VLA TECHNICAL REPORT #11
Revision 1

VACUUM AND CRYOGENICS CONTROL AND MONITOR

S. Burgan

September 1975

CONTENTS

I. LIST OF RELATED DOCUMENTS

Drawing Title	Number
1. Vacuum Control Panel	D13110M19
2. Enclosure Modification	C13130M2
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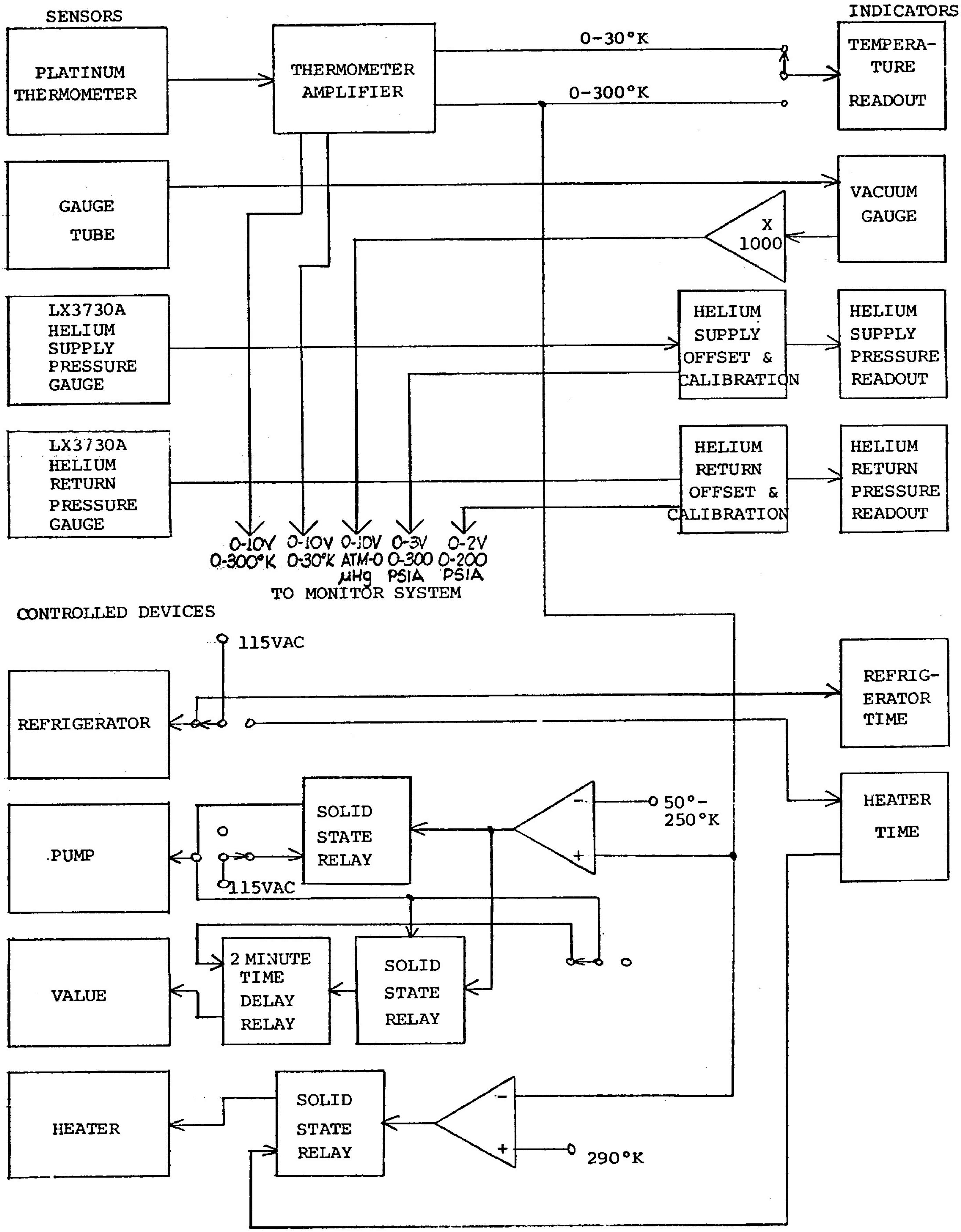
4. Meter Scale, Helium Return Pressure	B13130M5
5. Marking, Dial Temperature	C13110A1
6. PC Board Detail	C13130M3
7. PC Board Assembly	C13130P1

CRYOGENICS CONTROL PANEL: BLOCK DIAGRAM



NOTES:

1. All switches are shown in their "AUTO" or normal operating positions.
2. If any switch is not in its "AUTO" position, a red light on the panel will light.

III. THEORY OF OPERATION

The Cryogenics Control Panel contains several major sections; a thermometer amplifier, heater and pump/valve interlock comparators, a vacuum gauge amplifier, pressure gauge offset and readout circuitry, and controlled function switching circuitry.

1. Thermometer Amplifier

The thermometer amplifier consists of a dual op-amp, and associated components. The first op-amp is connected as a gain-of-ten differential amplifier with AC roll-off capacitors, and provides all necessary amplification for the 0-300°K range. This stage includes provisions for zeroing the amplifier and adjusting the platinum thermometer current for calibration (see schematic). The second op-amp is connected as a gain-of-60 non-inverting amplifier, and provides the additional gain needed to expand the scale to 0-30°K.

2. Interlock Comparators

The two comparators in this section are made from a single RC4558 dual op-amp, and some out-board components. The first op-amp is connected so as to sense when the temperature of the cold-stage falls below the set-point temperature (adjustable from 50-250°K). When this happens, the positive "ON" voltage being applied to the pump and valve solid state relays (SSR, SSR_2) is removed, thus shutting off these devices. The second op-amp is connected so as to sense when the cold-stage temperature exceeds 283°K. When this happens the "ON" voltage applied to the heater solid state relay SSR_3 is removed thus shutting off the heater.

3. Vacuum Gauge Amplifier

The vacuum gauge amplifier is very similar to the thermometer amplifier except that it has only one range. It contains adjustments for zeroing and gain control, and normally operates as a gain-of-1000 amplifier.

4. Pressure Gauge Offset and Readout

Helium supply and return pressures for the refrigerator are monitored using National Semiconductor LX3730A 0-300 PS1A pressure transducers. Since these devices give a 2.5V to 12.5V output (measured with respect to the devices negative terminal) for a 0-300 PS1a pressure range, it was desired to offset the negative terminal 2.5V below ground, thus giving an output of 0-10V for 0-300 PS1A measured with respect to ground. This offset is accomplished with R_{35} - R_{38}, which also enables the pressure gauges to be zeroed. Resistors R_{39} - R_{46} allow calibration of the pressure gauges at the high end of their scales, allow readout of the pressures on M_2 and M_3, and give easily interpretable voltages to the monitor system (0-3V for 0-300 PS1A on supply, and 0-2V for 0-200 PS1A on return.

5. Control Criteria

The overall logic of the system, combining the thermometer amplifier, comparators, solid state relays, and front panel switches, is as follows:

1. The valve will open after the pump has been on for two minutes.
2. The valve will open only if the cold-stage temperature is greater than a preset temperature T_o (normally about 200°K).
3. The pump will come on in "AUTO" only if the temperature is greater than T_o.
4. The heater will come on only if the refrigerator is off.
5. The heater will go off if the cold-stage temperature exceeds $\simeq$283°K.

IV. TEST AND CALIBRATION

Check all wiring! Pay particular attention to the wiring of the two helium pressure gauges, as these devices may be damaged or destroyed if power is improperly applied (requiring replacement and thus recharging of the refrigerator with helium).

Check and zero all front panel meters.

Make sure that the AC power connector ZVP3 is disconnected. Apply DC power to the panel. If anything obviously wrong is found at this point, remove the power and find out why.

Temperature Amplifier Calibration

Carefully SOLDER a small piece of #18 - #20 buswire between E24 and E25 on the PC board. With the temperature range switch in the 0-30°K position, adjust R_8 for zero on the temperature meter. Switch to the 0-300°K range, remove the short and adjust R_2 to give an accurate reading of the dewar cold stage temperature.

Making reference to the temperature VS voltage graph, find the voltage corresponding to the desired pump/valve cutout temperature. Measuring the voltage at IC_2-2, adjust R_{16} to the voltage just found.

Vacuum Gauge Amplifier Adjustment

Set S_5 to the "SHORT" position. Adjust R_{29} to give a voltage of 0.00 at E9. Set S_5 to the "OPERATE" position. Later, when the cold stage is cold, and a good vacuum is present in the dewar, adjust the vacuum gauge for a reading of 0µ (see vacuum gauge manual). Next adjust R_{32} for a reading of 10.00V at E9.

Bleed the helium pressure in the refrigerator down to atmospheric pressure. Adjust R_{36}, R_{38} so that atmospheric pressure is read on the supply and return pressure gauges M_2, M_3. Charge the refrigerator to a pressure of 200 PSIA. Adjust R_{42}, R_{46} to give readings of 200 PSIA on the meters.

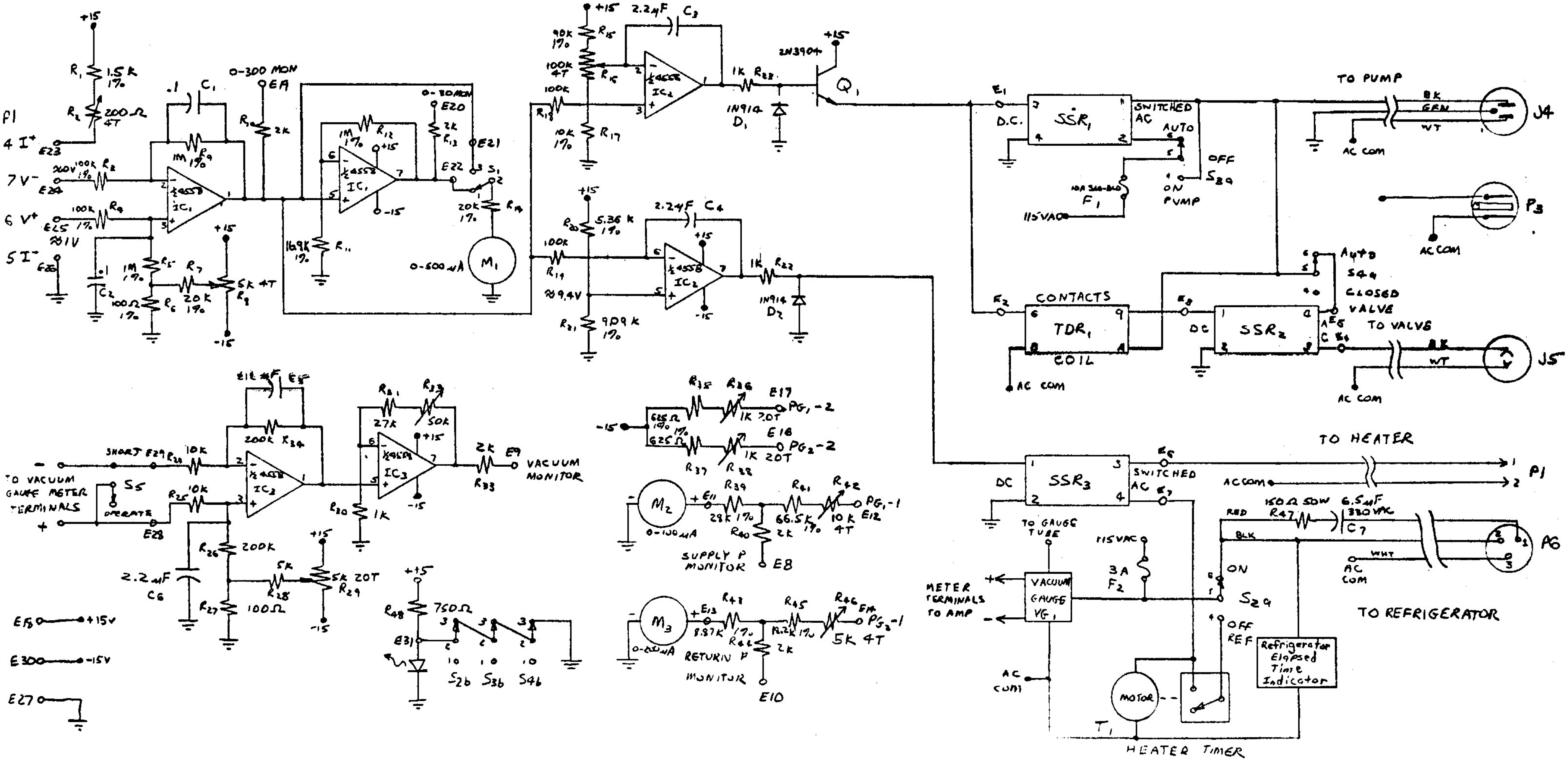
This completes calibration of the cryogenics control panel.

Final Checkout

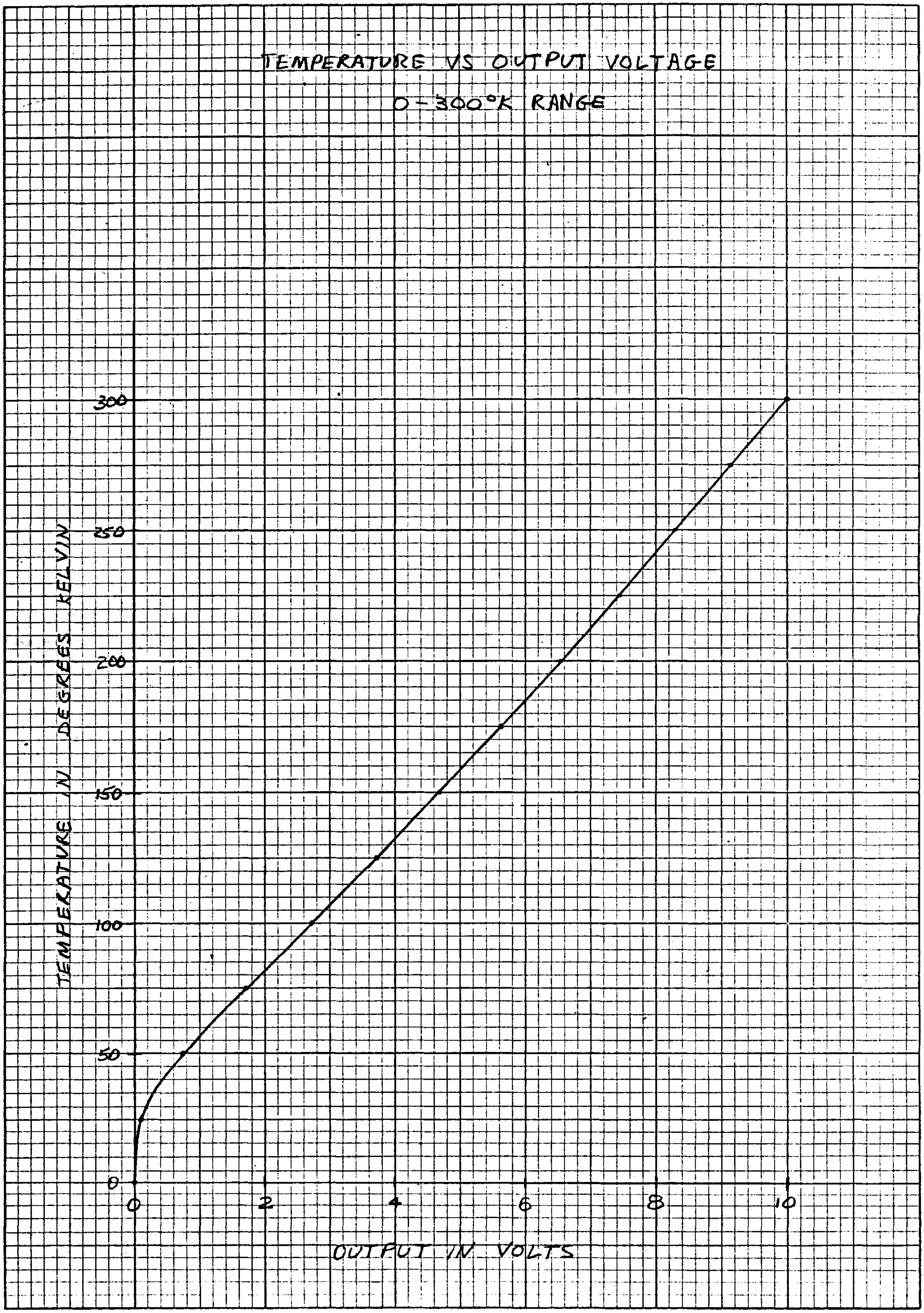
Connect the AC power plug ZVP3. Seal the dewar. Apply AC and DC power to the panel. To test for proper operation of the panel, verify the following statements:

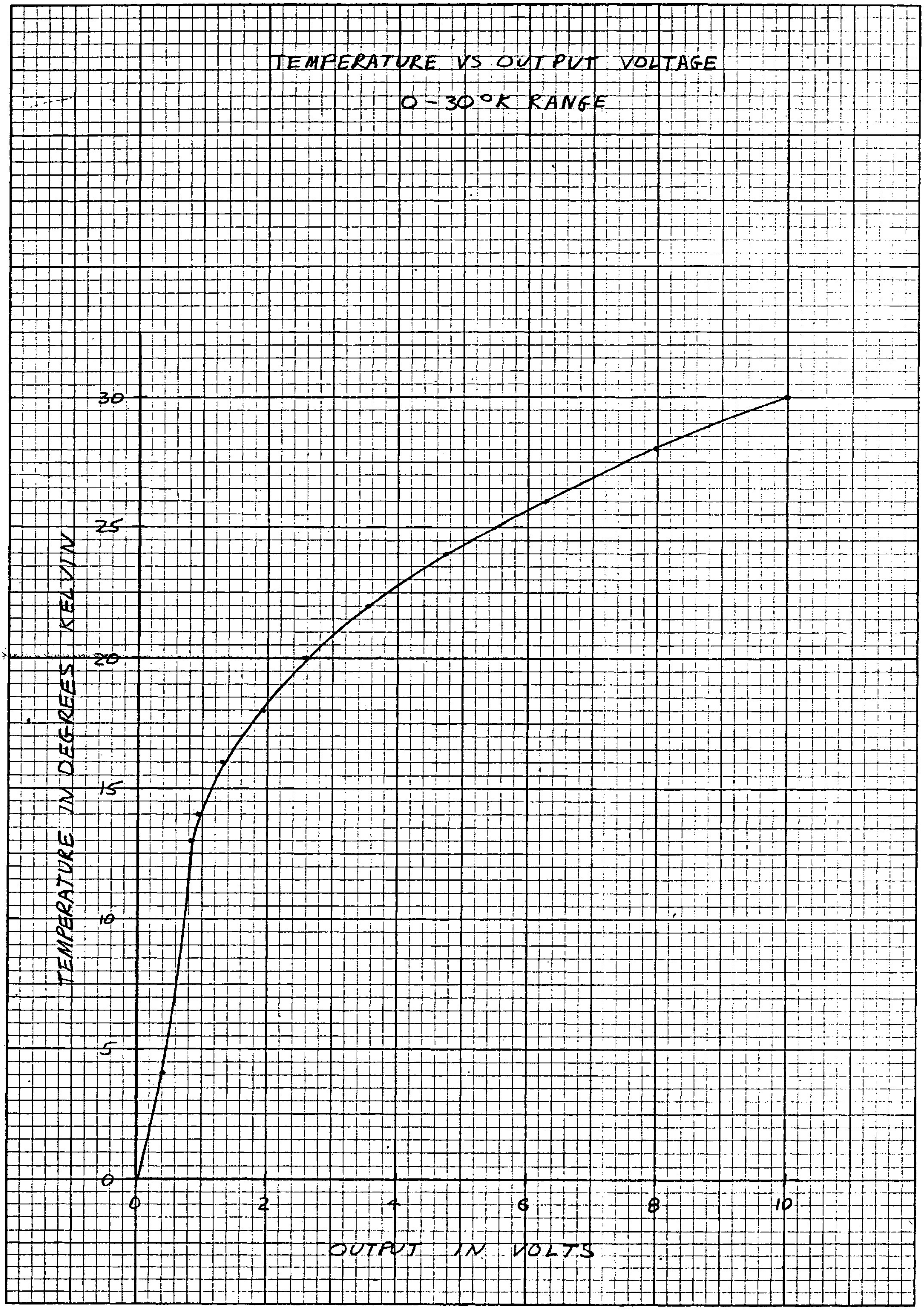
1. The valve opens in the auto position approximately two minutes after the pump comes on, and can be opened and closed at will with the valve switch after this time.

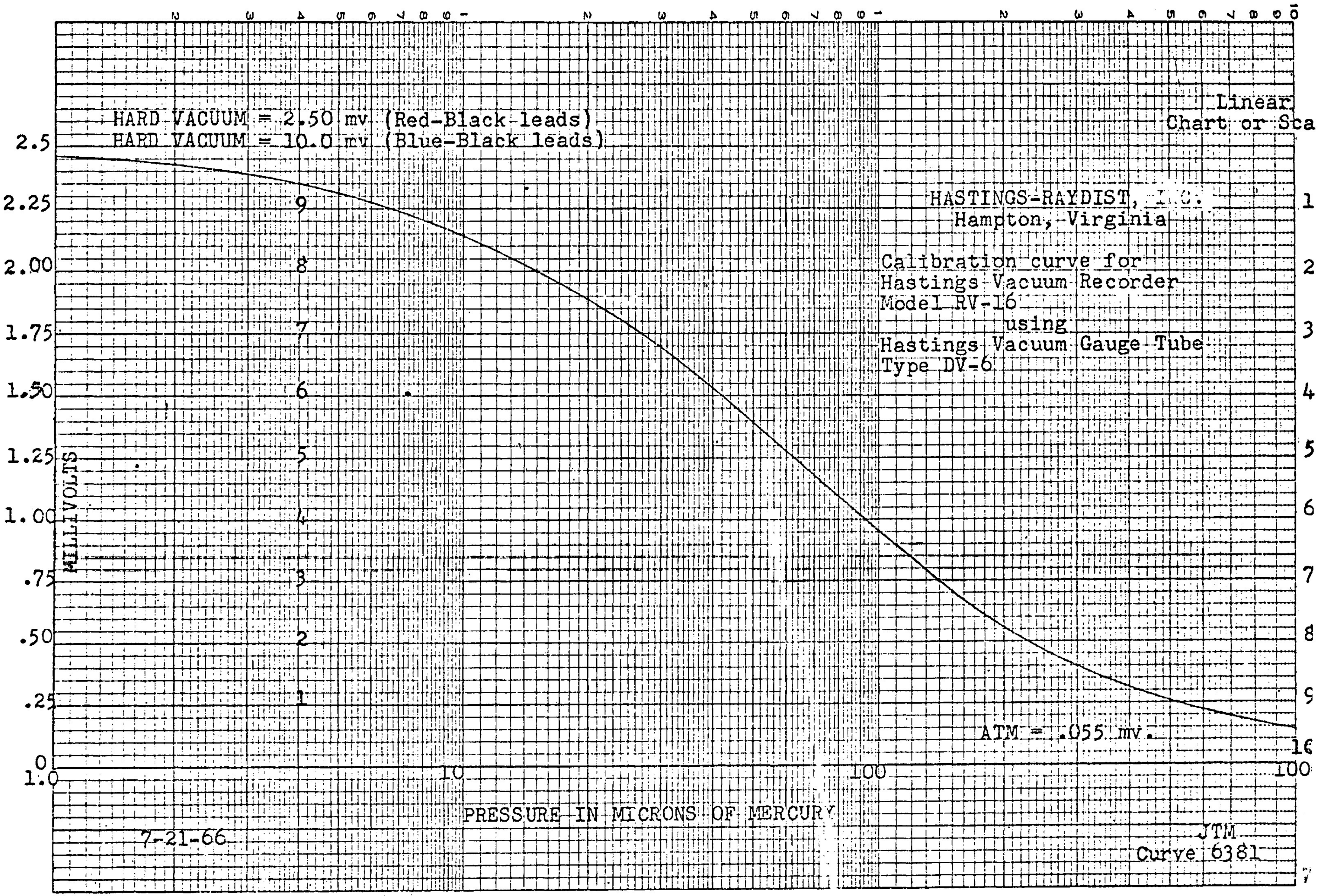
2. The pump and valve are both shut down in auto when the temperature falls below the preset temperature T_o. (NOTE: This can be tested by connecting a 1K 10T pot between PC terminals E24 and E25 with the thermometer connected. This allows variations in temperature to be simulated by adjusting the pot.)
3. The valve will open ONLY when the pump is on and the temperature is above T_o.
4. The heater is on only when the refrigerator is off, and the temperature is below approximately 283°K.
5. The heater timer functions properly.



P1
4 I+
E23
7 V-
E24
6 V+
E25
5 I-
0-300 MON
E19
0-30 MON
E20
E21
E22
S1
IC1
IC2
IC3
M1
0-600 μA
2N3904
Q1
1N914
D1
D2
2.2μF
C3
C4
C1
C2
C6
+15
-15
TO PUMP
BK
GRN
WT
J4
J5
P3
P6
AC COM
E1
D.C.
SSR1
SSR2
SSR3
SWITCHED AC
AUTO
OFF
ON
PUMP
S3a
F1
115VAC
S4a
CLOSED
VALVE
TO VALVE
E2
CONTACTS
TDR1
COIL
E3
E5
E6
DC
TO HEATER
E7
RED
BLK
WHT
TO REFRIGERATOR
TO GAUGE TUBE
METER TERMINALS TO AMP
VACUUM GAUGE VG1
3A
F2
S2a
OFF REF
Refrigerator Elapsed Time Indicator
MOTOR
T1
HEATER TIMER
TO VACUUM GAUGE METER TERMINALS
S5
OPERATE
SHORT
E28
E29
VACUUM MONITOR
E9
R33
E17
E18
PG1-2
PG2-2
M2
0-100 μA
SUPPLY P MONITOR
E8
E12
PG1-1
M3
RETURN P MONITOR
E10
PG2-1
E31
S2b
S3b
S4b
E15 +15V
E30 -15V
E27

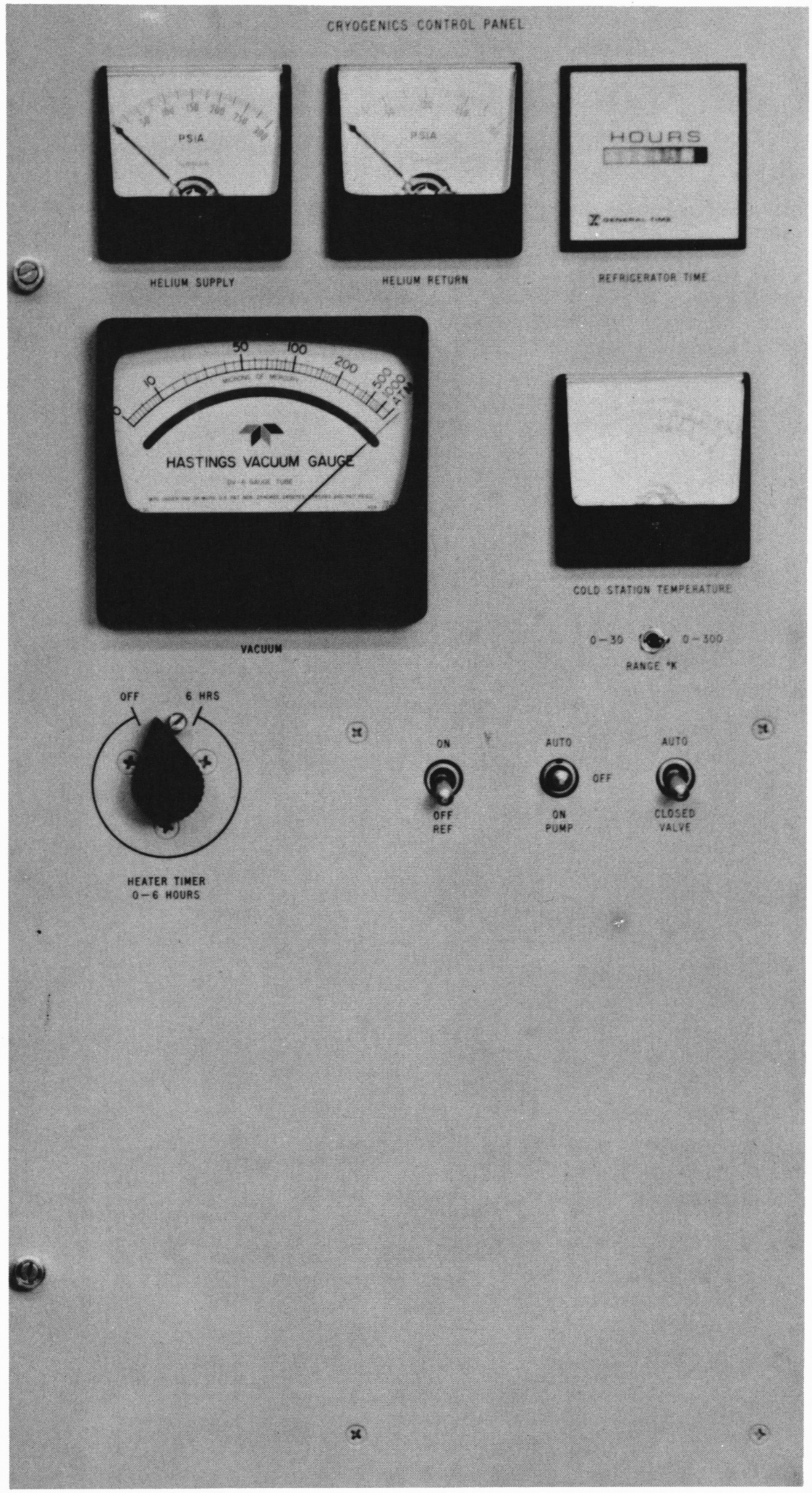

TEMPERATURE VS OUTPUT VOLTAGE
0-300°K RANGE
TEMPERATURE IN DEGREES KELVIN
300
250
200
150
100
50
0
0
2
4
6
8
10
OUTPUT IN VOLTS


TEMPERATURE VS OUTPUT VOLTAGE
0-30°K RANGE
TEMPERATURE IN DEGREES KELVIN
30
25
20
15
10
5
0
0
2
4
6
8
10
OUTPUT IN VOLTS

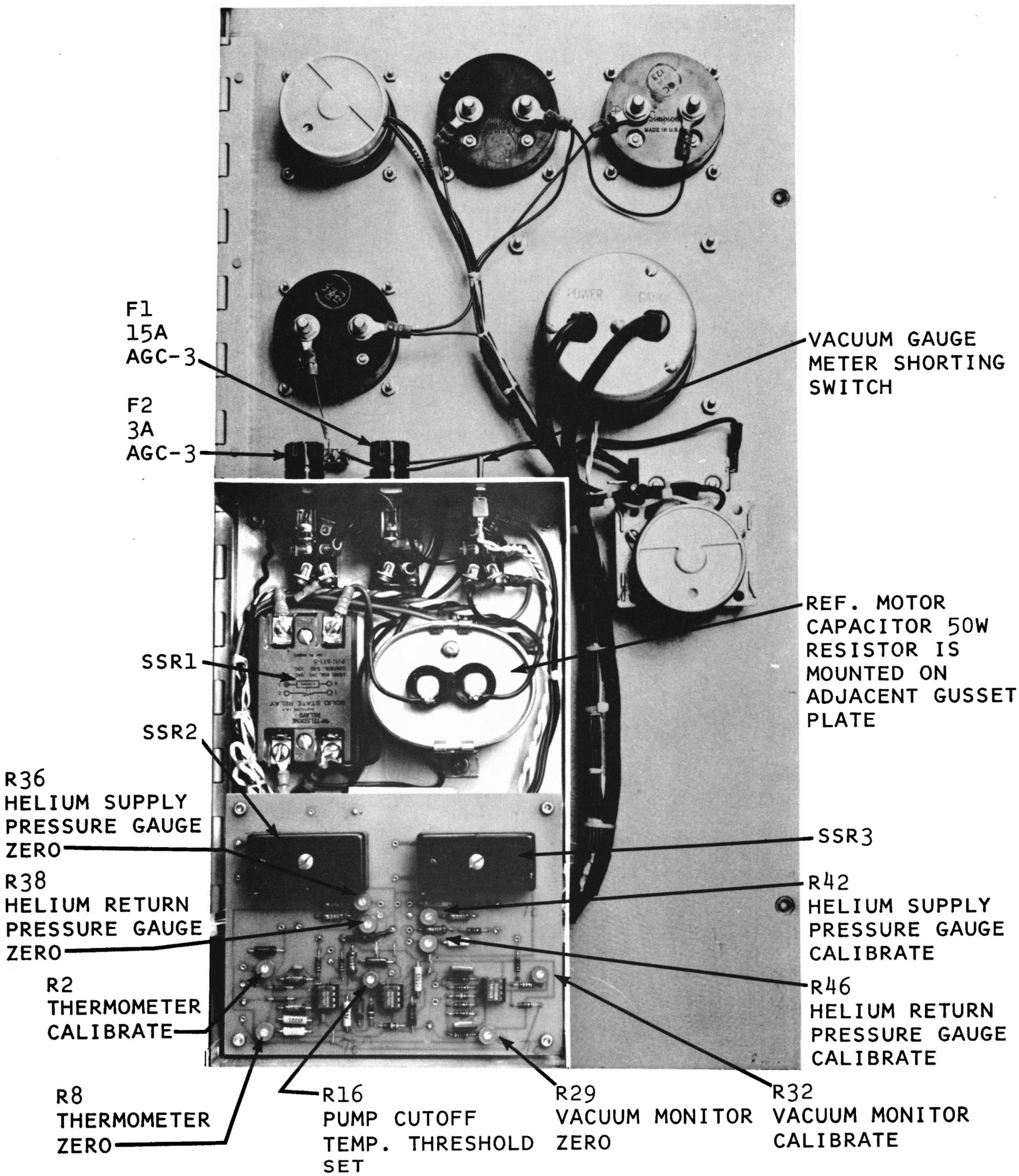


HARD VACUUM = 2.50 mv (Red-Black leads)
HARD VACUUM = 10.0 mv (Blue-Black leads)
Linear
Chart or Sca
HASTINGS-RAYDIST,
Hampton, Virginia
Calibration curve for
Hastings Vacuum Recorder
Model RV-16
using
Hastings Vacuum Gauge Tube
Type DV-6
ATM = .055 mv.
MILLIVOLTS
2.5
2.25
2.00
1.75
1.50
1.25
1.00
.75
.50
.25
0
1.0
10
100
PRESSURE IN MICRONS OF MERCURY
7-21-66
JTM
Curve 6381

CRYOGENICS CONTROL PANEL: FRONT VIEW



CRYOGENICS CONTROL PANEL: REAR VIEW



TEST SHEET

TEST CONDITIONS: Panel is connected to rack and both AC and DC power are applied. Switches are as follows: Temperature range 0-300, RFF off, pump off, valve closed. Vacuum gauge switch in OPERATE. Measurements taken after calibration. All voltages are with respect to ground.

TEST POINT	ALLOWABLE RANGE	MEASURED VALUE	FUNCTION
E25	0-1.11 depending on cold stage temp. (3)		V+ for P+ thermometer
E24	0.00 +.0015		V+ for P+ thermometer
E19	Cold stage temp $\pm5\%$		0-300°K monitor
E20 - E24 & E25 shorted	0.000 $\pm$.001		Thermometer Zero
E20 E24 & E25 open	13.5V $\pm$1		Thermometer output 0-300°K
IC_2-2	Pump/Valve cutout (1)		Pump/Valve cutout set point
E16	-1.5 - -3.5		Helium supply pressure gauge V^-
E17	-1.5 - -3.5		Helium return pressure gauge V^-
E12	Supply Pressure 30 $\pm5\%$		Helium supply pressure gauge V_o
E14	Return Pressure 30 $\pm5\%$		Helium return pressure gauge V_o
E8	Supply Pressure 100 $\pm5\%$		Helium supply pressure monitor
E10	Return Pressure 100 $\pm5\%$		Helium return pressure monitor
E9 S5 at Short	0.00 $\pm$.01		Vacuum gauge amplifier zero
E9 S5 at Operate	0-10V depending on vacuum (2)		Vacuum gauge amplifier zero
E1	Dewar Pressure $\pm5\%$ (2)		Dewar vacuum monitor

1. Voltage obtained from voltage to temperature chart.
2. Voltage obtained from voltage to vacuum chart.
3. See Rosemount data sheet for value of R_T at a given temperature.

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

☐ ELECTRICAL ☒ XX MECHANICAL BOM # A13130Z3 REV ____ DATE 3/27/75 PAGE 1 OF 1

MODULE # ____ NAME Cryogenics Control Panel DWG # ____ SUB ASMB ____ DWG # ____

SCHEMATIC DWG # ____ LOCATION ____ QUA/SYSTEM ____ PREPARED BY S. D. Burgan APPROVED ____

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
1		NRAO	D13110M19	Panel	1	
2		Simpson	1227	0-100μA meter with scale B13130M4	1	
3		Simpson	1227	0-200μA meter with scale B13130M5	1	
4		Simpson	1227	0-500μA meter with scale B13110A1	1	
5		General Time	AB51-007	0-6 Hr. Interval Timer	1	
6		Hastings/Raydyst	VT-6	Vacuum Gauge	1	
7		General Time	EF2735	Elapsed Time Indicator	1	
8		JBT	JMT 123	Miniature SPDT Toggle Switch	1	
9		Southco	47-10-204-10	Fasteners	2	
10				6-32x3/4" Philips head flathead screw HP Grey	4	
11				6-32x1/4" Threaded Spacer	4	
12				4-40x1/4" Threaded spacer, countersunk for 4-40 flathead	1	
13				4-40x3/8" Flathead Screw	1	
14		NRAO	A13130Z2	Cryogenics Control Panel Enclosure	1	
	R_{14}		RN60C	20K	1	

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

[XX] ELECTRICAL [ ] MECHANICAL BOM # A13130Z1 REV ____ DATE 3-27-75 PAGE 1 OF 3

MODULE # ____ NAME Cryogenics Control Panel DWG # ____ SUB ASMB PC Board DWG # ____

SCHEMATIC DWG # ____ LOCATION ____ QUA/SYSTEM ____ PREPARED BY ____ APPROVED ____

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
1		NRAO	B13130AB1	PC Board	1	
2	IC1-3	Raytheon	RC4558	Dual OP Amp	3	
3		Robinson Nugent	ICN-083-53	Mini Dip Socket	3	
4		Keystone	1562-2	Turret Terminals	31	
5	R_1		RN60C	1.5K Resistor	1	
6	$R_{3,4}$		RN55C	100K Resistor	2	
7	R_5		RN60C	1M Resistor	1	
8	R_6		RN60C	100Ω Resistor	1	
9	R_7		RN60C	20K Resistor	1	
10	$R_{9,12}$		RN60C	1M Resistor	2	
11	R_{11}		RN60C	16.9K Resistor	1	
12	R_{15}		RN60C	90K Resistor	1	
13	R_{17}		RN60C	10K Resistor	1	
14	R_{20}		RN60C	5.36K Resistor	1	
15	R_{21}		RN60C	9.09K Resistor	1	

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

[XX] ELECTRICAL [ ] MECHANICAL BOM # A1313021 REV ______ DATE ______ PAGE 2 OF 3

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA
16	$R_{35,37}$		RN60C	625Ω Resistor	2
17	R_{39}		RN60C	28K Resistor	1
18	R_{41}		RN60C	66.5K Resistor	1
19	R_{43}		RN60C	887K Resistor	1
20	R_{45}		RN60C	18.2K Resistor	1
21	$R_{10,13,33,40,44}$		RC07	2K Resistor 5%	5
22	$R_{22,23;30}$		RC07	1K Resistor 5%	3
23	$R_{24,25}$		RC07	10K Resistor 5%	2
24	$R_{26,34}$		RC07	200K Resistor 5%	2
25	R_{27}		RC07	100Ω Resistor 5%	1
26	R_{28}		RC07	5K Resistor 5%	1
27	R_{31}		RC07	27K Resistor 5%	1
28	$R_{18,19}$		RC07	100K Resistor 5%	2
29	R_{40}		RC07	470Ω Resistor 5%	1
30	$R_{8,46}$	Bourns	3339P	5K 4T	2
31	R_{16}	Bourns	3339P	100K 4T	1
32	R_{32}	Bourns	3339P	50K 4T	1

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

[XX] ELECTRICAL [ ] MECHANICAL BOM # ________ REV ________ DATE ________

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
33	$R_{36,38}$	Beckman	63WR1K	1K 22T	2	
34	R_{42}	Bourns	3339P-1-103	10K 4T	1	
35	R_2	Bourns	3339P-1-201	200Ω 4T	1	
36	C_1,C_2	Erie	8121-050-651-104M	.1μf 50V Capacitor	2	
37	C_3-C_6	Erie	8141-050-651-225M	2.2μf 50V Capacitor	4	
38	D_1,D_2		1N914	Signal Diode	2	
39	LED_1	Hewlett Packard		Red LED	1	
40	Q_1		2N3904	NPN Transistor	1	
41	$SSR_{2,3}$	Teledyne	601-1401P	Solid State Relay	2	
42	R_{29}	Beckman	63WR5K	5K 22T	1	
43						
44						

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

[XX] ELECTRICAL [ ] MECHANICAL BOM # A13130Z2 REV ____ DATE 3/27/75 PAGE 1 OF 2

MODULE # ____ NAME Cryogenics Control Panel DWG # ____ SUB ASMB Enclosure DWG # ____

SCHEMATIC DWG # ____ LOCATION ____ QUA/SYSTEM ____ PREPARED BY ____ APPROVED ____

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
1		NRAO	C13130M2	Enclosure Modification	1	
2		NRAO	A13130Z1	PC Board Assembly	1	
3	SSR	Teledyne	611-5	Solid State Relay	1	
4	TDR	Potter and Brumfield	CUA-42-70120	2 minute time delay relay	1	
5	C7	Superior Electric		6.5µF 330 VAC Capacitor	1	
6		Littlefuse	34028	AGC3 Fuseholder	2	
7		JBT	JMT123	SPDT Miniature Toggle Switch	1	
8		JBT	ST50N	DPDT Toggle Switch	1	
9		JBT	ST50P	DPDT Center Off Toggle Switch	1	
10		JBT	2TL1-30	DPDT Pull-to-unlock Toggle Switch	1	
11				2"x6-32 Spacers	4	
12				6-32x3/8" Panhead screws	4	
13				6-32x5/16 Hex Nuts	2	
14				10A Slo-Blo AGC3 Fuse	1	
15				3A AGC3 Fuse	1	

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

[XX] ELECTRICAL [ ] MECHANICAL BOM # A13130Z2 REV ______ DATE ______

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
16	R47	Dale	RH-50	150Ω 50W Resistor	1	
17	P1	Deutsch	DM9702-19S	7 Pin Connector	1	
18	P2	Amp Spec. Ind.	AMP201 298-3	14 Pin Connector	1	
19	J2	Amp Spec. Ind.	AMP201 355-3	14 Pin Connector	1	
20		Amp Spec. Ind.	AMP201 347-4	Hood	1	
21		Amp Spec. Ind.	AMP201 363-4	Hood	1	
22	$P_{3,4}$	Amphenol	160-9-N	Male Plug with back shell	2	
23	J_4	Amphenol	160-10-N	Female socket insert	1	
24		Amphenol	3-24	Back shell for Item 23	1	
25	P5	Arrow-Hart	7465	Midget Locking Connector	1	
26	J5	Arrow-Hart	7464	Midget Locking Connector	1	
27	P6	Deutch	DM97D2-3SX	3 Pin Connector	1	
28	J	Amp Spec. Ind.	204188-1	Pins, Crimp	14	
29	J	Amp Spec. Ind.	201328-1	Sockets, Crimp	14	
30	TB	Cinch	10-141	Terminal Block, 10 Term	1	
31	H	Cinch	141J	Jumpers	5	

WIRING LIST

FROM		COLOR	TO
ZVP1	Dewar Plug		
1		Black #16	E6
2		White #16	AC COM
3			
4		White/Black	E25 (V^+)
5		White/Brown	E24 (V^-)
6		White/Red	E26 (I^-)
7		White/Orange	E23 (I^+)
ZVJ1	Dewar Plug		
1			Heater 1
2			Heater 2
3			
4			Thermometer V^+
5			Thermometer V^-
6			Thermometer I^-
7			Thermometer I^+
ZVP2	Panel Plug		
A		Red	E18
B		Yellow	E30
C		Black #16 #24	Chassis Ground, E27
D		White/Blue	E17
E		White/Red	E16
F		White/Orange	E12
H		White/Green	E14
J		White/Red	E20
K		White/Blue	E8
L		Red	ZVP2-A
M		White/Black	E19
N		White/Orange	E10
P		Red	ZVP2-L
R		White/Green	E9

FROM		COLOR		TO
ZVJ2	Panel Jack	Red		+15V Bus
A		Red		+15V Bus
B		Yellow		-15V Bus
C		Black #16		To rack
D		Red	Helium Pressure Transducer	PG1-2 (Supply)
E		Red	" " "	PG2-2 (Return)
F		Brown	" " "	PG1-1 (Supply)
H		Brown	" " "	PG2-1 (Return)
J		White/Red		G11-J3-2
K		White/Blue		G11-J3-3
L		Green	Helium Pressure Transducer	PG1-5 (Supply
M		White/Black		G11-J3-1
N		White/Orange		G11-J3-4
P		Green	Helium Pressure Transducer	PG2-5 (Return)
R		White/Green		G11-J3-9
ZVP3	AC Power			
1		Black #16		F1, F2
2		White #16		
ZVJ4	Pump Jack			
1		Black #16		SSR_1-1, S_3-6, S_4-5, TDR_1-A
2		White #16		AC COM
3		Green #16		Chassis Ground
ZVP4	Pump Plug			
1		Black	AC Cord	To Pump
2		White		
3		Green		
ZVJ5	Valve Jack			
1		Black #16		E4
2		White #16		AC COM
ZVP5	Valve Plug			
1		White		To Valve Solenoid
2		White		

FROM	COLOR	TO
ZVP6		
1	Black #16	C7-1
2	Red #16	S_2-4, Ref Timer-1
3	White #16	AC COM
E1	White/Yellow	SSR_1-3
E2	White/Green	TDR_1-6
E3	White/Blue	TDR_1-9
E5	White/Violet	S_4-6
E7	White/Grey	Heater Time Switch NO
E11	White/Black	M_2+
E13	White/Red	M_3+
E15	White/Orange	M_1, M_2, M_3
E21	White/Yellow	S_1-3
E22	White/Green	S_1-1
E27	Black	Chassis Ground
E28	White/Blue	VG_1-
E29	White/Violet	VG_1+
E31	White/Grey	LED_1+

INSTRUCTION MANUAL

HASTINGS VACUUM GAUGE

Model VT-SERIES & EVT-SERIES

CONTENTS

TELEDYNE HASTINGS-RAYDIST • HAMPTON, VIRGINIA 23661 U.S.A.
PHONE (804) 723-6531

TELEDYNE
HASTINGS-RAYDIST

HAMPTON, VIRGINIA 23661 (804) 723-6531

Specification Sheet No. 305A

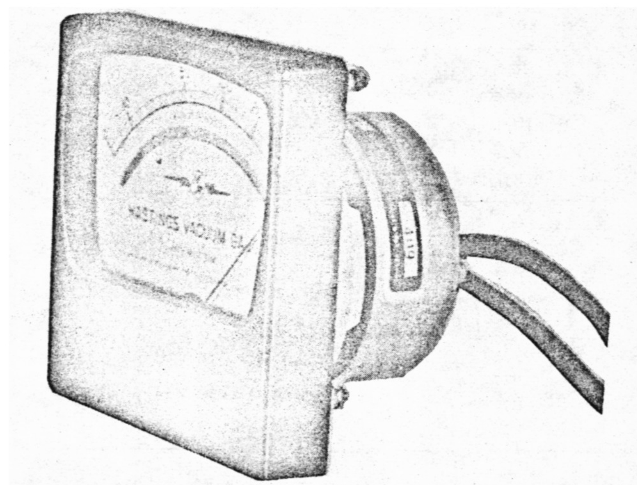
HASTINGS COMPACT VACUUM GAUGES
VT SERIES

FEATURING MINIATURIZED CIRCUITRY

IMPROVED PERFORMANCE • EXTREME VERSATILITY

FEATURES

- READY FOR YOUR PANEL
- COMPACT SIZE SAVES SPACE
- SELF-CONTAINED-CIRCUIT
- INTERCHANGEABLE GAUGE TUBES
- MULTI-POSITION ATTACHMENTS AVAILABLE
- TAUT BAND METER

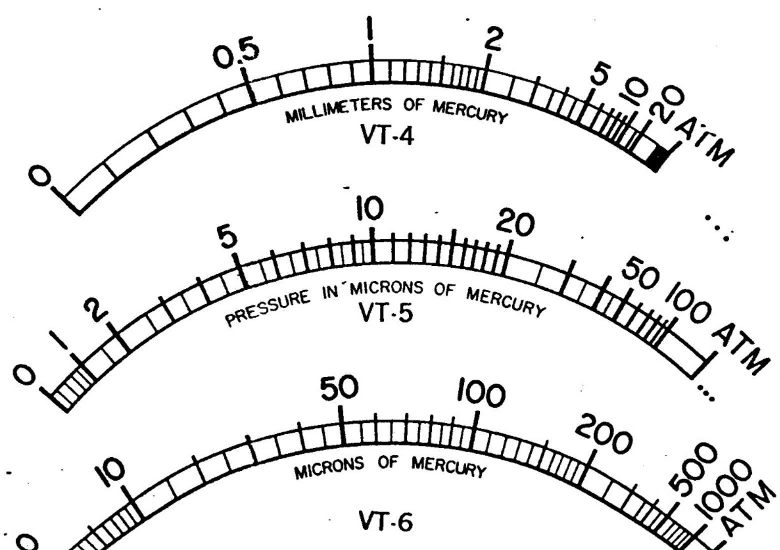


AVAILABLE IN 3 RANGES

DESCRIPTION

The compact size of the VT Series offers extreme versatility for all vacuum gauge applications. A self-contained gauge circuit is attached to the rear of the direct reading meter. Solid state circuitry throughout assures long life and low maintenance cost. Circuit includes voltage regulation. Complete assembly mounts in standard 4" meter cut-out.

These instruments utilize Hastings rugged but sensitive gauge tubes which are designed specifically for each range. Tubes are matched and interchangeable without calibration adjustments. They are compensated for temperature and rate of change of temperature. Hastings metal type gauge tubes are connected to the vacuum system by a standard 1/8" IPS male pipe thread. Weather resistant, stainless steel/ceramic and pyrex glass tubes are also available.



ACTUAL SIZE

*Manufactured under one or more U.S. patents and patents pending.

CHARACTERISTICS

Power: 115 volt AC/DC or 230 volt AC/DC—Any frequency. Less than 1 watt drain.

Size: 4¼" Wide X 4" High X 2⅜" Depth behind panel.

Cables: 8' Power Cable and 8' Cable to gauge tube attached. Extensions available.

Weight: Approximately 1½ lbs. including cable and gauge tube.

Warm-up time: Less than 3 seconds.

Accuracy: 2% of full scale angular meter deflection

Temperature Compensation: The only gauge tubes compensated for both ambient temperature and rate of change.

ACCESSORIES

MULTI-POSITION SWITCHING ATTACHMENTS:

For mounting behind panel adjacent to meter. Includes pilot light, ON-OFF switch, selector switch and 8 foot cables.

MODEL VL-2: Two-position

MODEL VL-5: Five-position

KIT 1: For desk or bench use. Brass stand with in-the-line cord switch.

KIT 2: For panel or cabinet installation. Pilot light and ON-OFF switch.

EXTENSION CABLES: Available in 8', 25', 50', 75' and 100' lengths.

GAUGE TUBE INSTALLATIONS: Quick connects, dropout traps, adapters, and valved quick connects. (Request Specification Sheet #352.)

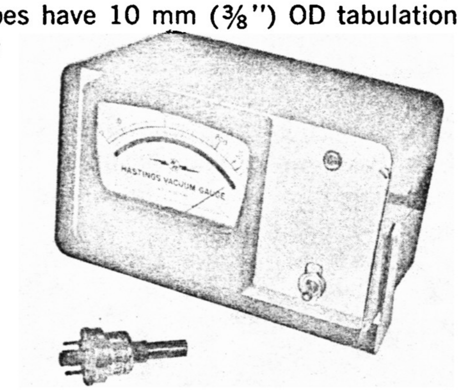
SELECTION CHART

	MODEL 115 vac	MODEL 230 vac	METAL TUBE	PYREX TUBE	WEATHER RESISTANT MONEL TUBE	STAINLESS CERAMIC TUBE
0-20 mm Hg						
Compact	VT-4	EVT-4	DV-4DM	DV-16D	DV-4R	DV-34
Cabinet	VT-4B	EVT-4B	DV-4DM	DV-16D	DV-4R	DV-34
Cabinet-2 Pos.	VT-4S2	EVT-4S2	DV-4DM	DV-16D	DV-4R	DV-34
Cabinet-5 Pos.	VT-4S	EVT-4S	DV-4DM	DV-16D	DV-4R	DV-34
0-100μ Hg						
Compact	VT-5	EVT-5	DV-5M	DV-18	—	—
Cabinet	VT-5B	EVT-5B	DV-5M	DV-18		
0-1000μ Hg						
Compact	VT-6	EVT-6	DV-6M	DV-20	DV-6R	DV-36
Cabinet	VT-6B	EVT-6B	DV-6M	DV-20	DV-6R	DV-36
Cabinet-2 Pos.	VT-6S2	EVT-6S2	DV-6M	DV-20	DV-6R	DV-36
Cabinet-5 Pos.	VT-6S	EVT-6S	DV-6M	DV-20	DV-6R	DV-36

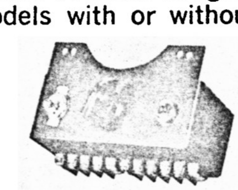
Metal tubes have ⅛" IPS male thread connection. Pyrex tubes have 10 mm (⅜") OD tabulation
Stainless/ceramic tubes require adapter cable Type OM-1-MSF

PRINCIPLE OF OPERATION

Operation of Hastings vacuum gauges is based on a patented* noble metal thermopile circuit. The hot junctions of the thermopile are heated directly by an ac current while the cold junctions are kept at the ambient temperature by heavy mounting studs. Thus a dc voltage is generated between the hot and cold junctions. As the pressure decreases, the lowering of the thermal conductivity of the gas surrounding the hot junctions tends to increase the temperature of the hot junctions, thus increasing the output of the thermopile. A third unheated couple is connected in opposition to the heated couples and responds only to sudden ambient temperature changes, providing instantaneous compensations for transient temperature effects.



Hastings Compact Vacuum Gauges are also available as cabinet models with or without switching units.



Switching Attachments, 2 or 5 positions

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HAMPTON, VIRGINIA 23661, U.S.A. PHONE (804) 723-6531
PRINTED IN U.S.A. TWX: 710-882-0085
SPECIFICATION SHEET #305A

HASTINGS COMPACT VACUUM GAUGES

VT, EVT - SERIES

INSTALLATION AND OPERATION

General:

The Hastings Compact Vacuum Gauges, Models VT-4, VT-5 and VT-6 are completely self-contained instruments with the circuitry mounted on the rear of the indicating meter barrel. Two 8 ft. cables are attached, one for connection to the gauge tube and the other for connection to 115 volt a-c/d-c power. The power cable has a grounded 3-wire type plug.

Models EVT-4, EVT-5, and EVT-6 are identical except they are designed for use on 230 volt a-c power. No power plug is supplied. Wire the power cable per information below. Substitute 230 volts for other references to 115 volts in this manual.

Hastings gauges are calibrated at the factory and no further adjustments should be required. The panel cut-out dimensions are shown in the outline drawing. Install the meter on the panel using the hardware supplied.

Cabinet Models VT-4B, VT-5B, and VT-6B require only installation of gauge tube and cable as described below and plugging into power line. Turn "ON-OFF" switch "ON" to place in operation.

Install the gauge tube in the vacuum system with the open end pointing down so as to be self-draining should any vapors condense in it. Either thread it into a 1/8" female IPS thread or use Hastings Quick Connect "O" ring seals for a vacuum-tight installation. Plug the gauge tube cable into the gauge tube.

Power:

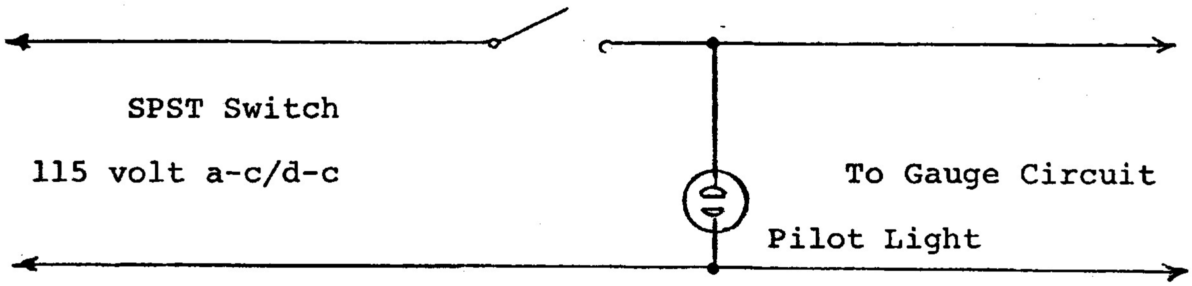
Connect the instrument into any single-phase a-c or d-c line with the power cord. Any power 90-140 volts a-c or 110-150 volts d-c (or 200-250 volt for 230 volt EVT-Series) can be used. Line frequency is unimportant and 50, 60 or 400 cycle power will provide satisfactory operation. A 3-wire grounded power cord is supplied. The instrument is now in operation.

If an on-off switch is desired, any switch may be wired into the power cable to provide this function. If you wish to "break" both hot leads use a double pole single throw switch. The power cable may also be cut off and wired into any master switch or circuit breaker on your panel.

CAUTION: <u>IF CUTTING CABLES, DO NOT INTERCHANGE POWER AND GAUGE TUBE CABLES.</u>

<u>If a Hastings Panel Kit</u> is utilized, a single pole switch is provided for this purpose, also a panel light is included which should be wired as shown below. The pilot light provided in this kit

installs in an 11/16" diameter hole, the switch in a 15/32" diameter hole. These holes may be located anywhere convenient on your panel.



Power Cable Color Code: 115 volt a-c on black and white leads. Green is the grounded wire. The grounded lead may be soldered to a grounded lug or left unused as desired.

D-C Power: The gauge may be operated from d-c power of from 110-150 volts without modification. If the gauge fails to operate at first, reverse polarity of the d-c at the line cord.

The gauge may be left operating continuously without harm. Power drain is low -- less than 1 watt; operation cost is insignificant.

Replacement Tubes:

Gauge tubes supplied with these instruments are "matched" type tubes and are interchangeable without recalibration.

Gauge tubes of different type numbers and pressure ranges are color coded to prevent mix up.

Multi-Position Gauges with Switching - Models VT-4S, VT-5S, VT-6S, and VT-4S2, VT-5S2, VT-6S2 Models EVT-4S, EVT-5S, EVT-6S and EVT-4S2, EVT-5S2, EVT-6S2

Cabinet models with switching require only installation of gauge tubes as previously described and connection of the appropriate cables from the instrument to the gauge tube. Plug power cable into power line and turn the ON-OFF switch to "ON". The instrument is now in operation. Selection of the individual gauge tube is achieved by use of the rotary switch located on the front panel.

Recalibration:

Recalibration if necessary can be performed using the techniques described in this manual. The current set potentiometer is a multi-turn trim potentiometer located on the left side of the gauge circuit attached to the rear of the meter when looking at the instrument from the rear. A small hole marks this location into which a small screw driver will easily adjust this potentiometer. Normally readjustment should not be necessary.

INSTALLATION OF SWITCHING ATTACHMENTS FOR VT-SERIES VACUUM GAUGES

Two-position and five-position switching attachments are available for use with the VT-Series vacuum gauges. These switching attachments can be mounted on either side, on the top or on the bottom of the gauge adjacent to the meter or they can be mounted some distance away from the gauge if desired. Maximum panel thickness for these attachments is 1/8".

A FULL SIZE TEMPLATE IS ENCLOSED TO FACILITATE PANEL LAYOUT.

Bottom Mounting: Drill panel holes as shown on cut-out drawing in this manual.

Side Mounting: Use the center line for the meter itself to locate the holes for the switching attachment. The attachment will extend above and below the meter outline approximately 3/16" when side mounted.

The meter center line, C_L-C_L, is 3/16" above the A-A' meter-hole center line. The X-X' center line will be 2-25/32" from the B-B' center line. When making template or drawing for the attachment holes, simply rotate the attachment outline 90° as desired, about the intersection of center lines B-B' and C_L-C_L. Holes are pre-drilled in the attachment to fit the meter mounting bolts for all combinations of side, top, or bottom mountings. Note that when looking at the vacuum gauge from the front, if the attachment is mounted on the right side the pilot light is on top. When the attachment is mounted on the left side, the holes are reversed and the pilot light is on the bottom.

Top Mounting: Rotate and invert the location of the attachment on B-B' center line. Note that the pilot light hole will now be on the left side and toggle switch hole on the right side of the selector switch hole which is on the B-B' center line.

To Mount the Attachment:

1. Install the meter and gauge first, assemble nuts on all mounting bolts and tighten. Cables may be prepared previous to mounting if desired.

2. Remove selector switch knob and on-off escutcheon plate. DO NOT REMOVE NUTS WHICH FASTEN SWITCHES TO ATTACHMENT. DO NOT TOUCH PILOT LIGHT AS IT MERELY EXTENDS THROUGH PANEL HOLE.

3. Position THE ATTACHMENT OVER THE METER MOUNTING BOLTS AND NUT, sliding it into the panel.

4. With the extra switch bushing nuts, assemble the escutcheon plate on the toggle switch, and tighten both switches to the panel.

5. Replace the knob on selector switch checking positions to match panel numbers or decal numbers.

6. Add extra 6-32 nuts behind the attachment on the meter mounting bolts and tighten. The attachment is now mounted and ready for wiring.

Preparation of Cables and Wiring:

Prepare the power cable by cutting it approximately 10" from the gauge-circuit. Strip this short section of cable an inch or so from the end, tin the leads and solder lug terminals to the black and white wires. Attach these two leads to the terminal board marked 115 volt output on the attachment. The green wire is the grounded lead. It may be cut off close to the cable, taped and left unused or soldered to a grounded lug bolted anywhere.

Next prepare the long section of the power cable in the same manner as above. This is the section with the 3-prong line plug attached. Connect the black and white leads to the terminal board marked 115 volt input. The green wire may be grounded as above or left unused. If wiring through a master switch or circuit breaker on your panel, this or any other 2 or 3 wire cable can be used for the input power line.

Prepare the gauge tube cable by cutting it off approximately 10" from the gauge-circuit. Solder lug terminals to each lead on the short piece of cable. Connect to the terminal board which has 3 terminals so that the green lead is connected to the center terminal. The black and white leads attach to either end terminal. If the board is numbered 1, 2, 3 connect black 1, green 2, white 3. Discard the remaining gauge tube cable with socket.

With 2-position switching attachments, plug one end of each 8 ft. CF-8-OFV gauge tube cable into a gauge tube and the other end into the appropriate cannon connector on the attachment switching. If extension cables are supplied, connect them between the switching attachment and the 8 ft. gauge tube cable.

With 5-position switching attachments, the cables are already attached to the switching attachment, and it is only necessary to plug the cables into the gauge tubes. If extension cables are supplied, connect them between the already connected cables and the gauge tubes.

The instrument is now ready to be plugged into 115 volts a-c and operated. If d-c power is used and the gauge does not operate at first, reverse polarity of the power leads. No damage will occur if connected in the wrong polarity. Leads may be easily reversed at the 115 volt input terminal board.

Turn the ON-OFF switch to "ON" and the gauge tube is now in operation.

NOTE: The cables may be prepared with lug terminals prior to installation on the panel if it is awkward to perform this operation after mounting.

PROCEDURE FOR CHECKING CALIBRATION OF HASTINGS VACUUM GAUGES

All Hastings Vacuum Gauges have been carefully checked and calibrated at the factory before shipment. If at any time you desire to check the calibration you may find one of the following methods helpful:

A. Quick Check of Calibration:

The simplest and quickest method of checking operation and calibration of a gauge and gauge tube is to keep a new spare clean gauge tube on hand as a "standard". When in doubt, install the old and new gauge tubes together in the same vacuum system (preferably a clean dry one) and pump until a steady pressure is observed. Plug the gauge into the old and new gauge tube alternately. If the old tube reads a higher pressure than the new one it indicates a contaminated tube which has caused a shift in calibration of the tube. Cleaning this tube by swishing gently in a solvent such as acetone or trichloroethylene may restore calibration. Thoroughly dry the tube and degas it before reinstalling in a vacuum system so the solvent will not contaminate your system. If the gauge tube calibration cannot be restored by cleaning the tube, replace it with a new gauge tube. If it is OK, remove the "standard" and store in a clean dry place for future use.

The Hastings Dual Valved quick connect described in the Specification Sheet 352 of this manual is ideal for this type of check. This adaptor permits two tubes to be installed in a single gauge tube system connection.

B. To Check Indicator:

All calibration voltages are set at the factory and will rarely change unless the "Current Set" control is disturbed. If you wish to check the calibration of the indicator, Hastings-Raydist manufactures a Reference Gauge Tube for this purpose. (See Specification Sheet 353.) The Reference Gauge Tube is sealed at a particular pressure and when plugged into the indicator should read that pressure. If it does not, adjust the "Current Set" control until it does. The indicator itself is now in calibration.

NOTE: This does not check the calibration of the gauge tube being used. See Paragraph A.

C. To Check Span:

Hastings Vacuum Gauges are calibrated by spanning each instrument between two known and easily reproduced pressures and then carefully checking several points in between. To check the span, proceed as follows:

1. Turn power on and allow several minutes for warm-up. With the gauge tube exposed to atmospheric pressure and held in

a vertical position, stem down, the meter should read "ATM". If it does not, adjust the mechanical zero of the meter until it does.

2. Evacuate the gauge tube down to any pressure as long as it is known to be less than one-tenth of a micron and continue pumping for at least fifteen minutes after gauge reaches a steady reading. The meter should now read "zero". If it does not, adjust the "Current Set" control until it does. (The Current Set control is usually located on the front panel of standard models and on the back of the meter housing on compact models.)

3. Repeat steps 1 and 2, making slight readjustments if needed. Gauge now reads correctly throughout its range.

D. To Check Against McLeod Gauge:

If the user desires to carry out additional calibrations of the Hastings Vacuum Gauge, a McLeod Gauge may be used as a reference. There are many forms of the McLeod Gauge, but all of them require careful manipulation and precautions against the effects of water vapor and other condensable vapors or the resulting readings on the McLeod Gauge may be erroneous. A liquid nitrogen cold trap is required for best results with a McLeod Gauge. Rubber tubing is not suitable for making connections during calibration because this material is likely to outgas excessively at the lower pressures. Some types of plastic tubing, such as "Tygon" are superior to rubber, but metal or glass tubing is the best. The Hastings Gauge measures the total pressure of all gases and vapors present in the vacuum system and the McLeod Gauge measures only the partial pressures of the noncondensable gases unless special precautions referred to are taken.

E. CAUTION: Do not attempt to measure the resistance of the gauge tube element while it is under vacuum. Some ohmmeters apply measuring voltage sufficient to burn out the thermopile when under vacuum. The resistance of the gauge tube can be measured safely at atmospheric pressure. This measurement is made between pins 3, 5, and 7 counting clockwise from the key located on the base of the gauge tube. A Triplett Model 630 test set with the ohms switch on the X10 range is suitable for this purpose.

NOTES ON VACUUM MEASUREMENTS

Effects of Condensable Vapors:

If the readings of Hastings Gauges are to be compared with readings of other types of gauges, consideration must be given to the possible effects of condensable vapors on the other gauges. For example, none of the many types of the McLeod Gauge give correct readings if condensable vapors such as water, alcohol, acetone, etc., are present in the gauge. The McLeod Gauges operate by compressing the residual gases and vapors in obtaining a reading and this compression will tend to condense any vapors that are present. This usually results in the McLeod Gauge reading a pressure that is too low. Furthermore, two different types of McLeod Gauges may disagree and both be incorrect, if vapors are present. Unlike the McLeod Gauges, the Hastings thermopile vacuum gauges have the very useful property of responding to the total pressure of all gases and vapors that are present in the gauge tube.

To exclude vapors from the McLeod type of gauge it is necessary to use a trap of some kind that will absorb or condense the vapors. Water vapor is by far the most common source of this difficulty. A trap cooled by liquid nitrogen is effective in removing vapors, but even so it may be necessary to keep the McLeod Gauge constantly under vacuum for several hours, or days, with a trap before it will read correctly. Reference should be made to the instructions furnished by the manufacturer of the McLeod Gauge to be sure that it is provided with a suitable trap.

Outgassing:

Hastings Gauge Tubes are made of materials that have been proven by years of usage to be relatively free from outgassing. However, all surfaces of glass and metal that are exposed to the vacuum system may liberate gases and vapors that were previously absorbed during exposure to the atmosphere. If the surfaces are contaminated with foreign matter, this outgassing may be much more persistent than if the surfaces are clean. The possibility of outgassing must be considered in checking the accuracy of Hastings Gauges or in checking for leaks. This is especially important when working with pressures of less than 10 microns of mercury. In this range of pressures, outgassing from surfaces in a newly evacuated system may flood the enclosure. Also, if the system is being pumped continously, gauges spaced at different distances from the pump will register different pressures. For reliable comparison of different vacuum gauges, it is necessary then to insure that the vacuum system be free of any outgassing or other sources of apparent leaks. This can best be determined by closing the system off from the pumps and observing if there is any rise in pressure within the range of interest.

Ingassing:

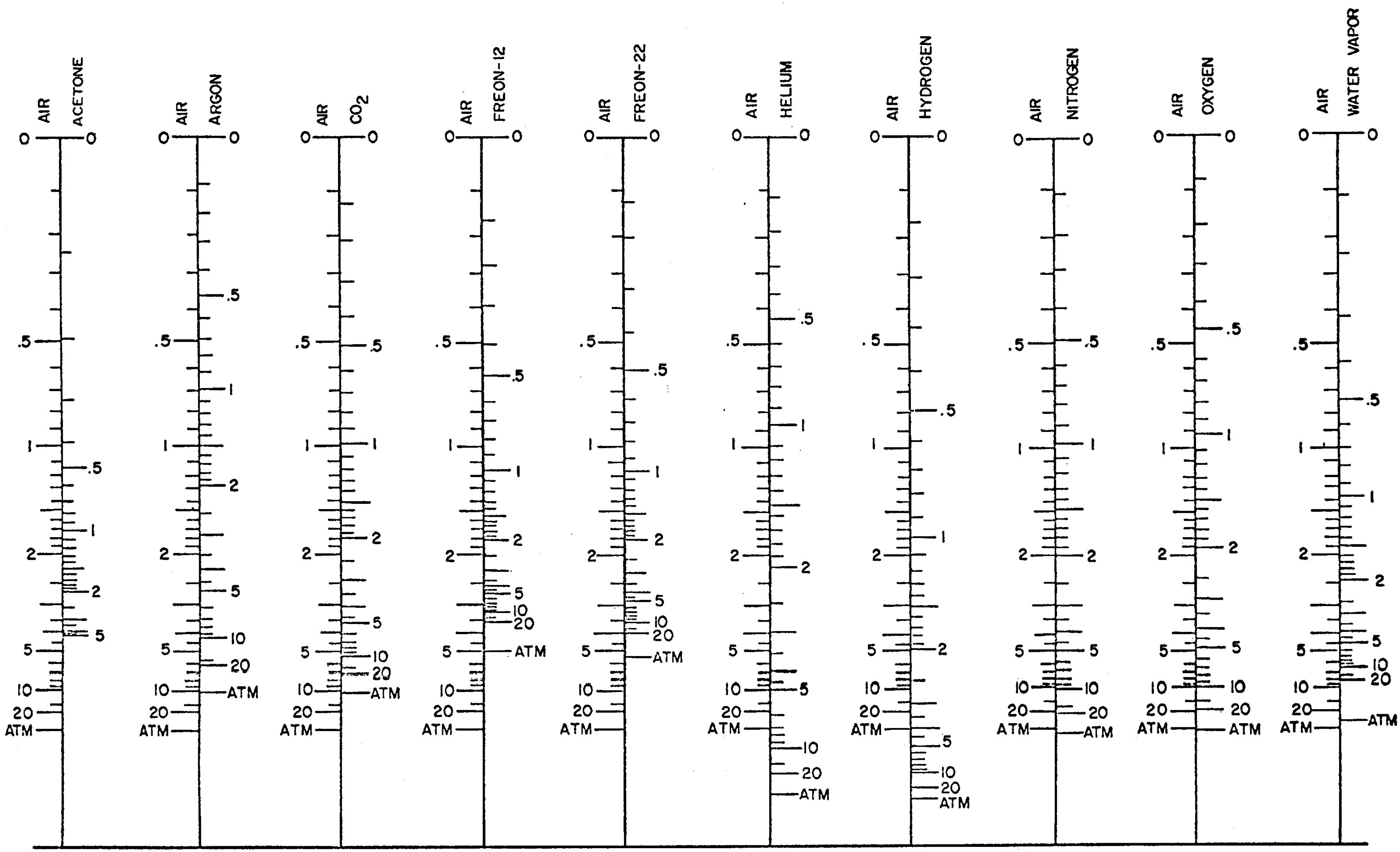
Ingassing is an effect opposite to outgassing and this can also lead to erroneous readings. Ionization gauges exhibit a kind of pumping action that tends to clean up residual gases in certain ranges of pressure and thereby lower the pressure. Also, if a cold trap is in a closed system, the total pressure may change considerably while condensable vapors such as water, carbon dioxide and mercury are being condensed.

Effect of Thermal Conductivity:

All Hastings Vacuum Gauges are originally calibrated in dry air. Since this calibration is a function of thermal conductivity, any gas having a thermal conductivity different from that of air will also have a different calibration. Nomograms are provided in each instruction manual to correct indicated pressures to actual pressures for several of the more common gases encountered in vacuum work.

Effect of System Conductance:

Each element that makes up a vacuum system has associated with it a certain conductance (this is the opposite of resistance). For example, baffles, connecting tubing, and sharp turns can all cause pressure drops throughout the system during pumping and during the time the system is reaching static equilibrium. It is not an uncommon occurrence to measure different pressures at different locations in a vacuum system. In checking the calibration of any vacuum gauge, care must be taken to insure that the gauge and the reference are at the same pressure.

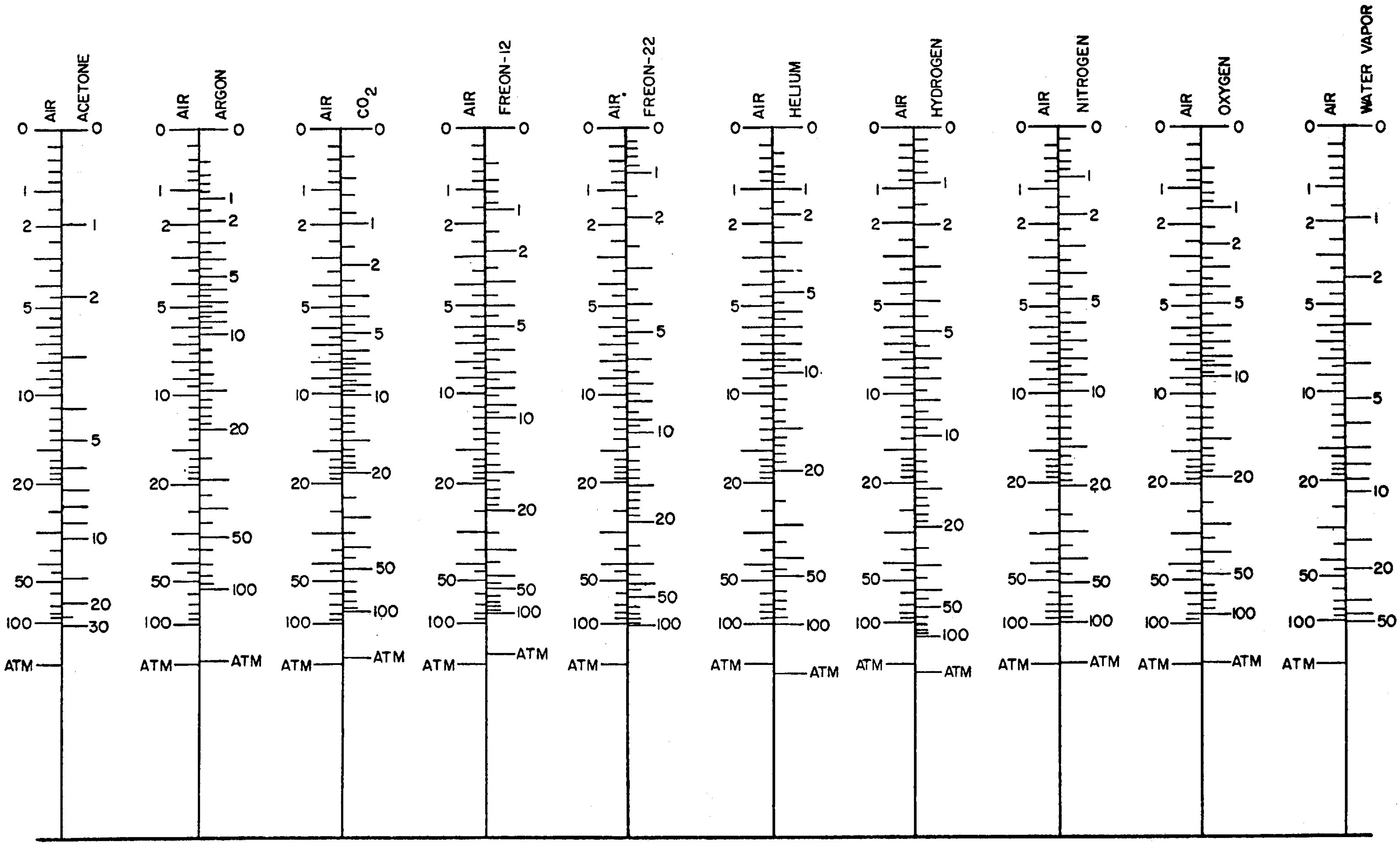


NOMOGRAM SHOWING CALIBRATION OF HASTINGS VACUUM GAUGES WHICH USE THE DV-4D GAUGE TUBE FOR GASES OTHER THAN AIR. TO FIND THE PRESSURE IN A GAS OTHER THAN AIR, LOCATE THE OBSERVED READING ON THE "AIR" SIDE OF THE APPROPRIATE SCALE AND READ, ON THE OPPOSITE SIDE OF THE SCALE, THE TRUE PRESSURE IN MILLIMETERS OF MERCURY FOR THE GAS BEING MEASURED.

PRINTED IN U.S.A.
SEPTEMBER 1967

HASTINGS-RAYDIST, INC.
HAMPTON, VIRGINIA

C-191



NOMOGRAM SHOWING CALIBRATION OF HASTINGS VACUUM GAUGES WHICH USE THE DV-5 GAUGE TUBE FOR GASES OTHER THAN AIR. TO FIND THE PRESSURE IN A GAS OTHER THAN AIR, LOCATE THE OBSERVED READING ON THE "AIR" SIDE OF THE APPROPRIATE SCALE AND READ, ON THE OPPOSITE SIDE OF THE SCALE, THE TRUE PRESSURE IN MICRONS OF MERCURY FOR THE GAS BEING MEASURED.

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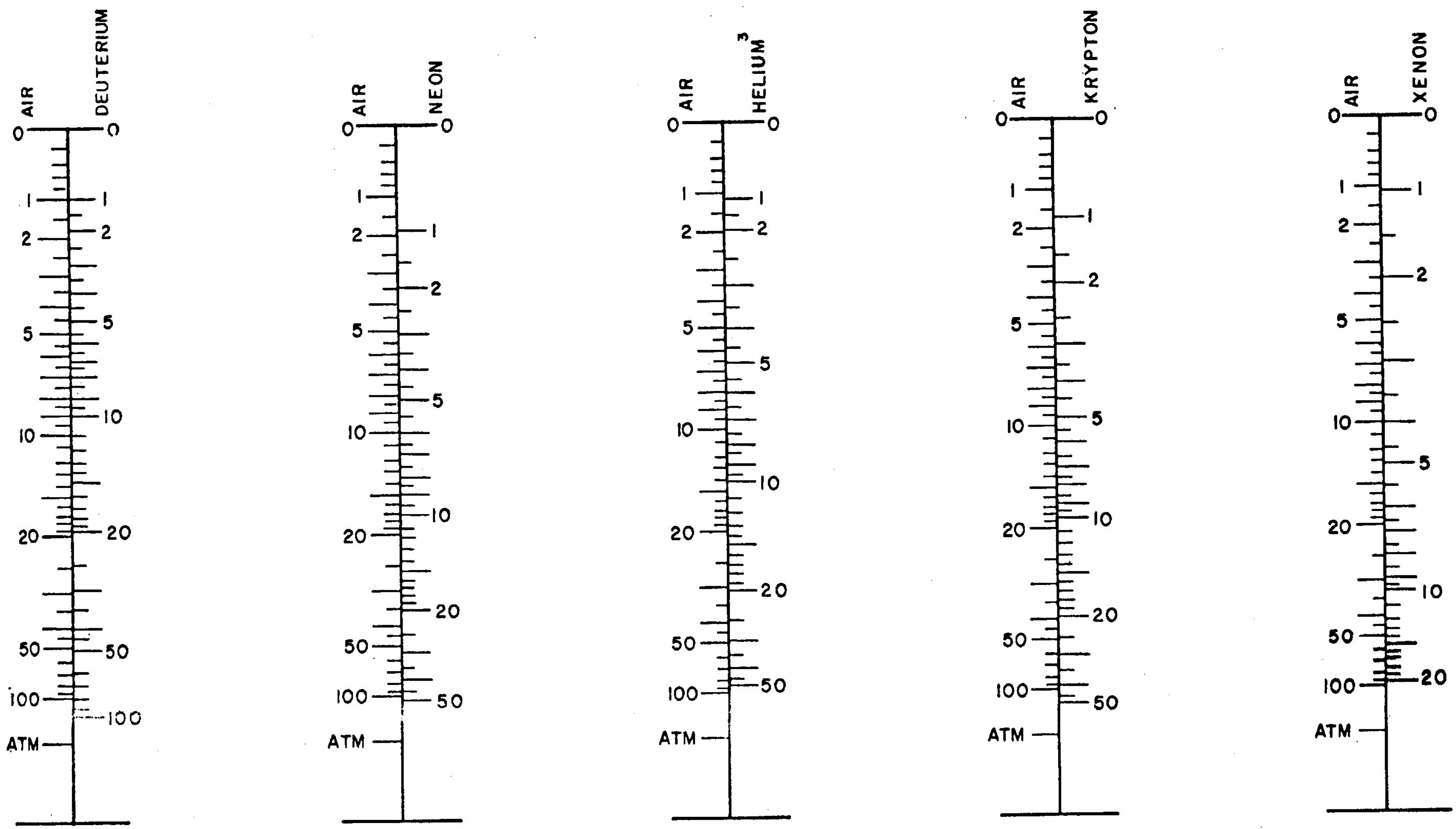
HASTINGS - RAYDIST, INC.
HAMPTON, VIRGINIA

C-183



NOMOGRAM SHOWING CALIBRATION OF HASTINGS VACUUM GAUGES WHICH USE THE DV-5 & DV-18 TUBES FOR THE GASES SHOWN ABOVE. TO FIND THE PRESSURE IN A GAS OTHER THAN AIR, LOCATE THE OBSERVED READING ON THE "AIR" SIDE OF THE APPROPRIATE SCALE AND READ, ON THE OPPOSITE SIDE OF THE SCALE, THE TRUE PRESSURE IN MICRONS OF MERCURY FOR THE GAS BEING MEASURED.

HASTINGS - RAYDIST
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C-196

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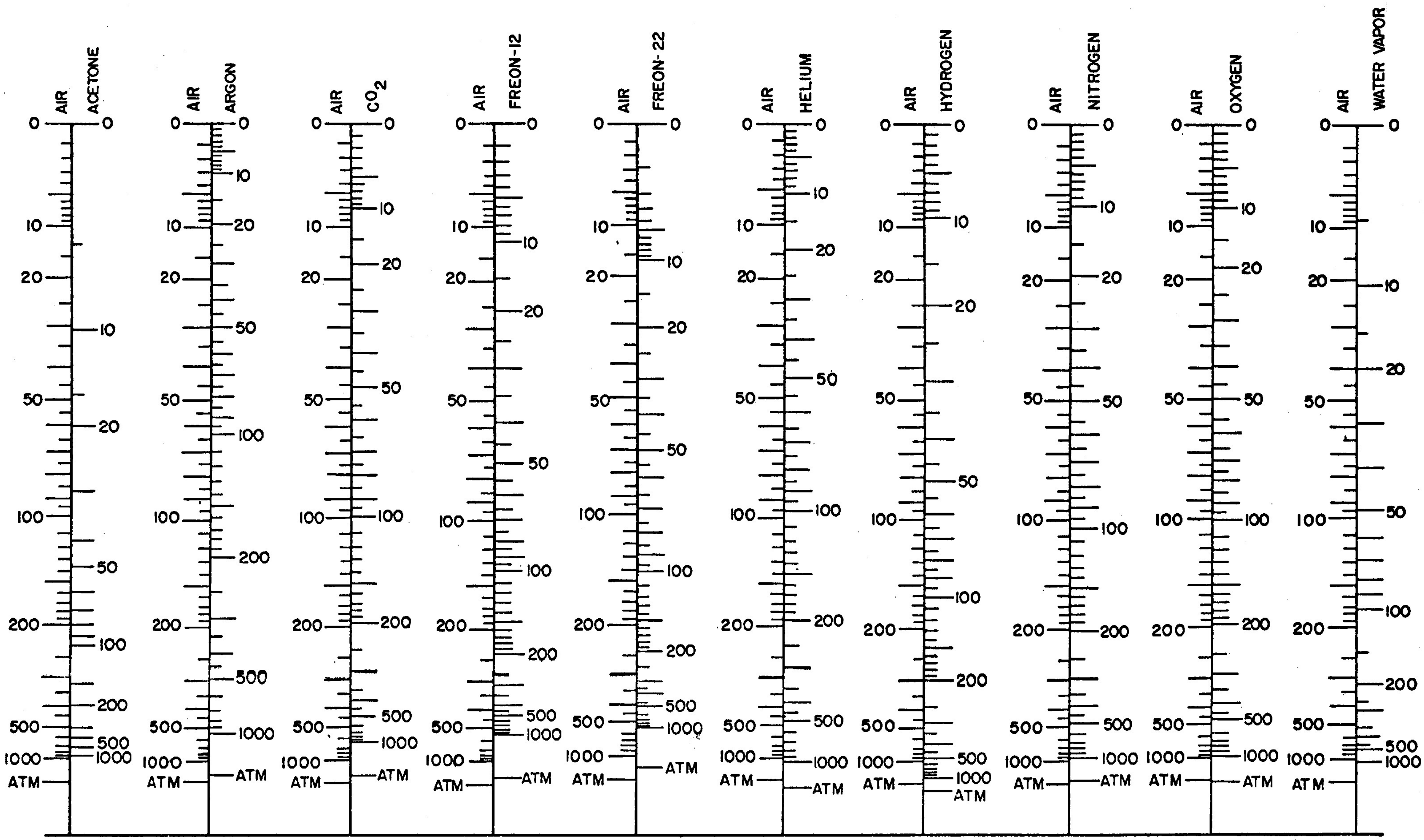

NOMOGRAM SHOWING CALIBRATION OF HASTINGS VACUUM GAUGES WHICH USE THE DV-6 GAUGE TUBE FOR GASES OTHER THAN AIR. TO FIND THE PRESSURE IN A GAS OTHER THAN AIR, LOCATE THE OBSERVED READING ON THE "AIR" SIDE OF THE APPROPRIATE SCALE AND READ, ON THE OPPOSITE SIDE OF THE SCALE, THE TRUE PRESSURE IN MICRONS OF MERCURY FOR THE GAS BEING MEASURED.

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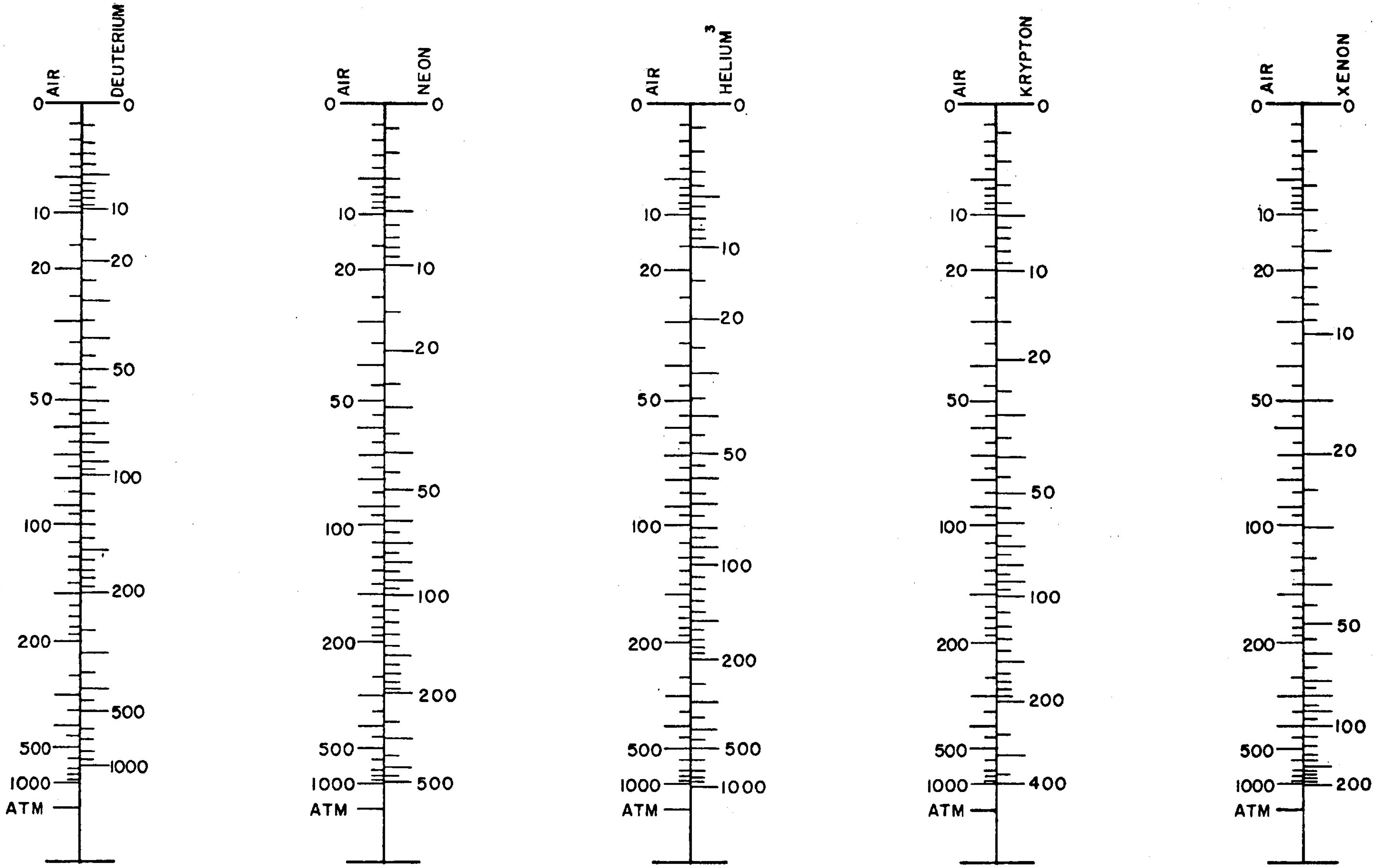
May, 1974

TELEDYNE HASTINGS-RAYDIST
HAMPTON, VIRGINIA, 23661, U.S.A.

C-184A



NOMOGRAM SHOWING CALIBRATION OF HASTINGS VACUUM GAUGES WHICH USE THE DV-6M, DV-6R, DV-20 & DV-36 GAUGE TUBES FOR THE GASES SHOWN ABOVE. TO FIND THE PRESSURE IN A GAS OTHER THAN AIR, LOCATE THE OBSERVED READING ON THE "AIR" SIDE OF THE APPROPRIATE SCALE AND READ, ON THE OPPOSITE SIDE OF THE SCALE, THE TRUE PRESSURE IN MICRONS OF MERCURY FOR THE GAS BEING MEASURED.

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HAMPTON, VIRGINIA

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JUNE, 1968

C-197

PARTS LIST

T-1	TOROID TRANSFORMER	28-8-166B
R-1	1000 Ω POTENTIOMETER	19-5-5A
R-2	15,000 Ω 1/2 WATT RESISTOR	18-2-138
R-3	15,000 Ω 2 WATT RESISTOR	18-2-162
R-4	100 Ω 1/2 WATT RESISTOR	18-2-365
C-1	4 mf. 250 V. CONDENSER	11-3-103
C-2	20 mf. 10 V. CONDENSER	11-3-102
D-1	ZENER DIODE	13-1-105
D-2	IN2071 DIODE	36-1-31
D-3	SURGE SUPPRESSOR	13-1-76A
Q-1,2	GA-1824 TRANSISTOR	51-2-1
J-1	TIN-8-OFV	65-41-41
M-1	METER	SEE NOTE No. 1
(1)	ALUMINUM COVER	28-6-265
(1)	AC LINE CORD W/PLUG	15-17-7A
(2)	HEYCO NO. 5	28-6-59
(2)	EYELETS #5502	
(16)	EYELETS	28-10-96

NOTE NO. 1

VT-5

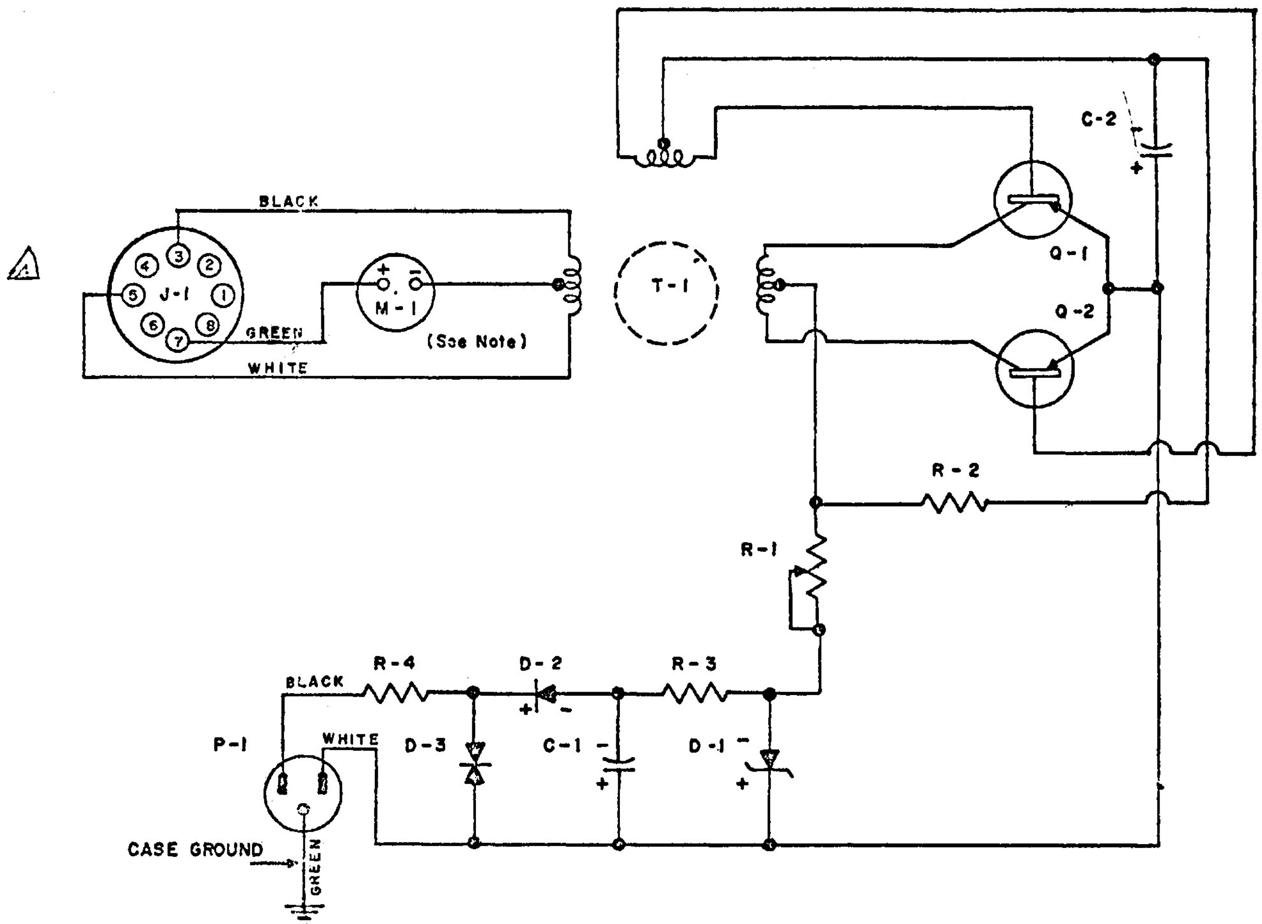
T-1	TOROID TRANSFORMER	28-8-171
R-1	2,000 OHM POTENTIOMETER	19-5-12

EVT - SERIES

R-4	6,800 OHM 2 WATT RESISTOR	18-2-13

METERS

M-1	VT-4 & EVT-4	24-1-352
M-1	VT-5 & EVT-5	24-1-262A
M-1	VT-6 & EVT-6	24-1-334



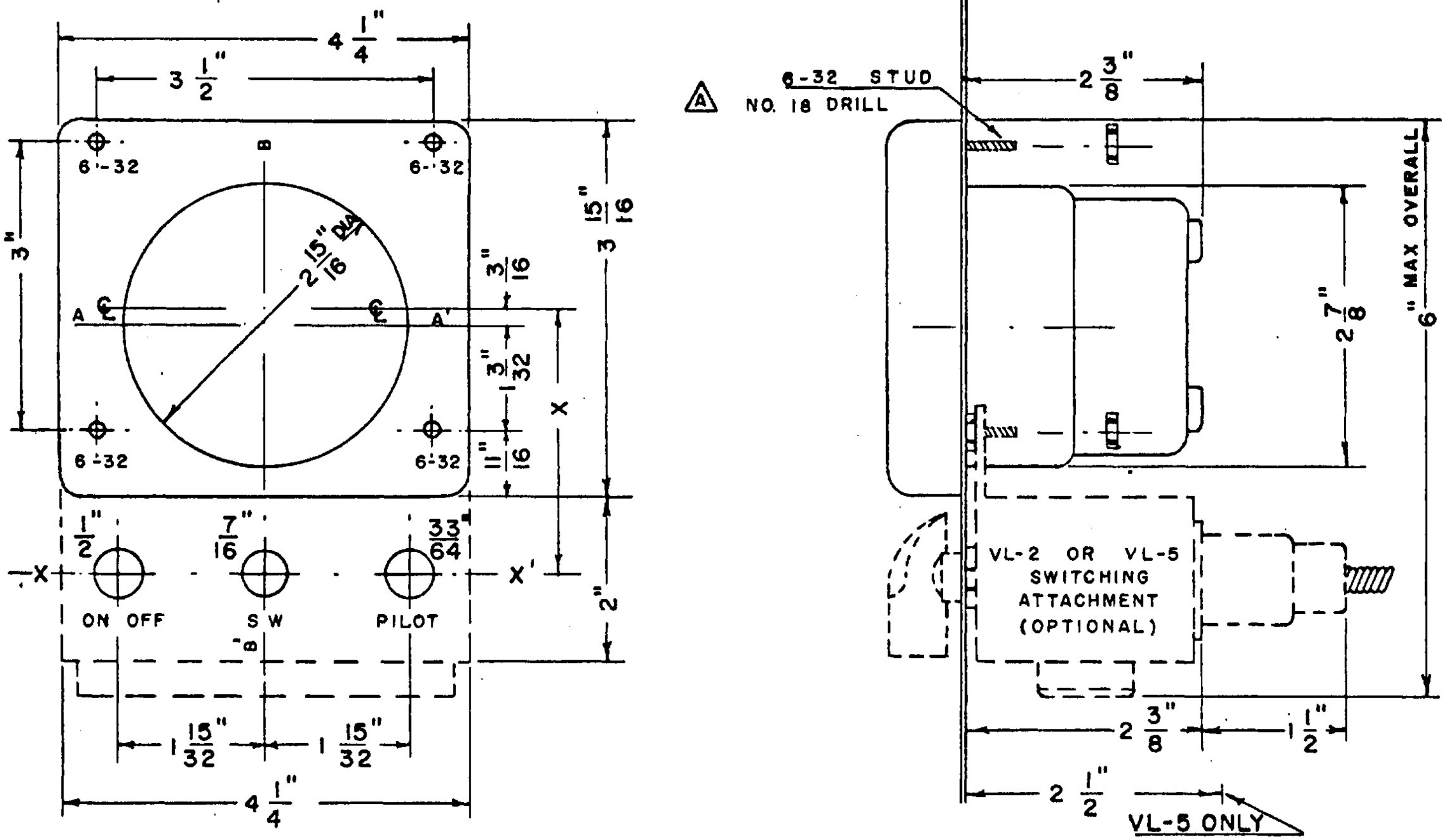
7554

LET.	REVISIONS	AUTH.	DATE

HASTINGS-RAYDIST
A TELEDYNE COMPANY
HAMPTON, VIRGINIA

HASTINGS
VACUUM GAUGE
MODEL: VT-4, VT-5, VT-6
EVT-4, EVT-5, EVT-6
SCHEMATIC

CK. DES.
DR. 6-21-72 APP. 6-21-72
SCALE
ASSY. DR. NO.
HA-10054



X = 2 25/32" FROM ℄ - ℄ CENTERLINE FOR TOP OR BOTTOM MTG., OR FROM B-B' FOR SIDE MTG.

REVISIONS

LET.	DESCRIPTION	AUTH.	DATE
Ⓐ	MOUNTING HOLES ENLARGED.	[illegible]	10/5/62

SCALE | ASSY. DWG. NO.

HASTINGS
VACUUM GAUGE
PANEL CUT-OUT & OUTLINE DRAWING
MODEL VT-4, 5 & 6

MATERIAL

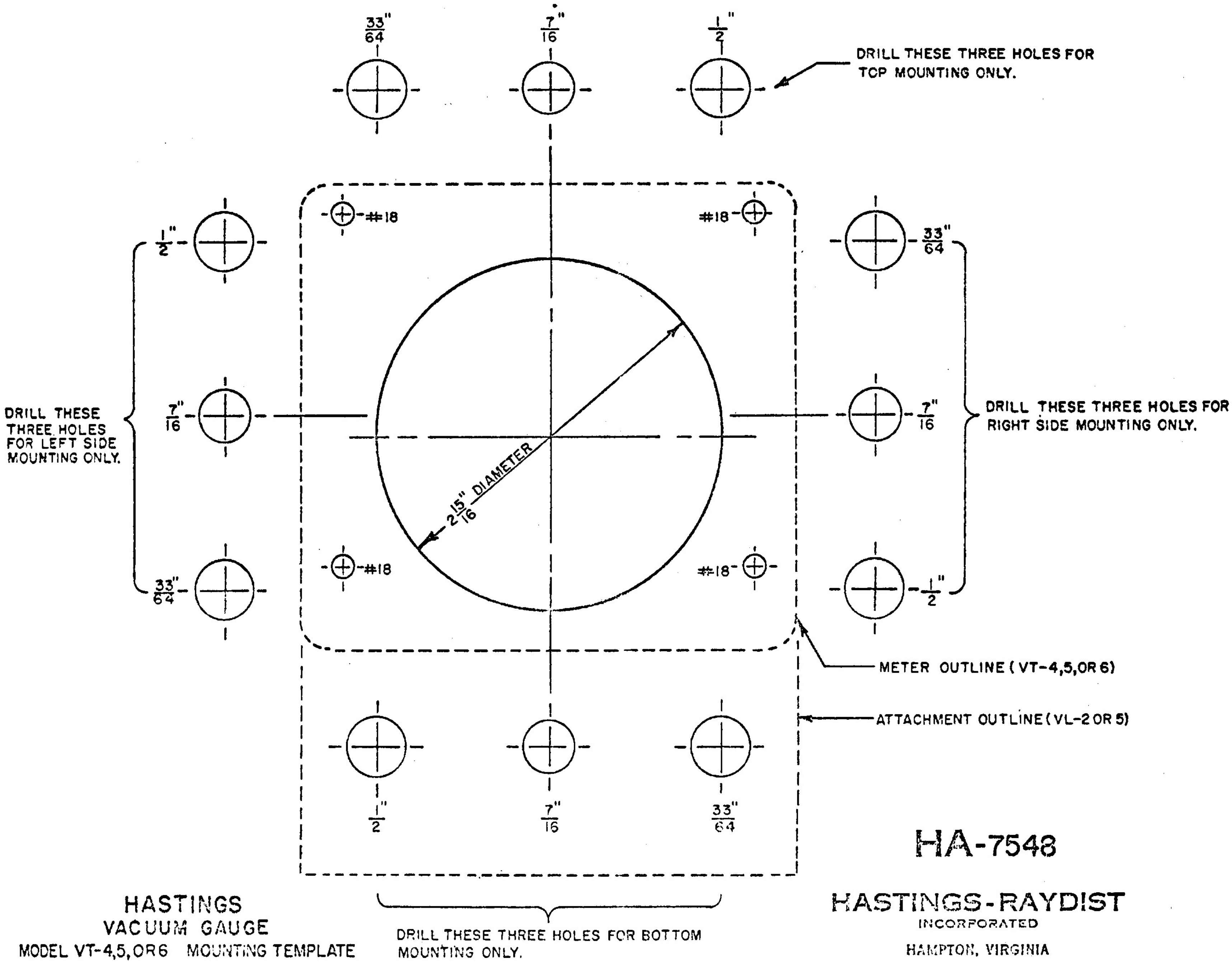
HASTINGS-RAYDIST
INCORPORATED
HAMPTON, VIRGINIA

TOLERANCES
FRAC. ± DEC. ± ANG. ±
UNLESS OTHERWISE SPECIFIED

HA-7420

DES. | CK.

DR. 11/13/61 M.E.B. | APP.



HA-7548

HASTINGS
VACUUM GAUGE
MODEL VT-4,5,OR 6 MOUNTING TEMPLATE

HASTINGS-RAYDIST
INCORPORATED
HAMPTON, VIRGINIA

TEMPLATE INSTRUCTIONS

To Use as Template for Single-Position Gauge Only:

1. Cross out all 12 attachment holes around perimeter of meter outline.

2. Position template on panel and fasten with scotch tape.

3. Center-punch larger meter hole and the 4 meter stud holes.

4. Drill or punch holes.

To Use as Template With VL-2 or 5 Switching Attachments:

1. In accordance with mounting position selected, cross out the 9 attachment holes not to be used.

2. Position template on panel and fasten with scotch tape.

3. Center-punch the large meter hole, the 4 meter stud holes and the 3 VL attachment.

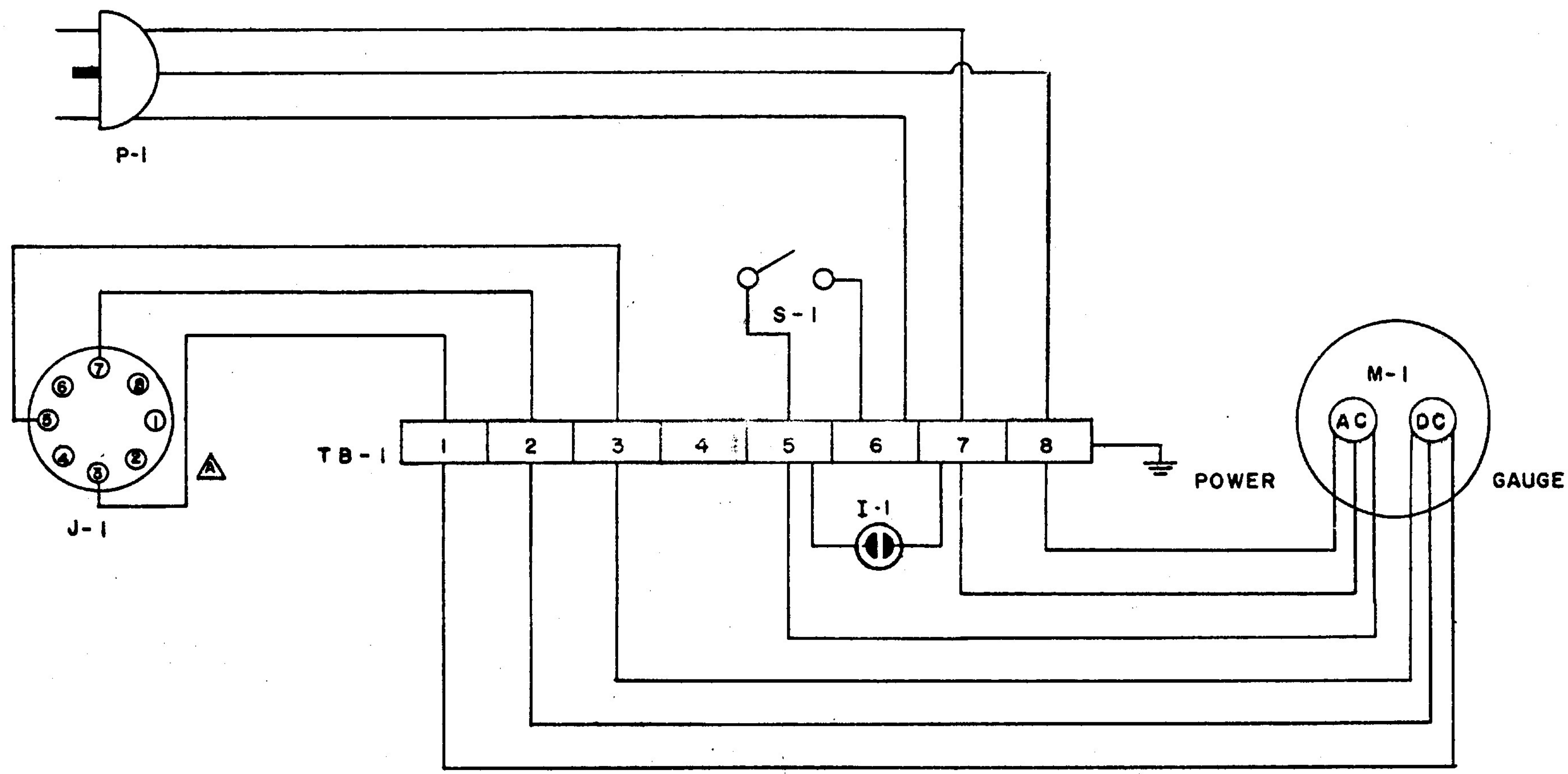
4. Drill or punch holes.

Assembly:

1. Install meter and tighten nuts on all studs. (DO NOT disassemble switch bushing nuts on the VL unit.)

2. Position the VL unit on rear of panel with the 2 switch bushings extending through the holes and using the two adjacent meter studs for additional mounting.

3. Use 2 additional bushing nuts on the 2 switch bushings extending through the panel and 2 additional #6-32 nuts on the meter studs. (See detailed instructions and drawings.)



PARTS LIST FOR VT-B

P-1	AC LINE CORD	15-17-7A
S-1	S.P.S.T. SWITCH	20-3-26
TB-1	8 TERMINAL BARRIER STRIP	16-23-27
I-1	PILOT LIGHT	22-2-54
(1)	VT CASE	65-46
(1)	TIN8OFV	65-41-41
(1)	HANDLE	28-5-23 B

REDRAWN 7/17/68

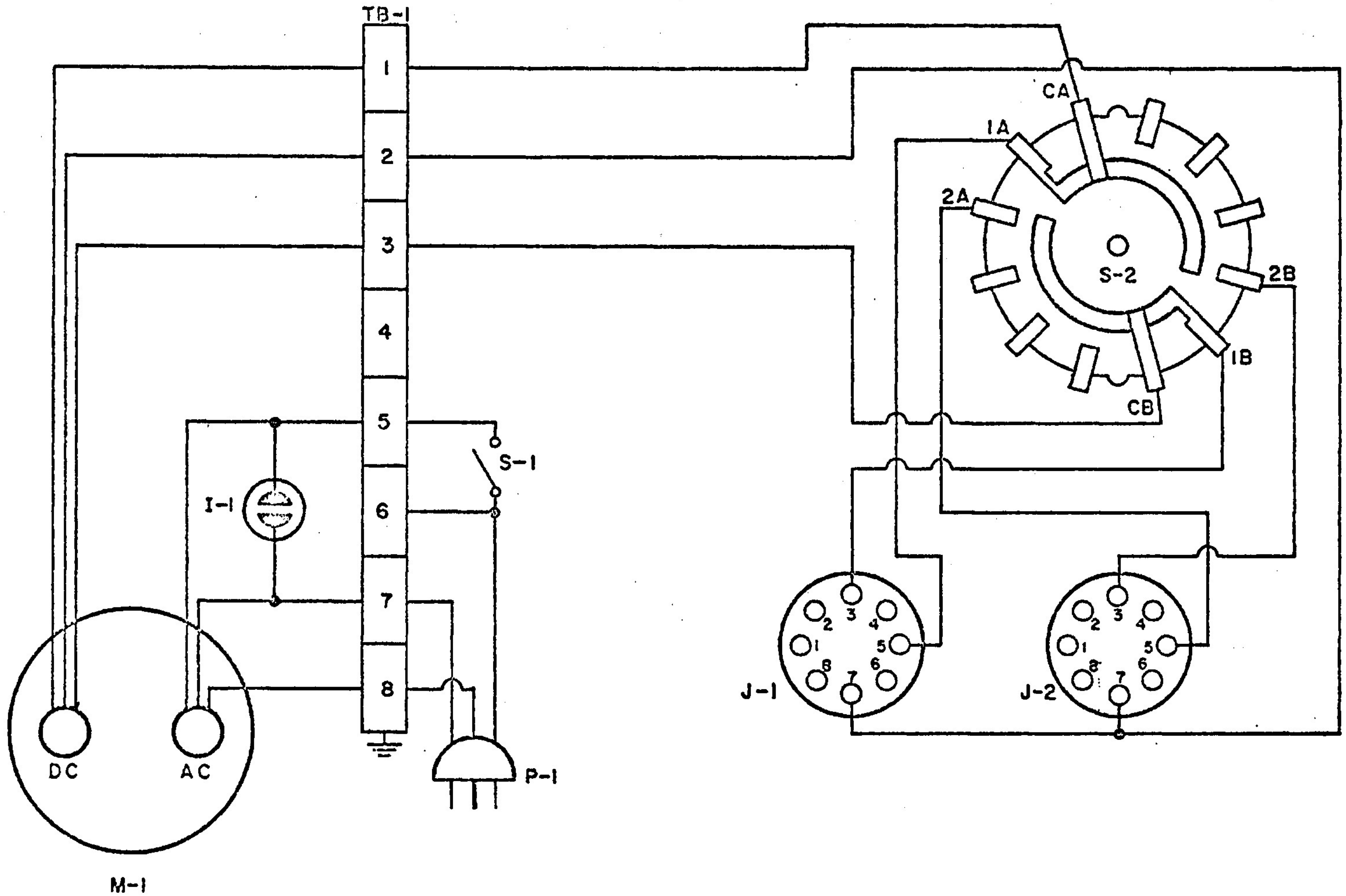
LET.	REVISIONS	AUTH.	DATE
B	ADDED HANDLE TO PARTS LIST	aac	10-14-71
A	BLK. LEAD CHGD. FROM PIN-1 to PIN-3	aac	2-2-70

HASTINGS-RAYDIST
A TELEDYNE COMPANY
HAMPTON, VIRGINIA

CK. aac 7-17-68 DES.
DR. 7/17/68 VMB APP.

HASTINGS
VACUUM GAUGE
MODEL VT-B & CVT-B SERIES SCHEMATIC

SCALE
ASSY. DR. NO.
HA-7541



TB-1	8 TERMINAL BARRIER STRIP	16 – 23 – 27
I – 1	INDICATOR LIGHT	22 – 2 – 54
P – 1	AC LINE CORD W/PLUG	15 – 17 – 7A
S – 1	TOGGLE SWITCH	20 – 3 – 26
S – 2	ROTARY SWITCH	20 – 5 – 40 (A)
J – 1	CABLE	65 – 41 – 41
J 2	CABLE	65 – 41 – 41
(1)	VT CASE	65 – 46

LET.	REVISIONS	AUTH.	DATE
A	CHG SYMBOL NO.		10-10-72

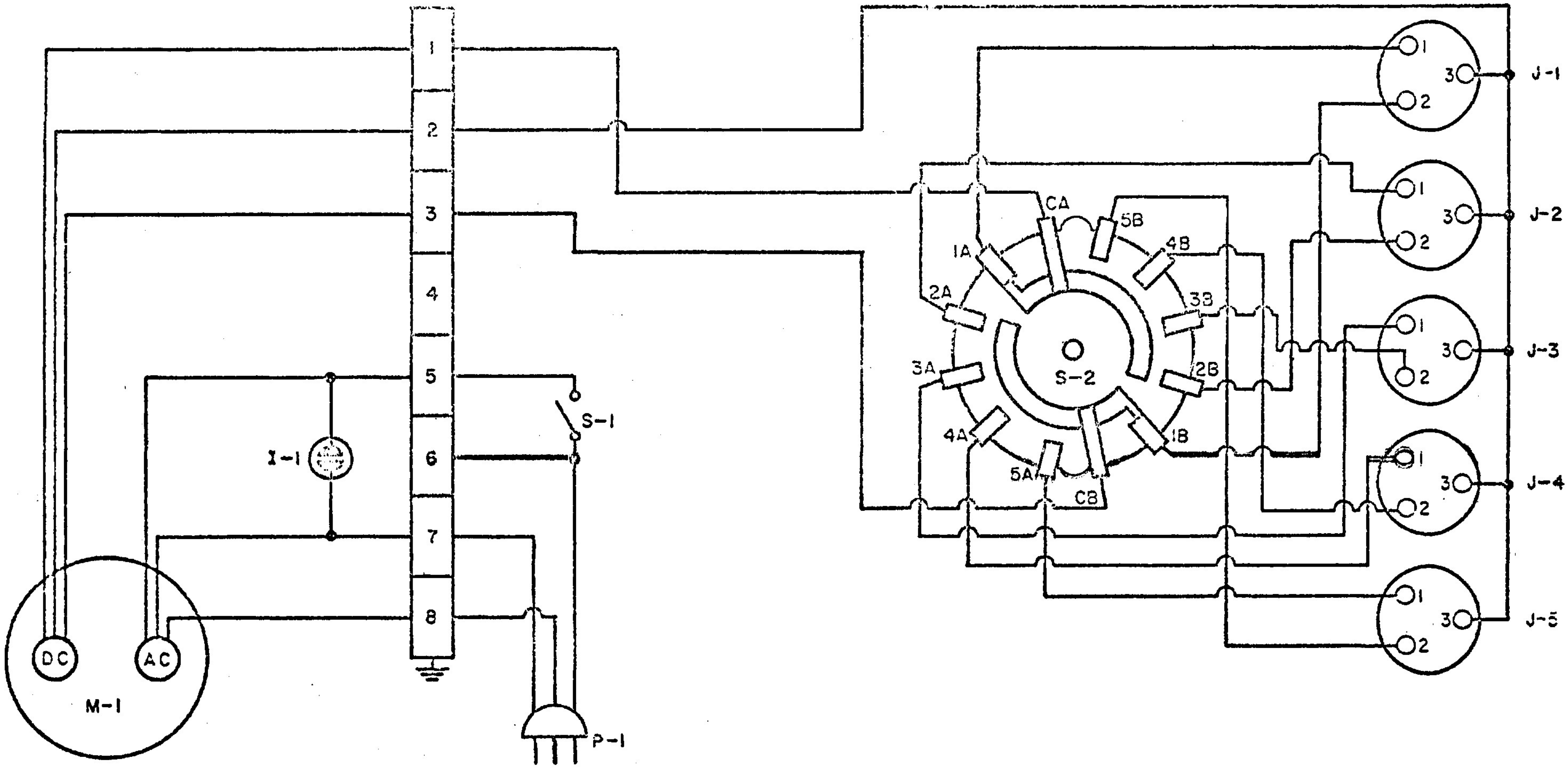
HASTINGS-RAYDIST
INCORPORATED
HAMPTON, VIRGINIA

CK. DES. DAVIS
DR. 11/19/65 O E W APP.

HASTINGS
VACUUM GAUGE
MODEL VT-S2 SERIES SCHEMATIC

SCALE
ASSY. DR. NO.

HA-7823



I - 1	INDICATOR LIGHT	22 — 2 — 54
J-1 THRU J-5	CONNECTOR	16 — 3 — 13
P — 1	AC LINE CORD W/PLUG	15 — 17 — 7A
S — 1	TOGGLE SWITCH	20 — 3 — 26
S — 2	ROTARY SWITCH	20 — 5 — 9 △A
TB-1	8 TERMINAL BARRIER STRIP	16 — 23 — 27
(1)	VT CASE	63 — 46

LET.	REVISIONS	AUTH.	DATE
△A	PARTS LIST REVISED		1-18-67

HASTINGS-RAYDIST
INCORPORATED
HAMPTON, VIRGINIA

CK. DES. DAVIS
DR. O E W. 11/18/65 APP.

HASTINGS
VACUUM GAUGE
MODEL VT-S SERIES SCHEMATIC

SCALE
ASSY. DR. NO.

HA-7699

CONVERSION FACTORS AND EQUIVALENTS

VOLUME, WEIGHT, MASS, AND PRESSURE

TO CONVERT FROM	SYMBOL	TO	SYMBOL	MULTIPLY BY
Atmospheres	atm	feet of H_2O	' H_2O	33.9
		inches of Hg	"Hg	29.9
		kilograms/sq. cm.	kg/cm^2	1.03
		millimeters of Hg	mm Hg	$7.60 \times 10^{+2}$
		pounds/sq. inch	psi	14.7
Cubic centimeters	cm^3 cc	cubic feet	ft^3	3.53×10^{-5}
		cubic inches	in^3	6.10×10^{-2}
		cubic meters	m^3	1.00×10^{-6}
		liters	l	1.00×10^{-3}
Cubic feet	ft^3	cubic centimeters	cm^3	$2.83 \times 10^{+4}$
		cubic meters	m^3	2.83×10^{-2}
		liters	l	28.3
Cubic meters	m^3	cubic centimeters	cm^3	$1.00 \times 10^{+6}$
		cubic feet	ft^3	35.3
		cubic inches	in^3	$6.10 \times 10^{+4}$
		liters	l	$1.00 \times 10^{+3}$
Grams	gm	kilograms	kg	1.00×10^{-3}
		pounds	lb	2.20×10^{-3}
Inches of H_2O @ 4^oC	" H_2O	millimeters of Hg	mm Hg	1.87
		pounds/sq. inch	psi	3.61×10^{-2}
Kilograms	kg	grams	gm	$1.00 \times 10^{+3}$
		pounds	lb	2.20
Liters	l	cubic centimeters	cm^3	$1.00 \times 10^{+3}$
		cubic feet	ft^3	3.53×10^{-2}
		cubic meters	m^3	1.00×10^{-3}
Millitorr (Microns of Hg)	mtorr μ Hg	atmospheres	atm	1.32×10^{-6}
		millimeters of Hg	mm Hg	1.00×10^{-3}
Pounds/sq. inch	psi lb/in^2	atmospheres	atm	6.80×10^{-2}
		feet of H_2O	' H_2O	2.31
		inches of H_2O	" H_2O	27.7
		inches of Hg	" Hg	2.04
		millimeters of Hg	mm Hg	51.7
Torr (Millimeters of Hg)	torr mm Hg	atmospheres	atm	1.32×10^{-3}
		bars	bar	1.33×10^{-3}
		inches of Hg	" Hg	3.94×10^{-2}
		inches of H_2O	" H_2O	5.36×10^{-1}
		microns of Hg	μ Hg	$1.00 \times 10^{+3}$
		millibars	mb	1.33
		millitorr	mtorr	$1.00 \times 10^{+3}$

1 pound AIR (STP) occupies 13.30 cu. ft. = 376.5 liters

1 cu. ft. AIR (STP) weighs 0.752 lbs. = 0.03411 Kg. = 34.11 gm.

1 pound-mole of ideal gas (STP) occupies 385 cu. ft.

1 gram-mole of ideal gas (STP) occupies 24.0 liters @ 20^oC.

STP = STANDARD TEMP. AND PRESSURE = 20^oC (68^oF) and 760 mm Hg (29.92" Hg)

TELEDYNE HASTINGS-RAYDIST
Hampton, Virginia 23661
Phone: (804) 723-6531

Printed in U.S.A.
March, 1974

C181B

CHARACTERISTICS OF HASTINGS VACUUM GAUGE TUBES

Metal Tube	DV-3M	DV-4AM	DV-4D	DV-5M	DV-6M	DV-8	DV-23	DV-24
"R" Series	---	---	DV-4R	---	DV-6R	---	---	---
Stainless/Ceramic	---	---	DV-34	---	DV-36	---	---	---
Pyrex	DV-17	DV-16	DV-16D	DV-18	DV-20	DV-31	DV-43	DV-44
Vacuum Gauge Model	GV-3,SV-1 VC-13, VC-23 RV-2C, RV-2S	SP-1,VC-14 VC-24,RV-4C RV-4S	VT-4,TP-7A CVT-14,CVT-24 RV-9,RV-14 TV-47	VT-5,LV-1 CVT-15,CVT-25 VC-15,VC-25 RV-15	VT-6,TV-4A TV-5A,CVT-16 CVT-26,RV-8 RV-16,TV-47	SL-1	VH-3,CVH-3	VH-4,CVH-24
Best Sensitivity Range	20-200 mtorr	0.2-5 torr	0,2-5 torr	2-20 mtorr	10-200 mtorr	0.1-10 mtorr	5 mtorr-1 torr	.1-5 torr
Usable Range	1-1000 mtorr	0.1-20 torr	0.1-20 torr	0.2-100 mtorr	1-1000 mtorr	0.1-10 mtorr	5 mtorr-5 torr	.1-20 torr
	(1 mtorr = 1 micron Hg. 1 torr = 1 mm Hg)							
Internal Volume of Gauge tube-Cu. in.	1/2	1/20	1/20	1/2	1/2	1/2	1/2	1/2
Thermopile Temperature								
In a High Vacuum	260°C	275°C	250°C	48°C	300°C	120°C	400°C	400°C
At Atmosphere	15°C	30°C	30°C	1.5°C	6°C	10°C	10°C	35°C
A-C Ampheres Through Tube	0.125	0.040	0.029	0.03	0.021	0.053	.04/.04	.03/.04
A-C Volts Across Tube	0.3	0.37	0.32	0.20	0.38	0.32	.20/.20	.19/.19
Watts Required by Tube	0.037	0.015	0.009	0.006	0.008	0.017	.016	.11
Output at High Vacuum-mv d-c	10	10	10	2	10	2	13	13
Internal Resistance-ohms	2.2	8	11	6	18	6	5/6	6.5/7.5
Response Time								
Zero to ATM-seconds	0.12	0.04	0.04	0.8	0.06	0.8	0.07	0.05
ATM to Zero-seconds	3.3	0.16	0.16	25	2.9	25	3.0	.2
A-C Connection Pin #	3-5	3-5	3-5	3-5	3-5	3-5	2-4,6-8	2-4/6-8
D-C Connection Pin #	7	7	7	7	7	7	---	---
Color of Base Metal Tube	Black	Blue	Purple	Red	Yellow	Green	Orange	White

Pressure and Temperature Data

Tube Type	Max. Pressure	Max. Temperature
Metal: DV-4AM & DV-4D	150 psig	100°C
All Others	50 psig	100°C
"R" Series	250 psig	150°C
Stainless/Ceramic	600 psig	300°C
Pyrex	15 psig	450°C

The gauge tubes can be expected to withstand the listed pressure and temperature without rupture but they are not warranted as safe under these conditions. For critical conditions or special testing, contact factory.

The above information includes nominal values only. Not to be used for design purposes or acceptance tests.

C-157C
Printed in USA

TELEDYNE HASTINGS-RAYDIST
Hampton, Virginia 23661

October 1974

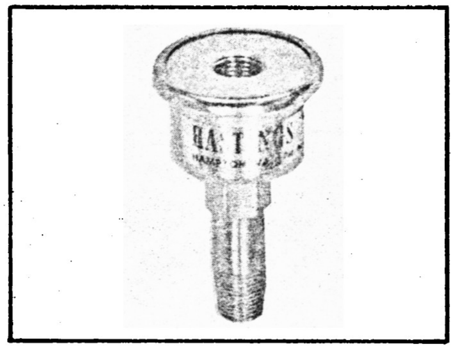
TELEDYNE
HASTINGS-RAYDIST

HAMPTON, VIRGINIA 23661 (804) 723-6531

Specification Sheet No. 352

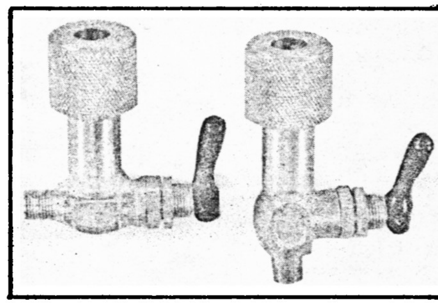
HASTINGS • INSTALLATION ACCESSORIES for VACUUM GAUGE TUBES

SAVE TIME - TROUBLE - TUBES



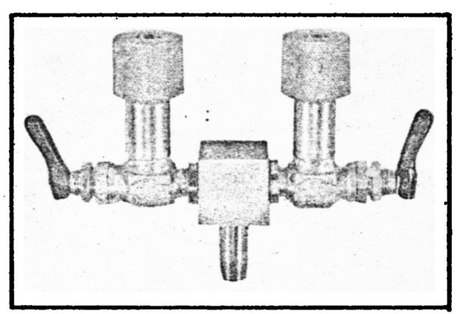
DROP-OUT TRAP Type DO-1

A particle drop-out trap which also provides an effective optical baffle. It has the equivalent of eight 90 degree bends. Protects gauge tube from flying particles, evaporated metals, etc. The gauge tube threads into the trap which installs in existing gauge tube fitting. Simple piggy-back installation. "Monel"/nickel plated brass constructed. Clean with steam, solvents, air hose, ultrasonics, etc. 1/8" NPT fittings: female for gauge tube, male to system.



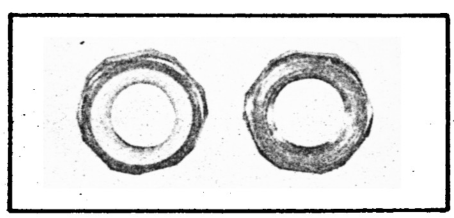
VALVED QUICK CONNECT Type OS-V & OS-VR

Provides a quick-connect "O" ring seal fitting for the gauge tube with toggle type shut-off valve. Permits removal and replacement of a gauge tube in many systems without "breaking" the entire system to atmospheric pressure. Also permits closing off tube during "dirty" portion of cycle. Installs in 1/8" NPT female thread. Type OS-VR is right angle pattern valve. Size: 1" x 3" x 3 1/2" Brass construction.



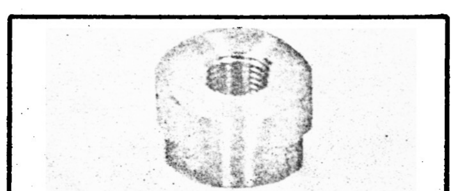
DUAL VALVED QUICK CONNECT Type OS-V2

Similar to above except permits use of an additional tube in a second pressure range, or as a calibration check against production tube. Keeps an unused spare ready to go. Installs in 1/8" female threaded fitting of existing gauge tube. Adjustable for angled or straight installation. Brass construction. 7 1/2" x 1" x 3 3/4".



HASTINGS SEAL-NUT Type OS-H

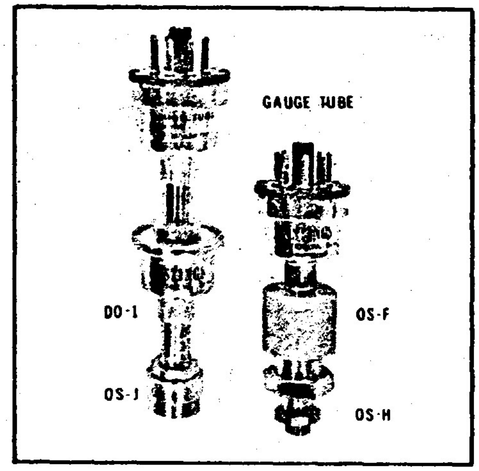
A metal hex nut with "Teflon" insert. Threads over 1/8" NPT male thread and jams against fitting to provide a dry, non-shredding reusable vacuum tight seal. Eliminates messy liquid sealants. Use to install gauge tubes, quick connects, drop-out trap and other 1/8" NPT male fittings in vacuum systems. Supplied in packages of 10, 25, 50 and 100.



TEE ADAPTOR Type OS-J

Adaptor solders into standard tubing "tee" to provide 1/8" NPT thread for gauge tubes, valved quick connects, DO-1, etc. Four sizes fit 3/4", 1", 1 1/4" and 1 1/2" OD tees. Nickle plated brass construction.

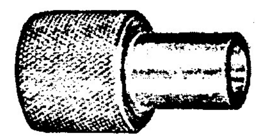
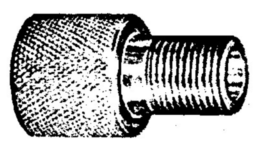
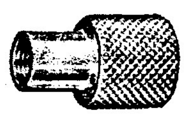
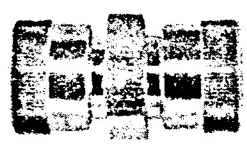
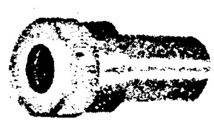
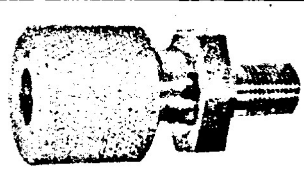
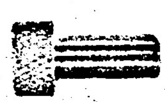
HASTINGS QUICK CONNECTS



H-R Quick Connects offer an "O" ring sealed fitting for Hastings and other gauge tubes with 1/8" pipe stems (.405" OD tubing). They provide a clean dry leak-tight seal and permit quick, easy removal and replacement of gauge tubes without wrenches or messy sealants.

Easiest conversion is with OS-F Quick Connect, which threads into existing gauge tube 1/8" NPT fitting on the system. Solder thread for permanent seal, or use H-R Seal Nuts.

RECOMMENDED PROCEDURE: Install all fittings so gauge tube opening points down, so as to be self-draining.

CONNECTION Gauge Tube Side Install Up	QUICK CONNECT	TYPE NO.	CONNECTION System Side Install Down
Fits Gauge Tube Stem "O" ring seal (QC Side)		OS-A	5/8" OD, .410 ID, solder or braze to system, tee, etc.
Fits Gauge Tube Stem "O" ring seal (QC Side)		OS-B	3/8" NPT male thread
Fits Gauge Tube male thread. (1/8" NPT female thread)		OS-C	Fits 8 mm and 5/16" OD smooth tubing, metal gauge to glass system, etc. (QC side)
Fits 1/2" OD smooth tubing, "O" ring seal (Both sides)		OS-D	Joins glass to metal tubing or to each other, used for Hastings McLeod Gauge Assembly and system connection.
Fits 8 mm and 5/16" OD smooth tubing "O" ring seal (QC Side)		OS-E	Closed end. Use as drain plug on cold traps, etc.
Fits Gauge Tube Stem "O" ring seal (QC Side)		OS-F	1/8" NPT male thread fits 1/8" NPT female thread where tube is removed.
.405" dia. blank plug with shoulder. (Same dia. as gauge tube stem)		OS-G	Install in quick connect to close system when gauge tube is removed. Supplied in package of 5.

TELEDYNE
HASTINGS-RAYDIST

HAMPTON, VIRGINIA 23661, U.S.A.
PRINTED IN U.S.A.
SPECIFICATION SHEET #352

PHONE (804) 723-6531
TWX: 710-882-0085

HASTINGS INSTALLATION ACCESSORIES

FOR VACUUM GAUGE TUBES

PRICE LIST

TYPE	DESCRIPTION		PRICE
DO-1	Particle Drop-Out Trap		$28.00
OS-V	Valved Quick Connect (Straight pattern)		19.00
OS-VR	Valved Quick Connect (Right angle)		21.00
OS-V2	Dual Valved Quick Connect		45.00
OS-A	Quick Connect (5/8" OD)		9.00
OS-B	Quick Connect (3/8" NPT)		9.00
OS-C	Quick Connect (Tube threads to 8 mm OD)		9.00
OS-D	Quick Connect (1/2" union)		14.00
OS-E	Quick Connect Drain Plug		10.00
OS-F	Quick Connect (1/8" NPT)		10.00
OS-G	Plug for Quick Connect	package of 5	8.00
OS-H	Hastings Seal Nuts (1/8" NPT)	package of 10	8.00
		package of 25	16.00
OS-J75	Tee Adaptor (for 3/4" OD tee)	package of 3	8.00
OS-J100	Tee Adaptor (for 1" OD tee)	package of 3	9.00
OS-J125	Tee Adaptor (for 1-1/4" OD tee)	package of 3	10.00
OS-J150	Tee Adaptor (for 1-1/2" OD tee)	package of 3	11.00

PRICES ARE SUBJECT TO CHANGE WITHOUT NOTICE.

ALL PRICES F.O.B. HAMPTON, VIRGINIA.

TERMS: NET 30 DAYS

TELEDYNE HASTINGS-RAYDIST

HAMPTON, VIRGINIA 23661 U.S.A.

TELEPHONE: 804-723-6531

TWX: 710-882-0085

printed in U.S.A.
July 1974

TELEDYNE
HASTINGS-RAYDIST

HAMPTON, VIRGINIA 23661 • (804) 723-6531

Specification Sheet No. 353A

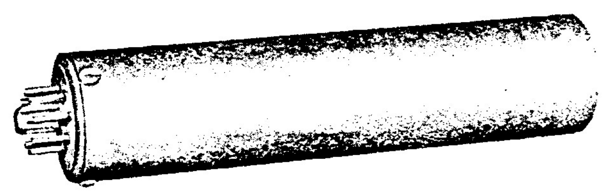
HASTINGS ®

REFERENCE TUBE

A QUICK CALIBRATION DEVICE FOR HASTINGS VACUUM GAUGES

General:

The Hastings Reference Tube is an evacuated, sealed vacuum gauge tube accurately calibrated and marked at its exact pressure. It is electrically equivalent to the metal and Pyrex gauge tubes used with Hastings Instruments. It permits quick and easy recalibration of Hastings Vacuum Gauge Indicators by merely plugging the instrument into the reference and adjusting the calibration "current set" potentiometer until the instrument reads the exact pressure noted on the reference. Hastings Reference Tubes are available equivalent to each Hastings Gauge Tube.



Construction:

Hastings Reference Tubes employ the same patented Hastings noble metal thermopile used in all Hastings Vacuum Gauge Tubes. The thermopile is sealed in a Pyrex glass capsule which has been evacuated, baked, outgassed, sealed and then aged to insure stability over long periods of time. The sealed capsule is then housed in a protective metal shell to provide a rugged, trouble-free assembly.

Calibration:

Considerable care and time are required in the manufacture to obtain the high degree of precision and stability required for the reference tube.

The thermopile is matched to the reference letter of the customer's tubes and maintains its calibration over long periods of time. However, for applications requiring the highest possible degree of accuracy a periodic return of the Reference Tube to the factory for a check and recalibration may be desirable. An annual or semiannual check assures the customer of an accurate and reliable reference at all times.

- **Instant Calibration Check**
- **Recalibration of Hastings Gauges**
- **Adjusts Gauge for Any Length Cable**

STABLE, ACCURATE, RUGGED, RELIABLE

Application:

Hastings Vacuum Gauge Indicators, Controllers or Recorders can be checked or recalibrated in seconds by merely plugging the gauge tube cable into the reference tube. If calibration adjustment is necessary the "Current Set" potentiometer is adjusted until the instrument indicates the exact pressure marked on the reference tube. The customer now knows his instrument is correctly calibrated.

Whenever cable lengths between gauge tube and instrument are changed some error may be introduced, requiring that the instrument be readjusted to compensate for any losses involved. By plugging the Reference Tube into the new cable and readjusting the instrument for a correct reading, this "error" is eliminated.

Manufactured under one or more U. S. Patents

REFERENCE TUBE

Selection:

Choose the reference tube which is equivalent to the Pyrex or metal Hastings Gauge Tube you are now using. The Reference Tube will be matched and sealed at a pressure falling on the lower portion of the scale and calibrated accurately at this exact pressure. For example, if an instrument uses a DV-3M Gauge Tube, a DB-17 Reference Tube is ordered. The customer receives a tube marked, possibly, 10 microns. This is the exact pressure to which the indicator should be adjusted when plugged into the reference tube.

SELECTION CHART

Equivalent Gauge Tube and Range			Reference Tube	
Metal	Pyrex	Range	Model No.	Price
*DV-3M	*DV-17	0-1000 Microns Hg	*DB-17	$140.00
*DV-4AM	*DV-16	0-20 mm Hg	*DB-16	140.00
DV-4D	DV-16D	0-20 mm Hg	DB-16D	140.00
*DV-5M	*DV-18	0-100 Microns Hg	*DB-18	145.00
DV-6M	DV-20	0-1000 Microns Hg	DB-20	140.00
DV-8M	DV-31	.01-10 Microns Hg	DB-31	145.00
DV-23		0-5000 Microns Hg	DB-33	140.00
DV-24		0-50 Torr	DB-44	140.00

*State reference letter of your Gauge Tube type for matching purposes.

IMPORTANT NOTE: These Reference Tubes are designed specifically for use with instruments employing Hastings circuitry and are NOT interchangeable with instruments using other circuitry. Connection to another manufacturer's instrument may result in burnout.

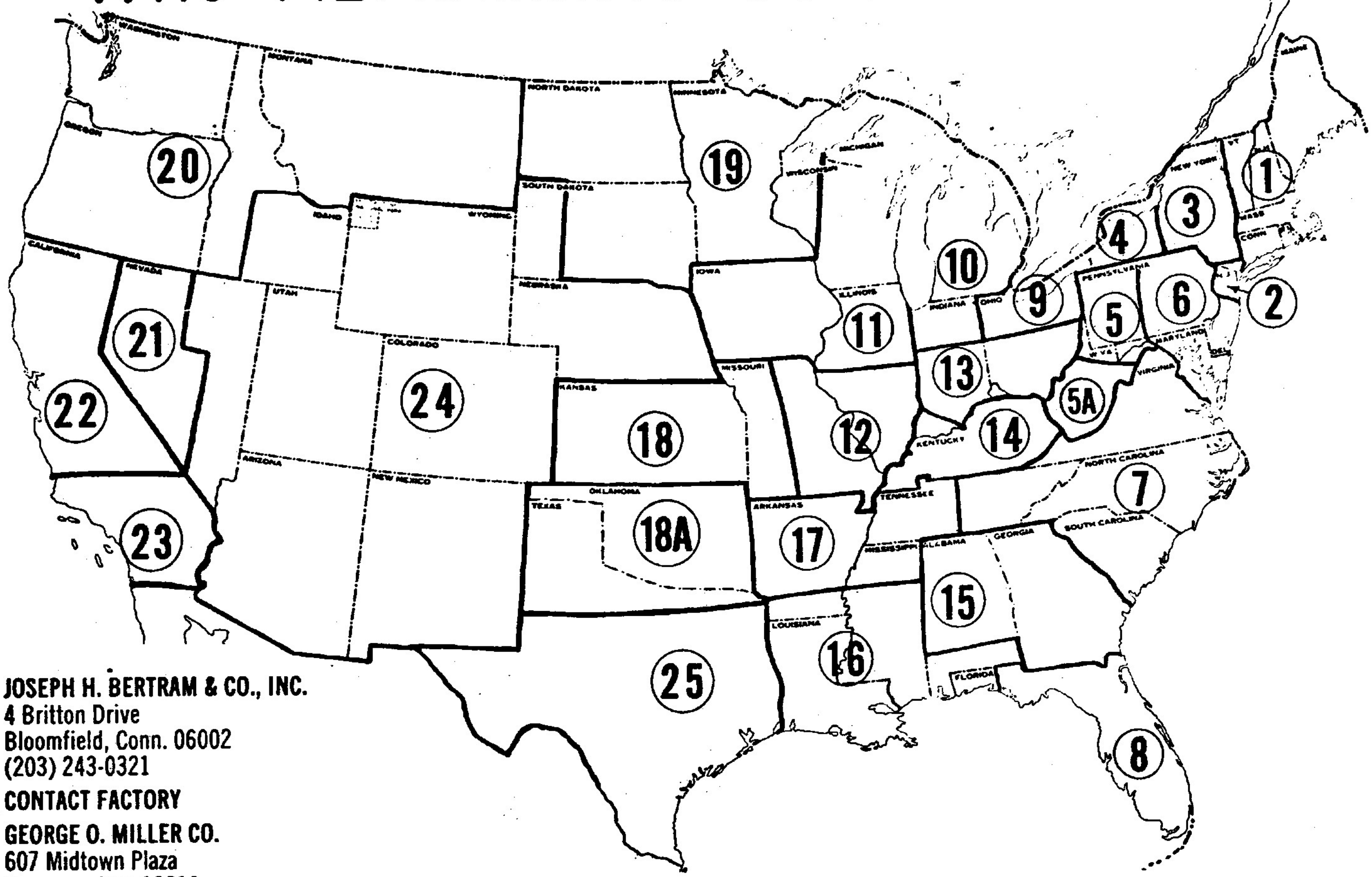
Hastings-Raydist manufactures a complete line of over 100 models of Recorders, Gauges and Controllers. Write for Catalog.

TELEDYNE HASTINGS-RAYDIST

HAMPTON, VIRGINIA 23661, U.S.A.
PRINTED IN U.S.A.
SPECIFICATION SHEET #353A

PHONE (804) 723-6531
TWX: 710-882-0085

WHO REPRESENTS US AND WHERE



(1) **JOSEPH H. BERTRAM & CO., INC.**
4 Britton Drive
Bloomfield, Conn. 06002
(203) 243-0321

(2) **CONTACT FACTORY**

(3) **GEORGE O. MILLER CO.**
607 Midtown Plaza
Syracuse, N.Y. 13210
(315) 478-3113

(4) **CASCADE CONTROL CORP.**
1 Grove Street
Pittsford, N.Y. 14534
(716) 385-1410

(5) **FOGLEMAN CO.**
3849 Willow Avenue
Pittsburgh, Pa. 15234
(412) 531-4005

(5A) **APPALACHIAN CONTROLS CO.**
401 Fourth Avenue
So. Charleston, W. Va. 25303
(304) 744-5324

(6) **TYLER GRIFFIN CO.**
46 Darby Road
Paoli, Pa. 19301
(215) 644-7710

(7) **CONTRACT FACTORY**

(8) **MILNE ASSOCIATES**
5131 St. Michael Avenue
Orlando, Florida 32809
(305) 855-1533

(9) **OHIO VALVE & EQUIPMENT CO.**
528 E. Washington Street
Chagrin Falls, Ohio 44022
(216) 247-6113

(10) **ANGER ASSOCIATES, INC.**
13126 Michigan Avenue
Dearborn, Mich. 48126
(313) 584-9853

(11) **BYRON ELLIS ASSOCIATES**
1650 Davis Street
Park Ridge, Ill. 60068
(312) 298-7626

(12) **ROGERS PROCESSING EQUIP. SYSTEMS**
8002 Florissant Road
St. Louis, Missouri 63121
(314) 521-7929

(13) **GEO. H. DRYSDALE & ASSOCIATES**
4512 Forest Trail
Cincinnati, Ohio 45244
(513) 752-2069

(14) **FLUIDAIRE COMPANY**
700 East Kentucky
Louisville, Ky. 40203
(502) 582-1144

(15) **G. H. CROSSLEY & ASSOCIATES**
3131 Maple Drive, N.E.
Atlanta, Georgia 30305
(404) 261-4278

(16) **ENSTOCKO COMPANY**
5945 Plank Road
Baton Rouge, La. 70805
(504) 356-2596

(17) **CENTRO INC.**
737 Jackson Avenue
Memphis, Tennessee 38107
(901) 526-0518

(18) **MIDWESTERN ENGINEERED EQUIP.**
1214 West 47th Street
Kansas City, Missouri 64112
(816) 531-1077

(18A) **TELSTAR INSTRUMENT CORP.**
4373 S. Yale Avenue
Tulsa, Oklahoma 74135
(918) 628-1011

(19) **PLANT EQUIPMENT INC.**
250 North Central Avenue
Wayzata, Minnesota 55391
(612) 473-2577

(20) **INSTRUMENTATION ENGRG. SALES CO.**
1001 Fourth Avenue
Seattle, Washington 98154
(206) 682-1123

(21) **CONTACT FACTORY**

(22) **WILNAT COMPANY**
1031 Fontana Drive
Alameda, Calif. 94501
(415) 483-9629

(23) **JEWETT COMPANY**
13111 Ventura Blvd.
No. Hollywood, Calif. 91604
(213) 789-8103

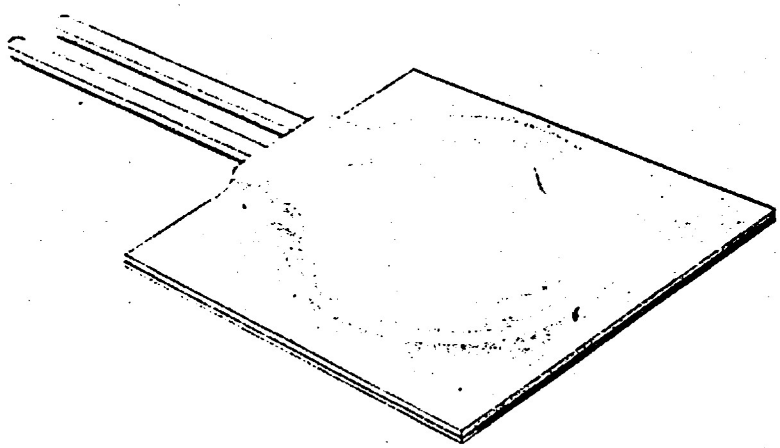
(24) **WILLIAMS-ASSOCIATES, INC.**
4614 Ironton Street
Denver, Colorado 80239
(303) 343-2911

420 Washington Street, S.E.
Albuquerque, New Mexico 87108
(505) 255-1638

7117 Third Avenue, Suite 100-B
Scottsdale, Arizona 85251
(602) 947-4297

(25) **INSTRUMATICS, INC.**
916 Boundary Street
Houston, Texas 77009
(713) 225-6626

MODEL 118G PLATINUM RESISTANCE TEMPERATURE SENSOR



Miniature size

High temperature capability

*Strain-free element **

GENERAL DESCRIPTION

The Model 118G surface sensor is designed to operate from -260°C to 1000°C. The sensing element is manufactured of pure platinum wire mounted in a strain-free manner in a platinum outer case.

The sensor is suitable for use in any non-conductive fluid or environment that is compatible with platinum and inorganic cement.

Model 118G may be mounted by spot welding, cementing, or clamping to a surface. The leads should not be bent nearer than 0.1 inch from the sensor.

PERFORMANCE SPECIFICATIONS

1. TEMPERATURE RANGE

-260°C to +1000°C.

2. RESISTANCE-TEMPERATURE RELATIONSHIP

Each sensor shall meet the resistance-temperature relationship shown in the table to the tolerance indicated. Different interchangeability tolerances are available (see price list options).

3. CALIBRATION

The sensor shall be calibrated at 0°C accurate to 0.04°C. Additional calibration at -268.95°C, -195.87°C, -182.97°C, 100°C and 260°C is available traceable to NBS.

4. REPEATABILITY

The sensor shall withstand 10 consecutive temperature shocks from liquid nitrogen to room temperature after which calibration at 0°C shall not change more than ±0.1°C.

5. INSULATION RESISTANCE

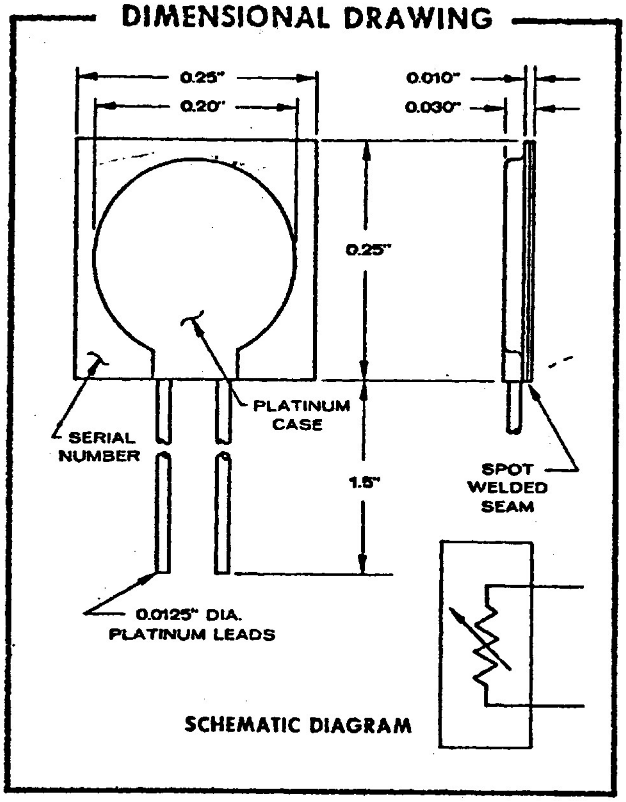
At room temperature with dry external surfaces, each sensor will be given an insulation resistance test. The insulation resistance between any lead and the sensor case shall exceed 10 megohms with 100 volts DC applied.

6. TIME CONSTANT

The time required for 63.2 percent response of an unmounted sensor, to a step change in temperature from room temperature air to #200 Dow Corning 1.5 CTSK oil flowing transverse to the sensing surface at 3 fps and at 76±4°C is less than 0.5 seconds.

ROSEMOUNT ENGINEERING COMPANY

* U.S. PATENT NO. 3,114,125



7. SELF HEATING

An unmounted sensor is capable of dissipating an I^2R power of 35 milliwatts with a temperature rise of less than 1°C when submerged in #200 Dow Corning 1.5 CTSK oil flowing transverse to the sensing surface at 3 fps and at 25±5°C.

8. VIBRATION

When the sensor and leads are firmly attached to a surface, the sensor shall withstand at least 50 g's peak or 0.5 inch double amplitude in any axis when cycled from 20 to 2000 Hz over a 15 minute time interval.

9. WEIGHT

The weight of the sensor shall be less than 0.5 gm.

10. IDENTIFICATION

The serial number will be marked on the sensor body in the approximate location shown. The sensor shipping container shall be labeled with the following minimum information:

Rosemount Engineering Company
Model 118G
Serial No. ____________

QUALITY ASSURANCE

REPAIR AND MAINTENANCE

The sensor is a non-repairable item and shall need no maintenance during its useful life.

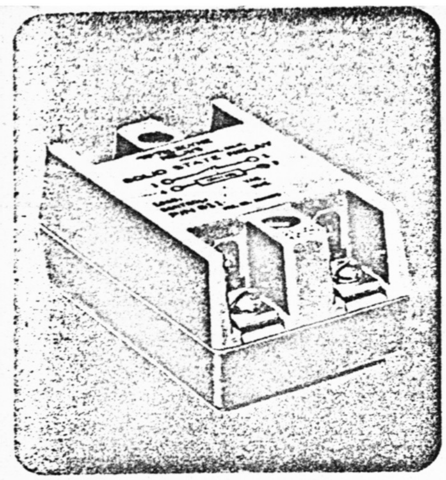
INDIVIDUAL TESTS

Each sensor shall be examined for high quality workmanship, conformance to the drawing, and shall undergo the tests defined or implied in paragraphs 2, 3 and 5. Other tests will be proposed on request.

RESISTANCE-TEMPERATURE RELATIONSHIP TABLE

TEMPERATURE (°C)	RESISTANCE (OHMS)
-260.00	.284
-250.00	.866
-225.00	7.008
-200.00	17.122
-175.00	27.942
-150.00	38.635
-125.00	49.158
-100.00	59.537
- 75.00	69.795
- 50.00	79.950
- 25.00	90.015
0.00*	100.00*
25.00	109.91
50.00	119.76
75.00	129.53
100.00	139.53
125.00	148.85
150.00	158.41
175.00	167.89
200.00	177.31
250.00	195.92
300.00	214.25
350.00	232.29
400.00	249.89
450.00	267.52
500.00	284.70
600.00	318.22
700.00	350.59
800.00	381.82
900.00	411.91
1000.00	440.85

*Denotes physical calibration point, interchangeable to ±2.0 ohms (±5.1°C).



TELEDYNE RELAYS

SOLID STATE AC RELAY

SERIES
611
40 AMP
140, 280 VAC
(SPST/N.O.)

FEATURES

- All solid state
- Optical isolation between control and load circuits
- Ultra sensitive control input — compatible with TTL logic
- Zero-voltage turn-on, zero current turn-off
- High output transient immunity (200v/usec Typ.)
- Multipurpose terminals—screws & quick disconnects
- High "contact" surge rating 1000% overloads)

APPLICATIONS

- Traffic control systems
- Computer peripherals
- Machine tool controls
- Process control systems
- Lamp loads
- Motor starting conditions
- Solenoid loads

PART NUMBERING	INPUT CONTROL VOLTAGE RANGE	OUTPUT VOLTAGE RATING (VAC)	OUTPUT (LOAD) CURRENT RATING & PART NUMBERS	
	3-28 VDC	140	611-5	40 AMPS
		250	611-6	

ELECTRICAL SPECIFICATIONS
(25°C unless otherwise specified)

INPUT (CONTROL) SPECIFICATIONS	MIN	TYP	MAX	UNITS
CONTROL VOLTAGE RANGE	3		28	VDC
INPUT CURRENT AT 5V CONTROL VOLTAGE ($-40°C \leq Ta \leq 80°C$)			6	MA
TURN-ON VOLTAGE	3.0			VDC
TURN-ON VOLTAGE ($-40°C \leq Ta \leq 80°C$)	3.8			VDC
TURN-OFF VOLTAGE ($-40 < Ta \leq 80°C$)			0.8	VDC
INPUT DEADBAND		500		MVDC
ISOLATION (INPUT TO OUTPUT, INPUT TO CASE)	10^9			OHMS
CAPACITANCE (INPUT TO OUTPUT)		8	10	PF
DIELECTRIC STRENGTH (INPUT TO OUTPUT, INPUT TO CASE)	1500			VAC(RMS) 60 Hz
REVERSE VOLTAGE PROTECTION	30			VDC

PATENT #3,648,075

OUTPUT (LOAD) SPECIFICATIONS		MIN	TYP	MAX	UNITS
OUTPUT CURRENT RATING (SEE FIGURE 2)		.05		40	AMPS (RMS)
LOAD VOLTAGE RATING (SEE PART NUMBERING)		12		140, 250	VAC(RMS)
FREQUENCY RANGE		50		70	Hz
SURGE CURRENT RATING (16MS) (SEE FIGURE 3)				1000	% OF RATING
OVER VOLTAGE RATING	611-5	200			V PEAK
	611-6	400			
CONTACT VOLTAGE DROP AT RATED CURRENT			.8	1.5	VAC
TURN-ON TIME (60 Hz)			3.0	8.3	MS
TURN-OFF TIME (60 Hz)			5.0	16.6	MS
ISOLATION (OUTPUT TO INPUT, OUTPUT TO CASE)		10^9			OHMS
DIELECTRIC STRENGTH (OUTPUT TO INPUT, OUTPUT TO CASE)		1500			VAC-60Hz
OFF-STATE LEAKAGE ($-40°C \leq Ta \leq 80°C$)	140V			8	MA(RMS)
	250V			13	
ZERO VOLTAGE TURN-ON POINT			±6		V(PEAK)
OUTPUT TRANSIENT IMMUNITY (SEE NOTE 1)		100	200		V/μ sec
TRIAC POWER DISSIPATION (SEE NOTE 2)				1.25	WATTS/AMPS

TELEDYNE RELAYS
3155 W. El Segundo Boulevard
Hawthorne, California 90250
(213) 973-4545 772-4357
TWX 910-325-6600

SPECIFICATIONS SHOWN HEREIN SUBJECT TO CHANGE WITHOUT NOTICE.

CHARACTERISTIC CURVES

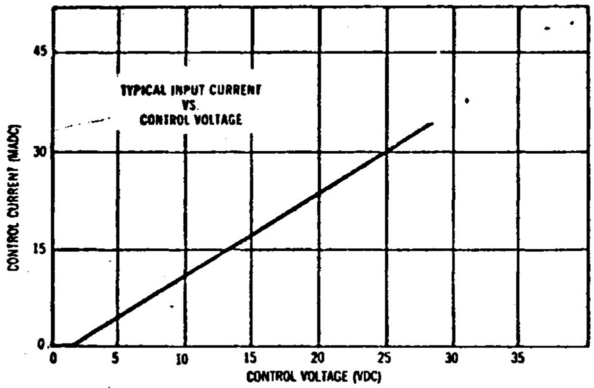


FIGURE 1

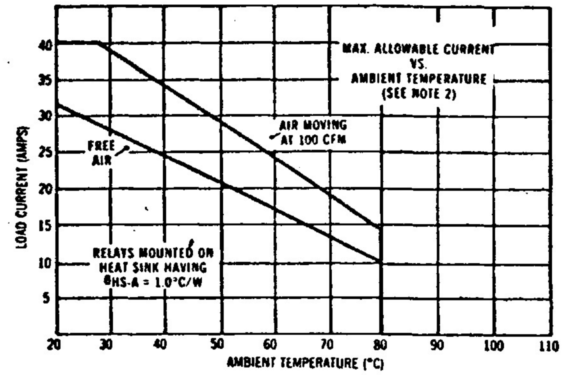


FIGURE 2

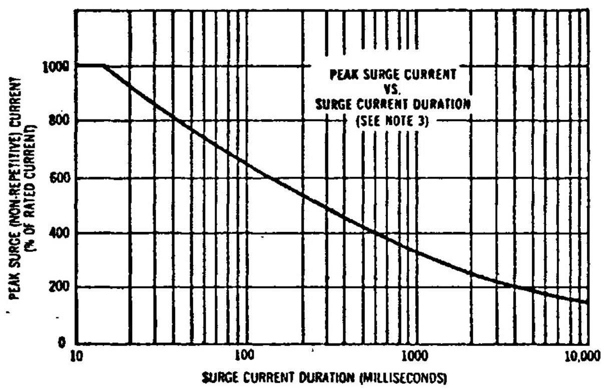
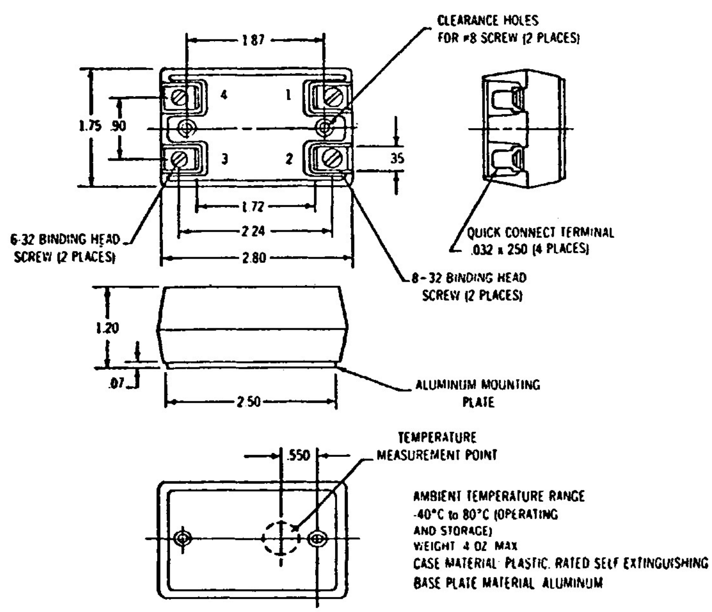
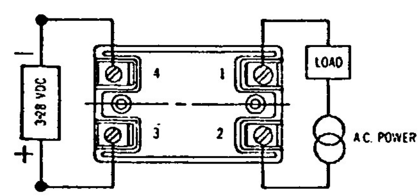


FIGURE 3

MECHANICAL SPECIFICATIONS



WIRING DIAGRAM



NOTES:

1. Output transient (dv/dt) protection is provided in all models, and they are designed to operate resistive or inductive loads.
2. Maximum triac junction temperature is 100°C. For any mounting conditions, θ_J-Base = 1.3°C/watt. Temperature measurement point on mounting base is shown on outline drawing.
3. Triac may lose blocking capability during and after surge until T_J falls below maximum.

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HAWTHORNE, CALIFORNIA 90250
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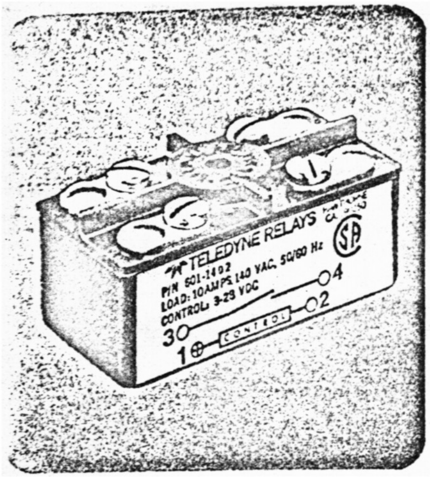

TELEDYNE RELAYS

SERIES
601-1400
5/10AMP
140/250VAC
(SPST/N.O.)

SOLID STATE AC RELAY
OPTICALLY ISOLATED —
ZERO VOLTAGE TURN-ON

FEATURES

- Zero Voltage Turn-On to minimize RFI
- All Solid State
- Total isolation between control and load circuits
- Ultra-sensitive control input-TTL compatible
- Adaptive package design for PC board or chassis mounting
- Terminal option - screws, quick disconnects and PC board solder pins
- Lack of moving contacts prevents arcing and sparking for switching in explosive atmospheres
- High contact surge rating
- High output transient immunity

APPLICATIONS

- Computer Peripherals
- Machine Tool Controls
- Process Control Systems
- Heating Controls

RELIABLE SOLID STATE SWITCHING OF

- Solenoids
- Motor Starters
- Motors
- Lamp Loads
- Transformers
- Heaters

PART NUMBERING

INPUT CONTROL VOLTAGE RANGE	OUTPUT VOLTAGE RATING	OUTPUT (LOAD) CURRENT RATING & PART NUMBERS	
		5 AMP	10 AMP
3-28 VDC	140 VAC	601-1401	601-1402
	250 VAC	601-1403	601-1404

(see note 4)

ELECTRICAL SPECIFICATIONS
(25°C unless otherwise specified)

INPUT (CONTROL) SPECIFICATIONS	MIN.	TYP.	MAX.	UNITS
CONTROL VOLTAGE RANGE	3		28	VDC
INPUT CURRENT AT 5V CONTROL VOLTAGE (see fig. 1)			6	MA
INPUT CURRENT AT 5V CONTROL VOLTAGE (—30°C ≤ Ta < 80°C)			6	MA
TURN-ON-VOLTAGE (see fig. 2)	3.0			VDC
TURN-ON-VOLTAGE (—30°C ≤ Ta ≤ 80°C)	3.8			VDC
TURN-OFF-VOLTAGE (see fig. 2)			1.0	VDC
TURN-OFF-VOLTAGE (—30°C ≤ Ta < 80°C)			0.8	VDC
INPUT DEADBAND		500		MVDC
ISOLATION (INPUT TO OUTPUT, INPUT TO CASE, OUTPUT TO CASE)	10^9			OHMS
CAPACITANCE (INPUT TO OUTPUT)		10	20	PF
DIELECTRIC (INPUT TO OUTPUT, INPUT TO CASE, OUTPUT TO CASE)	1500			VAC (rms) 60 Hz

PATENT #3,648,075 UL RECOGNITION—FILE NO. E47991

OUTPUT (LOAD) SPECIFICATIONS		MIN.	TYP.	MAX.	UNITS
OUTPUT CURRENT RATING (see part numbering) (see fig. 3 or 4 for temperature derating)		.05		5 and 10	AMPS (rms)
LOAD VOLTAGE RATING (see part numbering)		12		140 or 250	VAC (rms)
FREQUENCY RANGE		50		70	Hz
SURGE CURRENT RATING (see fig. 5) (16 MS)				1000	% of rating
CONTACT VOLTAGE DROP AT RATED CURRENT			.8	1.5	VAC
TURN-ON TIME (60 Hz)			3.0	8.3	MS
TURN-OFF TIME (60 Hz)			5.0	16.6	MS
DIELECTRIC STRENGTH (OUTPUT TO CASE)		1500			VAC (rms) 60 Hz
OFF STATE LEAKAGE (—30°C ≤ Ta ≤ 80°C)	-1401 -1402			8	MA (rms)
	-1403 -1404			13	MA (rms)
ZERO VOLTAGE TURN-ON POINT			±6		V(peak)
OFF-STATE dv/dt (see note 1)		100	200		V/μ sec
TRIAC POWER DISSIPATION	-1402, -1404			.90	WATTS/AMP
	-1401, -1403			.85	WATTS/AMP

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Hawthorne, California 90250
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TWX 910-325-6600

SPECIFICATIONS SHOWN HEREIN ARE SUBJECT TO CHANGE WITHOUT NOTICE.

CHARACTERISTIC CURVES

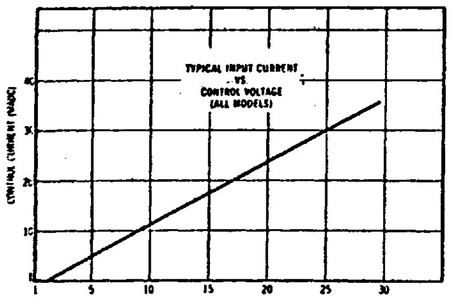


FIGURE 1

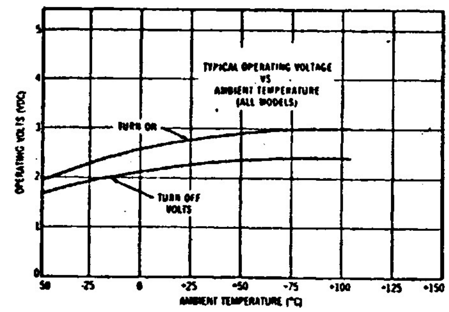


FIGURE 2

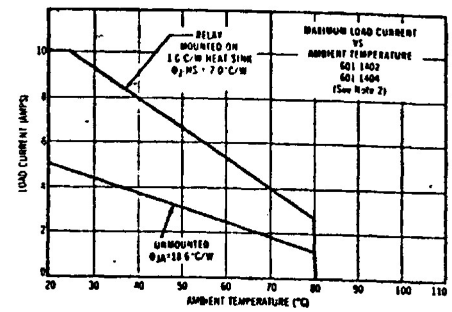


FIGURE 3

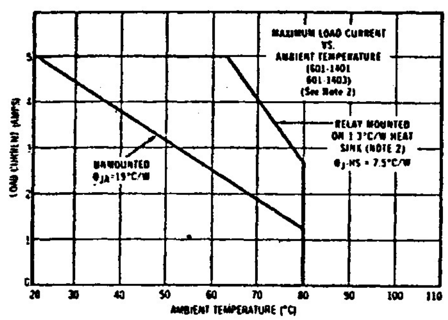


FIGURE 4

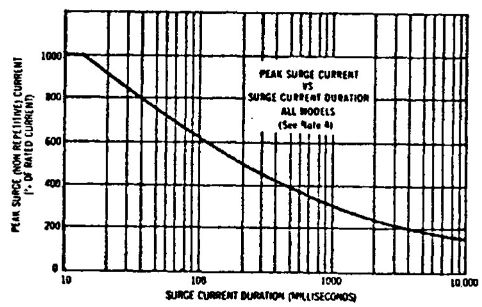


FIGURE 5

MECHANICAL SPECIFICATIONS

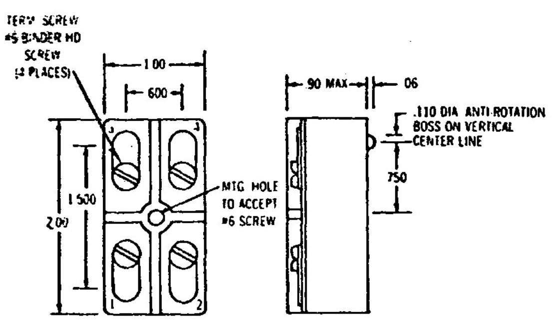


FIGURE 6
SCREW TERMINAL VERSION

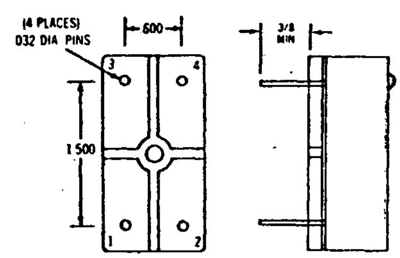


FIGURE 7
PC BOARD VERSION

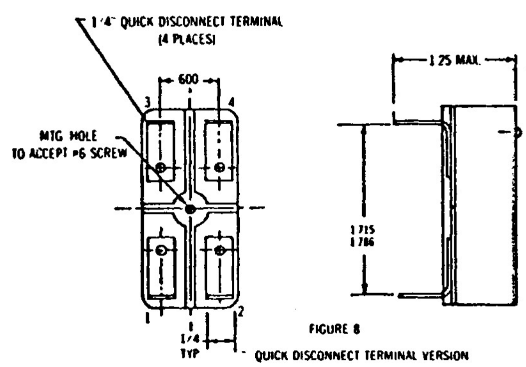
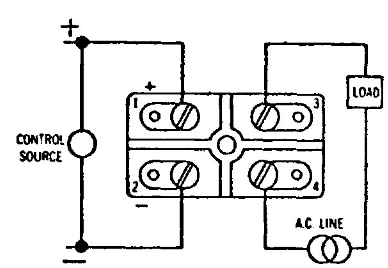


FIGURE 8
QUICK DISCONNECT TERMINAL VERSION

TOLERANCES
XX ± .01, XXX ± .005, ± 1/16

- AMBIENT TEMPERATURE RANGE
  -30°C TO +80°C (OPERATING & STORAGE)
- WEIGHT: 3 OZ. MAX.
- CASE MATERIAL: ALUMINUM, BLACK ANODIZED
- HEADER MATERIAL: PHENOLIC
- EPOXY ENCAPSULATED

WIRING DIAGRAM



NOTES:

1. Output transient (dv/dt) protection is provided in all models, and they are designed to operate resistive or inductive loads.
2. For any mounting conditions; 601-1401 & 601-1403, θ_J-HS=7.5°C/W. For 601-1402 & 601-1404, θ_J-HS=7°C/W Max. triac junction temperature is 100°C.
3. Basic part number provides screw terminals (Fig. 6). For P.C. Board Pins, add suffix "p" to part number (Fig. 7). For quick disconnect terminals, add suffix "Q" (Fig. 8).
4. Triac may lose blocking capability during and after surge until T_J falls below maximum.

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HAWTHORNE, CALIFORNIA 90250
(213) 973-4545 • 772-4357
TWX 910-325-6600

RAYTHEON

MONOLITHIC DUAL HIGH-GAIN OPERATIONAL AMPLIFIER

4558

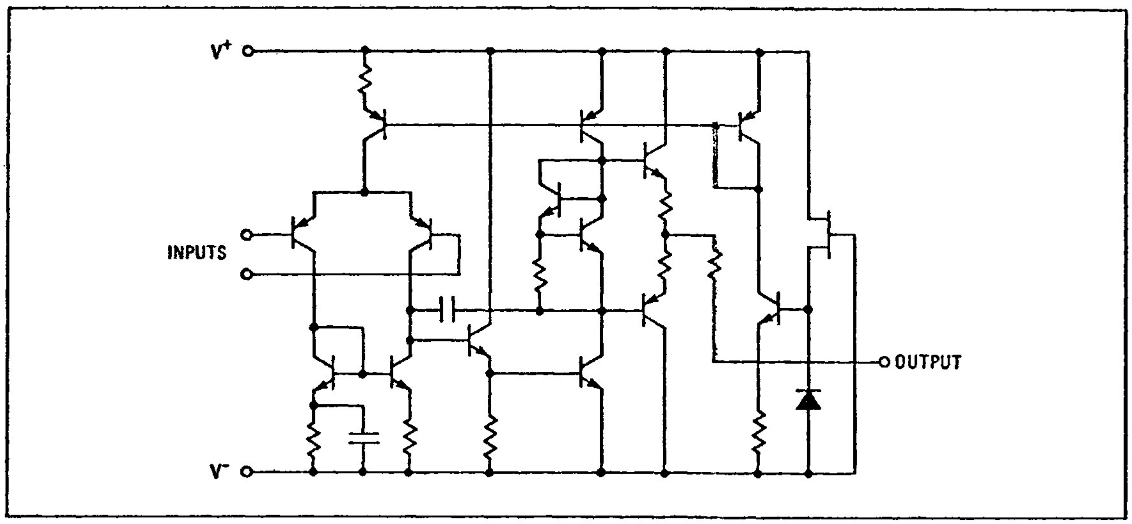
DESIGN FEATURES

- Supply voltage ±18V
- Continuous Short-circuit protection
- No Frequency Compensation Required
- No Latch-up
- Unity Gain Bandwidth 3MHz
- Large Common-mode and Differential Voltage Ranges
- Low Power Consumption
- Parameter Tracking Over Temperature Range
- Gain and Phase Match Between Amplifiers

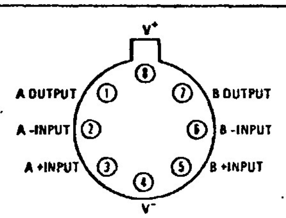
The RC4558 integrated circuit is a high gain operational amplifier internally compensated and constructed on a single silicon chip using the planar epitaxial process. It operates from 0°C to +70°C.

Combining all of the outstanding features of the 741 with the close parameter matching and tracking of a dual device on a monolithic chip results in unique performance characteristics. Excellent channel separation allows the use of the dual device in all single 741 operational amplifier applications providing the highest possible packaging density. It is especially well suited for applications in differential-in, differential-out as well as in potentiometric amplifiers and where gain and phase matched channels are mandatory.

SCHEMATIC DIAGRAM

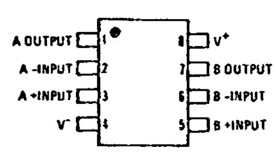


CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part No.:
RC4558T



DN Dual In-line Plastic Package
(Top View)

Order Part No.:
RC4558DN

MONOLITHIC DUAL HIGH-GAIN OPERATIONAL AMPLIFIER

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±18V
Internal Power Dissipation (Note 1)	500mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	0°C to +70°C
Lead Temperature (Soldering, 60s)	300°C
Output Short-circuit Duration (Note 3)	Indefinite

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_{CC} = ±15V unless otherwise specified)

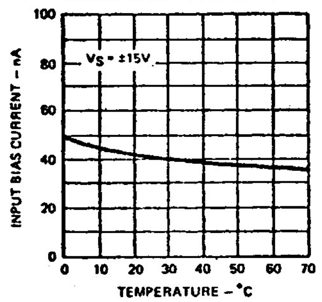
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$R_S \leq 10$ kΩ		0.5	6.0	mV
Input Offset Current			5.0	200	nA
Input Bias Current			40	500	nA
Input Resistance		0.3	5.0		MΩ
Large-Signal Voltage Gain	$R_L \geq 2$ kΩ $V_{out} = \pm 10$V	20,000	300,000		
Output Voltage Swing	$R_L \geq 10$ kΩ	±12	±14		V
	$R_L \geq 2$ kΩ	±10	±13		V
Input Voltage Range		±12	±14		V
Common Mode Rejection Ratio	$R_S \leq 10$ kΩ	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10$ kΩ		30	150	μV/V
Power Consumption			105	170	mW
Transient Response (unity gain) Risetime	V_{in} = 20 mV R_L = 2 kΩ $C_L \leq 100$ pF		0.13		μs
Transient Response (unity gain) Overshoot	V_{in} = 20 mV R_L = 2 kΩ $C_L \leq 100$ pF		5.0		%
Slew Rate (unity gain)	$R_L \geq 2$ kΩ		1.0		V/μs
Channel Separation	f = 10 kHz R_S = 1 kΩ		105		dB
Equivalent Noise Voltage Referred to Input	A_V = 100 R_S = 1 kΩ BW = 1 Hz		10		nV(Hz)½
Unity Gain Bandwidth (open-loop)			3.0		MHz
The following specifications apply for 0°C ≤ T_A ≤ 70°C unless otherwise specified.					
Input Offset Voltage	$R_S \leq 10$ kΩ			7.5	mV
Input Offset Current				300	nA
Input Bias Current				800	nA
Large-Signal Voltage Gain	$R_L \geq 2$ kΩ $V_{out} = \pm 10$V	15,000			
Output Voltage Swing	$R_L \geq 2$ kΩ	±10			V
Power Consumption	$V_S = \pm 15$V				
	T_A = 70°C		90	150	mW
	T_A = 0°C		120	200	

NOTES:

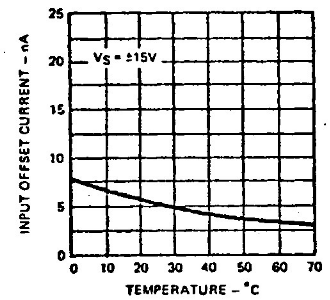
1. Rating applies for ambient temperatures to +25°C; derate linearly at 6.4 mW/°C for ambient temperatures above +25°C.
2. For supply voltages less than ±15V the absolute maximum input voltage is equal to the supply voltage.
3. Short-circuit may be to ground, one amplifier only. I_{SC} = 45mA (typical).

TYPICAL ELECTRICAL DATA

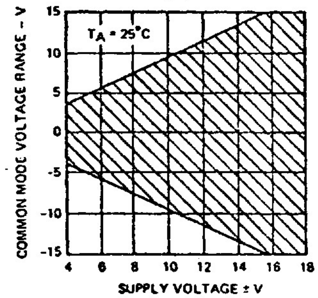
Input Bias Current as a Function of Ambient Temperature



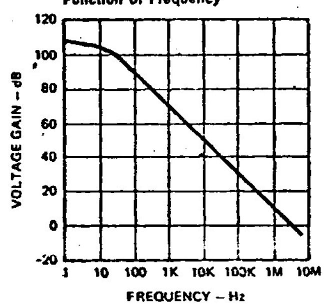
Input Offset Current as a Function of Ambient Temperature



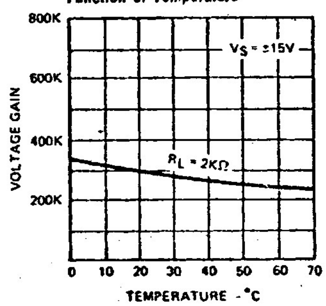
Common Mode Range as a Function of Supply Voltage



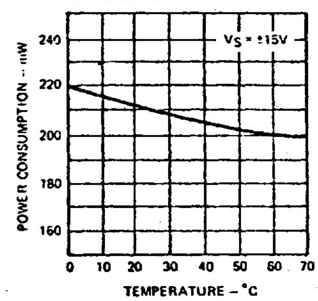
Open Loop Voltage Gain as a Function of Frequency



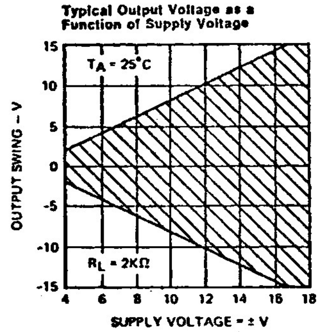
Open Loop Gain as a Function of Temperature



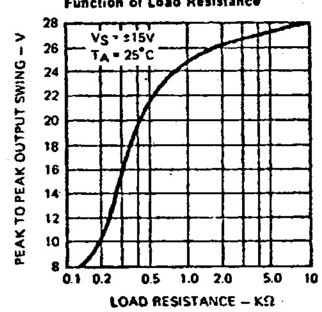
Power Consumption as a Function of Ambient Temperature



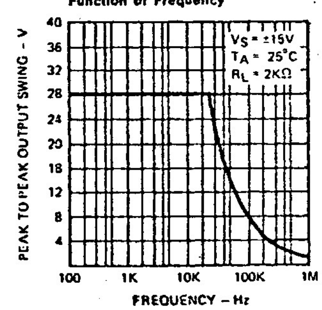
Typical Output Voltage as a Function of Supply Voltage



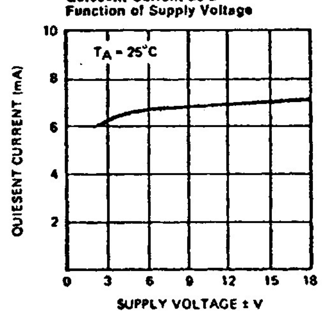
Output Voltage Swing as a Function of Load Resistance



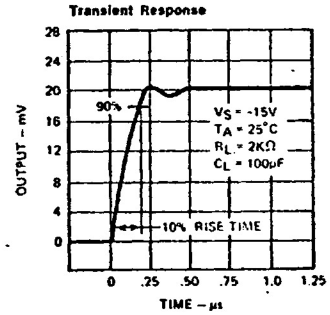
Output Voltage Swing as a Function of Frequency



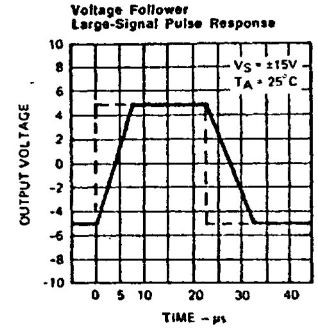
Quiesent Current as a Function of Supply Voltage



Transient Response



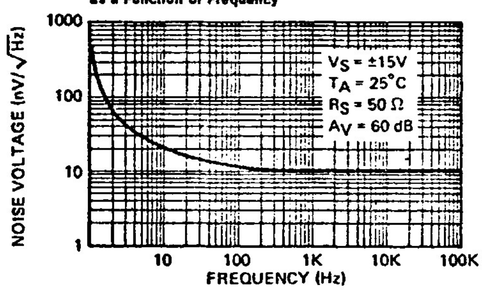
Voltage Follower Large-Signal Pulse Response



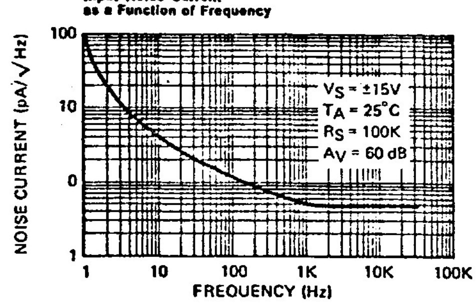
MONOLITHIC DUAL HIGH-GAIN OPERATIONAL AMPLIFIER

TYPICAL ELECTRICAL DATA

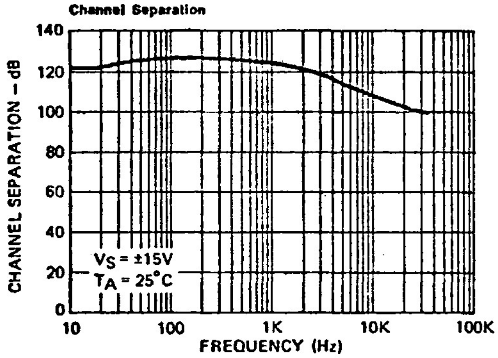
Input Noise Voltage as a Function of Frequency



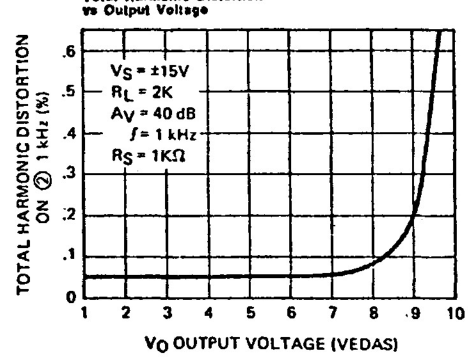
Input Noise Current as a Function of Frequency



Channel Separation



Total Harmonic Distortion vs Output Voltage



Distortion vs Frequency
Vo = 1vrms