DOE/PC/30243--T1

Progress Report

AN EXPERIMENTAL STUDY OF THE MULTIPLE STEADY STATES IN AN ADIABATIC COAL-LIQUEFACTION REACTOR

by

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For the period of

September 1, 1980 - February 28, 1981

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Objective of the Study

The purpose of the proposed study is to investigate experimentally the thermal behavior of coal liquefaction reactors. Specifically, the occurrence of multiple steady states in a continuous stirred tank adiabatic three-phase reactor are planned to investigate over a wide range of operating conditions. This report briefly describes the progress on this project made during the period September 1, 1980 - February 28, 1981.

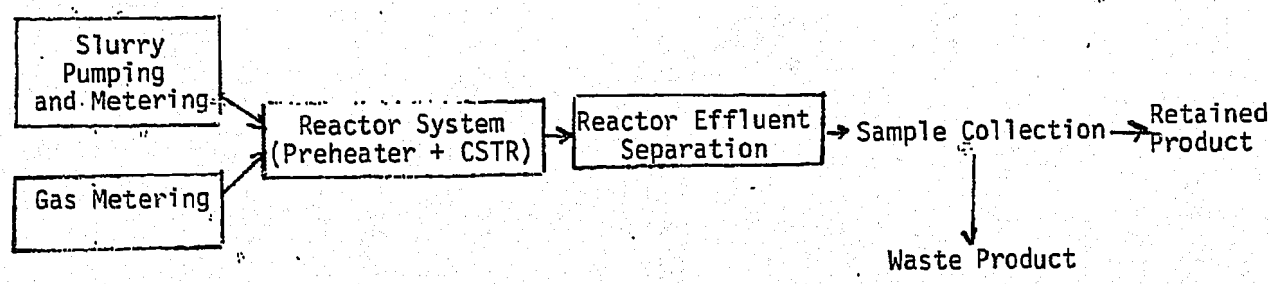
Achievements

As outlined in the work statement of the original proposal, during the past six months, a special custom-made adiabatic coal liquefaction reactor was designed and built. This was done at the expense of Gulf Research and Development Co. (as a part of cost sharing). The blueprints for the detailed design of the reactor is attached with this report. In this custom-made reactor the standard 1 liter autoclave was insulated in three parts. The insulation encompassed the controllers and heating elements such that the heat losses through the walls and the stirrer shaft are negligible. As noted from the attached blueprint, both reactor and the stirrer shaft were well insulated. It is estimated that this custom-made vessel will give the ratio of heat loss through reactor walls/heat generated less than .05.

The construction of the reactor will be completed during sometime at the end of February or the beginning of March 1981. The reactor will then be placed in the coal liquefaction unit described in Figure 1. During the next six month period the operational problems will be debugged and preliminary data for the multiple temperature steady states will be obtained. A brief description of the unit shown in Figure 1 is given below.

Process Flow Description

The experimental system may be considered to be made up of several interconnecting subsystems. The block diagram presented below defines these subsystems and shows their relationship to the entire experimental unit.



Each of the above illustrated component subsystems is briefly discussed below.

Slurry Pumping and Metering

The slurry pumping and metering system is designed to maintain a uniform feed slurry and to pump this slurry into the reactor system at a steady rate. In order to do this, an accurately formulated slurry blend is prepared external to the continuous unit and was transferred, as needed, to the continuous unit feed tank. The feed tank is equipped with an agitator and baffle system in order to insure that the slurry mixture would remain uniform. A Moyno pump, located beneath the feed tank, provides slurry feed to a Hills-McCanna (piston-type) high pressure charge pump, as well as sustaining a constant slurry recirculation to the feed tank. The Hills-McCanna pump sends the slurry, under unit pressure, to the reactor system. The slurry feed rate is determined by observing the weight loss of slurry from the feed tank with time. The feed tank is suspended

from a weigh cell in order to facilitate this weight measurement.

Gas Metering

A continuous supply of pure hydrogen is available from a pressured storage supply maintained by Gulf Science and Technology. The 5000 psi hydrogen is reduced for use, through an array of high pressure regulators, needle valves, and rotometers to the desired operating pressure. The system is equipped for calibrating the delivery of gas at operating pressure. Unit pressure is monitored at several locations throughout the unit, i.e., preheater inlet, reactor outlet, and at the separator system. Gas rate calibrations are made before and after each experimental run.

Reactor System

The reactor system consisted of a tubular preheater and a CSTR-type reactor. The preheater is a stainless steel tube which is segmentally wrapped for heating. This wrapping is segmented in such a way so as to provide a constant nominal slurry residence time in the heated preheater section, independent of the reactor SRT. The heated preheater section is controlled at a constant skin temperature of 400°C. The nominal slurry residence time in the heated section is about two minutes.

The reactor is a one liter, continuous, adiabatic stirred tank reactor. It is custom made and the details are given in the attached blueprints.

Reactor Effluent Separation

The reactor effluent is separated into two fractions by a high temperature-high pressure separator (325°C skin, unit pressure). These fractions include a heavy product (liquid underflow) which contain all of the product solids, and an overhead vapor stream (hydrocarbon liquids,

process water, gas products). The high temperature-high pressure separator is level controlled (residence time 10-18 minutes) through the use of high pressure let-down valves. The overhead stream is further separated in a low temperature-high pressure (105°C) separator and several additional low pressure separators. This separation scheme is detailed in Figure 1.

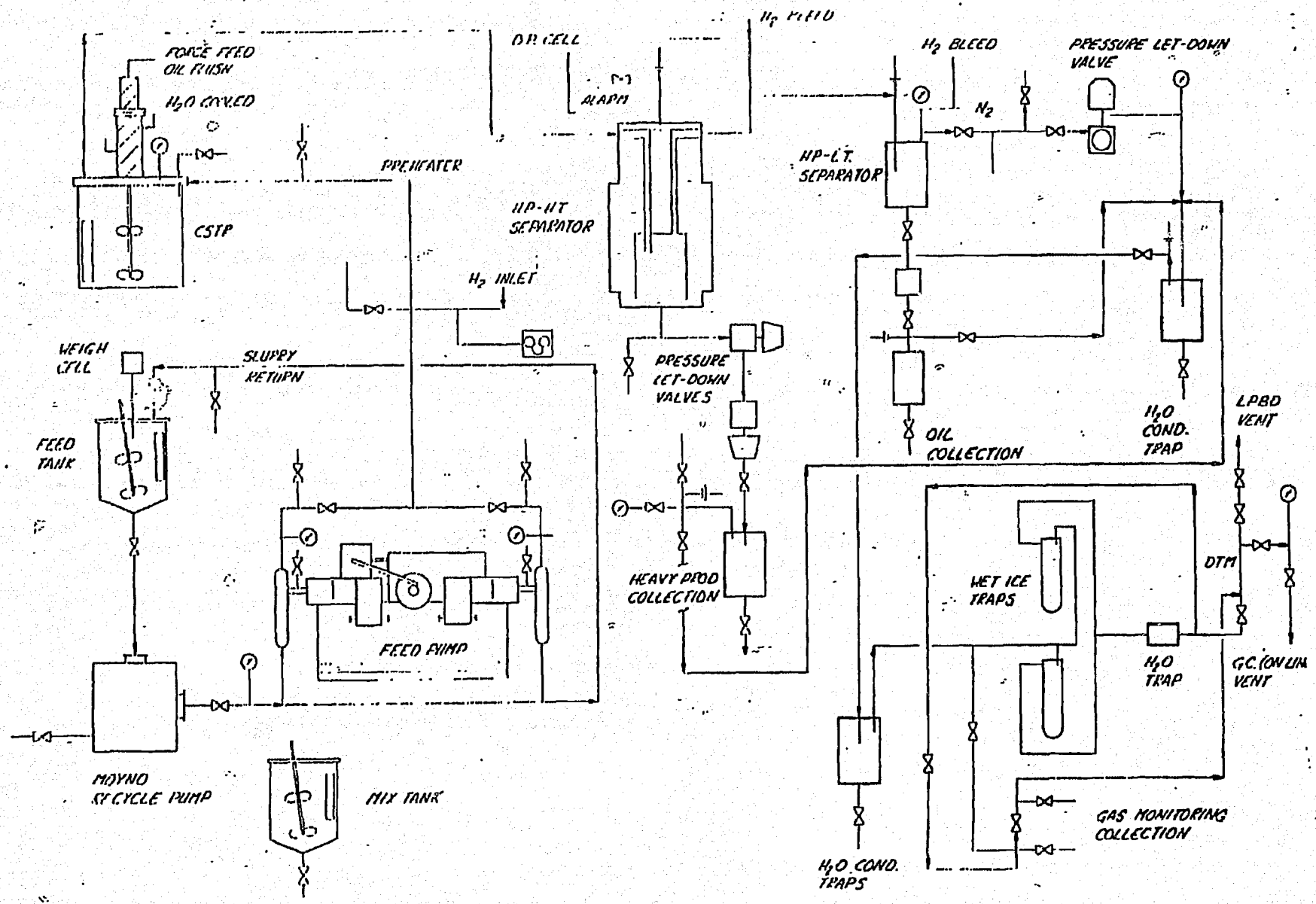


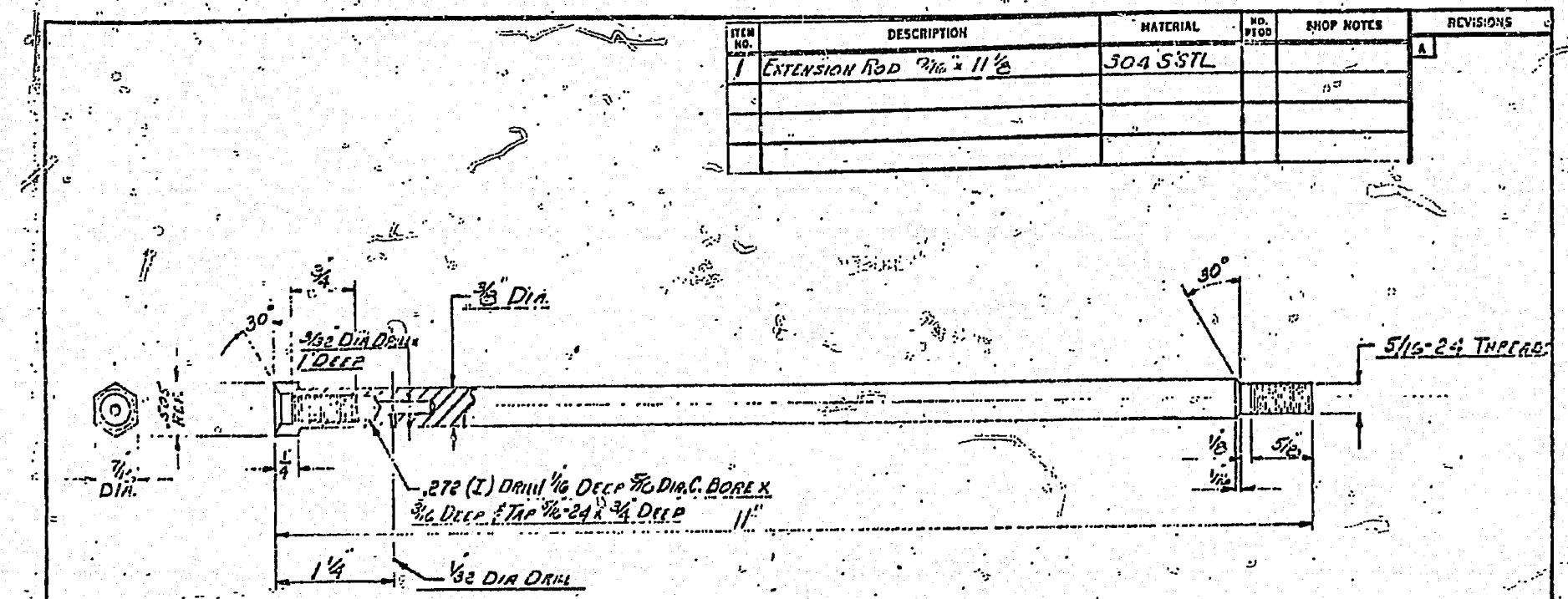
FIGURE 1: Schematic of the Gulf Coal Liquefaction Unit to be Used for the Present Study

BLUEPRINTS

for

ADIABATIC COAL LIQUEFACTION REACTOR

ITEM NO.	DESCRIPTION	MATERIAL	NO. REQ'D	SHOP NOTES	REVISIONS
1	EXTENSION ROD 7/16" x 11 1/8	304 S.S.T.L.			A



PROJ. NO.
JOB NO.
NO. REQ'D

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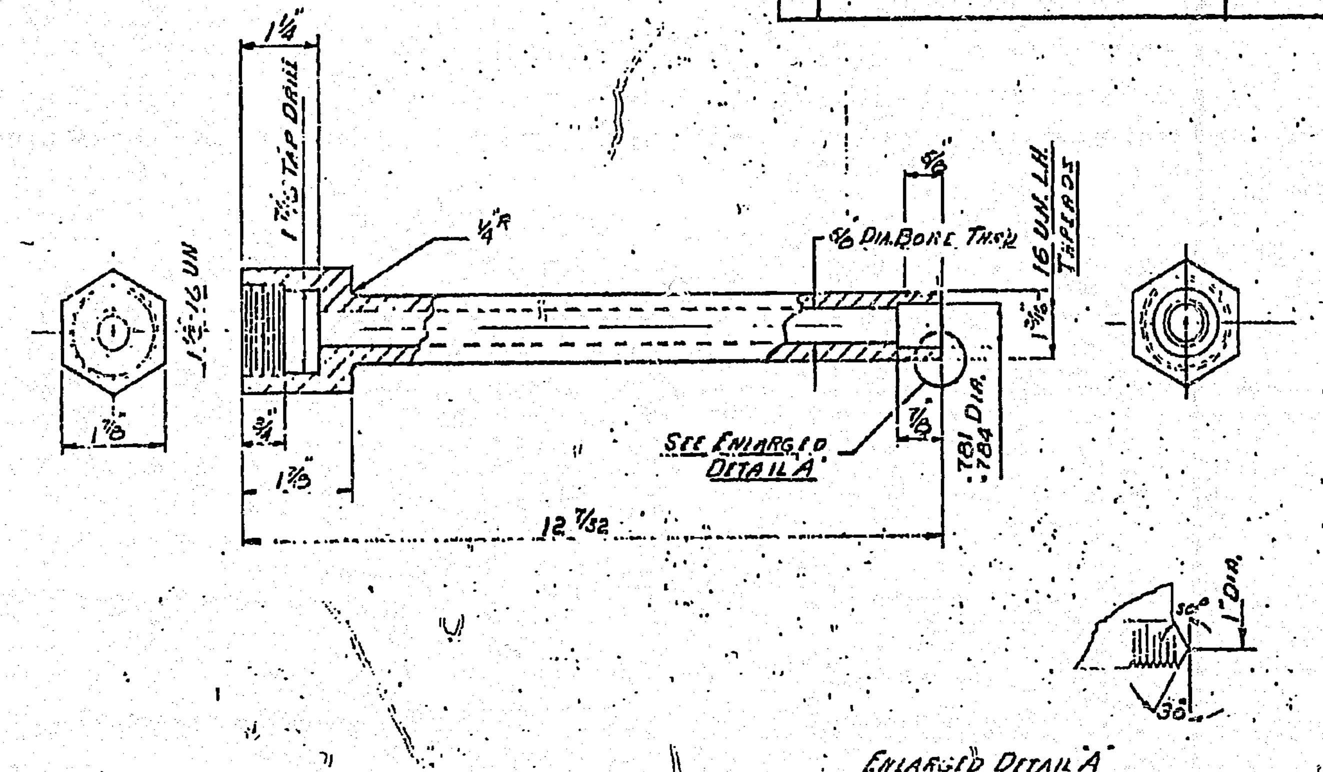
	DATE 1-29-81 SCALE FULL
	DRAWN J.J.H APVD.
	CHECKED APVD.
	DATE CHK'D APVD.
	DWG. NO. PB 300 81-12

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED			
BASIC DIMENSIONS	FRACTIONAL		CONCENTRICITY (TURNS & BORES) .010" F.I.R.
	MACHINE WORK	STRUCTURAL	ANGLES: ± 1° FILLETS: 1/64" TO 1/32" R.
UP TO 8"	± .010"	± 1/64"	BREAK CORNERS: 1/64" R. OR CHAMFER
8" TO 24"	± 1/64"	± 1/32"	REMS FINISH: 63 EXCEPT AS NOTED
OVER 24"	± 1/32"	± 1/16"	

ITEM NO.	DESCRIPTION	MATERIAL	NO. REQ'D	SHOP NOTES
1	Extension Rod	304 S'STL		

REVISIONS

A



PROJ. NO.
JOB NO.
NO. REQ'D

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED				
BASIC DIMENSIONS	FRACTIONAL		CONCENTRICITY (TURNS & BORES) .010" T.I.R.	
	MACHINE WORK	STRUCTURAL	ANGLES: ± 1°	FILLETS 1/64" TO 1/32" R.
UP TO 8"	± .010"	± 1/64"	BREAK CORNERS 1/64" R/OR CHAMFER	
8" to 24"	± 1/64"	± 1/32"	RMS FINISH 63 EXCEPT AS NOTED	
OVER 24"	± 1/32"	± 1/16"		

REF. DWGS. FD30032-11

CCL ADIABATIC REACTOR
Shaft Extension

GULF RESEARCH & DEVELOPMENT CO.
PITTSBURGH, PA.

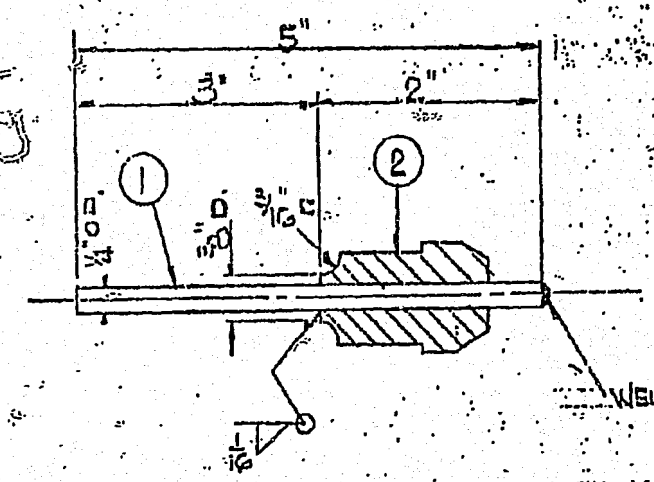
DATE 1-27-81 | SCALE Half
DRAWN J.L.P. | APVD
CHECKED | APVD
DATE CHKD | APVD

DWG. No. FB 300 32-11

IT	DESCRIPTION	MATL SPEC	QTY	MATERIAL
1	TUBE 1/8" O.D. x 1/16" I.D. x 5" LG		1	
2	SE PLUG 3/4" (CPX 120)	SS316	1	ALTEMP

REVISIONS

A



PROJ. NO.

JOB NO.

NO. REQ'D

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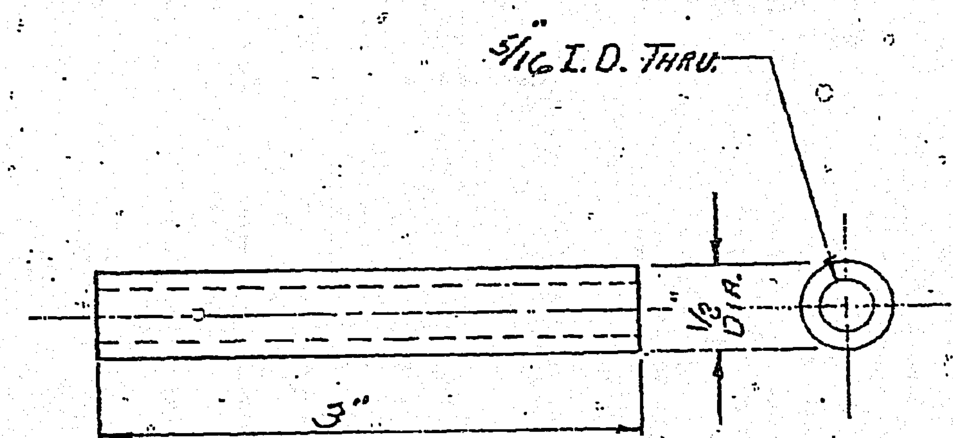
	DATE 2-10-71
	DWG. NO. PB 30032-15



MAT'L. ALUM. 2024 T4
SPACER 2-REQ'D.

BASIC DIMENSIONS	FRACTIONAL	
	MACHINE WORK	STRUCTURAL
UP TO 8"	±.010"	±1/64"
8" TO 24"	±1/64"	±1/32"
OVER 24"	±1/32"	±1/16"

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED

CONCENTRICITY (TURNS & BORES): .010" F.I.R.
ANGLES: ±1° FILLETS: 1/64" TO 1/32" R.
BREAK CORNERS: 1/64" R OR CHAMFER
RMS FINISH. 32 EXCEPT AS NOTED

GULF RESEARCH & DEVELOPMENT CO.
PITTSBURGH, PA.

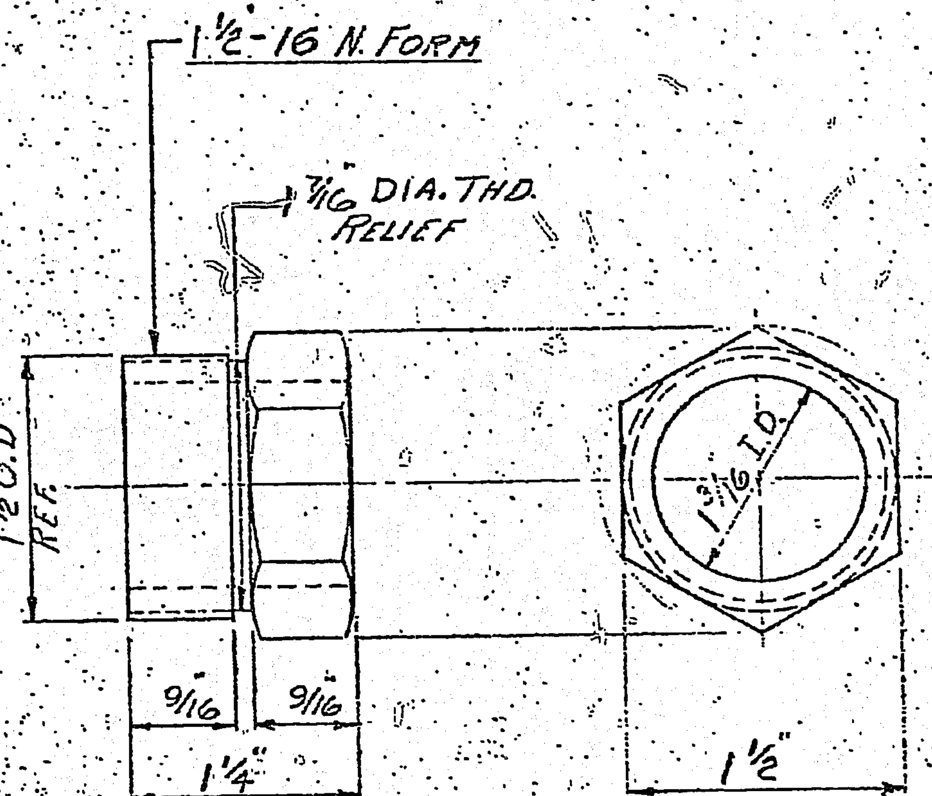
CCL ADIABATIC REACTOR
SPACER

REF. DW'G'S.
SCALE FULL | DRAWN J.J.P. | CHECKED | DATE CHK'D
DATE 2-5-71 | APP'V'D. | APP'V'D. | APP'V'D.
DWG. NO. PA30032-14

PROJ. NO.
JOB NO.
NO. REQ'D

REVISIONS

PW 1099-480



GLAND
17-4 PH
AUTOCLAVE ENGR.# 305D-6246
(PURCHASE FROM A.E. Co.)

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED

BASIC DIMENSIONS	FRACTIONAL MACHINE WORK	FRACTIONAL STRUCTURAL
UP TO 8"	±.010"	±1/64"
8" TO 24"	±1/64"	±1/32"
OVER 24"	±1/32"	±1/16"
CONCENTRICITY (TURNS & BORES): .010" F.I.R.		
ANGLES: ±1°	FILLETS: 1/64" TO 1/32" R.	
BREAK CORNERS: 1/64" R. OR CHAMFER		
RMS FINISH: 32 EXCEPT AS NOTED		

REVISIONS

PROJ. NO.
JOB NO.
NO. REQ'D

GULF RESEARCH & DEVELOPMENT CO. PITTSBURGH, PA.

CCL ADIABATIC REACTOR
GLAND

REF. DWG'S.				
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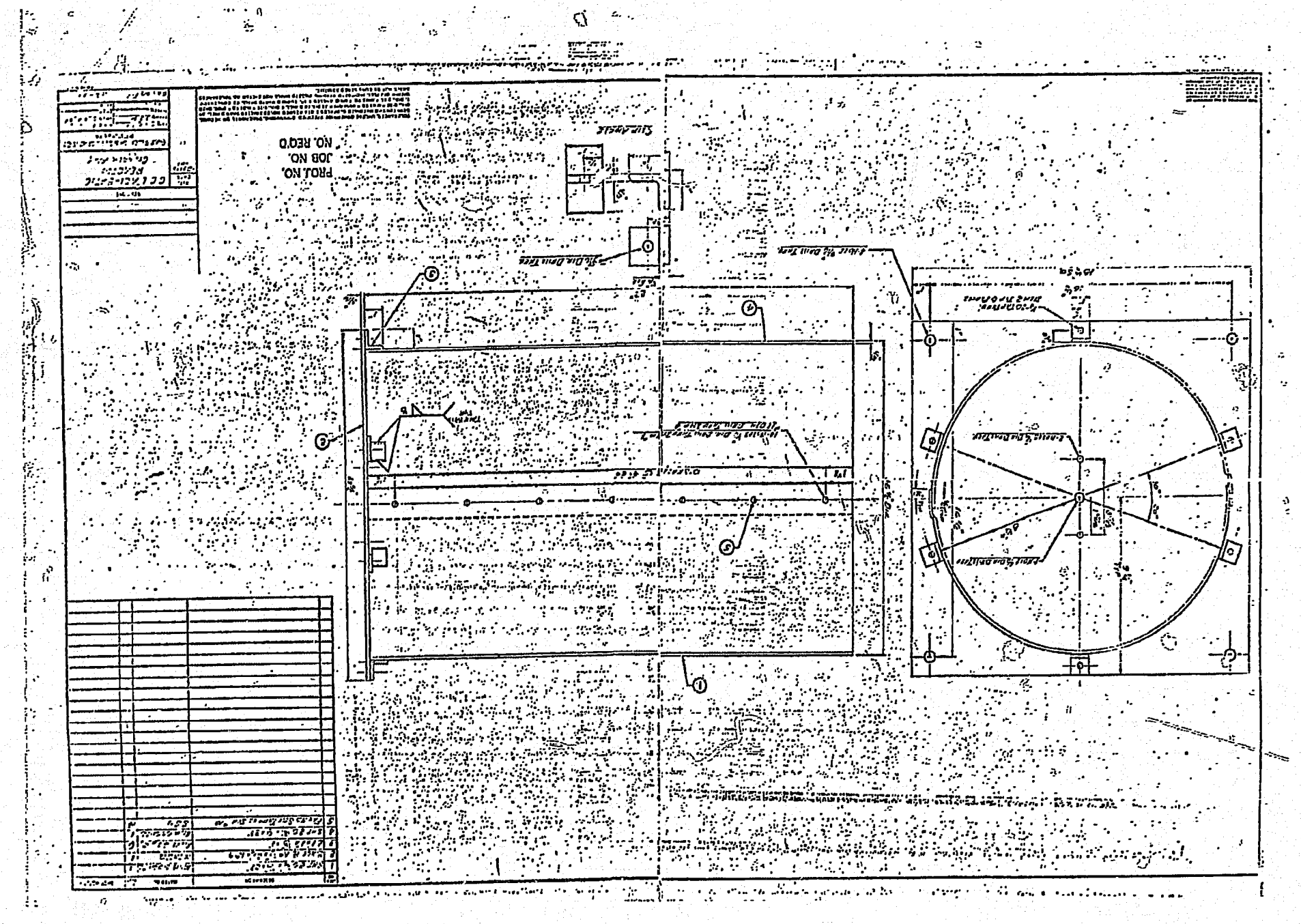
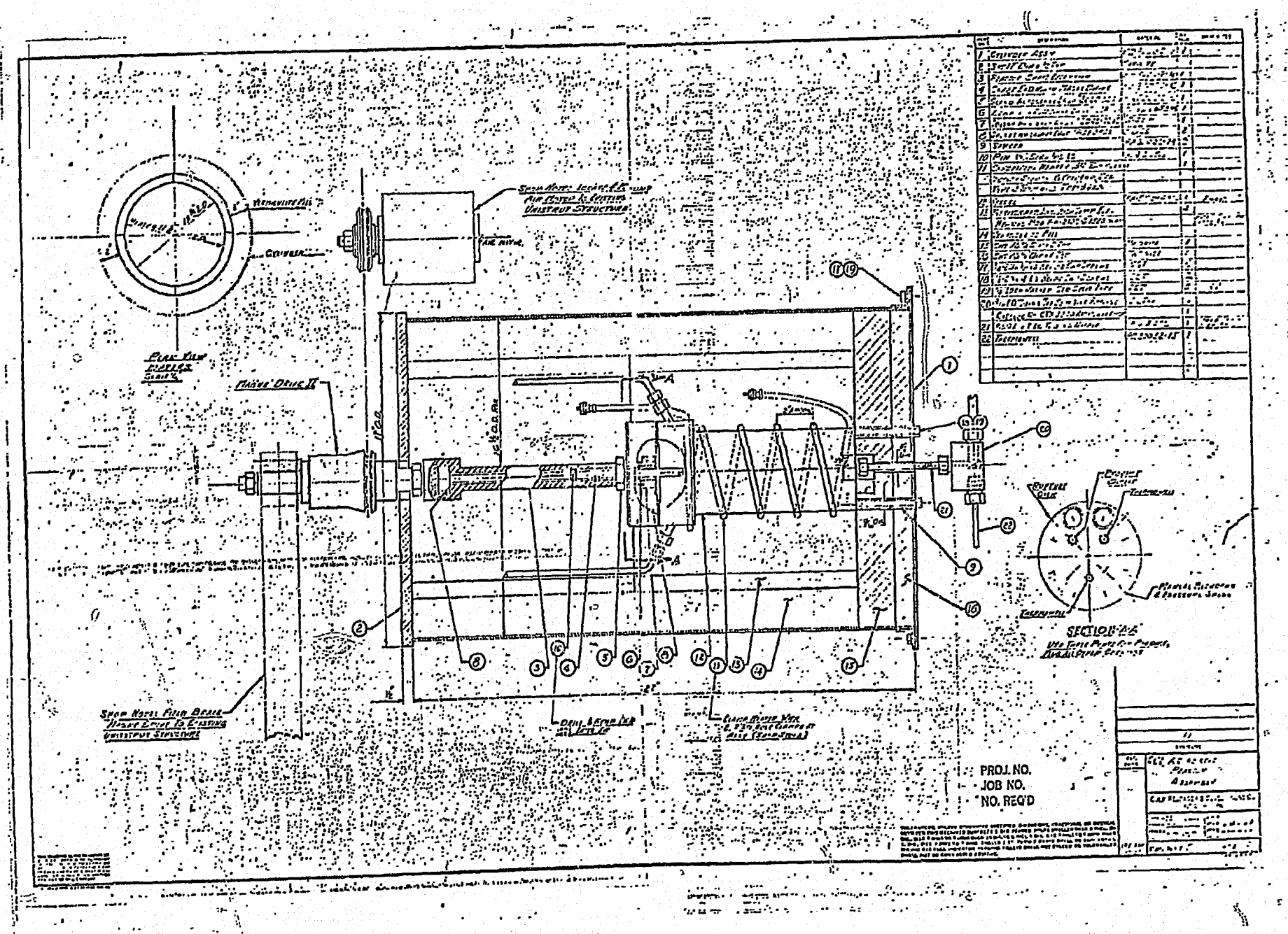
PW 1880-400

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