as the BM-AGA method), as well as studies of oxidation, plasticity, and expansion of coals. These methods have been used for the past 16 years in a Survey of the Gas,- Coke,- and Byproduct-Making Properties of American Coals and were designed to include investigation of many factors known to bear on the carbonizing properties of coal. During the war problems arose in the adaptation of new coals to the manufacture of metallurgical coke, and only that part of the procedure applying to high-temperature carbonization was used. Several of these special problems were incomplete at the close of the war, and the laboratory was occupied with rounding out such special investigations during most of the year.

## Results of Carbonization Tests

The sources of coals investigated are given in table 10, and their analyses are given in table 11. Analyses of standard coals used for blending also are given.

Tables 12 to 15, inclusive, give the results of carbonization tests made by the BM-AGA procedure. Table 12 gives the yields of carbonization products; tables 13 and 13a, the physical properties of the coke; table 14, the properties of the gas; and table 15, the properties of tar distillates and light oils.

TABLE 10. - Sources of coals tested

| Coal No. | Bed | Mine | Town | County | State |
|---|---|---|---|---|---|
| 253 | (Not named) | Vulcano | Punta Arenas | Province of Magallanes | Chile |
| 254 | do. | Elena | do. | do. | Do. |
| 230 | do. | Lirquen | | Province of Concepcion | Do. |
| 231 | do. | Copihues de Pupunahue | | Province of Valdivia | Do. |
| 279 | | | | | Peru |
| 245 | | McAlester Strip | Rockdale | Milan | Texas |
| 258 | Powellton | Powellton No. 2 | Ansted | Fayette | W. Va. |
| 259 | No. 2 Gas and Peerless | No. 3 North | do. | Fayette | Do. |
| 90 | Beckley | Stanaford | Mt. Hope | Raleigh | Do. |
| 280 | Pocahontas No. 4 | No. 6 | Eastgulf | do. | Do. |
| 281 | Pocahontas No. 3 | No. 2 and 3 | do. | do. | Do. |
| 276 | Lower Sunnyside | Sunnyside | | Carbon | Utah |
| 284 | | | Coal Creek | Gunnison | Colorado |
| 285 | | | do. | do. | Do. |
| 286 | | | do. | do. | Do. |

TABLE 11. - Analyses of coals[1]

| Coal No. | Description | Dry, mineral-matter-free, fixed carbon, percent | Condition[2] | Proximate, percent | | | | Ultimate, percent | | | | | Air drying loss, percent | Heating value, B.t.u. per lb. | Softening temperature of ash, °F. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Moisture | Volatile matter | Fixed carbon | Ash | Hydrogen | Carbon | Nitrogen | Oxygen | Sulfur | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 253 | 100 percent Vulcano mine | 48.5 | 1 | 30.0 | 30.0 | 27.0 | 13.0 | 6.5 | 41.3 | 0.6 | 38.3 | 0.3 | 15.5 | 7,230 | 2,190 |
| | | | 2 | - | 42.9 | 38.6 | 18.5 | 4.5 | 59.0 | .8 | 16.8 | .4 | - | 10,340 | - |
| | | | 3 | - | 52.7 | 47.3 | - | 5.5 | 72.5 | 1.0 | 20.6 | .4 | - | 12,690 | - |
| 254 | 100 percent Elena mine | 50.8 | 1 | 21.0 | 33.7 | 33.6 | 11.7 | 6.2 | 49.7 | .6 | 31.5 | .3 | 13.1 | 8,760 | 2,530 |
| | | | 2 | - | 42.6 | 42.6 | 14.8 | 4.9 | 62.9 | .8 | 16.2 | .4 | - | 11,090 | - |
| | | | 3 | - | 50.1 | 49.9 | - | 5.8 | 73.9 | .9 | 18.9 | .5 | - | 13,020 | - |
| 230 | 100 percent Lirquen mine | 51.5 | 1 | 15.1 | 35.7 | 36.5 | 12.7 | 5.9 | 56.3 | 1.0 | 23.4 | .7 | 4.9 | 9,990 | 2,250 |
| | | | 2 | - | 42.1 | 43.0 | 14.9 | 4.9 | 66.3 | 1.2 | 11.8 | .9 | - | 11,770 | - |
| | | | 3 | - | 49.4 | 50.6 | - | 5.8 | 77.9 | 1.4 | 13.9 | 1.0 | - | 13,830 | - |
| 231 | 100 percent Copihues de Pupunahue mine | 56.2 | 1 | 20.7 | 31.7 | 39.6 | 8.0 | 6.0 | 52.9 | 1.1 | 31.7 | .3 | 9.8 | 9,040 | 2,470 |
| | | | 2 | - | 40.0 | 49.9 | 10.1 | 4.6 | 66.7 | 1.4 | 16.9 | .3 | - | 11,400 | - |
| | | | 3 | - | 44.5 | 55.5 | - | 5.2 | 74.3 | 1.5 | 18.6 | .4 | - | 12,690 | - |
| 279 | 100 percent coal from Peru | 78.8 | 1 | .7 | 20.2 | 72.1 | 7.0 | 4.4 | 83.0 | .9 | 3.7 | 1.0 | 0.3 | 14,410 | 2,700 |
| | | | 2 | - | 20.4 | 72.5 | 7.1 | 4.3 | 83.6 | .9 | 3.1 | 1.0 | - | 14,520 | - |
| | | | 3 | - | 21.9 | 78.1 | - | 4.7 | 90.0 | 1.0 | 3.2 | 1.1 | - | 15,620 | - |
| 245 | 100 percent McAlester strip mine | 50.0 | 1 | 24.2 | 33.4 | 32.3 | 10.1 | 6.3 | 48.2 | .9 | 33.5 | 1.0 | 14.8 | 8,310 | 2,290 |
| | | | 2 | - | 44.0 | 42.6 | 13.4 | 4.7 | 63.5 | 1.2 | 15.9 | 1.3 | - | 10,960 | - |
| | | | 3 | - | 50.8 | 49.2 | - | 5.5 | 73.3 | 1.4 | 18.3 | 1.5 | - | 12,640 | - |
| 258 | 100 percent Powellton bed | 62.1 | 1 | 1.6 | 34.9 | 55.9 | 7.6 | 5.4 | 77.6 | 1.5 | 7.1 | .8 | 0.4 | 13,890 | 2,290 |
| | | | 2 | - | 35.4 | 56.9 | 7.7 | 5.3 | 78.9 | 1.5 | 5.8 | .8 | - | 14,120 | - |
| | | | 3 | - | 38.4 | 61.6 | - | 5.7 | 85.5 | 1.6 | 6.3 | .9 | - | 15,290 | - |
| 259 | 100 percent No. 2 Gas and Peerless bed | 63.3 | 1 | 1.8 | 33.6 | 56.3 | 8.3 | 5.2 | 77.0 | 1.5 | 7.1 | .9 | 0.6 | 13,710 | 2,890 |
| | | | 2 | - | 34.3 | 57.2 | 8.5 | 5.1 | 78.5 | 1.5 | 5.5 | .9 | - | 13,970 | - |
| | | | 3 | - | 37.4 | 62.6 | - | 5.6 | 85.7 | 1.6 | 6.1 | 1.0 | - | 15,270 | - |
| 75 | 100 percent Pocahontas No. 3 bed | 81.8 | 1 | 2.4 | 17.2 | 74.5 | 5.9 | 4.5 | 83.0 | 1.1 | 4.9 | .6 | 2.0 | 14,360 | 2,330 |
| | | | 2 | - | 17.6 | 76.3 | 6.1 | 4.3 | 85.0 | 1.2 | 2.8 | .6 | - | 14,720 | - |
| | | | 3 | - | 18.7 | 81.3 | - | 4.6 | 90.6 | 1.3 | 2.8 | .7 | - | 15,670 | - |
| 90 | 100 percent Beckley bed | 79.5 | 1 | 2.3 | 19.7 | 74.8 | 3.2 | 4.8 | 85.3 | 1.6 | 4.5 | .6 | 1.8 | 14,890 | 2,550 |
| | | | 2 | - | 20.2 | 76.6 | 3.2 | 4.7 | 87.4 | 1.6 | 2.4 | .7 | - | 15,240 | - |
| | | | 3 | - | 20.8 | 79.2 | - | 4.9 | 90.3 | 1.7 | 2.4 | .7 | - | 15,750 | - |
| 28 | 100 percent Pittsburgh bed | 61.5 | 1 | 1.5 | 35.9 | 56.3 | 6.3 | - | - | - | - | .9 | 0.5 | 14,010 | 2,780 |
| | | | 2 | - | 36.4 | 57.2 | 6.4 | - | - | - | - | .9 | - | 14,230 | - |
| | | | 3 | - | 38.9 | 61.1 | - | - | - | - | - | 1.0 | - | 15,190 | - |
| 280 | 100 percent Pocahontas No. 4 bed | 83.3 | 1 | 1.7 | 15.9 | 75.4 | 7.0 | 4.4 | 82.9 | 1.2 | 3.8 | .7 | 1.1 | 14,350 | 2,850 |
| | | | 2 | - | 16.1 | 76.8 | 7.1 | 4.2 | 84.3 | 1.2 | 2.5 | .7 | - | 14,600 | - |
| | | | 3 | - | 17.4 | 82.6 | - | 4.6 | 90.8 | 1.3 | 2.5 | .8 | - | 15,720 | - |
| 281 | 100 percent Pocahontas No. 3 bed | 83.3 | 1 | 1.7 | 15.9 | 75.7 | 6.7 | 4.3 | 82.9 | 1.1 | 4.2 | .8 | 1.2 | 14,360 | 2,910+ |
| | | | 2 | - | 16.2 | 77.0 | 6.8 | 4.2 | 84.4 | 1.2 | 2.6 | .8 | - | 14,610 | - |
| | | | 3 | - | 17.3 | 82.7 | - | 4.5 | 90.5 | 1.3 | 2.9 | .8 | - | 15,670 | - |
| 276 | 100 percent Lower Sunnyside bed | 57.0 | 1 | 3.7 | 38.9 | 50.5 | 6.9 | 5.5 | 73.3 | 1.6 | 11.2 | 1.5 | 1.4 | 13,170 | 2,550 |
| | | | 2 | - | 40.4 | 52.4 | 7.2 | 5.3 | 76.2 | 1.6 | 8.1 | 1.6 | - | 13,680 | - |
| | | | 3 | - | 43.6 | 56.4 | - | 5.7 | 82.0 | 1.8 | 8.8 | 1.7 | - | 14,730 | - |
| 284 | 100 percent core-drill hole No. 10-9, Paonia, Colo. coal log. 932 ft. 8-1/2-inch, 936 ft. 9-1/2-inch. | 57.3 | 1 | 2.4 | 40.4 | 53.5 | 3.7 | 5.7 | 77.8 | 1.6 | 10.2 | 1.0 | 0.8 | 14,030 | 2,160 |
| | | | 2 | - | 41.3 | 54.9 | 3.8 | 5.5 | 79.7 | 1.7 | 8.2 | 1.1 | - | 14,370 | - |
| | | | 3 | - | 43.0 | 57.0 | - | 5.7 | 82.9 | 1.7 | 8.6 | 1.1 | - | 14,940 | - |
| 285 | 100 percent core-drill hole No. 10-9, Paonia, Colo. coal log. 946 ft. 1-inch, 952 ft. 7-inch. | 57.1 | 1 | 2.4 | 39.9 | 52.3 | 5.4 | 5.6 | 76.9 | 1.5 | 10.1 | .5 | 1.0 | 13,770 | 2,140 |
| | | | 2 | - | 40.9 | 53.5 | 5.6 | 5.5 | 78.8 | 1.5 | 8.1 | .5 | - | 14,100 | - |
| | | | 3 | - | 43.3 | 56.7 | - | 5.8 | 83.4 | 1.6 | 8.7 | .5 | - | 14,940 | - |
| 286 | 100 percent core-drill hole No. 10-9, Paonia, Colo. coal log. 958 ft. 2-inch, 964 ft. 11-inch. | 58.2 | 1 | 2.1 | 38.4 | 52.4 | 7.1 | 5.5 | 75.7 | 1.5 | 9.7 | .5 | 0.7 | 13,630 | 2,690 |
| | | | 2 | - | 39.3 | 53.4 | 7.3 | 5.4 | 77.3 | 1.5 | 8.0 | .5 | - | 13,920 | - |
| | | | 3 | - | 42.4 | 57.6 | - | 5.8 | 83.4 | 1.7 | 8.5 | .6 | - | 15,020 | - |

1/ Analyses by H. M. Cooper, chemist, Bureau of Mines, Pittsburgh, Pa.
2/ 1, Sample as received; 2, moisture-free; 3, moisture- and ash-free.

TABLE 12. - Yields of carbonization products, as-carbonized basis

Coal 253 - 100 percent Vulcano mine
Coal 254 - 100 percent Elena mine
Coal 230 - 100 percent Lirquen mine
Coal 231 - 100 percent Copihues de Pupunahue mine
Coal 279 - 100 percent Peruvian coal
Coal 279A - 80 percent Lower Sunnyside bed and 20 percent Peruvian
Coal 258 - 100 percent Powellton bed
Coal 258A - 80 percent Powellton bed and 20 percent Pocahontas No. 3 bed (coal 75)
Coal 258B - 70 percent Powellton bed and 30 percent Pocahontas No. 3 bed (coal 75)
Coal 259 - 100 percent No. 2 Gas and Peerless bed
Coal 259A - 80 percent No. 2 Gas and Peerless bed and 20 percent Pocahontas No. 3 bed (coal 75)
Coal 259B - 70 percent No. 2 Gas and Peerless bed and 30 percent Pocahontas No. 3 bed (coal 75)
Coal 90 - 100 percent Beckley bed
Coal 90A - 80 percent Pittsburgh bed and 20 percent Beckley bed
Coal 90B - 70 percent Pittsburgh bed and 30 percent Beckley bed
Coal 280 - 100 percent Pocahontas No. 4 bed
Coal 281 - 100 percent Pocahontas No. 3 bed
Coal 276 - 100 percent Lower Sunnyside bed
Coal 276A - 90 percent Lower Sunnyside bed and 10 percent Lower Sunnyside char
Coal 276B - 90 percent Lower Sunnyside bed and 10 percent Gilsonite char
Coal 284 - Hole No. 10-9, Core Sample, Gunnison County, Colorado - 932'8-1/2" - 936'9-1/2"
Coal 285 - Hole No. 10-9, Core Sample, Gunnison County, Colorado - 946'1" - 952'7"
Coal 286 - Hole No. 10-9, Core Sample, Gunnison County, Colorado - 958'2" - 964'11"

| Coal No. | Retort diameter, inches | Carbonizing temperature, °C. | Yields, percent by weight of coal1/ | | | | | | | Yields per ton of coal1/ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Coke | Gas | Tar | Light oil | Free ammonia | Liquor | Total | Gas, cu.ft. | Tar, gallons | Light oil, gal. In gas | Light oil, gal. To 170°C. | $(NH_4)_2SO_4$, pounds |
| 253 | 10 | 1,000 | 41.2 | 30.7 | 0.9 | 0.55 | 0.032 | 21.9 | 95.3 | 16,350 | 1.8 | 1.54 | 0.04 | 8.0 |
| 253 | 13 | 600 | 45.6 | 14.2 | 3.1 | .43 | .024 | 33.1 | 96.5 | 5,650 | 7.5 | 1.28 | .28 | 4.5 |
| 254 | 10 | 1,000 | 46.5 | 25.6 | 2.0 | .65 | .041 | 19.2 | 94.0 | 15,350 | 4.3 | 1.81 | .10 | 8.5 |
| 254 | 13 | 600 | 51.3 | 14.2 | 4.5 | .56 | .009 | 26.5 | 97.1 | 5,650 | 10.9 | 1.69 | .60 | 5.2 |
| 230 | 13 | 600 | 56.7 | 12.7 | 6.1 | .63 | .030 | 20.5 | 96.7 | 5,200 | 14.7 | 1.95 | .85 | 14.0 |
| 231 | 13 | 600 | 53.4 | 11.8 | 2.4 | .41 | .014 | 28.9 | 96.9 | 4,750 | 5.6 | 1.23 | .18 | 6.2 |
| 279 | 13 | 900 | 83.7 | 10.2 | 2.3 | .43 | .099 | 1.7 | 98.4 | 10,200 | 4.7 | 1.19 | .08 | 8.7 |
| 279A | 13 | 900 | 68.1 | 15.9 | 5.2 | .78 | .114 | 7.2 | 97.3 | 10,450 | 10.7 | 2.12 | .68 | 20.3 |
| 258 | 18 | 900 | 70.1 | 14.6 | 6.9 | 1.11 | .163 | 5.6 | 98.5 | 10,400 | 14.2 | 3.09 | .65 | 17.7 |
| 258A | 18 | 900 | 73.1 | 13.5 | 5.6 | .96 | .142 | 5.5 | 98.8 | 10,300 | 11.6 | 2.67 | .60 | 18.5 |
| 258B | 18 | 900 | 74.4 | 13.0 | 5.4 | .85 | .145 | 5.4 | 99.2 | 10,200 | 11.2 | 2.37 | .50 | 18.1 |
| 259 | 18 | 900 | 71.3 | 14.2 | 6.3 | 1.17 | .183 | 5.6 | 98.8 | 10,250 | 12.8 | 3.20 | .54 | 19.9 |
| 259A | 18 | 900 | 73.7 | 13.2 | 5.4 | .97 | .192 | 5.2 | 98.7 | 10,050 | 11.1 | 2.68 | .45 | 20.4 |
| 259B | 18 | 900 | 75.1 | 12.7 | 5.2 | .82 | .157 | 5.4 | 99.4 | 10,050 | 10.9 | 2.30 | .59 | 19.7 |
| 90 | 13 | 600 | 84.1 | 7.4 | 3.6 | .40 | .059 | 4.3 | 99.9 | 4,450 | 7.9 | 1.18 | .42 | 7.8 |
| 90 | 13 | 700 | 81.5 | 9.5 | 3.4 | .47 | .212 | 4.5 | 99.6 | 7,100 | 7.3 | 1.37 | .32 | 22.7 |
| 90 | 13 | 800 | 80.7 | 10.3 | 3.3 | .48 | .219 | 3.8 | 98.8 | 9,350 | 6.7 | 1.33 | .24 | 21.3 |
| 902/ | 13 | 800 | 81.0 | 10.8 | 3.0 | .43 | .205 | 4.1 | 99.3 | 9,150 | 6.3 | 1.20 | .19 | 22.6 |
| 903/ | 13 | 800 | 80.9 | 10.7 | 2.2 | .50 | .193 | 4.3 | 98.8 | 9,300 | 4.6 | 1.38 | .17 | 23.4 |
| 904/ | 13 | 800 | 80.6 | 10.9 | 1.9 | .50 | .165 | 5.5 | 99.6 | 9,400 | 4.0 | 1.39 | .14 | 22.3 |
| 90 | 18 | 900 | 80.6 | 11.1 | 3.0 | .59 | .181 | 4.0 | 99.5 | 10,700 | 6.2 | 1.63 | .15 | 19.4 |
| 90A | 18 | 900 | 72.0 | 13.6 | 6.5 | 1.01 | .136 | 5.5 | 98.7 | 10,350 | 13.6 | 2.84 | 1.02 | 21.5 |
| 90B | 18 | 900 | 73.1 | 13.6 | 6.0 | 1.03 | .152 | 5.4 | 99.3 | 10,450 | 12.5 | 2.88 | .83 | 22.4 |
| 90 | 18 | 1,000 | 80.6 | 11.1 | 2.6 | .54 | .145 | 3.7 | 98.7 | 11,700 | 5.2 | 1.49 | .09 | 14.5 |
| 280 | 13 | 800 | 84.3 | 9.4 | 1.9 | .33 | .165 | 3.4 | 99.5 | 8,900 | 3.8 | .91 | .09 | 15.5 |
| 2805/ | 13 | 800 | 84.3 | - | 1.7 | .33 | - | 3.5 | - | - | 3.4 | .90 | .07 | - |
| 2806/ | 13 | 800 | 84.4 | 9.4 | 1.5 | .32 | 0.155 | 3.6 | 99.4 | 8,600 | 3.0 | .87 | .05 | - |
| 2807/ | 13 | 800 | 84.6 | 9.5 | 1.2 | .31 | .148 | 3.6 | 99.4 | 8,600 | 3.0 | .87 | .05 | - |
| 281 | 13 | 800 | 84.6 | 9.5 | 1.2 | .31 | .148 | 3.6 | 99.4 | 8,600 | 3.0 | .87 | .05 | - |

TABLE 13. - Physical properties of coke

Coal 258 - 100 percent Powellton bed
Coal 258A - 80 percent Powellton bed and 20 percent Pocahontas No. 3 bed (coal 75)
Coal 258B - 70 percent Powellton bed and 30 percent Pocahontas No. 3 bed (coal 75)
Coal 259 - 100 percent No. 2 Gas and Peerless bed
Coal 259A - 80 percent No. 2 Gas and Peerless bed and 20 percent Pocahontas No. 3 bed (coal 75)
Coal 259B - 70 percent No. 2 Gas and Peerless bed and 30 percent Pocahontas No. 3 bed (coal 75)
Coal 90 - 100 percent Beckley bed
Coal 90A - 80 percent Pittsburgh bed and 20 percent Beckley bed
Coal 90B - 70 percent Pittsburgh bed and 20 percent Beckley bed
Coal 280 - 100 percent Pocahontas No. 4 bed
Coal 281 - 100 percent Pocahontas No. 3 bed

| Coal No. | Retort diameter, inches | Carbonizing temperature, °C. | True specific gravity | Apparent specific gravity | Cells, percent | Shatter test, cumulative percent upon- | | | | Tumbler test, cumulative percent upon- | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2-in. screen | 1-1/2-in. screen | 1-in. screen | 1/4-in. screen | 2-in. screen | 1-1/2-in. screen | 1-in. screen | 1/4-in. screen |
| 258 | 18 | 900 | 1.90 | 0.89 | 53.2 | 54.5 | 82.5 | 94.0 | 98.0 | 1.8 | 28.5 | 53.9 | 67.2 |
| 258A | 18 | 900 | 1.91 | .88 | 53.9 | 58.2 | 85.8 | 95.7 | 98.5 | 4.8 | 33.0 | 59.1 | 70.5 |
| 258B | 18 | 900 | 1.91 | .88 | 53.9 | 55.6 | 84.2 | 95.2 | 98.6 | 6.6 | 35.9 | 60.9 | 72.0 |
| 259 | 18 | 900 | 1.89 | .91 | 51.9 | 54.8 | 80.6 | 93.9 | 98.3 | 2.9 | 31.9 | 58.5 | 70.8 |
| 259A | 18 | 900 | 1.90 | .92 | 51.6 | 49.9 | 81.2 | 94.8 | 98.6 | 4.9 | 30.9 | 61.3 | 74.8 |
| 259B | 18 | 900 | 1.91 | .90 | 52.9 | 53.2 | 80.8 | 95.0 | 98.7 | 5.0 | 32.5 | 59.9 | 73.7 |
| 90 | 13 | 600 | 1.57 | .75 | 52.2 | 92.8 | 97.1 | 97.7 | 98.6 | 41.0 | 62.5 | 65.1 | 65.4 |
| 90 | 13 | 700 | 1.72 | .81 | 52.9 | 94.5 | 96.9 | 98.1 | 98.8 | 45.0 | 65.7 | 68.2 | 68.9 |
| 90 | 13 | 800 | 1.85 | .82 | 55.7 | 80.6 | 94.4 | 97.4 | 98.7 | 26.9 | 58.3 | 66.6 | 68.6 |
| 90 1/ | 13 | 800 | 1.84 | .83 | 54.9 | 86.9 | 96.2 | 98.2 | 99.0 | 29.4 | 59.5 | 68.7 | 69.5 |
| 90 2/ | 13 | 800 | 1.83 | .83 | 54.6 | 85.6 | 94.6 | 97.3 | 98.8 | 33.3 | 55.9 | 63.7 | 65.7 |
| 90 3/ | 13 | 800 | 1.85 | - | - | - | - | - | - | 1.3 | 18.4 | 32.9 | 39.4 |
| 90 | 18 | 900 | 1.89 | 0.86 | 54.5 | 60.1 | 86.0 | 96.3 | 98.8 | 14.8 | 43.1 | 66.0 | 72.2 |
| 90A | 18 | 900 | 1.89 | .81 | 57.1 | 44.0 | 79.8 | 94.6 | 98.5 | 4.3 | 30.1 | 62.3 | 72.6 |
| 90B | 18 | 900 | 1.89 | .85 | 55.0 | 46.1 | 80.9 | 95.2 | 98.5 | 6.6 | 32.1 | 63.2 | 73.7 |
| 90 | 18 | 1,000 | 1.93 | .87 | 54.9 | 24.9 | 67.0 | 94.5 | 99.0 | .4 | 19.3 | 60.7 | 75.5 |
| 280 | 13 | 800 | - | .88 | - | 80.1 | 93.1 | 96.7 | 98.7 | 18.5 | 44.9 | 57.7 | 62.1 |
| 280 4/ | 13 | 800 | - | .85 | - | 79.9 | 88.9 | 94.8 | 97.3 | 15.4 | 40.0 | 52.5 | 56.2 |
| 280 5/ | 13 | 800 | - | .86 | - | - | - | - | - | 5.0 | 24.8 | 40.2 | 44.6 |
| 281 | 13 | 800 | - | .87 | - | 82.8 | 94.2 | 97.4 | 98.6 | 14.8 | 50.6 | 61.1 | 63.9 |
| 281 6/ | 13 | 800 | - | .84 | - | 80.3 | 94.0 | 95.9 | 97.9 | 15.1 | 46.4 | 53.9 | 55.9 |

Time oxidized in air at 100° C., days: 1/, 2.8; 2/, 10.2; 3/, 18.4; 4/, 3.8; 5/, 9.0; 6/, 5.0.

TABLE 13a. - Physical properties of coke (Columbia Steel Co. methods)

Coal 279 - 100 percent Peruvian coal
Coal 279A - 80 percent Lower Sunnyside bed (coal 276) and 20 percent Peruvian
Coal 284 - Hole No. 10-9, core sample, Gunnison County, Colorado - 932'8-1/2" - 936'9-1/2"
Coal 285 - Hole No. 10-9, core sample, Gunnison County, Colorado - 946'1" - 952'7"
Coal 286 - Hole No. 10-9, core sample, Gunnison County, Colorado - 958'2" - 964'11"
Coal 276 - 100 percent Lower Sunnyside bed
Coal 276A - 90 percent Lower Sunnyside bed and 10 percent Lower Sunnyside char
Coal 276B - 90 percent Lower Sunnyside bed and 10 percent Gilsonite char

| Coal No. | Retort diameter, inches | Carbonizing temperature, °C. | True specific gravity | Apparent specific gravity | Cells, percent | Shatter test, cumulative percent upon- | | | | Tumbler test, cumulative percent upon- | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1-1/2-in. screen | 1-in. screen | 3/4-in. screen | 1/2-in. screen | 1-1/2-in. screen | 1-in. screen | 3/4-in. screen | 1/2-in. screen |
| 279 | 13 | 900 | 1.92 | 0.87 | 54.7 | 68 | 94 | 97 | 98 | 47 | 79 | 83 | 86 |
| 279A | 13 | 900 | 1.93 | .81 | 58.0 | 58 | 90 | 95 | 98 | 36 | 75 | 82 | 86 |
| 284 | 13 | 900 | 1.90 | .73 | 61.6 | 51 | 81 | 88 | 94 | 22 | 62 | 71 | 80 |
| 285 | 13 | 900 | 1.90 | .73 | 61.6 | 28 | 70 | 80 | 91 | 19 | 53 | 64 | 76 |
| 286 | 13 | 900 | 1.92 | .76 | 60.4 | 37 | 80 | 89 | 96 | 25 | 65 | 76 | 84 |
| 276 | 13 | 900 | 1.93 | .75 | 61.1 | 43 | 75 | 84 | 92 | 20 | 55 | 65 | 76 |
| 276A | 13 | 900 | 1.94 | .82 | 57.7 | 62 | 88 | 93 | 96 | 27 | 67 | 75 | 82 |
| 276B | 13 | 900 | 1.93 | .81 | 58.0 | 64 | 89 | 93 | 96 | 30 | 67 | 73 | 78 |

TABLE 14. - Physical and chemical properties of gas

Coal 253 - 100 percent Vulcano mine
Coal 254 - 100 percent Elena mine
Coal 230 - 100 percent Lirquen mine
Coal 231 - 100 percent Copihues de Pupunahue mine
Coal 279 - 100 percent Peruvian coal
Coal 279A - 80 percent Lower Sunnyside bed and 20 percent Peruvian
Coal 258 - 100 percent Powellton bed
Coal 258A - 80 percent Powellton bed and 20 percent Pocahontas No. 3 bed (coal 75)
Coal 258B - 70 percent Powellton bed and 30 percent Pocahontas No. 3 bed (coal 75)
Coal 259 - 100 percent No. 2 Gas and Peerless bed
Coal 259A - 80 percent No. 2 Gas and Peerless bed and 20 percent Pocahontas No. 3 bed (coal 75)
Coal 259B - 70 percent No. 2 Gas and Peerless bed and 30 percent Pocahontas No. 3 bed (coal 75)
Coal 90 - 100 percent Beckley bed
Coal 90A - 80 percent Pittsburgh bed and 20 percent Beckley bed
Coal 90B - 70 percent Pittsburgh bed and 30 percent Beckley bed
Coal 280 - 100 percent Pocahontas No. 4 bed
Coal 281 - 100 percent Pocahontas No. 3 bed
Coal 276 - 100 percent Lower Sunnyside bed
Coal 276A - 90 percent Lower Sunnyside bed and 10 percent Lower Sunnyside char
Coal 276B - 90 percent Lower Sunnyside bed and 10 percent Gilsonite char
Coal 284 - Hole No. 10-9, core sample, Gunnison County, Colorado - 932'8-1/2" - 936'9-1/2"
Coal 285 - Hole No. 10-9, core sample, Gunnison County, Colorado - 946'1" - 952'7"
Coal 286 - Hole No. 10-9, core sample, Gunnison County, Colorado - 958'2" - 964'11"

| Coal No. | Retort diameter, inches | Carbonizing temperature, °C. | Specific gravity | Gross heating value[1] B.t.u. per cubic foot Determined | Gross heating value[1] B.t.u. per cubic foot Calculated | Gross heating value[1] B.t.u. per pound of coal | $H_2S$, grains per 100 cubic feet | Composition, dry, percent by volume $CO_2$ | Illuminants | $O_2$ | $H_2$ | CO | $CH_4$ | $C_2H_6$ | $N_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 253 | 10 | 1,000 | 0.497 | 365 | 379 | 2,980 | 70 | 9.1 | 2.1 | 0.4 | 53.8 | 24.7 | 7.1 | 1.5 | 1.3 |
| 253 | 13 | 600 | .667 | 499 | 471 | 1,410 | 200 | 24.9 | 2.3 | .3 | 38.5 | 6.0 | 24.0 | 3.1 | .9 |
| 254 | 10 | 1,000 | .444 | 456 | 410 | 3,500 | 80 | 8.8 | 3.3 | .4 | 52.4 | 21.9 | 11.9 | .2 | 1.1 |
| 254 | 13 | 600 | .668 | 543 | 519 | 1,530 | 200 | 22.2 | 2.9 | .3 | 36.6 | 5.9 | 27.5 | 3.7 | .9 |
| 230 | 13 | 600 | .644 | 633 | 602 | 1,650 | 440 | 17.8 | 4.0 | .3 | 34.1 | 6.0 | 30.2 | 6.4 | 1.2 |
| 231 | 13 | 600 | .663 | 561 | 559 | 1,330 | 180 | 22.1 | 2.2 | .3 | 30.2 | 7.6 | 31.4 | 5.3 | .9 |
| 279 | 13 | 900 | .264 | 522 | 509 | 2,660 | 310 | 1.0 | 1.7 | .4 | 66.1 | 3.2 | 26.4 | .0 | 1.2 |
| 279A | 13 | 900 | .403 | 605 | 587 | 3,160 | 580 | 2.5 | 5.0 | .3 | 50.7 | 8.2 | 30.6 | 1.0 | 1.7 |
| 258 | 18 | 900 | .371 | 618 | 606 | 3,210 | 240 | 1.9 | 4.9 | .2 | 52.8 | 5.5 | 32.0 | 1.5 | 1.2 |
| 258A | 18 | 900 | .347 | 592 | 578 | 3,050 | 200 | 1.5 | 4.0 | .2 | 56.3 | 4.7 | 31.3 | .6 | 1.4 |
| 258B | 18 | 900 | .337 | 585 | 570 | 2,980 | 190 | 1.4 | 3.4 | .3 | 57.9 | 4.5 | 30.2 | 1.1 | 1.2 |
| 259 | 18 | 900 | .367 | 605 | 593 | 3,100 | 390 | 1.8 | 4.8 | .2 | 53.7 | 5.7 | 31.8 | .8 | 1.2 |
| 259A | 18 | 900 | .349 | 590 | 579 | 2,960 | 330 | 1.8 | 4.1 | .3 | 56.2 | 5.1 | 30.8 | .8 | .9 |
| 259B | 18 | 900 | .335 | 578 | 570 | 2,900 | 300 | 1.5 | 3.6 | .4 | 58.2 | 4.7 | 28.9 | 1.5 | 1.2 |
| 90 | 13 | 600 | .440 | 747 | 736 | 1,660 | 190 | 1.3 | 1.0 | .4 | 38.3 | 2.3 | 50.6 | 5.1 | 1.0 |
| 90 | 13 | 700 | .356 | 641 | 636 | 2,280 | 190 | .9 | 1.5 | .4 | 50.8 | 2.6 | 40.1 | 2.6 | 1.1 |
| 90 | 13 | 800 | .292 | 561 | 554 | 2,620 | 170 | .8 | 2.2 | .4 | 61.9 | 2.7 | 29.7 | 1.1 | 1.2 |
| 90[2] | 13 | 800 | .306 | 568 | 562 | 2,600 | 160 | .8 | 2.0 | .4 | 60.8 | 2.7 | 30.8 | 1.3 | 1.2 |
| 90[3] | 13 | 800 | .307 | 562 | 553 | 2,610 | 160 | 1.4 | 2.1 | .4 | 60.1 | 3.7 | 30.2 | 1.0 | 1.1 |
| 90[4] | 13 | 800 | .308 | - | 534 | - | 130 | 1.7 | 2.2 | .4 | 61.3 | 4.0 | 28.9 | .3 | 1.2 |
| 90 | 18 | 900 | .275 | 533 | 528 | 2,850 | 150 | .6 | 2.0 | .4 | 65.0 | 2.5 | 27.9 | .3 | 1.3 |
| 90A | 18 | 900 | .349 | 592 | 583 | 3,060 | 310 | 1.4 | 3.7 | .4 | 55.3 | 5.5 | 31.3 | 1.2 | 1.2 |
| 90B | 18 | 900 | .346 | 587 | 579 | 3,070 | 300 | 1.3 | 3.4 | .3 | 56.4 | 5.1 | 30.8 | 1.4 | 1.3 |
| 90 | 18 | 1,000 | .252 | 517 | 500 | 3,020 | 160 | .6 | 1.6 | .4 | 68.2 | 3.1 | 24.9 | .0 | 1.2 |
| 280[5] | 13 | 800 | .280 | 529 | 525 | 2,350 | 210 | .9 | 1.6 | .4 | 64.2 | 3.6 | 27.6 | .6 | 1.1 |
| 280[5] | 13 | 800 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 280[6] | 13 | 800 | 0.292 | 528 | 525 | 2,270 | 210 | 1.0 | 1.7 | 0.1 | 63.4 | 3.3 | 28.6 | 0.1 | 1.8 |
| 280[7] | 13 | 800 | .287 | 515 | 515 | 2,270 | 190 | 1.5 | 1.5 | .4 | 64.5 | 3.3 | 27.8 | .0 | 1.0 |
| 280[7] | 13 | 800 | .288 | 528 | 531 | 2,360 | 180 | .7 | 1.5 | .3 | 63.7 | 2.9 | 29.0 | .5 | 1.4 |

TABLE 15. - Analysis of tar distillate and light oil

Coal 253 - 100 percent Vulcano mine
Coal 254 - 100 percent Elena mine
Coal 230 - 100 percent Lirquen mine
Coal 231 - 100 percent Copihues de Pupunahue mine
Coal 279 - 100 percent Peruvian coal
Coal 279A - 80 percent Lower Sunnyside bed and 20 percent Peruvian
Coal 258 - 100 percent Powellton bed
Coal 258A - 80 percent Powellton bed and 20 percent Pocahontas No. 3 bed (coal 75)
Coal 258B - 70 percent Powellton bed and 30 percent Pocahontas No. 3 bed (coal 75)
Coal 259 - 100 percent No. 2 Gas and Peerless bed
Coal 259A - 80 percent No. 2 Gas and Peerless bed and 20 percent Pocahontas No. 3 bed (coal 75)
Coal 259B - 70 percent No. 2 Gas and Peerless bed and 30 percent Pocahontas No. 3 bed (coal 75)
Coal 90 - 100 percent Beckley bed
Coal 90A - 80 percent Pittsburgh bed and 20 percent Beckley bed
Coal 90B - 70 percent Pittsburgh bed and 30 percent Beckley bed
Coal 280 - 100 percent Pocahontas No. 4 bed
Coal 281 - 100 percent Pocahontas No. 3 bed
Coal 276 - 100 percent Lower Sunnyside bed
Coal 276A - 90 percent Lower Sunnyside bed and 10 percent Lower Sunnyside char
Coal 276B - 90 percent Lower Sunnyside bed and 10 percent Gilsonite char
Coal 284 - Hole No. 10-9, core sample, Gunnison County, Colorado - 932'8-1/2" - 936'9-1/2"
Coal 285 - Hole No. 10-9, core sample, Gunnison County, Colorado - 946'1" - 952'7"
Coal 286 - Hole No. 10-9, core sample, Gunnison County, Colorado - 958'2" - 964'11"

| Coal No. | Retort diameter, inches | Carbonizing temperature, °C. | Distillate, percent by volume of dry tar | | | Neutral tar oil, percent by volume | | | Refined light oil from gas, percent by volume | | | | Olefins in crude light oil from gas, percent by volume |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Acids | Bases | Neutral oils | Olefins | Aromatics | Paraffins and naphthenes | Benzene | Toluene | Paraffins | Solvent naphtha | |
| 253 | 10 | 1,000 | 8.4 | 1.0 | 38.2 | 14.1 | 76.9 | 9.0 | 46.5 | 22.6 | 6.0 | 24.9 | 21.7 |
| 253 | 13 | 600 | 15.4 | 2.4 | 49.3 | 16.8 | 58.0 | 25.2 | 25.1 | 21.3 | 28.7 | 24.9 | 36.1 |
| 254 | 10 | 1,000 | 9.8 | 1.8 | 36.5 | 17.0 | 74.3 | 8.7 | 60.6 | 21.2 | 5.1 | 13.1 | 20.9 |
| 254 | 13 | 600 | 19.9 | 1.8 | 32.2 | 14.0 | 58.5 | 27.5 | 20.1 | 19.7 | 30.7 | 29.5 | 37.1 |
| 230 | 13 | 600 | 16.9 | 2.6 | 45.9 | 16.0 | 48.9 | 35.1 | 18.7 | 16.6 | 38.1 | 26.6 | 43.2 |
| 231 | 13 | 600 | 24.5 | 2.4 | 44.3 | 15.0 | 55.7 | 29.3 | 23.4 | 21.4 | 30.1 | 25.1 | 34.2 |
| 279 | 13 | 900 | 1.0 | .8 | 17.7 | 8.7 | 91.3 | .0 | 63.4 | 26.8 | 1.6 | 8.2 | 10.3 |
| 279A | 13 | 900 | 3.6 | 2.5 | 29.2 | 11.2 | 88.4 | .4 | 72.4 | 22.7 | 1.4 | 3.5 | 10.9 |
| 258 | 18 | 900 | 5.6 | 1.9 | 27.2 | 10.5 | 85.5 | 4.0 | 65.7 | 20.4 | 5.8 | 8.1 | 13.1 |
| 258A | 18 | 900 | 6.7 | 1.9 | 28.8 | 11.0 | 85.4 | 3.6 | 67.6 | 19.9 | 6.0 | 6.5 | 12.5 |
| 258B | 18 | 900 | 8.2 | 2.1 | 31.1 | 11.3 | 82.4 | 6.3 | 60.2 | 21.7 | 8.1 | 10.0 | 13.4 |
| 259 | 18 | 900 | 4.0 | 1.7 | 23.5 | 9.5 | 89.2 | 1.3 | 71.9 | 20.2 | 3.6 | 4.3 | 10.1 |
| 259A | 18 | 900 | 6.4 | 1.8 | 26.4 | 10.5 | 87.7 | 1.8 | 65.9 | 22.7 | 4.8 | 6.6 | 11.1 |
| 259B | 18 | 900 | 8.9 | 2.1 | 32.4 | 9.8 | 84.5 | 5.7 | 59.5 | 21.3 | 8.6 | 10.6 | 15.2 |
| 90 | 13 | 800 | 6.5 | .6 | 33.9 | 6.9 | 70.2 | 22.9 | 23.7 | 21.2 | 36.4 | 18.7 | 24.9 |
| 90 | 13 | 700 | 5.9 | .8 | 30.0 | 6.8 | 78.7 | 14.5 | 20.1 | 29.7 | 21.3 | 28.9 | 21.4 |
| 90 | 13 | 800 | 2.7 | 1.1 | 24.2 | 9.0 | 84.0 | 7.0 | 36.9 | 33.6 | 9.4 | 20.1 | 16.9 |
| 90 1/ | 13 | 800 | 3.5 | 1.1 | 24.3 | 8.4 | 91.3 | 2.6 | 31.3 | 36.1 | 9.3 | 23.3 | 13.6 |
| 90 2/ | 13 | 800 | 2.4 | 1.8 | 23.7 | 5.8 | 93.3 | .9 | 49.1 | 33.0 | 3.9 | 14.0 | 12.0 |
| 90 3/ | 13 | 800 | 3.9 | 1.8 | 24.0 | 8.1 | 90.7 | 1.2 | 46.9 | 34.2 | 4.3 | 14.6 | 12.9 |
| 90 | 18 | 900 | 2.6 | .7 | 19.4 | 8.0 | 86.5 | 5.5 | 60.4 | 24.5 | 3.8 | 11.3 | 12.3 |
| 90A | 18 | 900 | 7.4 | 1.9 | 32.0 | 11.0 | 81.9 | 7.1 | 63.4 | 18.8 | 8.9 | 8.9 | 13.2 |
| 90B | 18 | 900 | 6.4 | 1.7 | 28.9 | 8.3 | 86.2 | 5.5 | 68.5 | 17.7 | 7.3 | 6.5 | 12.4 |
| 90 | 18 | 1,000 | 1.3 | .8 | 18.0 | 8.3 | 90.3 | 1.4 | 70.2 | 19.1 | 2.4 | 8.3 | 9.8 |
| 280 | 13 | 800 | 1.8 | .5 | 19.1 | 6.7 | 92.8 | .5 | 45.4 | 37.8 | 2.9 | 13.9 | 11.3 |
| 280 4/ | 13 | 800 | 1.8 | .9 | 19.6 | 6.6 | 92.5 | .9 | 40.1 | 40.1 | 5.7 | 14.1 | 11.3 |
| 280 5/ | 13 | 800 | 2.0 | .7 | 19.9 | 5.0 | 94.5 | .5 | 34.0 | 41.9 | 6.6 | 17.5 | 12.9 |
| 280 6/ | 13 | 800 | 1.6 | 1.1 | 18.0 | 8.3 | 91.4 | .3 | 43.4 | 38.4 | 4.1 | 14.1 | 12.8 |
| 281 7/ | 13 | 800 | 2.4 | 1.1 | 18.3 | 9.1 | 90.5 | .4 | 37.8 | 39.9 | 7.9 | 14.4 | 11.9 |
| 281 8/ | 13 | 800 | 2.4 | .6 | 19.5 | 6.8 | 92.9 | .3 | 37.0 | 42.2 | 4.0 | 16.8 | 10.6 |
| 281 9/ | 13 | 800 | 2.0 | .9 | 18.1 | 7.6 | 91.9 | .5 | 41.6 | 36.2 | 8.5 | 13.7 | 13.0 |
| | 13 | 800 | 2.0 | 1.0 | 18.9 | 6.6 | 92.9 | .5 | 35.4 | 41.3 | 6.6 | 16.7 | 11.7 |
| 276 | 13 | 900 | 4.5 | 2.3 | 31.1 | 10.6 | 87.4 | 2.1 | 74.0 | 20.0 | 2.7 | 3.3 | 12.6 |
| 276A | 13 | 900 | 4.8 | 2.1 | 30.6 | 12.5 | 85.6 | 1.9 | 73.4 | 20.0 | 2.9 | 3.7 | 12.3 |
| 276B | 13 | 900 | 4.3 | 2.2 | 30.1 | 11.3 | 86.6 | 2.1 | 73.9 | 20.1 | 2.7 | 3.3 | 11.5 |
| 284 | 13 | 900 | 7.0 | 2.5 | 34.6 | 11.5 | 85.6 | 2.9 | 66.3 | 22.4 | 5.1 | 6.2 | 15.4 |
| 285 | 13 | 900 | 5.0 | 2.5 | 29.8 | 13.0 | 84.4 | 2.6 | 72.5 | 19.5 | 3.6 | 4.4 | 11.9 |
| 286 | 13 | 900 | 7.3 | 2.5 | 34.9 | 10.0 | 87.0 | 3.0 | 65.8 | 21.2 | 6.5 | 6.5 | 13.0 |

Time oxidized in air at 100° C., days:- 1/, 3.9; 2/, 5.0; 3/, 7.2; 4/, 2.7; 5/, 7.5; 6/, 11.9; 7/, 3.7; 8/, 8.3; 9/, 11.5.

Normally, coals of high-volatile A rank or higher give material balances (table 12) totaling 98.5 to 99.5 percent, and this figure serves as a check on the accuracy of the work. However, with high-oxygen coals containing high percentages of water, such as the Chilean subbituminous coals, there is a loss of moisture, and the material balances may fall as low as 94 percent. A large proportion of the water at high carbonizing temperatures is used in the formation of water gas, which complicates the process. The weight of water so used should appear as oxides of carbon and hydrogen, but determination of yields of gas on a weight basis is subject to considerable error and, furthermore, it is possible that with excessive amounts of water in the gas it is difficult to determine the saturation at the point of measurement. The yields of ammonia at carbonizing temperatures above 800° C. are generally lower than those obtained in refractory ovens, because at high temperatures the iron walls of the BM-AGA retorts decompose ammonia much more rapidly than do refractories.

For determining the shatter and tumbler indexes of coke (table 13) two methods are used - the BM-AGA methods following those approved by the American Society for Testing Materials and by the Columbia Steel Co. The former applies to Appalachian and Midwestern coals and the latter to the less strongly coking coals of the West. For guidance in interpreting results for a given coal, average results are available for coals previously tested.

For example, an average high-volatile A coal when carbonized at 900° C., in the 18-inch retort will yield coke having a 1-1/2-inch shatter index of 70, a 1-inch tumbler index of 51, and a 1/4-inch tumbler index of 72. Higher indexes indicate, better than average coke-making properties, whether the coal is of high-volatile A rank. Low- and medium-volatile coals and their blends will yield stronger cokes with higher indexes. The index which the Columbia Steel Co. emphasize most in interpreting results by their method of test is the proportion remaining on the 1/2-inch screen in the tumbler test; this figure should be 75 or higher. The Beckley coal for which results by the Bureau of Mines method are given in the table 13 is of low-volatile rank; the quality of coke is about average for low-volatile coals. The average 1-1/2-inch shatter index is 85, and the average tumbler index is 64. The effect of mild oxidation of the coal upon the quality of the coke is indicated by the shatter and tumbler indexes for coals 280 and 281. Here, the effect upon the tumbler index is most pronounced. The tumbler test emphasizes abradability in the coke, and it appears that the main effect of oxidation upon quality of the coke is to render it more abradable.

Properties of gases from coals tested during the year are given in table 14. For the most part the gases are normal, considering the rank and grade of the coals. However, the high yield of gas from the subbituminous Ruena coal (254) at 1,000° C. is abnormal; 3,500 B.t.u. in gas per pound of coal carbonized is as high as would be obtained from a good Appalachian gas coal; its heating value in B.t.u. per cubic foot, although not as high as would be obtained from a gas coal, is considered high enough for city distribution. The hydrogen sulfide content of this gas is very low - a desirable quality from the gas-maker's point of view.

Table 15 gives the properties of the tar distillates and light oils. The subbituminous Chilean coals show high percentages of tar acids and low aromatic content as compared with other coals of the table. Also, the benzene content of the light oils is low and the olefin content is high. This composition is characteristic of bituminous coals of low rank. The composition of tars from other coals in the table is also characteristic of strongly coking coals, the class to which they belong.

## Chilean Coals

The Chilean coals, Nos. 230, 231, 253, and 254,[60] were all subbituminous coals and noncoking. They were tested at the request of the Chilean Government. A "Technical Report of the Coal Mission on Coals of Chile," which included "Carbonizing Properties of Chilean Bituminous and Subbituminous Coals sampled by Engineers of the U. S. Bureau of Mines" and "Washing Characteristics of the Chilean Coals," was completed and transmitted through the Secretary of the Interior to the Secretary of State for transmittal to the Chilean Government. The main points of interest were yields of carbonization products at low temperatures and yield and quality of gases at high temperatures. Chile has no true gas coals and, accordingly, it was important to investigate all possible sources of gas for city distribution. The investigation showed that the Elena mine coal yielded 3,500 B.t.u. in gas per pound of coal carbonized, and the heating value per cubic foot was 456 B.t.u. It is considered feasible to supply such gas for domestic use. The low-temperature yields from these coals were as expected from coals of their rank.

## Texas Lignite

Texas lignite (coal 245) mixed with asphaltic oil residues was carbonized to determine whether a coke of metallurgical quality could be produced from such mixtures. It is known that asphaltic oils possess considerable binding power, and cokelike residues are obtained when they are carbonized with totally inert carbonaceous matter. The experimental procedure consisted in preparation of the raw lignite by drying and also precarbonization, mixing with 10 to 30 percent of the oil residue, and carbonizing the mixture with and without briquetting. Raw lignite mixed with oil also was carbonized, but a very porous coked residue bearing little resemblance to true coke was obtained. It was finally found necessary to prepare the lignite by carbonization, mix it with a viscous oil residue (15 to 20 percent), make a briquette, and then carbonize at a high temperature. Coke briquets so produced were dense and hard, but they contained too much ash (about 20 percent); furthermore, it is doubtful whether a coke produced by such an expensive process would compete with that made from Appalachian region coals.

## Peruvian Coal

A sample of Peruvian low-volatile coal taken by Thomas Fraser of the Bureau of Mines was carbonized at 900° C. A carbonization test was made,

[60] This series of numbers applies only to coals on which the complete BM-AGA procedure has not been used.

also, in which 20 percent of this coal was blended with 80 percent Sunnyside coal from Carbon County, Utah. Sunnyside coal was chosen for blending because its coking quality is similar to that of Chilean coals, and it is possible that this Peruvian coal will be exported to Chile for blending purposes. The Chilean Government proposes to establish a small steel industry, and low-volatile coal is needed for blending with native coals to produce metallurgical coke.

The chemical composition of the Peruvian coal is given in table 11. It contained 20.2 percent volatile matter, the ash content was moderate (7.0 percent), and the sulfur was satisfactorily low (1.0 percent). The coke was fine-grained and contained few fractures. Table 13a shows its physical properties (279) and those of the blend (279A) with Sunnyside coal, the coke tests being made by the Columbia Steel methods. Coke from 100 percent Sunnyside coal is included for comparison. The enormous improvement in coke from Sunnyside coal by blending with the Peruvian coal is evident. Therefore, the latter must be considered a very satisfactory coal for blending with coals of Sunnyside rank.

## Powellton and No. 2 Gas-Peerless Coals

Two West Virginia high-volatile coals that had been cleaned by a heavy-media (magnetite) process and their blends with 20 and 30 percent low-volatile coal were carbonized by the BM-AGA method at 900° C. Both coals were from Ansted, Fayette County, W. Va. Powellton coal was from the Powellton No. 2 mine, and No. 2 Gas-Peerless coal was from the No. 3 North mine. They were of similar rank and chemical composition (table 11); both contained moderate proportions of moisture, ash, and sulfur. The ash from Powellton softened at 2,290° F., whereas that from No. 2 Gas-Peerless, softened at 2,890° F. Their plastic properties also were similar - both coals attained high fluidity in the Gieseler test.

The yields in the BM-AGA test at 900° C. from Powellton and No. 2 Gas-Peerless coals were (table 12), respectively: Coke, 70.1 and 71.3 percent; and, upon the basis of per ton of coal, gas, 10,400 and 10,250 cubic feet; tar, 14.2 and 12.8 gallons; light oil in gas, 3.09 and 3.20 gallons; and ammonium sulfate, 17.7 and 19.9 pounds. Powellton coke resisted breakage in the shatter test more than No. 2 Gas-Peerless coke, but the latter was less abradable in the tumbler test. The 1-1/2-inch shatter and 1-inch tumbler indexes of both cokes were appreciably higher than the averages for 25 high-volatile A coals tested previously;[61] the averages for 25 coals were 70.4 and 50.8 for the 1-1/2-inch shatter and 1-inch tumbler, respectively. However, both 1/4-inch tumbler indexes were lower than the average 72.2. Blending with Pocahontas No. 3 coal strengthened the cokes from both coals. The abradability of Powellton coke was decreased significantly by blending with 20 percent of this low-volatile coal, but other effects were less

61/ Reynolds, D. A., and Holmes, C. R., Physical Properties of Cokes from Bureau of Mines-American Gas Association Tests at 800° and 900° C.: Bureau of Mines Rept. of Investigations 3650, 1942, 14 pp.