R.F BOOK

R.F. Note 69

December 19, 1980
J.Riedel

K800 TRANSMITTER-PLANS-AND OTHER THINGS

1. The grid circuit

RF Note #64 had something to say about the grid circuit for the 4684 tube. After considering many alternative schemes for the grid circuit I have now come up with a design which I think is the simplest and should work well. Fig. 1 is a schematic drawing of this design and Fig. 2 is a mechanical sketch showing how to implement it. The variable L2 in Fig. 1 is revealed in Fig. 2 to be a 1 meter long 81 ohm transmission line with a moving short. Its purpose is to resonate the grid capacity (C4 = 1200 pf) over the frequency range 9 to 27 MHz. The design should be capable of doing so over the range 8 to 30 MHz. The value of the required length L is

$$L = (\pi/2 - \text{atn}\ (CZ_O\omega)) \times 3E8/\omega \qquad \text{MKS units.}$$

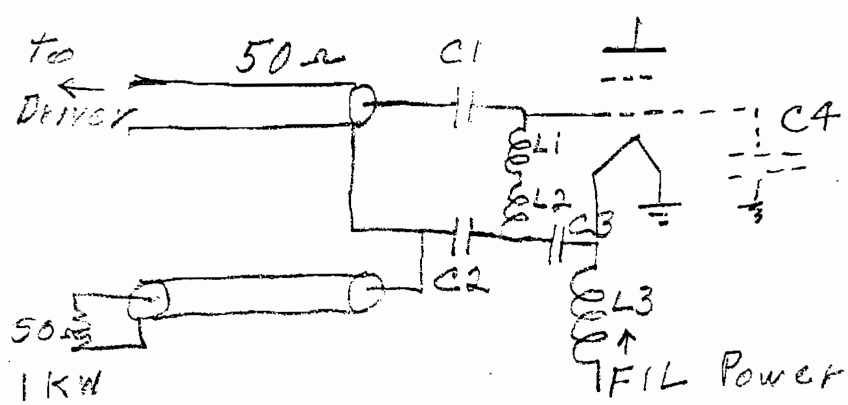


Figure 1

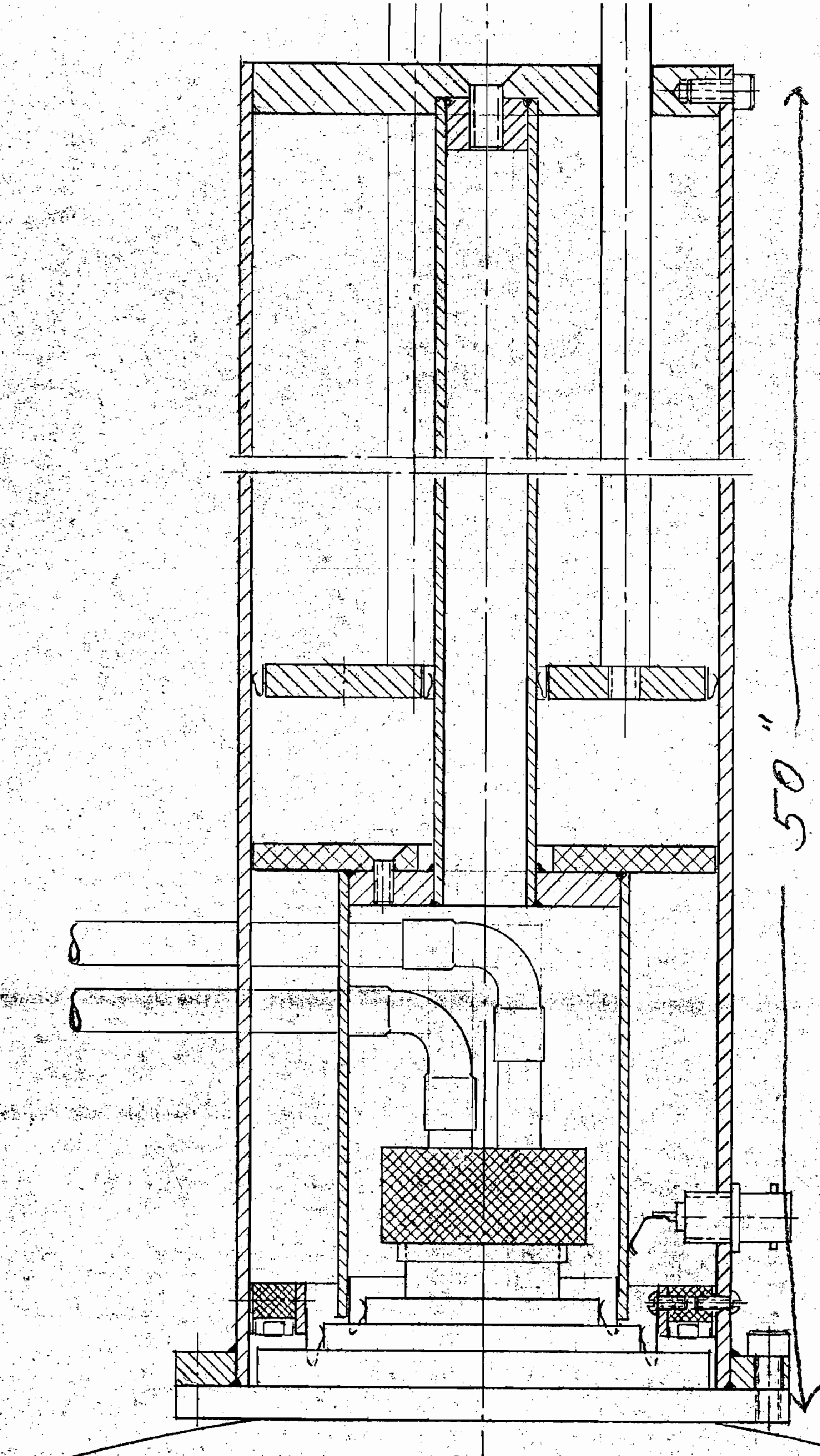


FIG 2

2. Testing the 4648 tube

The purpose of testing the 4648 tube is to find out how much drive voltage will be required. Normally one can calculate this from the manufacturers data sheets. Unfortunately, the manufacturer (RCA) informs me that the information on their data sheets is in error by at least a factor of 2. The best information I have is from Oak Ridge, where they are using this tube at a 125 kW level, and an extrapolation to our requirement of 200 to 250 kW seems to indicate that 150 V rms on the grid is adequate. If we broad band the drive at 50 Ω this means we need a 500 watt driver, and we can buy such a solid state driver for about $10K. If, however, 200 volts is required then the price of a solid state driver becomes excessive and we would drive it differently.

So we build a tube tester. Fig. 3 shows the circuit diagram of the tester and Fig. 4 shows the mechanical arrangement. The object is to generate a set of I_A, I_{SC} and I_g vs V_g for selected values of V_A and V_{SC}.

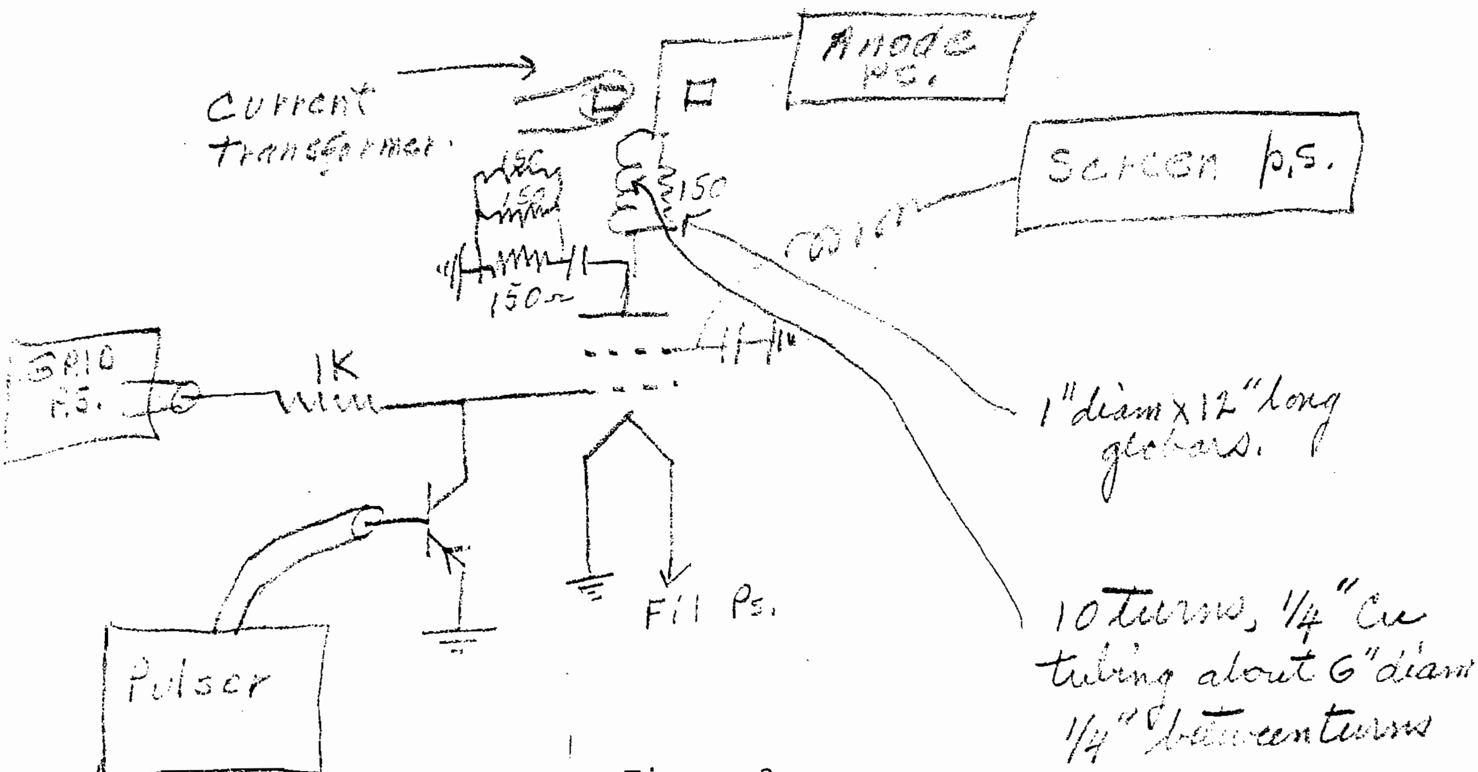
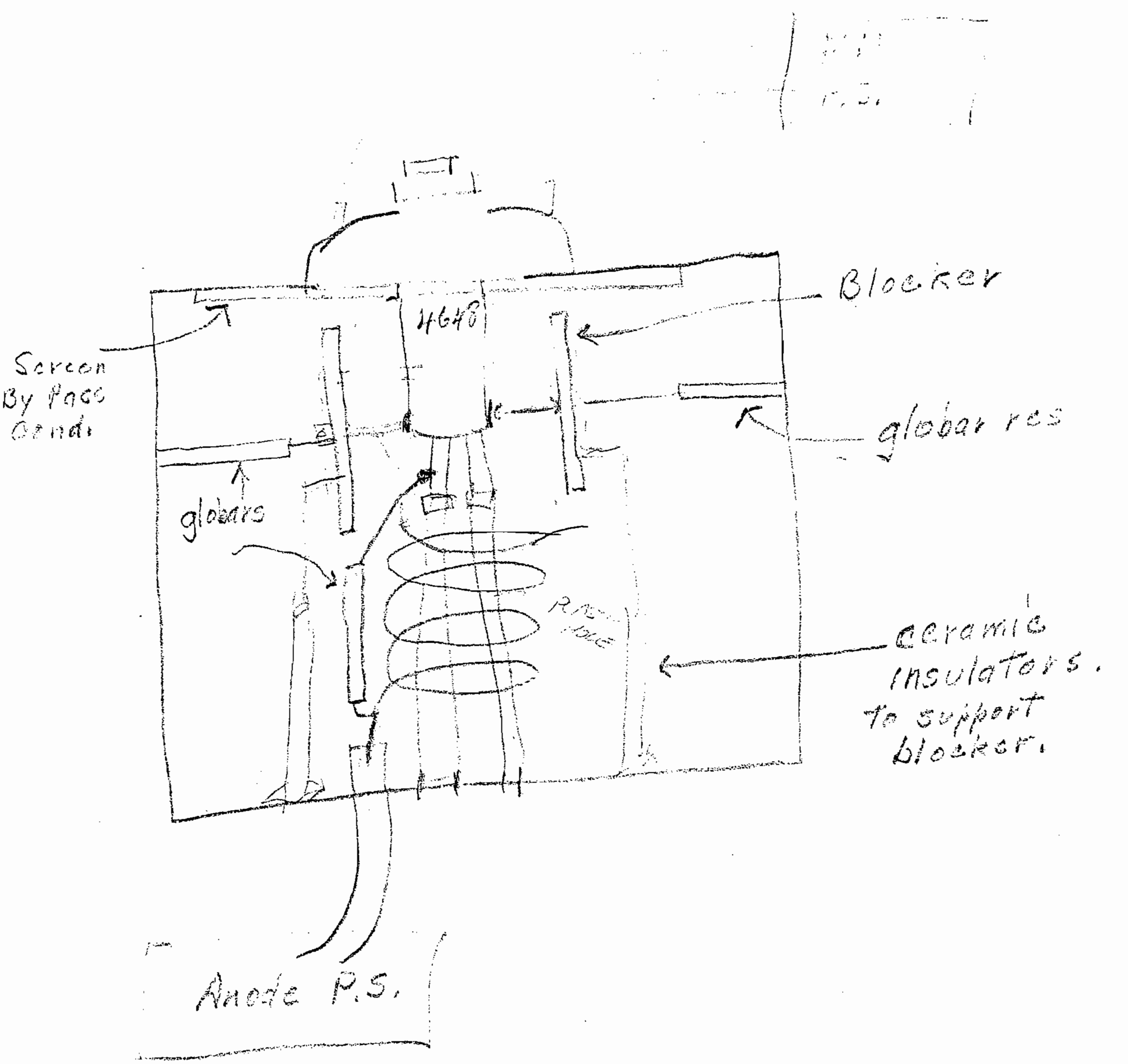


Figure 3



Blocker
4648
Screen By Pass Condi
globar res
globars
R.F.
ceramic insulators. To support blocker.
Anode P.S.

FIG 4

The selected values are:

V_A = 1.5, 2, 3, 10 kV

V_{SC} = 500, 750, 1000, 1400

The grid bias is set to cut the tube off (about-200 V), and then the grid is pulsed downward with 100 μs long pulses at a 30 Hz repetition rate and plate, screen and grid currents are measured to construct the curves. We need to turn on up to 120 amps. Thus the peak instantaneous power will be 1.2 MW but because of the duty factor the average power will be only 3600 watts.

The pulser and the transistor on the grid is the same one we use to permit the K50 transmitter tuves to act as a shunt regulator for the Levinthal P.S. The current transformer is the same one used to make the impulse measurements on the trim coils for the magnet.

The purpose of the various globars is to discourage the tube from becoming a self excited oscillator. The reason for the 100 μs wide pulse is to keep the anode supply from tripping off and also so that the anode voltage won't sag too much.

3. Driver

After spending some time considering using a solid state driver, I have decided to use vacuum tubes. The reason for this is conservatism. Solid state devices connected to the grid of a 250 kW tube are too apt to be scrogged. Now that we have decided to use a tube for the driver we concentrate on the best way to employ it. The most attractive way is to copy the K500 driver, employing a variable inductor between the driver anode and the final grid. This is difficult to do because of the large grid capacity. It would be easy to do if people would allow me to pump mercury into a container containing this coil. The geometry would be almost identical to the one employed at Orsay for this same tube. See Fig. 5.

However, conservatism again prompts me to do this more conventionally. Well, not altogether conventionally as I propose to employ a broad band transmission line transformer never constructed before. Fig. 6 shows the driver. The 4 to 1 transformer will permit the driver tube to work at 800 Ω (1 amp) and will have the same grid circuit as for the K500 drivers. This transformer is being constructed.

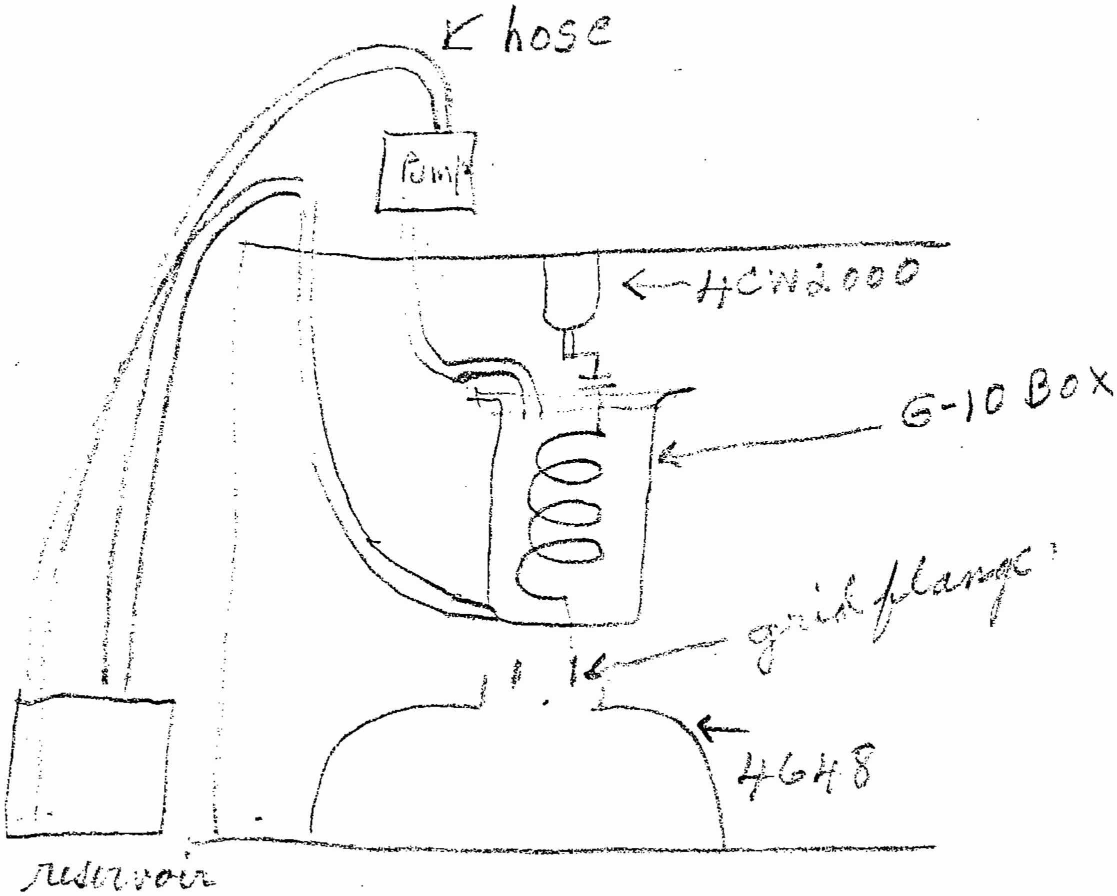
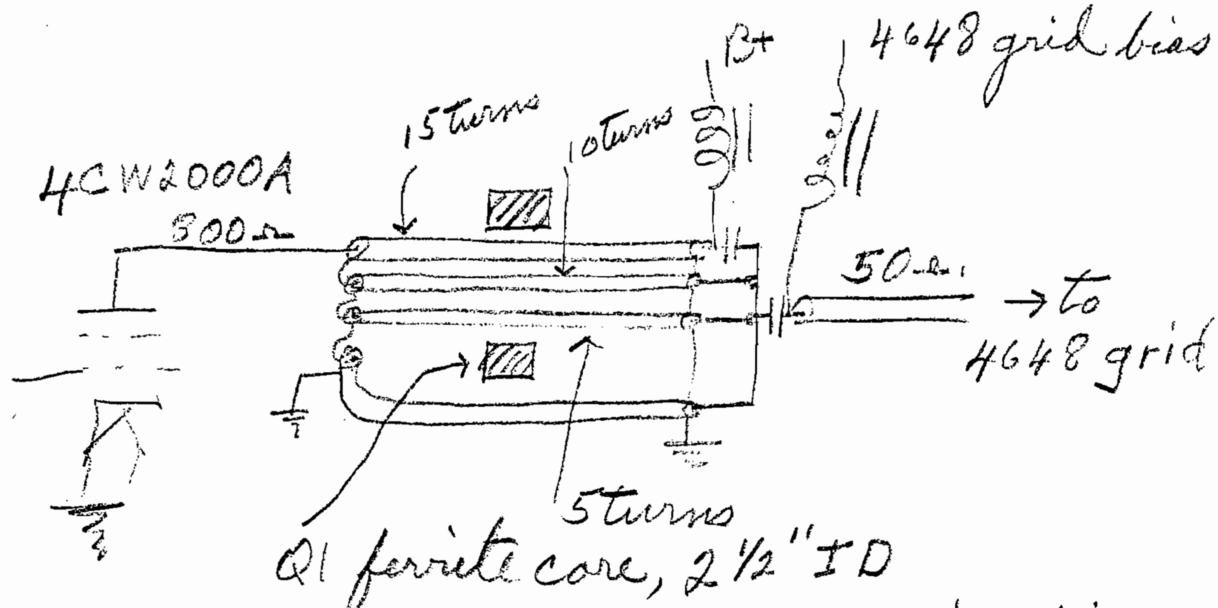


Fig 5



cables are 200 ohm twisted pair being the guts of RG75U. All cables are of the same length (about 10 feet).

FIG. 6

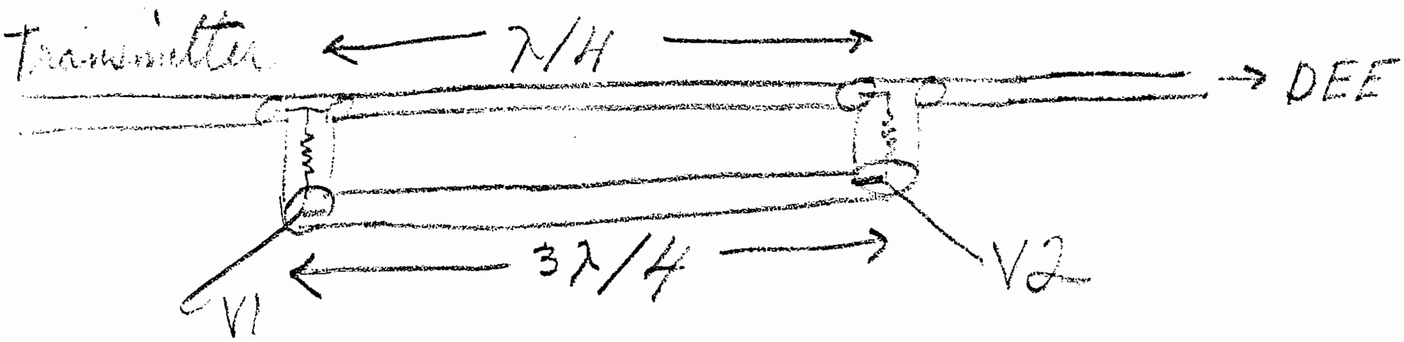


Fig 7.

K800 DEE STEM CONFIGURATION

On December 13-14, 1980 MV800A was repeatedly run to arrive at an optimum trade-off between the two goals of

1, making the power required at 27.5 MHz small and
2, making the length to the short at 9 MHz, also small.

This was done with the option of hogging out more iron. At 35 inches from the median plane we taper the outer conductor from 12 inches diameter to 24 inches at 55 inches from the median plane. The inner conductor tapers from 5" to 18". Then there is a uniform coaxial line of OD = 24", ID = 18" by 23" long extending to 78" from the median plane, before the short to a 8" inner conductor at 79" from the median plane.

The power at 27.5 MHz for 200 kV is 165 kW. At 9 MHz the distance to the short is 210" from the median plane and ΔL (push rod length) is 210-79 = 131". The power at F1 = 119 kW.

Thus, by cutting out more iron we save approximately 300 kW of power. Later we improved the geometry and arrived at a power requirement of only 140 kW for 27.5 MHz.

3 ϕ High Q Model

Herein we present the final plans for the 3 ϕ high Q model. we have purchased three surplus power amplifiers capable of outputting 100 watts. They are designed to operate from 225 to 400 MHz and we will modify them to run at 30 MHz. They consist of solid state amplifiers which drive the cathode of a grounded grid 6816 50 watt tetrode which in turn drives the grid of a 4C x 250B. All the power supplies are included and it only remains to change certain condensers and inductors to make them work at 30 MHz. One man month of T. Miyanaga's time should be enough to accomplish these modifications. Meanwhile D. Lawton is arranging it such that additional capacity plates will be added to the three dee boxes to pull the frequency down to 30 MHz.

Unfortunately the vendors of directional couplers for this 100 watt application wanted $750 apiece for them. So we devised a cheapie directional coupler as shown in Fig. 7. The cables are RG 58 V, of the lengths indicated. V1 reads only power going to the dees, V2 reads only reflected power!

K500 Transmitter

We received and tested the fine tuner vacuum condenser made by Dolinko and after only 5 minutes at only 12 kV peak rf at 30 MHz, it imploded. Immediately opening the anode box door, by feel, we found the glass envelope to be very hot.

So we give up on Dolinko and his pyrex glass condensers. Within two days we fabricated an air variable condenser and tested it. It works fine, acheiving a $\Delta F/F$ at 30 MHz of 1%. At 9 MHz this is only .3%. That is probably enough. If not it is easy to increase its effect.

Because of the large price ($650) of feed through condensers used in the anode lead filter box, Nurnberger tested the relative attenuation we would achieve with our cheapie Sprague hocky puck condensers replacing them. It was equivalent, so we will use the Sprague condensers for the K800 transmitters.

Meanwhile we have had a setback with the amplitude regulator, and also an advance. The advance is that we have arrived at a design which permits us to reliably attenuate the dee voltage signal in such a way that the computer can adjust this attenuation with an analog voltage. This means that the dee voltage, and also, for in-phase operation, the forward power, can be normalized so that meter readings will be frequency independent. Gress and Miyanaga developed this circuitry. The setback is that the override circuits don't work. But this is in the realm of the nitty gritty of electronics circuitry development and will no doubt be resolved. S. Francis is on top if this problem and no doubt will quickly resolve it!

It is bitter cold in Michigan, and though the work is fascinating, I yearn to depart for better climes. When the weather is more salubrious I will return, God permitting!