carbon and hydrocarbon deposits. Therefore, the compressor systems should be cleaned thoroughly at the time of the switch-over. The cleaning should include snubbers and suction bottles even if they have to be cut apart for the complete removal of carbon deposits.

Preheat air temperatures, after a year of operation, have been increased, and the desired capacity improvements have been achieved. The new system with the synthetic lubricant has had no detrimental effects on the catalyst or process to date.

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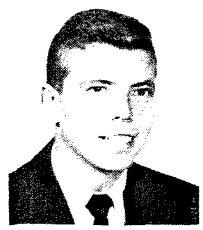

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