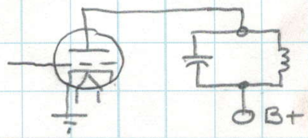
ENGINEERING SKETCH PAD

BY:	DATE:	SUBJECT: PAGE 38, RCA TRANSMITTING TUBE MANUAL	SHEET NO.: PAGE ① of
CHECKED BY:	DATE:	"OPERATING Q" of TANK CIRQUIT	JOB NO.:

→ THE EFFECTIVENESS OF A TANK CIRQUIT'S FLYWHEEL ACTION IS INDICATED BY THE "WATTLESS" POWER (IN VA) DEVELOPED IN THE TANK TO THE ACTUAL POWER (IN WATTS) DELIVERED BY THE TUBE.

* "OPERATING Q" of THE TANK IS AS FOLLOWS:
(AND IS PROPORTIONAL TO THE TANK CAPACITANCE)

$$Q = \frac{C \times f \times E_b}{300 \times I_b}$$



WHERE: C = TOTAL CAPACITANCE ACROSS THE TANK IN $\mu\mu f$.
f = mHz
E_b = DC PLATE POTENTIAL IN VOLTS.
I_b = TOTAL DC PLATE CURRENT OF THE STAGE IN MA.

→ THE IMPEDANCE of A PARALLEL-TUNED CIRQUIT AT RESONANCE (ITS EQUIVALENT RESISTANCE, Req) IS PROPORTIONAL TO THE TANK INDUCTANCE AND INVERSELY PROPORTIONAL TO THE TANK CAPACITANCE AND THE TANK COIL RESISTANCE.

APPROX. Req VALUE = $R_{eq} = \frac{L}{Cr}$

$$\boxed{\begin{array}{ll} X_L = 2\pi f L & f = mhz,\ L = \mu h \\ X_C = \frac{1}{2\pi f C} & f = mhz,\ C = \mu f \end{array}}$$

WHERE: $L = \mu H$
$C = \mu f$
r = AC RESISTANCE OF TANK-CIRQUIT INDUCTOR IN OHMS.

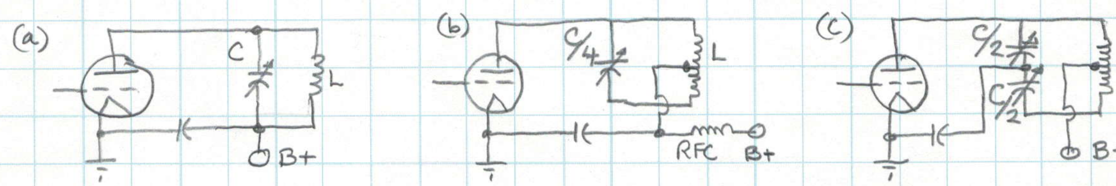
→ BECAUSE THERE IS A CONFLICT between THE CHARACTERISTICS REQUIRED for HIGH OPERATING Q AND THOSE REQUIRED for HIGH EQUIVALENT RESISTANCE, DETERMINATION OF PROPER VALUES for PLATE-TANK CIRQUITS IS OF UTMOST IMPORTANCE IN RF DESIGN.

THE FIRST STEP IN DESIGN IS THE DETERMINATION OF THE MOST SUITABLE OPERATING Q FOR THE TYPE OF SERVICE IN WHICH THE STAGE IS TO BE USED. TOO LOW A Q RESULTS IN A DISTORTED WAVE FORM CONTAINING MANY STRONG HARMONICS AND, THEREFORE, IS WASTEFUL OF POWER AND LIKELY TO PRODUCE STRONG INTERFERENCE. TOO HIGH A Q ON THE OTHERHAND, USUALLY RESULTS IN LARGE CIRCULATING CURRENTS AND, THEREFORE, IN SUBSTANTIAL TANK CIRQUIT LOSSES. A VALUE OF 10~15 IS GENERALLY RECOMMENDED for TELEGRAPHY SERVICE. A VALUE OF 12 IS MOST FREQUENTLY USED IN AMATURE & INDUSTRIAL EQUIPMENT.

→ THE NEXT STEP IS THE DETERMINATION OF THE TANK CAPACITANCE, C, FOR THE Q VALUE AND TUBE OPERATING CONDITIONS SELECTED. THIS VALUE IS OBTAINED FROM THE EQUATION TRANSPOSED TO FORM:

$$C = \frac{300 \times Q \times I_b}{f \times E_b}$$

THE USE OF THIS EQUATION APPLIES ONLY FOR SINGLE-ENDED TANK CIRCUITS WHICH ARE NOT SPLIT FOR NEUTRALIZATION OR OTHER PURPOSES, SUCH AS SHOWN BELOW (a)



WHEN A SPLIT-TANK CIRCUIT IS EMPLOYED FOR A SINGLE ENDED STAGE AS SHOWN IN (b) THE TOTAL CAPACITANCE SHOULD BE ONE-FOURTH THAT INDICATED BY EQUATION. THE CORRESPONDING TANK INDUCTANCE, THEREFORE, IS 4 TIMES THAT REQUIRED FOR A TANK CIRCUIT WHICH IS NOT SPLIT.

If THE TANK CAPACITOR IS A SPLIT STATOR TYPE, FIG (c), EACH SECTION SHOULD HAVE ONE-HALF THE CAPACITANCE INDICATED BY EQUATION.

→ WHEN THE REQUIRED TANK-CIRCUIT CAPACITANCE IS KNOWN, THE TANK INDUCTANCE CAN BE DETERMINED BY THE FOLLOWING EQUATION:

$$L = \frac{a^2 \times N^2}{9a + 10B}$$

WHERE $L = \mu h$

a = RADIUS IN INCHES

B = LENGTH IN INCHES

N = NUMBER OF TURNS

ENGINEERING SKETCH PAD

BY:	DATE:	SUBJECT:	SHEET NO.: PAGE ③ of
CHECKED BY:	DATE:	4CX250B / SSB OPERATION	JOB NO.:

1) PLATE VOLTAGE SELECTED TO BE 1800 VOLTS; GRID #2, 350 VOLTS.

2) POINT "A" FIG. 46 = 0.60 AMPS = $I_{b\,max}$ @ $E_{b\,min}$ 350 VOLTS. (PK PLATE CURRENT for ZERO BIAS)

3) SELECT VALUE of ZERO-SIG. PLATE CURRENT (I_{bo}) BETWEEN 1/6 & 1/10 of $I_{b\,max}$ found IN (2).
$I_{bo} = (1/6) \times 0.60 = 0.1$ AMPS ← POINT "B" FIG 46 @ 1800 VOLTS & 0.1 AMPS

4) DETERMINE MINIMUM PLATE VOLTAGE ($E_{b\,min}$) from POINT of $I_{b\,max}$ found IN (2)
$E_b = 1800$ VOLTS & $I_{bo} = 0.1$ AMPS (POINT "B")

5) E_{c1} @ ZERO SIGNAL IS ≈ −50 VOLTS @ POINT B

6) $I_{be} = I_{b\,max}/3 = 0.6/3 = 0.20$ AMPS

7) $I_b = I_{be}/1.4 = 0.20/1.4 = 0.14$ AMPS

8) FIG 47 $E_b = 350$ VOLTS AND E_{c1} 70 ON GRID #2. READ $I_{c2\,max} \cong 30$ mA (.030A)

9) $I_{c2e} = I_{c2\,max}/4 = .030/4 = .0075$A or 7.5 mA (#2 GRID GRID CURRENT @ PK of ENVELOPE)

10) $I_{c2} = I_{c2e}/1.4 = .030/1.4 = .021$A or 21 mA = (AVG GRID #2 CURRENT)

11) AVG GRID #2 DISSIPATION (P_{c2}) $\cong E_{c2} \times I_{c2} = 350 \times .021 = 7.35$ WATTS ← MAX = 12 WATTS! OK!

12) PEAK ENVELOPE POWER INPUT (P_{ine}) = $E_b \times I_{be} = 1800 \times 0.20 = 360$ WATTS ← VERY HIGH BUT IS PEAK

13) PEP OUTPUT = $(I_{b\,max}/4)(E_b - E_{b\,min}) = (0.60/4)(1800-350) = 217.5$ WATTS

14) AVG PLATE DISSIPATION (P_p) = $0.7\,P_{ine} - 0.5$ PEP $= 0.7(360) - 0.5(217.5) = 143.25$ WATTS

15) AVG POWER OUTPUT (P_o) = PEP/2 = 217.5/2 = 108.75 WATTS

16) EFFECTIVE RF LOAD RESISTANCE (R_p) = $2(E_b - E_{b\,min})\ I_{bo} = 2(1800-350)/0.60 =$
4833 Ω for 1 TUBE

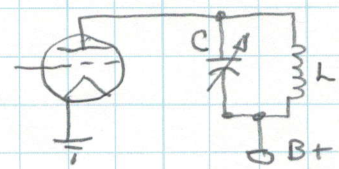
$R_p \approx 2417\,\Omega$ for 2 TUBES

410-00V Rev. 12-85 0741-900100 PD/50

ENGINEERING SKETCH PAD

BY:	DATE:	SUBJECT:	SHEET NO.: PAGE of (4)
CHECKED BY:	DATE:	4CX250B $E_b = 1800$ VOLTS $I_b = 600$ mA	JOB NO.:

EXAMPLES: (@ $f_0 = 3.5$ mhz)



ASSUME: $L = 28 \mu h$ | $X_L = 615.8 \Omega$

$C = 74 \mu\mu f$ | $X_C = 614.5 \Omega$

$f_0 \cong$ 3.5 mhz

APPROX. LOAD RESISTANCE =

$$R_{EQ} = \frac{L}{Cr} \qquad \frac{28}{.000075(615.8)} = \frac{28}{.0462} = 606.2 \Omega \text{ LOAD}$$

TOO LOW

$L = \mu h$

$C = \mu f$

r = AC RESISTANCE of TANK INDUCTOR IN OHMS (X_L)

$$Q = \frac{C \times f \times E_b}{300 \times I_b} \qquad Q = \frac{74 \times 3.5 \times 1800}{300 \times 600} = 2.59$$

TOO LOW

C' = TOTAL CAP. IN $\mu\mu f$ ACROSS TANK.

f = mHz

E_b = DC PLATE POTENTIAL.

I_b = TOTAL DC PLATE CURRENT IN MA.

ASSUME: $L = 14 \mu h$ | $X_L = 307.9 \Omega$

$C = 148 \mu\mu f$

$f_0 =$ 3.5mhz

$$R_{EQ} = \frac{L}{Cr} = \frac{14}{.000148(307.9)} = 307.9 \Omega \text{ LOAD}$$

TOO LOW ?

$$Q = \frac{C \times f \times E_b}{300 \times I_b} = \frac{148 \times 3.5 \times 1800}{300 \times 600} = 5.18$$

BETTER !!

ASSUME: $L = 5 \mu h$ | $X_L = 110 \Omega$

$C = 413.6 \mu\mu f$

$f_0 =$ 3.5mhz

$$R_{EQ} = \frac{L}{Cr} = \frac{5}{.000414(110)} = 109.9 \Omega \text{ LOAD}$$

REAL LOW!

$$Q = \frac{C \times f \times E_b}{300 \times I_b} = 14.48$$

GOOD!

Q = 12!

$$C = \frac{300 \times Q \times I_b}{f \times E_b} = \frac{300 \times 12 \times 600}{3.5 \times 1800} = 342.9 \mu\mu f = C'$$

$X_C = 132.6 \Omega$

$L = 6.03 \mu h$

ENGINEERING SKETCH PAD

BY:	DATE:	SUBJECT:	SHEET NO.: PAGE of 5
CHECKED BY:	DATE:	4CX250B E_b = 1800 VOLTS, I_b = 600 mA	JOB NO.:

L = 6.03 μh

3.5 mhz

Q = 12

$$C = \frac{300 \times Q \times I_b}{f \times E_b} = \frac{300 \times 12 \times 600}{3.5 \times 1800} = 342.9\ \mu\mu f = C$$

X_C = 132.6 Ω

L = 6.03 μh

4.0 mhz

Q = 12

$$C = \frac{300 \times 12 \times 600}{4.0 \times 1800} = 300\ \mu\mu f$$

X_C = 132.6 Ω

L = 5.28 μh

or for L = 6.03 μh @ 4.0 mhz,

Q = 10.5

X_L = 151.6 Ω

C = 262 μμf

L = 4.99 μh

3.5 mhz

Q = 14.5

$$C = \frac{300 \times 14.5 \times 600}{3.5 \times 1800} = 414.3\ \mu\mu f = C$$

X_C = 109.8 Ω

L = 4.99 μh

4.0 mhz (L = 4.99 μh @ 4.0 mhz)

Q = 12.69

X_L = 125.4 Ω

C = 317.2 μμf

≈ 250 pf

L = 5.5 μh

3.5 mhz: X_L = 120.95 Ω, C = 376 μμf, Q = 13.16

4.0 mhz: L = 5.5 μh, X_L = 138.23 Ω, C = 287.8 μμf, Q = 11.51

IDEAL

90 pf SPREAD

7.0 mhz: L = 3.02, X_L = 132.8 Ω, C = 171.2 μμf, Q = 11.98

7.3 mhz: L = 3.02 μh, X_L = 138.4 Ω, C = 157.5 μμf, Q = 11.5

≈ 110 pf

1.8 mhz: L = 10.8 μh, X_C = 122.4 Ω, C = 722 μμf, Q = 13.0

2.0 mhz: L = 10.8 μh, X_L = 136.03 Ω, C = 585 μμf, Q = 11.7

≈ 550 pf

ENGINEERING SKETCH PAD

BY:	DATE:	SUBJECT:	SHEET NO.: PAGE of 6
CHECKED BY:	DATE:	4CX250B $E_b = 1800$ VOLTS, $I_b =$ 600mA	JOB NO.:

14.0 mhz	L = 1.39 µh X_C = 122.43 Ω C = 92.9 µµf Q = 13.0	14.35 mHz	L = 1.39 µh X_L = 125.49 Ω C = 88.3 µµf Q = 12.68	+50pf
21.0 mhz	L = 0.96 µh X_C = 127.32 Ω C = 59.52 µµf Q = 12.5	21.450 mHz	L = 0.96 µh X_L = 130.05 Ω C = 57.05 pf Q = 12.24	+15pf
28.0 mhz	L = 0.72 µh X_C = 127.32 Ω C = 44.64 µµf Q = 12.5	29.7 mhz	L = 0.72 µh X_L = 135.05 Ω C = 39.7 µµf Q = 11.78	0pf
10.1 mhz	L = 2.01 µh X_C = 127.32 Ω C = 123.8 µµf Q = 12.5	10.15 mhz	L = 2.01 µh X_L = 127.95 C = 122.5 µµf Q = 12.44	80pf
18.068	L = 1.12 µh X_C = 127.32 Ω C = 69.18 µµf Q = 12.5	18.168	L = 1.12 µh X_L 128.03 Ω C = 68.4 µµf Q = 12.43	
24.89 mHz	L = 0.81 µh X_C = 127.32 Ω C = 50.22 µµf Q = 12.5	24.99 mhz	L = 0.81 µh X_L = 127.84 Ω C = 49.82 µµf Q = 12.45	10pf

ENGINEERING SKETCH PAD

BY:	DATE:	SUBJECT:	SHEET NO.: PAGE of 7
CHECKED BY:	DATE:		JOB NO.:

EXAMPLE PAGE 306 –

(10 TURNS #10
1" DIA
2" LONG)

$$\frac{a^2N^2}{9a+10b} = \frac{\cancel{7.8\mu}}{24.5}\ 7.8\mu h = \frac{.5^2(10)^2}{} = \frac{25}{4.5+20} = \frac{25}{24.5} = 1.02\mu h$$

14 mHz TOTAL

$$28\,mHz = \frac{.5^2 \times 4.5^2}{9(.5)+10(.9)} = \frac{5.0625}{13.5} = 0.375\mu h$$

$$21\,mhz = \frac{.5^2 \times 7.5^2}{9(.5)+10(1.5)} = \frac{14.0625}{19.5} = 0.721\mu h$$

$$14\,mhz = \frac{.5^2 \times 10^2}{9(.5)+10(2)} = \frac{25}{24.5} = 1.02\mu h$$

THESE FIGURES MATCH DATA FOR PI NETWORK ON P. 302 (811-A LINEAR)