DOE/MC/27423 -- 5753
(DE97005456)

Moving Bed Granular Bed Filter Development Program

Topical Report
September 1994

By:
J.C. Haas
J.W. Prudhomme
K. W. Wilson

Work Performed Under Contract No.: DE-AC21-90MC27423

For
U.S. Department of Energy
Office of Fossil Energy
Federal Energy Technology Center
Morgantown Site
Morgantown, West Virginia

By
Combustion Power Company
Oakland, California

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P.O. Box 880
Morgantown, West Virginia 26507-0880

By
Combustion Power Company
201 Webster Street
Suite 1700
Oakland, California 94612

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1.0 INTRODUCTION

Five test arrangements have been designed to support the Granular Bed Filter Development Program as defined in the Test Plan described in Task 3. The first arrangement is a 3.6 ft diameter half filter, with a glass covering along the cross section to allow visual examination of the granular alumina material passing through the filter. This unit will be used to evaluate up to 4 different filter discharge hopper designs and two different air inlet pipe configurations.

The second test arrangement is a 3.6 ft diameter full size filter having refractory lining to simulate actual surface roughness conditions. Results from the half filter testing will be applied to the hopper and inlet pipe design and positioning on the full size filter.

The third test arrangement will examine filter geometry scale up by testing a 6.0 ft diameter full size filter. The 6.0 ft filter will also have refractory lining to simulate actual surface roughness. All three of the filter units will be supported from a common structure and will use a common pneumatic transport system to circulate alumina from the filter drain back to the filter top.

The forth Test Arrangement consists of a small 12 inch diameter fluidizer to measure the minimum fluidization velocity of the 7 mm (approximate size) alumina material to be used in the filter assemblies.

The last Test Unit is used to evaluate relative abrasion characteristics of potential refractory and ceramic materials to be installed in high abrasion areas in the pneumatic transport piping. The unit consists of several 40" diameter cylinders each having a liner sample and alumina material. Each revolution alumina falls on to the liner surface causing some level of abrasion. The test is designed to run for 1000 hrs.

2.0 DESCRIPTION OF PROCESS CONTROLS

2.1 Granular Bed Filter Controls

The instrumentation and valving for the granular bed filter test units are defined on the Piping and Instrument Diagram included in this report. Air is supplied to the filter inlet using one or two blowers, depending on the filter size and capacity. Air flow is controlled manually with butterfly valves at each blower inlet. Flow is measured using an orifice.

For some of the planned tests, ash is introduced into the inlet air stream to determine the effects of ash on alumina material flow characteristics. The ash is from a local coal fired power plant and is metered into the air stream using a small bin with a variable speed, screw conveyor. An eductor is used to overcome the inlet air pressure and pneumatically convey the ash to the filter inlet pipe.

Inside the filter, the ash is captured by the granular alumina material and clean air exits the filter top. The test arrangement is located outdoors so the filter top is open to atmosphere. The filter material and ash drain out the filter bottom through a seal leg to a pneumatic lift pipe to return the alumina back to the filter top for another cycle. During the pneumatic transport process, ash is dislodged from the alumina and the ash exits with the lift air at the de-entrainment Vessel, due to the size and density difference. Instrumentation is positioned on the filter to manually record filter pressure drop, filter seal leg pressure drops, lift pipe pressure drop and de-entrainment vessel pressure. The filter pressure drop versus filter air flow are important performance measurements. The seal leg pressure drop is used to confirm that air is exiting from the filter rather than entering the filter at the seal leg. The out flow of air at the seal leg is necessary to maintain proper ash flow draining from the filter. A bleed line is mounted from the seal leg to the ash collection baghouse to maintain air flow down the seal leg when lift pipe air pressure is higher than the filter pressure.

The alumina circulation rate is controlled by varying the amount of injection air on the "L- Valve" at the base of the seal leg. The alumina flow rate is proportional to the lift pipe pressure drop and is used to set the circulation rate. A sight glass is mounted on the seal leg to visually measure the alumina velocity which is used to confirm the material mass flow. The lift air is supplied by a separate positive displacement type blower. The lift air flow is established by venting excess air at the blower discharge because the blower has fixed speed.

In addition to filter pressure drop, the filter flow characteristics will be determined by measuring the air flow distribution at the filter top using a thermoanemometer (designed for low air velocities). The alumina flow distribution will be determined by the movement of metal rods which descend into the filter with the alumina granules. The 3.6 ft diameter half filter will also allow visual observation of the alumina flow profile.

From the de-entrainment vessel, ash is pneumatically transported to a baghouse where the ash is separated from the air. The ash particles drain from the baghouse hopper to a 55 gallon drum for reuse or disposal. A suction fan is mounted downstream of the baghouse to control the de-entrainment vessel near atmospheric pressure. The fan is controlled manually by adjusting the inlet butterfly, similar to the air supply blowers.

2.2 Alumina Fluidizer Controls

The fluidizer unit is used to measure the minimum fluidization velocity of the 7 mm alumina material. Fluidizing air is supplied by one of the air supply blowers as described in Section 2.1. The unit is operated by gradually increasing the air flow while measuring the pressure drop across the bed until the bed begins to fluidize. The pressure drop versus air flow data as well as visual observation determine when fluidization begins.

2.3 Lift Pipe Liner Abrasion Unit Controls

Candidate refractory and ceramic materials will be tested for abrasion using a rotating drum abrasion test unit. Each refractory sample will be mounted in a separate fabricated enclosed cylinder along with a defined amount of 7 mm alumina. With each revolution alumina will drop on the test sample surface at a velocity similar to that inside the filter pneumatic lift pipe.

Each sample will be fired to typical operating temperatures (~1600 F) and weighed before testing. The cylinders are then assembled together to form one drum which mounts on a standard drum rotator. The 1/2 horsepower drum rotator operates at ~ 10 RPM for 1000 Hours. Each refractory sample is divided into two sections to simplify casting and each weigh approximately 30 lbs, depending on the sample thickness and material. The dust and media will be collected and weighed for mass balance.

3.0 DESCRIPTION OF SAMPLING AND ANALYTICAL EQUIPMENT

- Toledo Digital Scale (0-100 lbs, accuracy to .01 lbs)
- Triple Beam Balance (0-2 kg, accuracy to .1 g)

4.0 EQUIPMENT SPECIFICATIONS

ITEM	MANUFACTURER	STATUS	CAPACITY
Air Supply Blower No.1	Hoffman	Existing	2570 ACFM at 6.3 PSIG
Air Supply Blower No.2	Lamson or Eq.	Rental	2100 ACFM at 6.3 PSIG
Ash Eductor	CPC or Fox	New	2" Dia
Ash Feeder	Acrison or Eq.	Rental	12 Lb/Hr
Granular Bed Filter	CPC	New	3.6 and 6.0 Ft Dia
Bleed Eductor	CPC or Fox	New	1.5" Dia
Lift System PD Blower	PEGO or Eq.	Rental	260 ACFM at 6 PSIG
Baghouse	Micropul	Existing	900 ACFM at 6:1 Air/ Cloth
Suction Fan	Buffalo Forge	Existing	850 ACFM at 16 IWG static DP
Air Compressor	US Rental	Rental	100 SCFM at 100 PSIG
Fluidizer	CPC	New	12" Dia
Abrasion Test Drums	CPC	New	40" Dia
Drum Rotator	Advanced Handling Sys.	New	400 Lbs max at 10 RPM

5.0 INSTRUMENT AND VALVE SPECIFICATIONS

INSTRUMENTS:

PCV	105	Air Pressure Regulator	Any	0-30 PSIG	
PI	105	Regulator Pressure Gauge	Any	0-30 PSIG	
TI	108	Inlet Air Temperature		0-250 F	Bi-metalic
FE	108	Inlet Air Flow Orifice	CPC		
PDI	108	Inlet Air Orifice Dp	Dwyer	0-20 IWG	Magnehelic
PI	108	Inlet Air Pressure	Dwyer	0-5 IWG	Magnehelic
PI	110	GBF Inlet Air Pressure	Dwyer	0-5 IWG	Magnehelic
FI	112	Alumina Velocity Probe	CPC		
FI	115	Air Velocity Anemometer	Alnor		
PCV	116	Air Pressure Regulator			
PI	116	Regulator Pressure Gauge		0-10 PSIG	
PDI	118	Upper Seal Leg Dp	Dwyer	0-2 IWG	Magnehelic
PDI	120	Lower Seal Leg Dp	Dwyer	0-2 IWG	Magnehelic
FI	122	Seal Leg Sight Glass	CPC		
PSV	130	Blower Air Pressure Relief Vlv	by Blower MFG		
TI	135	Lift Air Temperature		0-250 F	Bi-metalic
FE	135	Lift Air Flow Orifice	CPC		
PDI	135	Lift Air Orifice Dp	Dwyer	0-20 IWG	Magnehelic
PI	135	Lift Air Pressure	Dwyer	0-5 PSIG	Magnehelic
FE	138	Injection Air Pitot Tube	Dwyer	1/4" Dia	
PDI	138	Injection Air Pitot Tube Dp	Dwyer	0-5 IWG	Magnehelic
YO	139	Lift Air Restriction Orifice	CPC		
PDI	142	Lift Pipe Dp	Dwyer	0-150 IWG	Magnehelic
PI	145	Deentrainment Vessel Pressure	Dwyer	0-5 IWG	Magnehelic
PDI	152	Baghouse Dp	Dwyer	0-10 IWG	Magnehelic
FE	201	Fluidizer Air Flow Orifice	CPC		
PDI	201	Fluidizer Air Orifice Dp	Dwyer	0-20 IWG	Magnehelic
PI	201	Fluidizer Air Pressure	Dwyer	0-5 PSIG	Magnehelic
TI	201	Fluidizer Air Temperature		0-200 F	Bi-metalic
PDI	205	Fluidizer Distributor Plate Dp	Dwyer	0-100 IWG	Magnehelic
PDI	210	Fluidizer Bed Dp	Dwyer	0-100 IWG	Magnehelic

VALVES:

HV	101	Blower No.1 Inlet Valve	Dezurick or Eq.	8" Dia	Butterfly
HV	102	Blower No.2 Inlet Valve	Dezurick or Eq.	8" Dia	Butterfly
HV	105	Ash Eductor Air Valve	Any	3/4" Dia	Ball
HV	116	Bleed Eductor Air Valve	Any	3/4" Dia	Ball
HV	117	Bleed Isolation Valve	Any	2" Dia	Ball
HV	132	Lift Air Vent Valve	Any	3" Dia	Gate
HV	138	Injection Air Valve	Any	1 1/2" Dia	Gate
HV	155	Baghouse Hopper Valve	Fabri or Eq.	8" Dia	Gate
HV	158	Suction Fan Inlet Valve	Dezurick or Eq.	8" Dia	Butterfly

6.0 UTILITY REQUIREMENTS

6.1 Compressed Air:

Ash Eductor Air	51 SCFM @ 25 psig
Bleed Eductor Air	36 SCFM @ 5 psig
Baghouse Pulse Air	5 SCFM @ 80 psig
Total Air	92 SCFM

6.1 Electrical: (Installed Horsepower)

Hoffman Blower Motor	125 HP @ 230VAC, 3 phase
Lamson Blower Motor	100 HP @ 230VAC, 3 phase
Suction Fan Motor	5 HP @ 230VAC, 3 phase
Lift Air Blower Motor	15 HP @ 230VAC, 3 phase
Ash Feeder Motor	1/2 HP @ 115VAC, 1 phase
Drum Rotator	1/2 HP @ 115VAC, 1 phase

6.2 Diesel Fuel:

Air Compressor	1.5-2 Gal/Hr

7.0 ESTIMATED COSTS

7.1 Task 5: Fabrication and Installation Costs:

Fabrication and installed costs are defined below using the cost format from the Option I Cost Proposal submitted to the U.S. Department of Energy during April, 1994. Some of the equipment costs are higher than originally estimated based on fabricator quotations. Also, some additional equipment must be rented that were originally thought to be available at CPC. These additional costs are listed separately. Every effort will be made to reduce costs in other areas to compensate for cost increases. Section 7.2 provides a detailed breakdown of the cost increases.

		April-1994 Cost Proposal Estimate	Additional Costs
Item 1a:	Purchased Parts	$37,600	$11,240
Item 1b:	Subcont. Items	$130,035	$6,460
Item 3:	Direct Labor	$10,172	$0
Item 4:	Labor Overhead	$15,258	$0
Item 7:	Travel	$44	$0

April 1994 Total Task 5 Direct Cost and Overhead $193,109

Revised Task 5 Total Direct Cost and Overhead $210,809

7.2 Task 5 Detail of Cost Changes

Item 1a: Purchased Parts

Addition:	Added Costs for Half Filter Assy.	$7,255
	Added Costs for Media Fluidizer	$1,235
	Added Costs for Liner Abrasion Unit (due to sampling preparation)	$2,750
	Total	$11,240

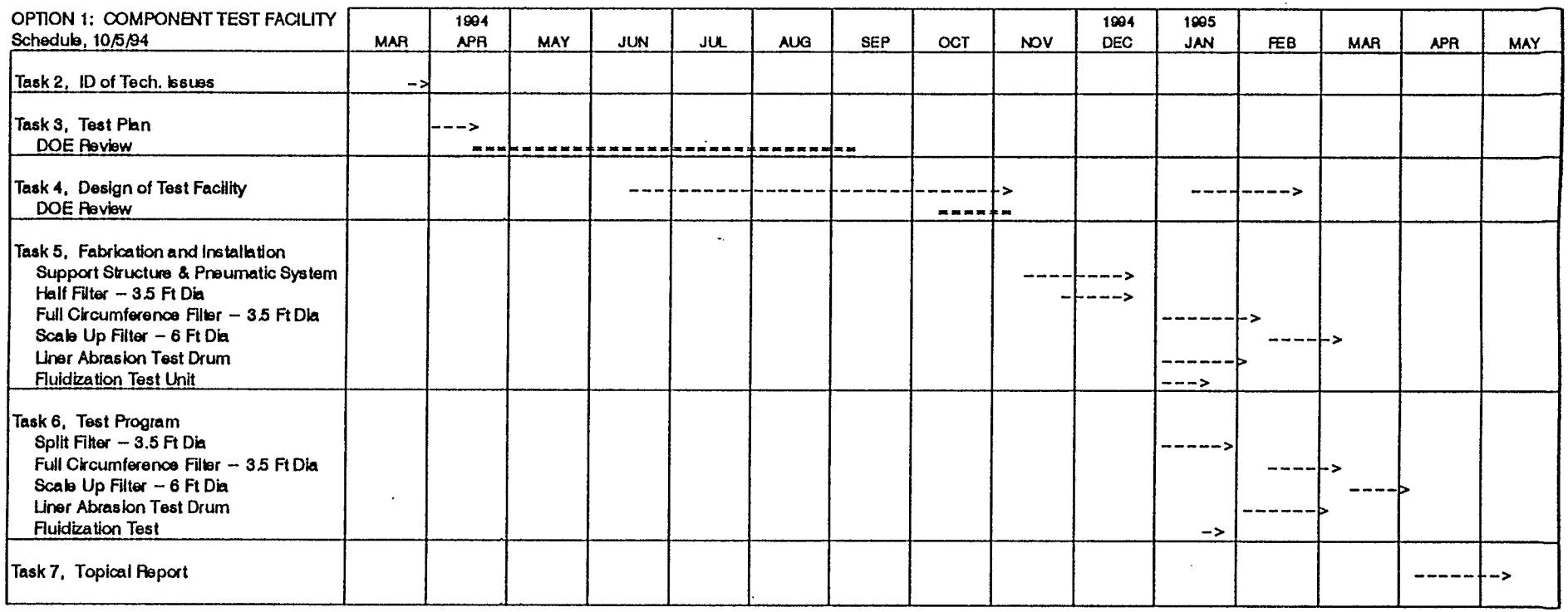
Item 1b: Subcontracts

Addition:	Rental of PD Blower @$400/mo	$1,600	(4 mo)
	Rental of Ash Feeder @$465/mo	$1,860	(4 mo)
	Rental of Air Compressor @$1000/mo	$3,000	(3 mo)
	Total	$6,460	

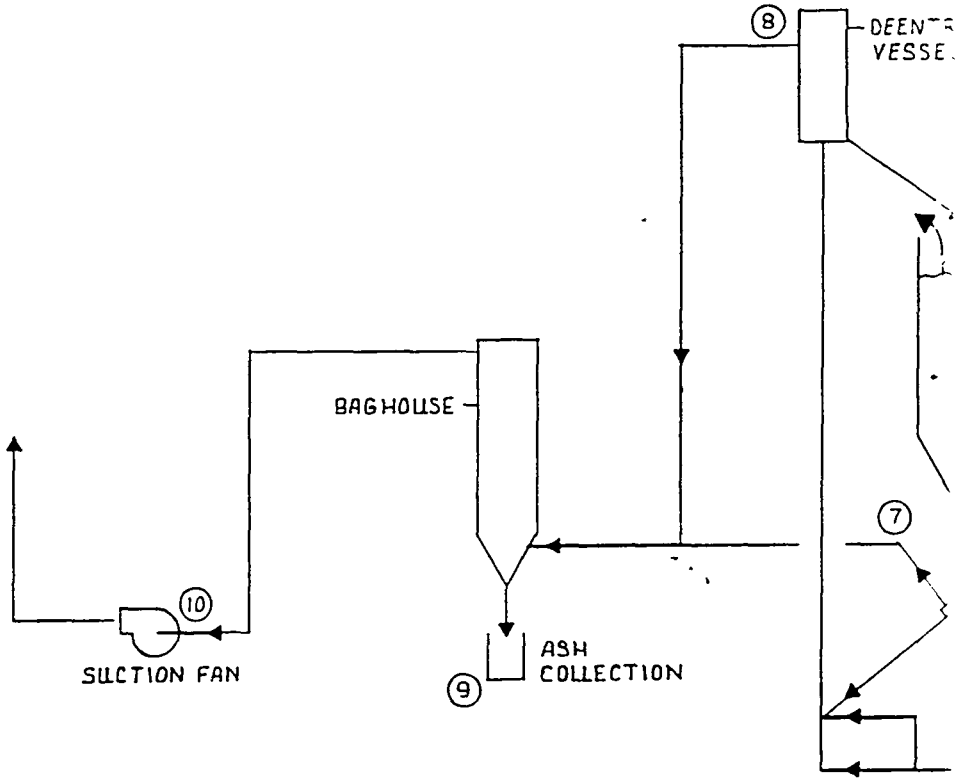
7.3 Total OPTION I Costs

The current cost trend for Option 3 is upward by about 5% based on the above changes in above costs. This is only a small part of the total contract. There are lots of opportunities to offset this trend in other tasks and stay

within budget.


OPTION 1: COMPONENT TEST FACILITY
Schedule, 10/5/94
1994
1995
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
Task 2, ID of Tech. Issues
Task 3, Test Plan
DOE Review
Task 4, Design of Test Facility
DOE Review
Task 5, Fabrication and Installation
Support Structure & Pneumatic System
Half Filter – 3.5 Ft Dia
Full Circumference Filter – 3.5 Ft Dia
Scale Up Filter – 6 Ft Dia
Liner Abrasion Test Drum
Fluidization Test Unit
Task 6, Test Program
Split Filter – 3.5 Ft Dia
Full Circumference Filter – 3.5 Ft Dia
Scale Up Filter – 6 Ft Dia
Liner Abrasion Test Drum
Fluidization Test
Task 7, Topical Report

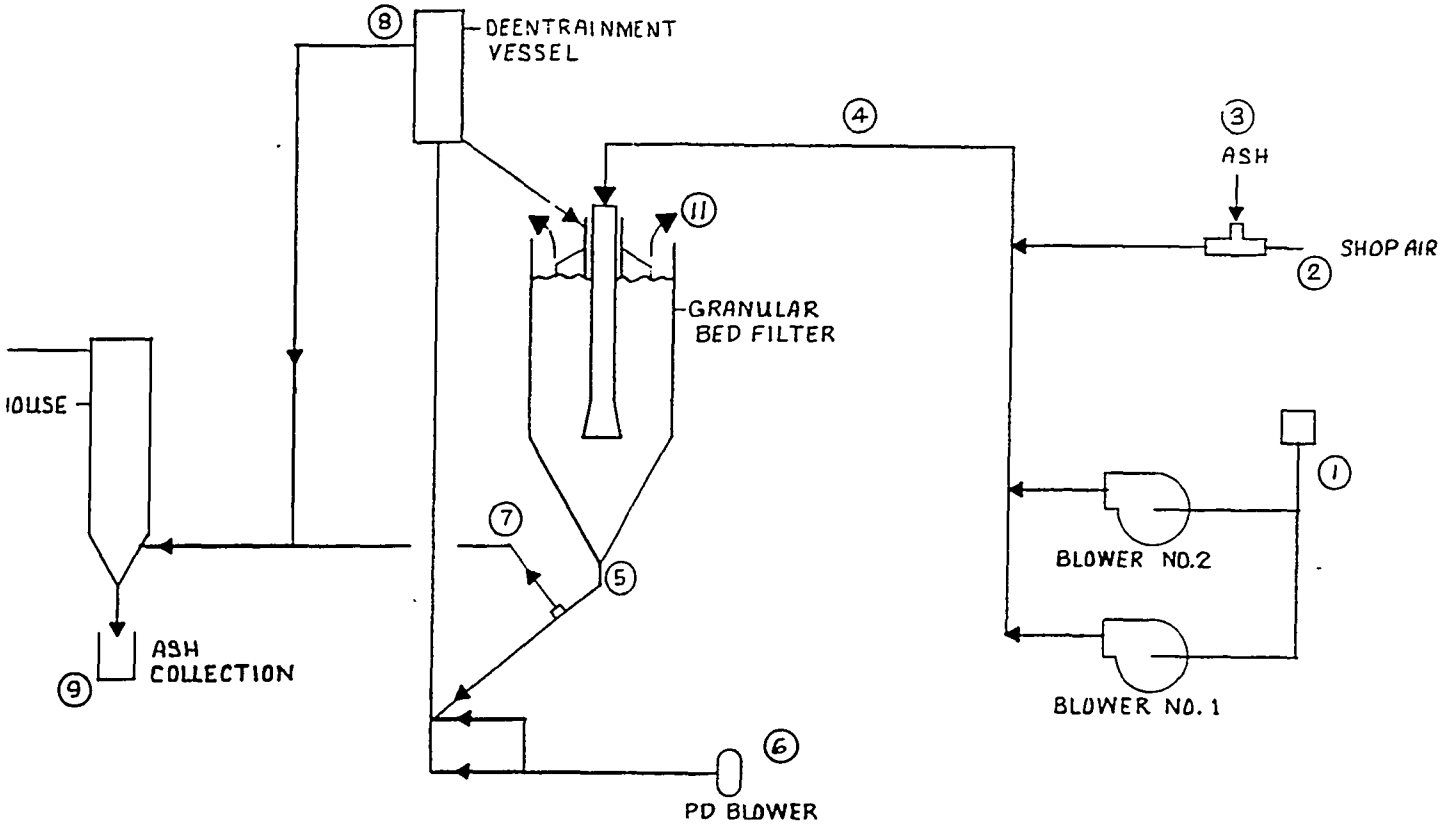
9.0 ENGINEERING DRAWINGS



ESTIMATED MAXIMUM FLOW CONDITIONS

	1	2	3	4	5	6	7	8	
	BLOWER INLET	EDUCTOR AIR INLET	ASH INLET	GBF AIR SUPPLY	GBF SOLIDS OUTLET	LIFT BLOWER INLET	SEAL LEG BLEEDAIR	DEV OUTLET	BA ASH
3.6 FT DIA. SPLIT FILTER									
AIR MASS FLOW, LB/MIN	167	~4	1	167	2	17	2	17	
PRESSURE, PSIA	14.7	~26.7	14.7	17.5	17.3	14.7		14.7	
TEMPERATURE, F	80		80	135	125	80	125	125	
AIR VOLUME FLOW, ACFM	2270		14	2100		230		250	
MEDIA FLOW, LB/MIN					120				
ASH FLOW, LB/MIN			6	6	6			6	
3.6 FT DIA. FULL FILTER									
AIR MASS FLOW, LB/MIN	333	~4	1	333	2	17	2	17	
PRESSURE, PSIA	14.7	~39.7	14.7	20.5	19.9	14.7		14.7	
TEMPERATURE, F	80		80	150	140	80	140	140	
AIR VOLUME FLOW, ACFM	4530		14	3670		230		260	
MEDIA FLOW, LB/MIN					240				
ASH FLOW, LB/MIN			6	6	6			6	
6.0 FT DIA FULL FILTER									
AIR MASS FLOW, LB/MIN	400	~4	1	400	2	17	2	17	
PRESSURE, PSIA	14.7	~19.7	4.7	16.4	15.2	14.7		14.7	
TEMPERATURE, F	80		80	120	110	80		110	
AIR VOLUME FLOW, ACFM	5440		14	5200		230		240	
MEDIA FLOW, LB/MIN					240				
ASH FLOW, LB/MIN			12	12	12			12	

(1)



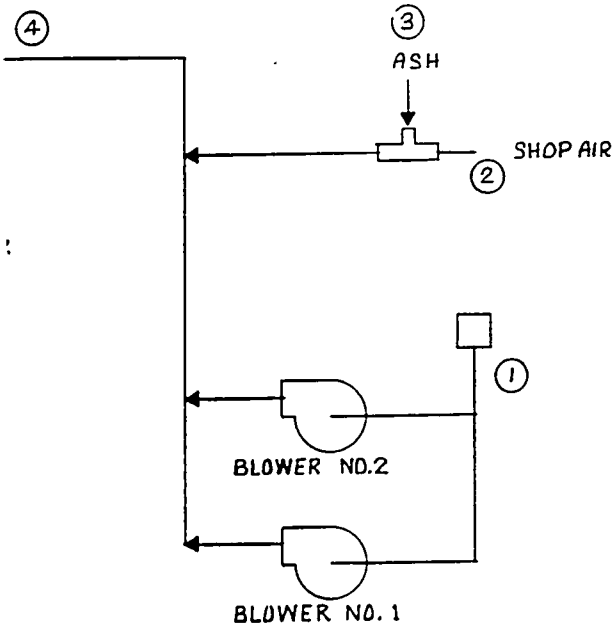
TED MAXIMUM FLOW CONDITIONS

3	4	5	6	7	8	9	10	11
SH ET	GBF AIR SUPPLY	GBF SOLIDS OUTLET	LIFT BLOWER INLET	SEAL LEG BLEEDAIR	DEV OUTLET	BAGHOUSE ASH REMOVAL	SUCTION FAN INLET	GBF OUTLET
	167	2	17	2	17		19	167
.7	17.5	17.3	14.7		14.7		14.1	14.7
)	135	125	80	125	125		120	70
	2100		230		250		290	2230
		120						
	6	6			6	6	<.03	<.06
	333	2	17	2	17		19	333
.7	20.5	19.9	14.7		14.7		14.0	14.7
)	150	140	80	140	140		135	70
-	3670		230		260		300	4440
		240						
	6	6			6	6	<.03	<.06
	400	2	17	2	17		19	400
7	16.4	15.2	14.7		14.7		14.2	14.7
)	120	110	80		110		110	70
-	5200		230		240		280	5330
		240						
	12	12			12	12	<.06	<.12

DRN	JNP	B
CHK	TWF	3
ENG	TWP	8
STR		
PRC		
PEJ	KSW	9/
APP	Albano	9/
MFG	JBO	8 2

(2)

REVISIONS			
FOR DESCRIPTION OF CHG SEE E. O			
NO	BY	DATE	APPR
01	JWP	9-28-94	AD



DEPARTMENT OF ENERGY
MOVING BED GRANULAR BED FILTER
DEVELOPMENT PROGRAM

TITLE
PROCESS FLOW DIAGRAM
GRANULAR BED FILTER - TEST UNITS

DRN	JWP	8-9-94
CHK	JWF	8-24-94
ENG	JWP	8-24-94
STR		
PRC		
PRJ	KBW	8/24/94
APP	[illegible]	8-25-94
REL	JEO	8-25-94

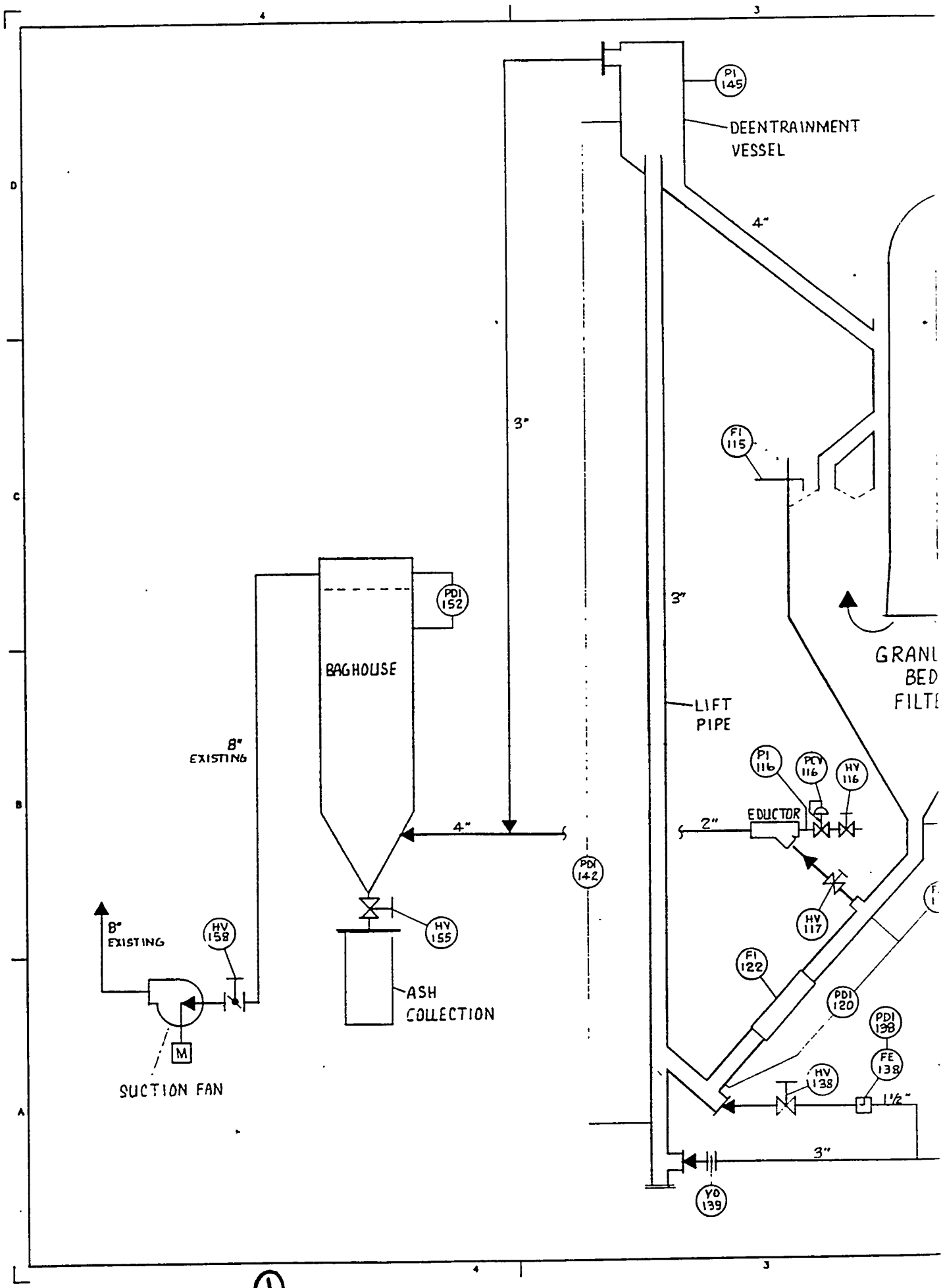
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES / MILLIMETERS. TOLERANCES: FRACTIONAL ± 1/16", DECIMAL ± .03, MILLIMETER ± 2, ANGLE ± 1°. THIRD ANGLE PROJECTION

DWG NO.	CONFIG REV	NO OF SHTS	DWG SIZE
1181-2210-01-200	01	1	4 D

SCALE | SHEET 1 OF 1

COMBUSTION POWER
Combustion Power Company, Oakland, California

3


PI 145
DEENTRAINMENT VESSEL
4"
3"
FI 115
3"
PDI 152
BAGHOUSE
8" EXISTING
4"
PDI 142
LIFT PIPE
PI 116
PDI 116
HV 116
EDUCTOR
2"
HV 117
8" EXISTING
HV 158
HV 155
ASH COLLECTION
M
SUCTION FAN
FI 122
PDI 120
PDI 138
FE 138
HV 138
1½"
3"
YO 139
GRANU
BED
FILTE
4
3
D
C
B
A

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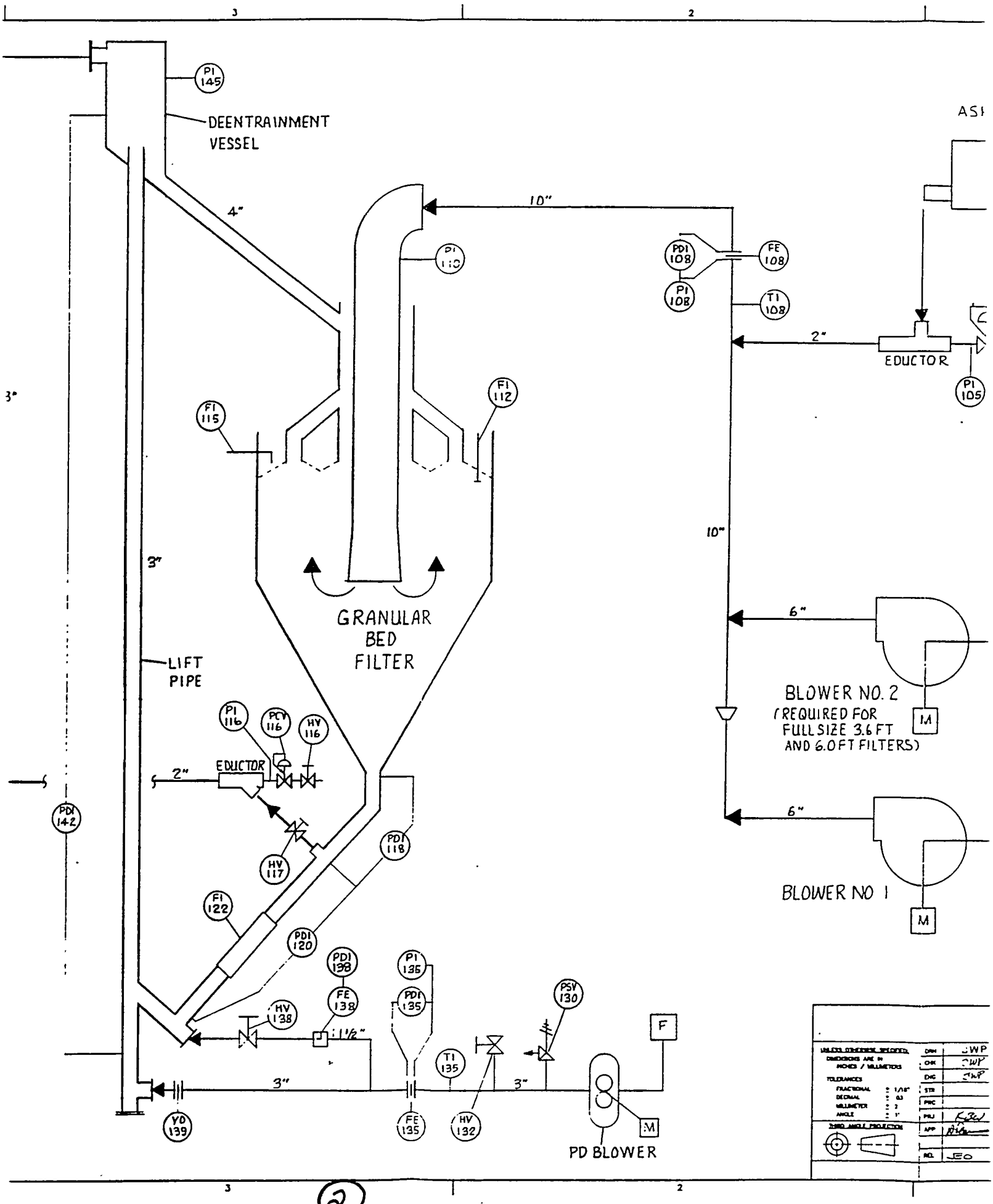
PI 145
DEENTRAINMENT VESSEL
4"
10"
PI 110
PDI 108
FE 108
PI 108
TI 108
2"
EDUCTOR
PI 105
FI 115
FI 112
3"
10"
GRANULAR BED FILTER
LIFT PIPE
6"
BLOWER NO. 2
(REQUIRED FOR FULL SIZE 3.6 FT AND 6.0 FT FILTERS)
M
PI 116
PCV 116
HV 116
2"
EDUCTOR
PDI 142
HV 117
PDI 118
6"
BLOWER NO 1
M
FI 122
PDI 120
PDI 138
FE 138
HV 138
1½"
PI 135
PDI 135
PSV 130
F
T1 135
3"
3"
YD 139
FE 135
HV 132
M
PD BLOWER

(2)

REVISIONS			
FOR DESCRIPTION OF CHG SEE E O			
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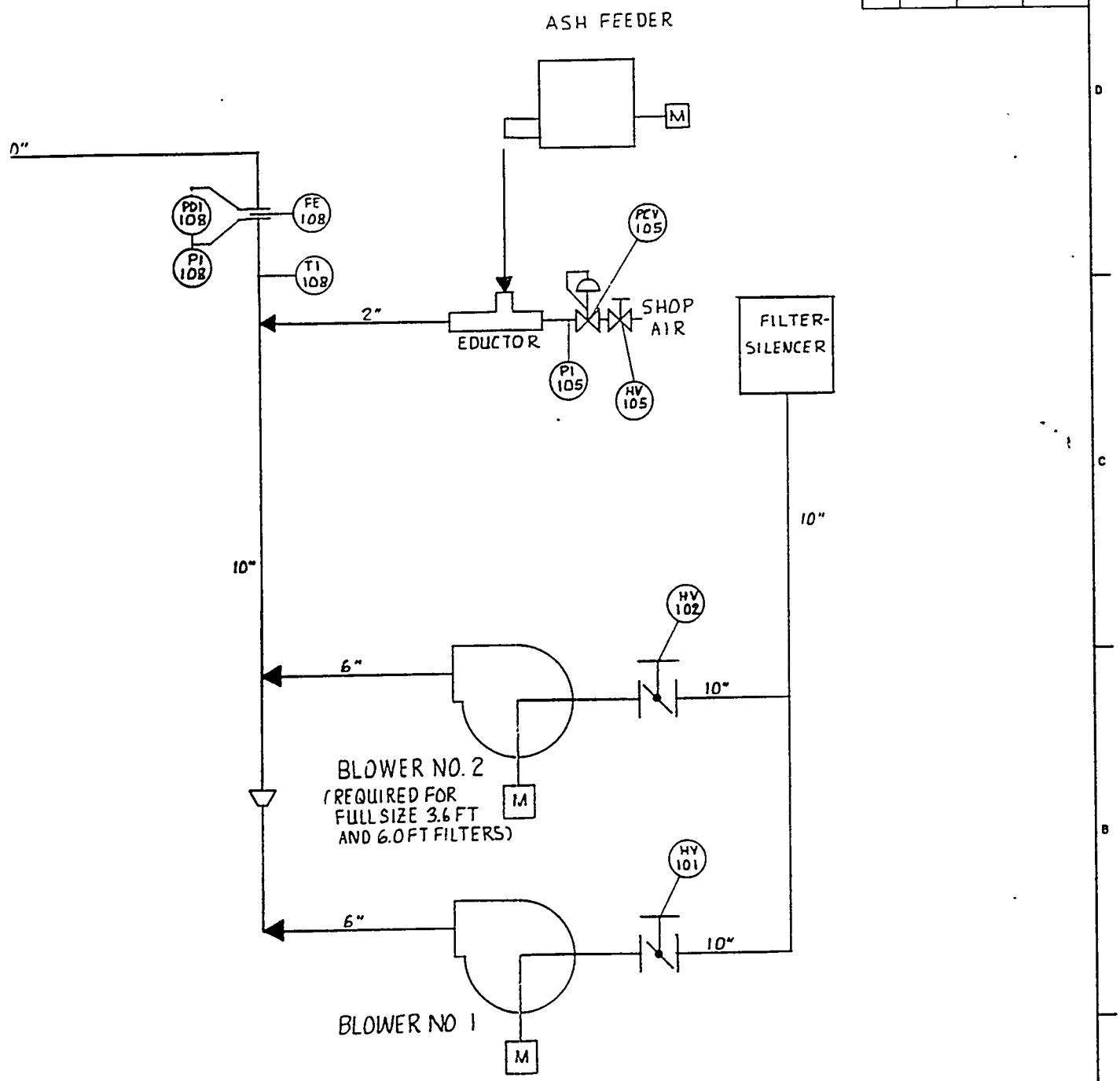
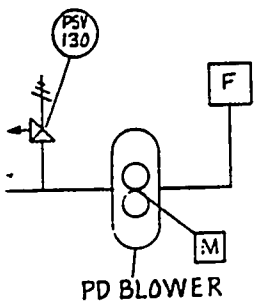




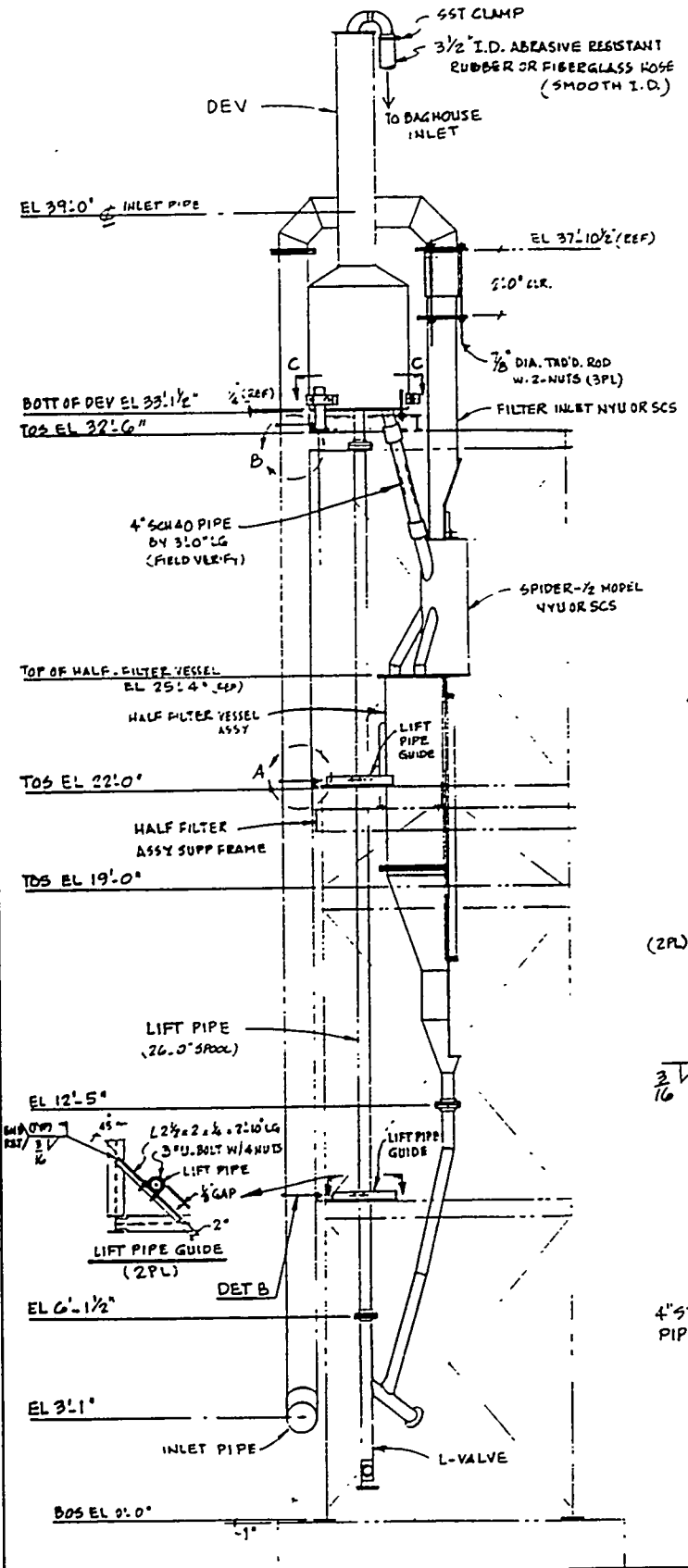
DEPARTMENT OF ENERGY
MOVING BED GRANULAR BED FILTER
DEVELOPMENT PROGRAM

TITLE
PIPING AND INSTRUMENT DIAGRAM
GRANULAR BED FILTER-TEST UNITS

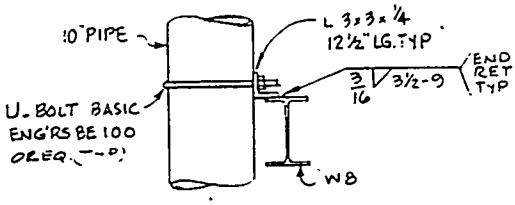
DRN	JWP	3-2-94
CHK	JWP	8-24-94
ENG	JWP	8-24-94
STR		
PRC		
PRJ		8-25-94
APP		8-25-94
REL	JEO	8 25 94

DWG NO. 1181-2310-01-300 | CONFIG | REV 01 | NO OF SHTS 1 | SIZE 4 | D
SCALE NONE | SHEET 1 OF 1

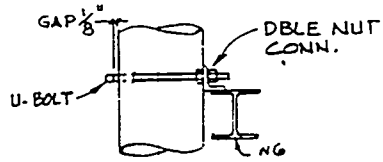
COMBUSTION POWER
Combustion Power Company, Oakland, California



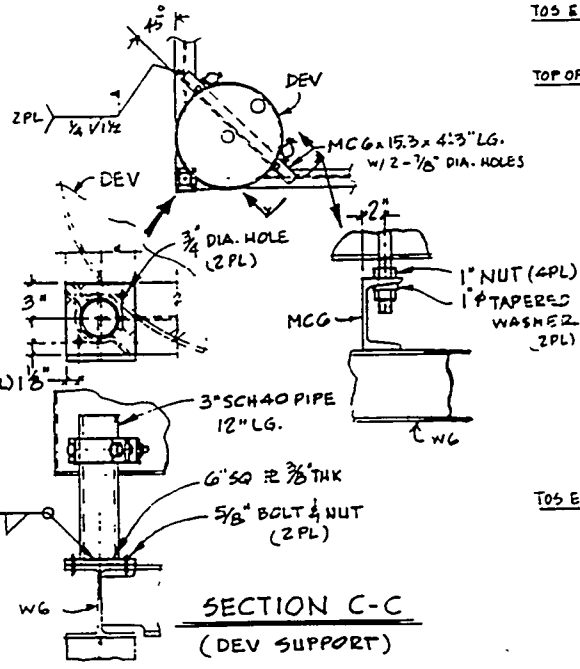
HALF FILTER ASSY.
(3'-7" I.D.)



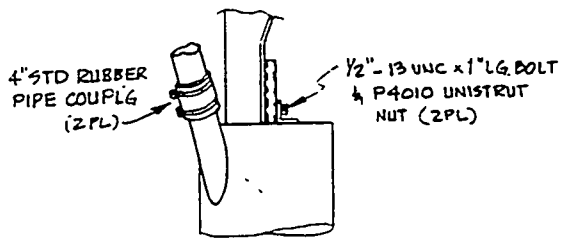
DETAIL A
(ANCHOR)



DETAIL B
(GUIDE - 2PL)



SECTION C-C
(DEV SUPPORT)

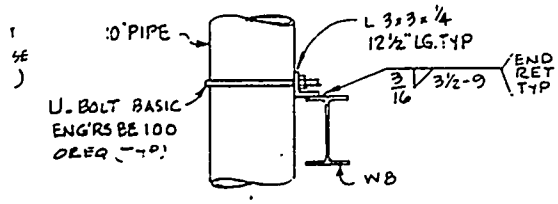


DETAIL D

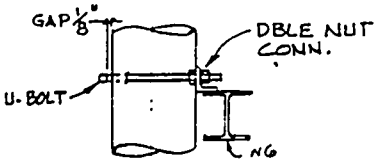
DE

EL 39'-0" ℄ INL
EL 38'-6¼" - BOTT OF DEV —
LIFT PIPE — (5'-4 ⅝" SPOOL)
INLET PIPE - SUPP FRAME (SEE DETAIL)
REMOVE SUPP C AND CLEAN WE
TOS EL 32'-6
TOP OF FILTER E
TOS EL 19'-0"
EL 6'-1½"

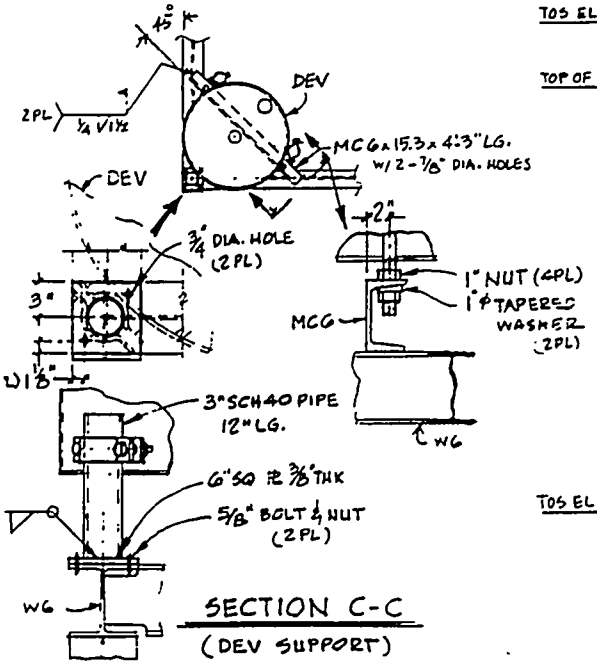
(1)



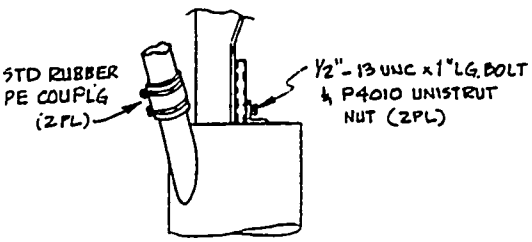
DETAIL A
(ANCHOR)



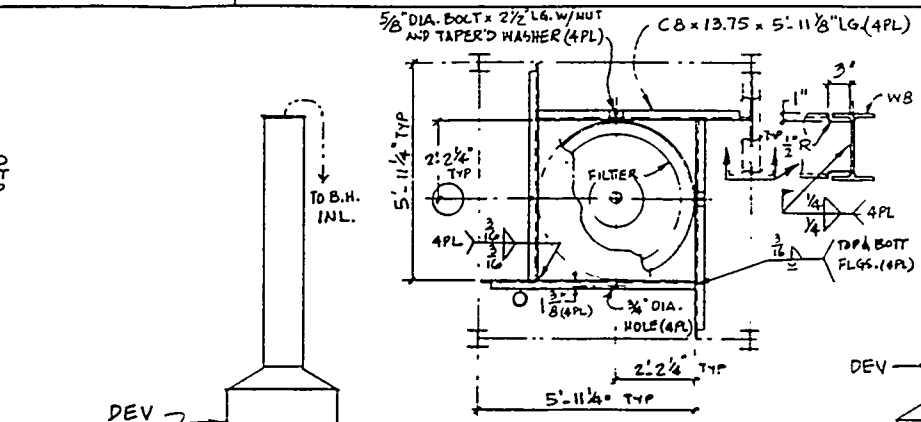
DETAIL B
(GUIDE - 2PL)



SECTION C-C
(DEV SUPPORT)



DETAIL D



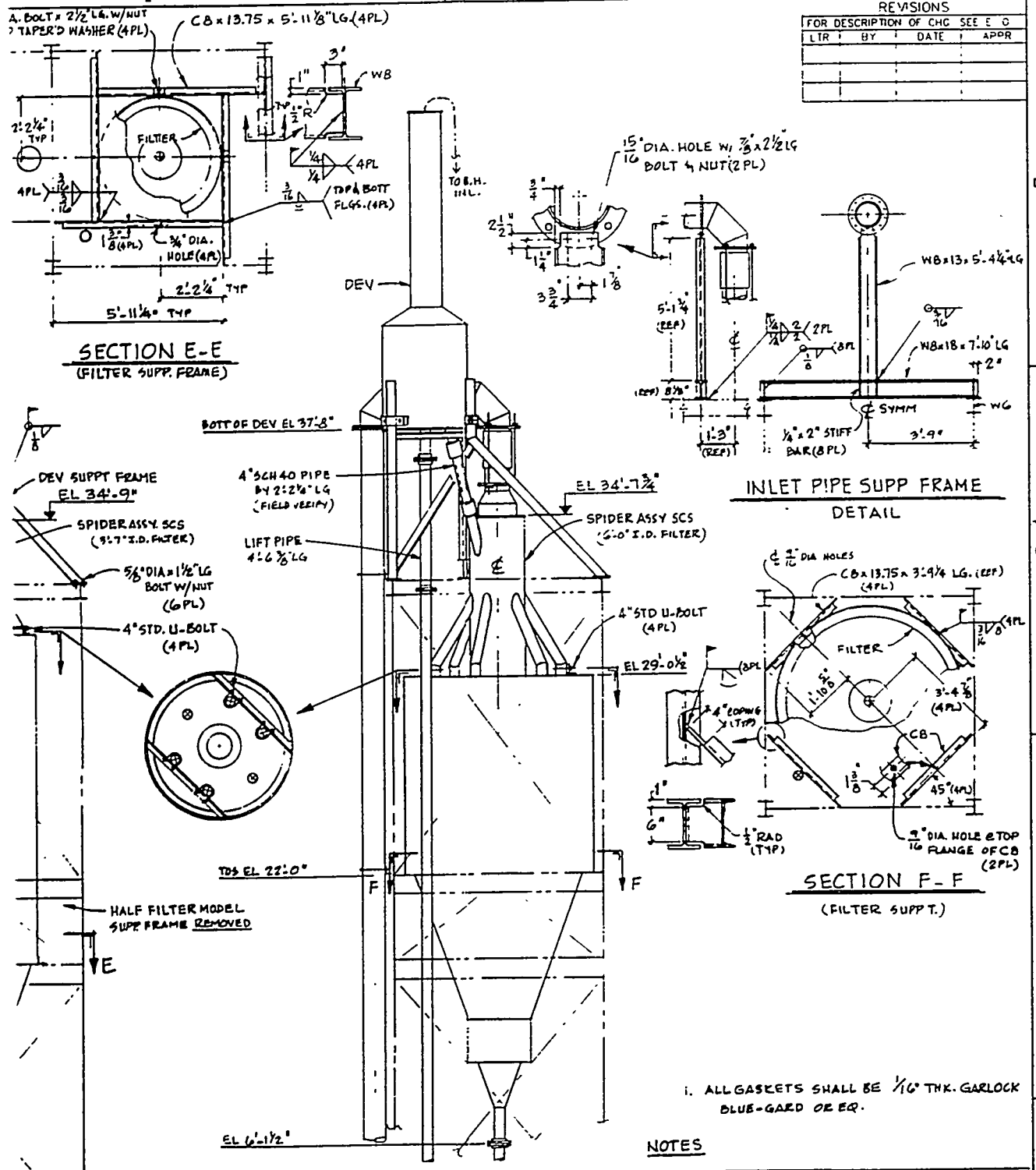
SECTION E-E
(FILTER SUPP. FRAME)

3'-7" I.D. FILTER ASSY

6'-0" I.D. FIL

UNLESS OTHERWISE SPECIFIED:		DRN	AL
DIMENSIONS ARE IN INCHES		CHK	
TOLERANCES		ENG	
FRACTIONAL	± 1/16"	STR	
DECIMAL	± .03	PIPE	
ANGLE	± 1°	PROJ	
		APP	
		MFG	

REVISIONS			
FOR DESCRIPTION OF CHG SEE E O			
LTR	BY	DATE	APPR



1. ALL GASKETS SHALL BE 1/16" THK. GARLOCK BLUE-GARD OR EQ.

NOTES

6'-0" I.D. FILTER ASSY

DEPARTMENT OF ENERGY
MOVING BED GRANULAR BED FILTER
DEVELOPMENT PROGRAM

TITLE
FILTER
GENERAL ARRANGEMENT

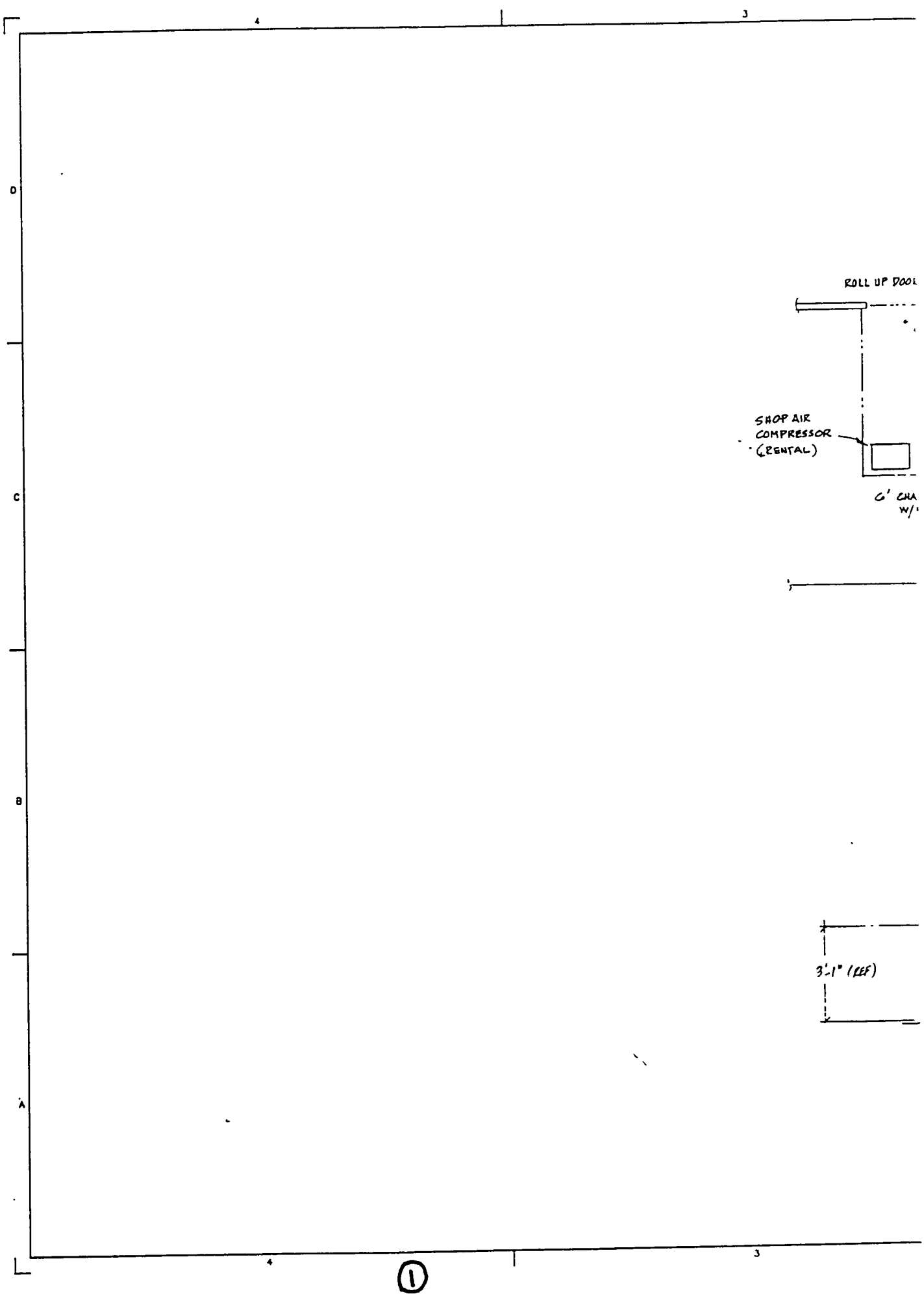
UNLESS OTHERWISE SPECIFIED	DRN	MJT	9-14-94
DIMENSIONS ARE IN INCHES	CHK	JWF	7-29-94
TOLERANCES	ENG		
FRACTIONAL ± 1/16"	STR	[signature]	9/20/94
DECIMAL ± .03	PRC		
ANGLE ± 1°	MFG	KGW	9/29/94
	APP	[signature]	9-29-94
	APP	K. Fogg	10-4-94

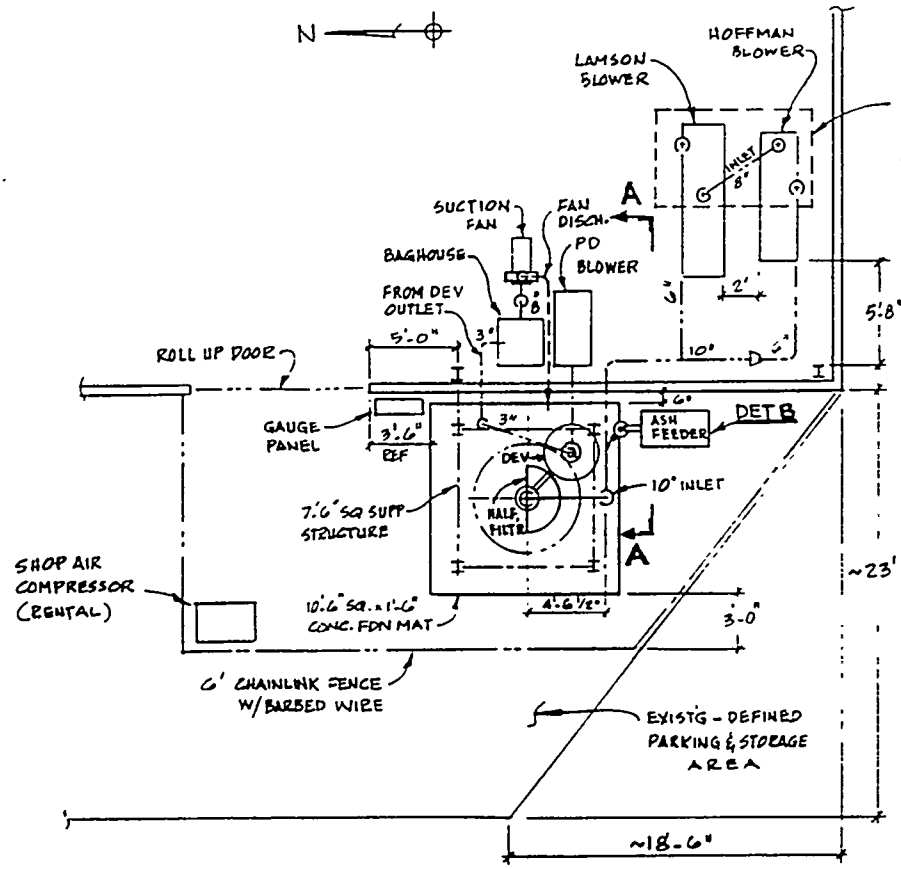
DWG NO 1181-2940-01-100 | CONFIG 1 | REV 0 | NO OF SHTS 2 | DWG SIZE D

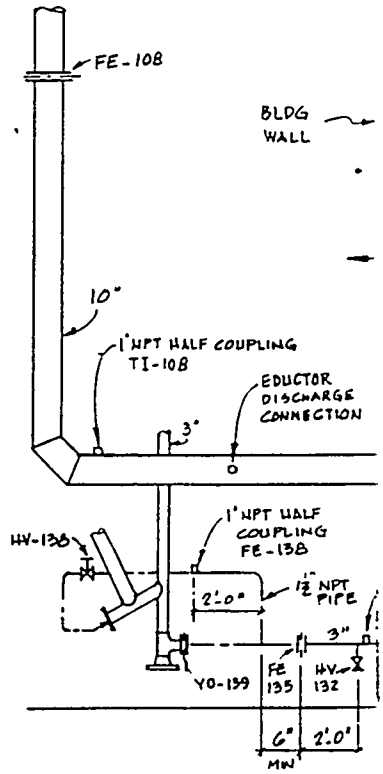
SCALE NONE | SHEET 1 OF 2

COMBUSTION POWER
Combustion Power Company, Menlo Park, California

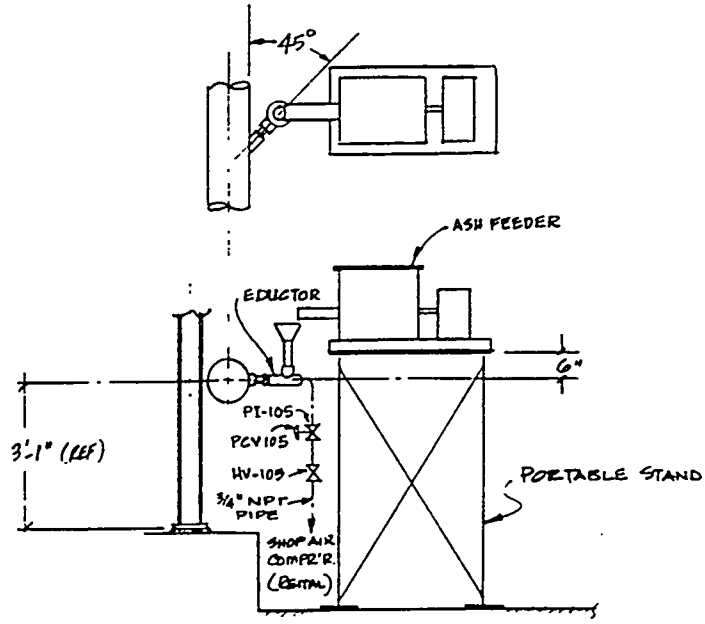
(3)


4
3
D
C
B
A
ROLL UP DOOR
SHOP AIR COMPRESSOR (RENTAL)
6' CHA
W/
3'-1" (REF)
4
3
1





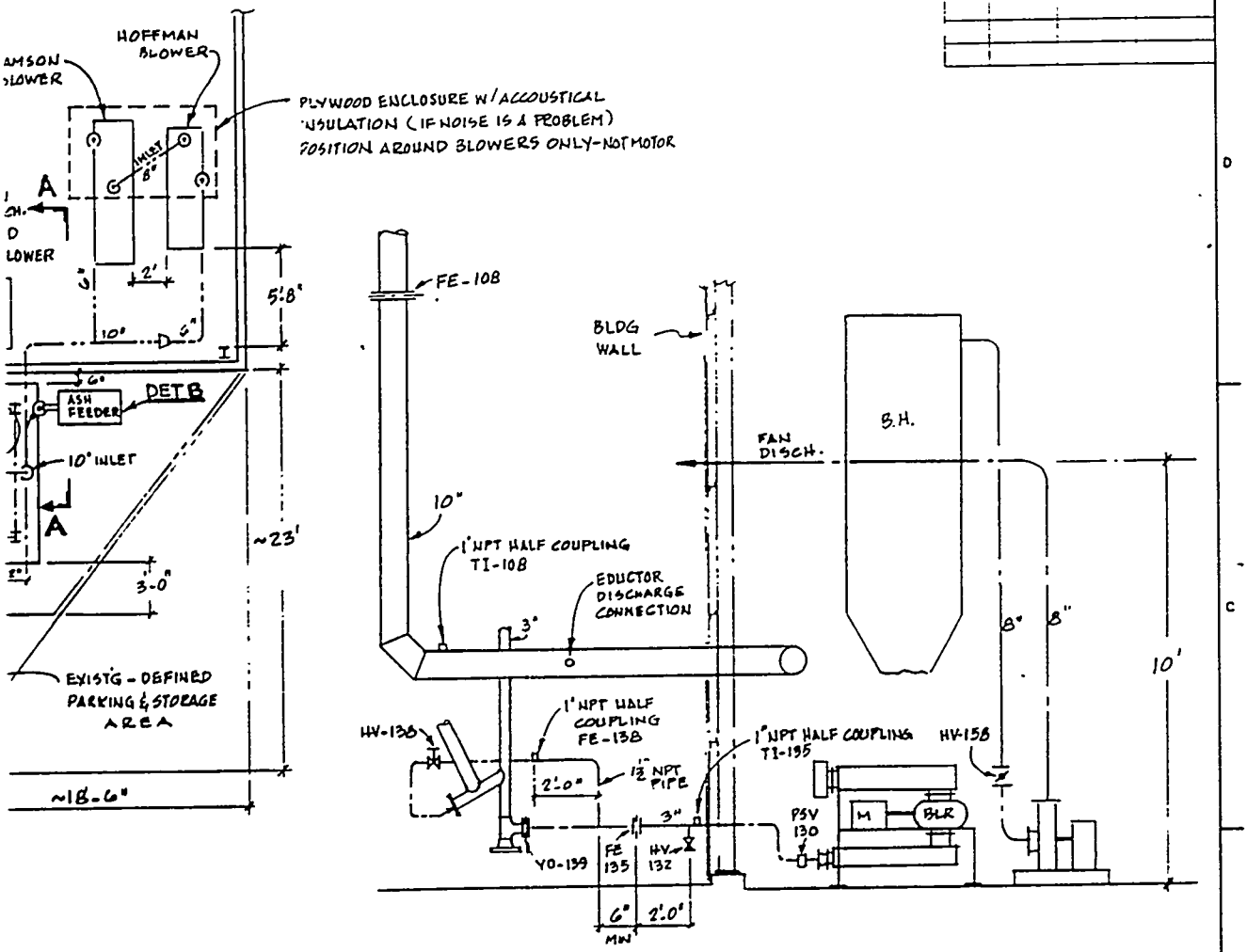
SE



DETAIL B

UNLESS OTHERWISE SPECIFIED:	DRN
DIMENSIONS ARE IN INCHES	CHK
TOLERANCES	ENG
FRACTIONAL ± 1/16"	STR
DECIMAL ± .03	PRC
ANGLE ± 1°	PRJ
	APP
	REL

REVISIONS			
FOR DESCRIPTION OF CHG SEE E O			
LTR	BY	DATE	APPR



SECTION A-A

FEEDER

6"

PORTABLE STAND

DEPARTMENT OF ENERGY
MOVING BED GRANULAR BED FILTER
DEVELOPMENT PROGRAM

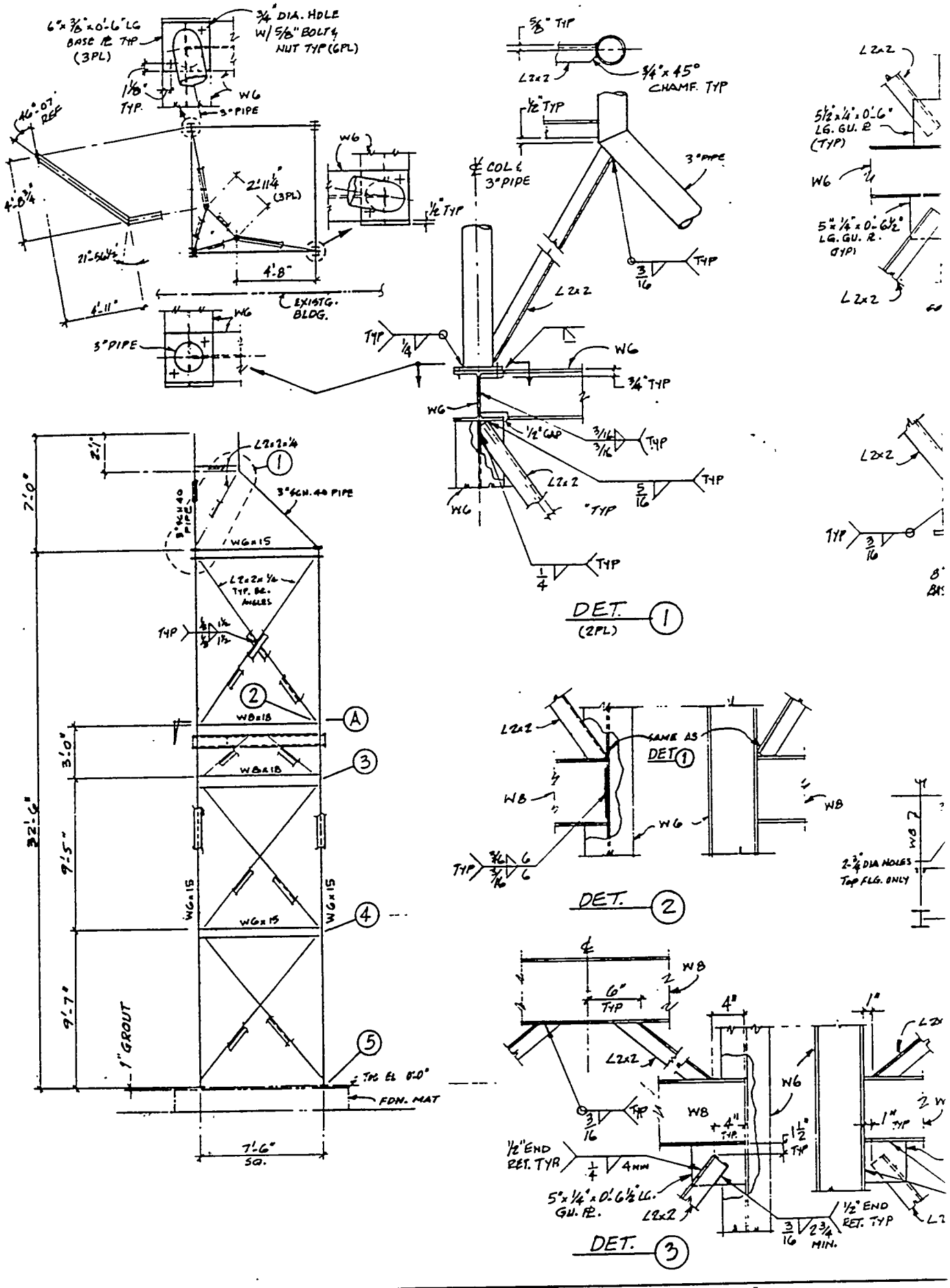
TITLE

FILTER
GENERAL ARRANGEMENT

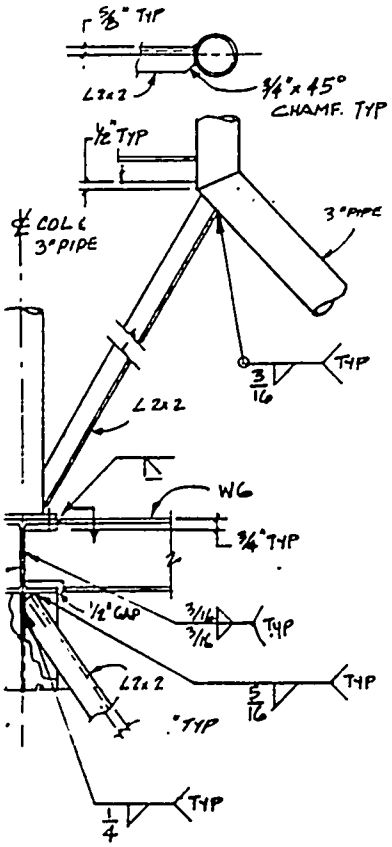
UNLESS OTHERWISE SPECIFIED:	DRN	
DIMENSIONS ARE IN INCHES	CHK	
TOLERANCES	DSG	
FRACTIONAL ± 1/16"	STR	
DECIMAL ± .03	PRC	
ANGLE ± 1°	PRJ	
	APP	
	REL	

DWG NO.	CONFIGURATION	NO OF SHTS	DWG SIZE
1181-2940-01-100	1	2	41D
SCALE NONE	SHEET 2 OF 2		

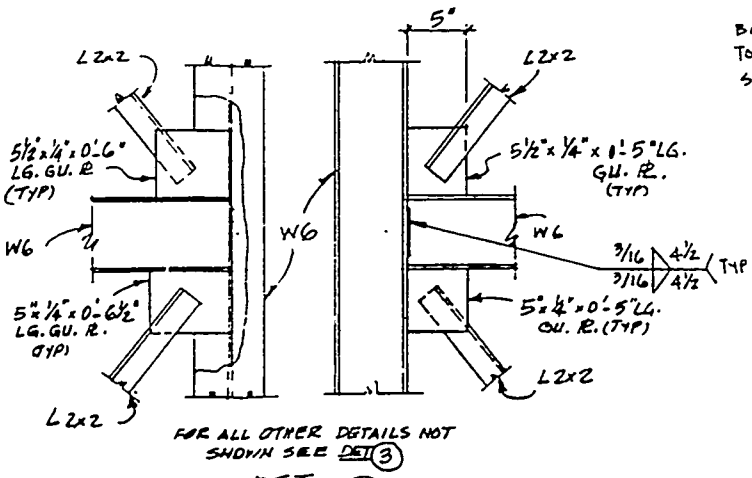
COMBUSTION POWER
Combustion Power Company, Menlo Park, California


6"x 3/8"x 0'-6" LG BASE PL TYP (3PL)
3/4" DIA. HOLE W/ 5/8" BOLT & NUT TYP (6PL)
1/8" TYP.
W6
3" PIPE
46°-0" REF
4'-0 3/4"
21'-5 1/2"
2'-11 1/4" (3PL)
4'-8"
4'-11"
EXIST'G. BLDG.
1/2" TYP
5/8" TYP
L2x2
3/4"x 45° CHAMF. TYP
COL ℄ 3" PIPE
3/16 TYP
1/4 TYP
3/4" TYP
1/2" GAP
5/16 TYP
DET. (1) (2PL)
5 1/2"x 1/4"x 0'-6" LG. GU. PL (TYP)
5"x 1/4"x 0'-6 1/2" LG. GU. PL (TYP)
2'-0"
3" SCH. 40 PIPE
WG x 15
L2x2x1/4 TYP. BC. ANGLES
WB x 18
3'-0"
32'-6"
9'-5"
9'-7"
1" GROUT
TOP EL 0'-0"
FDN. MAT
7'-6" SQ.
SAME AS DET (1)
WB
2-3/4" DIA HOLES TOP FLG. ONLY
DET. (2)
6" TYP
4"
1"
4" TYP
1 1/2" TYP
1/2" END RET. TYP
1/4 4mm
5"x 1/4"x 0'-6 1/2" LG. GU. PL
3/16
2 3/4" MIN.
DET. (3)

(1)

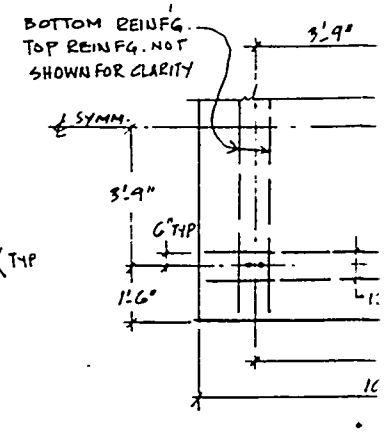


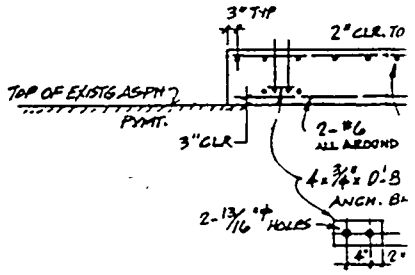
DET. (2PL) 1



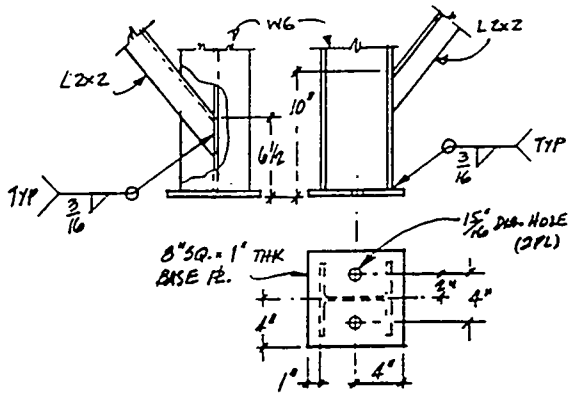
FOR ALL OTHER DETAILS NOT SHOWN SEE DET 3

DET. 4

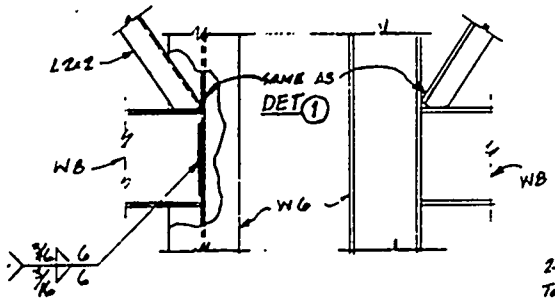




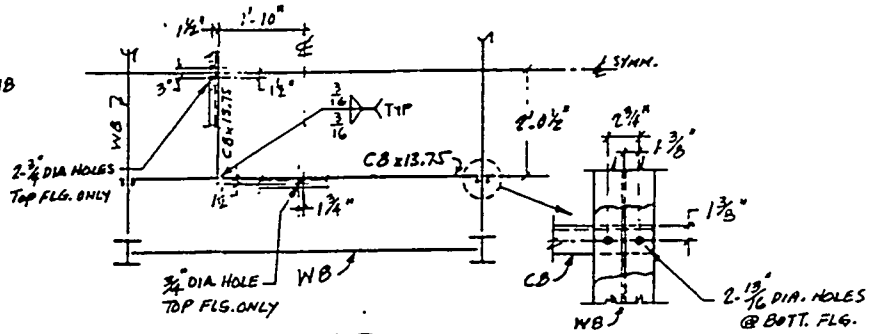
CONC. MAT



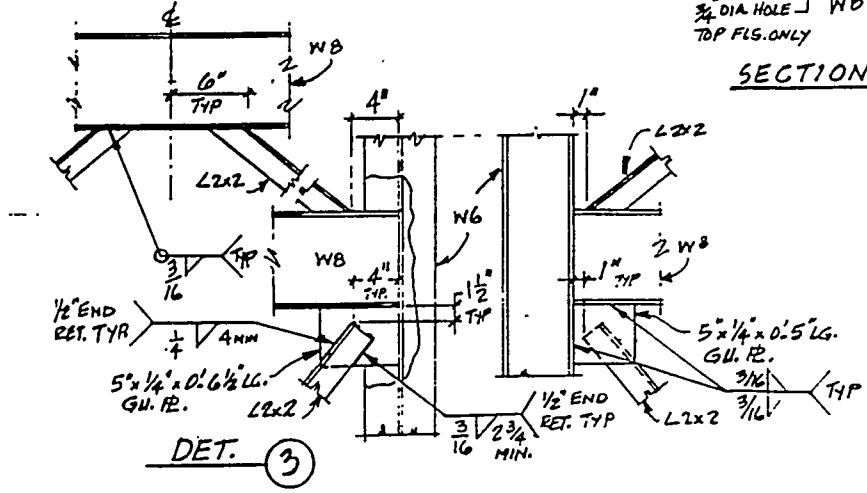
DET. 5



DET. 2

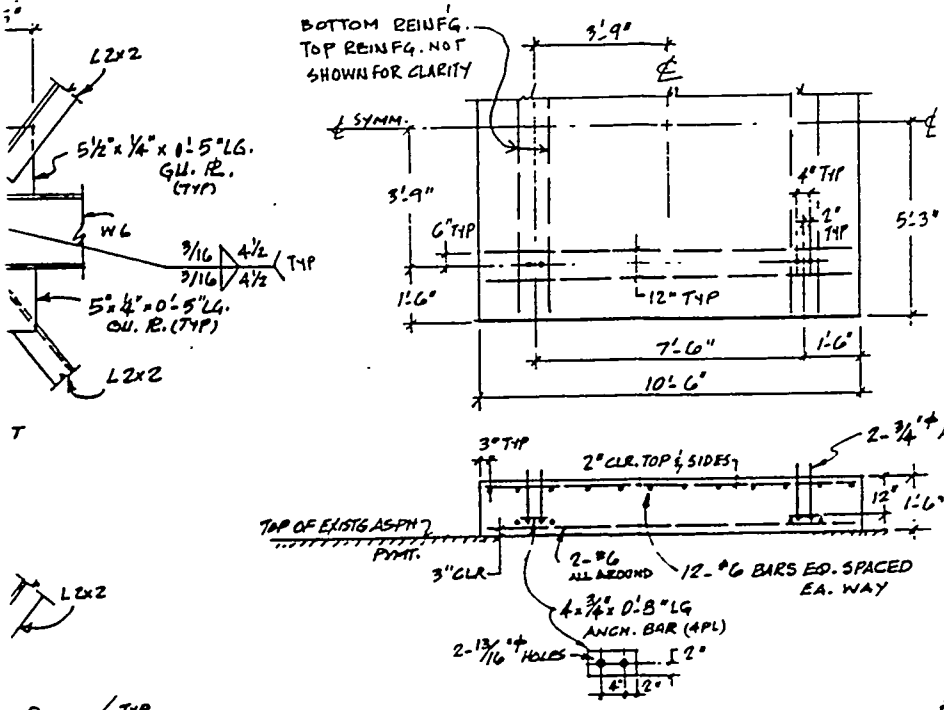


SECTION A

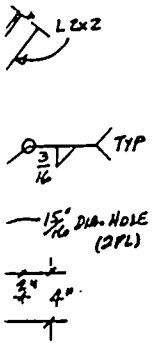


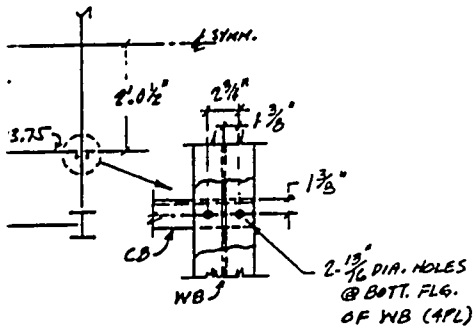
DET. 3

UNLESS NOTED	DRN	M
DIMENSION IN INCHES	CHK	M
TOLERANCE:	ENG	
FRACTIONAL ± 1/16"	STR	M
DECIMAL ± .03	PRC	
ANGLE ± 1°	PRJ	
	APP	M
	REL	K



CONC. MAT F.DN. DETAILS





REGISTERED PROFESSIONAL ENGINEER
WILLIAM J. THOMAS
C 16853
9/3/94
CIVIL
STATE OF CALIFORNIA

NOTES:

1. STRUCTURAL STEEL: ALL SHAPES, PLATES & BARS PER ASTM A36 OR BETTER.
2. PIPING: PER ASTM A53, GR A OR BETTER
3. CONCRETE: MIN. 28 DAY STRENGTH 2500 PSI
4. REINFORCEMENT: DEFORMED BARS PER ASTM A615, GR. 40 OR BETTER
5. WELDING: PER CPC STD. 1132.
6. PAINT WITH RED OXIDE PRIMER (POWER TOOL CLEAN PER SSPC-SP3)
7. DEBURR ALL SHARP EDGES & CORNERS PRIOR TO PAINTING.

UNLESS NOTED			
DIMENSION IN INCHES	DRN	N.J.T.	8/15/94
TOLERANCE:	CHK	WJT	9/12/94
FRACTIONAL ± 1/16"	ENG	WJT	9/12/94
DECIMAL ± .03	STR	WJT	9/12/94
ANGLE ± 1°	PRC		
	PRJ	WJT	9/12/94
	APP	WJT	9/12/94
	REL	K Bagi	9-13-94

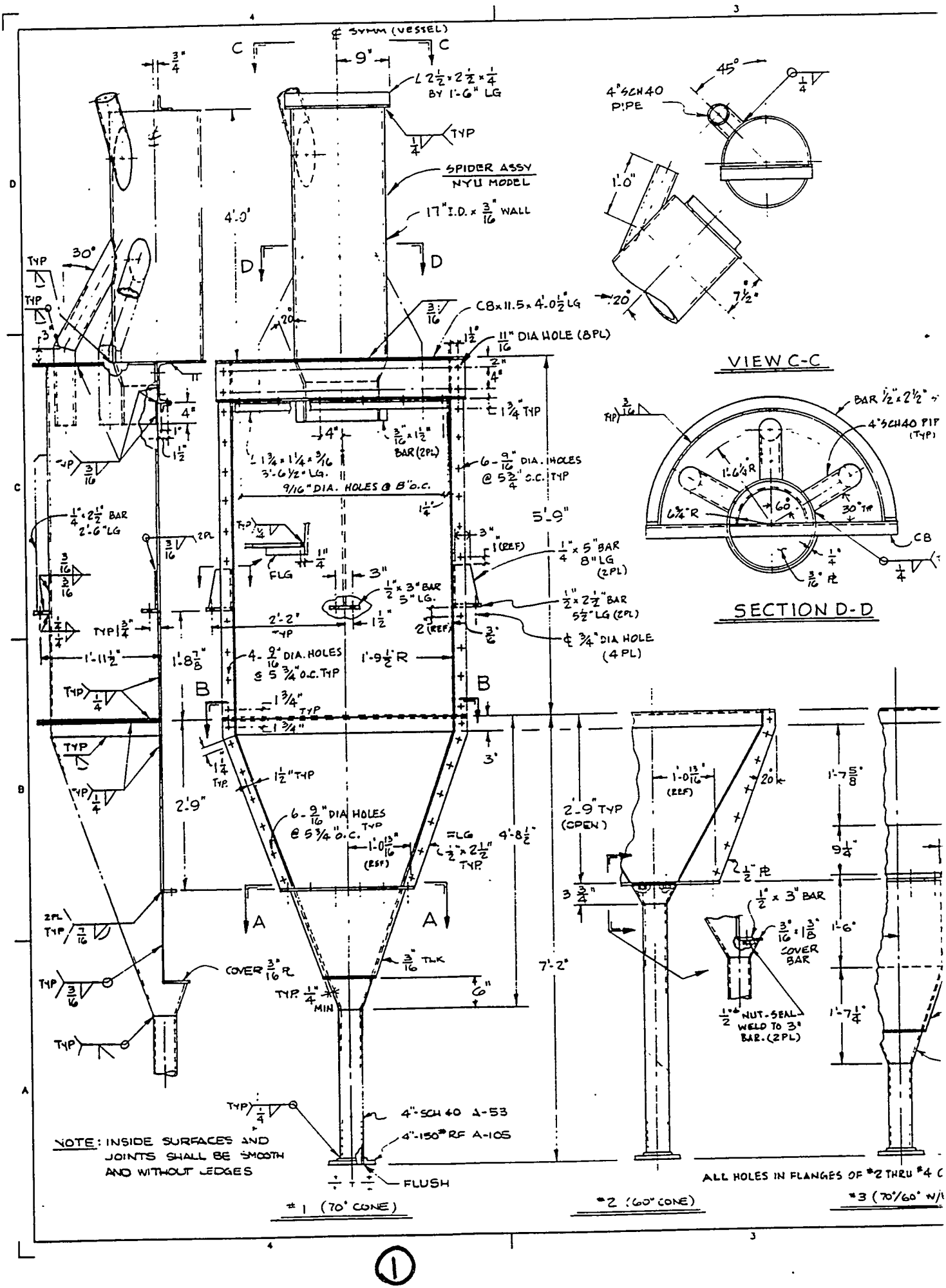
DEPARTMENT OF ENERGY
MOVING BED GRANULAR BED FILTER DEVELOPMENT PROGRAM

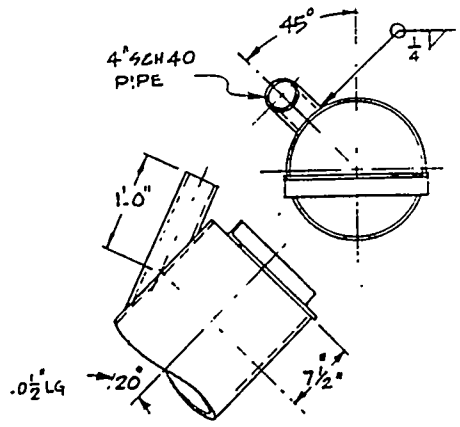
TITLE
SUPPORT STRUCTURE
GRANULAR BED FILTER TEST UNIT

DWG NO.	CONFIG REV	NO OF SHTS	DWG SIZE
1181-5080-01-116	0	4	D

SCALE NONE SHEET 1 OF 1

COMBUSTION POWER
Combustion Power Company, Menlo Park, California

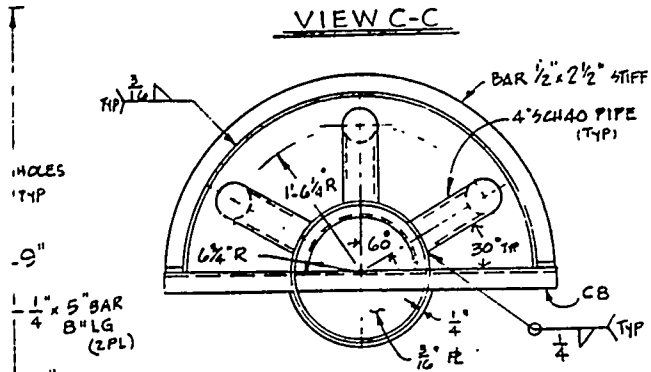

℄ SYMM (VESSEL)
C
C
9"
3/4"
L 2 1/2 x 2 1/2 x 1/4 BY 1'-6" LG
1/4 TYP
SPIDER ASSY NYU MODEL
17" I.D. x 3/16" WALL
4'-0"
D
D
TYP
30°
TYP
3"
20°
3/16
C8x11.5x4'-0 1/2" LG
1 1/2"
11/16" DIA HOLE (8PL)
2"
4"
1 3/4" TYP
4"
3/16" x 1 1/2" BAR (2PL)
L 1 3/4 x 1 1/4 x 3/16 3'-6 1/2" LG.
9/16" DIA. HOLES @ 8" o.c.
6 - 9/16" DIA. HOLES @ 5 3/4" o.c. TYP
1 1/4"
5'-9"
1/4" x 2 1/2" BAR 2'-6" LG
3/16 2PL
TYP 1/4
FLG
1"
3"
1" (REF)
1/4" x 5" BAR 8" LG (2PL)
1/2" x 3" BAR 5" LG.
1 1/2"
2'-2"
TYP
2 (REF)
3/8
1/2" x 2 1/2" BAR 5 1/2" LG (2PL)
℄ 3/4" DIA HOLE (4 PL)
TYP 1 3/4"
1'-11 1/2"
1'-8 7/8"
4 - 9/16" DIA. HOLES @ 5 3/4" o.c. TYP
1'-9 1/2" R
B
B
1 3/4" TYP
1 3/4"
TYP 1/4
3"
1 1/4" TYP.
1 1/2" TYP
2'-9"
6 - 9/16" DIA HOLES @ 5 3/4" o.c. TYP
1'-0 13/16" (REF)
FLG 1/2" x 2 1/2" TYP.
4'-8 1/2"
A
A
2PL TYP 3/16
TYP 3/16
COVER 3/16" R
3/16 TLK
TYP 1/4" MIN
6"
7'-2"
TYP
TYP 1/4
4"-SCH 40 A-53
4"-150# RF A-105
FLUSH
NOTE: INSIDE SURFACES AND JOINTS SHALL BE SMOOTH AND WITHOUT LEDGES
#1 (70° CONE)
4" SCH 40 PIPE
45°
1/4
1'-0"
20°
7 1/2°
VIEW C-C
BAR 1/2" x 2 1/2"
4" SCH 40 PIP (TYP)
1'-6 1/4" R
6 3/4" R
60°
30° TYP
CB
3/16" R
1/4
SECTION D-D
2'-9" TYP (OPEN)
1'-0 13/16" (REF)
20°
1/2" R
3 3/4"
1/2" x 3" BAR
3/16" x 1 3/8" COVER BAR
1/2" NUT - SEAL WELD TO 3" BAR. (2PL)
1'-7 5/8"
9 1/4"
1'-6"
1'-7 1/4"
ALL HOLES IN FLANGES OF #2 THRU #4 C
#2 (60° CONE)
#3 (70°/60° W/
4
3
1



.0 1/2" LG

HOLE (8 PL)

VIEW C-C



HOLES
TYP

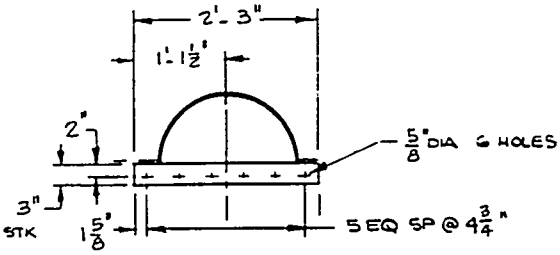
-9"

1 1/4" x 5" BAR 8" LG (2 PL)

1/2" x 2 1/2" BAR 5 1/2" LG (2 PL)

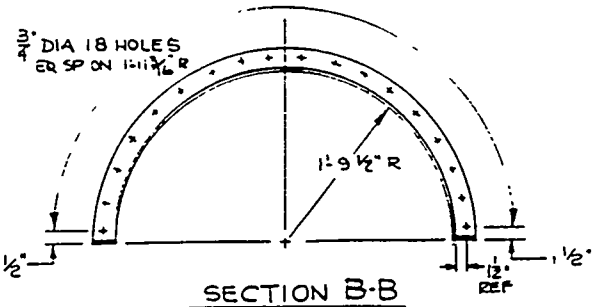
℄ 3/4" DIA HOLE (4 PL)

SECTION D-D



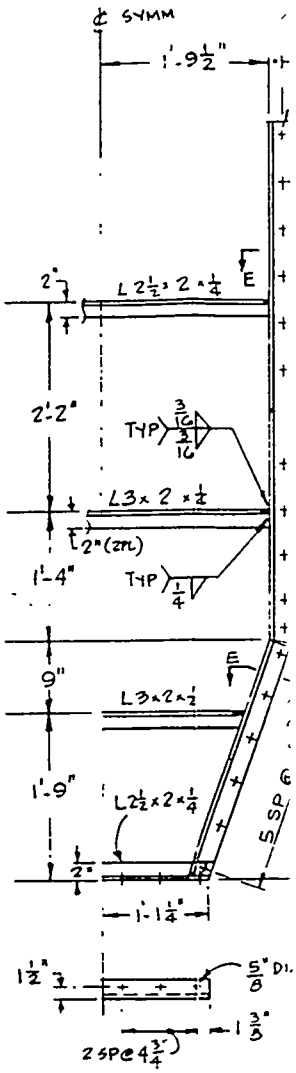
SECTION A-A

1/2" - 3" BAR ; SAME FOR ALL CONES

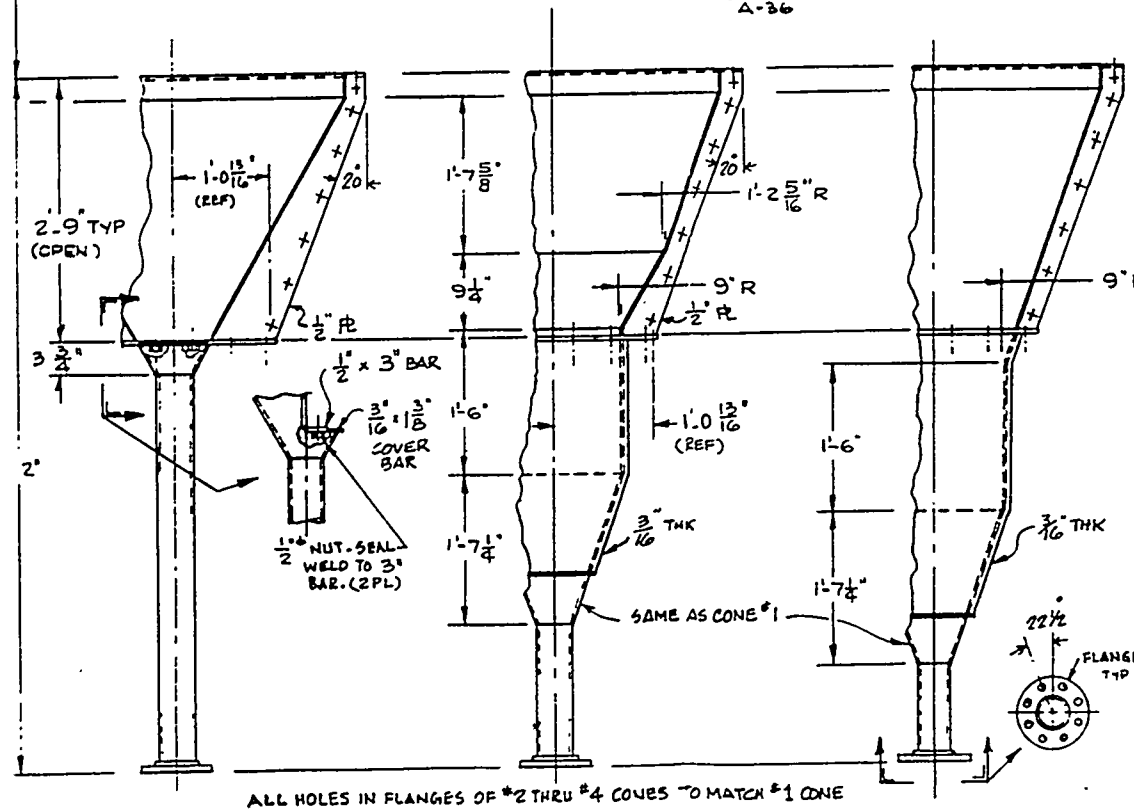


SECTION B-B

BAR 1/2" x 2 1/2" A-36 FLANGE ON CONES & BARREL



CLAMPING FRAM



ALL HOLES IN FLANGES OF #2 THRU #4 CONES TO MATCH #1 CONE

#2 (60° CONE)

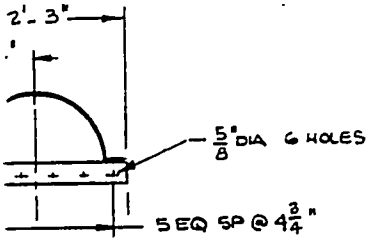
#3 (70°/60° W/EXT)

#4 (70° W/EXT)

UNLESS OTHERWISE SPECIFIED	DRN	M.J.T
DIMENSIONS ARE IN INCHES	CHK	
TOLERANCES	ENG	J.K.F
FRACTIONAL ± 1/16"	STR	
DECIMAL ± .03	PRC	
ANGLE ± 1°	PRJ	K.U.A
	APP	G.D.G
	REL	K Hughes Jr.

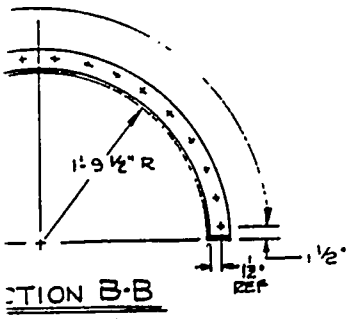
(2)

REVISIONS			
FOR DESCRIPTION OF CHG SEE E 0			
LTR	BY	DATE	APPR



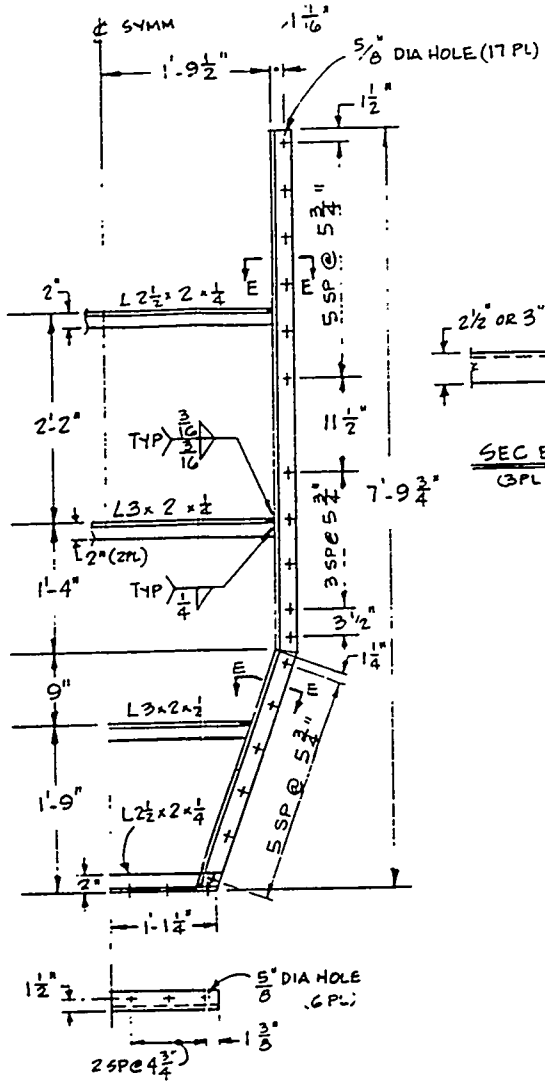
SECTION A-A

SAME FOR ALL CONES

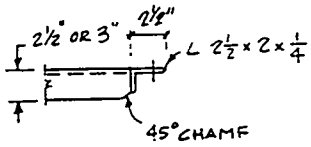


SECTION B-B

ON CONES & BARREL

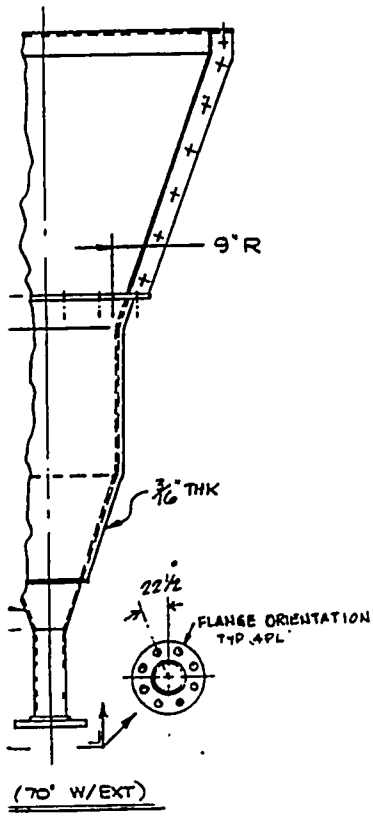


CLAMPING FRAME



SEC E-E

(3PL)



(70° W/EXT)

DEPARTMENT OF ENERGY
MOVING BED GRANULAR BED FILTER
DEVELOPMENT PROGRAM

TITLE

HALF FILTER VESSEL ASSEMBLY

UNLESS OTHERWISE SPECIFIED:	DRN	M.T.	9/23/94
DIMENSIONS ARE IN INCHES	CHK		
TOLERANCES	DWG	JEF	10/6/94
FRACTIONAL ± 1/16"	STR	[illegible]	9/26/94
DECIMAL ± .03	PRC		
ANGLE ± 1°	PRJ	KJW	10/6/94
	APP	GDG	10/6/94
	REL	K Hadley	11/4/94

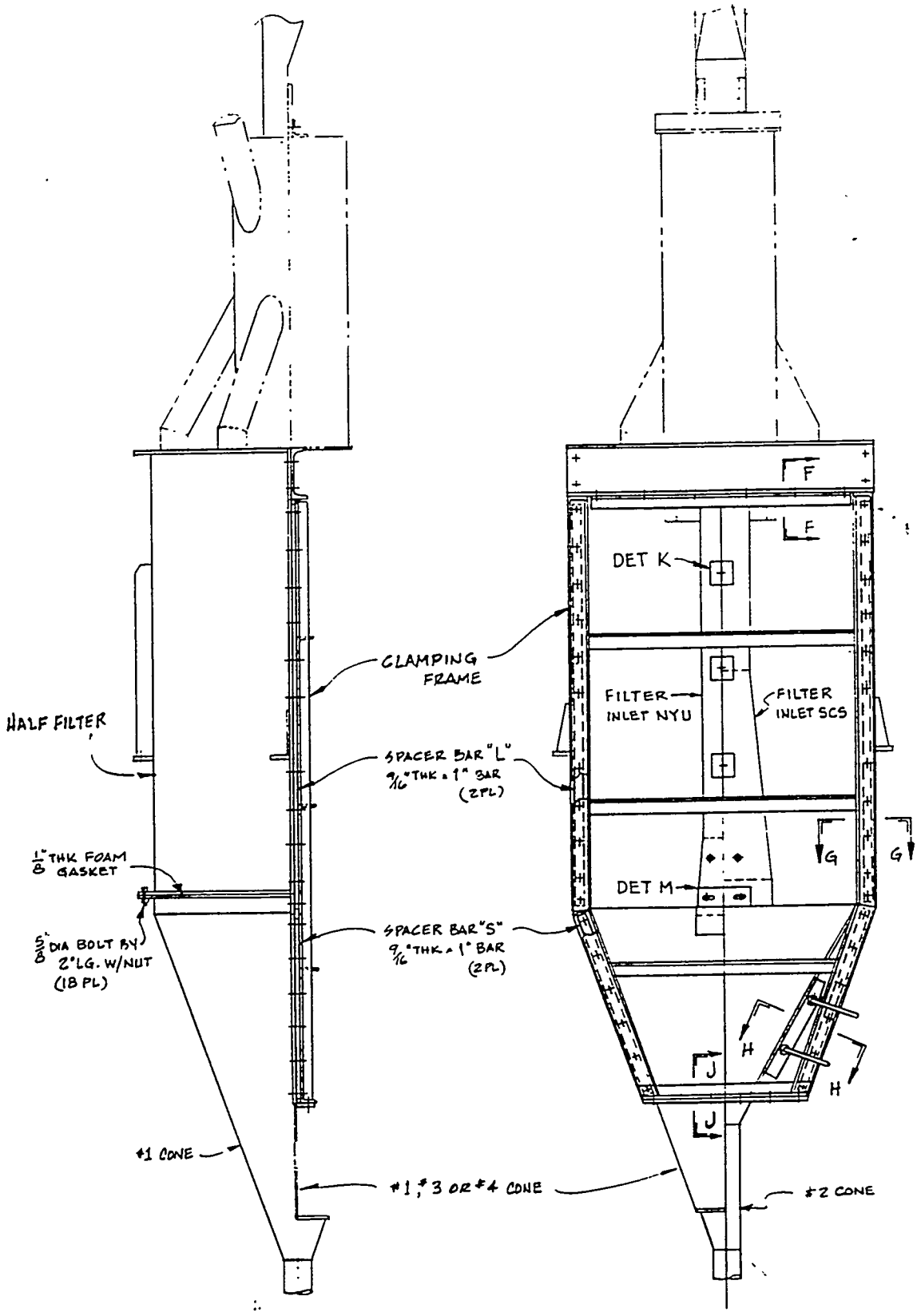
DWG NO. 1181-5010-01-190 | COMPLETE REV 1 1 | NO OF SHTS THIS SIZE 2 | SIZE D

SCALE 1" = 1'-0" | SHEET 1 OF 2

COMBUSTION POWER

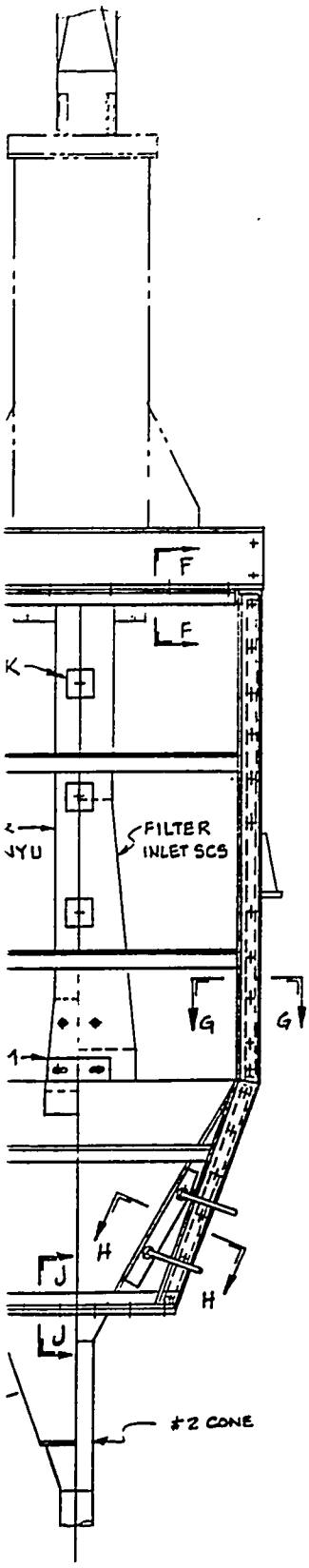
Combustion Power Company, Menlo Park, California

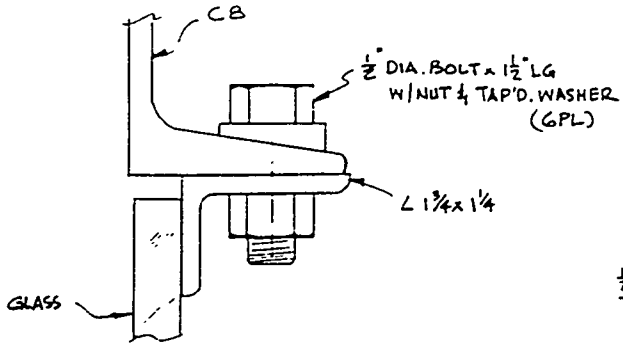
3



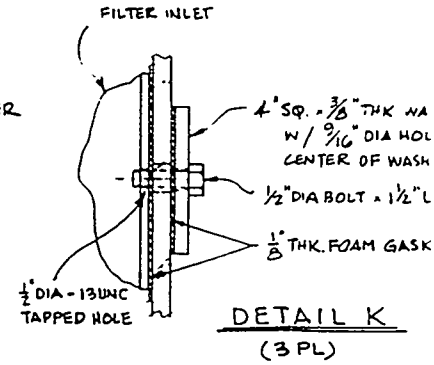
HALF FILTER ASSY
GLASS MOUNTING DETAILS

(1)

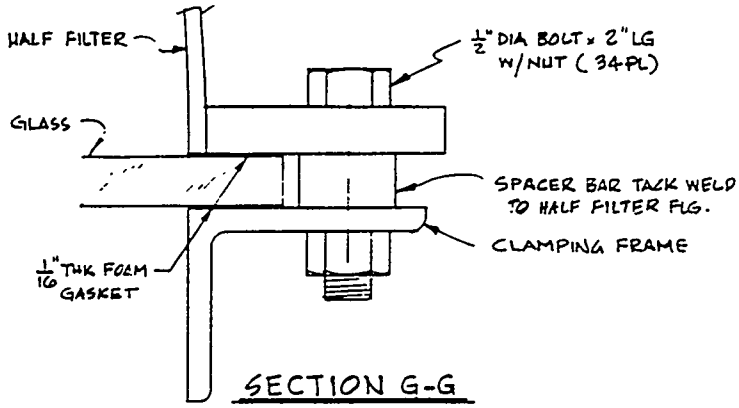




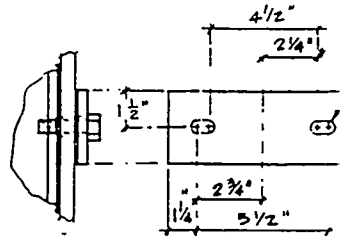
SECTION F-F



DETAIL K
(3 PL)

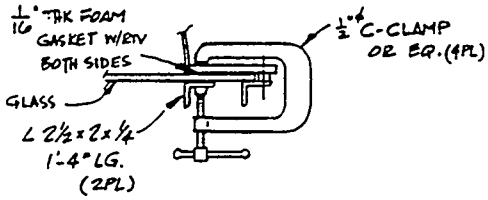


SECTION G-G

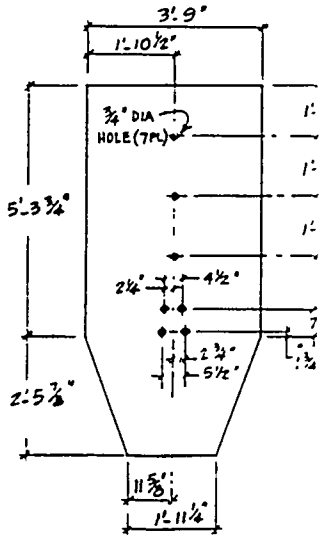


(ALL DETAILS NOT SHOWN SA

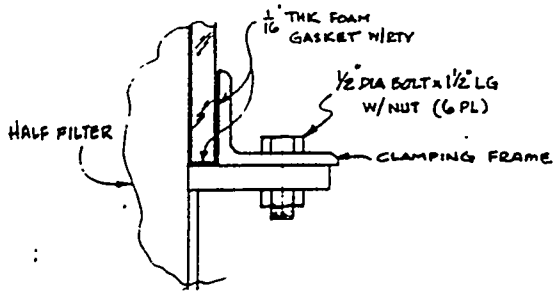
DETAIL M



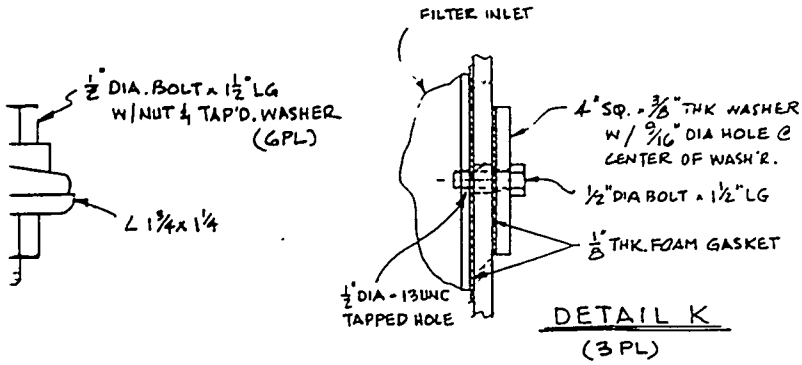
SECTION H-H



DETAIL OF
½" THK TEMPERED GLASS

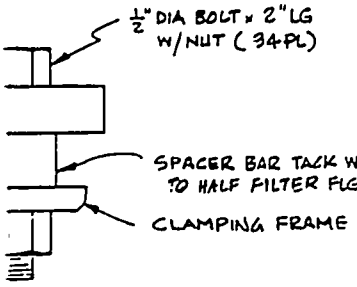


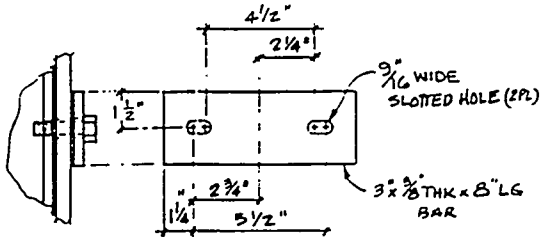
SECTION J-J



DETAIL K
(3 PL)

ION F-F

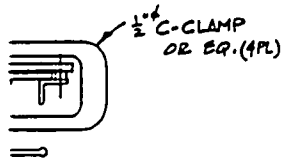


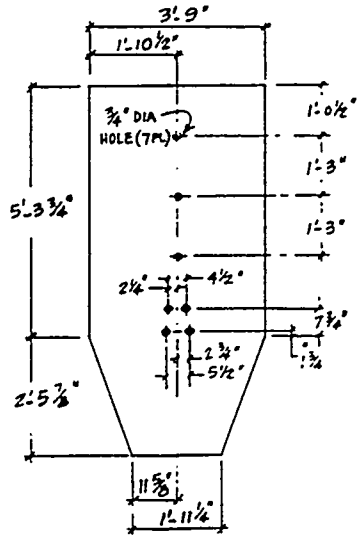


(ALL DETAILS NOT SHOWN, SAME AS DET K ABOVE)

DETAIL M

ON G-G





DETAIL OF
½" THK TEMPERED GLASS

ON H-H

AM
T W/ETY
" DIA BOLT x 1½" LG
W/NUT (6 PL)
— CLAMPING FRAME

J-J

NOTES:

3. WELD PER CPC ST1132
2. BREAK ALL SHARP EDGES.
1. STEEL FABRICATION PER CPC ST 1133.

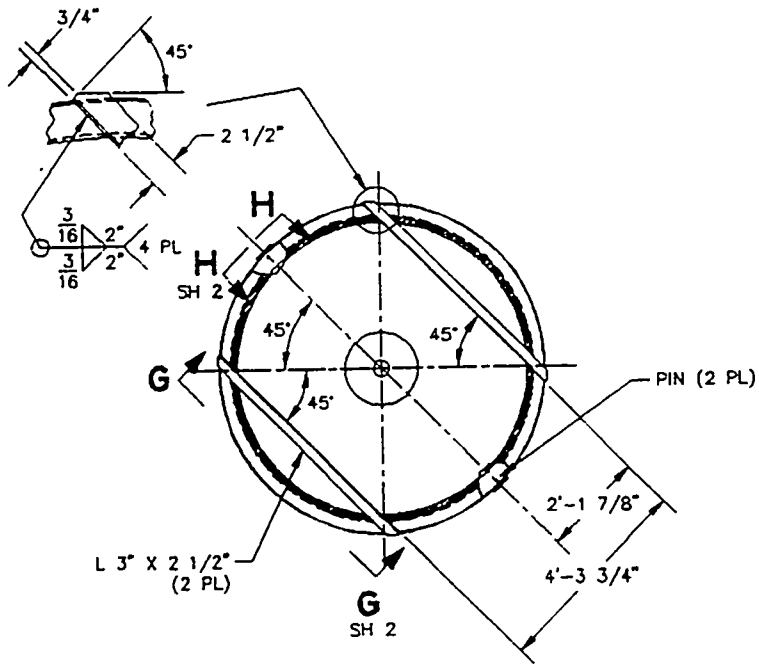
DEPARTMENT OF ENERGY
MOVING BED GRANULAR BED FILTER DEVELOPMENT PROGRAM

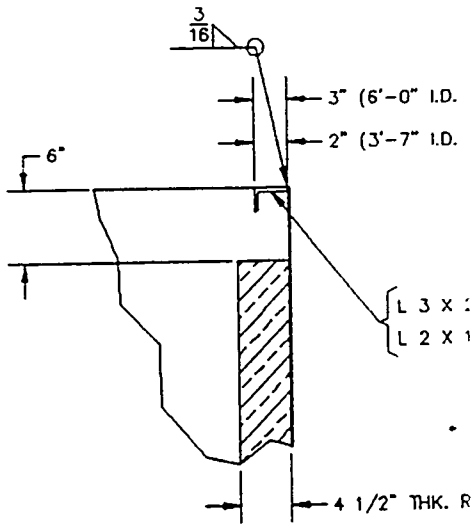
TITLE
HALF FILTER VESSEL ASSEMBLY

DWG NO.	CODE IDENT	REV	NO OF SHTS	DWG SIZE
1181-5010-01-190		0	2	4 D

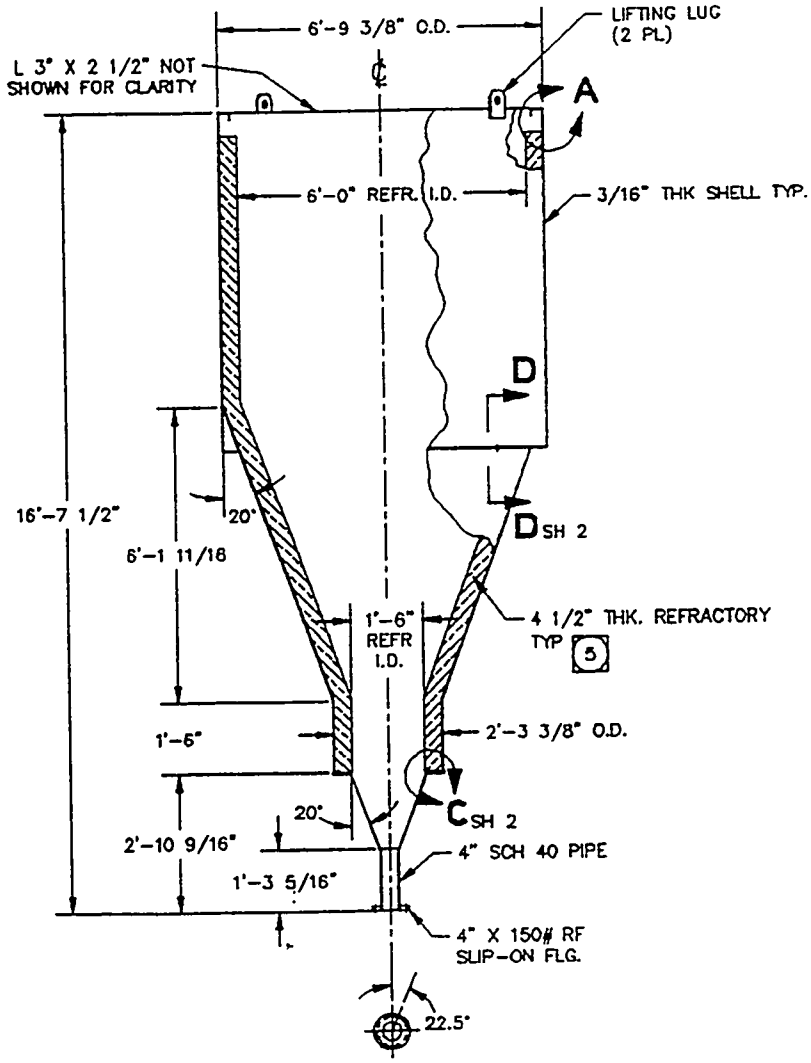
SCALE NONE | SHEET 2 OF 2

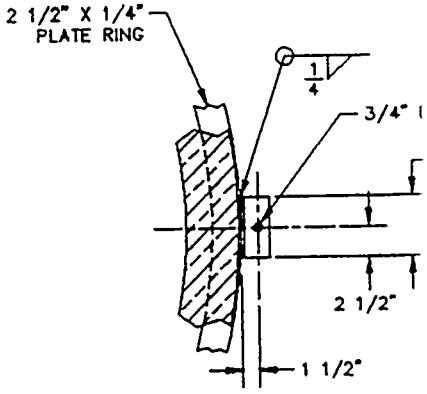
COMBUSTION POWER
Combustion Power Company, Menlo Park, California

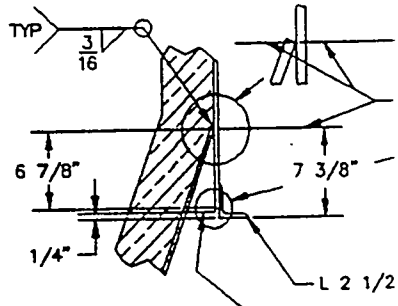




DETAIL A
SCALE: 1 1/2"=1'-0"





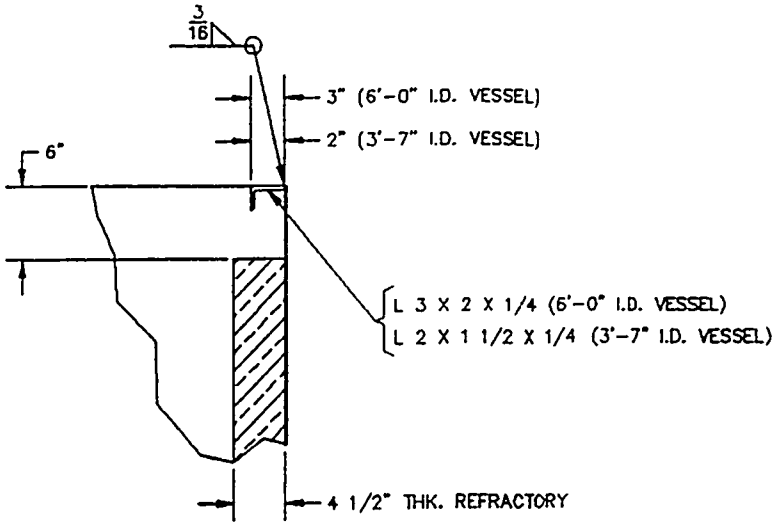


DETAIL B
SCALE: 1 1/2"=1'-0"
TYP 4 PL

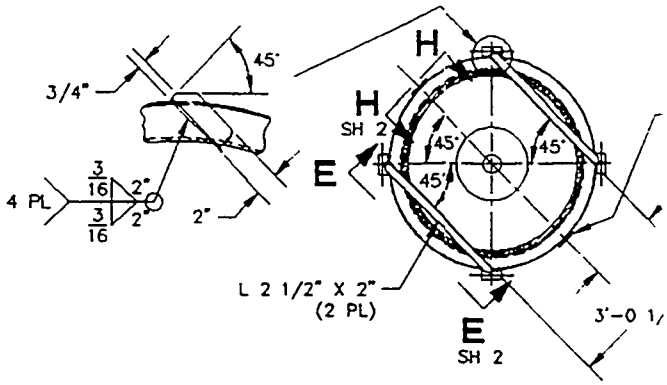
NO

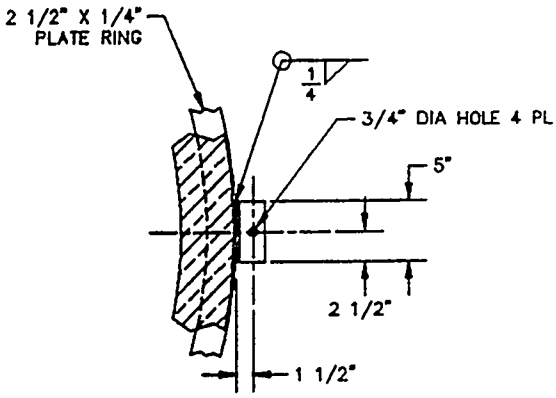
10-04-94 2:19 PM CAD# F:\1181\5010\02190-1

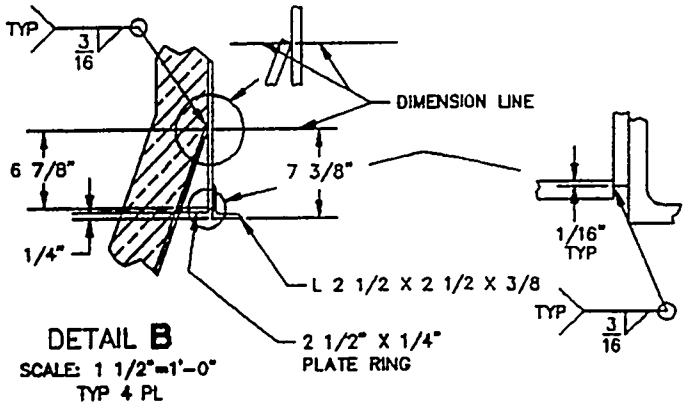
(1)



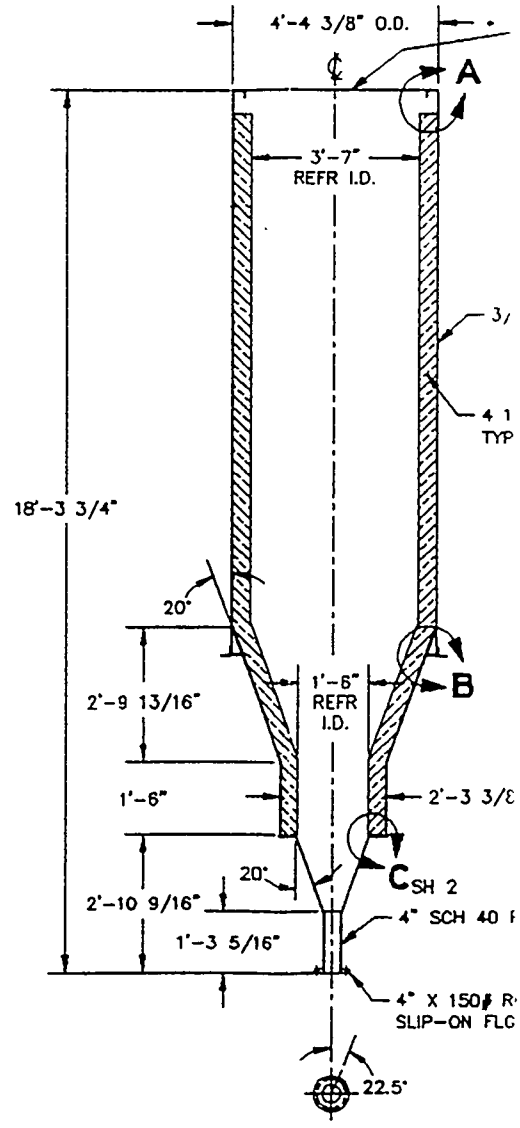
DETAIL A
SCALE: 1 1/2"=1'-0"







DETAIL B
SCALE: 1 1/2"=1'-0"
TYP 4 PL

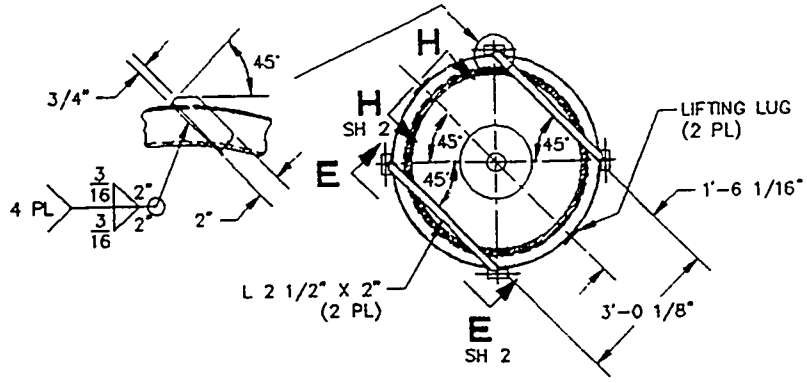


6. BRICK SHELVES WILL BE DEFINED BY REFRACTORY CONTRACTOR.
5. REFRACTORY: SUPER-DUTY BRICK OR EQUAL.
4. ALL 3/16" THK. CYLINDRICAL OR CONICAL PARTS SHALL BE JOINED WITH FULL PENETRATION BUTT WELD.
3. BREAK ALL SHARP EDGES.
2. ALLOY STEEL FABRICATION PER CPC ST1133.
1. ALL CARBON STEEL SHAPES AND PLATE MATERIAL PER ASTM A36 OR EQ.

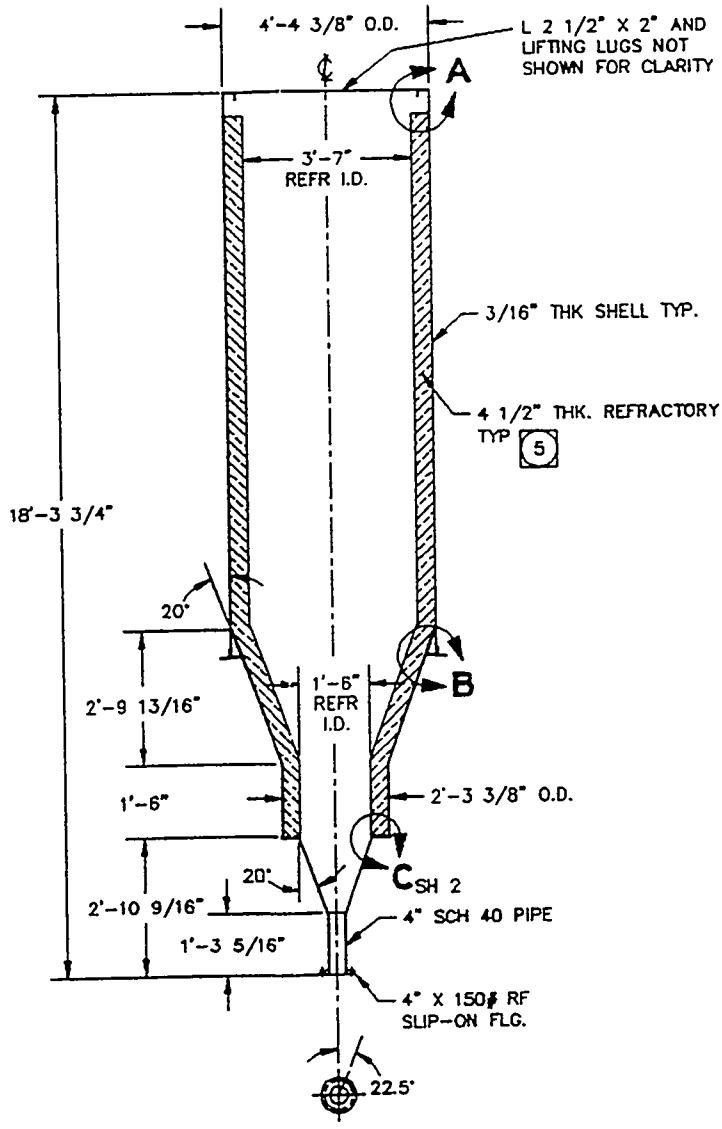
NOTES:

DRN	EA	7/8/94	
CHK	JWP	10/4/94	
ENG	JWP	10/4/94	
MFR	M Thomas	10/19/94	DWG NO. 118
PRC			
PRJ			
APP	A. Davis	10/5/94	
REL	K. Pauk	10/5/94	

REVISIONS			
FOR DESCRIPTION OF CHG. SEE E. O.			
NO.	BY	DATE	APPR.



SSEL)
. VESSEL)



BE DEFINED BY REFRACTORY CONTRACTOR.

R-DUTY BRICK OR EQUAL.

INDRICAL OR CONICAL PARTS
TH FULL PENETRATION BUTT WELD.

EDGES.

CATION PER CPC ST1133.

SHAPES AND PLATE MATERIAL
EQ.

DRN	EA	7/8/94
CHK	JWP	10/4/94
ENG	JWP	10/4/94
STR	MThomas	10/4/94
PRC		
PRJ		
APP	A. Davis	10/5/94
REL	K. Pope	10/5/94

TITLE: FILTER VESSEL ASSEMBLIES– 3'-7" DIA. AND 6'-0" DIA.

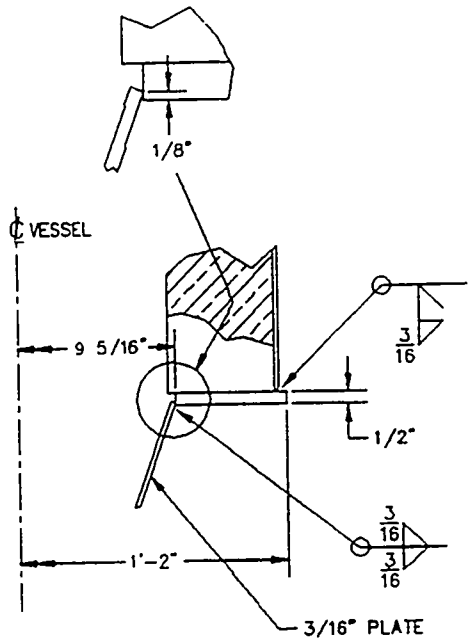
DWG NO. 1181-5010-02-190 | COMPANY REV 00 | NO OF SHTS 02 | DWG SIZE 4 D

SCALE 1/2" =1'-0" | SHEET 1 OF 2

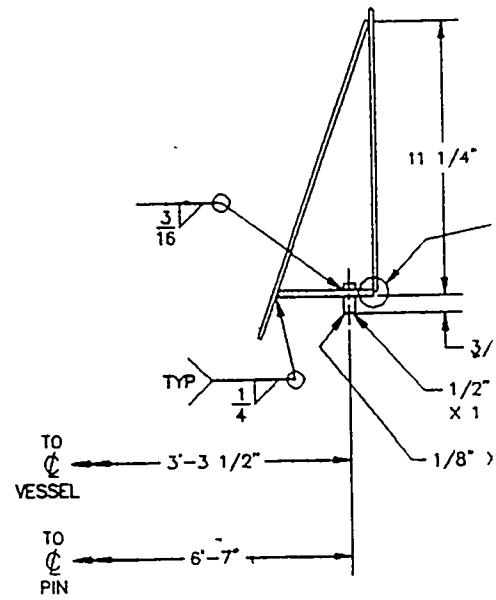
COMBUSTION POWER

Combustion Power Company, Oakland, California

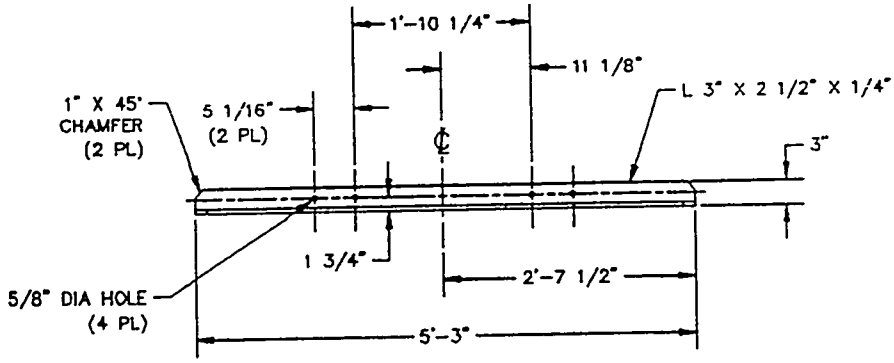
3



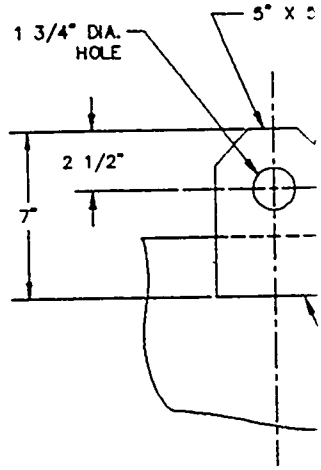
DETAIL **C** SH 1
SCALE: 3"=1'-0"



SECTION **D-D** SH
SCALE: 3"=1'-0"

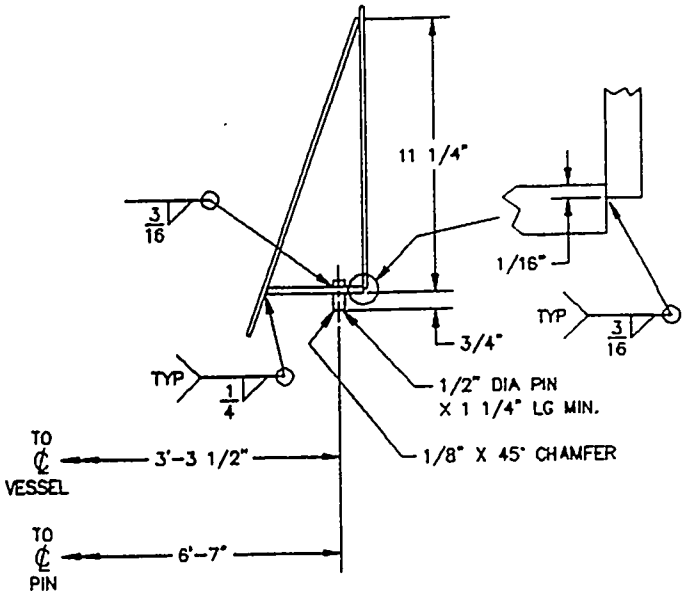


VIEW **G-G** SH 1
SCALE: 1"=1'-0"
TYP 2 PL

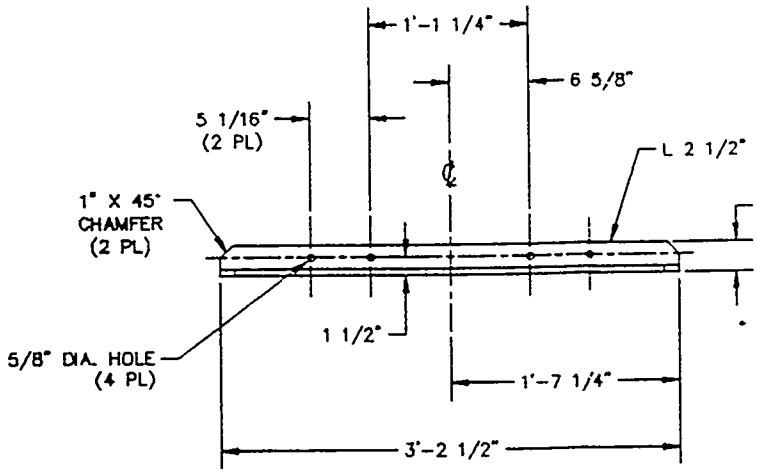


VIEW **H-H**
SCALE: 3"=1'

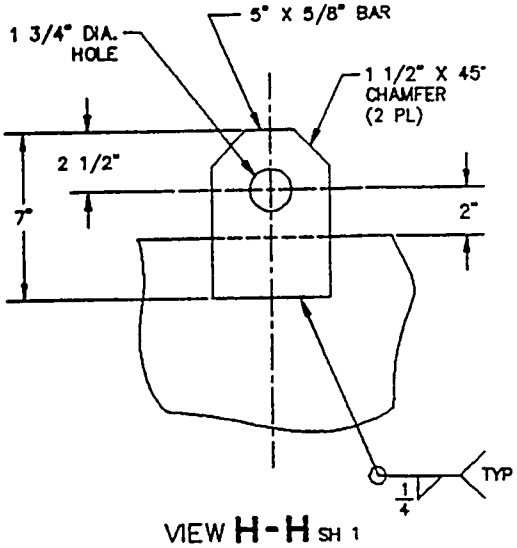
10-03-94 3:47 PM CAD# F:\1181\5010\02190-2



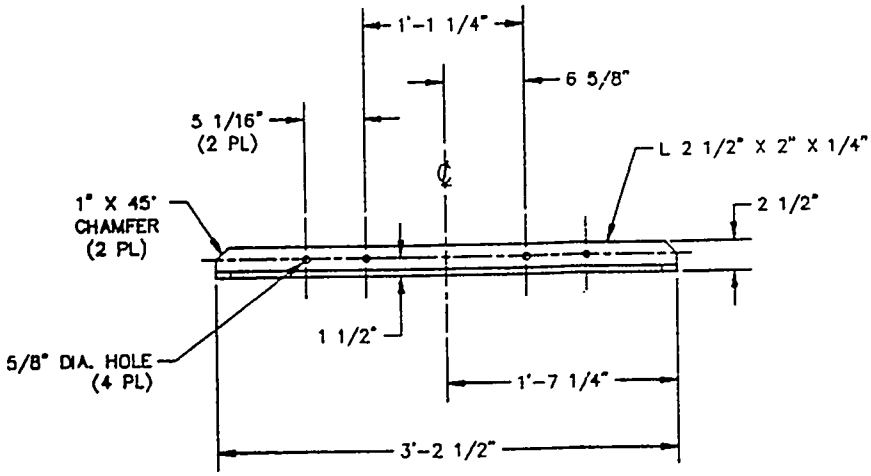
SECTION **D-D** SH 1
SCALE: 3"=1'-0"



VIEW **E-E** SH 1
SCALE: 1 1/2"=1'-0"
TYP 2 PL



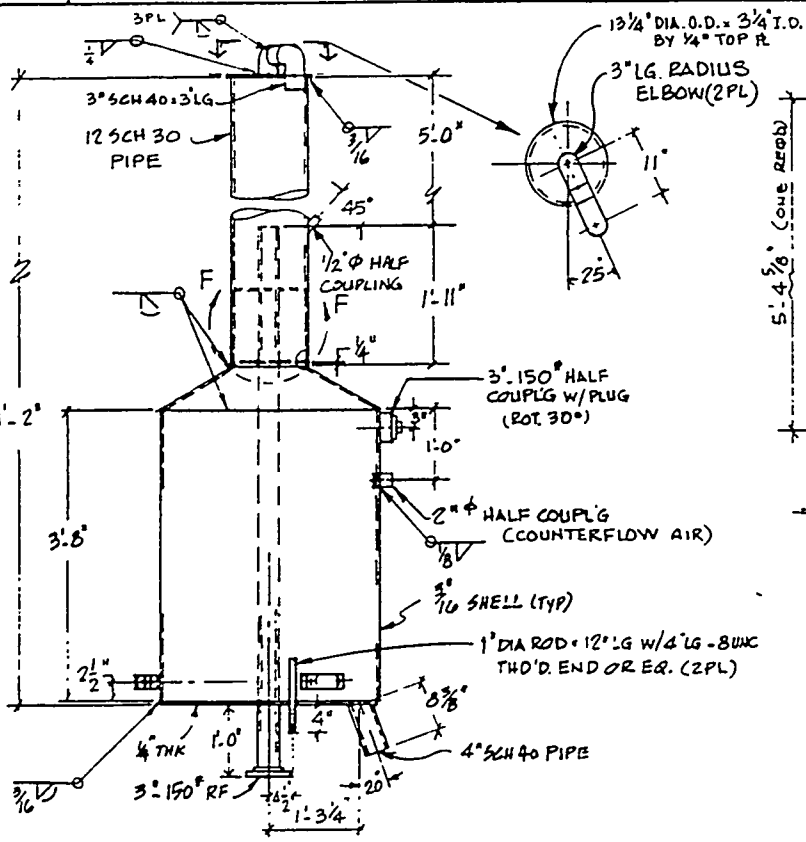
VIEW **H-H** SH 1
SCALE: 3"=1'-0"



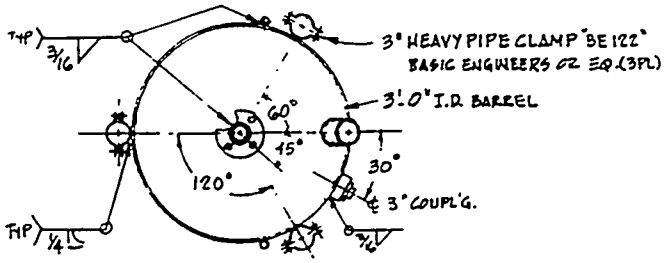
VIEW **E-E** SH 1
SCALE: 1 1/2"=1'-0"
TYP 2 PL

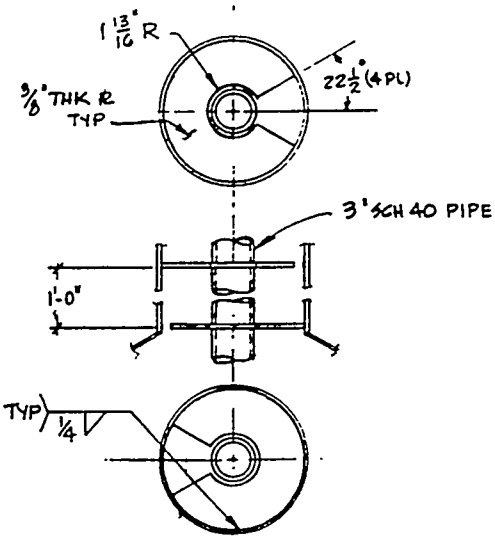
TITLE: FILTER VESSEL ASSEMBLIES– 3'–7" DIA. AND 6'–0" DIA.					
DWG NO. 1181–5010–02–190		COMPANY REV 00	NO OF SHTS 02	DWG SIZE 4	D
SCALE 1/2" =1'–0"	SHEET 2 OF 2				
COMBUSTION POWER Combustion Power Company, Goldens, California					

(3)

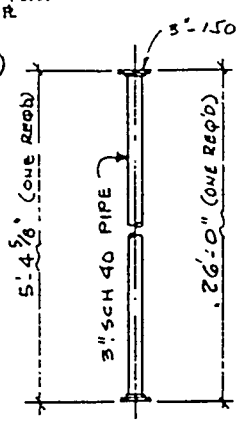


DE-ENTRAINMENT VESSEL (DEV)

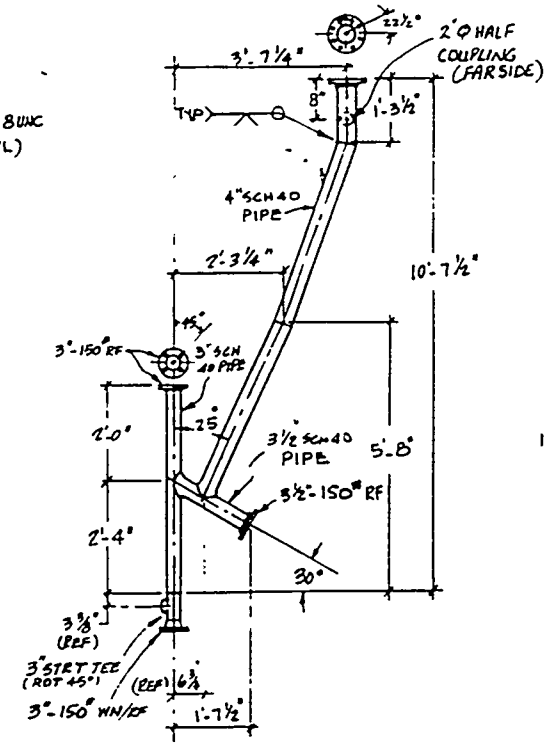




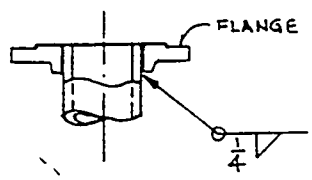
DETAIL F-F



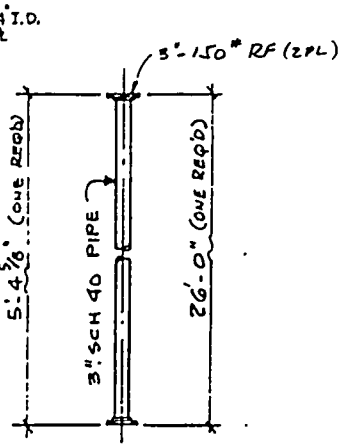
PIPE SPOOLS
LIFT PIPE



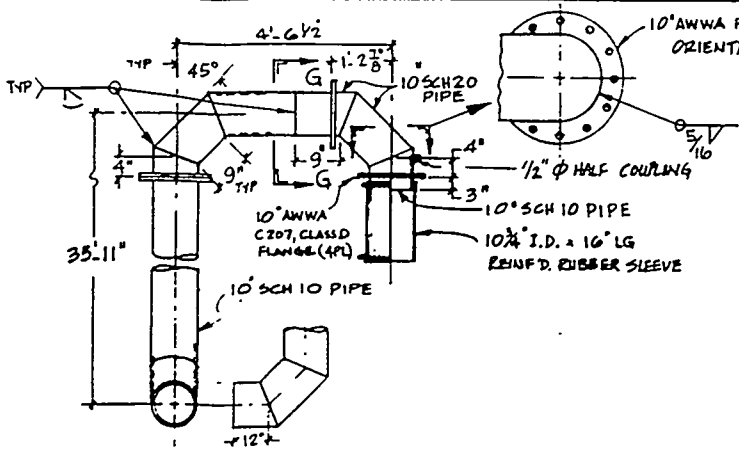
L-VALVE DETAILS



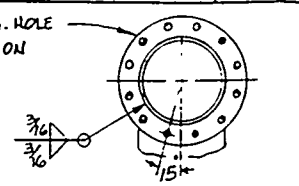
TYP FLANGE WELDING
DETAIL

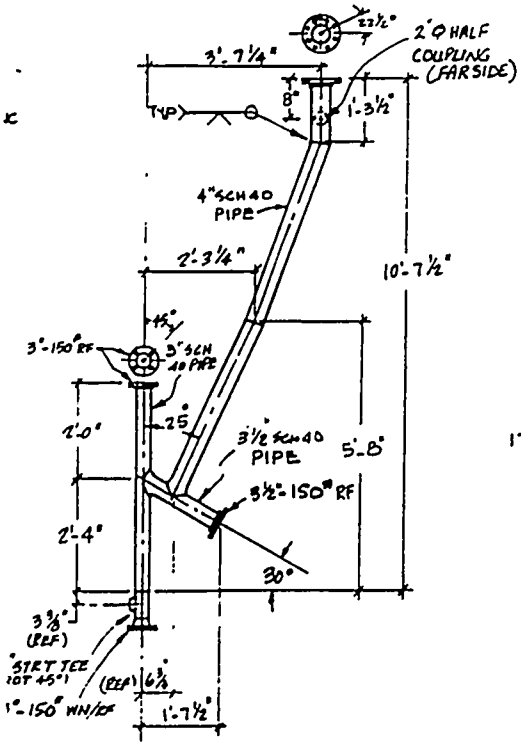


PIPE SPOOLS
LIFT PIPE

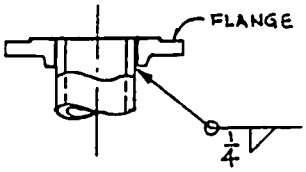


INLET PIPE
DETAILS

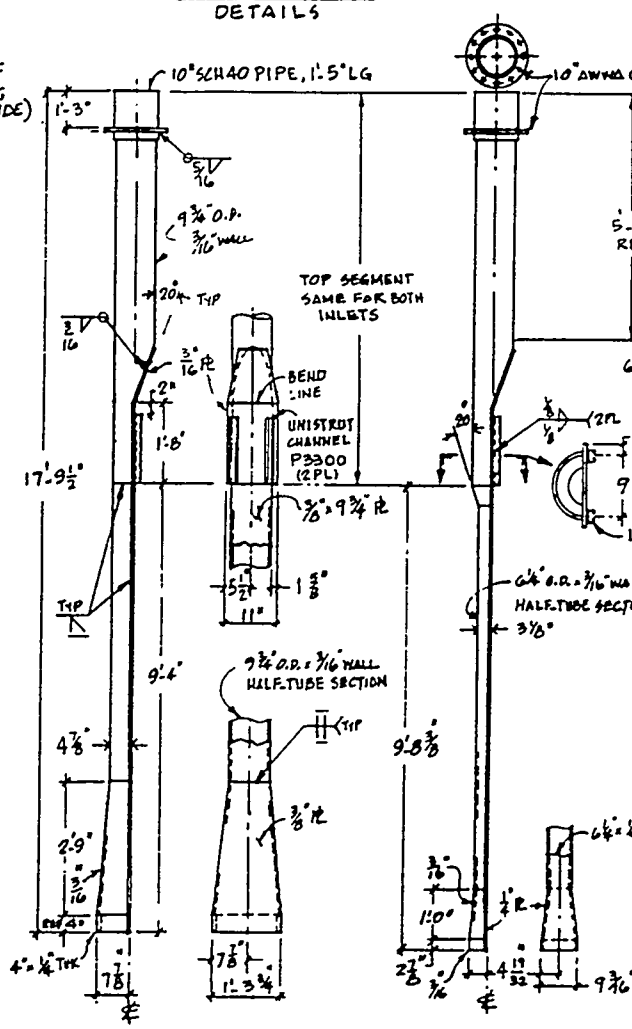




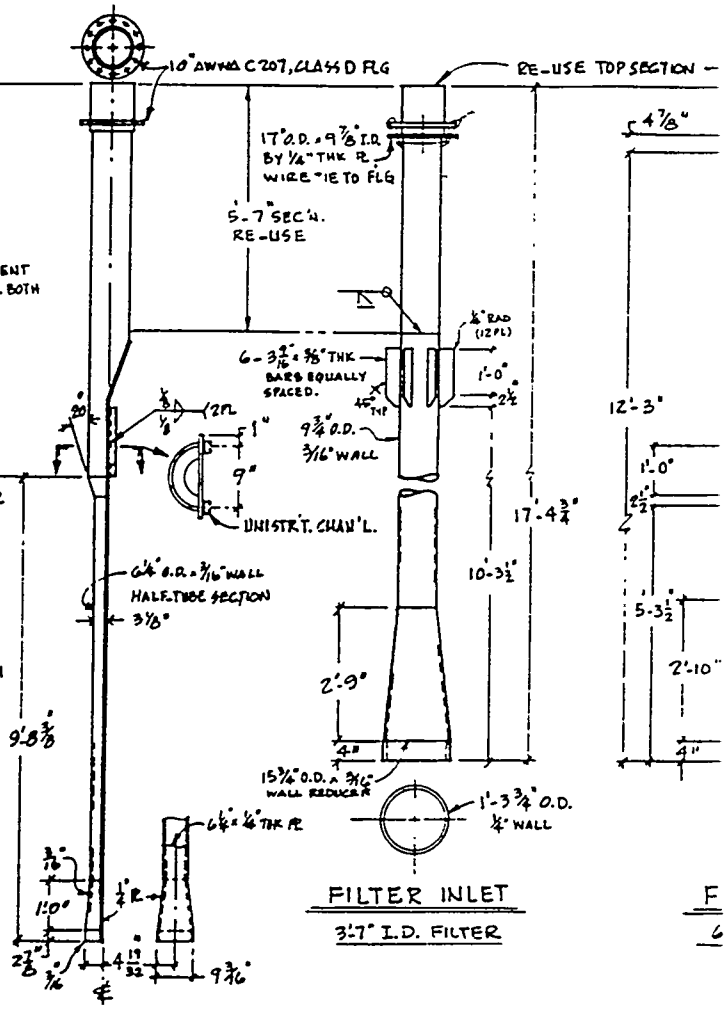
"L" VALVE DETAILS



TYP FLANGE WELDING
DETAIL



FILTER INLET SCS
9 3/8" I.D.
HALF-MODEL



FILTER INLET NYU
5 7/8" I.D.
HALF-MODEL

FILTER INLET
3'-7" I.D. FILTER

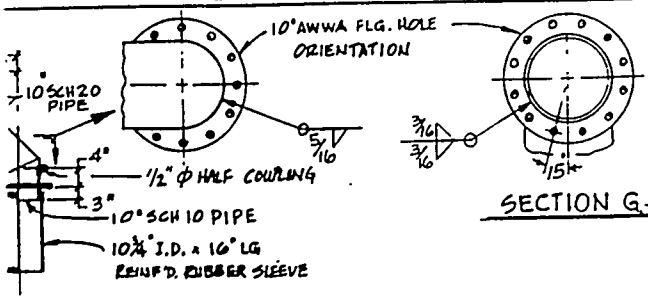
UNLESS OTHERWISE SPECIFIED:			
DIMENSIONS ARE IN INCHES		DRN	M.J.T. 9/7
TOLERANCES		CHK	JHF 15
FRACTIONAL	± 1/16"	ENG	JHF 15/16
DECIMAL	± .03	STR	Thomso 9/1
ANGLE	± 1°	PRC	
		PRJ	K. Wils 10/1
		APP	SDS 10/1
		REL	K Hagy 10/1

2. BREAK ALL SHARP EDGES.

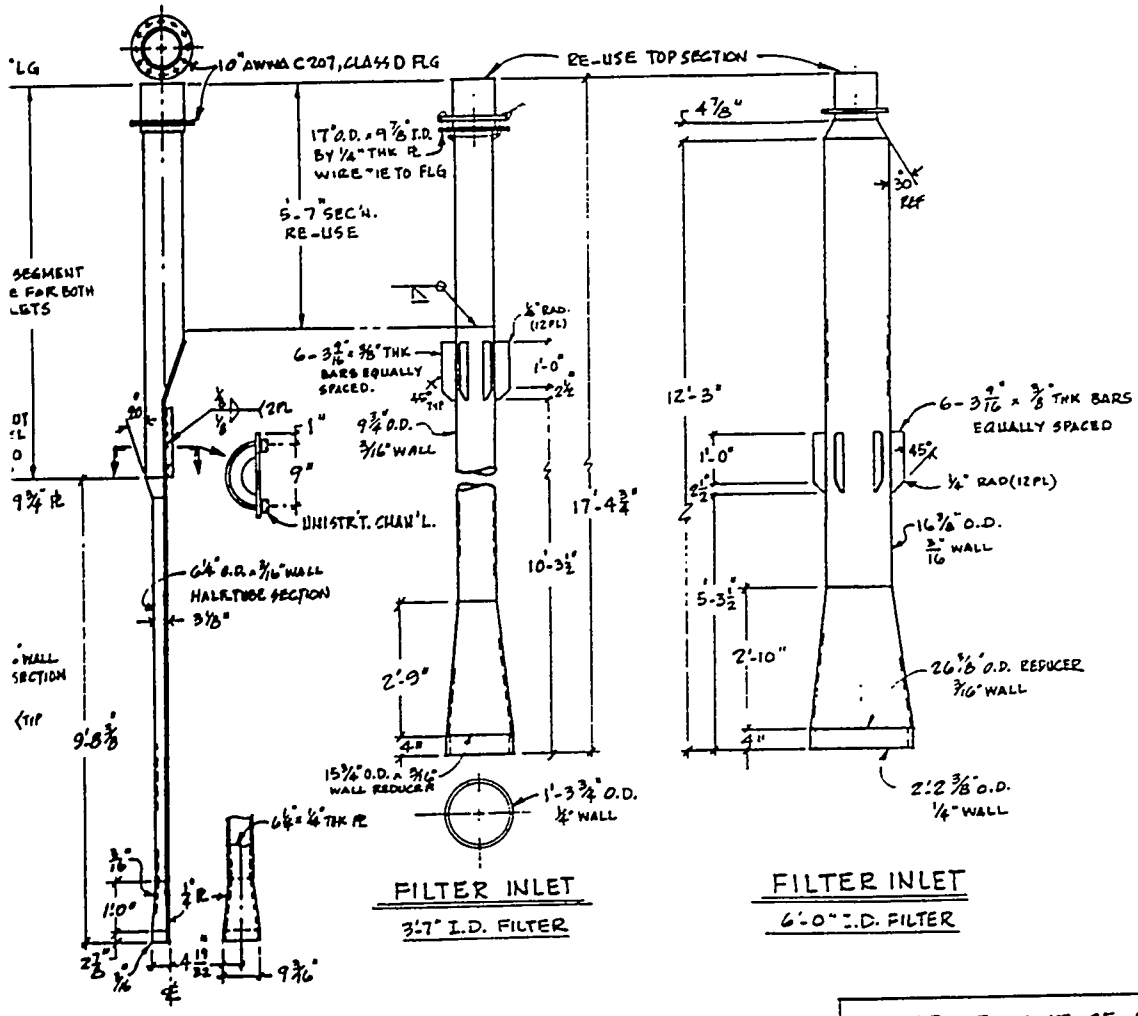
1. STEEL FABRICATION PER CPC ST1133 & WELDING PER CPC ST1132.

NOTES:

REVISIONS			
FOR DESCRIPTION OF CHG SEE E O			
LTR	BY	DATE	APPR



SECTION G-G



FILTER INLET
3'-7" I.D. FILTER

FILTER INLET
6'-0" I.D. FILTER

FILTER INLET NYU
5 7/8" I.D.
HALF-MODEL

DEPARTMENT OF ENERGY
MOVING BED GRANULAR BED FILTER
DEVELOPMENT PROGRAM

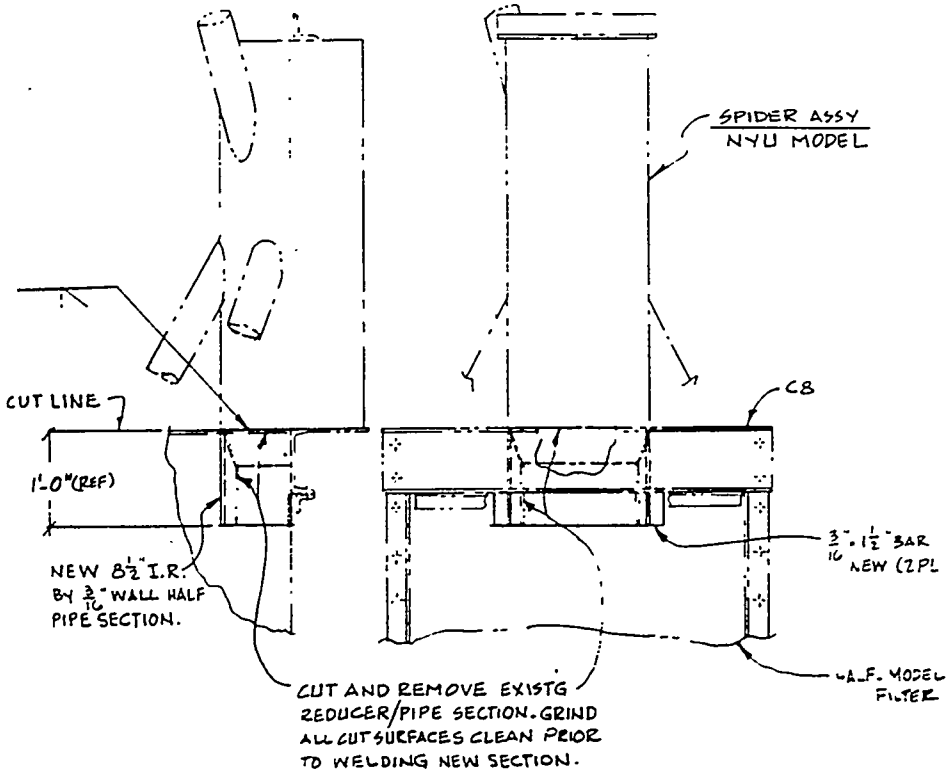
TITLE
DEV AND FILTER VESSEL INTERNALS

UNLESS OTHERWISE SPECIFIED:	DRN	M.J.T. 9/7/94
DIMENSIONS ARE IN INCHES	CHK	9/6/94
TOLERANCES:	ENG	9/6/94
FRACTIONAL ± 1/16"	STR	Thomas 9/12/94
DECIMAL ± .03	PRC	
ANGLE ± 1°	PRJ	K. Wills 10/6/94
	APP	10/6/94
	REL	K Hagy 10/6/94

DWG NO. 1181-5010-10-114 | CONFIG 1 | REV 0 | NO OF SHTS 2 | DWG SIZE A1D
SCALE NONE | SHEET 1 OF 2

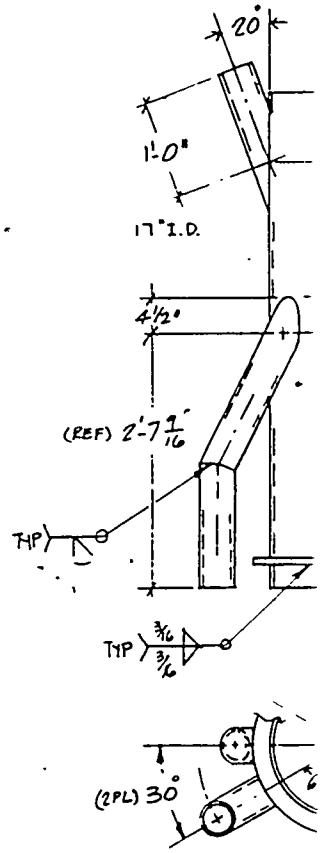
COMBUSTION POWER
Combustion Power Company, Menlo Park, California

CPC ST1133 & WELDING PER CPC ST1132.



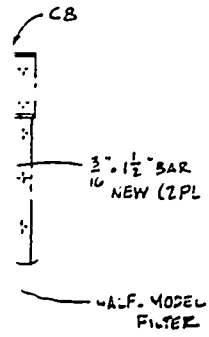
SPIDER ASSY.- SCS ½-MODEL

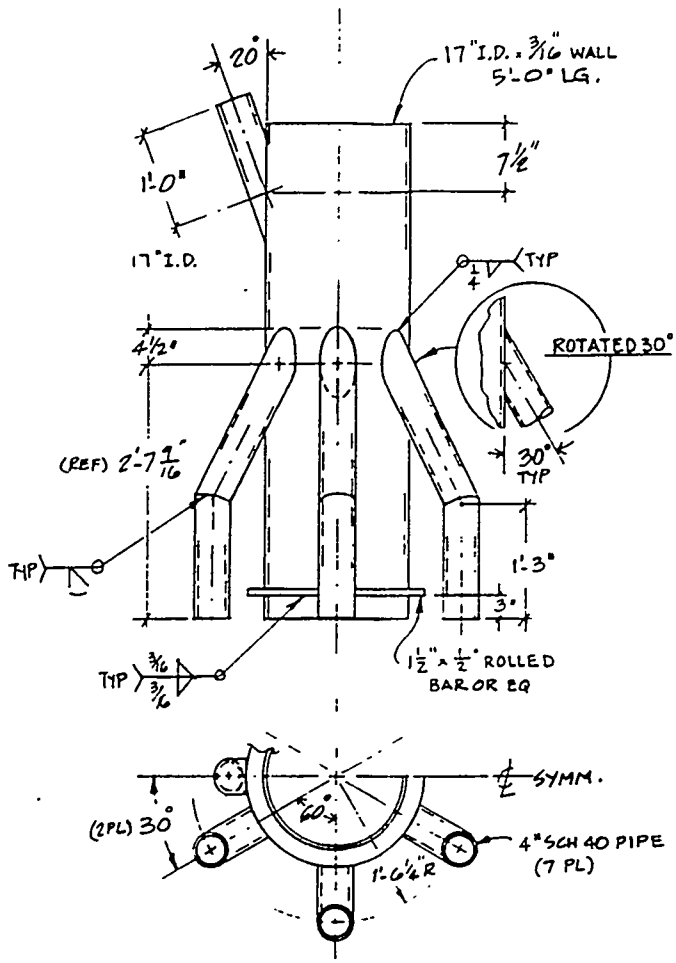
(USING REWORKED NYU MODEL - FOR WELDING & DETAILS NOT SHOWN SEE NYU MODEL)



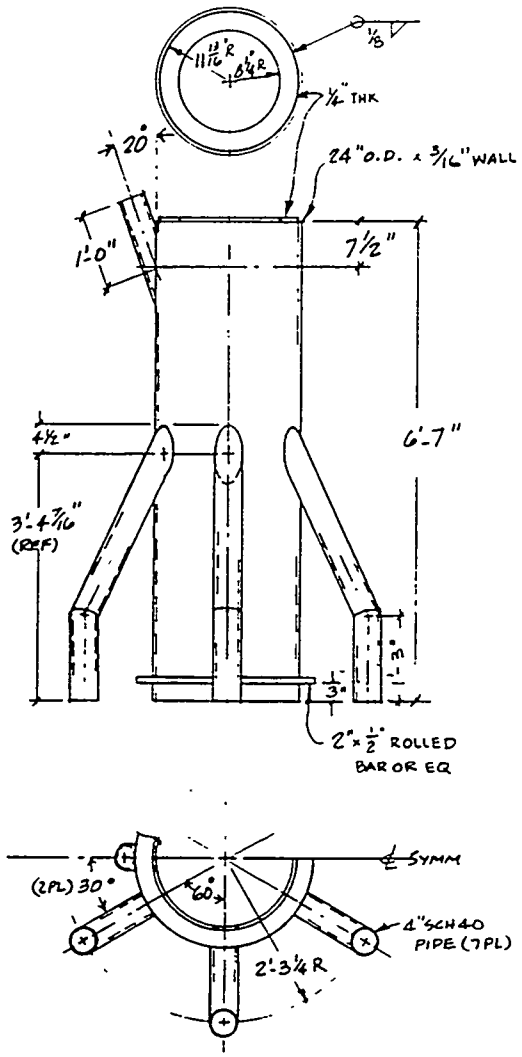
SPIDE
(3'-

IDER ASSY.
YU MODEL





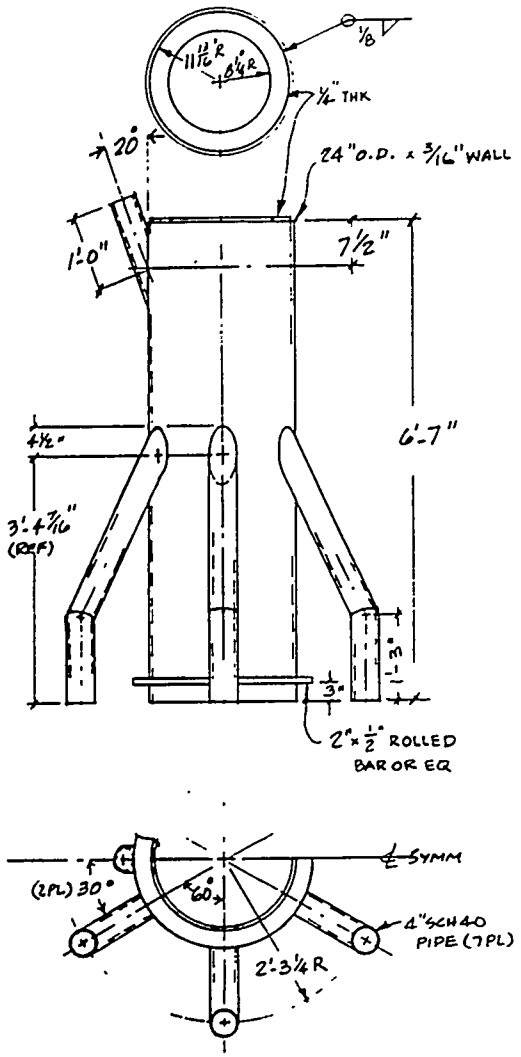
SPIDER ASSY. SCS MODEL
(3'-7" I.D. FILTER)



SPIDER ASSY - SCS MODEL
(6'-0" I.D. FILTER)

UNLESS OTHERWISE SPECIFIED:	DRN
DIMENSIONS ARE IN INCHES	CHK
TOLERANCES	ENG
FRACTIONAL ± 1/16"	STR
DECIMAL ± .03	PRC
ANGLE ± 1°	PRJ
	APP
	REL

REVISIONS			
FOR DESCRIPTION OF CHG SEE E O			
LTR	BY	DATE	APPR



SPIDER ASSY - SCS MODEL
(6'-0" I.D. FILTER)

DEPARTMENT OF ENERGY
MOVING BED GRANULAR BED FILTER
DEVELOPMENT PROGRAM

TITLE
DEV AND FILTER VESSEL
INTERNALS

DWG NO. 181-5010-10-114	CONTRACT	NO OF SHTS 2	SIZE D	REV
SCALE NONE	SHEET 2 OF 2			

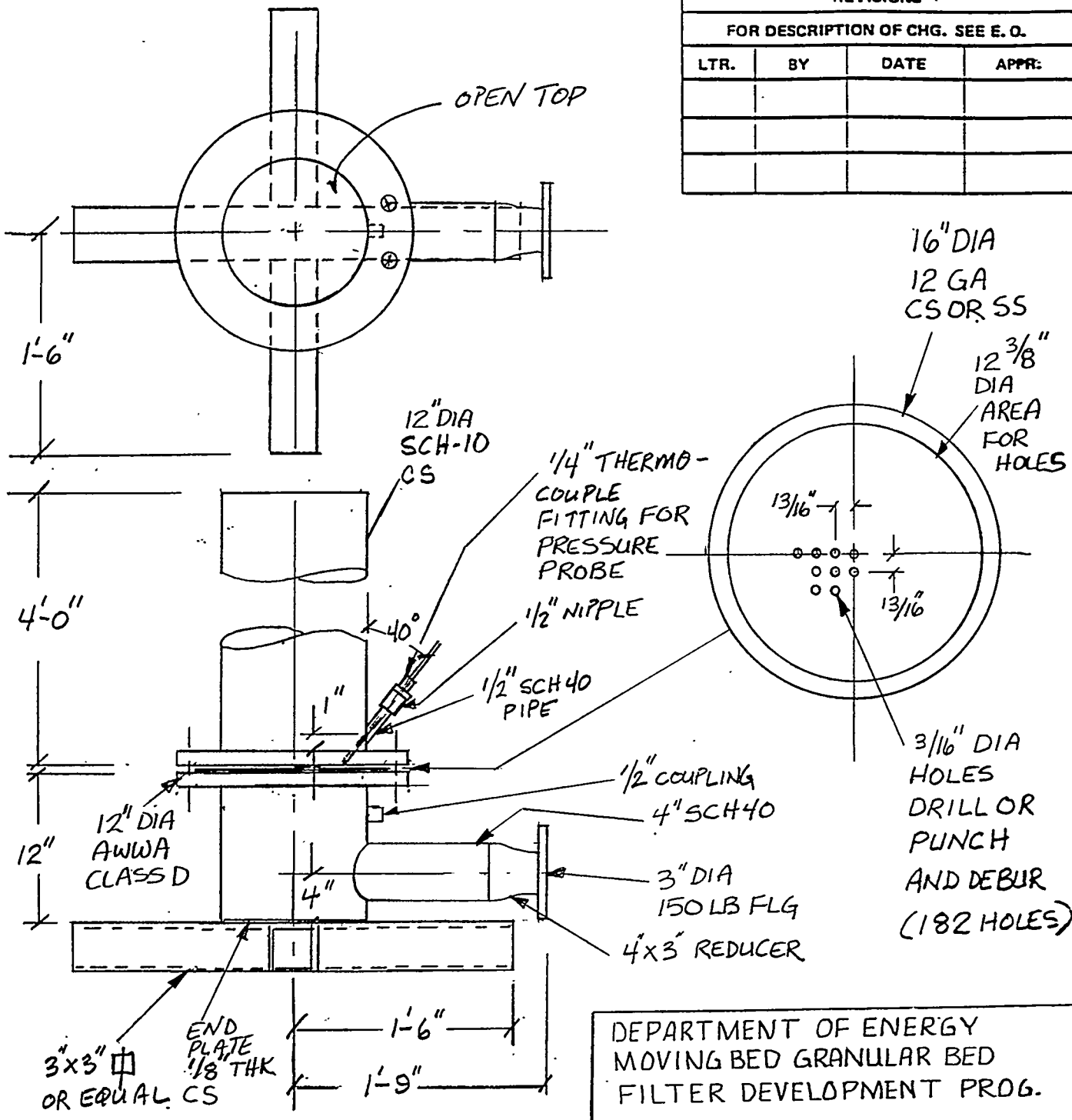
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES; TOLERANCES: FRACTIONAL ± 1/16", DECIMAL ± .03, ANGLE ± 1°

DRN | CHK | ENG | STR | PRC | PRJ | APP | REL

COMBUSTION POWER
Combustion Power Company, Menlo Park, California

3

REVISIONS			
FOR DESCRIPTION OF CHG. SEE E. O.			
LTR.	BY	DATE	APPR:



DEPARTMENT OF ENERGY
MOVING BED GRANULAR BED
FILTER DEVELOPMENT PROG.

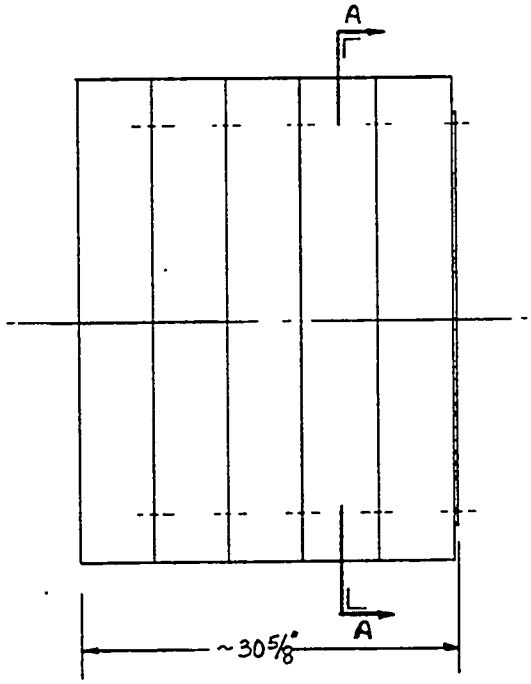
MEDIA FLUIDIZER TEST UNIT

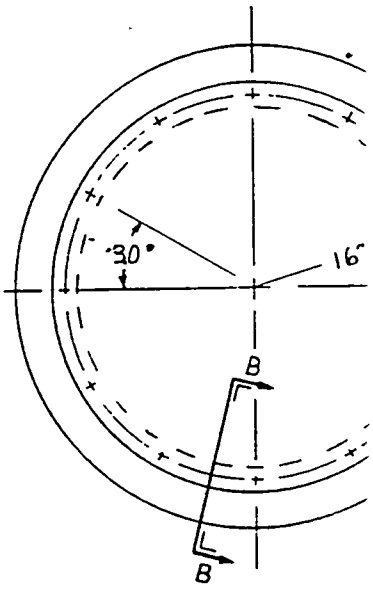
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES			
TOLERANCES			
FRACTIONAL	± 1/16"		
DECIMAL	± .03		
ANGLE	± 1°		
DRN	JWP	8-3-94	
CHK			
ENG	JWP	8-17-94	
STR			
PRC	JCH	8-24-94	
PRJ	JC Rev	8-23-94	
APP	[illegible]	8-25-94	
REL			

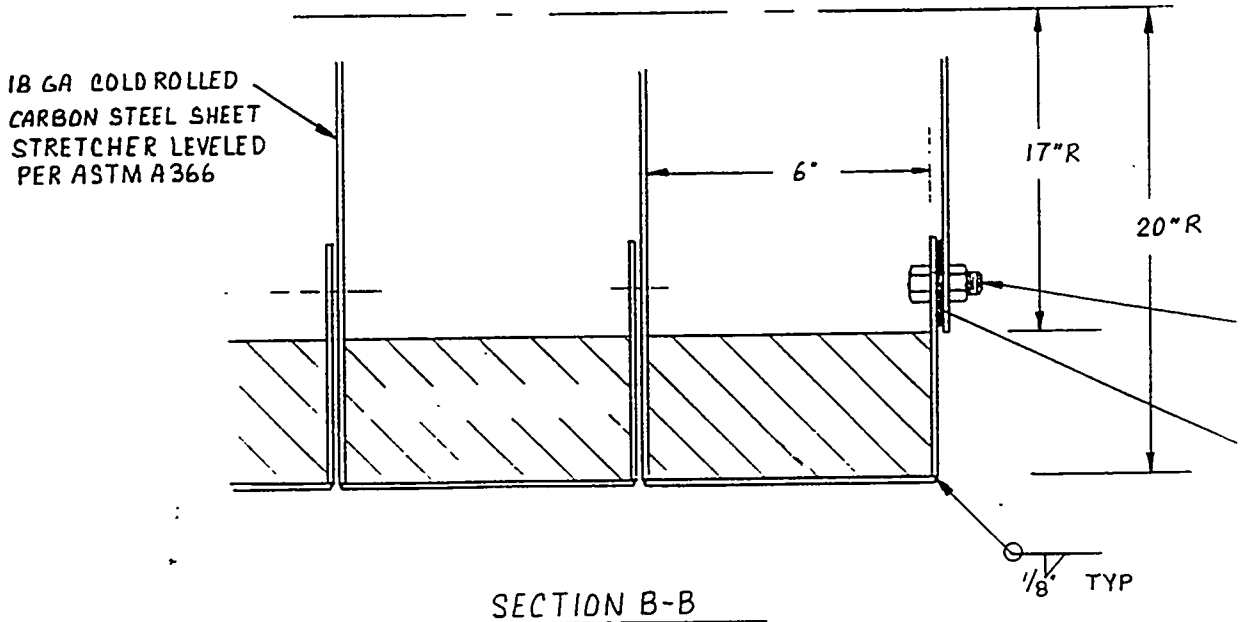
DWG CONFIG.	QTY REQ'D	NEXT ASSEMBLY

SIZE	DWG NO.	REV
A	1181-5090-01-107	0
SCALE NONE	SECTION	SHEET 1 OF 1

COMBUSTION POWER
Menlo Park, California

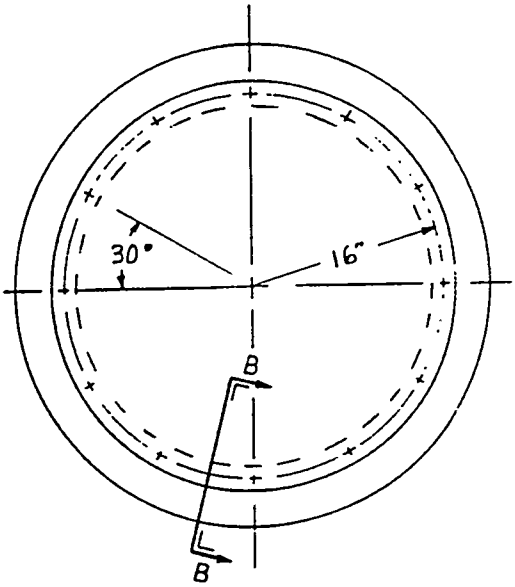

A
A
~30 5/8"

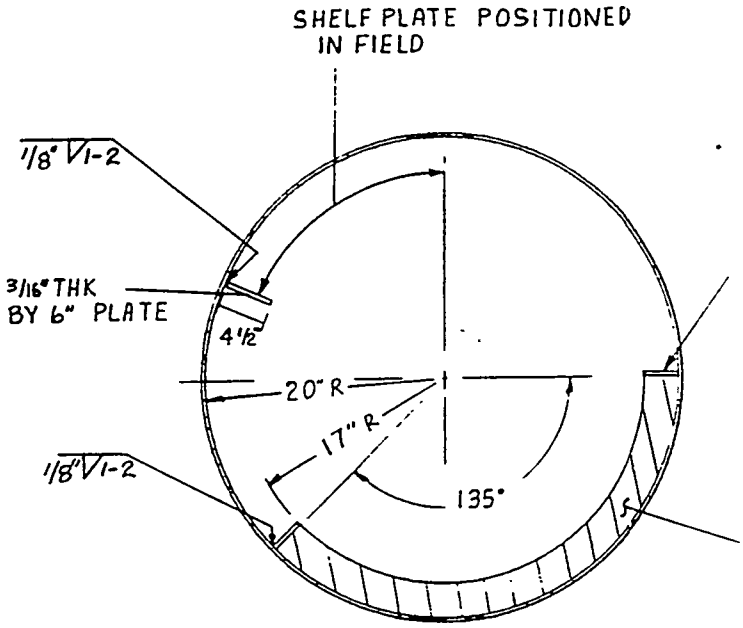

30°
16"
B
B


18 GA COLD ROLLED
CARBON STEEL SHEET
STRETCHER LEVELED
PER ASTM A366
6"
17"R
20"R
1/8" TYP

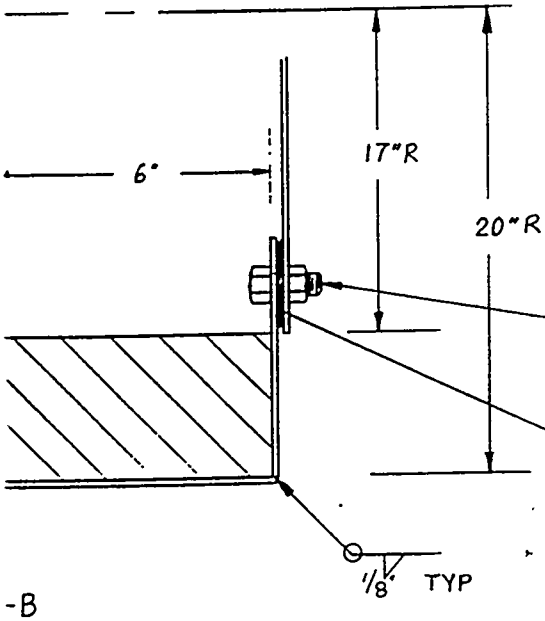
SECTION B-B

(1)





SECTION A-A

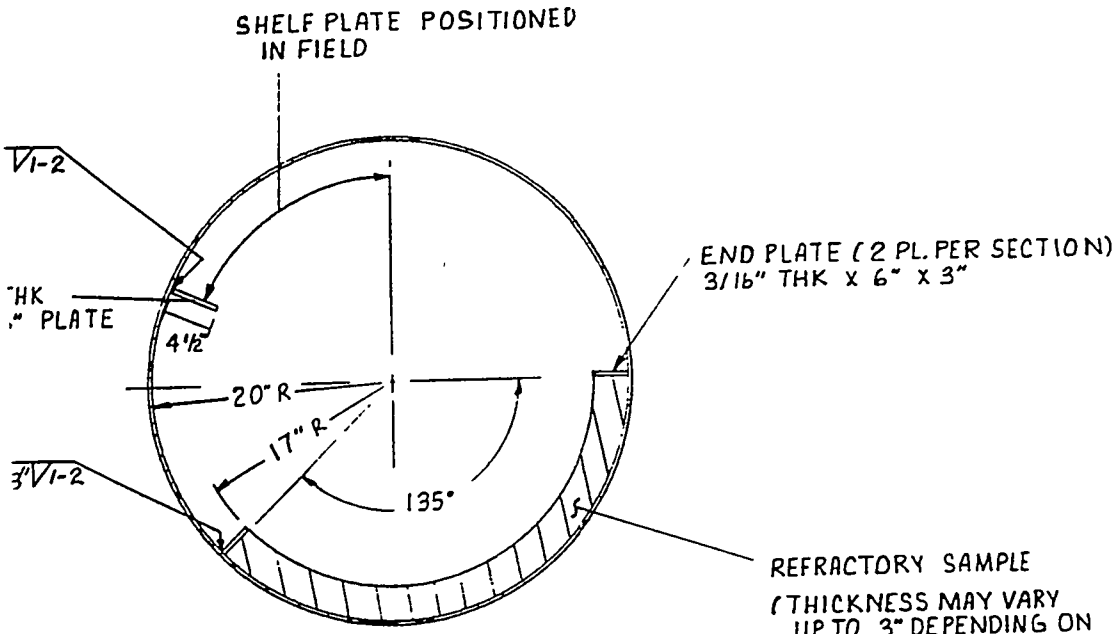


-B

NOTE 1. ASSEMBLY MOUNTS ON DRUM ROTATOR.

DRN	JWP	10
CHK	JEQ	10
ENG	JWP	10
STR		
PRC		
PRJ	K.S.W	10
APP	GDS	10
RD.	K. Pugh	10

REVISIONS			
FOR DESCRIPTION OF CHG SEE E. O			
NO	BY	DATE	APPR



SECTION A-A

TOTAL

; PL)

OUNTS ON DRUM

DEPARTMENT OF ENERGY
MOVING GRANULAR BED FILTER
DEVELOMENT PROGRAM

TITLE: ABRASION TEST UNIT ASSEMBLY

DRN	JWP	10/6/94
CHK	JEQ	10-6-94
DNG	JWP	10/6/94
STR		
PRC		
PRJ	K.S.W	10/6/94
APP	GOG	10/6/94
REL	K. Pugh	10/6/94

DWG NO. 1181-5090-02-107 | CONFIG | REV 0 | NO OF SHTS 1 | SIZE 4 D
SCALE NONE | SHEET 1 OF 1

COMBUSTION POWER
Combustion Power Company, Oakland, California

(3)