INTRODUCTION

This handbook is intended to be a collection of circuit diagrams and other relevant information about the locking servos of the 40 meter prototype Gravitational Wave Detector at Caltech.

The information contained in this handbook reflects the state of the servos as of July 1989. The handbook should be updated continuously; Otherwise it will be obsolete very soon.

In order to update a circuit diagram in the hand book; please make a copy of the old diagram and mark your changes on the copy. Then put the upgraded copy in front of the old diagram in the hand book. A short explanation of the changes on the diagram is also very desirable.

Thank you very much for your cooperation.

Yekta Gürsel
July 24, 1989

BATCH START

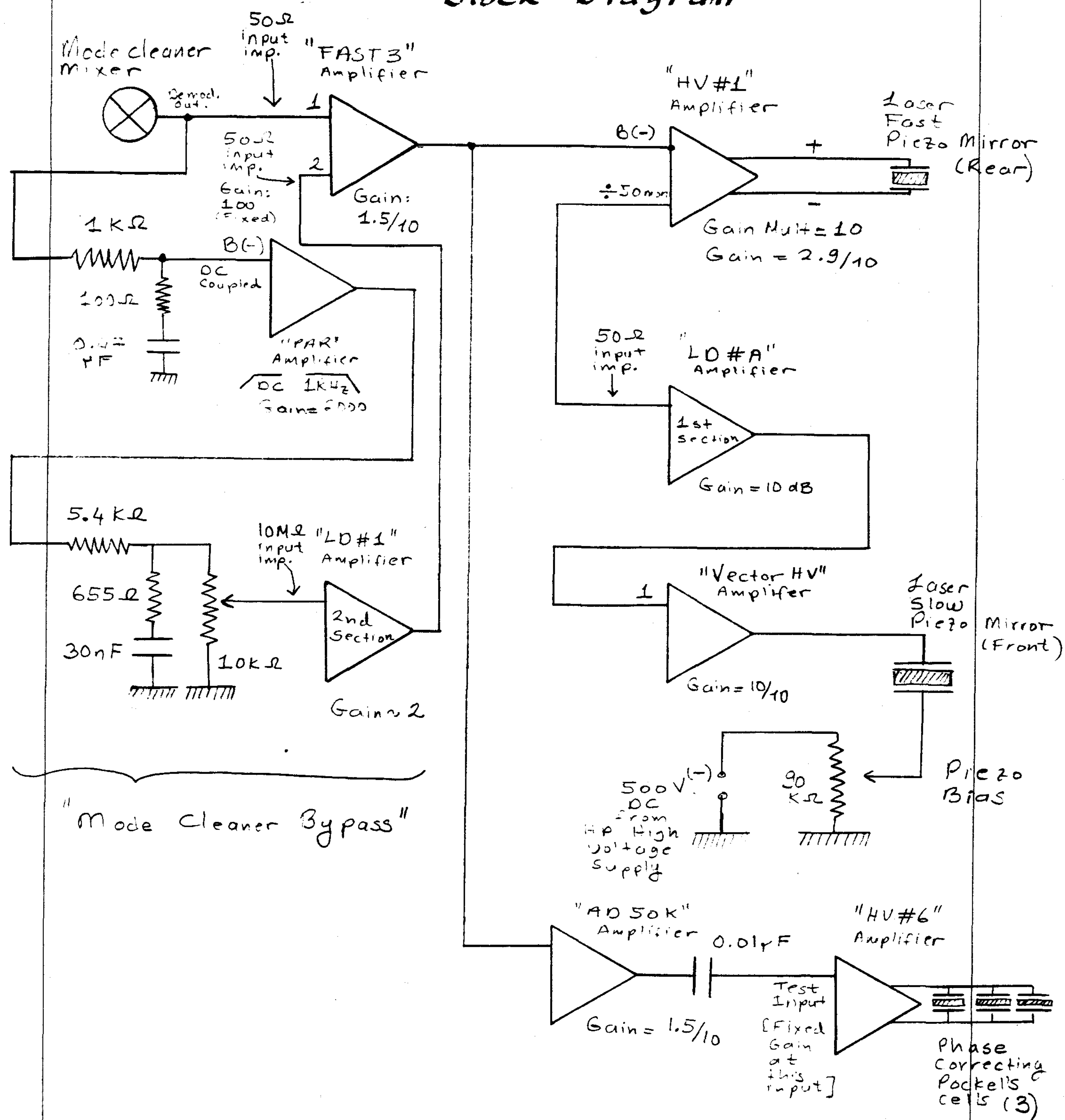
STAPLE

OR

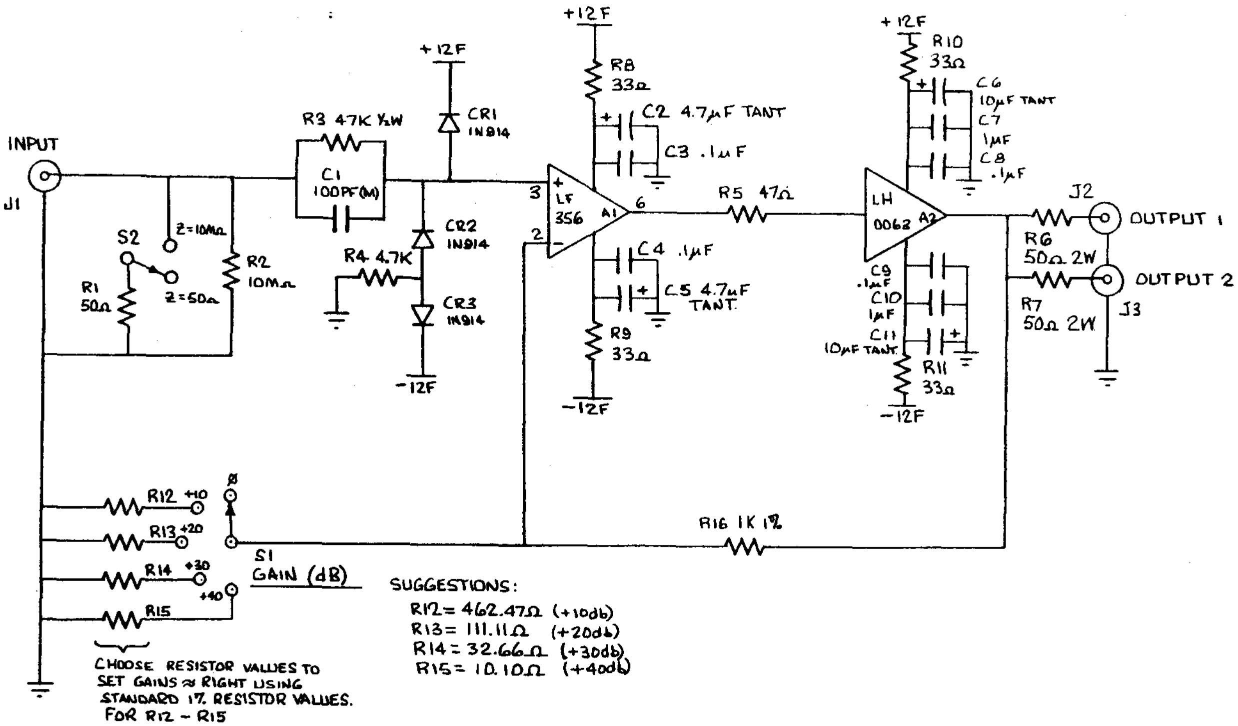
DIVIDER

Mode Cleaner Servo Loop

Block Diagram



July 21, 1989
YG



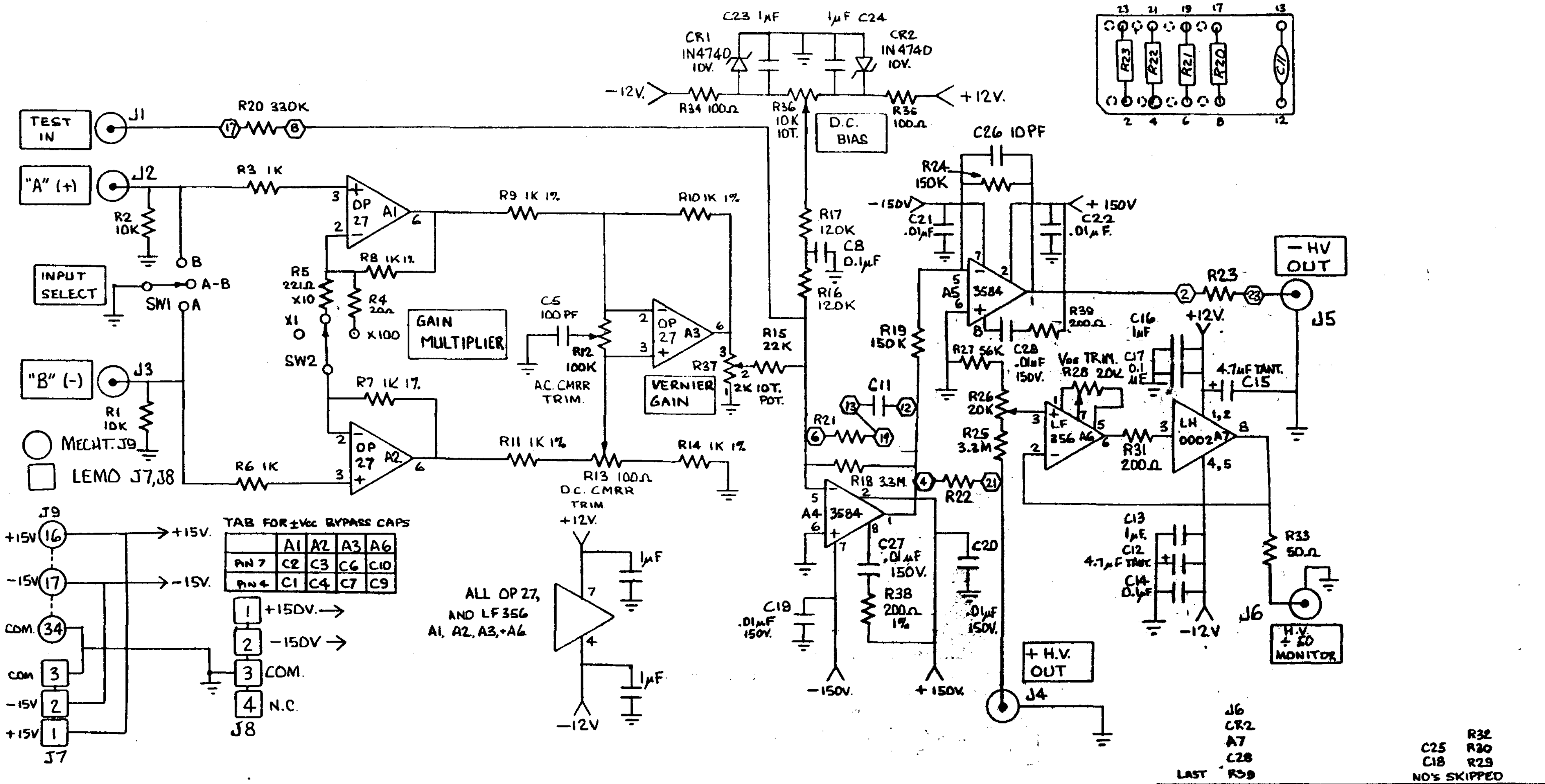
A2
CR3
S2
J3
R16
LAST C

CALIFORNIA INSTITUTE OF TECHNOLOGY
GRAVITATIONAL PHYSICS

LINE DRIVER

DRAWN BY B.T.	DATE 6-13-88	DRAWING NO.
CHECKED BY	SCALE	
APPROVED BY	W.O.	

88-0613-1



SMARTWRK FILE C:\ SMARTWRK HVAMP.PCB

DRAWN FROM E. LINDELEF OF 9-1-87 PRO HVAMP.PL

ADDED COMP. CARRIED PIN NO's TO DWG.

REPLACES 87-0901-1

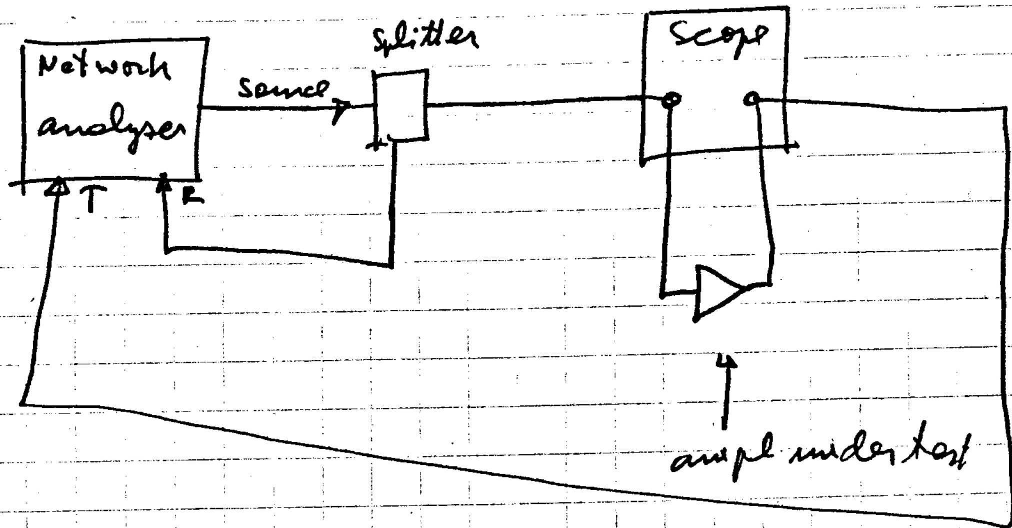
NOTES 1. ┌J┐ INDICATES JUMPER TO SHORT.

2. J7, J8, and J9 ARE ALL MOUNTED ON BACK PANEL.

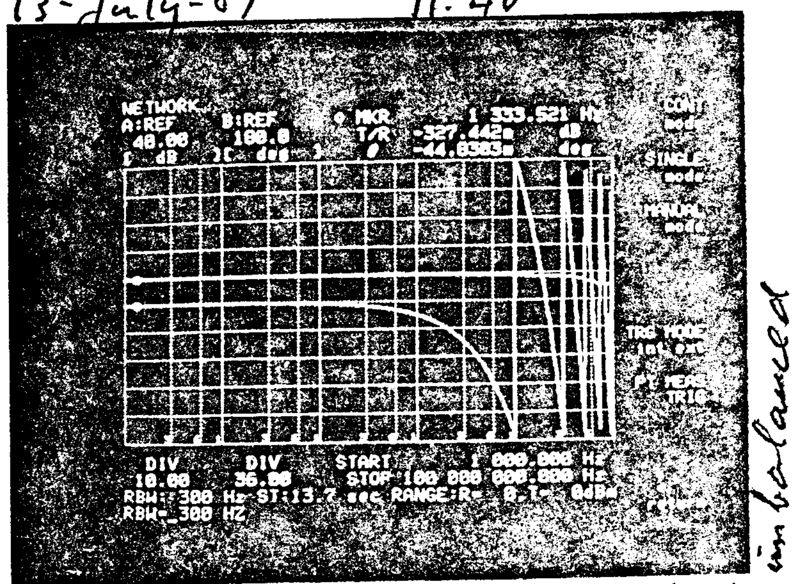
CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS			
HV AMPLIFIER ± 150V.			
DRAWN BY B. TINKER	DATE 3-4-88	DRAWING NO.	
CHECKED BY	SCALE		
APPROVED BY	W.O.		

88-0304-1

Since ~30' of cables were used to connect the amplifier under test (see diagram below), we took the response of the cables themselves (trace at 11:40)



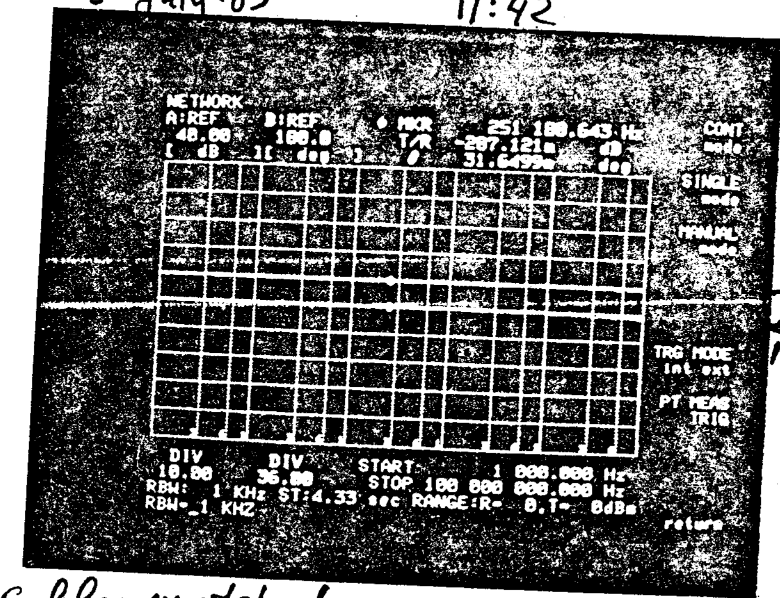
13-July-89 11:40



TR. FUNCTION OF CABLES – they are badly unbalanced

- It turns out that at 250 kHz the cables alone show a phase shift of 5°.
- Therefore, the ~3' cable from splitter to R input was replaced with a long cable, matched to the one in the test path. See traces overleaf

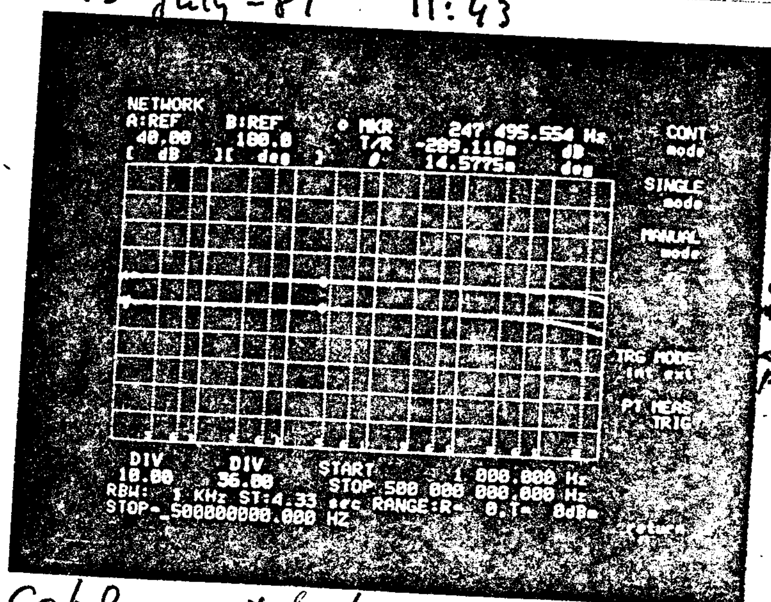
13-July-89 11:42



G
ph

Cables matched

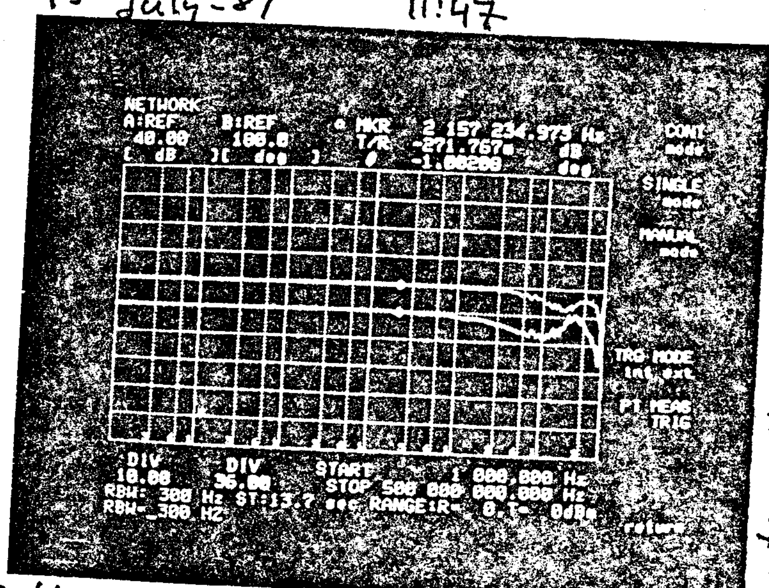
13-July-89 11:43



G
ph

Cables matched

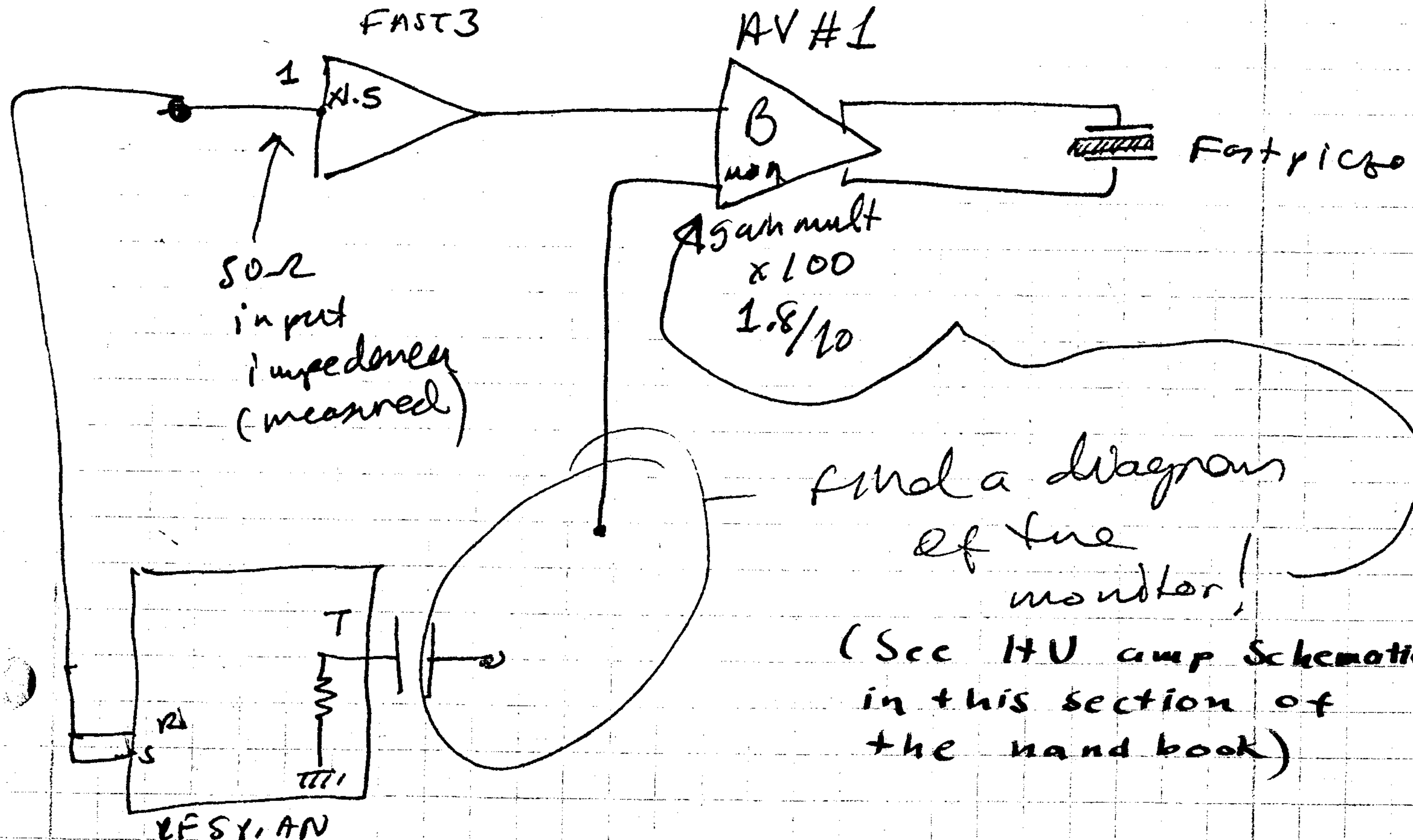
13-July-89 11:47



to scope

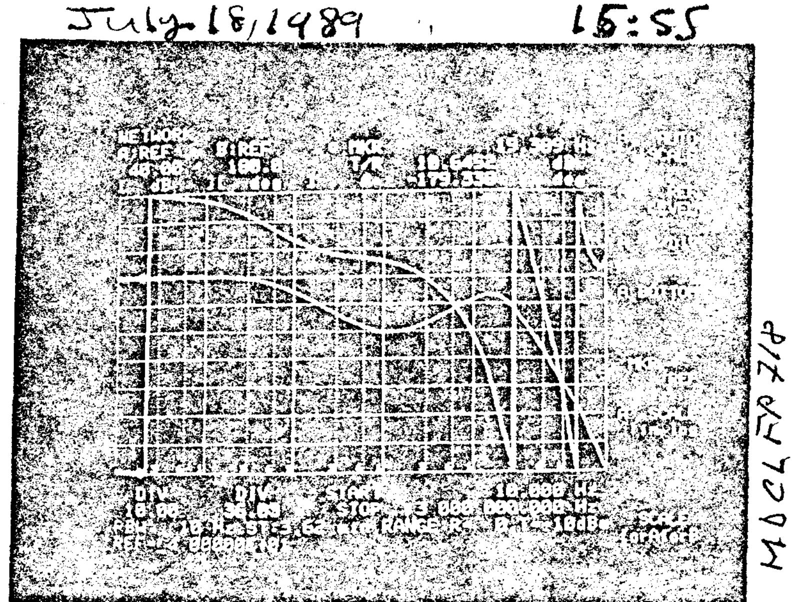
Cables matched, going through T's connected

Fast Piezo branch of mode cleaner loops (Transfer Function)



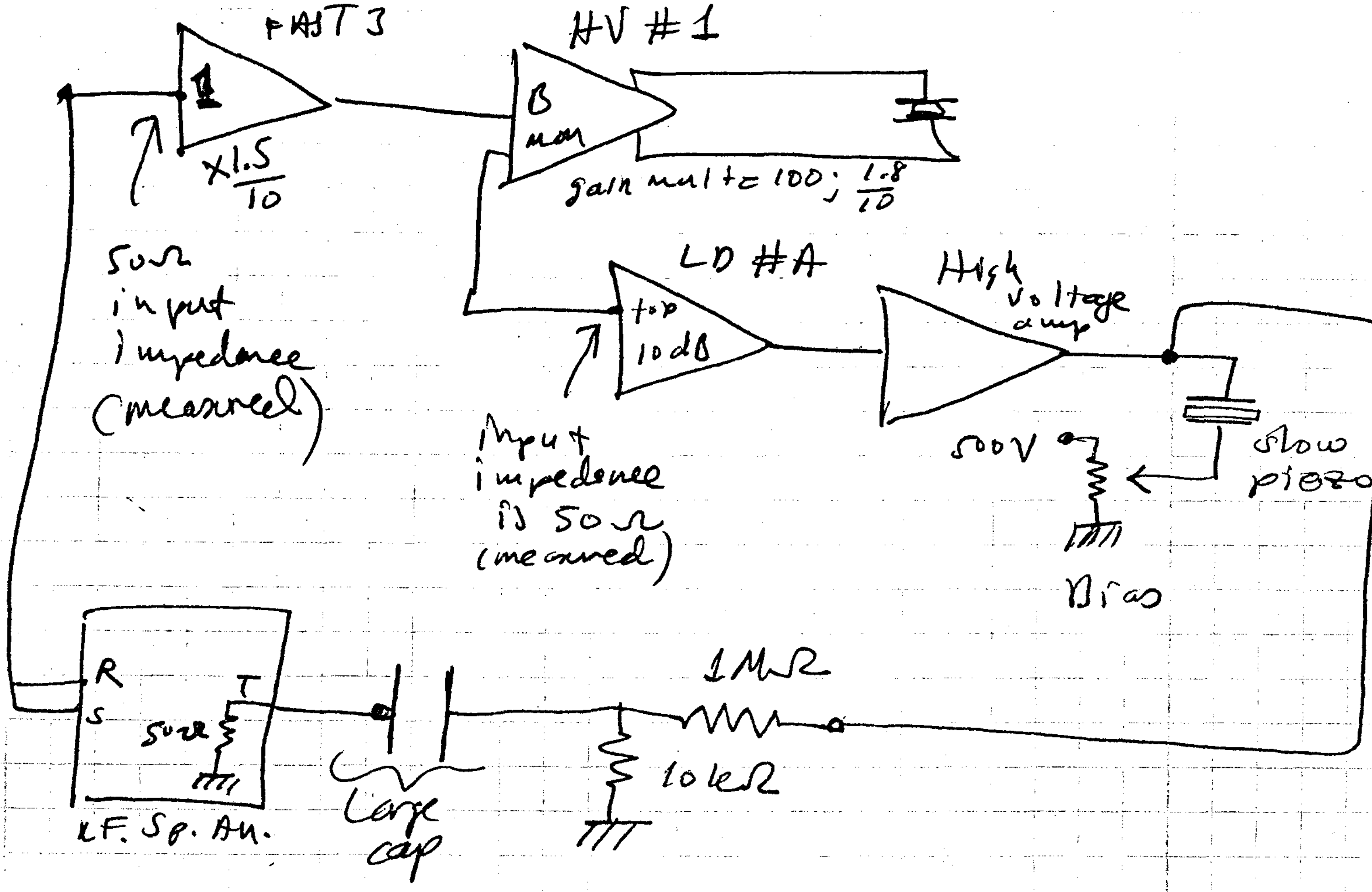
find a diagram of the monitor!
(See HV amp Schematic in this section of the hand book)

July 18, 1989 15:55

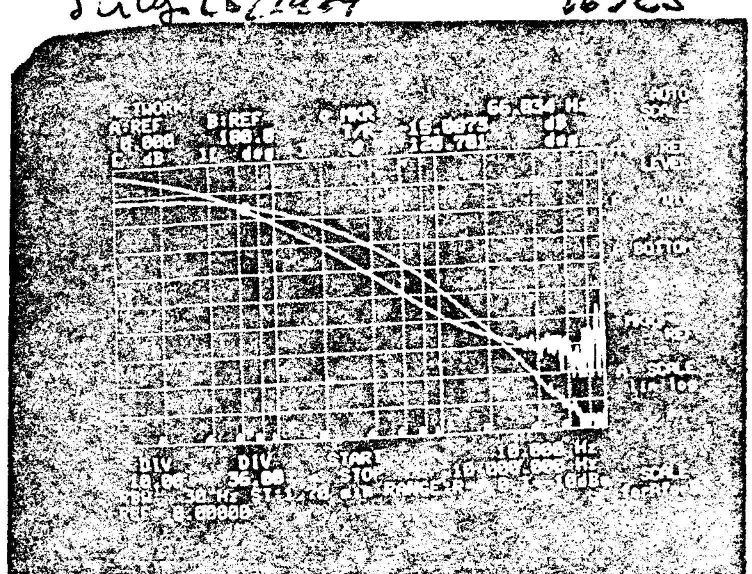


Fast piezo branch of mode cleaner Loop

Mode cleaner slow piezo branch ~~piezo~~ transfer function:



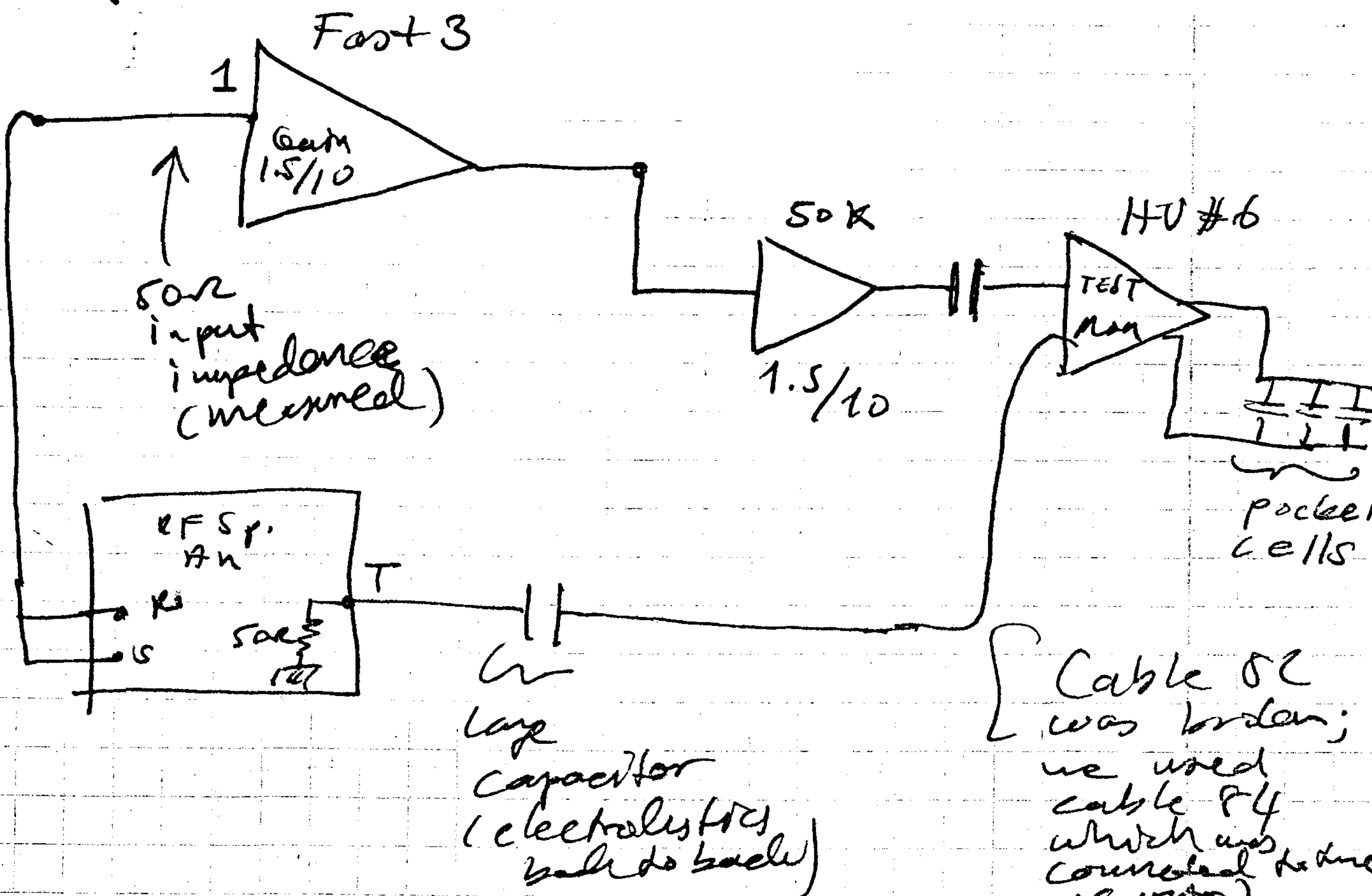
July 18, 1999 16:25



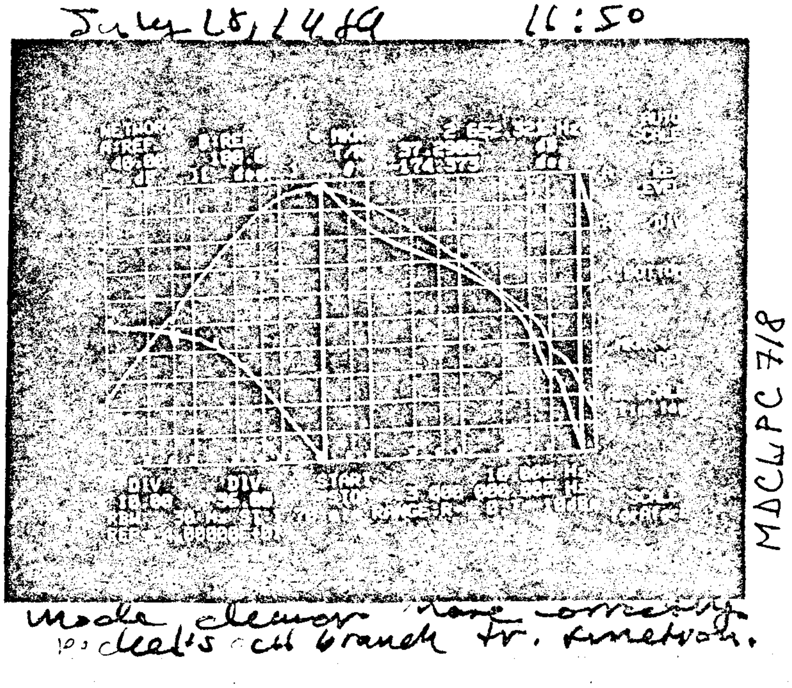
MDCLSP718

Mode cleaner slow piezo branch transfer function.

Mode cleaner phase correcting pockel's cells branch transfer function:



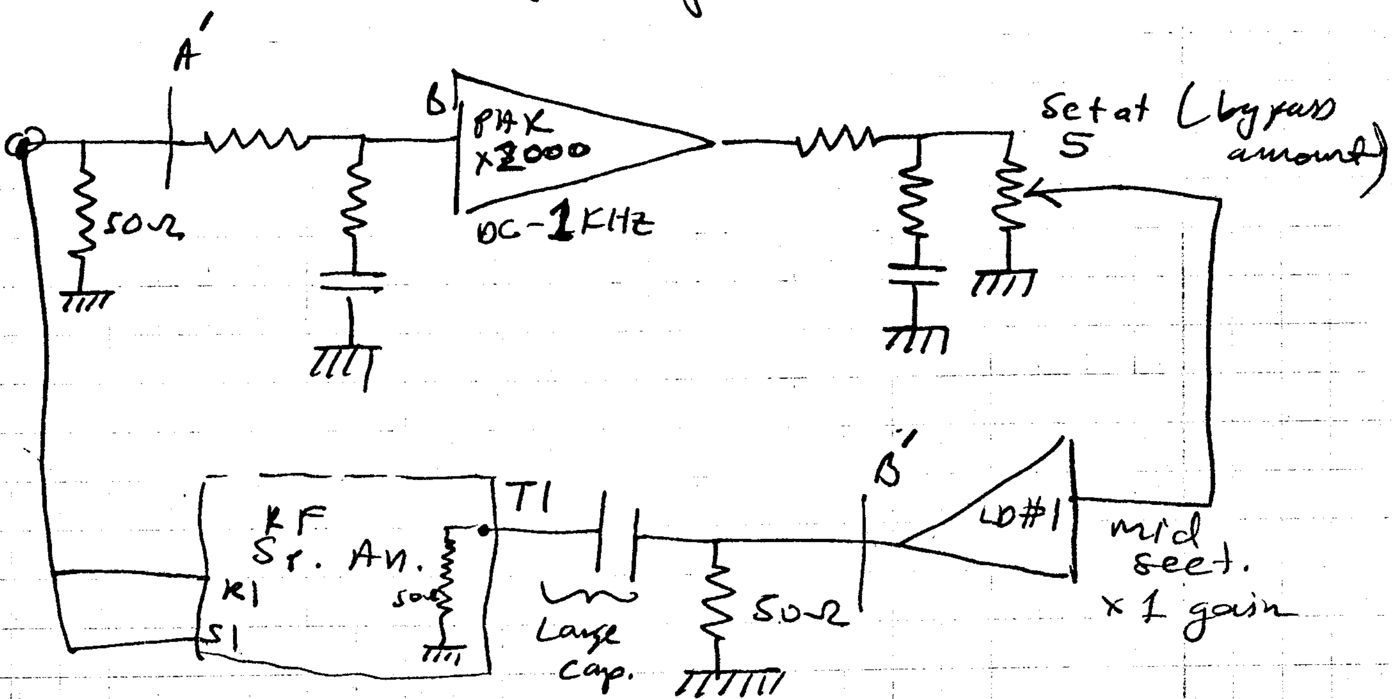
July 28, 1989 11:50



Mode cleaner phase correcting pockel's cell branch tr. function.

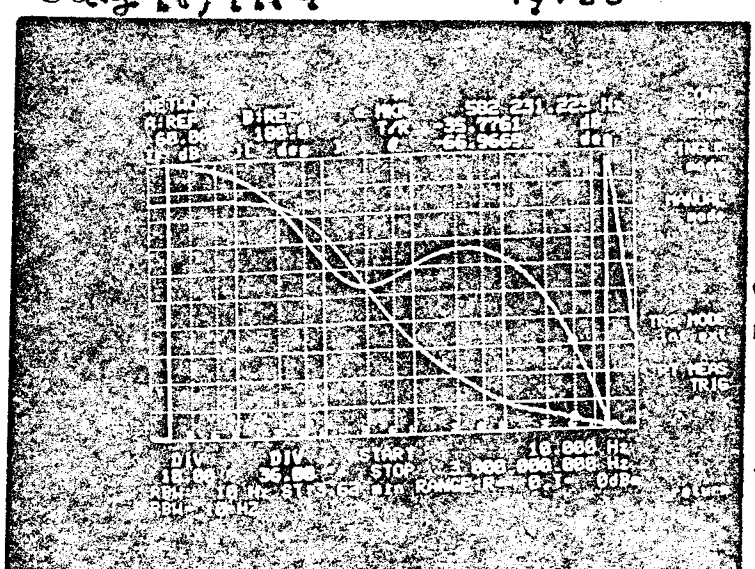
July 18, 1989
YG

Mode cleaner loop servo branch transfer functions:



A' to B' : Mode cleaner bypass circuit.

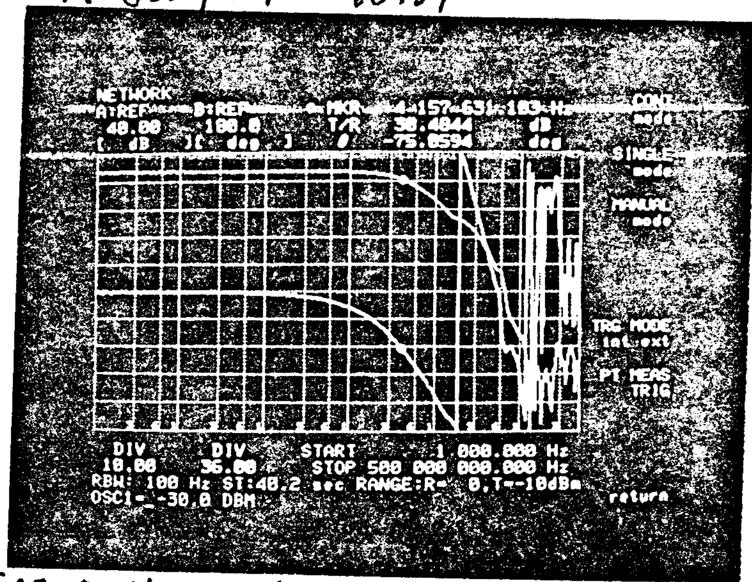
July 18, 1989 14:30



MDCLBP718

Mode cleaner bypass tr. funct.

14-July 89 10:59

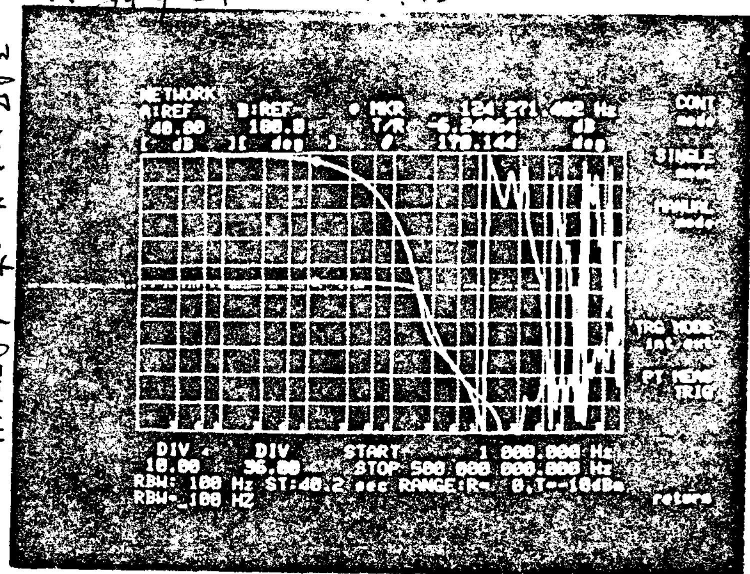


FAST 3 711V ←

FAST3, Var. in (max) 10°: 461.6 kHz

17 July 89 13:35

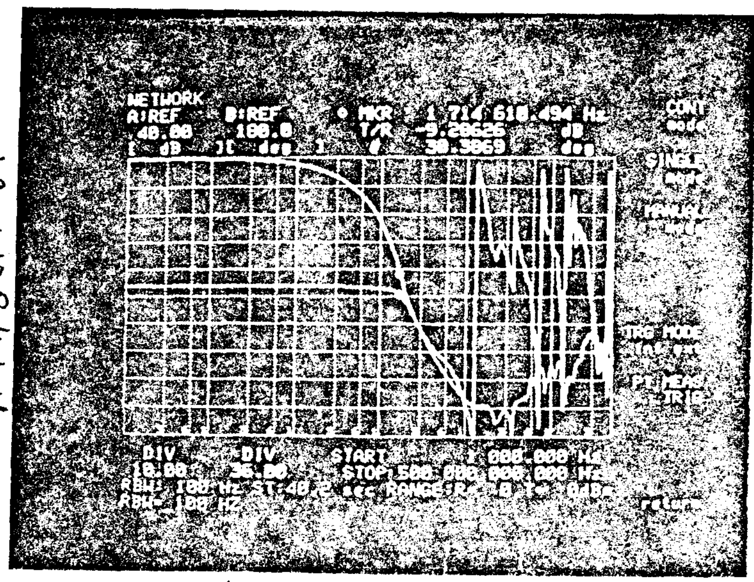
3dB point at: 1.955MHz



LDA MID ØDB

Line driver A, mid, 0dB, 50Ω out.

10° : 128.4 kHz

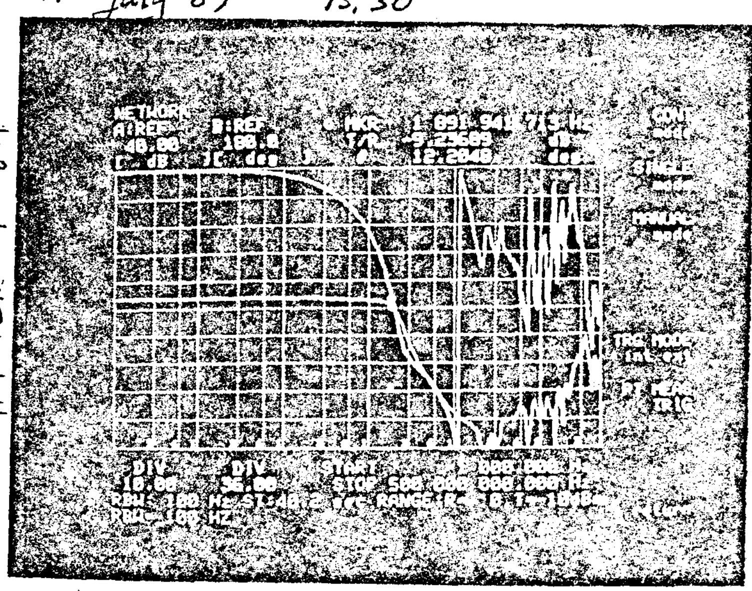


LDA LOW

Line driver A lower, 50Ω out, 0dB

17 July-89 13:30

10° at: 124 kHz

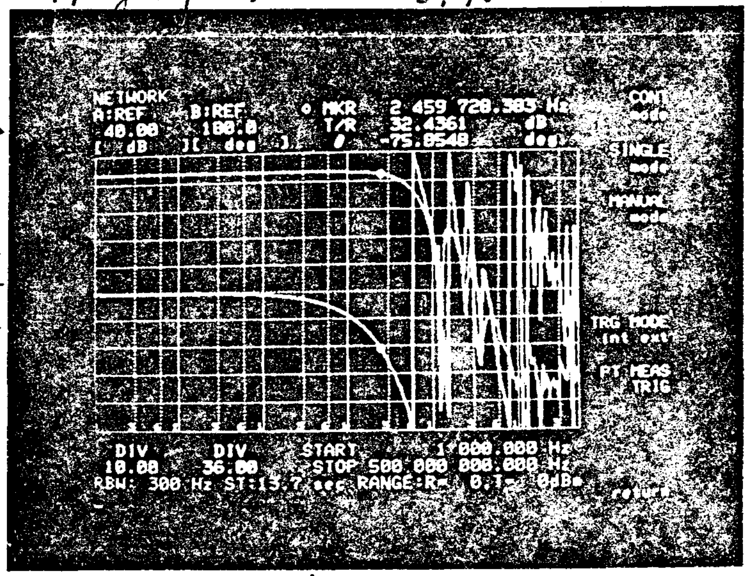


LDA UP ØDB

Line driver A, upper, 0 dB, 50Ω at outp.

17 July 1989

17 July 89 9:40



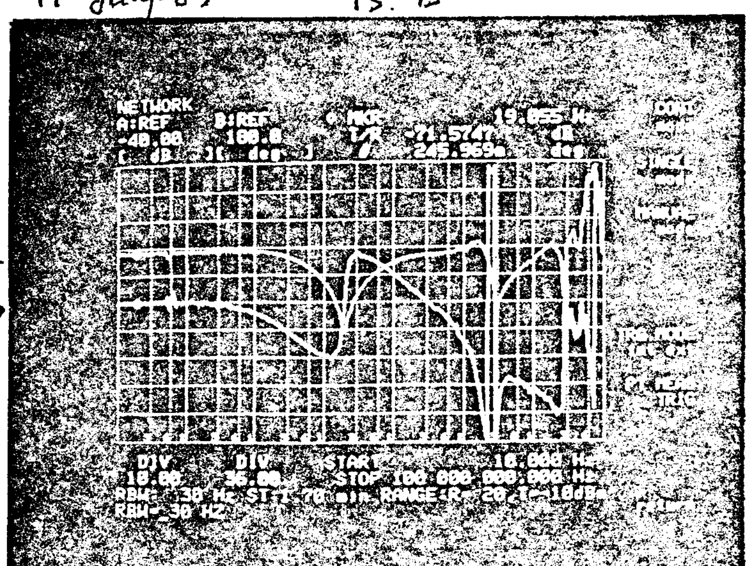
10° : 321 kHz

AXES: 100 MHz 40 dB

FAST 1 V

FAST 1 50 Ω out, V inp, full gain (33.5 dB)

17 July-89 13:43



e_R ∅

←

CROST 1

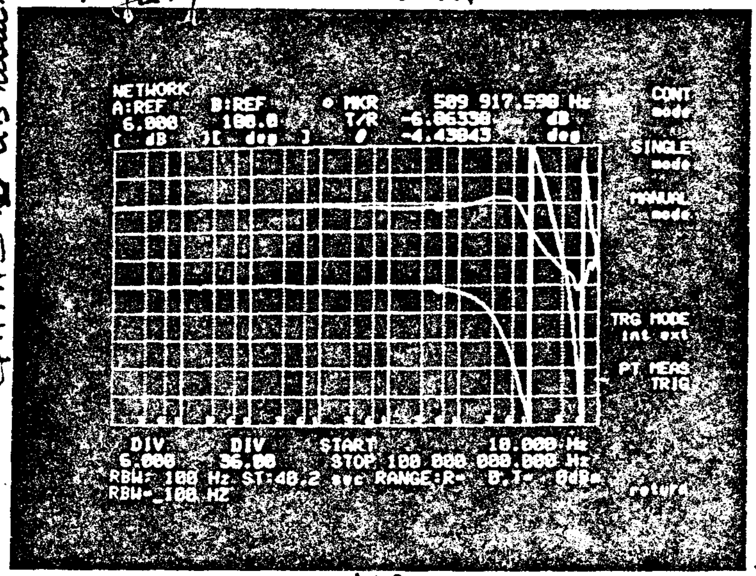
Crosstalk between HiJ. (in) and Lower (out) on LD#A

14-July-89

More transfer functions taken

14-July-89 10:17

GAIN = 0 dB nominal

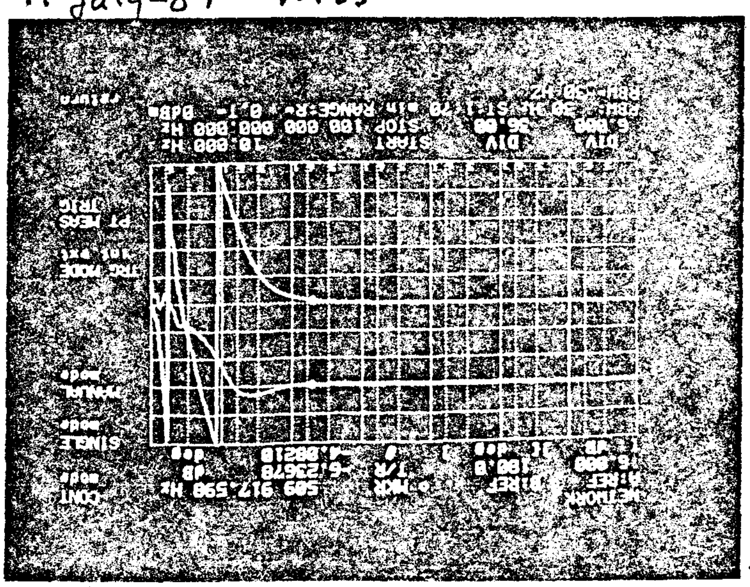


LD1 MID ←

LINE DRIVER 1, Middle, 50Ω in, out

14-July-89 10:25

GAIN = 0 dB nominal

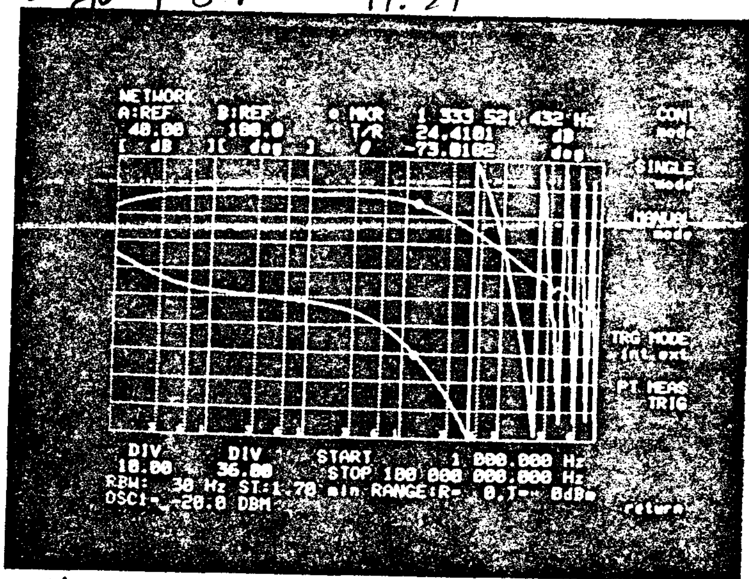


LD1 low

Line driver 1, Lower, 50Ω in out

13-July-89 11:21

AXES: 100 MHz 40 dB



← unmatched cables

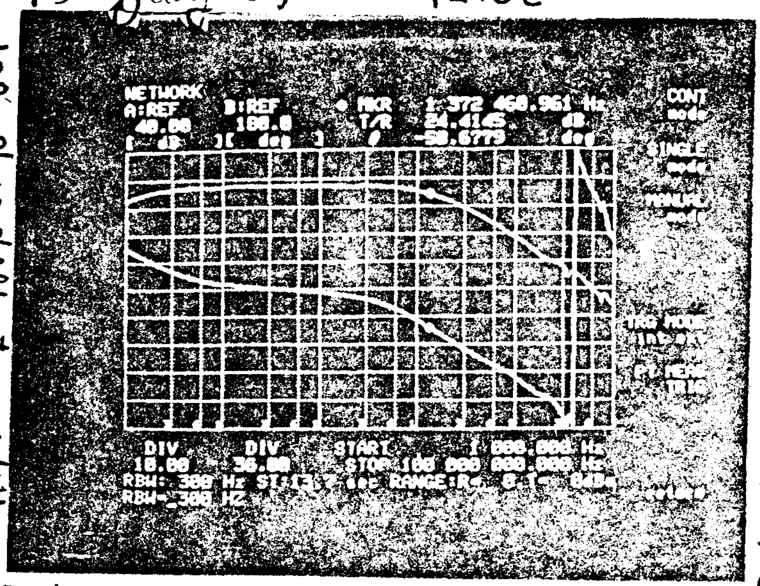
←

50K 713

50K 50Ω in and out

13-July 89 12:02

10° phase shift at 230 kHz



50K 7/3

50K ~~in and out~~

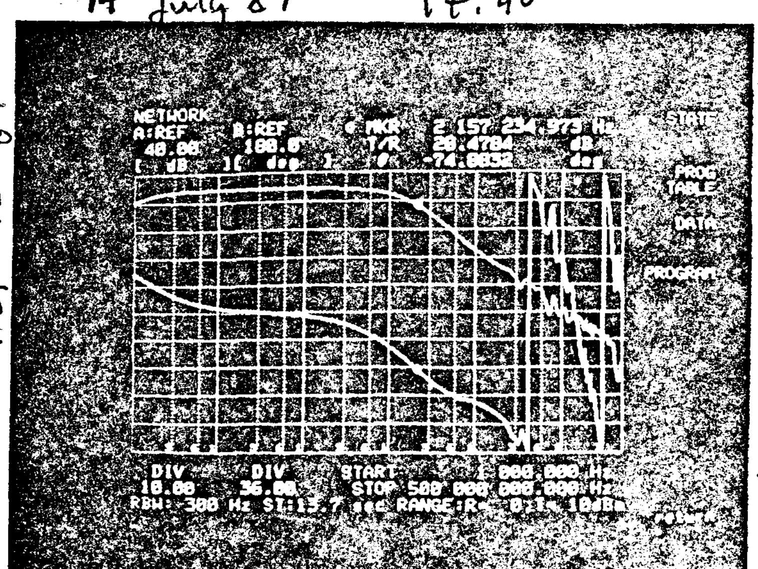
← matched cables

←

50K 50Ω in and out

14-July 89 17:40

10°: 203 kHz



←

50K 7/3

50K 50 ~~Ω~~ ~~and~~ out

CALIFORNIA INSTITUTE OF TECHNOLOGY

GRAVITATIONAL PHYSICS 130-33

November 16, 1988

Jeff Livas
MIT Gravitational Physics Group

Howdy, Jeff—

I've finally come up with the much–promised description and evaluation of our current (reasonably successful) fast piezo laser stabilization servo. The numbers are very crude but give all the qualitative features we actually observe in their respective places. Some of the numbers I quoted to you on the phone weren't quite right; one that I remember misquoting is the responsivity of our "slow" pzt stack. It is really more like 40 Å /volt.

The procedure I use for working out the crossover points between the various parallel signal paths in these "bypass topology" loops is to break them apart into subunits at those points where they share a common input or output. In this example, I've taken the output of the "Fast # 3" video preamplifier as one common signal path, and the laser output frequency (after all the contributions from fast and slow piezos and the phase–correcting Pockels cells have been added together) as another. The various electronic transfer functions of the parallel subunits are computed, multiplied by the electro–optic transfer functions of their respective actuators, and added together. It's easiest to just do this graphically on a log–log plot, since your input data is rarely more accurate than your pencil and (for a good robust design) the major stability criteria should be extremely insensitive to small changes in gain.

You should be warned of a few glitches that we'd rather not have. Since our PA-85 amp blew up we've been using the "HV # 6" in its place for the pockels cells. It unfortunately is not fast enough

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and has this weird wrinkle around 100 kHz where the inverting half poops out. With the PA-85 in place we got a unity–gain frequency of about 1 MHz rather than 350 kHz and no wrinkle. Also, you will note that the slow pzt/fast pzt crossover violates the canonical rule of "no crossovers at greater than 6 db/octave relative slope." We just barely get away with this one because this crossover is not far enough away from the "extra" pole to have the full effect of its phase shift. This is a marginal situation which we hope to correct in the next version.

In our conversation you asked about dealing with the resonance of the PZ80 piezo mirror at 5 kHz and I'm afraid I wasn't too clear about my recommendation. Just in case, let me state the problem more formally; one wants to attenuate the signal reaching the nasty element (the PZ80) by a large factor to prevent its resonant behavior from dominating over the righteous and properly–phased feedback going to, say, your fast piezo at that resonant frequency f_r. At the same time, the crossover rule prohibits you from adding too much phase shift at some lower frequency $f_{\mathrm{crossover}}$. The optimization therefore is for maximum attenuation in the stop band with minimum phase shift in the passband, and the solution we tend to use is a Butterworth filter with the 3dB point chosen at the geometric mean $f_{3\mathrm{dB}} = (f_r f_{\mathrm{crossover}})^{1/2}$ with whatever number of poles it takes to control the resonance.

Give me a ring if you have a chance to look at this stuff and we can discuss it. Happy frequency stabilization !!

Closing the loop,

M. E. Zucker

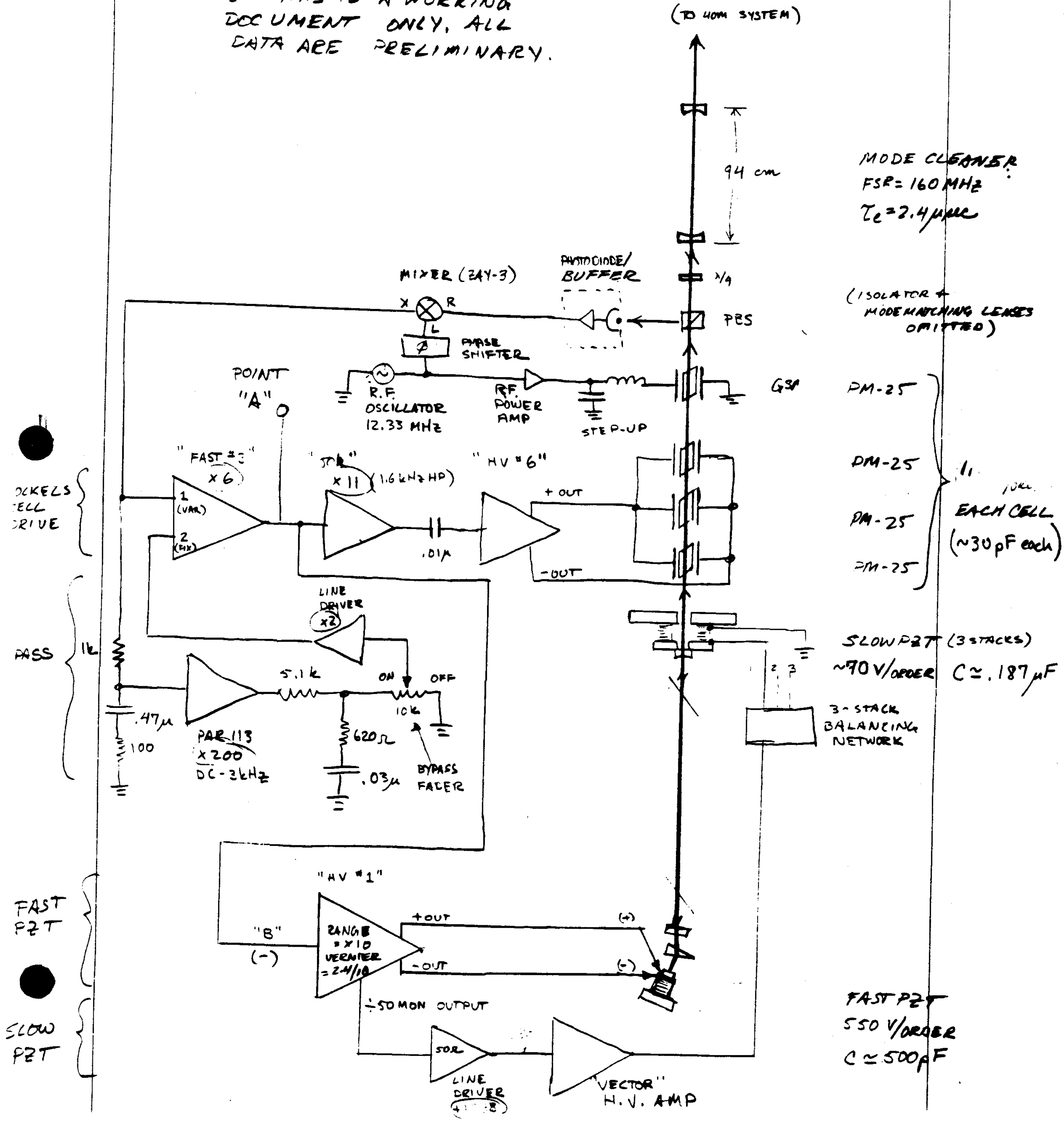
cc: Alex Abramovici
Bob Spero
Jeff Harman

①

11/14/88 MEZ

MODE CLEANER SERVO BLOCK DIAGRAM

NOTE: THIS IS A WORKING DOCUMENT ONLY. ALL DATA ARE PRELIMINARY.



11/14/88 MEZ

MODE CLEANER SERVO TRANSDUCERS (IN TERMS OF EQUIVALENT LASER FREQUENCY ν)

1. POCKELS CELLS

$$2\pi \nu_{laser} = \frac{\partial \phi_{laser}}{\partial t} \; ; \quad \phi_{laser} = 2\pi \nu_0 t + \phi_{pc} \; ; \quad \phi_{pc} = \frac{2\pi n_{pc} l_{pc}}{\lambda} \; ;$$

$$n_{pc} l_{pc} = K + \alpha V_{pc} \qquad (\alpha \simeq .22 \text{ nm/V for FM-25})$$

$$\phi_{pc} = 2\pi (K + \alpha V_{pc})/\lambda$$

$$\Rightarrow \delta \nu_{laser} = \frac{2\pi\alpha}{\lambda} \frac{dV_{pc}}{dt}$$

i.e., for $V_{pc} = V_0 \cos(2\pi f t)$ (single Fourier component at f)

$$\frac{\partial(\delta \nu_{laser})}{\partial V_0} = 2.7 \times 10^{-3} \frac{f}{V_0} = 2.7 \text{ Hz} \left(\frac{f}{1\text{kHz}}\right)\left(\frac{1 \text{ volt}}{V_0}\right)$$

NOTE: We're using 3 phase-adjusting pockels cells in series, driven in parallel.

2. FAST PIEZO MIRROR

Since $\frac{dV_{FPZT}}{dl} = 550$ V/order and the laser is ~2.3 meters long

$$\Rightarrow c/2l = 65 \text{ MHz} = 1 \text{ order}$$

$$\Rightarrow \frac{\partial \nu}{\partial V_{FPZT}} = \frac{65 \text{ MHz}}{550 \text{ V}} \simeq \frac{120 \text{ kHz}}{\text{volt}}$$

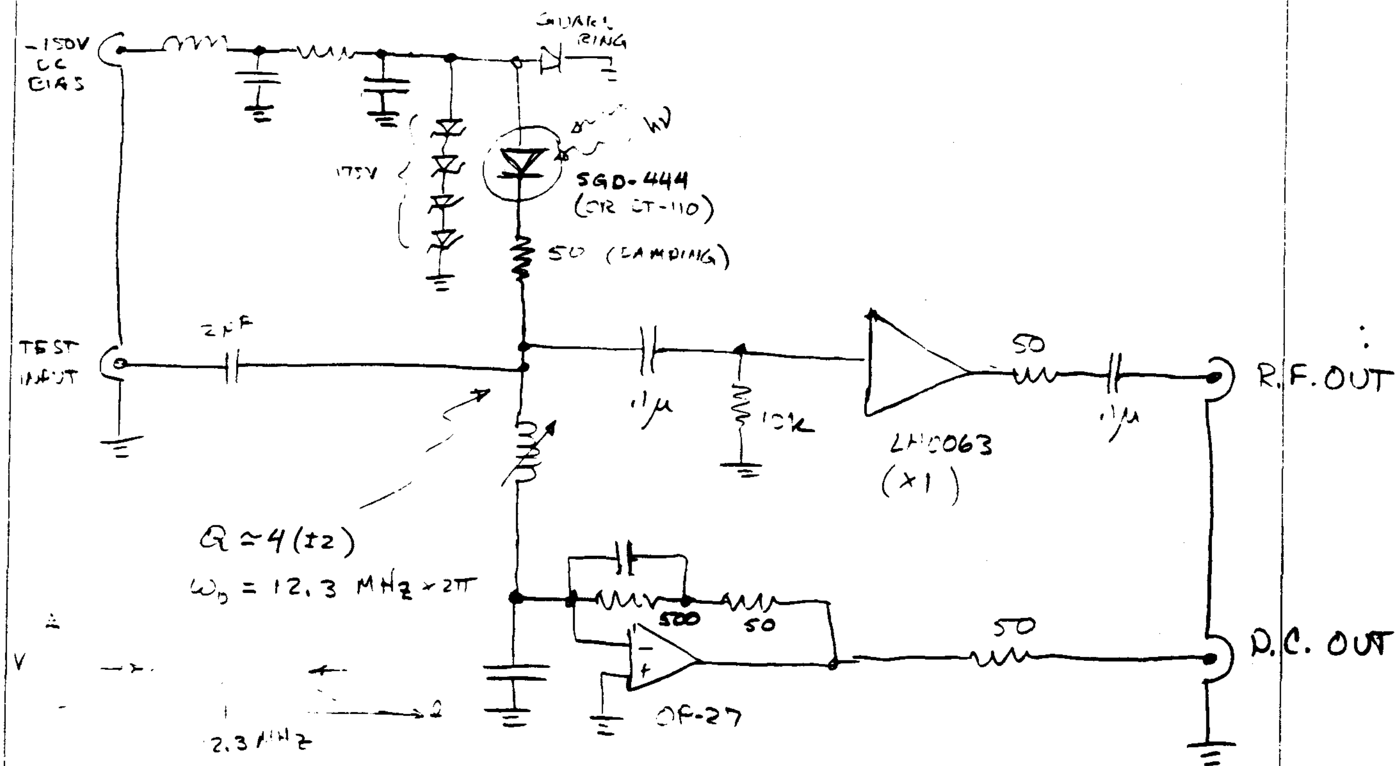
3. SLOW PIEZO MIRROR

Similarly, with $\frac{dV_{SPZT}}{dl} \simeq 70$ V/order, we get

$$\frac{\partial \nu}{\partial V_{SPZT}} = \frac{65 \text{ MHz}}{70 \text{ V}} \simeq \frac{930 \text{ kHz}}{\text{volt}}$$

11/14/88 MEZ

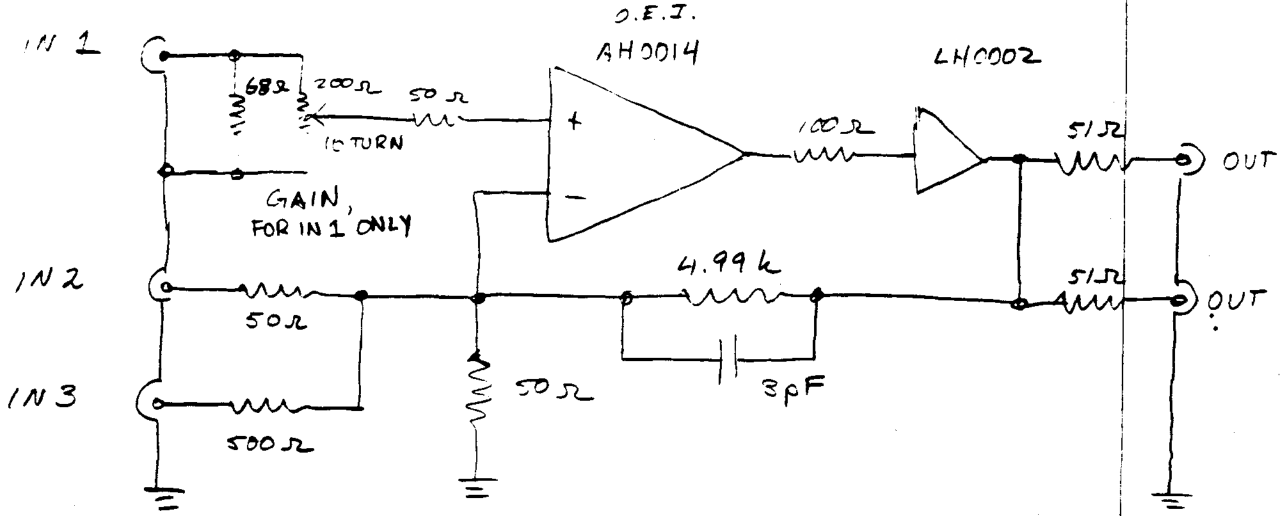
MODE CLEANER SERVO PHOTODIODE / BUFFER
(STANDARD CALTECH FRONT END)



R.F. DARK NOISE ≃ SHOT NOISE AT 1mW, 5145 Å

11/14/88 meg

MODE CLEANER SERVO "FAST #3" AMPLIFIER

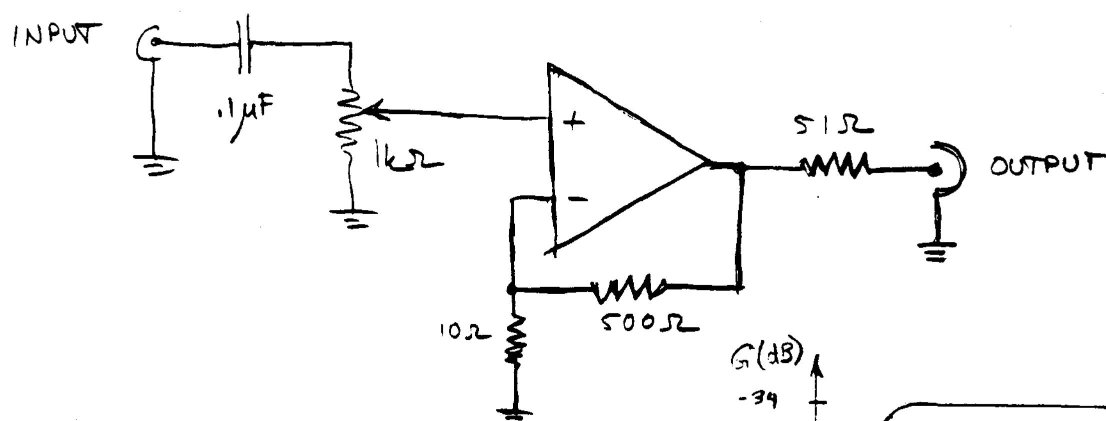


GAIN; IN 1 ×0 → ×100, DC - 10MHz

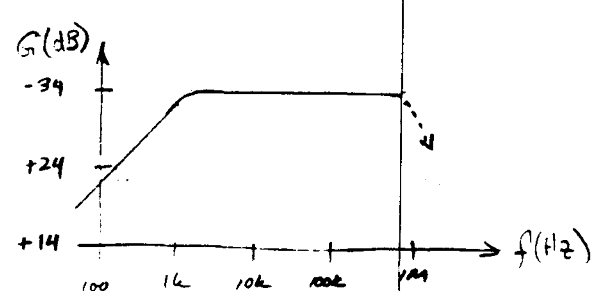
IN 2 × -100

IN 3 × 10

"50k" AMPLIFIER



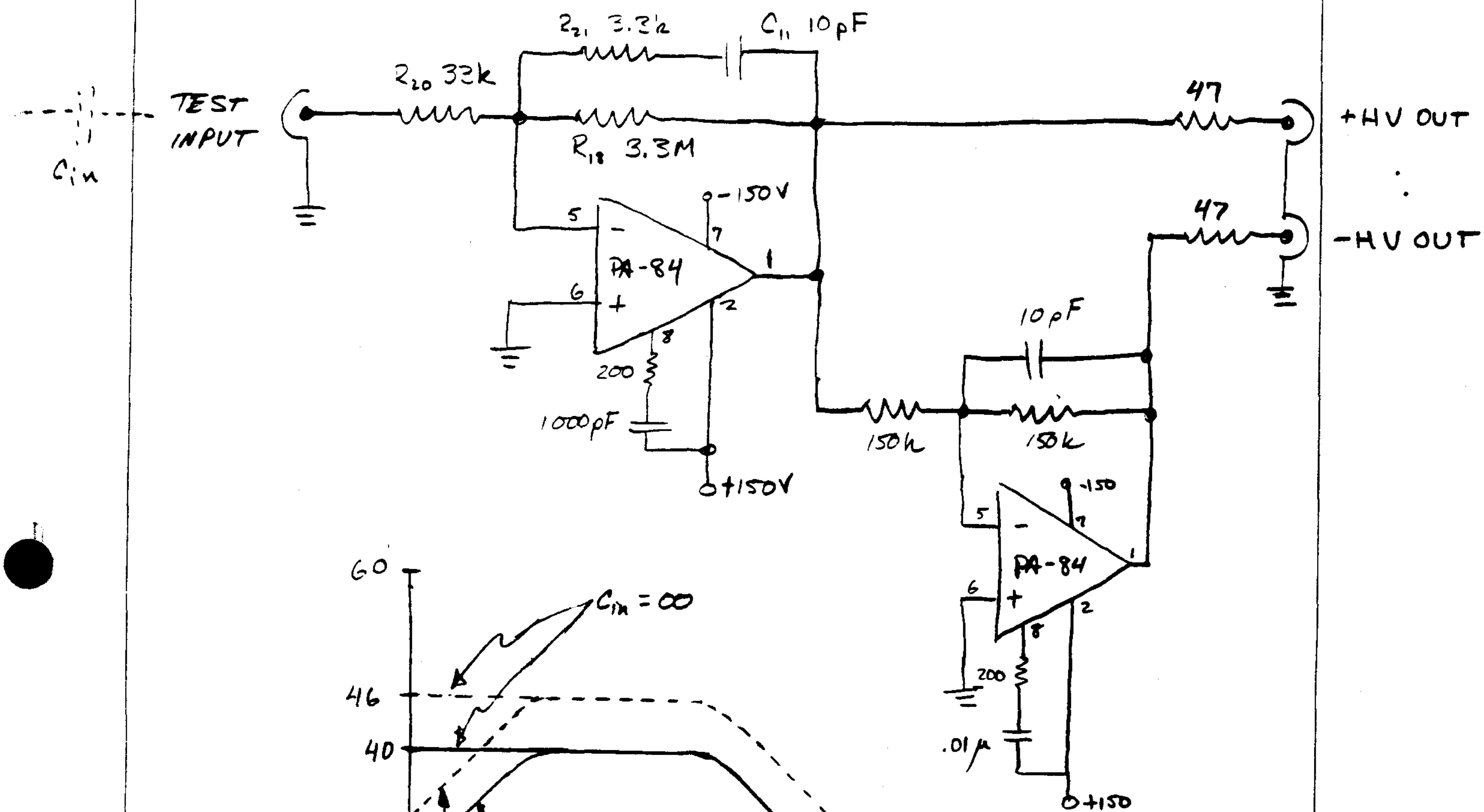
GAIN; ×50 MAX., 1.5kHz → ~700kHz

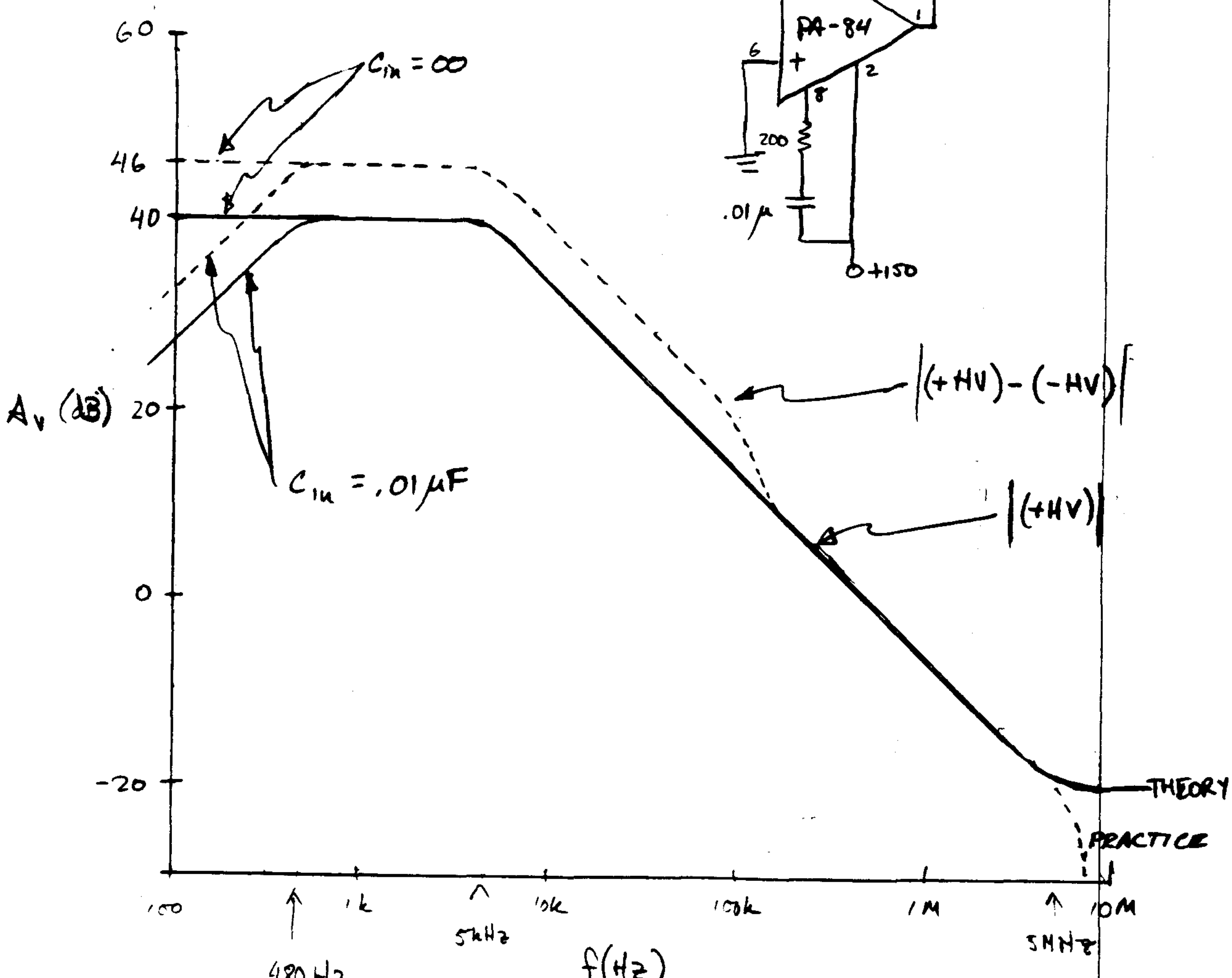


11/15/88 MEZ

MODE CLEANER SERVO LOOP "HV#6" AMP

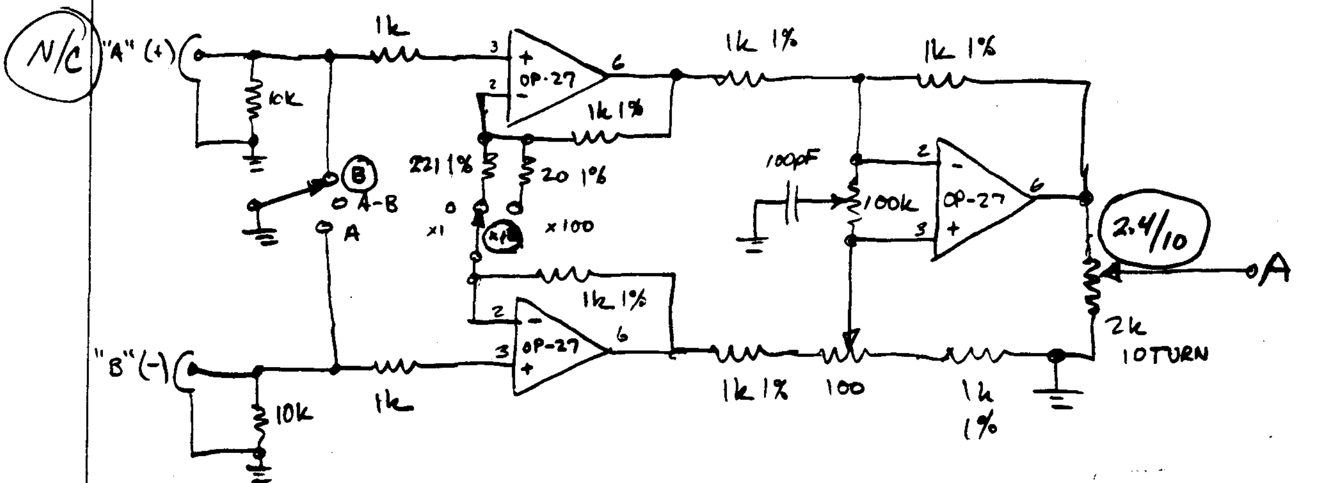
(IMPORTANT CIRCUITRY SHOWN — SEE GENERAL "HV AMP" SCHEMATIC FOR FULL DETAILS)

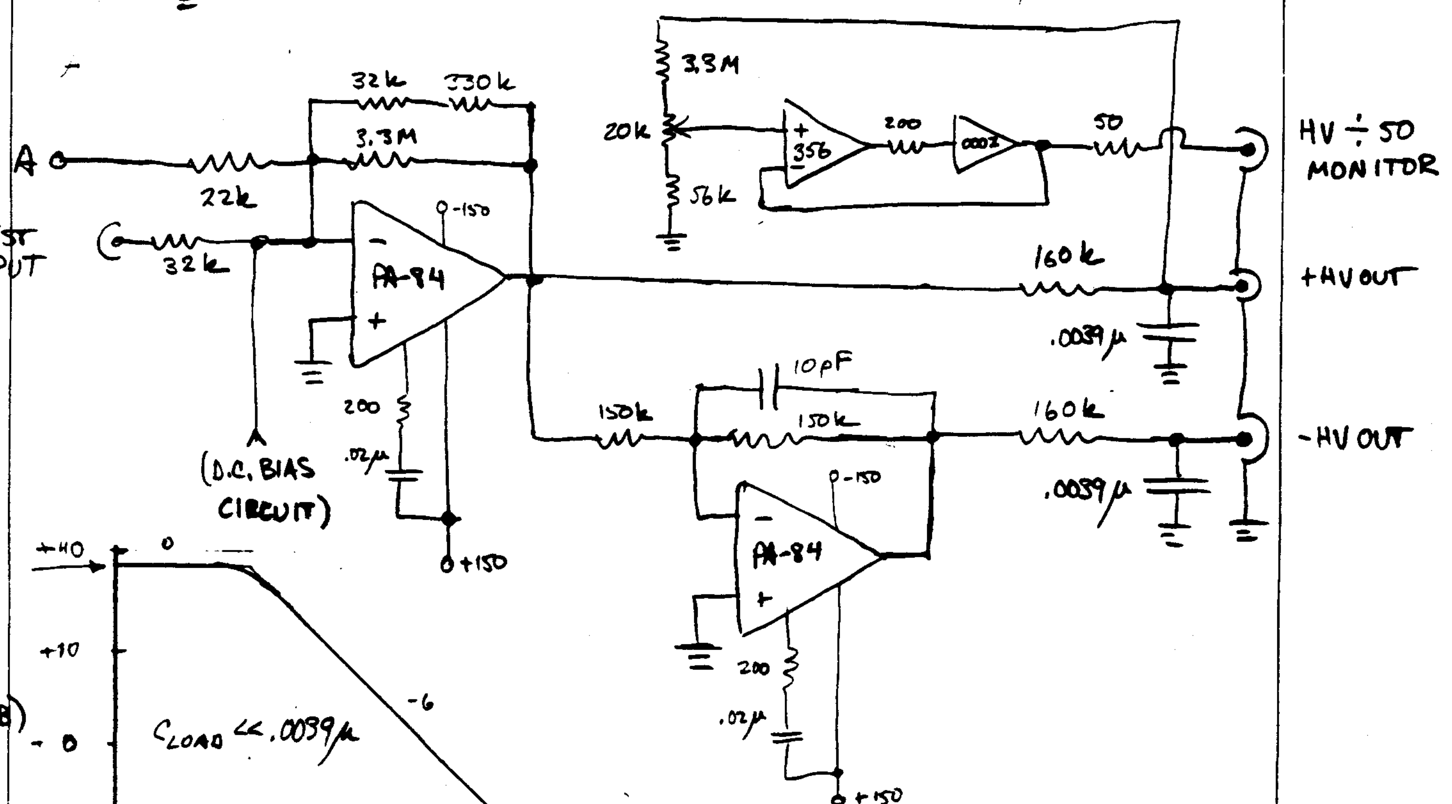


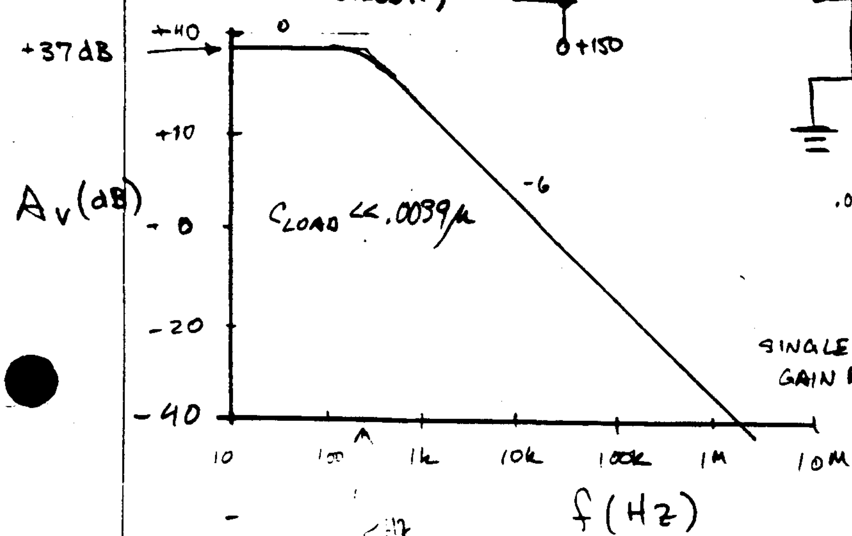


11/15/88 MEG

MODE CLEANER SERVO LOOP "HV #1" AMP
(IMPORTANT CIRCUITRY SHOWN – SEE GENERAL "HV AMP" SCHEMATIC FOR DETAILS).



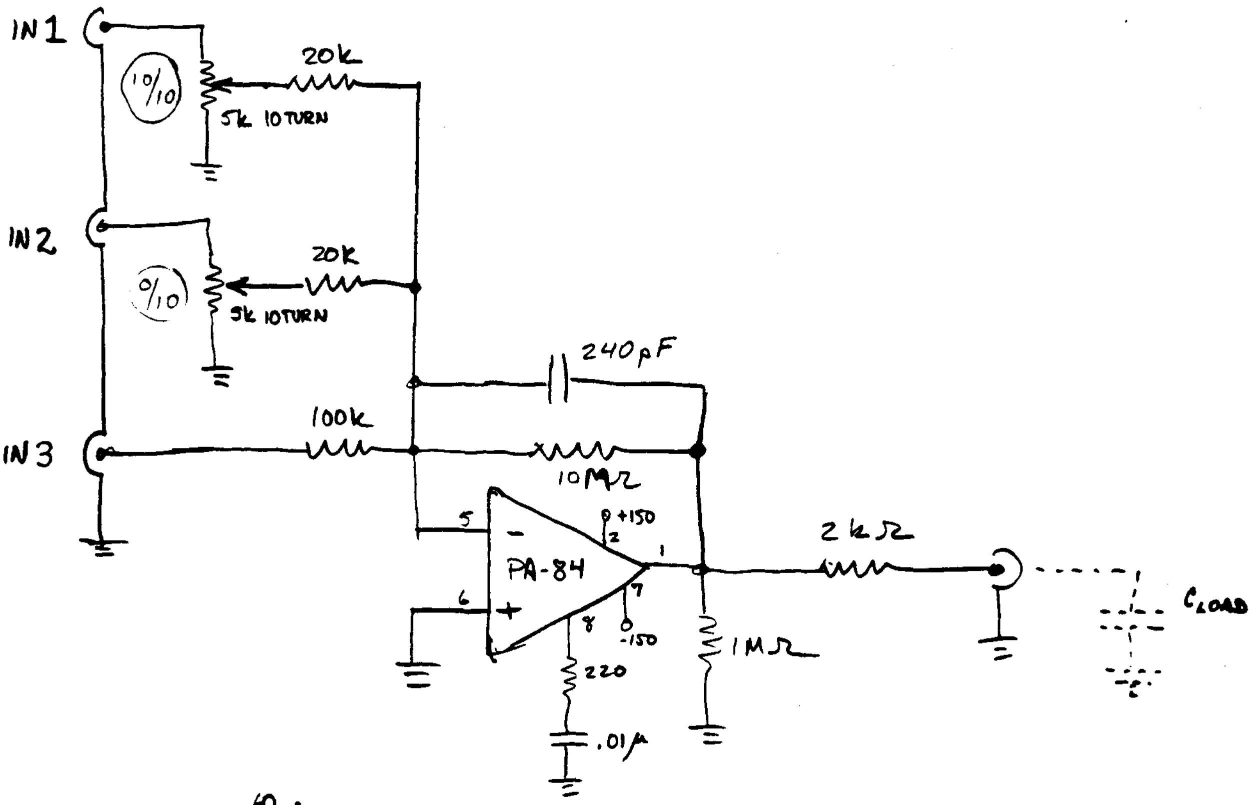


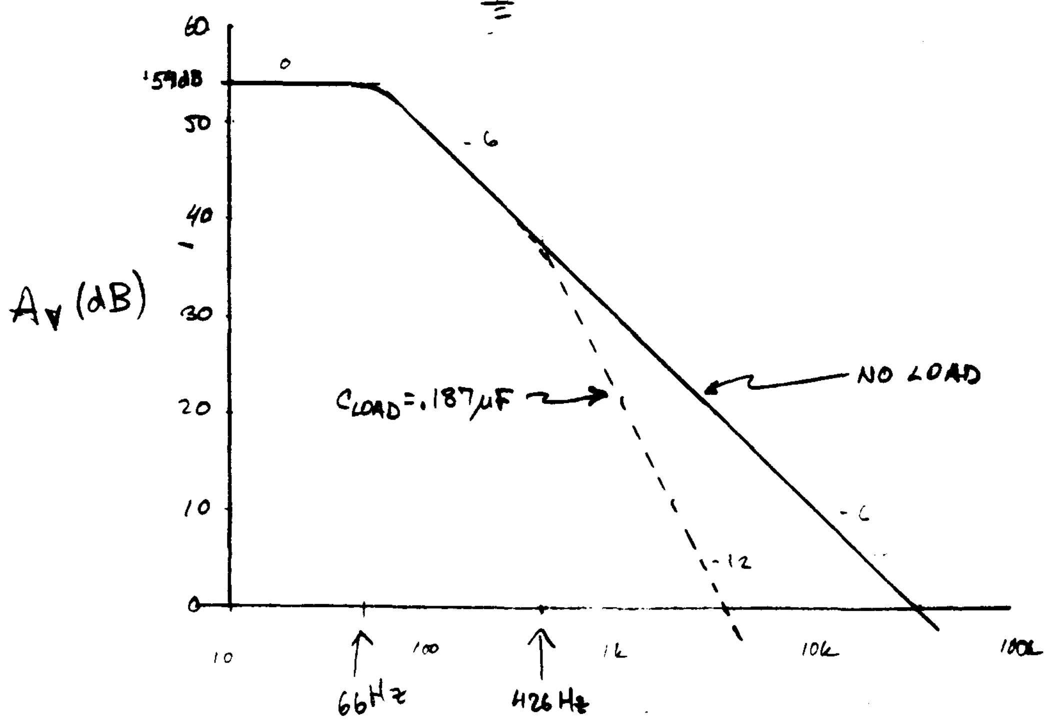


SINGLE-ENDED,
GAIN RANGE x10, VERNIER $\frac{2.4}{10}$

11/15/88

MODE CLEANER SERVO LOOP "VECTOR H.V. AMP"



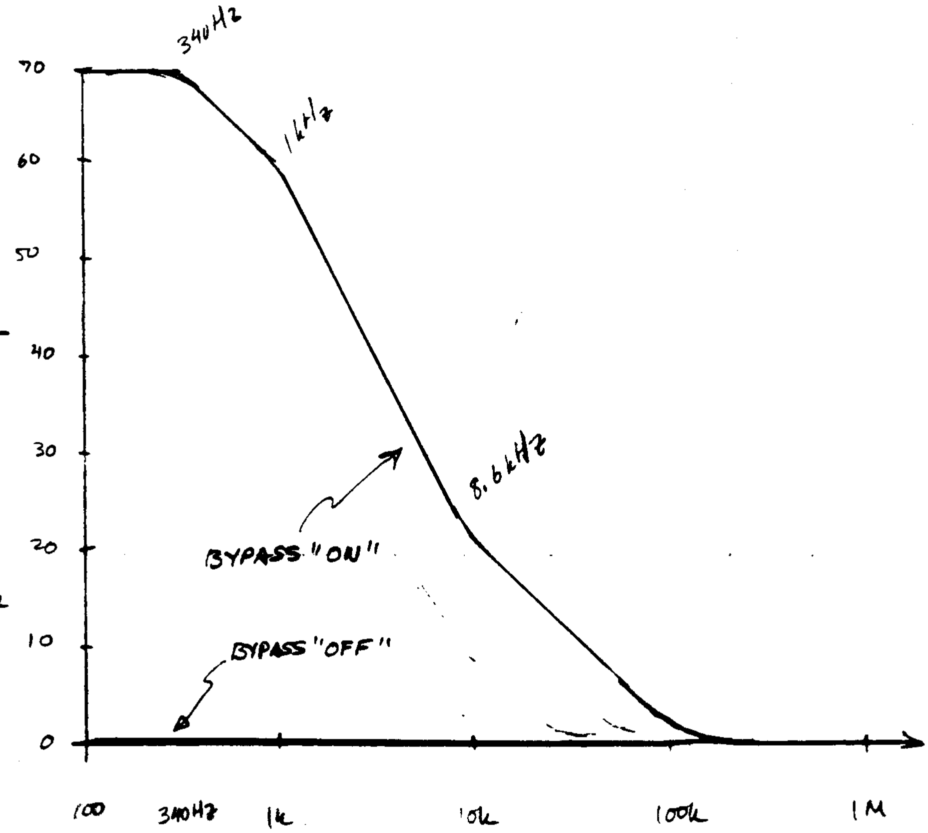


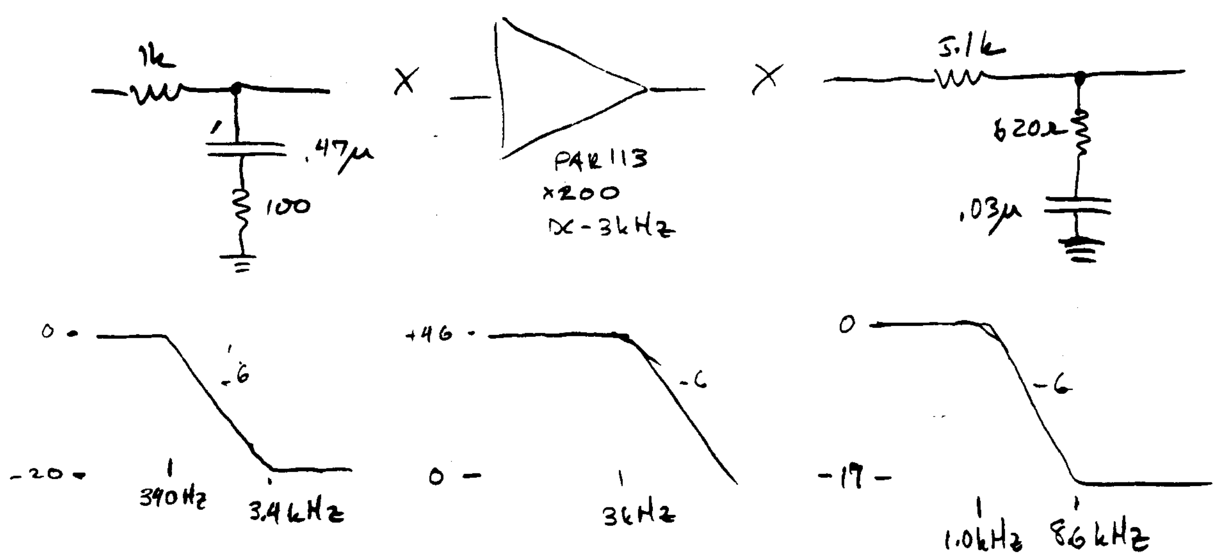
11/15/88 MEZ

MODE CLEANER SERVO BYPASS GAIN ENHANCEMENT

BYPASS GAIN BOOST (dB)

[Relative to "straight through" channel w/ FAST #3 gain pot set at 0.6/10]

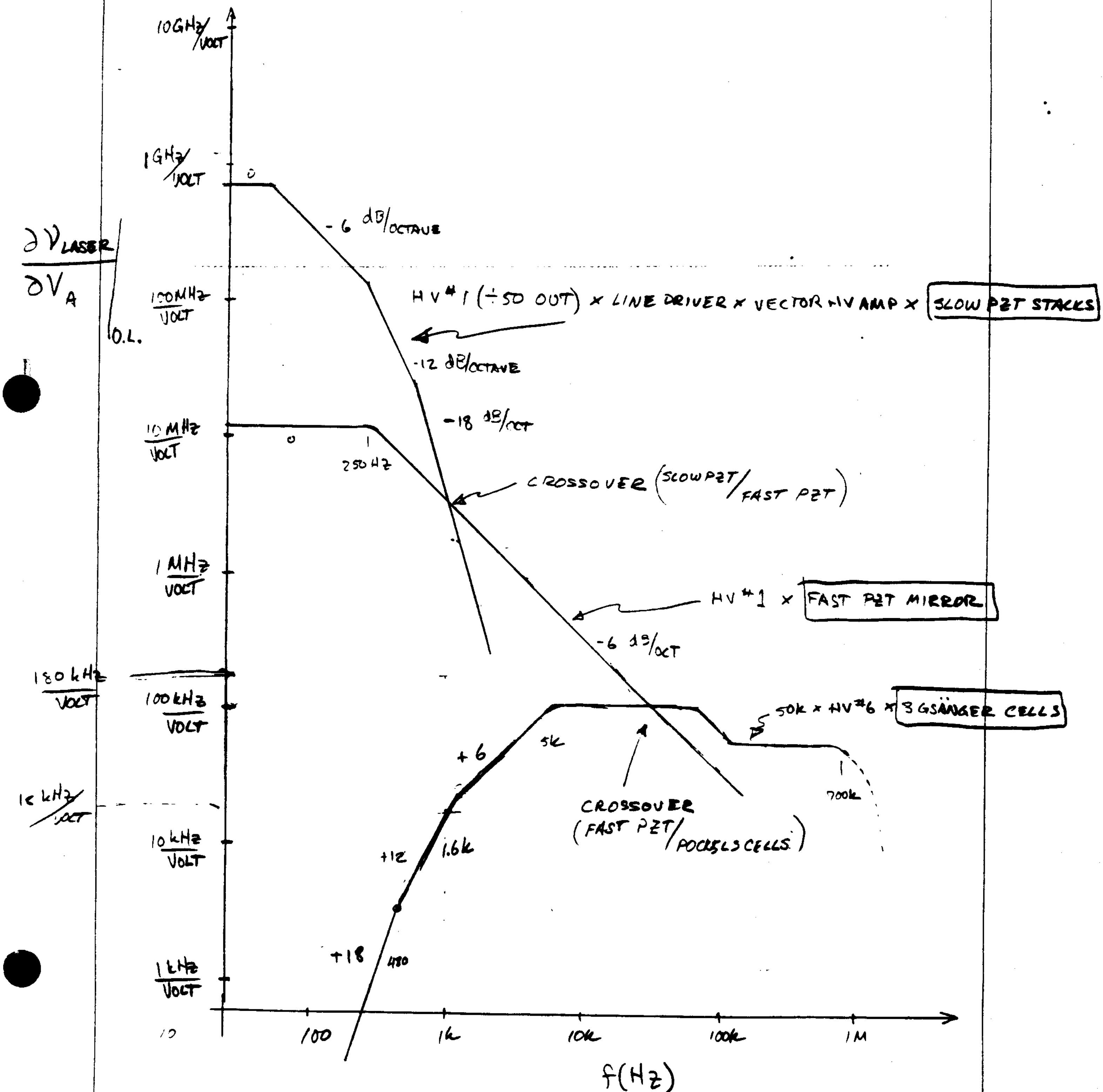




11/15/88 MEZ

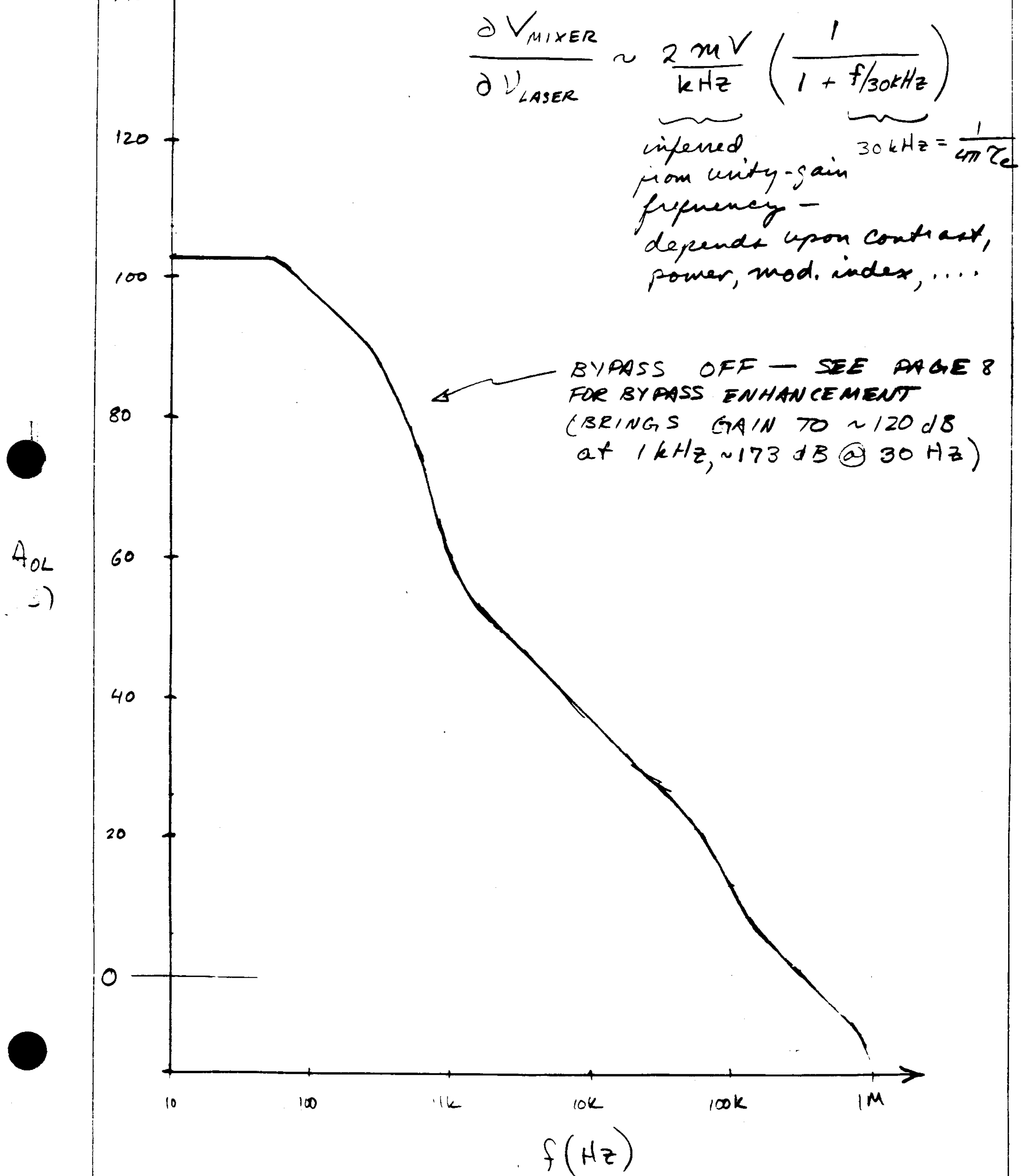
MODE CLEANER SERVO ELECTRONIC AND TRANSDUCER OPEN-LOOP TRANSFER FUNCTION

LASER FREQUENCY EXCURSION PER VOLT APPLIED AT POINT "A" (OPEN-LOOP)



11/15/88 MEZ

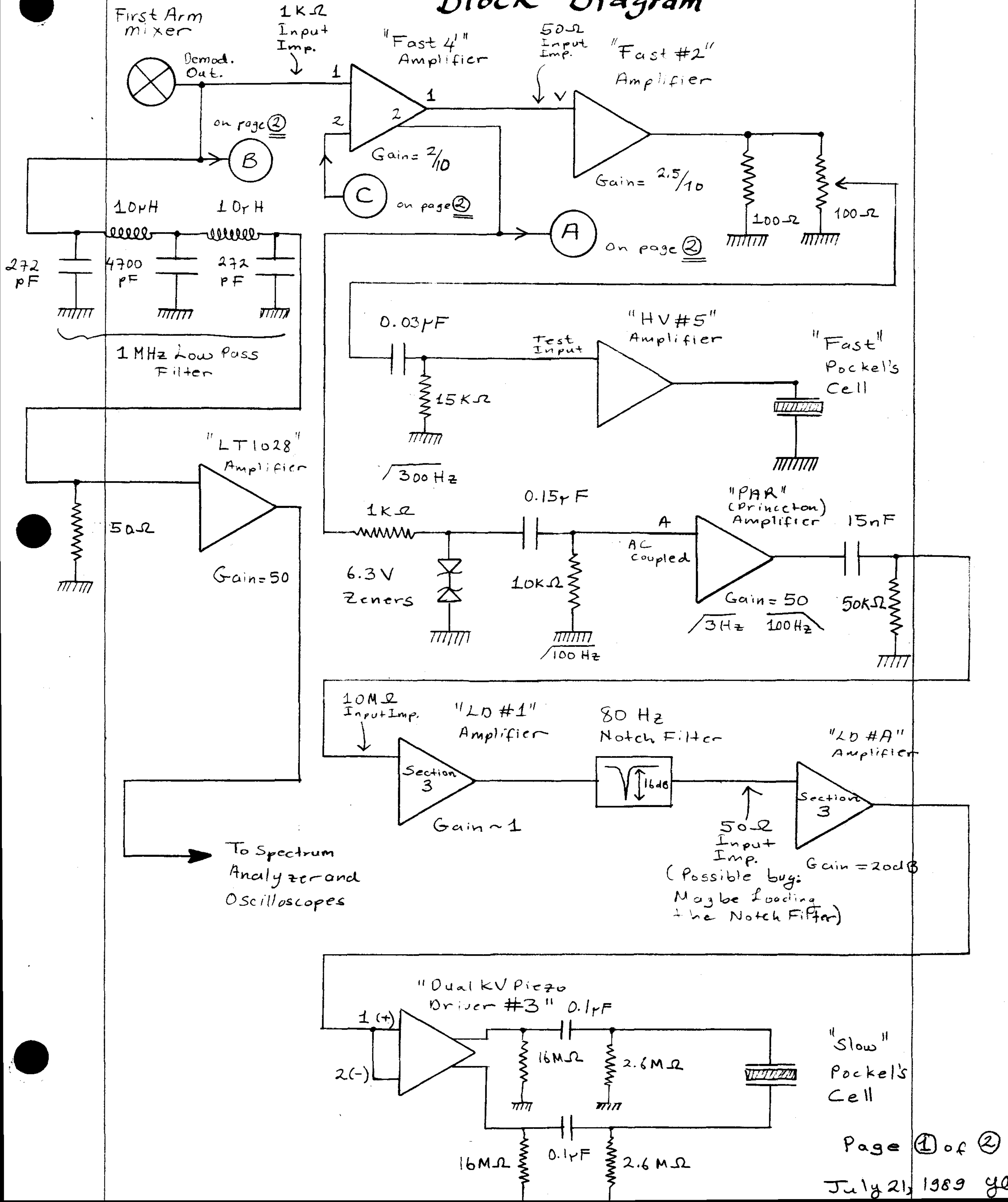
MODE CLEANER SERVO OPEN-LOOP GAIN (ESTIMATED) INCLUDING "OPTICAL TRANSFER FUNCTION"



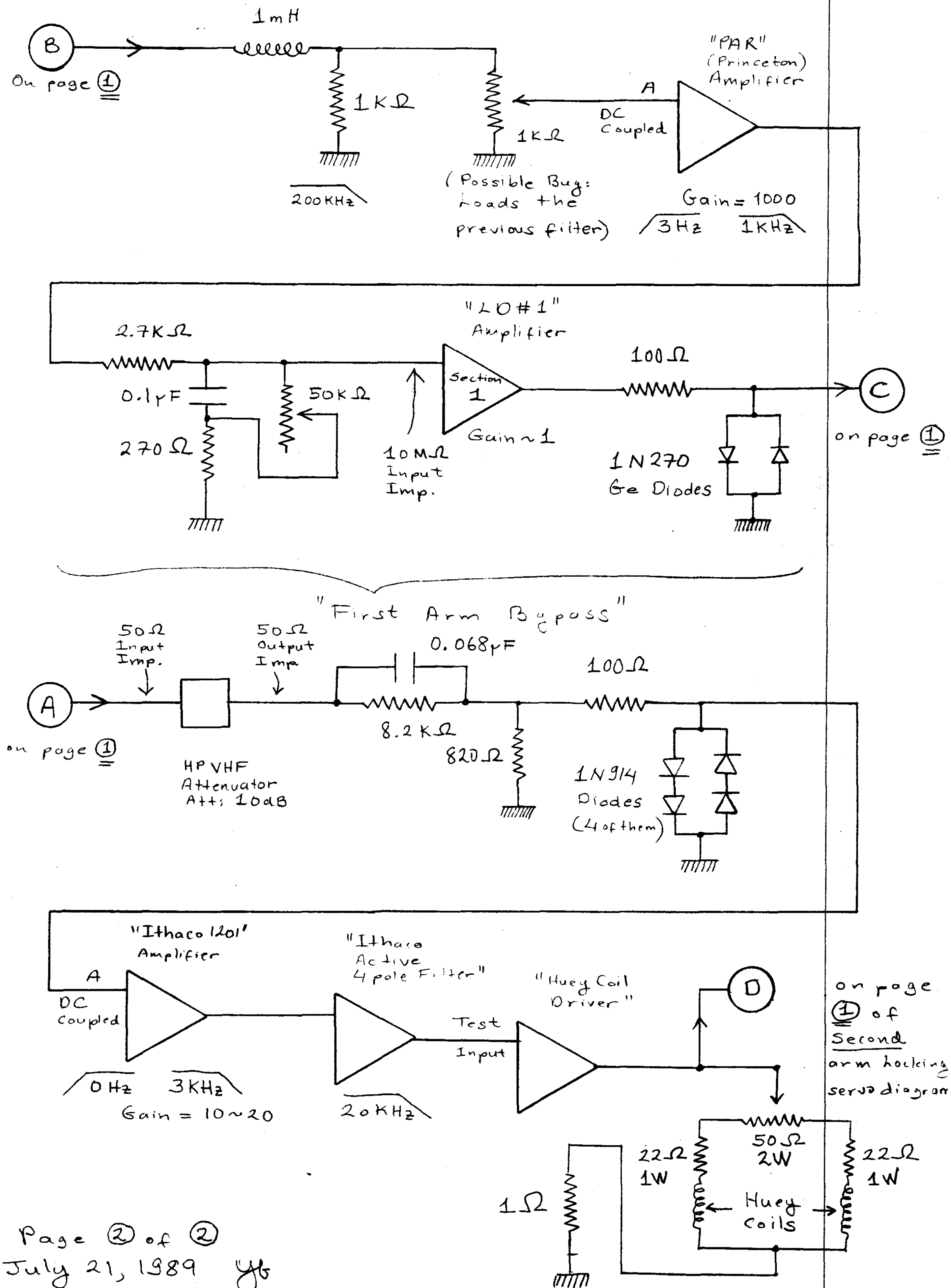
BATCH START

STAPLE
OR
DIVIDER

First Arm Servo Loop Block Diagram

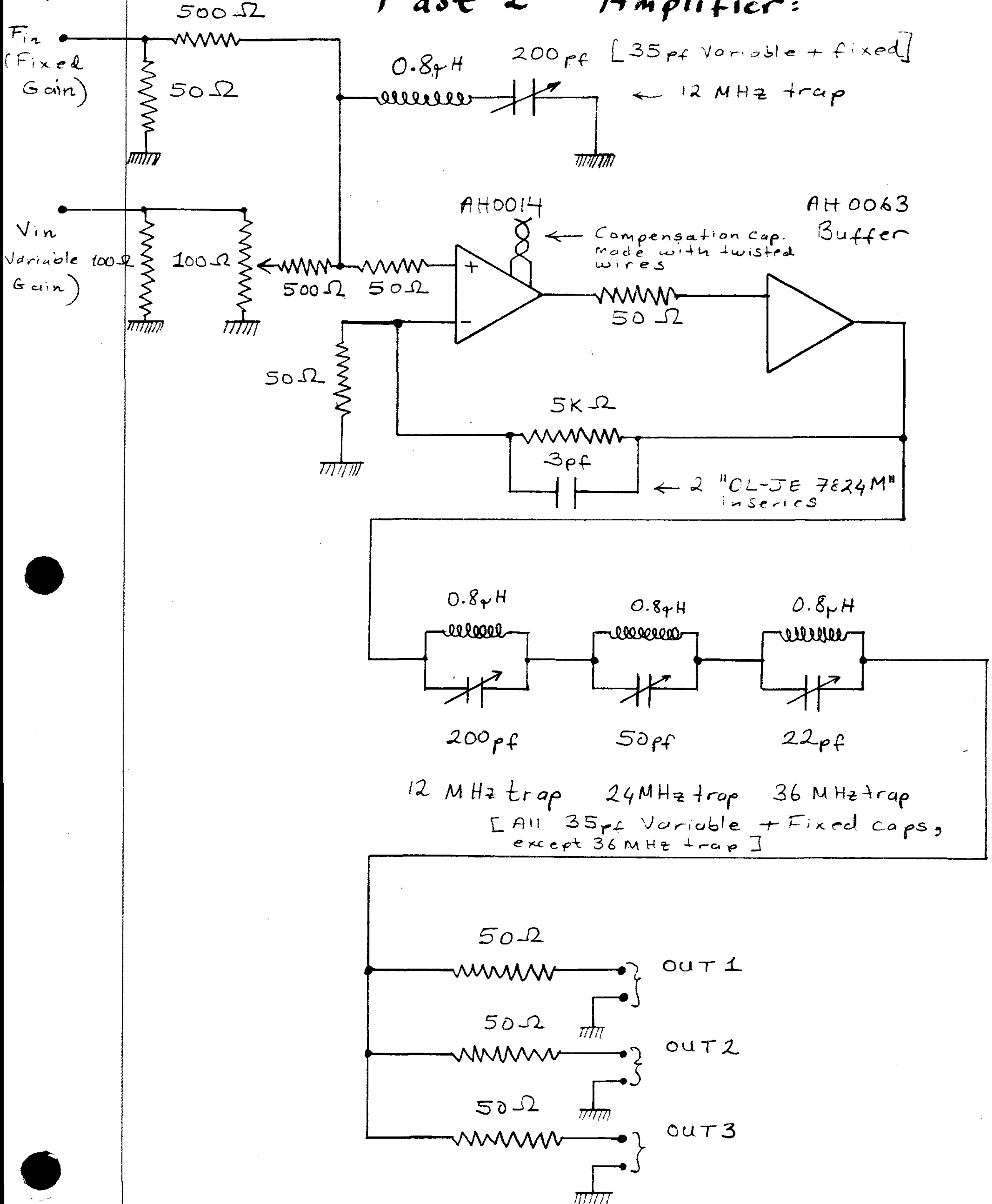


July 21, 1989 YG



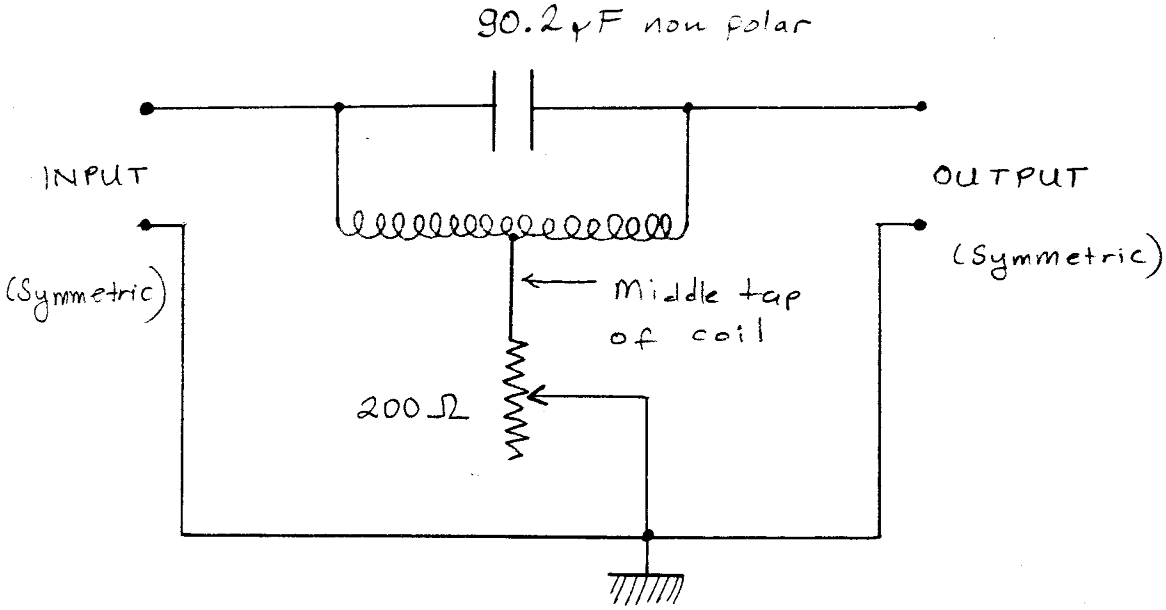
Page 2 of 2
July 21, 1989 YG

'Fast 2' Amplifier:



July 24, 1989
YG

80 Hz Notch Filter:



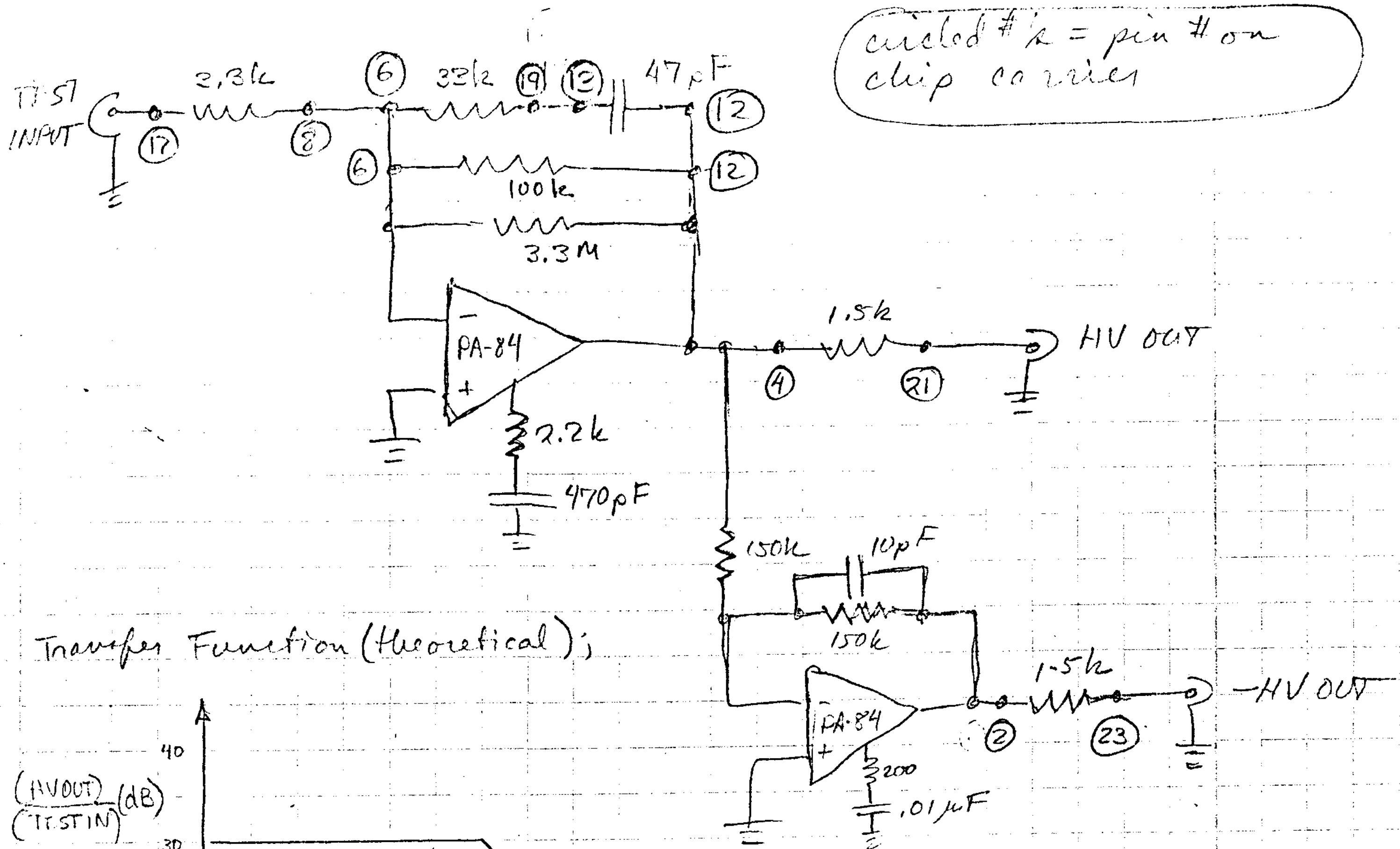
The coil is chosen in such a way that the resonance of the LC combination is 80 ∓ 1 Hz.

July 24, 1989 YB

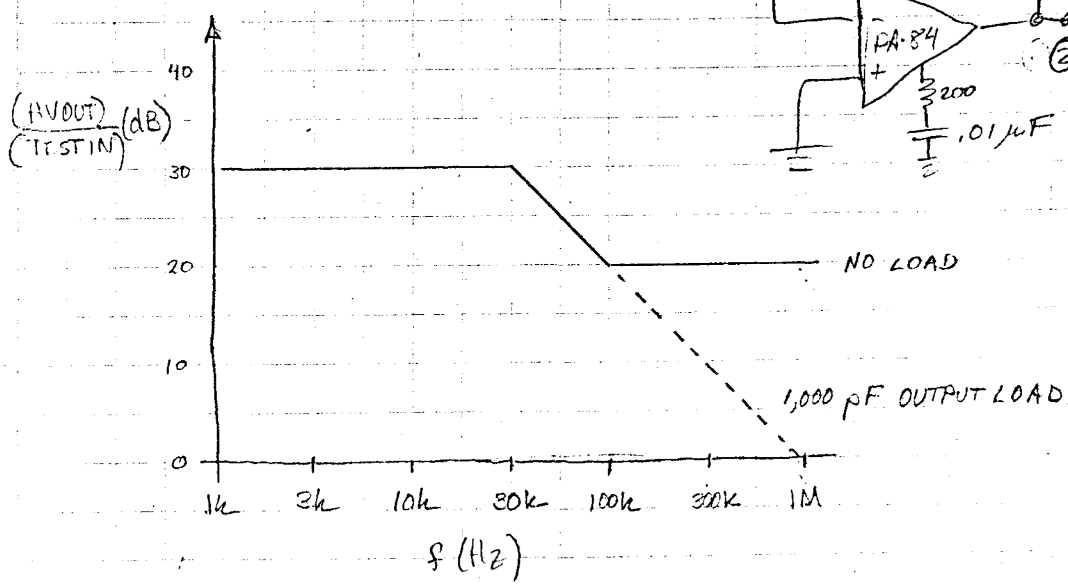
8/24/98

Another H.V. amp (LABELED "Y") has been modified for use in phase correcting loop (to replace/supplement "push" amplifier used for fast v.c. in previous setups).

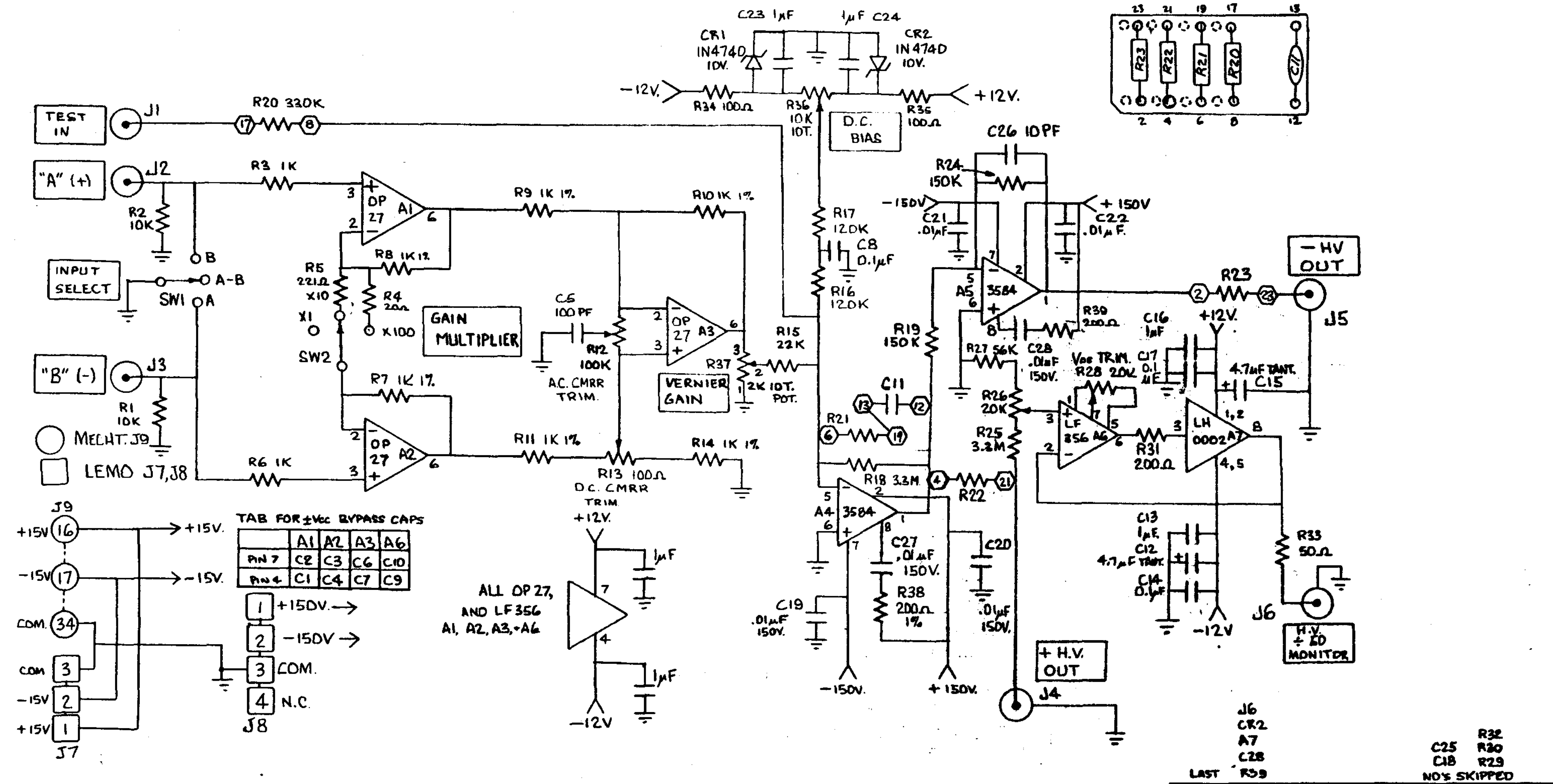
Relevant parts of circuit;



Transfer Function (theoretical);



Actual transfer function very close to theoretical, but peaky at ~2MHz



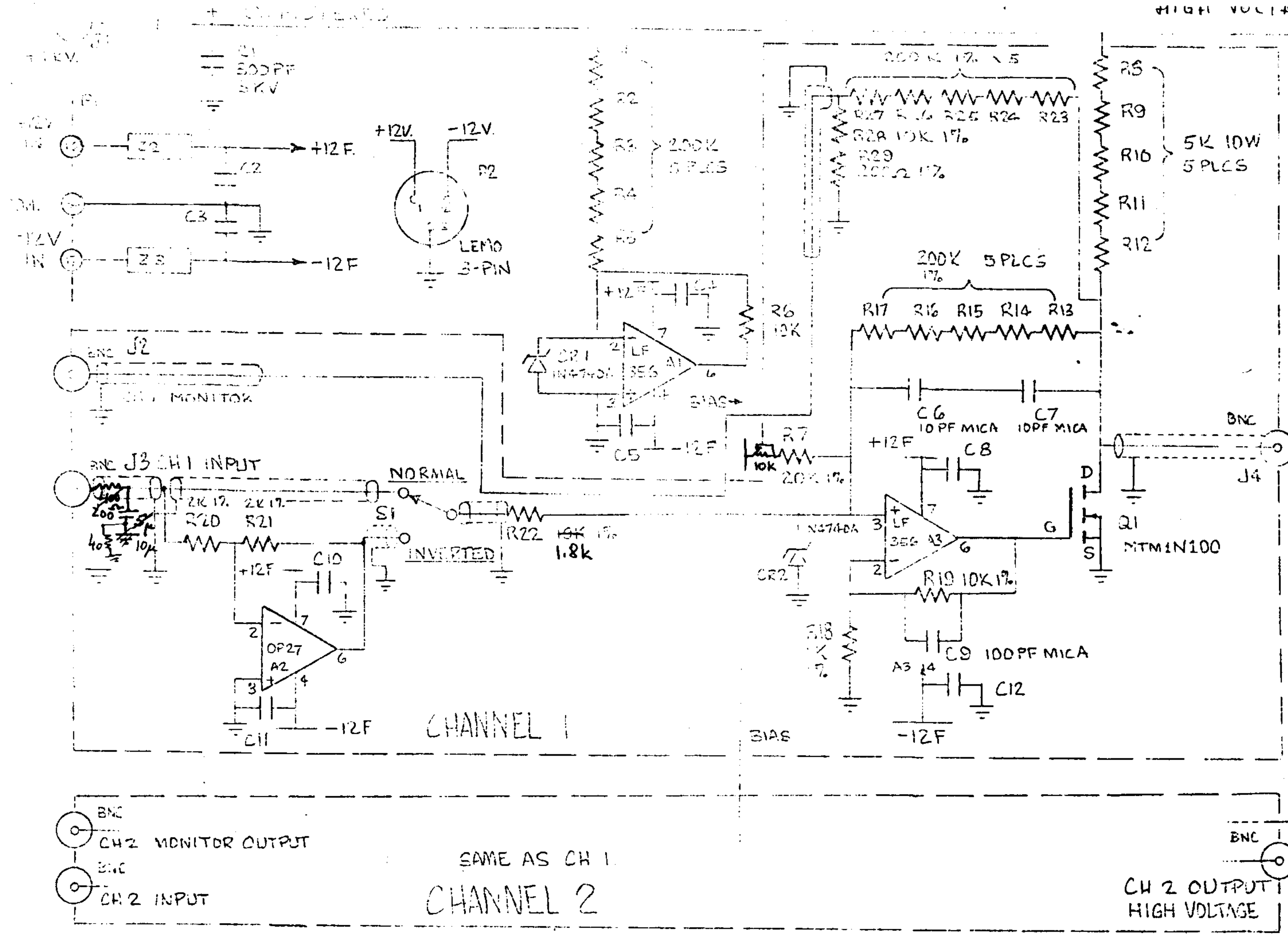
SMARTWRK FILE C:\SMARTWRK HVAMP.PCB
DRAWN FROM E. LINDELEF OF 9-1-87 PRO HVAMP.PL
ADDED COMP. CARRIED PIN NO's TO DWG.

REPLACES 87-0901-1

NOTES 1. ⌐J¬ INDICATES JUMPER TO SHORT.
2. J7, J8, and J9 ARE ALL MOUNTED ON BACK PANEL.

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS			
HV AMPLIFIER ± 150V.			
DRAWN BY B. TINKER	DATE 3-4-88		DRAWING NO.
CHECKED BY	SCALE		
APPROVED BY	W.O.		

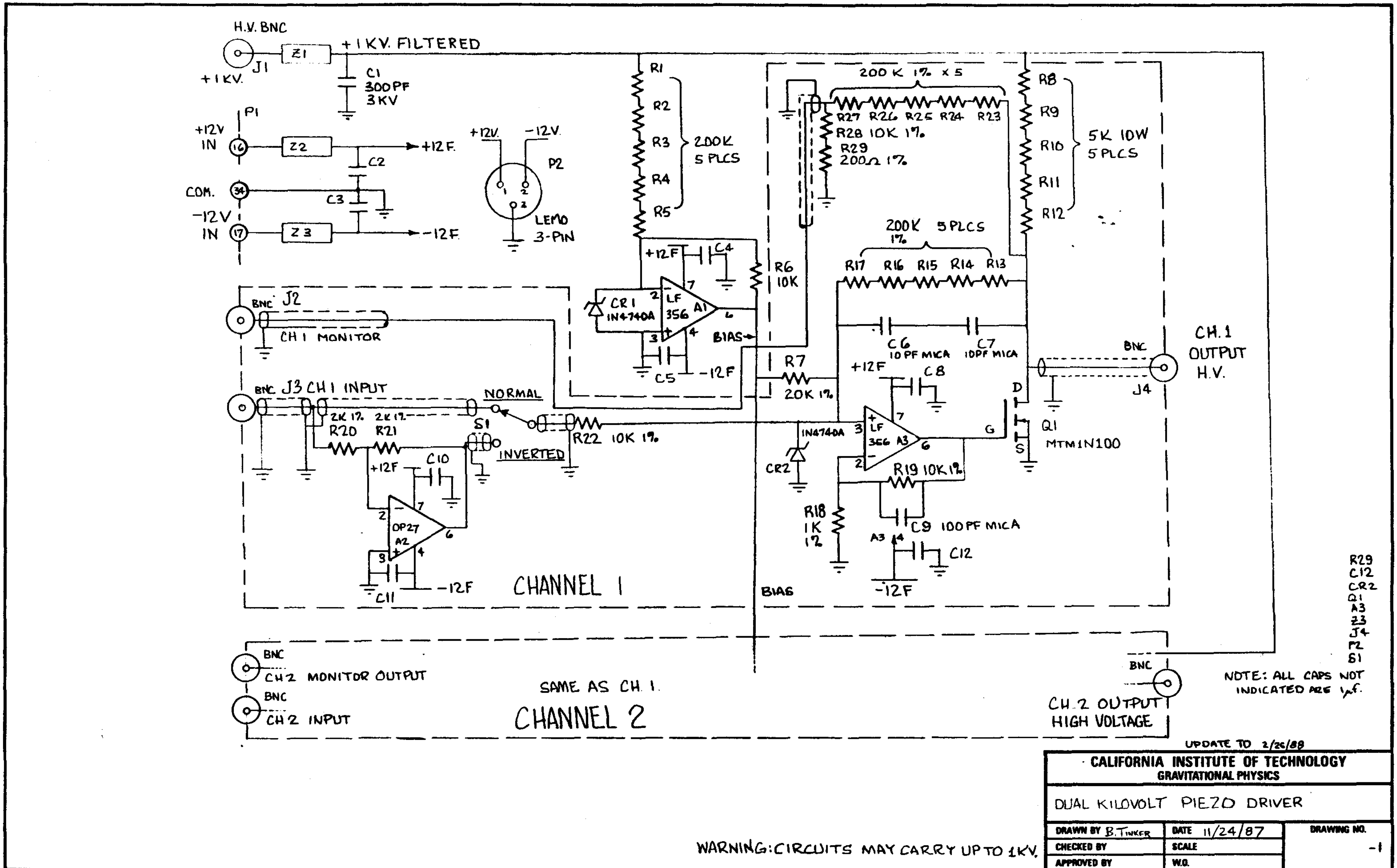
88-0304-1



HV amplifier # modified for use with phase correcting Pockels cell.

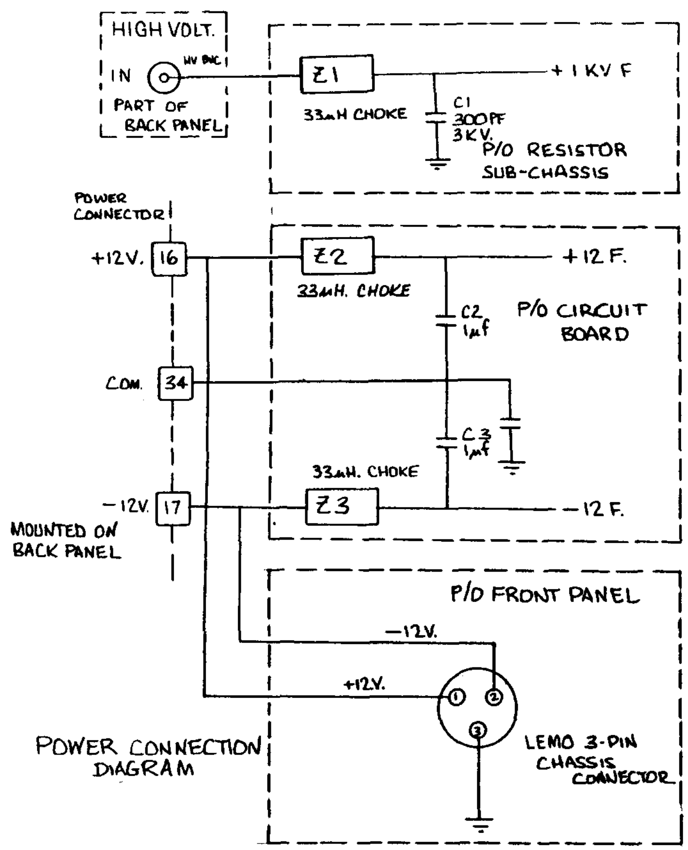
3-MARCH-

NOTE: ALL CAPS INDICATED ARE



BISHOP GRAPHICS/ACCUPRESS
REORDER NO. A38361

87-1124-1

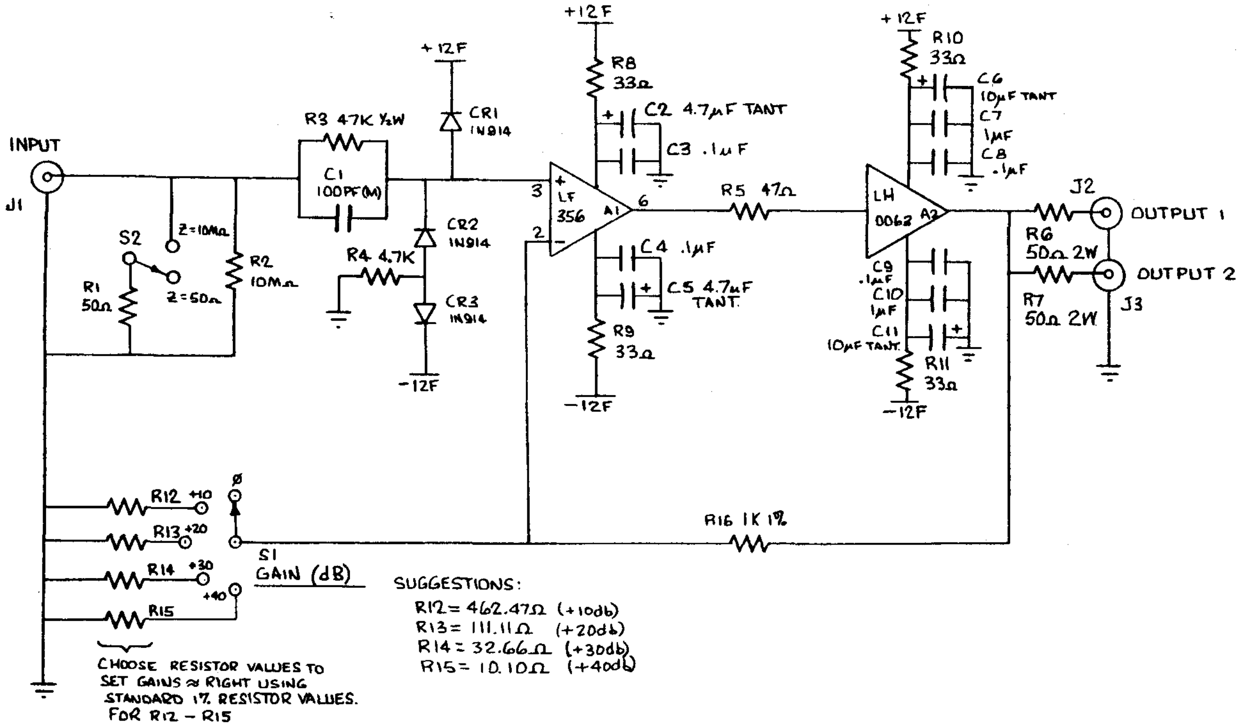


CALIFORNIA INSTITUTE OF TECHNOLOGY
GRAVITATIONAL PHYSICS

DUAL KILOVOLT PIEZO DRIVER

DRAWN BY B. TINKER	DATE 2-2-85	DRAWING NO. -2
CHECKED BY	SCALE	
APPROVED BY	W.O.	

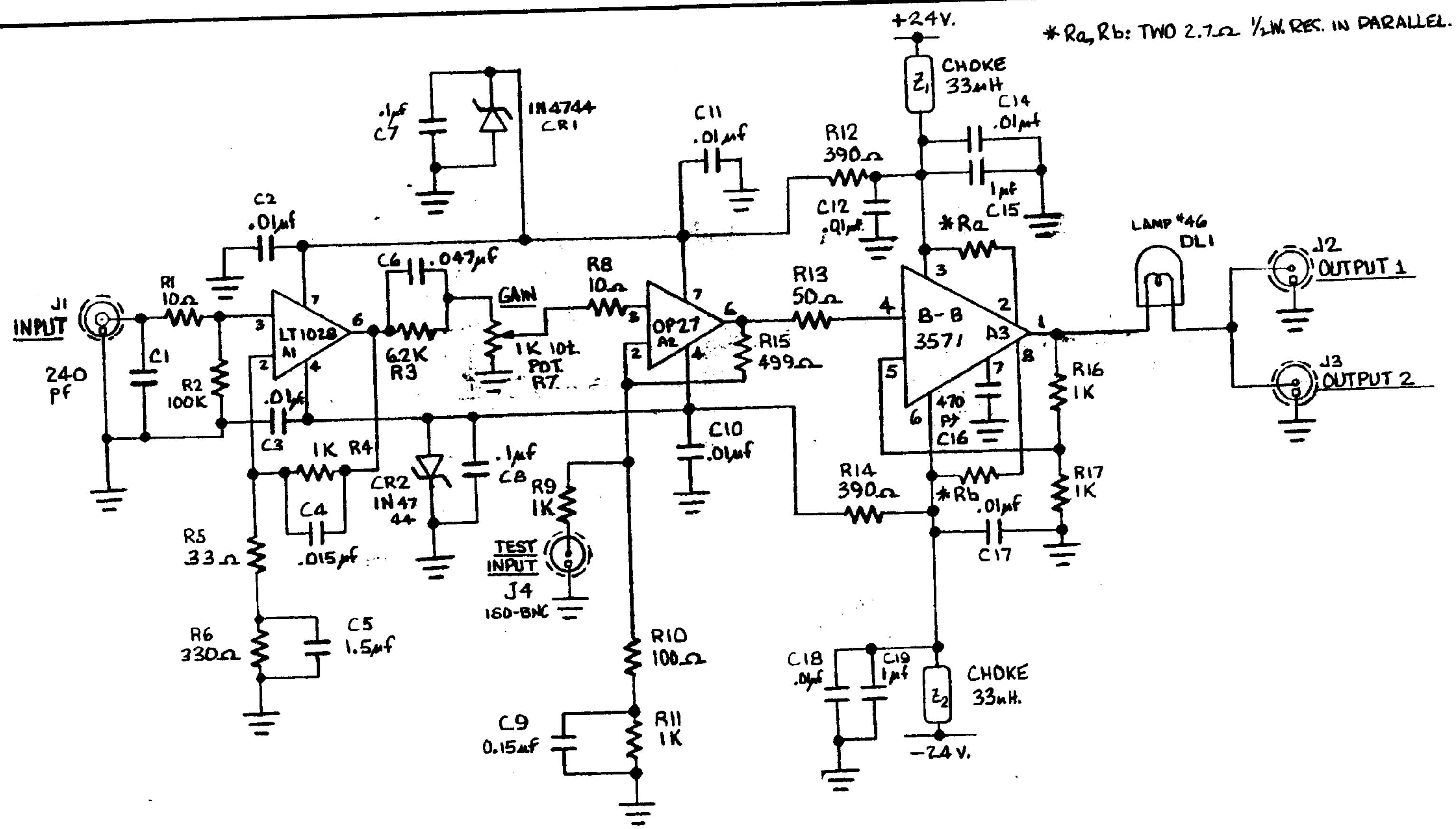
87-1124-2



A2
CR3
S2
J3
R16
LAST C

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
LINE DRIVER		
DRAWN BY B.T.	DATE 6-13-88	DRAWING NO.
CHECKED BY	SCALE	
APPROVED BY	W.O.	

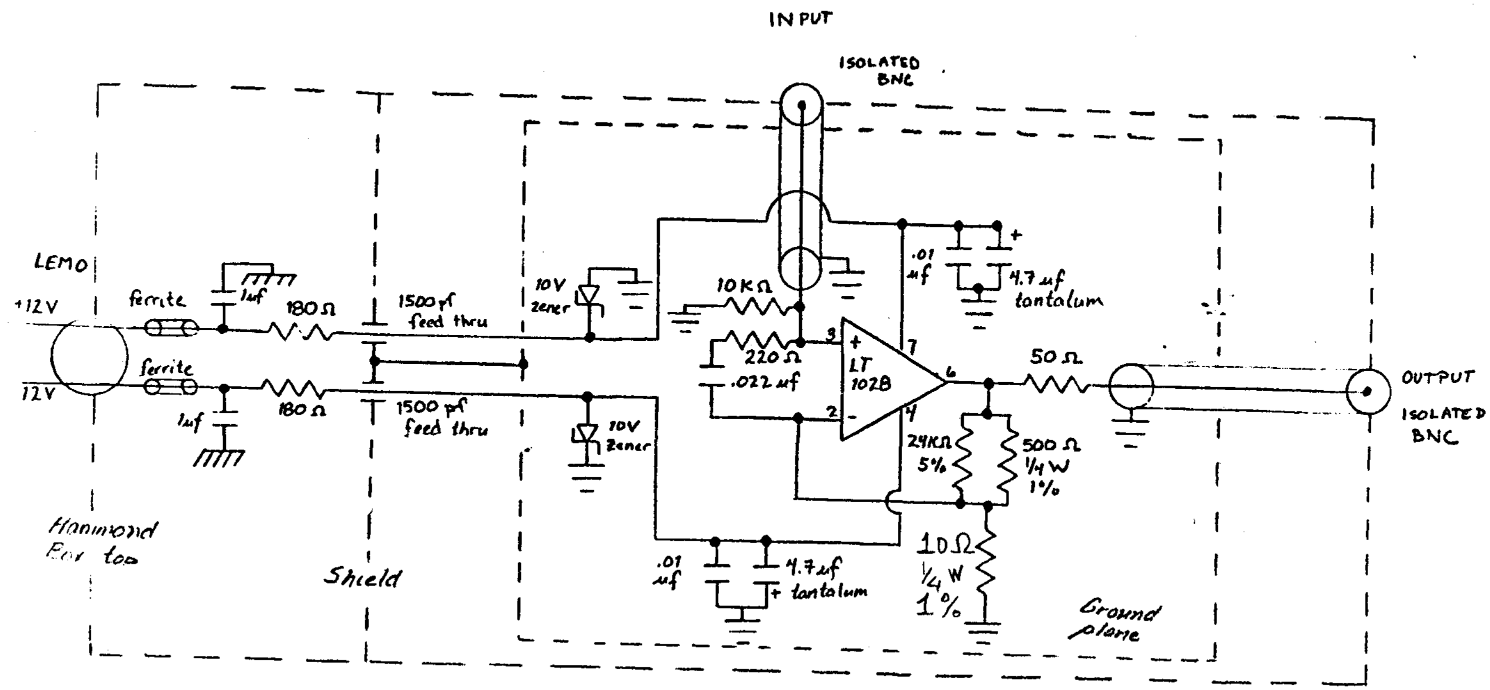
88-0613-1



3-1-88 R15 MOVED: 1K TO 500Ω
1-28-88 C16 FROM 220pf TO 470pf
UPDATE TO 9-8-78

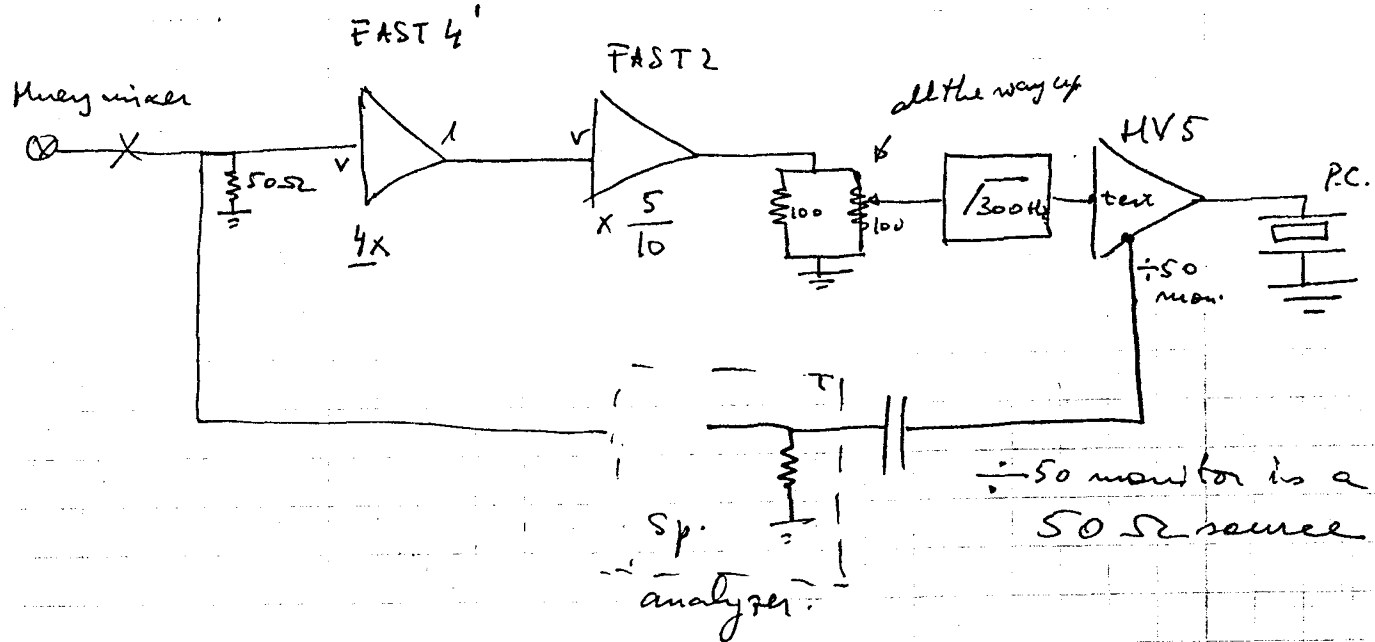
CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
COIL DRIVER HIGH CURRENT		
DRAWN BY B.T.	DATE 9-2-87	DRAWING NO.
CHECKED BY	SCALE	-1
APPROVED BY	W.O.	

87-0902-1

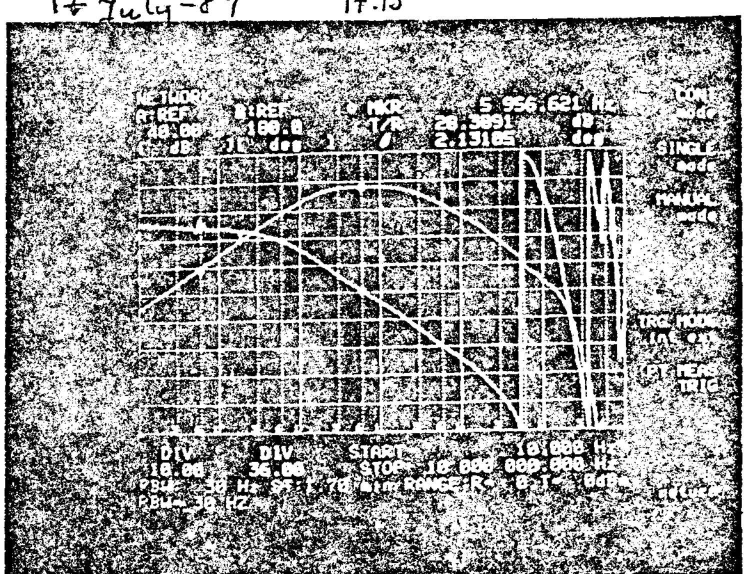


Low Noise Buffer
8-21-87

1st arm (phase correction) servo : fast Pockels cell loop



17 July-89 17:15



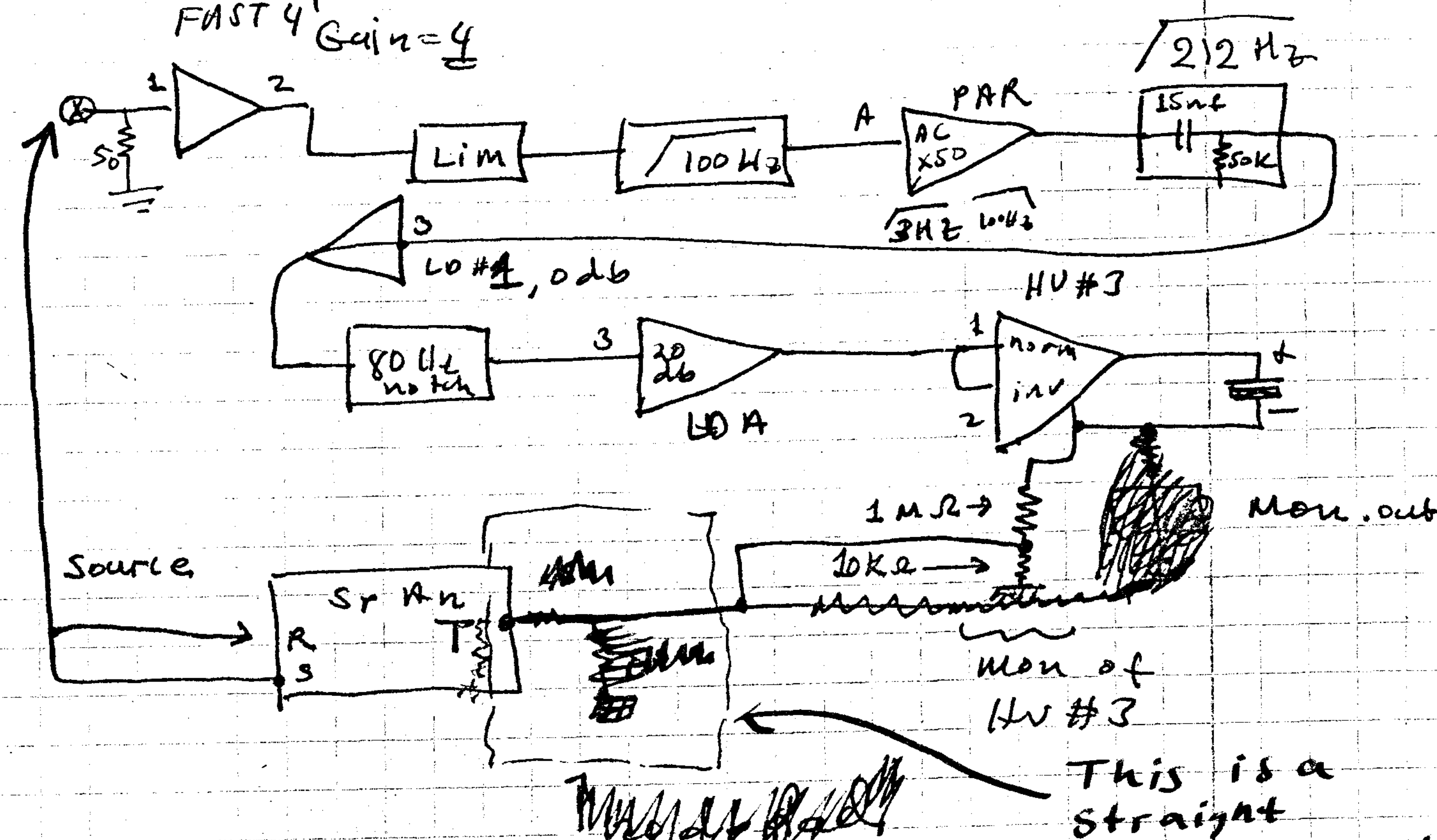
FASTP0717

Fast P.C. loop transf. function, 50 Ω at inp of Fast 4

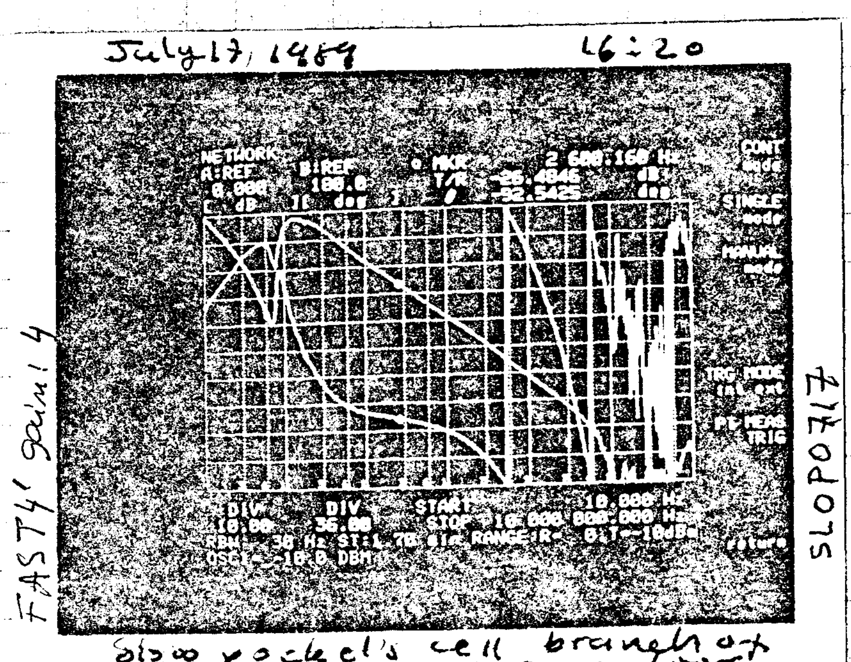
July 17, 1989
Jlh, AA, SH

Servo block frequency and phase response:

1st arm: Slow pockel's cell loop:



This is a straight connection, not a 20dB pad.

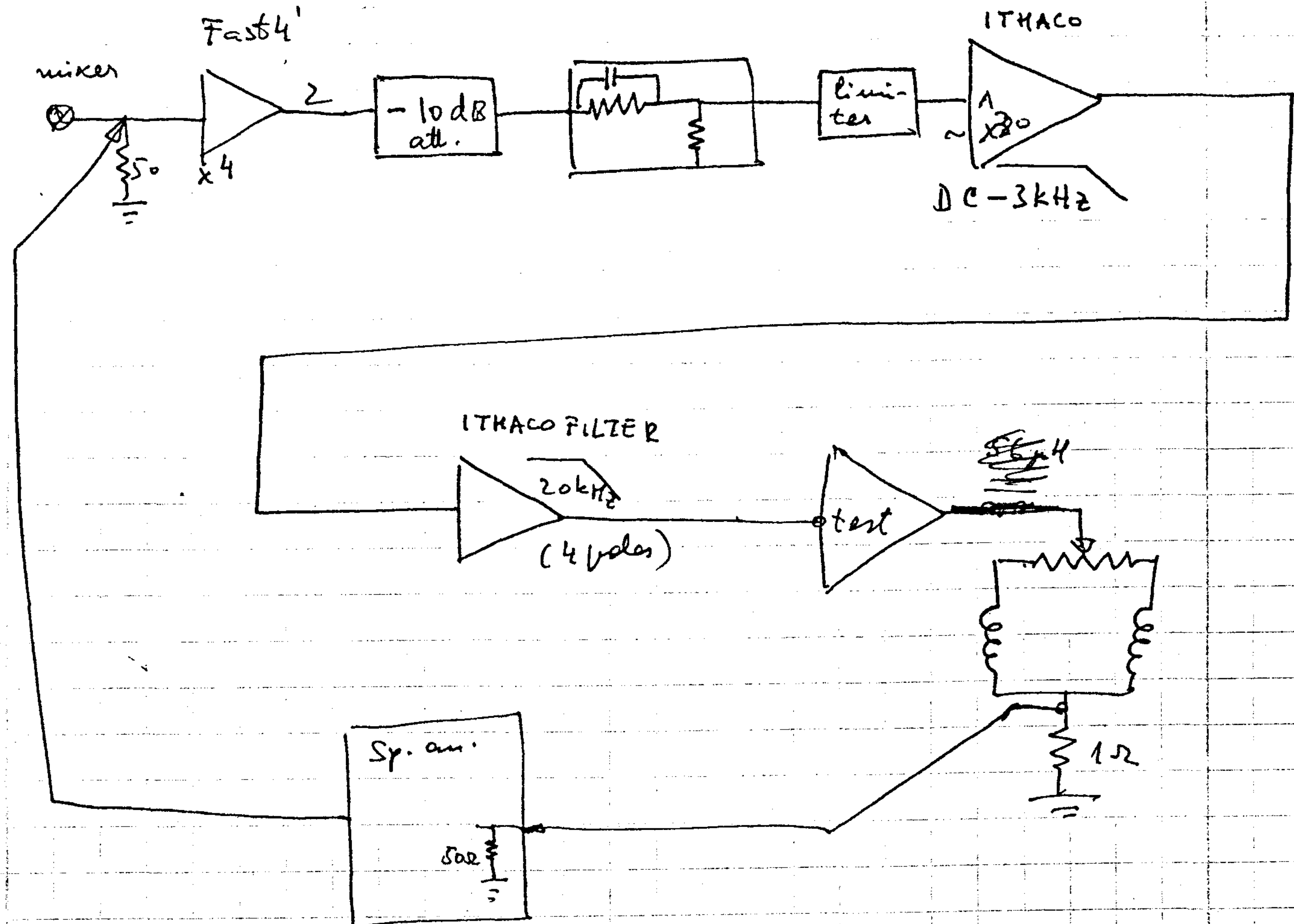


Slow pockel's cell branch of first arm servo loop

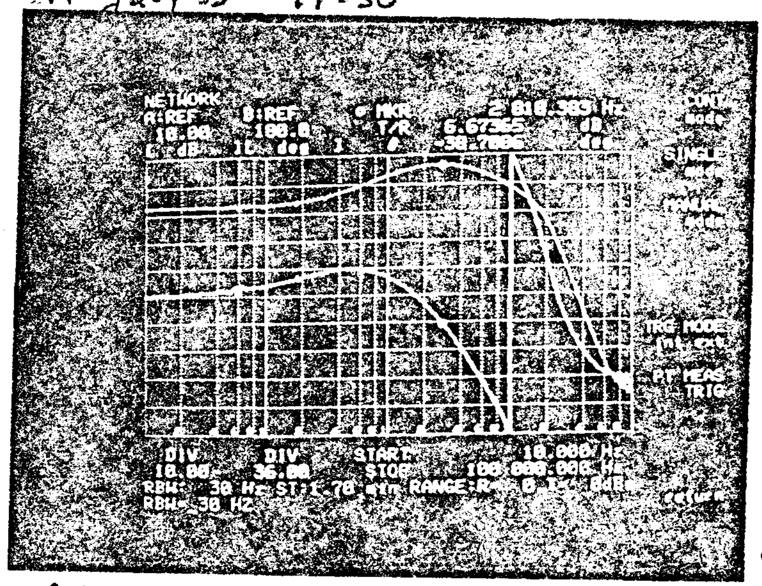
← real gain: add 92dB (see dividers on sketch above)

← 50Ω term at Fast 4 ampl.

1st arm (phase correcting) servo; coil driver leg



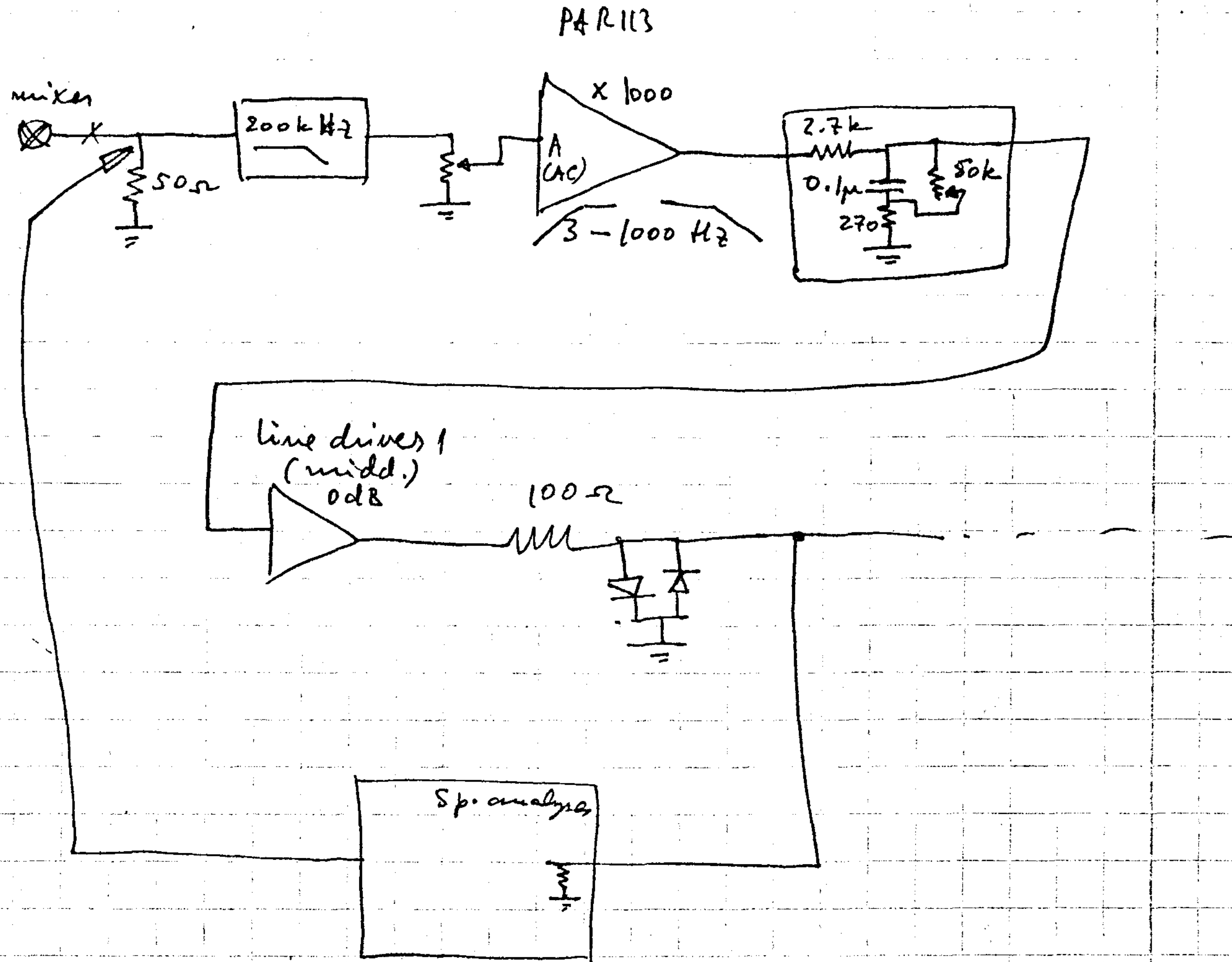
17 July 89 17:30



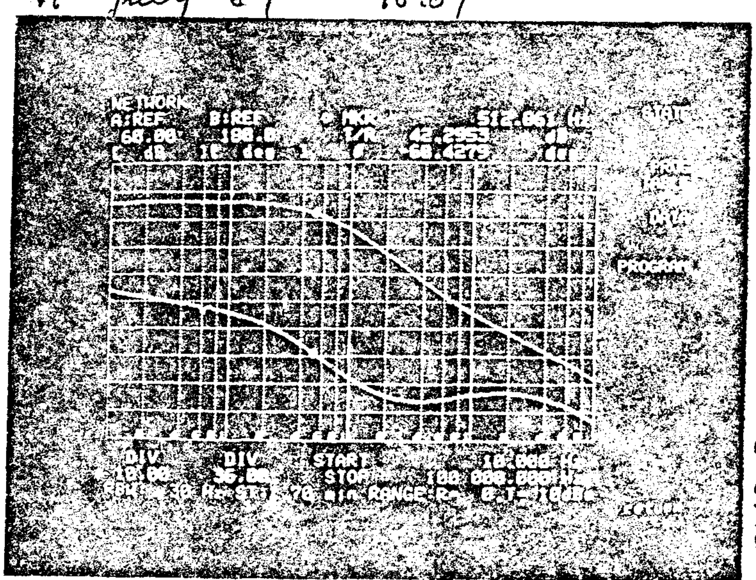
Coil leg response, 50Ω at inp of FAST4'

COIL717

1st arm locking (phase correction) servo: bypass



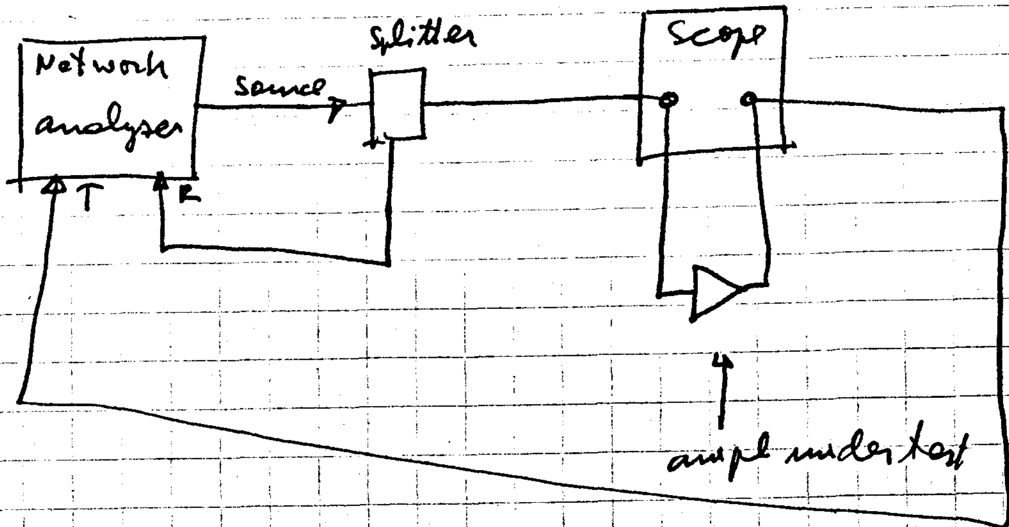
17 - July - 89   18:09



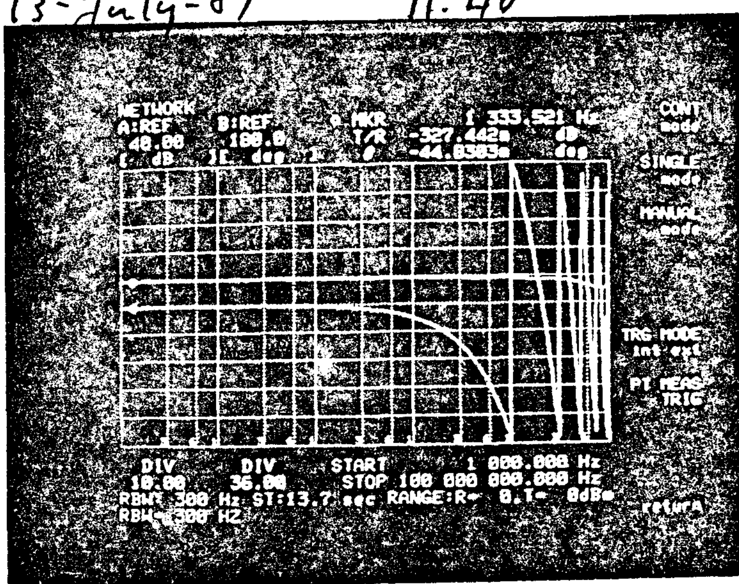
BYP 717

1st arm bypass response

Since ~30' of cables were used to connect the amplifier under test (see diagram below), we took the response of the cables themselves (trace at 11:40)



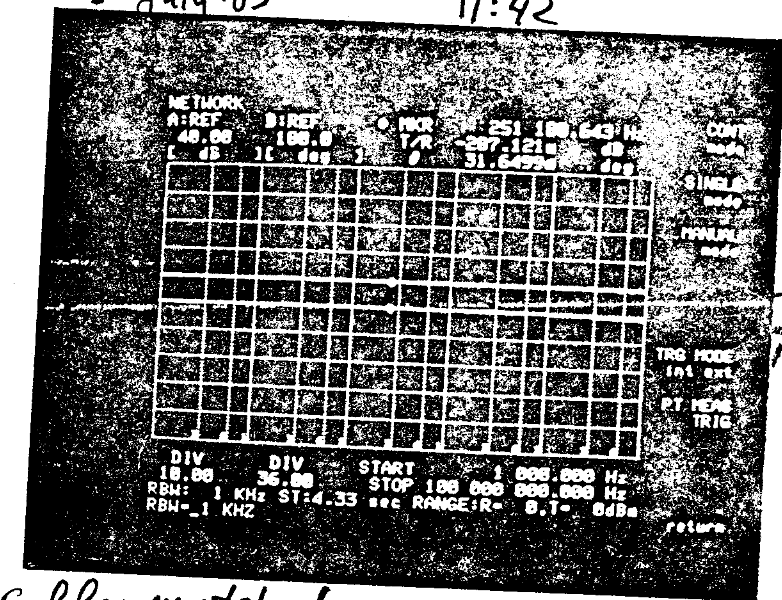
13-July-89 11:40



TR. FUNCTION OF CABLES – they are badly imbalanced

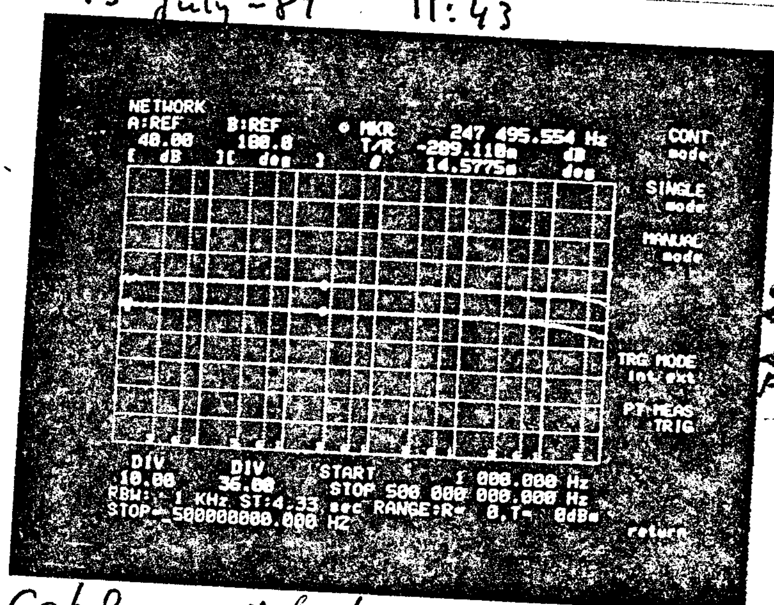
- It turns out that at 250 kHz the cables alone show a phase shift of 5°.
- Therefore, the ~3' cable from splitter to R input was replaced with a long cable, matched to the one in the test path. See traces overleaf

13-July-89 11:42



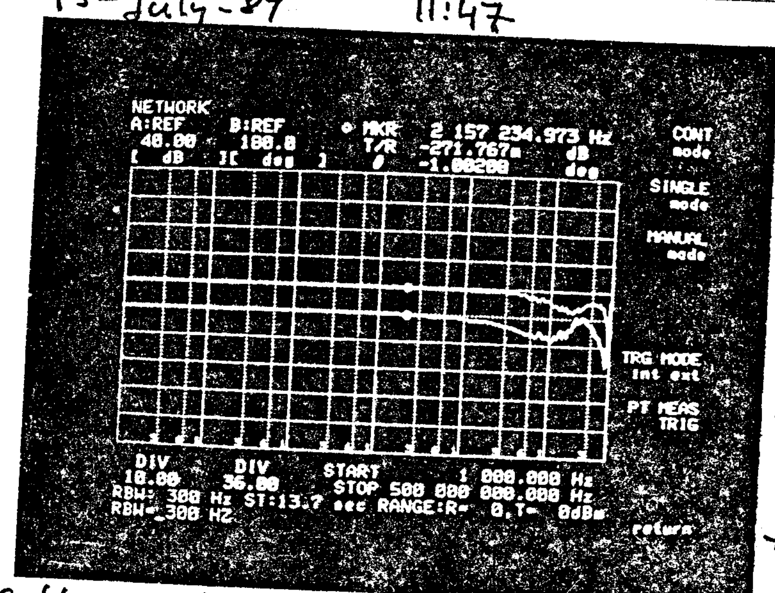
Cables matched

13-July-89 11:43



Cables matched

13-July-89 11:47



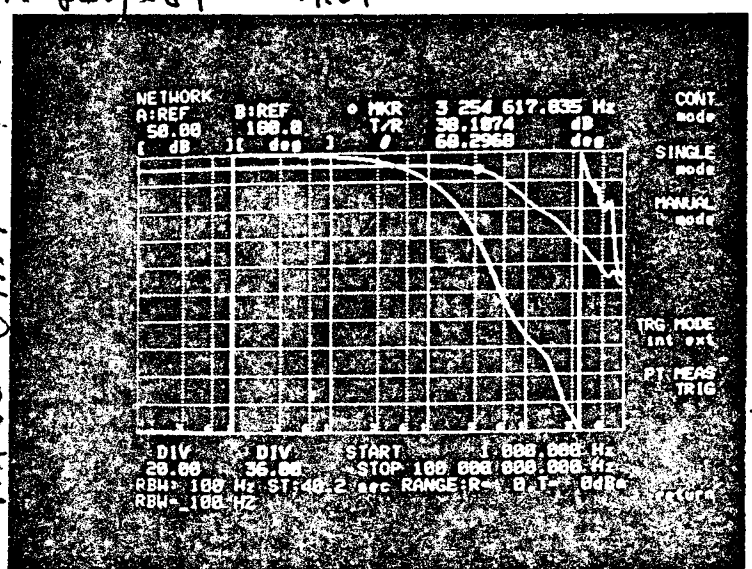
Cables matched, going thru T's connected

To obtain the correct phase response of the amplifiers in the 40 m system servos, we decided to measure their response again, this time with the matched cable.

The two ~~traces~~ transfer function (opposite page) clearly illustrate the difference between using unmatched/matc cables. All the following transfer functions have been measured with matched cables (see cable response on p. 78Y overleaf)

13-July-89 14:09

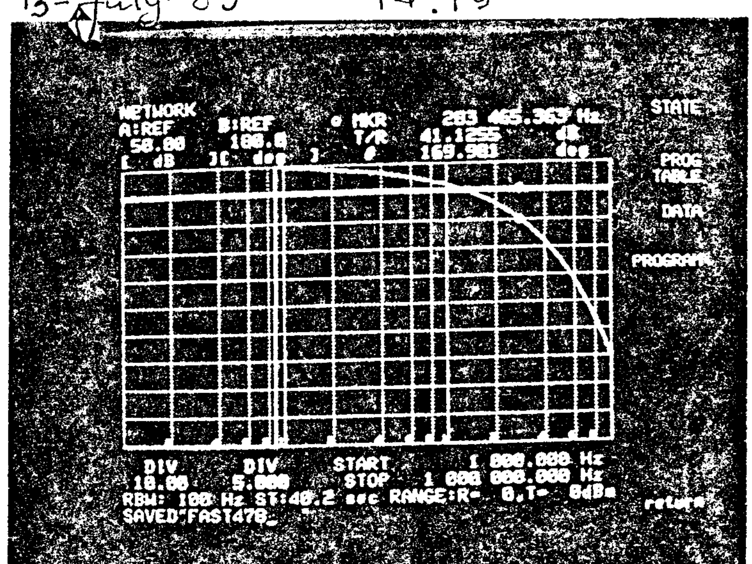
0° phase shift @ 282 kHz



FAST 477

FAST 4', 50 Ω out imp 1 (V) full gain

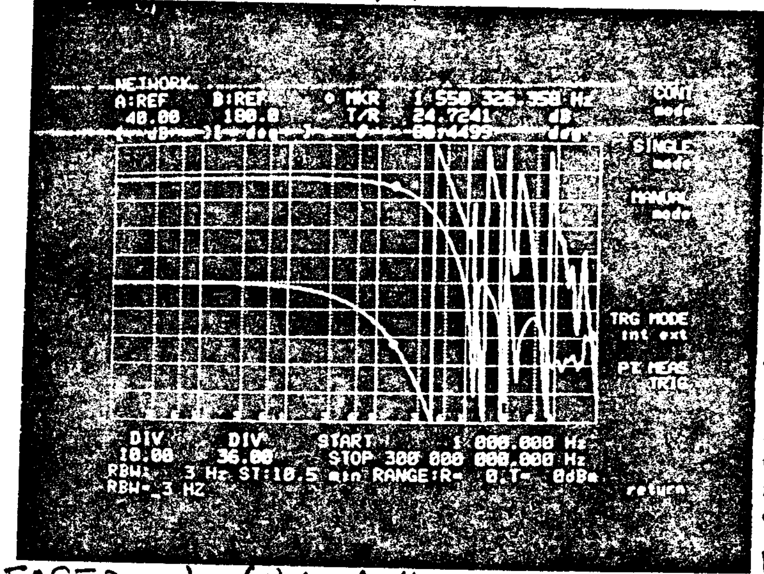
13-July-89 14:19



FAST 478

FAST 4' imp 1 (V)

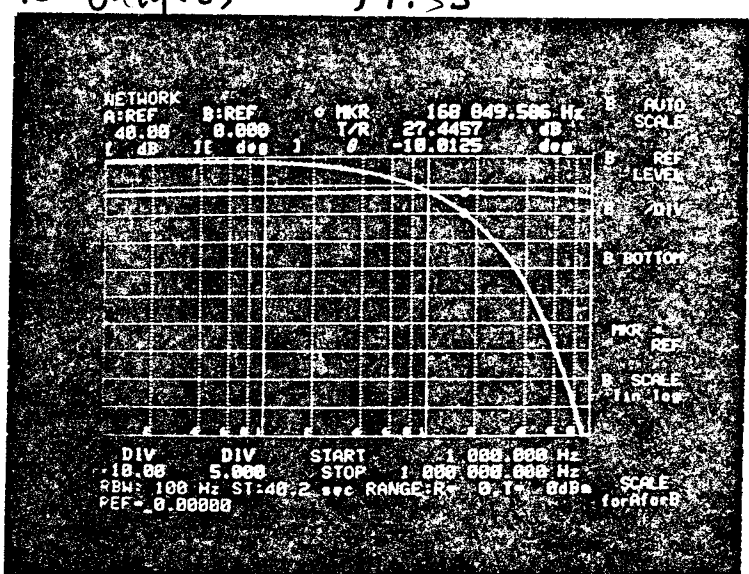
13-July-89 14:45



FAST2 inp(1)V full gain

FAST2 7101

13-July-89 14:35

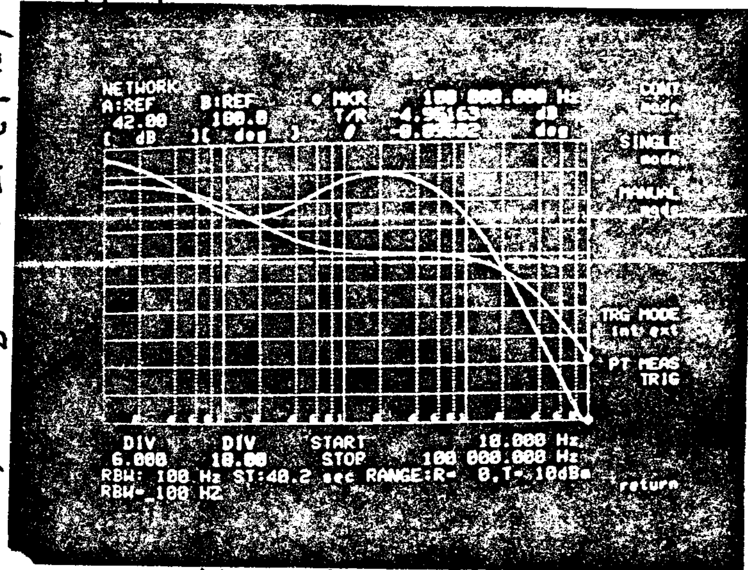


FAST2, inp1(V) full gain

FAST2 7102

13-July-89 15:30

Low Z ITHACO, 50Ω out

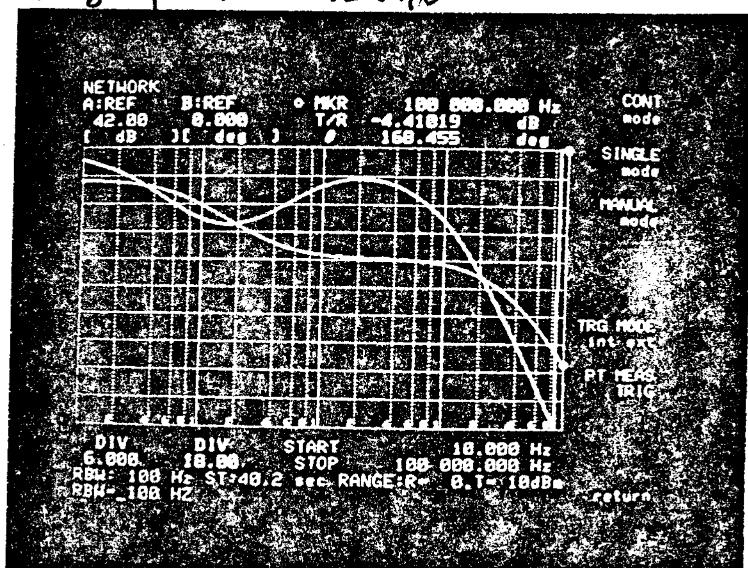


HV3710

wide open

HV3 monitor, left channel, through ITHACOx10

13-July-89 15:40

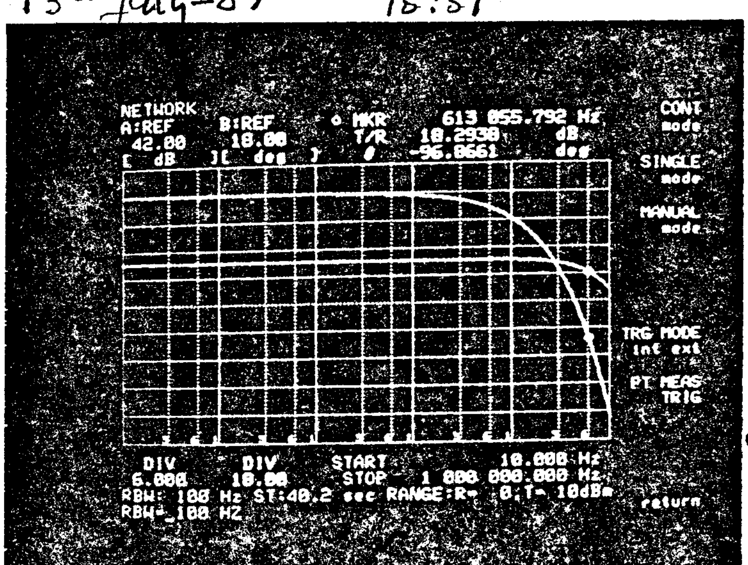


HV3710R

HV3 monitor, as 15:30, right channel

13-July-89 15:51

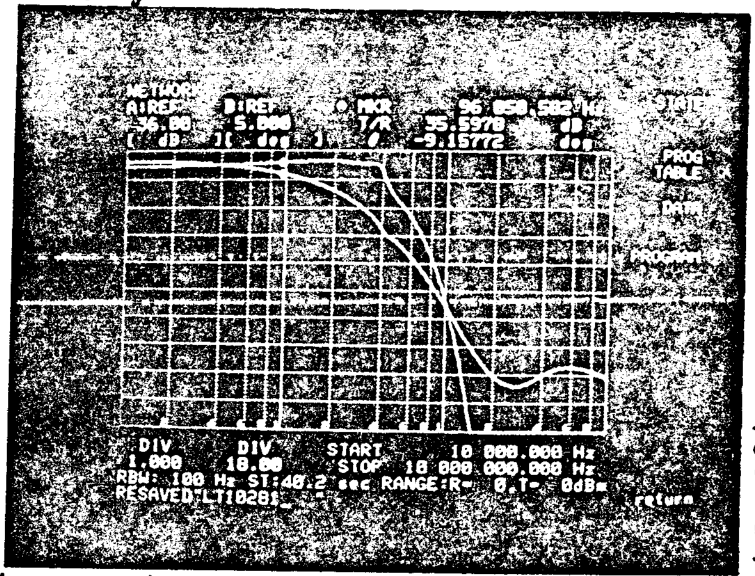
Hi Z in



ITHACO 710

ITHACO x10, Lo Z out, wide open

14-July-89 9:40

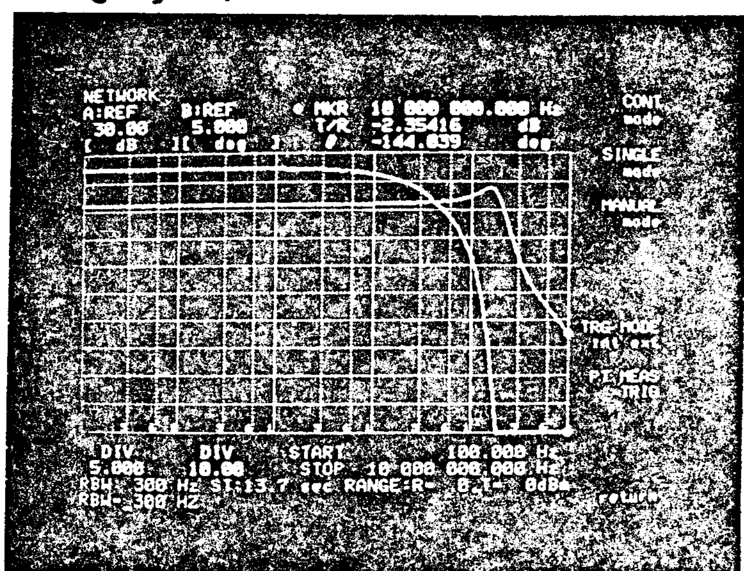


AXES: 10 MHz 36dB

LT10281

LT 10281 High Z in, 50 out

14-July-89 10:00

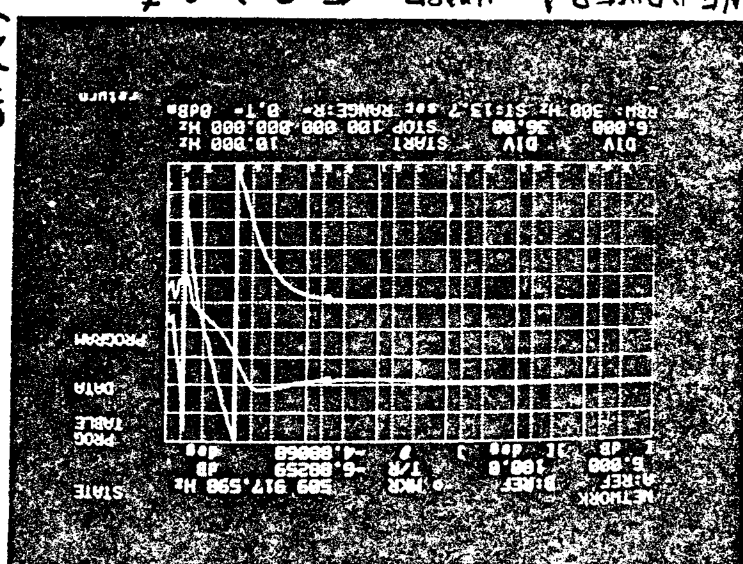


LT10282

LT1028 #2 HiZ in, 50 Ω out

LINE DRIVER 1 'upper', 50 Ω in/out

LD1UP



GAIN = 0 dB nominal

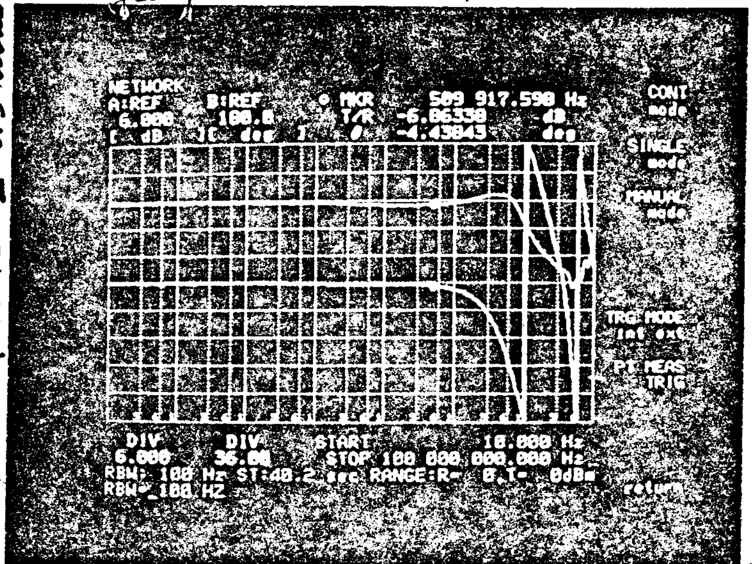
14-July-89 10:14

14-July-89

More transfer functions taken

14-July-89 10:17

GAIN = 0 dB nominal

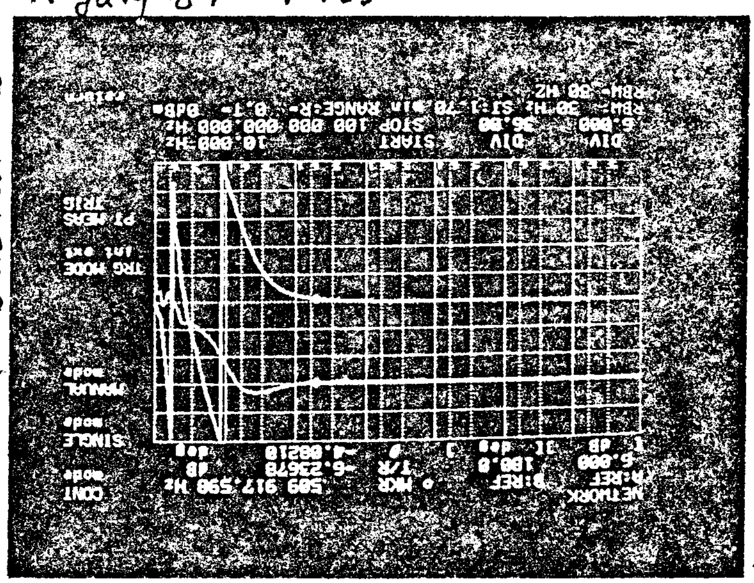


LD1 MID

LINE DRIVER 1, Middle, 50Ω in, out

14-July-89 10:25

GAIN = 0 dB nominal

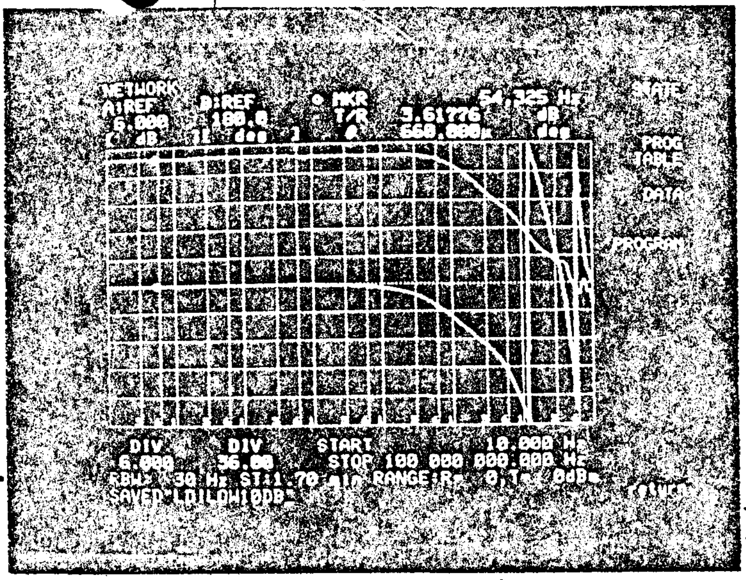


LD1 low

Line driver 1, Lower, 50Ω in out

14 July 10:34

GAIN : 1x10dB nominal

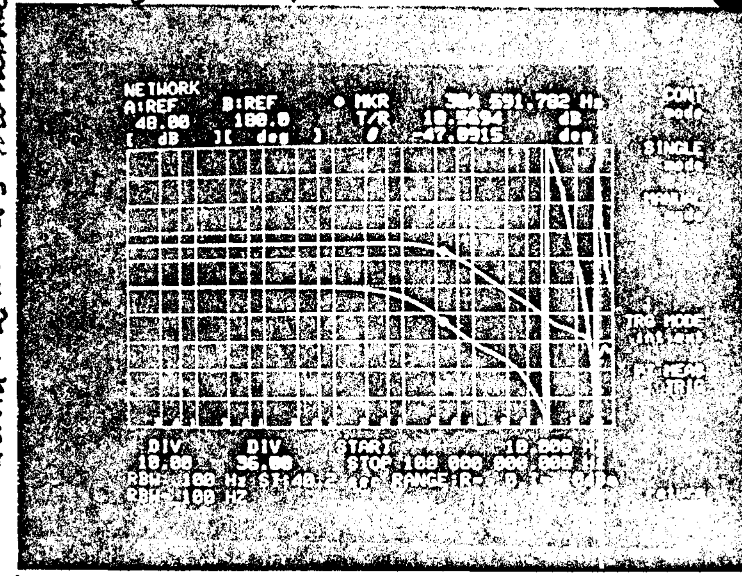


LD1LOW10dB

Line dr. 1 lower, 50Ω in out

14-July-89 10:36

Gain : 2x10dB nominal

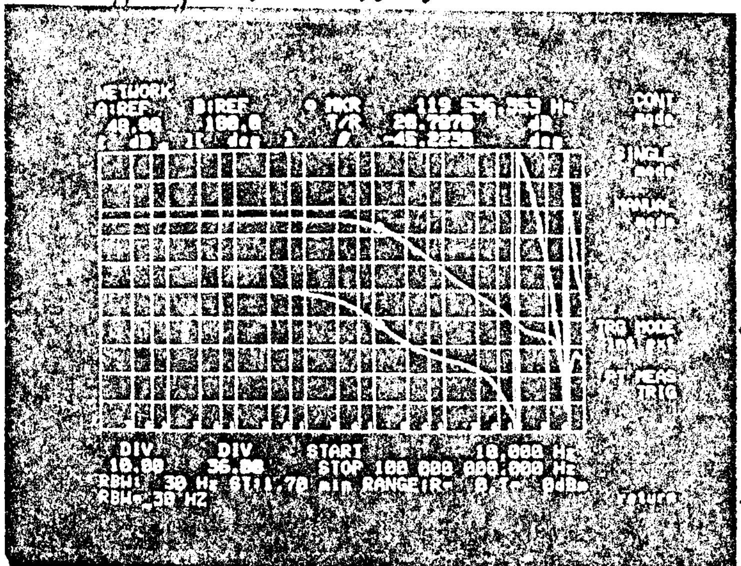


LD1LOW20dB

Line driver 1, lower, 50Ω in, out

14-July-89 10:40

GAIN : 3x10 dB nominal

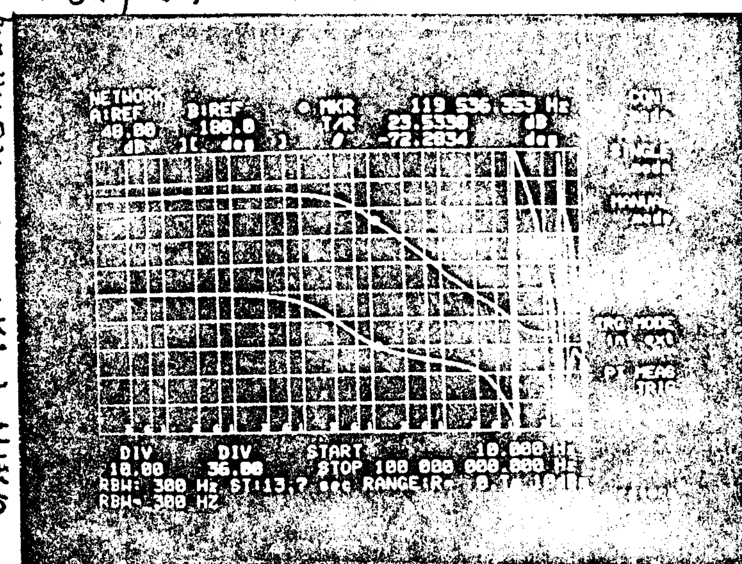


LD1LOW30dB

Line driver 1, lower, 50Ω in, out

14-July-89 10:45

GAIN : 4x10 dB nominal

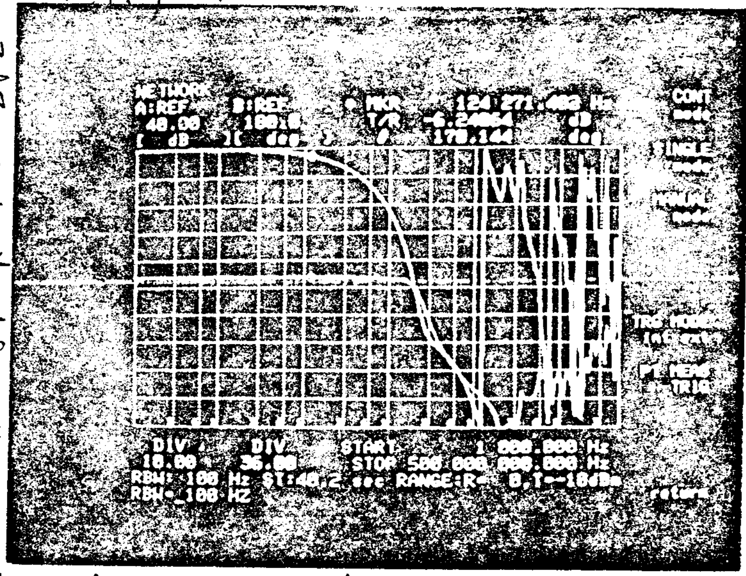


LD1LOW40dB

Line driver 1, lower, 50Ω in, out

17 July 89 13:35

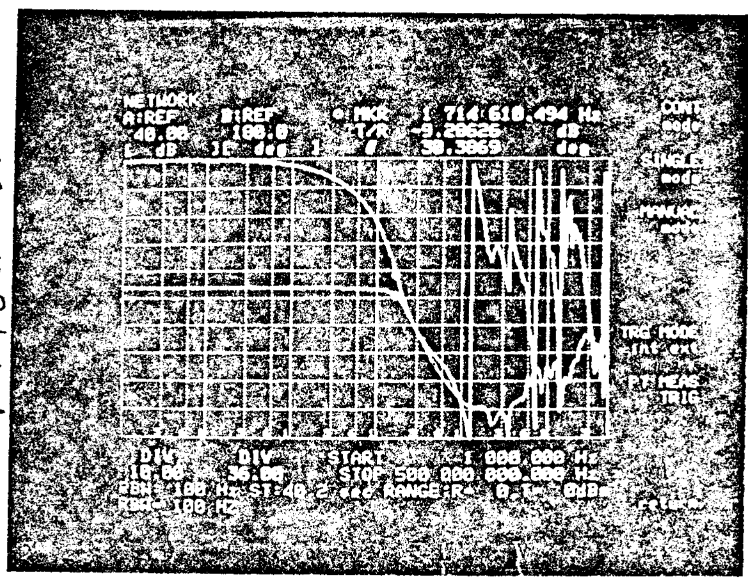
3dB point at: 1.955 MHz



LDA MID 0DB

Line driver A, mid, 0dB, 50Ω out.

10° : 128.4 kHz

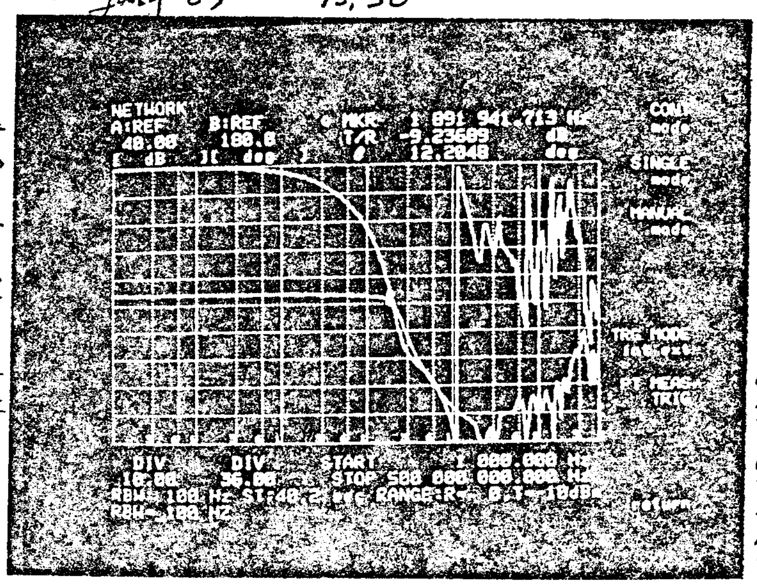


LDA LOW

Line driver A lower, 50Ω out, 0dB

17 July-89 13:30

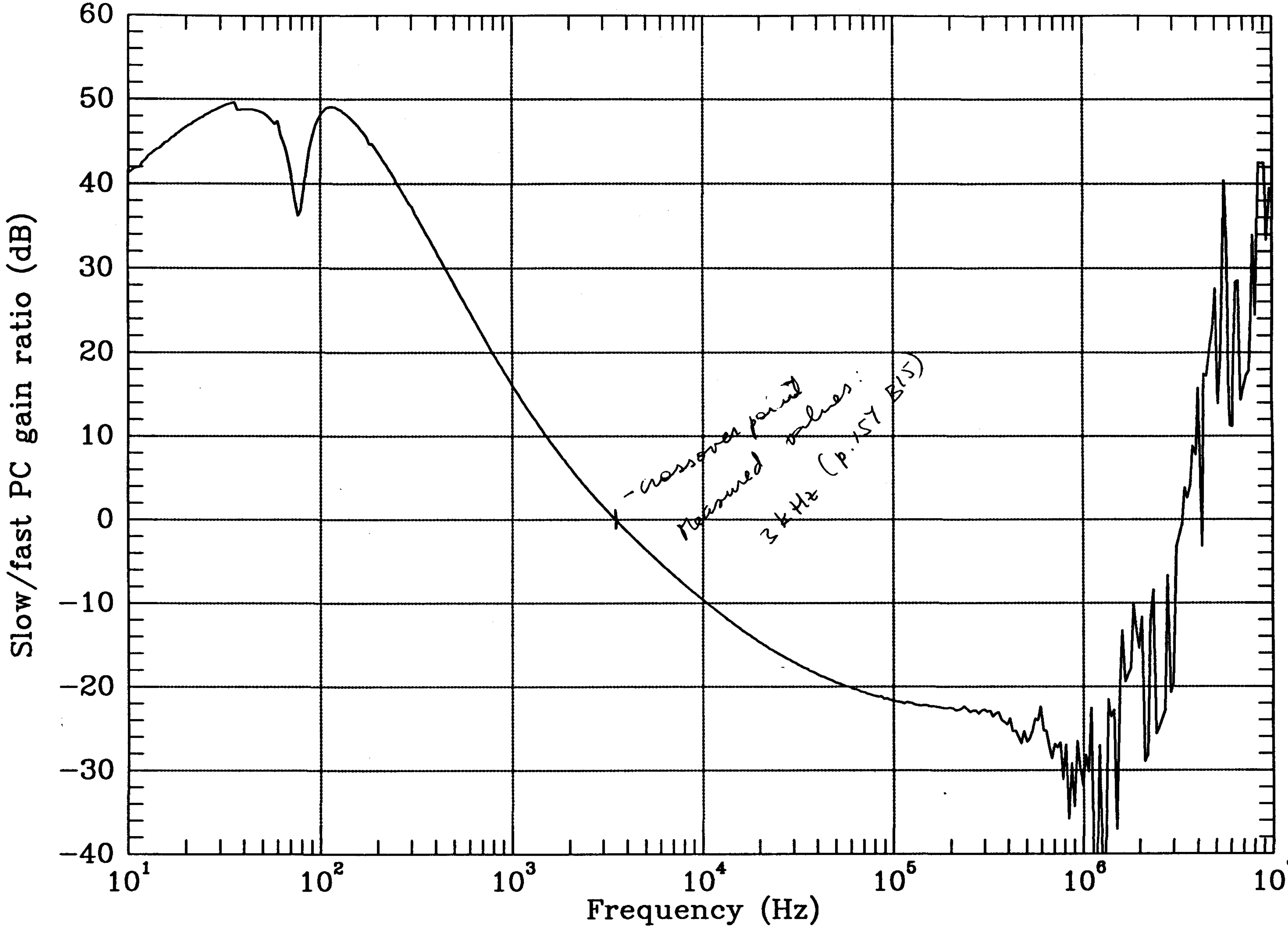
10° at: 124 kHz



LDA UP 0DB

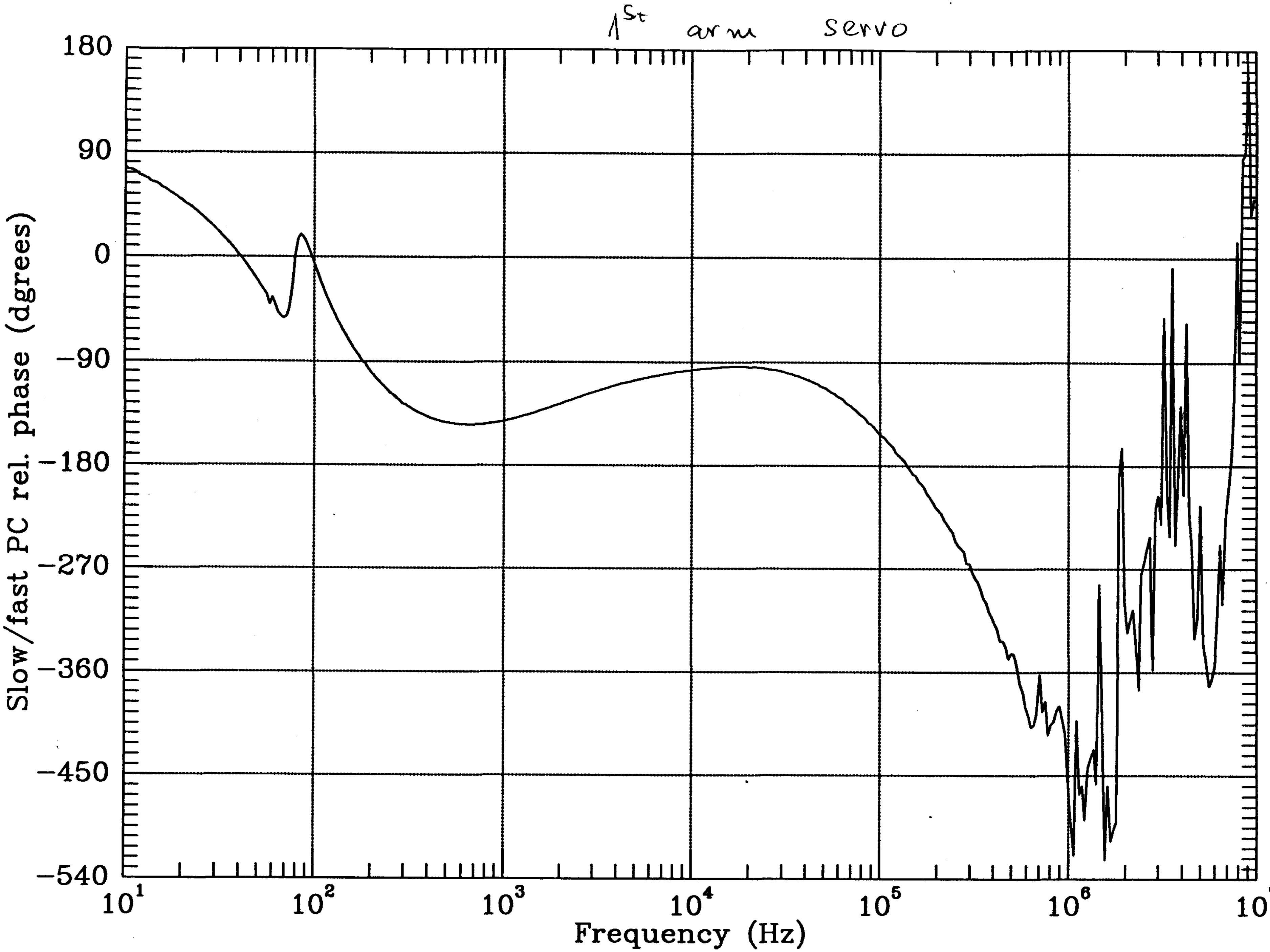
Line driver A, upper, 0 dB, 50Ω at outp.

1st arm servo



21-July-89

AA, YG, JL
measurement
processed
by AA

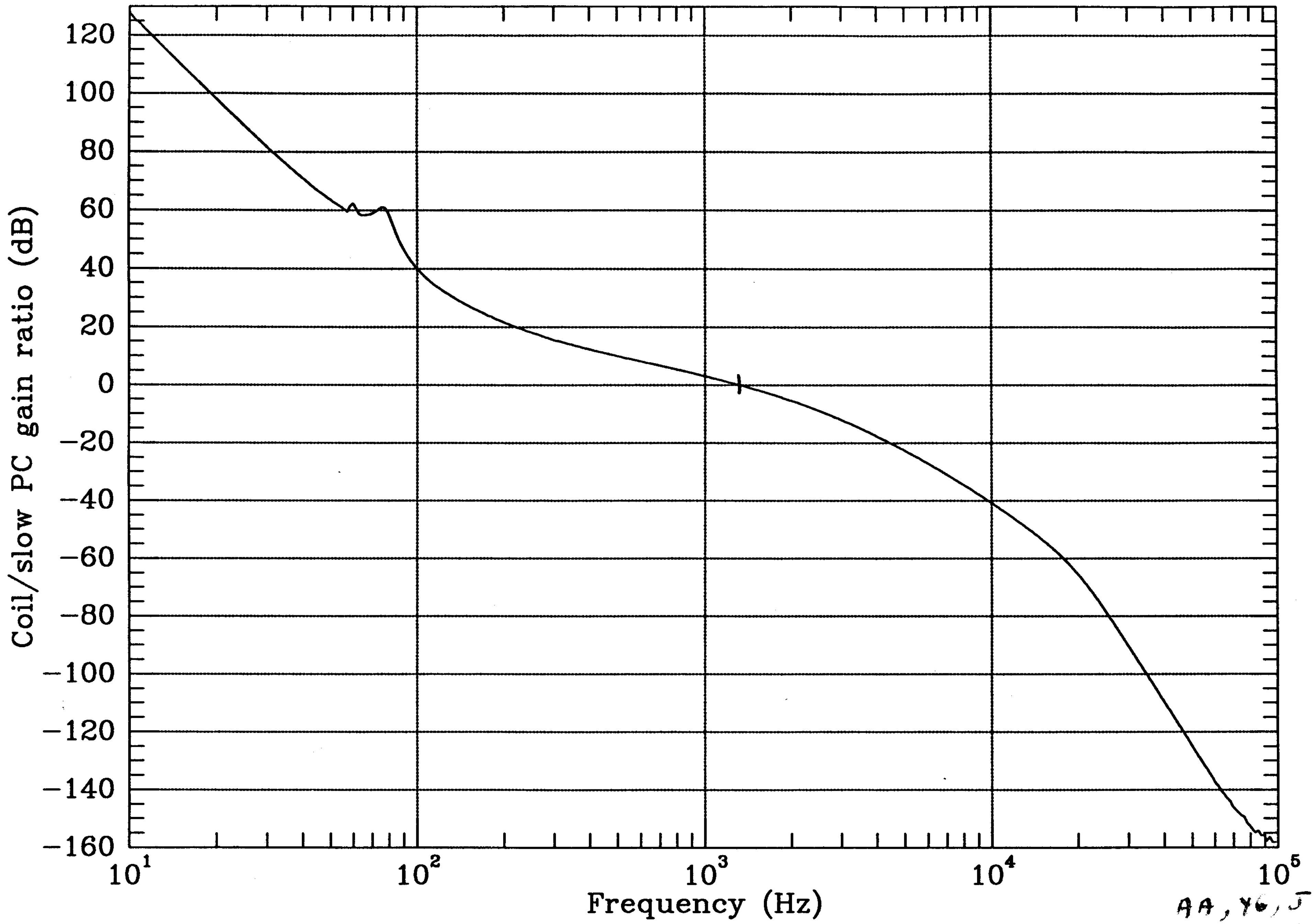


USES FILES: SLOPO721
FASTPO[illegible]1

21-July-89

4A, Y6, JH
measurement
processed
by 4A

1st arm servo

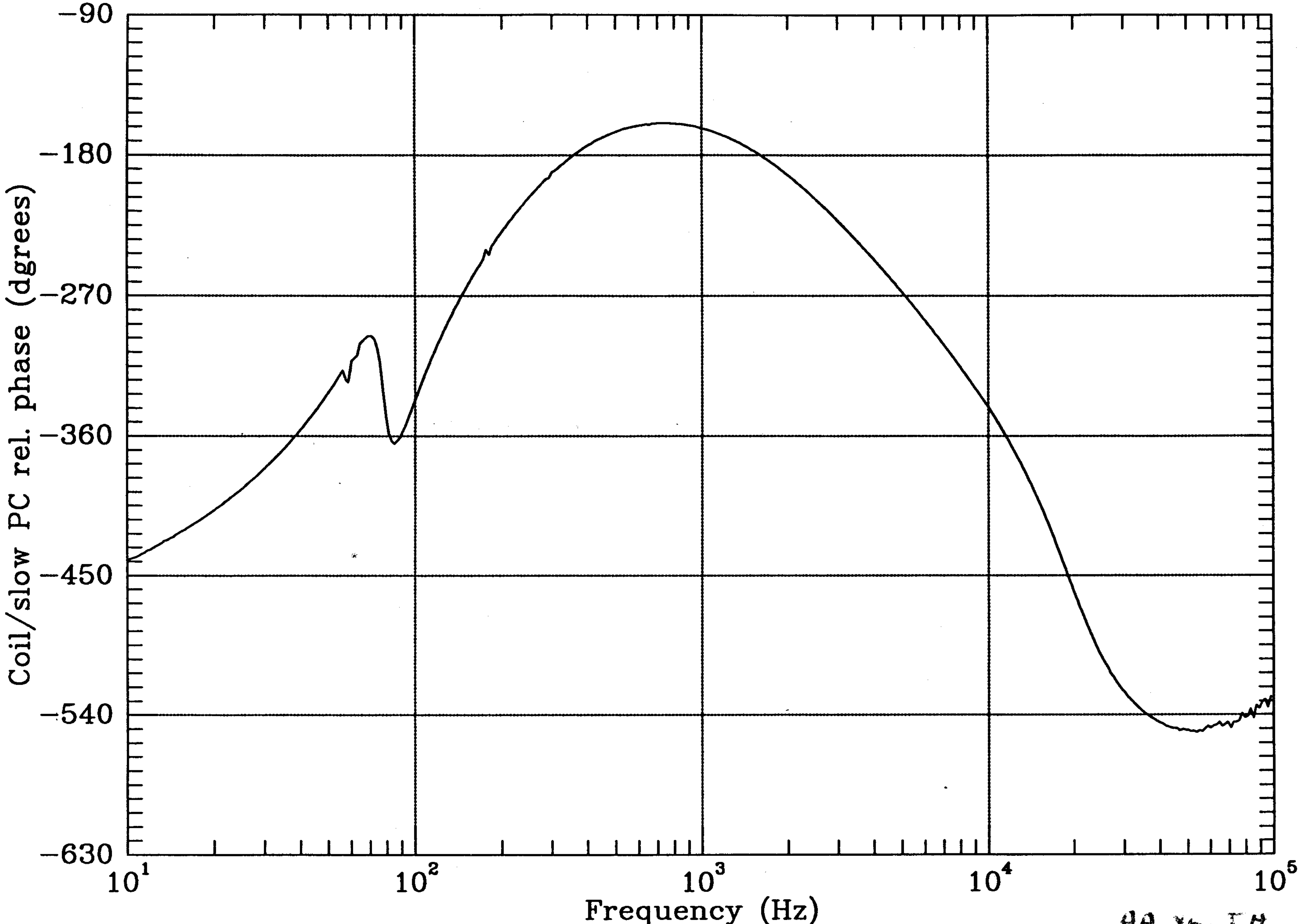


AA, YG, JH
measurements
processed by AA

21-Jul-89

uses coil, c.f, coilpc.pl

1st arm servo



AA, YG, JH
measurements
processed by AA

uses coilp ', coilpcpl1

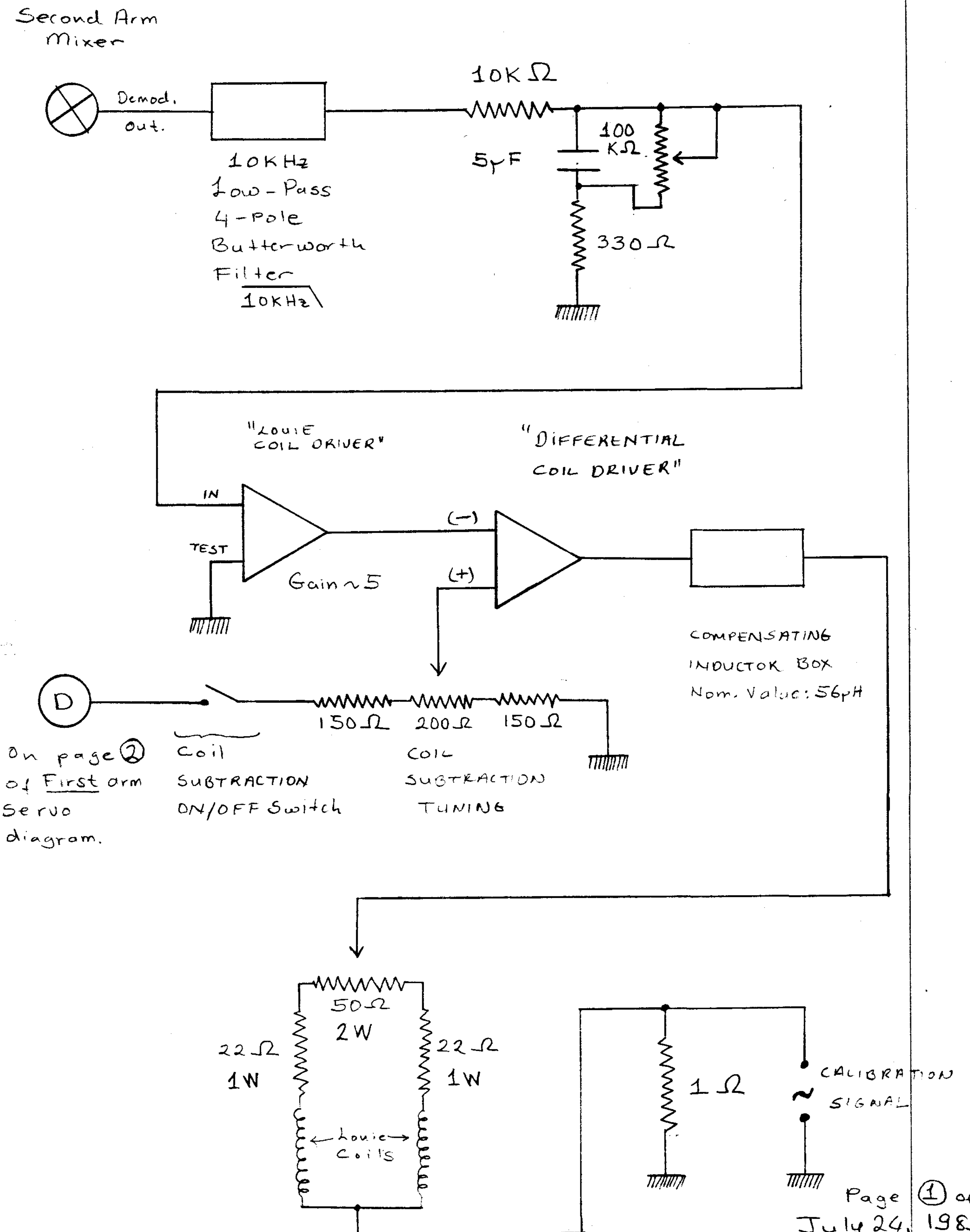
24- ly-89

BATCH
START

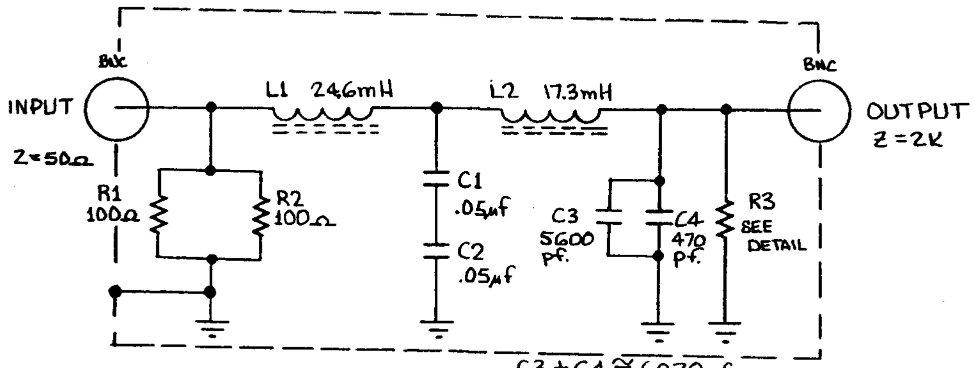
STAPLE
OR
DIVIDER

Second Arm Servo Loop

Block Diagram:



July 24, 1989 YG

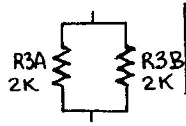


C3+C4≅6070pf
C1 AND C2=.025μf.

L1— WIND 248t. ON BOBBIN. USE CORE G-42213-40 AND MTG. CLIP. 24.6mH.
L2— WIND 208t. ON BOBBIN. SAME CORE AS L1. 17.3mH.
(WIRE IS #32 INSULATED COPPER)

NOTE: ALL CAPS. ARE MYLAR OR MICA.

R3 DETAIL



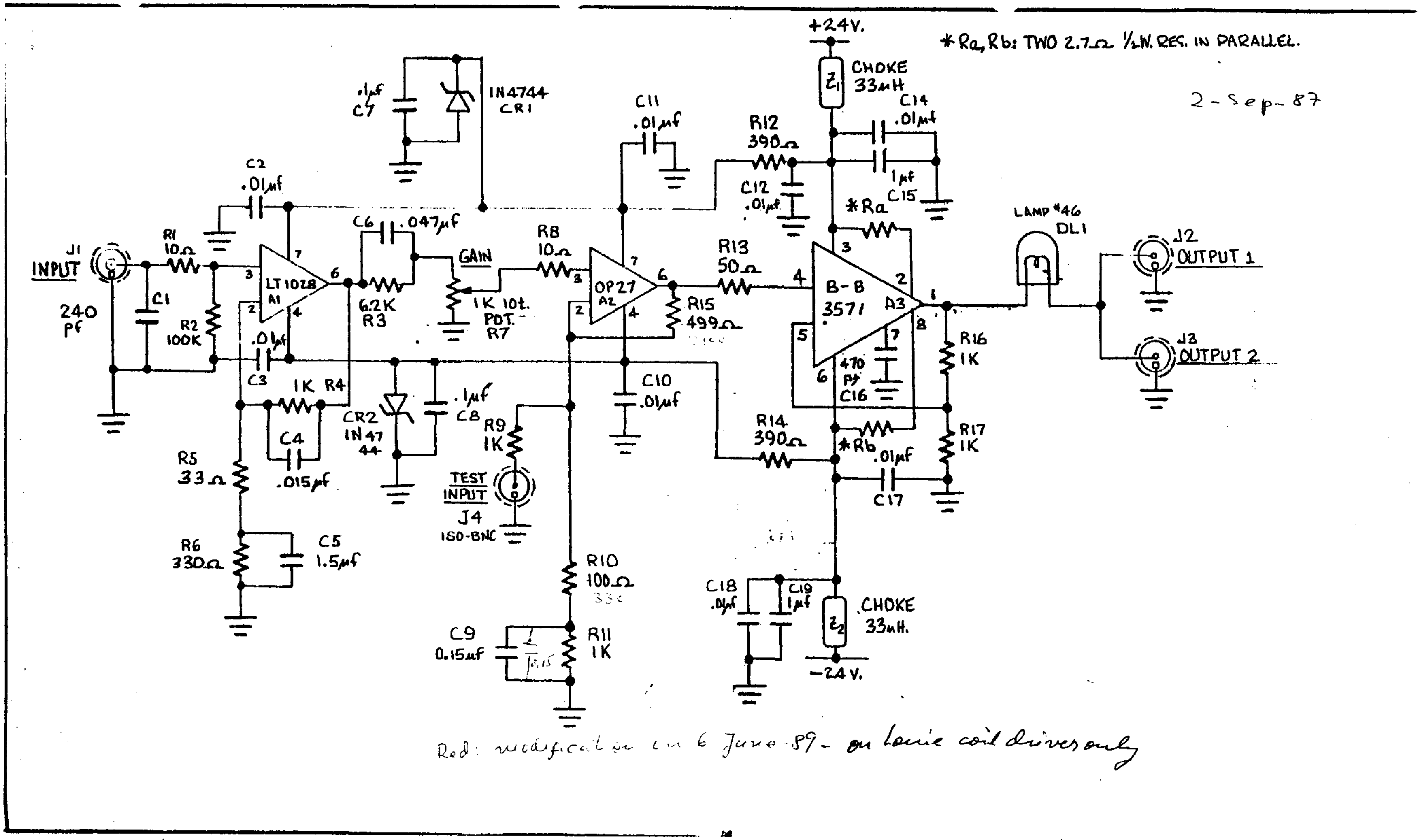
1. FOR 1K OUTPUT Z 2K RES IN PARALLEL
2. CUT ONE RESISTOR FOR 2K OUTPUT Z.

CUT-OFF=10 KHz at 3db POINT

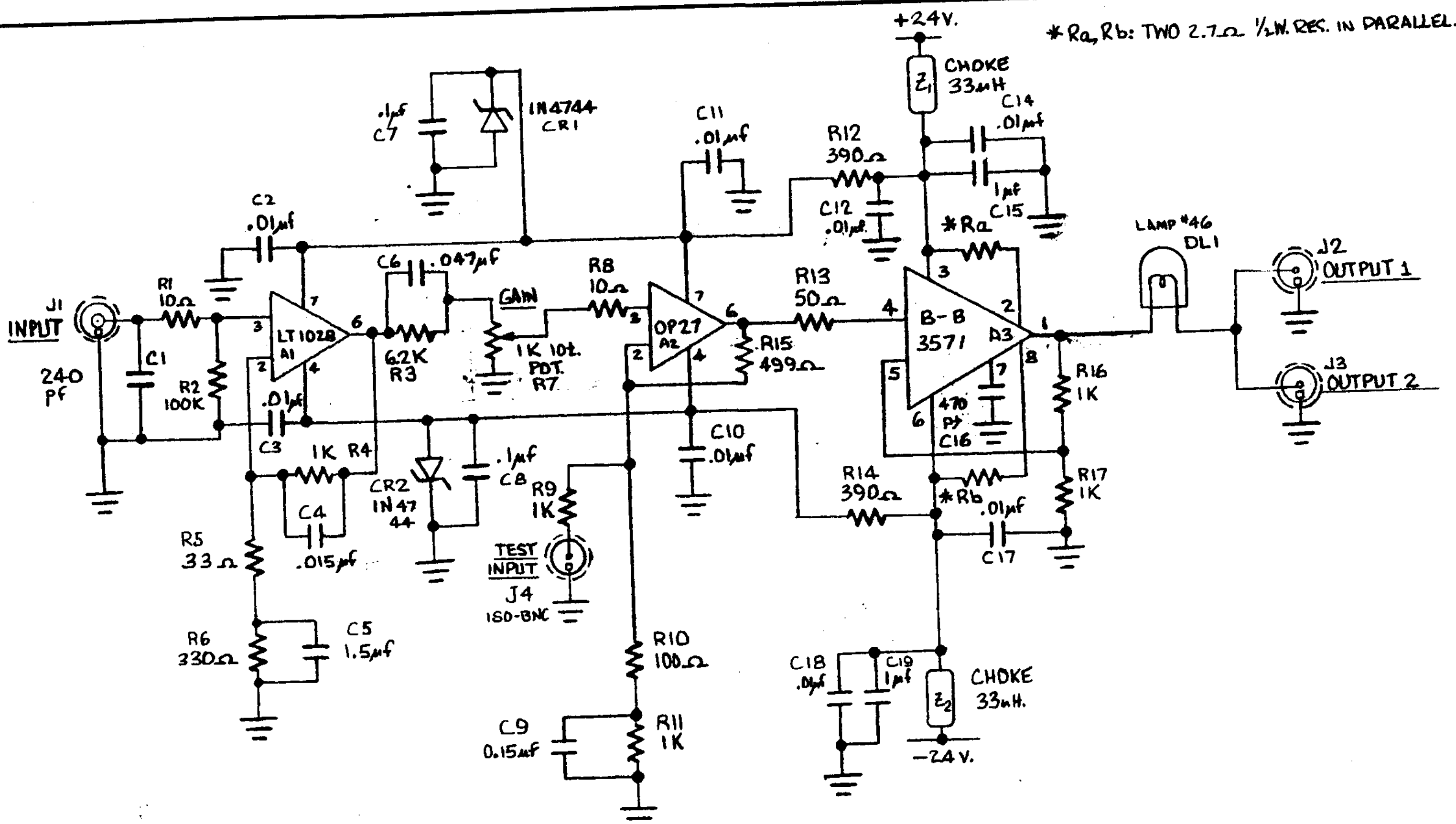
2-29-88 ADD R3 DETAIL

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
FOUR-POLE BUTTERWORTH FILTER		
DRAWN BY B. Tinker	DATE 08-11-87	DRAWING NO.
CHECKED BY	SCALE	-1
APPROVED BY	W.O.	

87-0811-1



+24V.
*Ra, Rb: TWO 2.7Ω ½W. RES. IN PARALLEL.
2-Sep-87
CHOKE 33mH
Z1
C14 .01μf
C15 1μf
R12 390Ω
C12 .01μf
C11 .01μf
.1μf C7
1N4744 CR1
C2 .01μf
C6 .047μf
GAIN
R8 10Ω
*Ra
LAMP #46 DL1
J1 INPUT
R1 10Ω
240 pf
C1
R2 100K
LT1028 A1
6.2K R3
1K 10t. POT. R7
OP27 A2
R13 50Ω
R15 499Ω
B-B 3571 A3
J2 OUTPUT 1
J3 OUTPUT 2
R16 1K
R17 1K
.01μf C3
1K R4
C4 .015μf
CR2 1N4744
.1μf C8
R9 1K
TEST INPUT J4
ISO-BNC
C10 .01μf
R14 390Ω
*Rb
.01μf C17
470 pf C16
R5 33Ω
R6 330Ω
C5 1.5μf
R10 100Ω
C9 0.15μf
R11 1K
C18 .01μf
C19 1μf
CHOKE 33mH.
Z2
-24V.

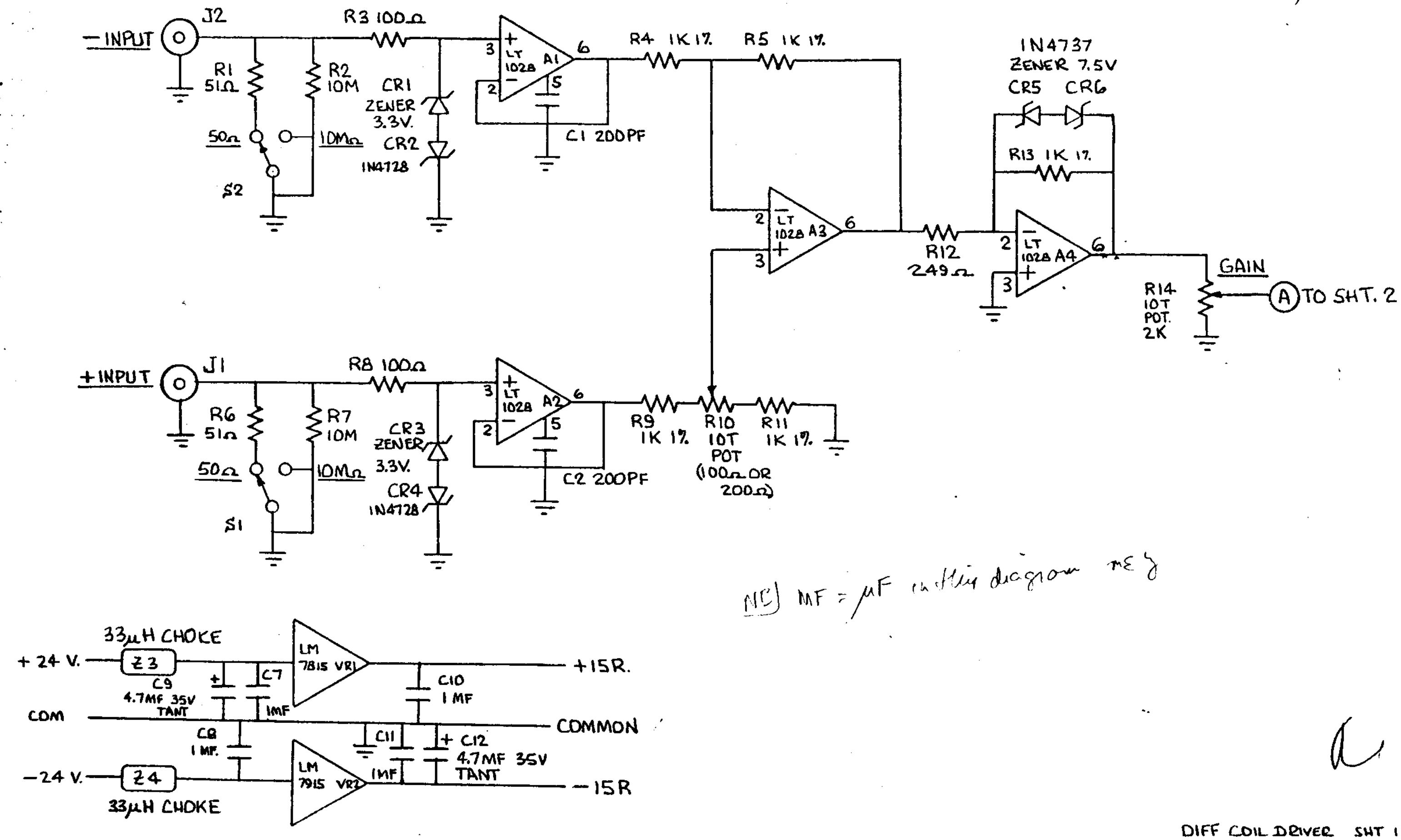


3-1-88 R15 MOVED: 1K TO 500Ω
1-28-88 C16 FROM 220pf to 470pf
UPDATE TO 9-8-78

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
COIL DRIVER HIGH CURRENT		
DRAWN BY B.T.	DATE 9-2-87	DRAWING NO. -1
CHECKED BY	SCALE	
APPROVED BY	W.O.	

87-0902-1

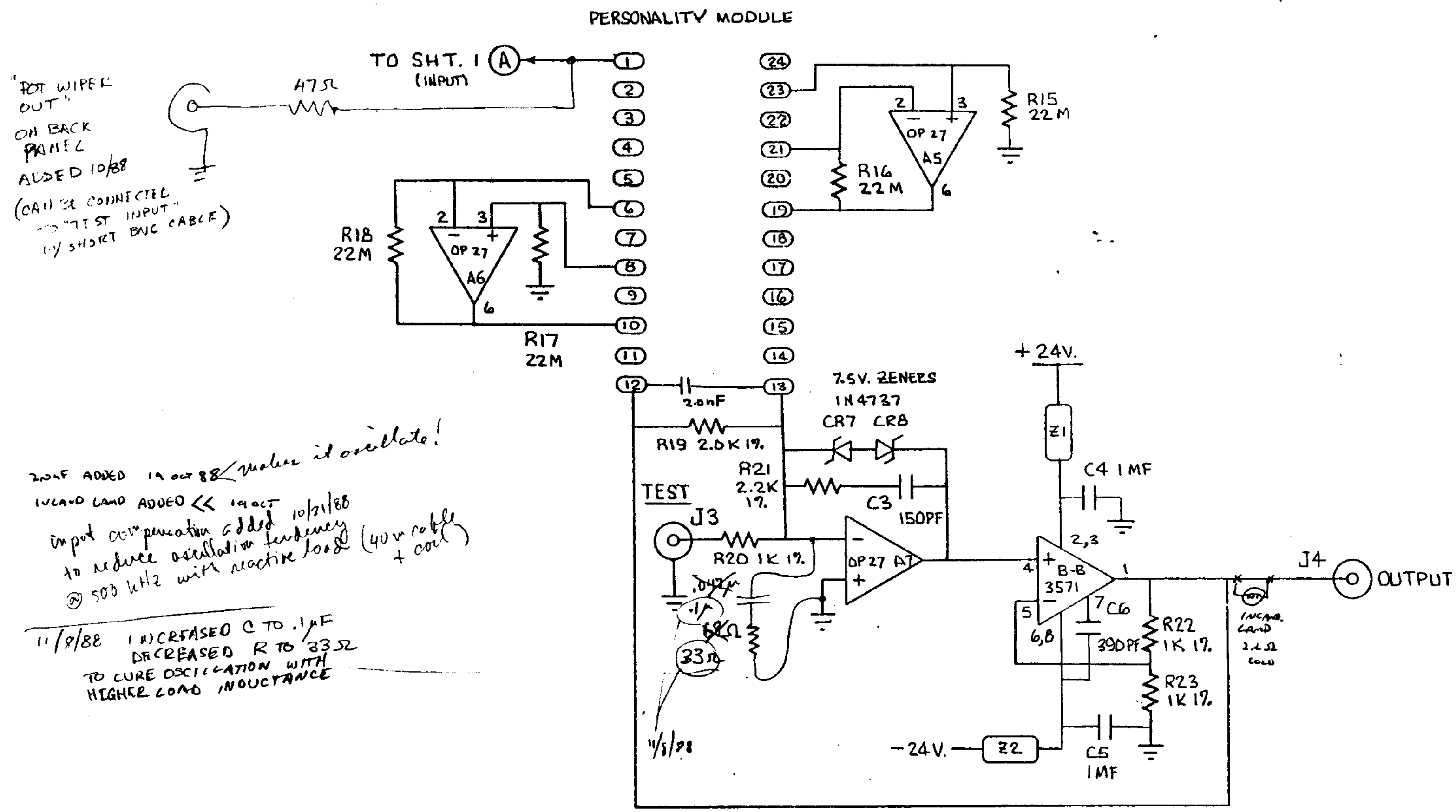
High current, programable, differential coil drive (MK II)



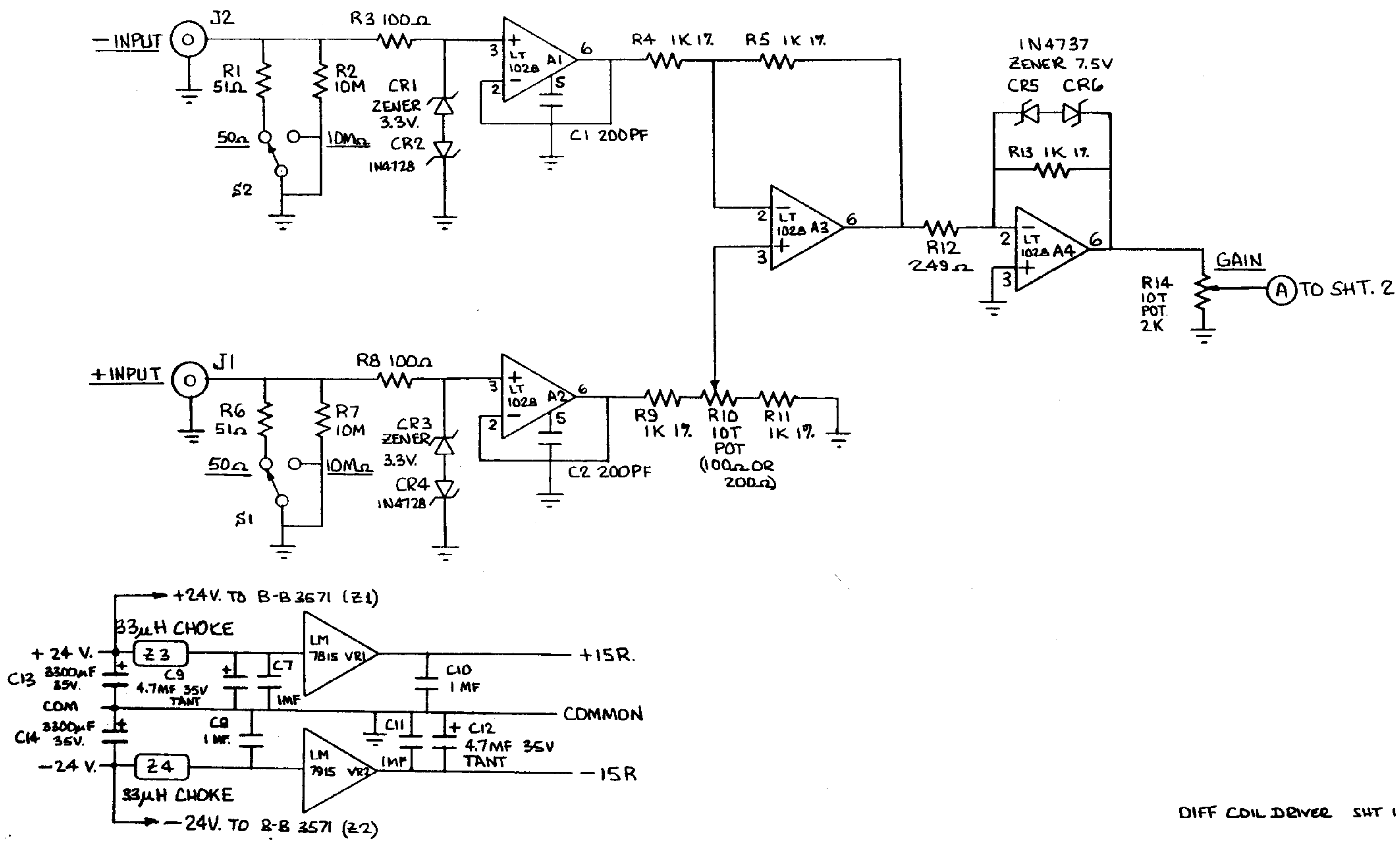
NB MF = μF in this diagram

DIFF COIL DRIVER SHT 1

CALIFORNIA INS



PERSONALITY MODULE
TO SHT. 1 (A)
(INPUT)
"POT WIPER OUT" ON BACK PANEL ADDED 10/88
(CAN BE CONNECTED TO "TEST INPUT" W/ SHORT BNC CABLE)
47Ω
R18 22M
OP 27 A6
R17 22M
R15 22M
OP 27 A5
R16 22M
20nF
R19 2.0K 1%
7.5V. ZENERS 1N4737
CR7 CR8
R21 2.2K 1%
C3 150PF
TEST J3
R20 1K 1%
OP27 A7
+24V.
Z1
C4 1MF
B-B 3571
C6
390PF
R22 1K 1%
R23 1K 1%
−24V.
Z2
C5 1MF
J4
OUTPUT
20nF ADDED 14 OCT 88 ← makes it oscillate!
INCAND LAMP ADDED ← 14 OCT
input compensation added 10/21/88 to reduce oscillation tendency @ 500 kHz with reactive load (40 m cable + coil)
11/8/88 INCREASED C TO .1μF DECREASED R TO 33Ω TO CURE OSCILLATION WITH HIGHER LOAD INDUCTANCE
.047μ .1μ
68Ω 33Ω
11/8/88

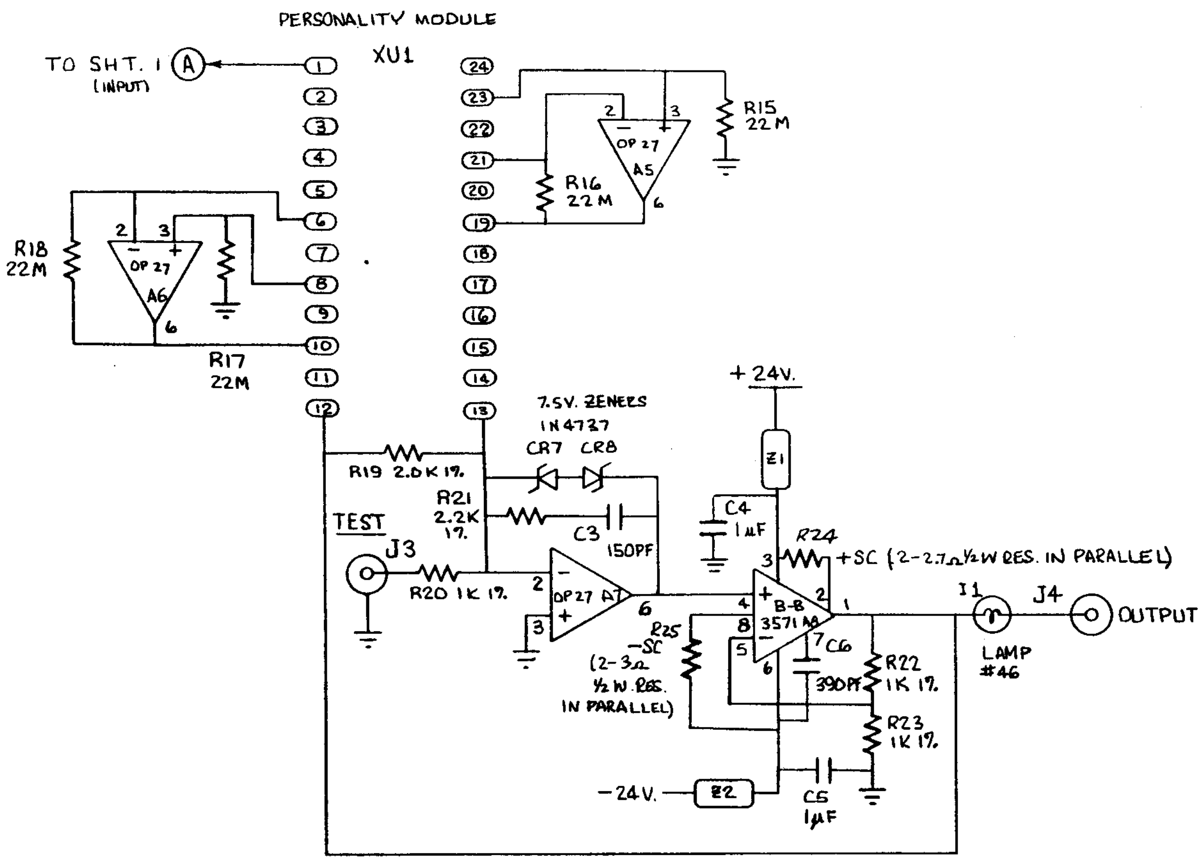


DIFF COIL DRIVER SHT 1

UPDATE 10/4/88 B.

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
PROG. DIFF. COIL DRIVER		SHT. 1
DRAWN BY B.T.	DATE 4-29-88	DRAWING NO.
CHECKED BY	SCALE	
APPROVED BY	W.O.	

88-0429-1

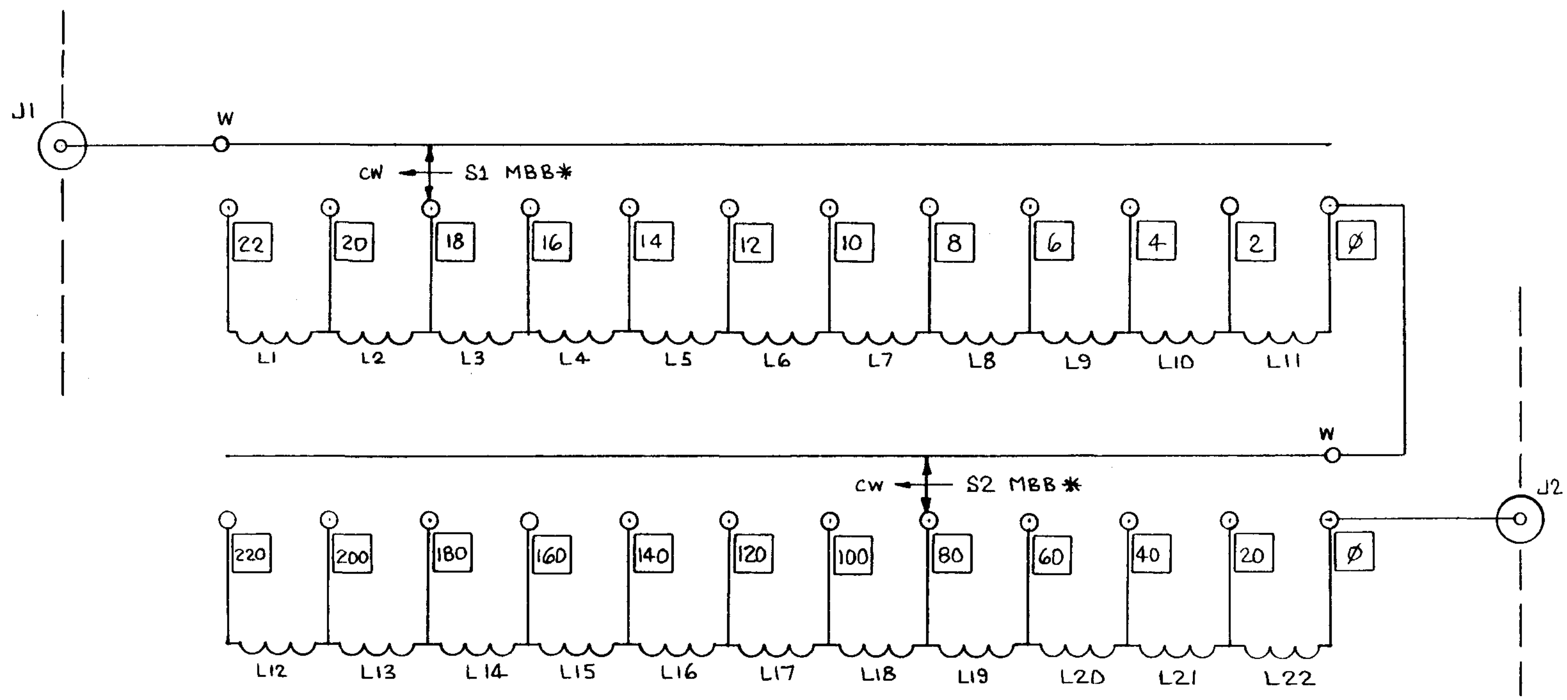


DIFF. COIL DRIVER SHT. 2

UPDATE 10/4/88

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
PROG. DIFF. COIL DRIVER		SHT. 2
DRAWN BY B.T.	DATE 4-29-88	DRAWING NO.
CHECKED BY	SCALE	
APPROVED BY	W.O.	

88-0429-2



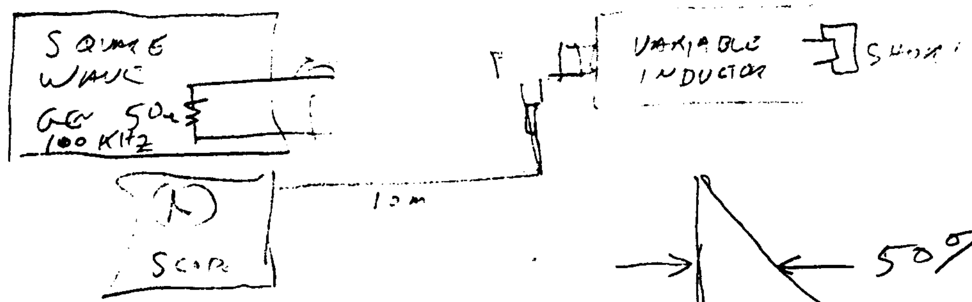
4. *S1 & S2 ARE MAKE-BEFORE-BREAK, 12-POSITION SWITCHES.
3. VALUES IN BOXES ARE IN μH.
2. L12 – L22 = 20μH
1. L1 – L11 = 2μH
NOTES:

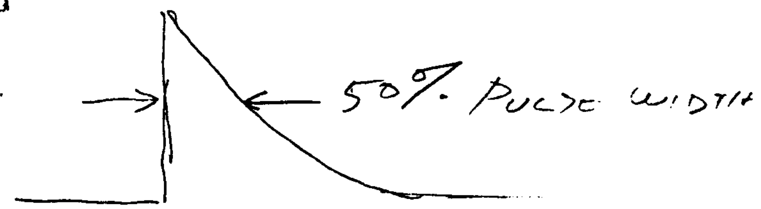
CALIFORNIA INSTITUTE OF TECHNOLOGY
GRAVITATIONAL PHYSICS

INDUCTANCE BOX: GRAVITY PHYSICS
RANGE: Ø TO 242μH IN 2μH STEPS

DRAWN BY R.T.	DATE 5-8-89	DRAWING NO.
CHECKED BY	SCALE	
APPROVED BY	W.O.	

VARIABLE INDUCTOR





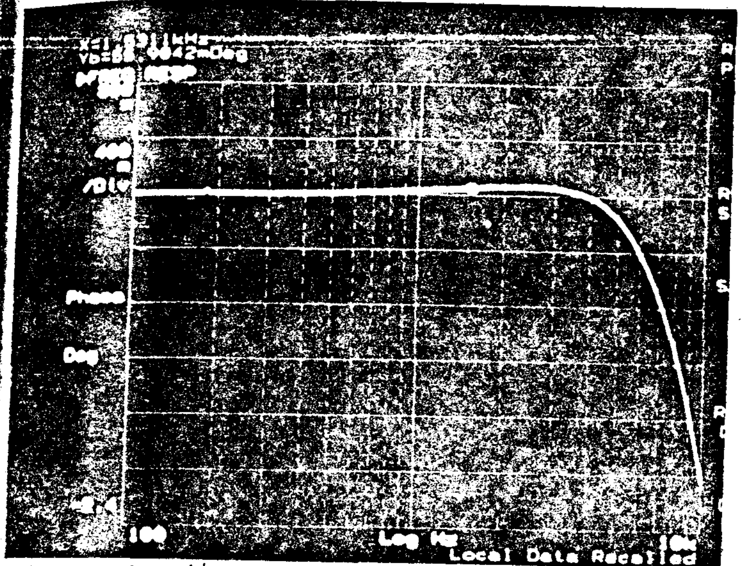
TEST SET UP

	INDICATED INDUCTANCE		50% PULSE WIDTH		INDUCTANCE	
	0	μHY	10	ns	<.7	μHY
	2	"	46	"	3.3	"
	4	"	86	"	6.2	"
	6	"	112	"	8.1	"
	8	"	160	"	11.5	"
VERNIER	10	"	180	"	13.0	"
	12	"	220	"	15.9	"
	14	"	250	"	18.0	"
	16	"	270	"	19.5	"
	18	"	290	"	20.9	"
	20	"	315	"	22.7	"
	22	"	350	"	25.2	"
	20	"	330	"	23.8	"
	40	"	660	"	47.6	"
	60	"	960	"	69.2	"
	80	"	1240	"	89.4	"
	100	"	1520	"	110.0	"
	120	"	1840	"	133.0	"
	140	"	2150	"	155.0	"
COARSE	160	"	2450	"	177.0	"
	180	"	2700	"	195.0	"
	200	"	3000	"	216.0	"
	220	"	3250	"	234.0	"

INDUCTANCE BOX TEST

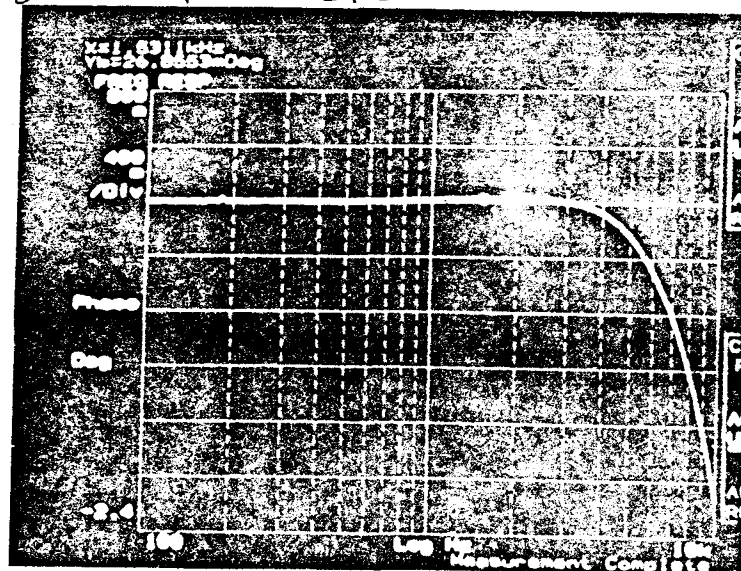
9-MAY-89

9-MAY-89 9:20



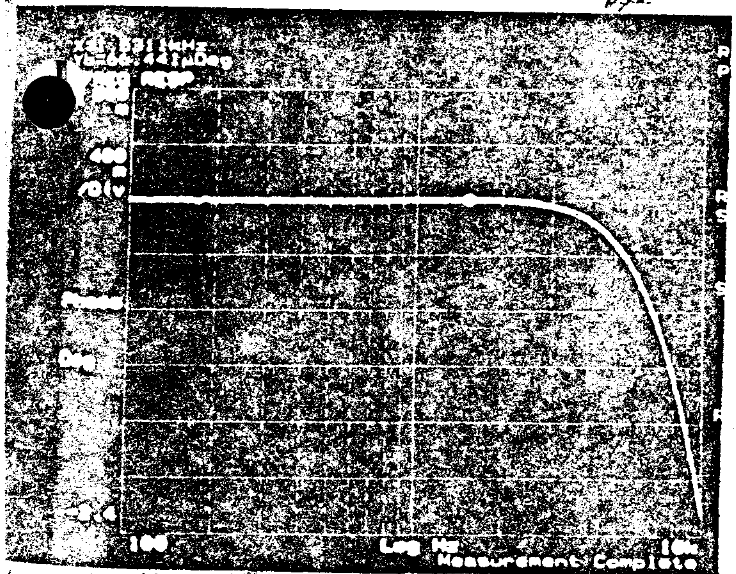
L = 52 μH

9-MAY-89 9:25



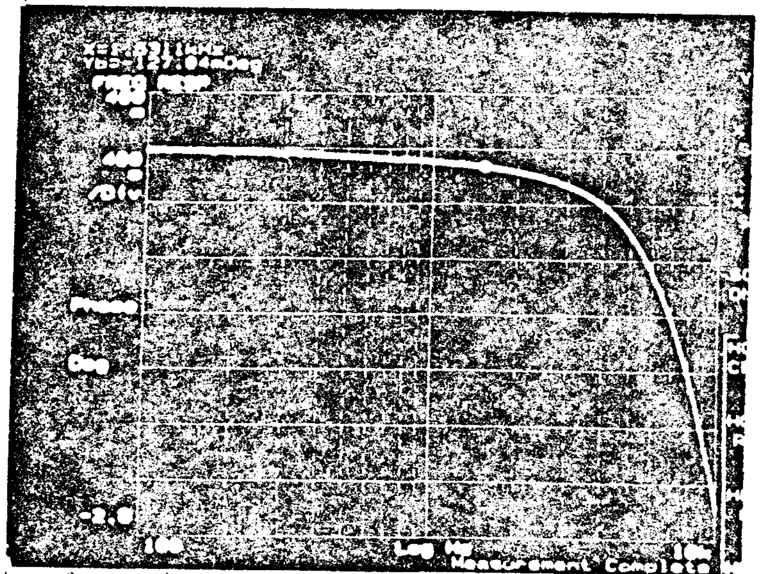
L = 54 μH

9-MAY-89 9:35



L = 56 μH

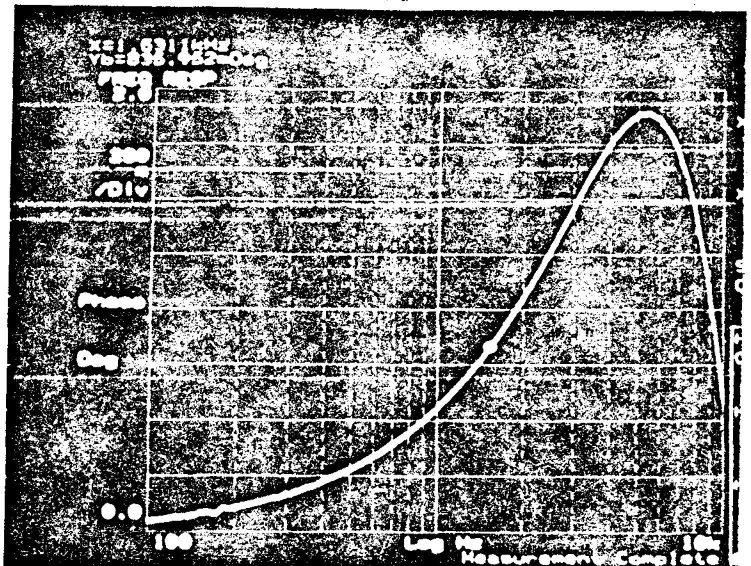
9-MAY-89 9:00



L = 60 μH

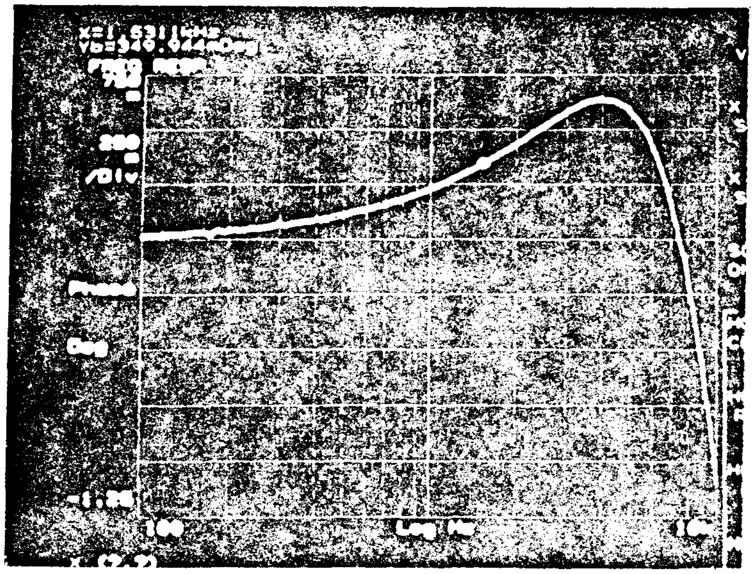
Using the new adjustable inductor in series w. Louie coils (instead of the fixed 80 μH one), phase matching of currents in the two coils for Huey, Louie respectively, was checked w. the set-up on p. 74. Results are shown in order of increasing L. Best matching: L = 56 μH → if the resulting 66 μdeg were the only limit, a foil subtraction of ~ 10^5 would be possible. Of course, at this level differences in the mass/pendulum (etc) response become the real limits.

9-MAY-89 8:50



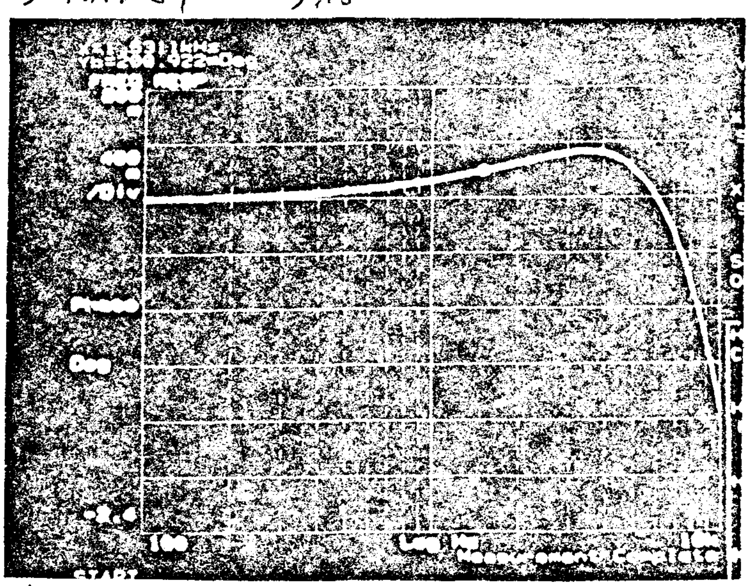
L = 0 μH

9-MAY-89 8:45

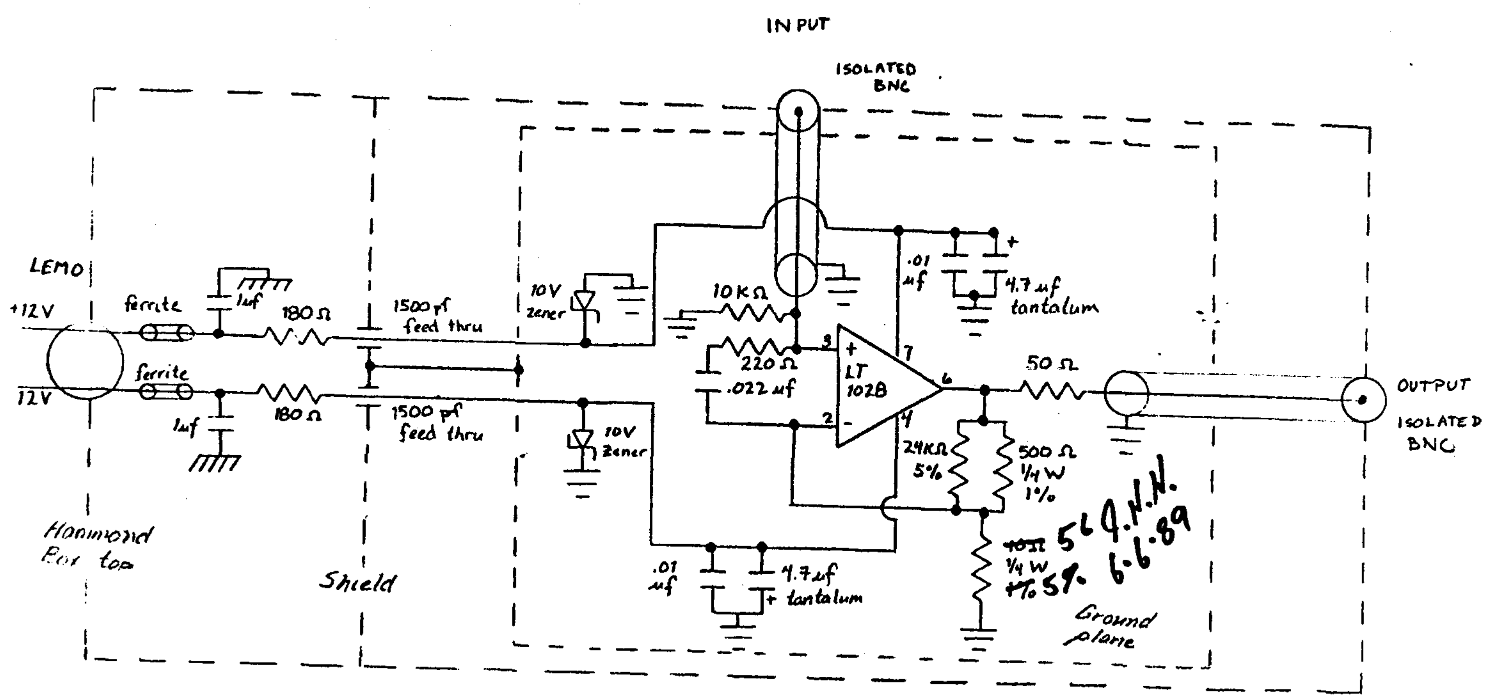


L = 34 μH

9-MAY-89 9:15



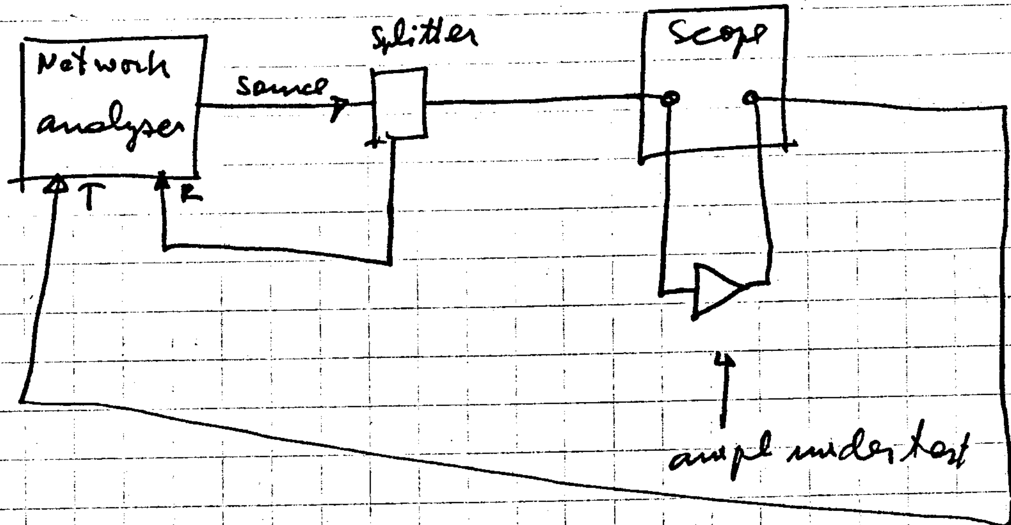
L = 40 μH



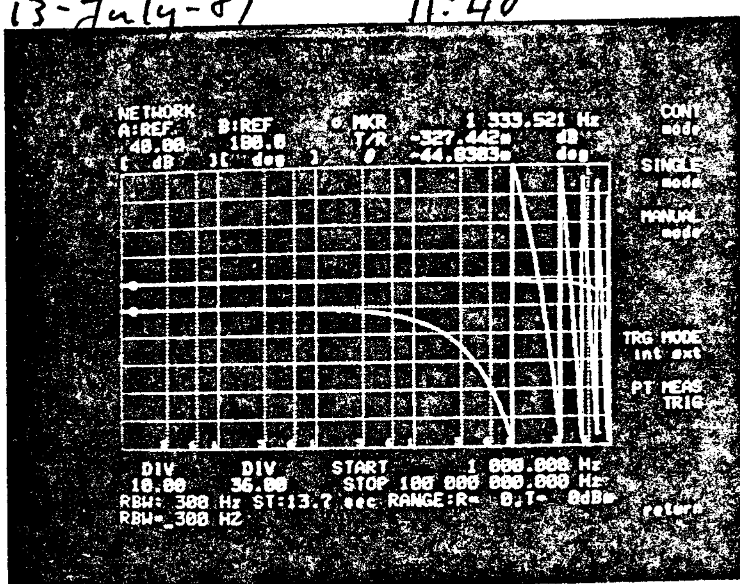
LOW NOISE BUFFER

8-21-87

Since ~30' of cables were used to connect the amplifier under test (see diagram below), we took the response of the cables themselves (trace at 11:40)



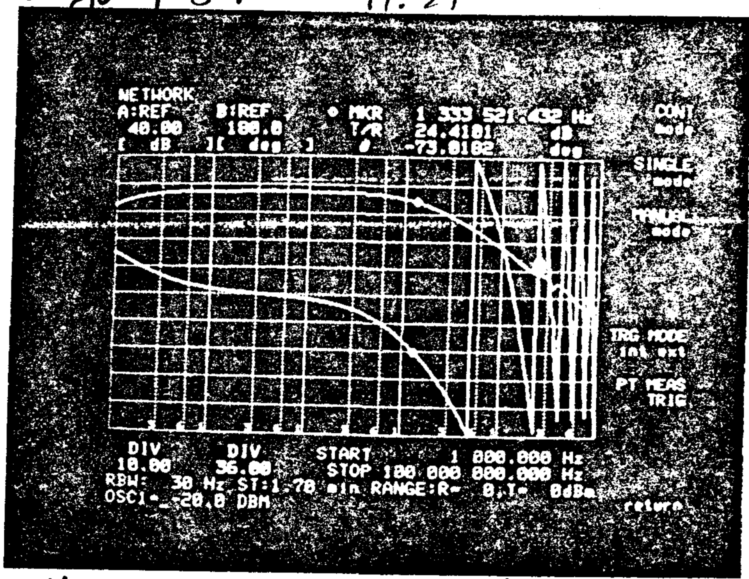
13-July-89 11:40



TR. FUNCTION OF CABLES – they are badly imbalanced

- It turns out that at 250 kHz the cables alone show a phase shift of 5°.
- Therefore, the ~3' cable from splitter to R input was replaced with a long cable, matched to the one in the test path. See traces overleaf

13-July-89 11:21



AXES: 100 MHz 40 dB

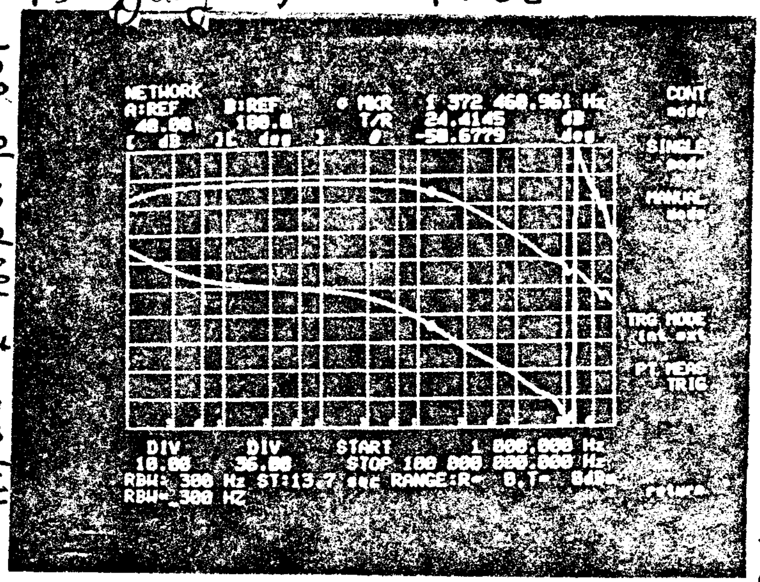
50K 713

← unmatched cables

50K 50Ω in and out

13-July 89 12:02

10° phase shift at 230 KHz



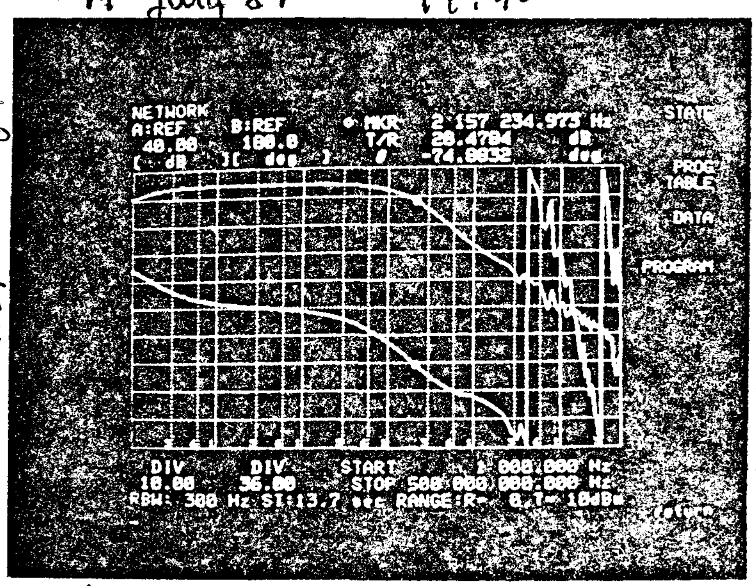
~~50K in and out~~ 50K 713

← matched cables

50K 50Ω in and out

14-July 89 17:40

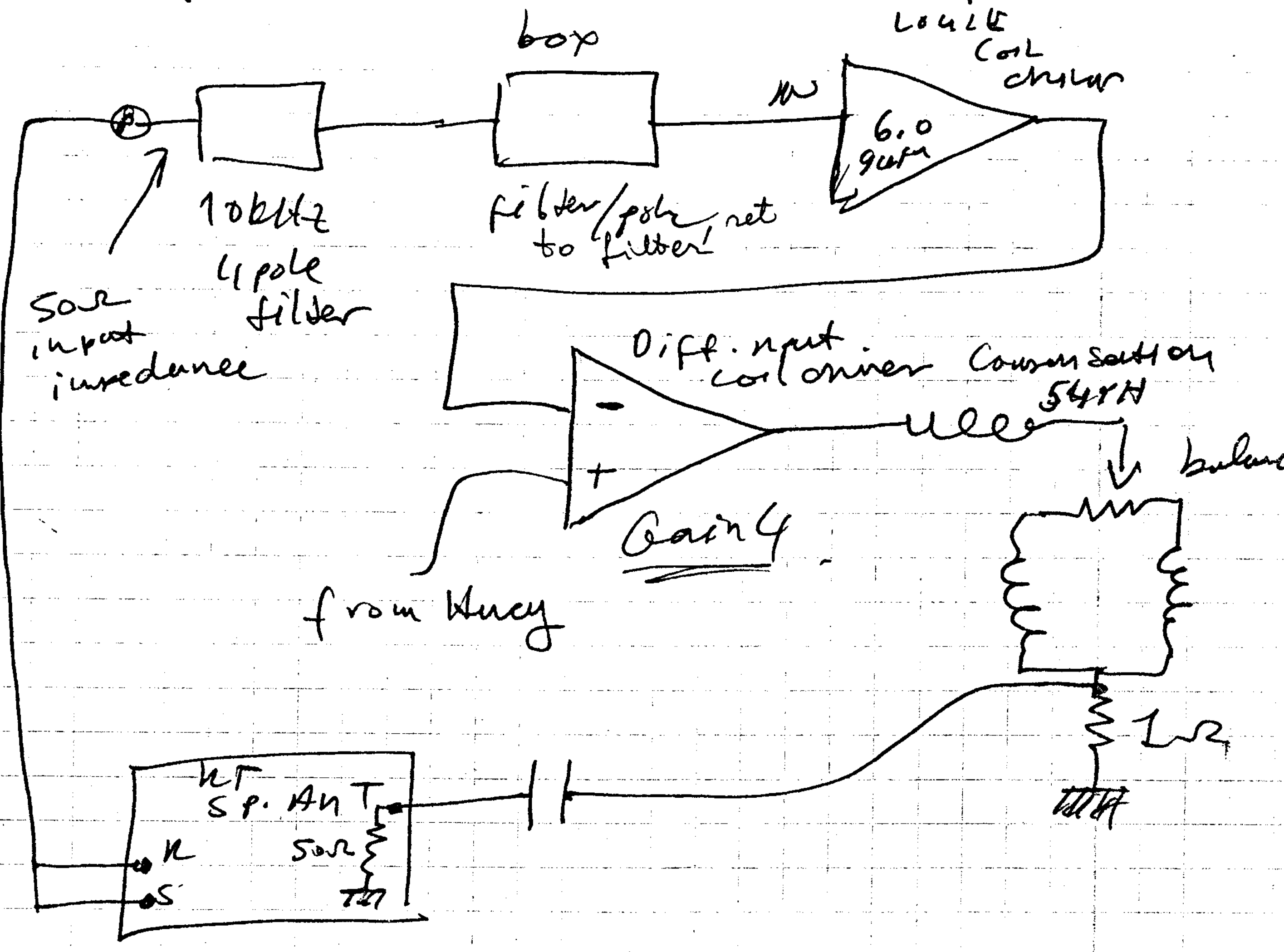
10°: 203 KHz



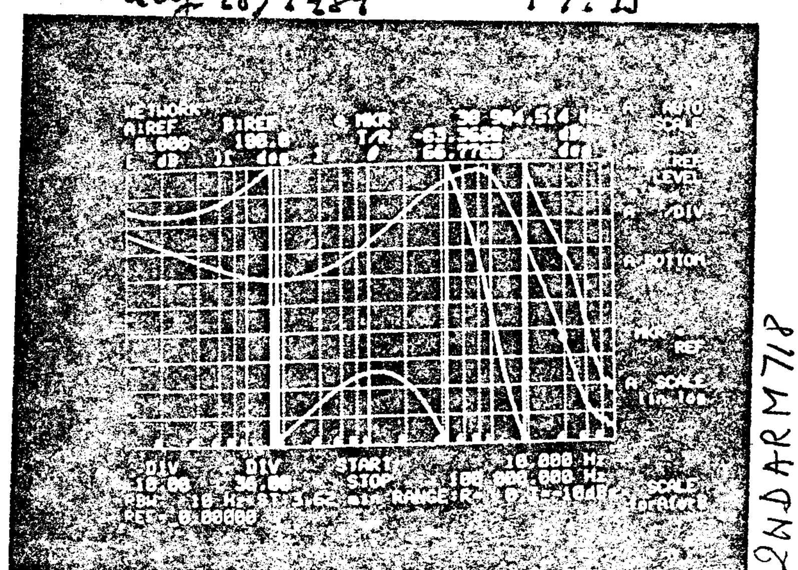
50K 713

50K 50 Ωin ~~and~~ out

Second arm chain transfer functions



July 18, 1989 17:15

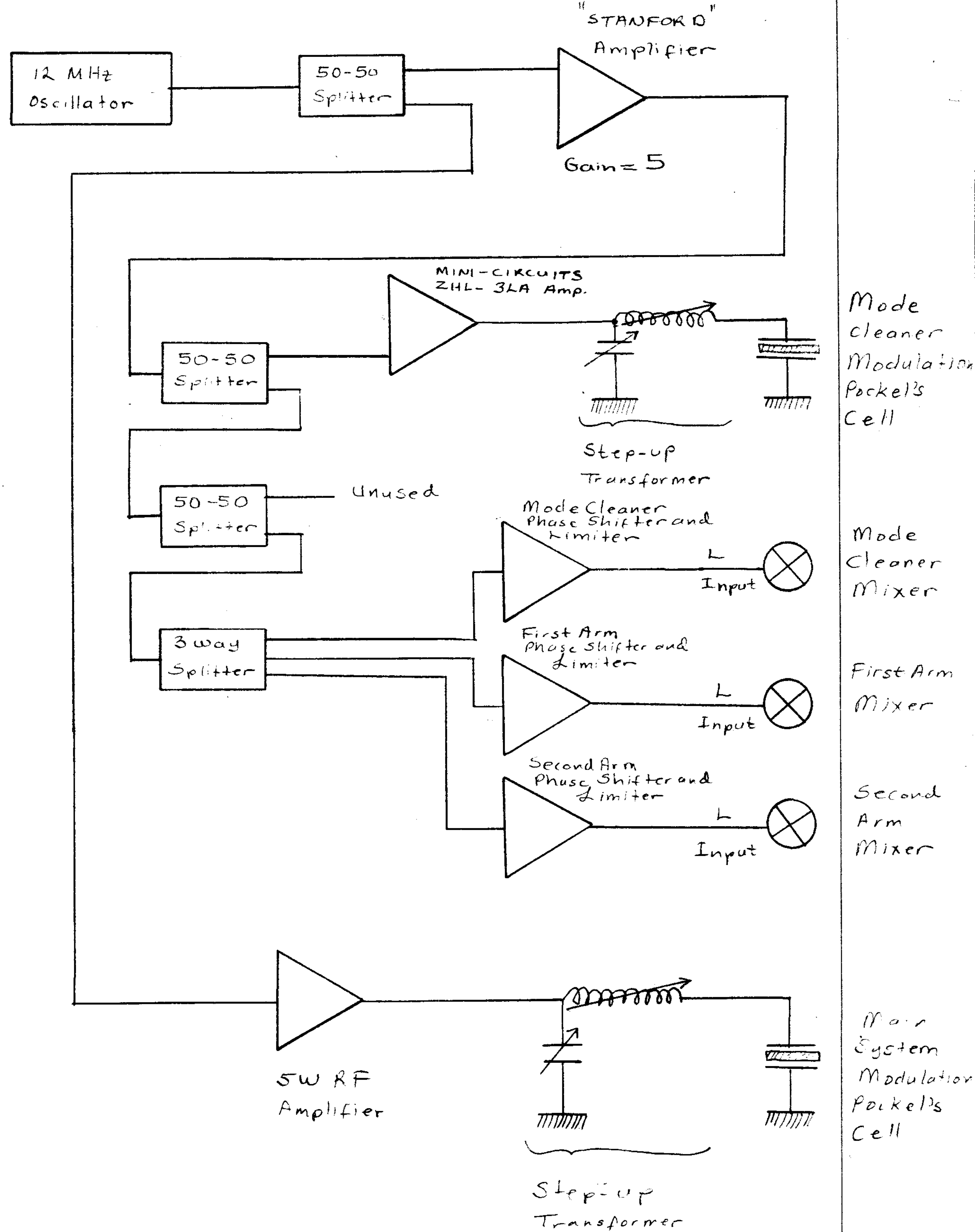


second arm chain transfer function

BATCH START

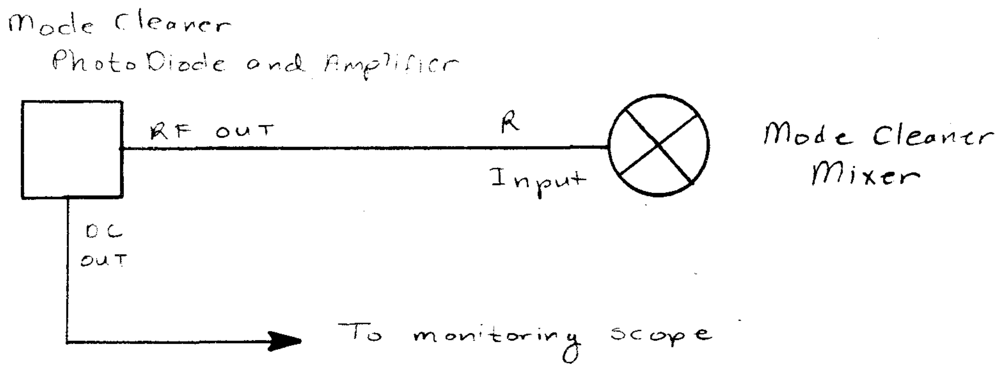
STAPLE
OR
DIVIDER

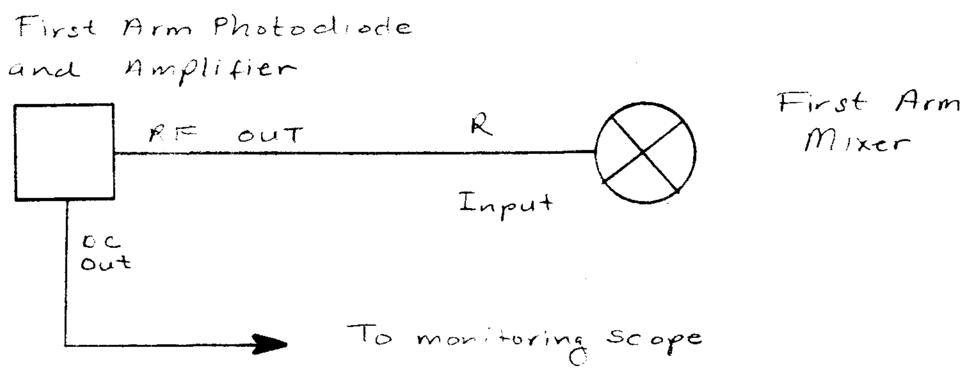
12 MHz RF distribution for Modulation:

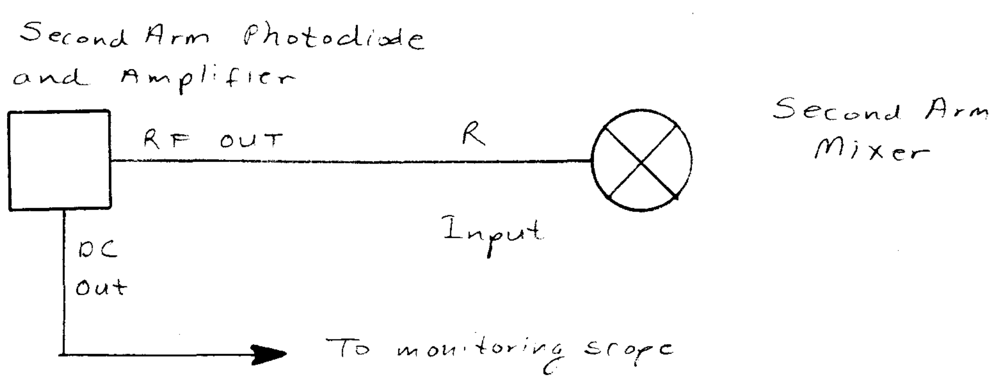


July 24, 1989
YG

Photo Detector Electrical Wiring Diagram:



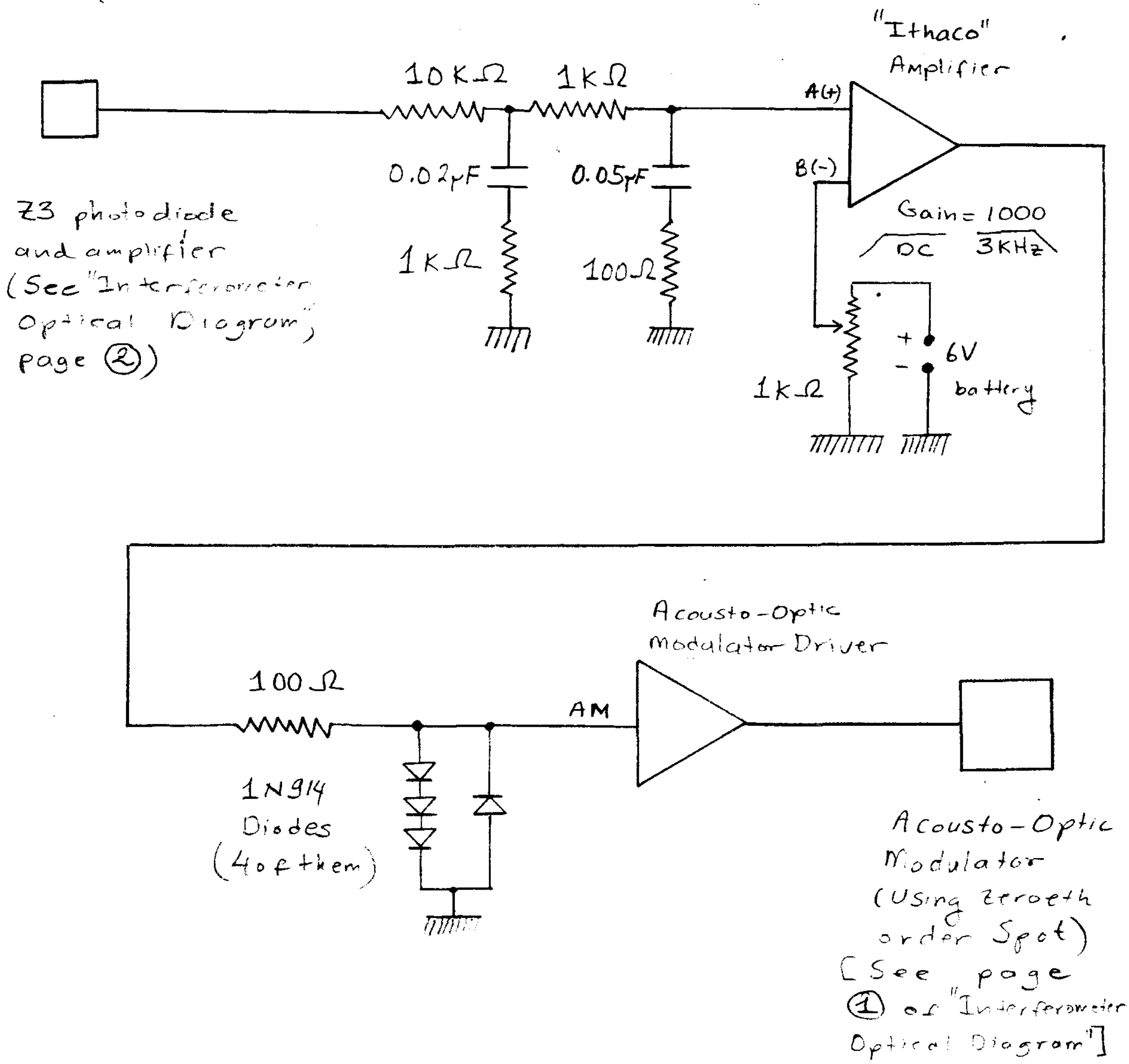




July 24, 1989

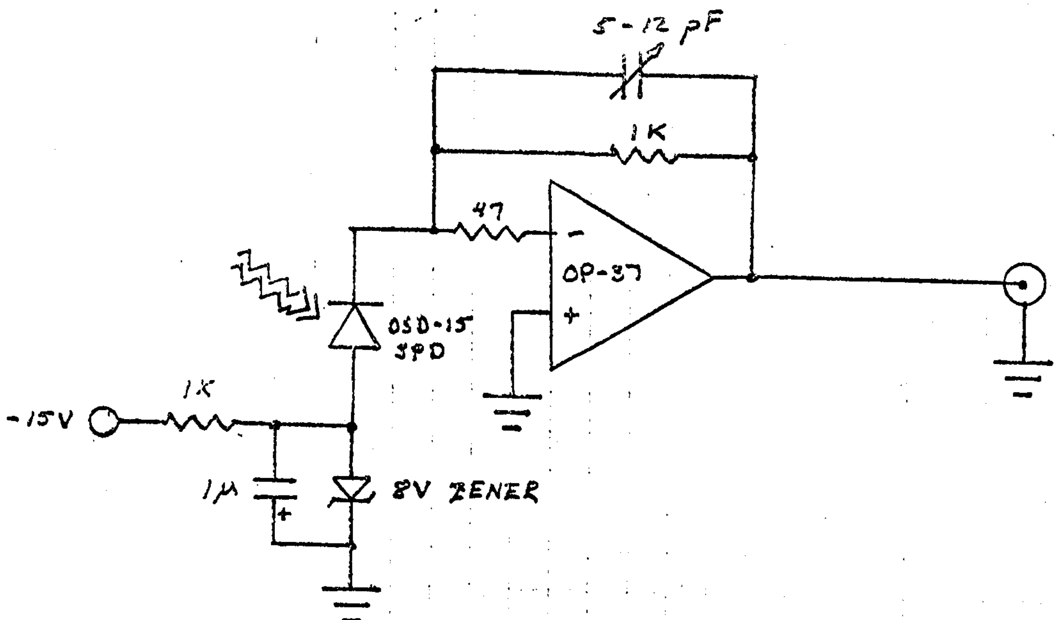
Intensity Stabilizing Servo

(The Noise Eater)



July 25, 1989 YG

NOISE EATER SENSING DIODE 2/27/85 MEZ



0.33 V/mW

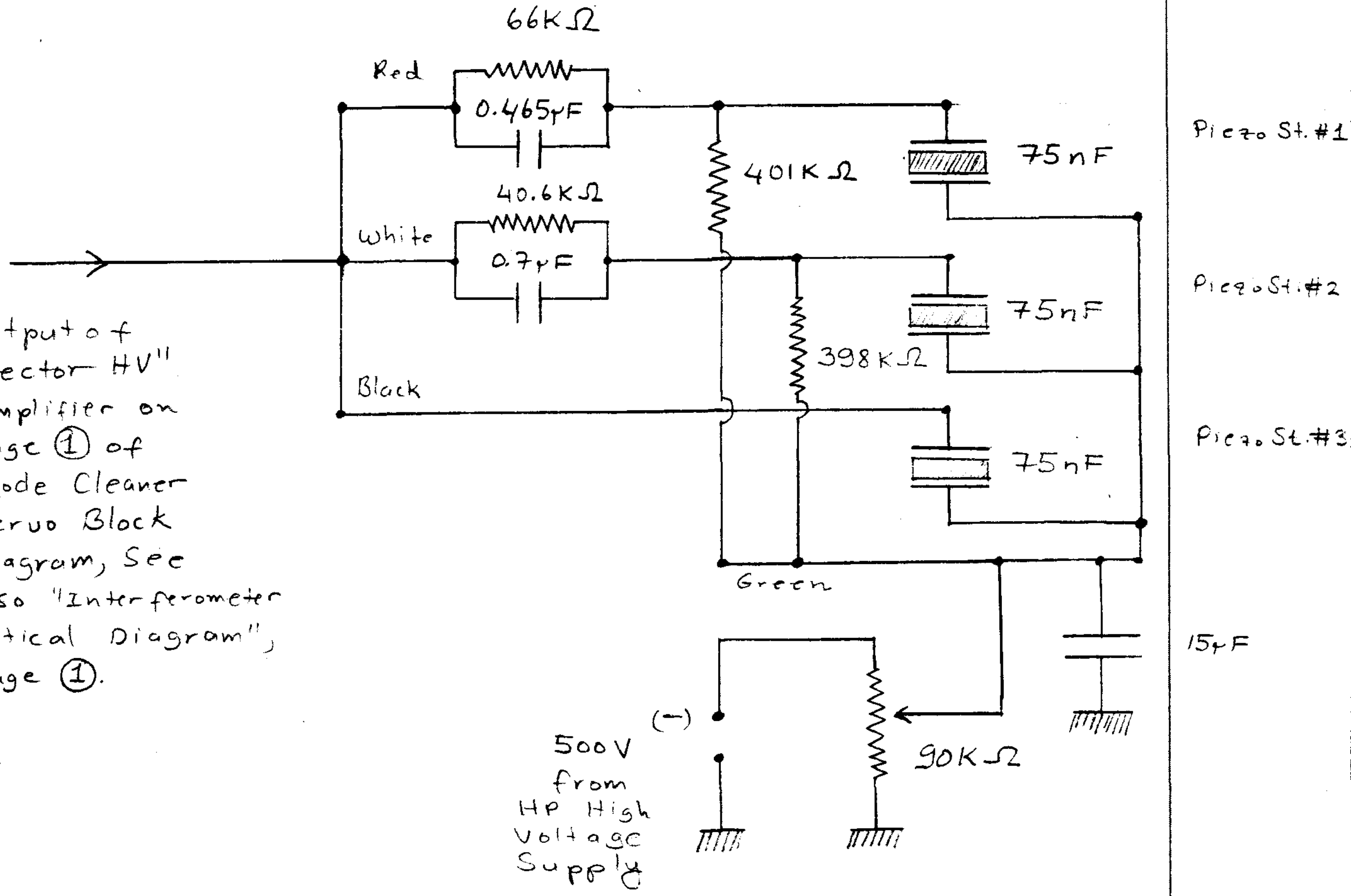
DARK NOISE ≃ 5 nV/√Hz (TYP.)

Photodiode Amplifier

(See "The intensity Stabilizing Servo" and the "Interferometer Optical Diagrams")

3 Piezo Stack Balancing Network

(For the Laser "BARNEY")

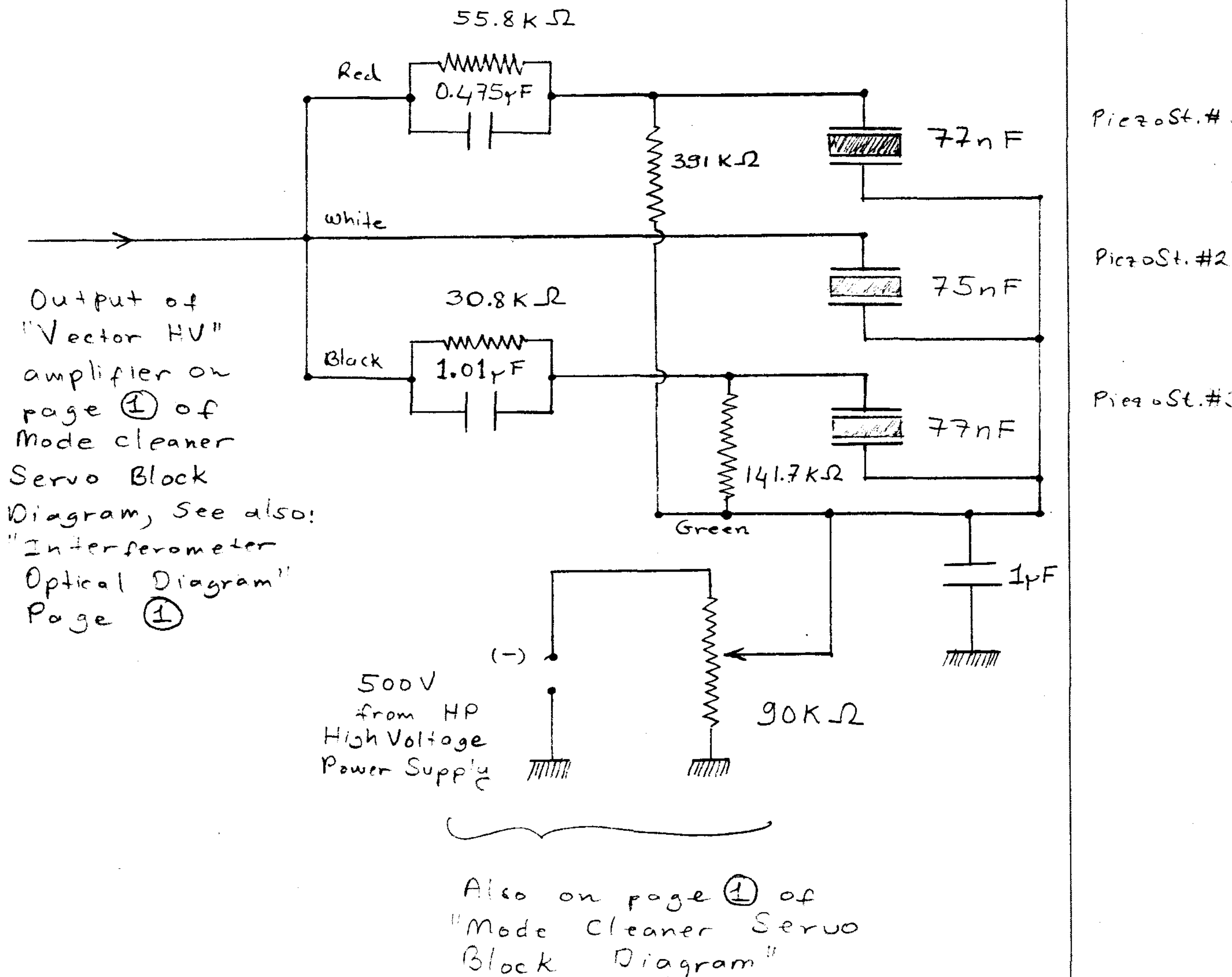


Output of "Vector HV" Amplifier on page ① of Mode Cleaner Servo Block Diagram, See also "Interferometer Optical Diagram", page ①.

Also on page ① of "Mode cleaner servo Block Diagram".

July 25, 1989 YG

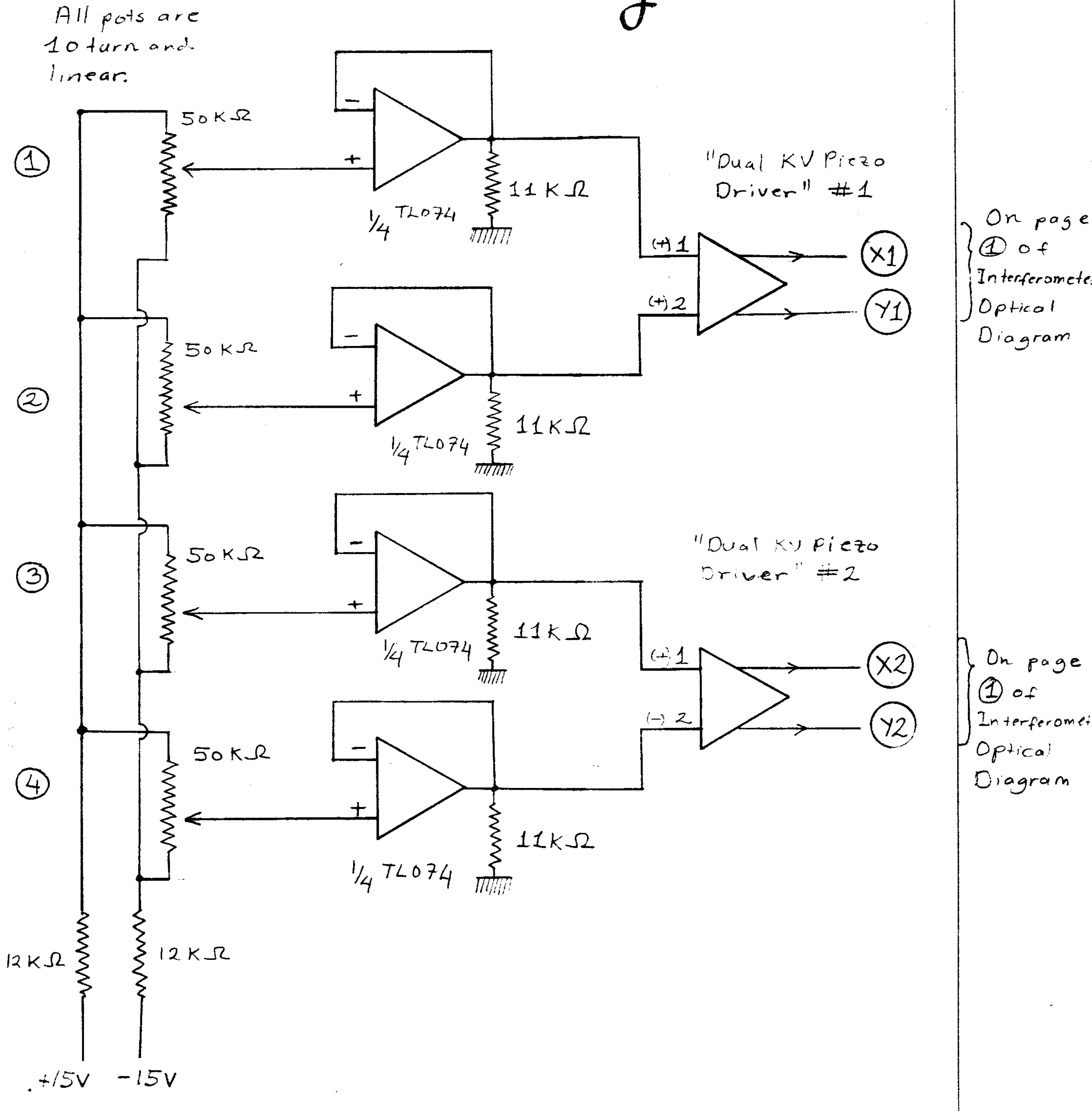
3 Piezo Stack Balancing Network (For the laser "FRED")



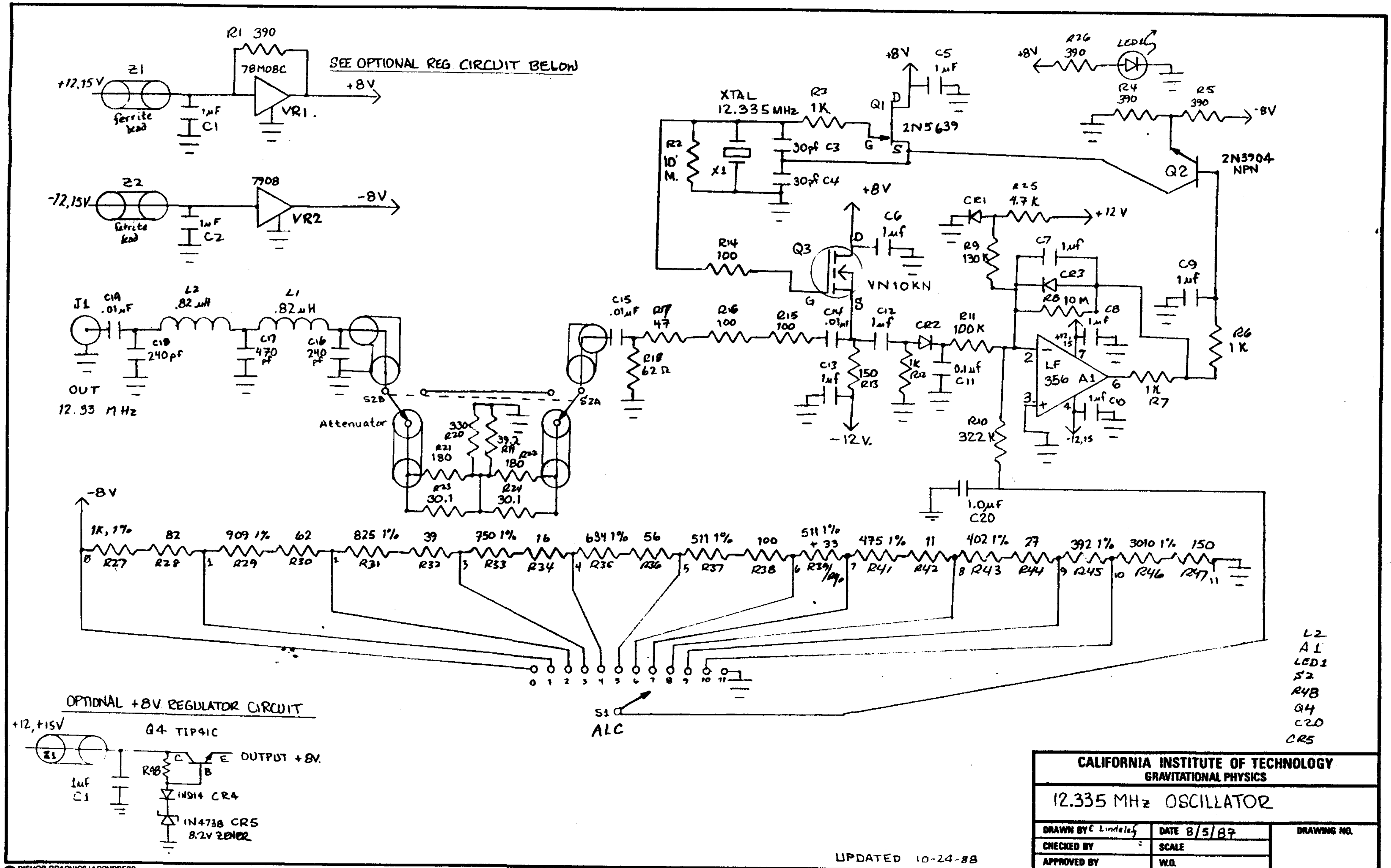
Page ① of ①

July 25, 1989 YG

Mode Cleaner Alignment Fine Tuning

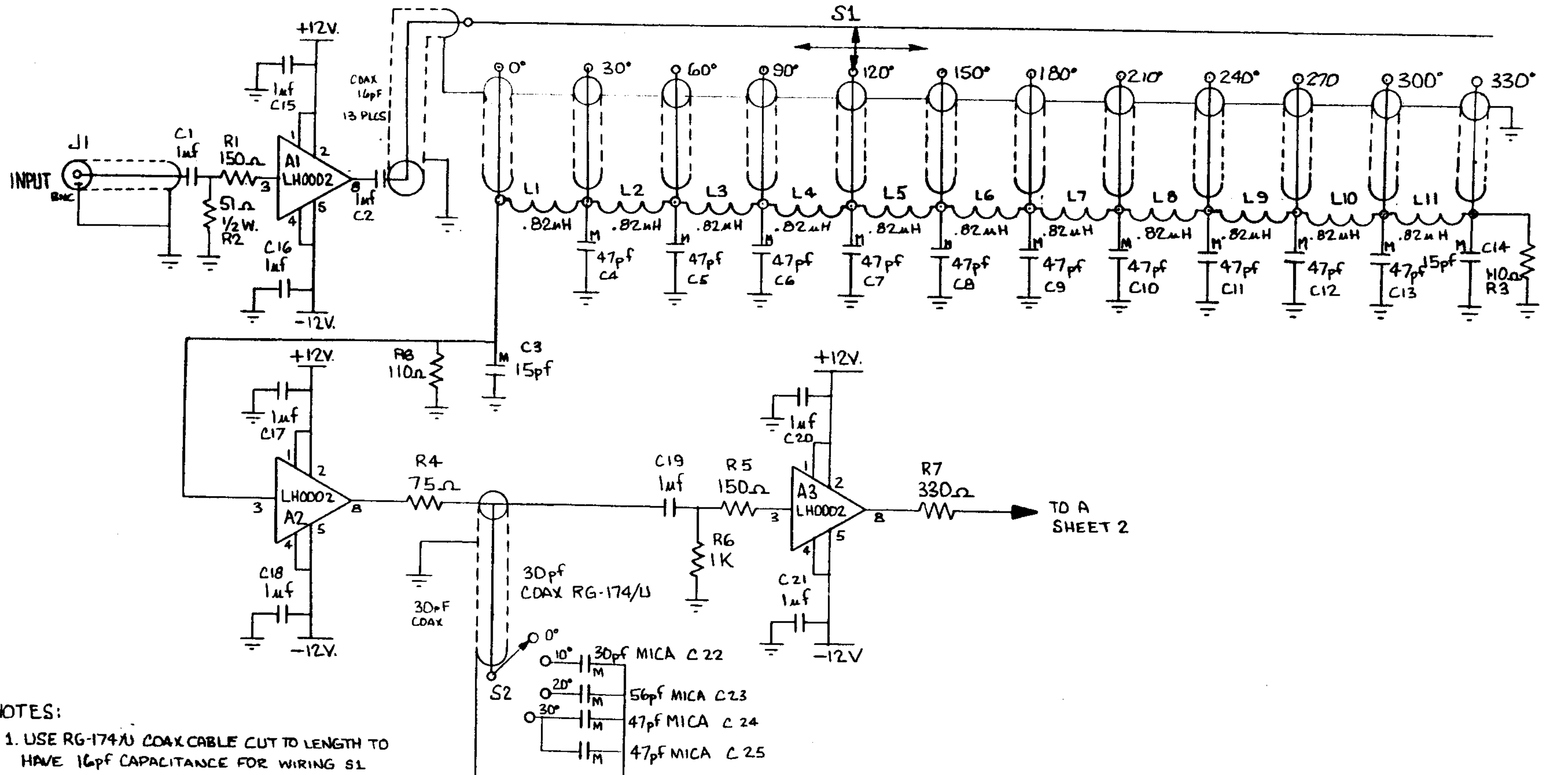


July 25, 1989



R1 390
78M08C
SEE OPTIONAL REG CIRCUIT BELOW
+12,15 V
Z1
ferrite bead
1μF C1
VR1
+8V
-12,15V
Z2
7908
-8V
1μF C2
VR2
XTAL 12.335 MHz
R3 1K
Q1
2N5639
+8V
C5 1μF
R2 10 M.
X1
30pf C3
30pf C4
+8V
R26 390
LED1
R4 390
R5 390
-8V
2N3904 NPN
Q2
R14 100
Q3
C6 1μf
VN10KN
CR1
R25 4.7 K
+12 V
R9 130K
C7 1μf
CR3
R8 10 M
C9 1μf
J1
C19 .01μF
L2 .82 μH
L1 .82 μH
C18 240pf
C17 470 pf
C16 240 pf
OUT 12.33 MHz
S2B
S2A
Attenuator
C15 .01μF
R17 47
R16 100
R15 100
C14 .01μf
C12 1μf
CR2
R11 100K
C8 1μf
R18 62 Ω
C13 1μf
150 R13
1K R12
0.1μf C11
LF 356 A1
R6 1K
1K R7
C10 1μf
-12V.
R10 322 K
330 R20
R21 180
39.2 R19
R22 180
R23 30.1
R24 30.1
1.0μF C20
-8V
1K, 1% R27
82 R28
909 1% R29
62 R30
825 1% R31
39 R32
750 1% R33
16 R34
634 1% R35
56 R36
511 1% R37
100 R38
511 1% + 33 R39/1%
475 1% R41
11 R42
402 1% R43
27 R44
392 1% R45
3010 1% R46
150 R47
0 1 2 3 4 5 6 7 8 9 10 11
S1
ALC
OPTIONAL +8V REGULATOR CIRCUIT
+12, +15V
Z1
1uf C1
Q4 TIP41C
R48
OUTPUT +8V.
1N914 CR4
1N4738 CR5 8.2V ZENER
L2
A1
LED1
S2
R48
Q4
C20
CR5
UPDATED 10-24-88
CALIFORNIA INSTITUTE OF TECHNOLOGY
GRAVITATIONAL PHYSICS
12.335 MHz OSCILLATOR
DRAWN BY E Lindelef
DATE 8/5/87
CHECKED BY
SCALE
APPROVED BY
W.O.
DRAWING NO.

87-0805-1

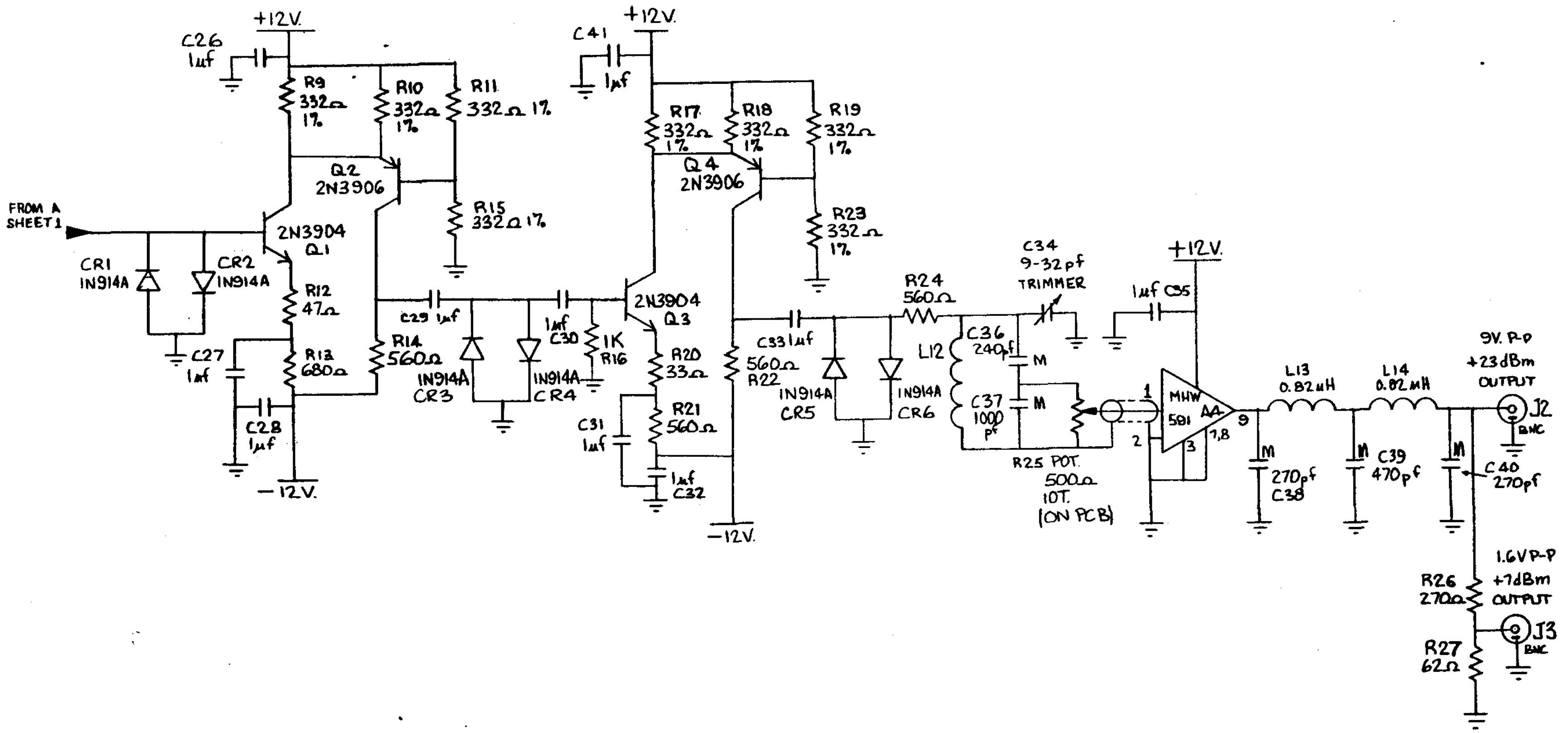


NOTES:

1. USE RG-174/U COAX CABLE CUT TO LENGTH TO HAVE 16pf CAPACITANCE FOR WIRING S1 FROM TERMINALS TO IND. 0.82uH
2. COAX FROM 75Ω/1uf NODE (OUTPUT OF A2) TO S2 WILL BE CUT TO A LENGTH TO HAVE A 30pf CAPACITANCE. DRESS COAX AWAY FROM COMPONENTS ON P.C.B.
3. GND ALL COAX FROM ISO-BNC ON FRONT PANEL TO P.C. CARD GND. PLANE.

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
12.33 MHZ. LIMITER PHASE SHIFTER SHEET 1		
DRAWN BY B.T.	DATE 11-6-87	DRAWING NO.
CHECKED BY	SCALE NONE	-1
APPROVED BY	W.O.	

87-1106-1



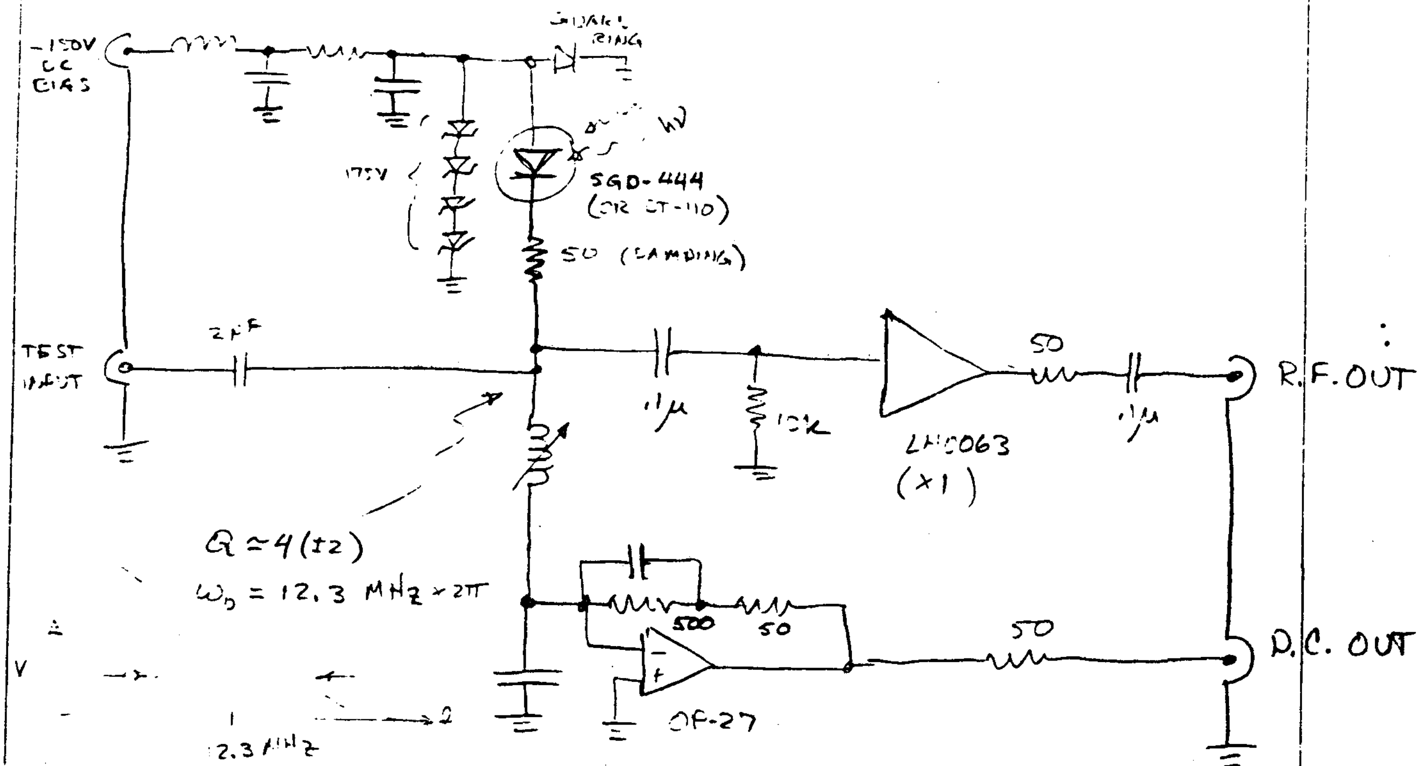
A4
Q4
J3
L14
CR6
C40
LAST NO. USED R27

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
12.33 MHZ. LIMITER PHASE SHIFTER SHEET 2		
DRAWN BY B.T.	DATE 11-6-87	DRAWING NO. -2
CHECKED BY	SCALE	
APPROVED BY	W.O.	

87-1106-2

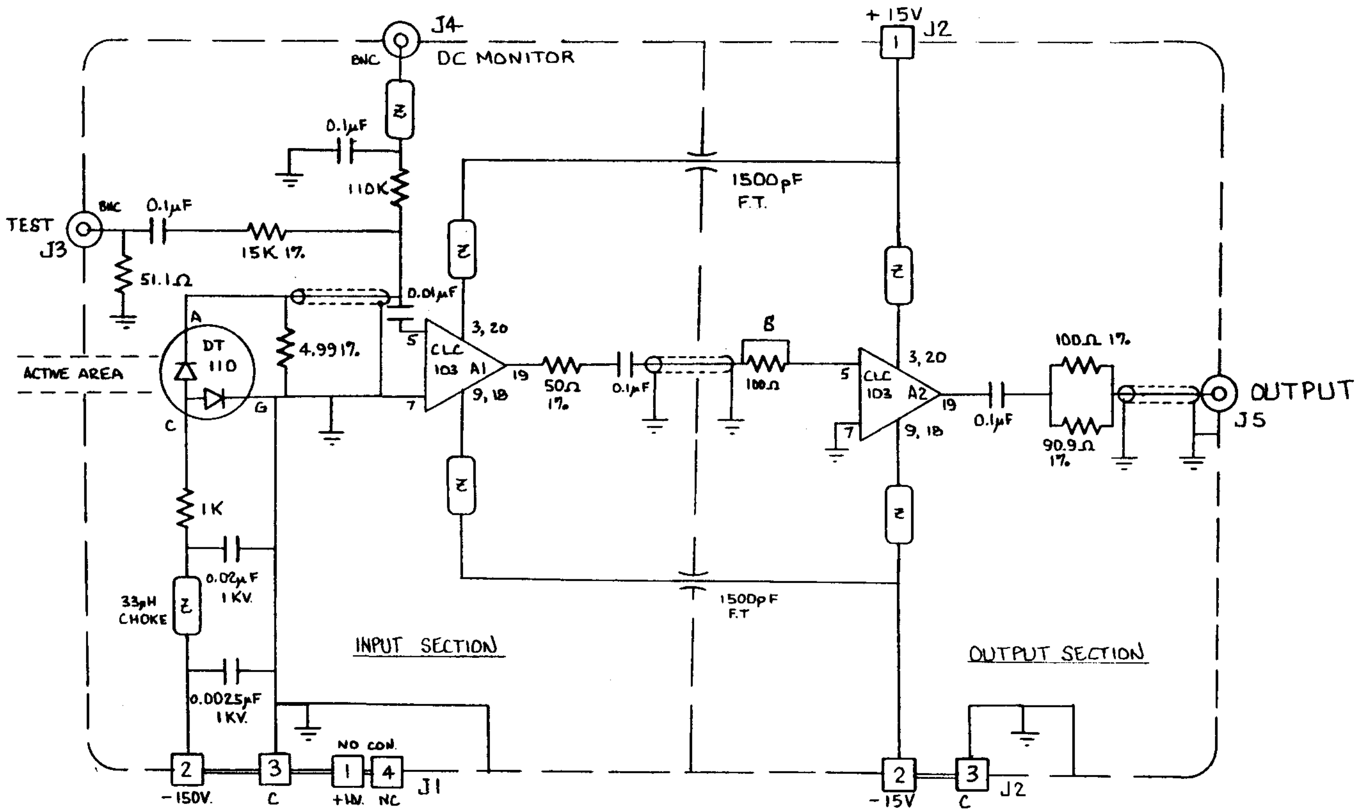
11/14/88 MEZ

MODE CLEANER SERVO PHOTODIODE / BUFFER
(STANDARD CALTECH FRONT END)



R.F. DARK NOISE ≃ SHOT NOISE AT 1 mW, 5145 Å

The First and The Second Arm Photodiodes are the same as this one. YG. July 25, 1989



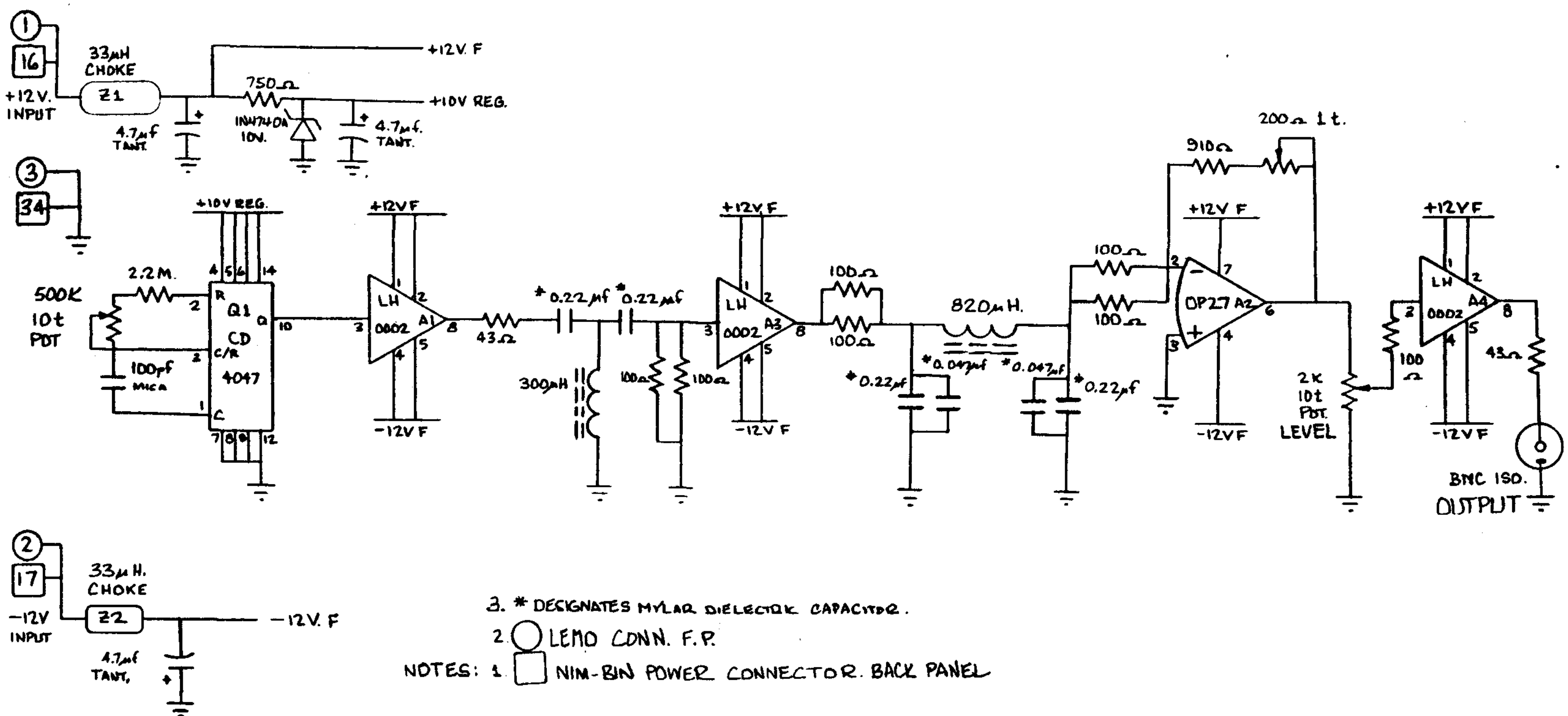
NOTE 1. COMPONENTS MARKED "Z" ARE 33μH. CHOKES.
2. RESISTORS ¼W 5% UNLESS MARKED.
3. J1 IS 4-PIN LEMO.
4. J2 IS 3-PIN LEMO

FAST PHOTODIODE AMP. 3/29/88

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
FAST PHOTODIODE AMPLIFIER SHT. 1		
DRAWN BY B.T.	DATE 3/29/88	DRAWING NO.
CHECKED BY	SCALE	-1
APPROVED BY	W.O.	

BISHOP GRAPHICS/ACCUPRESS
REORDER NO. A38381

88-0329-1



3. * DESIGNATES MYLAR DIELECTRIC CAPACITOR.

2. ◯ LEMO CONN. F.P.

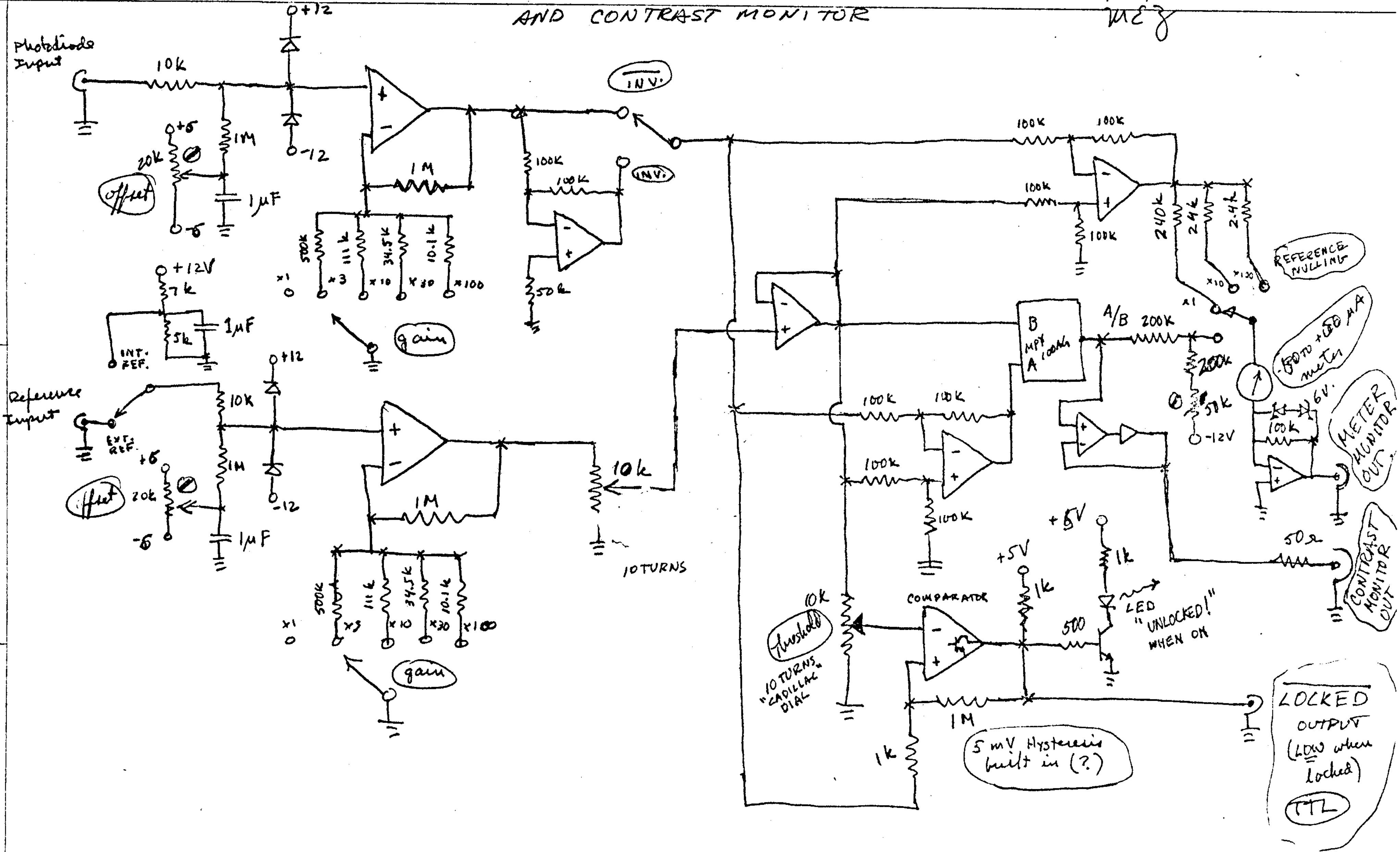
NOTES: 1. ☐ NIM-BIN POWER CONNECTOR. BACK PANEL

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS	
COMB CALIBRATOR	
DRAWN BY B.T.	DATE 9-24-87
CHECKED BY	SCALE
APPROVED BY	W.O.
DRAWING NO.	-1

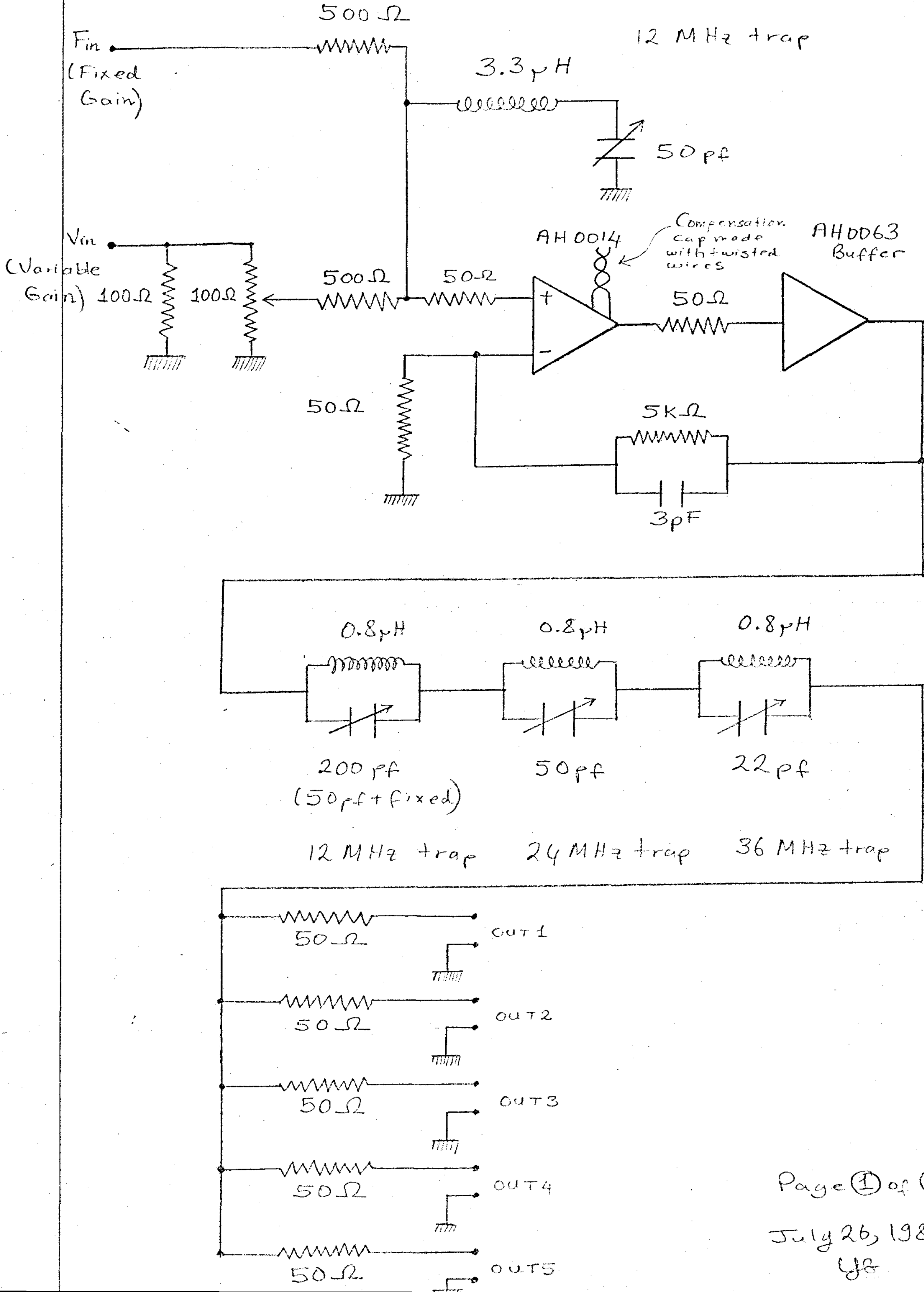
87-0924-1

LOCKUP DISCRIMINATOR
AND CONTRAST MONITOR

7/17/86
MEZ



"Fast 1" Amplifier

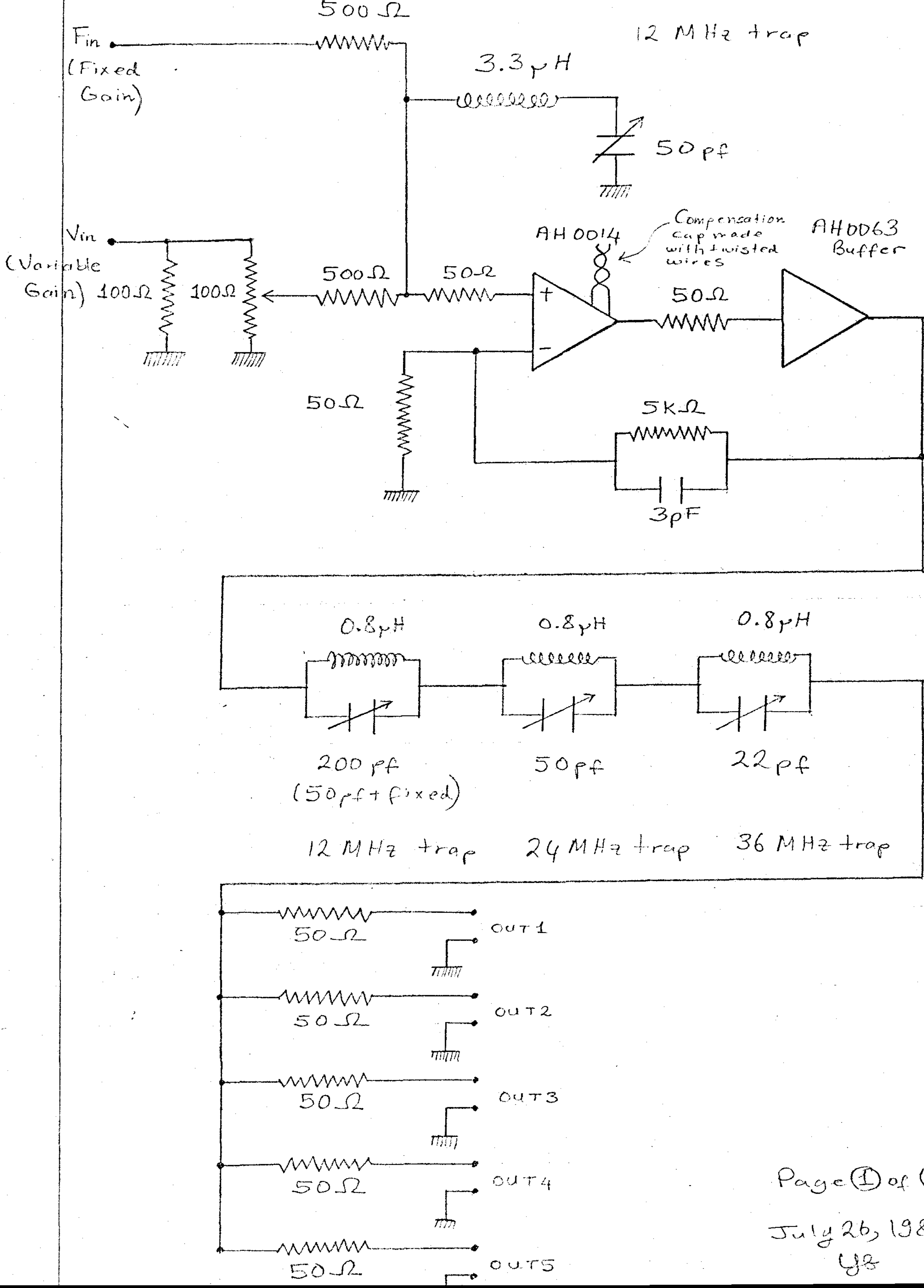


Page ① of ①.

July 26, 1989

YG

"Fast 1" Amplifier



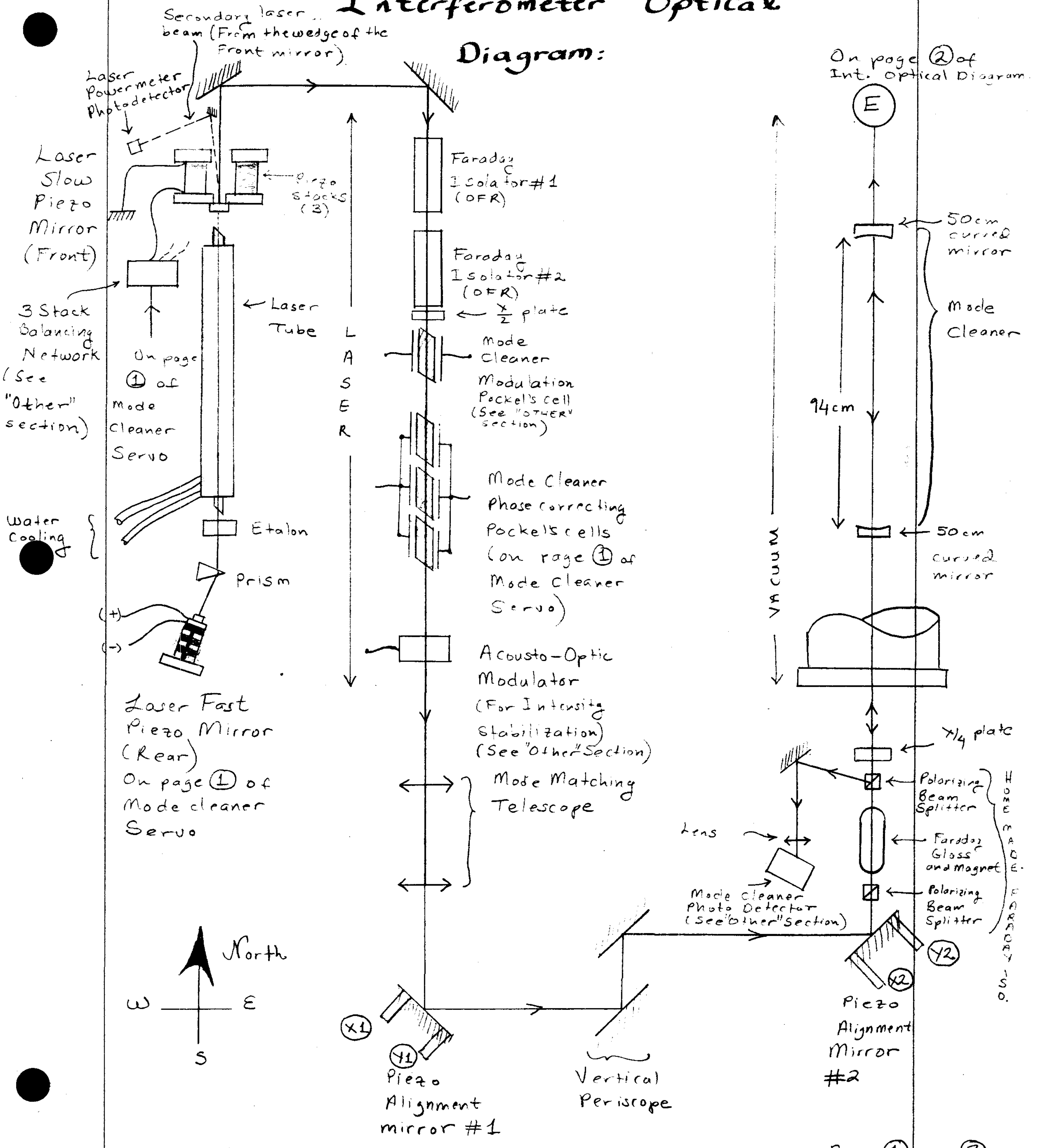
Page 1 of 1.

July 26, 1989
YB

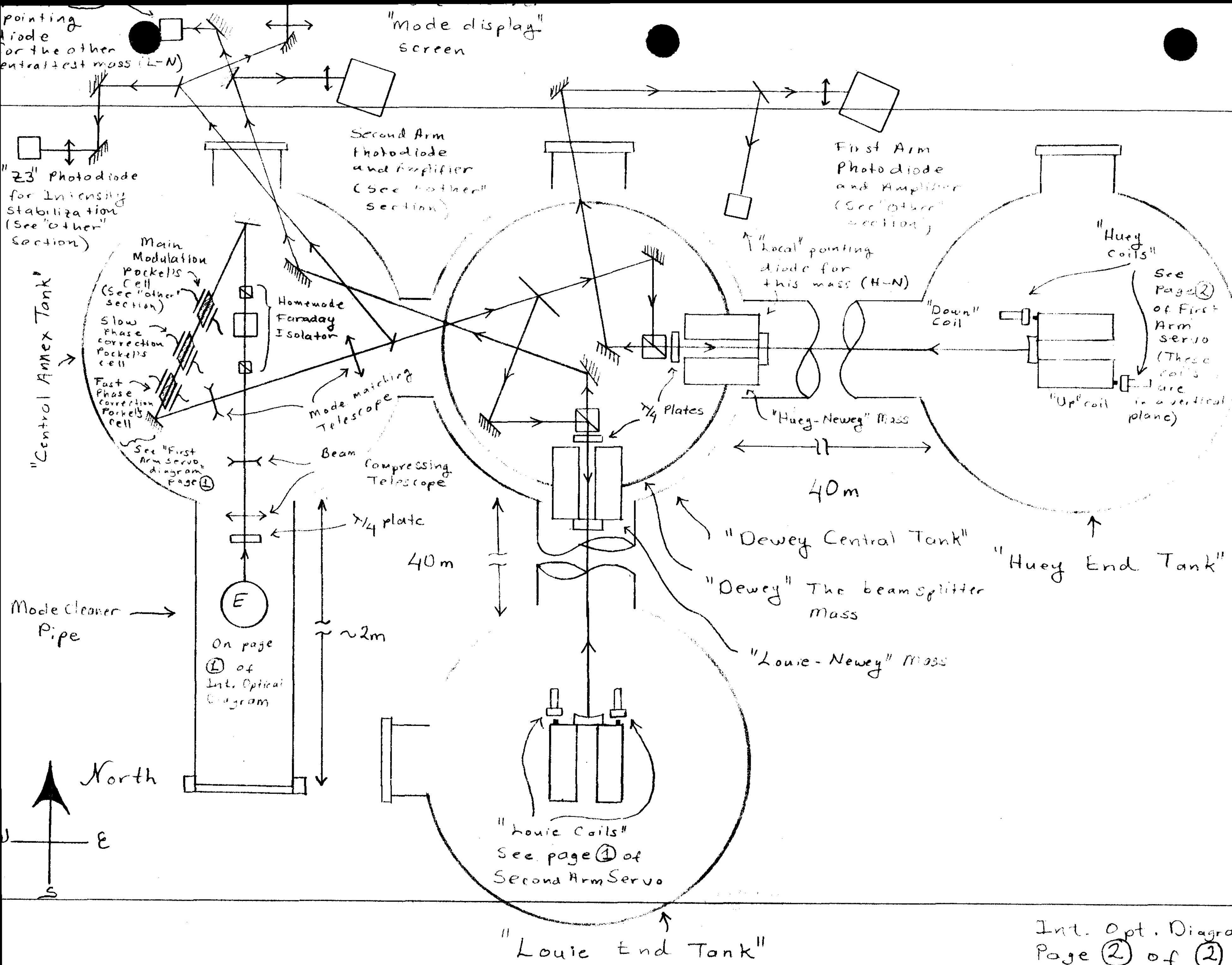
BATCH START

STAPLE
OR
DIVIDER

Interferometer Optical Diagram:



July 24, 1989 YG



Int. Opt. Diagram
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