SLURRY ELECTROLYTE PROCESS FOR REDUCING POWER CONSUMPTION FOR ALUMINUM SMELTING

PRESENTED TO

PRIMARY METALS COMMITTEE

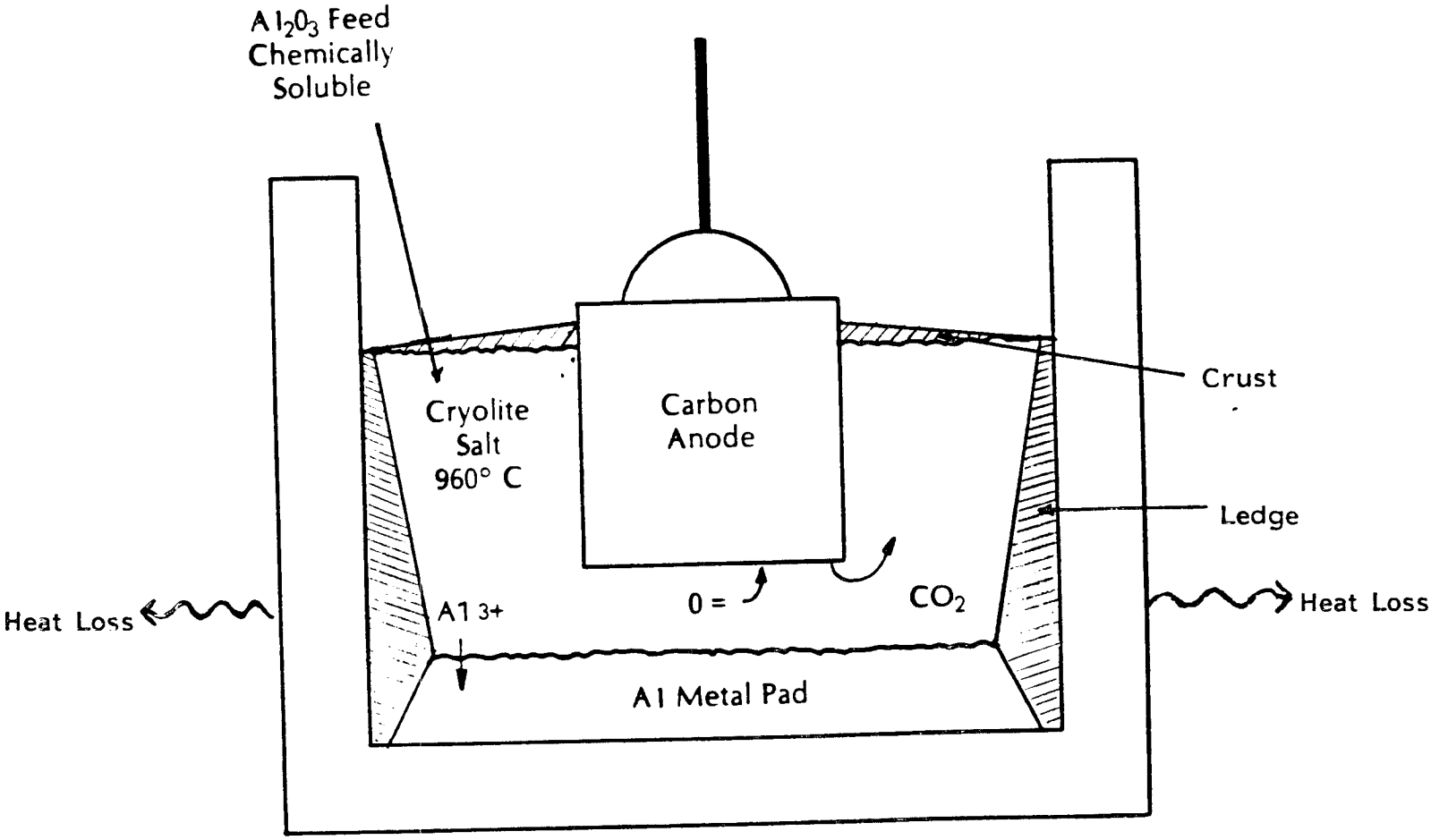
JUNE 2, 1983

TUCSON, ARIZONA

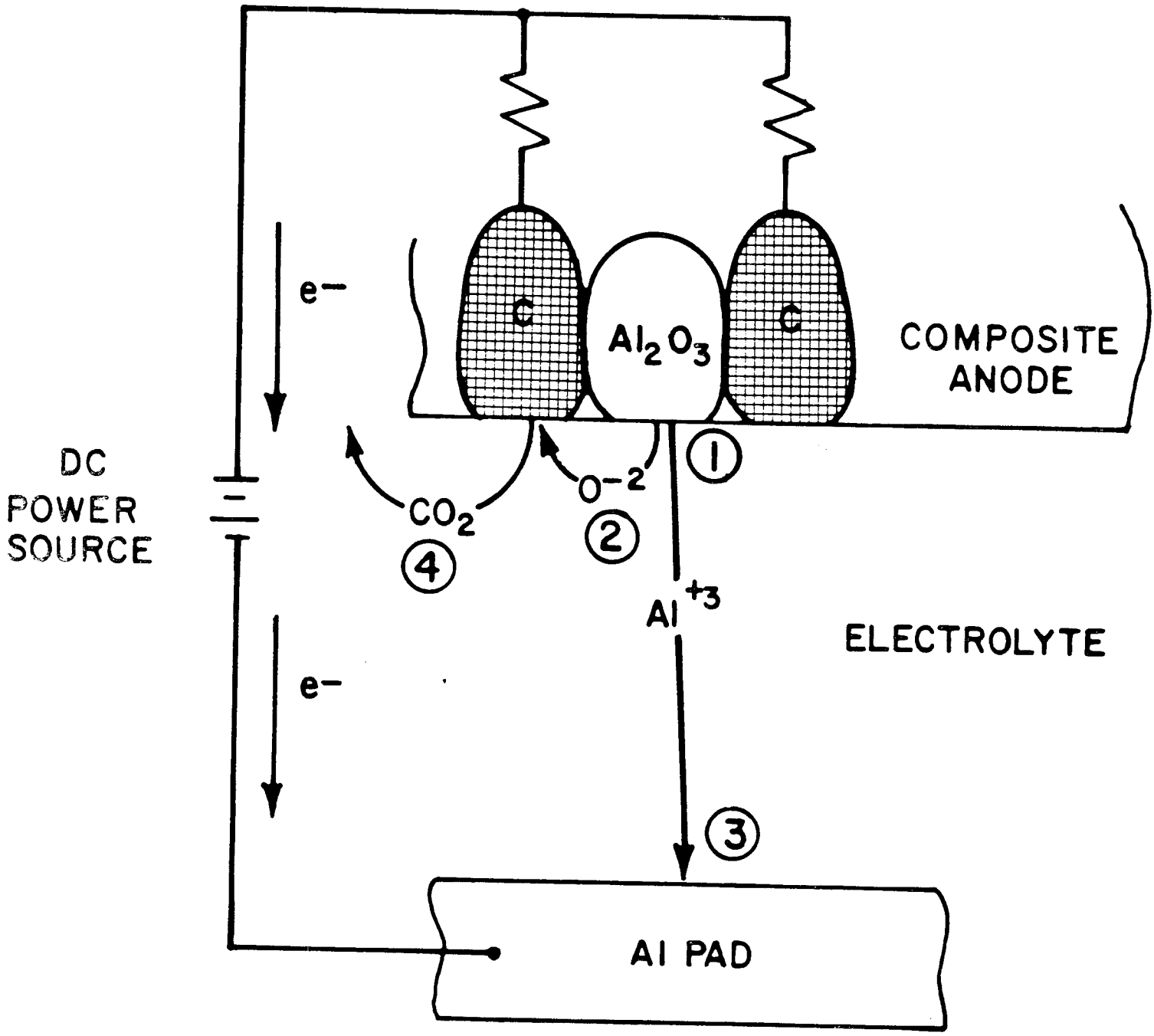
THE ARCO SLURRY ELECTROLYTE PROCESS FOR SMELTING ALUMINUM

- o WHAT IS IT
  - -- HALL CELL TECHNOLOGY
  - -- PREBAKED COMPOSITE ANODE
  - -- COMPOSITE PARTICLES ANODE
  - -- SLURRY ELECTROLYTE CONCEPT
- o PROGRAM OUTLINE
- o PRUDENT DEVELOPMENT COURSE
- o RAPID COMMERCIALIZATION SCHEME

Hall — Cell Technology



- TECHNICAL LIMITATIONS TO HALL CELL TECHNOLOGY
  - -- DEPENDS ON THE CHEMICAL SOLUBILITY OF Al_2O_3
  - -- OPERATE AT 950 TO 1000°C
  - -- DEPENDS ON HEAT LOSS TO MAINTAIN LEDGE



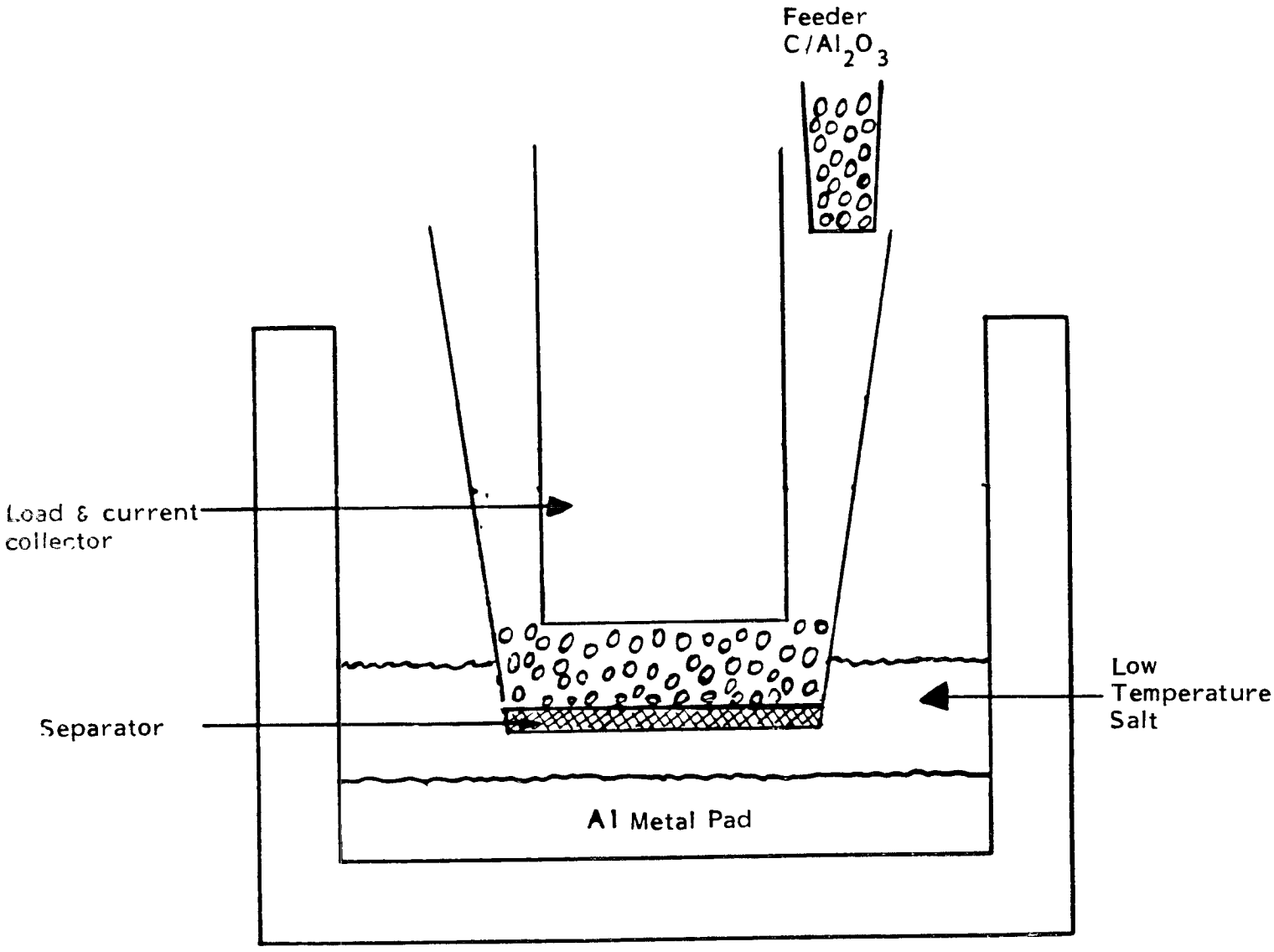
COMPOSITE ANODE PROCESS

- COMPOSITE ANODE FEATURES
  - -- INDEPENDENT OF THE CHEMICAL SOLUBILITY OF Al_2O_3
  - -- UNIFORM CONTINUOUS FEED OF Al_2O_3 FROM ANODE

- COMPOSITE ANODE IMPLICATIONS
  - -- LOW TEMPERATURE ELECTROLYTE (700-800°C)
  - -- FLEXIBLE ELECTROLYTE COMPOSITION
  - -- HIGH ANODE CURRENT DENSITY

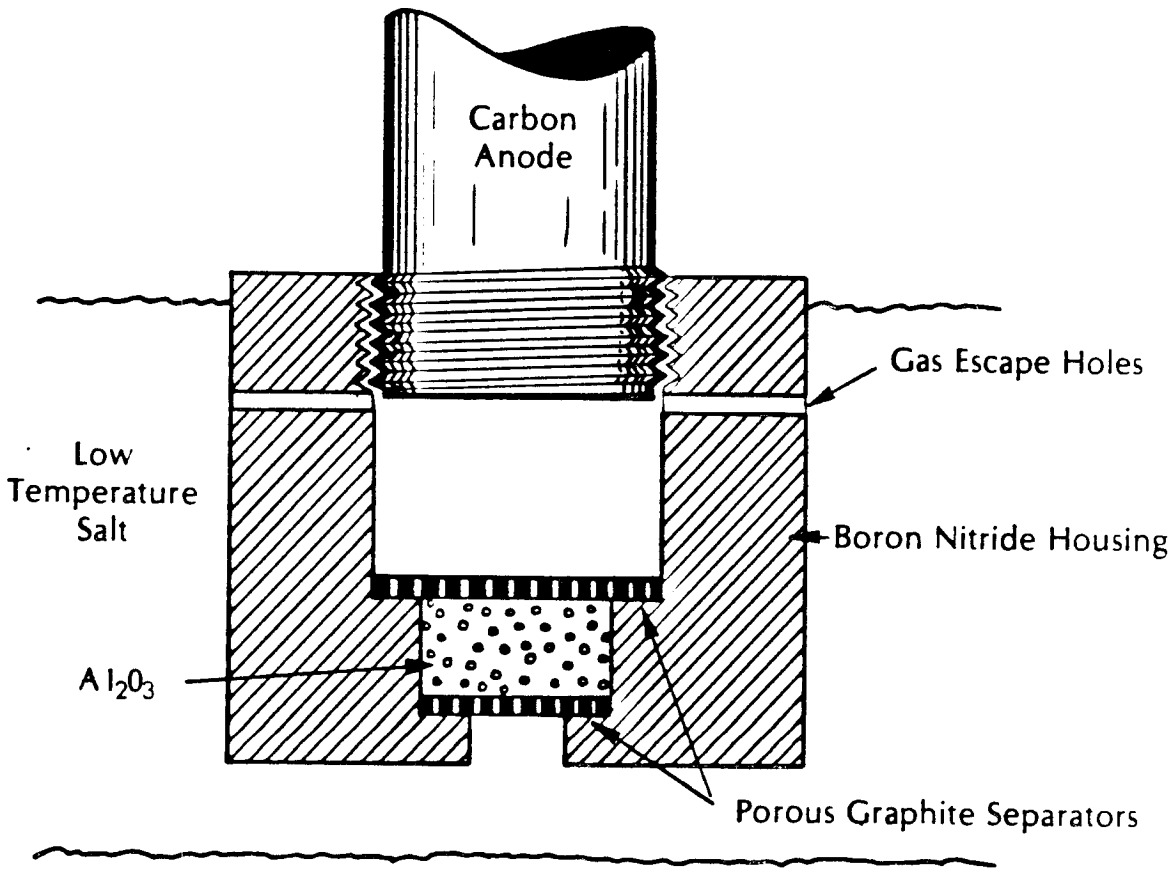
- TECHNICAL BARRIERS TO PREBAKED-COMPOSITE ANODE
  - -- ANODE RESISTIVITY
  - -- ANODE HANDLING

COMPOSITE PARTICLES ANODE

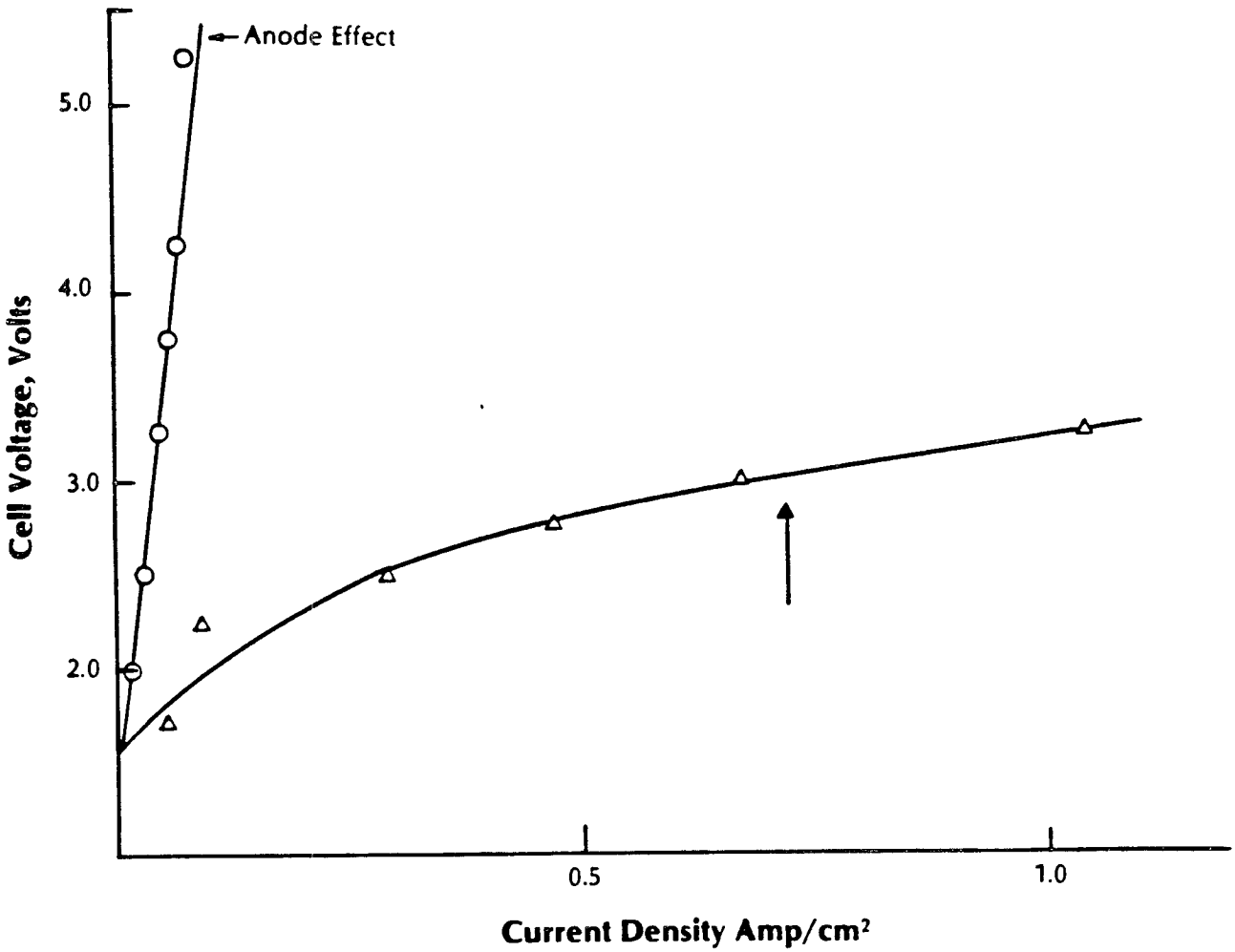


- TECHNICAL BARRIERS TO COMPOSITE PARTICLES
  - -- SEPARATOR
  - -- MECHANICS OF SYSTEM

The Arco Slurry Electrolyte Process
Proof of Principal



The Arco Slurry Electrolyte Process
Proof of Principal

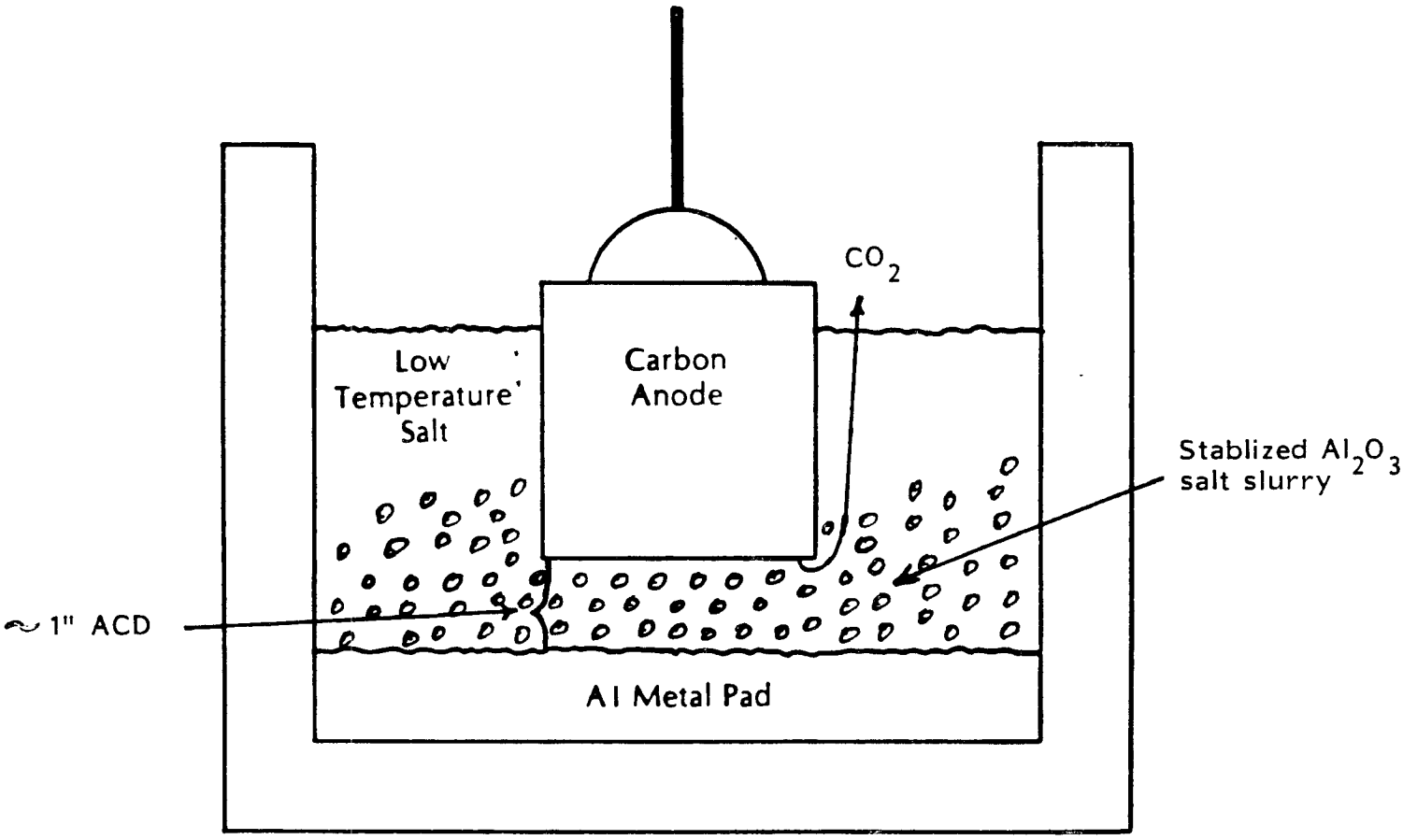


THE ARCO SLURRY ELECTROLYTE PROCESS

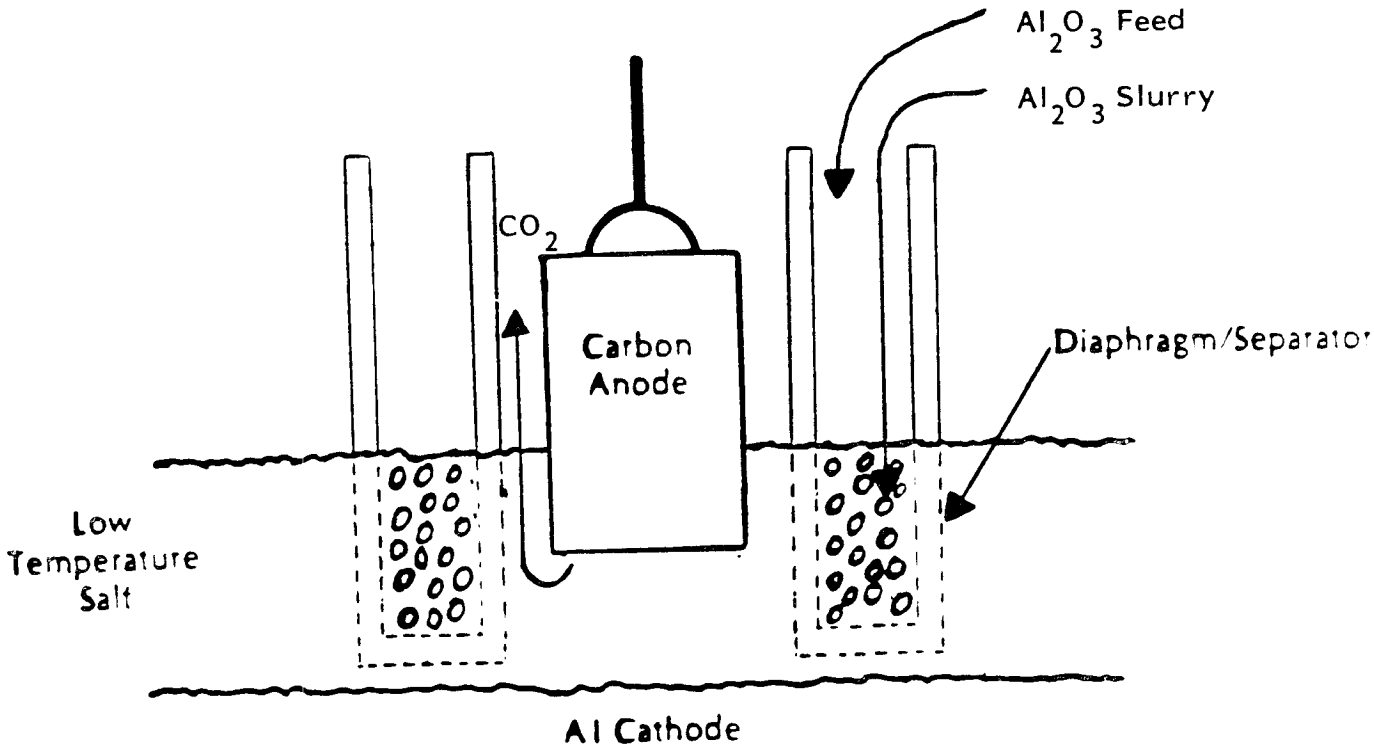
POSSIBLE SYSTEM CONFIGURATIONS

- STABLIZED SLURRY
- Al_2O_3 CONTAINER
- DRAINABLE CATHODE

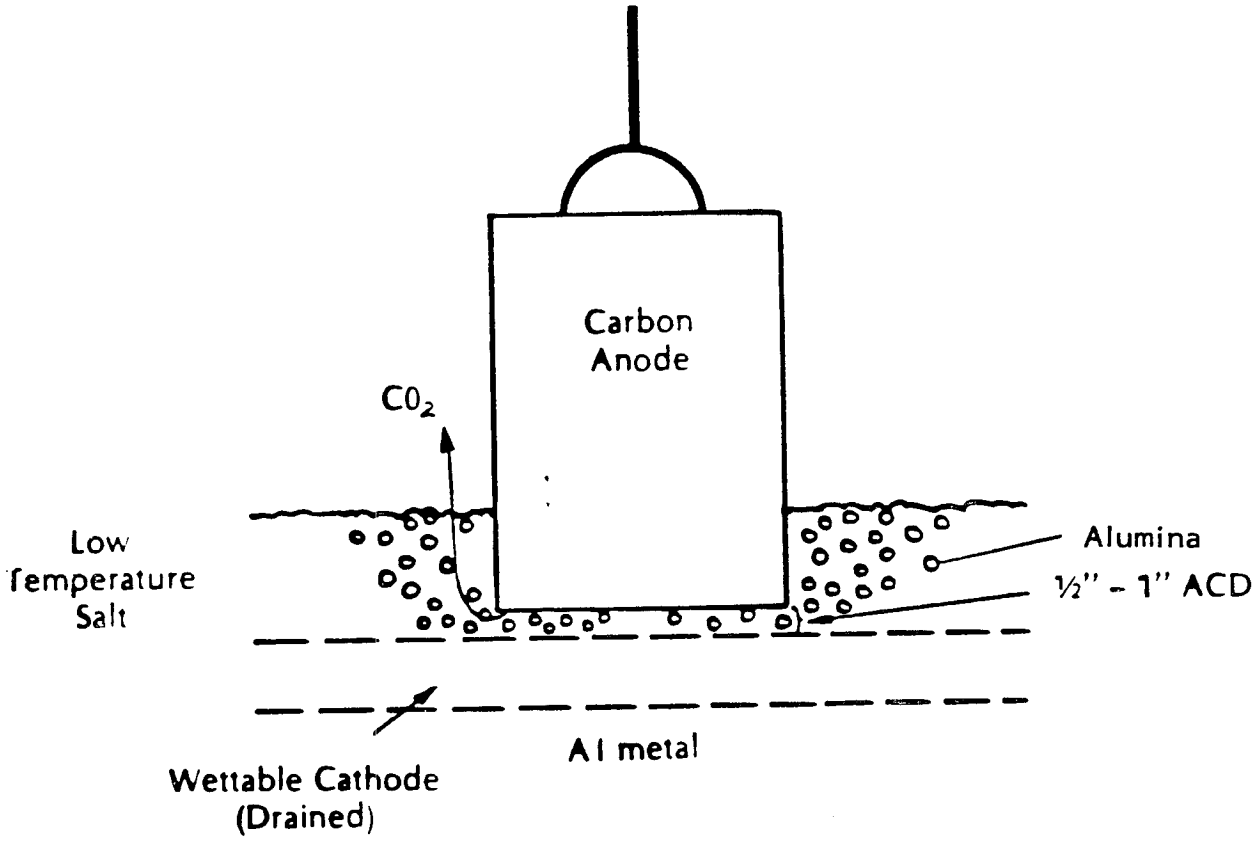
THE ARCO SLURRY ELECTROLYTE PROCESS
POSSIBLE SYSTEM CONFIGURATION



The Arco Slurry Electrolyte Process
Possible System Configuration



The Arco Slurry Electrolyte Process
Possible System Configuration



- CRITICAL QUESTIONS OF THE SLURRY ELECTROLYTE PROCESS
  - -- SLURRY STABILIZATION
  - -- Al_2O_3 CONTAINER
  - -- WETTABLE CATHODE

PROCESSES COMPARATIVE ANALYSIS

- ALUMINA MECHANISMS

  -- <u>HALL CELL TECHNOLOGY</u>

  $K_o > K_1$ SLUDGING

  $K_1 < K_2$ ANODE EFFECT

  $K_o \simeq K_1 \simeq K_2$ SMOOTH OPERATION

  -- <u>COMPOSITE ANODE</u>

  $K_o \simeq K_2$

  -- <u>SLURRY ELECTROLYTE</u>

  $K_1 \simeq K_2$

K_o = FEEDING RATE OF Al_2O_3

K_1 = SOLUBILITY RATE OF Al_2O_3

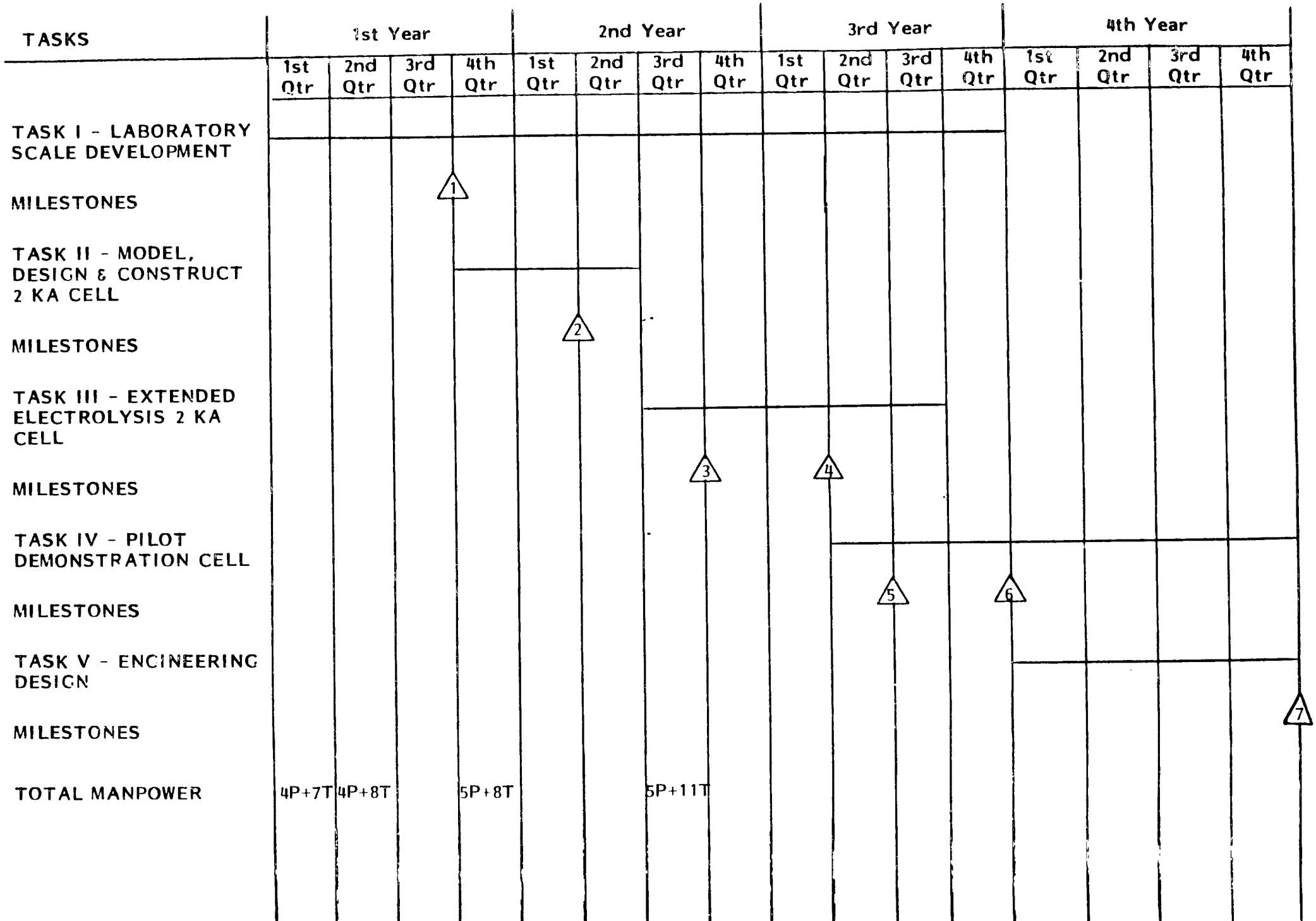
K_2 = CONSUMPTION RATE OF Al_2O_3

THE ARCO SLURRY ELECTROLYTE PROCESS

PROGRAM OUTLINE

TASK I	LABORATORY SCALE DEVELOPMENT
TASK II	MODELLING AND DESIGN 2 KA CELL
TASK III	EXTENDED ELECTROLYSIS
TASK IV	PILOT DEMONSTRATION
TASK V	ENGINEERING DESIGN OF COMMERCIAL CELL

SCHEDULE FOR PRUDENT DEVELOPMENT COURSE



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THE ARCO SLURRY ELECTROLYTE PROCESS

PROGRAM OUTLINE

TASK I LABORATORY SCALE DEVELOPMENT

- o ALUMINA STABILIZATION
  - -- ELECTROLYTE DEVELOPMENT
  - -- ALUMINA PREPARATION AND SOLUBILITY
  - -- GAS INDUCED CIRCULATION
- o MODELLING
- o ALUMINA CONTAINER (SEPARATOR)
- o WETTABLE CATHODE DEVELOPMENT

THE ARCO SLURRY ELECTROLYTE PROCESS

PROGRAM OUTLINE

TASK II MODELLING AND DESIGN 2 KA CELL

- o MASS AND HEAT TRANSFER MODELLING
- o SLURRY - GAS LIFT MODELLING
- o DESIGN 2 KA CELL
- o CONSTRUCTION OF 2 KA CELL
- o START-UP 2 KA CELL

THE ARCO SLURRY ELECTROLYTE PROCESS

PROGRAM OUTLINE

TASK III EXTENDED ELECTROLYSIS

- o CONTINUOUS ELECTROLYSIS OF 2 KA CELL
- o MATERIALS BALANCE
- o ECONOMIC IMPLICATIONS AND EVALUATIONS
- o PROCESS CONTROL AND INSTRUMENTATION IDENTIFICATION
- o DEVELOP A PILOT SCALE CONCEPT

THE ARCO SLURRY ELECTROLYTE PROCESS

PROGRAM OUTLINE

TASK IV PILOT DEMONSTRATION

- o IDENTIFY SYSTEM CONFIGURATION
- o ENGINEERING DESIGN 10-25 KA CELL
- o CELL CONSTRUCTION
- o DEMONSTRATE OPERABILITY/PROCESS CONTROL
- o DEVELOP A COMMERCIAL CONCEPT
- o PROJECT ECONOMICS OF COMMERCIAL OPERATION

THE ARCO SLURRY ELECTROLYTE PROCESS

PROGRAM OUTLINE

TASK V ENGINEERING DESIGN

- o MODEL AND DESIGN COMMERCIAL CELL
- o COST ESTIMATE CONSTRUCTION
- o UPDATE ECONOMIC PROJECTIONS

THE ARCO SLURRY ELECTROLYTE PROCESS
PRUDENT DEVELOPMENT COURSE
MILESTONE - TIME - KNOWLEDGE RELATIONSHIP

MILESTONE	TIME MONTHS	KNOWLEDGE
1	9	o MATHEMATICAL MODEL OF SLURRY CONCEPT o SLURRY STABILIZATION DEVELOPMENT
2	15	o DESIGN AND CONSTRUCT 2 KA CELL
3	21	o DEMONSTRATE OPERABILITY OF 2 KA CELL o INITIAL ECONOMIC EVALUATIONS
4	27	o IDENTIFY SYSTEM CONFIGURATION FOR PILOT CELL o PROCESS CONTROL IDENTIFICATION IN 2 KA CELL o UPDATED ECONOMIC PROJECTIONS
5	30	o DESIGN PILOT CELL COMPLETE o COMMIT TO PILOT CONSTRUCTION
6	36	o LAB DEV. PROGRAM COMPLETE o DEMONSTRATED OPERATION/PROCESS CONTROL o DEVELOPED COMMERCIAL CONCEPT/MODELLED o PROJECTED ECONOMICS OF COMMERCIAL OPERATION
7	48	o COMMIT TO COMMERCIAL CELL IN PLANT

THE ARCO SLURRY ELECTROLYTE PROCESS

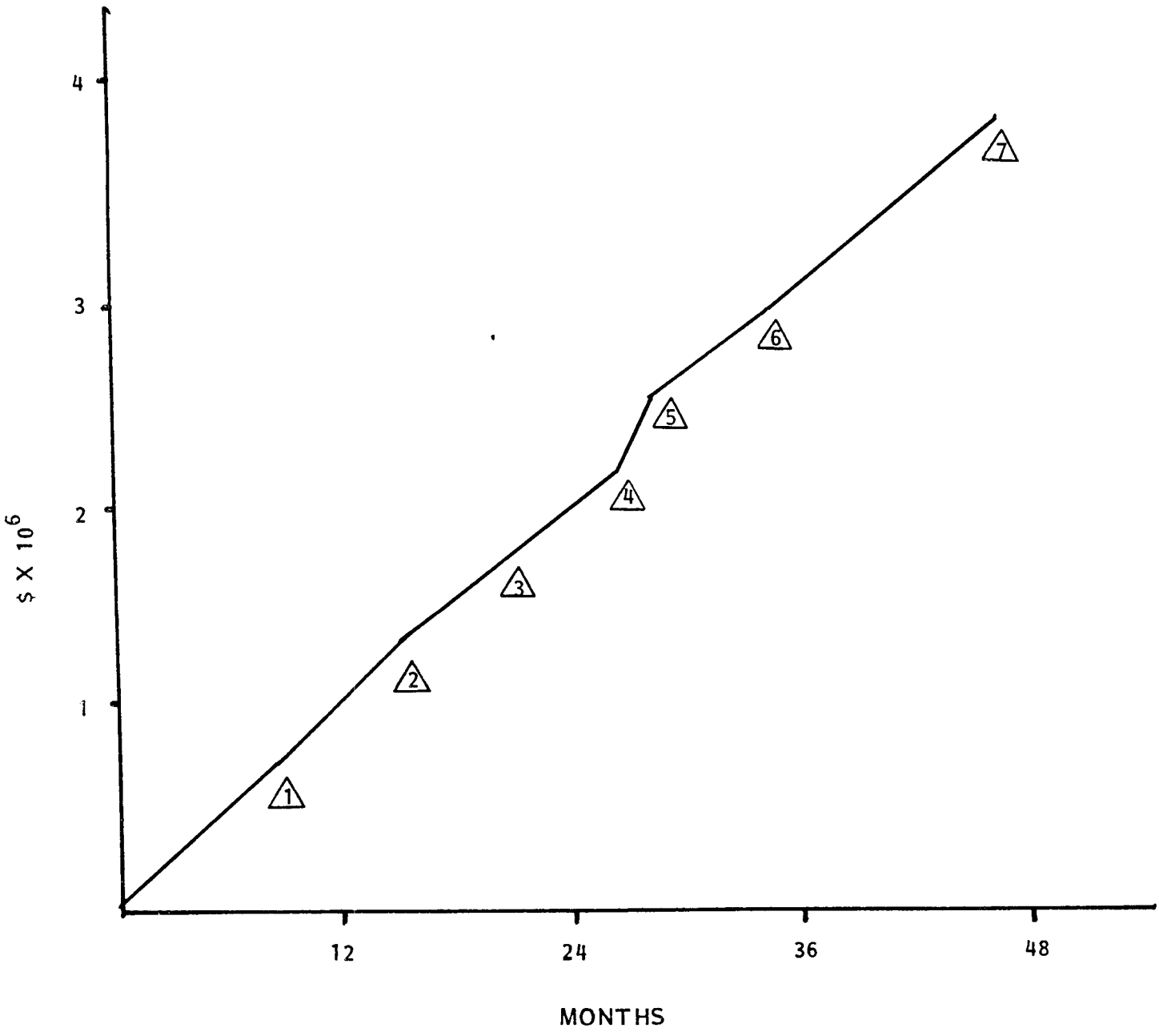
COST OF PRUDENT DEVELOPMENT COURSE

COST ITEMS	MILESTONE						
	1	2	3	4	5	6	7
PROF. MAN. YR 60K	180	150	150	150	75	150	300
TECHNICIAN 32K	184	128	128	176	88	176	352
MATERIALS & SUPPLIES	150	180	80	60	140	75	100
CAPITAL	150	50	--	50	50	--	--
SUBCONTRACT	100	50	50	20	--	*	--
TOTAL	764	558	408	436	353	401	752
CUMULATIVE	764	1322	1730	2166	2519	2920	3672

* COST FOR ENGINEERING COMMERCIAL CELL ESTIMATE 225 - 500

THE ARCO SLURRY ELECTROLYTE PROCESS

PRUDENT DEVELOPMENT COURSE
COST - MILESTONE RELATIONSHIP



RAPID COMMERCIALIZATION COURSE

TASKS	1ST YEAR				2ND YEAR				3RD YEAR				4TH YEAR			
	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
TASK I - LABORATORY SCALE DEVELOPMENT																
MILESTONE			1			2										
TASK II - DESIGN & CONSTRUCT 2 KA CELL																
TASK III - EXTENDED ELECTROLYSIS OF 2 KA CELL																
TASK IV - REVISE COMMERCIAL CONCEPT																
MILESTONE						2										
TASK V - ENGINEERING DESIGN OF COMMERCIAL CELL																
PROCUREMENT & CONSTRUCTION OF COMMERCIAL CELL								Plant								
MILESTONE								3	4							
TOTAL MANPOWER	7P+8T		7P+ 11T	7P+ 12T		7P+ 12T										

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THE ARCO SLURRY ELECTROLYTE PROCESS

RAPID COMMERCIALIZATION COURSE
MILESTONE - TIME - KNOWLEDGE RELATIONSHIP

MILESTONE	TIME MONTHS	KNOWLEDGE
2	6	o MATHEMATICAL MODEL OF SLURRY CONCEPT
		o SLURRY STABILIZATION DEVELOPMENT
		o DESIGN OF 2 KA CELL
2	15	o DEMONSTRATE OPERABILITY OF 2 KA CELL
		o REVISED COMMERCIAL CONCEPT
		o INITIAL ECONOMIC EVALUATIONS
3	21	o DESIGN OF COMMERCIAL CELL
		o ECONOMIC MODEL
		o COMMIT TO COMMERCIAL CELL
4	24	o LAB. DEV. PROGRAM COMPLETE
		o PROCESS CONTROL IDENTIFICATION
		o READY FOR PLANT OPERATIONS

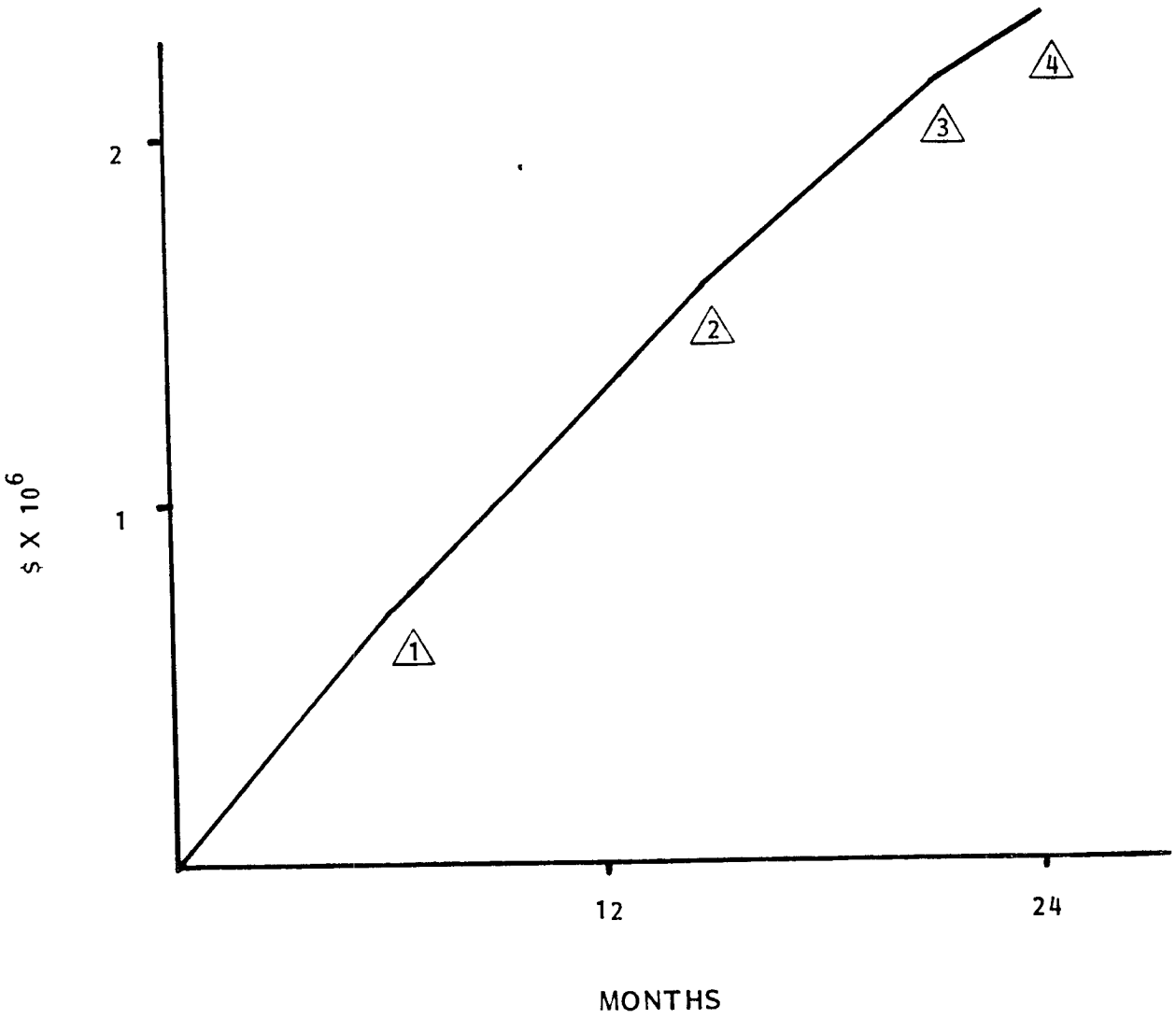
THE ARCO SLURRY ELECTROLYSIS PROCESS

COST OF RAPID COMMERCIALIZATION COURSE

COST ITEM	MILESTONE			
	1	2	3	4
PROF. MAN. YR 60K	210	315	210	210
TECHNICIAN 32K	128	280	192	93
MATERIALS & SUPPLIES	150	180	60	30
CAPITAL	150	80	--	--
SUBCONTRACT	100	50	*	--
TOTAL	738	905	462	228
CUMULATIVE	738	1643	2105	2333

* COST FOR ENGINEERING COMMERCIAL CELL ESTIMATE 225 - 500

THE ARCO SLURRY ELECTROLYTE PROCESS

RAPID COMMERCIALIZATION COURSE

COST - MILESTONE RELATIONSHIP