Title
PRESSURE DROP DESIGN DATA

Author
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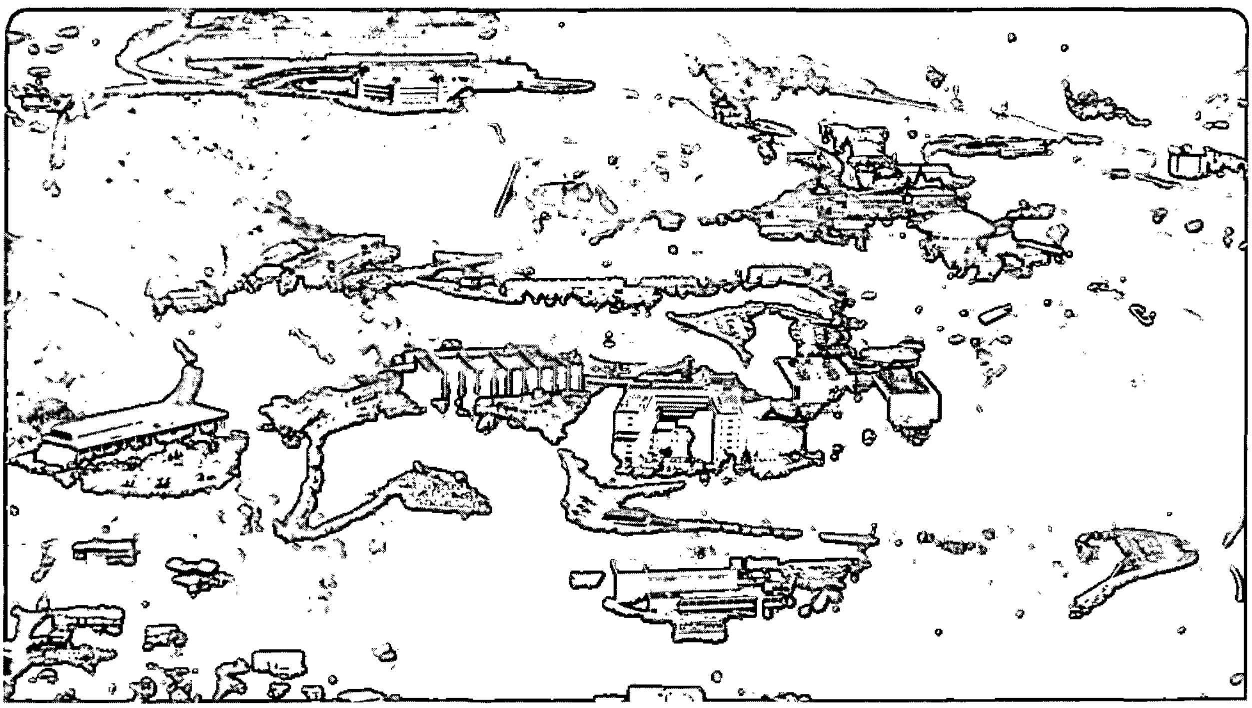
Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

Engineering & Technical Services Division



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LBID 227

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ENGINEERING NOTE

CODE	SERIAL	PAGE
ES0501	M4859B	1 OF 28

AUTHOR	DEPARTMENT	LOCATION	DATE
R. A. Byrns	Mechanical Engineering	Berkeley	September 1975

PROGRAM — PROJECT — JOB

ESCAR HELIUM REFRIGERATOR FACILITY

CRYOGENIC DISTRIBUTION

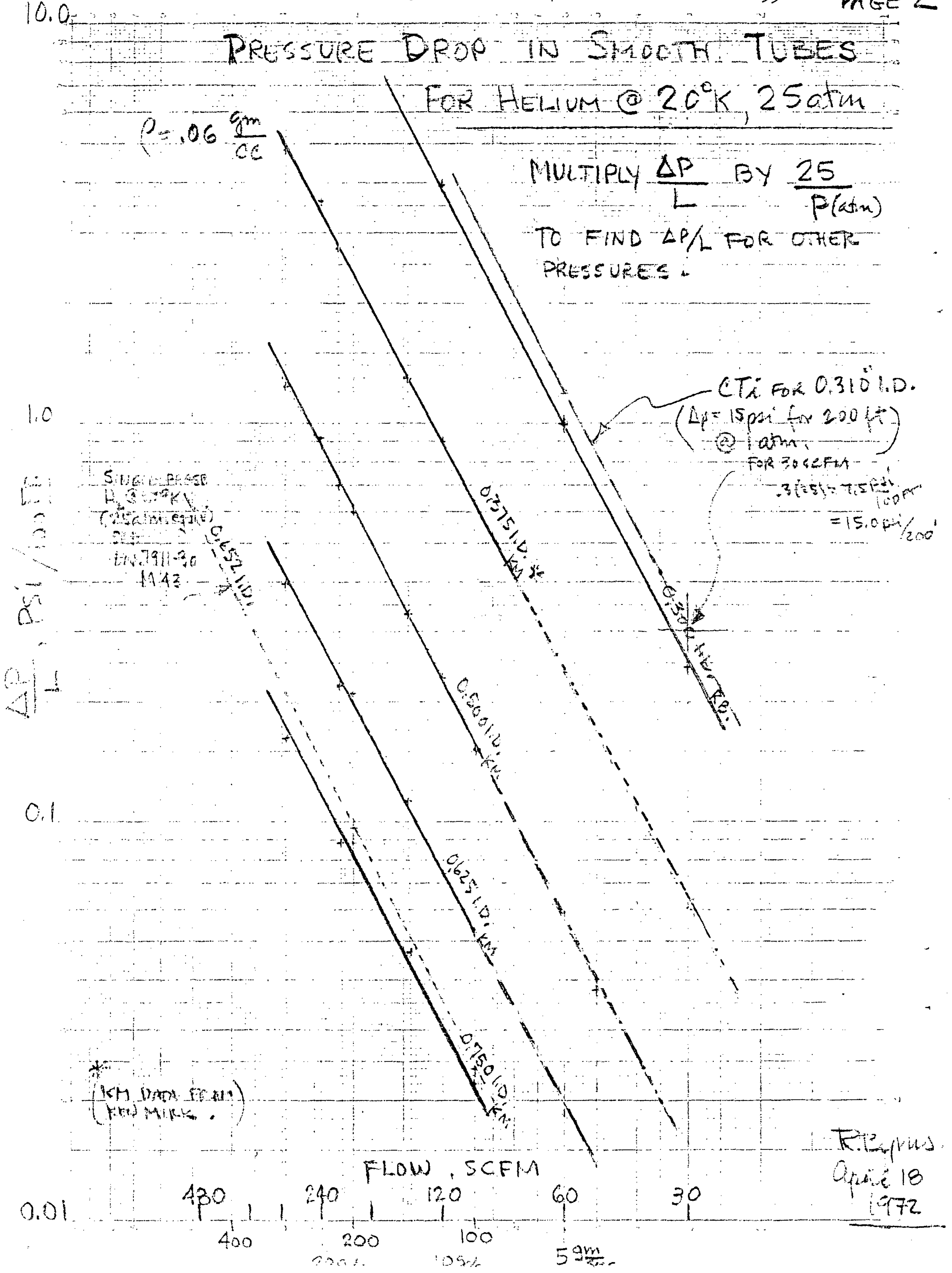
TITLE

PRESSURE DROP DESIGN DATA

"A" Revision January 7, 1976
"B" Revision April 15, 1980

R. Byrns 6 cc

/nh



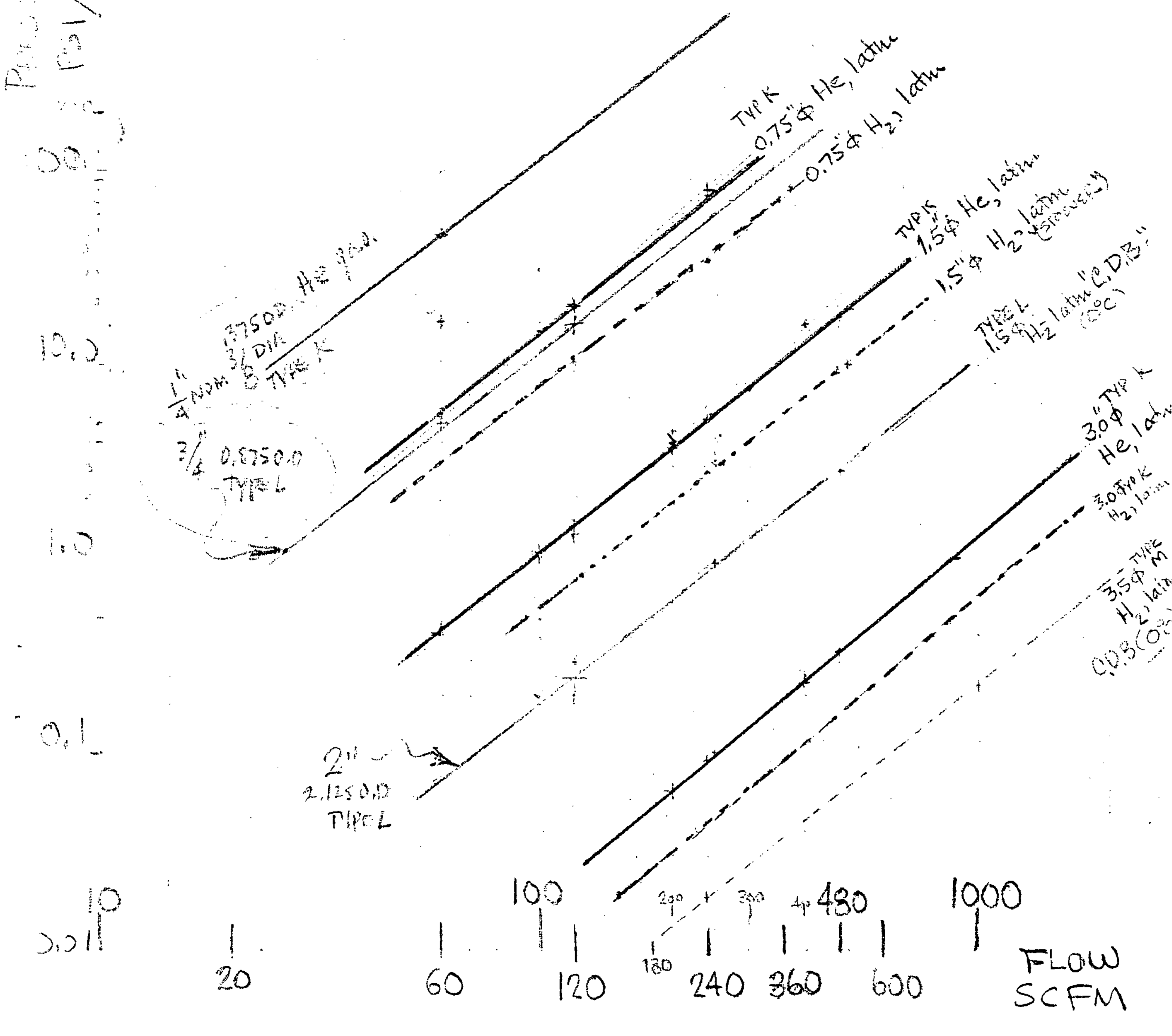
10.0
PRESSURE DROP IN SMOOTH TUBES
FOR HELIUM @ 20°K, 25atm
ρ = .06 gm/cc
MULTIPLY ΔP/L BY 25/P(atm)
TO FIND ΔP/L FOR OTHER PRESSURES.
CTi FOR 0.310" I.D.
(Δp = 15psi for 200 ft @ 1 atm.
FOR 30 SCFM
=15.0 psi/200'
1.0
0.375 I.D. KM *
0.652 I.D.
0.30 I.D. KB.
0.500 I.D. KM
0.1
0.625 I.D. KM
0.750 I.D. KM
* (KM DATA FROM KEN MIRK.)
FLOW, SCFM
0.01
480
240
120
60
30
400
200
100
R. Byrns
April 18
1972

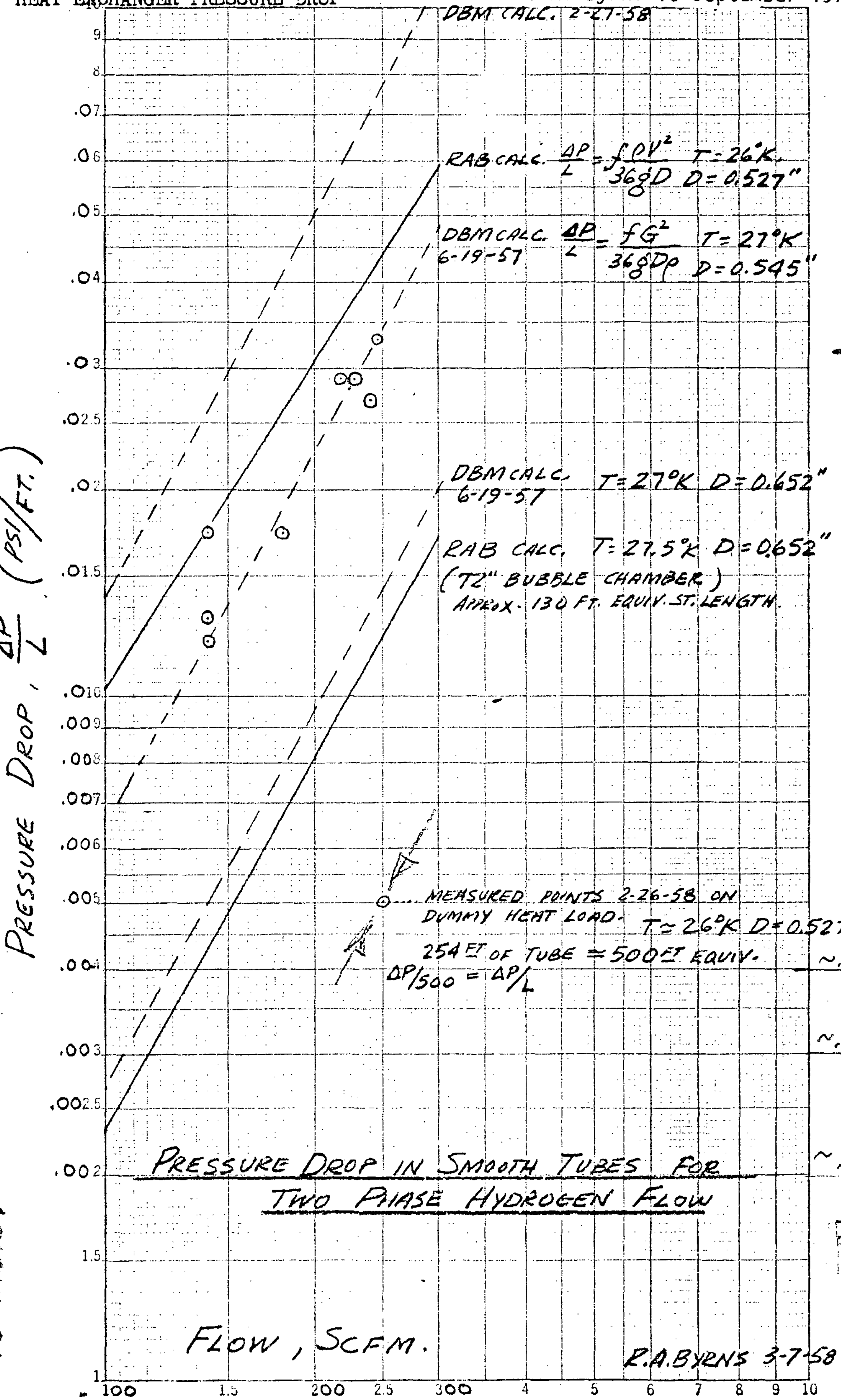
REF. APPLIED HEAT TRANSMISSION
STOEVER page 128
CRYO. DATA BOOK
page 106

R. Byrns
18 April 1972

PRESSURE DROP IN SMOOTH COPPER WATER TUBES. H_2 & He, 1 atm, 50°F

(DIVIDE $\frac{\Delta P}{L}$ BY P in atmospheres, absolute, to FIND $\Delta P/L$ FOR DENSITIES OTHER THAN 1 ATM.)





$\frac{\Delta P}{L} \propto \frac{f \rho V^2}{2 g D}$

~.008 (He-est)

~.006 (He)*

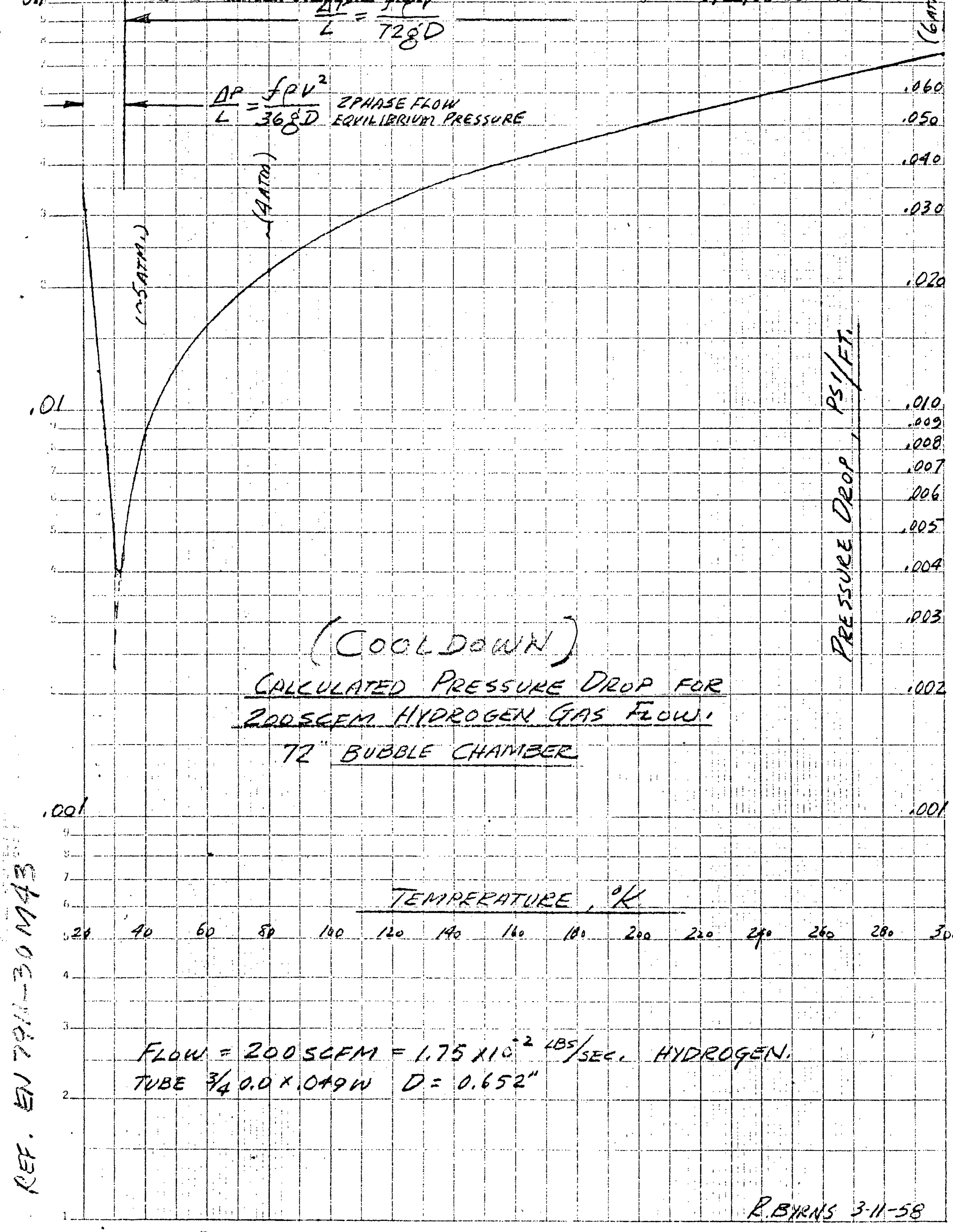
~.004 (He)

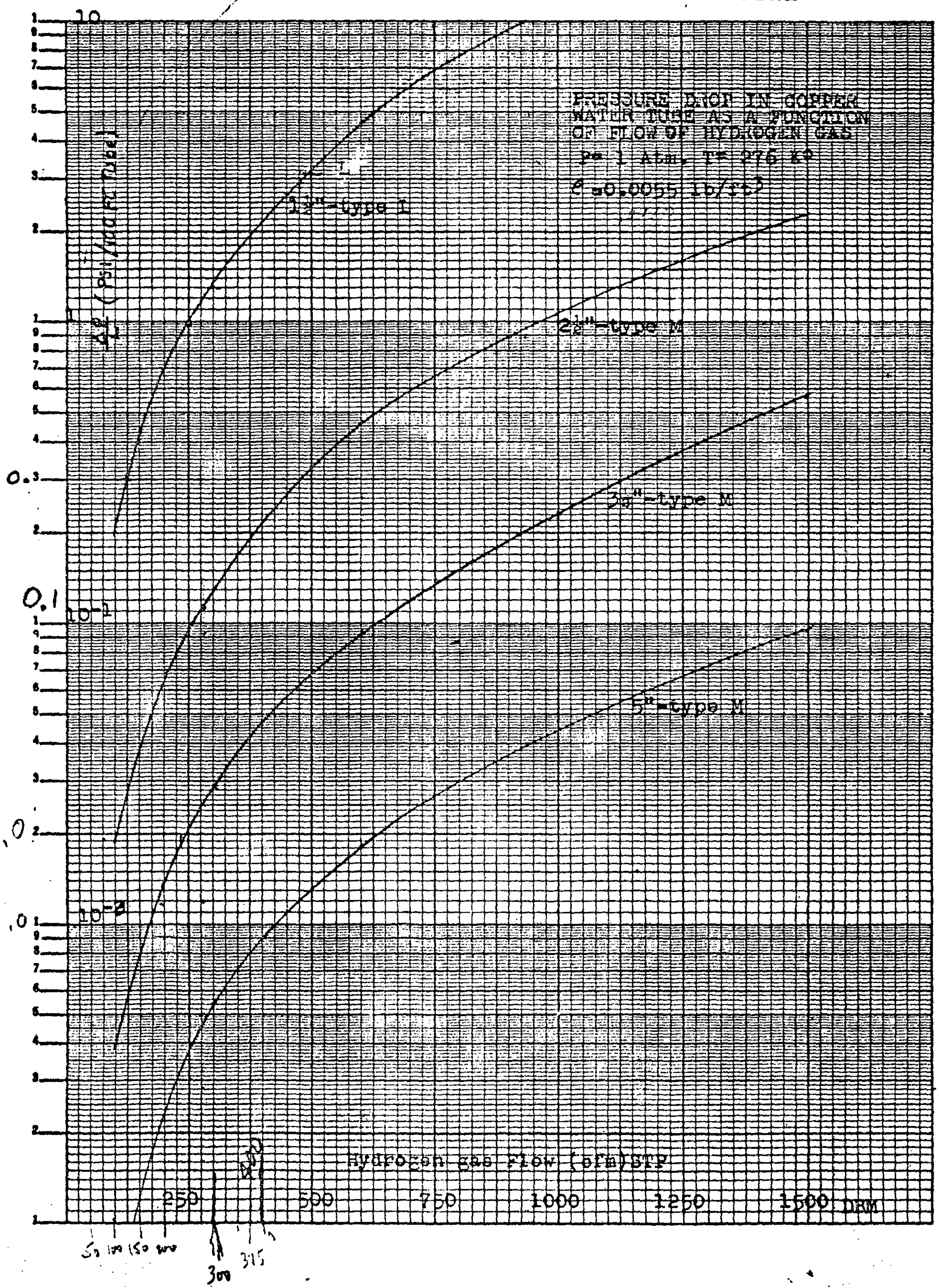
*He gas @ 23°K - D = 0.32

Δp = .024 psi/ft

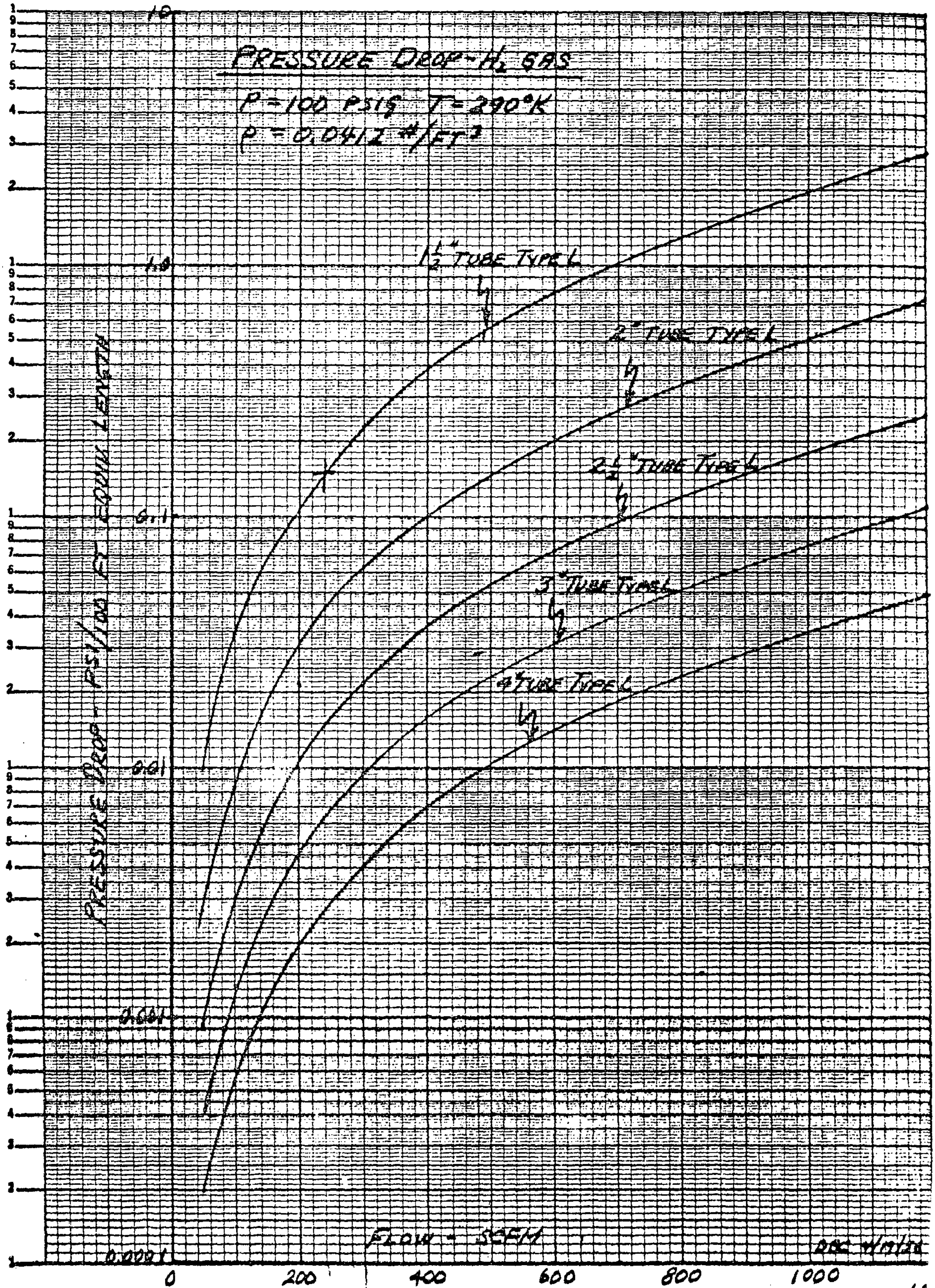
Δp = 4.8 psi

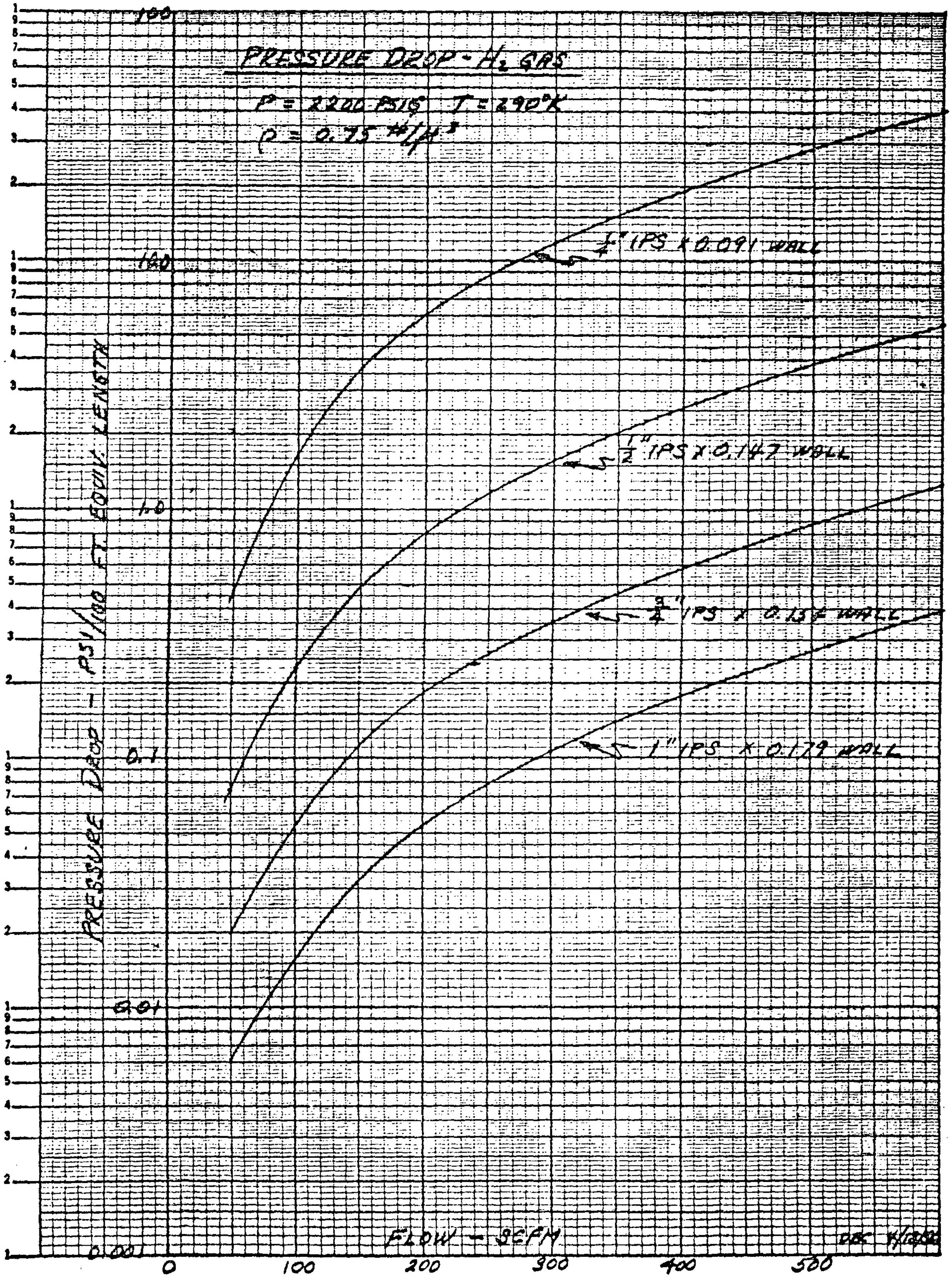
REF EN 7911-50 M45 72" H.B.C.

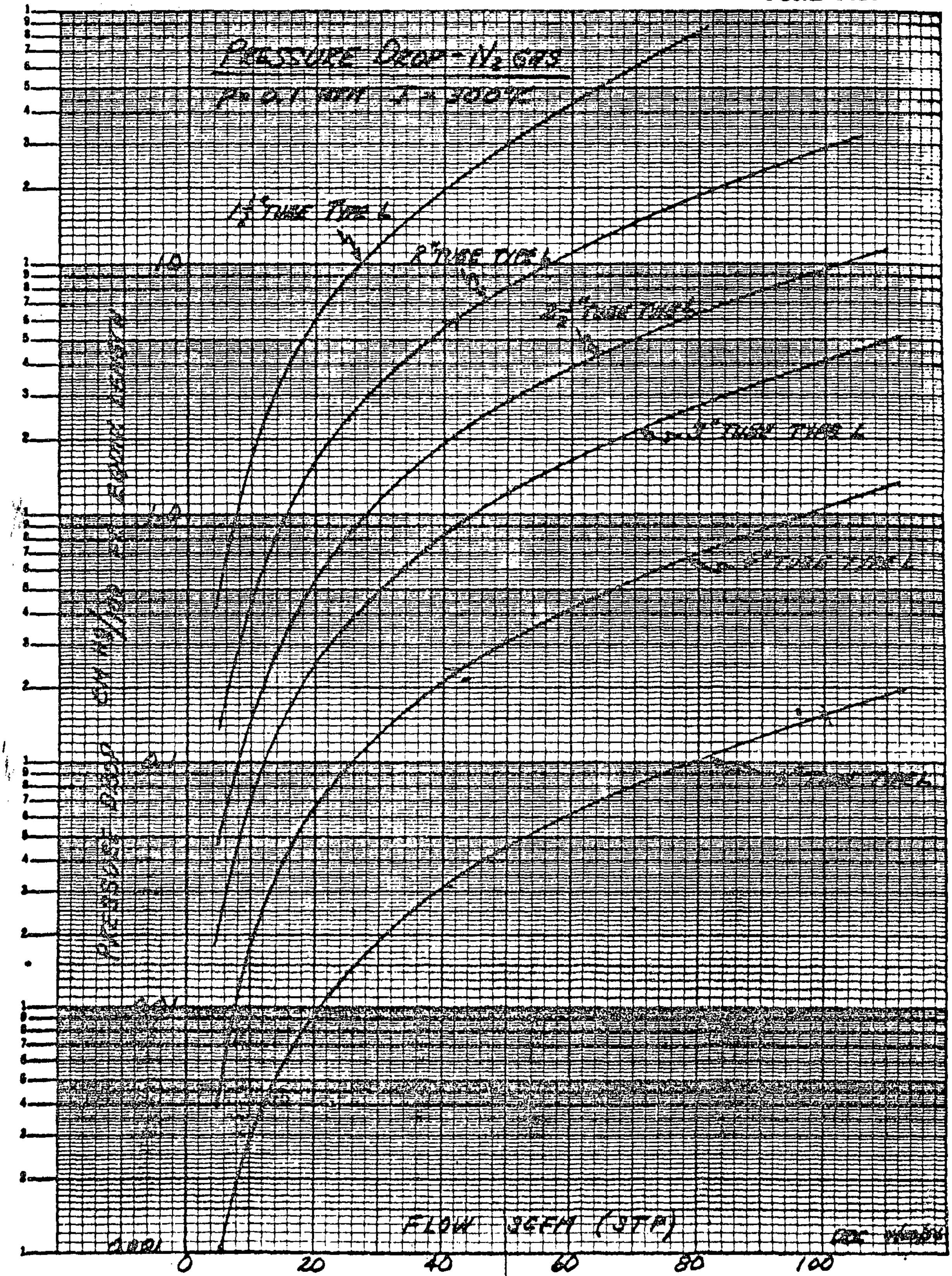

$\frac{\Delta P}{L} = \frac{f\rho V^2}{728D}$
$\frac{\Delta P}{L} = \frac{f\rho V^2}{368D}$
2 PHASE FLOW EQUILIBRIUM PRESSURE
(6ATM.)
(4ATM)
(~5ATM.)
(COOLDOWN)
CALCULATED PRESSURE DROP FOR
200SCFM HYDROGEN GAS FLOW.
72" BUBBLE CHAMBER
PRESSURE DROP, PSI/FT.
TEMPERATURE, °K
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
0.1 .01 .001
.060 .050 .040 .030 .020 .010 .009 .008 .007 .006 .005 .004 .003 .002 .001
FLOW = 200SCFM = 1.75 X 10⁻² LBS/SEC. HYDROGEN.
TUBE 3/4 O.D X .049W D = 0.652"
R.BYRNS 3-11-58
REF. EN 72N-30M43



Helium
1atm 0°C
ρ=.01114
FACTOR OF
2 over H_2


PRESSURE DROP-H2 GAS
P=100 PSIG T=290°K
ρ=0.0412 #/FT³
1½" TUBE TYPE L
2" TUBE TYPE L
2½" TUBE TYPE L
3" TUBE TYPE L
4" TUBE TYPE L
PRESSURE DROP - PSI/100 FT EQUIV LENGTH
FLOW - SCFM
10
1.0
0.1
0.01
0.001
0.0001
0
200
400
600
800
1000


PRESSURE DROP - H_2 GAS
P = 2200 PSIG T = 290°K
ρ = 0.75 #/ft³
1/4" IPS x 0.091 WALL
1/2" IPS x 0.147 WALL
3/4" IPS x 0.154 WALL
1" IPS x 0.179 WALL
PRESSURE DROP - PSI/100 FT. EQUIV. LENGTH
100
10
1.0
0.1
0.01
0.001
FLOW - SCFM
0
100
200
300
400
500


PRESSURE DROP - N_2 GAS
1½" TUBE TYPE L
2" TUBE TYPE L
2½" TUBE TYPE L
3" TUBE TYPE L
10
1.0
FLOW SCFM (STP)
0
20
40
60
80
100

Resistance of Valves and Fittings to Flow of Fluids

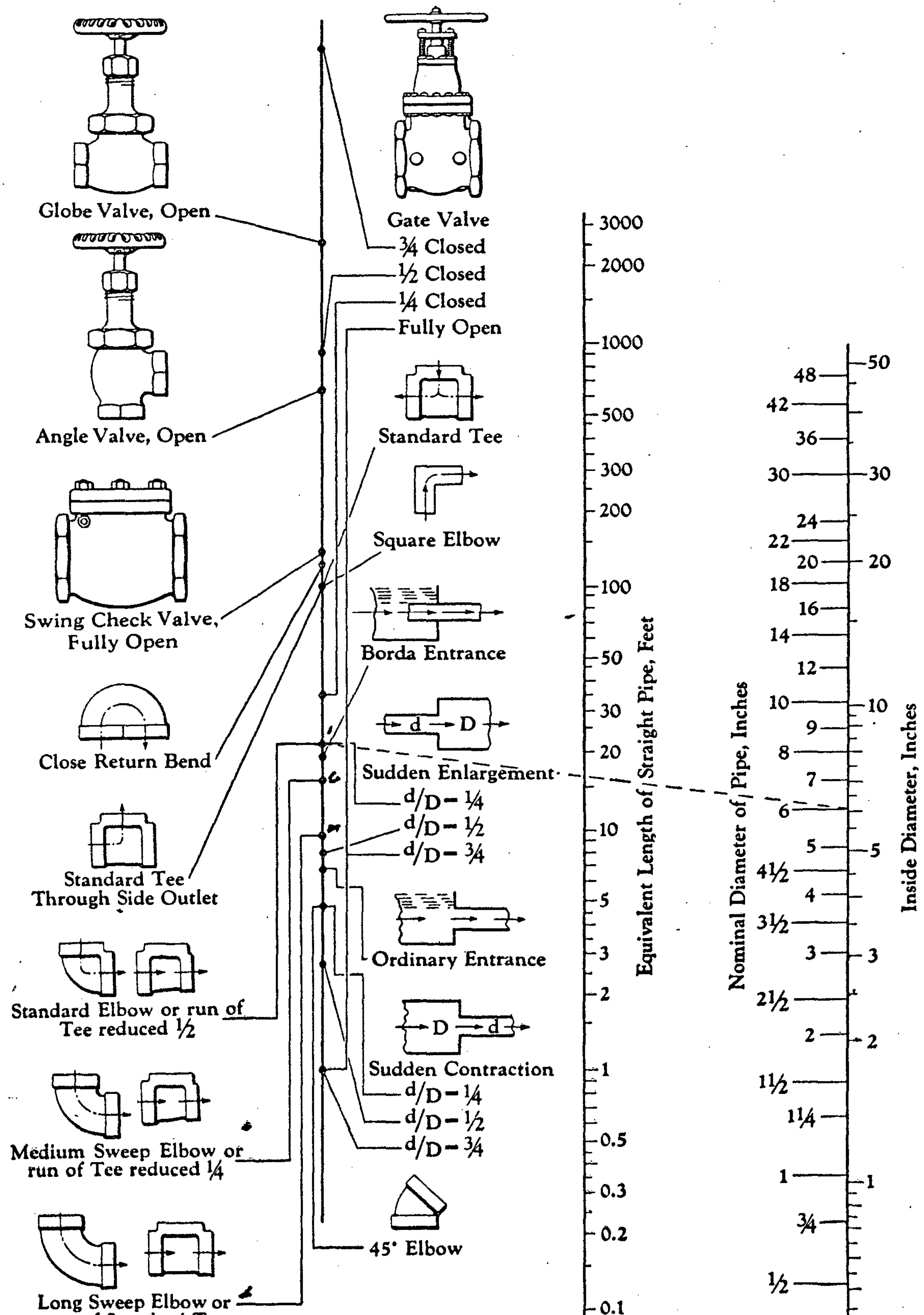


Figure 17

* CRANE TECH PAPER NO. 409 MAY 1942

CVI*

Pressure Drop Curves

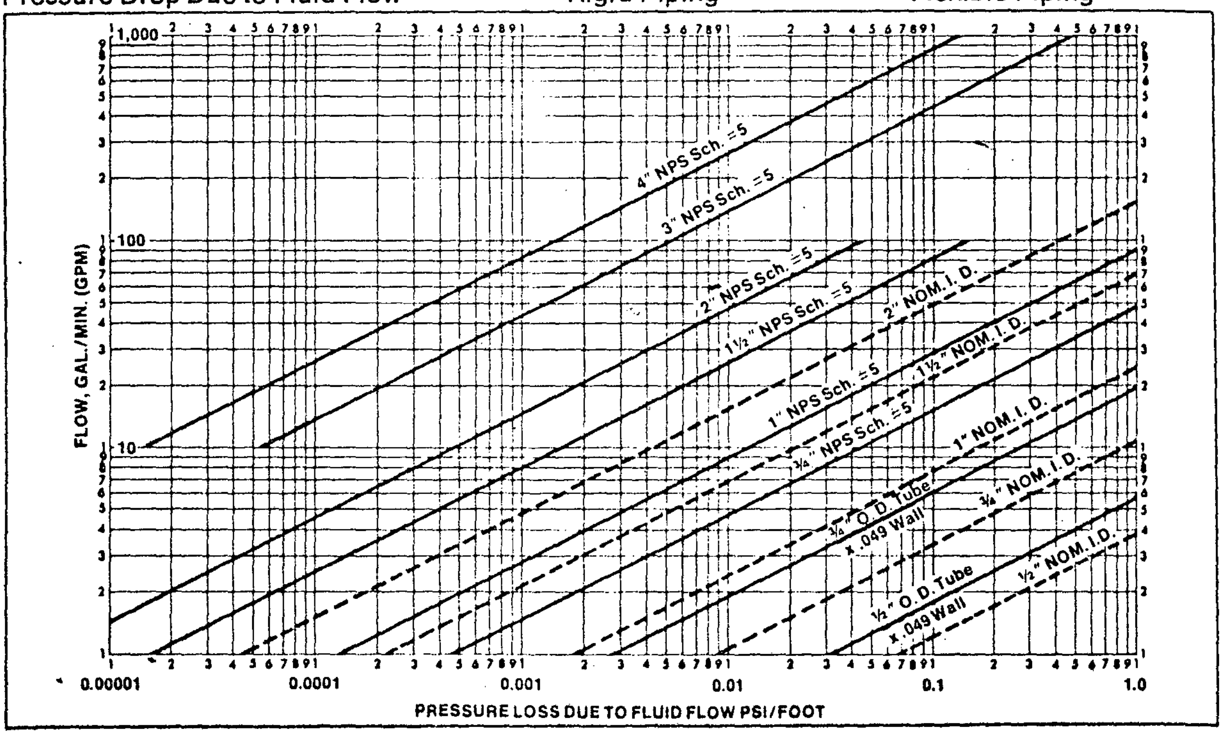
6

The following curves may be helpful in determining the proper line size for your transfer requirement. These charts represent loss of pressure due to fluid flow through a pipe. Total pressure drop also includes additional loss of pressure (head) due to any increase in elevation.

Please notice that a smaller diameter rigid pipe line can accommodate the same flow capacity as a larger diameter flex line. This is significant when considering heat-leak (liquid loss) and system purchase cost.

Liquid Nitrogen

Pressure Drop Due to Fluid Flow — Rigid Piping ——— Flexible Piping - - - -

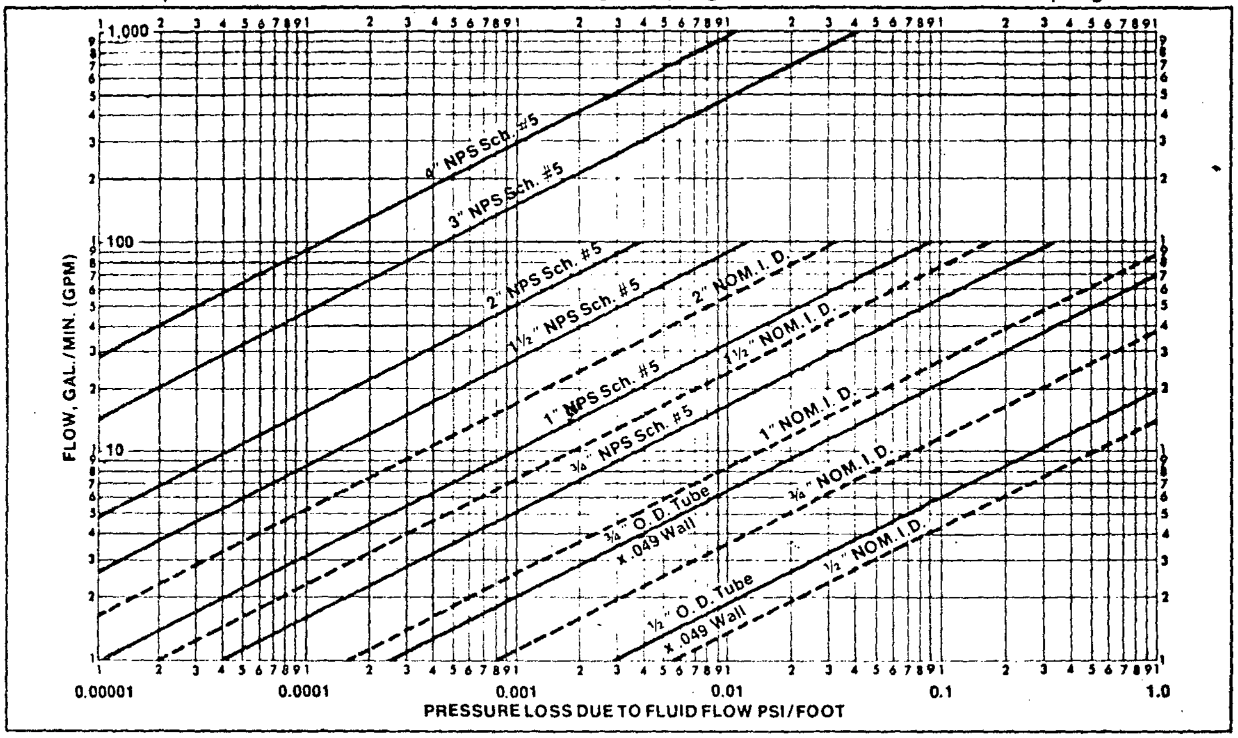


P.O. Box 2138
DATA FROM CVI CORP. COLUMBUS - OHIO - 43216
(1975) DIV. OF PENNWALT
614-876-7381

7

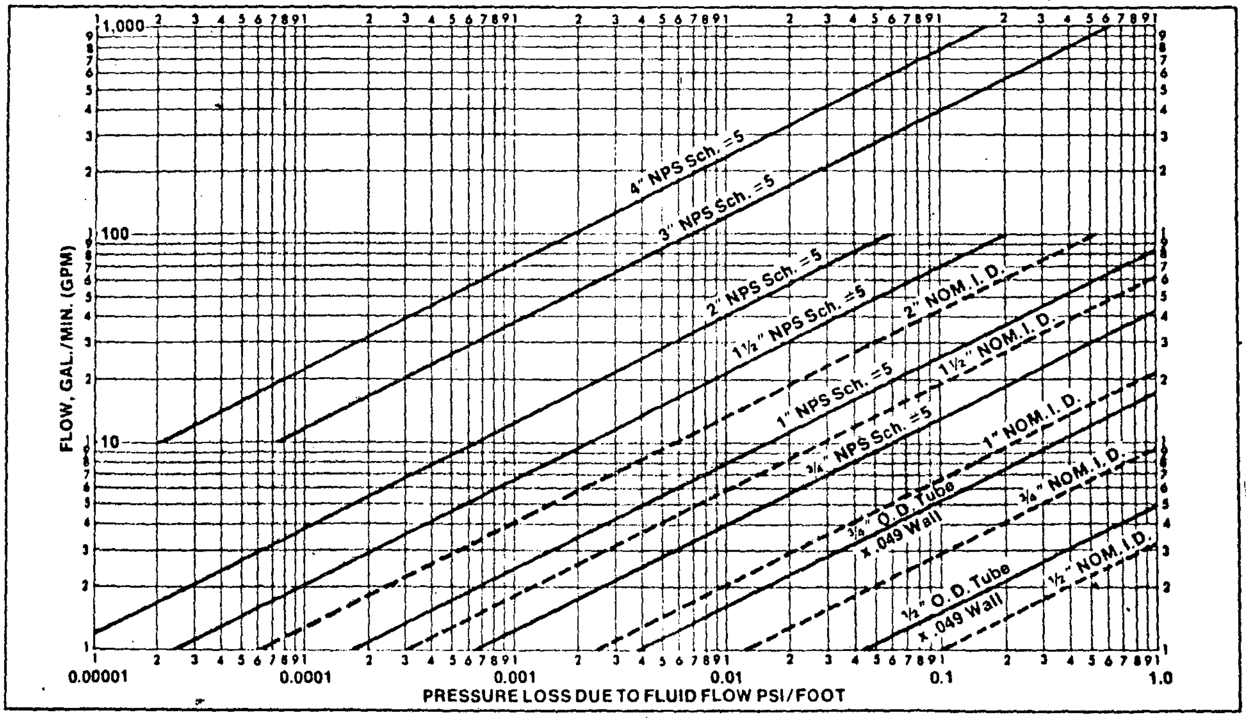
Liquid Hydrogen

Pressure Drop Due to Fluid Flow — Rigid Piping ——— Flexible Piping - - - -

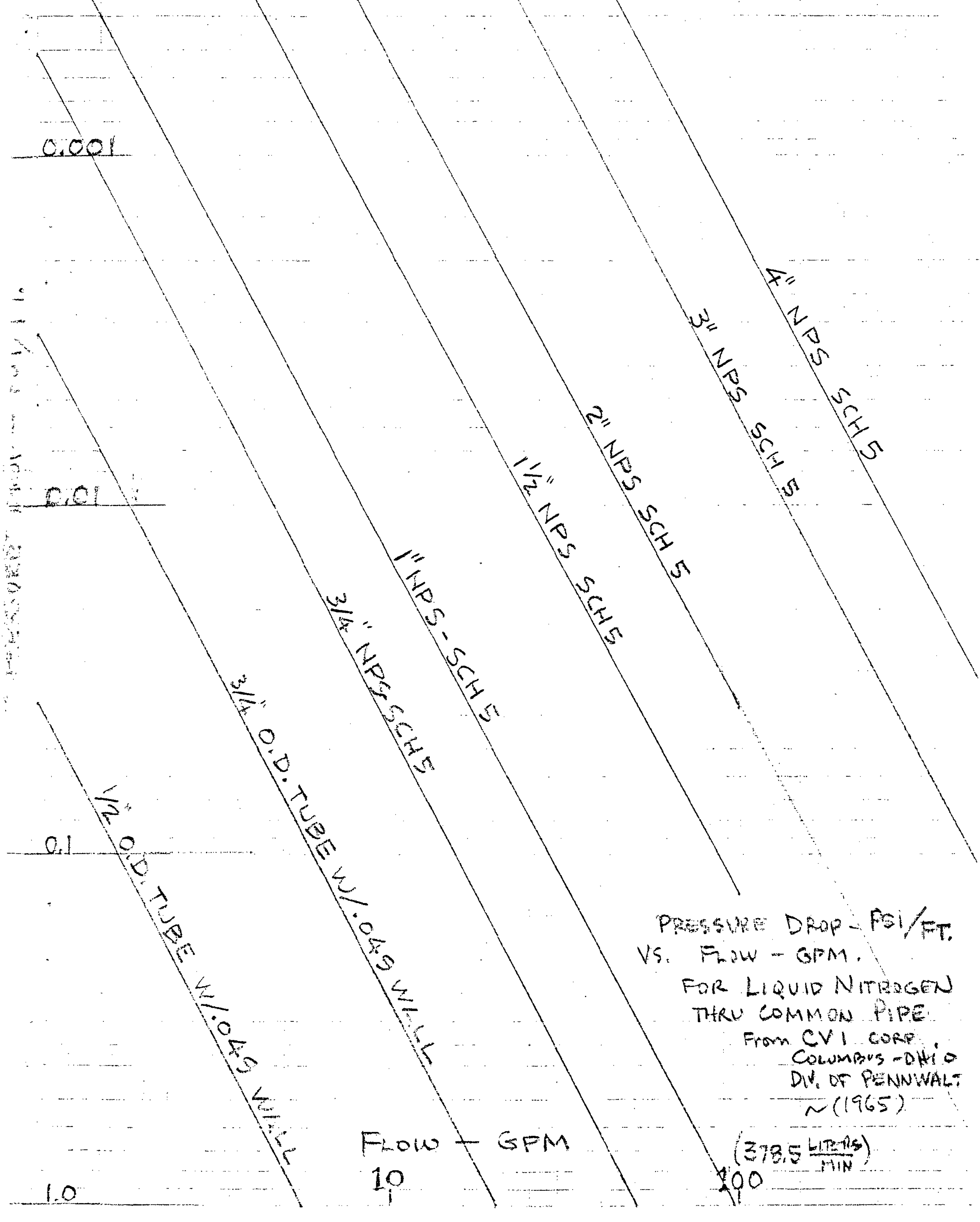


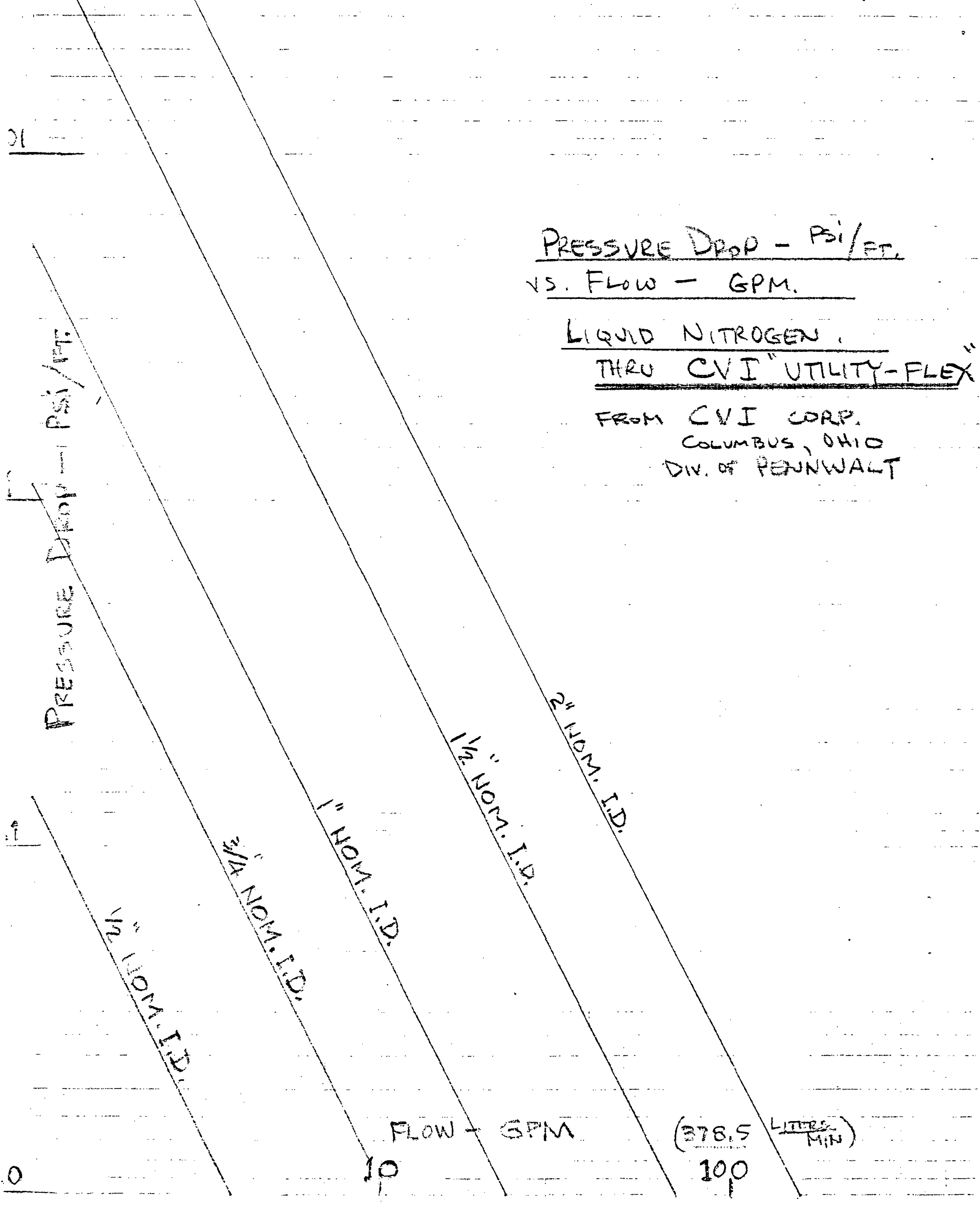
Liquid Oxygen

Pressure Drop Due to Fluid Flow — Rigid Piping ——— Flexible Piping - - - -

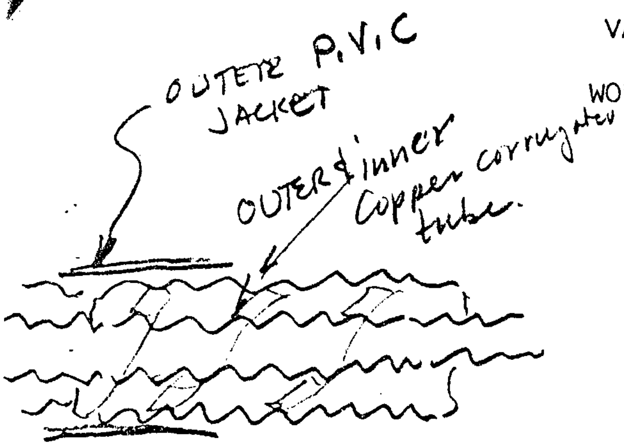


CVI DATA


0.001
0.01
0.1
1.0
4" NPS SCH 5
3" NPS SCH 5
2" NPS SCH 5
1 1/2" NPS SCH5
1" NPS - SCH 5
3/4" NPS SCH5
3/4" O.D. TUBE W/.049 WALL
1/2" O.D. TUBE W/.049 WALL
PRESSURE DROP - PSI/FT.
VS. FLOW - GPM.
FOR LIQUID NITROGEN
THRU COMMON PIPE
From CVI CORP.
COLUMBUS - OHIO
DIV. OF PENNWALT
~(1965)
FLOW - GPM
10
100
(378.5 LITERS/MIN)


PRESSURE DROP - PSI/FT.
VS. FLOW - GPM.
LIQUID NITROGEN.
THRU CVI "UTILITY-FLEX"
FROM CVI CORP.
COLUMBUS, OHIO
DIV. OF PENNWALT
PRESSURE DROP - PSI/FT
1/2" NOM. I.D.
3/4" NOM. I.D.
1" NOM. I.D.
1 1/2" NOM. I.D.
2" NOM. I.D.
FLOW - GPM
(378.5 LITERS/MIN)
10
100

VACUUM BARRIER CORPORATION
4 BARTEN LANE
WOBURN, MASSACHUSETTS 01801
(617) 933-3570



NOTE OBSOLETE DATE FOR PRICE

BULLETIN NO. SFA-100-1
1 FEBRUARY 1968

PRICE LIST

SEMIFLEX "A"

SEMI FLEXIBLE CRYOGENIC TRANSFER LINE

LINE SIZE	INNER I.D. (INCHES)	BASIC CHARGE WITH END TERMINALS	BASIC CHARGE WITH BAYONET ENDS	PRICE PER FOOT
A-5	0.65	$ 250.00	$ 320.00	$ 4.40
A-10	1.25	285.00	385.00	5.60
A-15	1.73	320.00	460.00	8.00
A-20	2.20	365.00	550.00	10.50

NOTES:

1. TOTAL LINE PRICE = OVERALL LENGTH X PRICE PER FOOT + BASIC CHARGE.
2. PACKAGING CHARGE TO BE ADDED TO ABOVE DEPENDING ON LINE LENGTH.
3. ALL LINES ARE FACTORY ASSEMBLED AND LEAK TESTED.
4. ENDS INCLUDE ONE PUMPING PORT AND ONE ANNULUS OVERPRESSURE RELIEF VALVE.
5. BAYONET ENDS INCLUDE ONE MALE AND ONE FEMALE.

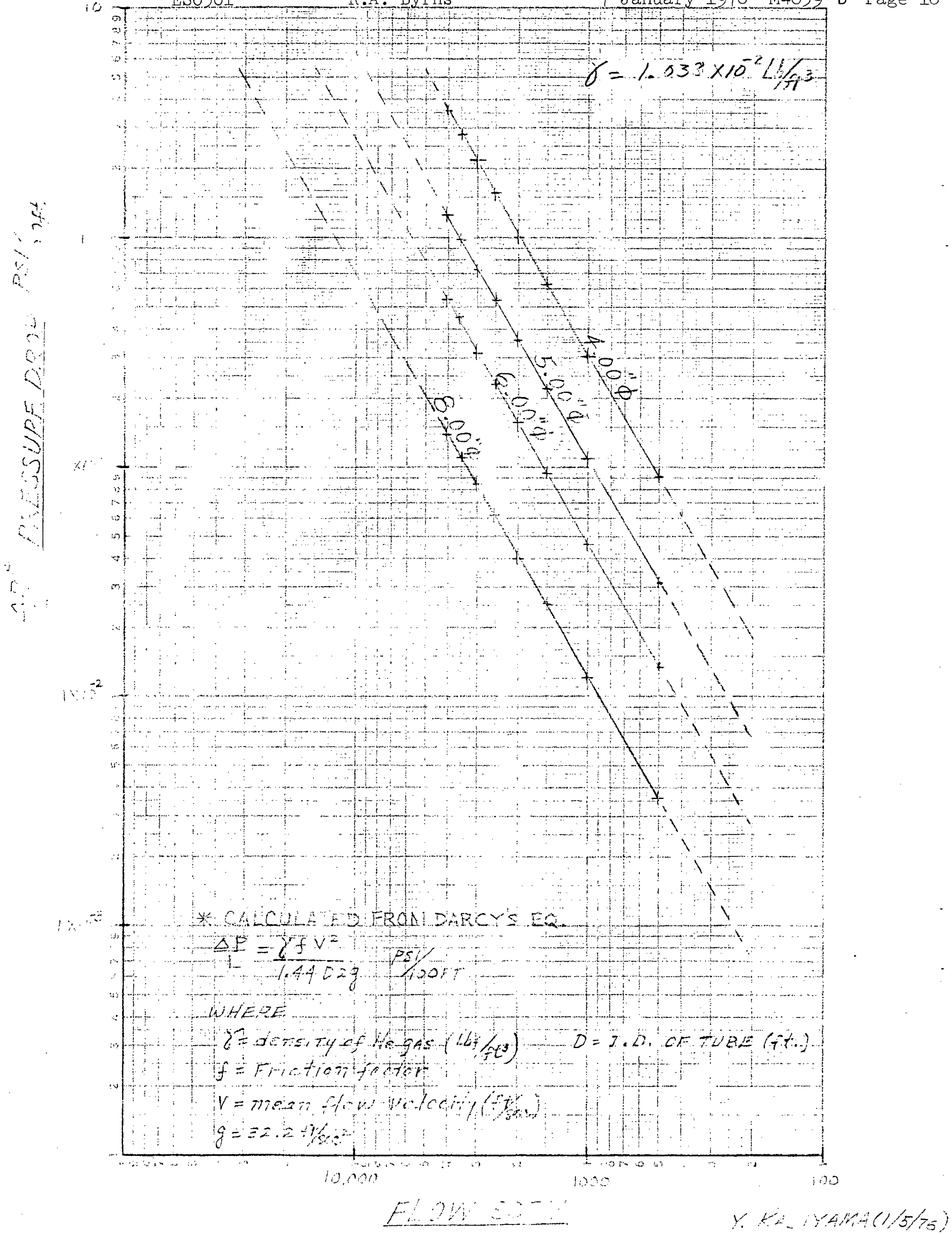
SELECTED DATA

SEMIFLEX A SIZE NUMBER:	A-5	A-10	A-15	A-20
Inside Dia. (Inches)	.646	1.245	1.730	2.205
Outside Dia. (Inches)	1.565	2.390	2.990	3.550
Weight (Lbs/Ft)	.9	1.2	1.7	2.2
Cool-Down (BTU/FT)	10 - 8	20 - 15	25 - 21	30 - 28
Heat Leak (BTU/HR/FT) (measured)	1.2	1.8	2.0	2.4
Bend Radius (Inches)	20	32	40	48
Flow Rate (Water-GPM) *				
0.01 PSI/FT Pressure Drop	.5	3.4	9.0	19.0
0.10 PSI/FT Pressure Drop	1.6	11.0	31.0	62.0
1.00 PSI/FT Pressure Drop	5.0	34.0	90.0	190.0

* IN PURE LIQUID CONDITION LN_2 HAS SIMILAR CHARACTERISTICS TO WATER

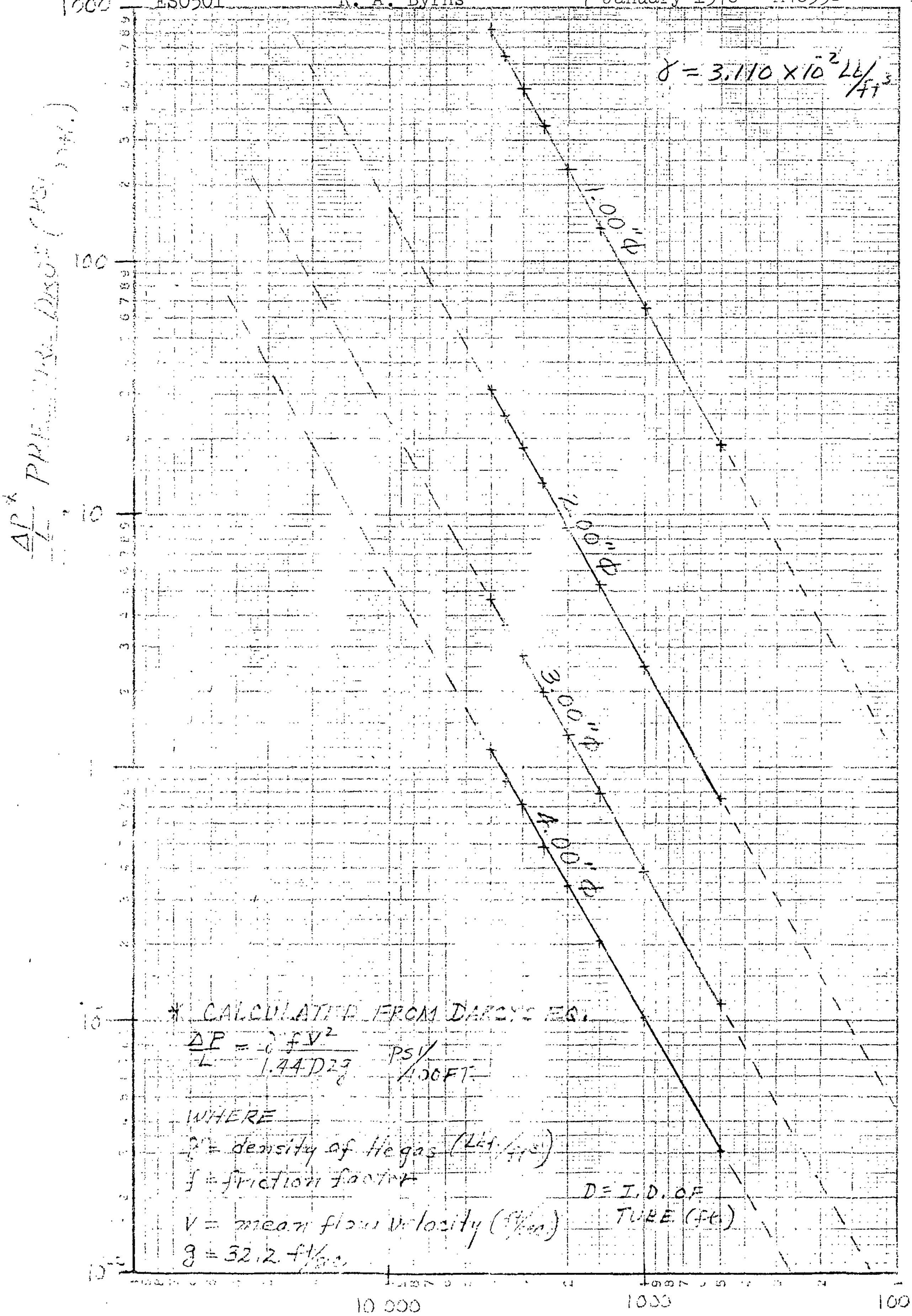
DESIGN-PRESSURE (PSi)	175	150	125	85

PRESSURE DROP IN SMOOTH COPPER WATER TUBES (TYPE K): He gas @ 1 atm. 20°C



Y. KAJIYAMA (1/5/76)

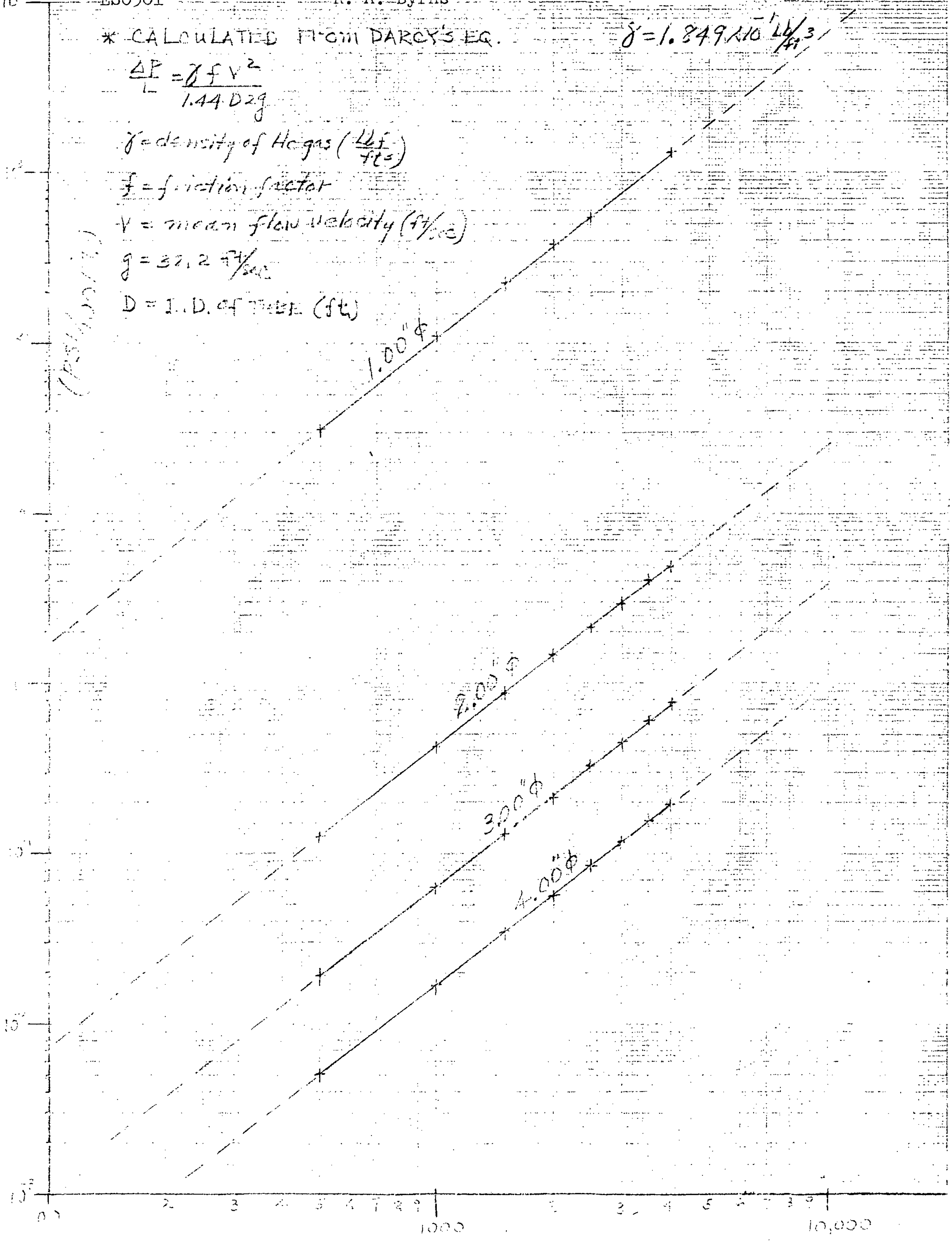
PRESSURE DROP IN SMOOTH COPPER WATER TUBES (TYPE K): He gas; @ 3 atm.; 20°C



FLOW SCFM

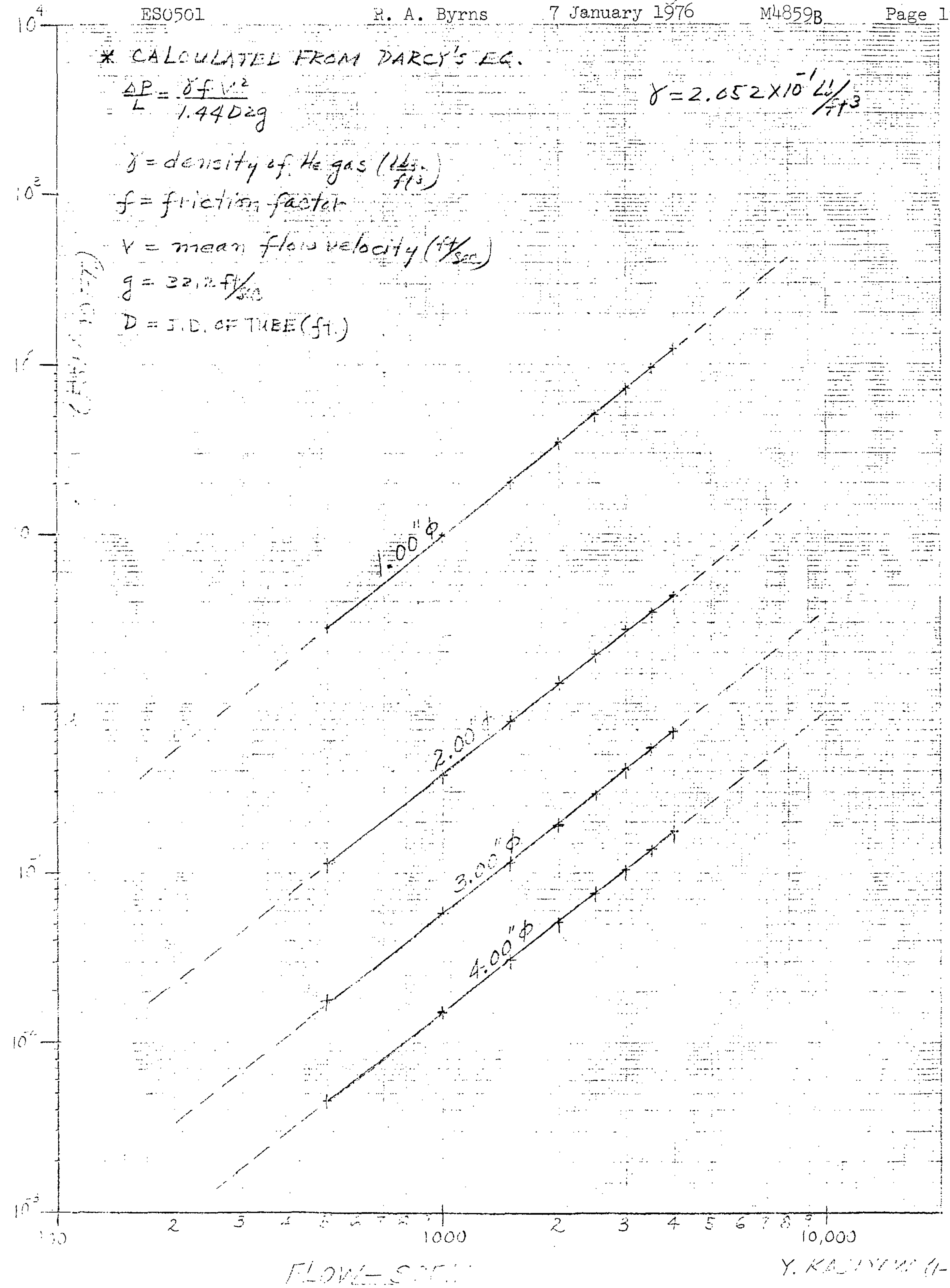
Y. KAJIYAMA (1-6-76)

PRESSURE DROP IN ... PER
WATER ... (TYPE K) ... gas

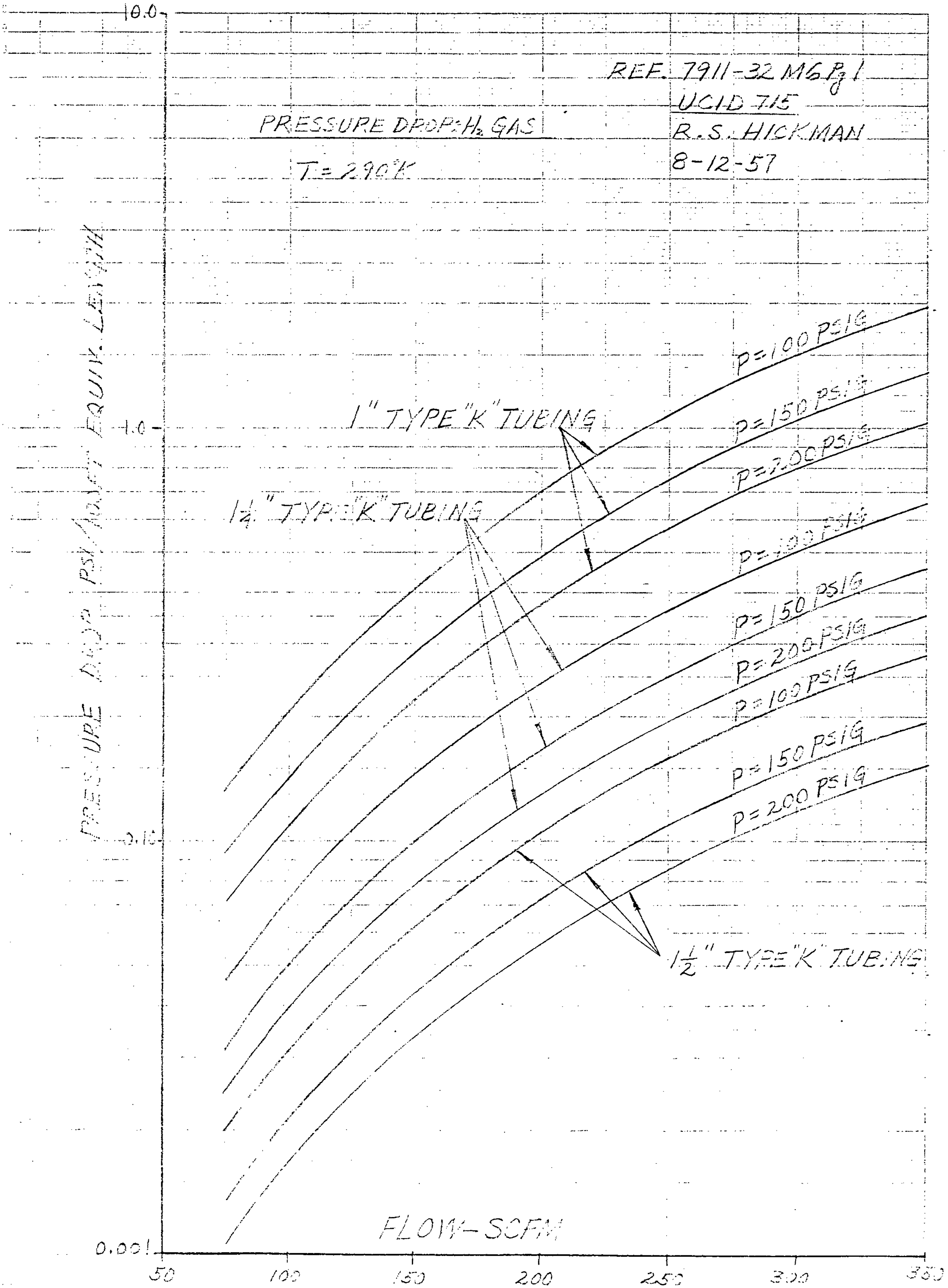


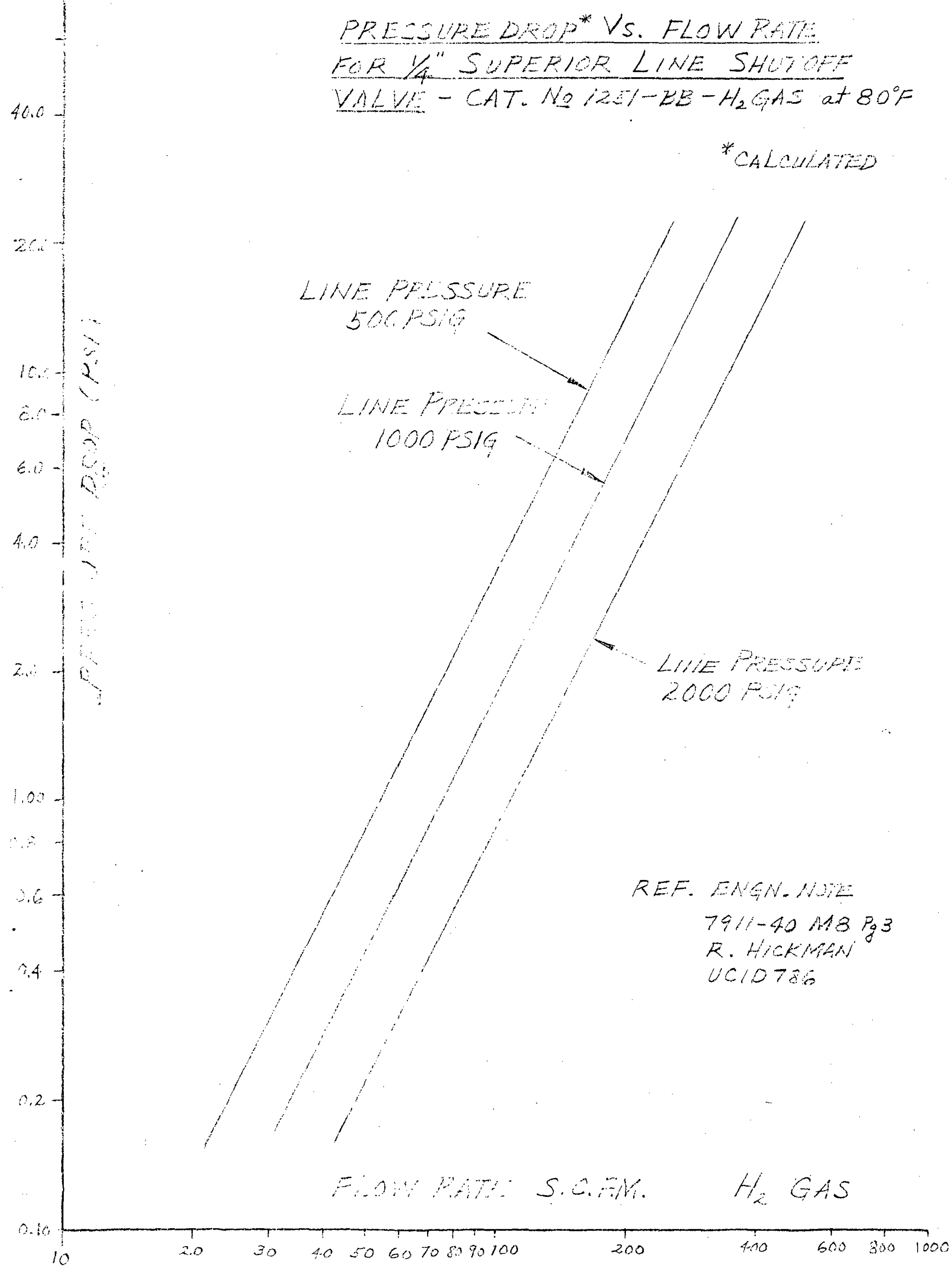
Y. KAJIYAMA

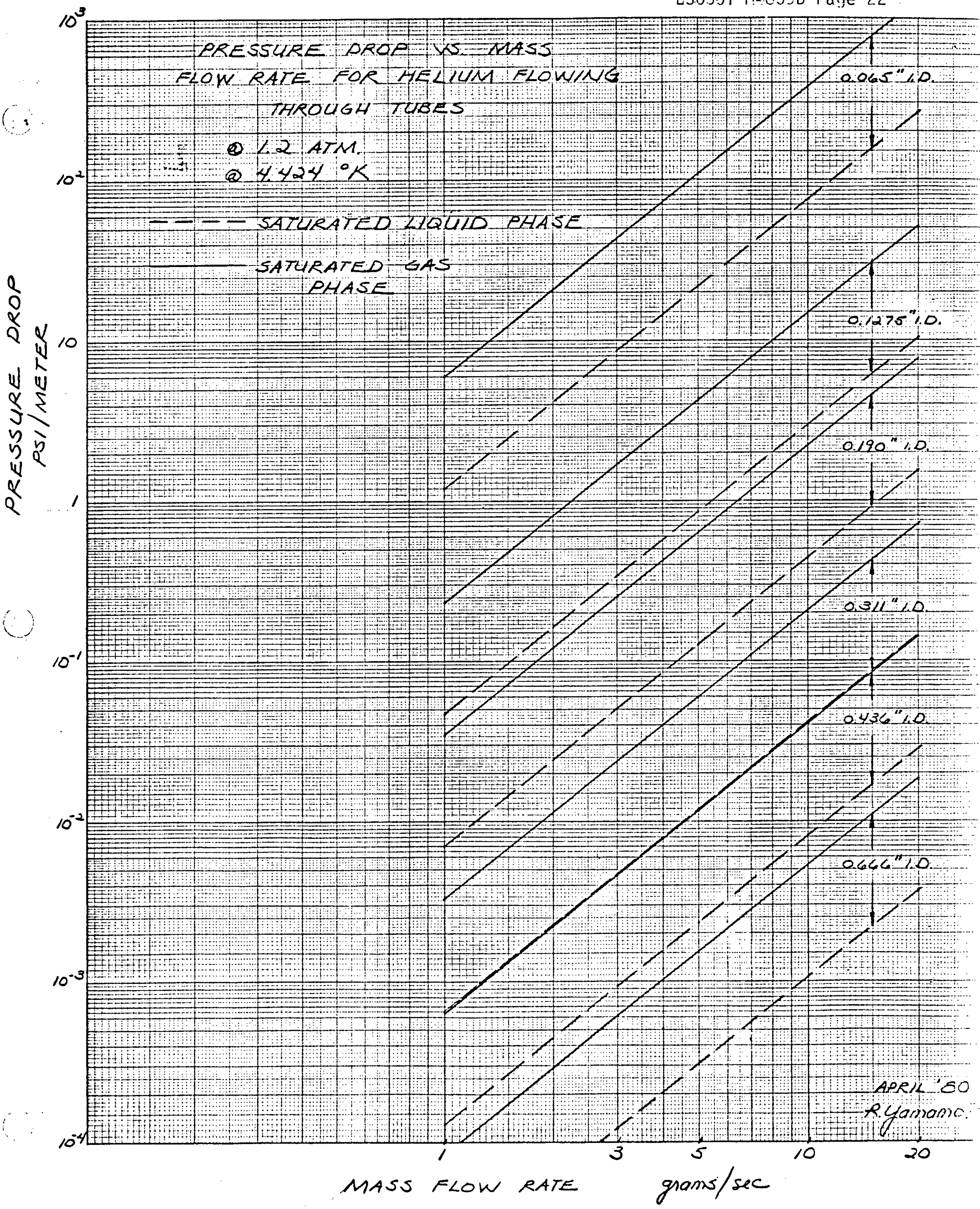
PRESSURE DROP IN SMOOTH COPPER WATER TUBES (TYPE K): He gas @ 20 atm, 20°C

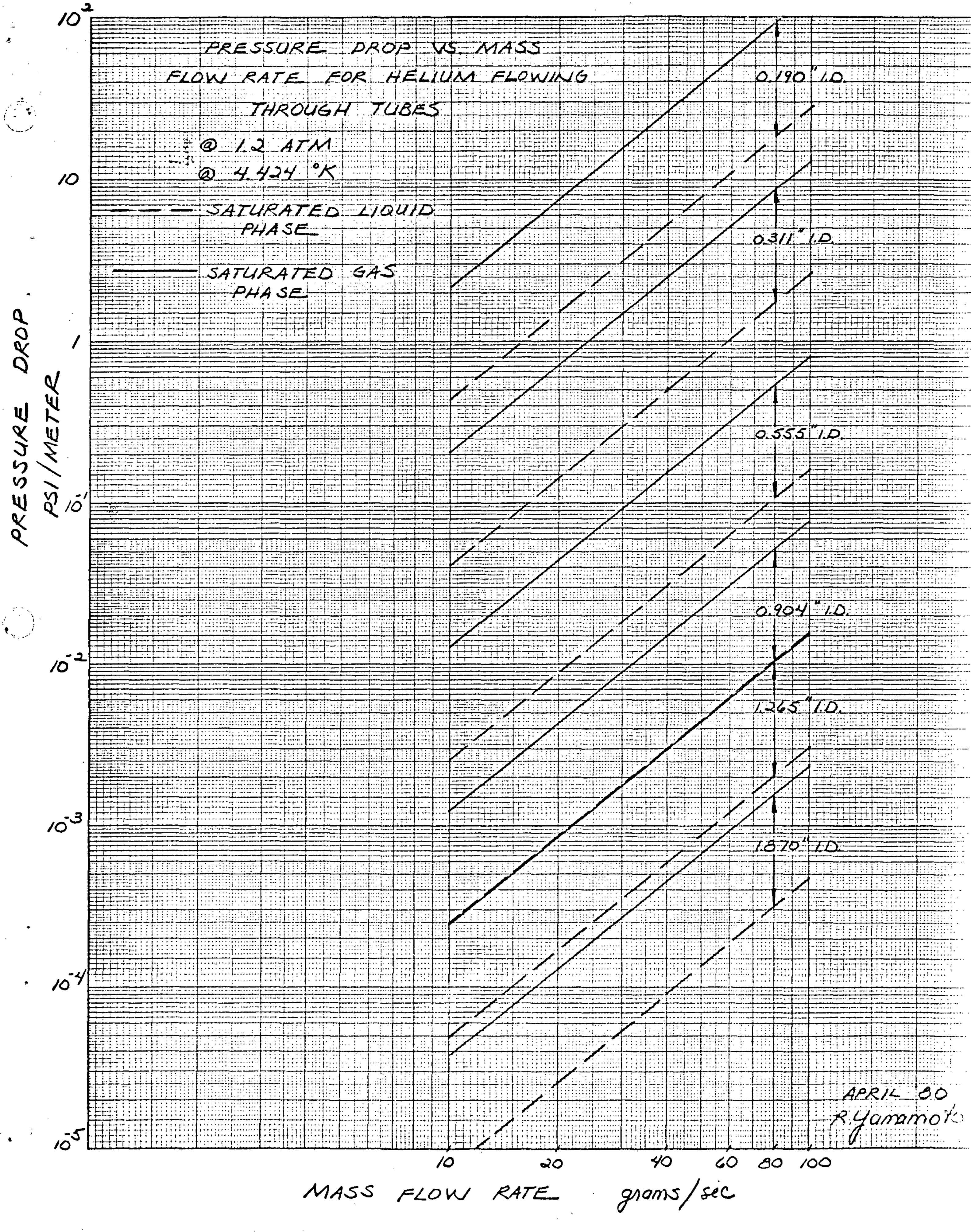


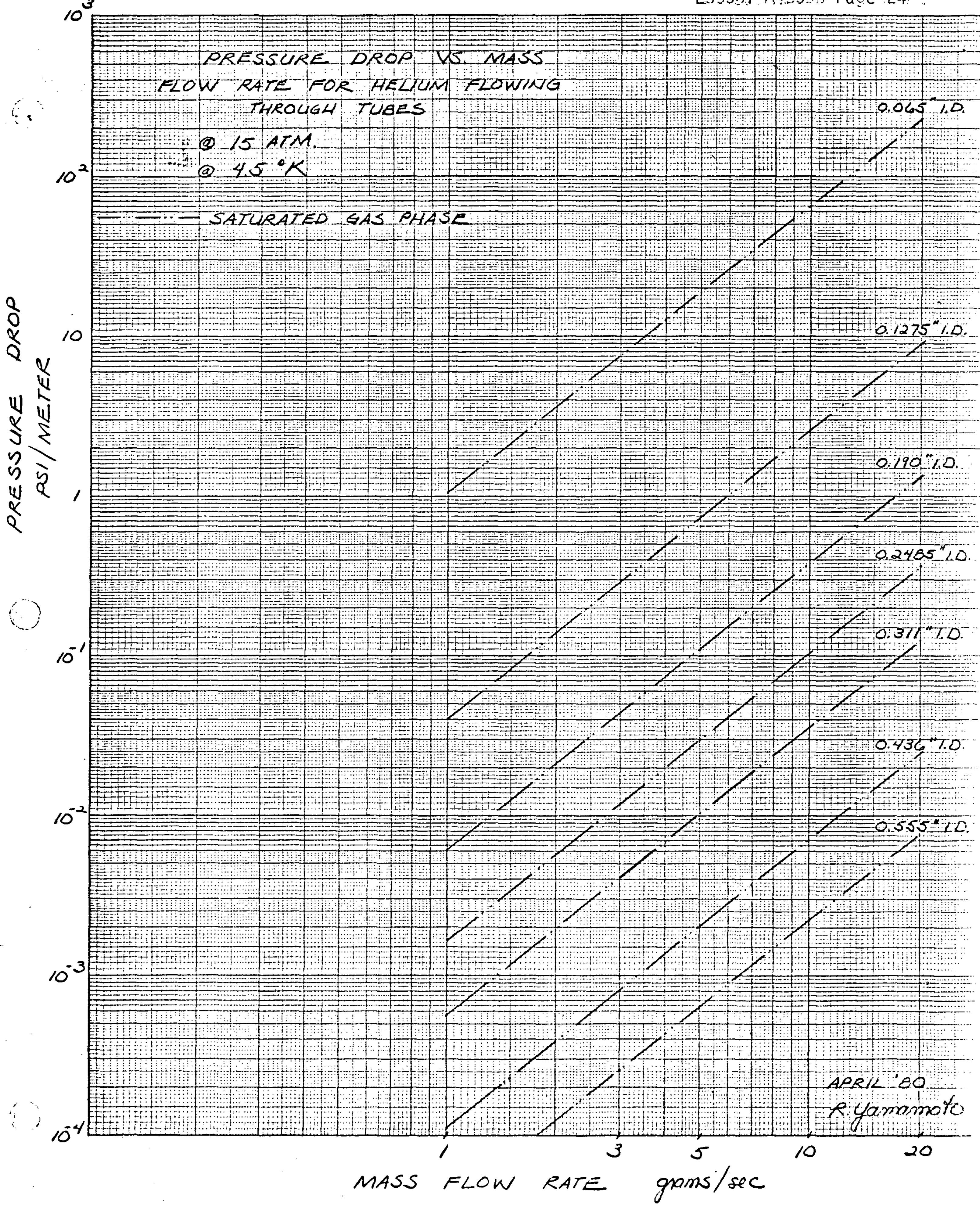
Y. KAJIYAMA (1-6-76)

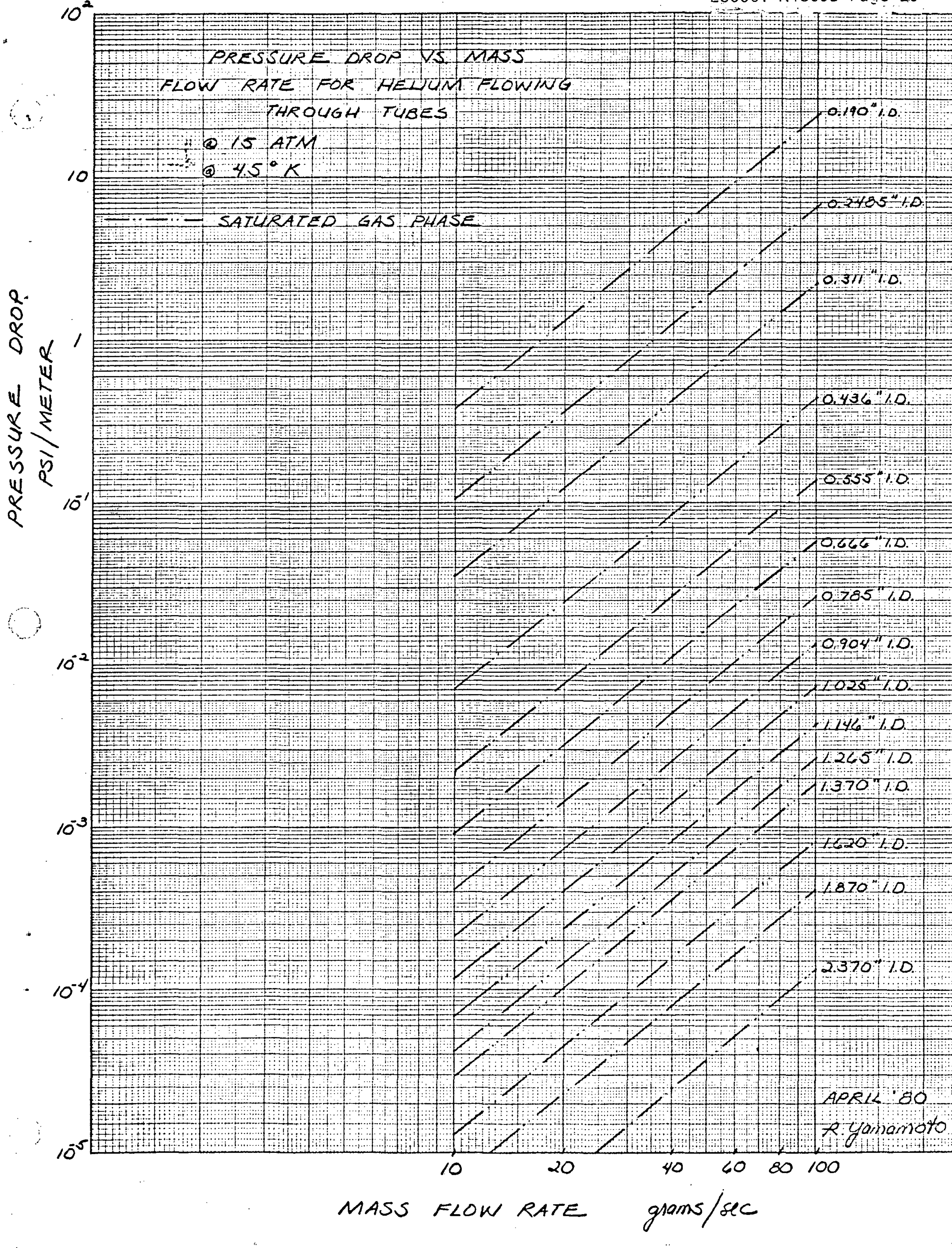

REF. 7911-32 M6 Pg 1
UCID 715
R. S. HICKMAN
8-12-57
PRESSURE DROP: H2 GAS
T = 290°K
PRESSURE DROP PSI/100 FT EQUIV. LENGTH
10.0
1.0
0.10
0.001
1" TYPE "K" TUBING
1¼" TYPE "K" TUBING
1½" TYPE "K" TUBING
P = 100 PSIG
P = 150 PSIG
P = 200 PSIG
P = 100 PSIG
P = 150 PSIG
P = 200 PSIG
P = 100 PSIG
P = 150 PSIG
P = 200 PSIG
FLOW—SCFM
50
100
150
200
250
300
350

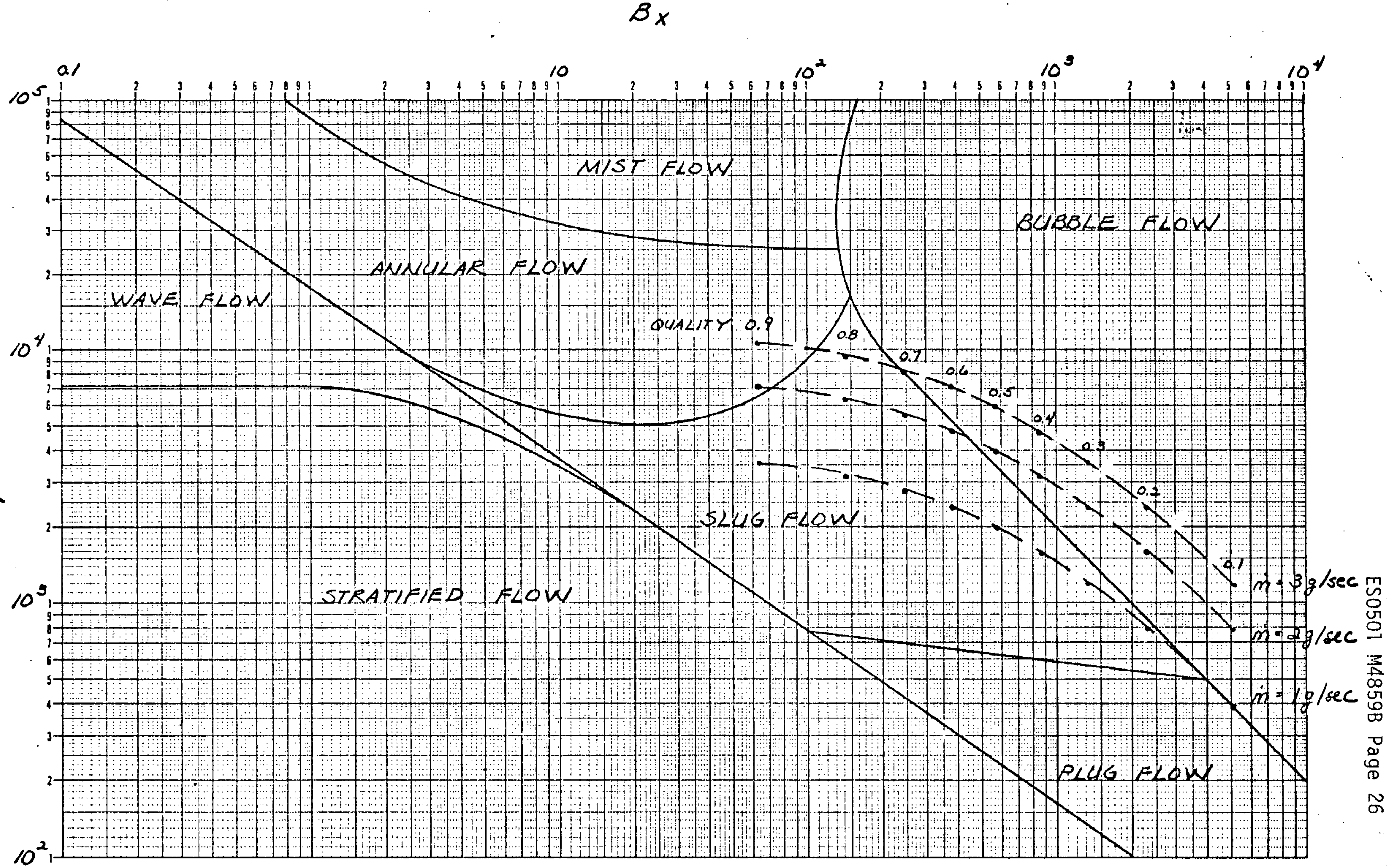

PRESSURE DROP* Vs. FLOW RATE FOR 1/4" SUPERIOR LINE SHUTOFF VALVE - CAT. No 1251-BB - H2 GAS at 80°F
*CALCULATED
LINE PRESSURE 500 PSIG
LINE PRESSURE 1000 PSIG
LINE PRESSURE 2000 PSIG
REF. ENGN. NOTE 7911-40 MB Pg 3 R. HICKMAN UCID786
FLOW RATE S.C.F.M. H2 GAS
100.0
80.0
40.0
20.0
10.0
8.0
6.0
4.0
2.0
1.00
0.6
0.4
0.2
0.10
10
20
30
40
50
60
70
80
90
100
200
400
600
800
1000


PRESSURE DROP VS. MASS FLOW RATE FOR HELIUM FLOWING THROUGH TUBES
@ 1.2 ATM.
@ 4.424 °K
SATURATED LIQUID PHASE
SATURATED GAS PHASE
0.065" I.D.
0.1275" I.D.
0.190" I.D.
0.311" I.D.
0.436" I.D.
0.666" I.D.
PRESSURE DROP PSI/METER
MASS FLOW RATE grams/sec
APRIL '80
R. Yamamo.


PRESSURE DROP VS. MASS FLOW RATE FOR HELIUM FLOWING THROUGH TUBES
@ 1.2 ATM
@ 4.424 °K
SATURATED LIQUID PHASE
SATURATED GAS PHASE
0.190" I.D.
0.311" I.D.
0.555" I.D.
0.904" I.D.
1.265" I.D.
1.870" I.D.
PRESSURE DROP PSI/METER
10²
10
1
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10
20
40
60
80
100
MASS FLOW RATE grams/sec
APRIL '80
R. Yamamoto

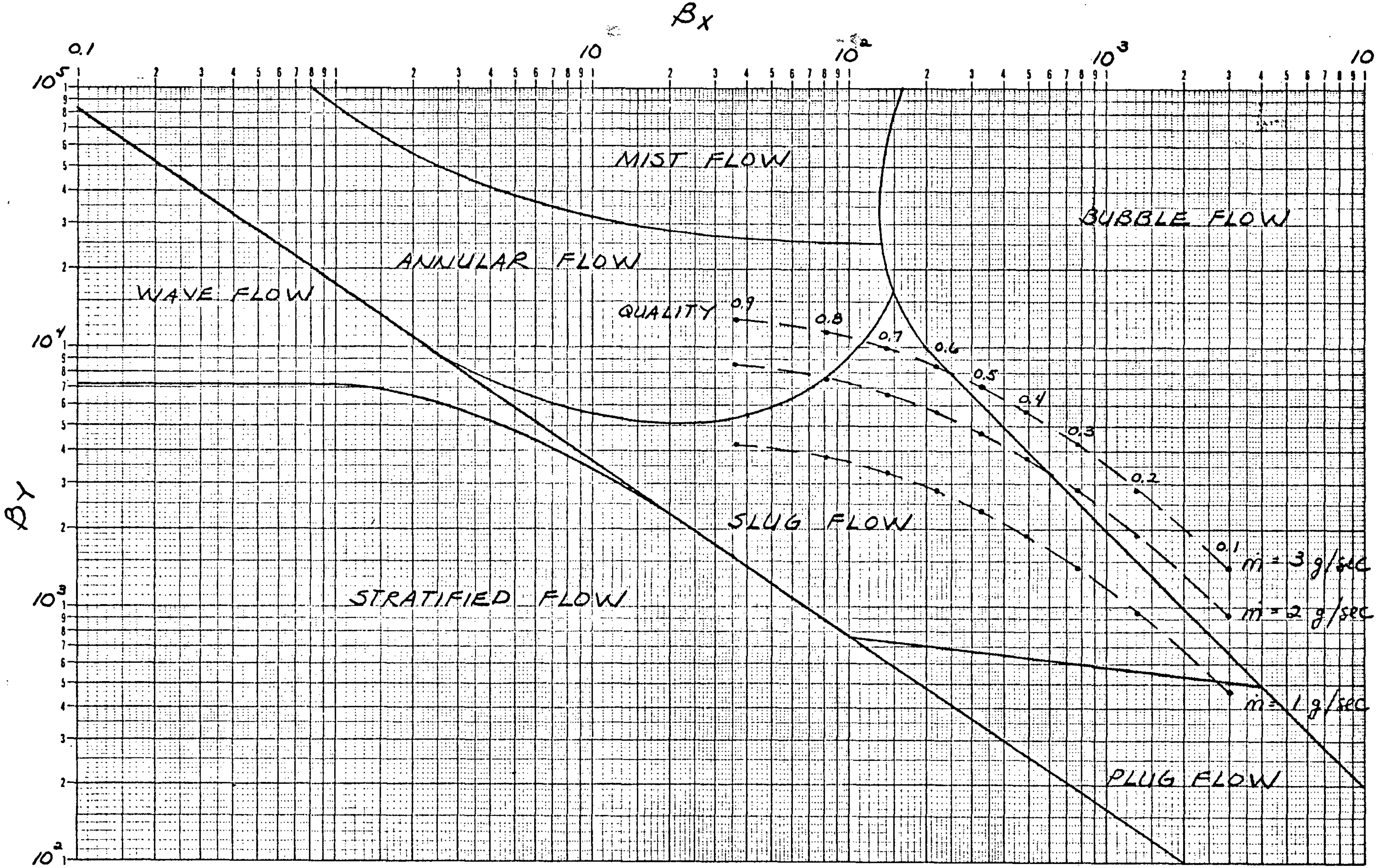

PRESSURE DROP VS. MASS FLOW RATE FOR HELIUM FLOWING THROUGH TUBES
@ 15 ATM.
@ 4.5 °K
SATURATED GAS PHASE
0.065" I.D.
0.1275" I.D.
0.190" I.D.
0.2485" I.D.
0.311" I.D.
0.436" I.D.
0.555" I.D.
PRESSURE DROP PSI/METER
MASS FLOW RATE grams/sec
10^3
10^2
10
1
10^-1
10^-2
10^-3
10^-4
1
3
5
10
20
APRIL '80
R. Yamamoto


PRESSURE DROP VS. MASS FLOW RATE FOR HELIUM FLOWING THROUGH TUBES
@ 15 ATM
@ 4.5° K
SATURATED GAS PHASE
PRESSURE DROP PSI/METER
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0.190" I.D.
0.2485" I.D.
0.311" I.D.
0.436" I.D.
0.555" I.D.
0.666" I.D.
0.785" I.D.
0.904" I.D.
1.025" I.D.
1.146" I.D.
1.265" I.D.
1.370" I.D.
1.620" I.D.
1.870" I.D.
2.370" I.D.
10
20
40
60
80
100
MASS FLOW RATE grams/sec
APRIL '80
R. Yamamoto



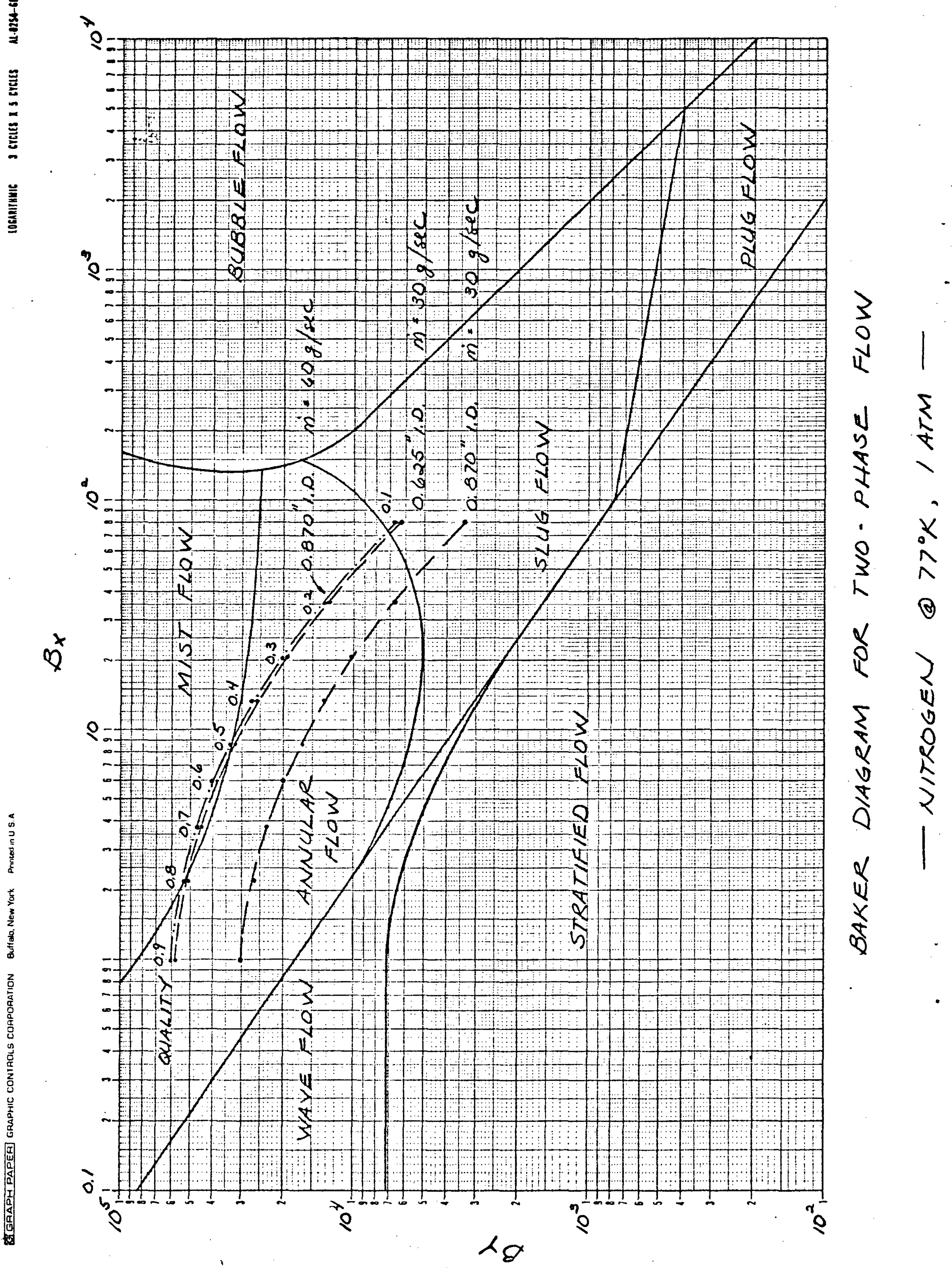
BAKER DIAGRAM FOR TWO-PHASE FLOW

— HELIUM @ 4.2°K, 1 ATM —
1.339 cm I.D. TUBE



BAKER DIAGRAM FOR TWO-PHASE FLOW

— HELIUM @ 3.8°K, 1 ATM —
1.339 cm I.D TUBE


BAKER DIAGRAM FOR TWO - PHASE FLOW
— NITROGEN @ 77°K, 1 ATM —
BUBBLE FLOW
PLUG FLOW
MIST FLOW
SLUG FLOW
ANNULAR FLOW
WAVE FLOW
STRATIFIED FLOW
QUALITY
ṁ = 40 g/sec 0.870" I.D.
ṁ = 30 g/sec 0.625" I.D.
ṁ = 30 g/sec 0.870" I.D.
Bx
By
LOGARITHMIC 3 CYCLES X 5 CYCLES AL-0254-60
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