TABLE 5.6-6 SUMMARY DATA FOR 150 PSIG AIR BLOWN LURGI GAS PRODUCER

1.	Raw Gas Gross Heating Value: Dry Basis, Btu/scf	158
2.	Thermal Efficiency, Cold, Percent	80.5
3.	Thermal Efficiency, Hot, Percent	91.0
	Mass Flows Per 100 lb Coal - As Fired	
4.	Dry, Raw Gas Produced, scf	7,200
5.	Steam Required, lb	90
6.	Air Required, scf	4,050
	Mass Flows Per MM Btu in Dry, Raw Gas	
7.	Steam Required, lb	81
8.	Air Required, lb	279
9.	Coal Required, lb	90.1
10.	Steam Decomposition, Percent	69.5
11.	Capacity, MM scfh	1.23
12.	Coal Input at Capacity, ton/hr as fired	8.58

APPENDIX 6.1

SUMMARY OF QUOTATIONS OBTAINED FOR EVALUATION OF GASIFICATION SYSTEMS

1. International Furnace Equipment Co. Ltd., Brierley Hill, England

   134,00 pounds sterling for two 10 ft 0 in. ID two-stage gas producers, with accessories, erected and installed in England.

2. Lurgi Gesellschaft fur Warmetechnik, mbH, Frankfurt, Germany

   DM 50.3 million for 8 gasifiers, each 3.7 meter ID, plus accessory equipment including a Rectisol gas purification plant, at North Sea port crated for export.

   DM 6.3 million for equipment to remove phenols from the gas concentrate of the 8 gasifiers, also at North Sea port crated for export.

3. Dr. C. Otto & Comp., Bochum, Germany

   DM 66.3 million for 6 gasifiers, waste heat boilers, coal feeding and ash discharging equipment, etc., for a complete Rummel modified gasification plant, erected and installed in Germany.

4. McDowell-Wellman Engineering Company, Cleveland, Ohio

   $80,000 for one 10 ft 0 in. ID Wellman-Galusha gas producer with dust cyclone f.o.b. Cleveland.

   $350,000 for three 10 ft 0 in. ID gas producers erected in a building.

   $100,000 for accessory coal conveying and charging equipment for above three producers, installed.

   $215,000 for gas cooling and cleaning equipment for above three producers, installed.

5. American Air Liquide, New York, New York

   $1,460,000 for the low temperature equipment, structure to house and support it, and insulation, CIF New York, for 500 tons per day of 98 percent oxygen, plus $175,000 erection cost.

   $2,228,000 for 1000 tons per day as above, plus $250,000 erection cost.

$4,256,000 for 2000 tons per day as above, plus $450,000 erection cost.

6. Lotepro Corporation, New York, New York

$2,150,000 for 1000 tons per day of 98 percent oxygen, plus $150,000 erection cost.

7. General Electric Company, Pittsburgh, Pa. (Local Sales Office)

(a) Motors - 1200 rpm unity power factor synchronous motors and exciters, f.o.b. point of manufacture.

2,000 hp	2,300 v	$ 21,500
4,000 hp	4,000 v	$ 36,500
8,000 hp	4,000 v	$ 65,500
16,000 hp	6,600 v	$128,500
32,500 hp	6,600 v	$259,500

(b) Steam Turbines - 600 psig, 750 F steam to 4 in. Hg absolute pressure, including sole plate and lubrication system, f.o.b. point of manufacture.

2,000 hp	9,400 rpm	$ 69,000
4,000 hp	7,000 rpm	$ 87,000
8,000 hp	4,800 rpm	$156,000
16,000 hp	3,600 rpm	$260,000
32,000 hp	2,400 rpm	$458,000

As above, but 1400 psig, 1000 F steam to 450 psig back pressure.

2,000 hp	9,400 rpm	$130,000
4,000 hp	7,000 rpm	$172,000
8,000 hp	4,800 rpm	$264,000
16,000 hp	3,600 rpm	$425,000
32,000 hp	2,400 rpm	$691,000

As above, but 1400 psig, 1000 F steam to 4 in. Hg absolute pressure.

2,000 hp	9,400 rpm	$118,000
8,000 hp	4,800 rpm	$201,000

8. Allied Chemical Company, New York, New York

Cost of 98 percent oxygen gas at atmospheric pressure on an "Over-the-Fence" supply basis, with steam cost of 30 cents per M lb at 600 psig, 750 F.

500 tons/day	$8.50 per ton
1,000 tons/day	$7.50 per ton
3,000 tons/day	$5.50 per ton

9. Foster Wheeler Corporation, Pittsburgh, Pa. (Local Sales Office)

$3,300,000 for major equipment and controls for generating 325,000 lb per hour of 1400 psig, 950 F steam in 2 boilers, delivered and erected.

10. Riley-Stoker Corporation, Pittsburgh, Pa.. (Local Sales Office)

$5,000,000 for approximate erected cost of major equipment and controls to produce 1,000,000 lb per hour of 600 psig, 750 F steam.

11. Selas Corporation of America, Dresher, Pennsylvania

$200,000 for shift reactors to shift 40,000,000 scfh of dry gas with 41 percent H_2, 2.2 H_2/CO ratio, to a 3/1 ratio, at 450 psig, 750 F inlet.

$600,000 for shift reactors to shift 50,000,000 scfh of dry gas with 31 percent H_2, 0.6 H_2/CO ratio, to a 3/1 ratio, at 450 psig, 750 F inlet.

12. Gesellschaft fur Lindes Eismachinen AG, Munich, Germany

$35,000,000 for the complete erected cost of acid gas removal using the Rectisol process for 1000 MM scfd of raw gas (dry basis) with the H_2S supplied in a stream suitable for a Firma Socaty sulfur plant.

13. Allis Chalmers Manufacturing Company, Milwaukee, Wisconsin

Axial flow air compressors with steam-turbine drive, base plate, and lubricating system, f.o.b. point of manufacture.

Discharge pressure 50 psig.

25,000 cfm	3,500 hp	$ 250,000
50,000 cfm	7,000 hp	$ 355,000
80,000 cfm	11,200 hp	$ 470,000
120,000 cfm	16,800 hp	$ 620,000
200,000 cfm	28,000 hp	$ 930,000
300,000 cfm	42,000 hp	$1,350,000

14. Western Gear Corporation, Pittsburgh, Pa. (Local Sales Office)

2,000 hp	1,200 rpm in/9,400 rpm out	$ 9,850
4,000 hp	1,200 rpm in/7,000 rpm out	$13,000
8,000 hp	1,200 rpm in/4,800 rpm out	$18,200
16,000 hp	1,200 rpm in/3,600 rpm out	$30,300
32,500 hp	1,200 rpm in/2,400 rpm out	$45,700

Gear prices for synchronous motor/rotary compressor applications, f.o.b. point of manufacture.

15. Clark Compressor Division of Dresser Ind., Pittsburgh, Pa. (Local Sales Office)

Air compressors and lubricating system, and intercoolers, f.o.b. Olean, New York, inlet pressure 14.14 psia, compression ratio 5.45.

43,000 scfm	8,050 hp	$226,500
85,000 scfm	15,360 hp	$453,000
165,000 scfm	29,700 hp	$846,000

Oxygen compressors and lubricating system, f.o.b., inlet pressure 15.2 psia, compression ratio 30.6.

8,450 cfm	3,150 hp	$218,000
16,900 cfm	5,850 hp	$286,000
33,800 cfm	11,700 hp	$572,000

APPENDIX 6.2

MATERIAL BALANCES, HEAT BALANCES, OVERALL MATERIAL BALANCES, SUMMARIES OF PROCESS DATA, AND SIMPLIFIED PROCESS SCHEMES FOR 250 MM SCFD PIPELINE GAS PLANTS

TABLE 6.2-1
Material Balance
Lurgi Dry-ash Gasifier

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1000.0	773.0	54.0	63.0	25.0	14.0	71.0
98% O_2	502.7			492.7		10.0	
STEAM	1815.0		201.7	1613.3			
JACKET STM.	285.0		31.7	253.3			
ADD'L MOIST.	36.6		4.1	32.5			
TOTAL IN	3,639.3	773.0	291.5	2,454.8	25.0	24.0	71.0
OUTPUT							
ASH	74.9	3.1	0.4	0.4			71.0
CO_2	1258.0	343.0		915.0			
CO	574.0	246.0		328.0			
H_2	88.1		88.1				
CH_4	168.0	126.0	42.0				
C_NH_M	8.8	7.5	1.3				
N_2	14.2					14.2	
H_2S	26.6		1.6		25.0		
TAR/OIL	51.3	43.2	4.7	3.4			
PHENOLS	5.5	4.2	0.4	0.9			
NH_3	11.9		2.1			9.8	
H_2O	1358.0		150.9	1207.1			
TOTAL OUT	3,639.3	773.0	291.5	2,454.8	25.0	24.0	71.0

BASED ON 1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-2
Heat Balance
Lurgi Dry-ash Gasifier

INPUT

	BTU
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	20,400
COAL MOISTURE SENSIBLE HEAT	2,500
OXYGEN SENSIBLE HEAT	24,100
STEAM TOTAL ENTHALPY	2,460,000
JACKET WATER SENSIBLE HEAT	42,000
SOLID RECYCLE SENSIBLE HEAT	—
LIQUID RECYCLE SENSIBLE HEAT	—
TOTAL IN	16,538,000

OUTPUT

ASH SENSIBLE HEAT	8,000
ASH COMBUSTIBLES HEATING VALUE	—
HOT RAW GAS HEATING VALUE	13,263,000
HOT RAW GAS SENSIBLE HEAT	1,105,000
WATER VAPOR TOTAL ENTHALPY	2,140,000
ENTRAINED SOLIDS SENSIBLE HEAT	—
JACKET STEAM TOTAL ENTHALPY	—
HEAT LOSS AND OTHERS	22,000
TOTAL OUT	16,538,000

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE, 32°F. (0°C.)

TABLE 6.2-3
Overall Material Balance
Pipeline Gas Production Based on the
Lurgi Dry-ash Gasifier

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	11,780
OXYGEN (98%)	5,700
BOILER FEED WATER MAKEUP	31,700
LIME	—
TOTAL IN	49,180

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	16,050
HYDROGEN SULFIDE	300
PROCESS EFFLUENT WATER*	24,470
AMMONIA	140
GAS LOSSES, TAR & PHENOLS	1,930
ASH (OR SLAG)	850
TOTAL OUT	49,180

* INCLUDES 3000 T/D WATER VAPOR VENTED FROM BY PRODUCT RECOVERY PLANTS.

TABLE 6.2-4

Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on the Lurgi Dry-ash Gasifier

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	11,780	TONS/DAY
b) BOILER COAL	1,080	TONS/DAY
TOTAL	12,860	TONS/DAY
2. OXYGEN REQUIREMENT (98%)	5,700	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	263,000	GPM
b) COOLING WATER MAKEUP	13,000	GPM
c) BOILER FEED MAKEUP	5,300	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	1,470,000	LBS./HR.
b) WASTE HEAT BOILERS	3,295,000	LBS./HR.
TOTAL	4,765,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	310	MM SCFD
b) "CO" TO BE SHIFTED	39	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	133	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	32.1	MM LBS./DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	2400	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, AND SCREEN TO $1\frac{1}{4}$" BY $\frac{1}{8}$" SIZE		
10. BYPRODUCT CHAR		
NONE TONS/DAY AT —		BTU/TON
11. THERMAL EFFICIENCIES		
a) OVERALL, COAL TO PIPELINE GAS	66.9%	
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	84.5%	

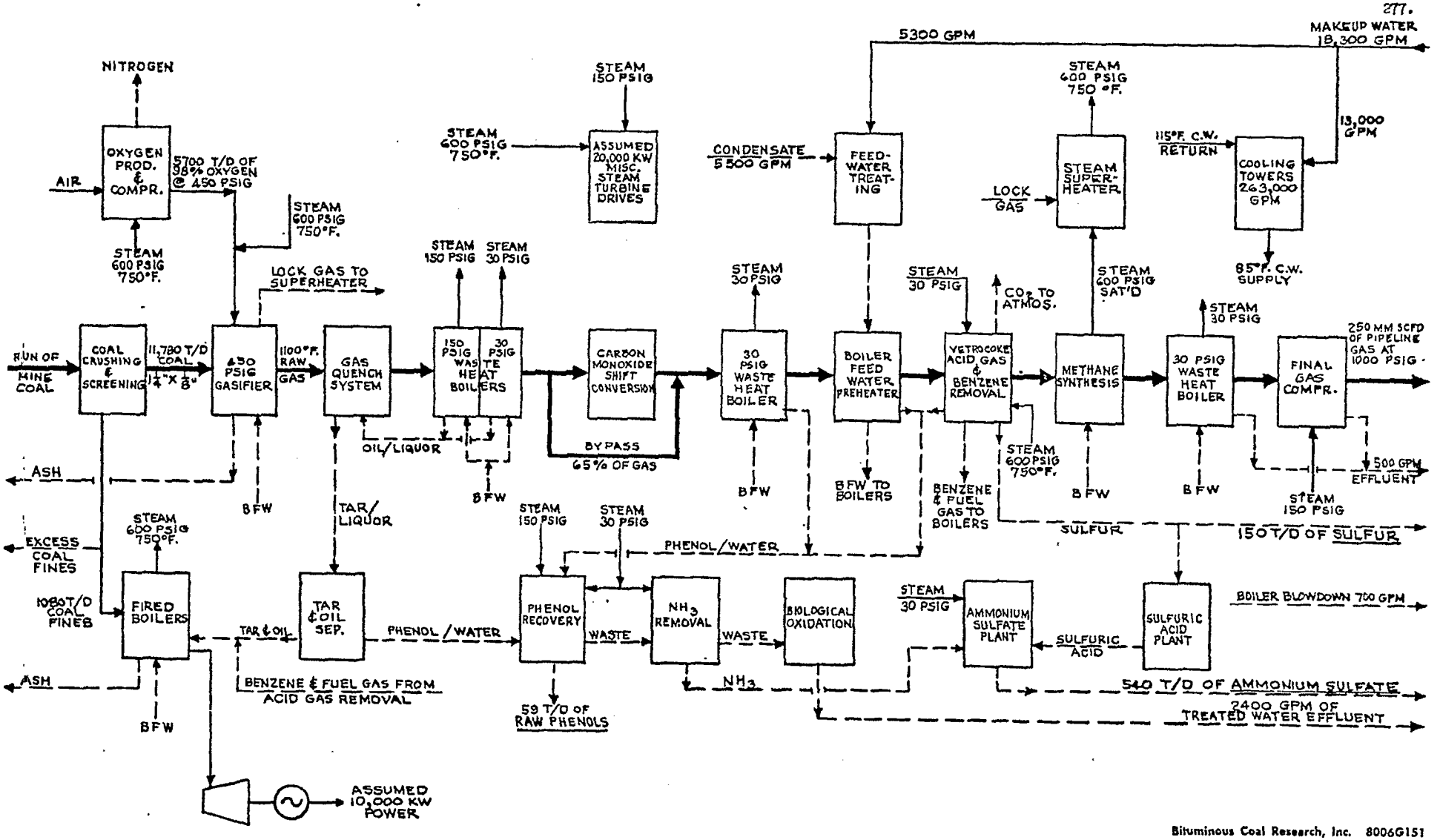

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Figure 6.2-1 Simplified Process Scheme for Pipeline Gas Production Using the Lurgi Dry-ash Gasifier (Process 11)

TABLE 6.2-5
Material Balance
Lurgi Slagging Gasifier

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1000.0	773.0	54.0	63.0	25.0	14.0	71.0
98% O_2	646.7			633.8		12.9	
STEAM	463.0		51.4	411.6			
LIME	77.0						77.0
ASH RECYCLE	160.0						160.0
ADD'L MOIST.	36.6		4.1	32.5			
TOTAL IN	2,383.3	773.0	109.5	1140.9	25.0	26.9	308.0
OUTPUT							
ASH	308.0						308.0
CO_2	189.7	51.7		138.0			
CO	1393.7	597.3		796.4			
H_2	50.2		50.2				
CH_4	100.0	75.0	25.0				
$C_N H_M$	7.0	6.0	1.0				
N_2	17.8					17.8	
H_2S	26.6		1.6		25.0		
TAR/OIL	45.8	39.4	4.1	2.3			
PHENOLS	3.7	2.9	0.2	0.6			
NH_3	11.0		1.9			9.1	
H_2O	228.0		25.3	202.7			
FATTY ACIDS	1.8	0.7	0.2	0.9			
TOTAL OUT	2,383.3	773.0	109.5	1,140.9	25.0	26.9	308.0

BASED ON 1000 LBS. OF COAL, INCLUDING 1.2% MOISTURE
FIGURES ARE TO SLIDE RULE ACCURACY

TABLE 6.2-6
Heat Balance
Lurgi Slagging Gasifier

INPUT

	BTU
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	20,400
COAL MOISTURE SENSIBLE HEAT	2,500
OXYGEN SENSIBLE HEAT	31,000
STEAM TOTAL ENTHALPY	627,000
JACKET WATER SENSIBLE HEAT	—
SOLID RECYCLE SENSIBLE HEAT	4,800
LIQUID RECYCLE SENSIBLE HEAT	—
TOTAL IN	14,675,700

OUTPUT

ASH SENSIBLE HEAT	252,500
ASH COMBUSTIBLES HEATING VALUE	—
HOT RAW GAS HEATING VALUE	12,488,000
HOT RAW GAS SENSIBLE HEAT	775,000
WATER VAPOR TOTAL ENTHALPY	360,000
ENTRAINED SOLIDS SENSIBLE HEAT	—
JACKET STEAM TOTAL ENTHALPY	—
HEAT LOSS AND OTHERS	790,200
TOTAL OUT	14,675,700

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE, 32°F. (0°C.)

TABLE 6.2-7
Overall Material Balance
Pipeline Gas Production Based on the Lurgi Slagging Gasifier

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	12,900
OXYGEN (98%)	8,050
BOILER FEED WATER MAKEUP	23,450
LIME	960
TOTAL IN	45,360

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	18,500
HYDROGEN SULFIDE	330
PROCESS EFFLUENT WATER*	17,380
AMMONIA	140
GAS LOSSES, TAR & PHENOLS	1,720
ASH (OR SLAG)	1,850
TOTAL OUT	45,360

* INCLUDES 1800 T/D WATER VAPOR VENTED FROM BYPRODUCT RECOVERY PLANTS.

TABLE 6.2-8

Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on the Lurgi Slagging Gasifier

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	12,900	TONS/DAY
b) BOILER COAL	510	TONS/DAY
TOTAL	13,410	TONS/DAY
2. OXYGEN REQUIREMENT (98%)	8,050	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	356,000	GPM
b) COOLING WATER MAKEUP	17,500	GPM
c) BOILER FEED MAKEUP	3,900	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	693,000	LBS./HR.
b) WASTE HEAT BOILERS	2,410,000	LBS./HR.
TOTAL	3,103,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	785	MM SCFD
b) "CO" TO BE SHIFTED	280	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	166	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	37.0	MM LBS/DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	1,500	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, AND SCREEN TO $1\frac{1}{4}$" BY $\frac{1}{8}$" SIZE		
10. BYPRODUCT CHAR		
NONE TONS/DAY AT	—	BTU/TON
11. THERMAL EFFICIENCIES		
a) OVERALL, COAL TO PIPELINE GAS	64.1	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	80.2	%

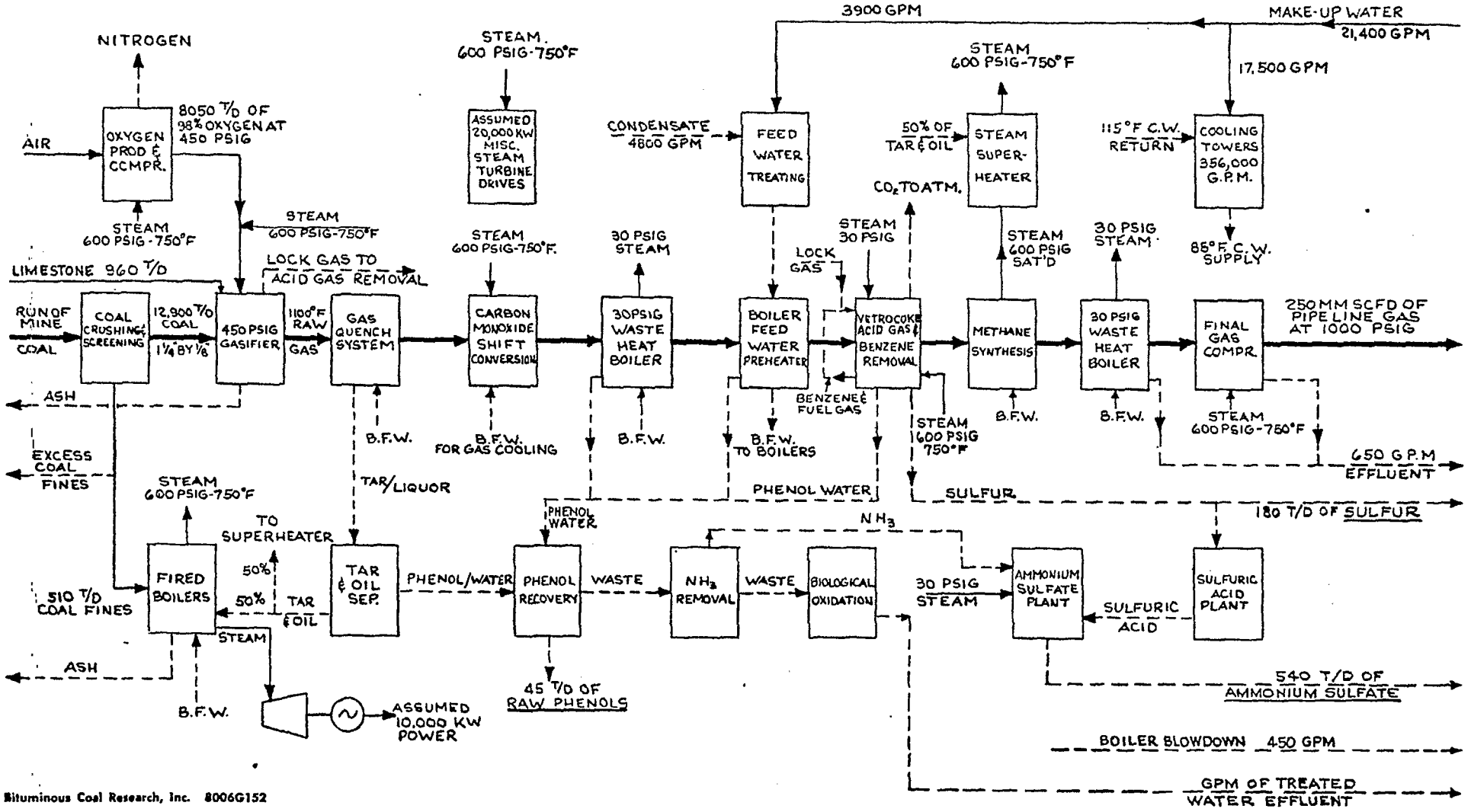

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Figure 6.2-2 Simplified Process Scheme for Pipeline Gas Production Using the Lurgi Slagging Gasifier (Processes 18, 19, and 20)

TABLE 6.2-9
Material Balance
Hydrocarbon Research Gasifier

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1000.0	773.0	54.0	63.0	25.0	14.0	71.0
98% O_2	542.0			531.0		11.0	
STEAM	1500.0		167.0	1333.0			
TOTAL IN	3042.0	773.0	221.0	1927.0	25.0	25.0	71.0
OUTPUT							
ASH	101.0	30.0					71.0
CO_2	990.0	270.0		720.0			
CO	763.0	327.0		436.0			
H_2	75.0		75.0				
CH_4	194.0	146.0	48.0				
C_NH_M							
N_2	25.0					25.0	
H_2S	26.6		1.6		25.0		
TAR/OIL							
PHENOLS							
NH_3							
H_2O	867.4		96.4	771.0			
TOTAL OUT	3042.0	773.0	221.0	1927.0	25.0	25.0	71.0

BASED ON 1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-10
Heat Balance
Hydrocarbon Research Gasifier

INPUT

	BTU
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	290,000
COAL MOISTURE SENSIBLE HEAT	—
OXYGEN SENSIBLE HEAT	126,000
STEAM TOTAL ENTHALPY	2,280,000
JACKET WATER SENSIBLE HEAT	—
SOLID RECYCLE SENSIBLE HEAT	—
LIQUID RECYCLE SENSIBLE HEAT	—
TOTAL IN	16,686,000

OUTPUT

ASH SENSIBLE HEAT	40,000
ASH COMBUSTIBLES HEATING VALUE	420,000
HOT RAW GAS HEATING VALUE	12,830,000
HOT RAW GAS SENSIBLE HEAT	1,620,000
WATER VAPOR TOTAL ENTHALPY	1,535,000
ENTRAINED SOLIDS SENSIBLE HEAT	—
JACKET STEAM TOTAL ENTHALPY	—
HEAT LOSS AND OTHERS	241,000
TOTAL OUT	16,686,000

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE, 32°F. (0°C.)

TABLE 6.2-11
Overall Material Balance
Pipeline Gas Production Based on the Hydrocarbon Research Gasifier

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	11,230
OXYGEN (98%)	5,870
BOILER FEED WATER MAKEUP	20,200
LIME	—
TOTAL IN	37,300

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	15,600
HYDROGEN SULFIDE	290
PROCESS EFFLUENT WATER	13,840
AMMONIA	—
GAS LOSSES, TAR & PHENOLS	1,130
ASH (OR SLAG)	1,100
TOTAL OUT	37,300

TABLE 6.2-12

Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on the Hydrocarbon Research Gasifier

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	11,230	TONS/DAY
b) BOILER COAL (INCLUDES PREHEAT COAL)	1,050	TONS/DAY
TOTAL	12,280	TONS/DAY
2. OXYGEN REQUIREMENT (98%)	5,870	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	241,000	GPM
b) COOLING WATER MAKEUP	12,000	GPM
c) BOILER FEED MAKEUP	3,400	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	493,000	LBS./HR.
b) WASTE HEAT BOILERS	3,247,000	LBS./HR.
TOTAL	3,740,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	606	MM SCFD
b) "CO" TO BE SHIFTED	89	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	128	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	31.2	MM LBS./DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	NONE	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, GRIND AND DRY TO $\frac{1}{32}$" BY 0 SIZE		
10. BYPRODUCT CHAR		
NONE TONS/DAY AT	—	BTU/TON
11. THERMAL EFFICIENCIES		
a) OVERALL, COAL TO PIPELINE GAS	70.1	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	88.0	%

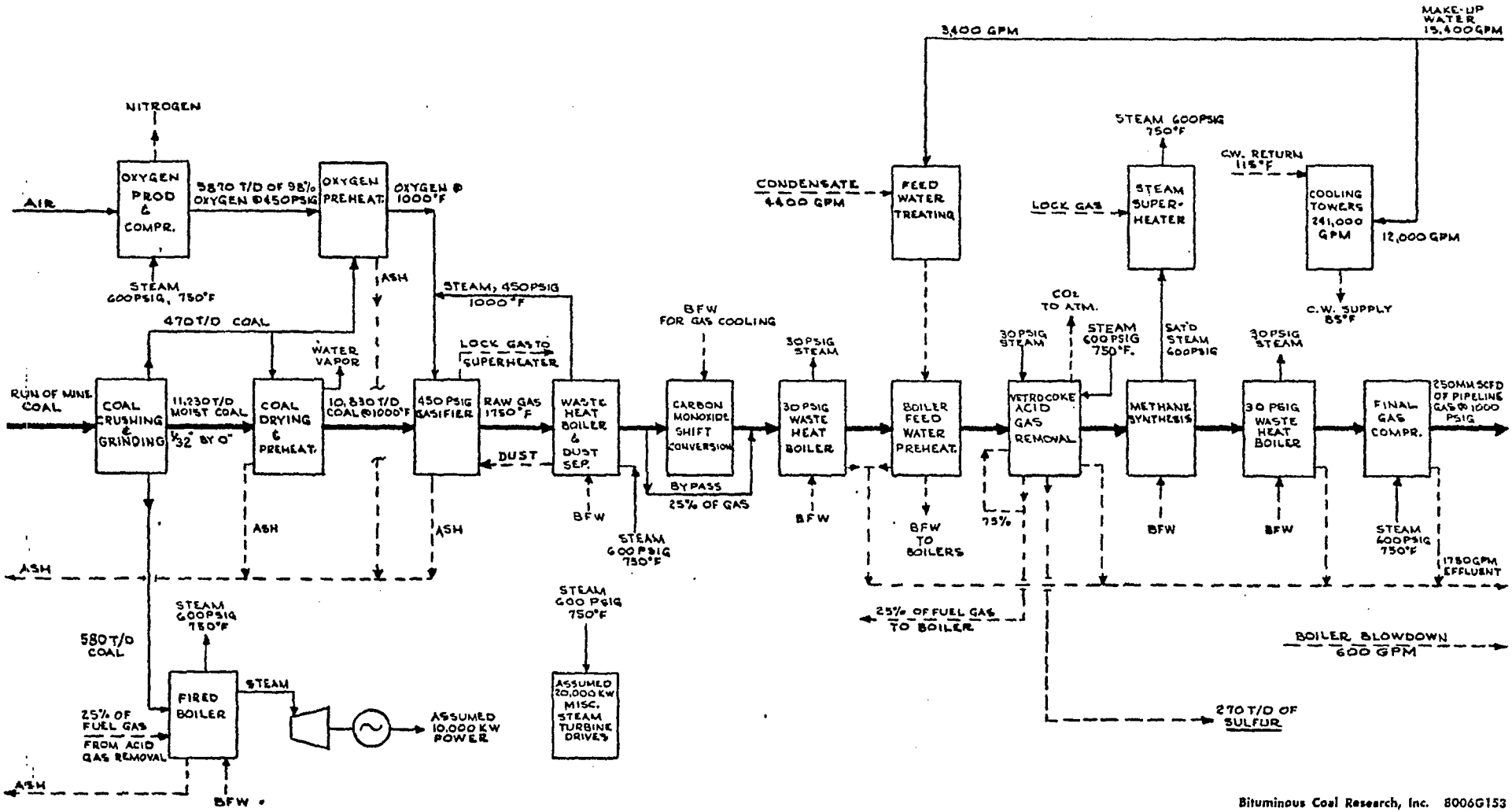

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Figure 6.2-3 Simplified Process Scheme for Pipeline Gas Production Using the Hydrocarbon Research Gasifier (Process 21)

TABLE 6.2-13
Material Balance
Bamag-Winkler Atmospheric Gasifier

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1000.0	773.0	54.0	63.0	25.0	14.0	71.0
98% O_2	639.8			627.0		12.8	
STEAM	529.0		59.0	470.0			
TOTAL IN	2168.8	773.0	113.0	1160.0	25.0	26.8	71.0
OUTPUT							
ASH	299.3	200.2	2.6	9.0	13.9	2.6	71.0
CO_2	525.0	143.0		382.0			
CO	954.0	409.0		545.0			
H_2	74.9		74.9				
CH_4	27.6	20.8	6.8				
C_NH_M							
N_2	24.2					24.2	
H_2S	11.8		0.7		11.1		
TAR/OIL							
PHENOLS							
NH_3							
H_2O	252.0		28.0	224.0			
TOTAL OUT	2,168.8	773.0	113.0	1,160.0	25.0	26.8	71.0

BASED ON 1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-14
Heat Balance
Bamag-Winkler Atmospheric Gasifier

INPUT

	BTU
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	20,000
COAL MOISTURE SENSIBLE HEAT	—
OXYGEN SENSIBLE HEAT	31,000
STEAM TOTAL ENTHALPY	665,000
JACKET WATER SENSIBLE HEAT	—
SOLID RECYCLE SENSIBLE HEAT	—
LIQUID RECYCLE SENSIBLE HEAT	—
TOTAL IN	14,706,000

OUTPUT

ASH SENSIBLE HEAT	145,000
ASH COMBUSTIBLES HEATING VALUE	3,020,000
HOT RAW GAS HEATING VALUE	9,475,000
HOT RAW GAS SENSIBLE HEAT	1,470,000
WATER VAPOR TOTAL ENTHALPY	549,000
ENTRAINED SOLIDS SENSIBLE HEAT	—
JACKET STEAM TOTAL ENTHALPY	—
HEAT LOSS AND OTHERS	47,000
TOTAL OUT	14,706,000

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE, 32°F. (0°C.)

TABLE 6.2-15
Overall Material Balance
Pipeline Gas Production Based on the
Bamag-Winkler Atmospheric Gasifier

INPUT

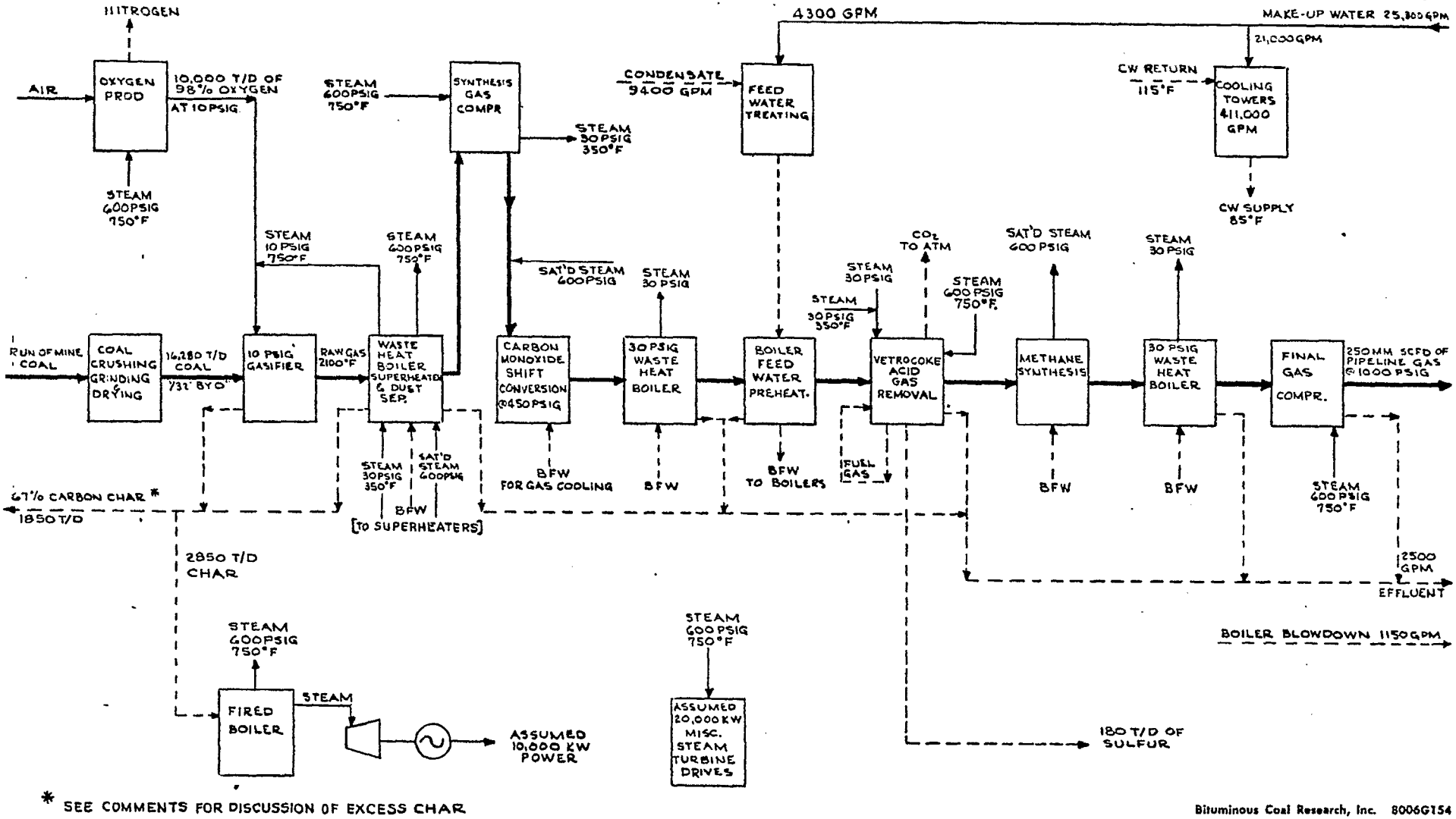
	TONS/DAY
COAL (4.7% MOISTURE)	16,280
OXYGEN (98%)	10,000
BOILER FEED WATER MAKEUP	25,700
LIME	—
TOTAL IN	51,980

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	19,100
HYDROGEN SULFIDE	190
PROCESS EFFLUENT WATER	21,900
AMMONIA	—
GAS LOSSES, TAR & PHENOLS	650
ASH (OR SLAG)	4,700
TOTAL OUT	51,980

TABLE 6.2-16
Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on the Bamag-Winkler Atmospheric Gasifier

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	16,280	TONS/DAY
b) BOILER COAL	—	TONS/DAY
TOTAL	16,280	TONS/DAY
2. OXYGEN REQUIREMENT (98%)	10,000	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	411,000	GPM
b) COOLING WATER MAKEUP	21,000	GPM
c) BOILER FEED MAKEUP	4,300	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	1,650,000	LBS./HR.
b) WASTE HEAT BOILERS	2,690,000	LBS./HR.
TOTAL	4,340,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	1,030	MM SCFD
b) "CO" TO BE SHIFTED	187	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	205	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	38.2	MM LBS./DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	NONE	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, GRIND AND DRY TO 1/32" BY 0 SIZE		
10. BYPRODUCT CHAR		
1,850 TONS/DAY AT	20×10^6	BTU/TON
11. THERMAL EFFICIENCIES		
a) OVERALL, COAL TO PIPELINE GAS	57.7	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	85.5	%



* SEE COMMENTS FOR DISCUSSION OF EXCESS CHAR

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Figure 6.2-4 Simplified Process Scheme for Pipeline Gas Production Using the Bamag-Winkler Atmospheric Gasifier (Process 7)

TABLE 6.2-17
Material Balance
Rummel Single-shaft Pressurized Gasifier

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1000.0	773.0	54.0	63.0	25.0	14.0	71.0
95% O_2	850.0			833.0		17.0	
STEAM	621.0		69.0	552.0			
TOTAL IN	2,471.0	773.0	123.0	1,448.0	25.0	31.0	71.0
OUTPUT							
ASH	73.0					2.0	71.0
CO_2	690.0	188.0		502.0			
CO	1358.0	582.0		776.0			
H_2	99.0		99.0				
CH_4	4.0	3.0	1.0				
C_NH_M							
N_2	29.0					29.0	
H_2S	27.0		2.0		25.0		
TAR/OIL							
PHENOLS							
NH_3							
H_2O	191.0		21.0	170.0			
TOTAL OUT	2,471.0	773.0	123.0	1,448.0	25.0	31.0	71.0

BASED ON 1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-18
Heat Balance
Rummel Single-shaft Pressurized Gasifier

INPUT

	BTU
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	20,000
COAL MOISTURE SENSIBLE HEAT	—
OXYGEN SENSIBLE HEAT	41,000
STEAM TOTAL ENTHALPY	841,000
JACKET WATER SENSIBLE HEAT	24,000
SOLID RECYCLE SENSIBLE HEAT	—
LIQUID RECYCLE SENSIBLE HEAT	—
TOTAL IN	14,916,000

OUTPUT

ASH SENSIBLE HEAT	60,000
ASH COMBUSTIBLES HEATING VALUE	—
HOT RAW GAS HEATING VALUE	12,320,000
HOT RAW GAS SENSIBLE HEAT	2,020,000
WATER VAPOR TOTAL ENTHALPY	414,000
ENTRAINED SOLIDS SENSIBLE HEAT	—
JACKET STEAM TOTAL ENTHALPY	—
HEAT LOSS AND OTHERS	102,000
TOTAL OUT	14,916,000

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE, 32°F. (0°C.)

TABLE 6.2-19
Overall Material Balance
Pipeline Gas Production Based on the
Rummel Single-shaft Pressurized Gasifier

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	13,060
OXYGEN (98%)	10,700
BOILER FEED WATER MAKEUP	23,500
LIME	—
TOTAL IN	47,260

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	21,700
HYDROGEN SULFIDE	340
PROCESS EFFLUENT WATER	17,460
AMMONIA	—
GAS LOSSES, TAR & PHENOLS	1,400
ASH (OR SLAG)	920
TOTAL OUT	47,260

TABLE 6.2-20
Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on the Rummel Single-shaft Pressurized Gasifier

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	12,650	TONS/DAY
b) BOILER COAL	950	TONS/DAY
TOTAL	13,600	TONS/DAY
2. OXYGEN REQUIREMENT (98%)	9,880	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	362,000	GPM
b) COOLING WATER MAKEUP	18,000	GPM
c) BOILER FEED MAKEUP	3,900	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	1,102,000	LBS./HR.
b) WASTE HEAT BOILERS	3,788,000	LBS./HR.
TOTAL	4,890,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	748	MM SCFD
b) "CO" TO BE SHIFTED	273	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	139.5	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	40.8	MM LBS./DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	NONE	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, GRIND AND DRY TO 1/8" BY 0 SIZE		
10. BYPRODUCT CHAR		
NONE TONS/DAY AT ———		BTU/TON
11. THERMAL EFFICIENCIES		
a) OVERALL, COAL TO PIPELINE GAS	63.2	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	79.0	%

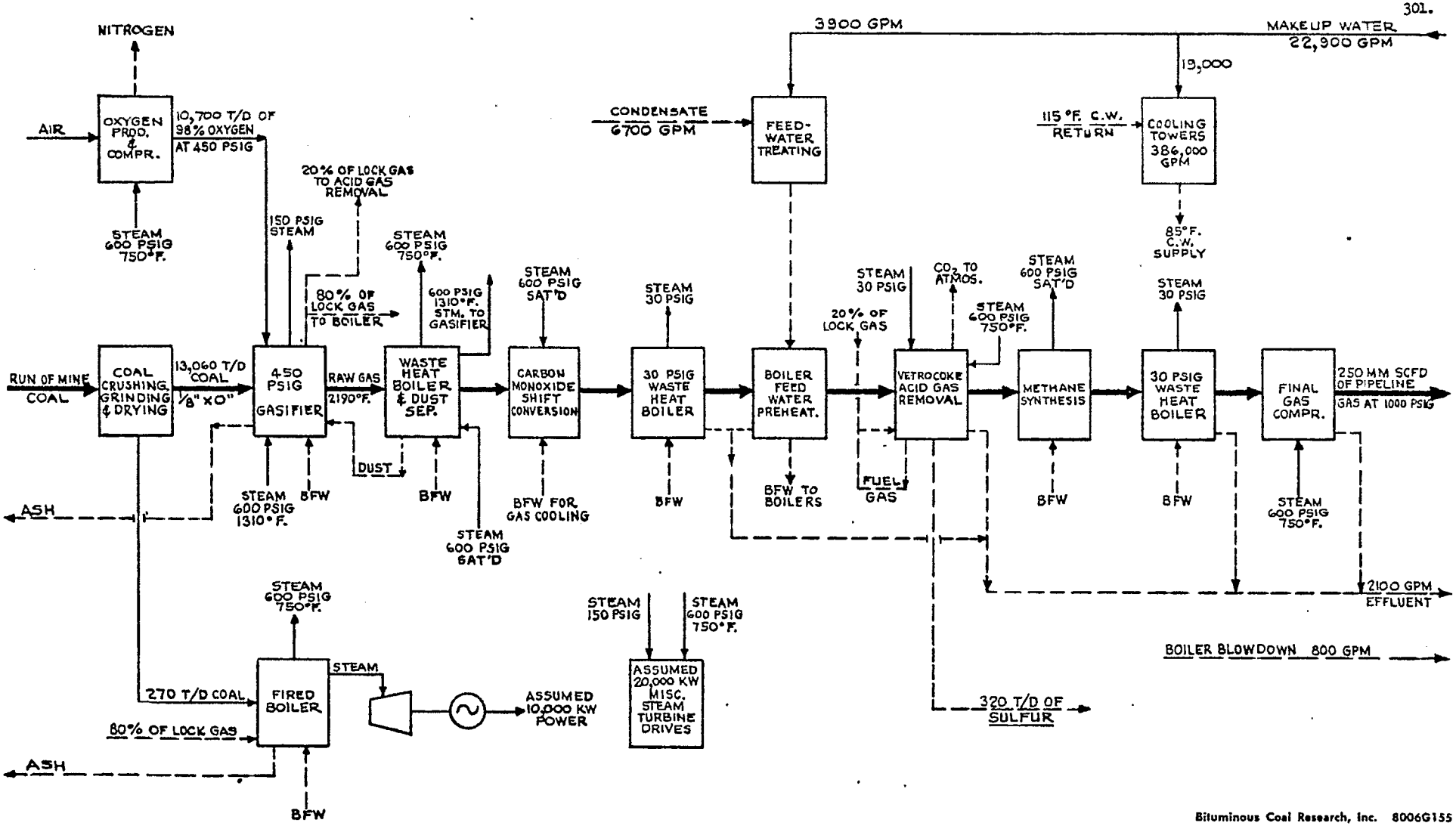

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Figure 6.2-5 Simplified Process Scheme for Pipeline Gas Production Using the Rummel Single-shaft Pressurized Gasifier (Process 61)

TABLE 6.2-21
Material Balance
Rummel Modified Single-shaft Pressurized Gasifier

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1000.0	773.0	54.0	63.0	25.0	14.0	71.0
98% O_2	810.2			794.0		16.2	
STEAM	411.1		45.7	365.4			
TOTAL IN	2,221.3	773.0	99.7	1,222.4	25.0	30.2	71.0
OUTPUT							
ASH	72.7					1.7	71.0
CO_2	385.0	105.0		280.0			
CO	1290.4	553.3		737.1			
H_2	34.1		34.1				
CH_4	153.0	114.7	38.3				
C_NH_M							
N_2	28.5					28.5	
H_2S	26.6		1.6		25.0		
TAR/OIL							
PHENOLS							
NH_3							
H_2O	231.0		25.7	205.3			
TOTAL OUT	2,221.3	773.0	99.7	1,222.4	25.0	30.2	71.0

BASED ON 1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-23
Overall Material Balance
Pipeline Gas Production Based on the
Rummel Modified Single-shaft Pressurized Gasifier

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	12,650
OXYGEN (98%)	9,880
BOILER FEED WATER MAKEUP	23,450
LIME	—
TOTAL IN	45,980

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	20,400
HYDROGEN SULFIDE	320
PROCESS EFFLUENT WATER	17,760
AMMONIA	—
GAS LOSSES, TAR & PHENOLS	1,170
ASH (OR SLAG)	890
TOTAL OUT	45,980

TABLE 6.2-24

Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on the
Rummel Modified Single-shaft Pressurized Gasifier

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	13,060	TONS/DAY
b) BOILER COAL	270	TONS/DAY
TOTAL	13,330	TONS/DAY
2. OXYGEN REQUIREMENT (98%)	10,700	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	386,000	GPM
b) COOLING WATER MAKEUP	19,000	GPM
c) BOILER FEED MAKEUP	3,900	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	364,000	LBS./HR.
b) WASTE HEAT BOILERS	4,546,000	LBS./HR.
TOTAL	4,910,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	1,080	MM SCFD
b) "CO" TO BE SHIFTED	229	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	225	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	43.5	MM LBS./DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	NONE	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, GRIND AND DRY TO 1/8" BY 0 SIZE		
10. BY-PRODUCT CHAR		
NONE TONS/DAY AT ———		BTU/TON
11. THERMAL EFFICIENCIES		
a) OVERALL, COAL TO PIPELINE GAS	64.4	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	84.8	%

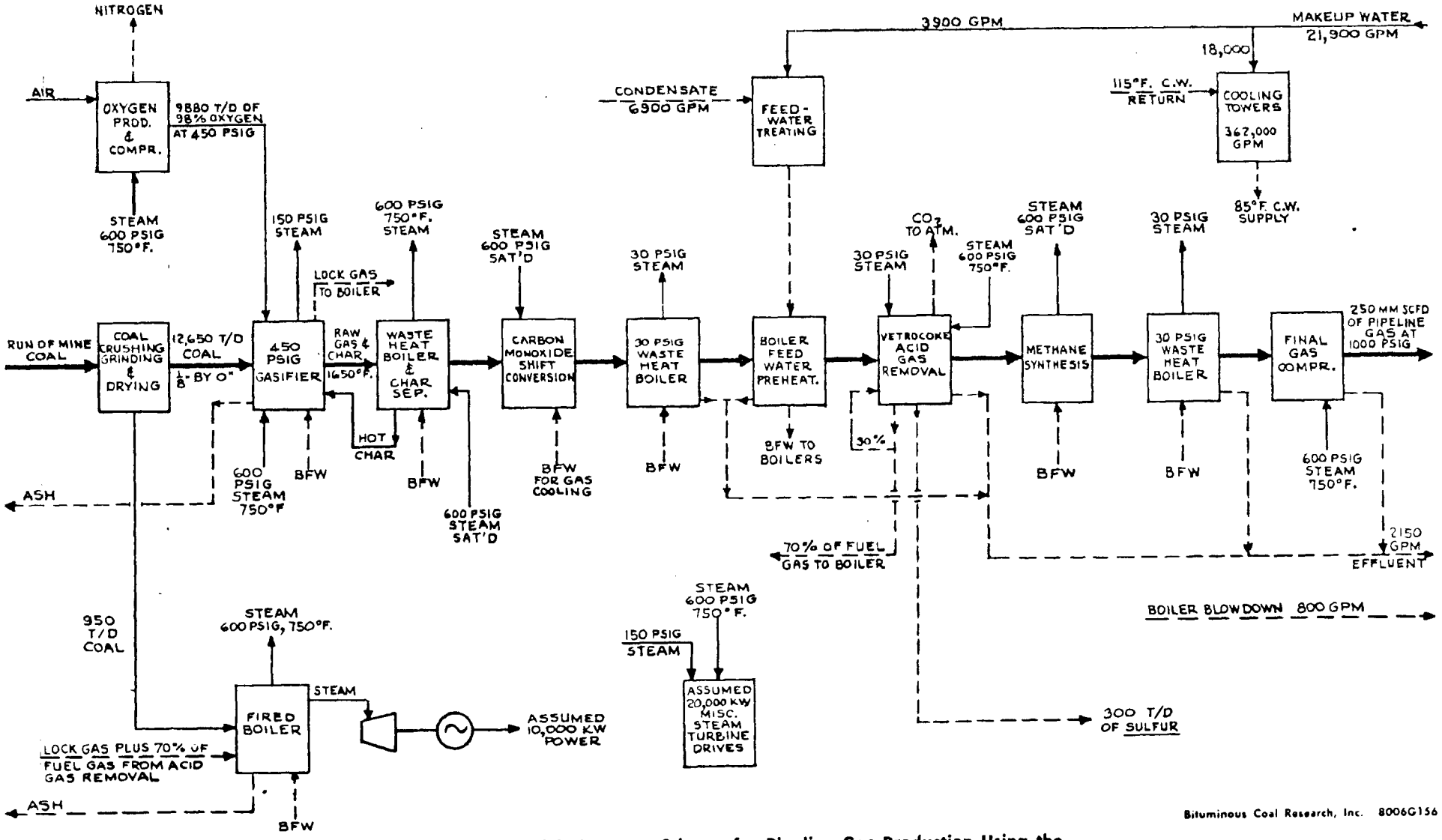

Figure 6.2-6 Simplified Process Scheme for Pipeline Gas Production Using the Rummel Modified Single-shaft Pressurized Gasifier (Process 62)

TABLE 6.2-25
Material Balance
Koppers-Totzek Pressurized Gasifier

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1000.0	773.0	54.0	63.0	25.0	14.0	71.0
98% O_2	1020.0			1000.0		20.0	
STEAM	500.0		55.5	444.5			
TOTAL IN	2,520.0	773.0	109.5	1,507.5	25.0	34.0	71.0
OUTPUT							
ASH	95.8	23.8				1.0	71.0
CO_2	495.0	135.0		360.0			
CO	1431.0	613.0		818.0			
H_2	66.4		66.4				
CH_4	1.6	1.2	0.4				
C_NH_M							
N_2	33.0					33.0	
H_2S	26.6		1.6		25.0		
TAR/OIL							
PHENOLS							
NH_3							
H_2O	370.6		41.1	329.5			
TOTAL OUT	2,520.0	773.0	109.5	1,507.5	25.0	34.0	71.0

BASED ON 1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-26
Heat Balance
Koppers-Totzek Pressurized Gasifier

	BTU
INPUT	
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	20,000
COAL MOISTURE SENSIBLE HEAT	—
OXYGEN SENSIBLE HEAT	49,000
STEAM TOTAL ENTHALPY	667,000
JACKET WATER SENSIBLE HEAT	—
SOLID RECYCLE SENSIBLE HEAT	—
LIQUID RECYCLE SENSIBLE HEAT	—
TOTAL IN	14,736,000
OUTPUT	
ASH SENSIBLE HEAT	79,000
ASH COMBUSTIBLES HEATING VALUE	—
HOT RAW GAS HEATING VALUE	10,530,000
HOT RAW GAS SENSIBLE HEAT	2,090,000
WATER VAPOR TOTAL ENTHALPY	895,000
ENTRAINED SOLIDS SENSIBLE HEAT	—
JACKET STEAM TOTAL ENTHALPY	—
HEAT LOSS AND OTHERS	1,142,000
TOTAL OUT	14,736,000

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE, 32°F. (0°C.)

TABLE 6.2-27
Overall Material Balance
Pipeline Gas Production Based on the
Koppers-Totzek Pressurized Gasifier

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	15,250
OXYGEN (98%)	15,100
BOILER FEED WATER MAKEUP	27,750
LIME	—
TOTAL IN	58,100

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	26,100
HYDROGEN SULFIDE	390
PROCESS EFFLUENT WATER	23,250
AMMONIA	—
GAS LOSSES, TAR & PHENOLS	1,510
ASH (OR SLAG)	1,410
TOTAL OUT	58,100

TABLE 6.2-28
Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on the Koppers-Totzek Pressurized Gasifier

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	15,250	TONS/DAY
b) BOILER COAL	90	TONS/DAY
TOTAL	15,340	TONS/DAY
2. OXYGEN REQUIREMENT (98%)	15,100	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	501,000	GPM
b) COOLING WATER MAKEUP	25,000	GPM
c) BOILER FEED MAKEUP	4,600	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	327,000	LBS./HR.
b) WASTE HEAT BOILERS	5,783,000	LBS./HR.
TOTAL	6,110,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	1,060	MM SCFD
b) "CO" TO BE SHIFTED	328	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	225	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	52.2	MM LBS./DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	NONE	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, GRIND AND DRY TO PULVERIZED FUEL SIZE		
10. BYPRODUCT CHAR		
NONE TONS/DAY AT ———		BTU/TON
11. THERMAL EFFICIENCIES		
a) OVERALL, COAL TO PIPELINE GAS	56.0	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	72.3	%

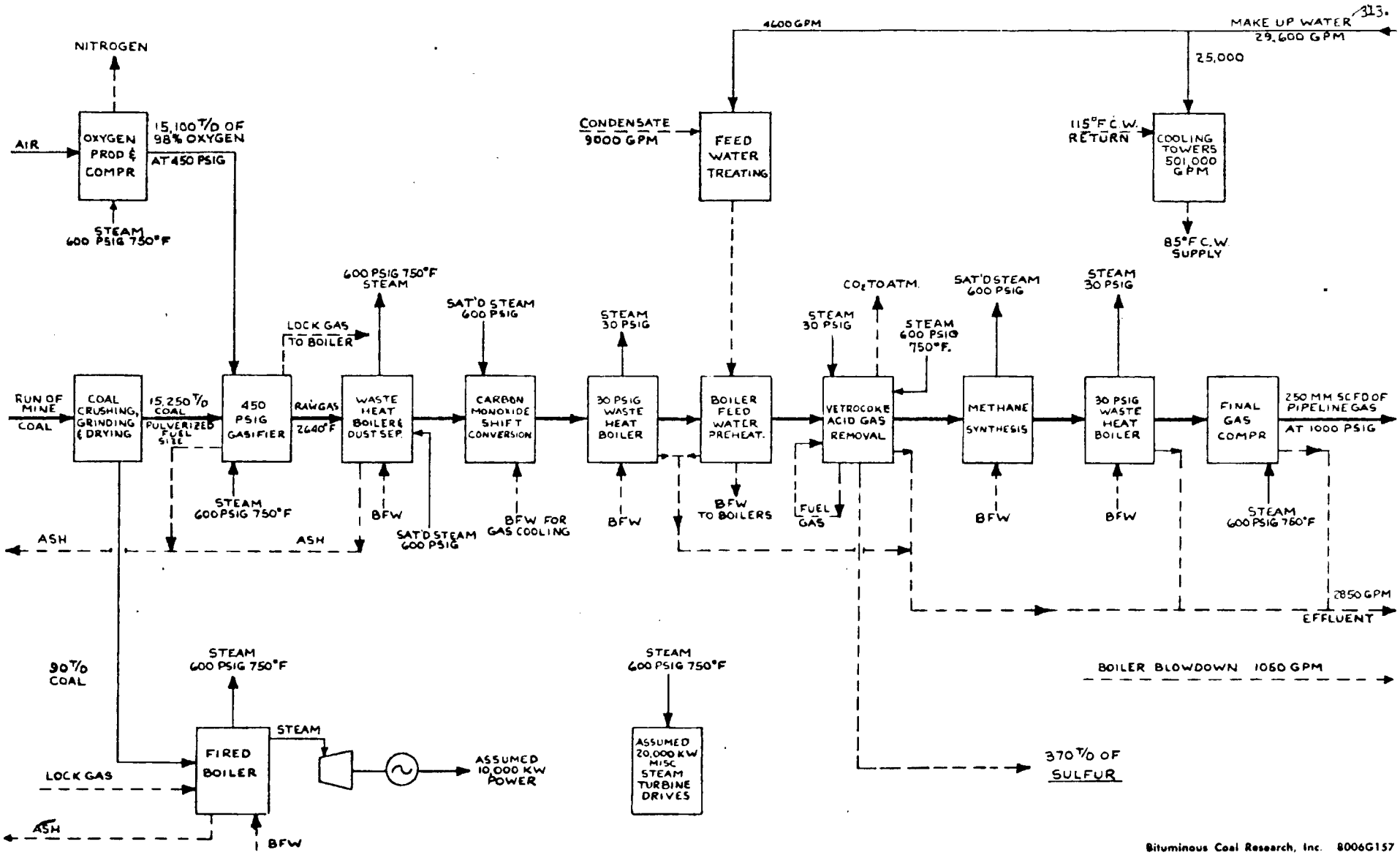

Figure 6.2-7 Simplified Process Scheme for Pipeline Gas Production Using the Koppers-Totzek Pressurized Gasifier (Process 60)

TABLE 6.2-29
Material Balance
Texaco Gasifier

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1,000	773	54	63	25	14	71
98% O_2	846			829		17	
STEAM	675		75	600			
TOTAL IN	2,521	773	129	1,492	25	31	71
OUTPUT							
ASH	140	69					71
CO_2	509	139		370			
CO	1,302	558		744			
H_2	77		77				
CH_4	10	7	3				
C_NH_M							
N_2						31	
H_2S	27		2		25		
TAR/OIL							
PHENOLS							
NH_3	31						
H_2O	425		47	378			
TOTAL OUT	2,521	773	129	1,492	25	31	71

BASED ON 1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-30
Heat Balance
Texaco Gasifier

INPUT

	BTU
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	140,000
COAL MOISTURE SENSIBLE HEAT	45,000
OXYGEN SENSIBLE HEAT	140,000
STEAM TOTAL ENTHALPY	790,000
JACKET WATER SENSIBLE HEAT	—
SOLID RECYCLE SENSIBLE HEAT	—
LIQUID RECYCLE SENSIBLE HEAT	—
TOTAL IN	15,105,000

OUTPUT

ASH SENSIBLE HEAT	70,000
ASH COMBUSTIBLES HEATING VALUE	970,000
HOT RAW GAS HEATING VALUE	10,840,000
HOT RAW GAS SENSIBLE HEAT	1,675,000
WATER VAPOR TOTAL ENTHALPY	925,000
ENTRAINED SOLIDS SENSIBLE HEAT	—
JACKET STEAM TOTAL ENTHALPY	—
HEAT LOSS AND OTHERS	625,000
TOTAL OUT	15,105,000

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE, 32°F. (0°C.)

TABLE 6.2-31
Overall Material Balance
Pipeline Gas Production Based on the Texaco Gasifier

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	14,300
OXYGEN (98%)	11,680
BOILER FEED WATER MAKEUP	19,220
LIME	—
TOTAL IN	45,200

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	22,450
HYDROGEN SULFIDE	370
PROCESS EFFLUENT WATER	14,330
AMMONIA	—
GAS LOSSES, TAR & PHENOLS	680
ASH (OR SLAG)	1,930
TOTAL OUT	45,200

TABLE 6.2-32
Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on the Texaco Gasifier

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	14,300	TONS/DAY
b) BOILER COAL (INCLUDES PREHEAT COAL)	1,300	TONS/DAY
TOTAL	15,600	TONS/DAY
2. OXYGEN REQUIREMENT (98%)	11,680	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	407,000	GPM
b) COOLING WATER MAKEUP	20,000	GPM
c) BOILER FEED MAKEUP	3,200	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	—	LBS./HR.
b) WASTE HEAT BOILERS	4,575,000	LBS./HR.
TOTAL	4,575,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	728	MM SCFD
b) "CO" TO BE SHIFTED	265	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	218	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	44.9	MM LBS./DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	NONE	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, GRIND AND DRY TO 1/32" BY 0 SIZE		
10. BYPRODUCT CHAR		
NONE TONS/DAY AT —		BTU/TON
11. THERMAL EFFICIENCIES		
a) OVERALL, COAL TO PIPELINE GAS	55.1	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	77.8	%

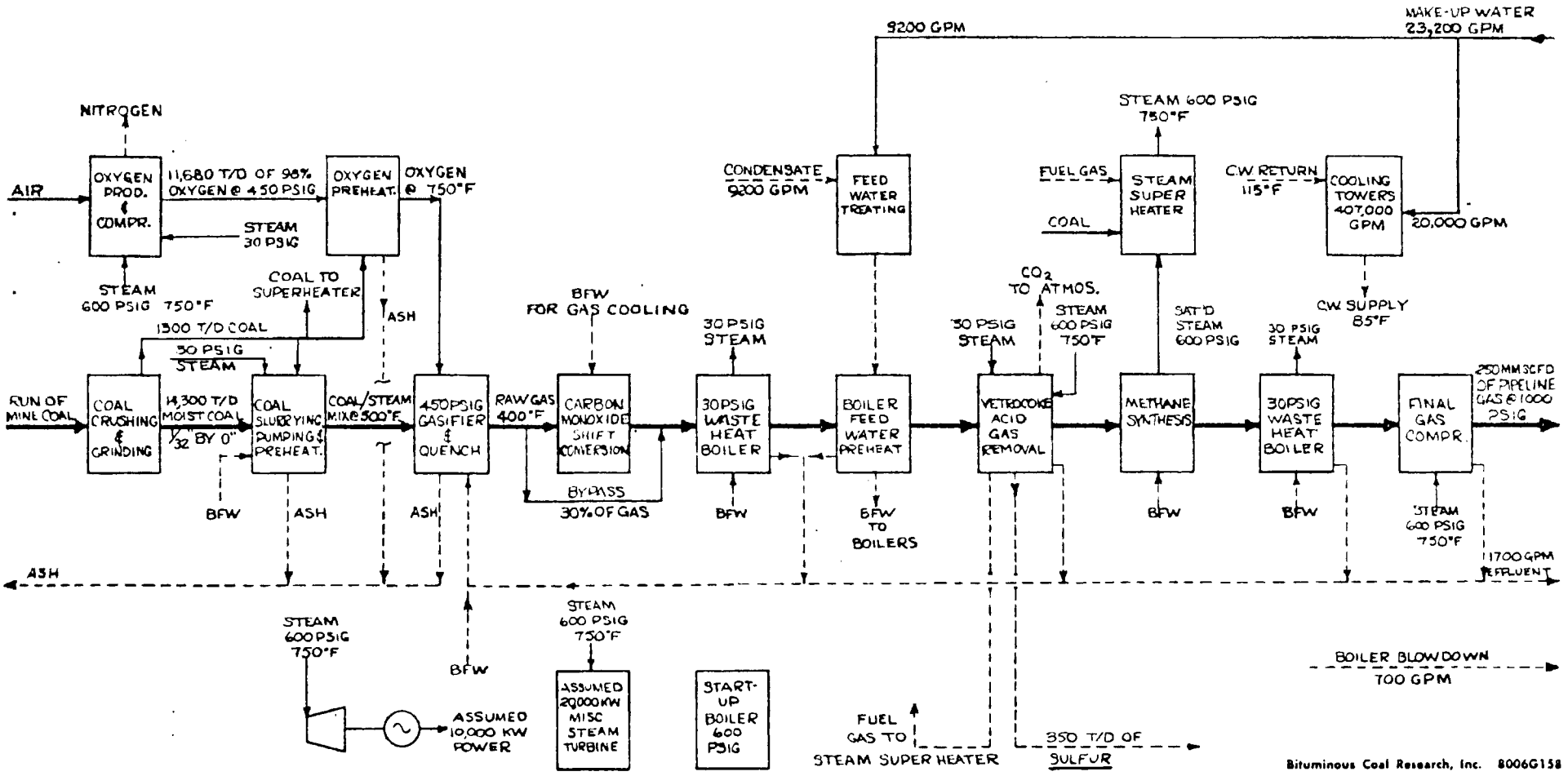

Figure 6.2-8 Simplified Process Scheme for Pipeline Gas Production Using the Texaco Gasifier (Process 22)

TABLE 6.2-33
Material Balance
Fixed-bed Super-pressure Gasifier

INPUT	LBS	C	H	O	S	N	ASH
COAL	1,000	773	54	63	25	14	71
98% O_2	422			413		9	
STEAM	2,006		223	1,773			
ADD. MOIST.	36		4	32			
TOTAL IN	3,464	773	281	2,291	25	23	71
OUTPUT							
ASH	74	3					71
CO_2	1,174	320		854			
CO	557	239		318			
H_2	80		80				
CH_4	207	155	52				
C_NH_M	9	8	1				
N_2	13					13	
H_2S	27		2		25		
TAR/OIL	51	43	5	3			
PHENOLS	6	5		1			
NH_3	12		2			10	
H_2O	1,254		139	1,115			
TOTAL OUT	3,464	773	281	2,291	25	23	71

BASED ON 1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-34
Heat Balance
Fixed-bed Super-pressure Gasifier

INPUT

	BTU
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	20,400
COAL MOISTURE SENSIBLE HEAT	2,500
OXYGEN SENSIBLE HEAT	21,000
STEAM TOTAL ENTHALPY	2,185,000
JACKET WATER SENSIBLE HEAT	28,100
SOLID RECYCLE SENSIBLE HEAT	—
LIQUID RECYCLE SENSIBLE HEAT	—
TOTAL IN	16,247,000

OUTPUT

ASH SENSIBLE HEAT	7,500
ASH COMBUSTIBLES HEATING VALUE	—
HOT RAW GAS HEATING VALUE	13,460,000
HOT RAW GAS SENSIBLE HEAT	910,000
WATER VAPOR TOTAL ENTHALPY	1,840,500
ENTRAINED SOLIDS SENSIBLE HEAT	—
JACKET STEAM TOTAL ENTHALPY	—
HEAT LOSS AND OTHERS	29,000
TOTAL OUT	16,247,000

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE, 32°F. (0°C.)

TABLE 6.2-35
Overall Material Balance
Pipeline Gas Production Based on a Fixed-bed Super-pressure Gasifier

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	10,880
OXYGEN (98%)	4,440
BOILER FEED WATER MAKEUP	28,200
LIME	—
TOTAL IN	43,520

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	14,570
HYDROGEN SULFIDE	280
PROCESS EFFLUENT WATER*	21,720
AMMONIA	130
GAS LOSSES, TAR & PHENOLS	600
ASH (OR SLAG)	780
TOTAL OUT	43,520

* INCLUDES 2,750 T/D WATER VAPOR VENTED FROM BY PRODUCT RECOVERY PLANTS.

TABLE 6.2-36
Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on a Fixed-bed Super-pressure Gasifier

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	10,880	TONS/DAY
b) BOILER COAL	1,290	TONS/DAY
TOTAL	12,170	TONS/DAY
2. OXYGEN REQUIREMENT (98%)	4,440	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	225,000	GPM
b) COOLING WATER MAKEUP	11,000	GPM
c) BOILER FEED MAKEUP	4,700	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	1,290,000	LBS./HR.
b) WASTE HEAT BOILERS	2,975,000	LBS./HR.
TOTAL	4,265,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	322	MM SCFD
b) "CO" TO BE SHIFTED	39	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	119	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	29.1	MM LBS./DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	1,960	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, AND SCREEN TO $1\frac{1}{4}$" BY $\frac{1}{8}$" SIZE		
10. BYPRODUCT CHAR		
NONE TONS/DAY AT ____		BTU/TON
11. THERMAL EFFICIENCIES		
a) OVERALL, COAL TO PIPELINE GAS	70.7	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	90.7	%

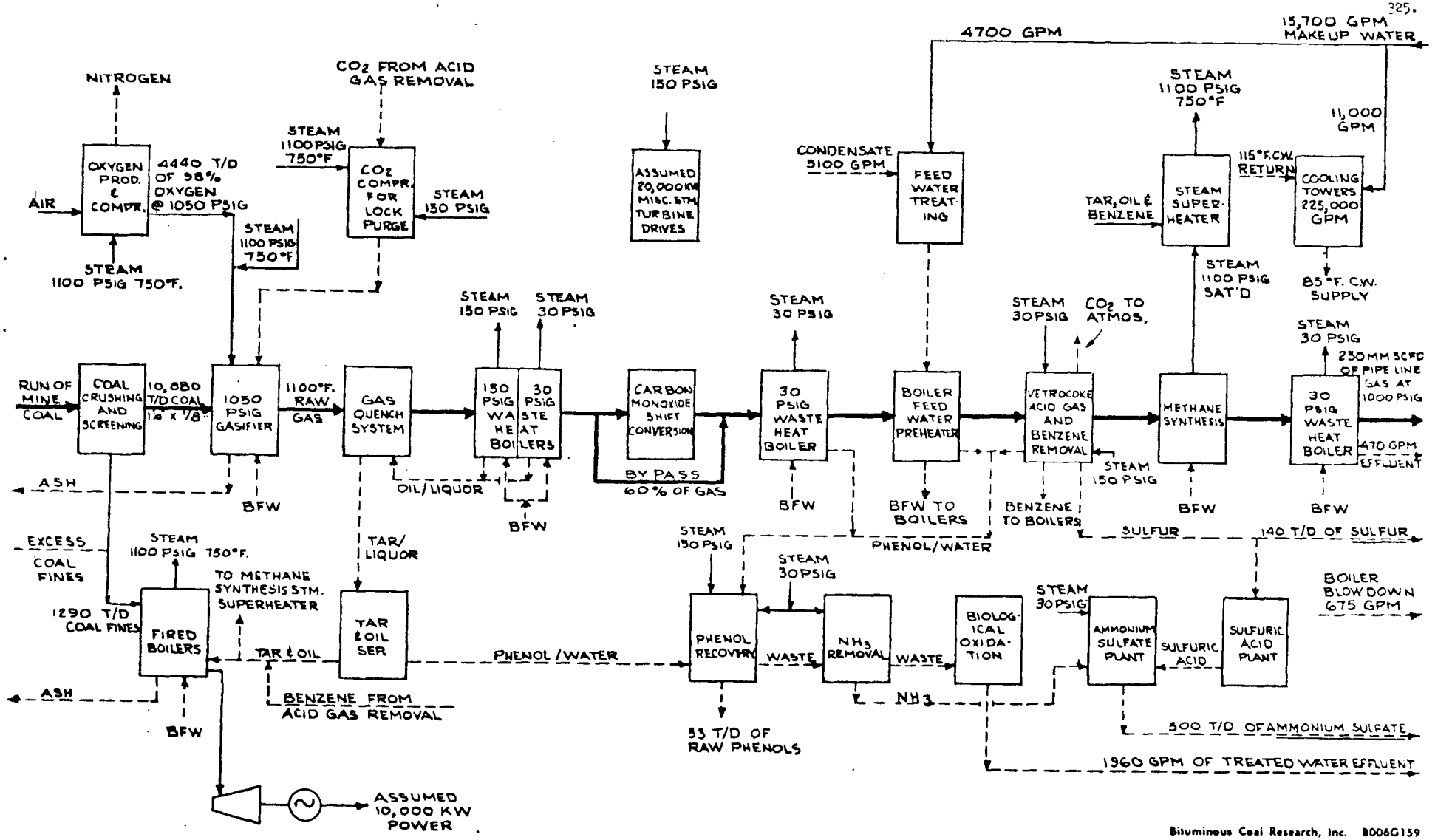

Figure 6.2-9 Simplified Process Scheme for Pipeline Gas Production Using a Fixed-bed Super-pressure Gasifier (Process 56)

TABLE 6.2-37
Material Balance
Fluidized-bed Super-pressure Gasifier

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1000	773	54	63	25	14	71
98% O_2	457			448		9	
STEAM	1332		148	1184			
TOTAL IN	2789	773	202	1695	25	23	71
OUTPUT							
ASH	101	30					71
CO_2	964	263		701			
CO	639	274		365			
H_2	52		52				
CH_4	275	206	69				
C_NH_M							
N_2	23					23	
H_2S	27		2		25		
TAR/OIL							
PHENOLS							
NH_3							
H_2O	708		79	629			
TOTAL OUT	2789	773	202	1695	25	23	71

BASED ON 1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-38
Heat Balance
Fluidized-bed Super-pressure Gasifier

INPUT

	BTU
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	290,000
COAL MOISTURE SENSIBLE HEAT	—
OXYGEN SENSIBLE HEAT	100,000
STEAM TOTAL ENTHALPY	2,000,000
JACKET WATER SENSIBLE HEAT	—
SOLID RECYCLE SENSIBLE HEAT	—
LIQUID RECYCLE SENSIBLE HEAT	—
TOTAL IN	16,380,000

OUTPUT

ASH SENSIBLE HEAT	40,000
ASH COMBUSTIBLES HEATING VALUE	420,000
HOT RAW GAS HEATING VALUE	12,780,000
HOT RAW GAS SENSIBLE HEAT	1,690,000
WATER VAPOR TOTAL ENTHALPY	1,372,000
ENTRAINED SOLIDS SENSIBLE HEAT	—
JACKET STEAM TOTAL ENTHALPY	—
HEAT LOSS AND OTHERS	78,000
TOTAL OUT	16,380,000

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE, 32° F. (0° C.)

TABLE 6.2-39
Overall Material Balance
Pipeline Gas Production Based on a
Fluidized-bed Super-pressure Gasifier

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	10,500
OXYGEN (98%)	4,650
BOILER FEED WATER MAKEUP	17,400
LIME	—
TOTAL IN	32,550

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	14,450
HYDROGEN SULFIDE	290
PROCESS EFFLUENT WATER	11,350
AMMONIA	—
GAS LOSSES, TAR & PHENOLS	—
ASH (OR SLAG)	1,020
TOTAL OUT	32,550

TABLE 6.2-40
Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on a Fluidized-bed Super-pressure Gasifier

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	10,500	TONS/DAY
b) BOILER COAL (INCLUDES PREHEAT COAL)	1,400	TONS/DAY
TOTAL	11,900	TONS/DAY
2. OXYGEN REQUIREMENT (98%)	4,650	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	208,000	GPM
b) COOLING WATER MAKEUP	10,000	GPM
c) BOILER FEED MAKEUP	2,900	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	837,000	LBS./HR.
b) WASTE HEAT BOILERS	2,538,000	LBS./HR.
TOTAL	3,375,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	495	MM SCFD
b) "CO" TO BE SHIFTED	81	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	94	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	28.9	MM LBS./DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	NONE	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, GRIND AND DRY TO 1/32" BY 0 SIZE		
10. BYPRODUCT CHAR		
NONE TONS/DAY AT —		BTU/TON
11. THERMAL EFFICIENCIES		
a) OVERALL, COAL TO PIPELINE GAS	72.3	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	91.4	%

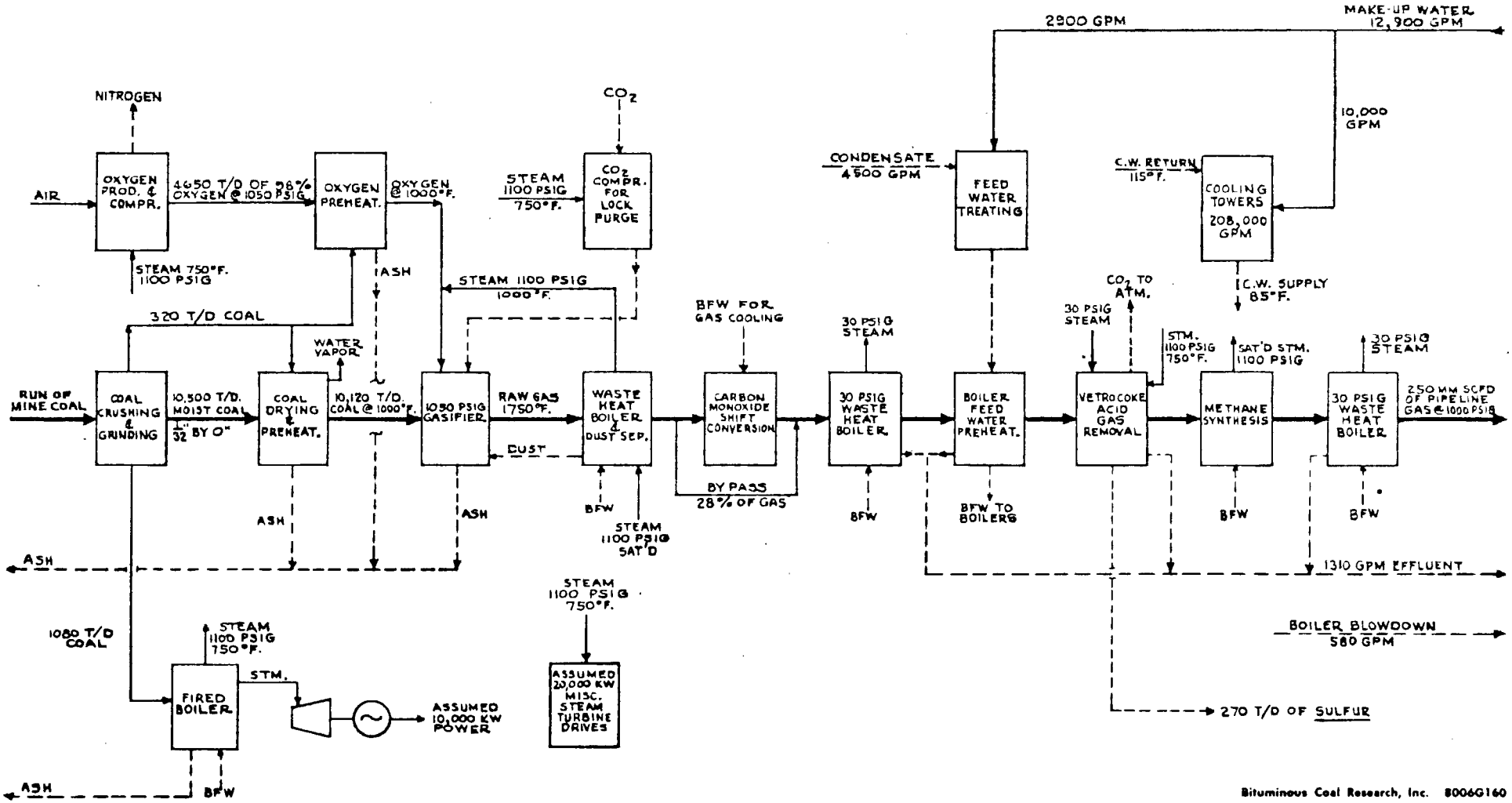

Figure 6.2-10 Simplified Process Scheme for Pipeline Gas Production Using a Fluidized-bed Super-pressure Gasifier (Process 57)

TABLE 6.2-41
Material Balance
Two-stage Super-pressure Entrained Gasifier R1

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1000	773	54	63	25	14	71
98% O_2	665			652		13	
STEAM	1250		139	1111			
TOTAL IN	2915	773	193	1826	25	27	71
OUTPUT							
ASH	71						71
CO_2	965	265		700			
CO	910	392		518			
H_2	78		78				
CH_4	154	116	38				
C_NH_M							
N_2	27					27	
H_2S	27		2		25		
TAR/OIL							
PHENOLS							
NH_3							
H_2O	683		75	608			
TOTAL OUT	2915	773	193	1826	25	27	71

1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-42
Heat Balance
Two-stage Super-pressure Entrained Gasifier R1

INPUT

	BTU
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	54,000
COAL MOISTURE SENSIBLE HEAT	6,500
OXYGEN SENSIBLE HEAT	113,000
STEAM TOTAL ENTHALPY	1,755,500
JACKET WATER SENSIBLE HEAT	—
SOLID RECYCLE SENSIBLE HEAT	306,000
LIQUID RECYCLE SENSIBLE HEAT	—
TOTAL IN	16,225,000

OUTPUT

ASH SENSIBLE HEAT	60,000
ASH COMBUSTIBLES HEATING VALUE	—
HOT RAW GAS HEATING VALUE	12,700,000
HOT RAW GAS SENSIBLE HEAT	1,530,000
WATER VAPOR TOTAL ENTHALPY	1,305,000
ENTRAINED SOLIDS SENSIBLE HEAT	475,000
JACKET STEAM TOTAL ENTHALPY	—
HEAT LOSS AND OTHERS	155,000
TOTAL OUT	16,225,000

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE, 32°F. (0°C.)

TABLE 6.2-43
Overall Material Balance
Pipeline Gas Production Based on the
Two-stage Super-pressure Entrained Gasifier R1

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	11,200
OXYGEN (98%)	7,200
BOILER FEED WATER MAKEUP	18,000
LIME	—
TOTAL IN	36,400

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	17,600
HYDROGEN SULFIDE	290
PROCESS EFFLUENT WATER	12,300
AMMONIA	—
GAS LOSSES, TAR & PHENOLS	—
ASH (OR SLAG)	770
TOTAL OUT	36,400

TABLE 6.2-44
Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on the Two-stage Super-pressure Entrained Gasifier R1

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	11,200	TONS/DAY
b) BOILER COAL	1,040	TONS/DAY
TOTAL	12,240	TONS/DAY
2. OXYGEN REQUIREMENT (98%)	7,200	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	301,000	GPM
b) COOLING WATER MAKEUP	15,000	GPM
c) BOILER FEED MAKEUP	3,000	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	504,000	LBS./HR.
b) WASTE HEAT BOILERS	3,346,000	LBS./HR.
TOTAL	3,850,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	859	MM SCFD
b) "CO" TO BE SHIFTED	121	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	146	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	35.2	MM LBS./DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	NONE	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, GRIND AND DRY TO $\frac{1}{8}$" BY 0 SIZE		
10. BYPRODUCT CHAR		
NONE TONS/DAY AT ———		BTU/TON
11. THERMAL EFFICIENCES		
a) OVERALL, COAL TO PIPELINE GAS	69.6	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	89.4	%

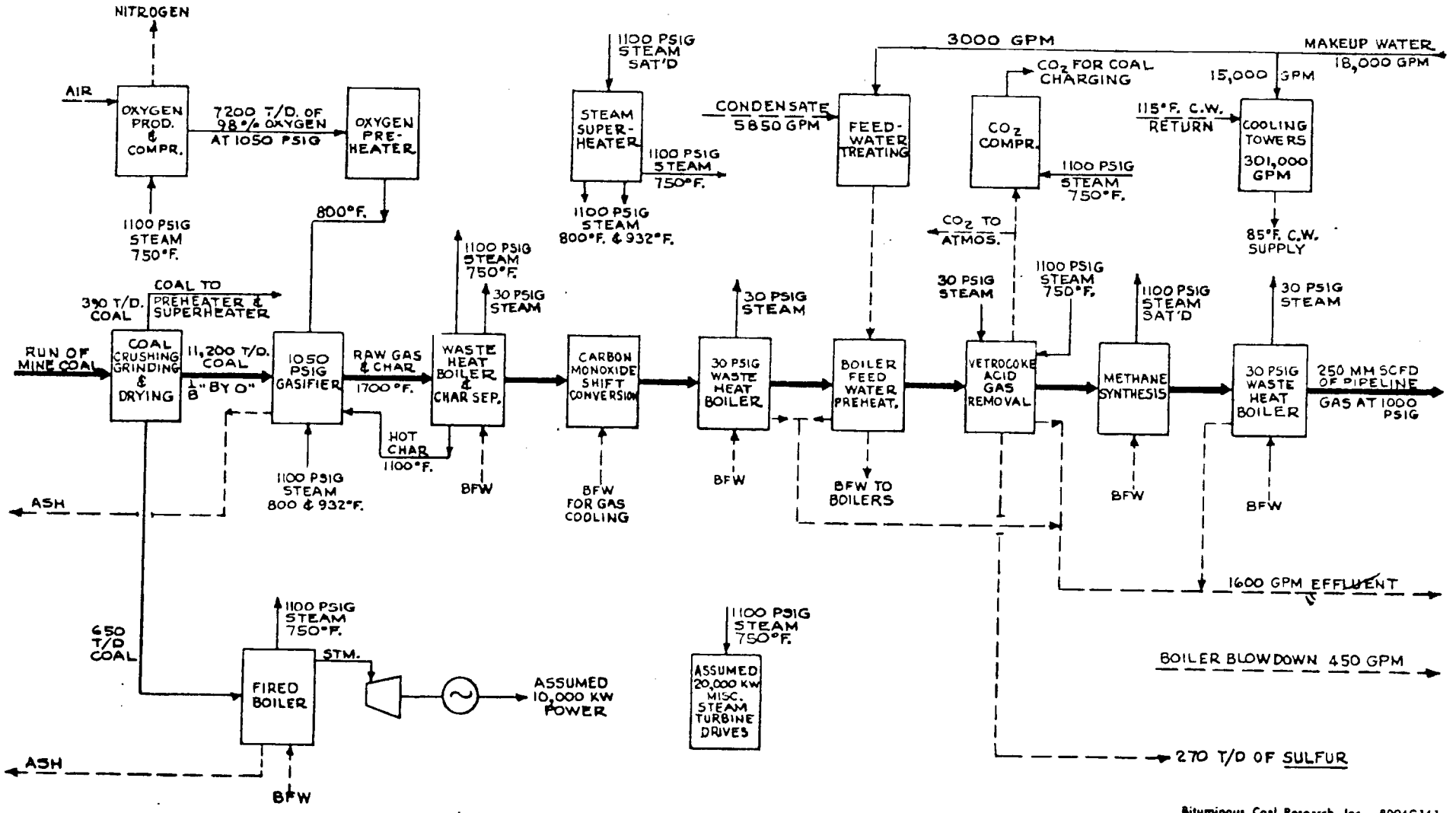

Figure 6.2-11 Simplified Process Scheme for Pipeline Gas Production Using the Two-stage Super-pressure Entrained Gasifier R1 (Process 58)

TABLE 6.2-45
Material Balance
Two-stage Super-pressure Entrained Gasifier R2

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1000	773	54	63	25	14	71
98% O_2	575			563		12	
STEAM	954		106	848			
TOTAL IN	2529	773	160	1474	25	26	71
OUTPUT							
ASH	71						71
CO_2	784	214		570			
CO	938	402		536			
H_2	60		60				
CH_4	209	157	52				
C_NH_M							
N_2	26					26	
H_2S	27		2		25		
TAR/OIL							
PHENOLS							
NH_3							
H_2O	414		46	368			
TOTAL OUT	2529	773	160	1474	25	26	71

1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-46
Heat Balance
Two-stage Super-pressure Entrained Gasifier R2

INPUT

	BTU
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	54,000
COAL MOISTURE SENSIBLE HEAT	6,500
OXYGEN SENSIBLE HEAT	98,000
STEAM TOTAL ENTHALPY	1,330,500
JACKET WATER SENSIBLE HEAT	—
SOLID RECYCLE SENSIBLE HEAT	306,000
LIQUID RECYCLE SENSIBLE HEAT	—
TOTAL IN	15,785,000

OUTPUT

ASH SENSIBLE HEAT	60,000
ASH COMBUSTIBLES HEATING VALUE	—
HOT RAW GAS HEATING VALUE	12,990,000
HOT RAW GAS SENSIBLE HEAT	1,400,000
WATER VAPOR TOTAL ENTHALPY	790,000
ENTRAINED SOLIDS SENSIBLE HEAT	475,000
JACKET STEAM TOTAL ENTHALPY	—
HEAT LOSS AND OTHERS	70,000
TOTAL OUT	15,785,000

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE; 32°F. (0°C.)

TABLE 6.2-47
Overall Material Balance
Pipeline Gas Production Based on the
Two-stage Super-pressure Entrained Gasifier R2

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	10,650
OXYGEN (98%)	5,910
BOILER FEED WATER MAKEUP	15,600
LIME	—
TOTAL IN	32,160

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	16,050
HYDROGEN SULFIDE	280
PROCESS EFFLUENT WATER	9,660
AMMONIA	—
GAS LOSSES, TAR & PHENOLS	—
ASH (OR SLAG)	730
TOTAL OUT	32,160

TABLE 6.2-48
Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on the Two-stage Super-pressure Entrained Gasifier R2

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	10,650	TONS/DAY
b) BOILER COAL	1,050	TONS/DAY
TOTAL	11,700	TONS/DAY
2. OXYGEN REQUIREMENT (98 %)	5,910	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	263,000	GPM
b) COOLING WATER MAKEUP	13,000	GPM
c) BOILER FEED MAKEUP	2,600	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	570,000	LBS./HR.
b) WASTE HEAT BOILERS	3,040,000	LBS./HR.
TOTAL	3,610,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	669	MM SCFD
b) "CO" TO BE SHIFTED	138	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	123.5	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	32.1	MM LBS/DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	NONE	GPM

9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, GRIND AND DRY TO $\frac{1}{8}$" BY 0 SIZE

10. BYPRODUCT CHAR

NONE TONS/DAY AT ____ BTU/TON

11. THERMAL EFFICIENCES		
a) OVERALL, COAL TO PIPELINE GAS	73.1	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	91.4	%

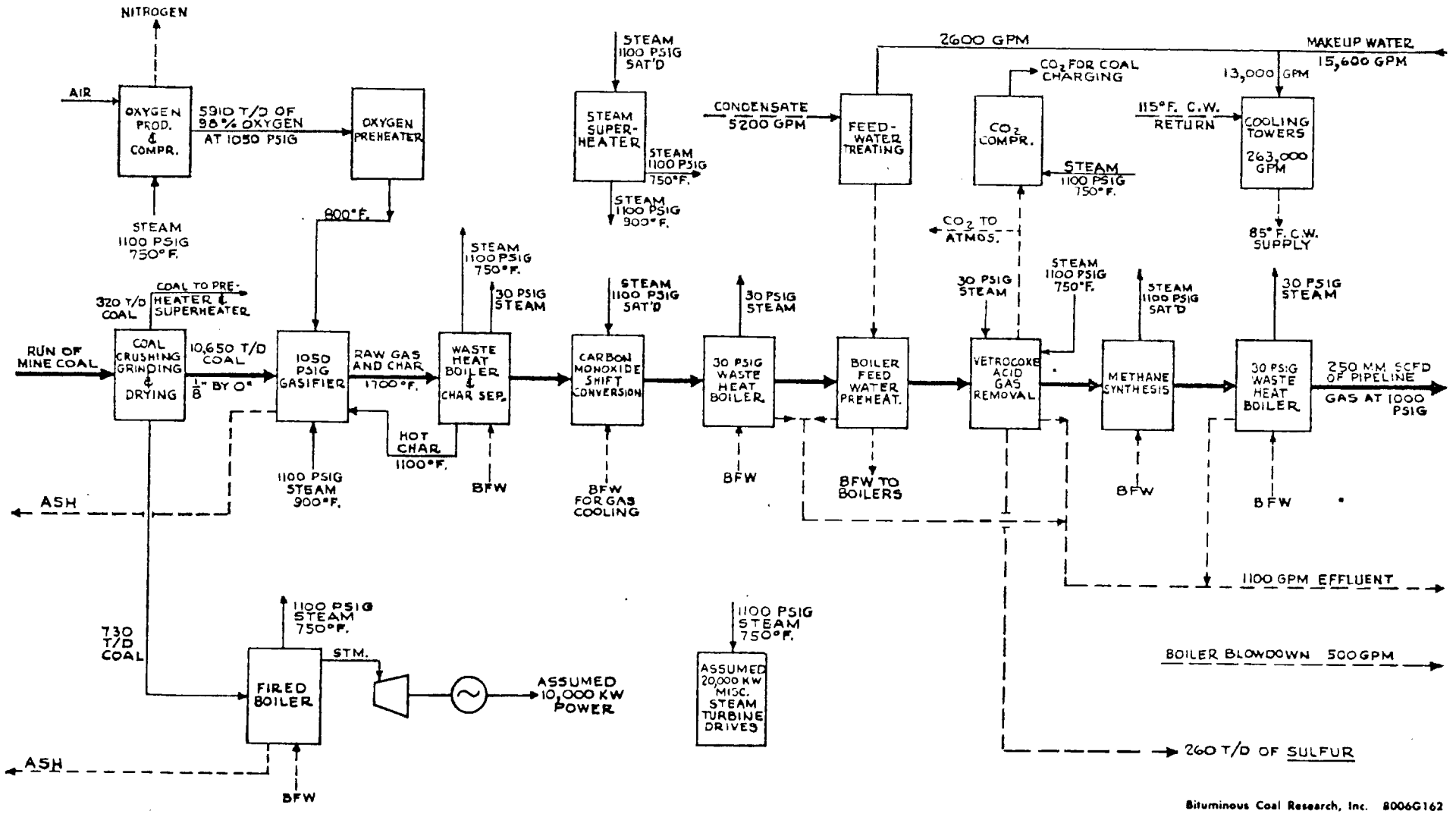

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Figure 6.2-12 Simplified Process Scheme for Pipeline Gas Production Using the Two-stage Super-pressure Entrained Gasifier R2 (Process 58)

TABLE 6.2-49
Material Balance
Two-stage Super-pressure Entrained Gasifier R3.4

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1000	773	54	63	25	14	71
98% O_2	504			494		10	
STEAM	730		81	649			
TOTAL IN	2234	773	135	1206	25	24	71
OUTPUT							
ASH	71						71
CO_2	597	163		434			
CO	991	425		566			
H_2	45		45				
CH_4	247	185	62				
C_NH_M							
N_2	24					24	
H_2S	27		2		25		
TAR/OIL							
PHENOLS							
NH_3							
H_2O	232		26	206			
TOTAL OUT	2234	773	135	1206	25	24	71

1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-50
Heat Balance
Two-stage Super-pressure Entrained Gasifier R3.4

INPUT

	BTU
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	54,000
COAL MOISTURE SENSIBLE HEAT	6,500
OXYGEN SENSIBLE HEAT	86,000
STEAM TOTAL ENTHALPY	1,000,500
JACKET WATER SENSIBLE HEAT	——
SOLID RECYCLE SENSIBLE HEAT	306,000
LIQUID RECYCLE SENSIBLE HEAT	——
TOTAL IN	15,443,000

OUTPUT

ASH SENSIBLE HEAT	60,000
ASH COMBUSTIBLES HEATING VALUE	——
HOT RAW GAS HEATING VALUE	13,180,000
HOT RAW GAS SENSIBLE HEAT	1,280,000
WATER VAPOR TOTAL ENTHALPY	440,000
ENTRAINED SOLIDS SENSIBLE HEAT	475,000
JACKET STEAM TOTAL ENTHALPY	——
HEAT LOSS AND OTHERS	8,000
TOTAL OUT	15,443,000

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE, 32°F. (0°C.)

TABLE 6.2-51
Overall Material Balance
Pipeline Gas Production Based on the
Two-stage Super-pressure Entrained Gasifier R3.4

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	10,350
OXYGEN (98%)	5,020
BOILER FEED WATER MAKEUP	15,000
LIME	—
TOTAL IN	30,370

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	15,100
HYDROGEN SULFIDE	270
PROCESS EFFLUENT WATER	8,850
AMMONIA	—
GAS LOSSES, TAR & PHENOLS	—
ASH (OR SLAG)	710
TOTAL OUT	30,370

TABLE 6.2-52
Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on the Two-stage Super-pressure Entrained Gasifier R3.4

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	10,350	TONS/DAY
b) BOILER COAL	1,070	TONS/DAY
TOTAL	11,420	TONS/DAY
2. OXYGEN REQUIREMENT (98 %)	5,020	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	235,000	GPM
b) COOLING WATER MAKEUP	12,000	GPM
c) BOILER FEED MAKEUP	2,500	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	620,000	LBS./HR.
b) WASTE HEAT BOILERS	2,680,000	LBS./HR.
TOTAL	3,300,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	669	MM SCFD
b) "CO" TO BE SHIFTED	158	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	109	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	30.2	MM LBS./DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	NONE	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, GRIND AND DRY TO $\frac{1}{8}$" BY 0 SIZE		
10. BYPRODUCT CHAR		
NONE TONS/DAY AT —		BTU/TON
11. THERMAL EFFICIENCES		
a) OVERALL, COAL TO PIPELINE GAS	75.0	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	92.8	%

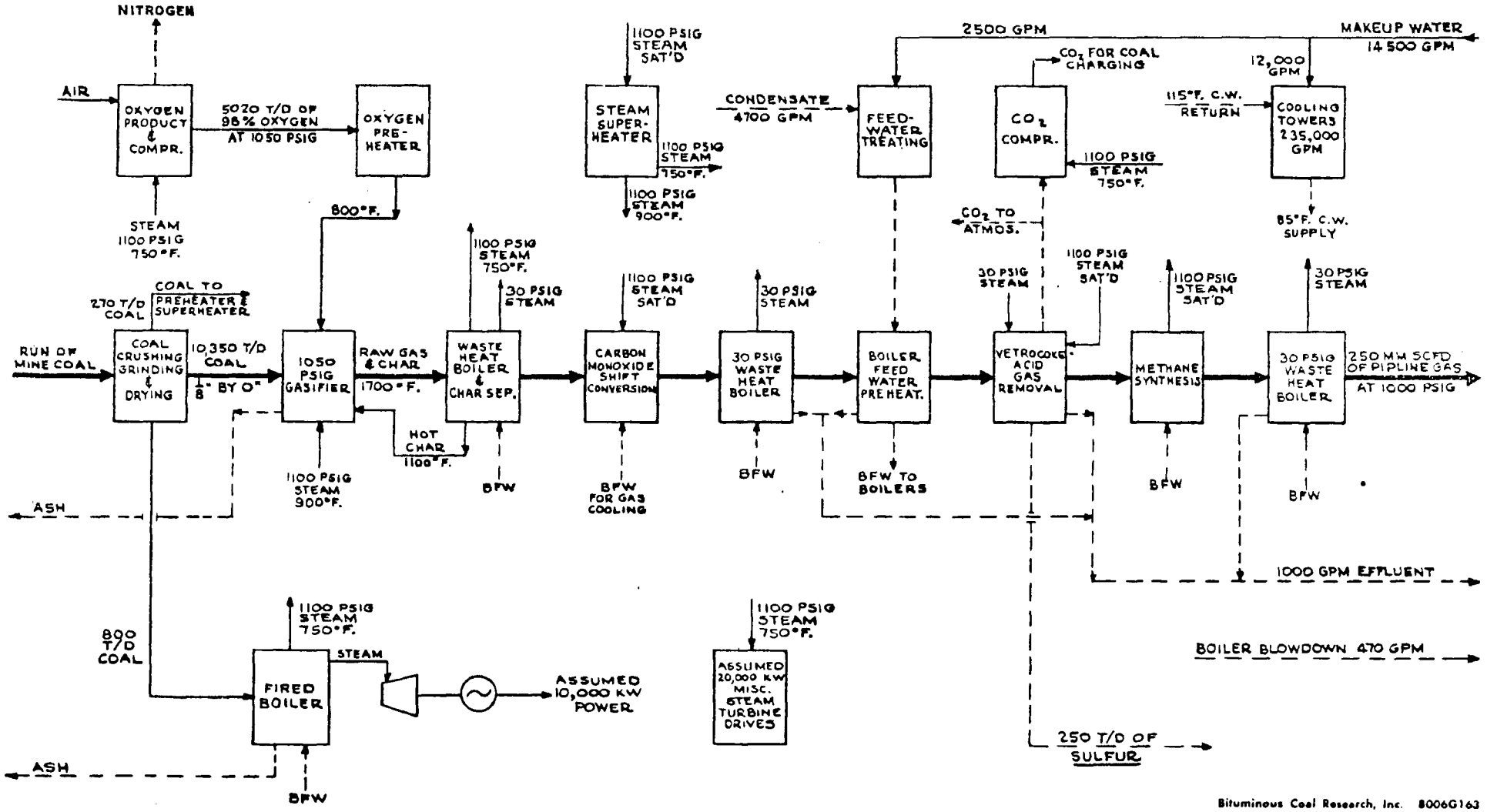

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Figure 6.2-13 Simplified Process Scheme for Pipeline Gas Production Using the Two-stage Super-pressure Entrained Gasifier R3.4 (Process 58)

TABLE 6.2-53
Material Balance
Catalytic Steam Methanation Gasifier

INPUT	LBS.	C	H	O	S	N	ASH
COAL	1000	773	54	63	25	14	71
98% O_2	204			200		4	
STEAM	1201		133	1068			
TOTAL IN	2405	773	187	1331	25	18	71
OUTPUT							
ASH	182	111					71
CO_2	1056	288		768			
CO	229	98		131			
H_2	38		38				
CH_4	368	276	92				
C_NH_M							
N_2	13					13	
H_2S	27		2		25		
TAR/OIL							
PHENOLS							
NH_3	6		1			5	
H_2O	486		54	432			
TOTAL OUT	2405	773	187	1331	25	18	71

BASED ON 1000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
FIGURES ARE TO SLIDE RULE ACCURACY.

TABLE 6.2-54
Heat Balance
Catalytic Steam Methanation Gasifier

INPUT

	BTU
COAL HEATING VALUE	13,990,000
COAL SENSIBLE HEAT	190,000
COAL MOISTURE SENSIBLE HEAT	8,000
OXYGEN SENSIBLE HEAT	50,000
STEAM TOTAL ENTHALPY	1,910,000
JACKET WATER SENSIBLE HEAT	—
SOLID RECYCLE SENSIBLE HEAT	112,000
LIQUID RECYCLE SENSIBLE HEAT	—
TOTAL IN	16,260,000

OUTPUT

ASH SENSIBLE HEAT	80,000
ASH COMBUSTIBLES HEATING VALUE	1,650,000
HOT RAW GAS HEATING VALUE	12,340,000
HOT RAW GAS SENSIBLE HEAT	1,580,000
WATER VAPOR TOTAL ENTHALPY	300,000
ENTRAINED SOLIDS SENSIBLE HEAT	120,000
JACKET STEAM TOTAL ENTHALPY	—
HEAT LOSS AND OTHERS	190,000
TOTAL OUT	16,260,000

BASED ON 1,000 POUNDS OF COAL, INCLUDING 1.2% MOISTURE.
BASE TEMPERATURE, 32° F. (0° C.)

TABLE 6.2-55
Overall Material Balance
Pipeline Gas Production Based on the Catalytic Steam Methanation Gasifier

INPUT

	TONS/DAY
COAL (4.7% MOISTURE)	10,460
OXYGEN (98%)	2,080
BOILER FEED WATER MAKEUP	14,900
CATALYSTS	470
TOTAL IN	27,910

OUTPUT

PIPELINE GAS	5,440
CARBON DIOXIDE	11,350
HYDROGEN SULFIDE	270
PROCESS EFFLUENT WATER	8,150
AMMONIA	40
GAS LOSSES, TAR & PHENOLS	—
CHAR	2,660
TOTAL OUT	27,910

TABLE 6.2-56
Summary of Process Data
250 MM scfd Pipeline Gas from Coal Based on the Catalytic Steam Methanation Gasifier

1. COAL REQUIREMENTS (AS MINED)		
a) PROCESS COAL	10,460	TONS/DAY
b) BOILER COAL	—	TONS/DAY
TOTAL	10,460	TONS/DAY
2. OXYGEN REQUIREMENT (98%)	2,080	TONS/DAY
3. WATER REQUIREMENTS		
a) COOLING WATER (30°F. RISE)	143,000	GPM
b) COOLING WATER MAKEUP	7,100	GPM
c) BOILER FEED MAKEUP	2,500	GPM
4. STEAM PRODUCTION		
a) FIRED BOILER	1,270,000	LBS./HR.
b) WASTE HEAT BOILERS	1,130,000	LBS./HR.
TOTAL	2,400,000	LBS./HR.
5. SHIFT CONVERSION		
a) TOTAL DRY GAS TO SHIFT	318	MM SCFD
b) "CO" TO BE SHIFTED	13	MM SCFD
6. METHANATION		
METHANE SYNTHESIZED	37	MM SCFD
7. ACID GAS REMOVAL		
CARBON DIOXIDE ABSORBED	22.7	MM LBS./DAY
8. WASTE TREATMENT		
EFFLUENT TO TREATMENT	NONE	GPM
9. TYPE OF PREPARATION FOR PROCESS COAL - CRUSH, GRIND & DRY TO 1/32" BY 0 SIZE		
10. BYPRODUCT CHAR		
TONS/DAY AT	NONE	BTU/TON
11. THERMAL EFFICIENCES		
a) OVERALL, COAL TO PIPELINE GAS	82.1	%
b) GASIFICATION, PROCESS COAL TO COLD RAW GAS	86.5	%

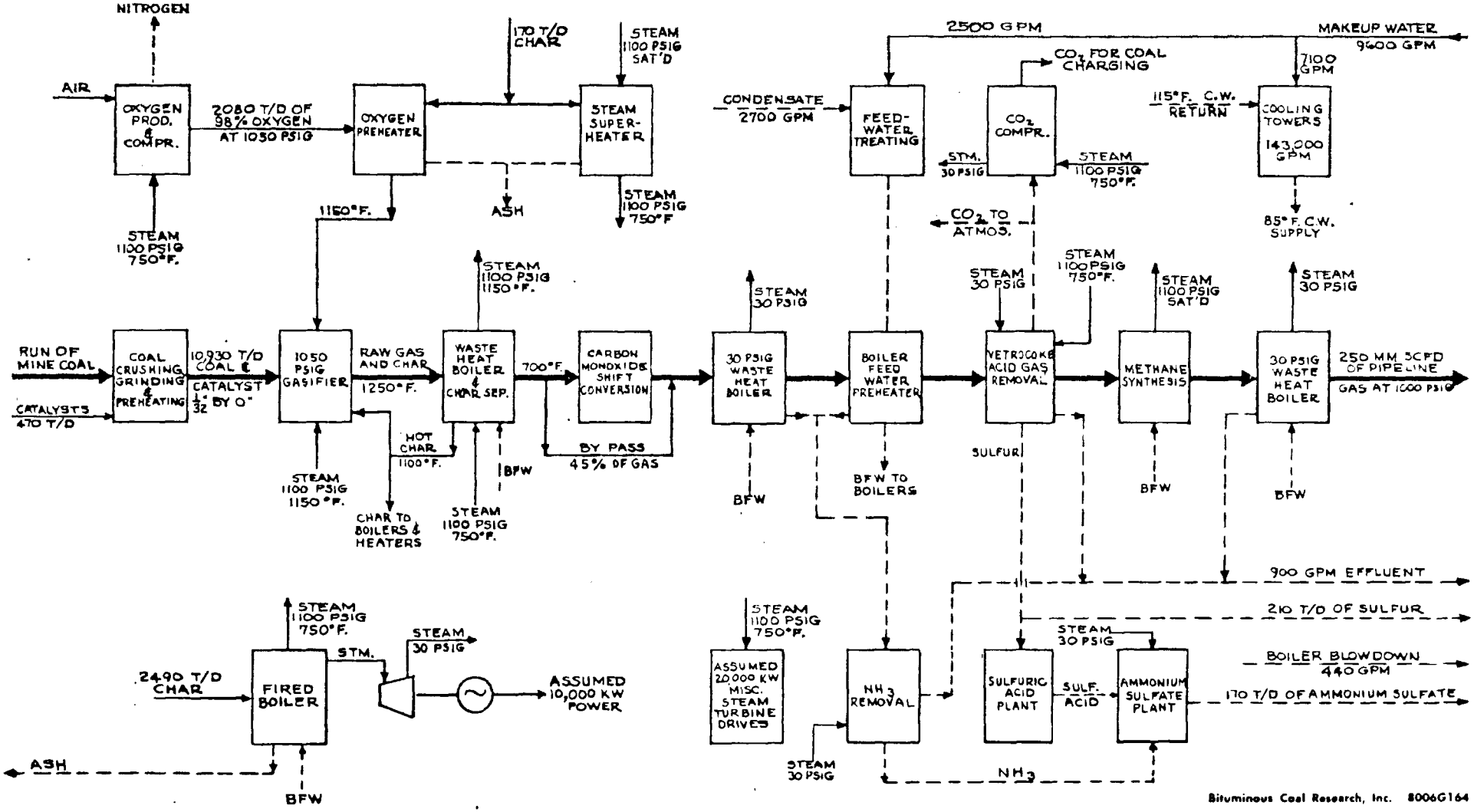

Figure 6.2-14 Simplified Process Scheme for Pipeline Gas Production Using the Catalytic Steam Methanation Gasifier (Process 65)

APPENDIX 9.1

HIGH-PRESSURE THERMAL SOFTENING PROPERTIES OF COALS

There are several interesting prospects for gasifying U.S. coals at reasonable costs using steam and oxygen including:

1. The adaption of European high-pressure fixed bed techniques, that are applicable to non-caking coals, to U.S. coals and to higher operating pressures;

2. Fluidized bed techniques that are mostly experimental; and

3. Conceptual pulverized coal entrained gasification techniques.

There is presently a concern for the softening of coal that is known to occur at low pressures; any additional softening of the coal particles could make any of these processes less attractive. However, there seems to be an absence of information on the high-pressure thermal properties of coal. A plastometer, suitable for high pressure testing, was therefore conceived.

The proposed plastometer (Figure 9.1-1) consists of a pressure tight cylinder with a heating jacket. Gas would be passed through the unit at a low constant rate, and would percolate through the test sample supported inside on a fritted disk.

The test procedure would consist of setting up a sample, and then pressurizing and leak testing at the desired test pressure. A flow rate would be set, and the cylinder would be heated at a programmed rate.

As the sample softened, the bed porosity would diminish, and a higher inlet pressure setting would be required to maintain the desired flow rate. As the coal resolidifies, the resistance would probably diminish close to the starting value. The correlation between cylinder temperature and pressure drop across the bed should give an empirical indication of the fluid properties of the specimen at the pressures selected.

A small unit of such a design would be used initially to determine the fluid properties of a variety of coals in different atmospheres. It should be possible to develop a standard procedure that would enable the correlation of high pressure plastic properties with other coal properties, especially petrographic, so that the high pressure fluid properties of any coal could be predicted.

Large units would also be built to simulate the conditions existing near the coal inlet of a fixed bed gasifier. The actual size of feed could be used and additives (such as recycled ash) or other devices proposed for reducing the effects of coal fluidity could be tested.

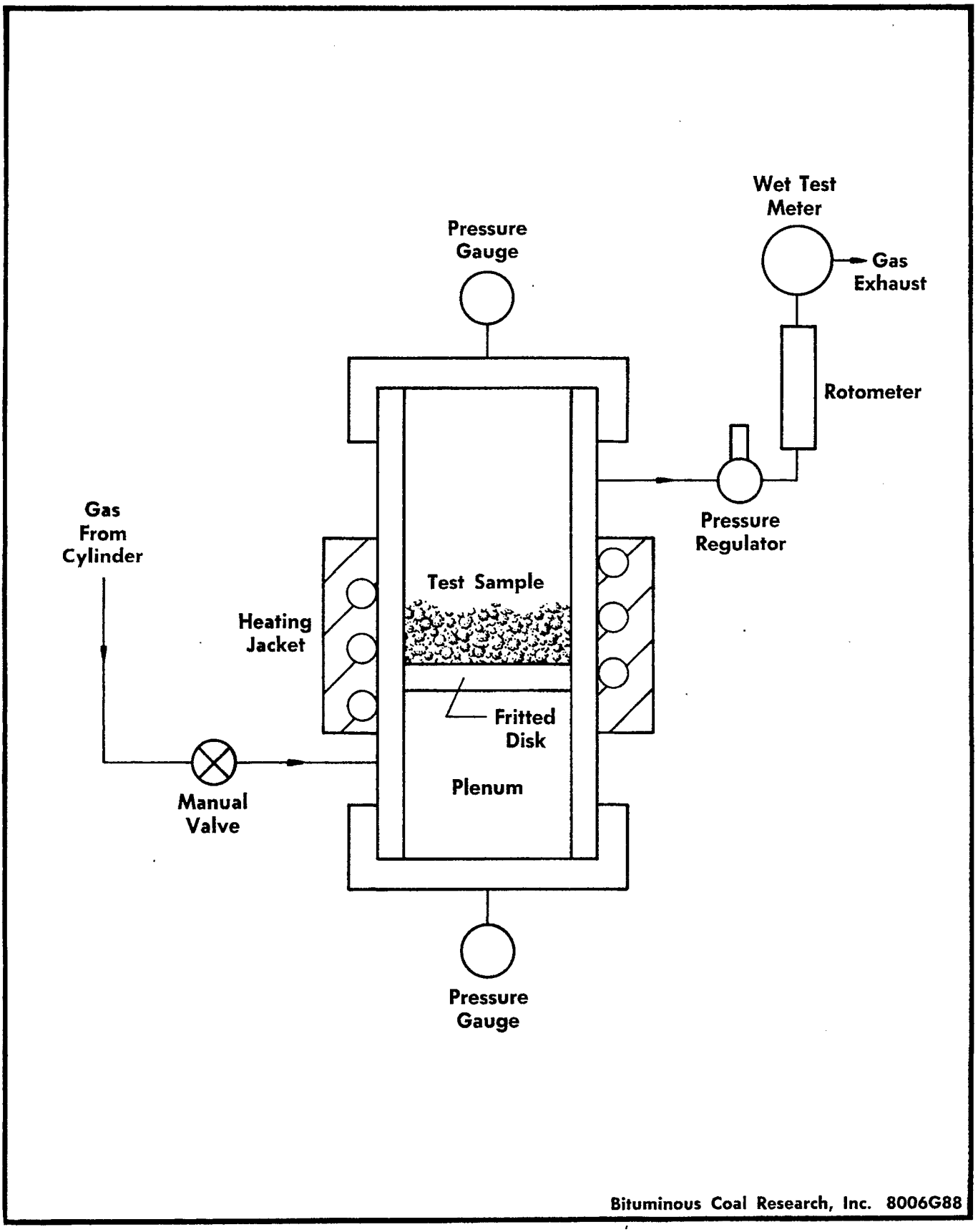

Figure 9.1-1 Schematic Diagram of Proposed High Pressure Coal Plastometer

APPENDIX 9.2

PARTIAL COAL GASIFICATION AS PART OF A POWER PLANT CYCLE

The gas turbine using gaseous or liquid fuels has found wide application for the generation of power in such applications as gas compression. It has not yet entered the field of large, central base-load power plants; the capacity of presently available gas turbines is considerably below that of steam turbines.

By contrast, the use of coal as gas turbine fuel is only in the development stage. A gas turbine that is directly fired with coal is undergoing tests at the U.S. Bureau of Mines. The main problem here is the removal of erosive dust from large amounts of products of combustion at high temperature.

Various combinations of process units for complete gasification of coal, followed by combustion of this gas and its use in a gas turbine, have been investigated in the U.S. and abroad. So far, an economical process has not evolved although a recent publication seems to indicate that gasification at high pressure of about 350 psi may change this (17) situation for power plants in the 30,000 kw range.

A different approach, namely the combined use of gas and steam turbines in large coal fired power plants, promises an increase of the power plant efficiency without an increase in investment cost. This would be accomplished by using gas obtained from the readily gasifiable portions of the coal as fuel for the gas turbine, and by feeding the char from the coal together with the gas turbine effluent into a steam boiler.

During the discussions of the BCR team with organizations in England and Germany, various processes for the partial gasification of coal have been found in pilot or commercial plants. It is well known that pulverized coal can be almost as rapidly devolatilized as the coal particle is heated. Data have now been obtained from pilot and commercial plants that are based on this fact. The rapid rate of the devolatilization of coal, or, in other words, the rapid gasification of its volatile matter makes it readily possible to include this reaction in the power plant cycle. Conducting this partial gasification under pressure produces a gas that can be cleaned at comparatively low temperature and used as fuel for the gas turbine. Since less compressed air is required than the gas that is generated under pressure, an overall saving in compression costs results from gasification at elevated pressure. The char from the devolatilization process is fed immediately into the boiler plant without being cooled.

Such a scheme for power generation provides about 20 to 40 percent of the total heating value of the coal as fuel for the gas turbine; one possible scheme is depicted in Figure 9.2-1. Since gas turbines developed so far are

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(17) Schuette, A., "The outlook and feasibility of the gas turbine with pressure gasifier for gasification of coal," Energie und Technik (8), 269-76 (1964).

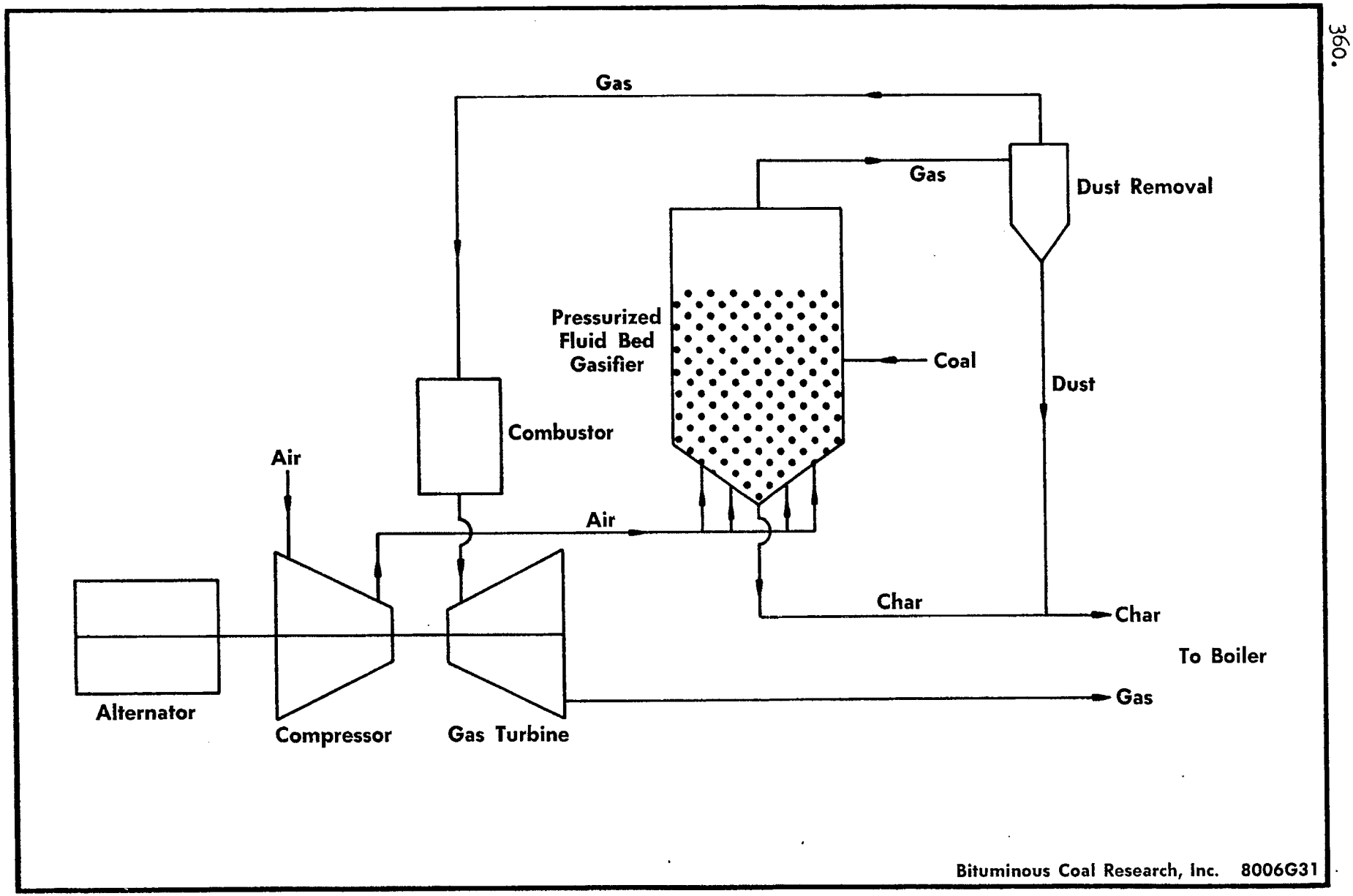

Figure 9.2-1 Combined Gas and Steam Turbine Power Plant Cycle Based on Fluidized-bed Gasification of Coal

of smaller capacity than steam turbines, such a combination of gas and steam turbines may provide utilization of largest possible engines in both stages.

The advantage of this cycle is, first, an improvement in efficiency due to the higher inlet temperature of the gas turbine of about 1400 F or more compared with about 950-1000 F for steam turbines. Secondly, the temperature of the devolatilization step may be as low as 1100 F compared with temperatures above 2000 F used in a boiler or a plant for the complete gasification of coal, and the reaction time is short which permits the use of low cost equipment. The gas produced is of high heating value compared to that of normal producer gas; thus, the quantity of gas from which dust must be removed is small in comparison with that in a direct fired coal gas turbine or that obtained from complete coal gasification. In addition, the temperature of the dust removal unit can be lower since the gas temperature will be increased by combustion before it enters the gas turbine. The space requirement of the partial gasification unit and the gas turbine are expected to be small, and this may make it practical to add such units to existing power plants to increase their capacity.

In addition to this, another advantage exists. The devolatilization of the coal can be conducted under such conditions that tar is obtained. Separation of this tar and its storage would provide a fuel for peak load gas turbines. It is known that gas turbines are especially suitable for this purpose since their start-up time is short and their investment cost low.

Among the processes that have been found for the devolatilization of coal are processes such as the partial carbonization of coal in a fluidized bed to produce a formed smokeless solid fuel in the Birch Coppice plant, and a similar unit in the Stoke Orchard laboratories of the National Coal Board in England. The Central Electricity Generating Board in Marchwood, England, experiments with a fluidized process for the rapid devolatilization of coal under pressure with direct air injection to produce gas for use in a gas turbine and hot char as boiler fuel. For this power plant cycle, an increase in efficiency is claimed without increase in power plant investment. In Germany, the LR Process was developed and a commercial scale unit to produce town gas as a byproduct of power generation by combustion of the char was operated at the Dorsten power plant in Germany. In this process, indirect heating of the fluidized bed is used.

Thus, an appropriate program of research should initially include the following:

a. Development of material and heat balances based on data from European plants,

b. Development of flow sheets and cost estimates for the generation of gas by partial coal gasification under pressure to produce a gas turbine fuel and selection of the most economical process,

c. Evaluation of the merits of this process in power plant cycles in cooperation with equipment builders to indicate the direction of further research. This should include the recovery and storage of tar for use in peak load gas turbines.

d. Delineation of a specific program of experimental work on that aspect of partial gasification which appears to be most promising.

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