6/4/58

Morecroft page 258 1927 edition

$$\text{Decrement} = \frac{\text{Energy dissipated}}{\text{Energy transferred}} = \delta = \frac{R}{2fL}$$

$$\frac{\delta}{\pi} = \frac{R}{2\pi f L} = \frac{1}{Q} \quad \text{or} \quad \delta = \frac{\pi}{Q}$$

$$\%\ \text{Loss} = \frac{\delta}{1+\delta} \times 100 = \frac{\frac{\pi}{Q}}{1+\frac{\pi}{Q}} = \frac{\frac{\pi}{Q}}{\frac{Q+\pi}{Q}} = \left(\frac{\pi}{Q+\pi}\right) 100$$

When $Q \gg \pi$

$$\text{Percent loss} = \frac{314}{Q}$$

If energy dissipated $= \Delta$, then $\delta = \frac{\Delta}{1-\Delta} = \frac{\pi}{Q}$

$$\text{Percent loss} = \frac{\Delta}{1} \times 100$$

$\Delta Q = \pi - \Delta\pi$ or $\Delta(Q+\pi) = \pi$, so $\Delta = \frac{\pi}{Q+\pi}$

$$\text{Percent loss} = \left(\frac{\pi}{Q+\pi}\right) 100 = \frac{314}{Q+\pi} \text{ percent}$$

8/4/56

Antenna Transformer Primary Design

Core is four slugs of powdered iron 1" long x 3/4" dia well faced and joined. Overall core 4" long, 3/4" dia. Wire is .093" O.D., enameled. Windings centertapped.

Design			A	B	C	D	E
Tube material			Poly	Paper	Paper	Paper .063 Poly .077	Paper
Tube wall thickness			.010"	.025"	.063"	.140"	.063"
Winding Turns			62	61	60	62	57
Winding length			2 5/8"	2 9/16"	2 9/16"	2 5/8"	2 1/2"
Without Cores	1700 KC	C	437.0	422.0	360.5	255.0	400.0 (1475 KC)
	1700 KC	Q	142	140	147	154	30 (1475 KC)
	3900 KC	C	107.0	103.5	98.3	62.0	100.0 (2290 KC)
	3900 KC	Q	187	187	189	193	10 (2290 KC)
	C_0 in pf		3.0	2.7	2.4	2.7	130
	L_0 in uh		19.9	20.6	23.2	34.0	22.0
With Cores	600 KC	C	419.0	430.5	427.0	403.0	400.0 (610 KC)
	600 KC	Q	68	73	79	88	20 (610 KC)
	1200 KC	C	99.0	102.5	102.5	97.4	100.0 (920 KC)
	1200 KC	Q	39	46	55	72	6? (920 KC)
	C_0 in pf		7.7	6.8	5.7	4.5	136
	L_0 in uh		16.5	161.3	163.0	173.0	127.0
	Permeability		8.29	7.82	7.02	5.09	5.8

(over)

interwound Primary

As winding is moved away from core the iron losses decrease, Q rises, permeability and capacity decrease.

Interwound Primary

Column Design E had only 3 cores each 1" long. Added measures on Q as follows.

Freq	456	475	500	525	550
Q	29	28	26	25	24
Approx C	838	760	674	606	536
X_L Ω			398Ω		
X_{C_0} Ω			2340Ω		

Interwinding produces very high distributed capacity. The capacity is poor power factor enamel on wire which makes a low Q.

3/4/58

Antenna Transformer Shield Design

A tube of 1/16" wall and 7/8" I.D. was placed over primary design "B". Shields with fingers 3/16" wide and spaces 1/8" wide were made. First one and then two shields were used overlapping to give entire metal coverage with insulation between shields.

		1 Solid Brass	1	2	1	2
Number of Shields						
Tube material		Paper	Paper	Paper	Poly	Poly
Insulation between shields		—	—	Scotch	—	Poly
Without Cores	1700 KC C	441.0	415.0	421.0	415.0	420.5
	1700 KC Q	90	110	61	119	75
	3400 KC C	103.5	98.0	99.2	99.8	100.5
	3400 KC Q	103	114	70	151	100
	C_o in pf	9.0	7.7	8.1	5.2	6.2
	L_o in uh	19.5	20.7	20.5	20.8	20.5
	Percent reduction L_o					
With Cores	600 KC C	452.0 (625 KC)	424.0	435.0	424.0	439.0
	600 KC Q	40 (625 KC)	45	21	47	25
	1200 KC C	103.0 (1250 KC)	96.5	101.0	98.2	103.5
	1200 KC Q	35 (1250 KC)	32	19	35	25
	C_o in pf	13.3	12.7	7.8?	10.4	8.3
	L_o in uh	140.0	161.0	159.0	162.0	157.0
	Percent reduction L_o					
	Permeability					
	Percent reduction Perm.					

8/4/56

Antenna Transformer Shield Design.

Ten turns of .001" thick poly tape were wound over the primary design "D". Then a brass shield .003" thick, 3" wide fastened over poly tape. Shield circumference $3\frac{5}{8}$".

		A	B	C	D	E
Design		A	B	C	D	E
Number of slots		1	2	4	8	16
Without Cores	1700 KC C	261.5	258.0	254.0	246.5	243.0
	1700 KC Q	75	69	64	60	71
	3400 KC C	49.0	47.2	47.1	44.5	46.0
	3400 KC Q	51	45	45	39	46
	C_o in pf	21.8	23.1	21.9	22.8	19.7
	L_o in μh	31.0	31.2	31.8	32.6	33.4
	Percent reduction L_o	8.9	8.2	6.5	4.1	1.8
With Cores	600 KC C	461.0	453.0	430.0	418.0	400.0
	600 KC Q	40	35	30	26	36
	1200 KC C	97.3	95.0	92.6	87.3	85.0
	1200 KC Q	38	34	30	25	26
	C_o in pf	23.9	24.3	19.9	22.9	20.0
	L_o in μh	145.0	147.5	156.5	159.5	167.5
	Percent reduction L_o	16.2	14.7	9.6	7.8	3.2
	Permeability	4.67	4.73	4.92	4.89	5.01
	Percent reduction Perm.	8.3	7.1	3.4	3.9	1.6

All slots about .020" wide along axis of coil from both ends to 1/8" from center of coil.

Antenna Transformer Shield Design (continued)

F	G	H	I	J	K	L	M
	Fingers .035" spacial .015" button .050"	Same as G. Shield bound tighter. Fewer & shorter fingers	Same as H. Now two slots spaced .01" across tape between			Wire fingers .015" dia. spaced .050" center to center. Shield to insulating cloth.	
32	73	73	73			70	
241.0	243.0	237.0	236.0			241.5	
84	111	96	86			106	
46.0	49.2	42.8	42.2			48.2	
49	78	46	41			55	
19.0	15.4	21.9	22.4			16.2	
33.8	33.9	33.8	33.9			34.0	
0.6	0.3	0.6	0.3			0	
390.0	390.0	384.0	385.0			389.0	
45	70	65	59			73	
82.5	85.1	79.0	79.0			84.1	
31	45	36	33			42	
20.0	16.5	22.7	23.0			17.5	
171.5	173.0	173.0	172.7			173.0	
0.9	0	0	0.2			0	
5.07	5.10	5.11	5.09			5.07	
0.4	0	0	0			0	

* shield 3 9/16" overall long, 3" wide, 1/4" center rib

C_0 changes somewhat because it was not possible to fasten shield onto assembly with same tightness each time.

8/4/56

Antenna Transformer Secondary Design

Primary coil design "C" was used, a 1/16" wall paper tube placed over primary. Secondary 1 3/32" I.D, 70 turns .035" dia enameled wire 2 1/2" long with 3/16" gap at center of winding. No shield between windings.

Core		Air		3" iron		4" iron	
Primary	C	430.0	1500KC	425.0	625KC	395.0	600KC
	Q	73		34		41	
	C	75.0	3000KC	73.0	1250KC	65.5	1200KC
	Q	—		—		16	
	Co pf	43.3		44.3		44.3	
	L uh	23.8		138.0		160uh	
	Permeability	1		5.8		6.72	
Secondary	C	440.0	1100KC	415.0	550KC	436.0	500KC
	Q	53		39		53	
	C	91.0	2200KC	79.0	1100KC	85.5	1000KC
	Q	—		—		25	
	Co pf	24.0		25.0		31.3	
	L uh	45.5		193.0		216.0	
	Permeability	1		4.25		4.75	
Primary plus Secondary	C	460.0	650KC	415.0	300KC	437.0	270KC
	Q	55		37		51	
	C	91.0	1300KC	79.5	600KC	85.0	540KC
	Q	—		—		26	
	Co pf	32.0		32.2		32.2	
	L uh	122.0		590		742.0	
	Permeability	1		4.83		6.09	

(over)

Core	Air	3" iron	4" iron
Mult	26.4	129.5	183
K %	80.2	79.2	98.5

Apparently the cores concentrate flux toward center of assembly and thus increase the primary inductance more than secondary.

Also extending cores an extra 1/2" beyond each end of winding causes stray fields to more nearly go thru both primary and secondary. Thus the coupling is increased to nearly 100%, a very desirable condition and well worth extra length of core.

Secondary should be two parallel windings wound in opposite directions on two halves of primary. The inside ends of secondary to be at high potential and outside ends to have taps switches to ground. Each winding to be 86 turns .012" wire tapped every 4 turns for 44 turns from outside end.

21-7-56

This transformer in tuner box "A"

Antenna Transformer.

Made up new transformer as follows,

A { Four cores each 1" long gave total length 4" x 3/4" diameter.

B { .063" wall paper tube 3 15/16" long } Total insulation 0.140"
.077" wall poly tube 3 1/2" long }

C { Primary 62 T, center tapped enameled wire 2 15/16" long.

D { .001" Poly tape 3/4" wide, 8 turns each side of center and 5 turns at each end. This compensates for scotch tape holding ends of primary and gives a smooth cylinder.

E { Faraday shield .003" brass 3" wide, 3 9/16" circumference, 32 fingers with .015" spacing approximately between fingers. Shield held in place by single layer of scotch tape.

F { .001" Poly tape 3/4" wide, 10 turns each of four pies to give a smooth cylinder. Single turn scotch tape over joints between pies.

G { Double secondary. Two halves wound in same direction with starts at center of assembly and working toward ends. #27 SWG enameled wire .0164" dia. Each half 73 turns tapped at 36 turns, 1 5/16" long. Space between two windings at center of assembly 3/16".

H { Two coats of collodion.
Entire assembly about 1 1/4" diameter. (Performance Over)

Length of wire in each half of primary 8 ft 7 inches.
Primary wire .0475 over enamel, .0450 copper
Secondary wire, .0179 " " , .0164 "

	Primary with Shield in place but no secondary	Primary only of entire assembly	Secondary only of entire assembly	Primary and secondary series aiding	Same but two coats of collodion applied over secondary.
Test Frequencies { Lower	600	550	500	255	255
Test Frequencies { Upper	1200	1100	1000	510	510
Lower Frequency { C pf	415.0	456.0	400	460	453
Lower Frequency { Q	47	35	34	40	39
Upper Frequency { C pf	75.7	48.0	53	67	64
Upper Frequency { Q	25	10	12	18	16
Distributed Capacity C_0 pf	37.4	88.0	62.7	64.0	65.7
Inductance, μh	155.8	154.0	218.3	745.0	751.0
$M = [L - (L_p + L_s)]/2$				186.4	189.4
$K = 2M/(L_p + L_s)$ percent				100.2	101.7

Slight errors in frequency and capacity make coupling appear greater than 100%. Probably about 99% actual.

Percent loss = 314/(35+3.14) = 8.2%
DB loss = 0.75 DB
Transformer efficiency = 91.8%

Distributed capacity of primary went way up when secondary added because shield now bound down tight to primary. Apparently more poly tape is needed between primary and shield.

5/8/56

This transformer in tuner box "B"

Antenna Transformer

General design same as 31-7-56. Details as follows.

A {Core same

B {Paper tube same
Poly tube 3¾ inches long

C {Primary 61 turns

D {Poly tape 16 turns near center and 14 turns at ends

E {Shield 3.1" wide, 3.6" long, 36 fingers, slots .02" wide. Fingers must be cut across grain of rolling to lie reasonably flat. If cut along grain of rolling large internal stresses are released and fingers curl and twist all out of shape and will not lie flat.

F {Poly tape same

G {Secondary wire .0158" over enamel, .0136" copper, #29SWG.
Each half has 88 turns with taps at 80 and 70 turns, 1⅜" long.
Space between windings at center ⅛" approx.

H {Collodion same.
Diameter same.   (Performance over)

Primary wound so that when looking at end of winding the direction of wire is clockwise when coming toward observer.

Secondary wound so that both inside ends are in same direction.

To be series aiding, both outside ends of secondary are connected together and to appropriate end of primary such that wire of two windings continues to turn in same direction.

		Primary only of the entire assembly	Secondary only of the entire assembly	Primary and secondary series aiding.
Test Frequencies	Lower KC	550	450	230
	Upper KC	1100	900	460
Lower Frequency	C pf	147	341	463
	Q	36	39	49
Upper Frequency	C pf	37	48.5	77.8
	Q	8	12	23
Distributed Capacity C_o pf		100	49.0	49.0
Inductance, uh.		153.0	320.7	945
M uh				235.5
K %				99.5

↑

Closing and opening secondary had no effect

Some peculiarity about increase of distributed capacity in primary over previous transformer even when more poly tape used between primary and shield. This should be investigated.

29/11/56

Transformers for Boxes C & D

Cores & tubing same.

Pair 62T enamelled centertapped.
2 7/8" long. dia over enamel.

10 turns poly tape each side centre
8 " " each end.

8/12/56

Shield same as others 36 fingers 0.10"

Four turns poly tape as this is all that remained.

10/12/56

Transformer box C

		Primary only of the entire assembly	Secondary only of the entire assembly	Primary and Secondary & Series aiding
Test Frequencies	Lower KC	520	450	225
	Upper KC	950	900	450
Lower Frequency	C pf	463	325	466
	Q	27	31	41
Upper Frequency	C pf	42 (error?)	31	66.2
	Q	5	8	12
Distributed Capacity C_o pf.		138.0	67.0	67.1
Inductance, µh		158.0	319.5	940.0
M µh				232.3
K %				97.9

Using less poly tape between primary to shield and shield to secondary increased the distributed capacity by 1/3 and reduced the Q at 500KC by 1/4 on pri and 1/5 on secondary and 1/6 on entire assembly. This is due to greater dielectric loss. The larger amount of insulation on transformer B is worth while. The inductances are not affected by any measurable amount.

(see over)

2/5/57

Put on new secondaries. Each 69 turns tapped at 55, 60, 65 turns.
Winding length 1 13/32".
Space between windings at center 1/8".
Wire #25 B+S. .0179" copper .0200" over enamel
Capacities went up a bit. Perhaps tighter winding.

	Primary alone of the Entire Assembly.	Secondary alone of the Entire Assembly.	Primary + Secondary Series Aiding.
Test Frequencies { Lower KC	535	500	260
Upper KC	1070	1000	520
Lower Frequency { C pf	460	434	458
Q	29	30	38
Upper Frequency { C pf	32	45	56
Q	5	8	10
Distributed Capacity C_o pf	110.7	89.7	78.0
Inductance, uh	154.5	194.0	699
M uh			175.2
K %			100.6

10/12/56

Transformer in Box D

		Primary only of the entire assembly	Secondary only of the entire assembly	Primary and secondary series aiding.
Test Frequencies	Lower KC	520	450	225
	Upper KC	950	900	450
Lower Frequency	C pf	456.5	326.0	462.0
	Q	28	31	41
Upper Frequency	C pf	42	31	65.3
	Q	5	8	12
Distributed Capacity Co pf		138.0	67.3	66.9
Inductance, uh		157.8	318.0	947.0
M uh				235.6
K %				99.1