B. Johnson

214-0034-01-01_00

RF NOTE #33

August 22, 1978
D. Birkett

Servoe Systems

The servoe systems in the grand plan can be approximated with a first order transfer function of a single pole α.

$$V(S) = \frac{\alpha}{s+\alpha} \qquad u(s)$$

where V is output, u is input.

In our feedback control systems, we use the electronics to "linearize" the systems, so that with a closed loop, the entire system is characterized by a single time constant. We also want maximum DC gain, because we don't use a mechanical brake. Both these requirements are satisfied if the open loop transfer function of the total system (electronics plus servoes) is just.

$$\frac{K}{s}$$

because this provides infinite DC gain (an integrator) and the closed loop (unity feedback) response is

$$\frac{\frac{K}{s}}{\frac{K}{s}+1} = \frac{1}{1+\frac{s}{K}}$$

i.e. the closed loop system is linearized.

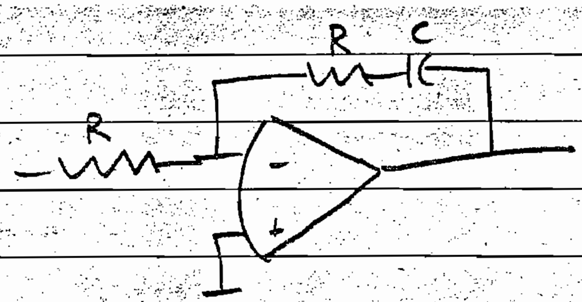
To get this type of open loop response, we require

$$\frac{K}{s} = X(s) \quad \frac{\alpha}{s+\alpha}$$

where X(s) is the transfer function of the electronics. Thus

$$X(s) = \frac{K}{\alpha} \quad \frac{s+\alpha}{s}$$

The op amp circuit



has the transfer fn. $\frac{s+\frac{1}{RC}}{s}$

so if we select $\frac{1}{RC} = \alpha$ and use the op amp for X(s).

$$\frac{K}{s} = \frac{s+\alpha}{s} \quad \frac{\alpha}{s+\alpha} = \frac{\alpha}{s}$$, thus $K = \alpha$

and the closed loop response is

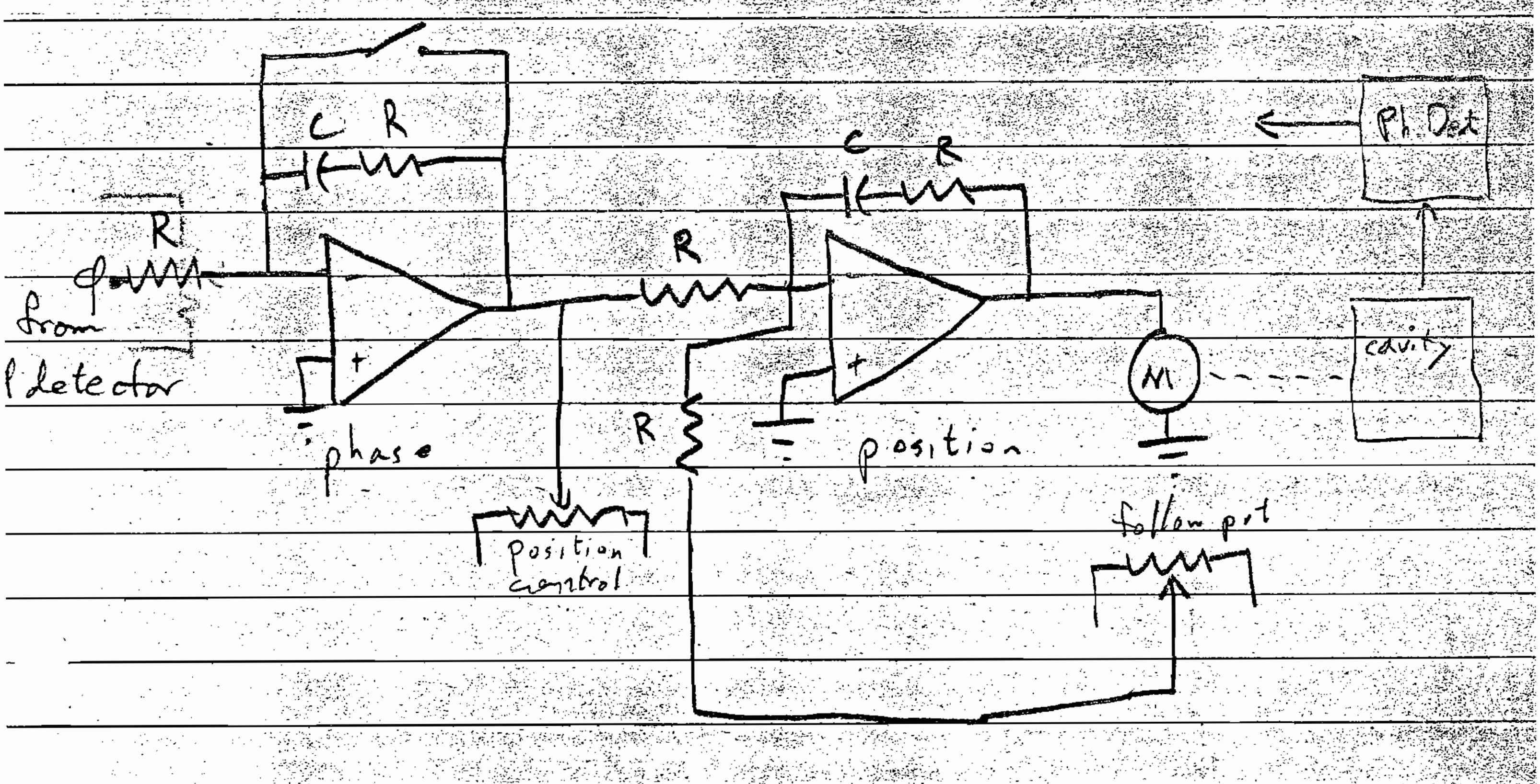
$$\frac{1}{1+\frac{s}{K}} = \frac{1}{1+\frac{s}{\alpha}} \equiv \frac{\alpha}{s+\alpha}$$

Notice that $\alpha = \frac{1}{RC}$ is an easy measurement to make on the mechanical system.

It may appear that the system will not be stable because the op amp is an integrator and it will integrate any error due to hysterisis. We looked for such a slow oscillation with the chart recorder on the sliding short system, and it must have been too small to see.

Phase and Position Controllers.

All our servoe electronics have the same form.



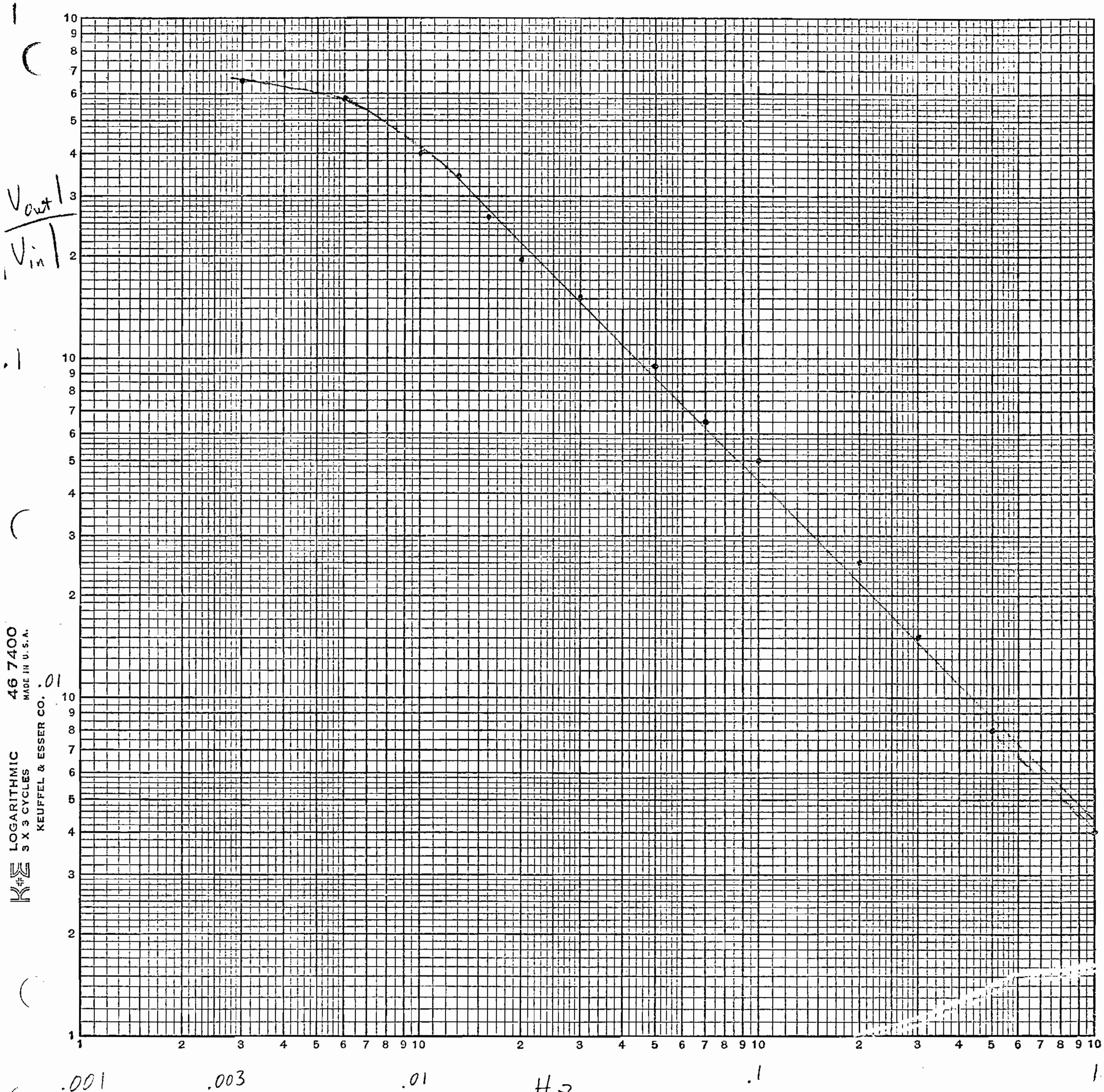
When R.F. is not present, the switch on the first op amp is closed, so that the circuit acts as position controller only. When RF is applied, the switch is open. Note that the second op amp plus motor, with loop closed, has the same transfer function as the open loop mechanical system

$$\frac{\alpha}{s+\alpha}$$

as was shown previously. Therefore, we select exactly the same RC network for the phase op amp, and exactly the same devivation obtains, with unity feedback thru the phase detector.

Sliding Short

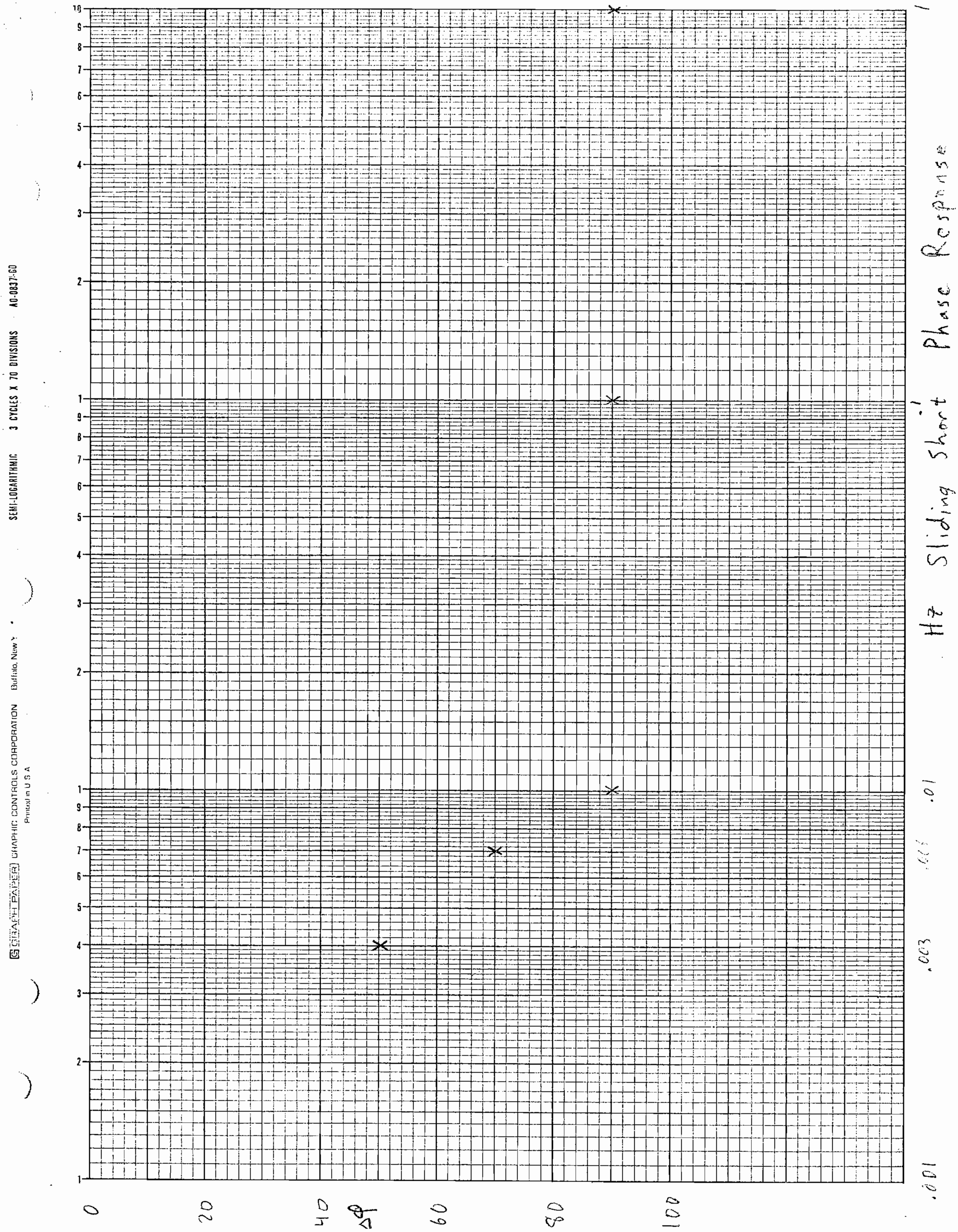
After some experimentation with the best method of moving the sliding short, we finally selected a hydraulic motor with chain drive with the follow pot mounted directly on the motor shaft. We decided upon these because the electric motor was not strong enough without an unacceptably small sprocket, and we wanted to remove chain oscillations from the system. (The chain is 20 ft long) The data was collected with finger stock at 20 lb friction load with considerable galling. Using this data we estimate the break frequency at around .003 Hz so that RC = 53 sec.



Amplitude Response

Sliding Short System

20 lb. friction load

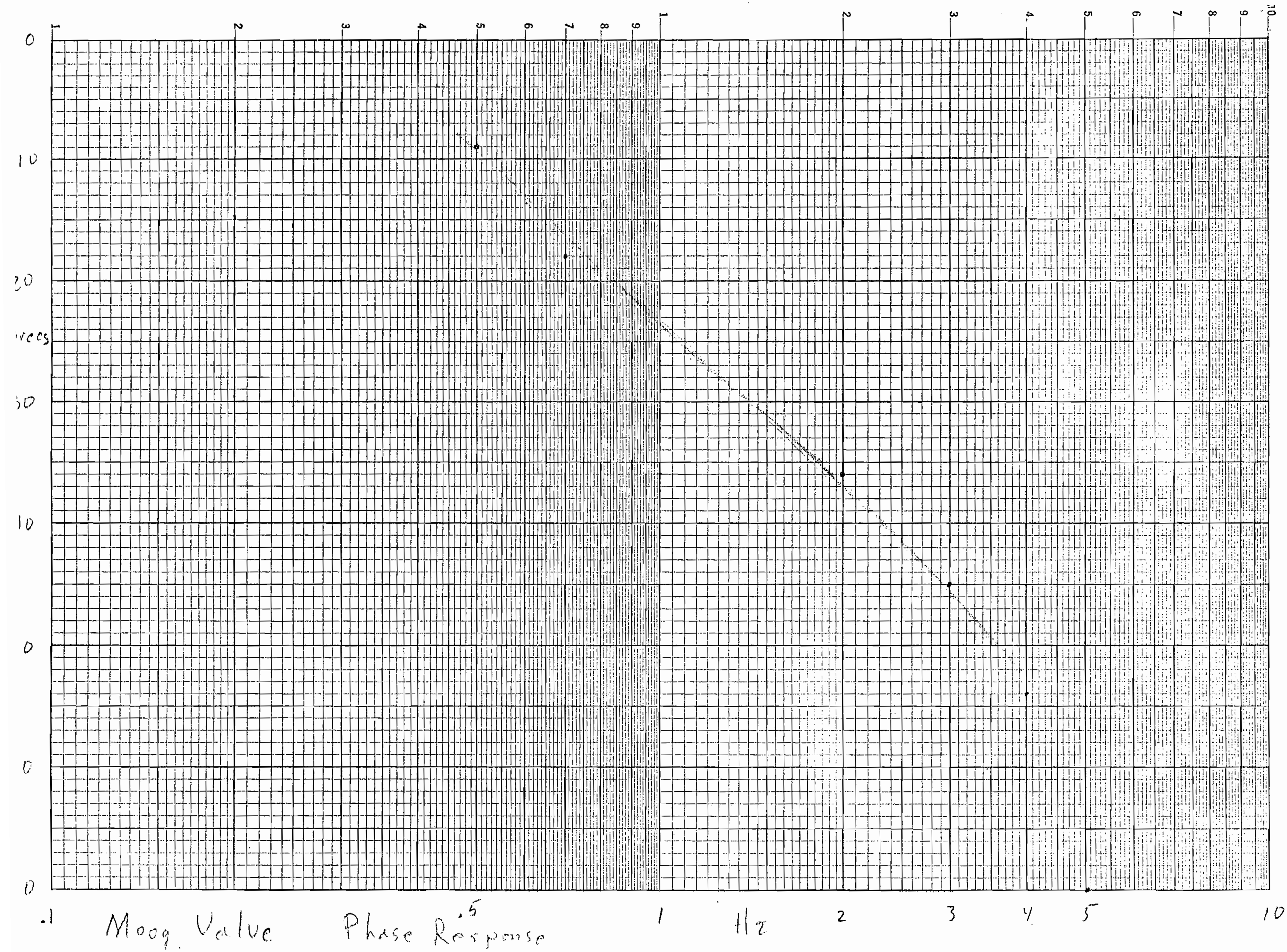

Hz Sliding Short Phase Response
.001
.003
.01
1
0
20
40
Δφ
60
80
100
SEMI-LOGARITHMIC 3 CYCLES X 70 DIVISIONS AO-0837-60
GRAPH PAPER GRAPHIC CONTROLS CORPORATION Buffalo, New Y
Printed in U.S.A.

Dee Fine Tuning

Fine tuning of the dee cavities will be via Moog valves driving variable capacitors, as opposed to sliding short inductors used elsewhere. The sliding shorts of the dee stems will be used only for rough tuning. The open loop frequency response of the moog valves is plotted on the following graphs. From this graph we estimate the break frequency to be about 4.5 Hz, so that RC = .033.

Driver Tuning

Variable inductors in the grid and plate circuit of the driver are tuned using DC motors. The grid coil is adjustible thru 8 revolutions, the plate coil thru 14. A ten turn follow pot (appropriately geared) is mounted with the motor assembly. Frequency response data has not been collected yet.


Moog Value Phase Response
Hz
.1
.5
1
2
3
4
5
10

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