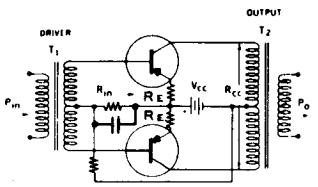
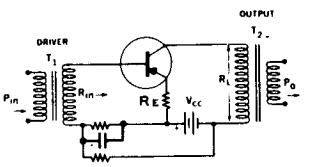
ELCOM Example Calculations For Transistorized Amplifiers.



Class B (Grounded Emitter)
Fig. 1



Class A (Grounded Emitter)
Fig. 2

PROBLEM 1:

To determine required primary impedance of Output Transformer T_2 and Transistor Dissipation.

Example 1

GIVEN:

$V_{CE} = 12$ volts $\approx V_{CC}$ (Supply Voltage)
$P_o = 5$ watts to Speaker Load

SOLUTION:

Assume Transformer Efficiency of 80%. Then Transistor Output power required $= \frac{5}{.8} = 6$ watts.

a. Using nomograph, draw straight line from Output Power of 6 watts on Scale B through Collector Volts V_{CE} of 12 on Scale D. Extend line and read Primary Impedance Rcc of 48 ohms C.T. for Class B operation on Scale E, or R_L of 12 ohms for Class A on Scale F.

b. Read Transistor Dissipation of 1.5 watts each for Class B operation on Scale A, or 12 watts for Class A on Scale C. Verify that Transistor Dissipation ratings are not exceeded.

c. Suitable Class B Output Transformer would be Elcom TO648C which has a rating of 48 ohms C.T. to 4/8/16 at 10 watts.

PROBLEM 2:

To determine primary and secondary Impedances of Driver Transformer (T_1) to match transistor Input Impedance (R_{in}). Also to determine required Driving Power (P_{in}).

For Class B Output Stage
(See Fig. 1 and footnotes)

$R_{in} \approx 4\ h_{ie}$ **(assuming R_E is negligible)**

$$P_{in} \approx \frac{4\ h_{ie}\ Po_{pp}}{(h_{fe})^2 Rcc}$$

For Class A Output Stage
(See Fig. 2 and footnotes)

$R_{in} \approx h_{ie}$ **(assuming R_E is negligible)**

$$P_{in} \approx \frac{h_{ie}\ Po_A}{(h_{fe})^2\ R_L}$$

Example 2

GIVEN:

Assume G.E. 2N656A's or RCA 2N1481's in Class B Output Stage of Example 1, Fig. 1.
Transistor Output Power $Po_{pp} = 6$ watts. $V_{CE} = 12$ Volts.
Primary Impedance R_{cc} of $T_2 = 48\Omega$ C.T.

SOLUTION:

a. Transistor handbook ratings of 2N656 are: $h_{fe} \approx 40$ and $h_{ie} \approx 200$.

b. $R_{in} \approx 4h_{ie} = 4x200 = 800\Omega$ C.T. Secondary Impedance of T_1.

c. $P_{in} \approx \frac{4h_{ie}\ Po_{pp}}{(h_{fe})^2\ Rcc} = \frac{4x200x6}{(40)^2x48} = 62.5$mw.

Allowing for typical transformer efficiency of 75%, Input Power to T_1 should be $\frac{62.5}{.75} = 83.3$mw.

d. Use nomograph to determine primary impedance of Driver Transformer T_1 by drawing line from 83.3mw. on Scale B through 12 volts D.C. on Scale D. Read Class A primary impedance of 850Ω on Scale F.(Assuming Driver is Class A)

e. Suitable Driver Transformer would be Elcom TI26. This transformer has a 1:1 impedance ratio whose impedance values and power handling capacity is close enough to required circuit values for proper performance.

REFERENCE INFORMATION

CLASS B FORMULAS (Assumes> 50mw. power level)

Transistor Power Output, $Po_{pp} = \frac{2V_{ce}^2}{R_{cc}}$ Power Gain, $G_{e_B} = \frac{(h_{fe})^2 R}{4\ h_{ie}}$

Power In, $P_{in} = \frac{Po_{pp}}{Ge_B} = \frac{4h_{ie}\ Po_{pp}}{(h_{fe})^2 R}$ $R_{in} = 4(h_{ie} + h_{fe}R_E)$ (When R_E is not negligible)

CLASS A FORMULAS (Assumes> 10mw. power level)

Transistor Power Output, $Po_A = \frac{V_{CE}^2}{2R_L}$ Power Gain, $G_{e_A} \approx \frac{(h_{fe})^2\ R_L}{h_{ie}}$

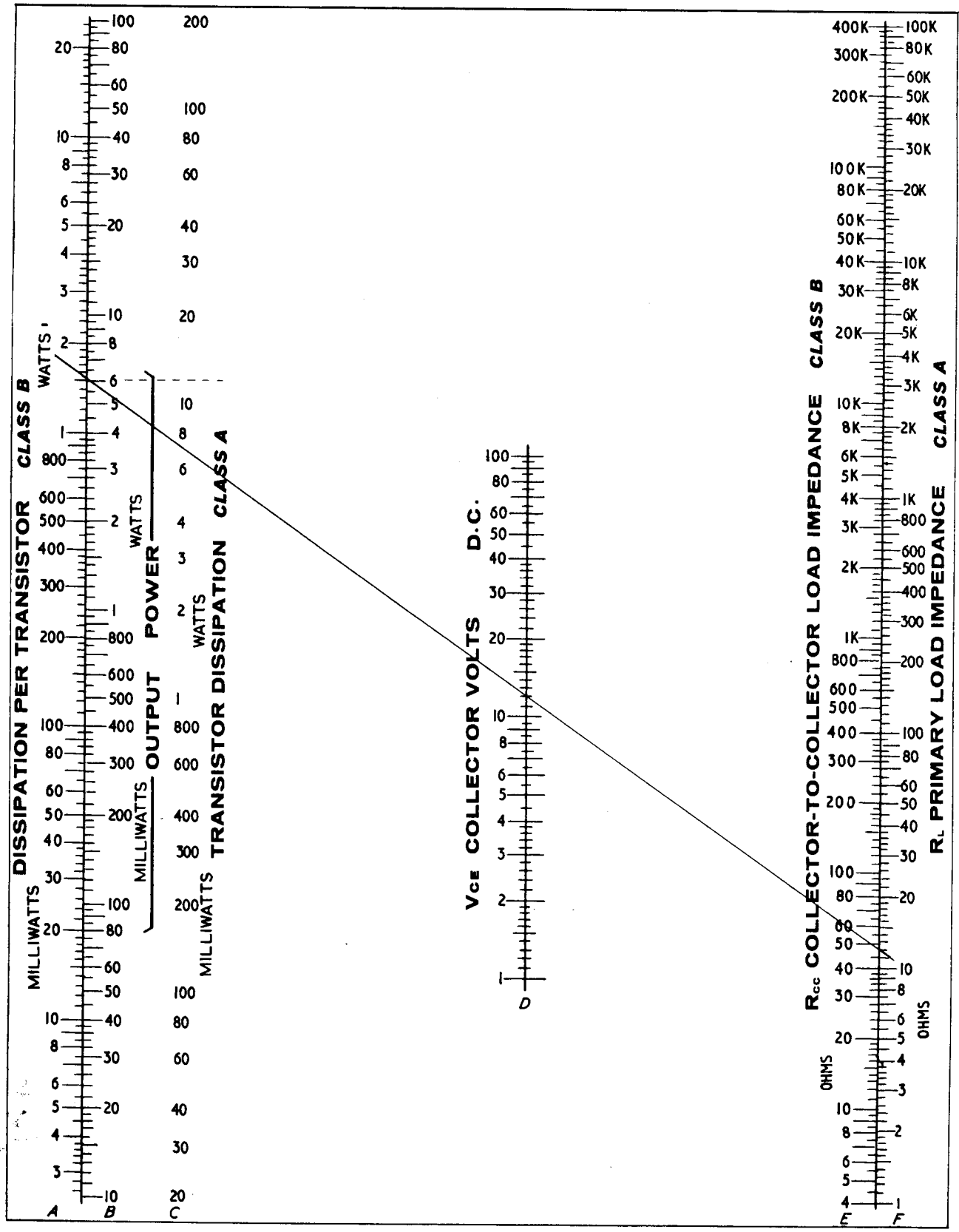
Power In, $P_{in} = \frac{Po_A}{G_{e_A}} = \frac{h_{ie}Po_A}{(h_{fe})^2 R_L}$ $R_{in} = h_{ie} + h_{fe}R_E'$ (when R_E is not negligible)

REFERENCES: Motorola 1960 Power Transistor Handbook pgs. 64-81.
G.E. Transistor Manual 5th Edition pgs. 44-47.

TRANSISTOR LOAD IMPEDANCE AND DISSIPATION NOMOGRAPH

FOR

CLASS A AND B TRANSFORMER COUPLE
TRANSISTOR AUDIO AND SERVO AMPLIFIER

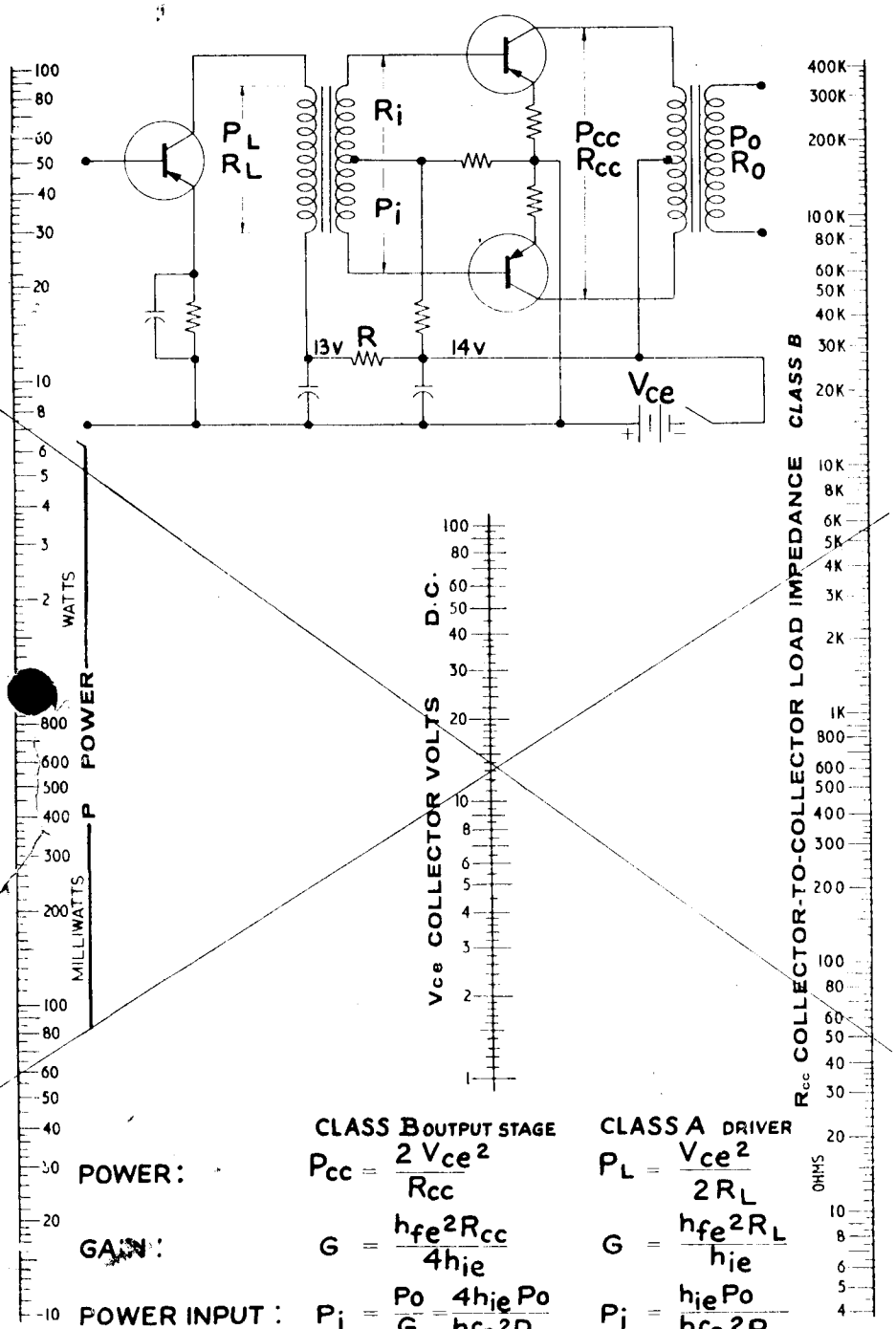


HAMMOND

TRANSISTOR LOAD IMPEDANCE NOMOGRAPH

TRANSISTOR AUDIO AND SERVO AMPLIFIERS

FOR CLASS B TRANSFORMER – COUPLED



	CLASS B OUTPUT STAGE	CLASS A DRIVER
POWER:	$P_{cc} = \frac{2\,V_{ce}^2}{R_{cc}}$	$P_L = \frac{V_{ce}^2}{2R_L}$
GAIN:	$G = \frac{h_{fe}^2 R_{cc}}{4h_{ie}}$	$G = \frac{h_{fe}^2 R_L}{h_{ie}}$
POWER INPUT:	$P_i = \frac{P_o}{G} = \frac{4h_{ie}P_o}{h_{fe}^2 R_{cc}}$	$P_i = \frac{h_{ie}P_o}{h_{fe}^2 R_L}$
INPUT RESIS.:	$R_i = 4h_{ie}$	$R_i = h_{ie}$

NOTES

1. When reading the R_{cc} scale, divide R_{cc} by 4 to get R_L; when entering the R_{cc} scale with R_L, multiply R_L by 4.
2. Pri. load impedance of single-ended stage is $R_L = \frac{R_{cc}}{4}$.
3. These formulae are approximations for convenience. For more exact relations reference should be made to suitable texts, particularly in regard to the transistor parameters, h_{ie} and h_{fe}.

Example: To determine the correct driver and output transformers in the above typical circuit —

V_{ce} = 14V DC amplifier supply
P_o = 6 watts power output
R_o = 8 ohms output impedance

1. Assume the output transformer efficiency to be 80%, then

$$P_{cc} = \frac{6}{0.8} = 7.5 \text{ watts.}$$

2. On the nomograph draw a line from 7.5 watts on **P** scale through 14 Volts on the V_{ce} scale to read 50 ohms on the R_{cc} scale. The nearest Hammond transformer would be the 147R which has a rating of 48 ohms ct to 4/8/16 ohms at 10 watts.

3. The driving power required for a pair of transistors having $h_{fe} = 40$, $h_{ie} = 100$ is $P_i = \frac{4(100)\,(7.5)}{40^2\,(48)} = 39$ mw.

Allowing for 67% efficiency, a driving power P_L of 59 mw should be available.

4. The secondary impedance of the driver transformer is equal to the input resistance (R_i) of the output transistors. R_i is usually specified for Class B power transistors, but where h_{ie} is given, R_i may be found approximately from the relation $R_i = 4\ h_{ie}$. Where $h_{ie} = 100$, $R_i = 400$ ct.

5. The primary impedance can be taken from the nomograph by drawing a line through 59 mw on the **P** scale and 13 volts on the V_{ce} scale. Being single-ended the primary impedance is

$$\frac{5600}{4} = 1400 \text{ ohms.}$$

The transformer is therefore 1400/400 ohms ct at 59 mw rating, and the Hammond type 148F would be about right. (1500/500 ohms ct)