

SECTION 5.0
SYNGAS UPGRADING
(Areas 209, 210, 211, 212, 405)

5.1 DESIGN BASIS

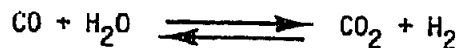
- 5.1.1 The syngas upgrading area has three trains, each with one third of the total plant capacity.
- 5.1.2 A saturator is used to adjust the steam/carbon ratio of the raw gas.
- 5.1.3 The shift reactor utilizes high temperature shift catalyst.
- 5.1.4 COS is converted to H₂S to improve sulfur removal.
- 5.1.5 For the purposes of this study, the Selexol process is used to lower the CO₂ and H₂S content to the required levels for methanol synthesis.
- 5.1.6 For the purposes of this study, an Air Resources "LO-CAT" unit is used for recovery of sulfur as molten liquid which is solidified and flaked. Thirty days storage capacity is provided for the flaked sulfur.
- 5.1.7 Two guard beds are provided for final treatment of the sweet synthesis gas. One bed is used to remove trace chlorides, the other bed is used to remove trace sulfur compounds. Each bed is designed for an expected life of three years (minimum).

5.2 PROCESS DESCRIPTION

5.2.1 Raw Gas Compression, Shift and Hydrolysis (Areas 209, 210; Dwgs. 5530-209-Y-001, 210-Y-001)

The clean raw gas from the eight gasifier units is collected in a single header which supplies 3 identical syngas preparation trains. In each train the raw gas is first compressed from 40 psia to 770 psia by a steam turbine driven 3-stage centrifugal compressor.

After compression a portion of the raw gas passes to a saturator vessel where the required steam to dry gas ratio for shift conversion is obtained by direct contact of the gas with hot water. Heat to produce the hot water is obtained by exchange with the hot gas leaving the shift reactor and from condensing crude methanol from the methanol synthesis area. From the saturator the gas passes to the shift reactor where the ratio of hydrogen to carbon monoxide is adjusted to the required level for methanol synthesis by the following reaction in the presence of a sulfur resistant Cobalt-Moly catalyst:



The exit gas from the shift reactor is combined with the remainder of the raw gas and then passes to the COS hydrolysis vessel where the gas is contacted over an alumina hydrogenation catalyst to convert the COS present in the gas to H₂S.

From the COS hydrolysis vessel, the raw gas is cooled by supplying heat to a methanol distillation column reboiler and to a boiler feedwater heater before being sent to the acid gas removal unit.

5.2.2 Acid Gas Removal and Makeup Gas Compression
(Areas 211, 212; Dwgs. 5530-211-Y-001, 212-Y-001)

The "Selexol" acid gas removal unit removes sulfur components in the gas and adjusts the CO₂ level to the required concentration for methanol synthesis.

Removal of the H₂S and CO₂ from the syngas is accomplished in two absorption vessels utilizing dimethylether of polyethylene glycol as a liquid absorbent.

The H₂S is subsequently steam stripped from the absorbent in a stripping tower and sent to the Lo-Cat sulfur recovery unit. The CO₂ is ultimately flashed from the absorbent by pressure let down in a flash drum and then vented to atmosphere, or is recovered for sale.

The sweet syngas from the Selexol unit then passes through two types of guard beds where trace chloride and sulfur compounds are removed by special catalysts. If not removed these compounds would lessen the effectiveness of the downstream methanol synthesis catalysts. Finally the upgraded gas pressure is raised to 1410 psia by the make up gas compressor prior to methanol synthesis.

5.2.3 Sulfur Recovery (Area 405, Dwg. 5530-405-Y-001)

Sulfur recovery is accomplished in an Air Resources LO-CAT unit.

The purge gas stream leaving the H₂S stripper in the "Selexol" acid gas removal area passes to a two stage H₂S absorption system where intimate contact of the gas with a

proprietary circulating liquid is effected. This liquid, consisting of a dilute chelated iron solution, converts the H_2S in the gas into elemental sulfur. The first stage utilizes the slight positive pressure of the gas to achieve a high degree of intimate contact with the circulating solution. This is followed by a packed absorption tower using a very large, open configuration plastic packing.

The spent solution from the absorption tower is pumped to a large aerated vessel where it is regenerated by blowing air into the tank. This re-oxidizes the chelated iron compound so that the solution can be returned to the absorption tower for further sulfur recovery.

Sodium thiosulfate is generated as a by-product which builds up in the recirculating solution and must be removed continuously after the concentration has built up to approximately 25%. Some catalyst is lost with this bleed stream and must be replaced with fresh catalyst.

The elemental sulfur formed in the absorbers is settled as a dilute slurry in the bottom of the oxidizer vessel and pumped through a heat exchanger train to a molten sulfur separator. Molten sulfur is withdrawn from the bottom of the separator vessel, solidified, flaked, and sent to storage. Clarified slurry returns to the process. The sulfur will be available for sale or disposal.

5.3 ENGINEERING DESIGN DATA

Design data pertinent to syngas upgrading is detailed in the Process Flow Diagrams immediately following this page, in the Equipment List beginning on page 5/6, and in the Drawings following page 5/21.

DRAWINGS RELATING TO SYNGAS UPGRADING

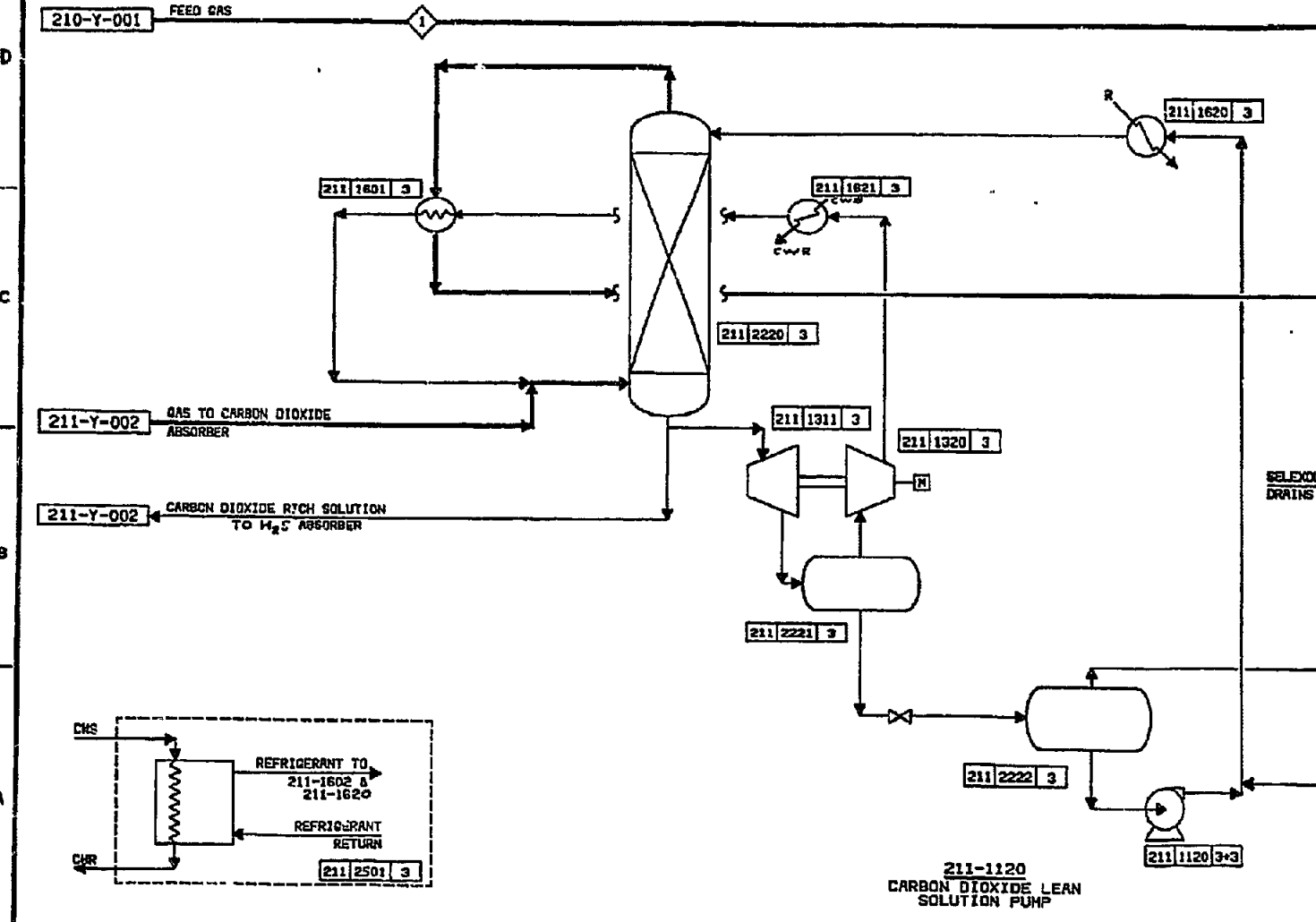
<u>DRAWING NO.</u>	<u>TITLE</u>
5530-209-Y-001	Raw Gas Compression
5530-210-Y-001	Shift Conversion and COS Hydrolysis
5530-211-Y-001	Acid Gas Removal - Carbon Dioxide Removal
5530-211-Y-002	Acid Gas Removal - H ₂ S Removal
5530-212-Y-001	Makeup Gas Compression
5530-405-Y-001	Sulfur Recovery

EQUIPMENT LIST

5530-209-P-001	Raw Gas & Methanol Compressor-Plan at Base
5530-209-P-002	Raw Gas & Methanol Compressor-Plan at Base
5530-209-P-003	Raw Gas & Methanol Compressor-Plan at 22'-0"
5530-209-P-004	Raw Gas & Methanol Compressor-Plan at 22'-0"
5530-209-P-005	Raw Gas & Methanol Compressor-Plan at 54'-0"
5530-209-P-006	Raw Gas & Methanol Compressor-Section A-A
5530-209-P-007	Raw Gas & Methanol Compressors-Section B-B
5530-210-P-001	Raw Gas & Methanol Area - General Arrangement
5530-210-P-002	Raw Gas Shift & Acid Gas Removal - Plan at Base
5530-210-P-003	Raw Gas Shift & Acid Gas Removal - Plan at 22'-0"
5530-210-P-004	Raw Gas Shift & Acid Gas Removal - Plan at 42'-0"
5530-210-P-005	Raw Gas Shift & Acid Gas Removal - Plan above 62'-0"
5530-210-P-006	Raw Gas Shift & Acid Gas Removal? - Elev. A-A
5530-210-P-007	Raw Gas Shift & Acid Gas Removal - Elev. B-B

ST-AN DESCRIPTION	FEED GAS			SN	MOD CC
	PHASE	W	B		
COMPONENT	SOL. WT.	MOLE	LB. MOLE/HR		
CARBON	12.011				MOLE
HYDROGEN	2.016	47.84	1219.76		26.0
HYDROGEN	20.014	1.15	1012.85		1.80
SULFUR	32.060				
OXYGEN	32.000				
C. LIME	35.453				
ASH					
WATER	18.018	0.74	120.49		
CARBON MONOXIDE	28.011	14.48	1376.45		18.00
CARBON DIOXIDE	44.011	13.81	1317.81		9.00
METHANE	16.043	2.62	2224.42		3.24
HYDROGEN SULFIDE	34.076	0.55	57.22		5.77
CARBONYL SULFIDE	60.071	2.77	0.19		1.77
SULFUR DIOXIDE	64.066				
METHANOL	32.043				
DIMETHYL ETHER	46.068				
HIGHER ALCOHOL	74.120				
SELCOL					
TOTAL (WEI)		100.00	9197.93		32.00
FLOW (DRY)	SCFH		33,814,454		24
TOTAL FLOW	LB/HR		1,333,359		73
PRESSURE	PSIA		295		3
TEMPERATURE	°F		160		
HW	BTU/LB				
HW (DRY)	BTU/SCF				

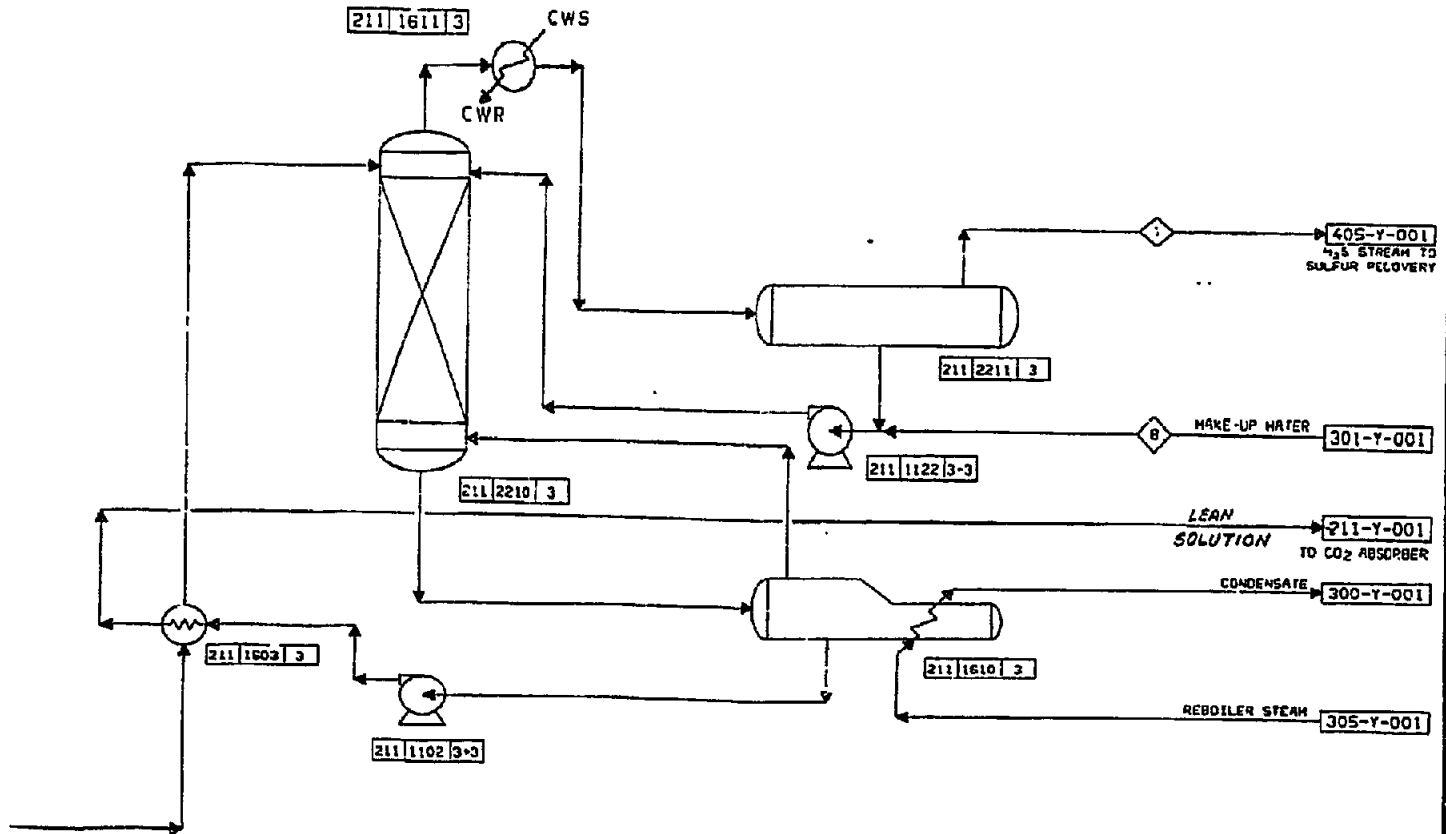
211-2501 REFRIGERATION PACKAGE 211-1601 RECYCLE GAS COOLER I 211-2220 CARBON DIOXIDE ABSORBER 211-1320 RECYCLE GAS COMPRESSOR II 211-1311 POWER RECOVERY TURBINE II 211-2221 FLASH DRUM II 211-2222 FLASH DRUM III 211-162 RECYCLE GAS COOLER II



NO.	DESCRIPTION	BY	CHK.	APPROVED	DATE	NO.	DESCRIPTION	BY	CHK.	APPROVED	DATE
1	ISSUED FOR FINAL REPORT	E.D.			...	1					
2	35-2501-23-S.O.					2					
3						3					
4						4					
5						5					

	10	11	12	13	14	15	16	17	18
	PROCESS CONDENSATE								
	L								
	H ₂ S	LEAN							
B	100.00	1765.6							
D	100.00	1745.3							
	1760.0								
	660								
	50								

1-2202 H DRUM I 211-1603 LEAN RICH SOLUTION EXCHANGER 211-2210 H₂S STRIPPER 211-1611 H₂S STRIPPER CONDENSER 211-1610 H₂S STRIPPER REBOILER 211-2211 SURGE TANK



11-1102 LEAN SOLUTION PUMP 211-1122 WATER REFLUX PUMP

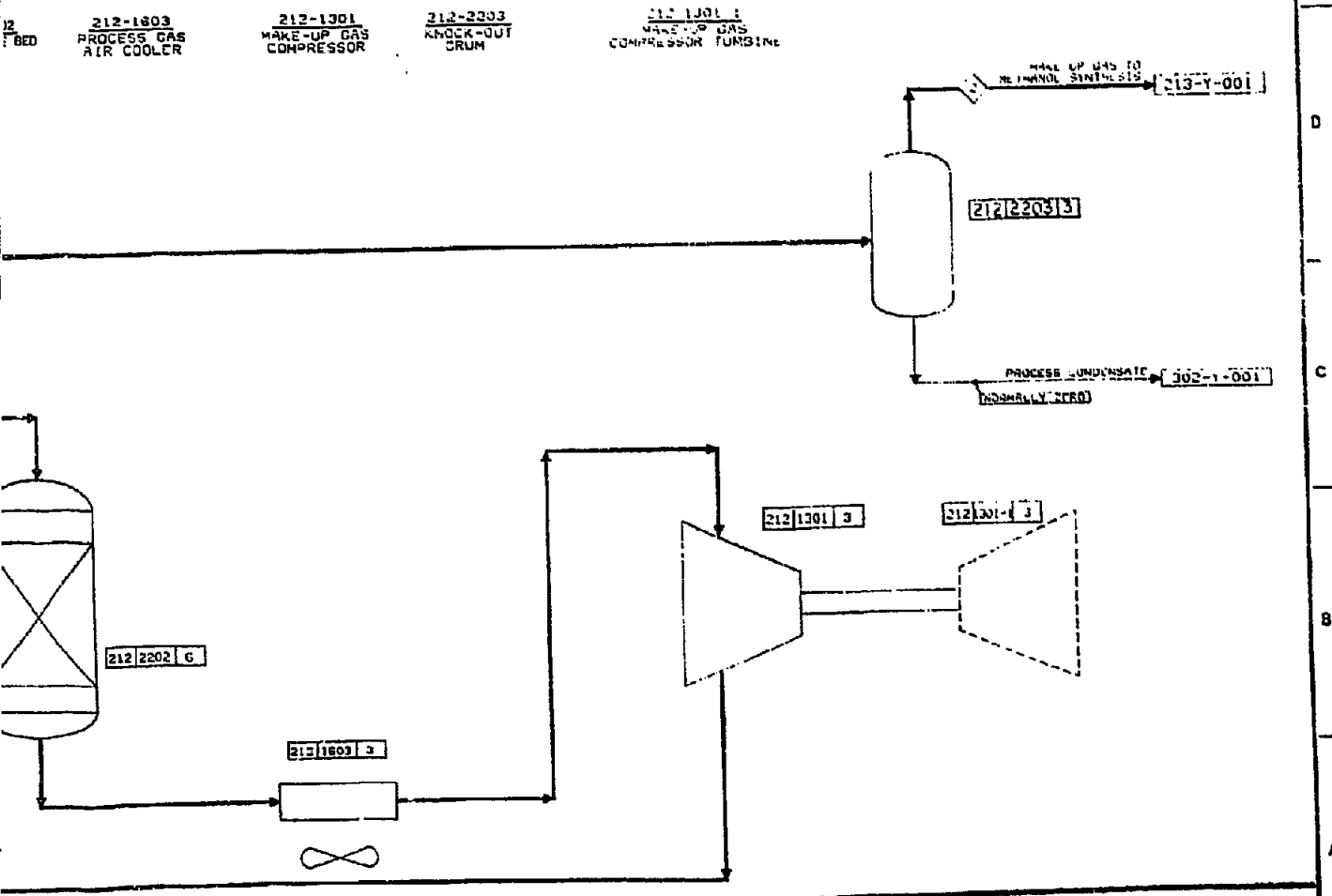
NOTE: This Print is the property of DAVY MCKEE CORPORATION. It must not be traced nor reproduced in any manner nor shall it be submitted to outside parties for examination without our consent. It shall be used only as a means of reference to work designed or furnished by us.

DESIGNED BY	DATE	DATE TO CLIENT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

CLIENT: CIRI/PLACER BELUGA MET-ANOL PROJECT COOK INLET, ALASKA
 TITLE: ACID GAS REMOVAL H₂S REMOVAL
 SCALE: _____ E/R NO. _____

Davy McKee
 ENGINEERS AND CONSTRUCTORS
 5530-211-Y-002
 REVISION:

9	10	11	12	13	14	15	16	17	18



NOTE: This Print is the property of DAVY MCKEE CORPORATION. It must not be traced nor reproduced in any manner nor shall it be submitted to outside parties for examination without our consent. It shall be used only as a means of reference to work designed or furnished by us.

CLIENT
 CIRI/PLACER
 BELUGA REMANOL PROJECT
 COOK INLET, ALASKA

Davy McKee
 ENGINEERS AND CONSTRUCTORS
 220 1942 Bldg 7279

DESIGNED BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE

A	B	C	D	E	F	G	H	I	J

TITLE
 MAKE-UP GAS COMPRESSION

SCALE: 1/2" = 1' - 0" BENCH: _____

REVISION
 5530-212-Y-001

10		11		12		13		14		15		16		17		18	

405-1601
SLURRY
PREHEATER

405-1602
SULFUR
MELTER

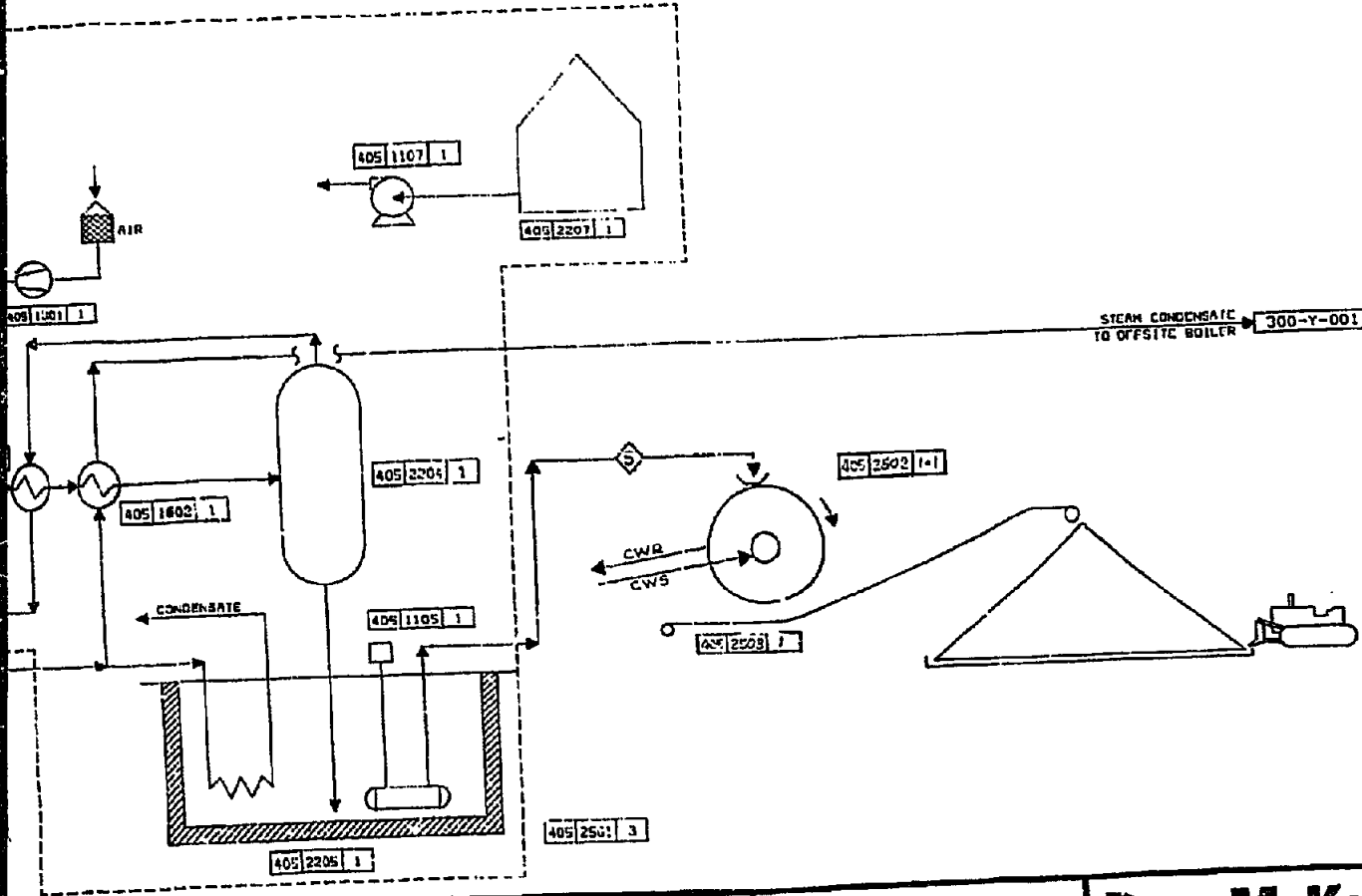
405-2204
SULFUR
COALESCER

405-2207
SULFUR STEAM
HEATED PIT

405-2502
SULFUR FLAKER

405-2507
CHEMICAL
INVENTORY TANK

405-2508
SULFUR
CONVEYOR



405-1107
CHEMICAL TRANSFER
PUMP

NOTE: This Print is the property of DAVY McKEE CORPORATION. It must not be traced nor reproduced in any manner nor shall it be submitted to outside parties for examination without our consent. It shall be used only as a means of reference to work designed or furnished by us.

CLIENT
CIRI/PLACER
BELUGA HATCHERY PROJECT
COOK INLET, ALASKA

Davy McKee
ENGINEERS AND CONSTRUCTORS
215 N 10th St, Anchorage, Alaska 99501

DESIGNED	BY	DATE	CHECKED	DATE
CCB	TRJ	3/1/77	TRJ	3/1/77
APPROVED 1	TRJ	3/1/77		
APPROVED 2				

TITLE
SULFUR RECOVERY

SCALE
AS SHOWN

DR. NO.
5530-405-Y-001



RAW GAS COMPRESSION - AREA 209

EQUIPMENT LIST

NOMENCLATURE:
 T - TYPE
 C - CAPACITY
 S - SIZE
 P/T - OPERATING PRESSURE/
 TEMPERATURE
 M - MATERIAL
 CS - CARBON STEEL
 SS - STAINLESS STEEL
 CI - CAST IRON
 D - DRIVE
 W - WEIGHT
 ACC - ACCESSORIES

ITEM	NO. REQUIRED	DESCRIPTION
209-1101	3	<p><u>Vacuum Condensate Pump</u></p> <p>T - Centrifugal C - 679 GPM @ 102°F, 1 psia ΔP = 65 psi M - Carbon Steel D - 45 hp, Electric</p>
209-1301	3	<p><u>Raw Gas Compressor</u></p> <p>T - 3-Stage Centrifugal S - 49,000 hp C - 62,500 ICFM @ 40 psia/104°F inlet Pi/Ti - Suction - 25 psig/104°F Po/To - Discharge - 755 psig/335°F D - Steam Turbine</p>
209-1301-1	3	<p><u>Raw Gas Compressor Turbine</u></p> <p>T - Condensing C - 309,926 lb/hr Steam Pi/Ti/Po - Steam Turbine, 855 psig/840°F/2" Hg Abs</p>
209-1601	3	<p><u>First Stage Intercooler</u></p> <p>T - Shell and Tube C - 49.55 MM Btu/hr M - Shell - Carbon Steel Tubes - Stainless Steel S - 4,350 sq ft Des P/T - Shell - 75 psig/110°F Tubes - 150 psig/355°F</p>

RAW GAS COMPRESSION - AREA 209

EQUIPMENT LIST

<u>ITEM</u>	<u>NO. REQUIRED</u>	<u>DESCRIPTION</u>
209-1602	3	<u>Second Stage Intercooler</u> T - Shell and Tube C - 47.73 MM Btu/hr M - Shell - Carbon Steel Tubes - Stainless Steel S - 4,000 sq ft Des P/T - Shell - 75 psig/110°F Tubes - 350 psig/370°F
209-2201	3	<u>First Stage Knockout Drum</u> T - Vertical, Cylindrical S - 13.25' ID x 25' T-T w/Demister M - Carbon Steel w/Stainless Steel 410 cladding for bottom 5' Des P/T - 150 psig/150°F
209-2202	3	<u>Second Stage Knockout Drum</u> T - Vertical, Cylindrical S - 10.25' ID x 25' T-T w/Demister M - Carbon Steel w/Stainless Steel 410 cladding for bottom 5' Des P/T - 350 psig/150°F
209-2501	3	<u>Vacuum Condensate Package</u> This system is to condense 309,926 lb/hr of steam and supply a turbine back pressure of 2" Hg Abs. Cooling water is available from 65°F to 95°F. This package unit is to include the following: Steam Ejector Condenser Condensate Tank

SHIFT CONVERSION AND COS HYDROLYSIS - AREA 210

EQUIPMENT LIST

NOMENCLATURE:
Y - TYPE
C - CAPACITY
S - SIZE
P/T - OPERATING PRESSURE/
TEMPERATURE
M - MATERIAL
CS - CARBON STEEL
SS - STAINLESS STEEL
CI - CAST IRON
D - DRIVE
W - WEIGHT
ACC - ACCESSORIES

<u>ITEM</u>	<u>NO. REQUIRED</u>	<u>DESCRIPTION</u>
210-1101	3 + 3	<u>Circulation Pump</u> T - Centrifugal C - 3485 GPM @ 745 psig, 335°F, ΔP=80 psi M - Carbon Steel D - 200 hp, Electric
210-1601	6	<u>Gas/Gas Interchanger</u> T - Shell and Tube C - 19.10 MM Btu/hr M - Shell - 1/2 Mo Tubes - 1-1/4 Cr - 1/2 Mo S - 1,420 sq. ft. per shell Des P/T - Shell - 835 psig/575°F Tubes - 820 psig/925°F
210-1602	3	<u>Saturator Water Heater I</u> T - Shell and Tube M - Shell - Carbon Steel Tubes - 1/2 Mo S - 5,200 sq. ft. Des P/T - Shell - 900 psig/500°F Tubes - 820 psig/750°F
210-1603	3	<u>Saturator Water Heater II</u> T - Shell and Tube M - Shell - Carbon Steel Tubes - Stainless Steel S - 4,700 sq. ft. Des P/T - Shell - 925 psig/450°F Tubes - 800 psig/525°F

SHIFT CONVERSION AND COS HYDROLYSIS - AREA 210

EQUIPMENT LIST

<u>ITEM</u>	<u>NO. REQUIRED</u>	<u>DESCRIPTION</u>
210-1604	3	<u>Condensate Heater</u> T - Shell and Tube M - Shell - Carbon Steel Tubes - Stainless Steel S - 7,400 sq. ft. Des P/T - Shell - 150 psig/300°F Tubes - 770 psig/325°F
210-1605	3	<u>Hydrolyzed Gas Condenser</u> T - Fin Fan M - Stainless Steel S - 4,300 sq. ft. bare area Des P/T - 770 psig, 200°F D - 2 x 30 hp, Electric
210-2201	3	<u>Saturator</u> T - Vertical, Cylindrical S - 13' ID x 39' T-T 18' Bed Height, 2390 cu ft of packing M - Carbon Steel Vessel, 2" R.R. Stoneware Packing Des P/T - 850 psig/525°F
210-2202	3	<u>CO Shift Vessel</u> T - Vertical, Cylindrical S - 13.75' ID x 15' T-T 6.8' Bed Height, 1,010 cu ft of packing M - 1.0 Cr - 1/2 Mo Catalyst - Co-Mo-SSK type Des P/T - 850 psig/900°F

SHIFT CONVERSION AND COS HYDROLYSIS - AREA 210

EQUIPMENT LIST

<u>ITEM</u>	<u>NO. REQUIRED</u>	<u>DESCRIPTION</u>
210-2203	3	<u>COS Hydrolysis Vessel</u> T - Vertical, Cylindrical S - 18.75' ID x 24' T-T 14' Bed Height, 3,865 cu ft of packing M - Carbon Steel Catalyst - CKA Alumina Des P/T - 850 psig/600°F
210-2204	3	<u>Knockout Drum I</u> T - Vertical, Cylindrical S - 9.25' ID x 25' T-T w/Demister M - Carbon Steel with Stainless Steel 410 cladding for bottom 5' Des P/T - 770 psig/200°F
210-2205	3	<u>Knockout Drum II</u> T - Vertical, Cylindrical S - 9.25' ID x 25' T-T with Demister M - Carbon Steel with Stainless Steel 410 cladding for bottom 5' Des P/T - 770 psig/150°F

ACID GAS REMOVAL - AREA 211

EQUIPMENT LIST

NOMENCLATURE:
 T - TYPE
 C - CAPACITY
 S - SIZE
 P/T - OPERATING PRESSURE/
 TEMPERATURE
 M - MATERIAL
 CS - CARBON STEEL
 SS - STAINLESS STEEL
 CI - CAST IRON
 D - DRIVE
 W - WEIGHT
 ACC - ACCESSORIES

ITEM	NO. REQUIRED	DESCRIPTION
211-1102	3 + 3	<u>H₂S Lean Solution Pump</u> T - Centrifugal M - Carbon Steel D - 800 hp, Electric
211-1103	3	<u>Selexol Recharge Pump</u> T - Centrifugal C - 1000 GPM @ Atm, Amb, ΔP=100 psi M - Carbon Steel D - 125 hp, Electric
211-1120	3+3	<u>CO₂ Lean Solution Pump</u> T - Centrifugal M - Carbon Steel D - 4,000 hp, Electric
211-1122	3+3	<u>Water Reflux Pump</u> T - Centrifugal M - Carbon Steel D - 1.0 hp, Electric
211-1301	3	<u>Recycle Gas Compressor I</u> T - Centrifugal S - 620 hp M - Carbon Steel D - Electric

ACID GAS REMOVAL - AREA 211

EQUIPMENT LIST

<u>ITEM</u>	<u>NO. REQUIRED</u>	<u>DESCRIPTION</u>
211-1310	3	<u>Power Recovery Turbine I</u> T - Hydraulic M - Carbon Steel D - 200 hp
211-1311	3	<u>Power Recovery Turbine II</u> T - Hydraulic C - M - Carbon Steel D - 1,160 hp
211-1320	3	<u>Recycle Gas Compressor II</u> T - Centrifugal S - 2,815 hp M - Carbon Steel D - Electric
211-1321	3	<u>CO₂ Vent Blower</u> T - Centrifugal M - Carbon Steel, Rubber Lined D - 1515 hp, Electric
211-1601	3	<u>Recycle Gas Cooler I</u> T - Shell and Tube M - Shell - Carbon Steel Tubes - Carbon Steel S - 590 sq ft Des P/T - Shell - 750 psig/150°F Tubes - 750 psig/150°F

ACID GAS REMOVAL - AREA 211

EQUIPMENT LIST

<u>ITEM</u>	<u>NO. REQUIRED</u>	<u>DESCRIPTION</u>
211-1602	3	<u>Feed Gas Cooler</u> T - Shell and Tube M - Shell - Carbon Steel Tubes - 316 Stainless Steel S - 3,200 sq ft Des P/T - Shell - 750 psig/150°F Tubes - 750 psig/150°F
211-1603	3	<u>Lean/Rich Solution Exchanger</u> T - Shell and Tube M - Shell - Carbon Steel Tubes - Carbon Steel S - 14,200 sq ft Des P/T - Shell - 150 psig/350°F Tubes - 750 psig/350°F
211-1604	3	<u>Recycle Compressor Gas Cooler</u> T - Shell and Tube M - Shell - Carbon Steel Tubes - Carbon Steel S - 180 sq ft Des P/T - Shell - 100 psig/150°F Tubes - 800 psig/450°F
211-1607	3	<u>Feed Gas - Process Gas Cooler</u> T - Shell and Tube M - Shell - Carbon Steel Tubes - 316 Stainless Steel S - 2,600 sq ft Des P/T - Shell - 750 psig/150°F Tubes - 750 psig/150°F

ACID GAS REMOVAL - AREA 211

EQUIPMENT LIST

<u>ITEM</u>	<u>NO. REQUIRED</u>	<u>DESCRIPTION</u>
211-1608	3	<u>CO₂ Vent Gas - Feed Gas Cooler</u> T - Shell and Tube M - Shell - Carbon Steel Tube - 316 Stainless Steel S - 1550 sq ft Des P/T - Shell - 750 psig/150°F Tubes - 750 psig/150°F
211-1610	3	<u>H₂S Stripper Reboiler</u> T - Shell and Tube M - Shell - Carbon Steel Tubes - Carbon Steel S - 3,600 sq ft Des P/T - Shell - 150 psig/360°F Tubes - 85 psig/360°F
211-1611	3	<u>H₂S Stripper Condenser</u> T - Shell and Tube M - Shell - Carbon Steel Tubes - 316 Stainless Steel S - 2,500 sq ft Des P/T - Shell - 150 psig/300°F Tubes - 85 psig/300°F
211-1620	3	<u>Lean Solution Cooler</u> T - Shell and Tube M - Shell - Carbon Steel Tubes - Carbon Steel S - 9,000 sq ft Des P/T - Shell - 350 psig/150°F Tubes - 750 psig/150°F

ACID GAS REMOVAL - AREA 211

EQUIPMENT LIST

<u>ITEM</u>	<u>NO. REQUIRED</u>	<u>DESCRIPTION</u>
211-1621	3	<u>Recycle Gas Cooler II</u> T - Shell and Tube M - Shell - Carbon Steel Tubes - Carbon Steel S - 810 sq ft Des P/T - Shell - 100 psig/150°F Tubes - 800 psig/450°F
211-2201	3	<u>H₂S Absorber</u> T - Packed Tower M - Carbon Steel - SA516-Gr. 70 Des P/T - 750 psig/80°F
211-2202	3	<u>Flash Drum I</u> T - Horizontal M - Carbon Steel - SA516-Gr. 70 Des P/T - 350 psig/75°F
211-2203	3	<u>Feed Gas Knockout Drum</u> T - Vertical, Cylindrical S - 8.5' ID x 27' T-T M - Carbon Steel-SA516-Gr. 70 Des P/T - 780 psig/75°F
211-2204	3	<u>Selexol Storage Tank</u> T - Vertical, Cylindrical C - 100,000 gal M - Carbon Steel Des P/T - Atm/Amb

ACID GAS REMOVAL - AREA 211

EQUIPMENT LIST

<u>ITEM</u>	<u>NO. REQUIRED</u>	<u>DESCRIPTION</u>
211-2210	3	<u>H₂S Stripper</u> T - Packed Tower M - Carbon Steel - SA516-Gr. 70 Des P/T - 85 psig/80°F
211-2211	3	<u>Surge Tank</u> T - Horizontal S - 1.25' ID x 6' M - Carbon Steel - SA516-Gr. 70 Des P/T - 85 psig/260°F
211-2220	3	<u>CO₂ Absorber</u> T - Packed Tower M - Carbon Steel - SA516-Gr. 70 Des P/T - 750 psig/75°F
211-2221	3	<u>Flash Drum II</u> T - Horizontal M - Carbon Steel - SA516-Gr. 70 Des P/T - 270 psig/75°F
211-2222	3	<u>Flash Drum III</u> T - Horizontal M - Carbon Steel - SA516-Gr. 70 Des P/T - 140 psig/75°F

ACID GAS REMOVAL - AREA 211

EQUIPMENT LIST

<u>ITEM</u>	<u>NO. REQUIRED</u>	<u>DESCRIPTION</u>
211-2501	3	<u>Refrigeration Package</u> This system is to remove 40.69 MM Btu/hr of duty at an operating temperature of -5°F.
211-2502	3	<u>CO₂ Vent Stack</u> T - Vent Gas Stack C - 6704 lb-mol/hr CO ₂ Vent Gas MW=44 P/T - 25 psig/77°F M - Carbon Steel

MAKE-UP GAS COMPRESSION - AREA 212

EQUIPMENT LIST

NOMENCLATURE:
 T - TYPE
 C - CAPACITY
 S - SIZE
 P/T - OPERATING PRESSURE/
 TEMPERATURE
 M - MATERIAL
 CS - CARBON STEEL
 SS - STAINLESS STEEL
 CI - CAST IRON
 D - DRIVE
 W - WEIGHT
 ACC - ACCESSORIES

ITEM	NO. REQUIRED	DESCRIPTION
212-1101	3 + 3	<u>Vacuum Condensate Pump</u> T - Centrifugal C - 142 GPM @ 102°F, 1 psia ΔP = 65 psi M - Carbon Steel D - 10 hp, Electric
212-1301	3	<u>Make-Up Gas Compressor</u> T - Single Stage Centrifugal S - 9,600 hp C - 3,205 ICFM @ 645 psig/100°F Des Pi/Ti - Suction - 645 psig/100°F Des Po/To - Discharge - 1,405 psig/277°F D - Steam Turbine
212-1301-1	3	<u>Make-Up Gas Compressor Turbine</u> T - Condensing C - 61,440 lb/hr Steam Pi/Ti/Po - Steam Turbine, 855 psig/840°F/2" Hg abs
212-1601	3	<u>Clean Gas Heater</u> T - Shell and Tube C - 29.78 MM Btu/hr M - Shell - Carbon Steel Tubes - Carbon Steel S - 20,770 sq. ft. Des P/T - Shell - 750 psig/275°F Tubes - 1,550 psig/300°F

MAKE-UP GAS COMPRESSION - AREA 212

EQUIPMENT LIST

<u>ITEM</u>	<u>NO. REQUIRED</u>	<u>DESCRIPTION</u>
212-1602	3	<u>Clean Gas Start-Up Heater</u> T - Shell and Tube C - 29.78 MM Btu/hr M - Shell - Carbon Steel Tubes - Carbon Steel S - 1,760 sq. ft. Des P/T - Shell - 125 psig/375°F Tubes - 750 psig/275°F
212-1603	3	<u>Process Gas Air Cooler</u> T - Fin Fan C - 25.77 MM Btu/hr M - Tubes - Carbon Steel S - 7,540 sq. ft. bare area Des P/T - 750 psig/275°F D - Electric, 4 x 20 hp
212-2201	6	<u>Chlorine Guard</u> T - Vertical, Cylindrical S - 11' ID x 30' T-T 17.9' Bed Height, 1,700 cu ft of Catalyst M - Carbon Steel Catalyst - ICI 59-3 Des P/T - 750 psig/275°F
212-2202	6	<u>Zinc Oxide Bed</u> T - Vertical, Cylindrical S - 14' ID x 35' T-T 27.6' Bed Height, 4,245 cu ft of Catalyst M - Carbon Steel Catalyst - ICI 32-4 Des P/T - 750 psig/275°F

MAKE-UP GAS COMPRESSION - AREA 212

EQUIPMENT LIST

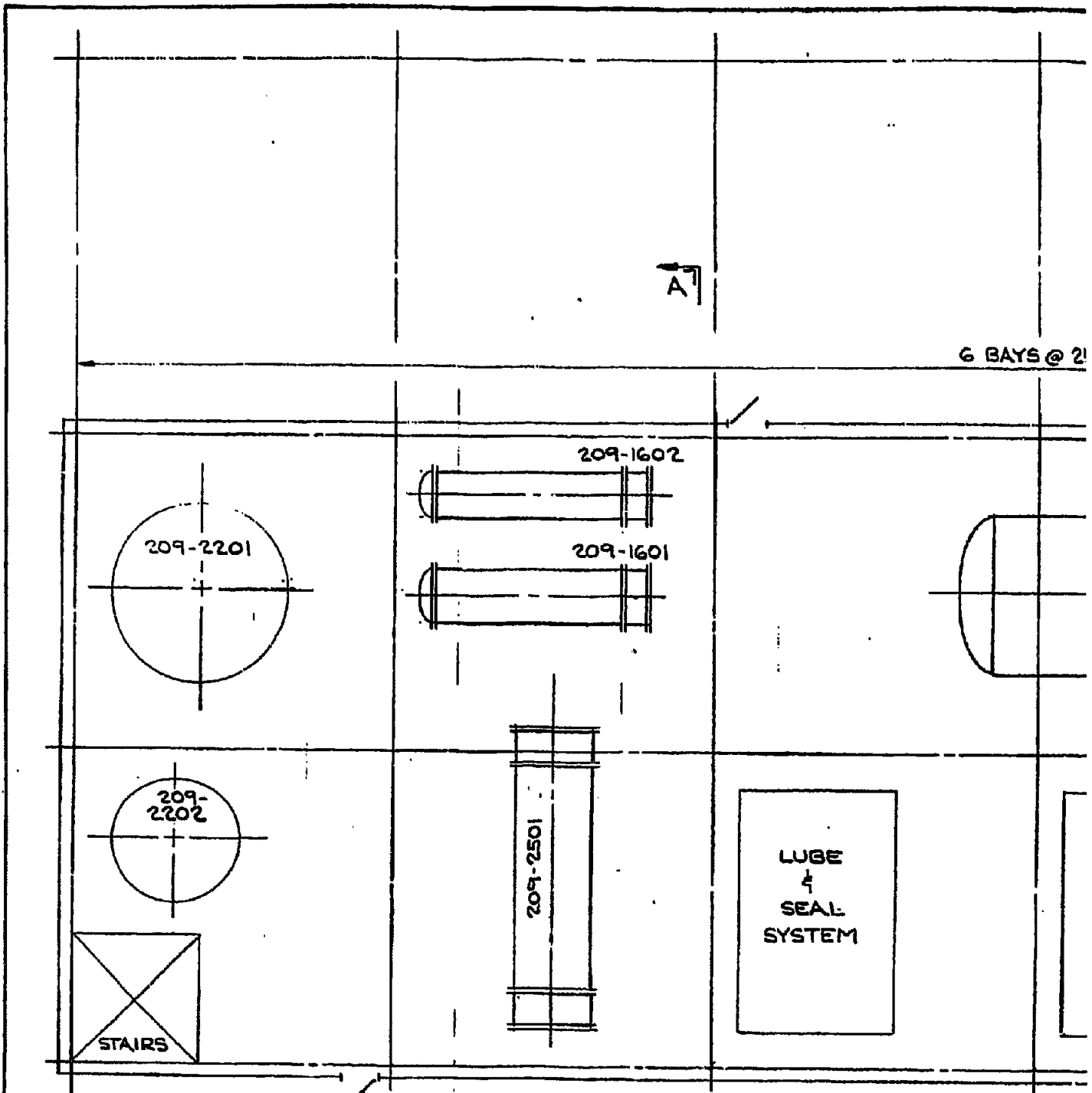
<u>ITEM</u>	<u>NO. REQUIRED</u>	<u>DESCRIPTION</u>
212-2203	3	<u>Knockout Drum</u> T - Vertical, Cylindrical S - 7.5' ID x 17' T-T M - Carbon Steel Des P/T - 1,550 psig/150°F
212-2501	3	<u>Vacuum Condensate Package</u> This system is to condense 61,440 lb/hr of steam and supply a turbine back pressure of 2" Hg Abs. Cooling water is available at 65°F to 95°F. This package unit is to include the following: Steam Ejector Condenser Condensate Tank

SULFUR RECOVERY - AREA 405

EQUIPMENT LIST

NOMENCLATURE:
 T - TYPE
 C - CAPACITY
 S - SIZE
 P/T - OPERATING PRESSURE/
 TEMPERATURE
 M - MATERIAL
 CS - CARBON STEEL
 SS - STAINLESS STEEL
 CI - CAST IRON
 D - DRIVE
 W - WEIGHT
 ACC - ACCESSORIES

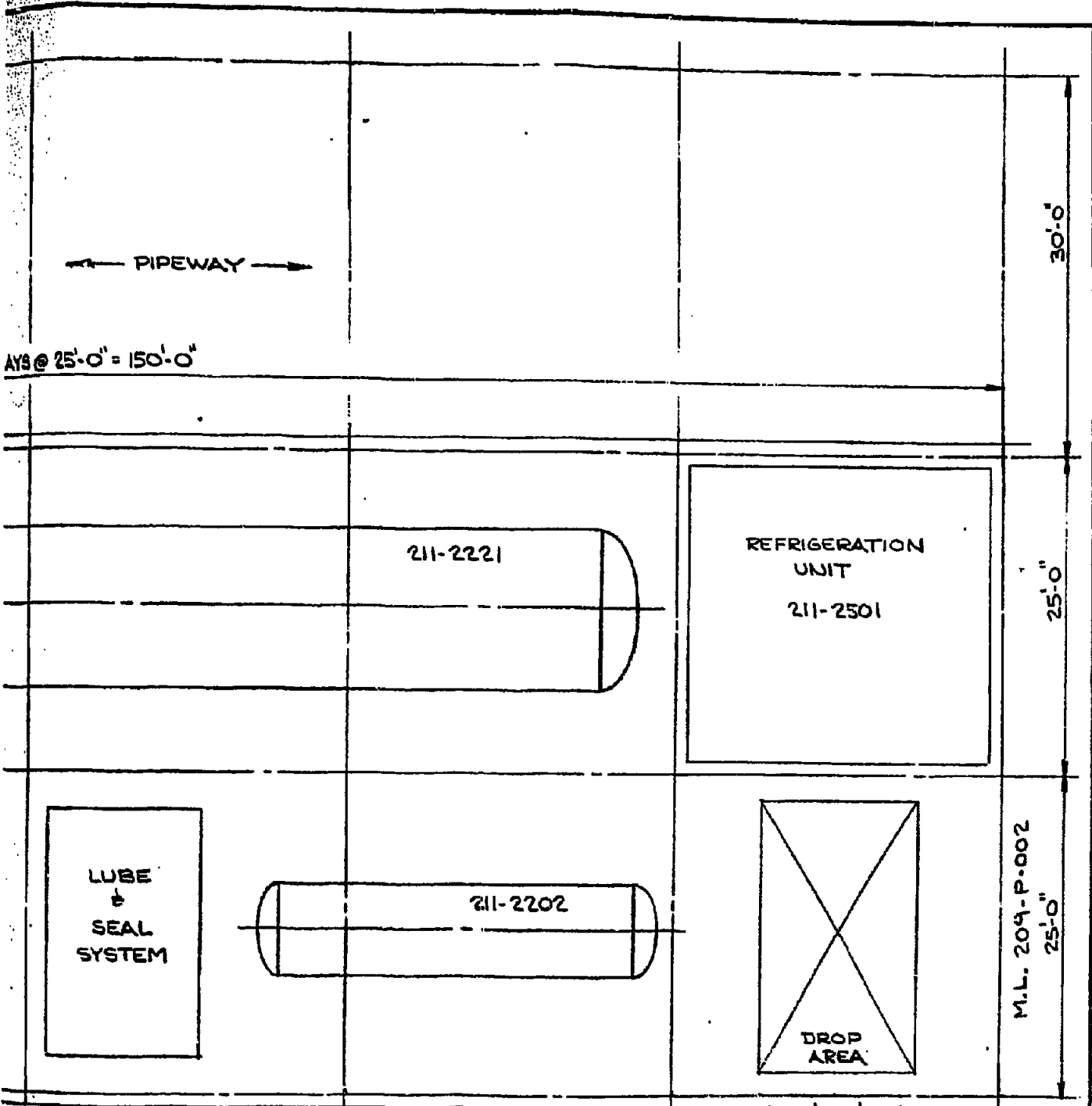
ITEM	NO. REQUIRED	DESCRIPTION
405-2501	3	<p><u>Sulfur Recovery Package</u></p> <p>This package system is to recover 8 STPD of elemental sulfur from 0.52 MM SCFH of gas.</p> <p>This package unit is to include the following:</p>
	1101	1+1 Circulation Pump I
	1102	1+1 Circulation Pump II
	1103	1 Sulfur Slurry Screw Pump
	1105	1 Vertical Pump
	1107	1 Chemical Transfer Pump
	1301	1 Air Blower
	1601	1 Slurry Pre-Heater
	1602	1 Sulfur Melter
	2201	1 Venturi Pre-Absorber
	2202	1 H ₂ S Absorber
	2203	1 Oxidizer Tank
	2204	1 Sulfur Coalescer
	2205	1 Steam Heated Pit
	2207	1 Chemical Inventory Tank
405-2502	1+1	<p><u>Sulfur Flaker</u></p> <p>T - Single Roll Drum C - 2000 lb/hr molten sulfur ACC - Water Cooled</p>
405-2503	1	<p><u>Sulfur Conveyor</u></p> <p>T - Belt Conveyor C - 1.11 TPH S - L = 72', W = 18" D - 3 hp, Electric</p>



(DWG. 209-P-006)

REVISIONS				REVISIONS				REFERENCES			
NO.	DESCRIPTION	BY	CHK.	DATE	NO.	DESCRIPTION	BY	CHK.	DATE	SHEG. NO.	TITLE
A	PREL. REVIEW	GW		6-5-81	0	ISSUED FOR FINAL REPORT	GW		7/20/81		
B	FINAL UPDATE	GW		6-24-81							

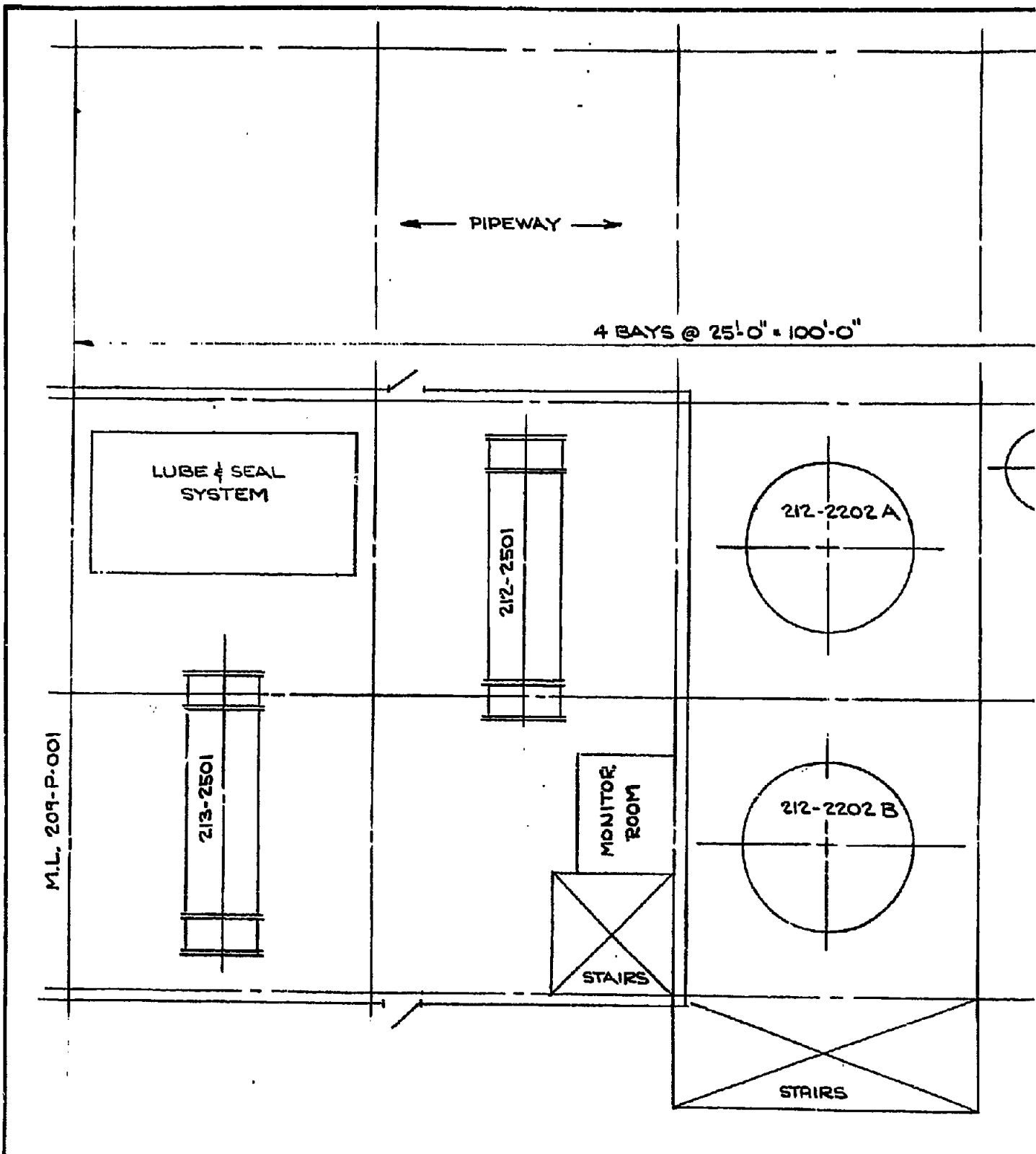
DWG 1158-1 REV. 4/86



AREAS 209 & 211
TYPICAL FOR MODULES 209A, B & C

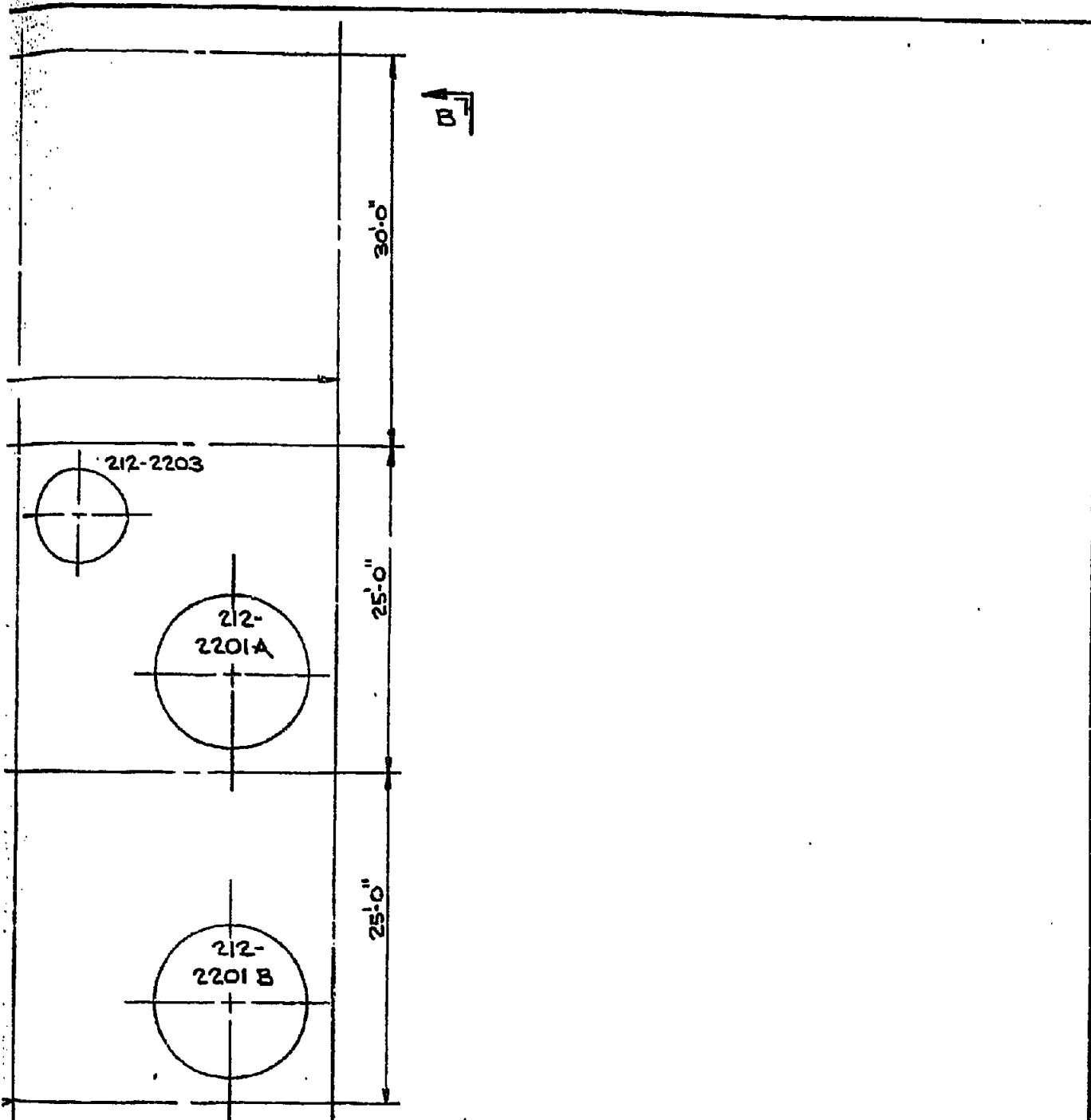
CLIENT CIRI/PLACER BELUGA METHANOL PROJECT COOK INLET, ALASKA		Davy McKee ENGINEERS AND CONSTRUCTORS	
SCALE 1"=10' DRAWING NO. 5530-209-P-001	REV. 	TITLE RAW GAS & METHANOL COMPRESSORS PLAN @ BASE	

APP	BY	DATE
APP	<i>[Signature]</i>	7/20/81
APP		
APP		
APP		



REVISONS				REVISONS				REFERENCES			
NO.	DESCRIPTION	BY	CHK.	DATE	NO.	DESCRIPTION	BY	CHK.	DATE	DWG. NO.	TITLE
A	PREL. REVIEW	CSW		6-5-81	0	ISSUED FOR FINAL REPORT	CSW		7/20/81		

DWG-1209 REV. 4/80



← B
← B
 AREAS 212 & 213
 DWG. 209-P-007 TYP. FOR MODULES 209A, B & C

CLIENT
 CIRI/PLACER
 BELUGA METHANOL PROJECT
 COOK INLET, ALASKA

Davy McKee
 ENGINEERS AND CONSTRUCTORS

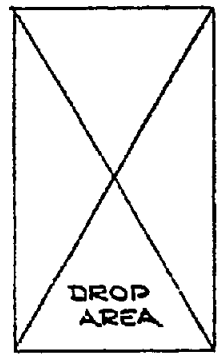
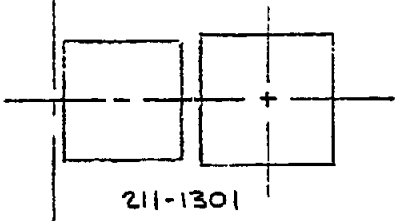
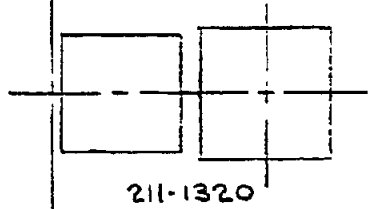
DES	BY	DATE
DRWN		
CHK'D		
APP	<i>gfs</i>	7/20/81
APP		

TITLE
 RAW GAS & METHANOL
 COMPRESSORS
 PLAN @ BASE

SCALE 1"=10'
 DRAWING NO.
 5530-209-P-002

REV.

← PIPEWAY →



M.L. 209-P-004

CLIENT
CIRI / PLACER
BELUGA METHANOL PROJECT
COOK INLET, ALASKA

Davy McKee
ENGINEERS AND CONSTRUCTORS

	DES	BY	DATE
	DRMN		
	CK'D		
	APP	<i>gfb</i>	7/20/81
	APP		

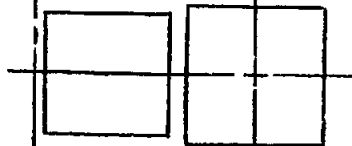
TITLE
RAW GAS & METHANOL
COMPRESSORS
PLAN @ 22'-0"

SCALE 1" = 10'
DRAWING NO.
5530-209-P-003

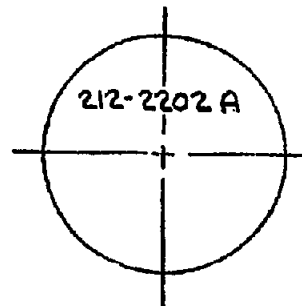
REV.

ML 209-P-003

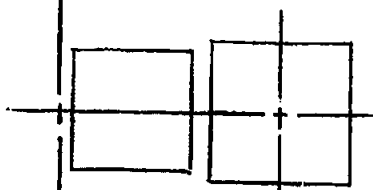
← PIPEWAY →



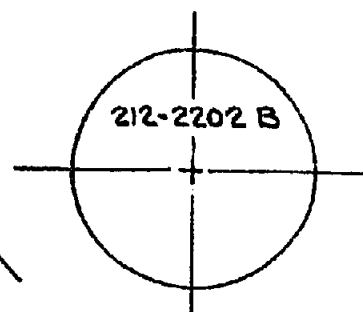
212-1301



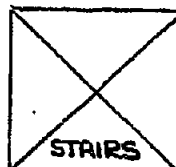
212-2202 A



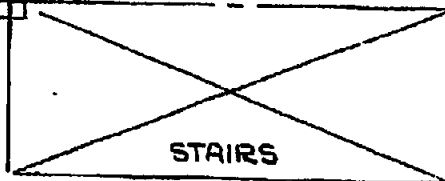
213-1301



212-2202 B



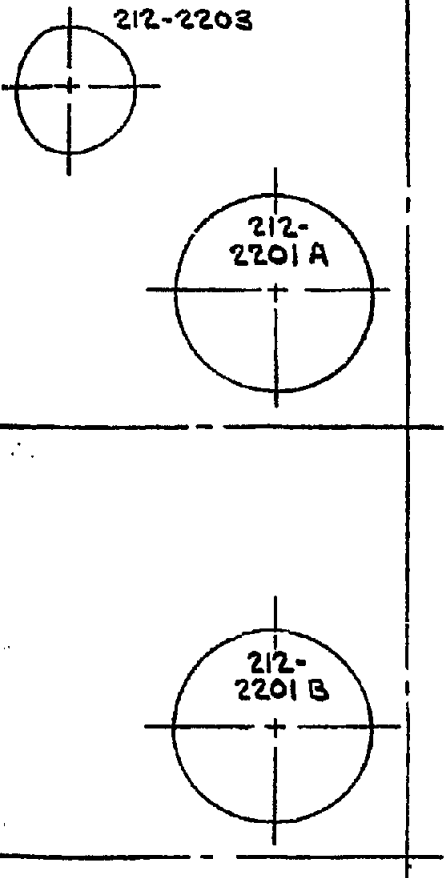
STAIRS



STAIRS

REVISIONS				REVISIONS				REFERENCES			
NO.	DESCRIPTION	BY	CHK.	DATE	NO.	DESCRIPTION	BY	CHK.	DATE	CHG. NO.	TITLE
A	PREL. REVIEW	GW		6-5-81	0	ISSUED FOR FINAL REPORT	GW		7/20/81		

DRAWING REV. 4/81



CLIENT
 CIRI/ PLACER
 BELUGA METHANOL PROJECT
 COOK INLET, ALASKA

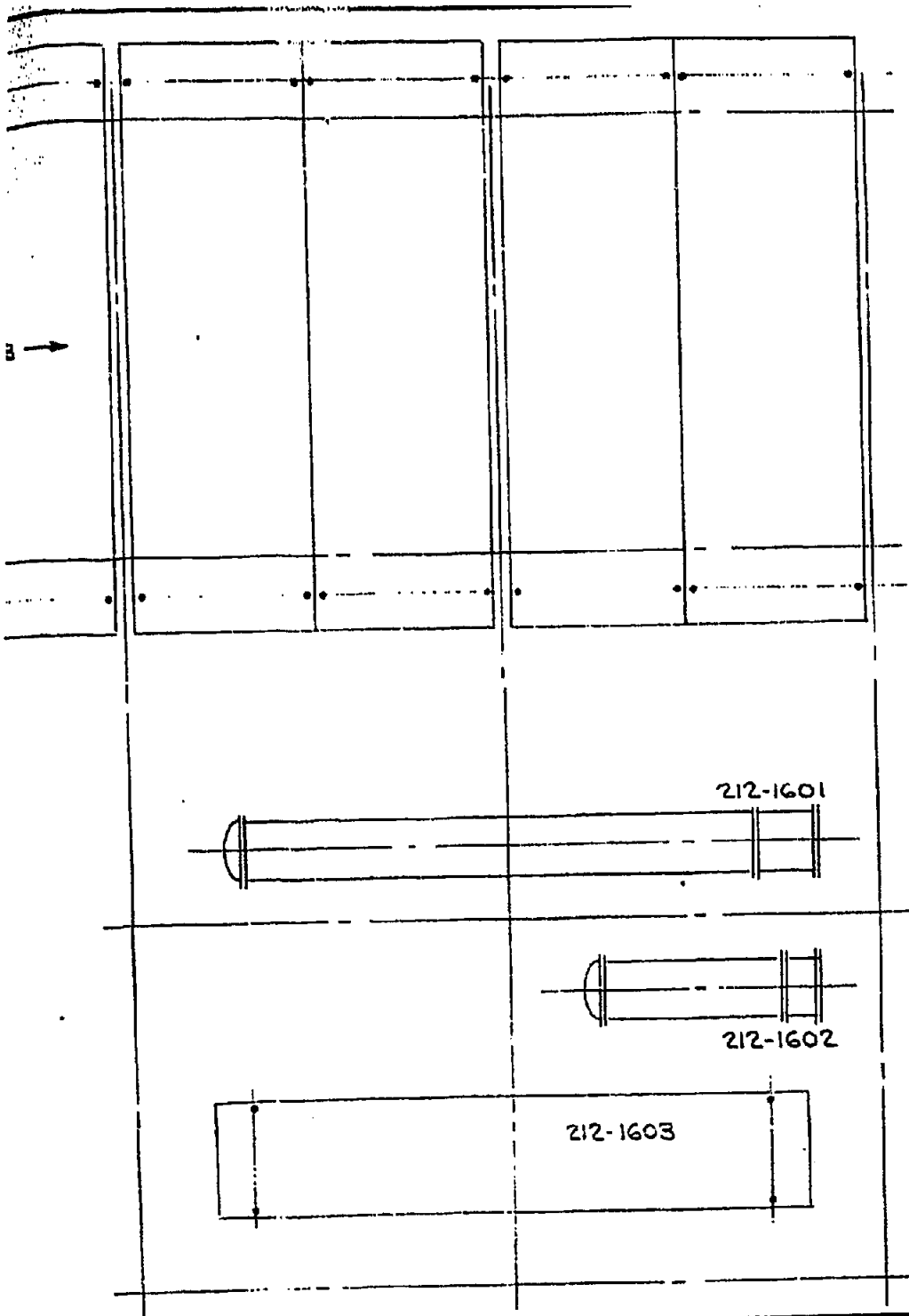
Davy McKee
 ENGINEERS AND CONSTRUCTORS

DES	BY	DATE
DRWN		
CHK'D		
APP	<i>[Signature]</i>	7/20/81
APP		

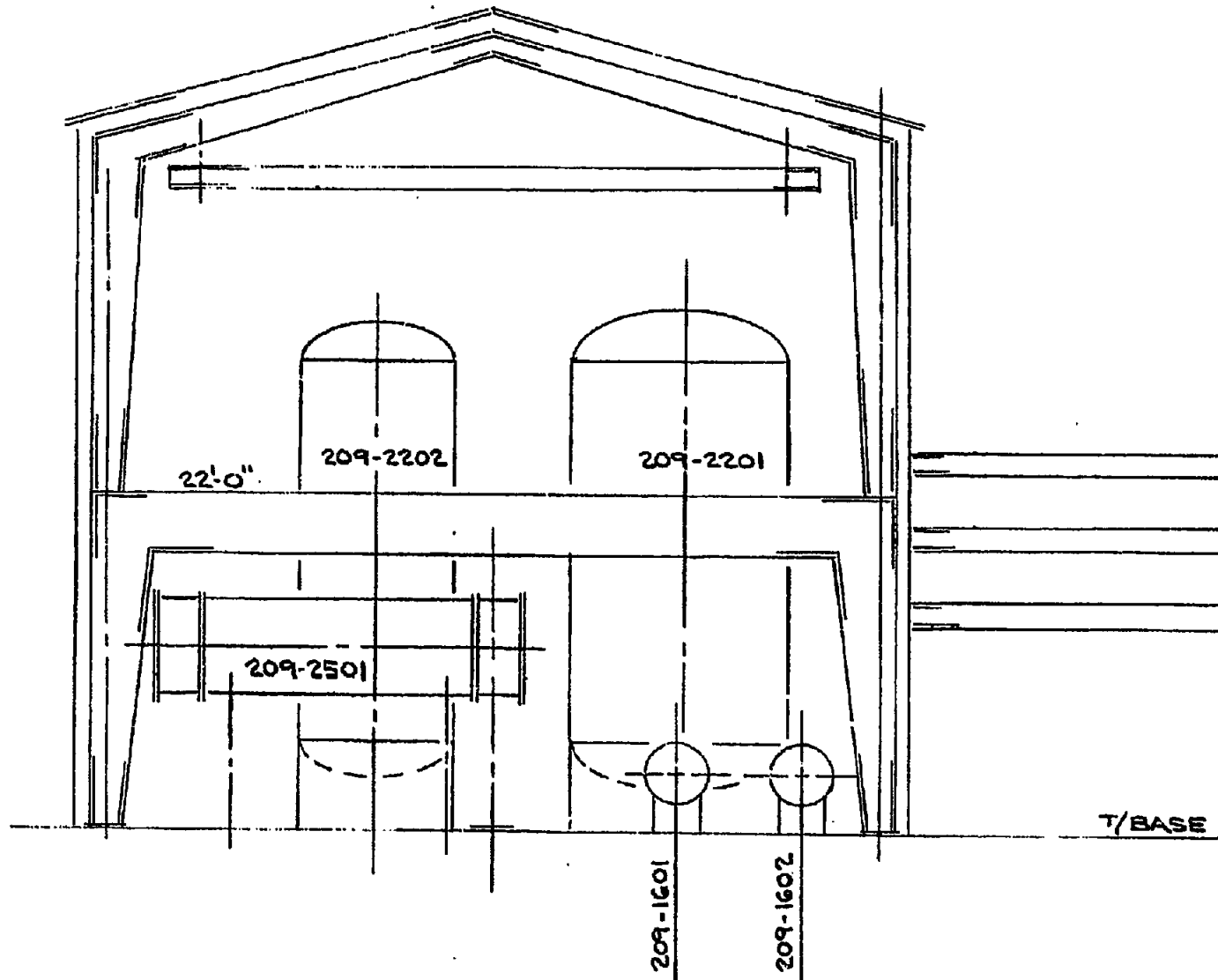
TITLE
 RAW GAS & METHANOL
 COMPRESSORS
 PLAN @ 22'-0"

SCALE 1" = 10'
 DRAWING NO.
 5530-209-P-004

REV.



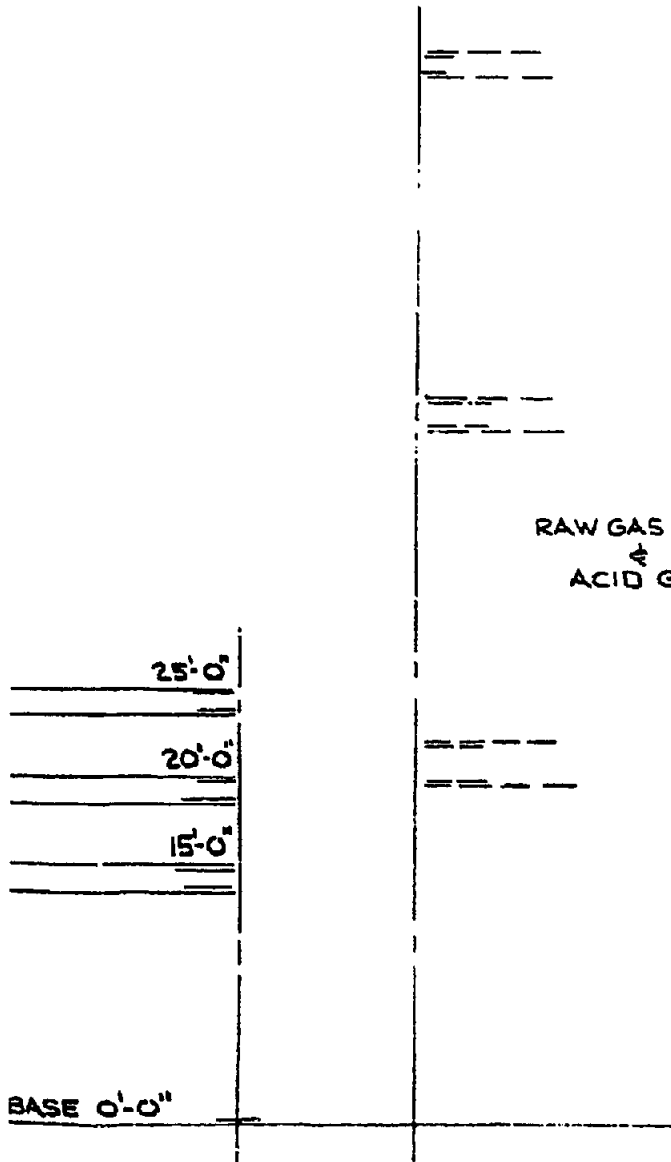
CLIENT			CIRI/PLACER BELUGA METHANOL PROJECT COOK INLET, ALASKA		Davy McKee ENGINEERS AND CONSTRUCTORS	
TITLE			RAN GAS & METHANOL COMPRESSORS PLAN @ 54'-0"		SCALE 1" = 10'	
DES					DRAWING NO.	
BY					5530-209-P-005	
DATE					REV.	
DRN						
CK'D						
APP						
APP						



SECTION A-A
(DWG. 209-P-001)

REVISIONS				REVISIONS				REFERENCES			
NO.	DESCRIPTION	BY	CHK.	DATE	NO.	DESCRIPTION	BY	CHK.	DATE	DWG. NO.	TITLE
A	PREL. REVIEW	GW		6-5-81	0	ISSUED FOR FINAL REPORT	GW		7/10/81		

209-1234 REV. 4/80



CLIENT
 CIRI/PLACER
 BELUGA METHANOL PROJECT
 COOK INLET, ALASKA

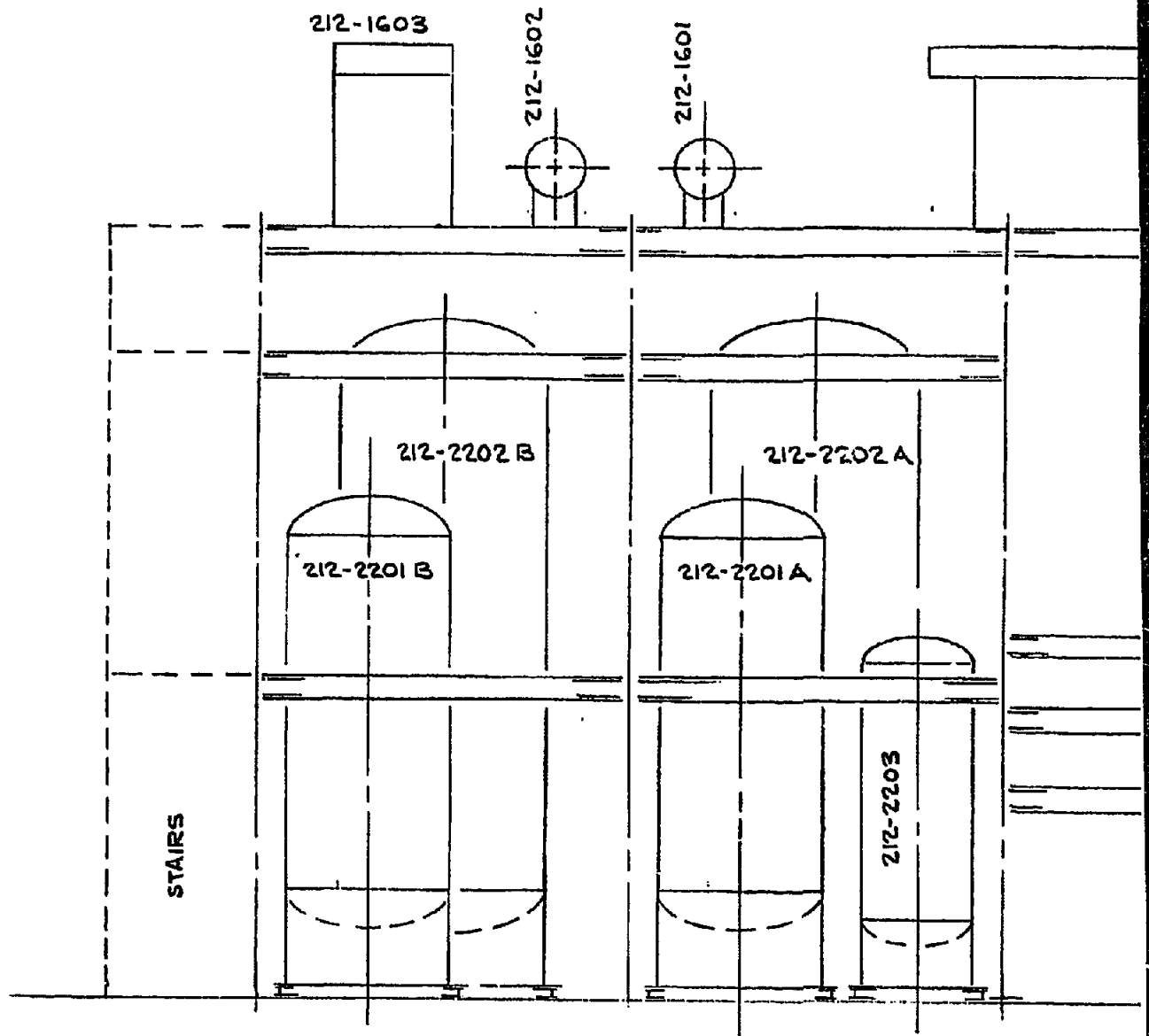
Davy McKee
 ENGINEERS AND CONSTRUCTORS

DES	BY	DATE
DESIGN		
CHK'D		
APP	<i>[Signature]</i>	7/30/81
APP		

TITLE
 RAW GAS & METHANOL
 COMPRESSORS
 SECTION A-A

SCALE 1" = 10'
 DRAWING NO.
 5530-209-P-006

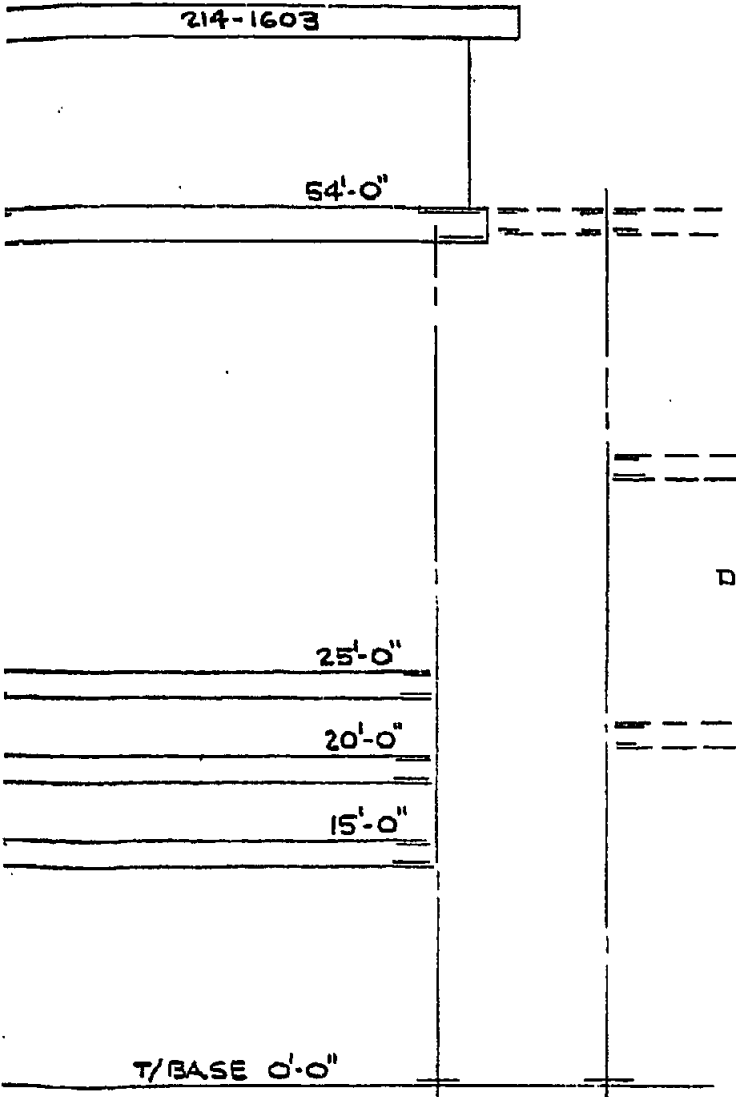




SECTION B-B
(DWG. 209-P-002)

REVISIONS					REVISIONS					REFERENCES	
NO.	DESCRIPTION	BY	CHK.	DATE	NO.	DESCRIPTION	BY	CHK.	DATE	DWG. NO.	TITLE
A	PREL. REVIEW	GW		6-5-81	0	ISSUED FOR FINAL REPORT	GW		7/30/81		

DWG-209-P-002 REV. A/80



DISTILLATION
UNIT

CLIENT
CIRI/PLACER
BELUGA METHANOL PROJECT
COOK INLET, ALASKA

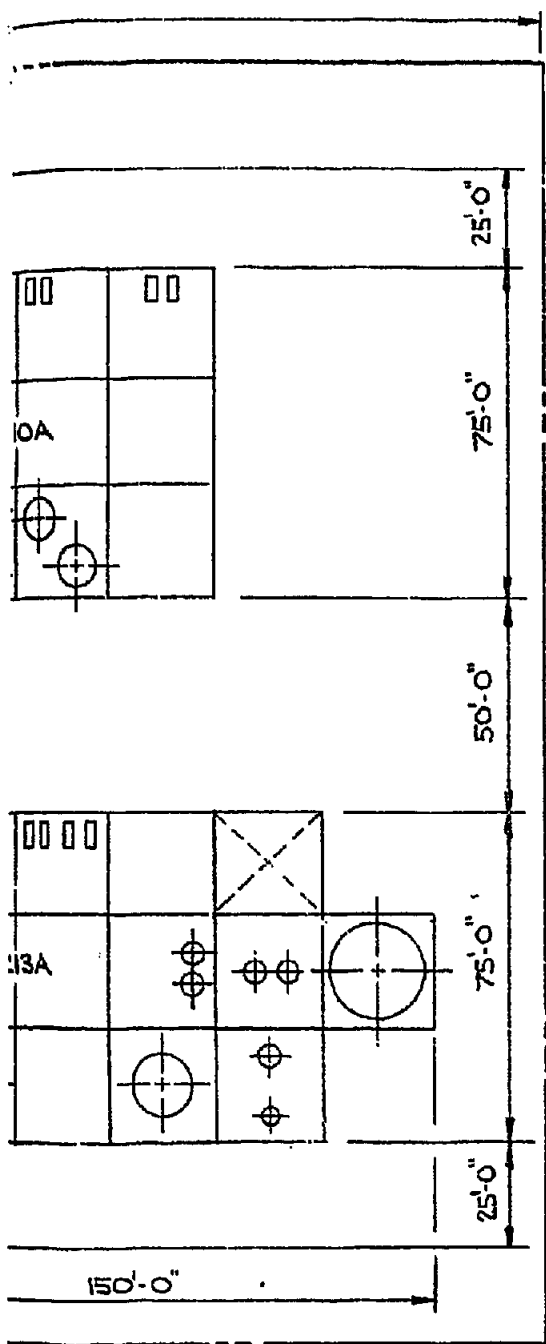
Davy McKee
ENGINEERS AND CONSTRUCTORS

DES	BY	DATE
DRNH		
CK'D		
APP	<i>[Signature]</i>	7/20/81
APP	<i>[Signature]</i>	

TITLE
RAW GAS & METHANOL
COMPRESSORS
SECTION B-B

SCALE 1" = 10'
DRAWING NO.
5530-209-P-007

REV.



TYP. FOR MODULES 209A, B & C, 210A, B & C, 213A, B & C

CLIENT			CIRI/PLACER BELUGA METHANOL PROJECT COOK INLET, ALASKA		Davy McKee ENGINEERS AND CONSTRUCTORS	
DES	BY	DATE	TITLE		SCALE 1"=40'	REV.
DRWN	S. WATKINS	6-10-81	RAW GAS & METHANOL AREA		DRAWING NO.	
CHK'D			GENERAL ARRANGEMENT		5530-210-P-001	
APP	<i>[Signature]</i>	7/20/81				
APP	<i>[Signature]</i>					

TYP. ALL PLANS

B ↓

210-1101

3 BAYS @ 25'-0" = 75'-0"

A ↑

TYP. ALL PLANS

AREAS 210 & 211

TYPICAL FOR
MODULES 210A, B & C

CLIENT
CIRI/PLACER
BELUGA METHANOL PROJECT
COOK INLET, ALASKA

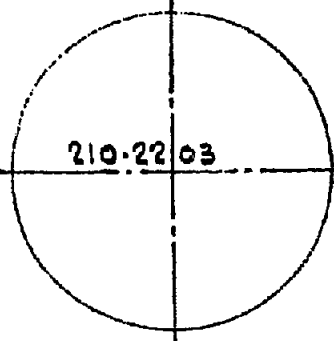
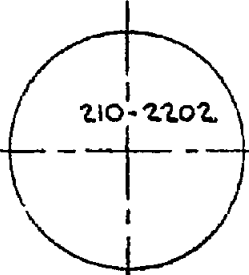
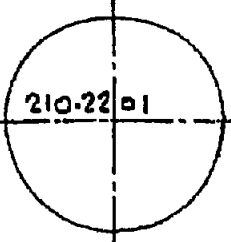
Davy McKee
ENGINEERS AND CONSTRUCTORS

DES	BY	DATE
DRAWN		
CK'D		
APP	<i>[Signature]</i>	7/20/81
APP		

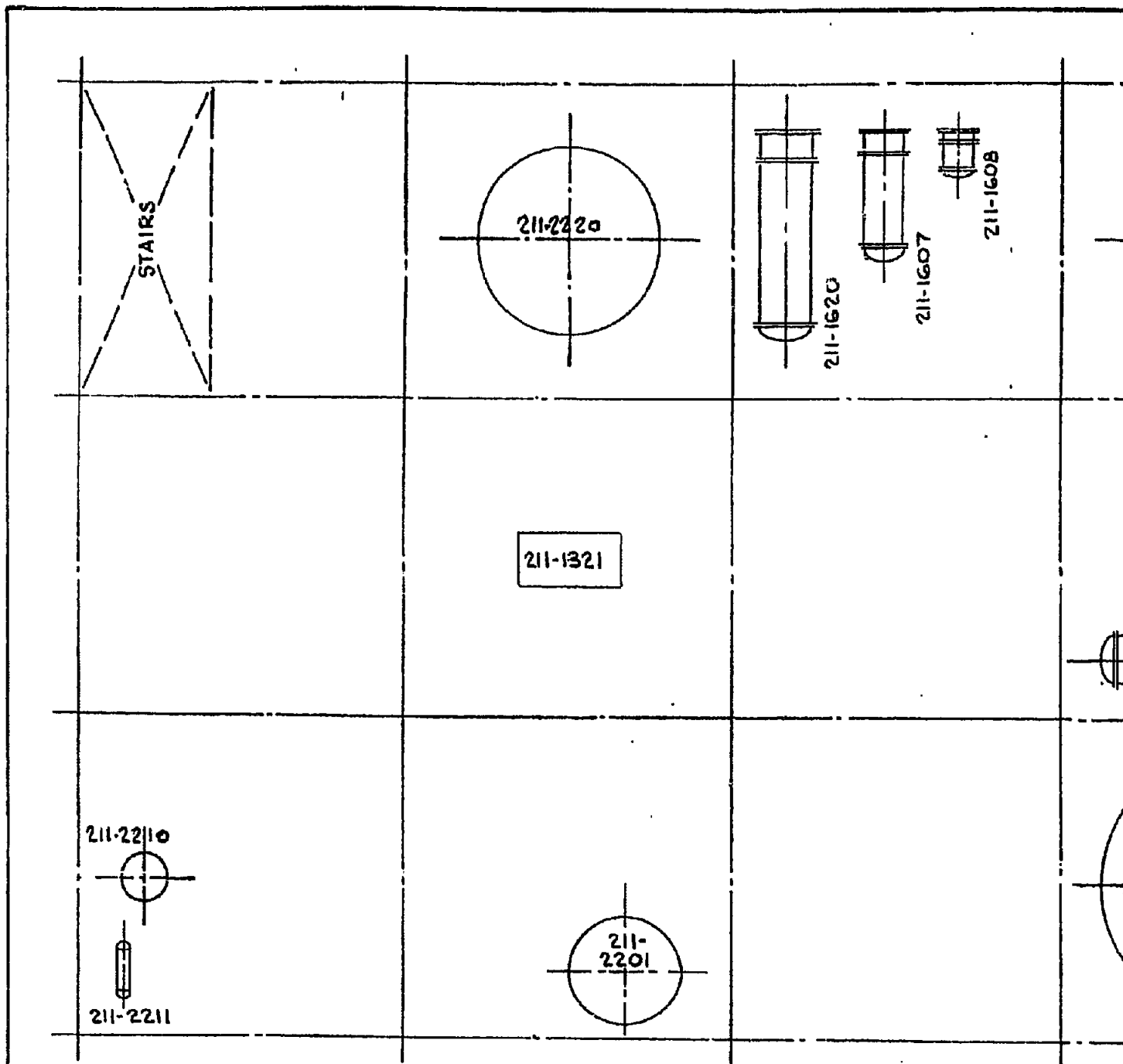
TITLE
RAW GAS SHIFT & ACID GAS
REMOVAL
PLAN @ BASE

SCALE 1" = 10'
DRAWING NO.
5530-210-P-002

REV.

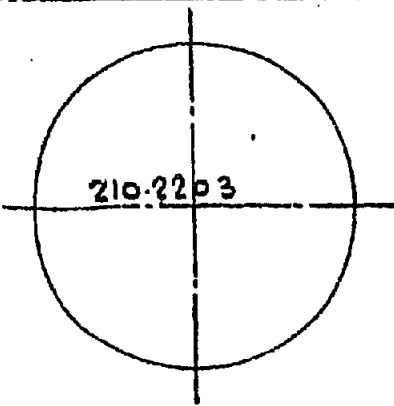
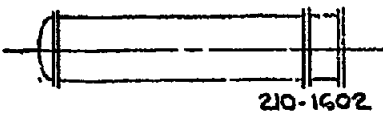
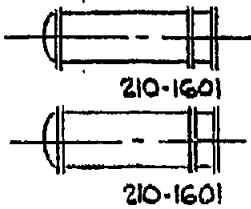
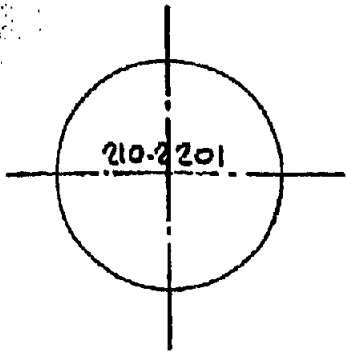



CLIENT			CIRI/PLACER BELUGA METHANOL PROJECT COOK INLET, ALASKA	Davy McKee ENGINEERS AND CONSTRUCTORS	SCALE 1" = 10'	REV.
TITLE			RAW GAS SHIFT & ACID GAS REMOVAL PLAN @ 22'-0"		DRAWING NO.	
DES	BY	DATE			5530-210-P-003	
DRNH						
CK'D						
APP	<i>[Signature]</i>	7/24/01				
APP						



REVISIONS				REVISIONS				REFERENCES	
NO.	DESCRIPTION	BY	CHK. DATE	NO.	DESCRIPTION	BY	CHK. DATE	DMG. NO.	TITLE
A	PREL. REVIEW	W.J.S	2-3-81	0	ISSUED FOR FINAL REPORT	GW	7/20/81		
B	FINAL UPDATE	GW	6-2-81						
C	REVISED	GW	6-24-81						

DRAFT-1 REV. 4/80



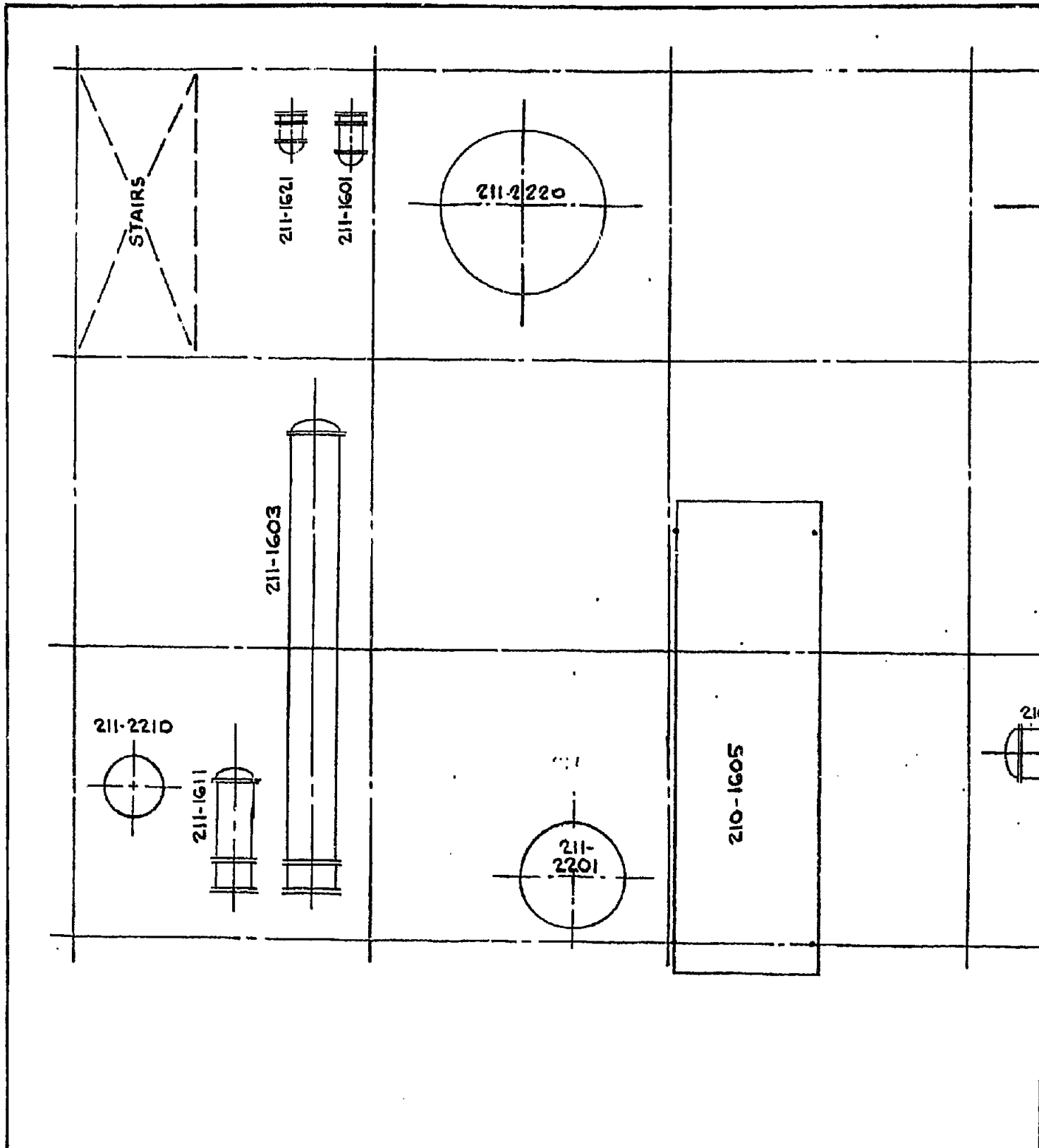
CLIENT
 CIRI/PLACER
 BELUGA METHANOL PROJECT
 COOK INLET, ALASKA

Davy McKee
 ENGINEERS AND CONSTRUCTORS

DES	BY	DATE
DRMN		
CK'D		
APP	<i>JFB</i>	7/20/81
APP		

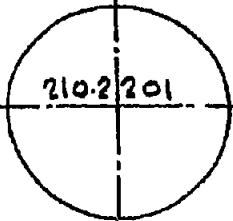
TITLE
 RAW GAS SHIFT & ACID GAS
 REMOVAL
 PLAN @ 42'-0"

SCALE " = 1'	REV.
DRAWING NO. 5530-210-P-004	

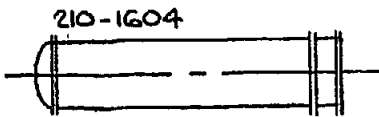


REVISIONS				REVISIONS				REFERENCES	
NO.	DESCRIPTION	BY	CHK. DATE	NO.	DESCRIPTION	BY	CHK. DATE	DWG. NO.	TITLE
A	PREL. REVIEW	W.J.S.	2-3-81	0	ISSUED FOR FINAL REPORT	GU	7/20/81		
B	FINAL UPDATE	GW	6-2-81						

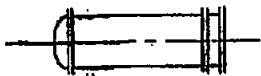
211-1603-1 REV. 4/80



210-2201



210-1604



210-1603

CLIENT

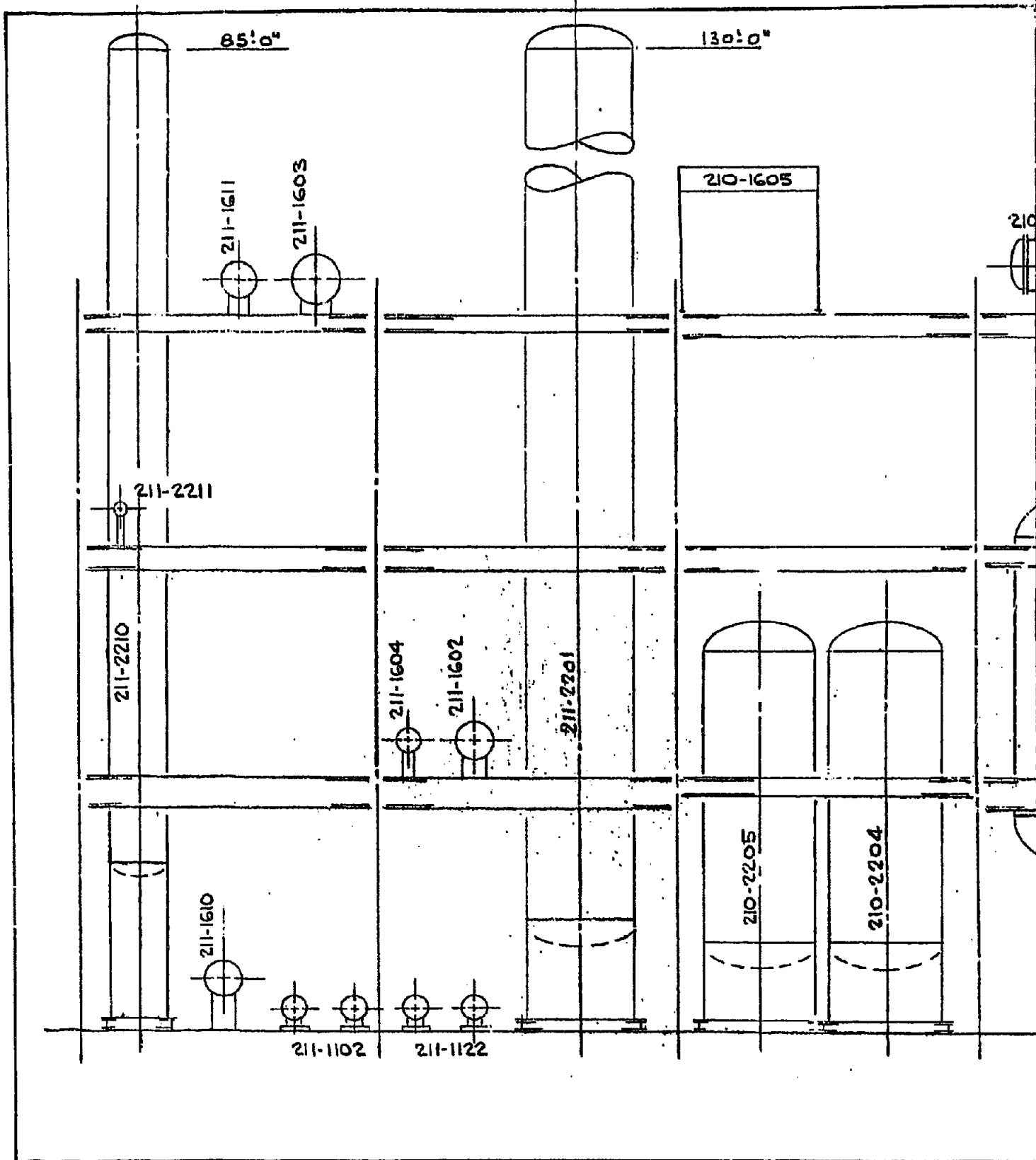
CIRI/PLACER
 BELUGA METHANOL PROJECT
 COOK INLET, ALASKA

Davy McKee
 ENGINEERS AND CONSTRUCTORS

DES	BY	DATE
DRNH		
CK'D		
APP	<i>rfh</i>	7/20/81
APP		

TITLE
 RAW GAS SHIFT & ACID GAS
 REMOVAL
 PLAN ABOVE 62'-0"

SCALE 1"=10'	REV.
DRAWING NO.	
5530-210-P-005	

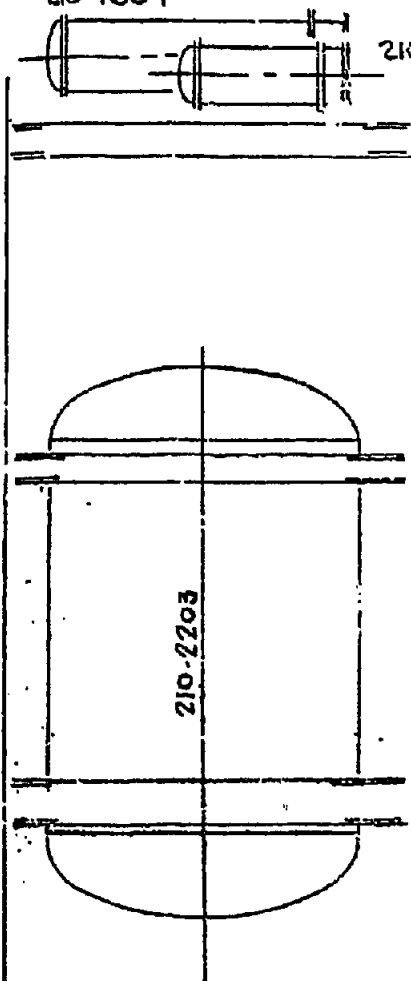


REVISIONS				REVISIONS				REFERENCES	
NO.	DESCRIPTION	BY	CHK. DATE	NO.	DESCRIPTION	BY	CHK. DATE	ORG. NO.	TITLE
A	PREL. REVIEW	W.J.S	2-3-81	0	ISSUED FOR FINAL REPORT	GW	7/20/81		
B	FINAL UPDATE	GW	6-2-81						

DAP-1128-1 REV. 4/80

210-1604

210-1603



62'-0"

42'-0"

22'-0"

TOP OF BASE 0'-0"

CLIENT
 CIRI/PLACER
 BELUGA METHANOL PROJECT
 COOK INLET, ALASKA

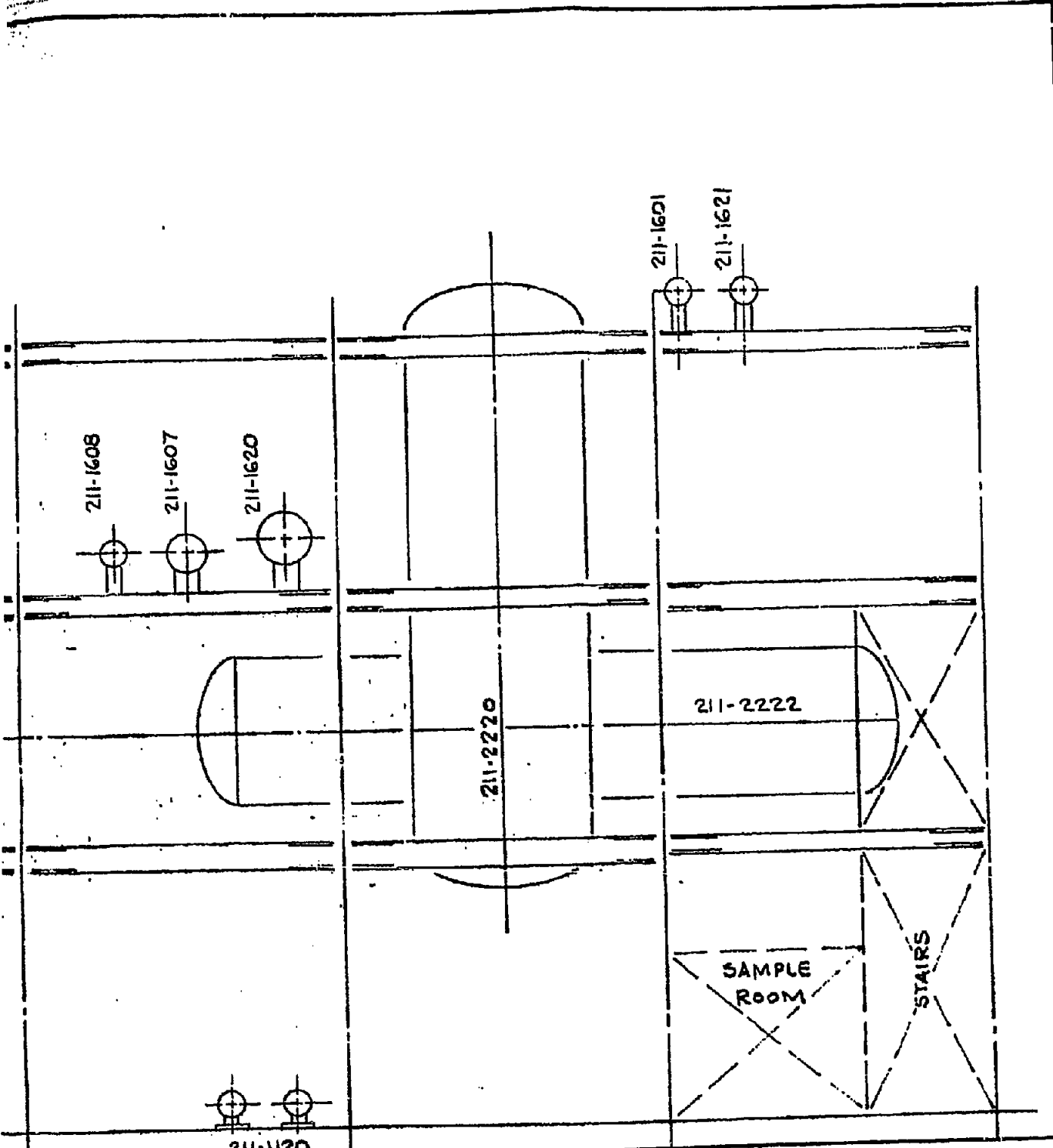
Davy McKee
 ENGINEERS AND CONSTRUCTORS

DES	BY	DATE
DRMN		
CK'D		
APP	<i>gfs</i>	7/20/91
APP		

TITLE
 RAW GAS SHIFT & ACID GAS
 REMOVAL
 ELEVATION A-A

SCALE 1"=10'
 DRAWING NO.
 5530-210-P-006

REV.



CLIENT
 CIRI/PLACER
 BELUGA METHANOL PROJECT
 COOK INLET, ALASKA

Davy McKee
 ENGINEERS AND CONSTRUCTORS

DES	BY	DATE
DRHN		
CK'D		
APP	<i>enfs.</i>	7/20/81
APP		

TITLE
 RAW GAS SHIFT & ACID GAS
 REMOVAL
 ELEVATION B-B

SCALE 1"=10'
 DRAWING NO.
 5530-210-P-007

REV.