KF BOOK

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RF NOTE #26

March 24, 1978
by J. Riedel

Contents:

1. SCREEN BYPASS CONDENSER

It has been decided that we will purchase 18 metalized 5 mil Kapton condensers for use as screen bypassers in the modified socket for the 4CW100000E transmitting tubes. While visiting Eimac in April, an attempt will be made to get them to incorporate these in their tube socket. Failing this, we have a design to do it ourselves, and the only thing not yet designed is the manner of vacuum impregnating them with RTV.

To find out whether these condensers would comfortably survive a plate to screen spark we immersed an 8" by 11" 5 mil aluminized capacitor under transformer oil and dumped 15 KV onto it several times. It survived. So we proceed with confidence, but are installing three adjustable spark gaps on the screen grid flange which will be set to break down at 3 KV.

2. FILAMENT BYPASS CONDENSER

The drafting department will draw the details of how to make this item here using the 2 mil aluminized mylar. The target lab will etch the edges.

3. MONITORING BYPASS CONDENSER

Same as item above. S. Francis is supervising the construction and testing of these.

4. AMPLITUDE DETECTION AND REGULATION

Mr. Gress has demonstrated that the scheme of taking the sum and difference of a variable rf signal and a fixed high level (5 volts) rf signal and phase detecting these will result in an amplitude detector which is both fast and linear down to zero volts of the varying signal. We will use this scheme for amplitude detection (see page 4, bottom figure of RF Note #19 for diagram). If it proves to not be stable enough for the final regulation we will smoothly switch over to a simple peak detector just before turning on the ion source.

5. DRIVER-FINAL GRID CIRCUITRY

This is evolving, and so far no stumbling blocks have proven insurmountable. The two-step scheme for tuning the grid circuit, described in the previous note, works O.K. Various components to complete construction of the prototype transmitter are on order.

6. OUTPUT DIRECTIONAL COUPLER

This, at present, is an essential requirement of the overall plan for the rf system, and unfortunately, the object, or a design for it, does not exist! We wrote letters to several companies asking for a quote and they all gave "no quotes" except one. A man from Bendix phoned saying they would submit a quote, but we have not received one. So this deserves further attention. Maybe we will have to improve our smarts and invent one.

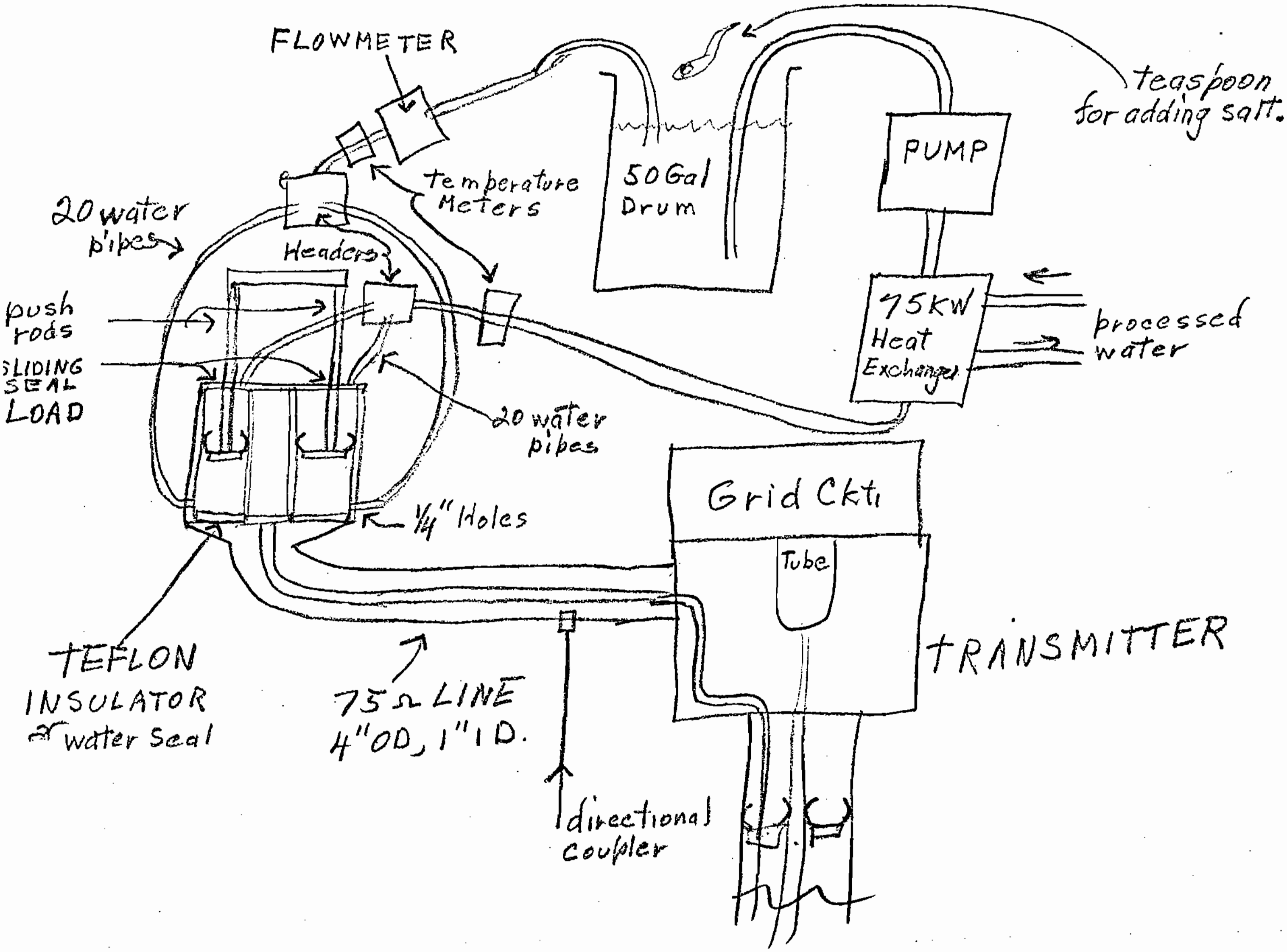
7. POWER SUPPLIES

Specifications have been written for the transmitter anode and filament power supplies, and now that we have an Electronics draftsman, Mr. Swartz, the necessary accompanying drawings will soon be ready so that by April 1 we should be able to go out for bidding on these. A bidders' list has been assembled thanks to Mr. Mosko of ORNL. These specifications and drawings should be given RF Note numbers and included in the RF book.

8. PROPOSED TRANSMITTER TEST LOAD

Although we plan to test the first transmitter by using it to power the existing cyclotron, there are reasons why it would be desirable to have an independent test load. First, the cyclotron only tunes up to 22 mHz which is not a good test for operation at 60 mHz. Secondly, the power demand of the present cyclotron is less than 75KW, again not a good test.

Fortunately, a simple and cheap test load is easy to make -- as follows. The proposal is to use one (1) meter of the transmission line copper tubing we have already purchased (4.125 inch inner conductor, 8.75 inch outer conductor), the same as used on the high Q model, and fill it with recirculating conducting water to dissipate and remove the 75 KW of heat. A moving fingered short identical to that used on the high W model will be capable of tuning this load over the range 7.5 to 60 mHz and by adjusting the water conductivity ($\sim 7x10^3$ Ωcm) this load will look like 75 ohms. Below is a sketch of the hook-up:



TRANSMITTER TEST CIRCUIT

Water has a dielectric constant of about 80, thus all dimensions in it (electromagnetically) get shrunk by 9 and the resonator will tune over the range 60 to 7.5 mHz with lengths from 5.5 inches to 44 inches and the Z_o will be 50/9 ~5 ohms. Thus we want to make the Q=15 so that the shunt impedance, Rs, will be 75 ohms, terminating the directly coupled 75 ohm transmission line. Now pure water has a Q of 40 at 40 mHz and the Q varies approximately as 1/F. 10^4 Ωcm water thus has a Q of 20 at 40 mHz and it is easy to adjust it downwards by adding a little salt (NaCl).

The dielectric strength of water is the same as most things, namely about 2 KV/mil, but there can exist problems due to the dielectric constant discontinuity between water and other things which forces most of the electric field to exist in them. Thus bubbles cannot be tolerated as they will break down even with the modest 3 KV rms we will have on the load. That is why the figure is drawn so that the insulator is the bottom, and also why there are 20 (maybe 40 is better) inlet and outlet water pipes so that the flow will be laminar and there will be no places where flow does not exist. Maybe a header fed by a hundred small holes is better.

The power will be monitored in two ways. The conductivity will be adjusted so that the directional coupler reads no reflected power and then a voltmeter reading gives the power. To check this result the ΔT and water flow gives the absorbed power. Tres simple (trey samp). I don't think this kind of load has ever been used before. If anyone can find a reason why it won't work please let me know!

9. EXPERIMENT TO DETERMINE HOW PRESENCE OF MAGNETIC FIELDS ALTERS SPARKING THRESHOLD

At the end of February 1978, the following experiment was made. The cyclotron was operating at a sparking threshold voltage of 60 KV. Then, after buggering an interlock, the magnet was turned off and the rf reapplied. Sparking commenced at 30 KV. But in less than five minutes the sparking threshold had reached the same value of 60 KV that had existed in the presence of the magnetic field. Jump to your own conclusions, but be wary of assuming that more voltage can be tolerated in 50 KG fields than 15 KG fields!

10. EXPERIMENT ON SLOW RF TURN-ON

At this same time, P. Miller demonstrated that the rf could be turned on arbitrarily slowly without having problems with multipactoring or gas discharges. This phenomena had been witnessed before with old machines. Apparently, with driven transmitters, the dee system finally gives up and doesn't try to resist being turned on. It has been "conditioned", like Pavlov's dogs. However others find that with new systems sometimes it is impossible to pass through various threshold dee voltages (100 to 1000 volts) unless the rf is turned on fast. One million volts per millesecond was a number once experimentally determined as being the minimum turn-on rate to permit successful passage through various multipactoring thresholds. So I have decided to not be misguided by the results of the experiment mentioned above.

11. TOP TO BOTTOM DEE CAPACITY ASYMMETRY

A look at the effect of top to bottom capacity dissymmetry in a dee-stem -- At 30 mHz, equivalent lumped dee cap = 250 pf, and the dee coupling capacitor is 2.5 pf. Thus, if we do not put in a dummy coupling capacitor on top we will have a dissymmetry of 1%. If we cause a similar dissymmetry in the position of the stem short circuit (.62 inches) then everything is O.K. and it simply means that the upper stem current will be less than the lower stem current by 1%.

If, however, we set the two shorts to be the same distance from the median plane then the proper tuning will be done by moving each short .32 inches closer to the median plane, and about 14 amps will flow from the upper dee to the lower dee. Most of this current will flow along the outer dee edge where the upper and lower dee halves are connected together, but a portion will flow along the small connection near the ion source.

Let us guess that the impedance from stem to stem via the outer path is 1/4 the impedance via the central connection. These impedances vary sort of logarithmically with the geometry which is why this ratio isn't larger. So let us say that 4 amps will flow on the inner connector. Now if this connector is tungsten with a width of 1/4 in. and length of 1 in., the heat will be

$$I^2R = 16 \times 6 \times 10^{-6}\ \Omega\text{cm} \times \frac{1}{.25 \times 2.54 \times 10^{-3}} = .15 \text{ watts}$$

which is no problem. However if the tungsten gets up to 2300°K then the resistivity will be ten times higher and the dissipation will be .45 watts, still O.K.

12. AMPLITUDE REGULATION AND TURN-ON SEQUENCE

A lengthy diatribe has been written on this subject, including a picture of suggested console panels, buttons, lights and meters. However these items need more thought, so are being withheld. During April, while sitting in a patio well protected from the torrid sun of Le Paz, Mexico, and sipping tequila as I watch the beautiful senioritas dancing on the beach in front of the azure blue sea my mind will be stirred, no doubt, to complete the design. As the sun rhythmically moves in and makes its periodic crescendos in time or syncopation with the strumming guitars and the tapping of the dancers' heels, one after another good idea will be generated.

Suffice it to present the first part of these ideas.

1. When the "get ready" button is pushed, each transmitter turns on except for application of screen voltage to the final, and the amplitude servoe is biased so that no drive voltage is outputted from the amplitude attenuator.

2. When the "ON LOW" button is pushed, the screen voltage is turned on and relays associated with the amplitude servoe actuate to request a dee voltage of about 100 volts, probably with reduced servoe gain. These relays also switch the amplitude feedback signal from the peak detector to the balanced mixer detector, which is linear over the entire amplitude range, though probably not as stable. The phase loops, which are amplitude independent, are

supposed to adjust the fine tuner, the coupling capacitor, the transmitter tuner, and the two grid coils. At this time, if there is a question as to whether everything is O.K. with respect to the dee and the moving short, such as when one is starting up on a new frequency, one observes the dee rf voltage on the oscilloscope to note that it is indeed about 100 volts, and compares the position of the coupling capacitor with the look-up table for that frequency. If the Q of the resonator is low due to a bad rf joint, the coupling capacitor setting will be wrong and some investigating should be done before proceeding further. The ratio of the transmitter/dee voltage should be checked, as well as the ratio drive to plate rf.