214-0028-01-01_00

R.F. NOTE #27

May 15, 1978
J. Riedel

Contents:



## Dee Stem with Insulator - Further Considerations

The present plan for the dee-stem rf structures is to first build the "dee-stem with insulator" structure described in RF Note #17, which can cover the frequency range 9 to 32 mHz, and when this works, to convert over to the high frequency scheme (H.F.R.F.) described in RF Note No. 23. This latter configuration is the one suitable for a stand-alone 500 MeV machine, whereas the former is primarily useful as an injector cyclotron into the 800 MeV machine.

Before commencing with the detailed design of the vacuum part of the stem for the "dee stem with insulator" structure, it seemed reasonable to inquire whether or not this part of the stem could be the same for both systems, namely, whether or not the stem could simply be a 4.125 inch diameter pipe the whole way, remembering that the design described in RF Note #17 called for the stem to stepwise increase in diameter as it approached the insulator to 12 inches inside the insulator. Now the reason for so increasing this diameter was to push up the high frequency limit. Thus a top frequency of 32 mHz was realizable. Meanwhile the information on what the top frequency would be with a uniform stem was lost.

So MSUDS was revived and the two cases were recalculated. Figure 1 shows the results. The uniform 4.125" diam. stem yields an upper frequency limit of 26 mHz and also causes the lowest frequency to be raised by 10% to 10 rather than 9 mHz. Thus we can say that the step change in the stem is justified!

## Quick Look at the 800 MV RF System

Now that we have an idea as to what the magnet will look like it is possible to guess at a dee structure and calculate an rf system. We presume that the ID of the outer stem conductor will be 12 inches and the inner conductor starts out as 6 inches, changing to 10 inches at 36 inches from the median plane and then to 8 inches for the region where the short moves. In this region the outer conductor will be 18 inches diam.

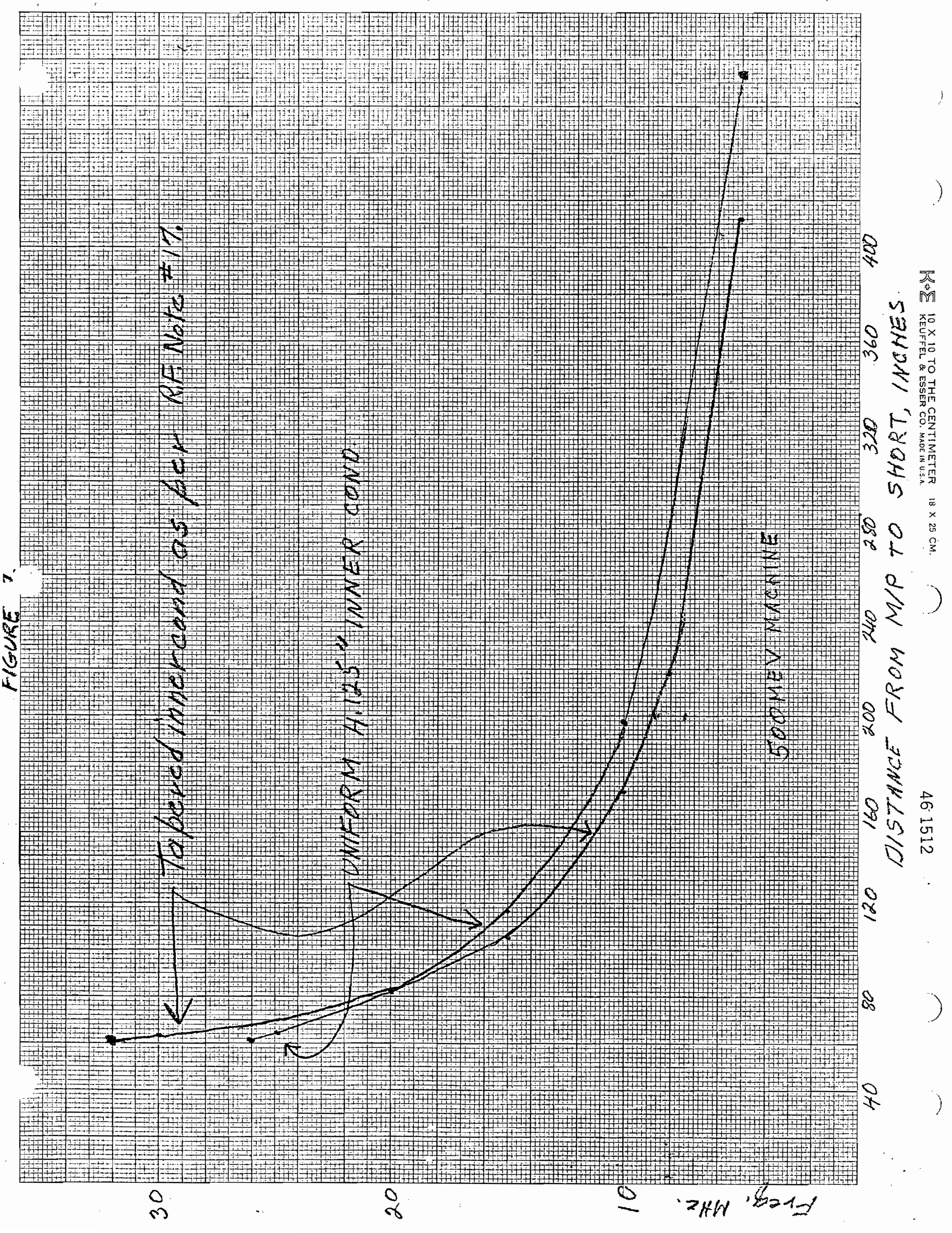


FIGURE 1.
Tapered inner cond as per RF Note #17.
UNIFORM 4.125" INNER COND
500MEV MACHINE
DISTANCE FROM M/P TO SHORT, INCHES
40
80
120
160
200
240
280
320
360
400
Freq, MHz.
30
20
10
10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 1512

Figure 2 shows the Frequency vs. short position. Table I gives various results. Symbology is the same as in RF Note #17. The power is about 150 KW per dee for 200 KV peak. Figure 3 and Table II gives more information, again consult RF Note 17 for symbology.

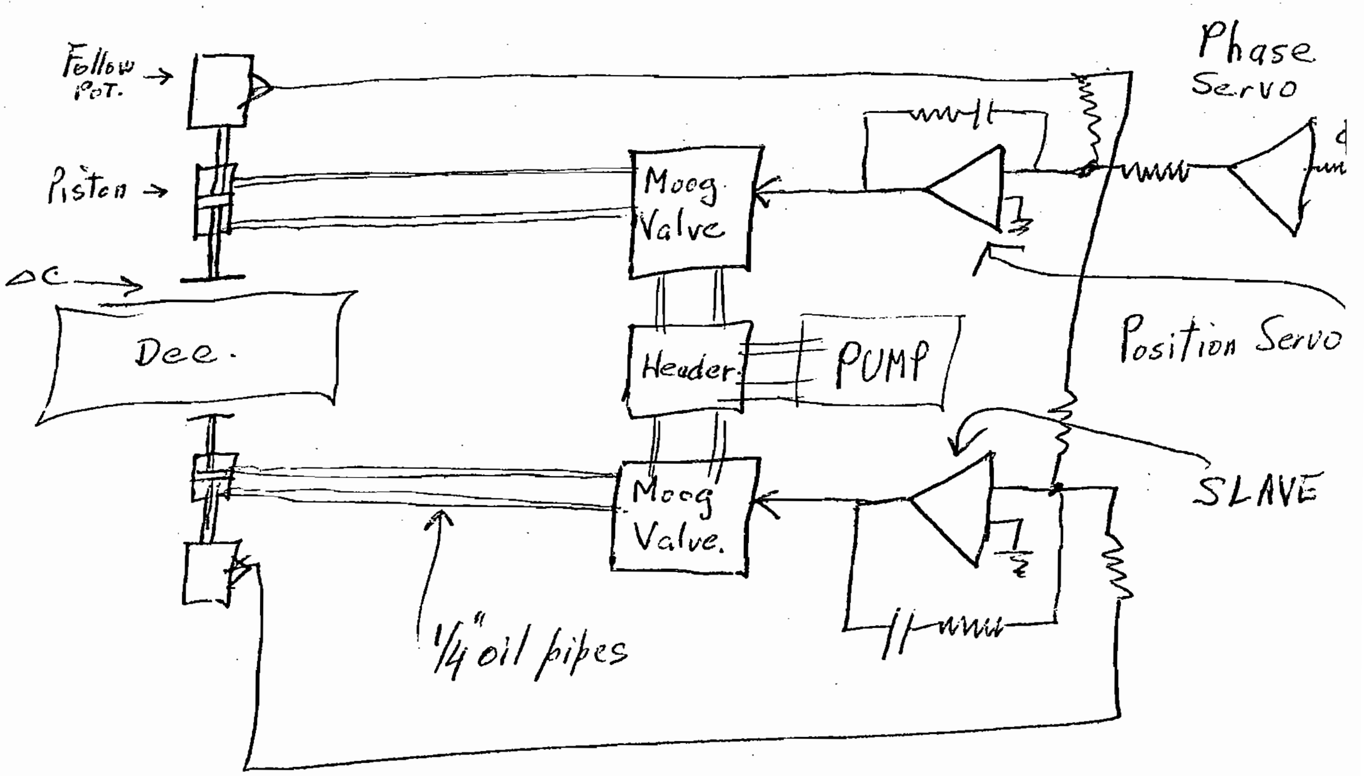
## Coupling Capacitor

A satisfactory design for the coupling capacitor exists. All that remains is to implement it.

## Fine Tuning

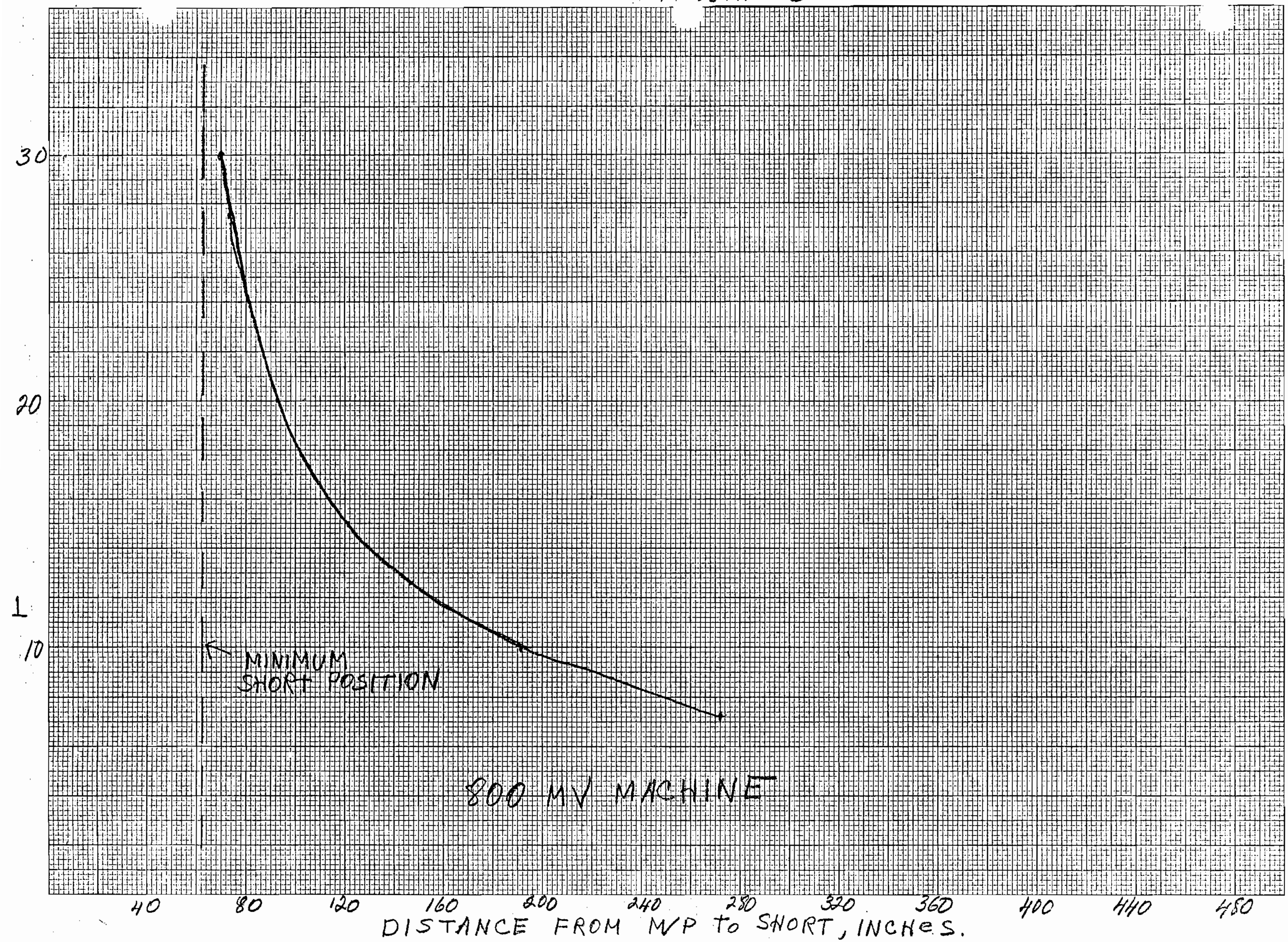
A satisfactory design for the fine tuning exists. It is a compromise between various persons' ideas, and it is to be hoped that it will do better than the traditional soup which received the attention of too many cooks. A 3/4 inch diam piston will cause a 4x4" copper plate to move from 1 inch to 2 inches from the dee. A formed metal bellows of 2 inches diameter provides the barrier between hi and lo quality vacuums and a 5-inch wide 5 mil hard copper foil will carry off most of the current. The dissipation at 30 mHz can be .3 watts/$cm^2$ and the cooling will be by radiation, resulting in a foil temperature of perhaps 150$^\circ$C which is O.K.

To keep the bellows cool a small amount of air will be blown through it. A linear follow pot will provide position information. The manner in which upper and lower trimmers will be controlled is shown in the sketch below.




TRIMMER CAPACITOR CONTROL SCHEME

FIGURE 2




46 1512
K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

TABLE I.

| F | ΔL | L | W | $I_m$ | Q | $R_S$ | E | $C_{eq}$ | $C_c$ |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 391 | 453 | 208 | 3300 | 3774 | 96 | 785 | 1250 | 14 |
| 7.5 | 211 | 273 | 201 | 3700 | 4515 | 99 | 908 | 964 | 9 |
| 10 | 129 | 191 | 205 | 4200 | 5024 | 97 | 1034 | 823 | 7 |
| 12.5 | 85 | 147 | 214 | 4600 | 5352 | 93 | 1150 | 730 | 5 |
| 15 | 59 | 121 | 224 | 5100 | 5530 | 89 | 1240 | 657 | 5 |
| 17.5 | 43 | 105 | 234 | 5500 | 5572 | 85 | 1300 | 590 | 4 |
| 20 | 31 | 93 | 243 | 5800 | 5500 | 82 | 1340 | 533 | 3 |
| 22.5 | 23 | 85 | 251 | 6100 | 5372 | 80 | 1350 | 480 | 3 |
| 25 | 17 | 79 | 258 | 6200 | 5175 | 77 | 1340 | 425 | 3 |
| 27.5 | 12 | 74 | 263 | 6300 | 4900 | 75 | 1304 | 380 | 2 |
| 30 | 8 | 70 | 268 | 6100 | 4700 | 74 | 1260 | 385 | 2 |

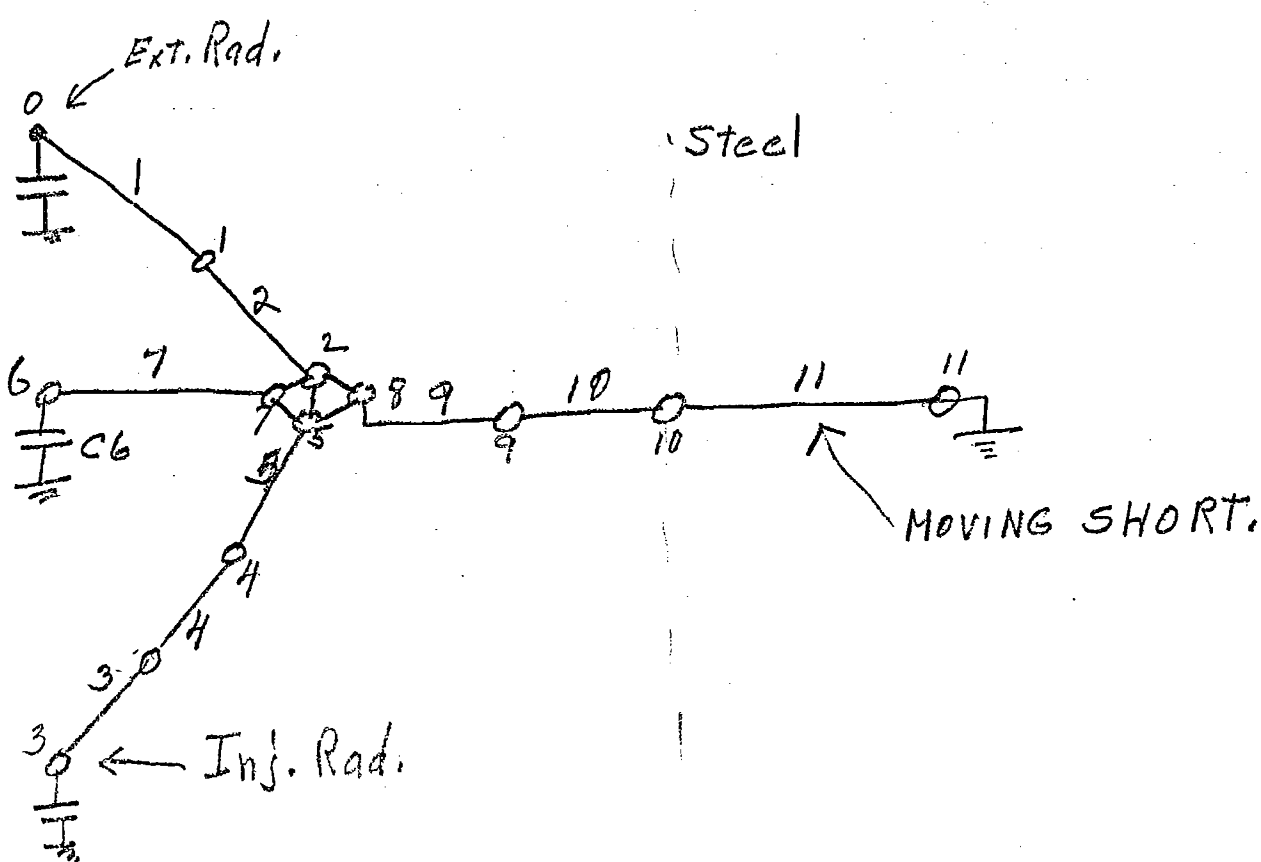



FIG. 3

TABLE II.

| N | ΔL | L | $Z_o$ | A | B | G | H | W | C |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | – | – | – | – | – | – | 144 |
| 1 | 11 | 11 | 54.5 | 6 | 4 | 2 | 6 | 1600 | |
| 2 | 11 | 11 | 41.7 | 10 | 6 | 4 | 3 | 2100 | |
| 3 | 0 | 0 | – | – | – | – | – | | 3 |
| 4 | 11 | 11 | 40 | 10 | 6 | 2 | 6 | 400 | |
| 5 | 11 | 11 | 43 | 11 | 4 | 4 | 3 | 1600 | |
| 6 | 0 | 0 | – | – | – | – | – | | 4.8 |
| 7 | 10 | 10 | 43 | 8 | 6 | 3 | 3 | 250 | |
| 8 | 0 | 0 | – | – | – | – | – | | |
| 9 | 26 | 36 | 41.5 | – | – | – | – | 40,000 | – |
| 10 | 26 | 62 | 10.9 | – | – | – | – | 60,000 | |
| 11 | * | * | 48.6 | – | – | – | – | 90,000 | |

*see Fig. 2 and Table I

## Insulators

Maybe everyone doesn't know it, so I will state it here for posterity. The present plan is to build the DEE-STEM WITH INSULATOR system first! This requires an insulator. The insulators have been ordered from WESGO, then LBL will braze them to the copper flanges. Then we will vacuum evaporate 10 angstroms of titanium on them and they will work! If LBL fails to get good vacuum tight seals, then we will deposit the titanium and make compression seals with iridium "O" rings. So this problem is solved!

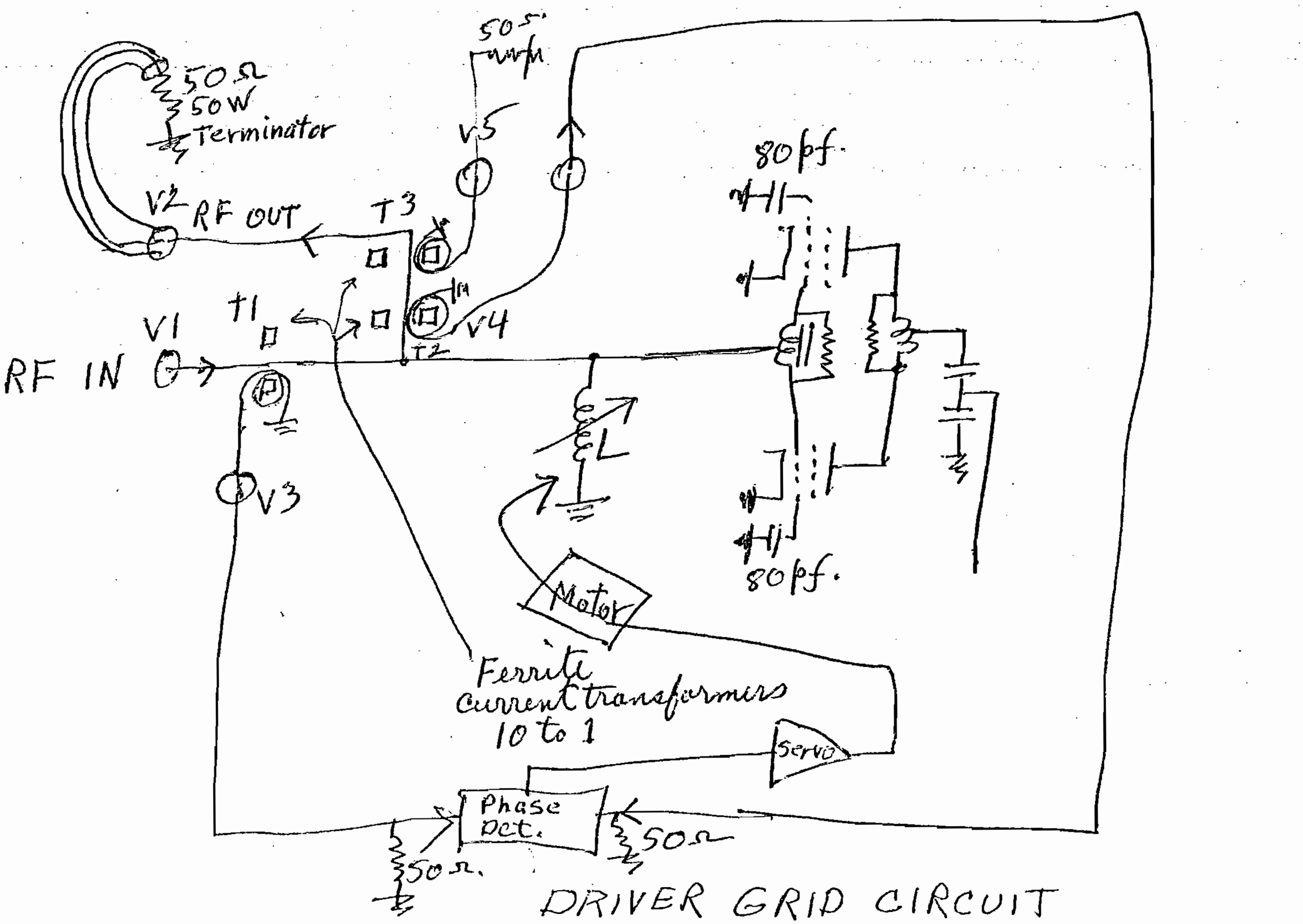
## Blockers

The anode blocking capacitor insulators are ordered from WESGO who will also apply a Moly metallization to the proper surfaces. Then LBL will copper plate them and then we will have perfect blockers! (Why aren't other laboratories doing anything for us?)

## Driver Grid Circuit

We are involved in the nitty-gritty of assembling the prototype driver and final grid circuit. No problems have developed as yet, but, on the other hand we have only tested the grid circuit of the driver. I have decided to herein document the reasoning behind a, I think, completely new way to establish a criterion for tuning the grid circuit of the driver.

Below is a sketch of the circuit. The rf drive voltage is about 50 volts, T3 and V5 give an output of 10% of this, because it feeds a terminator. This will be the voltage monitor on the grid




DRIVER GRID CIRCUIT

of the driver. T2 and V4 similarly give the voltage and phase of the grid voltage which is sent to the phase detector. T1 and V3 give the current to the grid and terminator circuit. The criterion for proper tuning (adjustment of L) is that V3 be in phase with V4. Simple, eh!

The push pull mode between the two grids is 118 mHz, but very well damped by the damping circuit. L causes other modes (such as 112 mHz, 160 mHz, etc.) but hopefully these will cause no trouble.

The driver circuit has been tested to full power (50 watts) and it was discovered that everything is cool unless L is badly mistuned, in which case T1 explodes. So we simply pass a law that L is not allowed to be mistuned (this will be done with appropriate interlocking).

## Driver Plate and Final Grid Circuit

This current was presumed satisfactory in March. However it must be tested at full power. This will be done in two steps. First, the 1KW 50 ohm resistor on the final grid will be removed and the 50 watt amplifier will be coupled into the circuit in such a manner as to provide the proper rf voltages. This will test heating in the coils and leads (the current is 60 amps at 60 mHz). Then various power supplies presently available in the lab will be connected to the driver filaments, grids, screens and plates, the 1 KW resistor connected, and the driver will be really tested. This will occur in June on my next visit. At this same time we will be able to close the phase loops on the tuning of the two variable inductors.

## Final Screen Bypass Capacitors

These 5 mil capton double metallized, drilled and etched capacitors have been ordered. Now we must design a fixture to vacuum impregnate them with RTV so that they will be immune to water spills. I hope I don't have to do this, but unless we can find someone else who would just love to impregnate them, I suppose I will have to. Any volunteers? The capacitors cost about 4K, the associated hardware probably another 2 K. So it would certainly be worth another 1 or 2 K to properly immortalize them.

## Anode Power Supply

We went out to some 12 bidders for the 450 KW final power supply. They were to respond in one month, and most did, saying "NO BID". In fact all did except those who didn't even respond. Bah! What has happened to these manufacturers who are eager and greedy for work and profit? The normal response is that it is such a small thing that they can't be bothered -- this for 100 or 200 K$!! Maybe we should have asked China to submit a bid. One manufacturer admitted that the basic transformer-rectifier package would cost $18,000. The frills apparently cost 10 times the meat. So we are mulling about this. This was the main reason to assess the power requirement of the 800 MeV machine. We are now considering buying a 1.1MW power supply suitable for powering both rf systems.