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Dear Jerry:

I am sending you material that summarizes one phase of the work I have done to date. It presents in somewhat more complete form what I told you at our meeting December 6th.

Figure 1 is a comparison of the JPL results and my results using my computer model and the JPL servo constants. My model is identical to the JPL model except that I neglect all structural and soil damping and I consider to be infinitely stiff that spring that lies between the motor rotor and the assembly consisting of the bull gear, yoke and tube. The agreement between the two results indicates to me that the results of both computations are correct. It is interesting to note that an even simpler model which considers the spring between the foundation and the stator gear case to be also infinitely stiff gives results that are the same, to the third significant figure, as those obtained from the model used.

Figure 2 shows the response to a unit step using more nearly optimum servo constants. The vertical scale of Figure 2 is ten times that of Figure 1. Two different curves are shown. One rises somewhat more rapidly than the other but rings at higher amplitude. The first has a maximum overshoot of about 3.5% and the second a maximum overshoot of less than 1%. The ringing that is apparent is due to the absence of damping.

Figure 3 shows how the response to a unit step is modified by the presence of damping. The damping used is that predicted by JPL, about 5% of critical. The dashed plot if continued to 2.5 seconds shows a maximum error of .25% at that time. While this does not strictly meet the specified value of .1 arc second 2.5 seconds after a 2 arc minute change, it certainly represents useful performance.

I am also enclosing a drawing which shows the general arrangement of the position control system. The position control is effected in two modes. The first makes use of a computer to program a digital to analog converter with the velocity desired to effect acquisition of the desired position. The second mode is used only in the R.A. drive and is used to track at sidereal rate. The rate may be adjusted by the computer in increments of about 1000th of an arc second per second over about a 1% range. It is relatively easy to change the design at this stage to make the resolution or the range different.

I do not yet have what appears to me to be a satisfactory scheme for changing control modes.

At our meeting on December 7th I stated some conclusions that I would like to reiterate at this time.

1. If all structural elements come out as rigid as calculations indicate, the performance of the positioning system will be limited almost solely by the spring rate between the foundation and inertial space. Any change in this constant will be reflected in the response time. The response time is inversely proportional to the square root of this spring rate.

2. For no damping in the soil and a response to a step command that is about 95% complete in about 1/2 second, the pointing angle will oscillate with about 1% of the amplitude of the change commanded. With damping present this oscillation will die out at a rate governed by the damping.

3. The design will be such that the servo constants may be easily and precisely set in the field. Hence even if the calculated spring rates and damping ratios are off by large factors, it will still be relatively simple to obtain the optimum response permitted by the physical parameters that actually exist.

The "not to exceed" total of your P.O. was originally $19,370. This was supplemented by $2,920 for a total of $22,290. An invoice was submitted for approximately $1960 on February 29 of this year so the remaining amount authorized is $20,330.

Since February 29 I have spent about $4500 in labor, about $500 in computer expense and about $150 in travel expense, for a total of $5,250. I estimate that I will put in about another $1,000 before the end of December so at that time I will have spent about $6,250 since the last invoice. The total spent will then be about $7,210 and the remaining amount authorized $15,080. As I estimate that I am about 50% complete and only about 33% of the authorized funds will be used by December 31, I feel that the money is in good shape. I would like to bill for the time since my last invoice ~~before~~ on December 31 of this year. Is the form that I used for my February 29 invoice satisfactory?

I am not certain whether the University of Hawaii or I should do the design pertaining to the protective circuitry which will cut off the drive in the event of amplifier or control system failure.

I would appreciate your advice on this point.

Yours very truly,

Haskell

Haskell Shapiro

HS:eb

Enclosures

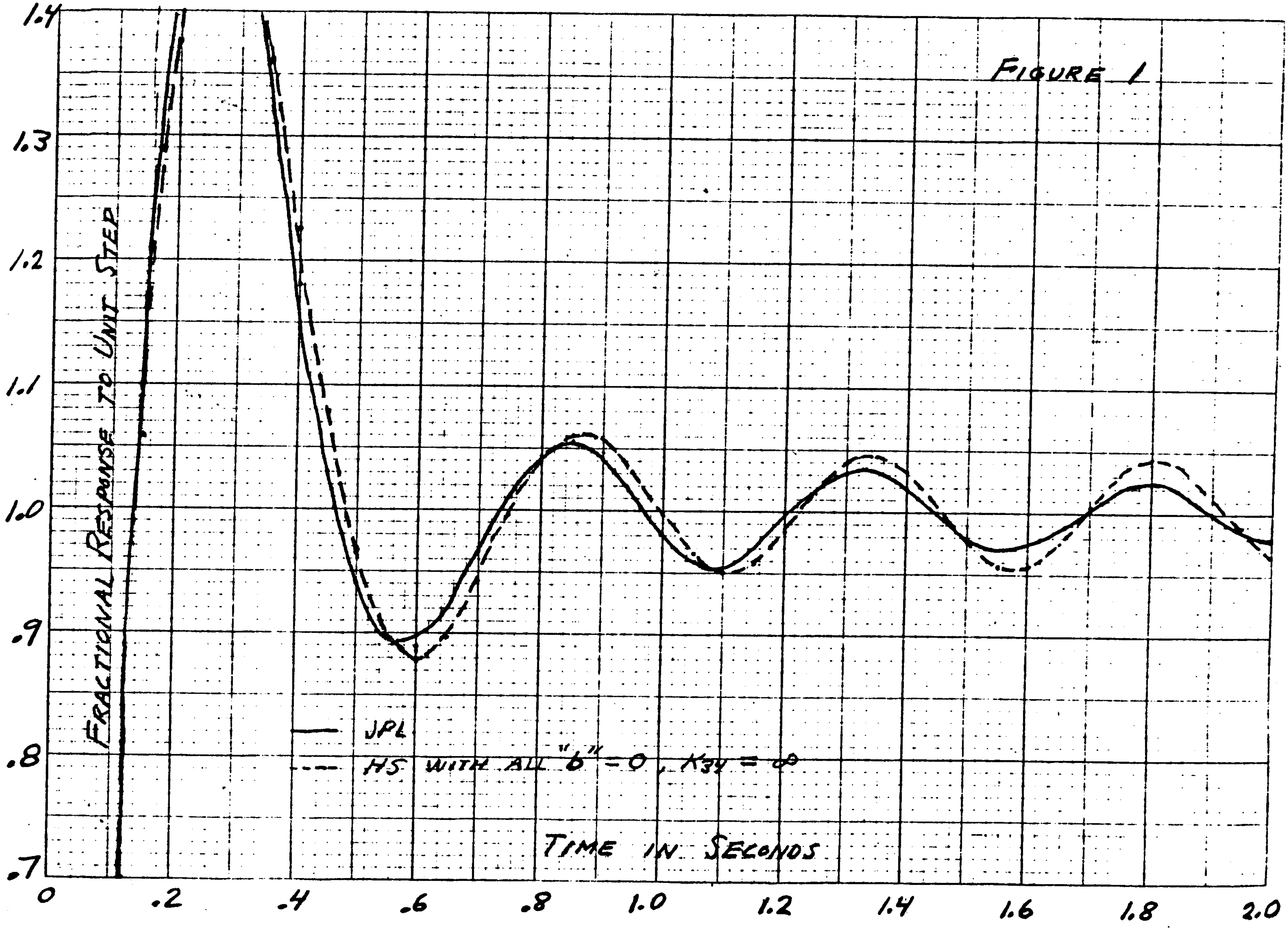


FIGURE 1
FRACTIONAL RESPONSE TO UNIT STEP
TIME IN SECONDS
JPL
HS WITH ALL "b" = 0 , K34 = ∞
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0

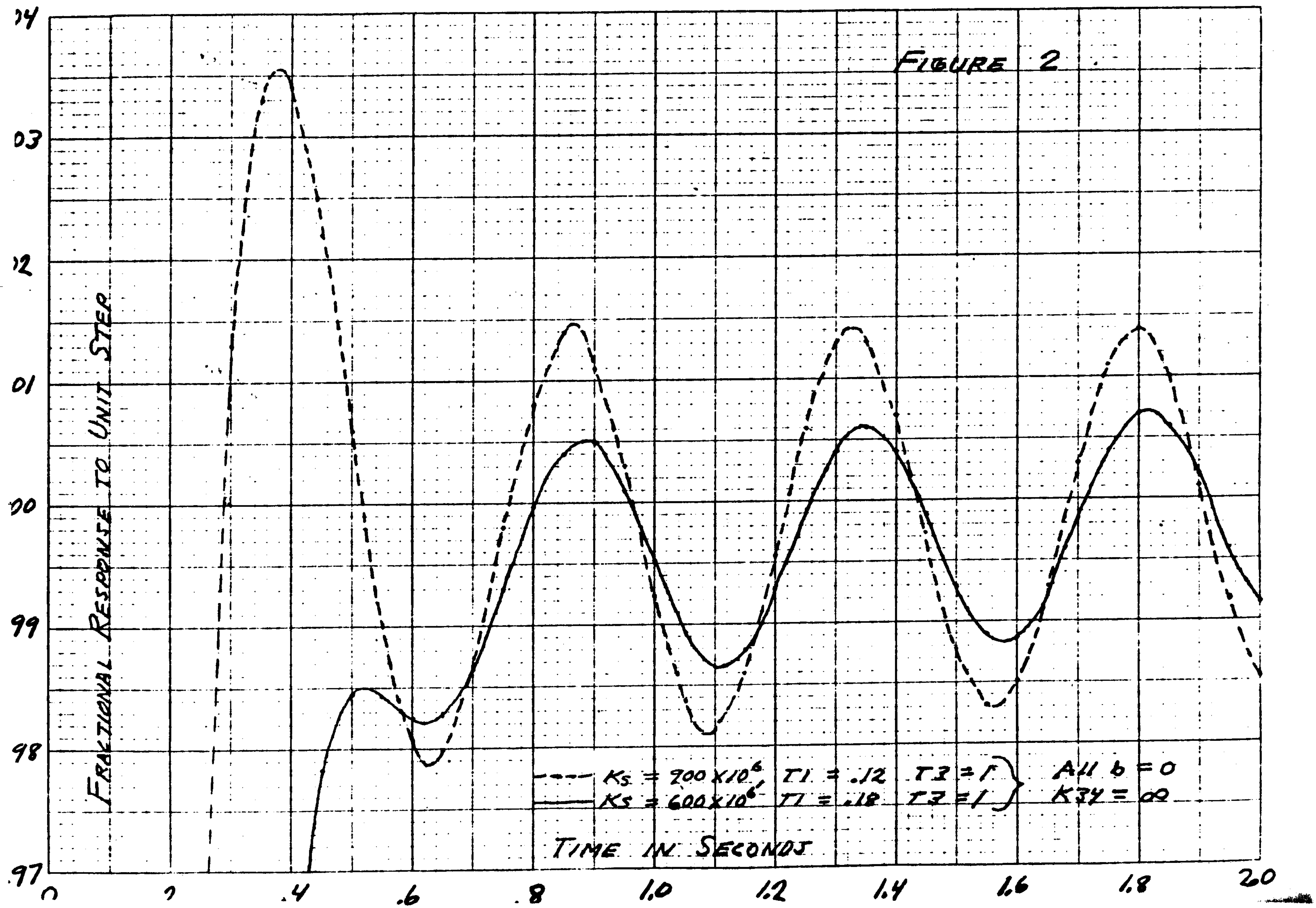


FIGURE 2
FRACTIONAL RESPONSE TO UNIT STEP
TIME IN SECONDS
Ks = 900 X 10^6, T1 = .12 T3 = 1
Ks = 600 X 10^6 T1 = .18 T3 = 1
All b = 0
K34 = ∞
.97
98
99
00
01
02
03
04
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0

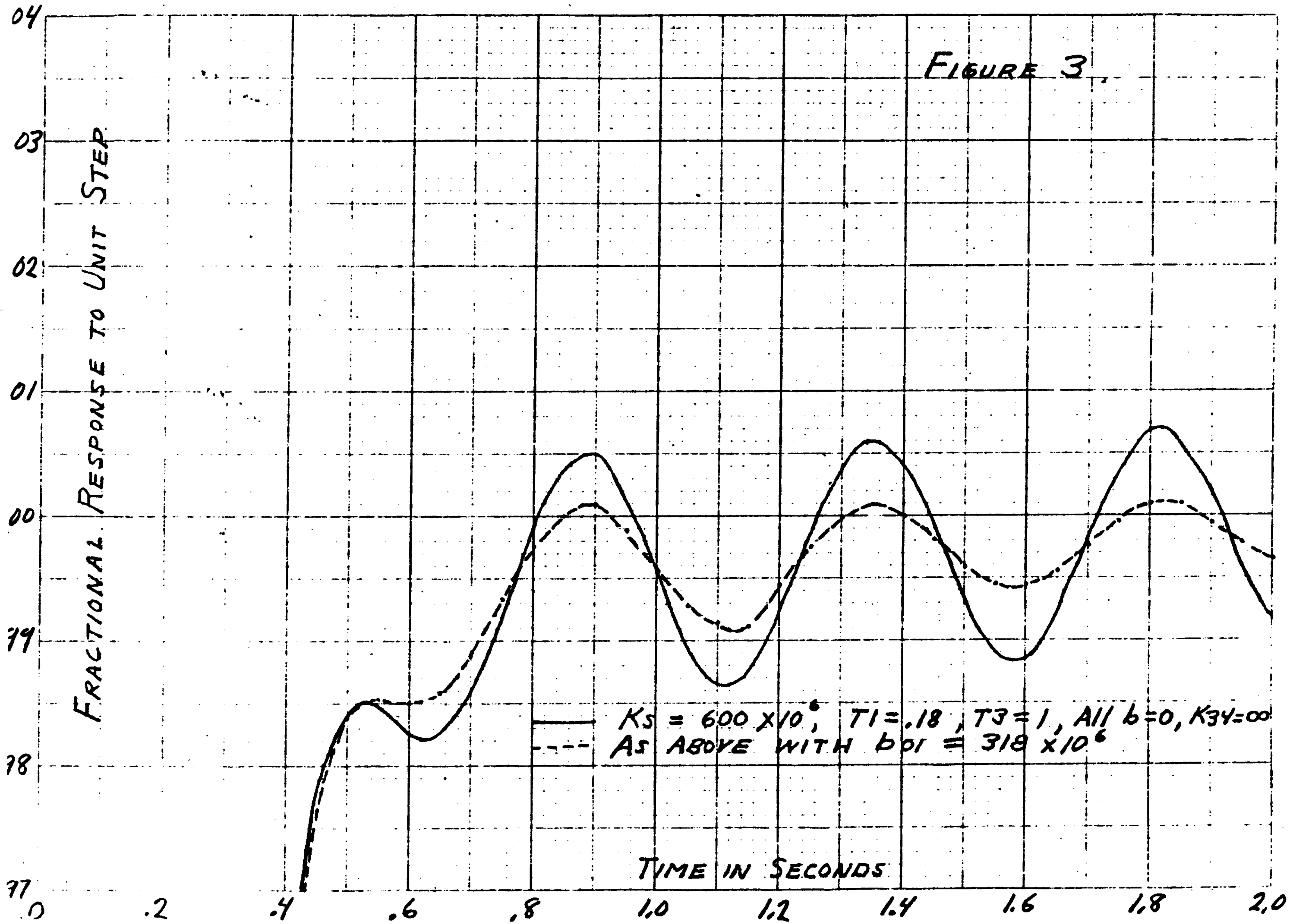
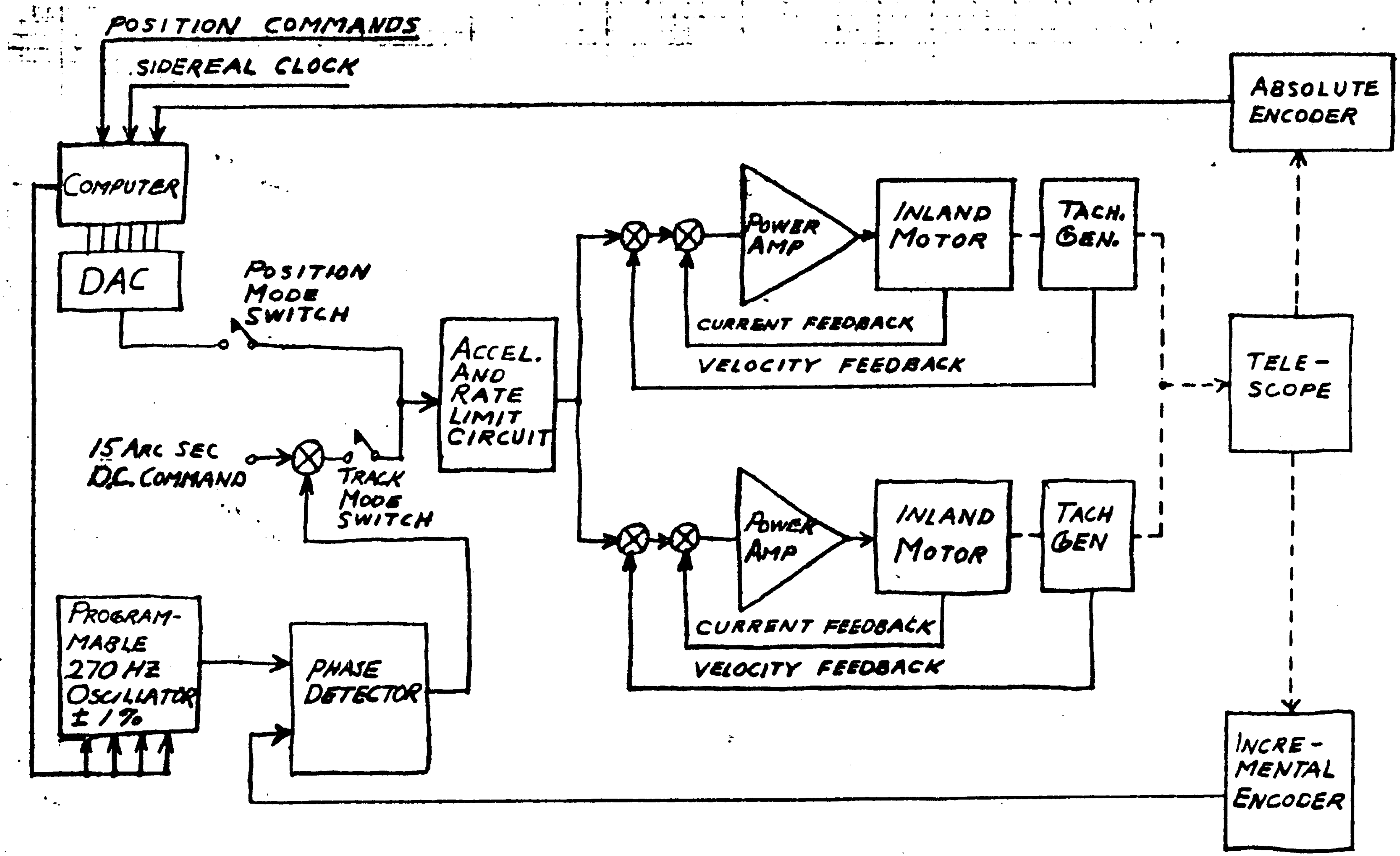
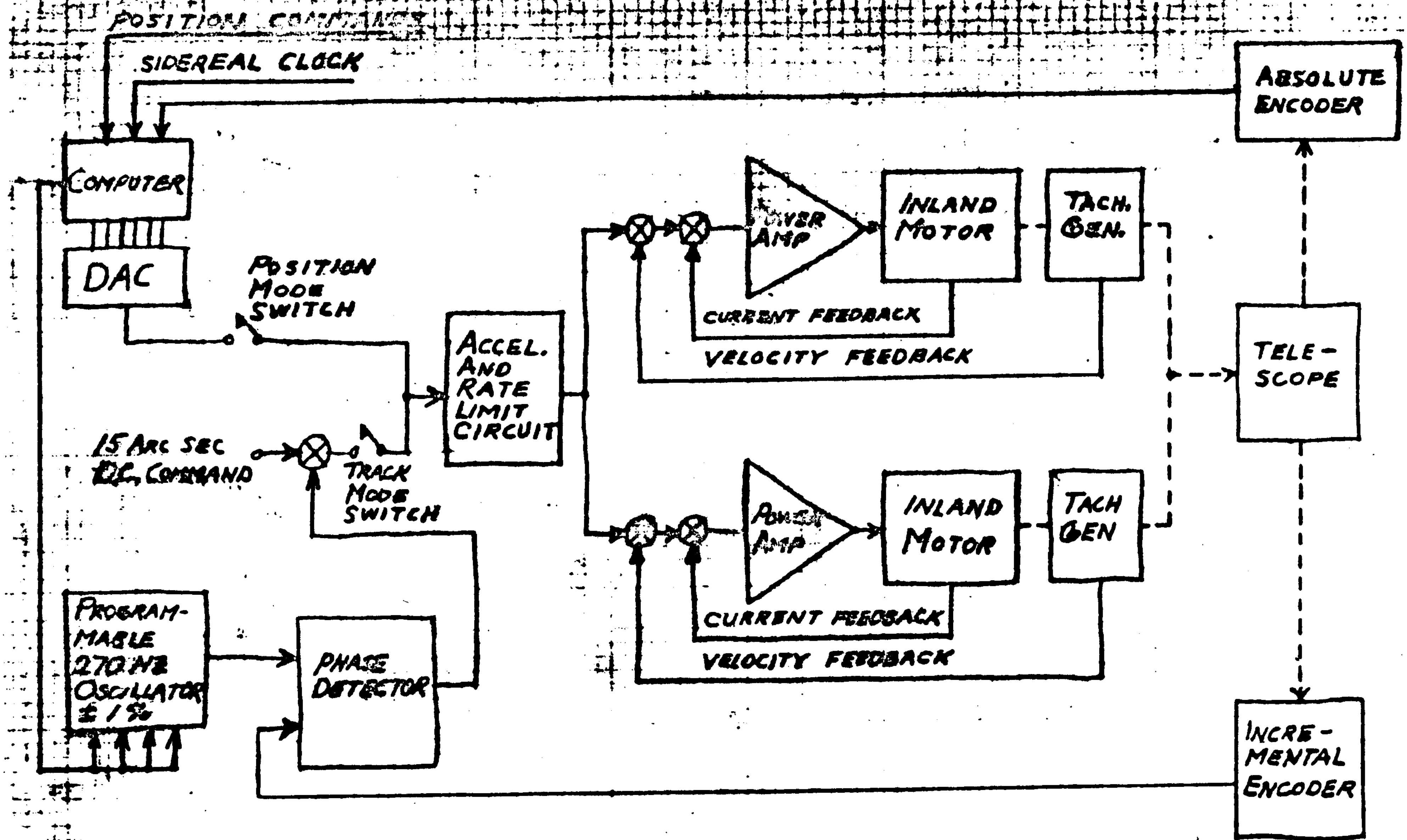


FIGURE 3
FRACTIONAL RESPONSE TO UNIT STEP
04
03
02
01
00
99
98
97
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
TIME IN SECONDS
Ks = 600 X 10^6, T1 = .18, T3 = 1, All b = 0, K34 = ∞
AS ABOVE WITH b01 = 318 X 10^6



I/R TELESCOPE DRIVE
J/N 333



I/R TELESCOPE DRIVE
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