TABLE 17. - Effect of fine crushing of coal on physical properties of coke

Coal	Crushing	Shatter index, cumulative percent upon-		Tumbler index, cumulative percent upon-	
		1-1/2-inch screen	1-inch screen	1-inch screen	1/4-inch screen
Indianola	0- to 1/4-inch	66.3	89.2	49.2	70.7
Do.	0- to 1/8-inch	74.1	91.5	58.6	74.5
Russellton	0- to 1/4-inch	68.9	88.2	49.1	72.8
Do.	0- to 1/8-inch	77.0	92.3	56.2	73.0
Crescent	0- to 1/4-inch	70.6	92.6	53.9	70.2
Do.	0- to 1/8-inch	70.6	92.5	55.8	70.7
Clyde	0- to 1/4-inch	68.0	92.0	54.4	71.9
Do.	0- to 1/8-inch	66.1	93.1	58.4	71.8
Elkhorn	0- to 1/4-inch	83.4	92.8	56.5	70.7
Do.	0- to 1/8-inch	79.5	93.4	62.9	75.3

The properties of the tar and light oil do not correlate closely with coal rank. The proportion of acids in the tar distillate is lowest (2.4 percent) for the highest-ranking coal (America), but the percentage for Sayre mine, Mary Lee Bed, coal is 6.5; and this coal ranks higher than Russellton mine, Thick Freeport-bed coal, for which the percentage is only 3.7. The percentages of paraffins and naphthenes in the neutral oils was definitely higher for the higher-ranking coals from Alabama. The proportions of benzene and toluene in the light oils ranged from 65.0 to 72.8 and from 18.1 to 21.8, respectively, with virtually no relation to rank of coal.

Argentine Asfaltita

Three samples of Argentine asfaltita, each weighing about 300 pounds, were received for carbonization tests made in the 13-inch BM-AGA retort at 900° C. The samples were marked Nos. 1, 2, and 3 and were distinguished by the amount of asphaltic material soluble in carbon disulfide; extractable matter was 8.4, 49.7, and 48.8 for samples 1, 2, and 3, respectively. Abraham's "Asphalts and Allied Substances" calls the material asphaltite, or more specifically, "grahamite." The moisture contents were 1.0, 1.6, and 0.9 percent; the ash, 5.9, 3.7, and 3.3 percent; the sulfur 2.1, 2.3, and 2.3 percent; and heating values, 14,990, 15,690, and 15,990 B.t.u. respectively, for the three samples. Sample 1 could be carbonized 100 percent, but samples 2 and 3 swelled out of the retorts and could be carbonized only by mixing with equal parts of sample 1.

The cokes from asfaltita resembled those from Utah coals in structure, but they were much weaker than those from the best Utah coals. It is believed, however, that they are strong enough to serve as domestic fuel. Because of the high asphaltic content, the yield and quality of the gas was

very high; the heating value per cubic foot ranged from 710 to 746 B.t.u., and the heat in gas per pound of material ranged from 4,450 to 4,980 B.t.u. The tar and light oil were highly aromatic. Aromatic compounds in tar were concentrated in naphthalene and anthracene salts, and in the light oil they appeared largely as benzene. The highest yield of pure benzene obtained was about five gallons per ton.

Venezuelan Coal

A 400-pound sample of Naricual Basin coal, Venezuela, contained 3.6 percent moisture, 2.1 percent ash, and 0.5 percent sulfur. It contained 54.8 percent fixed carbon on the dry, mineral-matter-free basis and had a heating value of 14,060 on the moist, mineral-matter-free basis; therefore, it ranks as high-volatile A coal. It was known to be deficient in coking properties, and the problem was to determine if metallurgical-quality coke could be produced from blends of this coal and asphaltic oil-still residue. BM-AGA tests at 900° C. indicated that blending with 10 percent still residue improved the coke, although it was still inferior to that from Lower Sunnyside (Utah) coal. Further experiments, using larger proportions of residue, may beneficiate the coke more, but richer mixtures are difficult to prepare and carbonize; they give excessive amounts of spongy coke at the center of the charge.

Naricual coal yielded 59.6 percent coke, 23.1 percent gas (equivalent to 12,550 cubic feet per ton), 12.9 gallons of tar, 4.17 gallons of light oil, and 29.6 pounds of ammonium sulfate per ton. The heating values of the gas (614 B.t.u. per cubic foot and 3,850 B.t.u. per pound of coal) were high. The composition of the tar and light oil was similar to that from domestic high-volatile coals. Blending with asphaltic residue raised the heating values of the gas significantly and increased the proportion of benzene in the light oil.

Expansion-Test Investigations

Figure 35 shows a vertical section of the small vertical oven, and figure 36 is a photograph showing the oven open. The coking chamber is 12 inches long and 5 inches wide and holds about 17 pounds of coal when filled to a depth of 9-$\frac{1}{2}$ inches. The bottom and ends are fire brick, and the heated walls are silicon carbide plates. Each wall is heated by nine horizontal coils of 13-gage nickel-chromium wire, with resistance adjusted to give uniform heating. The maximum variation in the temperature across the walls is 25° C., a large part of which occurs near the edges of the walls.

A large number of tests have been made over a period of 3 years by several operators with various adjustments of test conditions in the hope that a schedule could be worked out that would produce uniform results. Results in table 18 are typical of the unsatisfactory performance of the oven.

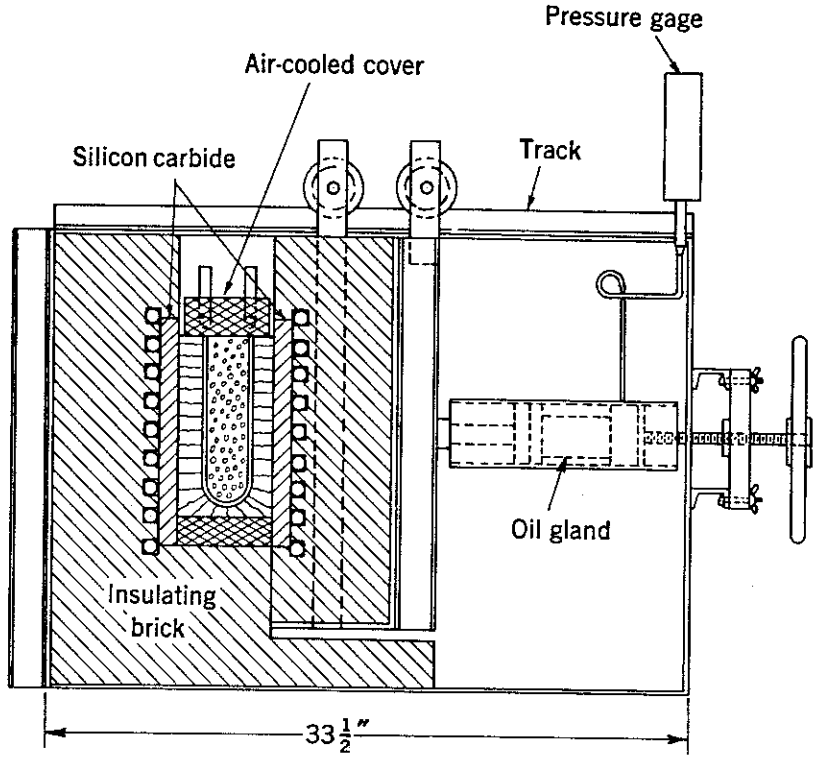

Figure 35. - Small, vertical oven.

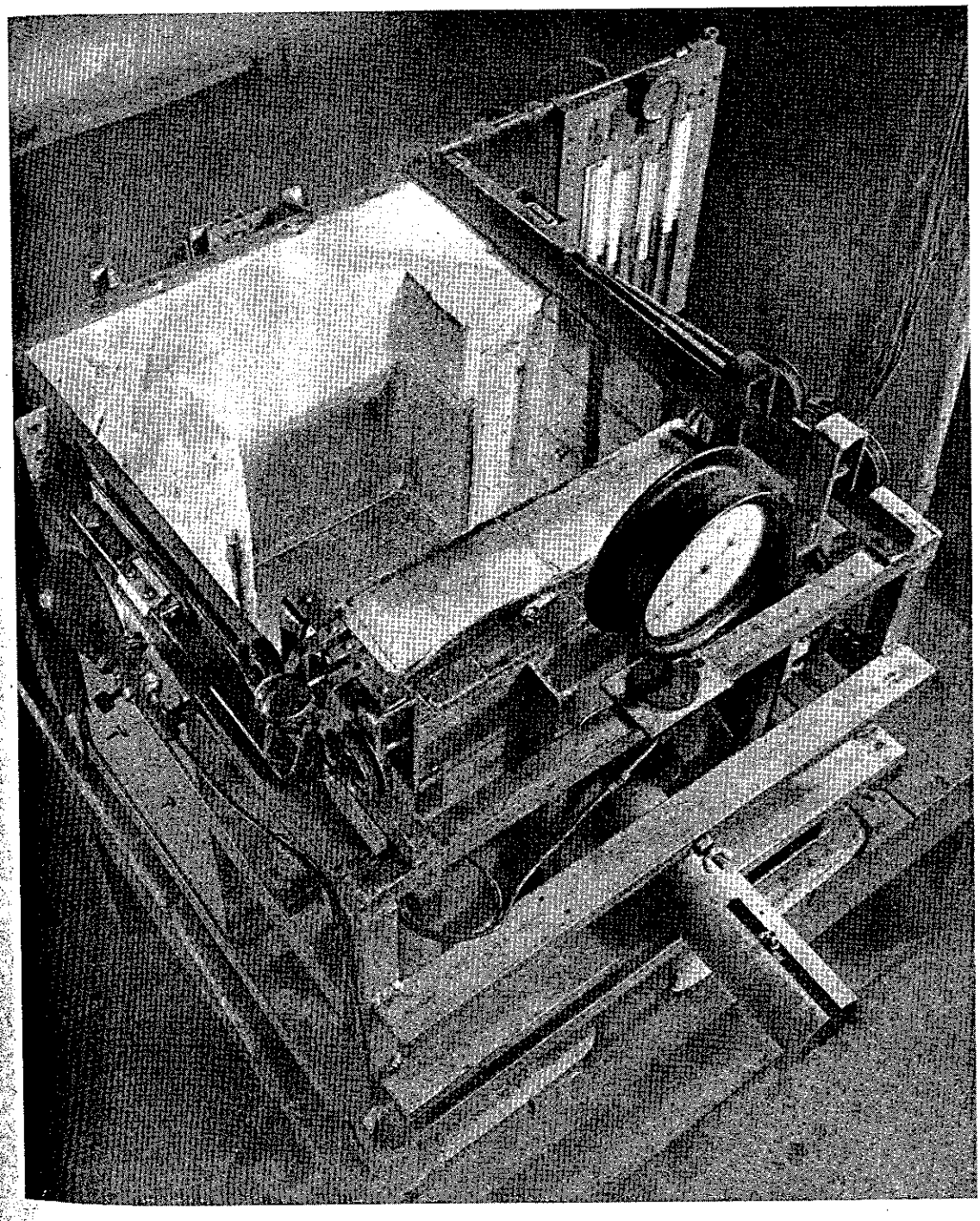

Figure 36. - Small, vertical oven, showing interior.

TABLE 18. - Agreement of test results from small vertical oven

Coal 89 - 100 percent Pocahontas No. 6 bed
Coal 82D - 35 percent Eagle bed, 35 percent Powellton bed, and 30 percent Pocahontas No. 3 bed
Coal 235 - From coal-charging car at coke oven at Rosita, Coahuila, Mexico
Coal 238B - 70 percent Powellton bed and 30 percent Pocahontas No. 3 bed

Coal No.	Test No.	Bulk density, pounds per cubic foot	Maximum pressure, pounds per square inch		Deviation of wall pressure from the average
			Gas	Wall	
		Free top.	2,000°-2,200° F. schedule		
89.	SV-14	49.0	14.0	7.7	+1.6
	SV-8	49.1	14.0	7.3	+1.2
	SV-15	49.2	4.2	2.1	-4.0
	SV-9	49.4	9.0	7.2	+1.1
	Average	49.2	10.3	6.1	2.0
89	SV-2	50.0	9.0	3.2	-1.6
	SV-12	50.0	8.0	3.6	-1.2
	SV-13	50.3	13.0	5.8	+1.0
	SV-10	50.3	12.0	5.8	+1.0
	SV-7	50.6	4.9	3.3	-1.5
	SV-6	50.6	15.0	7.0	+2.2
	Average	50.3	10.3	4.8	1.4
89	SV-1	51.3	8.0	8.0	+2.7
	SV-4	51.3	11.7	5.2	- .1
	SV-5	51.3	9.0	5.4	+ .1
	SV-11	51.9	5.0	2.4	-2.9
	Average	51.5	8.4	5.3	1.5
		Confined top - cooled.	2,000°-2,200° F. schedule		
82D	SV-7	48.2	6.0	3.0	-0.2
	SV-8	50.4	5.5	3.2	.0
	SV-9	50.4	2.2	3.9	+ .7
	SV-10	50.4	4.0	2.7	- .5
	SV-14	50.4	6.0	3.0	- .2
	Average	50.0	4.7	3.2	.3
235	SV-4	51.2	-	1.9	-0.5
	SV-5	51.2	-	2.3	- .1
	SV-6	51.2	-	2.9	+ .5
	SV-7	51.2	-	1.8	- .6
	SV-8	51.2	-	2.5	+ .1
	SV-9	51.2	-	2.8	+ .4
	Average	51.2	-	2.4	.4
238B	SV-1	51.2	-	8.2	+3.7
	SV-2	51.2	-	4.3	- .2
	SV-3	51.2	-	4.9	+ .4
	SV-4	51.2	-	4.6	+ .1
	SV-5	51.2	-	3.8	- .7
	SV-6	51.2	-	3.2	-1.3
	SV-7	51.2	-	2.7	-1.8
	Average	51.2	-	4.5	1.2

Table 19 compares results on the same coals for the sole-heated, large vertical, and small vertical slot ovens. The coals expanding most in the sole-heated oven show the highest pressures in both vertical ovens, but the tests do not place the coals in the same order. The small vertical oven gives the highest pressures, except in one case, and here the maximum pressure is so small as to be almost within limits of experimental error. The gas pressure is always high in the small vertical oven, and it is erratic. This is undoubtedly a contributing factor in the high wall pressure for this oven and also in lack of agreement between duplicate results. The high ratio of thickness of the plastic layers at the center to the total thickness of the charge in the small vertical oven would favor high expansion pressures; or, stated in another way, the pressure developed at the center is less-relieved by the relatively thin layer of contracting coke. Development of high erratic gas pressures behind the plastic envelope in the small vertical oven is perhaps its more serious defect. Other factors contributing to high results in this oven should be constant under uniform test conditions, and it therefore should be possible to correlate them with those of the larger test ovens.

The sole-heated oven was used in 101 tests to determine the expanding properties of the 29 coal samples and blends described in table 20. New samples of standard high- and low-volatile coals used for blending with BM-AGA coals were received and tested in the sole-heated oven. High-volatile Pittsburgh-bed, Warden mine coal (m28), contracted 14.0 percent as compared with 13.7 percent for a sample received in 1938. This coal was oxidized in air at 100° C. for various periods and tested after each stage in the sole-heated oven. The results of these tests are given in table 21. The low-volatile sample, Pocahontas No. 3 bed, Carswell mine (coal d75), expanded 19.7 percent as compared with 21.7 and 24.4 percent for former samples.

Lower Banner-bed coal from No. 56 mine, Dante, Russell County, Va. (coal 91), contracted 25.8 percent in the sole-heated oven. The oxidized samples contracted less as oxidation progressed. This increase in expanding tendency may account for the improvement in coke quality sometimes found with slight oxidation. The 1-$\frac{1}{2}$-inch shatter index of the coke from this coal was not improved, but the 1-inch tumbler index was increased from 49.7 percent for the unoxidized coal to 57.9 percent for the second oxidation stage. The tumbler index decreased to 53.5 percent for the last or third oxidation stage. Lower Banner coal in 80:20 and 70:30 blends with Pocahontas No. 3 contracted 11.5 and 6.0 percent, respectively. Both of these blends should be safe for industrial use, since neither expanded under a constant applied load of 2.2 pounds per square inch during carbonization in the sole-heated oven.

Two additional samples of Lower Banner coal (c91 and d91), which represented other parts of the No. 56 mine, contracted less than the carbonization sample.

TABLE 19. - Comparison of results from three types of expansion ovens

Coal XP-38 - 85 percent Pittsburgh bed and 15 percent Upper Kittanning bed
Coal 235 - From coal-charging car at coke oven, Rosita, Coahuila, Mexico
Coal XP-56A - 80 percent Pittsburgh bed and 20 percent Pocahontas No. 3 bed
Coal 82D - 35 percent Eagle bed, 35 percent Powellton bed, and 30 percent Pocahontas No. 3 bed
Coal 87A - 80 percent Pittsburgh bed and 20 percent Hill bed (washed)
Coal 89 - 100 percent Pocahontas No. 6 bed
Coal 257 - 49.5 percent Eagle bed and 50.5 percent Pocahontas No. 3 bed
Coal 81A - 80 percent Powellton bed and 20 percent Pocahontas No. 3 bed
Coal XP36 - 100 percent Mary Lee bed

	Sole-heated oven	Large vertical oven			Small vertical oven		
Coal No.	Average maximum expansion at bulk density of 55.5 lb. per cu. ft., percent	Bulk density, lb. per cu. ft.	Maximum pressure, lb. per square inch		Bulk density, lb. per cu. ft.	Maximum pressure, lb. per square inch	
			Wall	Gas		Wall	Gas
XP-38	-	53.1	0.7	0.7	48.4	0.4	0.6
235	-12.7	51.5	1.2	1.3	1/50.1	2.6	3.1
XP 56A	- 6.4	49.8	1.5	1.8	1/49.6	1.9	4.2
82D	- 3.6	49.0	1.5	2.4	1/50.7	3.2	6.5
87A	- 1.5	50.7	1.7	-	1/50.3	2.9	5.0
89	+ .2	-	-	-	1/50.1	4.3	8.5
257	+ 2.1	1/49.9	3.6	4.4	1/2/50.0	4.6	9.5
81A	+ 3.2	50.7	2.2	3.4	49.2	5.6	12.0
XP-36	+ 4.4	3/51.8	2.2	3.3	4/49.3	4.3	9.0

1/ Tested at 2,000°-2,200° F. heating schedule; all other tests in both large and small vertical ovens made at 2,300°-2,500° F. heating schedule.
2/ Single test only.
3/ Moisture content, 8.7 percent.
4/ Moisture content, 1.5 percent.

TABLE 20. - Description of coals and blends tested[1/]

Coal No.	Description
m28	Pittsburgh bed, Warden mine (washed)
d75	Pocahontas No. 3 bed, Carswell mine, Kimball, McDowell County, W. Va.
91	Lower Banner bed, No. 56 mine, Dante, Russell County, Va. Breakthrough between 3d and 4th mains, N. 1,420 feet, W. 290 feet from drift mouth.
c91	Special expansion sample of coal 91 from first right, 400 feet off fourth main.
d91	Special expansion sample of coal 91 from No. 6 room, 239 feet off first left moist coal face.
91A	80 percent coal 91 and 20 percent coal d75.
91B	70 percent coal 91 and 30 percent coal d75.
291A	50 percent coal 291 and 50 percent coal c75.
291B	70 percent coal 291 and 30 percent coal c75.
296	Sayreton run-of-mine on which float-and-sink has been made and determination for ash analyzing 10.30.
297	Sayreton No. 2 washed and crushed to approximately 68 percent minus 1/8-inch mesh.
298	Sayreton fine coal. Sampled and screened with 60 percent through 1/8-inch mesh. Sample then through hammer mill and screened, with approximately 75 percent through 1/8-inch mesh.
299	Sayreton coarse coal. Sampled and screened with 30 percent through 1/8-inch mesh. Sample then through hammer mill and screened, with approximately 75 percent through 1/8-inch mesh.
300	Sayreton average coal. Sampled and screened, with 45 percent through 1/8-inch mesh. Sample then through hammer mill and screened, with approximately 75 percent through 1/8-inch mesh.
317	Pocahontas No. 3 bed.
317A	20 percent coal 317 and 80 percent coal m28.
304	Morgantown, W. Va., Ordnance sample 1. Mixture of coal from Rosedale mine and McCartney mines, Monongalia County, W. Va.
305	Morgantown, W. Va., Ordnance sample 2. Composed of same coals as 304.
306	Morgantown, W. Va., Ordnance sample 3. Composed of same coals as 304.
310A[1/]	Blend of Argentine asfaltitas. 50 percent 310 and 50 percent a310.

1/ See table 11 for description of coals 291, 292, 293, 294, 295, 308, 309, 310, 310A, 312, and 313.

TABLE 21. - Expansion test results in sole-heated oven

Coal No.	Moisture, percent	Expansion, percent		
		Calculated to 55.5 lb. per cu. ft.		
		As tested	Dry basis	Dry solid coal
m28	1.6	-14.0	-12.6	30.2
m28 1/	1.9	- 7.7	- 5.9	39.6
m28 2/	1.9	- 5.9	- 4.1	42.8
m28 3/	-	-10.2	-	-
d75	2.8	+19.7	+23.1	89.0
91	1.5	-25.8	-24.7	11.5
91 4/	1.7	-17.8	-16.4	24.1
91 5/	1.4	-16.9	-15.7	25.8
91 6/	1.7	-16.1	-14.6	27.8
c91	1.5	-25.5	-24.4	12.3
d91	2.5	-22.2	-20.2	17.9
91A	1.6	-11.5	-10.2	34.8
91B	1.6	- 6.0	- 4.5	43.7
291	2.4	-12.7	-10.5	35.3
291A	2.0	+ 7.1	+ 9.2	65.8
291B	2.2	+ 1.5	+ 3.7	56.4
292	2.7	-14.6	-12.2	33.7
293	3.3	-16.6	-13.8	29.3
294	3.5	-15.3	-12.2	32.1
295	4.0	-11.1	- 7.4	41.4
296	1.3	- 7.6	- 6.4	44.2
297	2.2	- 2.2	.0	53.2
298	5.9	- 8.9	- 3.2	48.6
298 7/	.9	- 4.2	8/- 3.4	48.4
299	5.9	- 7.4	- 1.6	50.3
299 7/	.9	- 2.6	8/- 1.7	50.0
300	6.2	- 8.3	- 2.3	49.8
300 7/	1.1	- 2.6	8/- 1.7	50.8
308	4.6	- 2.9	+ 1.8	55.1
309	7.2	- 7.3	- .1	52.4
312	6.8	- 4.3	+ 2.6	58.0
313	6.7	-11.3	- 4.9	47.0
317	4.3	+ 4.9	+ 9.6	-
317A	1.9	- 5.6	- 3.8	44.1
304	4.0	-26.1	-23.0	18.5
305	4.5	-29.9	-26.6	15.1
306	3.9	-30.7	-27.8	12.0

1/ Oxidized 3.2 days in air at 100° C.
2/ Oxidized 3.0 days in air at 100° C.
3/ Oxidized 6.0 days in air at 100° C.
4/ Oxidized 3.9 days in air at 100° C.
5/ Oxidized 11.2 days in air at 100° C.
6/ Oxidized 19.2 days in air at 100° C.
7/ Coal dried in laboratory.
8/ Not maximum expansion. Test bulk densities were greater than 55.5 lb. per cu. ft., which gave positive expansions during part of the test.