Cylindrical Section. - Four views are presented, figures 21, 22, 23, and 24. Figure 21 is a southeast view. Note the expansion joints. Figure 22 is a southwest view with the gas-exit duct in the upper right. The somewhat eroded area below it was probably caused by condensate drip from the cold, water-cooled surface of the exit gas pipe. Figure 23 is a northwest view. In the lower left corner is the manhole through which the gasifier was entered. Figure 24 is a south view of the roof. Note again the expansion joints and the cracks formed as the gasifier cooled. The larger hole in the top center is the explosion riser. There is some spalling of the brick around it and the near sight port. The duct on the right is the gas-exit port. Note that all of these views show the absence of slag in the upper part of the cylinder.

Ash Legs. - Figures 25, 26, and 27 show the north, middle, and south sections of the gasifier floor at the entrance to the respective ash legs. The slagging over is quite apparent.

South Cone. - The south cone (fig. 28) shows furrowing on the west side in approximately the same location and to the same degree as in the north cone. Attack on the east side was similar. The cone brick had advanced about 1 inch beyond the face (see meter stick resting on it). This had not been observed before the cold inspection.

To enter the gasifier through the manhole in the lower west section of the cylinder necessitated removal of a section of the brickwork (see fig. 23). The exposed inner brick cross section showed a uniform discoloration due to slag penetration of about 1 inch.

Slag and Ash

Slag was obtained in these operations principally from the ash legs. This material passed into the water seal of the ash legs and was hoed out after each run. The material appeared in the form of chunks, needles, and fines.

Analysis of this material closely paralleled the composition of the coal ash from which it was derived. Carbon analysis showed little present. Thus, for a sample taken October 4, 1949, in percent:

Chunks: Carbon = 0.2, SiO_2 = 46.0

Needles: Carbon = 0.5, SiO_2 = 53.5

SiO_2 content of ash of the coals used averaged around 50 percent. A typical analysis of a Rock Springs, Wyo., coal ash follows:

	Percent
SO_2	49.9
Al_2O_3	20.8
Fe_2O_3	7.9
CaO	11.5
MgO	1.7
SO_3	5.9
Alkalies	2.3

Fusibility of the coal ash and slag appeared to vary with different lots of coal. Softening points of the slag ranged from 2,200° to 2,600° F.; an even wider range was noted for the ash from the coal.

Beginning with run 19, the slag obtained from the ash legs during each run was collected and weighed. The weights per unit of operating time varied considerably from run to run, even though coal-feed rates were fairly uniform owing, no doubt, to the uneven slag flow through the ash legs. Furthermore, higher temperature operation, obtained mainly by increasing the oxygen-coal ratio, gave a higher percentage of slag and melted out slag accumulations from previous lower temperature runs. For example, the average slag weight obtained in runs 19 through 40 was 11 pounds per hour, but the rate was 55 pounds per hour for run 32, which operated at the relatively high oxygen-coal ratio of 11.0 cubic feet per pound.

The ash slagged in those runs averaged about 9 percent of the total in the coal charged. This is appreciably higher than the 3-1/2 percent obtained as an average for extended run 43. However, this latter run was made at an average oxygen-coal ratio of around 8 cubic feet per pound, whereas runs 19 through 40 were made at ratios of around 10.

Most of the ash leaving the gasifier in the gas stream was removed in the ducts, the waste-heat boiler, and in the washer-cooler. No attempt was made however, to establish the amount removed at the different points. The ash from the waste-heat boiler tubes was removed by steam jets and then flushed from the bottom with water. At all other points it was removed by direct water flushing or scrubbing. These ash slurries joined and flowed to the settling basins. Here most of the ash settled, and the water was drawn off and recirculated. A small percentage of the ash floated on the water surface.

A number of samples were taken from the settling basin. The analyses are given in table 8.

TABLE 8. - Analysis of samples from ash-settling basins

Run Number	Percent, dry basis: Noncombustibles	Percent, dry basis: Volatile matter	Carbon conversion, percent
18	33.5	3.7	83.6
19	35.9	3.5	82.8
24	34.2	4.0	87.3
27	35.0	3.0	83.1
29	29.6	2.9	79.2
31	28.6	2.7	79.1
32	44.6	2.4	89.8
43 (Avg. data)	22.5	-	75

A few percentage analyses, dry basis, were made of the floating material:

Noncombustibles	Volatile matter
14.6	3.4
18.1	4.1
14.8	4.0

As might be expected, the noncombustible portion of the ash goes up with the carbon conversion in the run. This shows clearly in (figure 29), which was plotted from the above data on ash analyses. Also, calculations were made from the ash analyses as a rough check on carbon conversions based on gas production and analyses, as demonstrated in calculations for typical run 18.

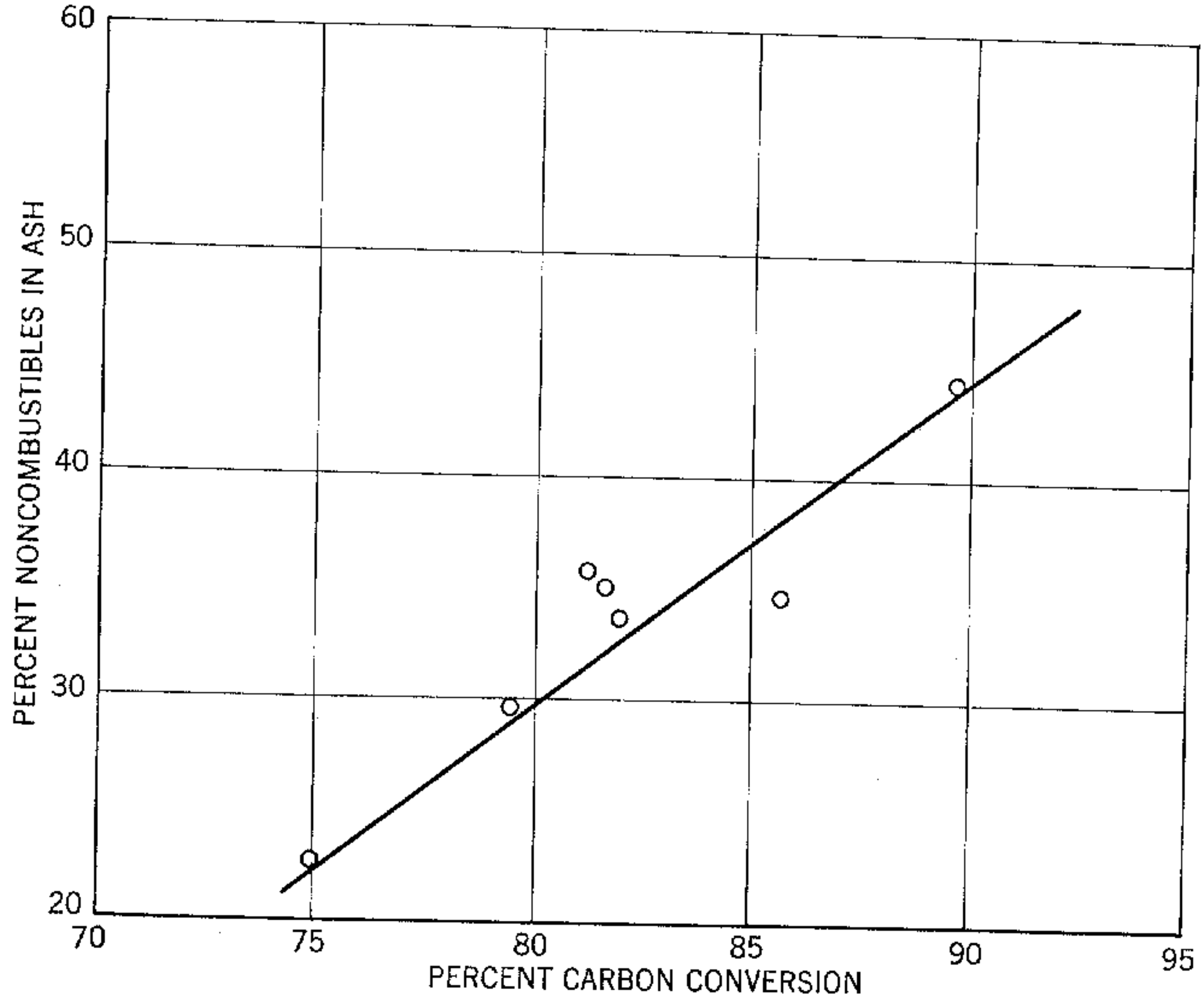

Figure 29. - Relation between carbon conversion and noncombustibles in ash.

A sample of the settled ash from run 43 was dried and checked for size distribution:

	Percent
On 100-mesh..................	4.9
On 100- to 150-mesh..........	11.3
On less than 150-mesh........	83.8

This is somewhat coarser than the coal-size feed, but no appreciable fusing or agglomeration is indicated. This material settles fairly clear in a few hours and could be conveniently handled in a continuous-settler clarification system.

APPENDIX A

Tabulated Data

(Explanatory notes for tabulated data)

1. Forty-six runs in all were made or attempted. Data presented in this Appendix begin with run 13, after the preliminary test operations. Data from runs 15, 22, 30, 34, 37, 38, 39, 42, 44, 45, and 46 are not presented because of events in the course of the runs that made the results questionable.

2. Coal and oxygen were fed at room temperature.

3. The cone temperatures were taken by optical pyrometers sighting into porcelain target tubes set at right angles to the cone wall, with the tips flush with the wall.

4. Data from the last 3 days of operation only for run 43 are presented.

5. CH_4 analysis in the gas includes any higher hydrocarbons that might be present.

6. Organic sulfur content of the make gas, based on a few analyses, was about 7 grains per 100 cu. ft.

7. Data from several runs not mentioned in the main body of the report are given in this Appendix. They did not fall within the categories selected for data analysis.

Run No.	Date	Period of stable operation, hr.	Raw coal		Process oxygen			Process steam			Total std. c.f./hr.
			Rate, lb./hr.	Percent H_2O	Rate, std.c.f./hr	Purity, Percent O_2	Std.c.f. of 100 percent O_2 per lb.dry coal	Rate, lb./hr.	Temp., °F.	Lb. steam per lb. dry coal	
13	8/16/49	4-1/2	2,530	4.0	17,740	96.7	7.0	2,330	1,610	1.0	71,200
14A	8/17/49	1-1/2	2,350	4.0	17,690	96.9	7.6	2,330	1,650	1.0	66,900
14B	8/17/49	1/2	2,350	4.0	18,050	96.9	7.8	2,330	1,615	1.0	67,700
14C	8/17/49	3/4	2,350	4.0	18,700	96.9	8.0	2,330	1,595	1.0	68,450
16	8/23/49	2	2,220	3.8	20,000	95.8	9.0	2,300	1,725	1.1	71,200
17	8/26/49	3	2,020	3.3	19,580	95.2	9.5	2,320	1,562	1.2	65,800
18	8/29/49	3	1,980	3.4	19,690	95.2	9.8	1,800	1,485	.9	63,800
19	8/30/49	3-1/4	1,970	4.0	20,130	95.0	10.1	2,000	1,525	1.1	62,900
20A	9/1/49	1/2	2,060	4.4	20,900	95.0	10.1	2,000	1,435	1.0	63,000
20B	9/1/49	1/2	2,060	4.4	20,600	95.0	9.9	2,000	1,395	1.0	63,400
20C	9/1/49	1/2	2,060	4.4	20,240	95.0	9.8	1,800	1,375	.9	63,000
21A	9/8/49	2-1/2	1,340	5.4	13,080	94.7	9.8	1,800	1,695	1.4	44,100
21B	9/8/49	2-3/4	1,340	5.4	13,080	94.7	9.8	1,800	1,695	1.4	44,600
23A	9/14/49	2-1/4	2,070	5.4	18,230	95.0	8.9	2,300	1,745	1.2	65,000
23B	9/14/49	3/4	2,070	5.4	20,050	95.0	9.7	2,300	1,725	1.2	66,900
24	9/15/49	2-3/4	1,310	4.8	13,600	95.2	10.4	2,300	2,115	1.9	46,600
25	9/16/49	3/4	2,050	4.6	18,950	95.2	9.2	2,300	2,120	1.2	64,600
26	9/20/49	1-1/2	2,220	5.0	20,400	95.4	9.2	2,100	1,740	1.0	67,700
27	9/26/49	2-1/2	2,030	4.1	21,075	94.9	10.3	2,300	1,740	1.2	62,580
28A	9/29/49	1/2	2,000	4.3	21,220	96.0	10.6	1,810	1,730	.9	64,500
28B	9/29/49	1-1/3	2,000	4.3	21,240	96.0	10.6	1,810	1,725	.9	62,200
28C	9/29/49	1/2	2,000	4.3	21,240	96.0	10.6	1,810	1,710	.9	60,500
29	10/7/49	1-1/2	2,350	3.0	21,200	95.2	8.9	1,830	1,770	.8	72,000
31	10/21/49	2	2,270	3.8	20,880	96.1	9.2	1,790	1,690	.8	69,800
32	10/25/49	3	2,060	3.2	22,940	95.6	11.0	1,610	1,680	.8	68,000
33A	10/28/49	2	1,500	4.1	15,340	95.5	8.9	1,200	2,045	.8	48,900
33B	10/28/49	1-1/4	1,500	4.1	13,370	95.5	8.9	1,200	2,000	.8	45,820
35	11/4/49	5	2,300	4.2	21,600	95.6	9.4	1,800	1,700	.8	72,500
36	11/25/49	3	2,150	1.3	21,600	95.7	9.7	1,790	1,705	.8	73,770
40A	1/25/50	1	2,360	4.9	21,540	94.7	9.1	2,030	1,705	.9	73,950
40B	1/25/50	2	1,970	4.9	18,420	94.8	9.3	2,030	1,665	1.1	62,680
41A	2/3/50	2-1/4	2,380	6.1	21,820	95.0	9.3	2,250	1,690	1.0	75,800
41B	2/3/50	1-3/4	2,380	6.1	21,810	95.2	9.3	2,070	1,660	.9	76,110
43	4/12/50	6-1/2	2,630	5.0	22,330	95.2	8.5	2,010	1,645	.8	78,650
43	4/12/50	7-3/4	2,700	5.7	22,260	97.0	8.5	2,010	1,635	.8	81,750
43	4/13/50	6-3/4	2,670	4.6	22,010	96.1	8.3	2,020	1,665	.8	81,930
43	4/14/50	7	2,600	4.3	22,200	95.0	8.5	2,020	1,640	.8	77,130

Decomposed steam		Undecomposed steam, lb.	Per M std.c.f. of $CO + H_2$		B.t.u. eff.; Net ht. value gas ÷ net ht. value coal	Temperatures, ° F.				W	
Lb.	Lb./lb. dry coal		Lb. dry coal	Std.c.f. 100% O_2		North cone	South cone	Exit gas	"Thermal balance"	C	H_2
340	0.14	2,120	46.6	325	52.0	2,655	2,560	2,080	2,385	74.2	5.2
300	.13	2,150	45.0	343	53.0	1/ 2,375		2,110	2,490	74.2	5.2
305	.14	2,150	44.4	345	54.0	1/ 2,370		2,140	2,476	74.2	5.2
310	.14	2,150	43.7	351	54.0	1/ 2,460		2,160	2,574	74.2	5.2
330	.15	2,090	39.0	350	60.7	2,535	2,500	2,230	2,465	74.2	5.2
320	.16	2,150	38.3	365	62.0	2,500	2,525	2,275	2,436	74.2	5.2
240	.13	1,660	37.1	364	63.8	2,620	2,630	2,295	2,515	74.2	5.2
220	.12	1,890	38.0	383	62.4	2,620	2,620	2,220	2,390	74.2	5.2
210	.11	1,870	41.3	416	57.2	2,465	2,400	2,230	2/2,620	74.2	5.2
205	.11	1,820	39.7	395	59.5	2,620	2,640	2,270	2/2,540	74.2	5.2
180	.09	1,650	39.1	383	60.6	2,640	2,640	2,325	2/2,470	74.2	5.2
245	.19	1,640	39.5	388	60.6	2,545	2,165	2,180	2,320	73.6	5.2
260	.21	1,630	38.1	374	62.5	2,250	2,635	2,250	2,260	73.6	5.2
365	.19	2,050	38.1	338	63.3	2,520	2,530	2,335	2,280	73.6	5.2
345	.18	2,080	37.2	362	65.0	2,645	2,650	2,415	2,445	73.6	5.2
285	.23	2,090	36.4	379	65.7	2,545	2,540	2,305	2,340	73.6	5.2
320	.16	2,090	38.2	353	3/	2,650	2,560	2,360	3/	73.6	5.
280	.13	1,950	38.9	359	62.2	2,585	2,590	2,390	2,530	73.6	5.
190	.10	2,210	40.4	415	60.0	1,900	2,075	2,200	2,650	73.6	5.
150	.08	1,760	39.7	421	3/	2,050	2,125	2,150	3/	73.6	5.
135	.07	1,860	39.5	420	3/	1,985	2,165	2,135	3/	73.6	5.
85	.04	1,990	41.3	439	3/	1,995	2,200	2,180	3/	73.6	5.
270	.12	1,650	38.3	339	63.1	2,440	2,500	2,335	2,385	73.6	5.
225	.10	1,670	38.9	357	62.2	2,470	2,585	2,355	2,375	73.6	5.
165	.08	1,530	36.3	399	67.0	2,620	2,710	2,405	2,680	73.6	5.
145	.10	1,130	37.5	382	64.5	2,450	2,475	2,305	2,480	73.6	5.
155	.11	1,110	39.6	351	61.2	2,300	2,380	2,270	2,390	73.6	5.
290	.13	1,620	37.1	349	65.3	2,630	out	2,315	2,435	73.0	5.
335	.16	1,490	35.2	342	68.9	2,530	2,540	2,395	2,570	73.0	5.
335	.15	1,820	37.5	342	62.6	2,560	2,420	2,260	2,380	75.5	5.
285	.15	1,850	38.1	355	61.4	2,125	2,375	2,275	2,320	75.5	5.
365	.17	2,040	36.8	342	63.9	2,290	2,275	out	2,260	75.5	5.
365	.16	1,860	36.5	340	64.3	2,225	2,250	out	2,340	75.5	5.
270	.11	1,880	39.7	338	58.7	2,470	2,450	1,955	2,360	76.2	5.
325	.13	1,850	38.7	329	60.3	2,500	2,425	1,985	2,275	76.2	5.
335	.13	1,810	38.8	321	62.4	2,490	2,520	out	2,380	73.0	5.
240	.10	1,900	40.0	339	60.0	2,530	2,500	out	2,370	73.0	5.

1/ Average optical readings--regular instrument out of adjustment.

2/ Questionable; data available inadequate for precise calculation.

3/ Not calculated

APPENDIX B

Purpose of Runs and Alterations of Operating Conditions

Run No.	
13	To obtain base operating data with fine coal (88 percent through 200-mesh). This became the standard coal size used in later runs.
14	To study the effect of an increased oxygen-coal ratio.
15	To test new 16-inch projection burner nozzles. Results not reported because of trouble with coal weights and grind.
16	To obtain base operating data with 16-inch projection burner nozzles.
17	To study performance at a higher oxygen-coal ratio.
18	To obtain operating data at reduced steam-coal and increased oxygen-coal and increased oxygen-coal ratios.
19	To test the effect of steam jets into the gasification zone.
20A	To test the effect of steam injected into the coal-oxygen flame through the burner nozzles.
20B	To obtain data, operating with steam jets as in run 19, to compare with section A of this run.
20C	To obtain base data in normal operation to compare with sections A and B of this run.
21	To study the effect of the broken steam nozzle in the south cone. Section A of the run was made with 1 burner in south end and 3 in the north, and for B this order was reversed.
22	To obtain base operating data on the third car of Rock Springs, Wyo., coal. Results not reported because of unsteady operating conditions.
23	To obtain base operating data on the third car of Rock Springs, Wyo., coal, with operating conditions similar to run 17.
24	To test effect of higher steam-coal ratio and steam temperature.
25	To check results of run 24.
26	To obtain more base operating data with third car of Rock Springs, Wyo., coal.
27	To test operation with 45-inch projection burner nozzles.
28A	To obtain base operating data in this series with 45-inch projection burner nozzles.
28B 28C	To test the effect of steam injection into the oxygen-coal flame through the 45-inch burner nozzles.
29	To study performance with a steam distributor removed (south cone).
30	To check results of run 29. Data not presented because of fluctuating coal feed and gas make.

31 To check operations with a modified steam ring (giving less spin to the entering steam) installed in the north cone.

32 To test gasifier performance at high oxygen-coal ratios. For this run a 16-inch projection burner nozzle and modified steam ring were also installed in the south cone.

33 To observe performance with increased residence time. This was obtained with a reduced coal rate and using only four burners.

34 To study performance with flush burners. Trouble with the make-gas meter make results uncertain.

35 To obtain data with flush burners.

36 To test the effect of very fine coal (90 percent through 325-mesh).

37 To check results of run 36. No reliable data obtained owing to erratic coal feed and flashbacks.

38 To obtain base data on normal coal grind after the series with very fine grind.

39 To test operation with superheated steam injected through a burner nozzle (north) at high velocity. Run shut down early because of flashbacks.

40 To obtain base operating data on No. 6 car of Rock Springs, Wyo., coal.

41 To repeat conditions of run 39.

42 To obtain more data with superheated steam injection, but mechanical difficulties prevented sustained operations.

43 To check operations for a protracted period of time. Low oxygen-coal ratios maintained to avoid excessive gasifier temperatures.

44 To test operation with superheated steam injected into the oxygen-coal feed
45 pipes. No reliable data were obtained, owing to erratic operation accompanied
46 by flashbacks.