RF Note #13

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8/20/77
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The transmitter + ~~parasitics~~

The design of the output stage of the final transmitter is gelling. We propose to use the Eimac 100,000W tube. Now the whole thing about a driven final is to make sure it doesnt parasitically self oscillate, and secondly to minimize the drive requirements. To reduce the liklihood of parasitic oscillations one minimizes the number of components and keeps them simple, and one arranges to have the grid circuit be very lossy for frequencies higher than the operating range of frequencies. To minimize the drive requirements one operates the anode at as high a voltage as is practicable because the tube current is determined by the drive voltage but the output power by the voltage times the current. ~~The~~ Eimac rates the B+ supply as 20 KV maximum, so we buy a 20 KV power supply but plan to run at 17 KV. Assuming 2 KV min. instantaneous plate voltage, the peak r f swing is 15 KV, r m s is 10.5 KV and the peak to peak voltage is 32 KV.

The calculated output power required is about 50KW, so we design for 75KW. ~~Thus the Ams tube current must be~~ Further, although we can probably achieve 80% effeciency, we assume only 60%. So the power supply must be rated at 20KV, 7.5 amps dc for each of 3 transmitters. $150 \times 3 = 450$ KW B^+ supply. The rms tube current must be $\frac{75 \cancel{+50}}{10.5} = 7$ amps.

~~The ratio of the plate rf voltage~~ and the impedance into which the tube is working is $(1.06 \times 10^4)^2 / 7.5 \times 10^4 = \cancel{3400}\ 1500\,\Omega$.

The tube has a plate capacity of 60 pf, but with the addition of the blocker, and the blocker choke, this will probably increase to 70 pf. This capacity will be in series with the blocker capacity of say 1000 pf, so that the effective capacity on top of the resonator will be $70 \times 1000/(70+1000) = 65$ pf. Now it is proposed that the resonator be a $\lambda/4$ transmission line loaded with this 65 pf, and that this line be a 6" O.D. pipe inside a 3 ft square box. Setting d = diam of center cond. and D the sides of the square we set $\rho = D/d$ and $A = 1 + 0.405\rho^{-4} / (1 - 0.405\rho^{-4})$,

$$B = (1 + 0.163\rho^{-8}) / (1 - 0.163\rho^{-8})$$

$$C = (1 + 0.067\rho^{-12}) / (1 - 0.067\rho^{-12})$$ and find Z_0

$$Z_0 = [138 \log \rho + 6.48A - 0.48B - 0.12C]$$

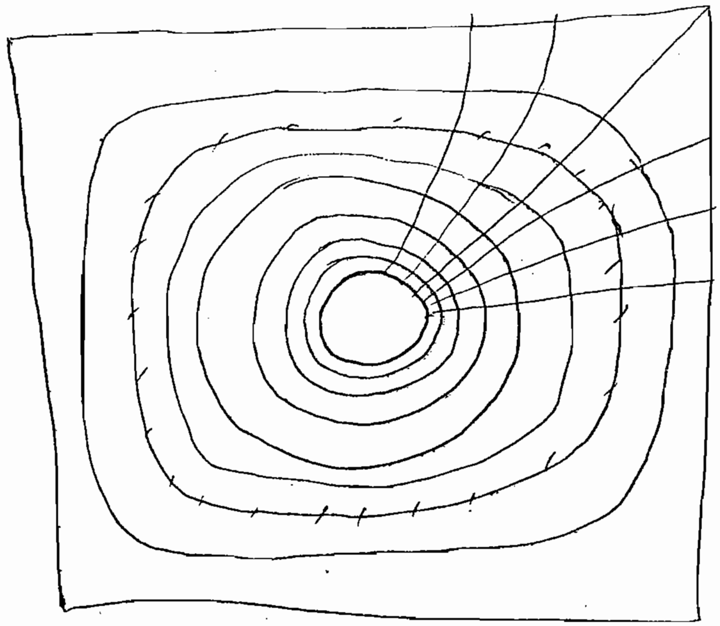
$$= 107 + 1.0003 - 1.[illegible] = 107\,\Omega$$

For this large $a\rho$ the Z_0 is the same as for a coax line of diameters d and D. The phase angle of the incident wave at the anode is atn $\frac{I Z_0}{V_t}$ = atn $\omega C Z_0$ = 67.55°, 1.18 rad so at
60 mHz we need a line of 22.4° or 12 inches
and at 15 mHz " " " " " 58.8° or 10.7 ft

SEE RF NOTE # 18 APPENDIX # 1

It will be difficult to push the sliding short to 12", so in the region where the tube is we will ~~reduce~~ reduce Z_0 by bringing in false walls. To couple the power out into a 50 Ω load we will use a loop which intercepts a constant fraction of the total flux as the short moves. The radial position of this loop, which ideally would be an angular fraction of a third cylinder in a circular transmission line, in fact lies along the ~~fr~~ fractional periphery of a magnetic field line. ~~This li~~ Since the flux intercepted by this loop wants to be $\sqrt{50/1500}$ = .183 of the total flux. So one plots the magnetic field lines and on ~~the~~ a orthogonal field lines integrates the ~~tl~~ total flux and identifies the magnetic field line which has .183 of the total flux between it and the sides of the box.

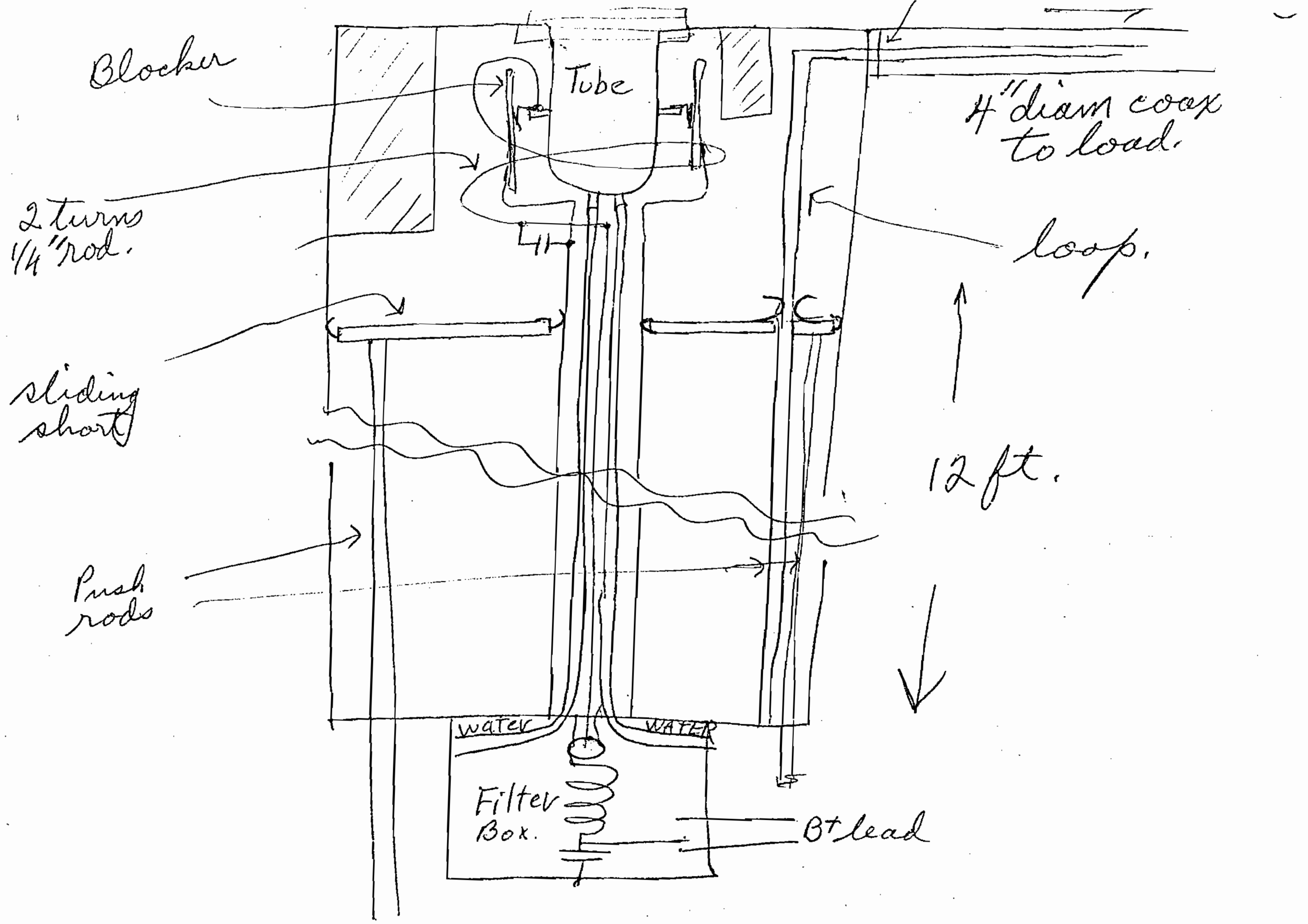
The plot will look something like this.



Having done this one can count up the ~~total number of squares, divide by the number of field magnetic field lines and be content with the number 107 ohms multiply by 377~~ the number of magnetic field lines, divide by the number electric field lines, multiply by 377 and be content with an answer of 107 Ω.
Let us assume that the hashed line is the line that has .183 of the flux between it and the wall. This is an equipotential line and a conductor can be placed here. ~~If one calculates the impedance Z1 of this line to the wall one finds that it is 50 Ω and the impedance to the center conductor is 107 − 50 = 57 Ω~~

In the circular approximation of this configuration one finds that if r_1 = inner radius = 3 inches, r_3 = outer radius = 18" then r_2, the radius of the loop is 13" and ~~that~~ the impedance to ground of r_2 is 19.5 Ω and that inorder for our loop to have a Z_0 of 50 Ω we would only use 140° of it. That is, if a 140° fraction of a 13" radius ~~[illegible]~~ cylinder was used it would have a Z_0 of 50 Ω and intercept .183 of the flux! So for the square outer wall one must find the equivalent surface that does all this!

Originally one thought to penetrate the ~~annulus~~ moving short circuit plane with this distorted semi cylinder using finger stock to make a wiping contact. However, since so much of the outer portion of the moving short would thus be left unsupported it seems that perhaps it would be better to approximate the semicylinder with 1" diam cu pipes placed on 2" centers. The final arrangement would be something like shown in fig. 2.



Blocker
Tube
2 turns
1/4" rod.
4" diam coax
to load.
loop.
sliding
short
12 ft.
Push
rods
WATER
WATER
Filter
Box.
B+ lead

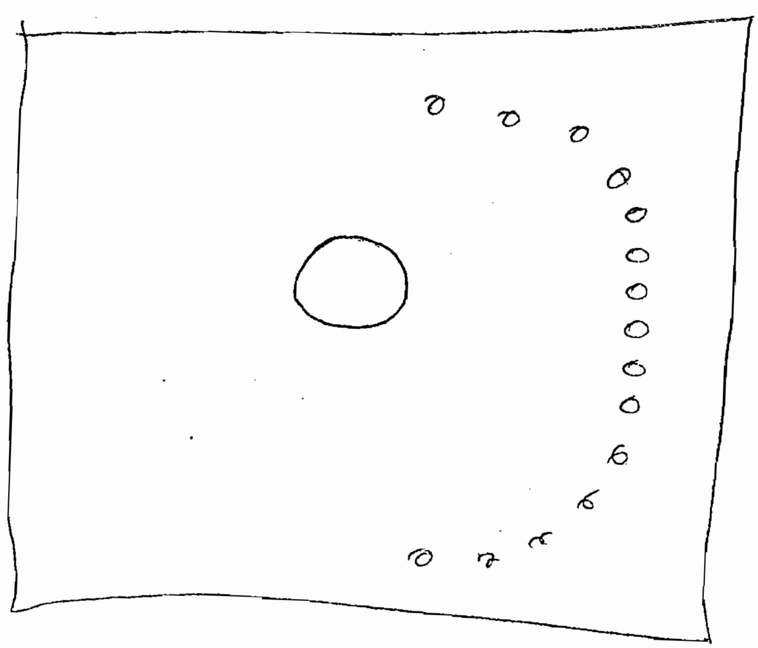


FIG 2

Tolerances

It would be a bad mistake if the loop intercepted too little flux, but if it intercepted too much, say by 20%, this would simply mean that more drive would be required, and more plate current. So it would seem that if, on page 3, we design to intercept ~~0.2 of~~ 20% of the flux then ±10% tolerance on $\lambda 2$ is O.K.

If the impedance of the loop is off by 20% no one will care, or even know. It simply means that, due to reflections, there will be more current flowing on the loop and more dissipation, but this is not important.