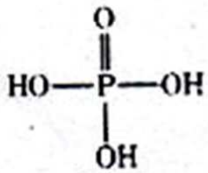
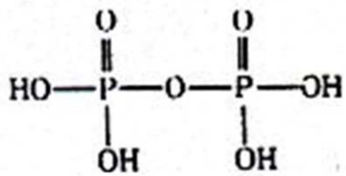
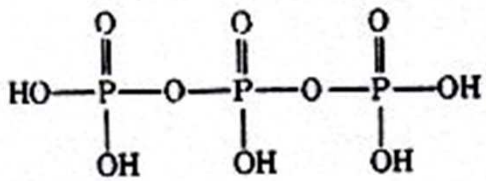
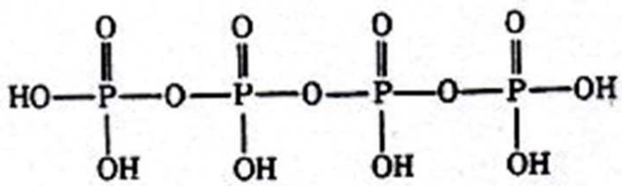
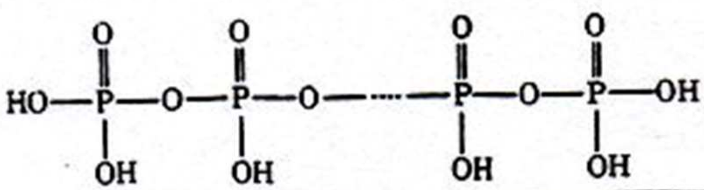
Phosphoric Acid

Table 6. The Linear Polyphosphoric Acids of General Formula $H_{n+2}P_nO_{3n+1}$[a]

Formula	Wt % P_2O_5	Structure	Prefix	Number of dissociated hydrogen atoms: Strong	Number of dissociated hydrogen atoms: Weak
H_3PO_4	72.42		mono- (ortho)	1	2
$H_4P_2O_7$	79.76		di- (pyro)	2	2
$H_5P_3O_{10}$	82.54		tri- (tripoly)	3	2
$H_6P_4O_{13}$	84.01		tetra-	4	2
$H_{n+2}P_nO_{3n+1}$			poly	n	2

Some Phosphoric acid uses

- Heavy duty alkaline cleaning products
- Laundry Detergents
- Emulsion polymerisation
- Textile auxiliaries
- Acid cleaners
- Metal working fluids
- Emulsifiers
- Wetting agents
- Dispersants
- Water based lubricants
- Intermediate for the synthesis of other anionic surfactants
- Coca cola

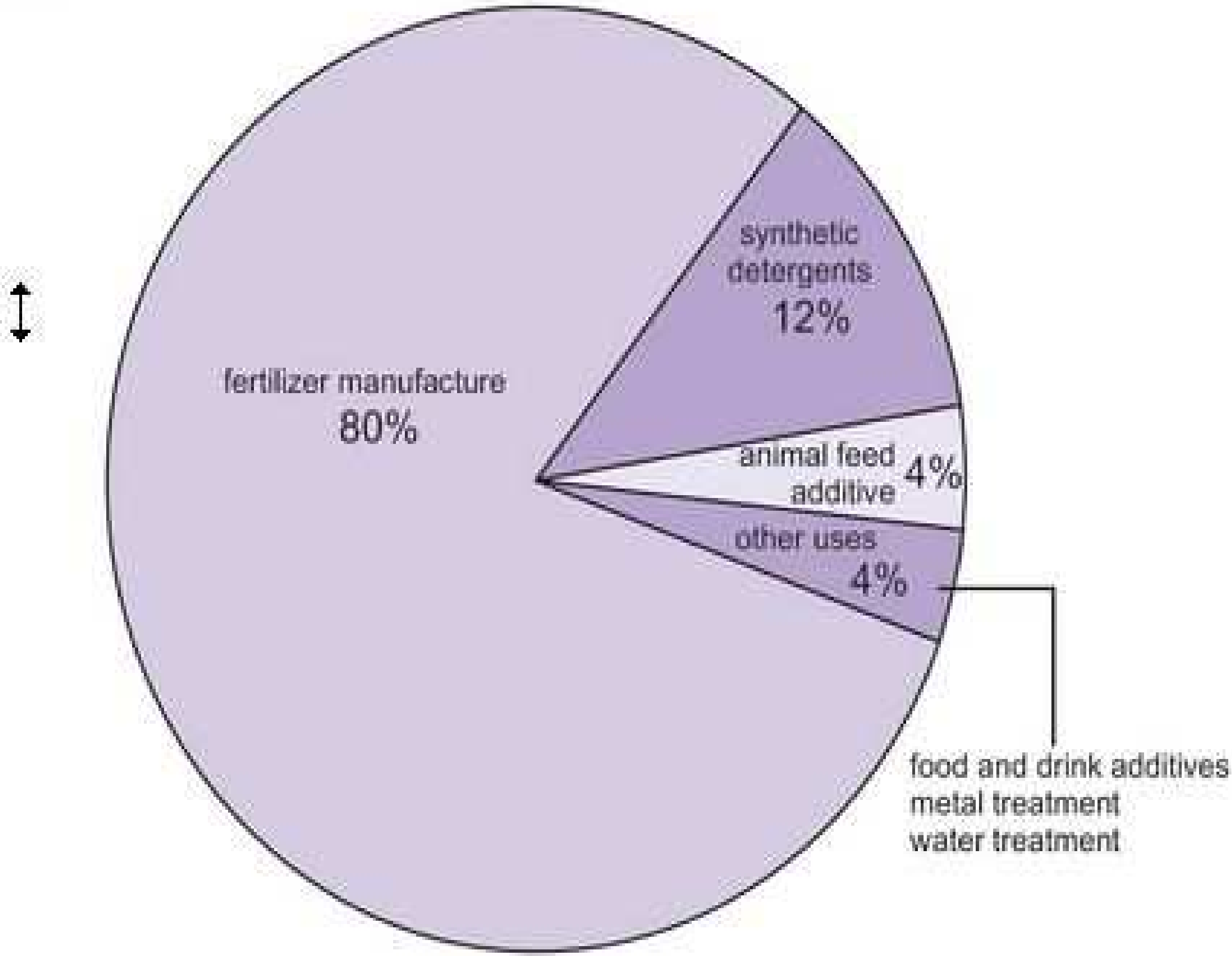
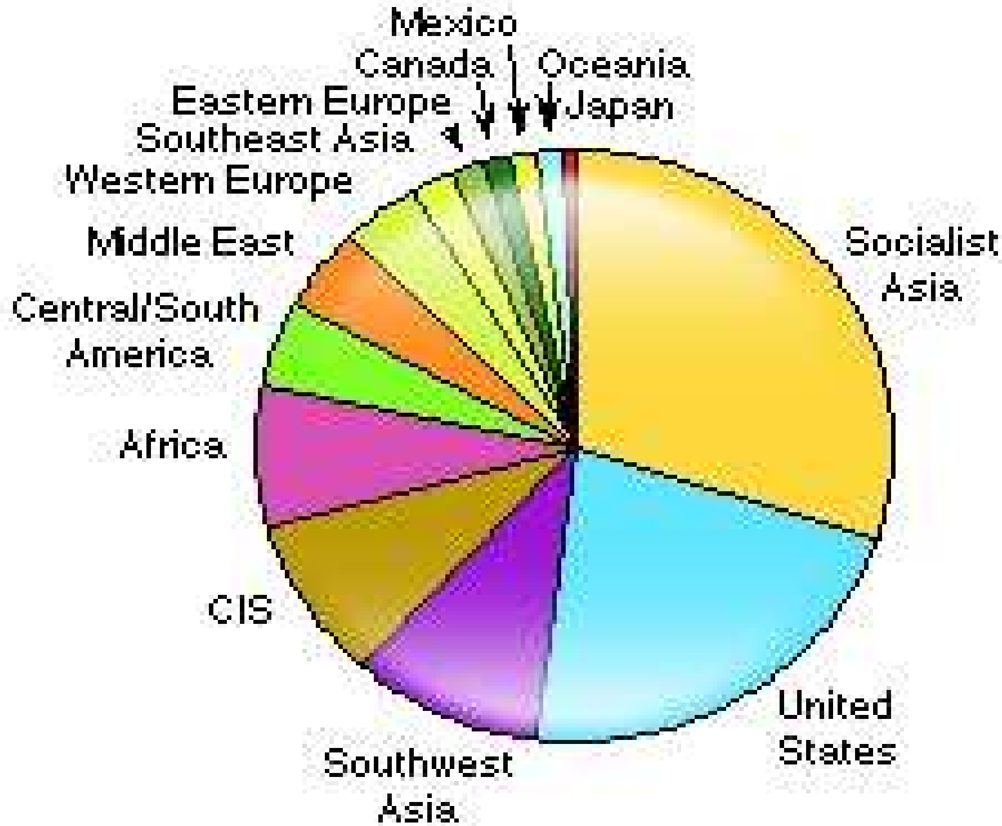


Figure 1 Uses of phosphoric acid.

World Consumption of Wet-Process Phosphoric Acid—2009



World Phosphoric Acid Supply/Demand

Source : IFA PIT Committee

Production of Phosphoric acid

Chemical Reaction:

$$Ca\ (PO_4)_2 + 3H_2SO_4 + H_2O \rightarrow 3CaSO_4 - 2H_2O + 2H_3PO_4$$

Phos Rock + Sulphuric Acid + Water → Gypsum (hydrated) + Phosphoric Acid

divided into three simplified steps.

1. The tricalcium phosphate constituent is converted to phosphoric acid and calcium sulfate.

$$Ca_3(FO_4)_2 + H_2SO_4 \rightarrow 2H_3PO_4 + 3CaSO_4 \qquad (1)$$

2. The calcium fluoride constituent of the fluorapatite reacts with sulfuric acid to produce hydrogen fluoride and calcium sulfate.

$$CaF_2 + H_2SO_4 \rightarrow 2HF + CaSO_4 \qquad (2)$$

3. The calcium carbonate constituent is converted to carbon dioxide and calcium sulfate.

$$CaCO_3 + H_2SO_4 \rightarrow CO_2 + CaSO_4 + H_2O \qquad (3)$$

The entire reaction between the major constituents and sulfuric acid is as follows:

$$Ca_{10}(PO_4)_6F_2 \cdot CaCO_3 + 11H_2SO_4 \rightarrow 6H_3PO_4 + 11CaSO_4 + 2HF + H_2O + CO_2 \qquad (4)$$

The hydrogen fluoride produced may react with silica to form silicon tetrafluoride, which then hydrolyzes to fluosilicic acid:

$$4HF + SiO_2 \rightarrow SiF_4 + 2H_2O \qquad (5)$$

$$3SiF_4 + 2H_2O \rightarrow 2H_2SiF_6 + SiO_2 \qquad (6)$$

The $CaSO_4$ formed in the reactions can be in three stages of hydration: anhydrite, hemihydrate (sometimes called semihydrate), or di-

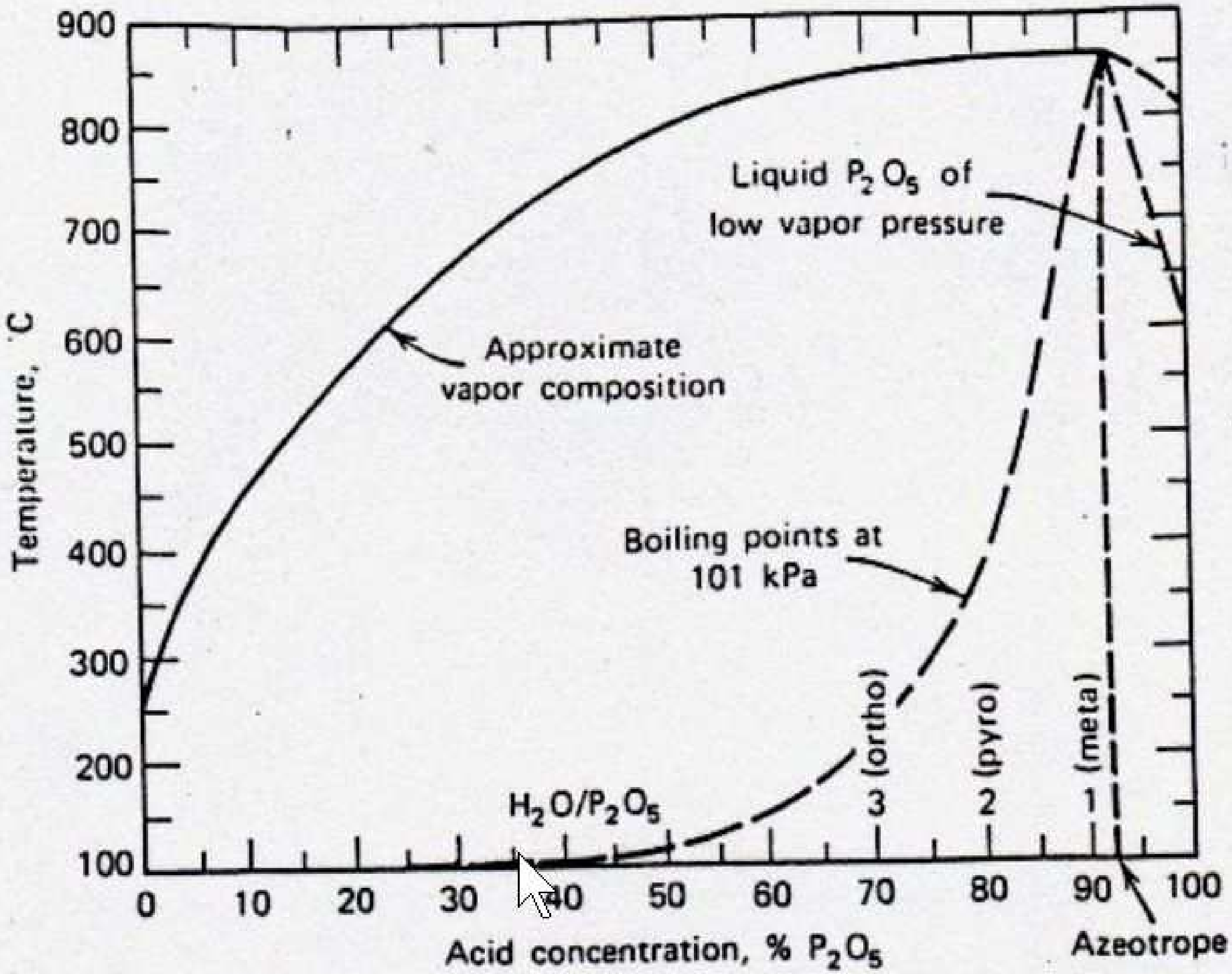
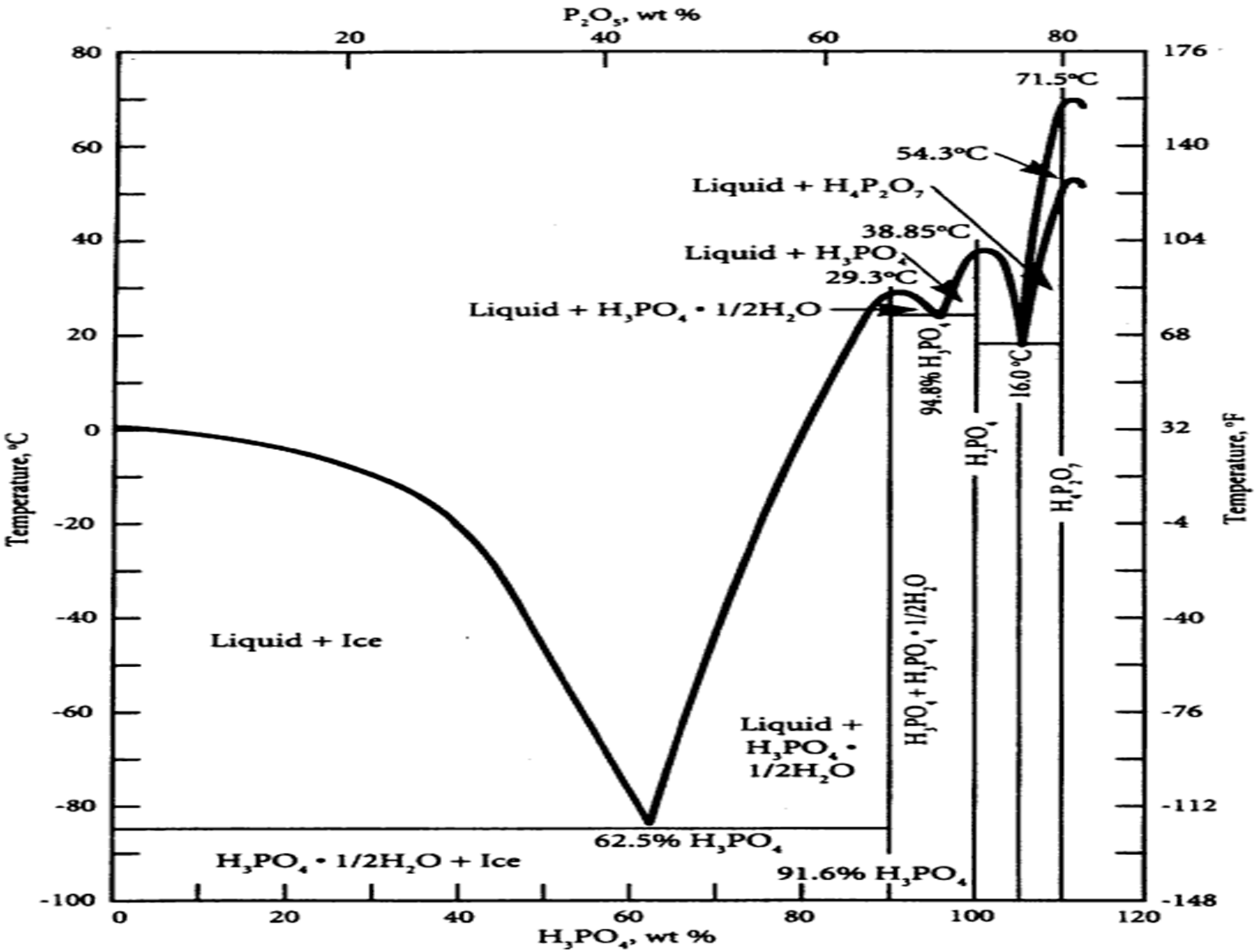


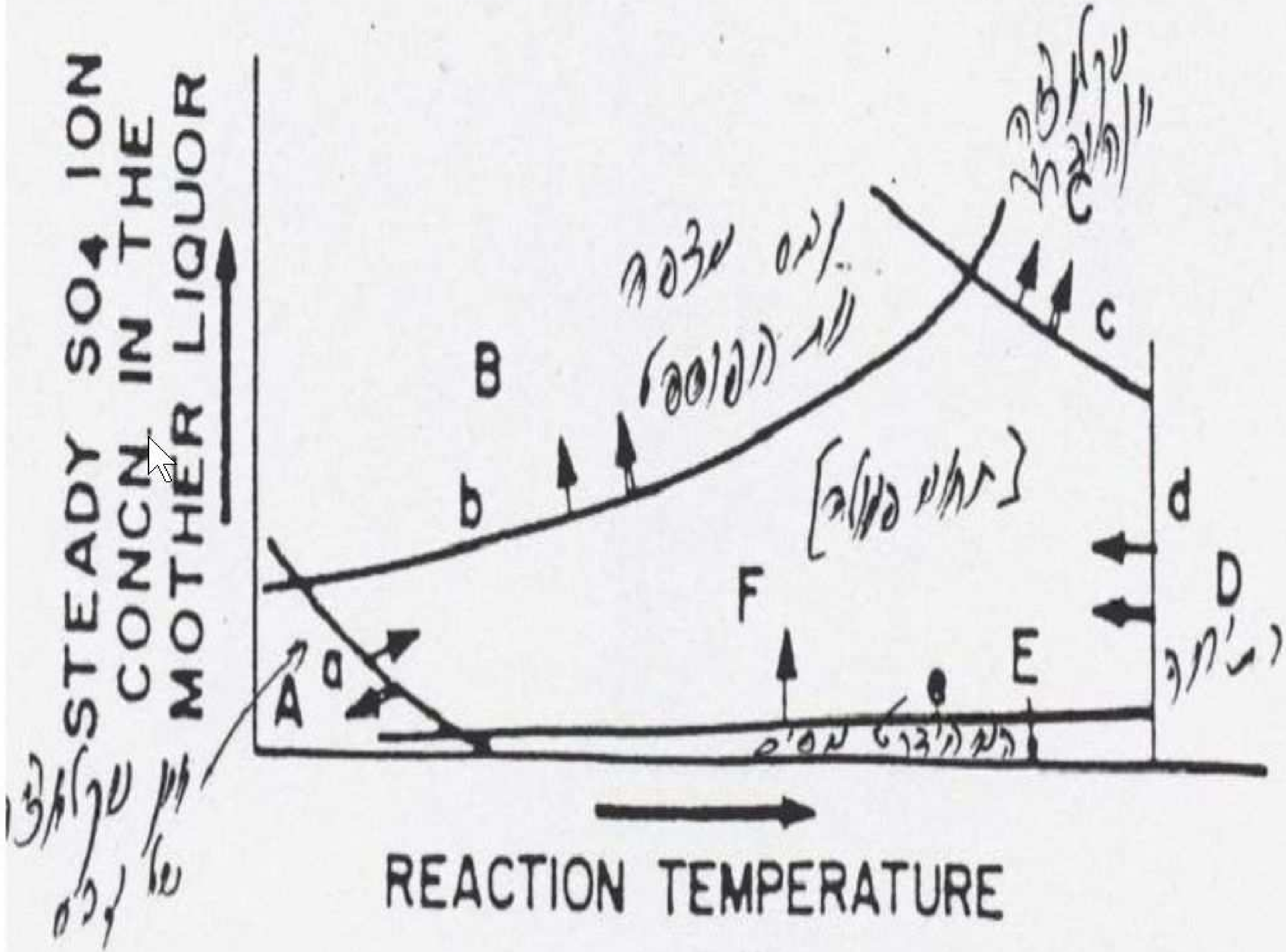
Figure 6. Temperature–composition diagram for system H_2O–P_2O_5 at 101 kPa (1 atm).

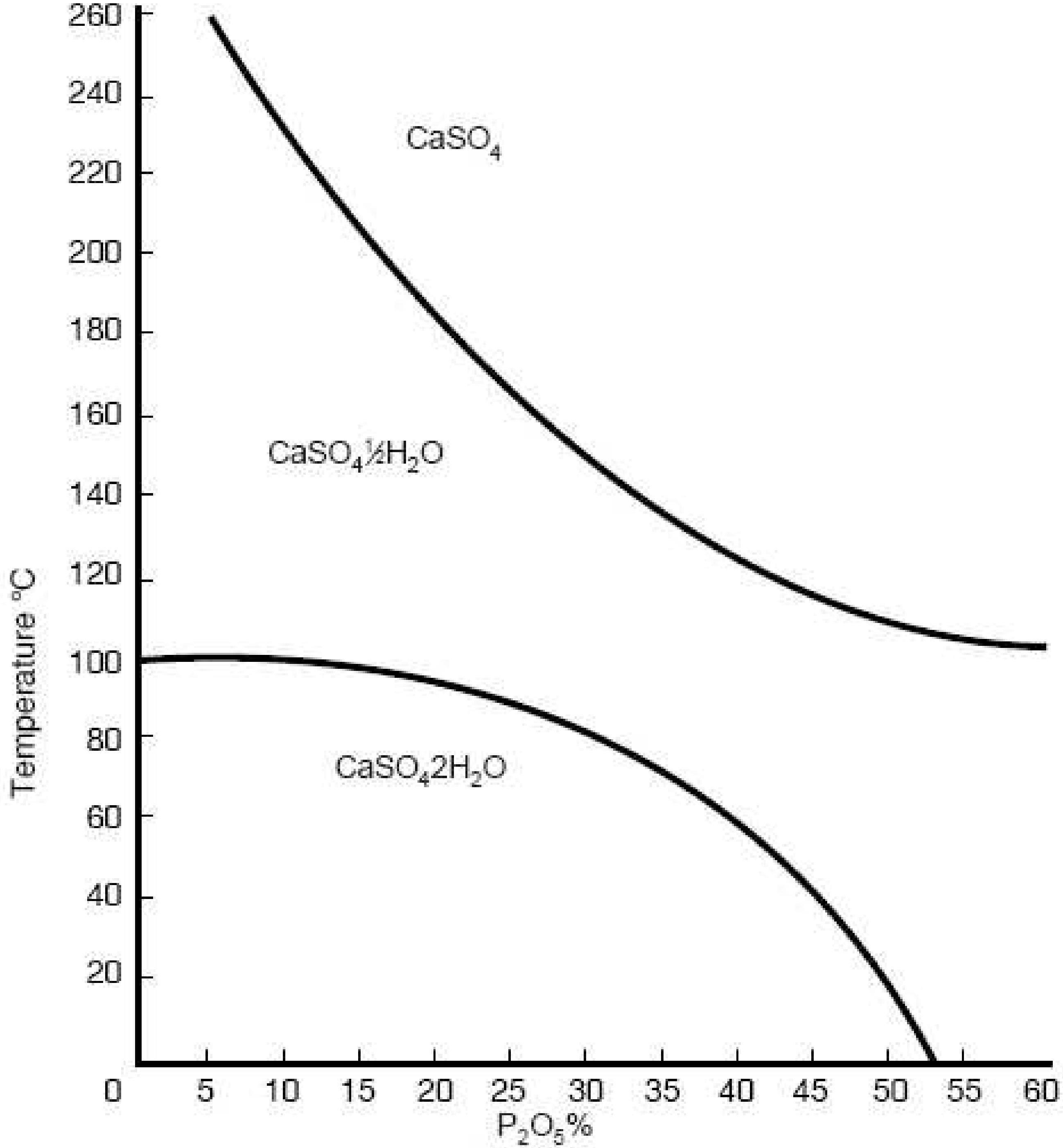
$$H_4P_2O_7 \rightleftharpoons H_3P_2O_7^- \rightleftharpoons H_2P_2O_7^{2-} \rightleftharpoons HP_2O_7^{3-} \rightleftharpoons P_2O_7^{4-} \quad (11)$$

$$K_1 \simeq 10^{-1} \qquad K_2 \simeq 1.5 \times 10^{-2} \qquad K_3 \simeq 2.7 \times 10^{-7} \qquad K_4 \simeq 2.4 \times 10^{-10}$$



P2O5, wt %
20
40
60
80
71.5°C
54.3°C
Liquid + H4P2O7
38.85°C
Liquid + H3PO4
29.3°C
Liquid + H3PO4 • 1/2H2O
94.8% H3PO4
16.0°C
H3PO4
H4P2O7
Liquid + Ice
Liquid + H3PO4 • 1/2H2O
H3PO4 + H3PO4 • 1/2H2O
62.5% H3PO4
H3PO4 • 1/2H2O + Ice
91.6% H3PO4
Temperature, °C
Temperature, °F
H3PO4, wt %
80
60
40
20
0
-20
-40
-60
-80
-100
176
140
104
68
32
-4
-40
-76
-112
-148
0
20
40
60
80
100
120


STEADY SO4 ION CONCN IN THE MOTHER LIQUOR
REACTION TEMPERATURE
A
a
B
b
C
c
D
d
E
e
F

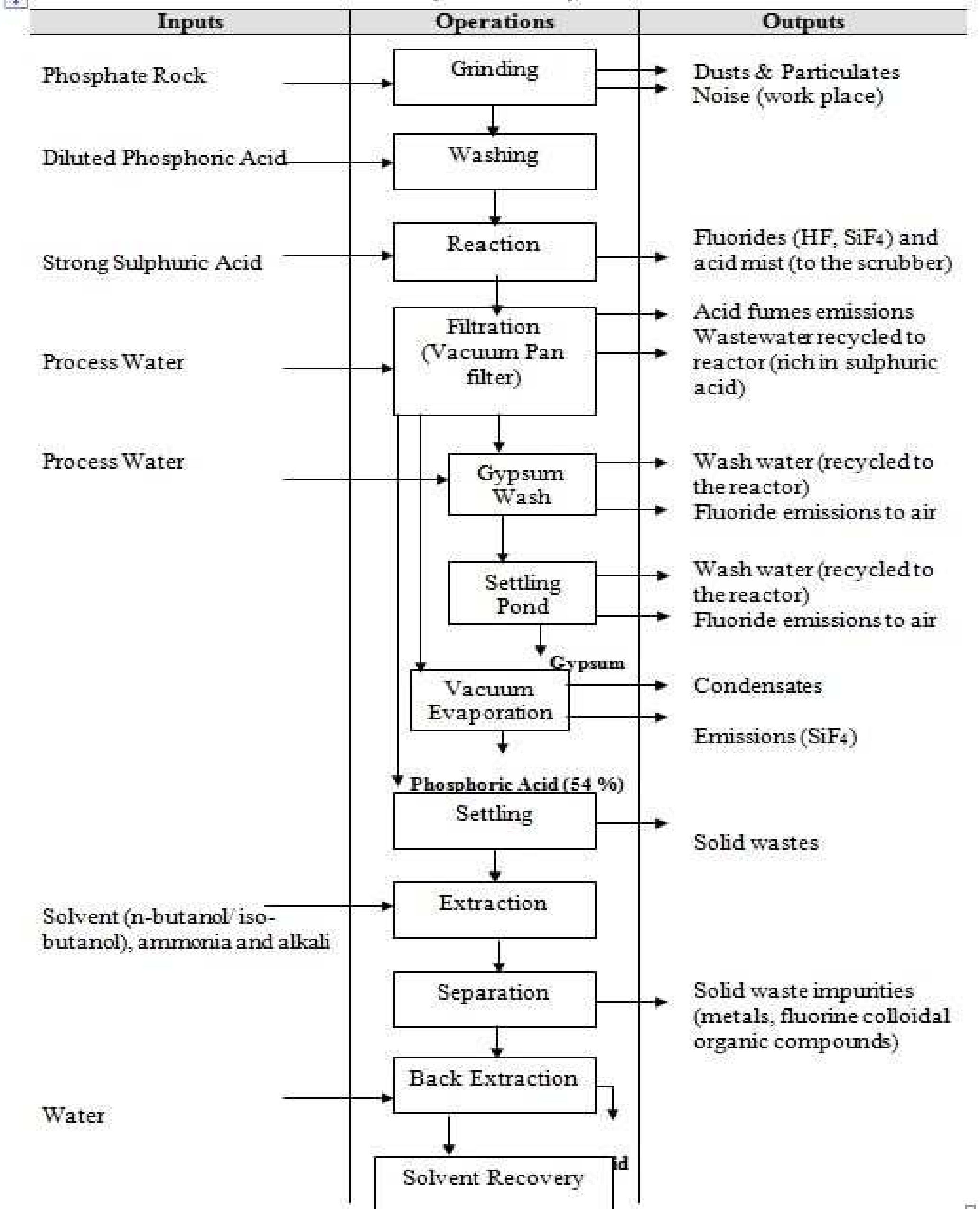


260
240
220
200
180
160
140
120
100
80
60
40
20
Temperature °C
CaSO4
CaSO4½H2O
CaSO42H2O
0
5
10
15
20
25
30
35
40
45
50
55
60
P2O5%

able 7. **Comparison of Wet-Acid Processes and Products**

ype of rocess	Principal developers	Operating temperature, °C: Extraction	Operating temperature, °C: Crystal conversion	Acid concentration, % P_2O_5	Acid impurity level vs dihydrate acid	Suitability of calcium sulfate for wallboard or cement	%
ihydrate	Prayon, Dorr and others[a]	71–85	none	28–32		no	95
emihydrate	Fisons	91–99	none	45–50	ca same	no	91–94
nhydrite	Nordengren Central Glass of Japan	102–238	none	40–50	lower	no	91
ihydrate–hemihydrate	Société de Prayon Nissan, NKK Mitsubishi, Fisons, Singmaster	62–68	93–99	33–38	higher	yes	97
emihydrate–dihydrate	Breyer/Heurty, Dorr HYS[c]	91–99	60–19	30–35[b] 40–50[d]	depends on process variation can be lower	yes	96–98

Fig (5) Process Flow Diagram for Phosphoric Acid Manufacturing (Wet Process)



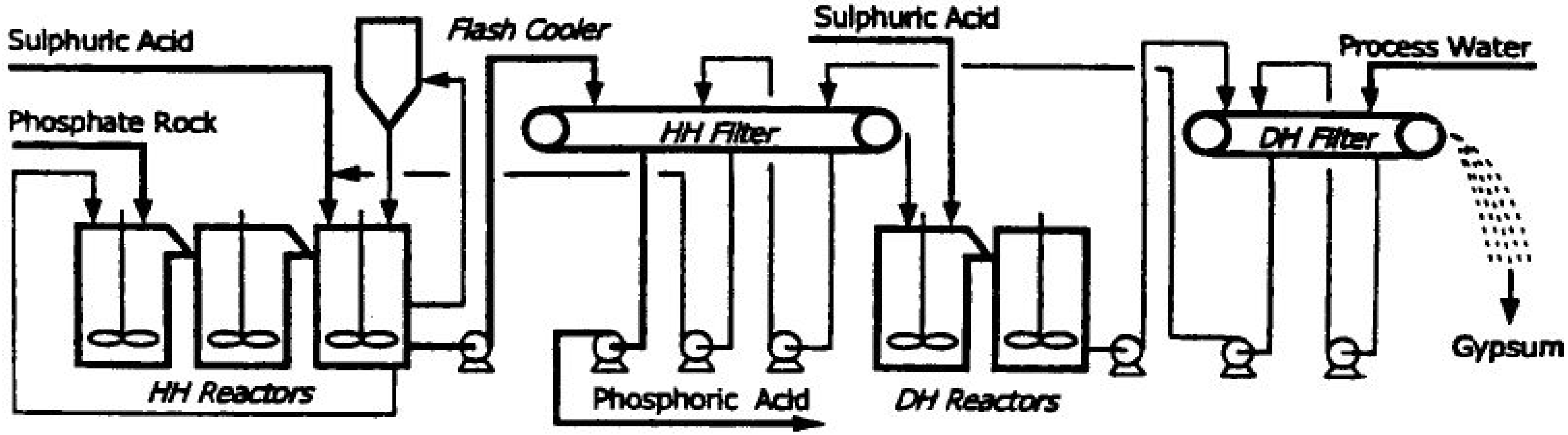


Fig. 23.12. Hydro fertilizer technology hemihydrate process.

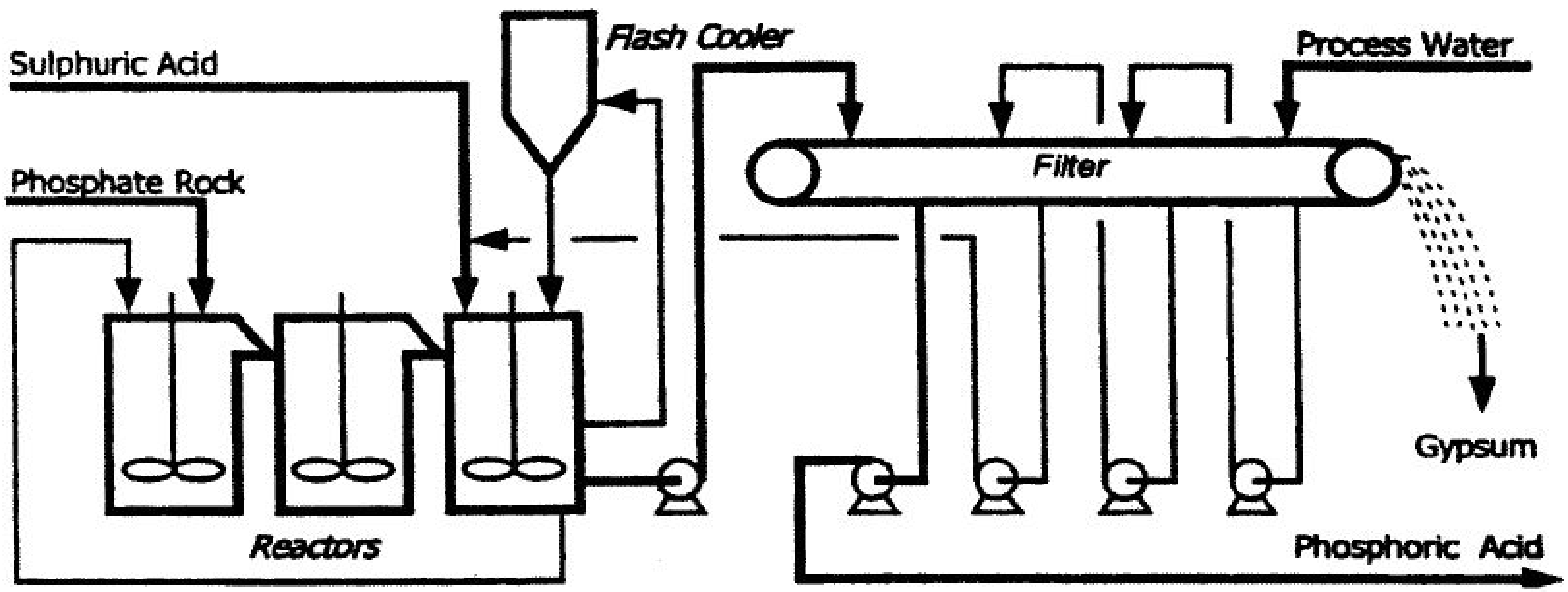


Fig. 23.13. Hydro fertilizer technology hemihydrate process.

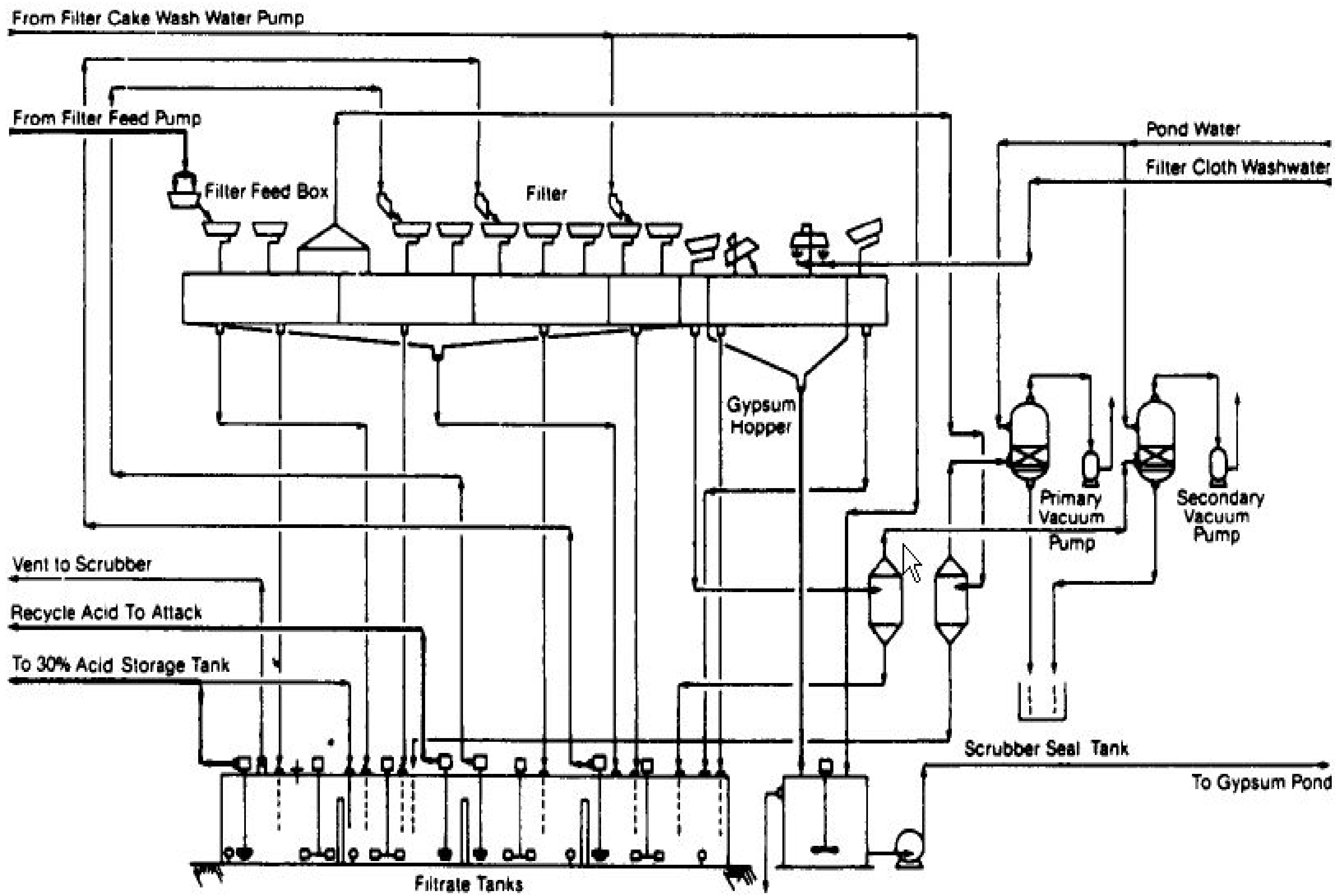


Fig. 23.14. Flow diagram of filtration section of a wet process phosphoric acid plant. *(Prayon process, courtesy Davy Mckee Corp.)*

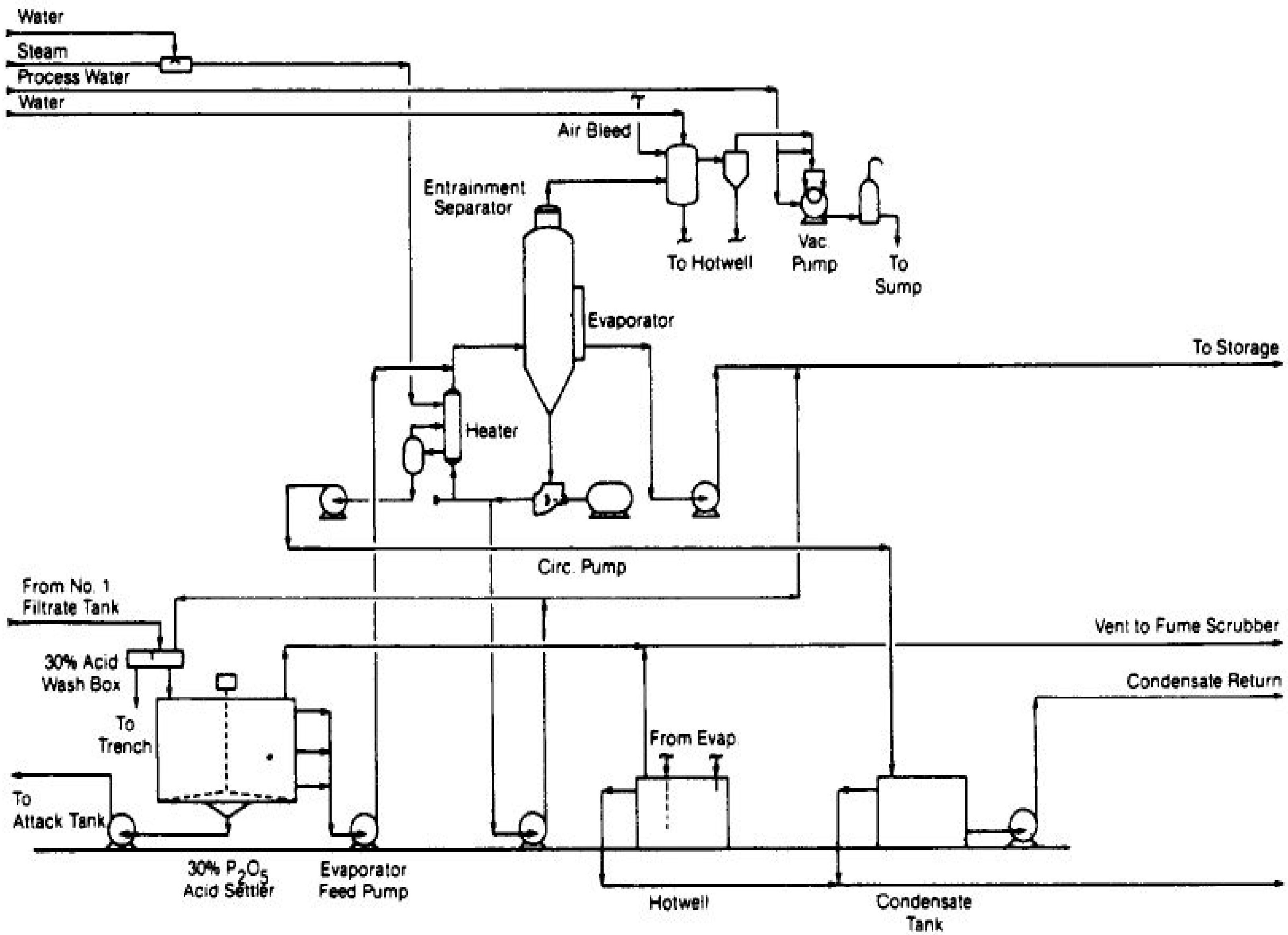


Fig. 23.15. Flow diagram of evaporation section of a wet process phosphoric acid plant. *(Courtesy Davy Mckee Corp.)*

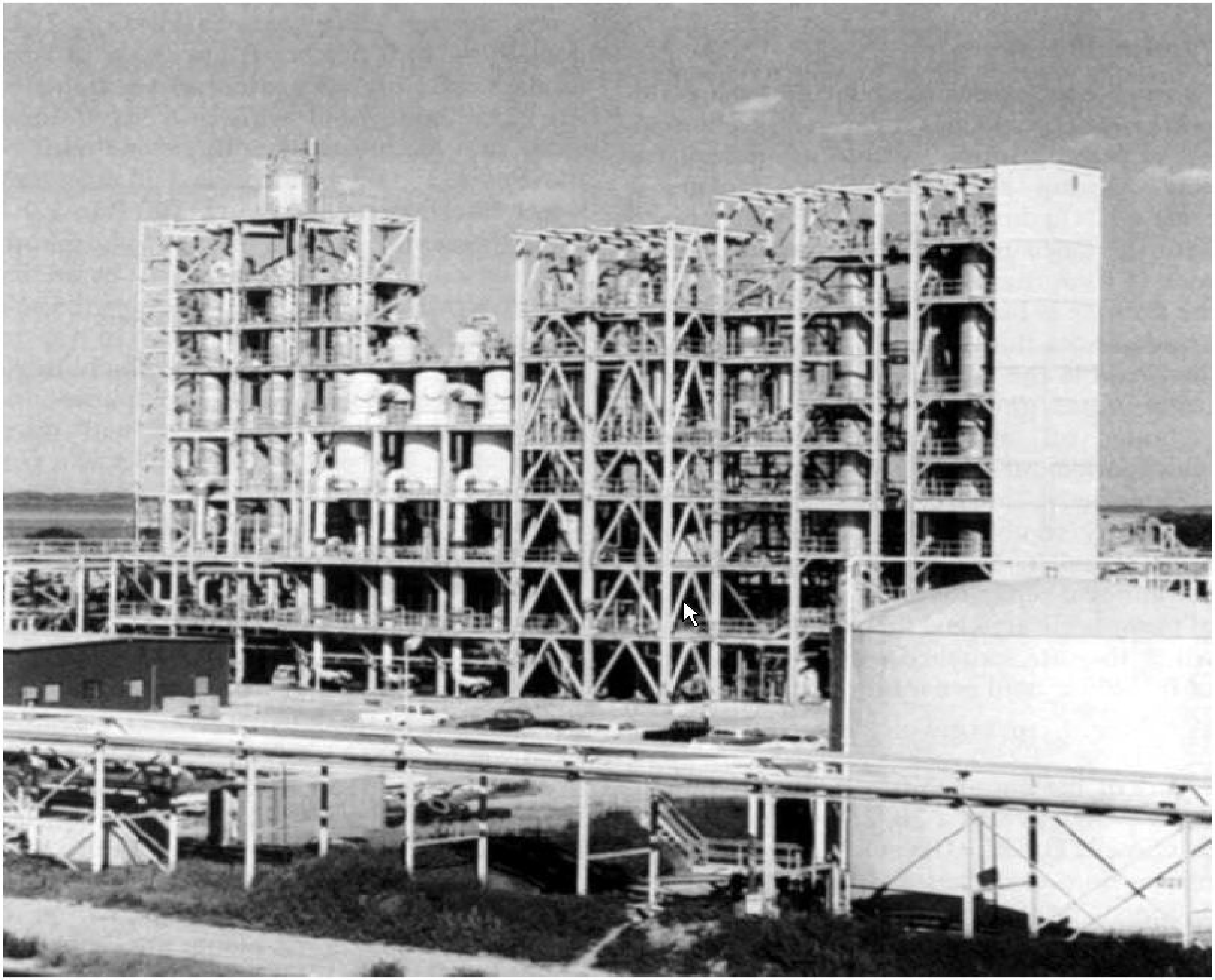


Fig. 23.16. Purified phosphoric acid plant for P.A. Partnership, Aurora, NC. (*Courtesy P.A. Partnership and Jacobs Engineering.*)

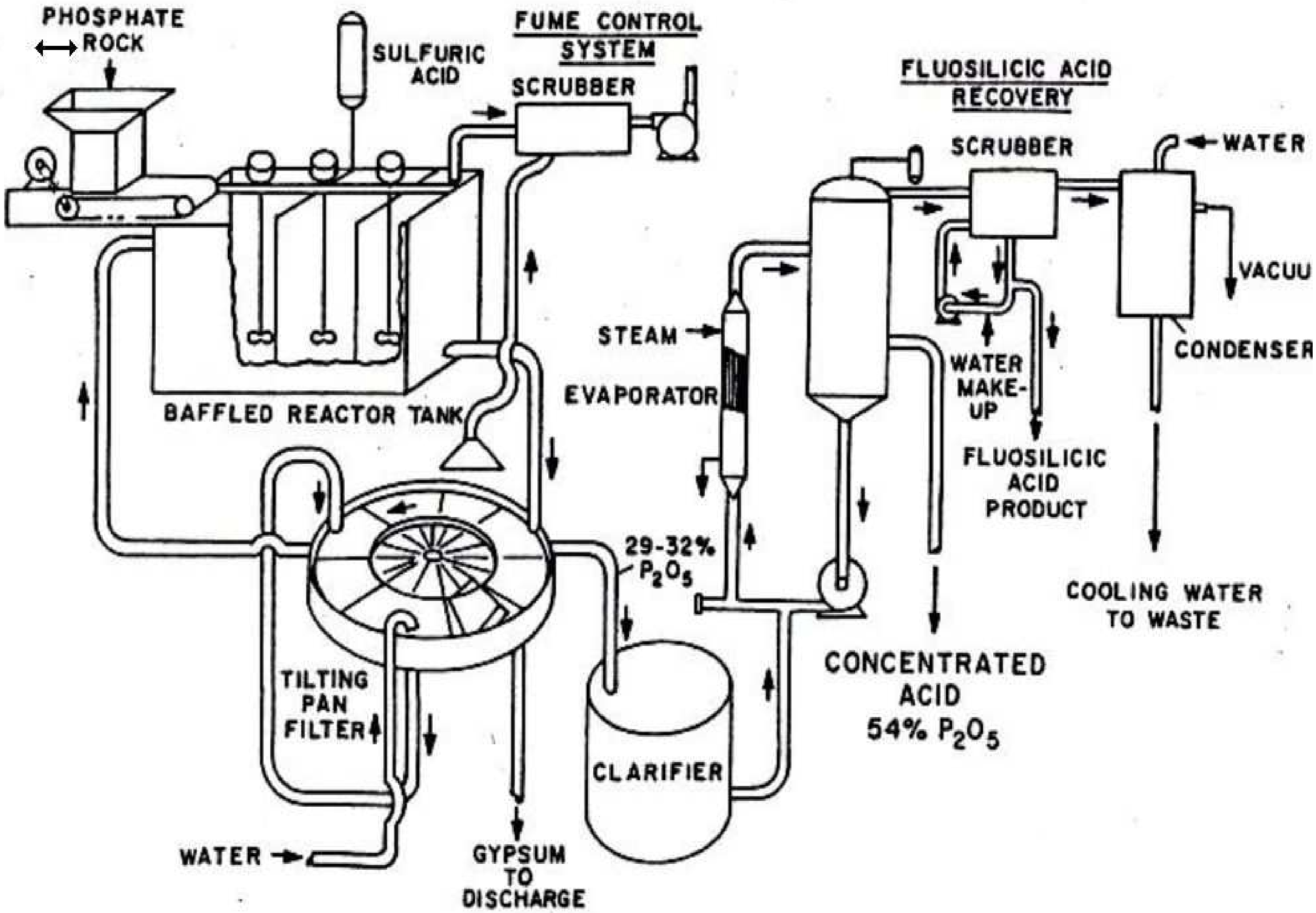


FIG. 3. Flow diagram for typical wet-process phosphoric acid plant.

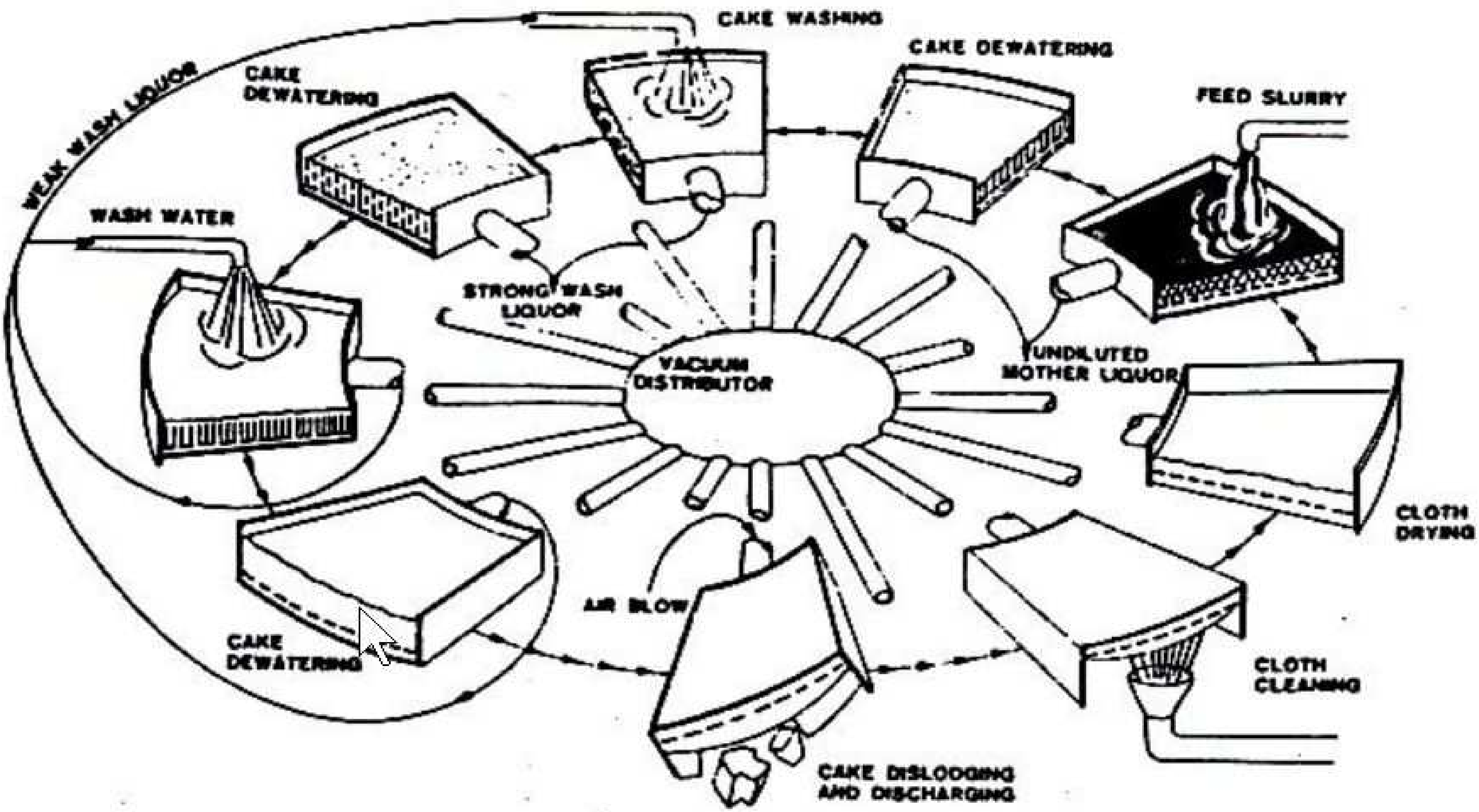
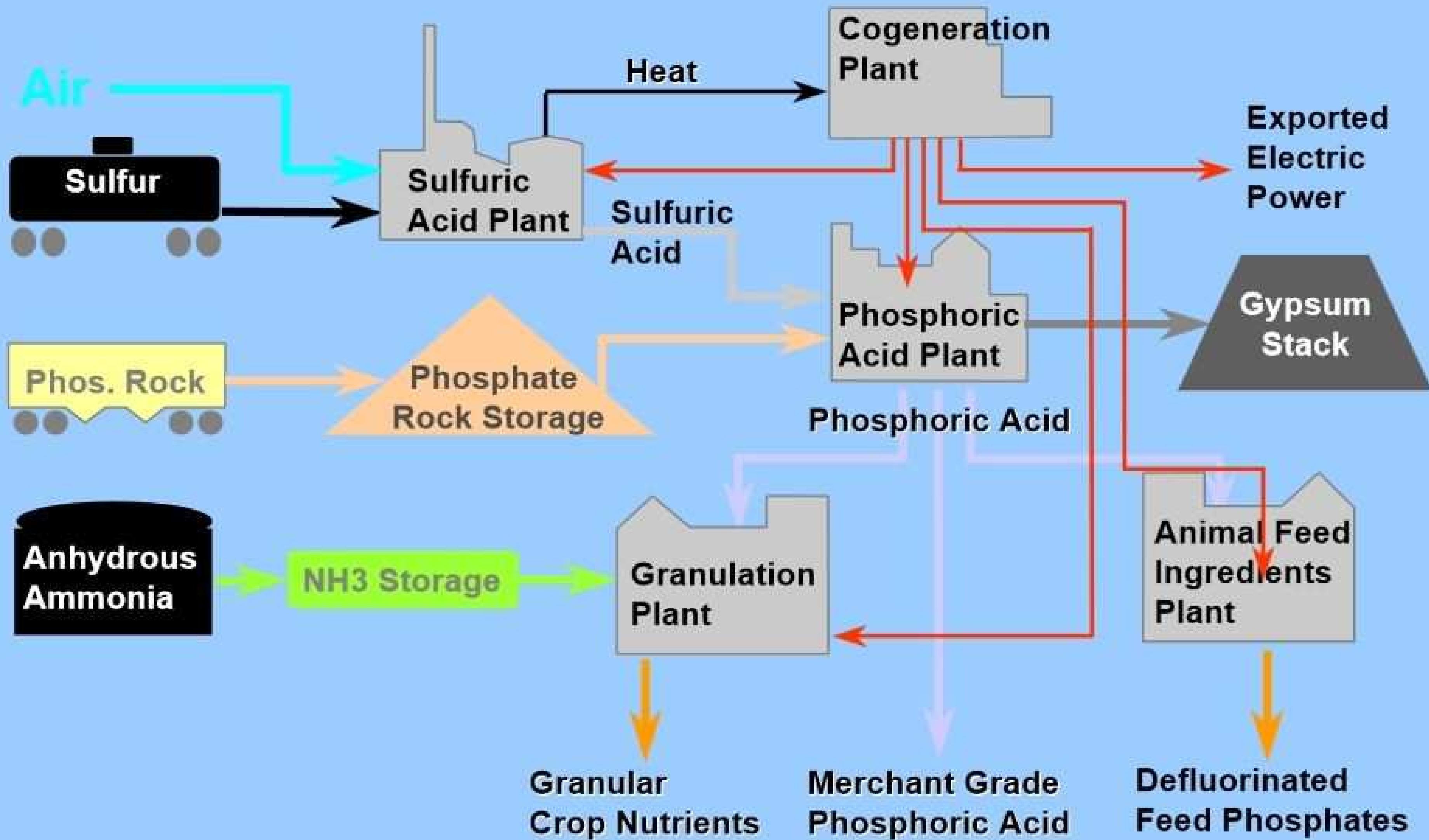


FIGURE 5. Operation of the Bird-Prayon Tilting-pan Vacuum Filter

Processing Plant Flowsheet



Sulfuric acid process

Step 1 - Production of sulfur dioxide

$S + O_2 \rightarrow SO_2$ $\Delta H = -300$ kJ mol

Step 2 - Conversion to sulfur trioxide

$SO_2 + 1/2 O_2 \rightarrow SO_3$ $\Delta H = -100$ kJ mol

Step 3 - Absorption of $SO_3$to form sulfuric acid

$SO_3 + H_2O \rightarrow H_2SO_4$ $\Delta H = -200$ kJ mol

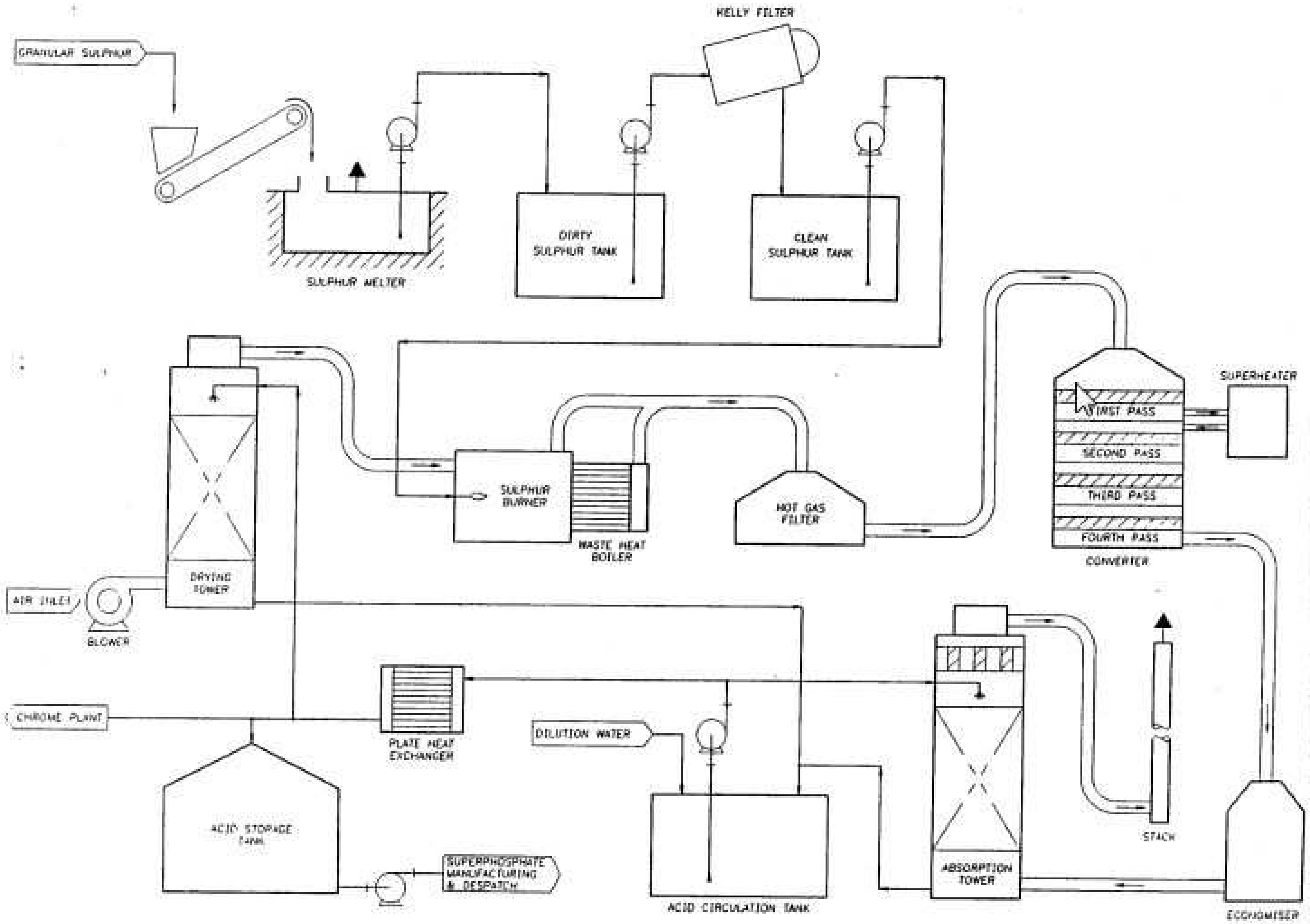


Figure 2 - Process flow diagram of the sulfuric acid plant

Superphosphates

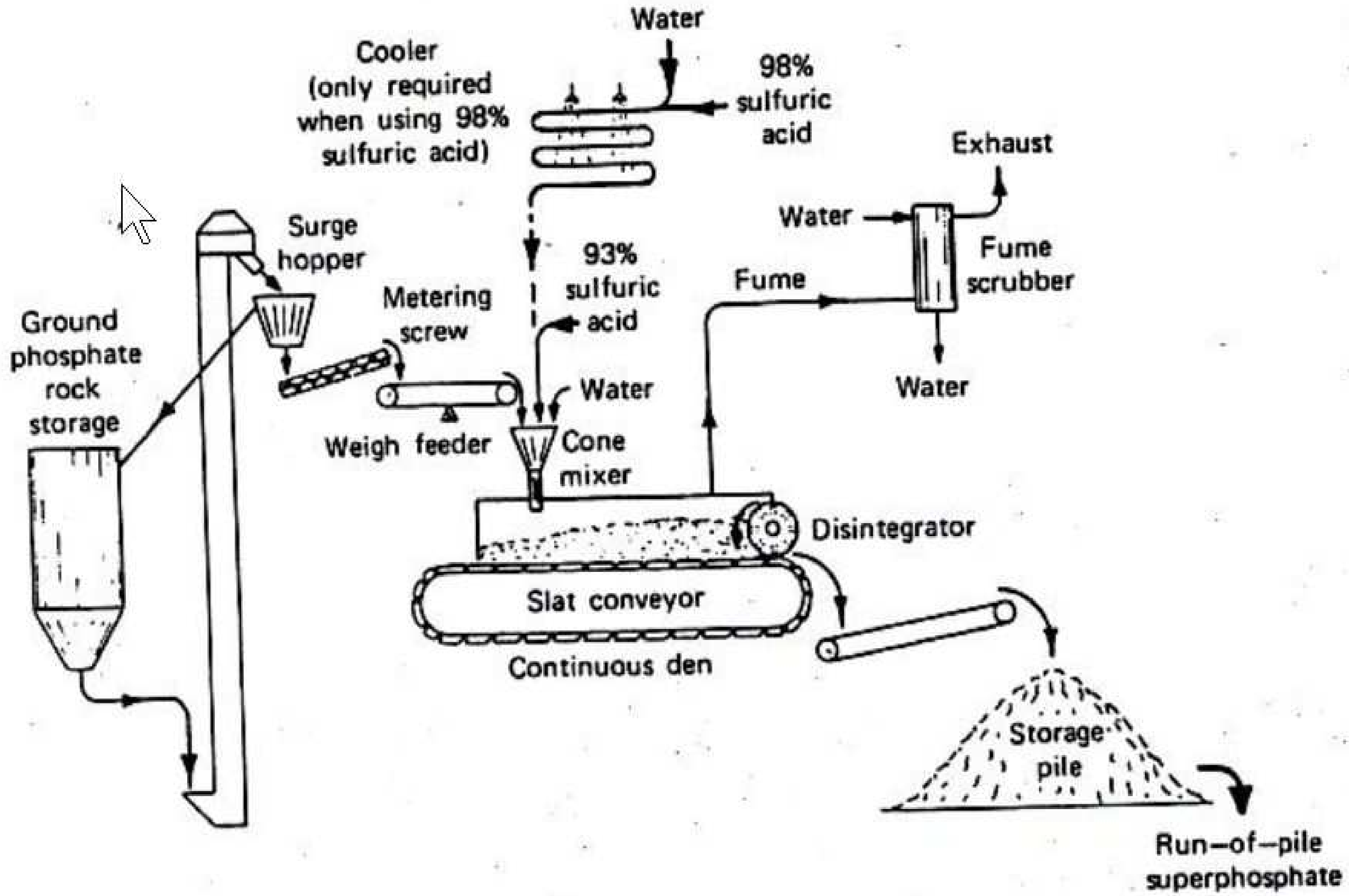


Figure 8. Continuous process for manufacture of normal superphosphate. Courtesy of TVA.

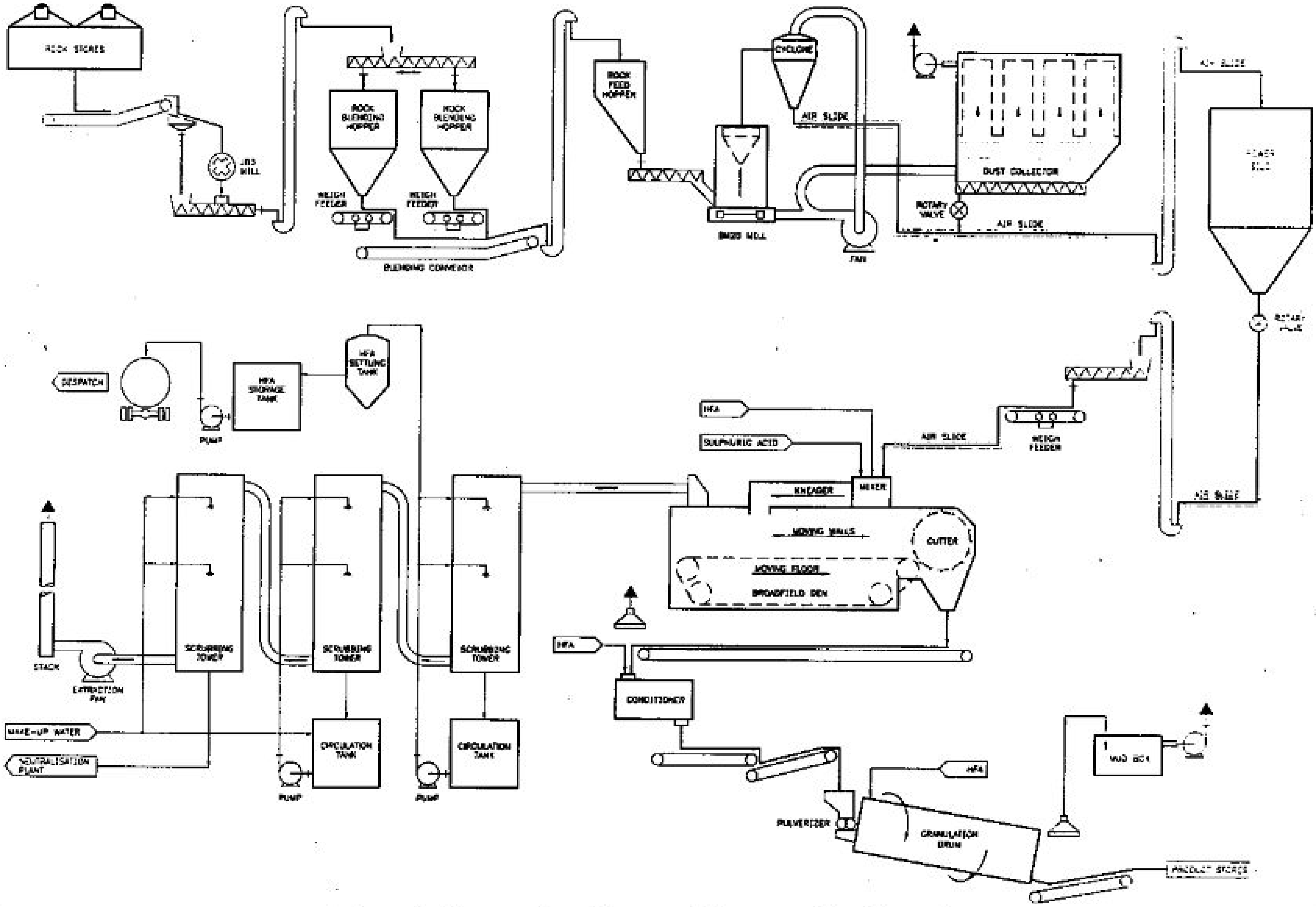
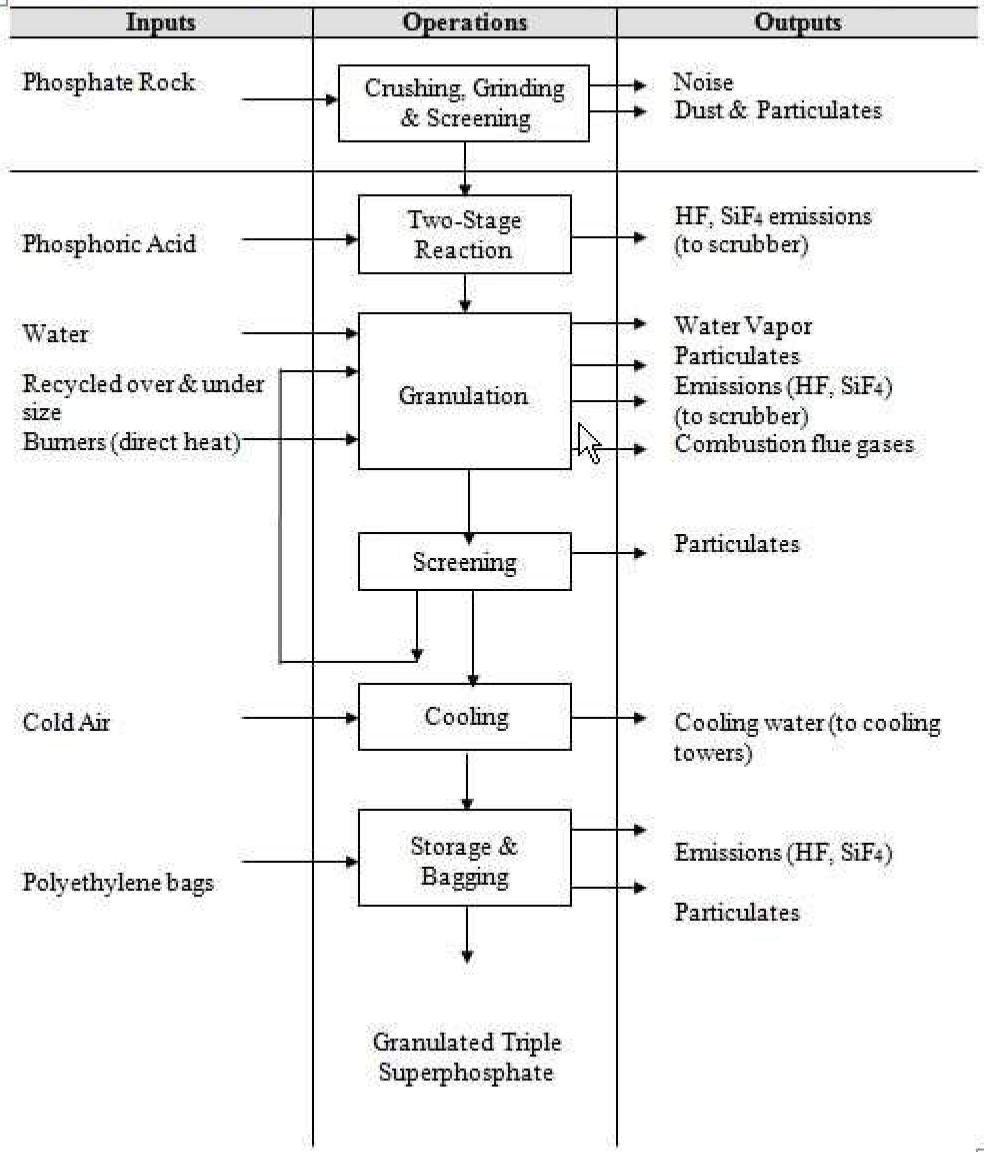


Figure 4 - Process flow diagram of the superphosphate plant

Fig (4) Process Flow Diagram for Triple Superphosphate Manufacturing



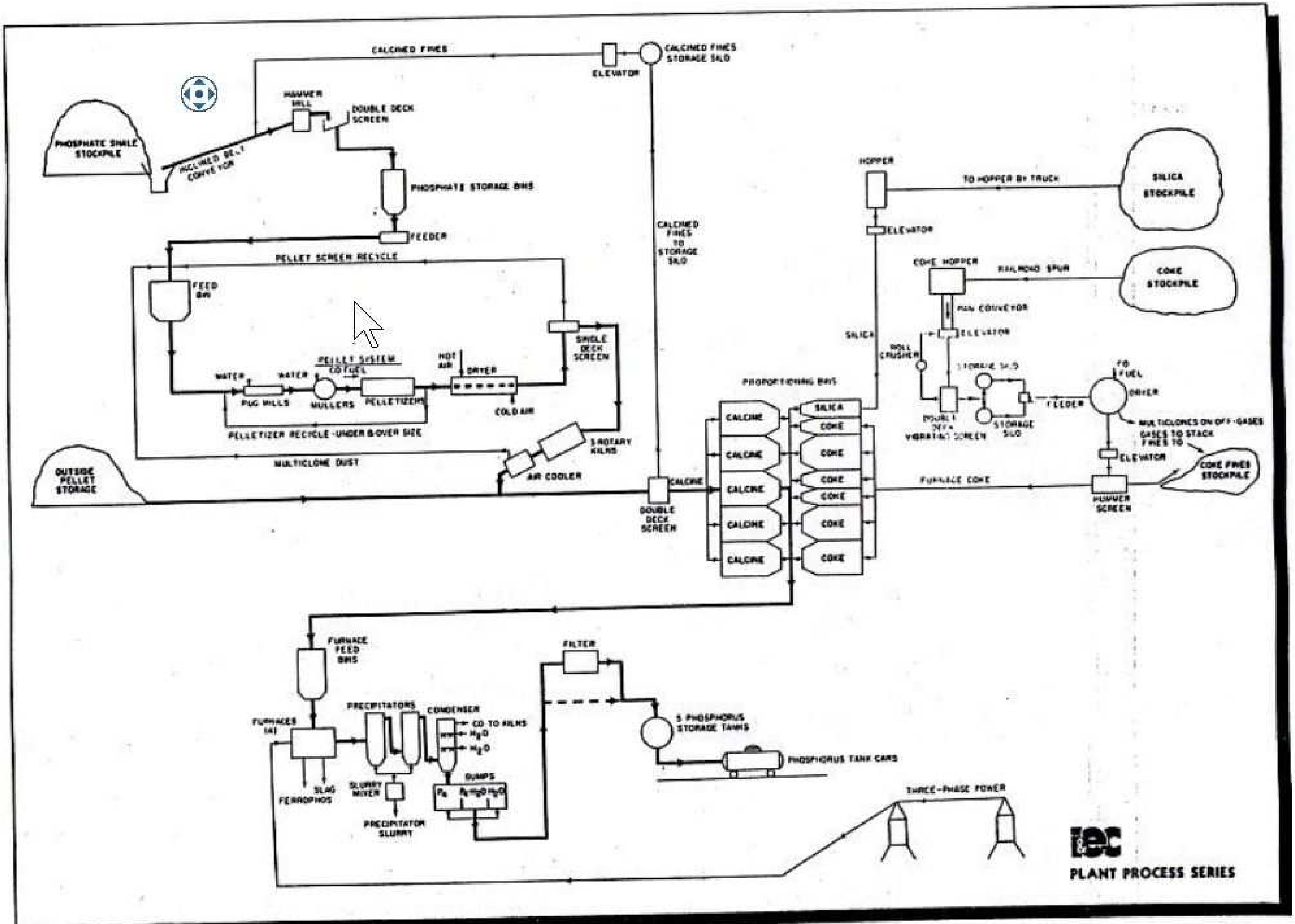
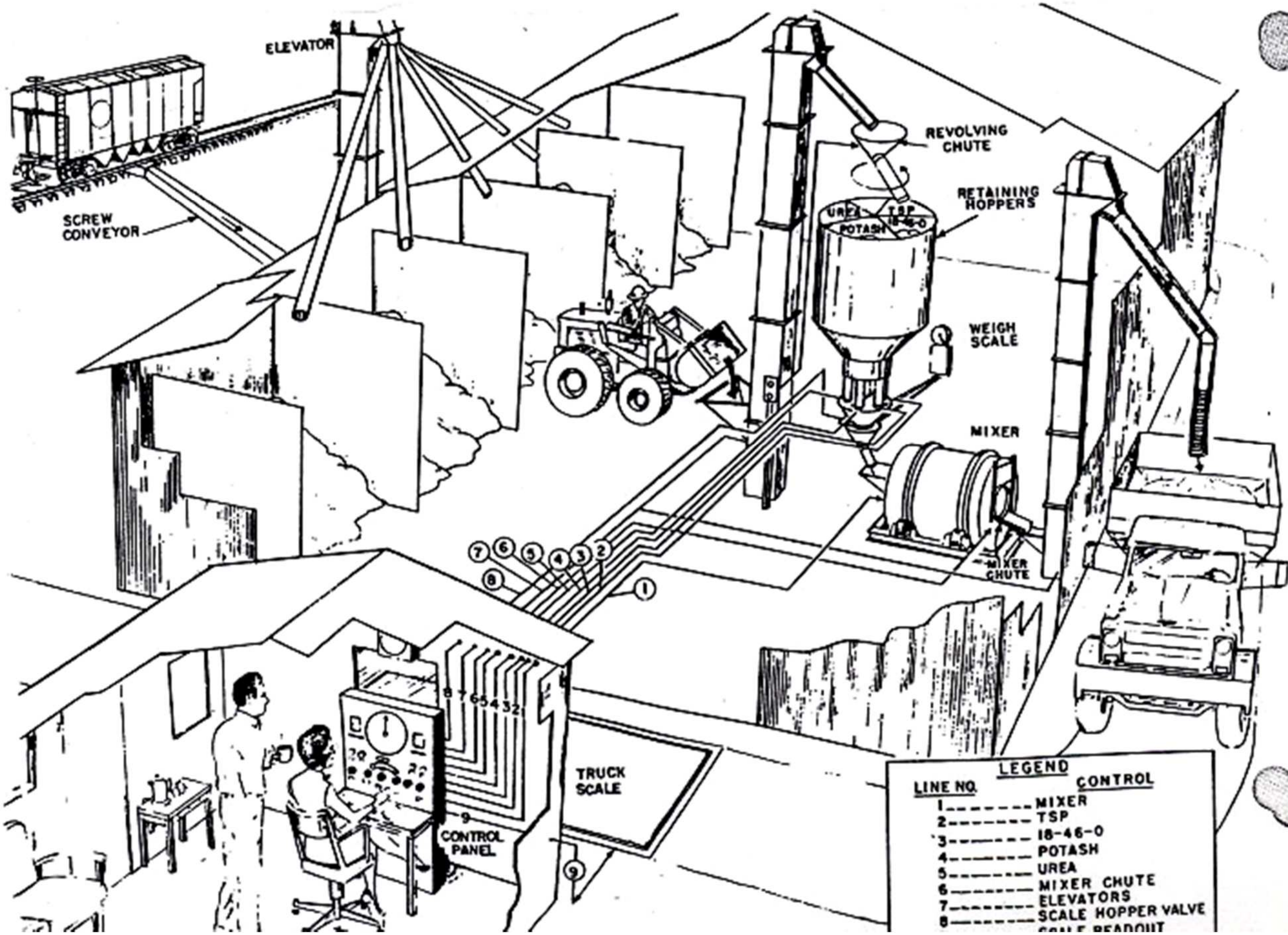


Figure 1. Flow sheet for production of elemental phosphorus by electric furnace by Westvaco Mineral Product Division, Food Machinery & Chemical Corp.

FIG. 5. Suspension fertilizer system using solid feeds.



Phosphoric acid derivatives

- MCP – Mono calcium phosphate
- DCP – Di calcium phosphate
- MAP – Mono ammonium phophate
- DAP- Di ammonium phosphate
- Sodium polyphosphates

Figure 2 – World Uranium Mined Production in 2006[3]

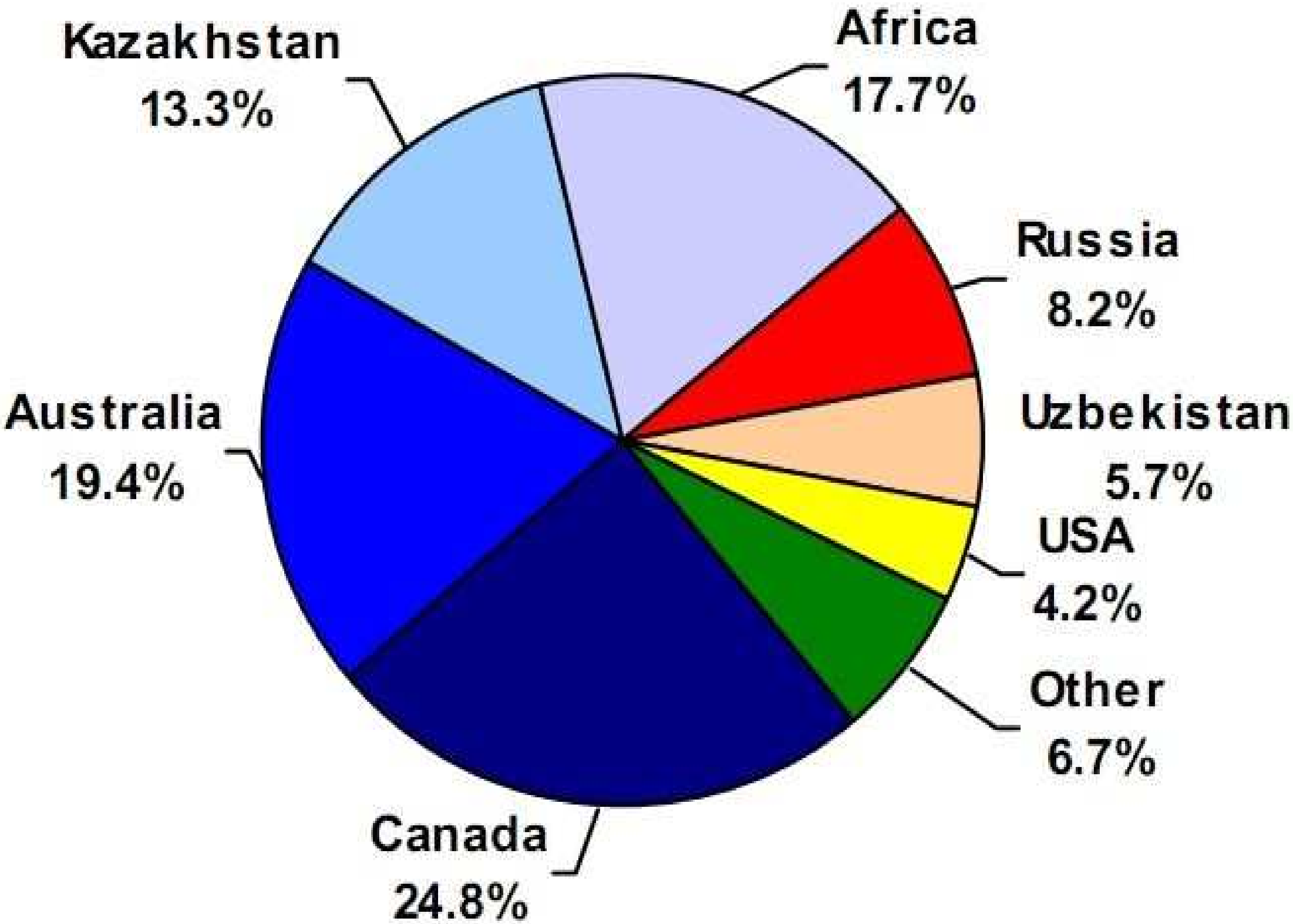
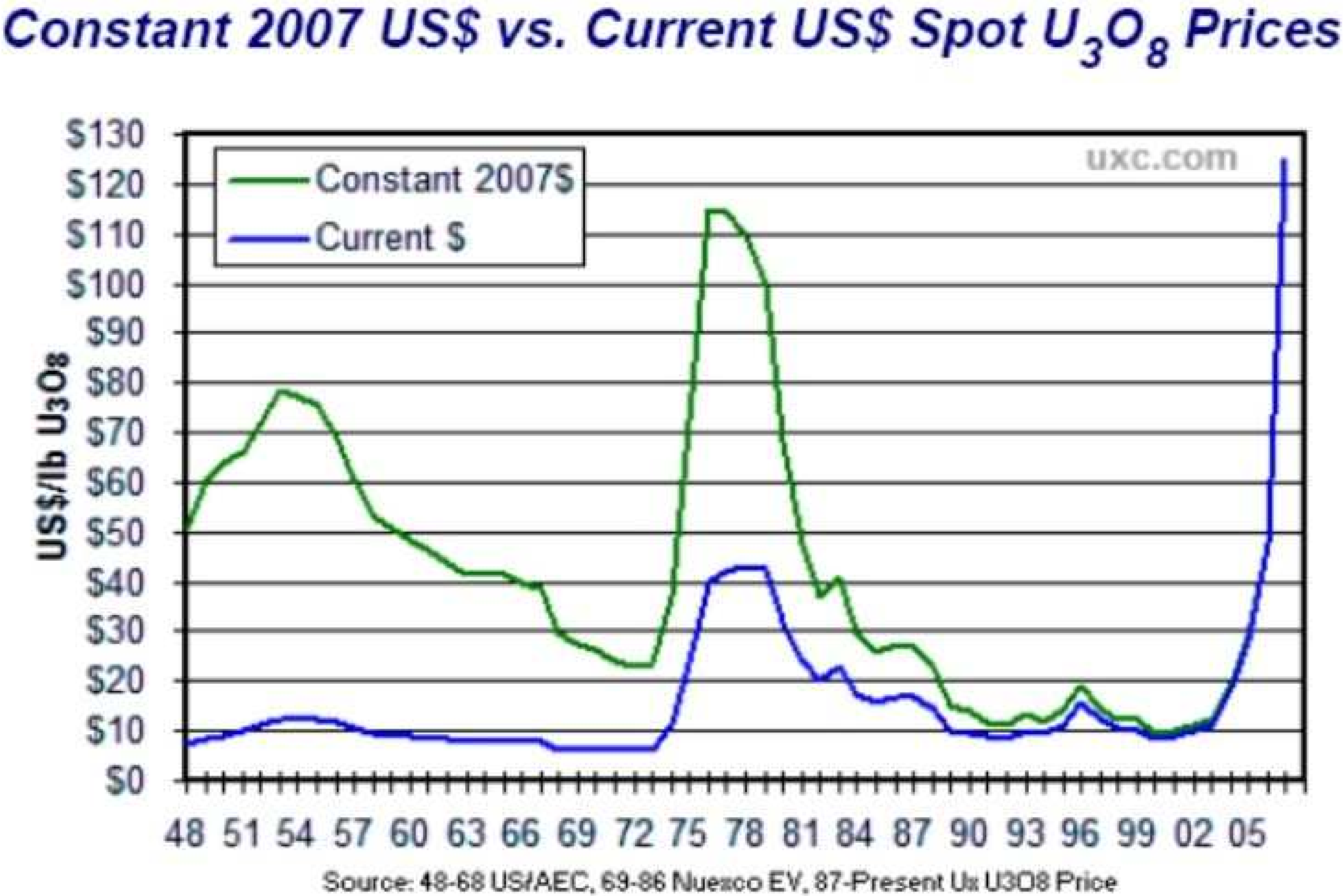


Figure 4 – History of U3O8 Spot Prices 1948-2007



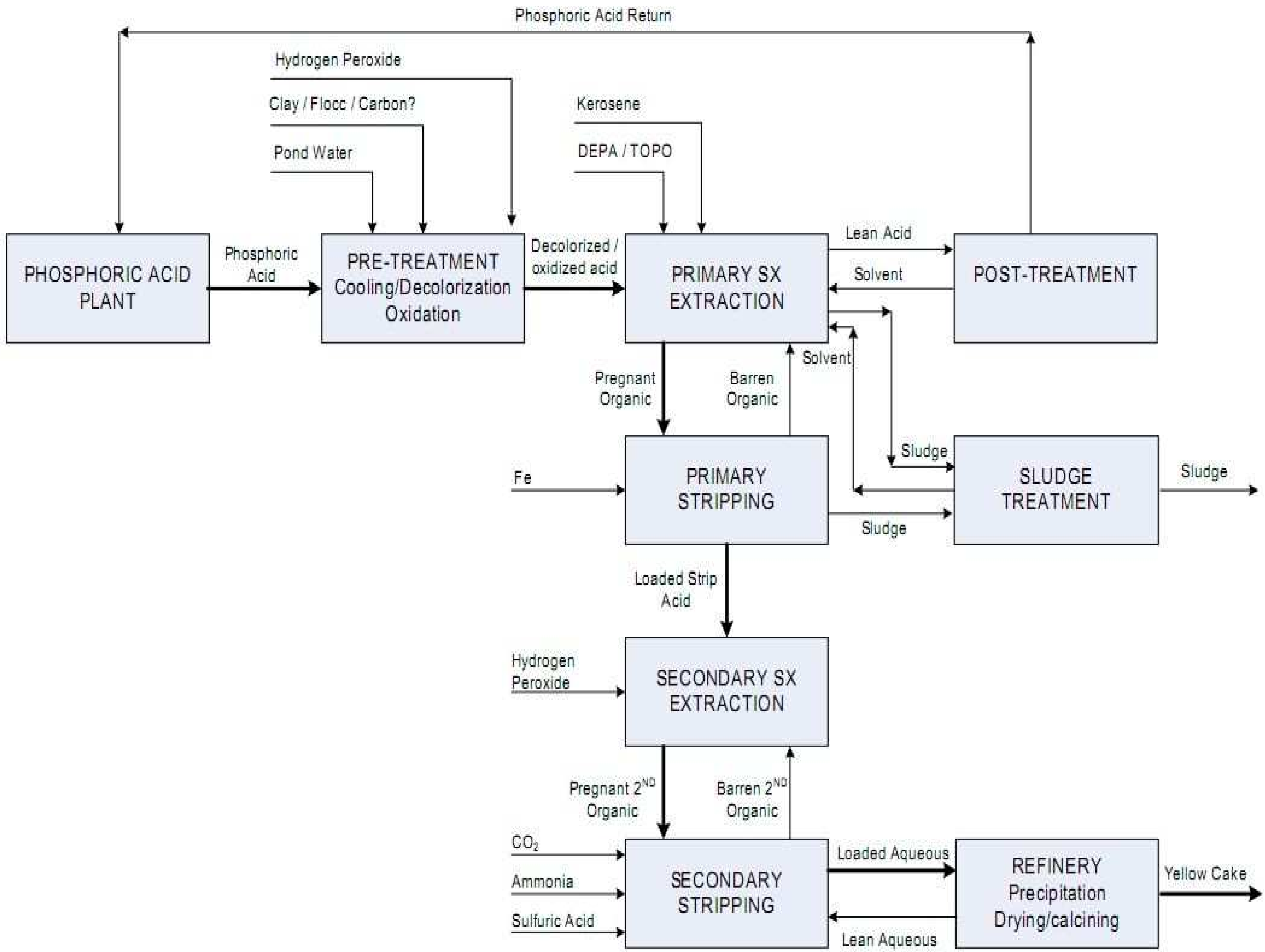
4 – Uranium Content of Selected World Phosphate Rock(4

Country	Deposit	U (ppm)		
Algeria	Djebel Onk	25		
	Djebel Kouif	100		
Australia	Duchess	80	to	92
China	Undifferentiated	10	to	39
Egypt	Abu Tartur	40	to	120
Israel	Arad	150		
Jordan	Shidyia	46		
Morocco	Bucraa	70	to	80
	Khourigba	80	to	120
Peru	Sechura	47	to	80
Saudia Arabia		25	to	85
Senegal	Taiba	64	to	70
Syria	Khneifiss	75		
Tanzania	Minjingu	390		
Togo		77	to	110
Tunisia		12	to	88
USA	Central Florida	59		200

Table 5 – Past Uranium From Phosphoric Acid Projects

Company		Process	Capacity t/y P_2O_5	Capacity lb/y U_3O_8	Start	Close
Blockson	IL	Precipitation	100,000	80,000	1952	1961
IMC	FL	OPPA	100,000	80,000	1955	1961
IMC	FL	DEPA-TOPO	1,700,000	1,360,000	1980	1992
US Phosphoric Products (Gardinier)	FL	OPPA Revised	200,000 450,000	160,000 360,000	1955 1979	1961 1982
URC/WR Grace	FL	OPAP	330,000	264,000	1976	1980
WMC/Farmland	FL	DEPA-TOPO	450,000	360,000	1978	1981
Freeport/Agrico/IMC	LA	DEPA-TOPO	950,000	760,000	1978	1998
Freeport/Agrico/IMC	LA	DEPA-TOPO	540,000	432,000	1980	1998
CFI	FL	DEPA-TOPO	950,000	760,000	1980	1992
CFI	FL	DEPA-TOPO	600,000	480,000	1980	1985
ESI/Western Coop	Canada	OPAP DEPA-TOPO	110,000	88,000	1980	1981
Chemie Rupel	Belgium	DEPA-TOPO	140,000	112,000	1980	1998
China Phosphate	Taiwan	DEPA-TOPO	33,000	26,400	1981	1985
SOM	Iraq	DEPA-TOPO	90,000	72,000	1984	1991

Figure 3 – Typical SX Process Flow Diagram



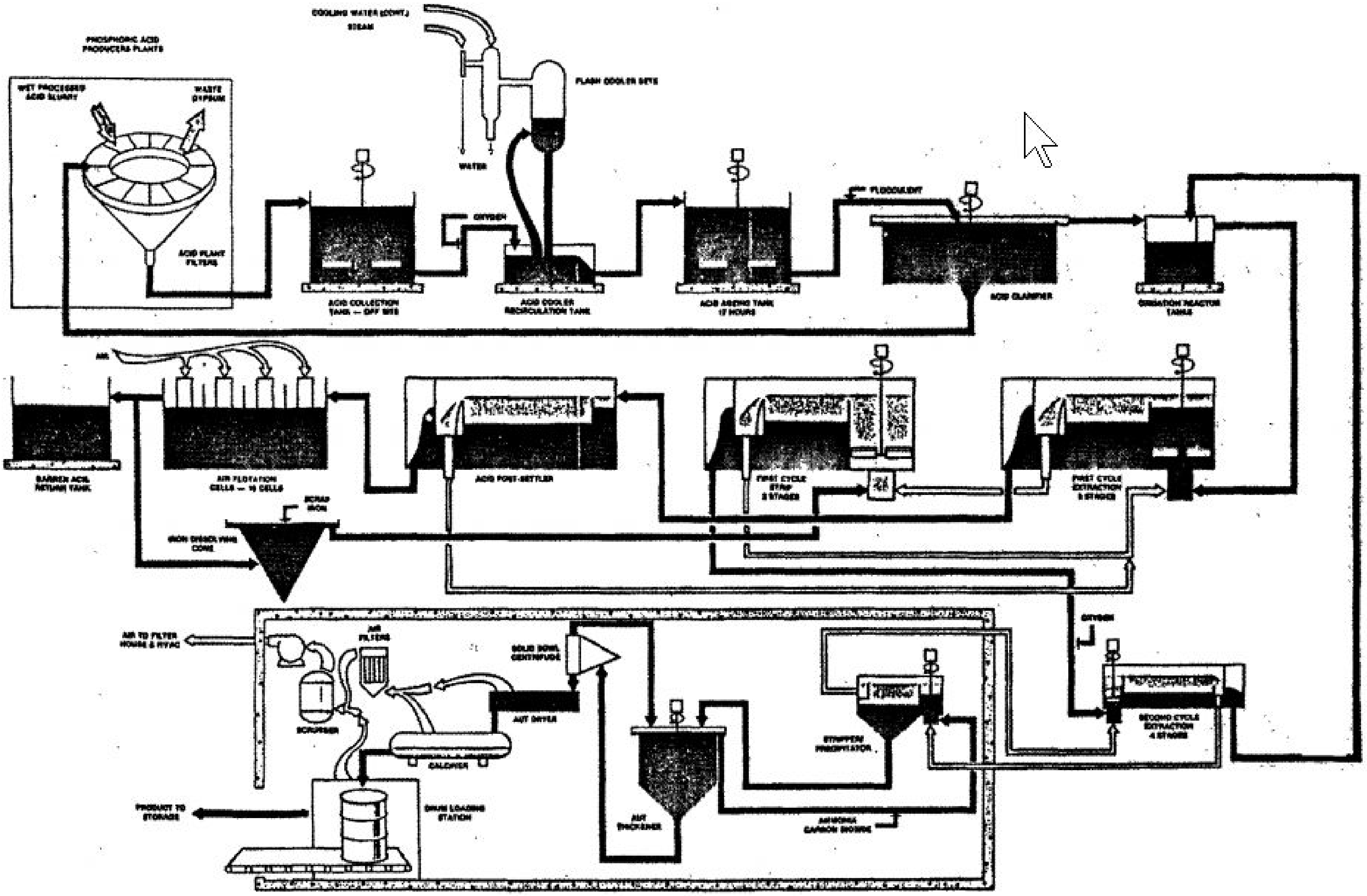


FIG. 1. Flow sheet of the DEHPA/TOPO process.