214-0054-01-01_00

RF Book

RF Note #53

September 10, 1979
J. Riedel

On Fishing and Golf

In my last RF note I ended by saying that I proposed to do some fishing, and that while waiting for fish to bite some good ideas, maybe even great ideas, would come to me. Unfortunately, though, I never found the time to fish and so I returned barren of any new idea. However, this last Labor Day weekend I played some golf. Now the bane of golf is slow play (by others, of course) so that between putting out and teeing off I had a great deal of time to contemplate the various problems of the rf system. Now these five minute intervals are not as conducive to arriving at great conclusions as are the several hours one has while fishing, still, after eighteen holes some of my thoughts were clarified, and I herein present them.

TURN ON--New Ideas

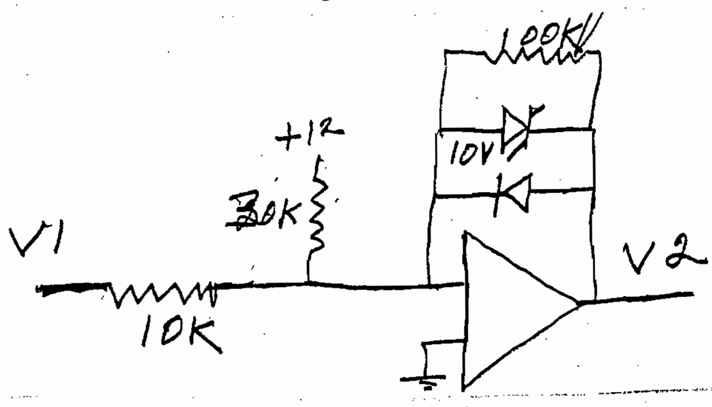
After some illuminating discussions with H. Blosser, who, as a result of operating experience with our rf test fixture feels he understands all the problems attendent with turn on, we have arrived at a new philosophy for turn on, whether it be for one dee at a time or all three simultaneously.

First, it is predicated that adequate nonlinear feedback from excessive anode current, excessive screen current, excessive drive voltage etc. to the amplitude regulator are capable of over-riding the rf demand setting in such a manner as to limit the drive voltage so that no interlocks trip out, and a drive level is arrived at which results in not exceeding any disasterous results.

The voltage regulator loops are "closed" and the demand voltage set for a modest value of approximately 20 kv. Then the operator presses the "RF ON" button and a 1μs rise time gate level (appropriate for the demand setting, say 1 volt, arrives at the amplitude regulator and rf drive is turned on at maximum level. The dee voltage will either 1) rise to 200 or 300 volts and be limited there due to multipactoring in a time of a few μs, or 2) rise to 20 kv in about 20 μs and then spark down, or 3) rise to 20 kv and remain regulated at that level. We define a time T1 (settable from .2 to 2 seconds) called "WAIT TIME." Now at any time after turn on if we have a spark somewhere, or if we have an excessive-dv/dt or input from 1st event det. indicating a dee spark, the ON gate is to disappear and reappear after T1.

We next define a time T2, adjustable between 20 and 200 μs after turn on. At T2 a gate is generated which allows us to look at a logic "or" whose inputs are comparators looking at the dee voltage, the drive voltage and, the reflected power. If the dee voltage is still less then 5 kv or the drive voltage or reflected power is excessively high we turn off and wait a time T1 and try again. There is to be a resettable but non interacting indication of which of the "ored" voltages turned us off.

The entry of this "ON" gate to the regulator is via the following circuit.



if V1=0 then V2 = -10 and RF is ON
if V1=-5 then v2=0 and RF is OFF

Module, Bin, and Controls Layout

R.F. Note #39 described a first look at the possible module, bin & controls layout for the R.F. system. This is a second look, and, hopefully, will be the way we will initially start up. However, these things are bound to evolve and I,m sure that in a year or two there will be another look.

After cogitating awhile, and with the nitty-gritty details always in the back of our mind, we choose to first design the front panels and then use this layout as a guide as to how to proceed with the details. So on the next several pages we present pictures of:

1. The two NIM Bins and their modules associated with the synthesizer.
2. In each of three station racks we show transmitter NIM BIN #1
3. In each of the three station NIM Bins we show transmitter NIM BIN #2
4. Again, we show the station control panel
5. And also the station meter panel
6. As well as the high quality RF cable bulkhaead feed-thru panel.

The above are contained in four (4) relay racks in the control room. These racks are within six feet or so of the console which will house the master controls for the RF system.

The control center for interlocks will be out at the power supply location (about 300 ft from the control room and accessable via a mountain goat trail over the beam line shielding). The Modicon will be there with its status light indicators. Eventually these will be capable of being read by the computer and available at the console. But at the start we will use bicycles. But then maybe nothing will even go wrong, and we'll never need to go there! Ha! As mentioned in the last RF note the DEE voltage regulator will have to be split into two parts, the control part being in BIN #1 and the heart out near the vault.

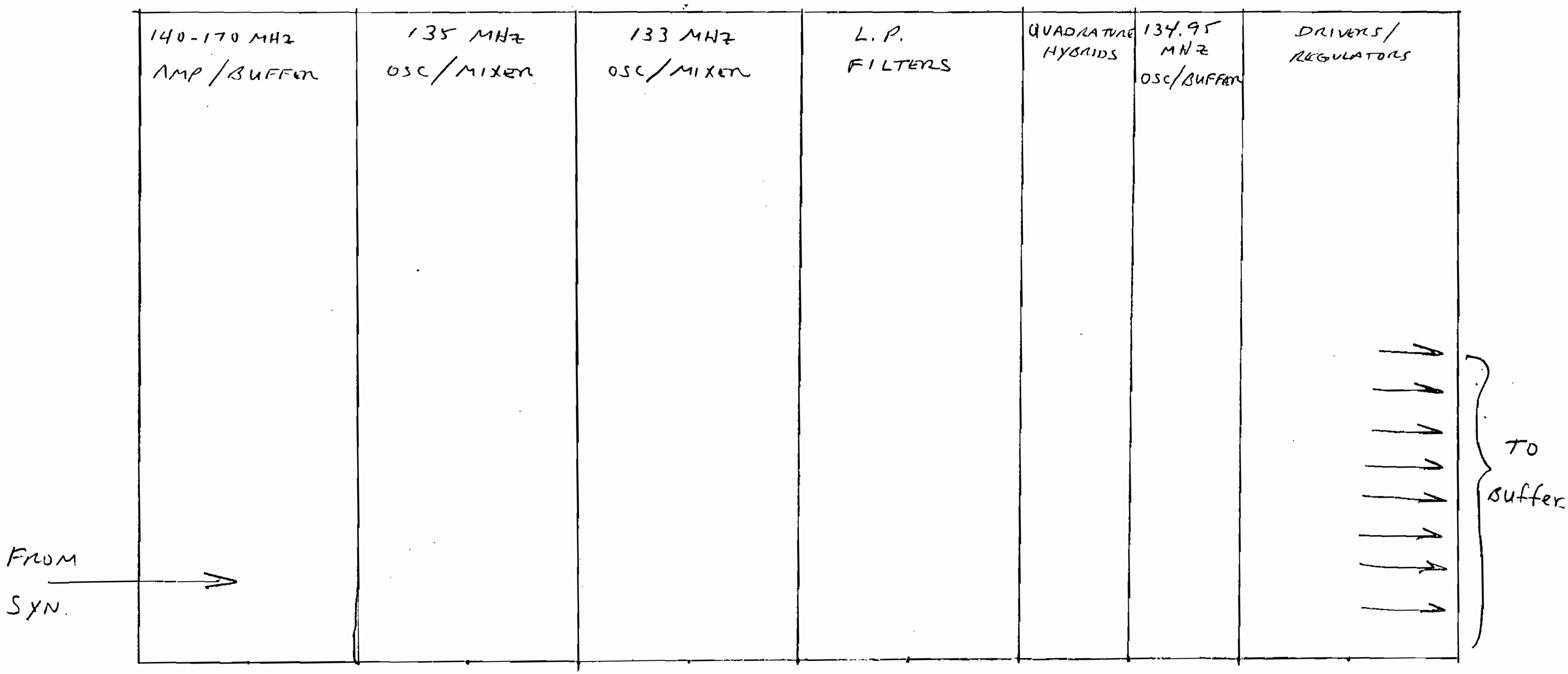
Voltage Regulator

After considerable thought, procrastination, change of mind, etc. we have finally decided on what the voltage regulator circuit will be. We will chuge one together for TEST 5. Figure 7 is the circuit diagram. Notice that we are using W. Johnson's method of overriding the rf command instead of Riedel's (see "Improvements in the Michigan State University Cyclotron RF System"by W.P. Johnson and P.K. Sigg, IEEE Transactions on Nuclear Science NS-16 No. 3).

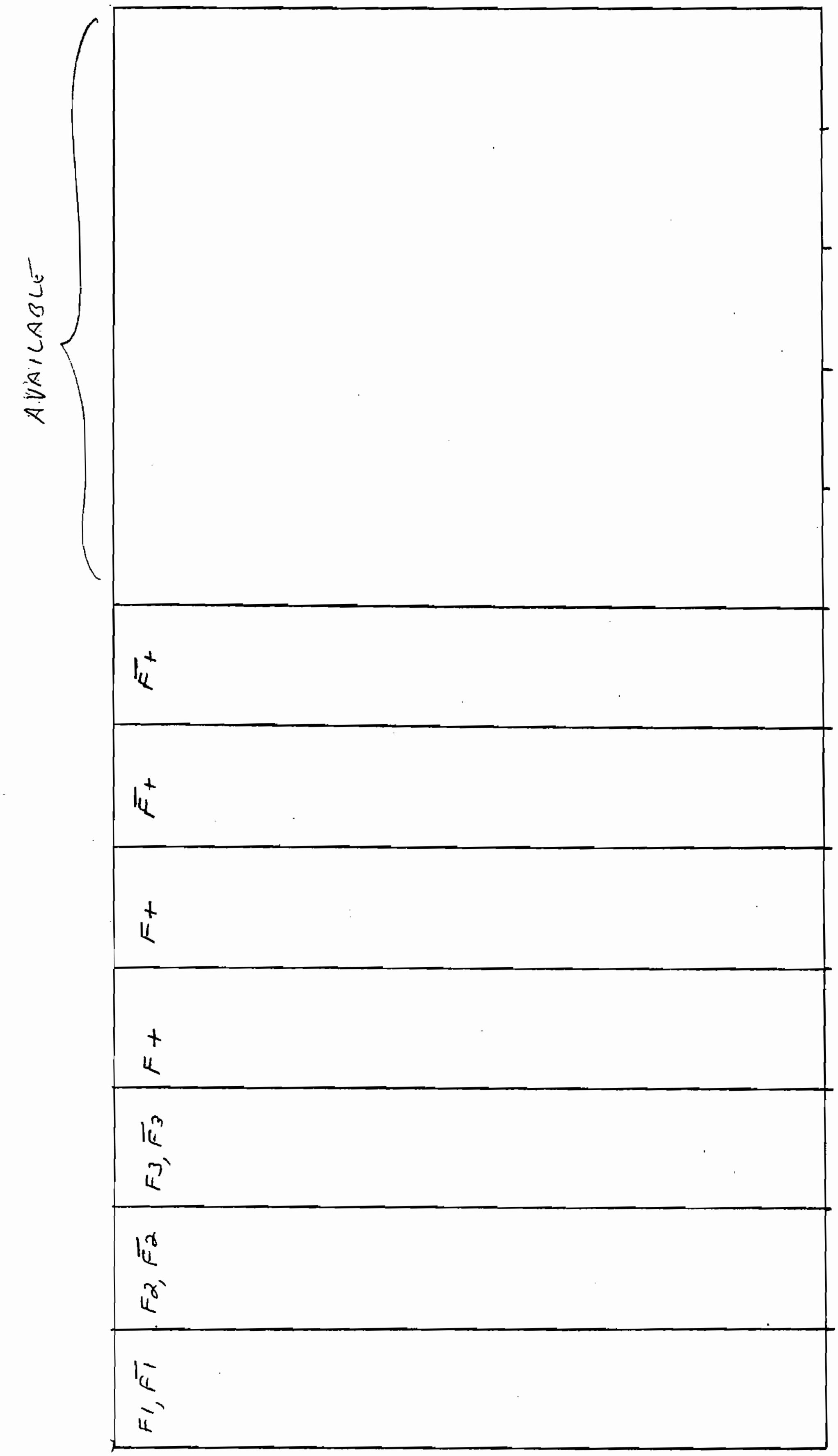
The peak detector is fairly linear down to 10 mv. Both the peak detector op amp and the main servo op amp are AM 500G3, with dc gain = 10^6 and unity gain at 100 MHz. The command, V1, is remote. A two conductor shielded cable can connect this command to a magnet controller for eventual computer control. But initially this cable will be connected to the station control panel, where a local-remote switch can divert control to the console. At the console a knob controlling three floating 0 to +10 volt sources will be used. The only grounds will be point G at the regulators.

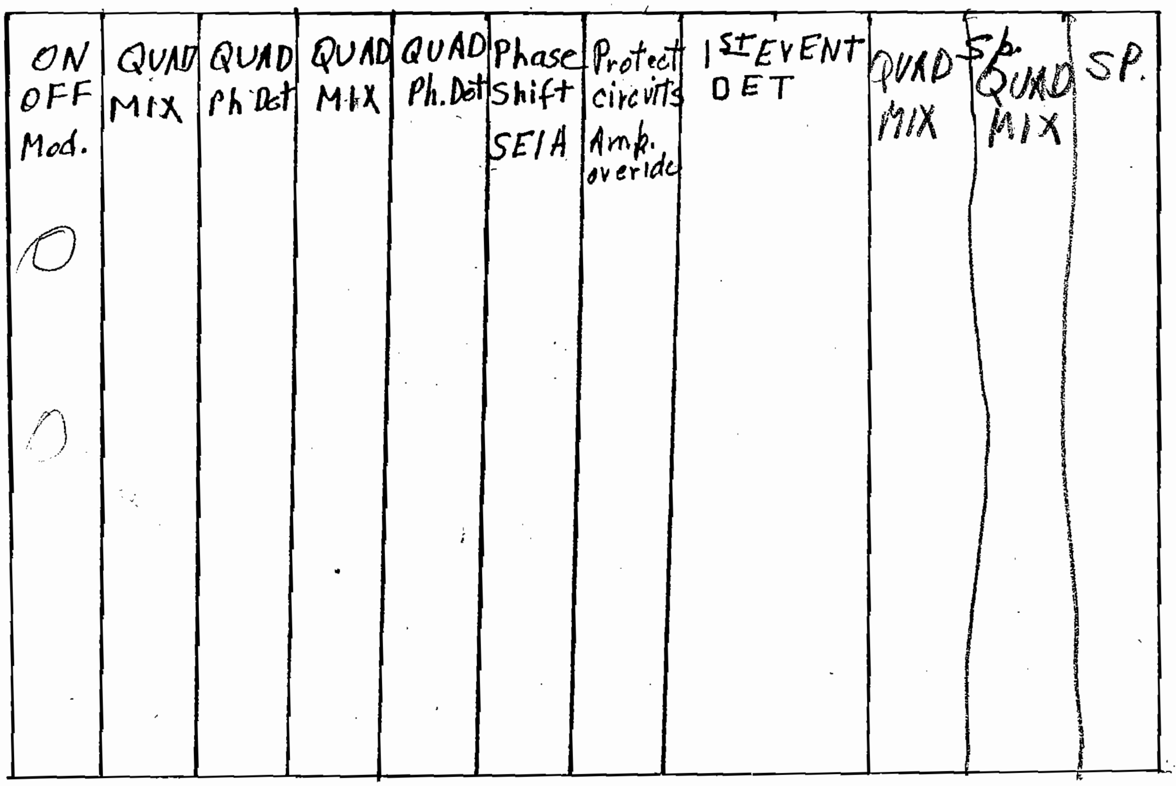
6

SYNTHESI ER BIN.



BUFFER B1





STATION NIM BIN #1

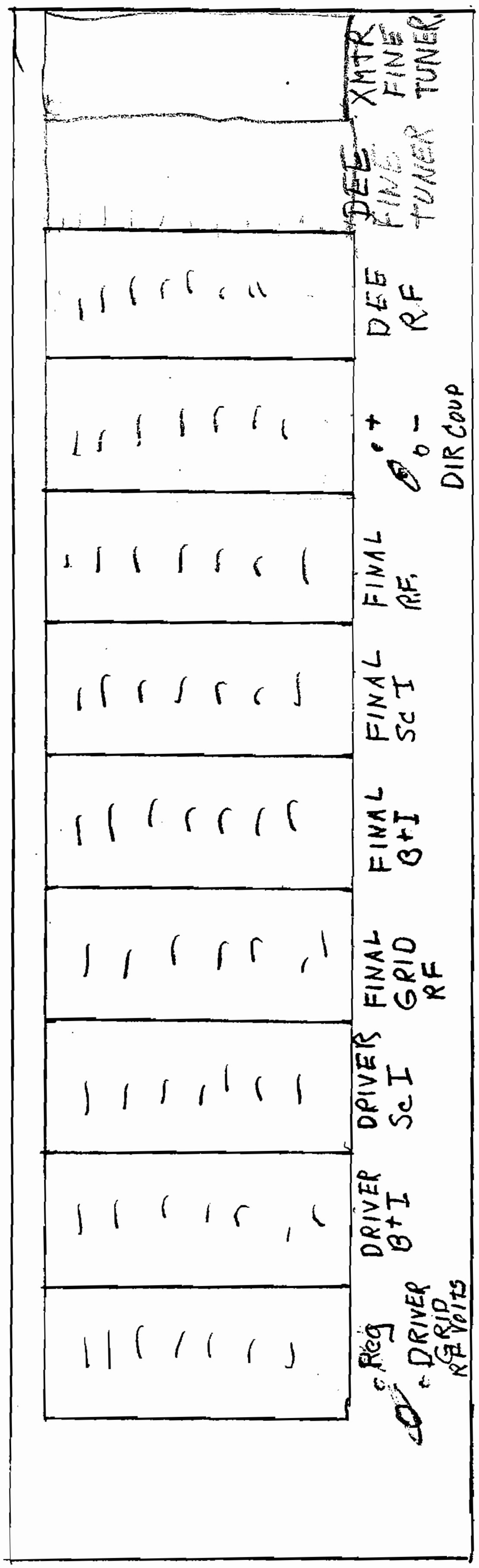
8

Insert trans fine tuner →

SE3A DRIVER GRID	SE4A FINAL GRID	SE5A TRANS STEM	SE6A TRANS COUP	SE7A DEE COUP	SE8A DEE STEM B.B. TOP	SE9A DEE STEM B.B Bot	SE10A FINE TUNER TOP	SE11A FINE TUNER Bottom	Sp.	Sp.

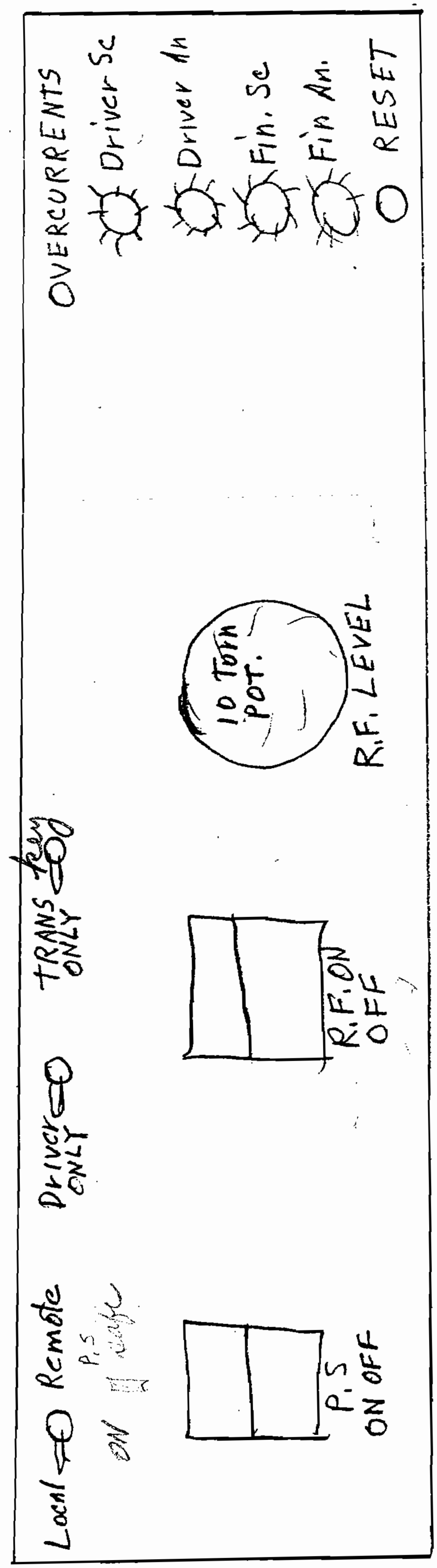
STATION NIM BIN #2

10

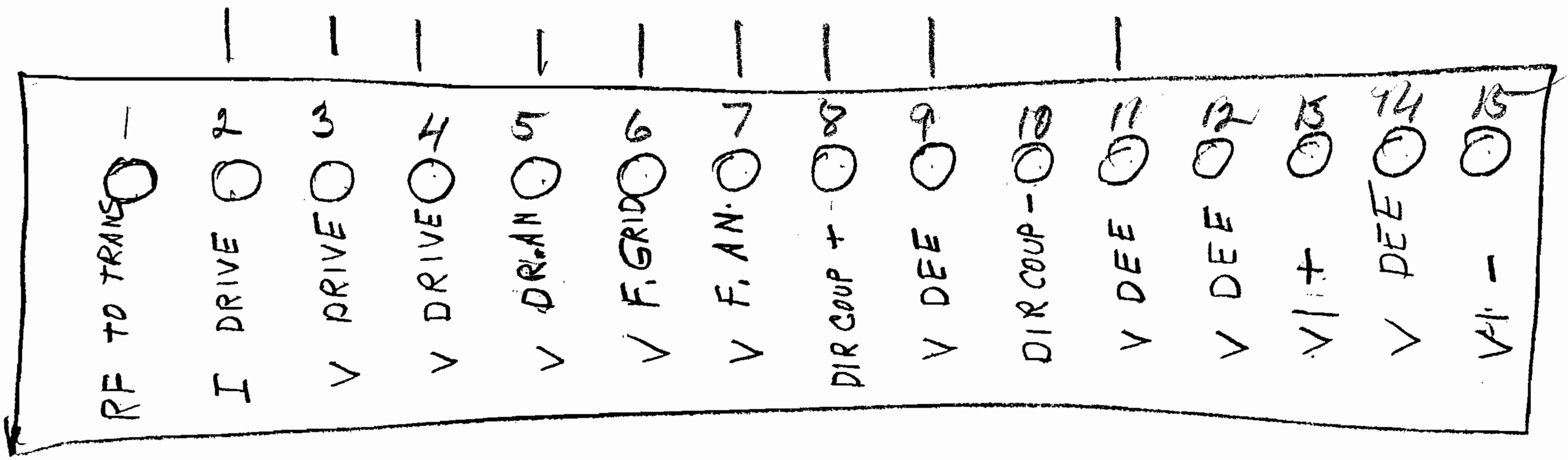


STATION METER PANEL

27 + 37 + 57



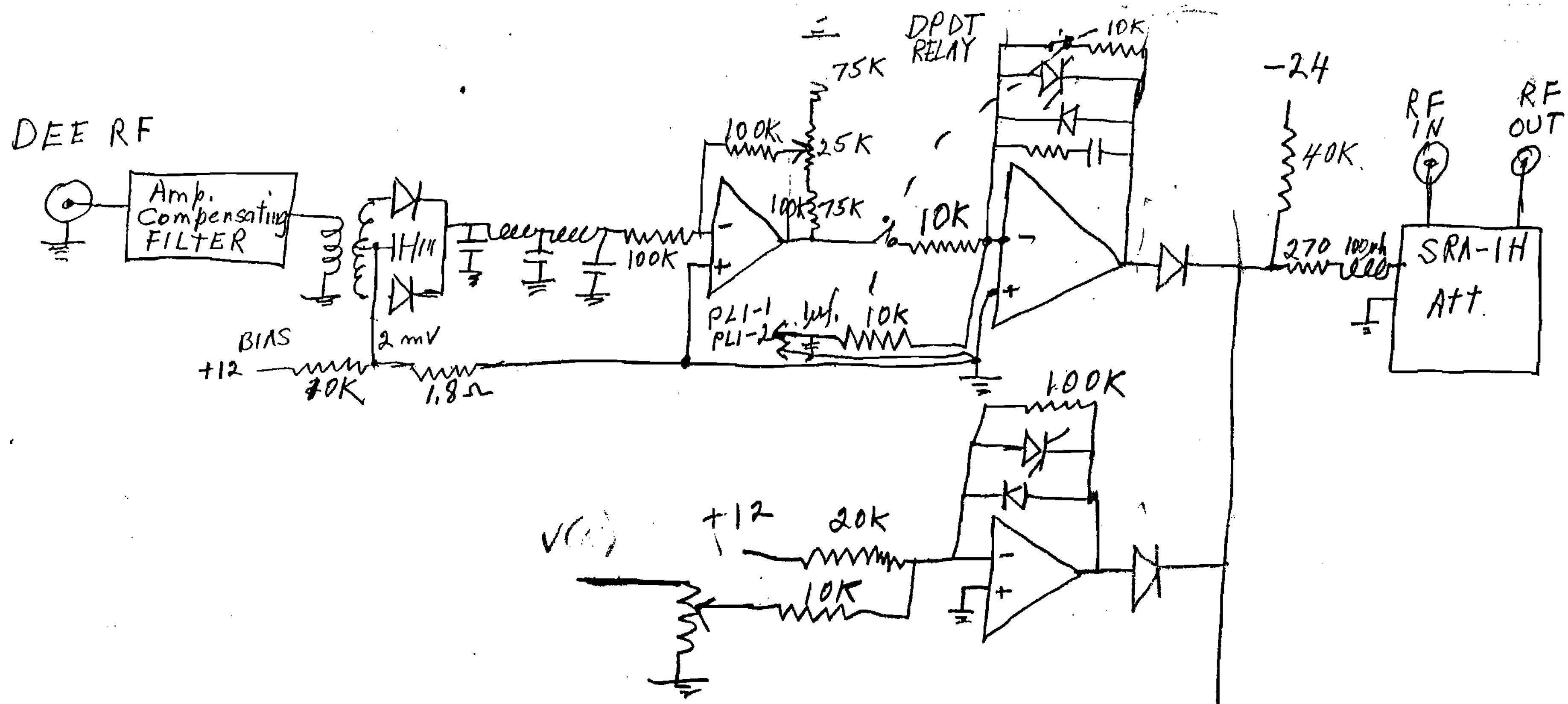
STATION CONTROL PANEL



BULKHEAD FEED THRUS
FOR HIGH QUALITY CABLES TO AND
FROM VAULT.

these are foam dielectric 1/2" semi rigid cables with special type N connectors.

Actually, with a 19" panel and 1" spacing we will provide for 17 feedthrus.



#1 = ON OFF
#2 = Final screen current
#3 = Driver grid voltage
#4 = Anode RF
#5 = Final anode current

5 more like above overrider

Fig. 7 amplitude regulator at vault.

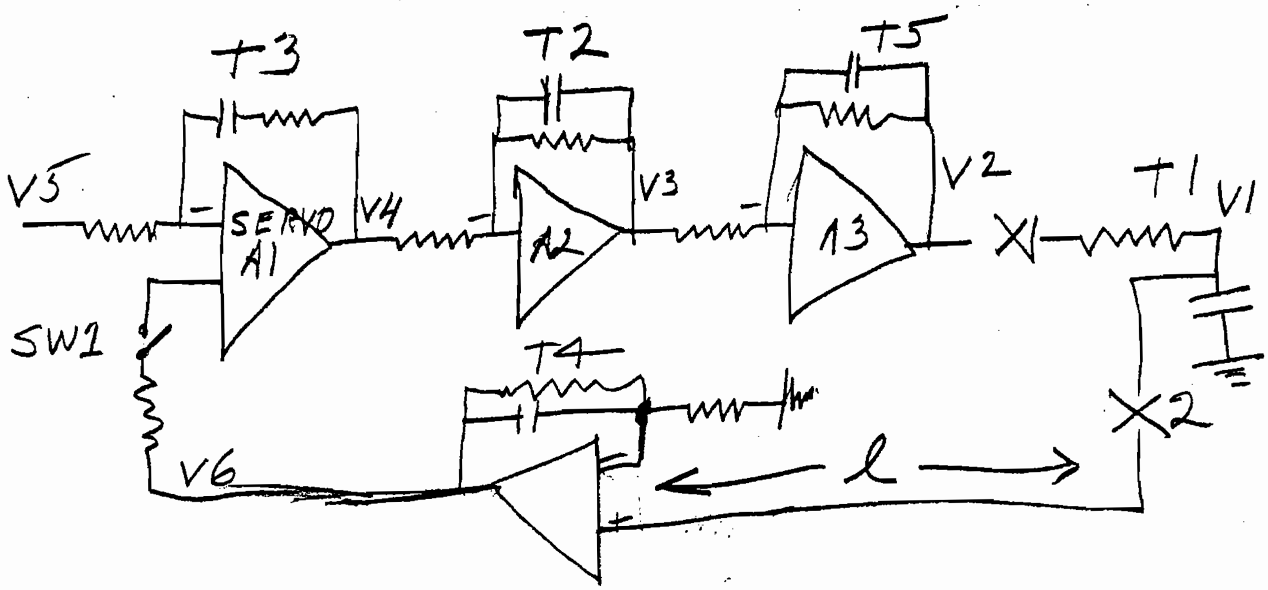
We provide six (6) parallel amplitude override circuits, some linear above a certain threshold, and others just quashing gates. These circuits normally have -10 volt outputs, but because of the diodes, are at zero and normally don't interfer with the amplitude regulator, whose output is constrained to go from 0 to -5 volts. This is what I call negative logic. I could never have invented it (kudos to Johnson) and had great difficulty understanding it. But, after making a truth table, and a computer program to simulate it, I have become a reluctant believer in it. The main reason for adopting it is that, according to Johnson, it works! Here is the truth table: for N=2 to 7.

V1	<0>-5	<0<-5
V(N)	-12	>V1
V8	V1	V(N)

V8 is the output which controls the attenuator.

whichever V(N)> V1 controls. Maybe I should call it antilogic, since V1 can never be larger than 0 then any V(N) at zero results in V8 =0.

We have a computer program that we presume properly simulates the various elements in the amplitude servoe loop and solves for open and closed loop performance. The equivalent circuit that this program calculates is below.



where V5 is the command volts (-10 volts at a frequency varying from .01 to 10^6 Hz.) V4 is the output of the servo amplifier A1 which has a dc gain of $G\phi(\approx 10^6)$ and a unity gain frequency of $F\phi(\approx 10^6)$. A2 is the driver anode final grid circuit which has a gain of 35.7 and a time constant of +2. A3 is the final amplifier with a gain of 40 and a time constant (because of the 10KW load) sufficiently small to be neglected. X1 is the transform ratio of transmitter to dee = 7 and T1 is the dee time constant (2RC or $Q/\pi F$). X2 is the monitor divider ratio (10^{-4}) and T4 is the time constant of our voltage detector plus fan out op amp. ℓ is the cable length from the dee monitor to the detector.