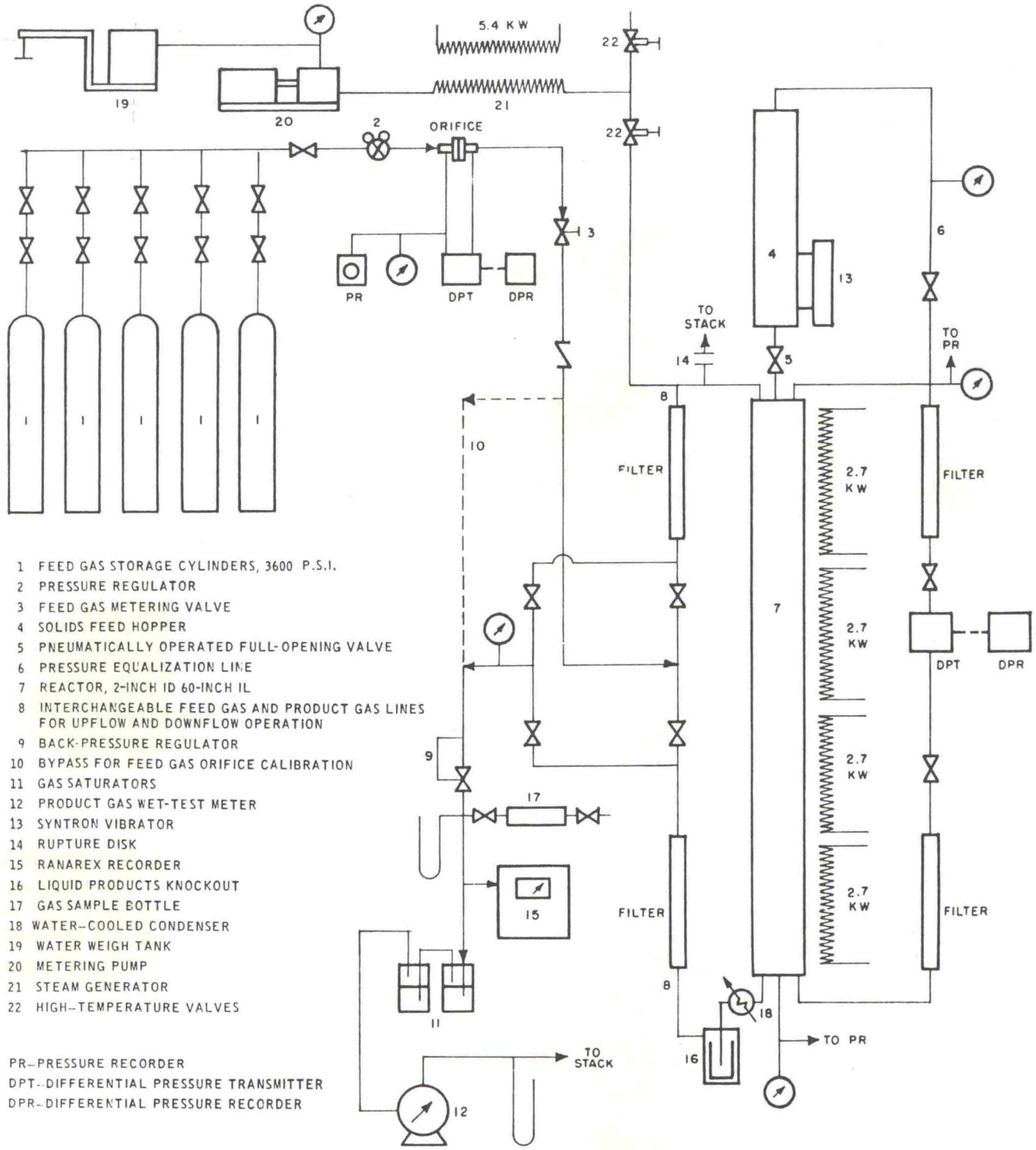

Figure 1. Semiflow reactor system for study of rates of hydrogasification of solid fossil fuels at temperatures to 1700° F. and pressures to 3000 p.s.i.g.

or less. The reactor was first heated up to the desired operating temperature. Then gas flow, at the desired rate, was started through the reactor. The heat input to the reactor was then adjusted so that all temperatures within the reactor remained constant. When the system was stabilized completely, the run was initiated by opening the valve between the feed hopper and the reactor.

At typical conditions of 1500 p.s.i.g., 1700° F., and a hydrogen flow rate of 100 SCF per hour, the first hydrogasification products appeared in the exit gas at the sampling manifold in approximately 10 seconds. During the initial period of high conversion rate, samples were taken at time intervals as short as 5 seconds to delineate the exact course of the reaction. Temperatures at the center of the coal charge, at a point 6 inches above the charge, and at the bottom of the insert were recorded continuously by means of a high-speed temperature recorder, which recorded each temperature at approximately 3-second intervals.

When the reaction rate had reached a value too small to be measured accurately at the high gas rates employed (usually after about 600 seconds), the run was stopped. The electric heaters were turned off and the reactant gases were purged from the reactor with nitrogen. The reactor was kept filled with nitrogen until the temperature was low enough to allow retrieval of the coal residue.

Results

Exploratory Tests. Before the test program was initiated, several exploratory tests were conducted at the base condi-

Table I. Coal Analyses

Coal	Bituminous coal char		Anthracite
Type	Low temperature		Medium volatility
Source	Consolidation Coal Co. (Montour No. 10 mine)		Anthracite Experiment Station, U. S. Bur. Mines
Particle size, U. S. standard sieve	−16, +20	−40, +50	−16, +20
Ultimate analysis, wt. % (dry basis)			
Carbon	78.3	79.5	83.3
Hydrogen	3.46	3.46	2.47
Nitrogen and oxygen (by difference)	10.03	10.12	2.90
Sulfur	1.01	0.91	0.88
Ash	7.20	6.01	10.45
Total	100.00	100.00	100.00
Proximate analysis, wt. %			
Moisture	1.7	2.3	0.7
Volatile matter	17.3	17.9	5.7
Fixed carbon	73.9	73.9	83.2
Ash	7.1	5.9	10.4
Total	100.0	100.0	100.0

Coal	Bituminous coal		Lignite
Type	Pittsburgh Seam		North Dakota
Source	Consolidation Coal Co. (Montour No. 4 mine)		Truax-Traer Co. (Velva mine)
Particle size, U. S. standard sieve	−16, +20		−16, +20
Ultimate analysis, wt. % (dry basis)			
Carbon	75.9		65.4
Hydrogen	5.01		4.49
Nitrogen and oxygen (by difference)	8.99		23.21
Sulfur	1.54		0.45
Ash	8.56		6.45
Total	100.00		100.00
Proximate analysis, wt. %			
Moisture	1.1		6.8
Volatile matter	33.5		41.2
Fixed carbon	56.9		46.0
Ash	8.5		6.0
	100.0		100.0

tions of 1000 or 1500 p.s.i.g. and 1700° F., with a hydrogen flow rate of 100 SCF per hour. It was necessary to select sample weights which gave small temperature changes and low concentrations of methane in the exit gas, without impairing analytical accuracy.

With 50- and 20-gram samples of low-temperature bituminous coal char (−8, +16 sieve size), the maximum exit gas methane content was too high and the temperature changes during the run were too great to allow the assumption of differential reaction conditions. In tests with 10- and 5-gram samples of −16, +20 sieve size low-temperature bituminous coal char, the exit gas methane contents approached the desired levels, and reaction rates (expressed as pounds of carbon converted to gaseous hydrocarbons per pound of carbon remaining in bed per hour) were similar. With bituminous coal char, temperature changes were not completely eliminated even with the 3-gram sample (Figure 2). However, further reductions in sample weight would have reduced methane concentrations in the exit gas to values too low for accurate measurement of reaction rates.

With low-temperature bituminous coal char at nominal run temperatures of 1700° F., two periods of high rate were observed (Figure 2). The second, occurring after approximately 30% carbon gasification, was a result of increases in the temperature of the char sample due to the inability of the char sample to dissipate the high heat of reaction to the surroundings. This was substantiated by conducting a further test with a 3-gram sample weight. Here rate increased only slightly at carbon conversions above 30%. In tests with unpretreated coals, and with bituminous coal char at 1300° and 1500° F., no second period of high rate was observed.

It was also necessary to select a coal particle size for the remainder of the test program. An effect of particle size on the rate of reaction could indicate the presence of significant diffusional resistances. Tests conducted with 10-gram samples of −16, +20 and −40, +50 sieve size material (Figure 3) indicate negligible effects of particle size on the reaction rate. The displacement of the rate curve for the −40, +50 sieve size material was probably due to the slower feeding rate of the more finely divided material, or to an initial holdup in the coal feed hopper. On the basis of duplicate tests to check reproducibility, it was believed that these small differences were within the limits of experimental and analytical accuracy.

From the results of these exploratory tests, the following base conditions were selected for the remainder of the tests, unless otherwise noted:

Temperature	1700° F.
Pressure	1500 p.s.i.g.
Sample weight	5 and 10 grams
Coal particle size	−16, +20 sieve size
Feed gas flow rate	100 SCF per hour