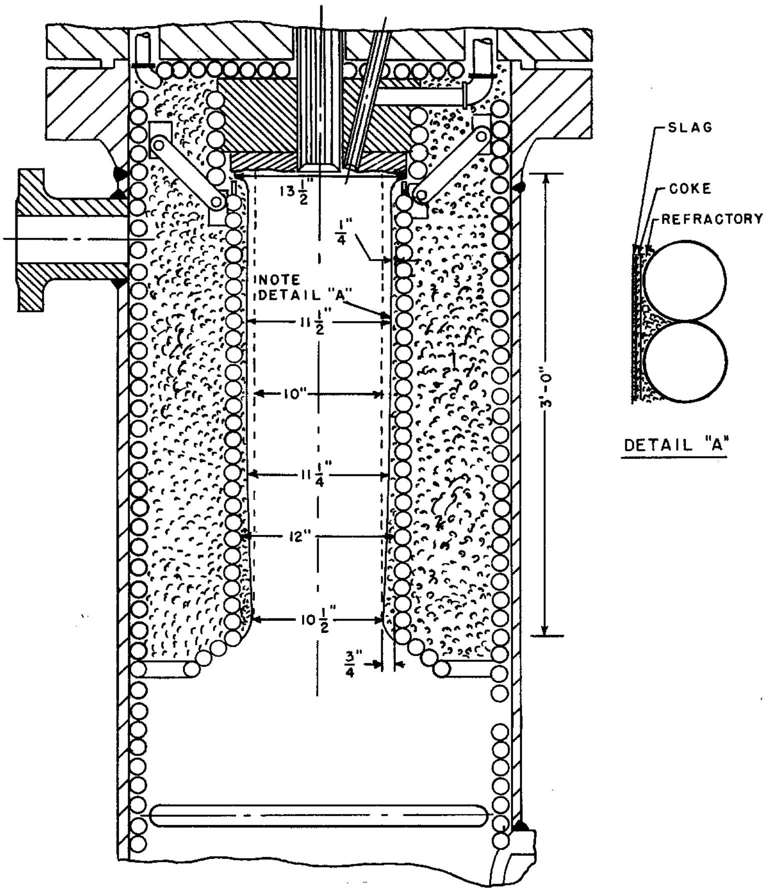

FIGURE 8. - Refractory Condition Following Test P-39, Gasifier 3.

satisfactory. At times, however, large pieces of slag blocked the 4-inch-diameter opening from the gasifier to the slag lock hopper; therefore, the hopper was attached directly to the bottom of the gasifier--a change that increased its opening from 4 inches to that of the bottom of the gasifier--about 15 inches. Thereafter, the slag hopper operated satsifactorily as a sump for slag accumulated during a test. In a commercial gasification plant the slag-outlet valve at the base of the gasifier probably would be 18 or 20 inches in diameter and blockage much less likely.

Flow Metering

Product gases were metered with a high-pressure orifice meter and a Roots-Connersville meter. These meters and the low-pressure orifice meter provided a double check on gas metering. Larger piping and a larger orifice plate were installed in the steam-oxygen system, and a differential-pressure transmitter was used to relay the impulse. Incipient blockage of the crossover from the gasifier to the scrubber caused fluctuations in pressure, which interferred with flow-meter accuracy, so a sight glass was installed in the lower section of the gasifier to permit observation of any change in the water level that might indicate blockage. Provision was made for flushing out the sight glass with clean water.

Figure 12 shows the water-metering system for the redesigned gasifier (gasifier 3, design 3). The system consisted of positive-displacement and orifice-type flow meters to measure cooling water used in: (1) Reaction-zone liner coil, (2) upper-shell coil, (3) lower-shell coil, (4) head or top coil, (5) reactant-injection and pilot burner jackets, and (6) gasifier sprays.

Separate manual controls and water meters were provided for the shell and liner coils of the gasifier and for the gasifier spray coil, so that the heat losses from each source could be determined. Metering equipment also was provided to measure the different flows of inert gas used for the coal feeder and the various purging operations.

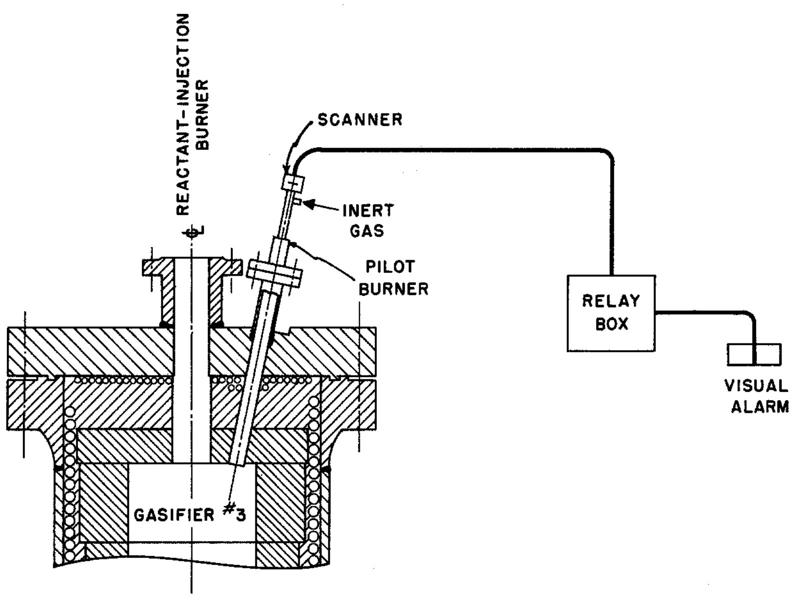

FIGURE 9. - Arrangement of Fireye on Pressure Gasifier 3.

Temperature Measurement

The locations of the thermocouples imbedded in the reaction-zone brickwork of the refractory-lined gasifier are shown in figure 3, page 7. Their positions varied in vertical distance below the coal-steam-oxygen burner face and radial distance from the hot face of the refractory lining.

The general locations of the thermocouples in the redesigned gasifier (gasifier with water-cooled liner) are shown in figure 5, page 9, and the method of installing them and detailed locations are shown in figure 13. Although these thermocouples were installed in similar locations to those of the thermocouples in the refractory-lined gasifiers, it was realized that they would be as sensitive to the effects of variations in cooling-water flows through the liner coil as to actual variations in thermal conditions within the chamber; nevertheless, it was expected that they would serve as operating guides.

Twelve thermocouples were installed in gasifier 3, design 3--four at each of three levels. As shown in figure 13, points A, B, C, and D, thermocouples were installed at each level as follows: (1) In the refractory bonded to the reaction-zone side of the reaction-zone liner coil (point A); (2) on the liner-coil wall facing the reaction zone (point B); (3) on the liner-coil wall facing the shell coil (point C); and (4) in the refractory between the shell coil and the liner coil (point D).

Erosion of the refractory lining of the reaction-zone cooling coil has been noted. One of the first indications of erosion was the failure of the thermocouples in the refractory on the interior surface of the coil, point A, figure 13. These thermocouples were nearest the source of heat. Erosion also exposed the open end of the thermocouple protecting tube, allowing undecomposed process steam to condense therein and thus shorting one or both of the couples sharing the protecting tube.

In preparing for the third test run with the redesigned gasifier (No. 3, design 3), it was found that an explosion in the reaction chamber during a previous run had sprung the shell and reaction-zone coils shearing the thermocouples shown in figure 13. Thus, in all succeeding runs no temperature readings were available for the region immediately around the reaction zone.

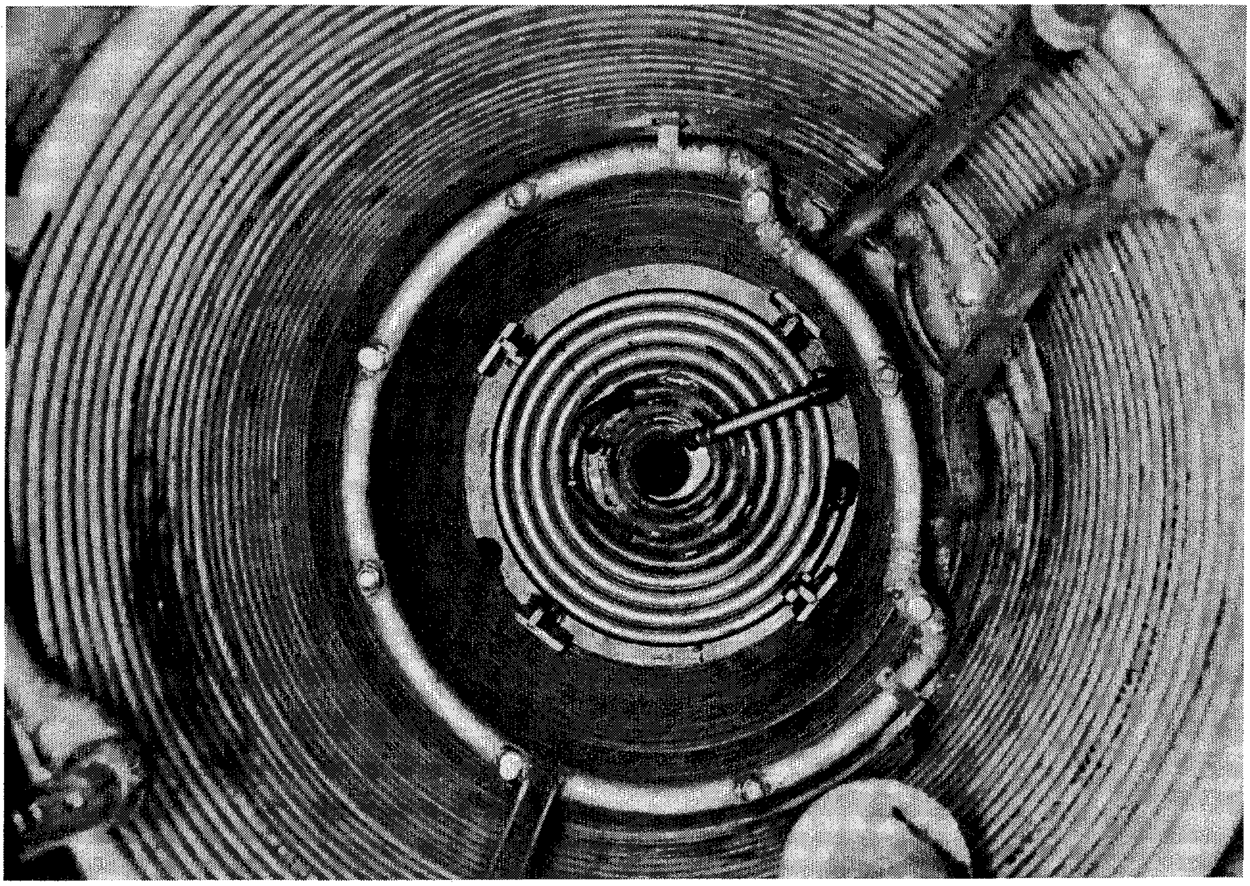

FIGURE 10. - View of Spray Coil.

Scrubber

Product gas and water from the gasifier quench zone flow into a standpipe in the gasifier, through a crossover pipe, and into the scrubber. The water admitted through the scrubber sprays and the water from the gasifier are withdrawn from the bottom of the scrubber. The larger volume of make gas handled during low-pressure operation imposed an added burden on the crossover connection between the gasifier and the scrubber. To reduce this burden, the gasifier spray water was removed from the gasifier by providing a continuous bleed, thus reducing the pressure drop through the crossover. An automatic liquid-level controller maintains a constant scrubber water level. During gasification, the inlet and outlet water lines to this controller are purged periodically to remove deposited particles carried over from the gasifier. This purging supplements a constant small flow (metered) of water into the lines.

Before test P-47, the scrubber was cleaned out, and broken Raschig rings (1-inch-diameter) were replaced with new rings. The depth of the bed was 42 inches. After test P-47, the scrubber was again cleaned out, and the 1-inch rings were replaced with a 42-inch bed of 2-inch rings. However, because of water carryover, the depth of the bed was lowered to 34 inches for run P-49.

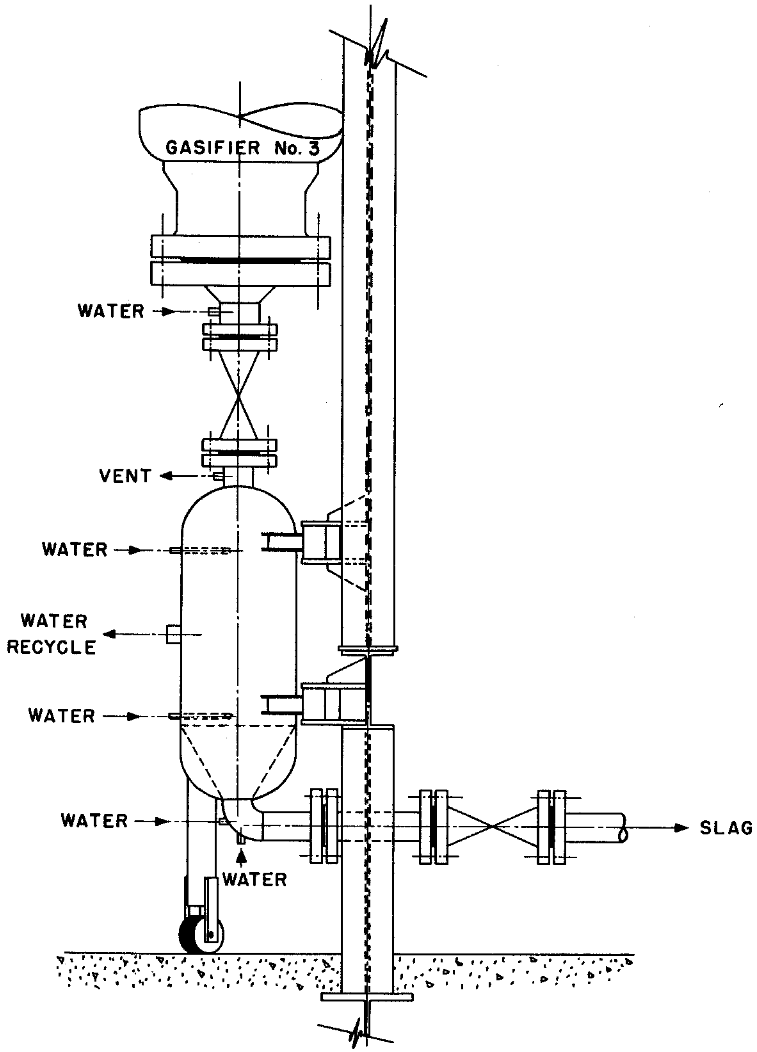

FIGURE 11. - High-Pressure Gasifier; Slag-Removal Equipment.

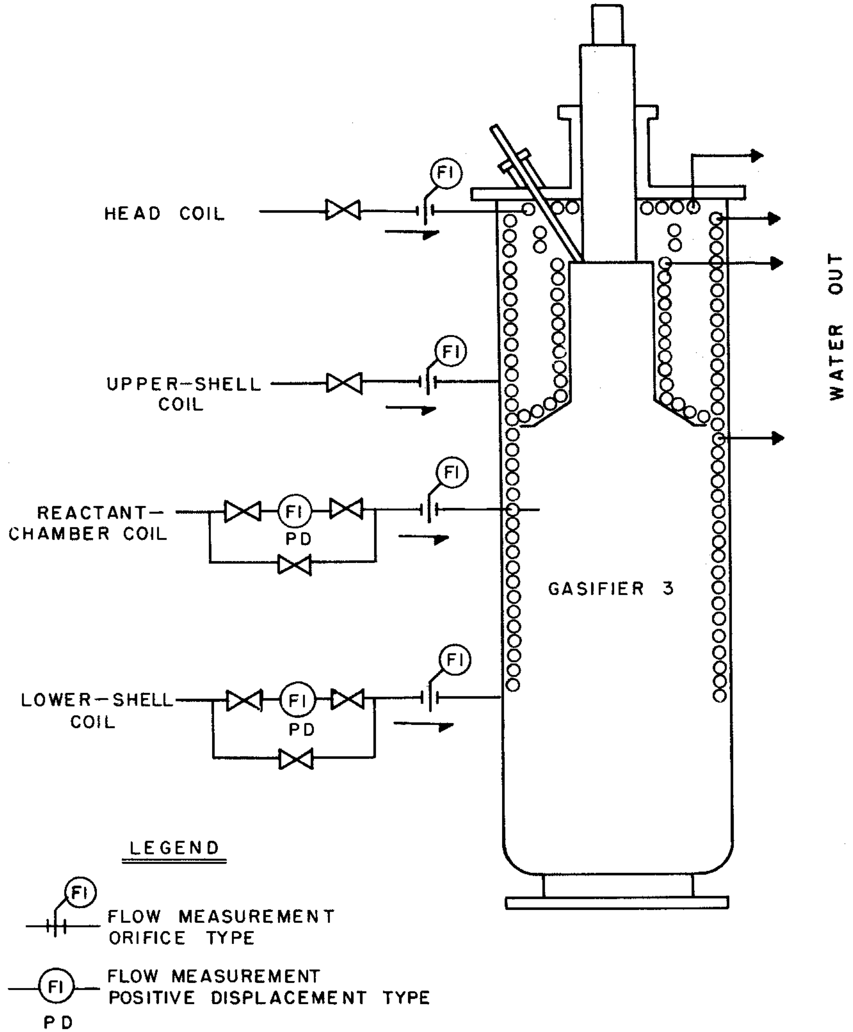

FIGURE 12. - Simplified Flow Diagram of Cooling-Water Metering System for Gasifier 3.

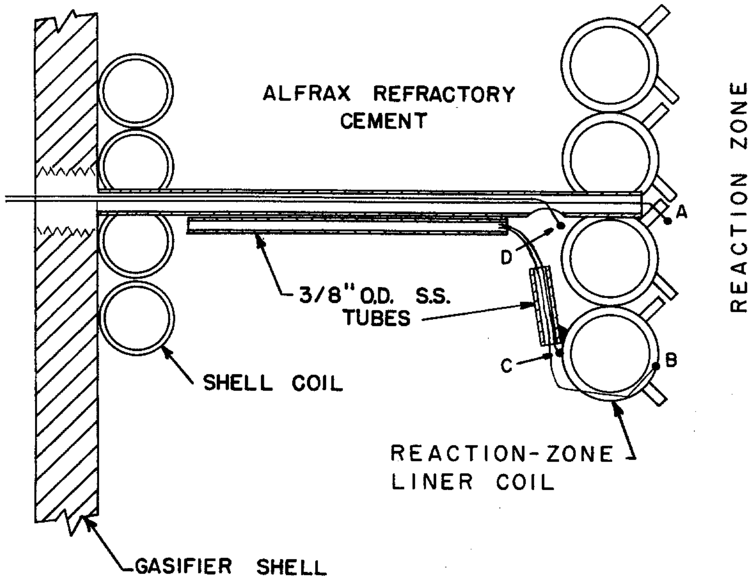

FIGURE 13. - High-Pressure Gasifier; Method of Thermocouple Installation at Reaction-Zone Liner Coil.

As water carryover still persisted at 100 p.s.i.g. operating pressure, the Raschig rings were removed from the scrubber for run P-52; in all subsequent runs, the scrubber was operated without Raschig-ring packing, with no measurable reduction in efficiency.

For greater flexibility in pilot-plant operation, an additional gas letdown valve was installed downstream from the scrubber. With this valve in place, the letdown equipment comprised an automatic 3/4-inch valve and an automatic 1/2-inch valve (either could be used, depending upon which one gave best pressure control) and a manual bypass valve in parallel. A Venturi-type pressure letdown valve (fig. 14) had the longest life. Abrasion of this valve by carbon and fine ash particles was principally on the disk and removable seat. No measurable wear of the valve body was observed. The entire pressure letdown from the gasifier operating pressure to atmospheric pressure was made across this Venturi-type valve.

The spray water was increased to handle the increased gas yields from the higher coal-feed rates. The dust content of the gas leaving the scrubber was consistently low, so that use of the Thiesen washer that had been installed for secondary cleanup was unnecessary.

Table 2 shows the dust-removal effectiveness of the scrubbing system, including gasifier sprays, crossover, and scrubber, for runs conducted at 300 p.s.i.g. The dust content of the gas leaving the reaction zone of the gasifier was probably about 5,000 to 10,000 grams per 100 std. c.f.

Coal-Feeding Equipment

The principal change to the continuous coal feeder was the relocation of the position of entry of the coal transfer line. Previously, this transfer line from the batch weigh tanks, shown in figure 15 (the batch weigh tanks are shown in fig. 1, p. 5, as "Transfer hopper"), entered the continuous feeder below the level of the top of the extraction funnel in the feed line to the gasifier. It was relocated to a position above the extraction funnel (fig. 1)--a change that reduced fluctuations in the coal-feed rate.

The steel-wool filter in the continuous feeder used for distribution of fluidizing gas was replaced with a plate having a multiplicity of small

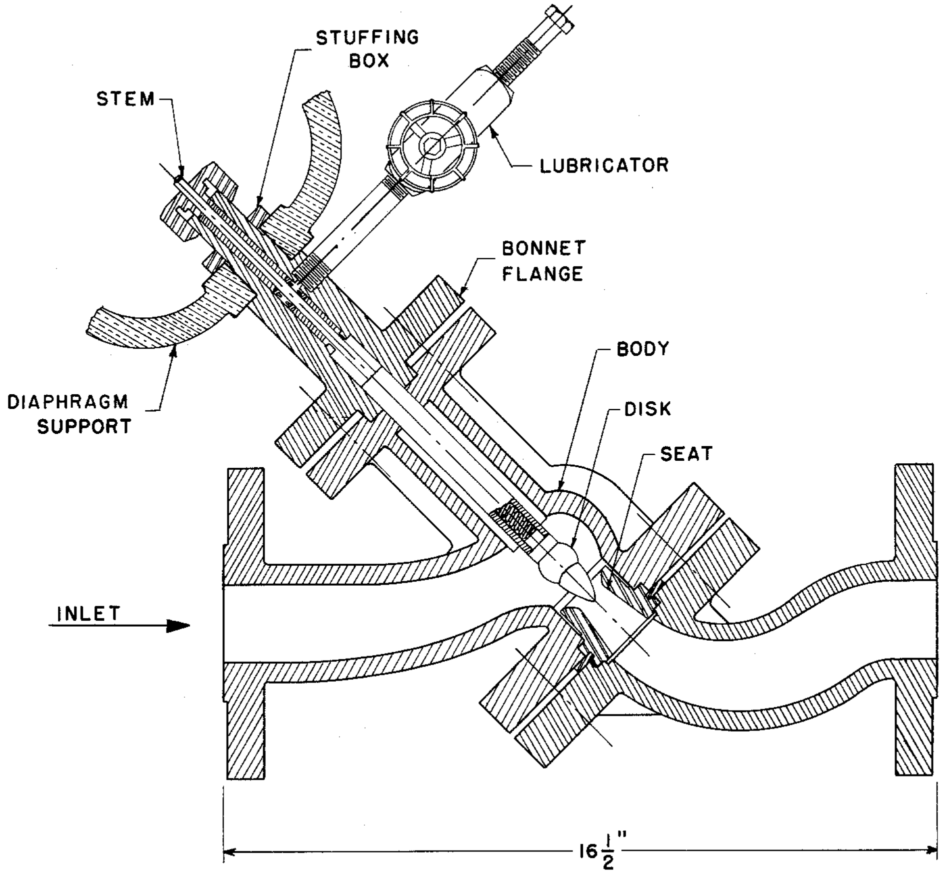

FIGURE 14. - Venturi-Type, High-Pressure, Water-Letdown Valve.

drilled ports. This change improved distribution and provided a more uniform coal-feed rate to the gasifier.

In run P-46, the fluidizing-gas recycle-compressor aftercooler became plugged. It was cleaned at the end of the run. The continuous feeder also was cleaned, and the number and size of the ports in the distribution plate were changed to give a higher jet velocity at each port. Before run P-49, the recycle compressor was completely overhauled.

In some tests the actual coal-feed rate to the gasifier varied as much as 10 percent from the intended rates indicated by the setting of the coal-feed meter. Actual rates, which were determined by weighting the coal charged to the feeder and subtracting the weight of the coal remaining in the feeder at the end of the run, were used to calibrate the coal-feed meter for subsequent runs. Nevertheless, the coal rates indicated by the setting of the meter often disagreed with the actual rates, so a reliable value for the actual coal rate for each run could not be determined until the gasifier was shut down and the coal in the feeder weighed. During these runs actual coal rates did not vary more than 3 percent, but they did not always agree with the desired rates.

After run P-38, the coal preheater was not used.

TABLE 2. - Results of high-pressure water scrubbing of make gas from gasifier 3

Run and period	Coal rate, lb./hr.	Product gas, std. c.f./hr.	Scrubber water, lb./hr.	Dust content of exit gas from scrubber: Grains per 100 std. c.f.	Dust content of exit gas from scrubber: Grains per 100 cu.ft.[1]	Scrubber packing condition	Remarks
43D...	647	21,410	7,200	0.42	9.06	1-inch rings, 48-inch bed (runs 43-45).	Rust from sample tube in dust samples (runs 43, 44, 45, 46).
43D...	647	21,410	5,100	.64	13.78		
44H...	1,437	45,260	6,550	1.02	21.86		
44H...	1,437	45,260	6,550	.41	8.89		
44I...	1,054	34,970	7,200	.42	9.06		
44I...	1,054	34,970	5,100	.35	7.61		
45M...	692	19,800	6,550	.36	7.76		
45M...	692	19,800	4,600	.85	18.12		
450...	1,029	29,215	6,700	.46	9.87		
450...	1,029	29,215	5,600	.40	8.53		
46Q...	1,398	47,120	7,200	2.12	45.08	1-inch rings, 24-inch bed (run 46),	
46Q...	1,398	47,120	7,200	1.07	22.86		
47C...	1,062	34,930	6,550	.35	7.57	new 1-inch rings, 24-inch bed (run 47).	New sample tube (runs 47, 48).
47C...	1,062	34,930	5,600	.37	7.87		
47D...	1,062	32,720	5,600	.29	6.27		
47D...	1,062	32,720	6,550	.26	5.61		
48B...	1,341	39,710	6,100	.34	7.23	2-inch rings, 42-inch bed (run 48).	
48B...	1,341	39,710	6,100	.32	6.80		
48E...	1,341	44,965	6,300	.24	5.10		
48E...	1,341	44,965	5,200	.33	7.02		
48F...	1,341	45,410	6,550	.29	6.17		
48F...	1,341	45,410	6,550	.29	6.17		

1/ At flowing pressure and temperature.

Steam-Oxygen Heater

The combination superheated-steam generator and oxygen preheater was the same one previously described.[10] During run P-31 the oxygen heating coil was damaged by failure of the control valves. The coil was removed, and in subsequent runs the oxygen used for gasification was not preheated but was mixed

10/ Strimbeck, G. R., Cordiner, J. B., Jr., Taylor, H. G., Plants, K. D., and Schmidt, L. D., Progress Report on Operation of Pressure-Gasification Pilot Plant Utilizing Pulverized Coal and Oxygen: Bureau of Mines Rept. of Investigations 4971, 1953, 27 pp.

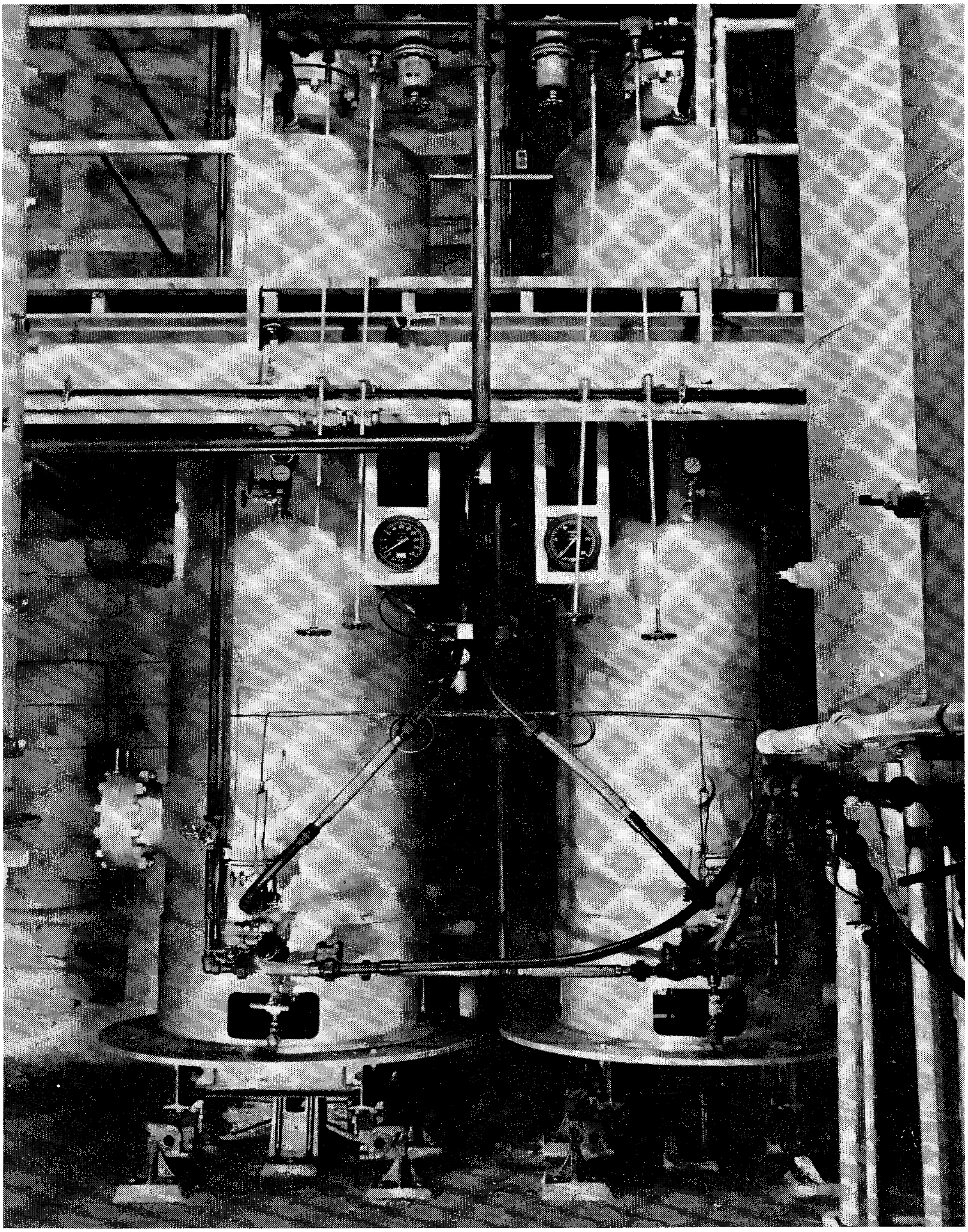

FIGURE 15. - Coal-Feeding-System Weigh Tanks.