A few flanged joints, particularly in hot lines, tended to leak but generally could be sealed by dropping the pressure 1,000 to 2,000 p.s.i. and raising it again when the leak had stopped. A leak at one flange in the center bank of the feed-product exchanger could not be completely stopped by this procedure but did not become serious enough to require stopping operations. Otherwise, performance of high-pressure valves, fittings, piping, and vessel closures was satisfactory.

Summarizing, in addition to producing good-quality gasoline this run proved that:

1. Oils containing very high percentages of tar acids can be processed over K-536 catalyst.

2. Feed stocks with wide variations in composition can be processed with almost equal facility.

3. Distillation is essential for removing undesirable high-boiling polymers and solids from feed stocks that have been stored for long periods.

4. Constant temperatures in catalyst beds can best be maintained by combined manual and instrument control of cooling gas.

5. It is feasible to heat vapor-phase feed stocks in the presence of only small amounts of hydrogen to 700° to 750° F. without coking, allowing gases and oils to be heated separately under the most favorable conditions, using equipment that is most economical to build and maintain.

1952 Plant Improvements and Future Program

The principal developments during the past year and the main problems requiring further development work and studies are summarized.

1. New high-pressure injection pumps have been manufactured and are available, both in simplex and duplex arrangement (see fig. 3). In addition to effective plunger guiding and sturdy pump alinement, the new design incorporates the following features:

a. Compound two-layer fluid end construction, resulting in uniform stress distribution, lower unit stresses, and thinner walls that can be thoroughly forged and inspected before assembly.

b. Valve ports, plunger space, and stuffing box an integral unit, eliminating several joints and attendant bolting and sealing problems.

c. No bolt holes in the inner pressure cylinder.

d. Fine machine finish on all internal surfaces.

e. Spring-loaded, short length, plastic chevron-ring packing assembly.

f. Improved packing lubrication, employing the principle of injecting the lubricant from the low-pressure end during the suction stroke (see fig. 4).

g. Centrally located steam drive.

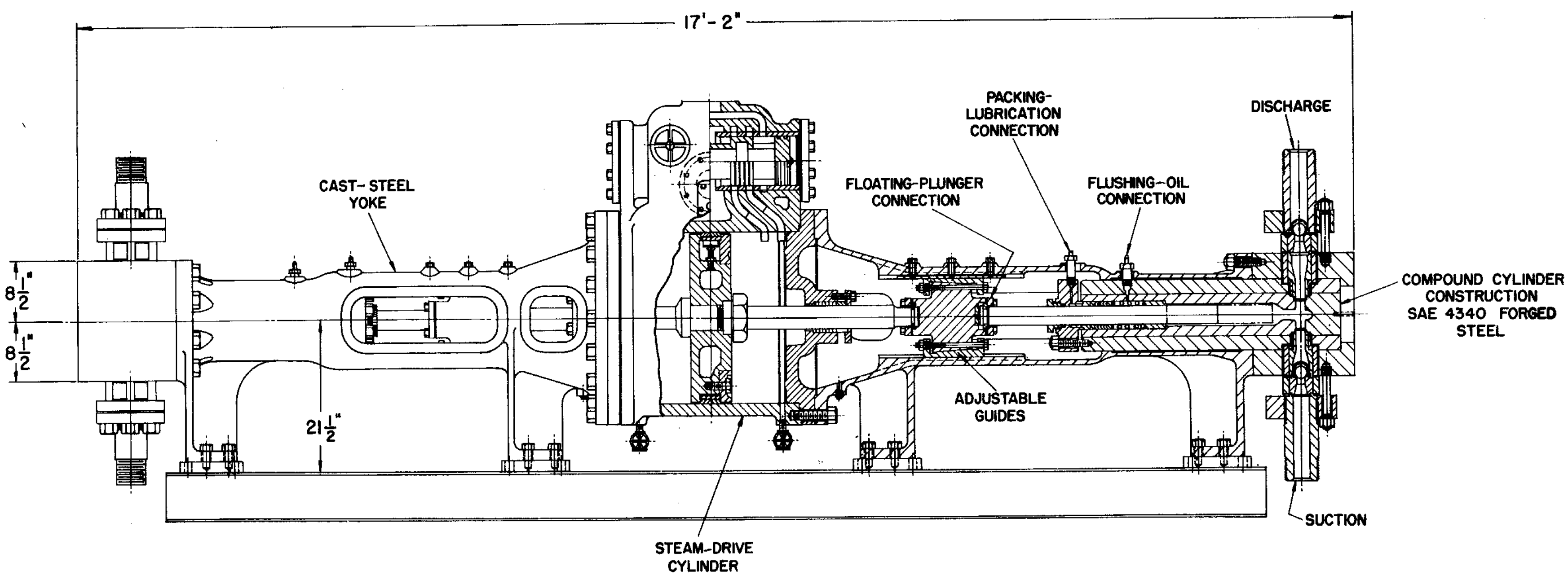

Figure 3. - New high-pressure injection pump.

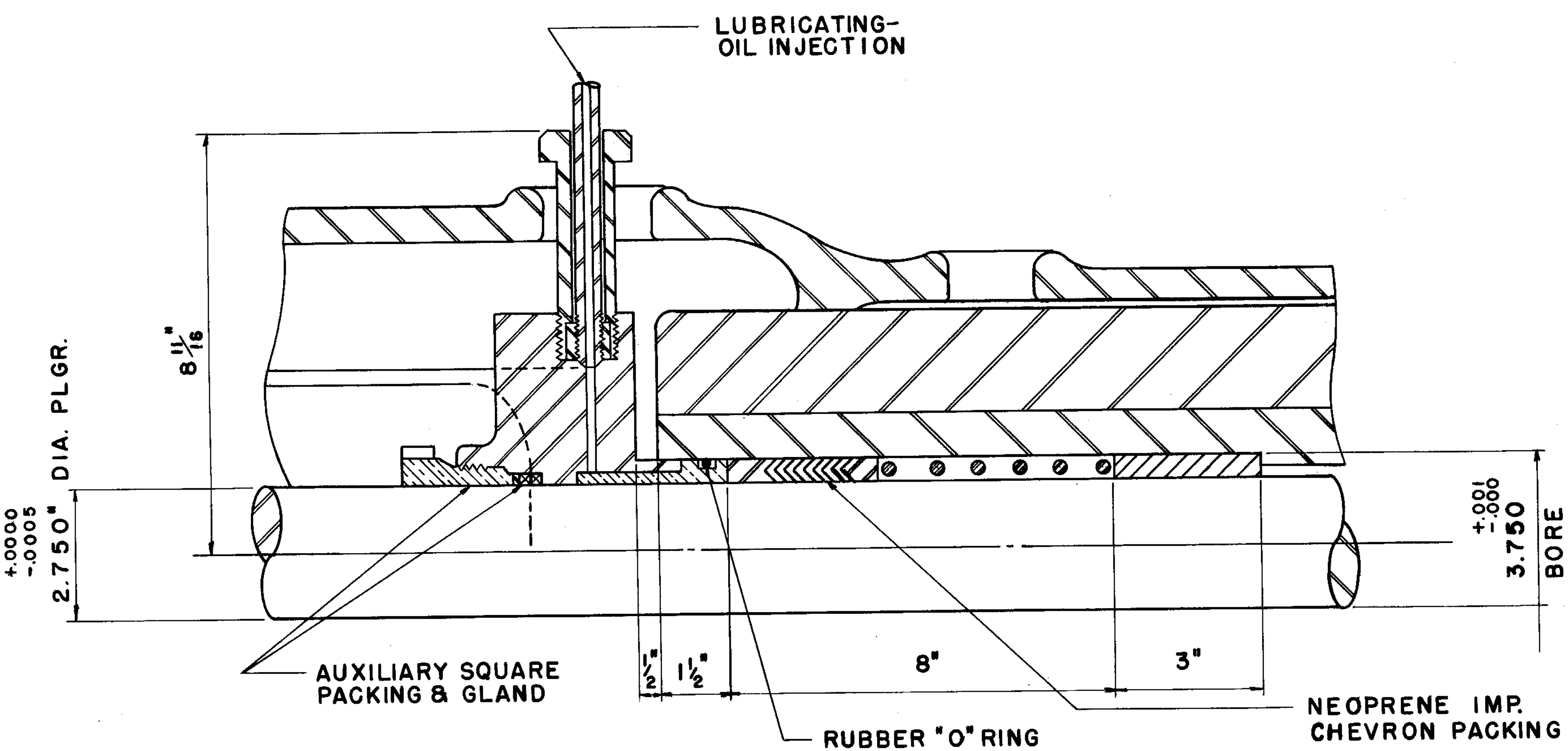

Figure 4. - New high-pressure injection-pump packing gland.

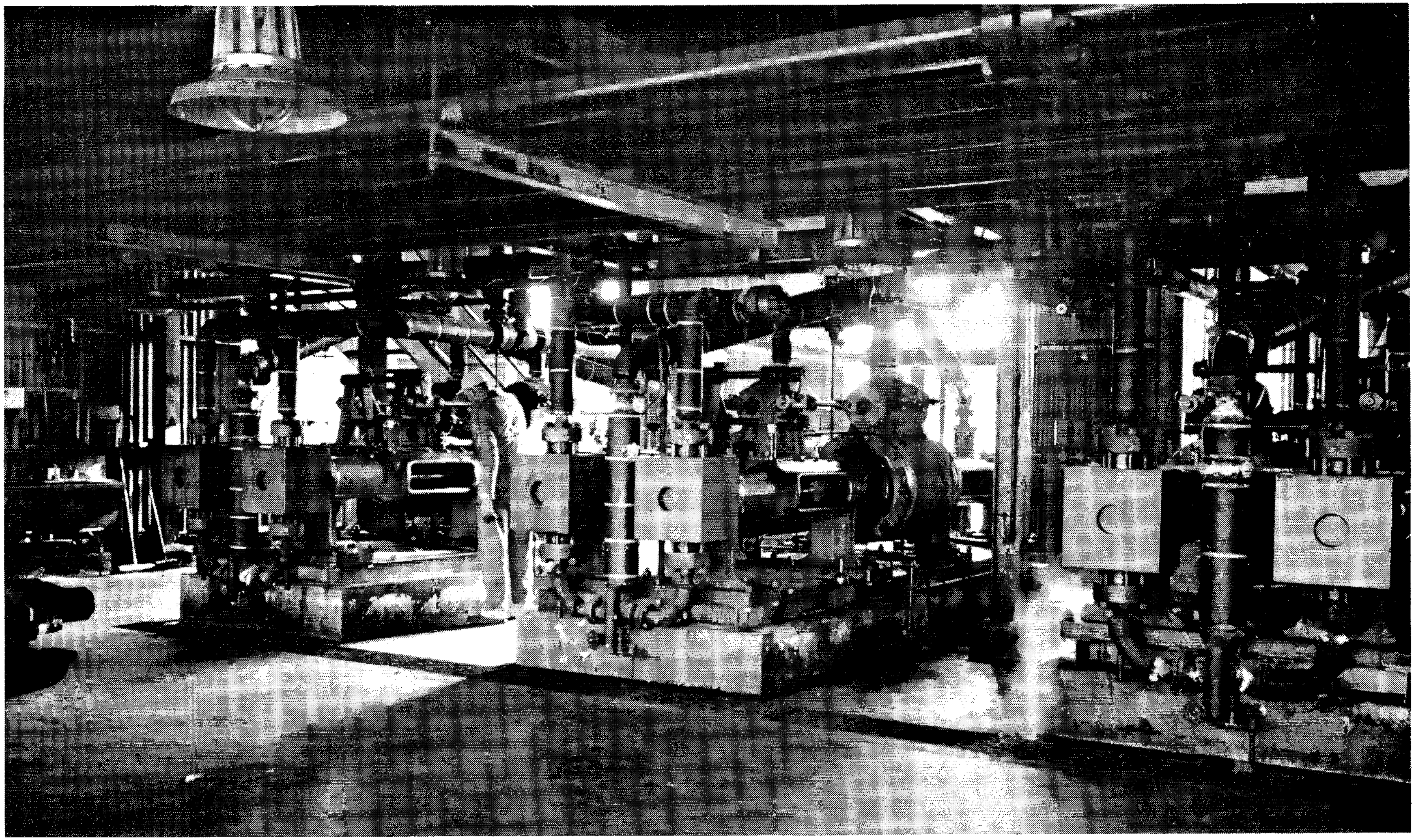

Figure 5. - Paste-injection pumps.

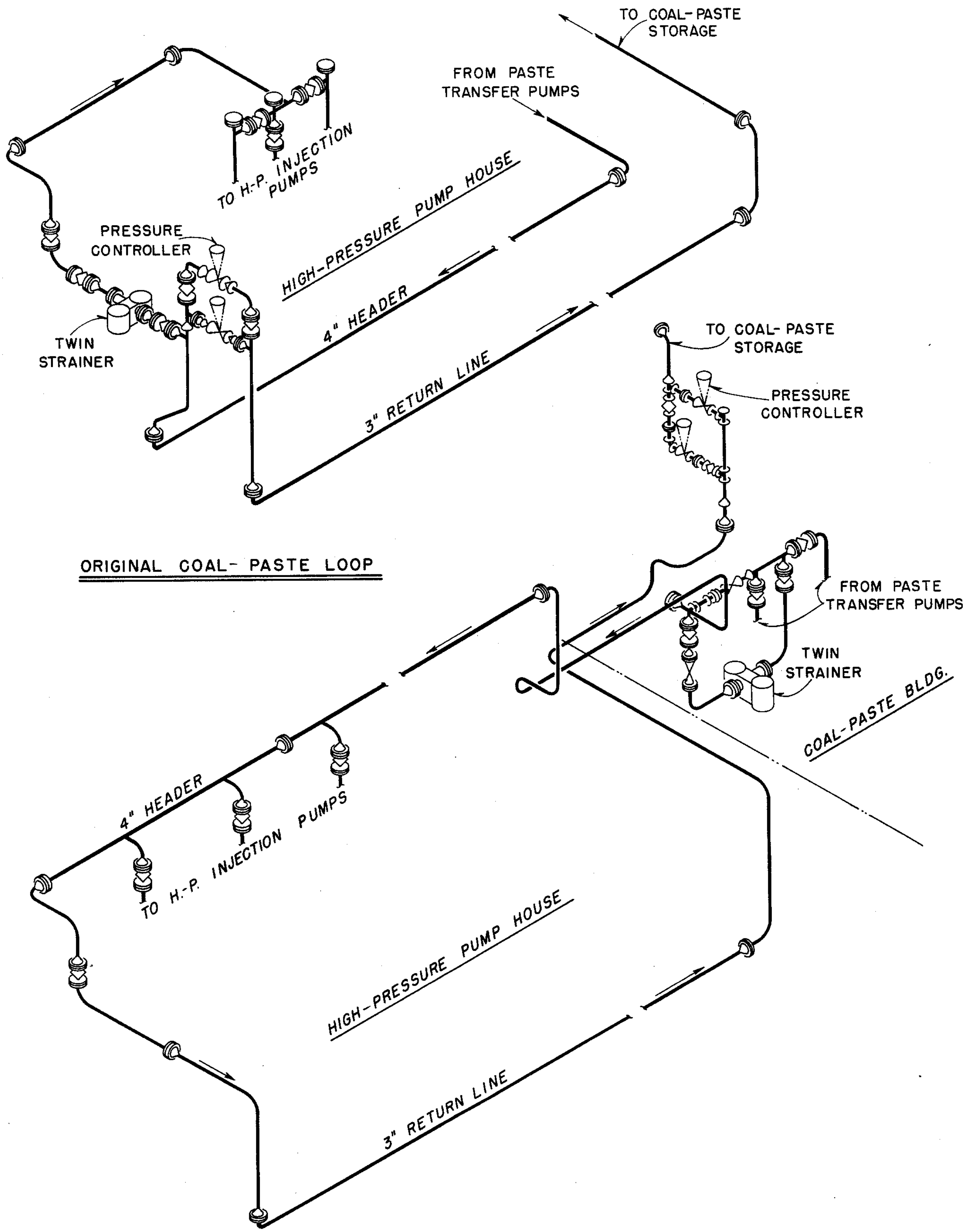

Figure 6. - Original and modified coal-paste loop.

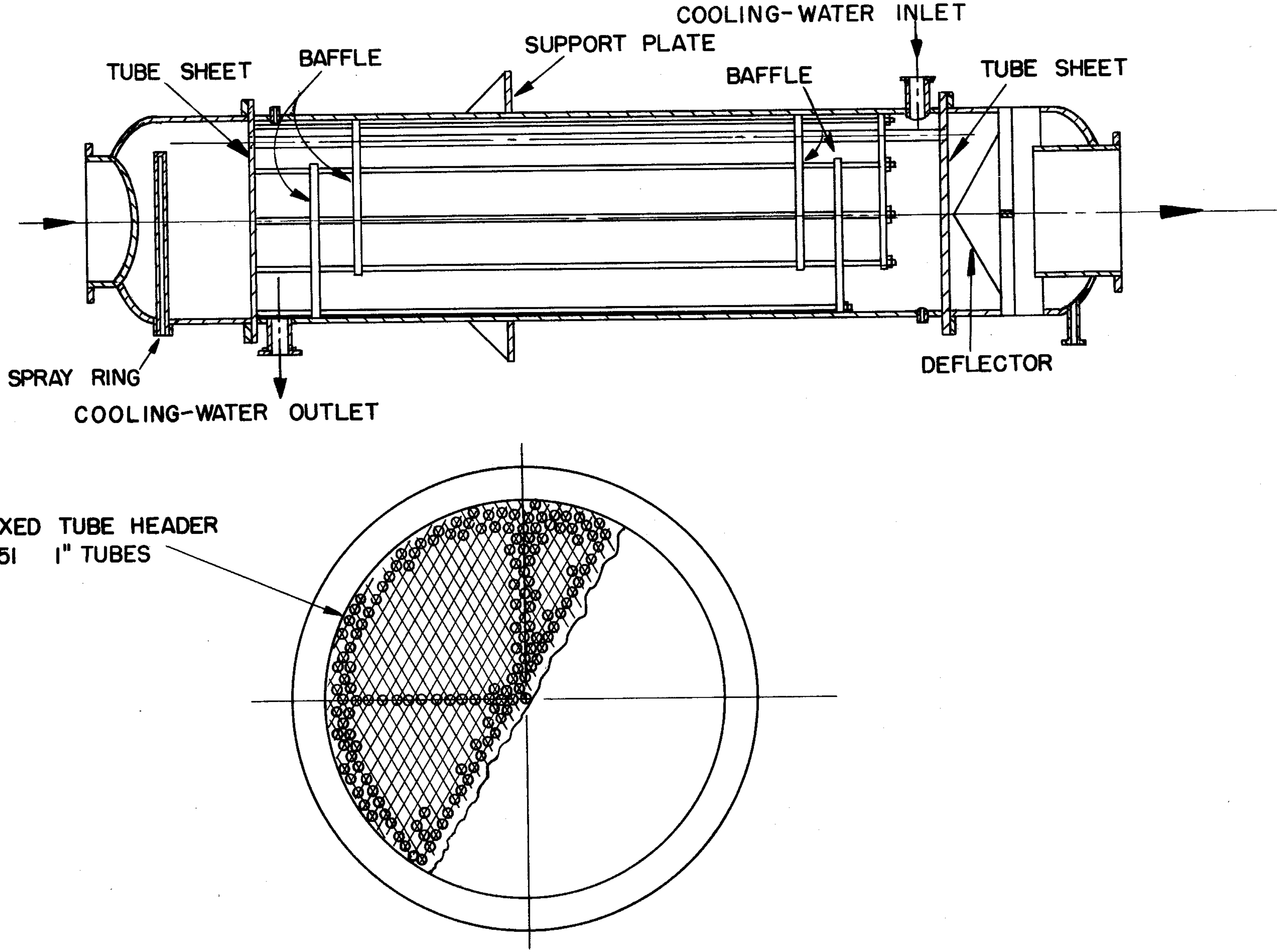

Figure 7. - Cross section of flue-gas cooler.

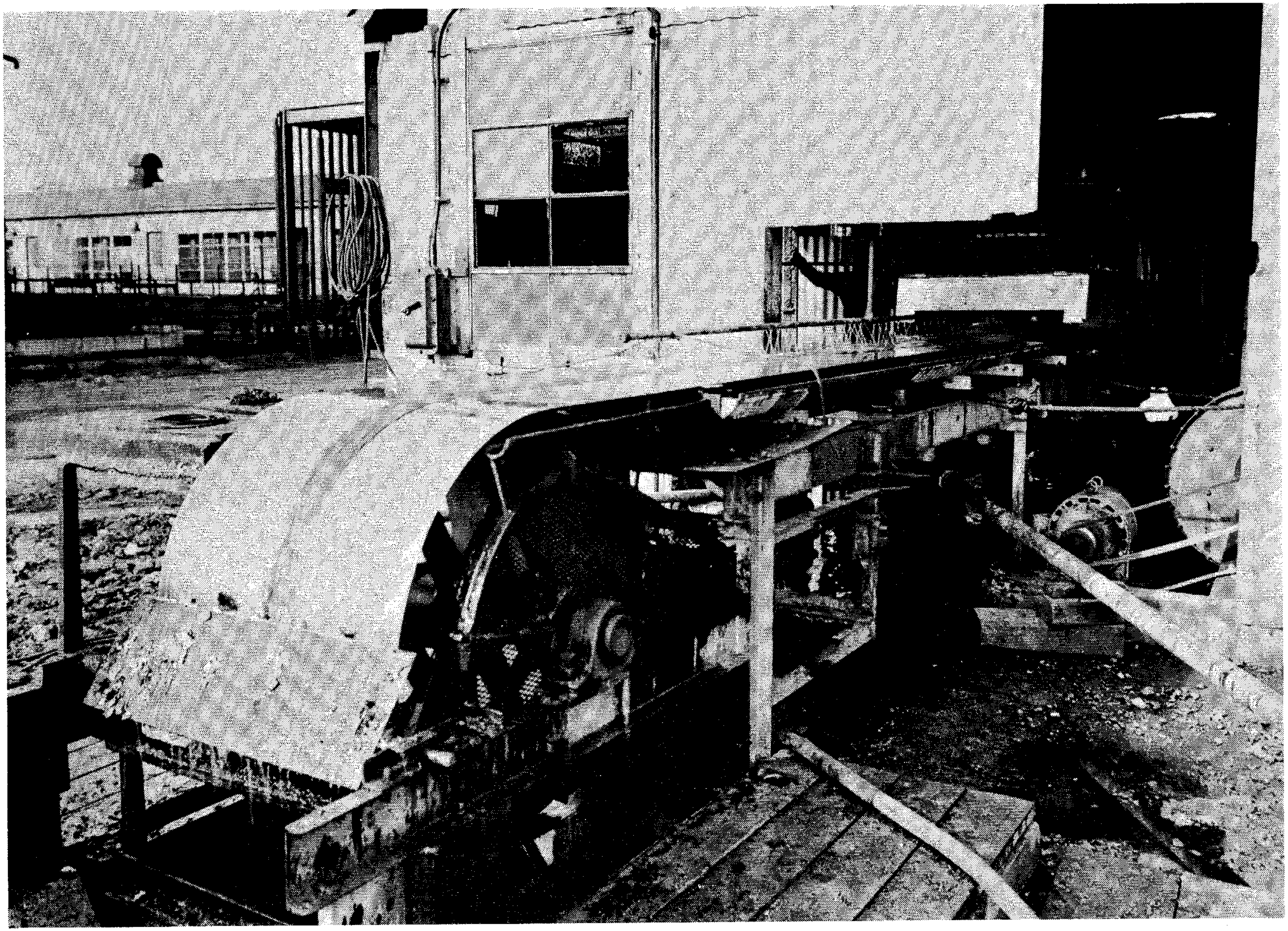

Figure 8. - Water-sprayed metal-belt-conveyor pitch-disposal unit.

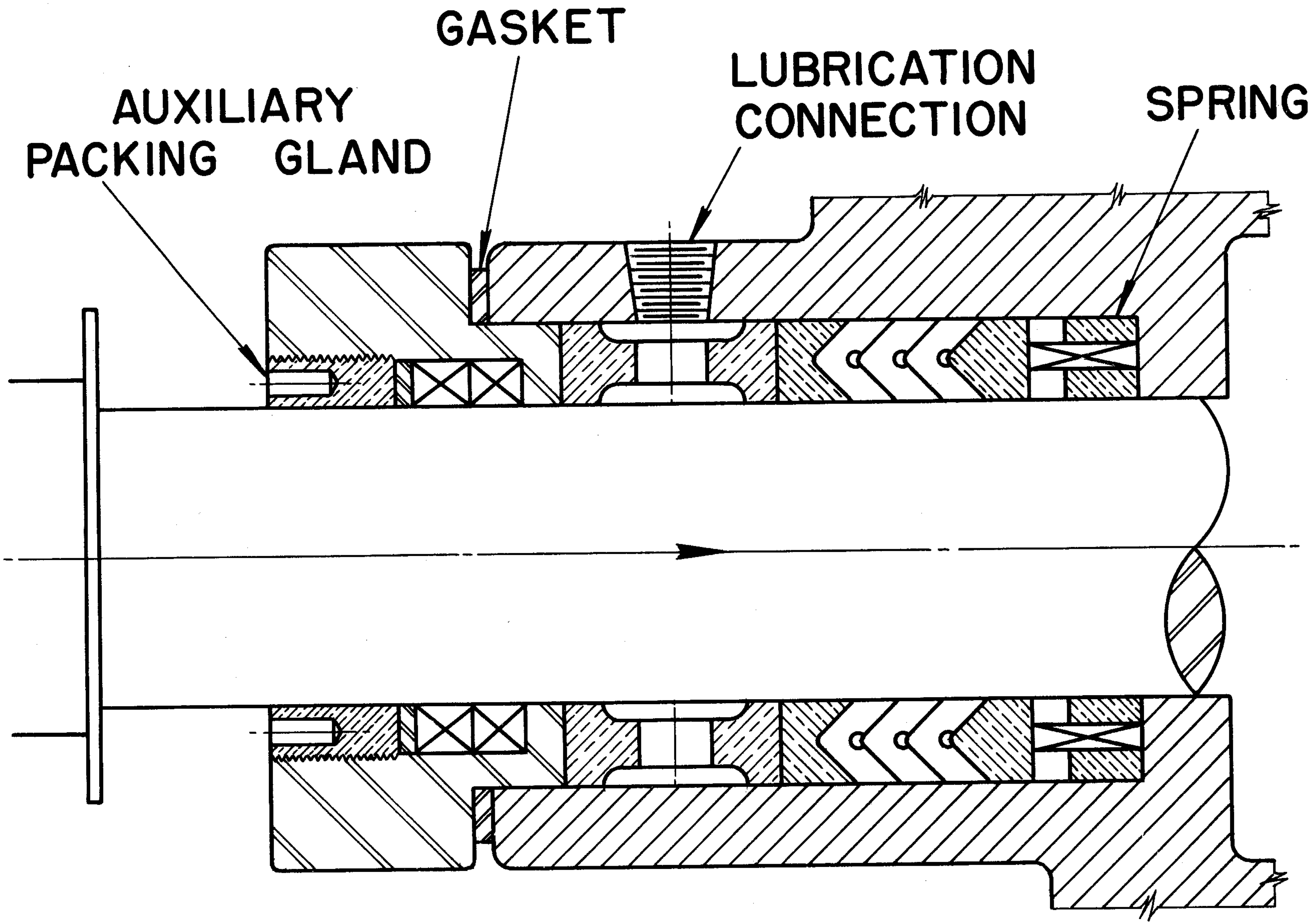

Figure 9. - Centrifugal pump packing for heavy-solids-bearing oils.

Three of the new duplex pumps have been installed (see fig. 5) in the paste service and are giving excellent performance, particularly as regards control, smoothness of operation, reliability, and durability of moving parts.

The revised paste circuit includes major revisions of the paste loop (see fig. 6) to simplify the manifolding, both at the paste-circulating and injection pumps, and transfer of the paste strainers and back-pressure control system from the injection pump house to the paste-preparation building, where the over-all pasting and circulating operation is now efficiently controlled by the paste-preparation operator.

2. A number of changes were recently made to simplify and increase the capacity of the coal-preparation plant. Improvements include a recycle-gas cooler (see fig. 7) to remove moisture from the circulating inert gas; a sifting machine to remove coarser than 30-mesh material from the pulverized coal more efficiently than is possible with a classifier; a simpler and more positive arrangement for adding dry catalyst to the raw coal (stoker feeder), immediately followed by water sprays to simulate direct impregnation in hopes of obtaining nearly the same results as would be achieved if it were feasible to directly impregnate the dry, pulverized coal with the rather corrosive iron sulfate catalyst solution.

3. Numerous changes were made in the flash-distillation system, used for removing solids from heavy oil, to make this equipment safe to operate with less manpower while recovering a higher percentage of the available oil. The improvements installed and tested include: A new-type flash-tower bottom, with outside electric heaters to keep the pitch more fluid; a recycle line to the original heavy-oil let-down supply tanks to improve the control of feed to the unit and assist in start-ups; installation of a water-sprayed metal belt conveyor (see fig. 8) for cooling and conveying the hot pitch to a portable belt conveyor used for continuously loading the cooled pitch; and new nozzles for flashing the oils that do not require outer-steam compartments, which were subject to frequent coking. Recent provisions for adding superheated steam in the lower section of the flash chamber keep the oil vapors high in the tower, prevent their recondensation in the pitch, and reduce oil fumes at the pitch outlet. The resultant higher bottom temperature (600° F.) also greatly improves flow conditions of the thicker pitch.

4. Considerable study and experimentation were carried on to find the proper packing and application of such materials in various injection services, as well as in pumps handling oils containing solids at moderate pressures. Packing arrangements, which allow lubricating oil to be supplied continuously through the packing, have been successfully applied and tested in water- and oil-injection pumps and in hydrogen-circulating compressors operating at high pressure on both suction and discharge strokes. Several successful applications of lubricated chevron packing have also been made to centrifugal pumps (see fig. 9), for pasting oil containing abrasive solids and operating at pressures up to 125 p.s.i.

5. Noteworthy improvement was obtained in liquid-phase conversion after installation of a new piping arrangement, to allow continuous desanding of the converters direct to the hot catchpot without substantial let-down of pressure. Steam tracing, additional cooling gas lines to the converters, and a new cooling gas meter for measuring the flow of tempering hydrogen to the outlet of the paste preheater have made it possible to control the initial reactions in the first converter more closely and to decrease the paste-heater load to a minimum required for initiating and sustaining reactions.

To increase converter space-time yields and to decrease formation of solids in converters, a comparative study was made between operations of European plants and the demonstration plant. The results indicate that plants wherein the slenderness ratio (that is, length divided by diameter) did not exceed 55, operated with the following characteristics:

1. Difficult converter-temperature control.

2. Unequal distribution of hydrogen.

3. Low liquid velocities resulting in deposition of solids in the last converter.

4. Excessive quantities of hydrogen required through the preheater for creating a minimum velocity for turbulence condition.

5. Tendency toward high production of gas.

6. Necessity of operating at relatively low temperature.

7. Low throughputs and yields.

In view of this experience and study, consideration is being given to further decreasing the demonstration-plant converters from 21 inches to 16 or 18 inches in diameter and to use of the spare converter as a third liquid-phase converter, which would provide additional cooling-gas points and a slenderness ratio conducive to more favorable processing conditions.

6. Ease of installation, cleaning, inspection, maintenance, and safety of welded flexibly supported hot stall tubing have been proved by a series of successful runs, which included several periods of wide fluctuations in pressure and temperature, some under severe emergency depressuring or shut-down conditions. None of the welded piping has failed, and no serious leakage difficulty has resulted at clean-outs, joints connecting long runs of pipe, or joints near anchors.

7. The former seven-pass, vapor-phase, feed-product heat exchanger gave very unsatisfactory results owing to frequently plugged or coked tubes, which caused unsteady heat transfer. It now functions smoothly, since the number of parallel passes was reduced to three, provision was made for cleaning both sides of the inside tubes, and it was repiped to allow separate heating of the gas and liquid streams before mixing. Likewise, the original split-flow-type vapor-phase preheater proved unsatisfactory because of localized hot spots and poor temperature control. After rearrangement for series flow, the performance and temperature control are excellent, with little or no indication of hot spots or coking.

8. The accuracy and mechanical functioning of the pulverized coal-weighing equipment (star feeder and Waytrol) have been greatly improved by removing most of the Waytrol cabinet to allow proper inspection, cleaning, servicing, and adjustment of the equipment. Installation of a variable-speed drive on the star feeder improved its operation and the over-all coal-weighing operation. A special chute to direct the coal flow to calibration equipment has recently been put in service to check the coal rate periodically.

9. Frequent and accurate measurement and recording of converter temperatures have been secured by installing two dynalog, rapid-balancing, multipoint instruments, using circular charts. These instruments permit critical converter points to be observed, compared, and quickly corrected for safe, efficient operation.

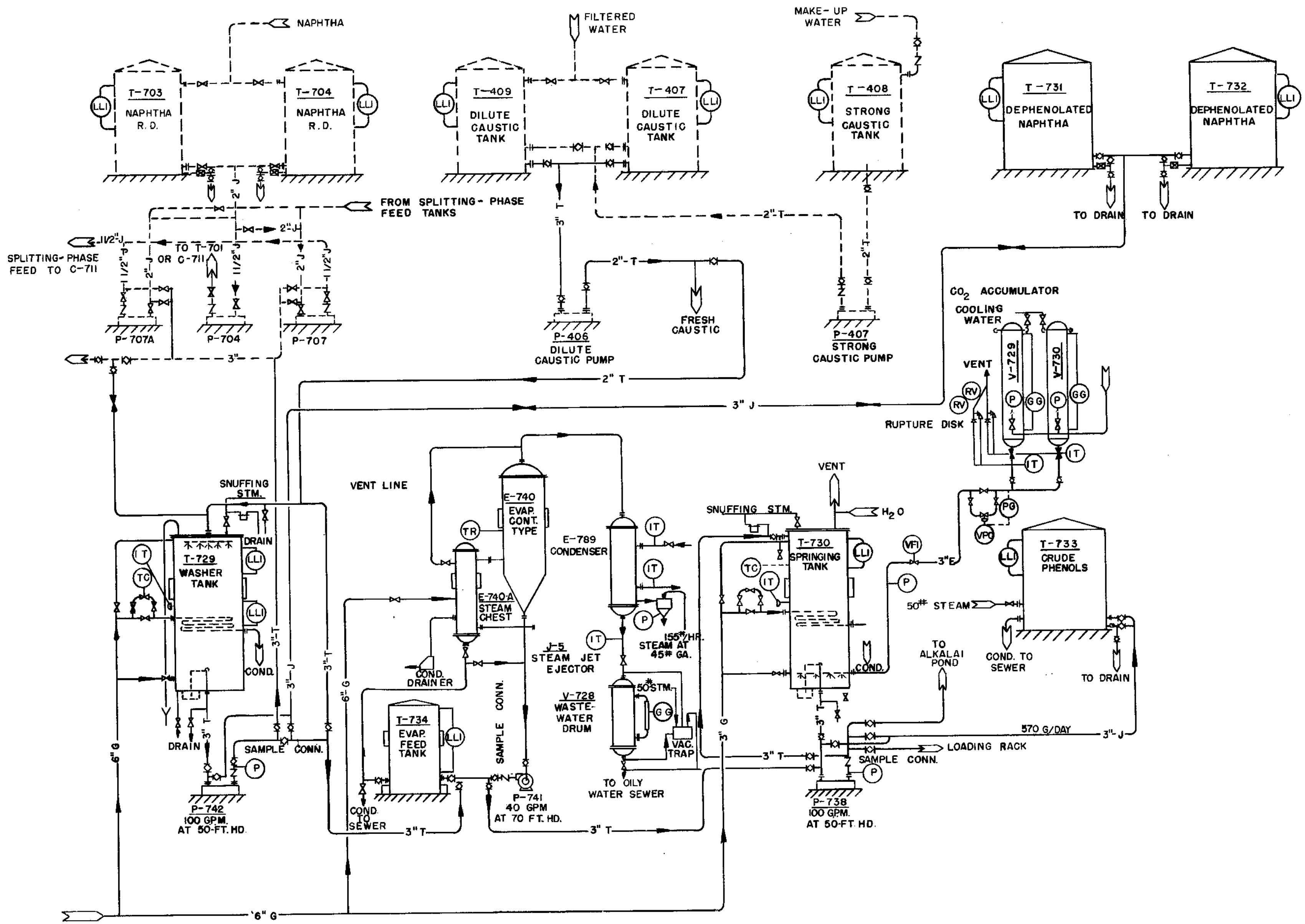

Figure 10. - Tar-acid recovery-unit flow diagram.

10. Considerable progress has been made in solving the very troublesome problem of measuring heavy-oil streams containing solids. Pasting oils, containing 8 to 10 percent solids, are now measured quite accurately with orifices and close-mounted differential-pressure-converter cells. A Venturi tube with a differential-pressure-converter cell has been used to measure heavy-oil let-down flash-distillation feed with fair success, and similar installations for measuring paste streams are ready for trial runs.

11. Despite extensive steam tracing, winter operations impose very severe instrument-control and measuring problems. Fresh hydrogen blow-back connections recently made to the cold catchpot and wash-oil liquid-level instrument lines should aid in preventing freeze-ups and salt plugging in some of the equipment, which still does not function reliably under subfreezing conditions.

12. A tar-acid-recovery unit for treating large batches of naphtha is under construction (<u>see</u> fig. 10). With this unit in periodic service, it will be possible to separate the commercially recoverable tar acids, which will then be made available through cooperative agreements to companies interested in their further evaluation. It is also planned to determine the effect on gasoline quality, yields, and process conditions of removal of these materials from vapor-phase-feed stocks.

13. Four additional tanks were installed in the heavy-oil area to supply clean, heavy oils to make up deficits incurred during high conversion operations, presupposing a more efficient solids-removal, oil-recovery system available. A second larger section was added to the oily water separator to alleviate stream pollution and provide recovery of both heavier- and lighter-than-water oil components from streams entering the trap. These additions permit greater freedom of operation and improve the accuracy and completeness of material balances.

Continued and substantial progress was made during the past year; however, some old problems and a number of new ones require development work. These problems generally involve improvement of process-coal weighing, removal of solids, liquid-phase conversion, instrumentation, and high-pressure pumping facilities.

Batch-type pulverized-coal-weighing equipment is on order, and its installation in parallel with the present star feeder and Waytrol system should go a long way toward checking and accurately determining the coal actually fed to the process.

It is expected to improve operation of the flash-distillation unit to a point where less than 1 pound of oil will be lost per pound of solids removed and a more operable unit will be developed. It is planned to accomplish this by modifying the flash nozzles, by continued use of superheated steam in the lower flash tower, and possibly by reducing the length of the flash chamber to prevent cooling and condensation of lighter oils in the pitch. This should allow a higher-solids-content pitch to be withdrawn but reduce the need for overflashing, with its consequent coking of the furnace tubes and flash nozzle chambers. Arrangements have been provided to operate the Bird and DeLaval centrifuges experimentally in series so that all filtrate will be withdrawn from the DeLaval and all residue will be produced by the Bird centrifuge. By this method a cleaner feed is delivered to the DeLaval, which should make it more operable and produce a cleaner filtrate and higher solids-content residue. Some test work has been begun to evaluate sole ovens for oil recovery and solids removal from heavy-oil let-down. This work may be extended by an agreement with a nearby carbonizing and engineering company, which has small-scale equipment for such test work. Some laboratory investigations are under way, and two precoat filter companies are willing to cooperate in supplying small test units when the work can be scheduled.