BITUMINOUS COAL RESEARCH, INC.
SPONSORED RESEARCH PROGRAM

GAS GENERATOR RESEARCH AND DEVELOPMENT
FLUIDIZED BED GASIFICATION

Progress Report No. 11-A
(BCR Report L-478)

I. INTRODUCTION

This report summarizes progress achieved during the month on the program "Fluidized-bed Gasification" which is a part of the general program, "Gas Generator Research and Development," being conducted by Bituminous Coal Research, Inc., for the Office of Coal Research. This represents the eleventh report of progress under Contract No. 14-32-0001-1207.

Design work on the fluidized-bed gasification PEDU progressed with receipt of preliminary material balances from Foster Wheeler. The laboratory work centered on the use of a new flow system for the fluidized-bed batch reactor.

II. PROGRESS ACHIEVED DURING THE MONTH ENDING JULY 25, 1972

A. Fluidized-bed PEDU

Foster Wheeler Corporation reported that they have been averaging between 40 and 60 manhours per week on this project. It was estimated that this number would double or triple as soon as the work progressed to the point where mechanical design could begin. The PEDU design engineering package should be completed in three months, which is in agreement with the original FWC estimate of three to four months.

A trip was made to Foster Wheeler on July 25, 1972. At that time, three preliminary material balances were given to BCR as FWC Drawing No. 11-22 334. The three cases covered were gasification of Pittsburgh seam coal with air and steam, with oxygen and steam, and with air and carbon dioxide. No preheat was provided on any feed gas stream. Consequently, the gross heating value of the product gas from the air-steam system was less than 100 Btu/scf. Foster Wheeler was directed to revise the material balances with the target to be a product gas with a gross heating value of 150 to 175 Btu/scf or better. This would be accomplished in part by high preheat of the air stream, thus reducing the amount of air needed to maintain the desired reaction temperature. In the PEDU, the air stream will be heated electrically.

The following design topics were discussed:

1. The pneumatic lifting of coal to the coal feed vessel should use nitrogen as the transport gas. Foster Wheeler will size the feed bin based on the time needed to fill it, with the realization that coal feed to the gasifiers may be interrupted for a short period of time without greatly disturbing the system. Foster Wheeler will recommend a method or methods of measuring the solids flow based on their past experience.

2. The system pressure will be controlled by a valve located downstream of the gas cooler and scrubber.

3. The special design problem of the 2100 F piping connecting Stage 3 with Stage 1 was discussed. This was deferred pending consultation with Foster Wheeler metallurgical and piping experts.

4. The external location of the cyclones was reiterated. Ducon will be consulted with regard to cyclone design.

5. A tentative startup procedure was discussed. It was found necessary to provide a Stage 3 by-pass to ensure ease of startup. This will enable all three stages to be brought up to temperature independently.

6. BCR was asked to recommend a gas scrubbing system. Foster Wheeler is considering an oil-wash system that may be commercially available from firms such as Blaw-Knox or Black, Sivalls and Bryson.

7. Foster Wheeler's preliminary design calls for Stage 1 and Stage 3 reactors to be 12 inches ID and Stage 2 to be 16 inches ID. For the base case design, residence times of at least 30 minutes will be provided in all stages.

B. Laboratory Investigations

Rate of effort on this phase of the project was light during the month because of vacations and military reserve training. However, the fluidized-bed batch reactor system was redesigned and was operated for the first time with on-stream gas analysis.

1. Char Reactivity Studies: A new Hewlett Packard X-Y recorder, Model Number 7034 A, was installed in the TGA apparatus. The equipment was calibrated and readied for operation; however, no immediate tests are planned pending collection and interpretation of data from the batch reactor.

2. Fluidized-bed Gasification Batch Reactor: Figure 16 shows the new flow scheme for the batch reactor. The gas flows and system pressure and temperature can now be accurately controlled. The product gas is analyzed by an in-line F and M gas chromatograph which has been calibrated for oxygen, hydrogen, carbon monoxide, carbon dioxide, and nitrogen, with helium as the carrier gas.

Figure 17 is a typical product gas analysis of a gasification run made with FMC char. Reactor pressure was 50 psig and the reaction temperature was 940 C. Twenty grams of char were charged to the reactor, and the system was brought to temperature and pressure under nitrogen flow. The nitrogen was then turned off and the air and carbon dioxide flow was started. Air was fed at the rate of 900 standard milliliters per minute and carbon dioxide at the rate of 750 standard milliliters per minute. Table 7 is a summary of the material balance calculations from a test point taken ten minutes after the start of the run. The data indicate that all of the oxygen reacted with the char to carbon monoxide and that the carbon dioxide usage was 45 percent. That is, 45 percent of the carbon dioxide in the feed was converted to carbon monoxide.

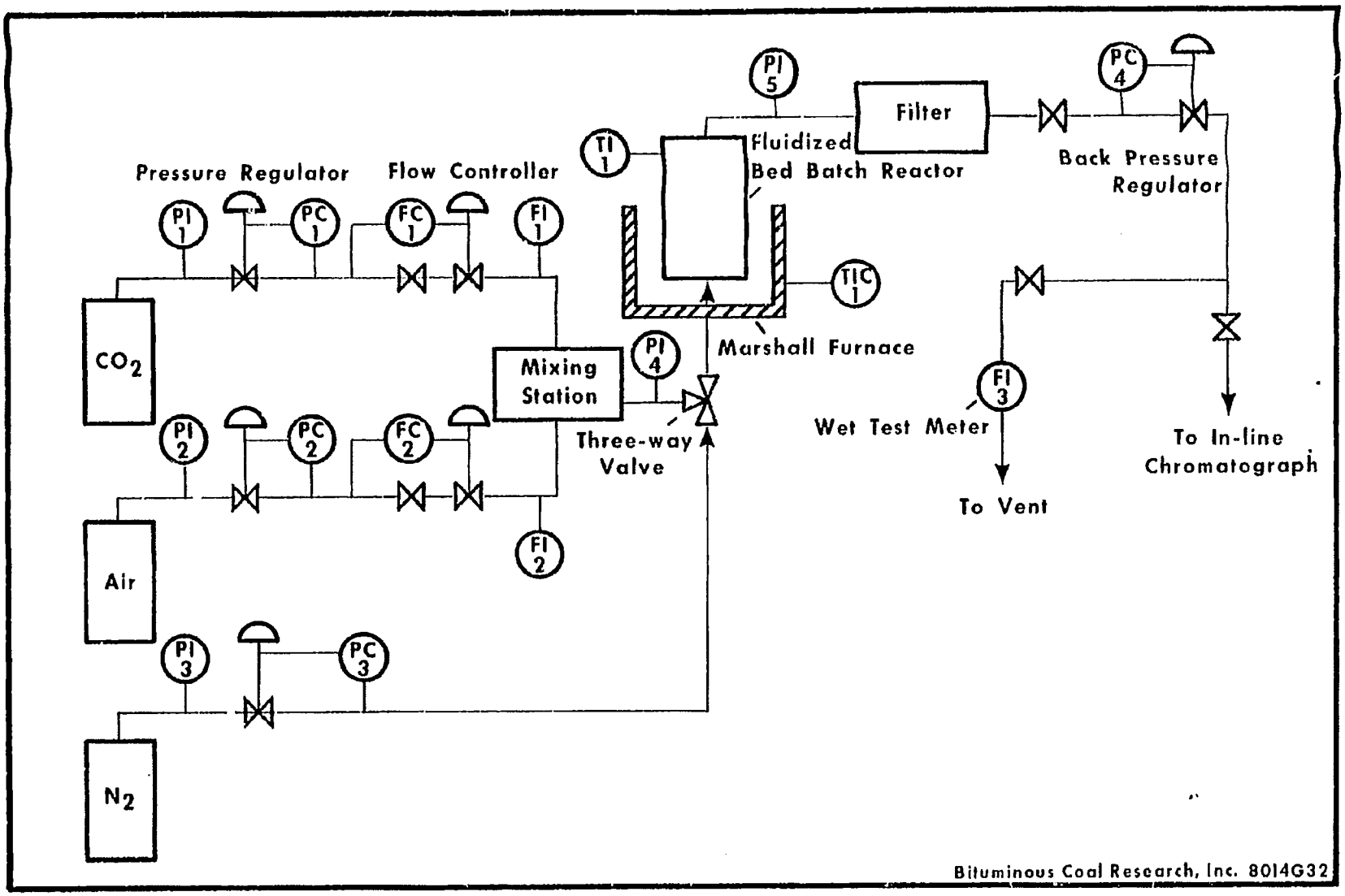

Figure 16. Flow Scheme for Fluidized-bed Batch Reactor

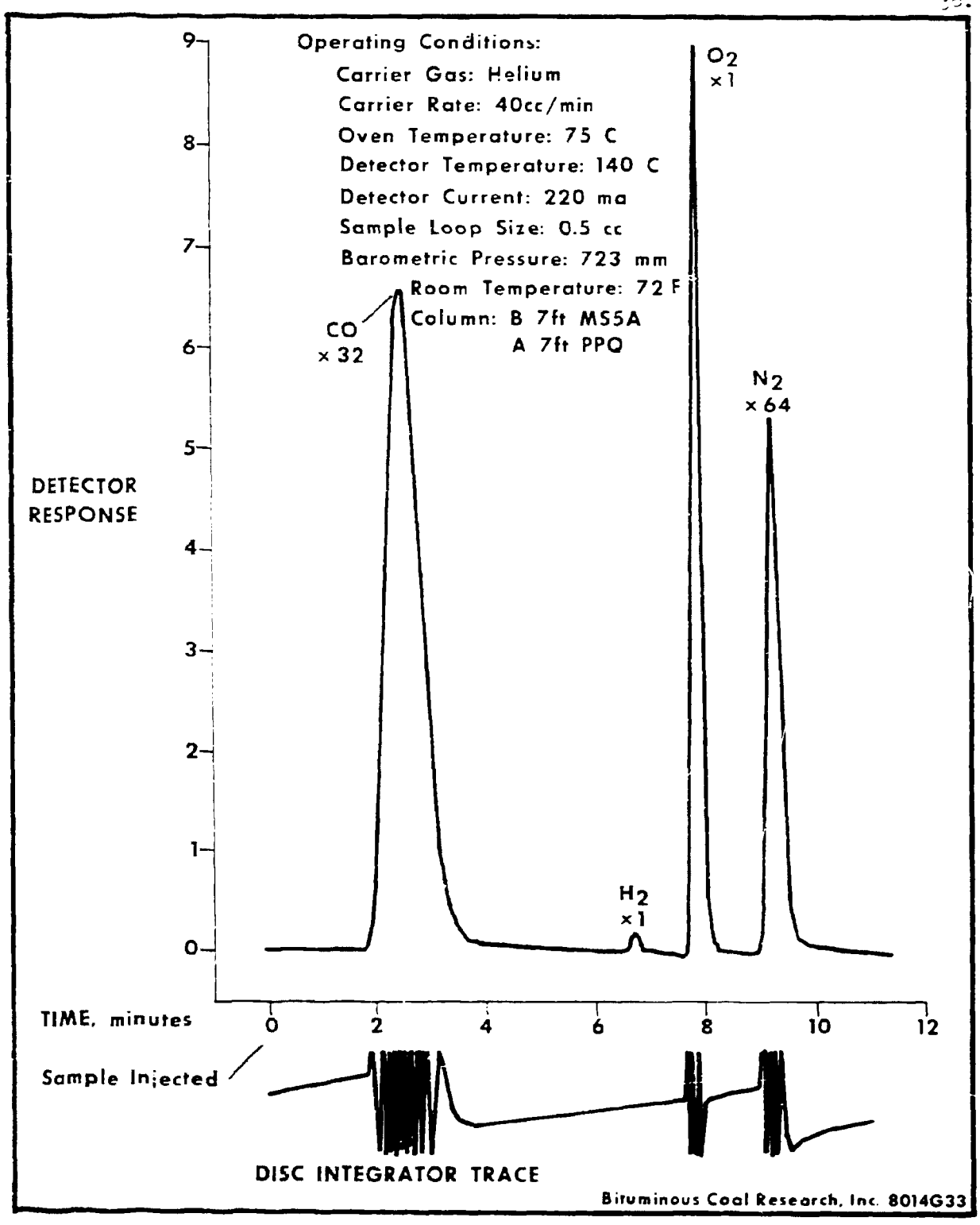

Figure 17. Typical Chromatographic Analysis of the Product Gas from the Fluidized-bed Batch Reactor

TABLE 7. MATERIAL BALANCE FOR FLUIDIZED-BED BATCH REACTOR AIR-BLOWN GASIFICATION TEST NUMBER 1
(20 g Char Charged)

	Feed		Product	
Component	mole percent	g moles/min	mole percent	g moles/min
Oxygen	11.5	0.0084	0.3	trace
Nitrogen	43.5	0.0316	32.7	0.0324
Carbon Dioxide	45.0	0.0330	18.7	0.0185
Carbon Monoxide	--	--	47.8	0.0474
Hydrogen	--	--	0.5	trace
Total	100.0	0.0730	100.0	0.0983

Feed gas rate 1650 sml/min
Product gas rate 2210 sml/min

	In	Out
Total g moles Carbon*	0.033	0.0659
Total g moles Oxygen	0.0414	0.0422
Total g moles Nitrogen	0.0316	0.0324

* Carbon gasification rate 0.033 g moles/min

Carbon dioxide utilization 45 percent

The carbon gasification rate was 0.033 g moles/min. Of this, 0.0168 g moles reacted with oxygen and 0.0162 g moles reacted with carbon dioxide.

III. FUTURE WORK

Design work on the fluidized-bed PEDU will continue. Foster Wheeler's rate of effort on this project should increase during the next report period. Material and energy balance calculations will be completed and mechanical design should be well underway.

Air-blown gasification studies will continue, using the fluidized-bed batch reactor.

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