EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

4-1000A

POWER TETRODE
•
MODULATOR
OSCILLATOR
AMPLIFIER

The Eimac 4-1000A is a beam power tetrode with a maximum plate dissipation rating of 1000 watts. Intended for use as an amplifier, oscillator, or modulator, the 4-1000A is capable of efficient operation well into the vhf range.

In FM broadcast service on 110 Mc., two 4-1000A tetrodes will deliver a useful power output over 5000 watts.

Operating under class AB_2 modulator conditions with less than 10 watts of peak driving power, two of these tubes will deliver 3900 watts of output power.

With zero watts driving power in class AB_1, a pair of 4-1000A tetrodes will deliver 3800 watts of power output.

Cooling of the tube is accomplished by radiation from the plate and by circulation of forced-air through the base and around the envelope. Cooling can be simplified through the use of the Eimac 4-1000A Air-System Socket.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	7.5 volts
Current	21 amperes
Grid-Screen Amplification Factor (Average)	
Direct Interelectrode Capacitances (Average)	
Grid-Plate (without shielding, base grounded)	0.24 $\mu\mu f$
Input	27.2 $\mu\mu f$
Output	7.6 $\mu\mu f$
Transconductance (i_b = 300 ma., E_b = 2500 v., E_{c2} = 500 v.)	10,000 umhos
Highest Frequency for Maximum Ratings	110 Mc

MECHANICAL

Base	5-pin metal shell (see dwg.)
Basing	See drawing
▶ Recommended Socket	Eimac 4-1000A Air-System Socket
Mounting position	Vertical, base down or up
Cooling	Radiation and forced air
Recommended Heat Dissipating Connector:	
Plate	Eimac HR-8
Maximum Over-all Dimensions:	
Length	9.63 inches
Diameter	5.25 inches
Net Weight (tube only)	1.5 pounds
Shipping Weight	12 pounds

If an Air-System Socket is used, mounted on a 1/4" deck, the over-all dimensions of the system including chimney and HR-8 cooler are

Length	11.75 inches
Diameter	7.5 inches

Note: Typical operation data are based on conditions of adjusting to a specified plate current, maintaining fixed conditions of grid bias, screen voltage and r-f grid voltage. It will be found that if this procedure is followed, there will be little variation in power output between tubes even though there may be some variation in grid and screen currents. Where grid bias is obtained principally by means of a grid resistor, to control plate current it is necessary to make the resistor adjustable.

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR
Class AB

MAXIMUM RATINGS (PER TUBE)

D-C PLATE VOLTAGE	6000 MAX. VOLTS
D-C SCREEN VOLTAGE	1000 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT	700 MAX. MA
PLATE DISSIPATION	1000 MAX. WATTS
SCREEN DISSIPATION	75 MAX. WATTS

TYPICAL OPERATION
Class AB_1 (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	4000	5000	6000	volts
D-C Screen Voltage	1000	1000	1000	volts
D-C Grid Voltage (approx.)*	—115	—125	—135	volts
Zero-Signal D-C Plate Current	300	240	200	ma
Max-Signal D-C Plate Current	1.05	1.00	.95	amp
Zero-Signal D-C Screen Current	0	0	0	ma
Max-Signal D-C Screen Current	60	60	64	ma
Effective Load, Plate-to-Plate	7000	10,000	14,000	ohms
Peak A-F Grid Input Voltage (per tube)	115	125	135	volts
Driving Power	0	0	0	watts
Max-Signal Plate Dissipation (per tube)	930	950	930	watts
Max-Signal Plate Power Output	2340	3100	3840	watts

*Adjust to give stated zero-signal plate current. The D-C resistance in series with the control grid of each tube should not exceed 250,000 ohms.

TYPICAL OPERATION
Class AB_2 (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	4000	5000	6000	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage (approx.)*	—60	—70	—75	volts
Zero-Signal D-C Plate Current	300	200	150	ma
Max-Signal D-C Plate Current	1.20	1.10	.95	amp
Zero-Signal D-C Screen Current	0	0	0	ma
Max-Signal D-C Screen Current	95	90	65	ma
Effective Load, Plate-to-Plate	7000	11,000	15,000	ohms
Peak A-F Grid Input Voltage (per tube)	140	145	130	volts
Max-Signal Peak Driving Power	11.0	11.0	9.4	watts
Max-Signal Nominal Driving Power (approx.)	5.5	5.5	4.7	watts
Max-Signal Plate Dissipation (per tube)	900	850	900	watts
Max-Signal Plate Power Output	3000	3800	3900	watts

*Adjust to give stated zero-signal plate current.

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION", POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS.

▶ Indicates changes from sheet dated 11-15-50.

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C Telegraphy or FM Telephony

MAXIMUM RATINGS (Key-down conditions, per tube to 110 Mc.)

D-C PLATE VOLTAGE	6000 MAX. VOLTS
D-C SCREEN VOLTAGE	1000 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	700 MAX. MA
PLATE DISSIPATION	1000 MAX. WATTS
SCREEN DISSIPATION	75 MAX. WATTS
GRID DISSIPATION	25 MAX. WATTS

TYPICAL OPERATION (Frequencies below 110 Mc., one tube)

D-C Plate Voltage	3000	4000	5000	6000	volts
D-C Screen Voltage	500	500	500	500	volts
D-C Grid Voltage	—150	—150	—200	—200	volts
D-C Plate Current	700	700	700	700	ma
D-C Screen Current	146	137	147	140	ma
D-C Grid Current	38	39	45	42	ma
Screen Dissipation	73	69	73	70	watts
Grid Dissipation	5	6	7	6	watts
Peak R-F Grid Input Voltage (approx.)	290	290	355	350	volts
Driving Power (approx.)*	11	12	16	15	watts
Plate Power Input	2100	2800	3500	4200	watts
Plate Dissipation	670	700	690	800	watts
Plate Power Output	1430	2100	2810	3400	watts

*Apparent driving power requirements increase above 30 Mc. At 110 Mc. the driver should be capable of supplying 200 watts per tube to take care of feed-through, circuit losses, and radiation.

TYPICAL OPERATION (110 Mc., two tubes, push-pull)

D-C Plate Voltage	4000	5000	6000	volts
D-C Screen Voltage	450	500	500	volts
D-C Grid Voltage	—150	—160	—180	volts
D-C Plate Current	1.15	1.25	1.25	amps
D-C Screen Current	280	240	250	ma
D-C Grid Current	80	80	100	ma
Screen Dissipation (per tube)	63	60	63	watts
Driving Power (approx.)	350	400	400	watts
Plate Power Input	4600	6250	7500	watts
Plate Dissipation (per tube)	650	850	900	watts
Useful Power Output	3000	4200	5200	watts

These 110 Mc. typical performance figures were obtained by direct measurement in operating equipment. The output power is useful power measured in a load circuit. The driving power is that taken by the tube and a practical resonant circuit. In many cases with further refinement and improved techinques, better performance might be obtained.

PLATE MODULATED RADIO FREQUENCY AMPLIFIER

Class-C Telephony—Carrier Conditions

MAXIMUM RATINGS (Per tube to 110 Mc.)

D-C PLATE VOLTAGE	5000 MAX. VOLTS*
D-C SCREEN VOLTAGE	1000 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	600 MAX. MA
PLATE DISSIPATION	670 MAX. WATTS
SCREEN DISSIPATION	75 MAX. WATTS
GRID DISSIPATION	25 MAX. WATTS

*5500 Max. volts below 30 Mc.

TYPICAL OPERATION (Frequencies below 110 Mc., one tube)

D-C Plate Voltage	3000	4000	5000	5500*	volts
D-C Screen Voltage	500	500	500	500	volts
D-C Grid Voltage	600	600	600	600	ma
D-C Plate Current	—200	—200	—200	—200	volts
D-C Screen Current	145	132	130	105	ma
D-C Grid Current	36	33	33	28	ma
Screen Dissipation	72	66	65	52	watts
Grid Dissipation	5	4	4	3	watts
Peak A. F. Screen Voltage (100% modulation)	250	250	250	250	volts
Peak R-F Grid Input Voltage	340	335	335	325	volts
Driving Power**	12	11	11	9	watts
Plate Power Input	1800	2400	3000	3300	watts
Plate Dissipation	410	490	560	670	watts
Plate Power Output	1390	1910	2440	2630	watts

*5500 volt operation may be used only below 30 Mc.

**Apparent driving power requirements increase above 30 Mc. At 110 Mc. the driver should be capable of supplying 200 watts per tube to take care of feed-through, circuit losses, and radiation.

Pulse Service—For information on Pulse Service Ratings, "Application Bulletin No. 3, Pulse Service Notes", will be furnished free on request.

APPLICATION

MECHANICAL

Mounting—The 4-1000A must be mounted vertically base up or base down. The socket must be constructed so as to allow an unimpeded flow of air through the holes in the base of the tube. The socket must also provide clearance for the glass tip-off which extends from the center of the base. The metal tube base shell should be grounded by means of suitable spring fingers. A flexible connecting strap should be provided between the HR cooler on the plate terminal and the external plate circuit. The socket must not apply excessive lateral pressure against the base pins. The tube must be protected from severe vibration and shock.

▶ **Cooling**—Adequate forced-air cooling must be provided to maintain the base seal temperatures below 150°C and the plate seal below 200°C. The problem of cooling is greatly simplified by using the Eimac 4-1000A Air-System Socket and its accompanying chimney. This system is designed to maintain the correct balance of cooling air for the various parts of the tube. The minimum quantity of air required by this system for maximum power output at 110 Mc. is 45 cfm at an inlet static pressure of approximately 1.2 inches of water.

In the event that an Air-System Socket is not used, provision must be made to circulate air through the base, around the envelope and over the plate seal. This is in addition to the normal cooling required by the base. Seal temperature limitations may require that cooling air be supplied to the tube even when filament alone is on during standby periods.

Tube temperatures may be measured with the aid of "Tempilaq", a temperature-sensitive lacquer manufactured by the Tempil Corporation, 132 West 22nd Street, New York 11, N. Y.

ELECTRICAL

Filament Voltage—For maximum tube life the filament voltage, as measured directly at the filament pins, should be the rated voltage of 7.5 volts. Unavoidable variations in filament voltage must be kept within the range from 7.13 to 7.87 volts.

Bias Voltage—The D-C bias voltage for the 4-1000A should not exceed 500 volts. If grid-leak bias is used, suitable protective means must be provided to prevent excessive plate or screen dissipation in the event of loss ▶ of excitation, and the grid-leak resistor should be made adjustable to facilitate maintaining the bias voltage and plate current at the desired values from tube to tube. In the case of operation above 50 Mc., it is advisable to keep the bias voltage as low as possible. (See "Operation".)

Screen Voltage—The D-C screen voltage for the 4-1000A should not exceed 1000 volts. The screen voltages shown under "Typical Operation" are representative voltages for the type of operation involved.

▶ Indicates changes from sheet dated 11-15-50.

Plate Voltage—The plate-supply voltage for the 4-1000A should not exceed 6000 volts in CW and audio applications. In plate-modulated telephony service above 30 Mc., the D-C plate-supply voltage should not exceed 5000 volts; however, below 30 Mc., 5500-volt operation may be used.

Grid Dissipation—Grid dissipation for the 4-1000A should not be allowed to exceed 25 watts. Grid dissipation may be calculated from the following expression:

$$P_g = e_{cmp} I_c$$

where: P_g = Grid dissipation,
e_{cmp} = Peak postive grid to cathode voltage, and
I_c = D-c grid current.

e_{cmp} may be measured by means of a suitable peak volt-meter connected between filament and grid. (For suitable peak v.t.v.m. circuits, see for instance, "Vacuum Tube Ratings", Eimac News, January 1945. This article is available in reprint form on request.)

Screen Dissipation—The power dissipated by the screen of the 4-1000A must not exceed 75 watts. Screen dissipation is likely to rise to excessive values when the plate voltage, bias voltage or plate load are removed with filament and screen voltages applied. Suitable protective means must be provided to limit screen dissipation to 75 watts in event of circuit failure.

Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4-1000A should not be allowed to exceed 1000 watts.

In plate modulated amplifier applications, the maximum allowable carrier-condition plate dissipation is 670 watts. The plate dissipation will rise to 1000 watts under 100% sinusoidal modulation.

Plate dissipation in excess of the maximum rating is permissible for short periods of time, such as during tuning procedures.

OPERATION

CLASS-C R-F AMPLIFIER

Neutralization—If reasonable precautions are taken to prevent coupling between input and output circuits, the 4-1000A may be operated up to the 10 Mc. region without neutralization. In the region between 10 Mc. and 30 Mc., the conventional type of cross-neutralizing may be used with push-pull circuits. In single-ended circuits ordinary neutralization systems may be used which provide 180° out of phase voltage to the grid. A simple and effective method of neutralizing single-ended tetrode circuits is described by Warren B. Bruene in "How to Neutralize Your Single-Ended Tetrode Final", in the August, 1950, issue of CQ magazine.

At frequencies above 30 Mc. the feedback is principally due to screen-lead-inductance effects. Feedback is eliminated by using series capacitance in the screen leads between the screen and ground. A variable capacitor of from 25 to 50 uufds will provide sufficient capacitance to neutralize each tube in the region of 100 Mc. When using this method, the two screen terminals on the socket should be strapped together by the shortest possible lead. The lead from the mid-point of this screen strap to the variable capacitor and from the variable capacitor to ground should be made with as low inductance as possible.

In general, plate, grid, filament and screen bypass or screen neutralizing capacitors should be returned to r-f ground through the shortest possible leads.

In order to take full advantage of the high power gain obtainable with the 4-1000A, care should be taken to prevent feedback from the output to input circuits. A conventional method of obtaining the necessary shielding beween the grid and plate circuits is to use a suitable metal chassis with the grid circuit mounted below the deck and the plate circuit mounted above the deck. Power supply leads entering the amplifier should be bypassed to ground and properly shielded to avoid feedback coupling in these leads. The output circuit and antenna feeders should be arranged so as to preclude any possibility of feedback into other circuits.

VHF Circuits—A typical linear tank circuit for use with the 4-1000A in the 110 Mc. region consists of a "quarter wavelength" plate tank and a "half wavelength" grid tank circuit. Precautions must be observed in the placement of components to avoid the possibility of accidentally creating higher frequency tank circuits than the desired one. This could occur if a tuning capacitor were placed in a position on the line where it would create a resonant circuit at or near a harmonic frequency. A properly neutralized amplifier at the fundamental frequency would appear regenerative at higher parasitic frequencies and instability or oscillation would result.

Any capacitance tuning in the plate line should be kept to a small value, acting as a trimmer for the shorting-bar tuning. Such a variable capacitor should be positioned on the plate line as close as possible to the plate leads. The tuning capacitor on the "half wave" grid line should be positioned at the extreme end of the line away from the tube.

In many cases where parasitic oscillation or regenerative harmonic amplification occurs, it is not evident until grid excitation at the fundamental frequency is applied. If the amplifier tunes in a normal manner and the efficiency appears normal for the frequency of operation, it may be assumed that the amplifier is free of parasitic oscillation and harmonic regeneration.

VHF Operation—Above 50 Mc., electron transit time factors in the tube become important, increasing in degree as the frequency is increased. When the grid swings highly negative in potential, electrons, "trapped" enroute by the rapidly changing r-f voltage, can be deflected from their normal paths. If excessively large r-f plate voltages exist due to light plate loading, these electrons are rejected at high velocity to bombard tube parts normally outside the electron stream. This effect occurs when an amplifier goes into parasitic oscillation, as there is practically no loading in the plate circuit and the excitation is almost always extremely high. Bombardment can cause premature tube failure by a focusing of stray electrons on metal parts or the glass envelope of a tube. Such concentration of a stray electron stream will usually overheat the material at the point of focus, with the probability of gas evolvement that can lead to loss of filament emission or destruction of the tube. Where glass is the overheated material, a small hole or "suck-in" can occur, opening the tube to atmosphere. Dependent upon the degree of bombardment, tube failures can occur in a matter of minutes, or after a few thousand hours of life. Either way, the full life potential is not realized.

In order to minimize stray bombardment, the following rules should be followed in vhf operation of straight through amplifiers.

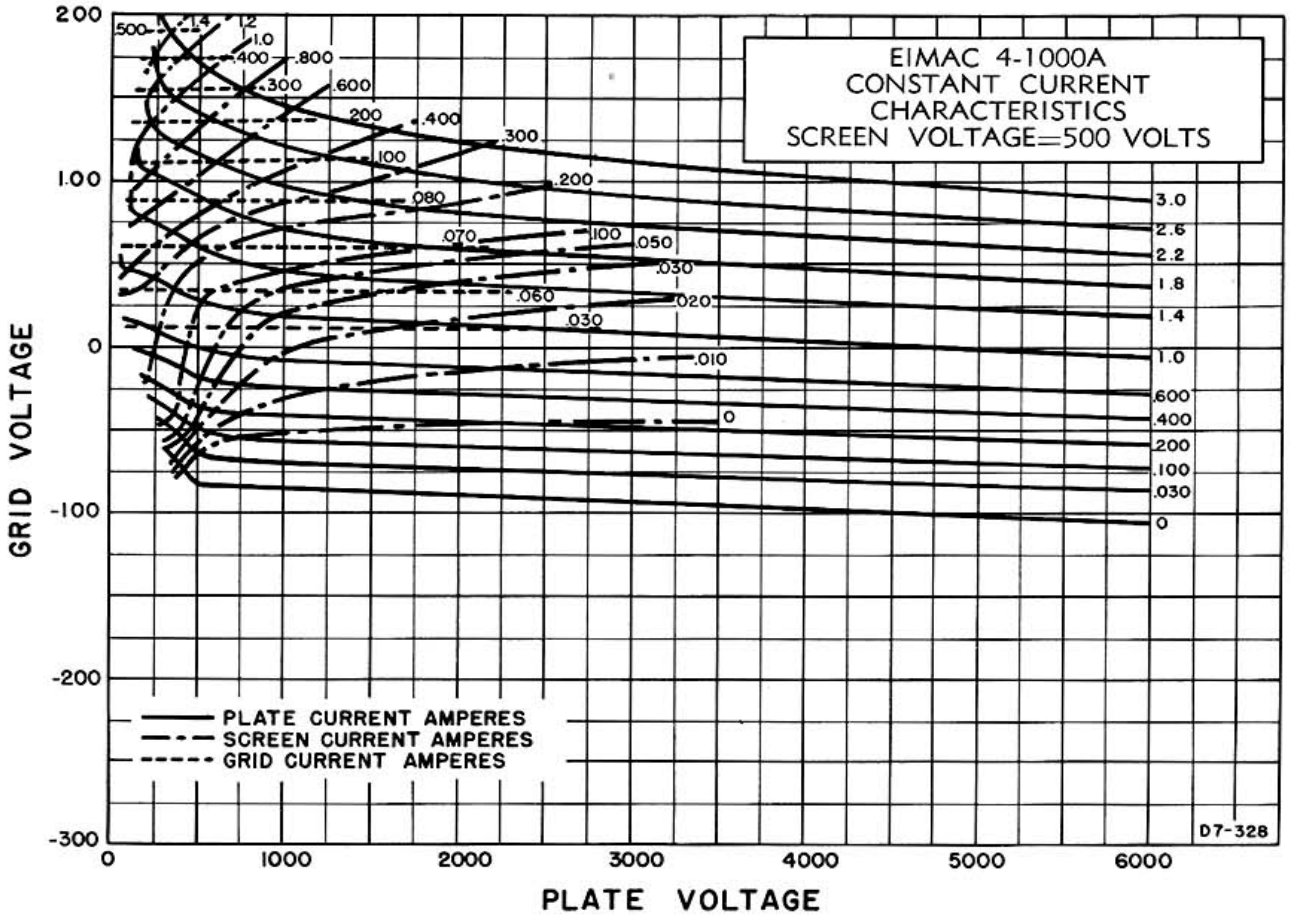
1. Use a minimum amount of bias (not over 1.5 to 2.0 times cut-off).

2. Use only enough drive to obtain satisfactory operation and good plate efficiency.

3. Use fairly heavy plate loading. Low plate voltage and high plate current is better than high plate voltage and low plate current. Avoid operating the stage unloaded or lightly loaded. If conditions are such that the stage must be operated lightly-loaded, then the driving power should be reduced proportionately. Install under-current protection, especially where unloaded operation can occur due to antenna failures or transmission line icing.

4. Operate the screen grid at a reasonably high voltage, still keeping within screen dissipation ratings.

▶ Indicates changes from sheet dated 11-15-50.


EIMAC 4-1000A
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE=500 VOLTS
GRID VOLTAGE
PLATE VOLTAGE
200
1.00
0
-100
-200
-300
0
1000
2000
3000
4000
5000
6000
PLATE CURRENT AMPERES
SCREEN CURRENT AMPERES
GRID CURRENT AMPERES
D7-328
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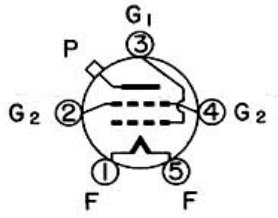
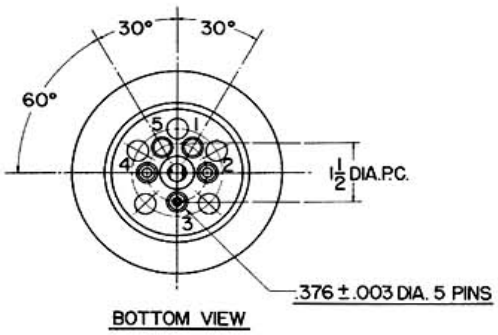
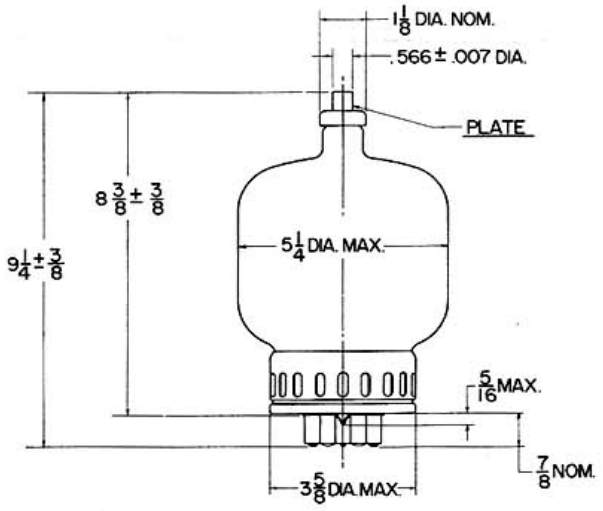
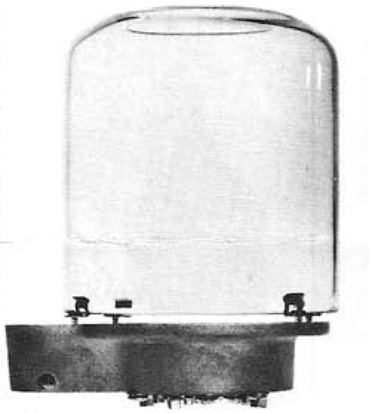

G1
P
G2
G2
F
F


30°
30°
60°
1½ DIA. P.C.
.376 ± .003 DIA. 5 PINS
BOTTOM VIEW


1⅛ DIA. NOM.
.566 ± .007 DIA.
PLATE
8⅜ ± ⅜
9¼ ± ⅜
5¼ DIA. MAX.
5/16 MAX.
7/8 NOM.
3⅝ DIA. MAX.

EITEL-McCULLOUGH, INC.
SAN BRUNO, CALIFORNIA

4-1000A
AIR-SYSTEM SOCKET



In order to simplify the cooling problem of the Eimac 4-1000A tetrode and assure adequate air-flow to the various seals, the Eimac Air-System Socket was developed. This system is so designed that the correct amount of cooling air is distributed to the various seals in the right proportion.

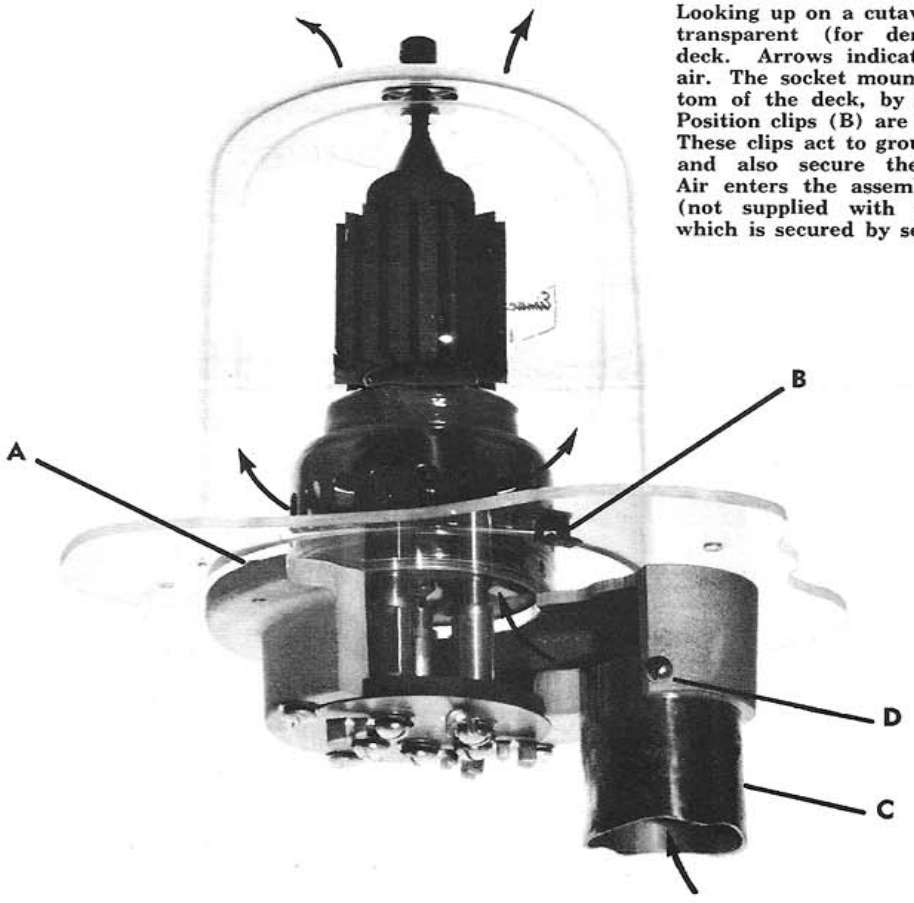
The Air-System Socket includes a socket to support the 4-1000A tetrode and to make the necessary base connections, and a complete air cooling system. The air enters the bottom of the socket through a 2-inch duct, cools the base terminals, flows through the base of the tube, is guided by the socket chimney past the glass envelope, and is directed against the heat dissipating connector at the plate terminal. A minimum quantity of air is thereby used effectively to cool the tube adequately under the severest requirements of the tube's ratings.

A flow of 45 CFM of air is required at an inlet static pressure of approximately 1.2" of water. The blower must be capable of supplying these requirements and also whatever added pressure drop is introduced by the connecting ducts and air filters.

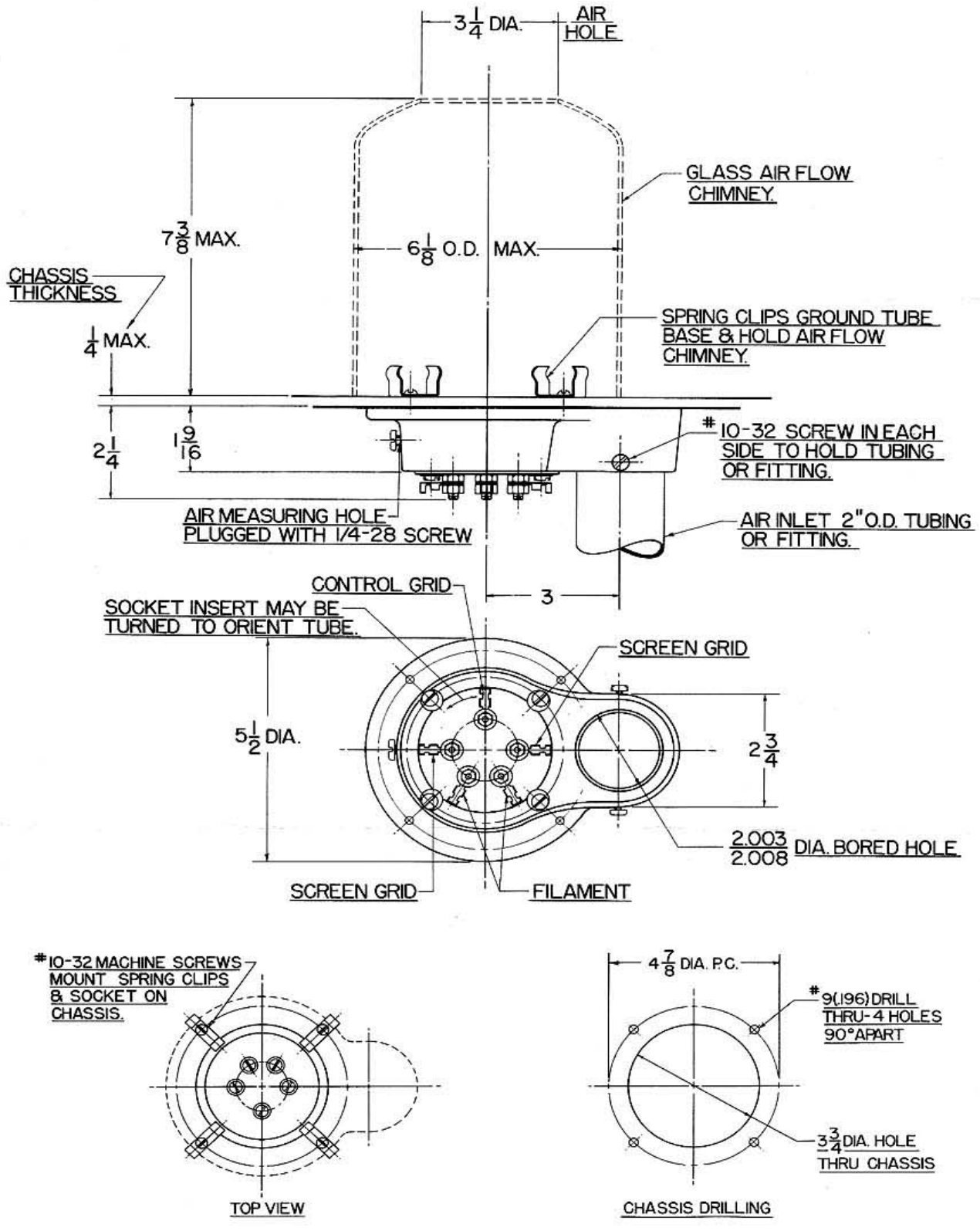
These air figures are based on sea-level operation with an ambient temperature of 25°C, and for amplifier operation at 110 Mc. where the r-f charging current into the plate-screen capacitance is most severe. Cooling with this air flow will keep all base seals below the maximum allowable temperature limit of 150°C and the plate seal below the allowable limit of 200°C. Proper flow of air can be indicated by measuring the pressure existing in the cast socket. A ¼" hole, tapped with 28 threads per inch, is provided to make connection to a water manometer. The static pressure at this point is 1.2" of water when 45 CFM is flowing. The manometer tube probe should be flush with the inside surface of the socket manifold. The hole in the probe should be made with a No. 31 drill.

Where operation is below 30 Mc., an air flow of at least 30 CFM is adequate. This corresponds to an inlet pressure at the 4-1000A socket of 0.3" of water.

In making electrical connections to the socket terminals, flexible leads should be used to preserve the freedom of motion of the connector jacks of the socket. A screw driver slot has been provided inside the jacks to hold the jacks while tightening the nuts on the underside of the socket. The first nut seats on a shoulder to prevent clamping the jack to the insulating material. The second nut should be used to secure the connector terminal lugs.



Looking up on a cutaway socket mounted on transparent (for demonstration purposes) deck. Arrows indicate the flow of cooling air. The socket mounts, flush with the bottom of the deck, by means of screws (A). Position clips (B) are on the top of the deck. These clips act to ground the tube base shell and also secure the air-system chimney. Air enters the assembly through duct (C), (not supplied with the socket assembly) which is secured by set-screw (D).



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