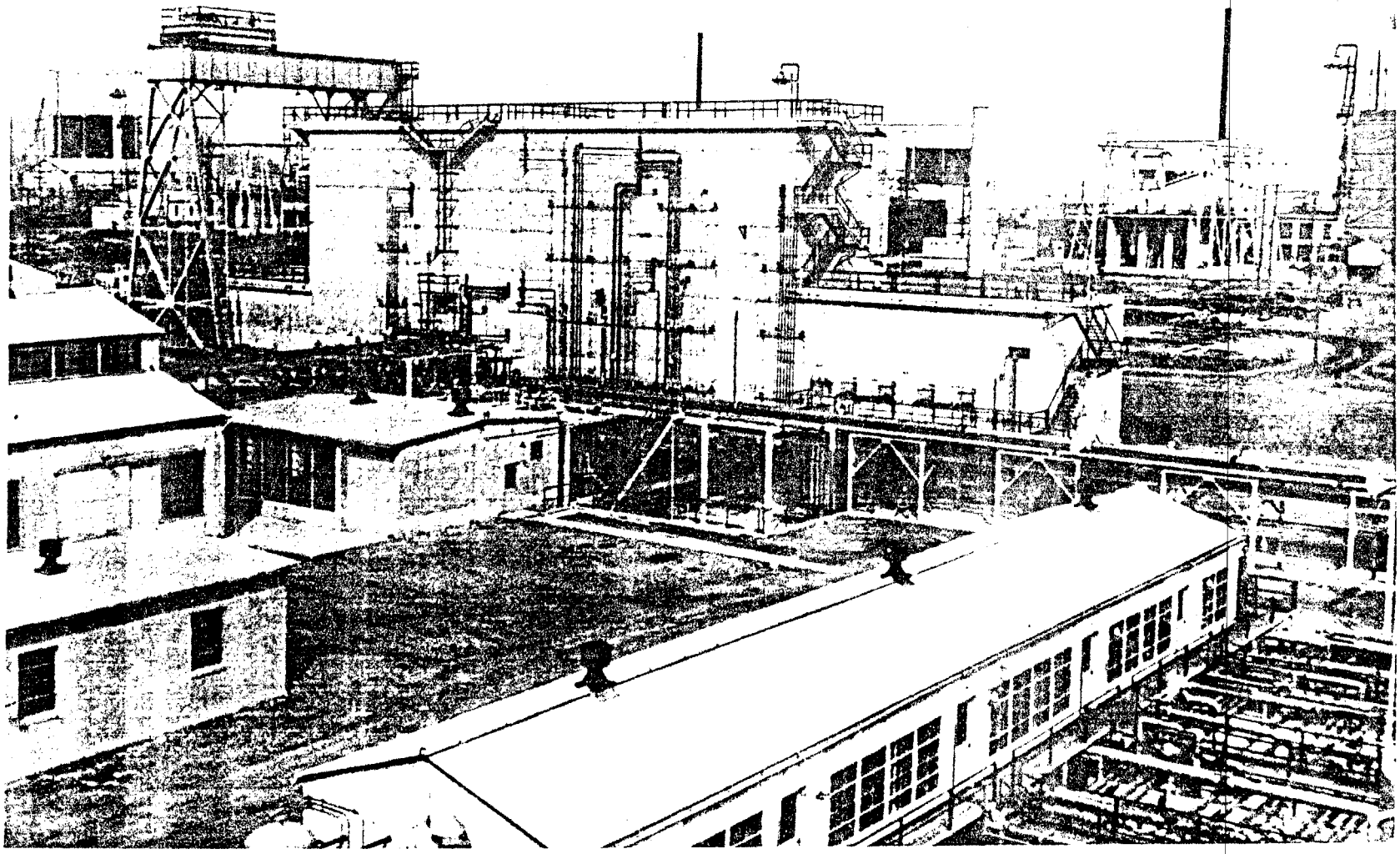


FIGURE 50. - *Rear View of Reinforced-Concrete Structure for Coal-Hydrogenation Stalls at Demonstration Plant; Pump and Control Buildings in Foreground.*

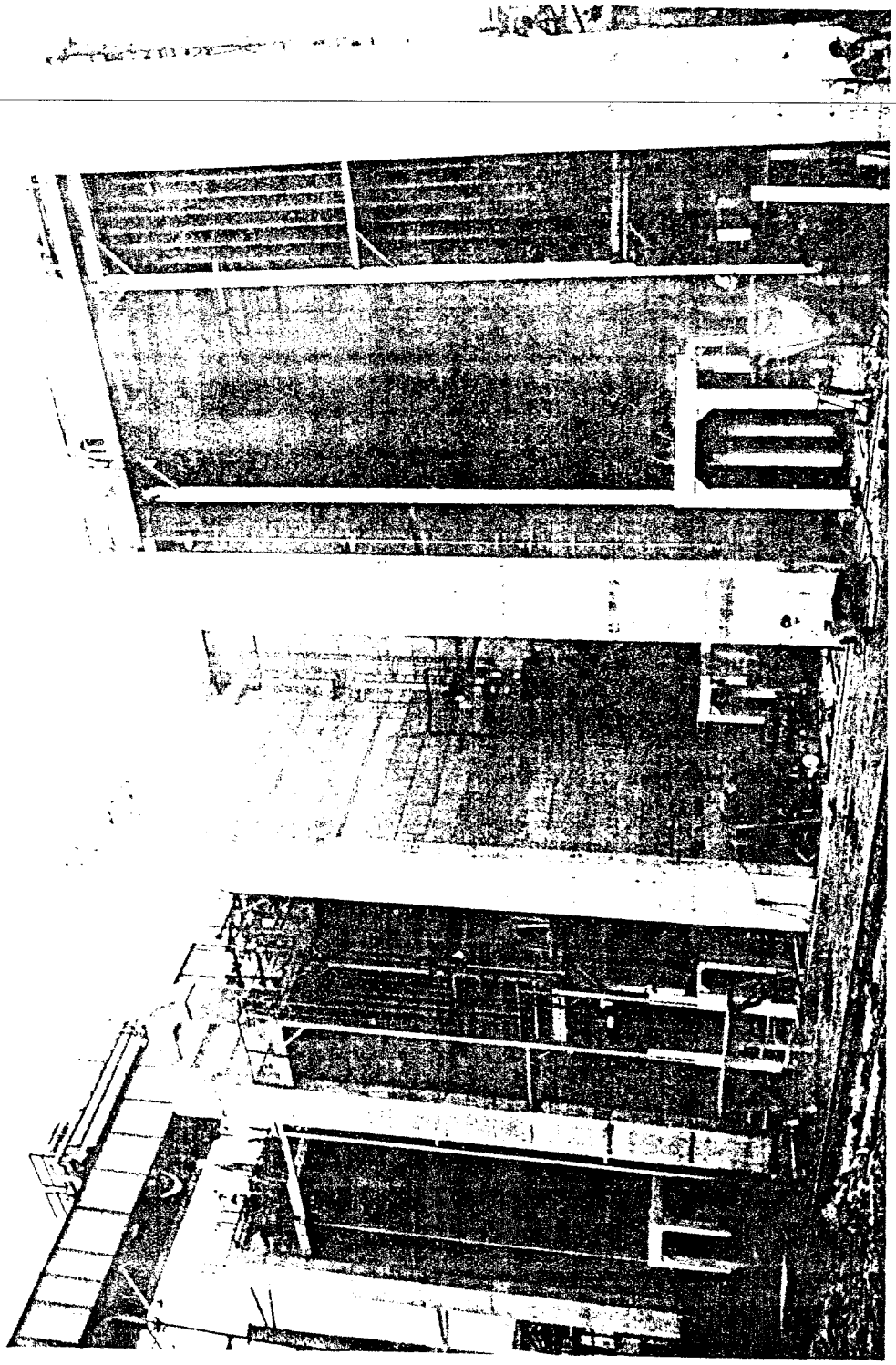


FIGURE 51. - Forged-Steel Vessels in Coal-Hydrogenation Stalls at Demonstration Plant.

The site for the plant was selected late in 1945. Reasons for selecting this site (10) and a description of the proposed 200-barrel-per-day demonstration plant are given in Bureau publications (11). Construction was begun in April 1947.

Cost considerations led to the decision that all equipment installed in the high-pressure area should be suitable for 700 atmospheres (10,300 p.s.i.) working pressure (12). As built, the hydrogenation plant included: Two preheater stalls (one each for the liquid and vapor phase), two hot stalls and two cold stalls, and numerous buildings to house coal and paste preparation, paste injection, high-pressure-hydrogen recirculation, instrumentation, distillation, and pumps (12).

The plant was first operated in February 1949 to produce, in the vapor-phase unit, a high-quality diesel fuel from a tar distillate made by low-temperature carbonization of a North Dakota lignite. This diesel fuel drove the train that transported guests assembled at St. Louis, Mo., to the demonstration plant for its dedication, and return (13, 14, 40). Later that year the liquid-phase unit was brought on stream on high-temperature tar, and subsequently changed over to coal. Six coals, ranging in rank from lignite to high-volatile-A bituminous, were processed, and 1,500,000 gallons of gasoline was produced.

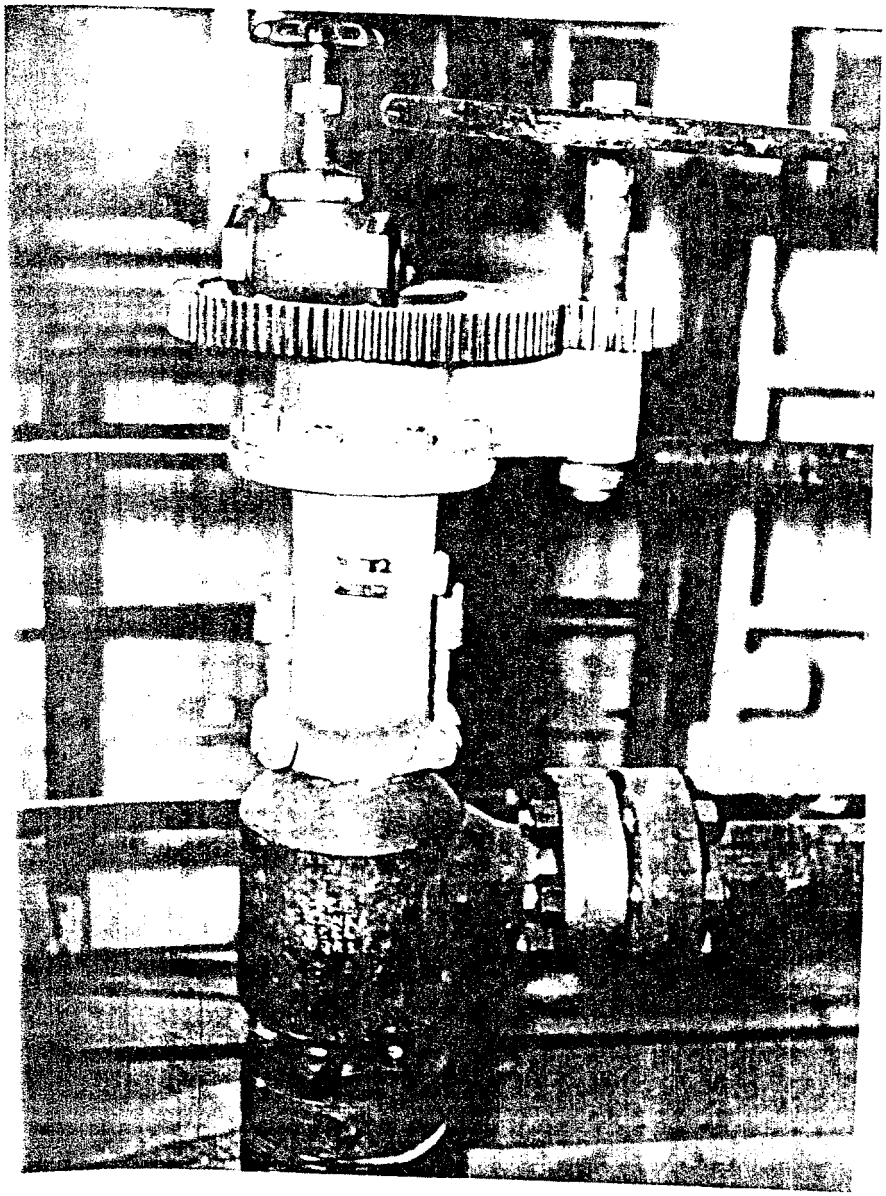
Equipment Development

The German coal-hydrogenation plants used low-alloy steels, heat treated to high strength for hot tubing. American metallurgists advised against undertaking a steel-development program and suggested instead selection of available steel alloys of adequate high-temperature strength and corrosion resistance. This advice was accepted. However, before this demonstration plant was designed and built, there had been no sizable coal-hydrogenation unit in America, and no great amount of information was available on the design and fabrication of high-pressure equipment of this type and size. Some special interest therefore attaches to the equipment eventually utilized.

Pressure Vessels. - Vessels for various services were specified to be of either forged or multilayer types and then were selected on the basis of lowest cost to the Government. The vessels selected had bolted heads and delta gasket seals. Some initial difficulty in making leakproof joints with the delta seals was solved by a slight change in gasket dimensions.

High-Pressure Tubing. - High-pressure tubing presented a special problem. The wall thicknesses required were beyond the experience of the tubing manufacturers. For the highest temperature service, Type 316 stainless steel was selected. One tubing manufacturer accepted an order for a small number of such tubes, with the agreement that the Bureau of Mines would accept the product whether or not a suitable tube was produced. It was found that the tubing manufacturer could draw satisfactory tubes of Type 316 stainless steel by cold finishing and could also draw tubes of low-chrome steels, which were selected for lower temperature service.

High-Pressure Valves. - Valve manufacturers were reluctant to undertake design and production of valves for a working pressure of 700 atmospheres. One large manufacturer finally accepted the job of designing and fabricating such valves, with design assistance from the demonstration-plant contractor and the Bureau of Mines. There resulted a satisfactory family of manually operated valves, ranging from 5/8 to 2-1/2 inches nominal size, essentially the range required for commercial-size synthetic-fuels plants. A starting point for this valve was a 700-atmosphere German valve with its multiple component parts held together by threads. The American-designed valve (see fig. 52) gave trouble-free service and cost less than had been estimated before design (15, 16).



IGURE 52. - Comparison of Standard (upper left) and 700-Atmosphere Valves, the Latter Developed for Coal-Hydrogenation Demonstration Plant.

Injection Pumps. - The most troublesome high-pressure unit was the injection pump which forced the mixture of coal and heavy recycle oil into the preheaters and converters (14; fig. 10 and pp. 5 and 6). The pumps first installed, although of heavy construction, had internal valves and several passages inside the blocks. After about 1 million stress reversals (operation is at 10 to 15 times per minute, from 100 p.s.i.g. to 700 atmospheres) the high-pressure cylinder forgings of these pumps broke internally (14, 15). Temporarily, the valves were removed to external locations, and higher strength materials used in the cylinder block (15); but alining the pump plungers, and the short life of the packing, were still troublesome.

The injection pump was so vital to operation that it was decided that a completely suitable pump should be developed. The new pump had the steam drive cylinder in the middle, with compound pressure cylinders at each end (see fig. 53). The pump valves were on the outside and attached only to the outer forging of the high-pressure cylinder. The plunger was lubricated on the suction stroke only. Synthetic rubber impregnated duck packing was used. This pump was tested in two runs of long duration and gave very reliable service.

Preheaters. - In Germany the preheaters were convection heated. Elaborate arrangements were used to temper the heating gas by blending it with products of combustion. For the demonstration plant a radiant-fired paste preheater was adopted. It was made of Type 316 stainless steel of suitable wall thickness, with pressure-welded return bends on the bottom and with forged and flanged return bends on the top. The 316 stainless-steel tube was fitted with a chrome-steel jacket tube, which left a 1/4-inch-wide annulus between tube and jacket.

The vapor-phase preheater, as built, consisted of two parallel passes - both radiant fired. Some trouble from unequal flow of liquid to sections of the vapor-phase preheater was speedily corrected by using a series flow through the preheater.

This preheater gave admirable service. If a full-scale hydrogenation plant to produce gasoline were to be built now, radiant-fired preheaters would probably be used in both liquid and vapor phases (15, 16).

Welded Joints. - Several times during the early liquid-phase runs there were leaks at lens-ring-flanged joints at various places in the hot stall. Such leaks were almost totally eliminated by using welded joints or solid lens rings to replace the hollow-lens-ring joints, as developed in Germany for hot joints. About 90 percent of the originally bolted joints were later welded.

Operation

Coals Hydrogenated to Gasoline. - A wide variety of coals were liquefied: High-volatile bituminous coals from southwestern Wyoming, western Kentucky, southern Illinois, and southwestern Pennsylvania; subbituminous coal from northeastern Wyoming; and a lignite from North Dakota. Pertinent information as to operating experience and as to yields of gasoline, tar acids, and other products (fig. 54), is given in various Bureau publications (14-18, 20).

Instrumentation. - Instrumentation on a rather complete scale gave much smoother operation than was possible with manual control (15). Pneumercator tubes worked fairly well for liquid-level indication and control. Strain-gage-type manometers were unsuccessful for differential pressure measurements and control because of the fragile diaphragm. Diaphragms for such instruments were ruptured by the unavoidably large pressure differences.

Heavy-Oil Letdown. - Discharge of heavy-oil letdown (H.O.L.D.) was always troublesome. This material carried the high-boiling product, as well as

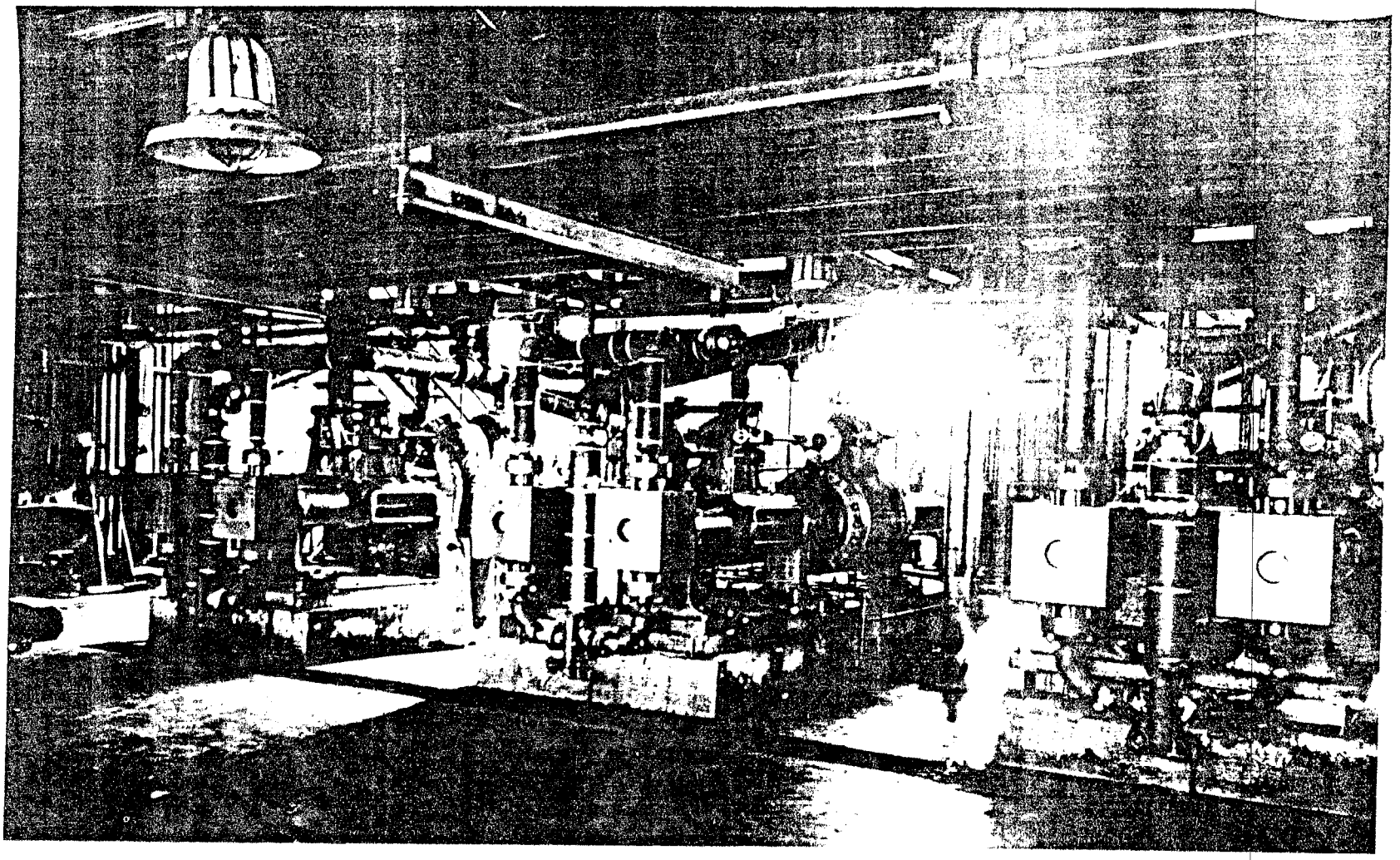


FIGURE 53. - High-Pressure Duplex Injection Pumps Adapted for Coal-Hydrogenation Demonstration Plant.

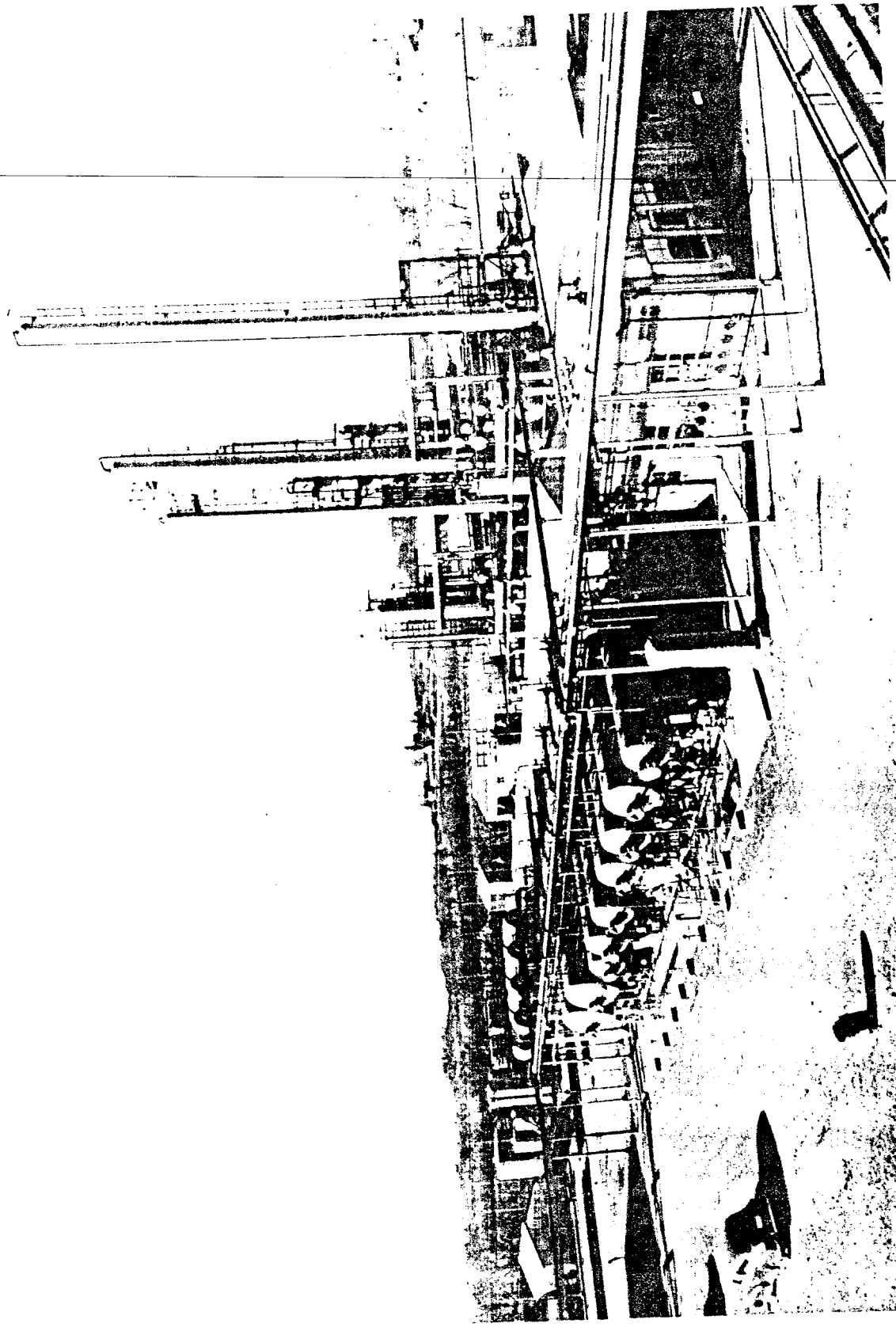


FIGURE 54. - Distillation Equipment at Coal-Hydrogenation Demonstration Plant for Upgrading Products to Gasoline and Fuel Oils.