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1. Transmitter
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5. R.F. Room
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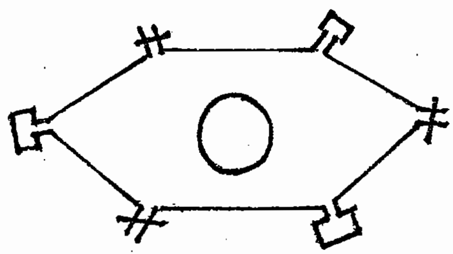
1. TRANSMITTER

The conceptual design of the transmitter is now considered firm (except for the important detail of how to build the outer conductor of the stem). Let's talk about this.

First, the transmitter stem is going to be identical with the dee stems below the insulator with the exception that no water cooling will be used. We have ordered enough 3/32" copper to build 9 outer stems with a threefold hexagonal symmetry as below:



And we are betting that this will work O.K. H. Blosser has undertaken the responsibility to see that it will!

There has been a problem about how to assemble and disassemble the transmitter tube. It has finally been decided that the superstructure consisting of the driver and the 1/2" thick aluminum plate on which the tube is suspended, will be lifted up two feet to permit easy access to everything. This is an unconventional way of changing tubes and I was against it, but bowed to majority opinion on how it should be done.

A problem about the screen bypass condenser has developed. Computer calculations show that this capacitor should be 1000 times the plate screen capacity: about 50,000 pfs. To avoid the problems arising from using paralleled discrete capacitors with their multitudinous resonances we propose to use a capacitor consisting of 5 mil doubly metalized Kapton, suitably masked off at all edges. However, the manufacturer quoted an alarming price to do this (>$2000). Worse, he would not guarantee that these would hold 2000V. Fortunately, H. Hilbert has found an out for us from a maker of superinsulation and with the expertise of Dallas Cole in etching the edges, we can probably produce the required capacitors for very little expense.

2. TRANSMISSION LINES

Originally we planned to use 50Ω transmission lines from the transmitter to the dees. However, it was found much easier to find suitable penetration places through the moving short anulus of the transmitter stem for 75 ohm lines than for 50 ohm lines. Using 75 ohm lines permitted a larger distance from the outer wall to be obtained. So we made the decision to use 75 ohm lines, naively thinking that these would be as easy to procure as 50Ω lines, especially so since any damn fool knows that a 75Ω line is a more efficient means of conducting rf power from one place to another than is a 50Ω line.

But lo and behold! Andrews only makes 50 ohm lines. And Prodelin only makes 75 ohm lines in 1 3/4" and 6 1/8". 3" lines are all we need.

For these reasons, and in order to avoid future frustrations, and to save money we have decided to build our own lines using standard copper pipe. Fortunately it turns out that standard 4" pipe as the outer conductor and standard 1" pipe as the inner conductor results in a 75.04 Ω line. We will need about 50 feet of this.

3. DRIVER

We have received the variable inductor from Multronics (what a nice word (incidentally the contact man there is Tom Jones, a nice name)). Francis threw a sheet metal box together and we simulated the grid capacity of the final and the plate capacity of the driver (300 and 50 pfs respectively) and found that we could achieve the frequency range 6 to 40 mHz. So we can proceed with confidence to design and build the driver. Fig. 1 is the circuit diagram of the driver, and Table 1 specifies the components.

I will now endeavor to explain the whys, whats and wherefores of it. P1 and P2 are type N connectors and the cables leading away are RG9V. Nominal value for V1 is 50 volts peak, meaning that nominally only 25 watts is needed from the solid state amplifier, hereafter called the predriver.

C2 and C3 as well as C18 and C19 are capacitor dividers, flat over our frequency range when 50 ohm cables (RG19V again) leading from P3 and P5 are terminated. Nominal value of V3 and V9 is 5V rms. T1 is a current transformer employing a small ferrite core. L1 is a variable inductance (about 4" cube) which will resonate out the sum of C2, C7 and C8 (about 170 pf). The criterion for adjusting L1 with the servo positioner M1 is that V4 and V3 be inphase. Thus P3 and P7 go to a phase detector whose output will feed an L1 servo amplifier which will drive M in an analog manner. P2 feeds a remote 50 ohm 50 watt BIRD terminator.

V2, the grid bias will be about -60 volts dc and PL2-1 feeds a 5 volt signal to the interlock circuitry. The complications introduced by T2, R9 and T3, R6, as well as R7, R8 are part of RF wizardry, calculated to discourage the paralleled tubes from self-oscillating in push-pull at some high frequency. V6, a measure of the screen voltage, nominally 5 volts, will feed the interlock chain. V5 will be a regulated 325 volts. The filters are obvious.

The ratio V7/V8, when L2 resonates out everything is to be set to be 5 by adjusting C13 to be about 50 pf. C23 is to remove the DC from C13 which doesn't like DC, and R17 is to make sure that there will be no DC there. Nominal value of V7 is 1200 volts peak and for V8 it is -250 volts peak, resulting in a nominal dissipation into the 1KW terminator of 625 watts. However, in case we have made an error, the two tubes can easily supply 1KW resulting in V8 = 316V peak.

The criterion for adjusting M2 with the L2 servo is that V9 be inphase with V3, there being 180 degrees difference between V7 and V8. I guess everything else is too obvious to belabour.

The driver tubes will be working class AB, the current never quite being completely cut off. V12, the plate voltage is 3KV at zero current and 2800 volts at nominal current of about 1.5 amps.

*Driver Interlock chain

1. Water flow interlock closed
2. Air flow interlock closed
3. Turn filaments on
4. Grid bias interlock closed
5. Plate voltage interlock closed
6. Final interlock chain closed
   OR final filament voltage off
7. Screen voltage interlock closed

4. CERAMIC PROCUREMENT PROBLEM

We need 6 dee stem insulators identical to those used at FNAL, and 3 blockers for the transmitter. We went out on bid. Coors "no bid" metallizing the insulators, also WESGO. Coors will metalize the blocker but not WESGO. So it seems we could order the blockers from Coors.

However FNAL informs us that there is a Japanese firm that can make both. So H. Hilbert has sent off a package of specifications to them. Let us pray that the Japanese will come through.

5. RF ROOM

The RF group has now moved into a new and spacious room. Soon we will fill it with RF. At least we can try to proceed in an organized manner. We have started a filing system and Bob Gress is in charge of this. We will soon be hurting for lack of an electronics draftsperson. However at least we have some labelled file folders to put circuit diagrams in!

*I hadn't planned on talking about interlocking at this time, but since it has to be done at some time, and since I am snowbound in my Cherry Lane apartment (this is January 27), I might as well do it now.

TABLE 1

T1		current transformer, homemade core → 1/4" diam ferroxcube μ≈1000 Primary = two turns #14 formvarcoated magnet wire Secondary = 20 turns #32 formvarcoated magnet wire
T2		6 turns centertaped on above core using #18 wire.
T3		6 turns centertaped. #16 bare cu. wire wound close spaced but not touching on teflon tape covered 1/2" length of broadcast ferrite antenna rod.
T4		same as T1
C1		.1 μf, 100V, Barium titanate disk capacitor
C2		200 pf, mica
C3		2000 pf barium titanate (note L1 may have trouble resonating this much capacity, so we will erase C2, C3 if this is so and use the output of T4 and V3 instead) Even with C2, the Q of the grid cht. is only 1.
C4,C5,C6,C9, C10,C12,C20, C21	=	.1μf, 1000 volt ceramics
C7,C8	=	grid capacity, 80 pf each
C13	=	10 to 50 pf. vacuum variable capacity
C23	=	2000 pf, 5KV Sprague barium titanate cap.
C16	=	10000 pf mica transmitting cap. Sprague
C17	=	same
C19	=	2000 pf same as C3. We may make this out of metalized kapton.
C18	=	$\frac{5}{250}$ x C19 = 40 pf, mica, 500 volt
C14,C15	=	~5000 pf, 5KV, barium titanate.
R1	=	50 Ω → actually this is the terminator of the cable.
R2	=	50Ω, AB, 1 watt comp.
R3	=	50Ω, AB, 2 watt comp.
R4	=	100K, 2W comp.
R5	=	1.5K, 1W comp.

TABLE 1, continued

R6	=	250 ohm globar (~10W)
R7,R8	=	10Ω, 2W, comp.
R9	=	50Ω, 2W, comp.
R10	=	10 Megs. 2W, comp.
R11	=	16K, 2W, comp.
R12	=	50Ω, 2W, comp.
R13	=	100K, 2W, comp.
R14	=	$\frac{5}{300}$ x R13 = 1670, 2W, comp.
R15	=	10K, 2W, comp.
R16	=	$\frac{5}{60}$ x R15 = 833Ω, 2W, comp.
L1	=	variable inductor purchased from Multronics 4.4×10^{-8} H to 1.25×10^{-6}H rated at 2 amps.
L2	=	variable inductor from Multronics 2.6×10^{-7} H to 7.4×10^{-6}H rated at 30 amps.
L3,L4, L5,L8	=	30 turns #34 magnet wire on same cores as used for +1. L~.5 mH.
L7,L6,L9	=	the guts of RG58V wound on 2" diam. ferrite cores, about 30 turns.
M1,M2	=	geared servo dc motors 300 inch ounces torque

Power supplies

PS1.	6.3 volts, amps. filtered to reduce ripple to 1% rms
PS2.	Driver bias supply -30 to -70 volts, 100 ma. Regulated to 1%, but filtered to reduce ripple to .01%.
PS3.	Driver screen supply. 325 volts, 100 ma. filtered to reduce ripple to .01%.
PS4.	Driver plate supply. 3 KV no load. 2.8 KV with 2 amps load. Filtered to reduce ripple to .1%.
PS5.	Final grid supply. -200 to -350 volts, 100 ma. 1% regulation, .1% ripple.

TABLE 1, continued

PS6.	Final filament supply. V, amps. d.c. Motor drive variac for regulation and slow turn-on. Filtered to .1% ripple (peak to peak). Regulation determined by adjustable microswitch on variac.
PS7.	Final screen supply. 750 to 1500 volts D.C. 300 ma. ripple <.5%. 5% regulation.
PS8.	Final B^+ supply.

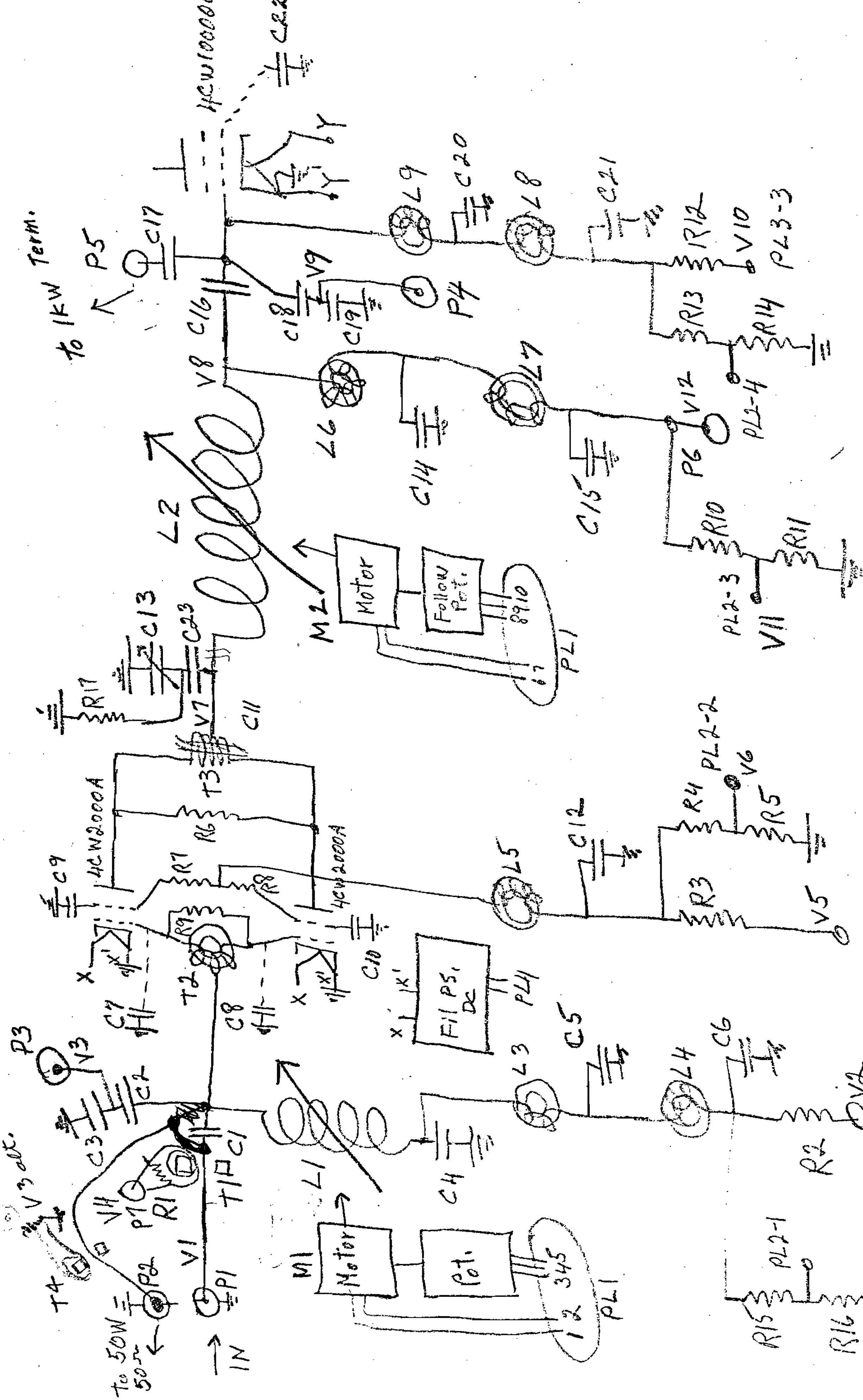

IN
To 50W 50Ω
to 1KW Term.
Motor
Pot.
Motor
Follow Pot.
Fil PS. DC
HCW2000A
HCW2000A
HCW10000E
L1
L2
M1
M2
PL1
PL1
PL2-1
PL2-2
PL2-3
PL2-4
PL3-1
PL3-2
PL3-3
PL4

FIG 1
DRIVER

Philosophy of control for the r.f. system

1. Each of the three rf systems will be capable of operating alone, for test and debugging purposes.

2. The operation of each rf system will be further capable of operating in a "transmitter only" mode,in which the output drive line is disconnected; and in a "driver only" mode in which the final tube is rendered safe.

3. For the final normal operation mode there will be only one panel which controls all three transmitters. This panel will have a 3 position switch labeled "inphase", "clockwise", and "counterclockwise". It will have a potentiometer for setting the amplitude of the dees, labeled "dee voltage".

4. It will have a pushbutton labeled "RF ON" and another labeled "RF OFF".

5. It will have three status lights labeled "T1 ready", "T2 ready", "T3 ready". If these lights are not lit then it will be useless to push the "RF ON" button.

6. It will have 6 meters. Three for the dee voltages, and three for the dee phases.

7. It will have three lights which will flash on and off if any of the three dees has neither the commanded voltage or phase.

8. There will be a panel for each of the three transmitters, presumably immediately below the master panel. These will be labelled transmitter "A", "B", "C".

9. Each "local" panel will have a two position switch labeled "remote", "local". If any are in the "local" position, the master panel "ON" button is inoperative, and and the "ready" light on the master panel for that transmitter is off.

10. Each transmitter panel will display a series of status lights (about 10).

11. Each transmitter panel has a potentiometer labeled "dee voltage", of significance only when the switch mentioned in 9 above is in the "local" position.

12. Meters on each transmitter panel will display "trans. volts", "drive volts", "predrive volts", "final I", "driver I".

13. Each transmitter panel will have another two position switch labeled "NORMAL", "Driver Only". When in "Driver Only" position, the final filament will be off.

14. Below this will be the NIM bins, containing, for each transmitter, the following modules:
    Amplitude servoe, phase shifter, phase servoe, fine tuner, coarse tuner, driver servoes

15. But then I realize I forgot about the turn-on problem. We will resolve that later. In the meantime the above may be useful if only to elicit constructive comments and recommendations from others.