

General Process Flow Diagram

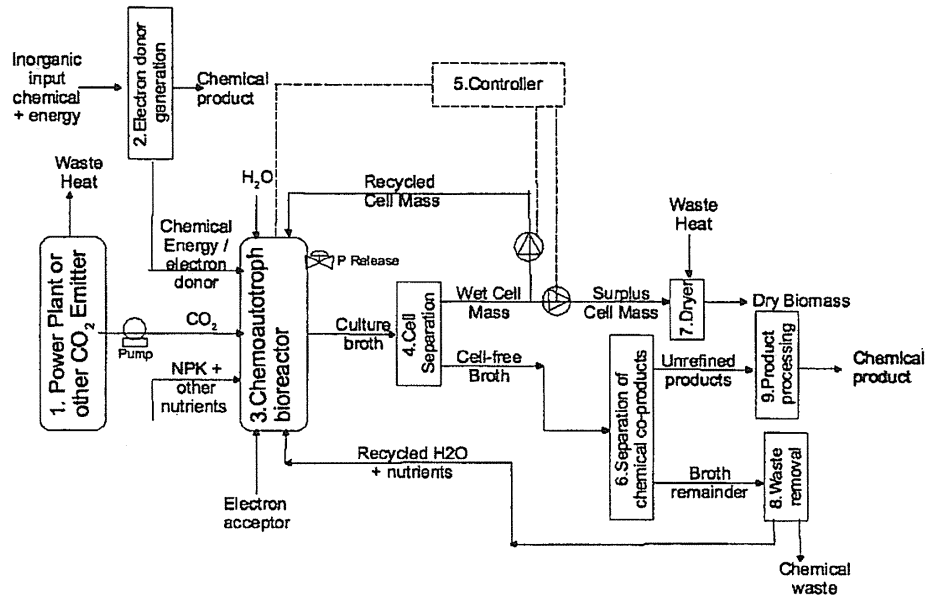


FIG. 1

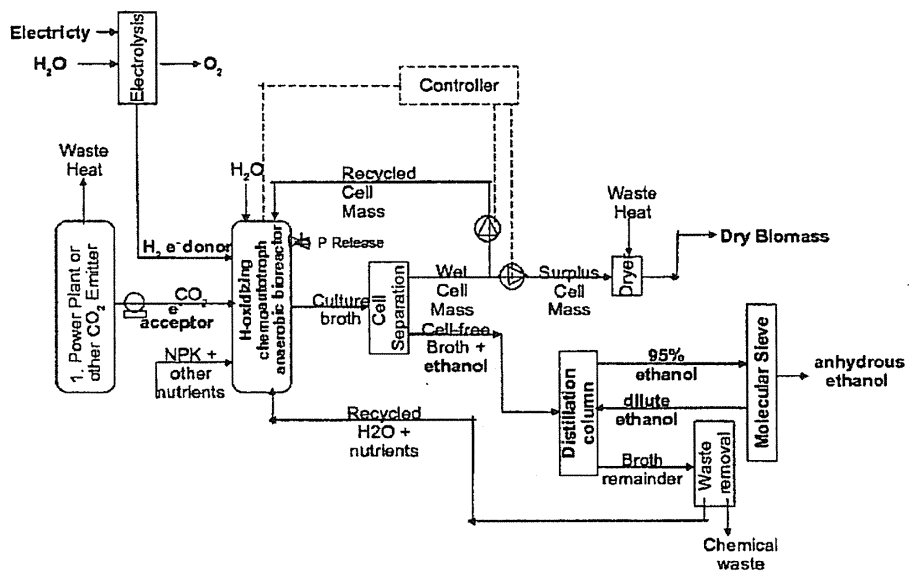
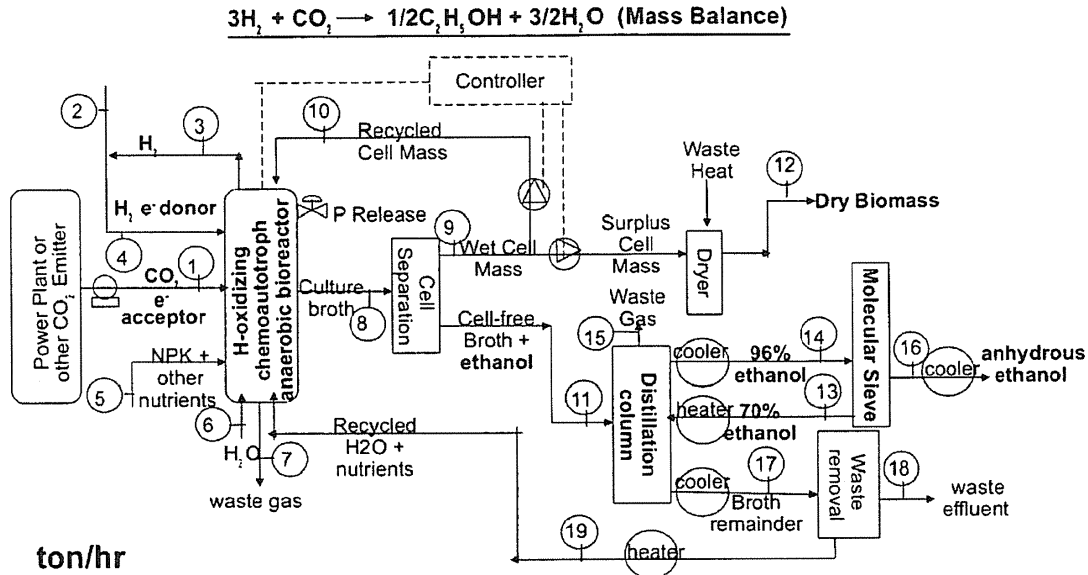


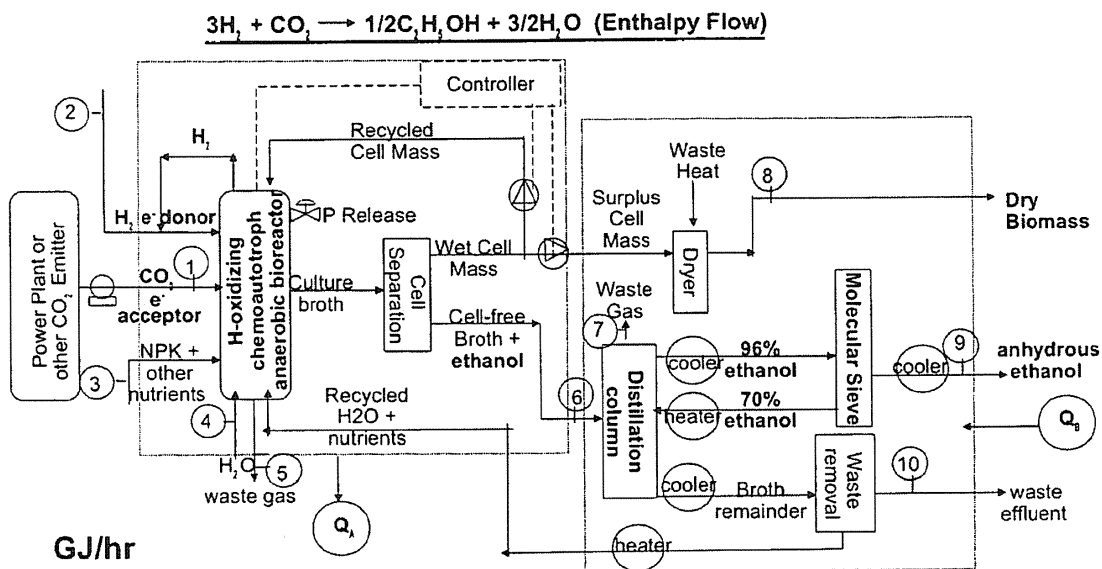
FIG. 2



Line number	1	2	3	4	5	6	7	8	9
stream	CO2 feed	H2 new	H2 recycle	H2 feed	nutrient feed	H2O feed	waste gas	medium	Cell mass
CO2	7.73	-	1.13	1.13	-	-	0.01	0.38	-
N2	19.64	-	-	-	-	-	19.64	-	-
H2	-	1.00	0.20	1.20	-	-	-	5.36E-04	-
Nutrients	-	-	-	-	9.45E-04	-	-	1.25	-
H2O	-	-	-	-	-	trace	-	382.87	4.20
ethanol	-	-	-	-	-	-	-	3.83	-
acetic acid	-	-	-	-	-	-	-	0.76	-
biomass	-	-	-	-	-	-	-	1.80	1.80
T (degrees C)	150.00	37.00	37.00	37.00	37.00	37.00	37.00	37.00	37.00

Line number	10	11	12	13	14	15	16	17	18	19
stream	Cell recycle	Cell-free	Dry	Reflux	Top	Waste Gas	C2H6O	Bottom	Effluent	Recycle
CO2	-	0.38	-	-	-	0.38	-	-	-	-
N2	-	-	-	-	-	-	-	-	-	-
H2	-	5.36E-04	-	-	-	5.36E-04	-	-	-	-
Nutrients	-	1.25	-	-	-	-	-	1.25	9.45E-04	1.25
H2O	4.20	378.67	trace	0.17	0.18	-	0.01	378.66	2.89E-01	378.37
ethanol	-	3.83	-	0.39	4.22	-	3.83	trace	-	-
acetic acid	-	0.76	-	-	-	-	-	0.76	5.79E-04	0.76
biomass	1.80	-	trace	-	-	-	-	1.80	-	-
T (degrees C)	37.00	37.00	37.00	37.00	37.00	78.20	37.00	37.00	37.00	37.00

FIG. 3

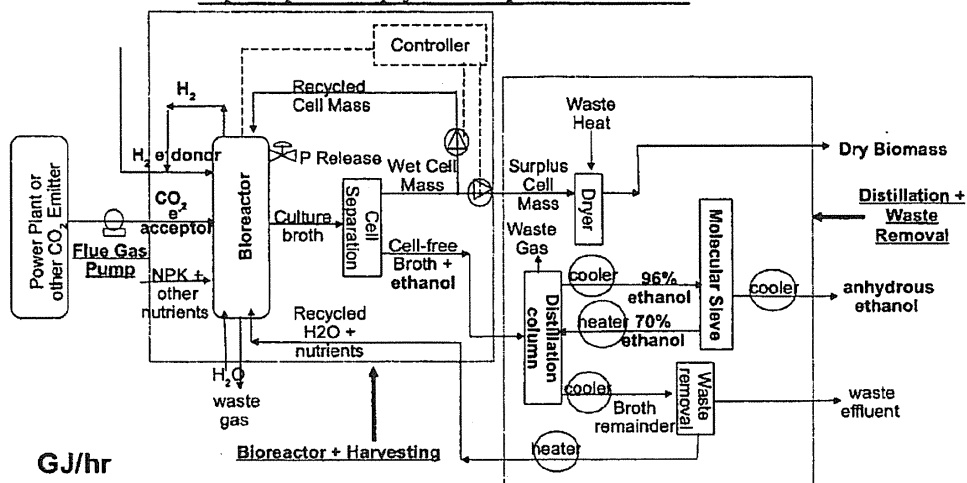


Line number	1	2	3	4	5	6	7
stream	CO ₂ feed	H ₂ new	nutrient feed	H ₂ O feed	waste gas	Cell-free	waste gas
CO ₂	0.80	-	-	-	1.13E-04	3.66E-03	1.65E-02
N ₂	2.32	-	-	-	0.22	-	-
H ₂	-	0.16	-	-	-	8.40E-05	3.74E-04
Nutrients	-	-	trace	-	-	trace	-
H ₂ O	-	-	-	trace	-	17.47	-
ethanol	-	-	-	-	-	0.10	-
acetic acid	-	-	-	-	-	trace	-
biomass	-	-	-	-	-	-	-
Q (heat)	-	-	-	-	-	-	-
T (degrees C)	150.00	37.00	37.00	37.00	37.00	37.00	78.20

Line number	8	9	10	11	A	B
stream	Dry	Anhydrous	Effluent	Recycle	Chemosynthesis	Distillation
CO ₂	-	-	-	-	-	-
N ₂	-	-	-	-	-	-
H ₂	-	-	-	-	-	-
Nutrients	-	-	trace	trace	-	-
H ₂ O	trace	trace	trace	17.26	-	-
ethanol	-	0.10	-	-	-	-
acetic acid	-	-	trace	trace	-	-
biomass	trace	-	-	-	-	-
Q (heat)	-	-	-	-	-29.97	42.94
T (degrees C)	37.00	37.00	37.00	37.00	37	78.2

FIG. 4

$$3\text{H}_2 + \text{CO}_2 \longrightarrow 1/2\text{C}_2\text{H}_5\text{OH} + 3/2\text{H}_2\text{O} \text{ (Energy Balance)}$$



Energy Input					
input point	Process Heat	Waste Heat	Chemical Energy	Electricity	Total energy
Flue Gas Pump	0	0	0	7	7
Bioreactor + harvesting	0	3	130	13	146
Distillation + waste removal	43	0	0	5	48
Total Input	43	3	130	25	201

Energy Output					
Output point	Process Heat	Waste Heat	Chemical Energy	Electricity	Total energy
Flue Gas Pump	0	7	0	0	7
Bioreactor + harvesting	0	43	103	0	147
Distillation + waste removal	0	48	0	0	48
Total Output	0	98	103	0	201

FIG. 5

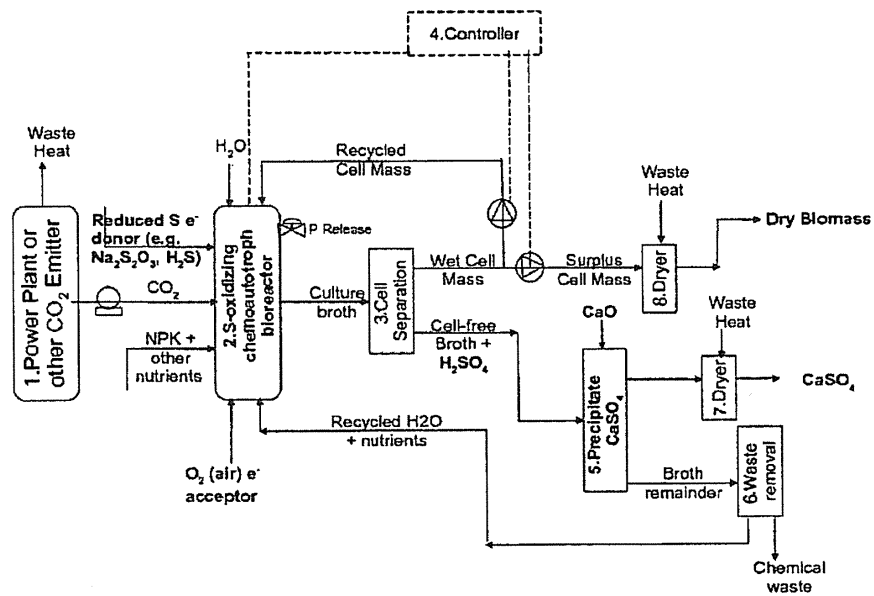
S-oxidizer

FIG. 6

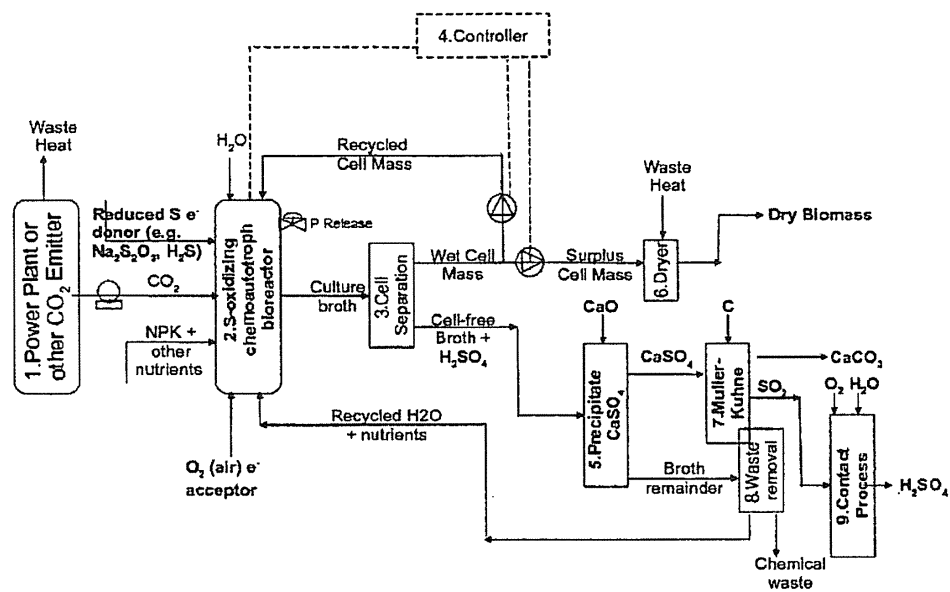
S-oxidizer

FIG. 7

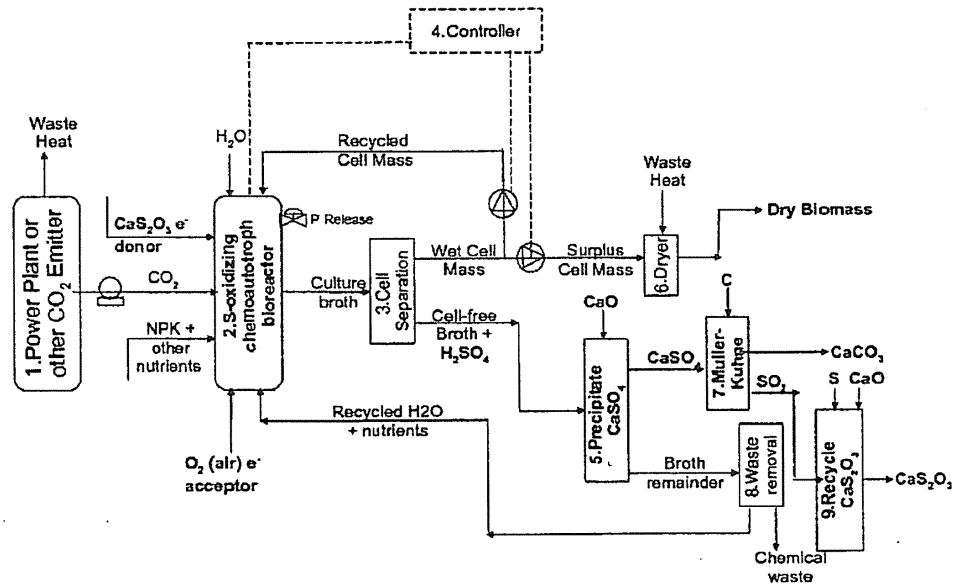
S-oxidizer

FIG. 8

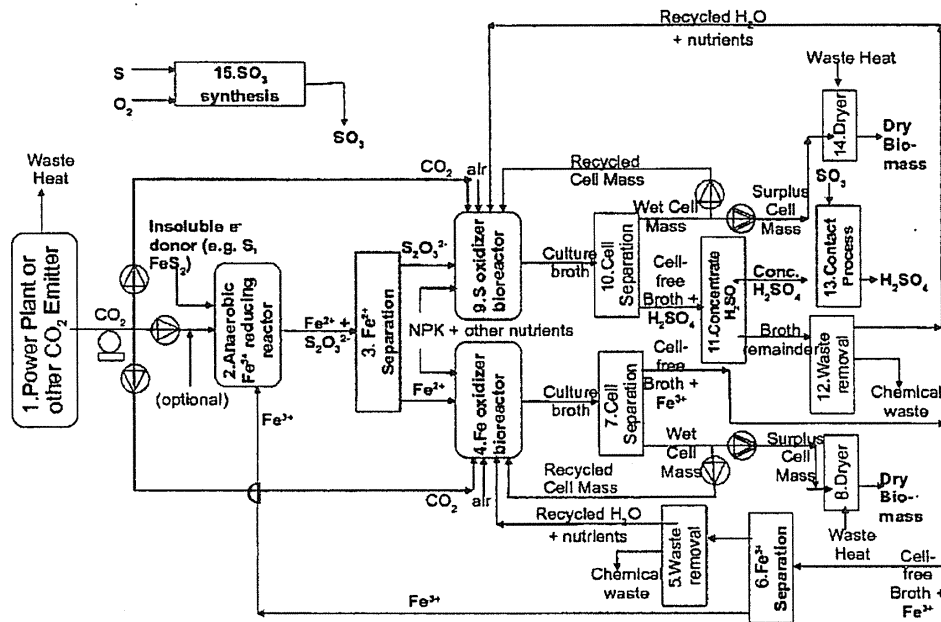
S and Fe-oxidizers

FIG. 9

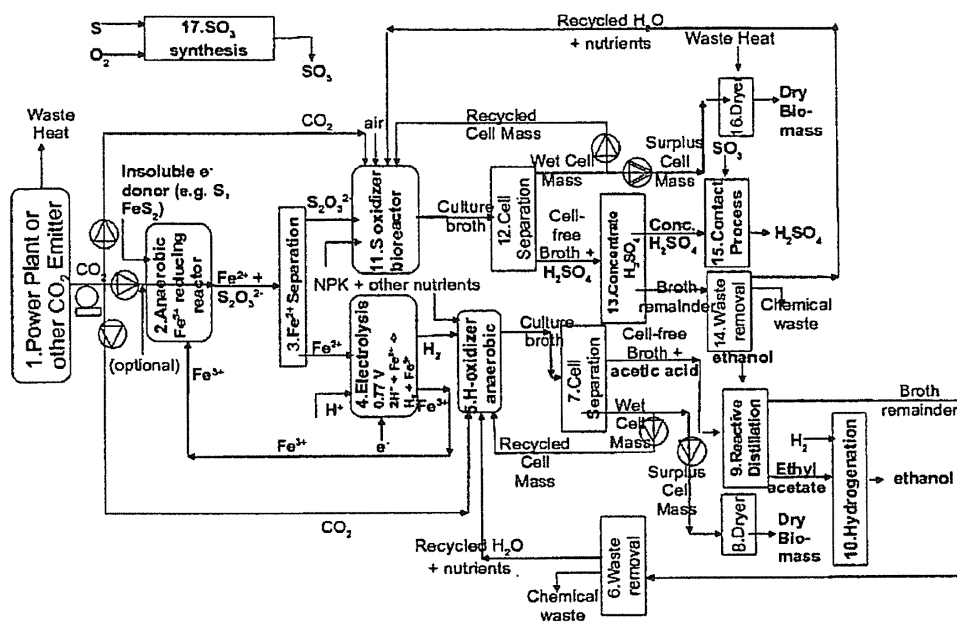
S and H-oxidizers

FIG. 10

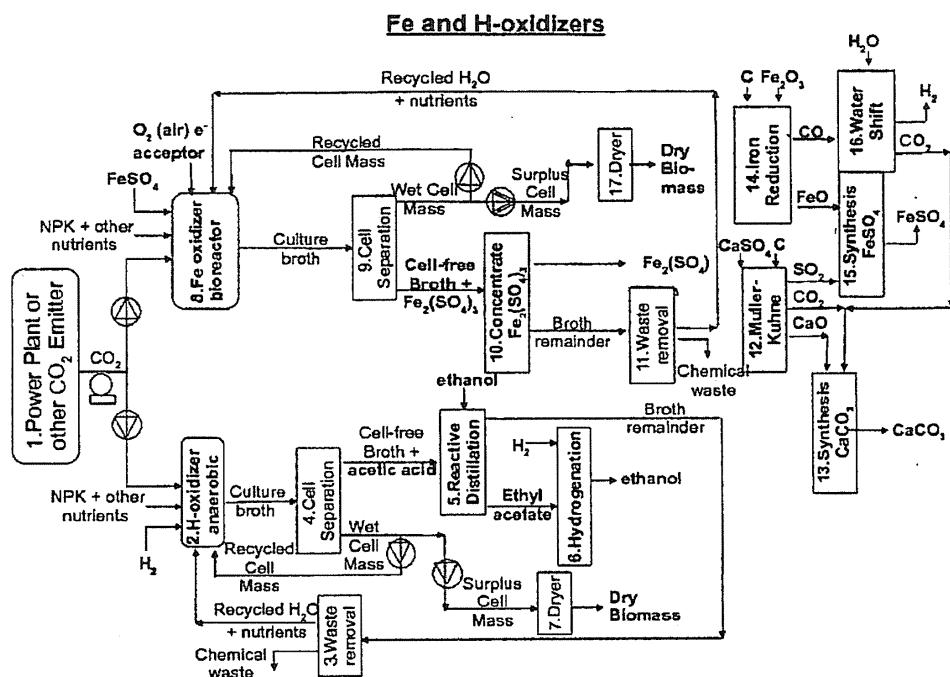


FIG. 11