(Reprinted from January, 1945 industrial edition of the Eimac News)

Vacuum Tube Ratings

Vacuum Tube Ratings

The data presented on tube data sheets are usually divided into three categories, (1) Electrical and Mechanical Characteristics, (2) Maximum Ratings and (3) Typical Operating Conditions. Electrical and mechanical characteristics are self-explanatory. The typical operating conditions are intended to guide the user in application of the tube under certain "typical" conditions. Several typical operating conditions for each class of service are usually given, with plate voltage as the independent variable. The conditions are chosen so that maximum performance is obtained for each value of plate voltage.

The conditions indicated as "typical" are not the only ones under which the tube can be used, however, and for this reason maximum ratings are given, so that if the user desires to choose his own conditions he will know the maximum capabilities of the tube in regard to certain restricting factors.

Maximum ratings are set solely on a basis of expected tube life. Each rating has been carefully determined by the tube manufacturer as the maximum value which will still permit a reasonable life expectancy for the tube.

Ordinarily the manufacturer sets each limit on an individual basis without regard to any other limit except where such limits are by their nature interdependent within the tube itself. Where the limits are interdependent in this way simultaneous operation at the maximum ratings involved is assumed in setting the limits, which may then be used as individual maximums.

Maximum Plate Dissipation

The plate dissipation of all radiation-cooled Eimac tubes is limited by plate temperature and its effects on parts of the tube other than the plate. The plates of all radiation-cooled Eimac tubes will withstand several times their maximum rated plate dissipation, but the heat generated by such operation has a considerable effect on other parts of the tube. The radiant heat from the plate causes the grid, filament and envelope to become heated, while heat conducted away from the plate by the plate lead contributes to the heating of the plate seal.

These effects are not ordinarily instantaneous, however, and for this reason all radiation-cooled Eimac tubes may be momentarily subjected to plate dissipation in excess of the maximum rating. The maximum plate dissipation rating is intended to set a point where continuous operation may be carried out without damage to any part of the tube, even though the other portions may at the same time be operating at their maximum ratings.

Regardless of other conditions, the maximum plate dissipation rating should not be exceeded in continuous operation. Plate dissipation in excess of the maximum rating is permissible for short periods of time with all Eimac radiation-cooled types.

Maximum Plate Voltage

Since Eimac tubes have no internal insulators, the only purpose of the maximum plate voltage limitation is to set a point above which the glass envelope will become damaged from dielectric losses or to set indirectly a limit to the r.f. charging current flowing in the plate and filament leads. The charging current is a function of the r.f. plate voltage, which is in turn a function of the d.c. plate voltage; this makes it possible to set an adequate limit on r.f. plate current without requiring the difficult task of determining the current directly. Most Eimac maximum plate voltage ratings fall in the r-f-plate-current-limit category. However, an example of the glass-stress type of limit may be seen in the UH-50 data. This tube has the same electrode structure as the 75TL. Due to the fact that its grid and plate leads are adjacent at the top of the envelope, however, the UH-50 has a maximum plate voltage rating of 1250 volts, whereas its counterpart, the 75TL, which has widely separated electrode terminations, has a maximum plate voltage rating of 3000 volts.

Regardless of other conditions, the maximum plate voltage rating should not be exceeded.

Maximum Plate Current

The maximum d-c plate current limit on Eimac tubes is based on the available filament emission. The maximum figure is intended to set a value which may be easily realized throughout the life of the tube. There has been no conclusive indication to date that excessive current has any direct effect on the life of the filament, although there is a certain amount of evidence to support such a belief. However, if operating conditions are chosen which require that the maximum plate current limitation be exceeded at the start of tube life, it may become increasingly difficult to maintain the excessive plate current as the tube ages.

Regardless of other conditions, the maximum plate current rating should not be exceeded.

Maximum Grid Ratings

Maximum grid current ratings, when coupled with maximum bias voltage or maximum r-f grid voltage ratings could conceivably limit grid dissipation. In many tubes, however, there is little justification for an indepedent grid bias or r-f grid voltage rating from a practical standpoint. Actually, of course, excessive r-f or bias voltage could cause excessive seal heating or breakdown of glass insulation. On most Eimac tubes these limitations are more academic than actual, since the magnitudes of voltage required to damage the tube are far in excess of those needed in practice, and their use results in no advantage to the tube user.

In the practical sense, the only grid limitation for most Eimac tubes is grid dissipation. Excessive grid dissipation can result in either primary (thermionic) emission from the grid or in deformation or melting of the grid through overheating. Most Eimac tubes now have non-emissive grids, so that deformation or melting is usually the only result of excessive grid dissipation.

In the past, maximum grid dissipation has been more or less implied, rather than stated, on the Eimac tube data sheet by indicating a maximum grid current value. It was assumed that the tube user would not be likely to use more grid bias than necessary, since this would result in an increase in driving power without other compensating advantages, and that with a maximum grid current rating grid dissipation was thereby limited by practical considerations rather than by a definite statement. When the limit of grid dissipation was exceeded the user was usually made aware of the fact through a falling off of grid current as primary grid emission started to take place. The grid-emission phenomena is characteristic of tubes which do not employ special non-emissive grids, and its meaning is generally understood by the great majority of tube users.

The introduction of the non-emissive grid has led to difficulties with the maximum-grid-current rating, since there is generally little sign of grid emission in these tubes up to the point where the grid is permanently deformed by overheating. Obviously a new system of maximum grid ratings is required.

While it would be possible to set a limit on grid dissipation by giving maximum figures for both grid current and bias or peak r-f voltage, this has not been considered to be advisable since it places unnecessary and artificial restrictions on the application of the tubes. The new method of rating will consist only of a maximum on grid dissipation, and, in a few cases where glass-stem insulation is involved, a limit on r-f grid voltage. This grid-rating system will be used on all future printings of Eimac tube data sheets.

The influence of plate dissipation on grid temperature has been taken into consideration in setting up the grid dissipation maximums. The maximum grid dissipation figure given for each tube may be used simultaneously with maximum rated plate dissipation.

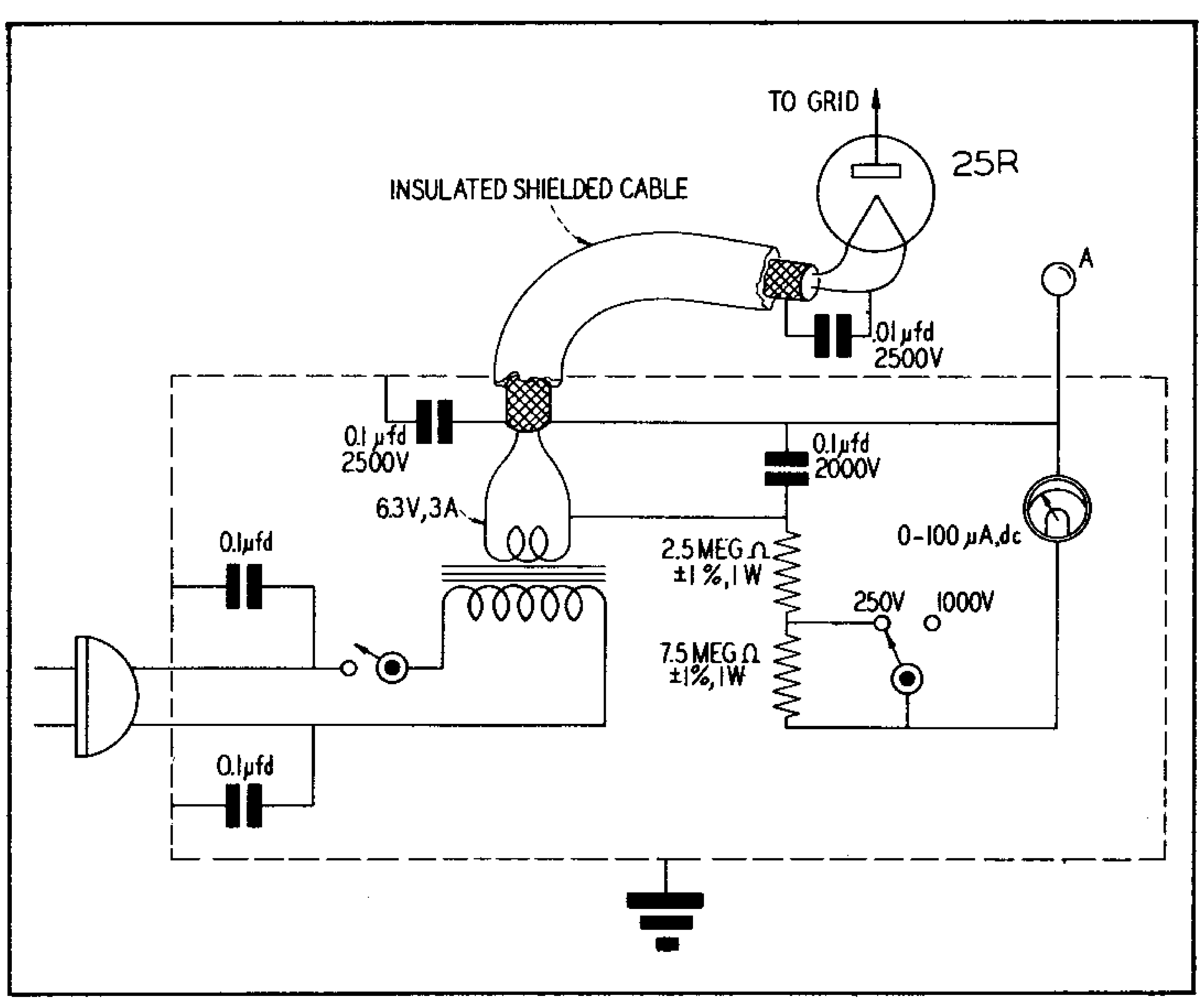


Figure 1. Peak vacuum tube voltmeter for making E_{gm} or e_{cmp} measurements.

Grid Dissipation Measurement

The obvious objection to grid-dissipation ratings is the necessity of determining the actual value of grid dissipation. Since grid dissipation is always equal to the total grid driving power less the power lost in the bias source, it is a simple matter to determine grid dissipation if the driving power is known. Driving power is equal to the driver output less the loss in the coupling circuits between the driver and the amplifier grid circuit (the coupling circuits include the driver plate tank, the coupling transmission line, and the amplifier grid tank, if one is used). Ordinarily, the losses in the coupling circuits will amount to about 30 per cent of the driver output. If this method is used:

$$P_g = N\,(P_{o\ driver}) - E_c I_c$$

Where P_g = Grid Dissipation
N = Coupling Efficiency (Ordinarily $N = 0.7$)
$P_{o\ driver}$ = Driver output power
E_c = D-C Bias Voltage
I_c = D-C Grid Current

Another method of determining grid dissipation is to subtract the bias loss from the driving power calculated by Thomas' formula[1]:

$$P_d = E_{gm}\, I_c$$

Where E_{gm} = Peak R-F grid voltage

Grid dissipation is then approximately equal to:

$$P_g = I_c\,(E_{gm} - E_c) \text{ or alternatively}$$

$$P_g = e_{cmp}\, I_c,$$ [2]

Where e_{cmp} = Peak Positive Grid Voltage

In order to use these expressions for P_g it is necessary to determine either E_{gm} or e_{cmp}. A suitable peak voltmeter for this purpose is shown in figure 1. When terminal (A) is connected to the negative end of the C-bias supply the meter reads E_{gm}. With (A) connected to ground, the meter indicates e_{cmp}. The first method of connection is most useful in measuring total grid driving power. When used to determine grid dissipation or driving power on a push-pull stage by measuring the voltage on each grid separately it may be advisable to shunt the "free" side of the grid tank circuit with a small capacitor having a capacitance equal to that introduced by the v.t.v.m.

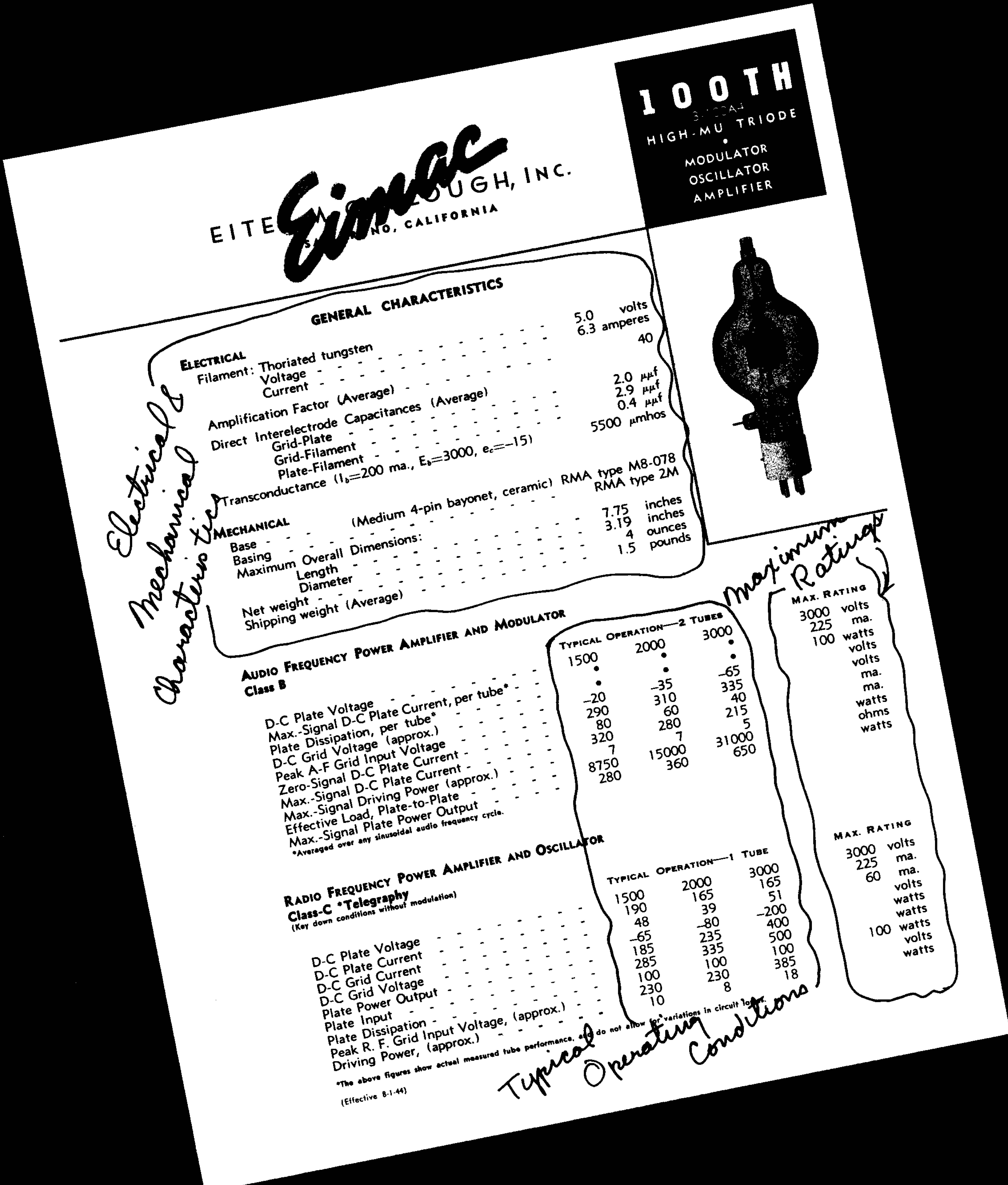
The following is a tabulation of the maximum allowable grid dissipation for a group of Eimac tubes:

TYPE	MAX PG (WATTS)	TYPE	MAX PG (WATTS)
*25T	7	250TL	35
3C24	8	304TH	60
**35T	15	304TL	50
35TG	15	450TH	80
UH50	13	450TL	65
75TH	16	750TL	100
75TL	13	1000T	80
152TH	30	1500T	125
152TL	25	2000T	150
250TH	40		

*Max. E_{gm} 500 v.
**Max. E_{gm} 500 v.

Regardless of other conditions, the maximum grid dissipation rating should not be exceeded.

1. Thomas, "Determination of Grid Driving Power in Radio Frequency Amplifiers," **Proc. I.R.E.**, Vol. 17, p. 1134 (1933).
2. Everitt, "**Communication Engineering**" p. 562; McGraw-Hill.



Eimac

EITE[...]UGH, INC.

S[...]NO, CALIFORNIA

100TH

3-100A4

HIGH-MU TRIODE

MODULATOR
OSCILLATOR
AMPLIFIER

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	5.0 volts
Current	6.3 amperes
Amplification Factor (Average)	40
Direct Interelectrode Capacitances (Average)	
Grid-Plate	2.0 µµf
Grid-Filament	2.9 µµf
Plate-Filament	0.4 µµf
Transconductance (I_b=200 ma., E_b=3000, e_c=−15)	5500 µmhos

MECHANICAL

Base	(Medium 4-pin bayonet, ceramic) RMA type M8-078
Basing	RMA type 2M
Maximum Overall Dimensions:	
Length	7.75 inches
Diameter	3.19 inches
Net weight	4 ounces
Shipping weight (Average)	1.5 pounds

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR
Class B

	Typical Operation—2 Tubes			Max. Rating
D-C Plate Voltage	1500	2000	3000	3000 volts
Max.-Signal D-C Plate Current, per tube*	•	•	•	225 ma.
Plate Dissipation, per tube*	•	•	•	100 watts
D-C Grid Voltage (approx.)	−20	−35	−65	volts
Peak A-F Grid Input Voltage	290	310	335	volts
Zero-Signal D-C Plate Current	80	60	40	ma.
Max.-Signal D-C Plate Current	320	280	215	ma.
Max.-Signal Driving Power (approx.)	7	7	5	watts
Max.-Signal Effective Load, Plate-to-Plate	8750	15000	31000	ohms
Max.-Signal Plate Power Output	280	360	650	watts

*Averaged over any sinusoidal audio frequency cycle.

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR
Class-C *Telegraphy
(Key down conditions without modulation)

	Typical Operation—1 Tube			Max. Rating
D-C Plate Voltage	1500	2000	3000	3000 volts
D-C Plate Current	190	165	165	225 ma.
D-C Grid Current	48	39	51	60 ma.
D-C Grid Voltage	−65	−80	−200	volts
Plate Power Output	185	235	400	watts
Plate Input	285	335	500	watts
Plate Dissipation	100	100	100	100 watts
Peak R. F. Grid Input Voltage, (approx.)	230	230	385	volts
Driving Power, (approx.)	10	8	18	watts

*The above figures show actual measured tube performance, and do not allow for variations in circuit loss.

(Effective 8-1-44)

Front page of a typical Eimac data sheet, annotated to the accompanying discussion on vacuum tube ratings