

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY  
- LIGO -

CALIFORNIA INSTITUTE OF TECHNOLOGY  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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<h2>Drop Test - COC Carrier and Shipping Case</h2>
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*Distribution of this draft:*

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of the LIGO Project..

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# 1 ABSTRACT

The drop test of the shipping case containing the COC carrier and dummy optic was performed at National Technical Systems in Fullerton, CA on 8/30/96. The dummy optic, secured within the COC carrier, was made of aluminum, and exactly the size and shape of a large LIGO optic, but with 27% more mass.

The case was dropped in ten different orientations from a height of 36" onto a concrete floor. The setup consisted of a hinged platform with a stretched bunji cord attached for quick separation from the case at drop-time, a mounted triaxial accelerometer (accel), and electronic monitoring equipment including two oscilloscopes.

The test revealed inadequacy of the shipping case, with the current foam insert design, to shield the carrier from the resulting shock forces. The carrier experienced shock forces of up to approximately 200g. It appears likely that a greater thickness of foam (as well as a larger case) will be deemed necessary. Stress analysis of the COC carrier standoffs will determine whether the standoffs should be thickened and provided with threaded inserts.

# 2 PROCEDURE RECAP

(See attached NTS Log Sheet, graphs, sketches and photos)

The accel was initially mounted with dental cement to the side of the dummy optic, approximately centered between its top and bottom, with axes oriented as sketched. After a couple of drops to get the 'feel' and adjust equipment settings, the setup was seen to provide very good control of the drop orientation with no interference from the platform owing to the pre-loaded bunji cord. The drops were executed with good results until the 7th drop, at which time the case and carrier were opened revealing damage to the carrier including completely stripped threads in the mounting screw holes of the hinged standoff, looseness of the other two standoffs at the base, bending of the top plate hold-down screws and locating pins, fracturing of the L-section teflon base pad at the hinged standoff, buckling of the top face of the cover and a sheared mounting screw to the left handle plate. The accel was broken free from the optic and had left an imprint in the side of the cover. After re-mounting the accel to the cover as sketched with the original axes orientations, the test was resumed with the optic in its non-secure condition in the damaged carrier. The accel was broken loose again on the 8th drop, and re-mounted in approximately the same location for the 9th and 10th drops. The final three drops yielded questionable output results (see table below). Through the course of the test, the case incurred mainly cosmetic damage, and was not rendered unusable.

NOTE: The worst case drop (with this test's carrier/case orientation) would presumably be a front side drop, in which the weaker mounted hinged standoff would take the full impact of the optic. This drop was not executed in this test

## APPENDIX 1 PEAK ACCELERATION VALUES

Table 1:

Drop #	Orientation	Peak Acceleration (G)		
		$X_p$	$Y_p$	$Z_p$
1	bottom	-72	-2	-2
2	side, hinge	-78/97	193/-80	106/-115
3	left side, handle	-49/15	-15/8	-75/0
4	bottom left edge	80/-70	197/168	67/-118
5	top left edge	-95/29	-67/67	-50/35
6	top side edge (hinge)	21/3	40/-3	4/-1
7	bottom side edge (latch)	-82/15	-71/49	-27/53
8 <sup>a</sup>	top left corner (latch)	-110/80	-70/55	-112/128
9 <sup>a</sup>	bottom left corner (latch)	-175/74	197/-60	164/-119
10 <sup>b</sup>	top	14/-12	8/-9	6/-8

a. Suspect output traces. Plots decay to non-zero steady state values.

b. Outputs not as expected.  $Y_p$  &  $Z_p$  values should be near zero.



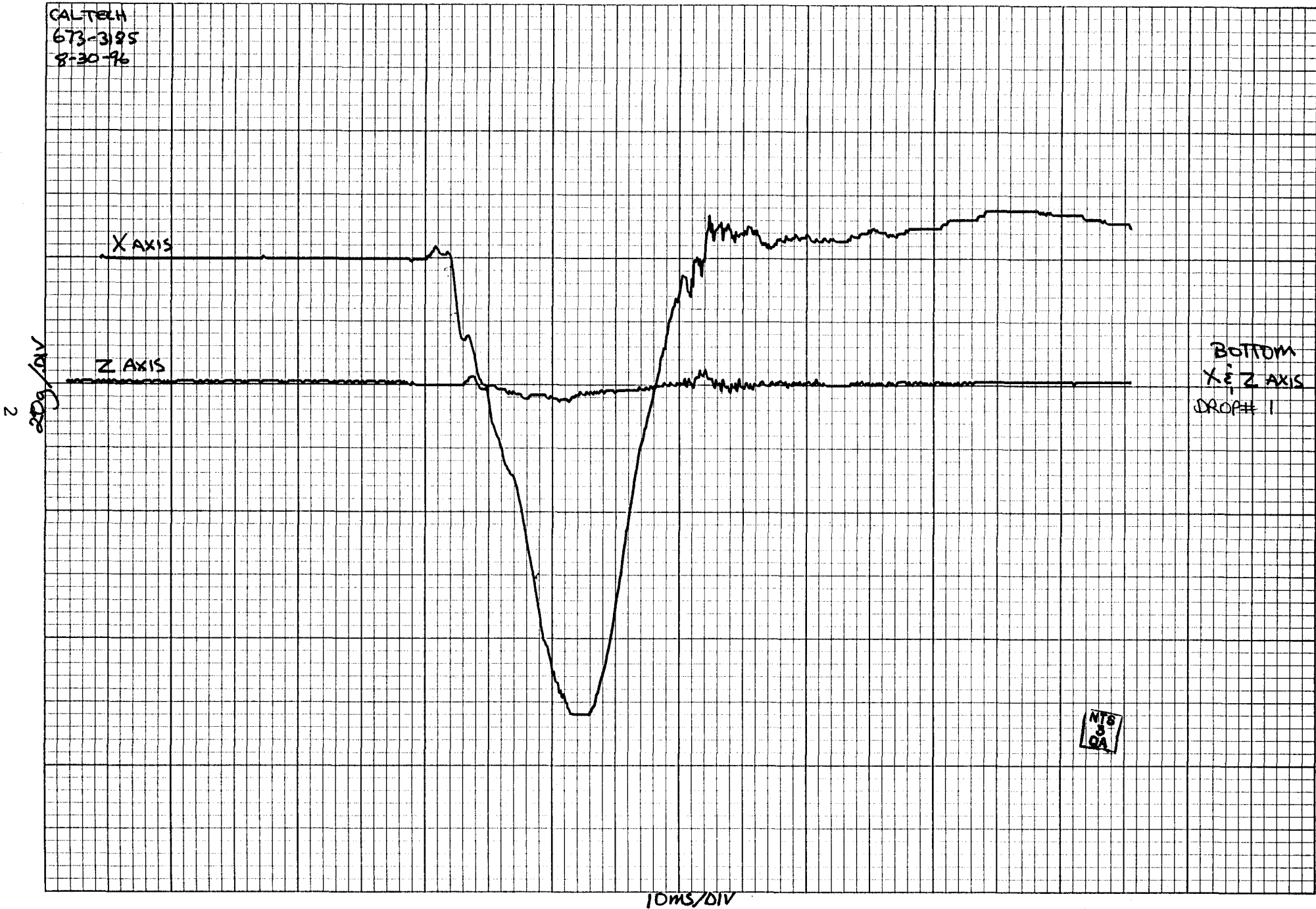
GENERAL LOG SHEET

TEST 36" FREE FALL DROP MJO 673-3185  
 CUSTOMER CALIFORNIA INSTITUTE OF TECH. DATE 8-30-96  
 TEST ITEM CARGO CONTAINER P/N \_\_\_\_\_ S/N \_\_\_\_\_  
 SPECIFICATION CUSTOMER VERBAL PAR \_\_\_\_\_

DATE	TIME	LOG ENTRIES	INITIAL
8-30-96	0900	SET UP DROP APPARATUS, ATTACH ACCELEROMETER TO DUMMY MASS, START TEST DROP 1 BOTTOM, COMPLETE 2 SIDE (HINGE), COMPLETE 3 LEFT SIDE (HANDLE), COMPLETE 4 BOTTOM LEFT EDGE, COMPLETE 5 TOP LEFT EDGE, COMPLETE 6 TOP SIDE EDGE (HINGE), COMPLETE 7 BOTTOM SIDE EDGE (LATCH), COMPLETE 8 TOP LEFT CORNER (LATCH) COMPLETE 9 BOTTOM LEFT CORNER (LATCH) COMPLETE 10 TOP, COMPLETE	
8-30-96	1330	TEST COMPLETE	

PAGE 1 OF 1 TEST BY T. Hendon DATE 8-30-96  
 ENGR. \_\_\_\_\_ NTS & CA GOV'T QAR \_\_\_\_\_

CALTECH  
673-3185  
8-30-96



CAL TEN  
673-3185  
8-30-96

20g<sup>ε</sup>/DIV

Y AXIS

Bottom  
Y AXIS  
DROP # 1

NTS  
3  
PA

10ms/DIV

CAL TECH  
673-3185  
8-30-96

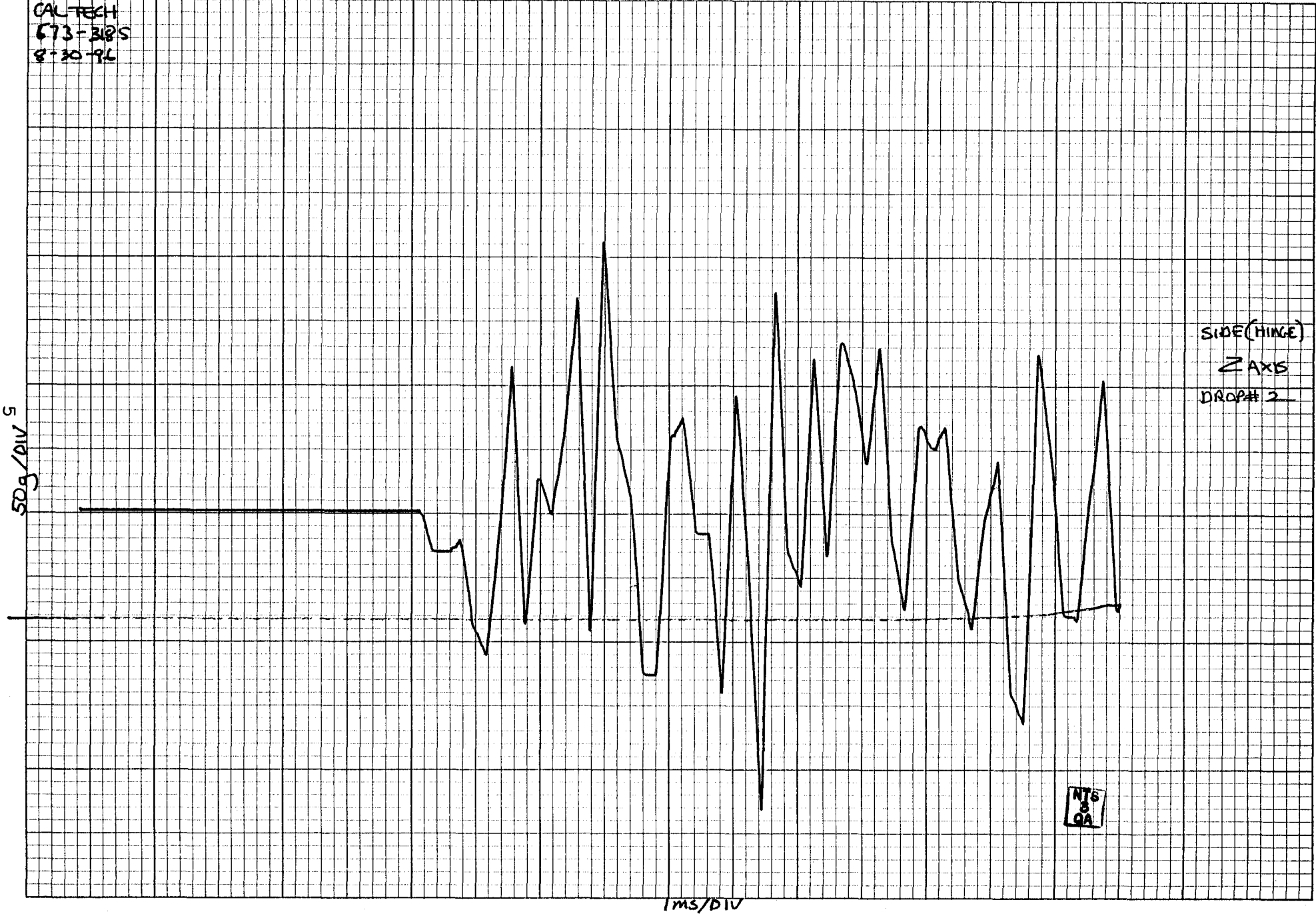
50g/div

SIDE (HIVE)  
Y AXIS  
DROP # 2

NTS  
3  
DA

1 ms/div

CALTECH  
673-3185  
8-30-96



SIDE (HINGE)  
Z AXIS  
DROPH # 2

NTS  
&  
PA



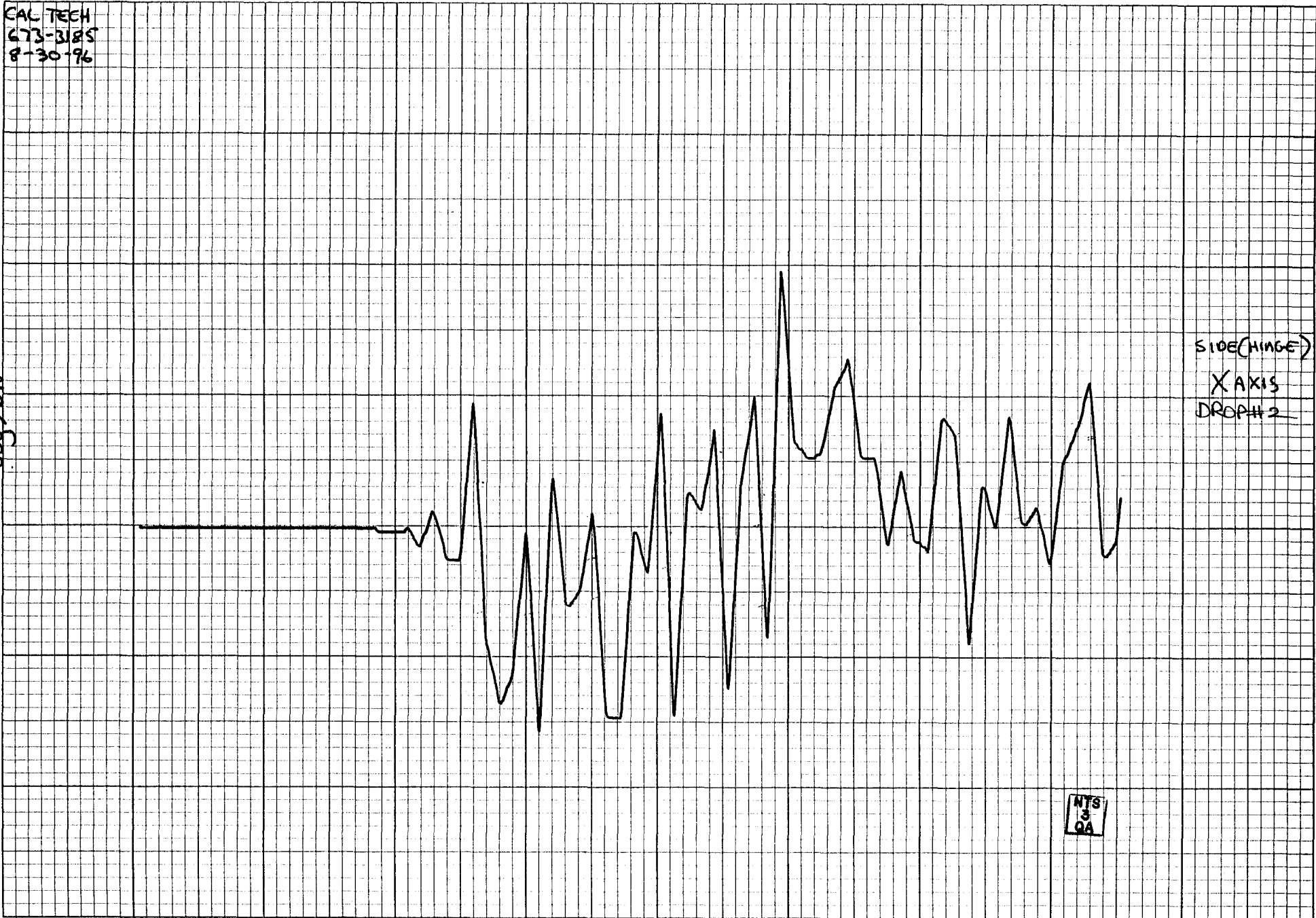
CAL TECH  
673-3185  
8-30-96

SDg/DIV

SIDE(HINGE)  
X AXIS  
DROPH#2

1ms/DIV

NYS  
3  
QA



CAL TECH  
673-3185  
8-30-96

L  
50g/DIV

Z AXIS

X AXIS

LEFT SIDE  
(HANDLE)  
Z & X AXIS  
DROU# 3



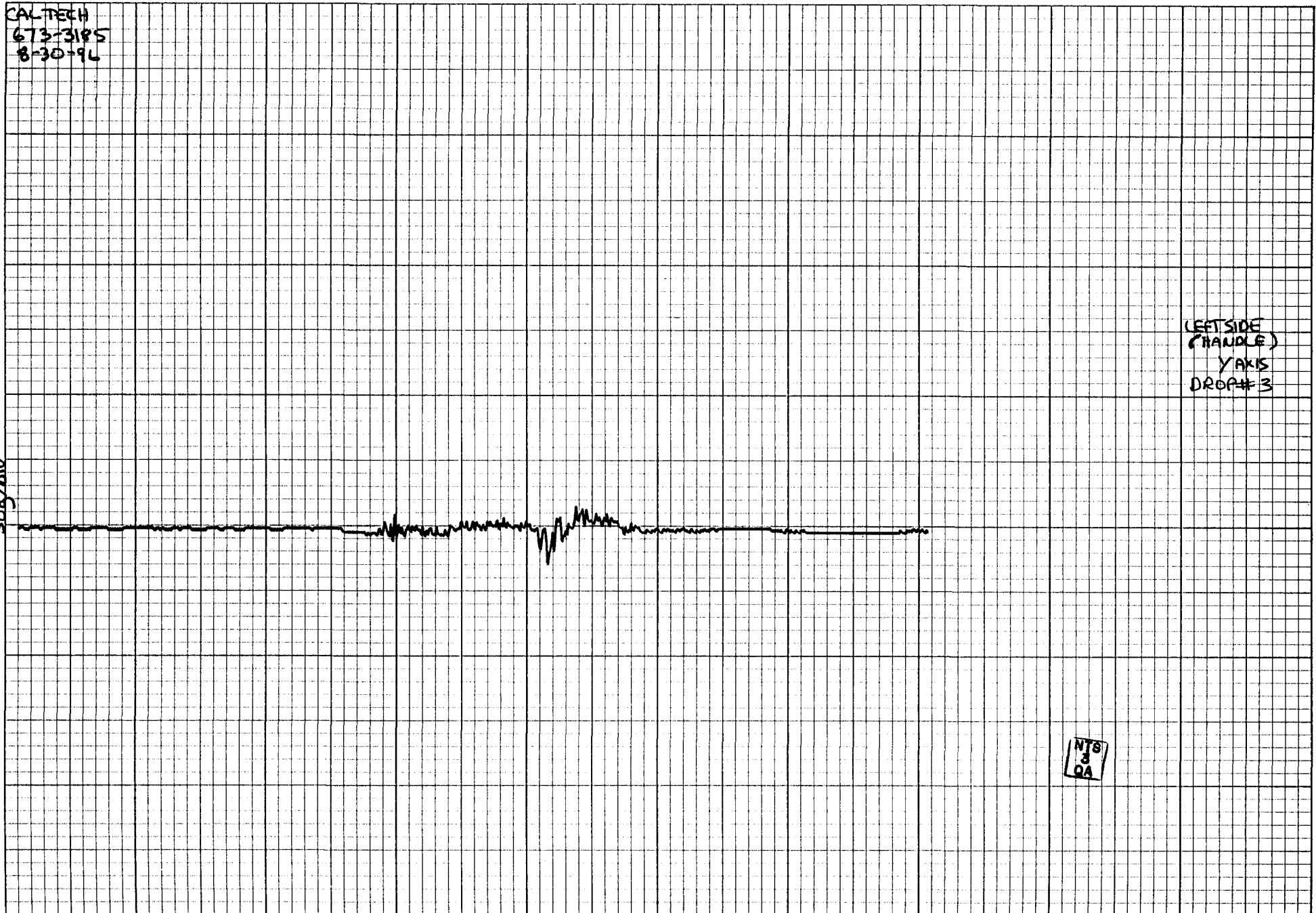
10ms/DIV

NTS  
3  
QA

CALTECH  
673-3185  
8-30-94

(LEFT SIDE  
HANDLE)  
Y AXIS  
DROP# 3

8  
50g/DIV



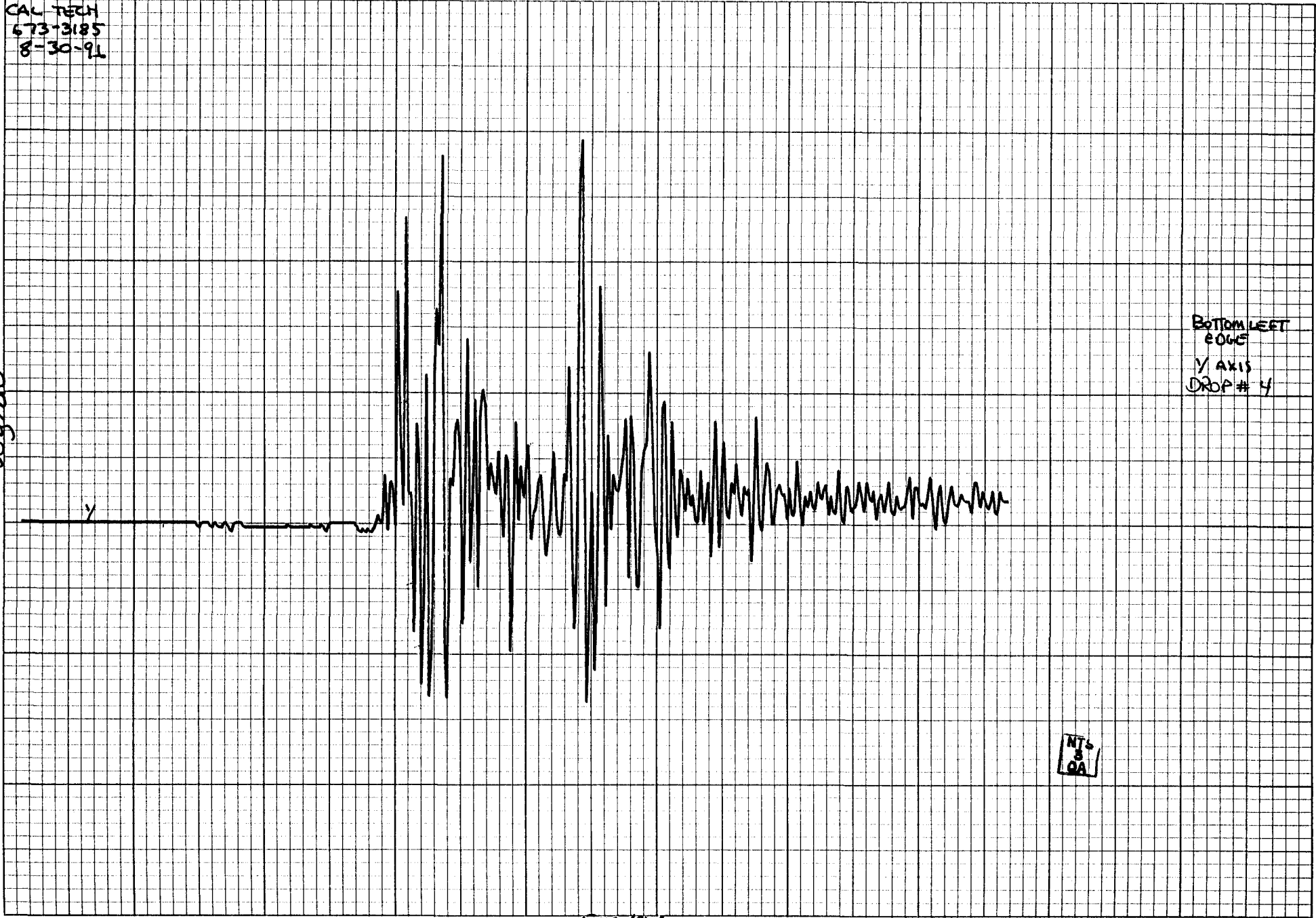
10ms/DIV

NTS  
3  
RA

CAL TECH  
673-3185  
8-30-91

50g/DIV

BOTTOM LEFT  
EDGE  
Y AXIS  
DROP # 4



5ms/DIV

NT 3 0A

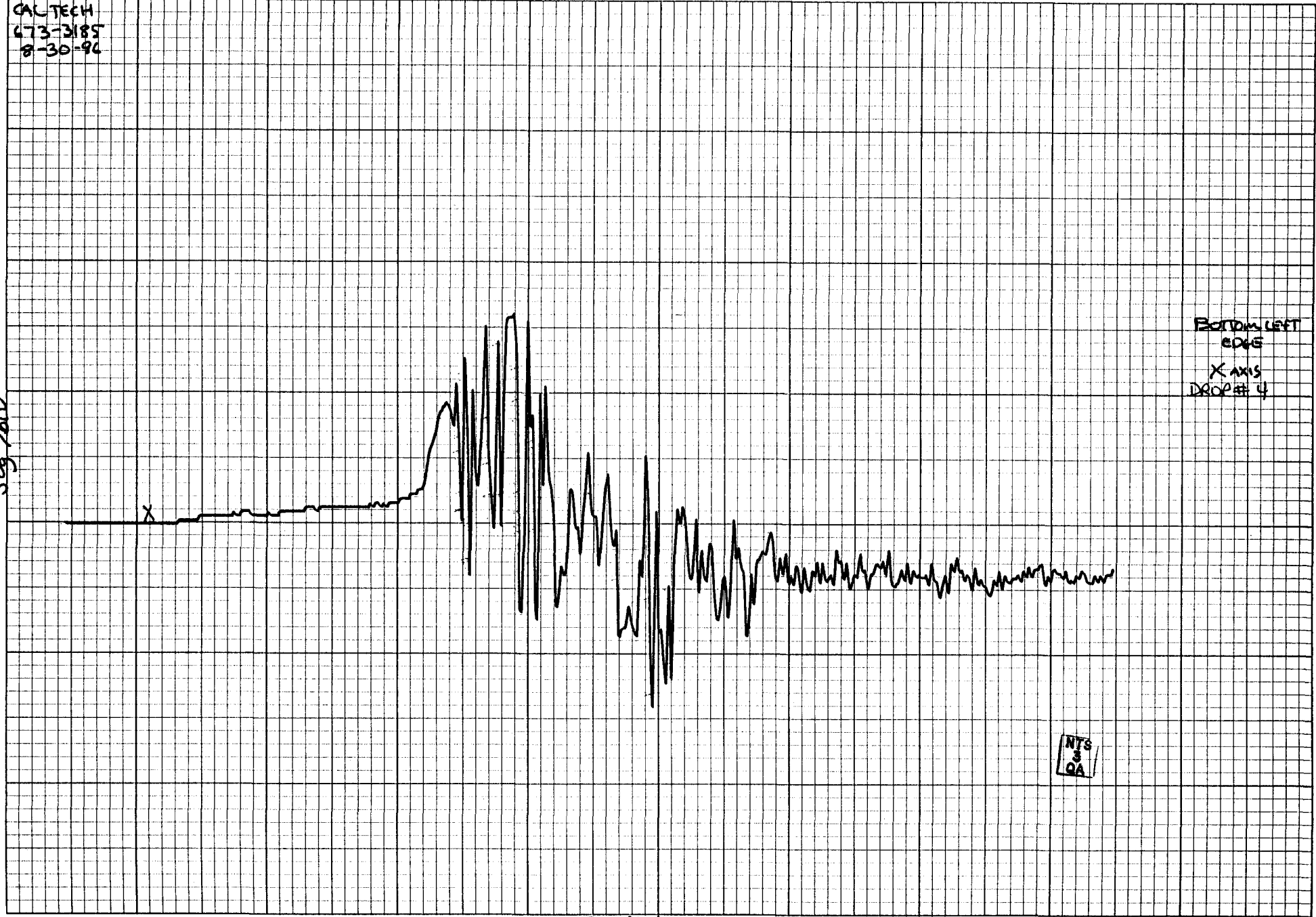
CAL TECH  
673-3185  
8-30-94

50g / 10V  
10

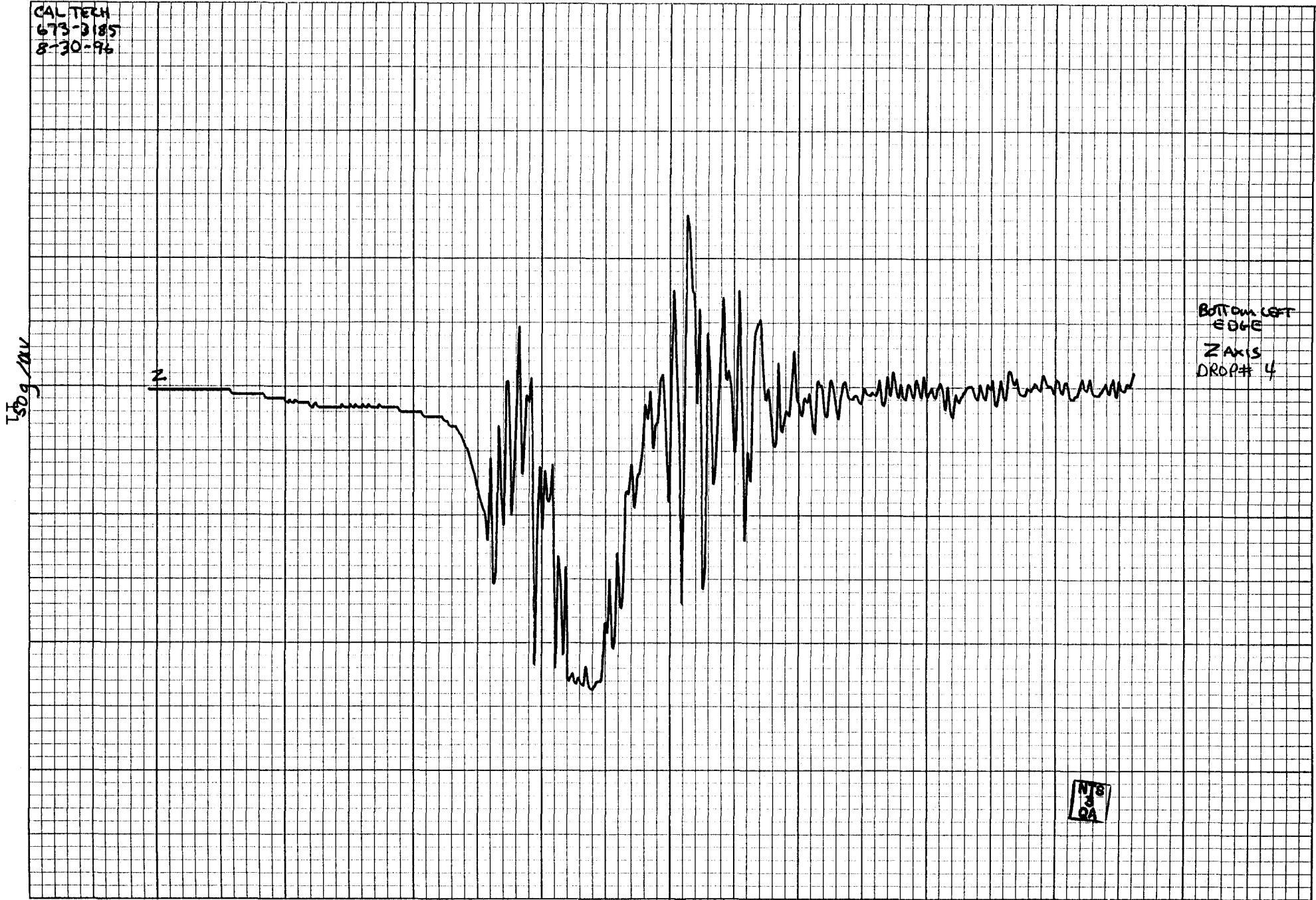
Bottom LEFT  
edge  
X-axis  
Drop # 4

NTS  
3  
QA

5ms / 10V



CAL TECH  
673-3185  
8-30-76



BOTTOM LEFT  
EDGE  
Z AXIS  
DROP# 4

CAL TECH  
673-3185  
8-30-96

50g/div  
I<sub>2</sub>

Z AXIS

X AXIS

TOP LEFT  
EDGE  
Z & X AXIS  
DROP # 5

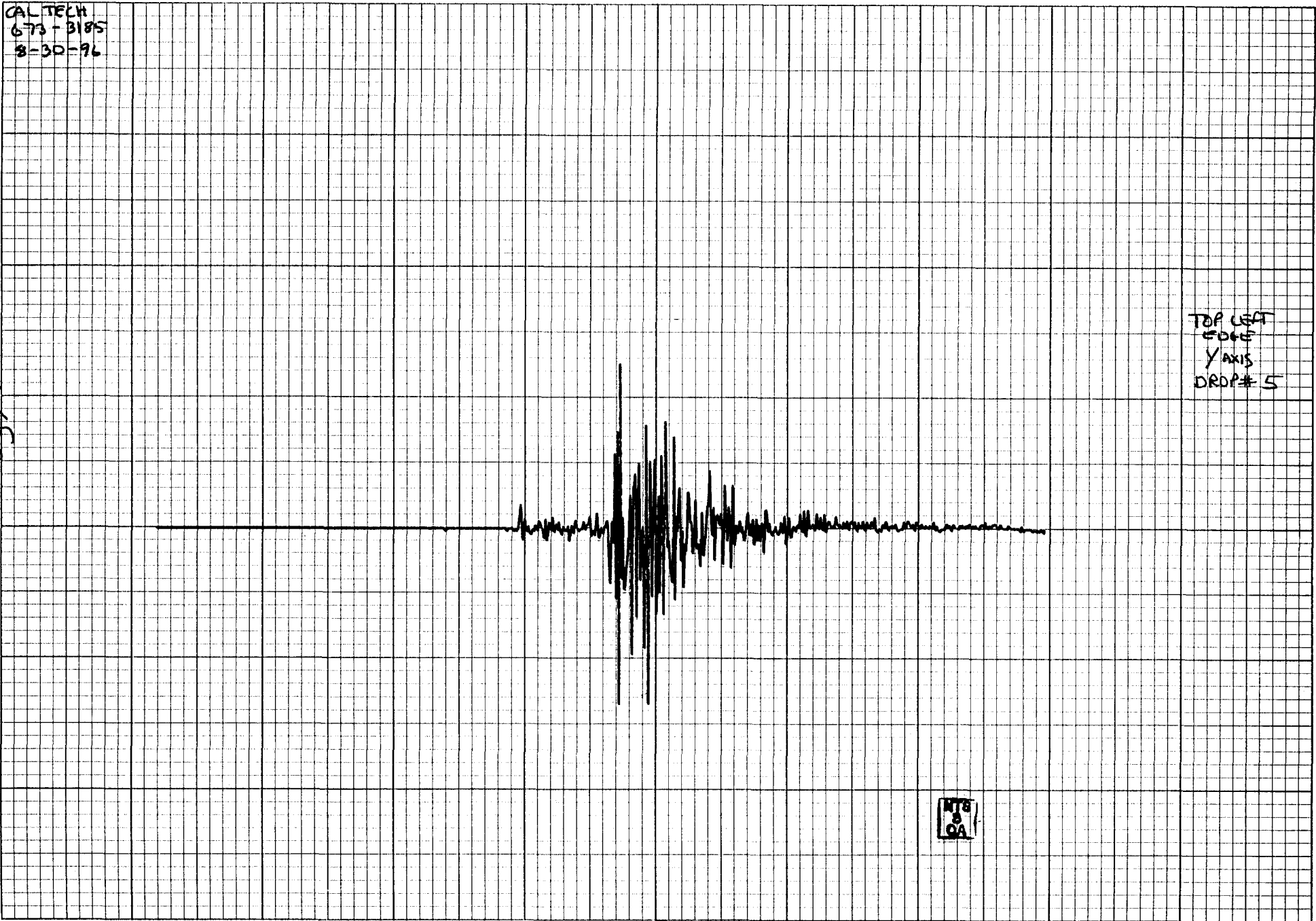
NTS  
&  
PA

5ms/div

CALTECH  
673-3185  
8-30-96

110/50  
13

TOP LEFT  
EDGE  
Y AXIS  
DROP# 5



5ms/DIV

MTS  
8  
CA



CALTECH  
673-3185  
8-30-96

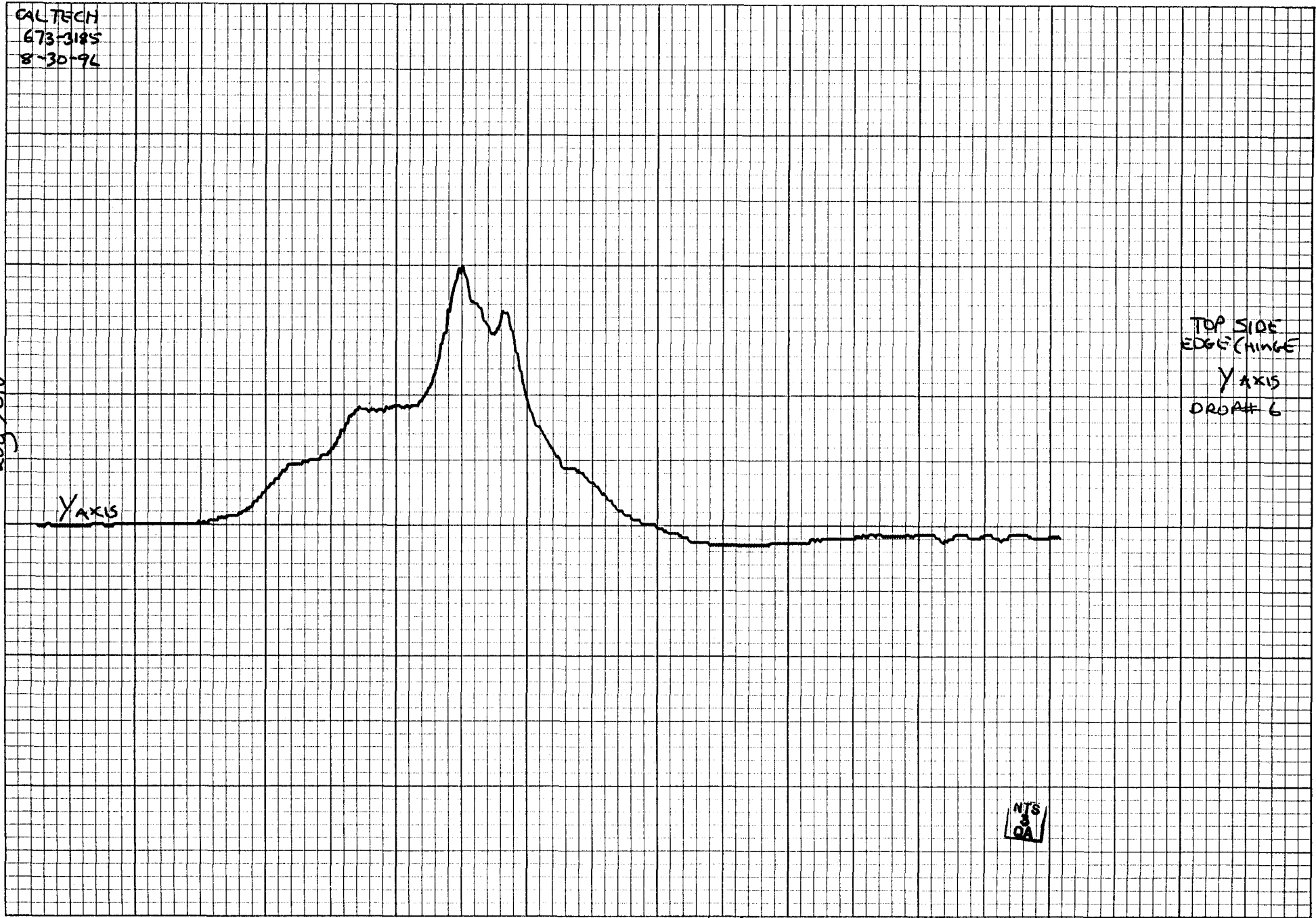
20g I/V

TOP SIDE  
EDGE CHANGE  
Y AXIS  
DROPT# 6

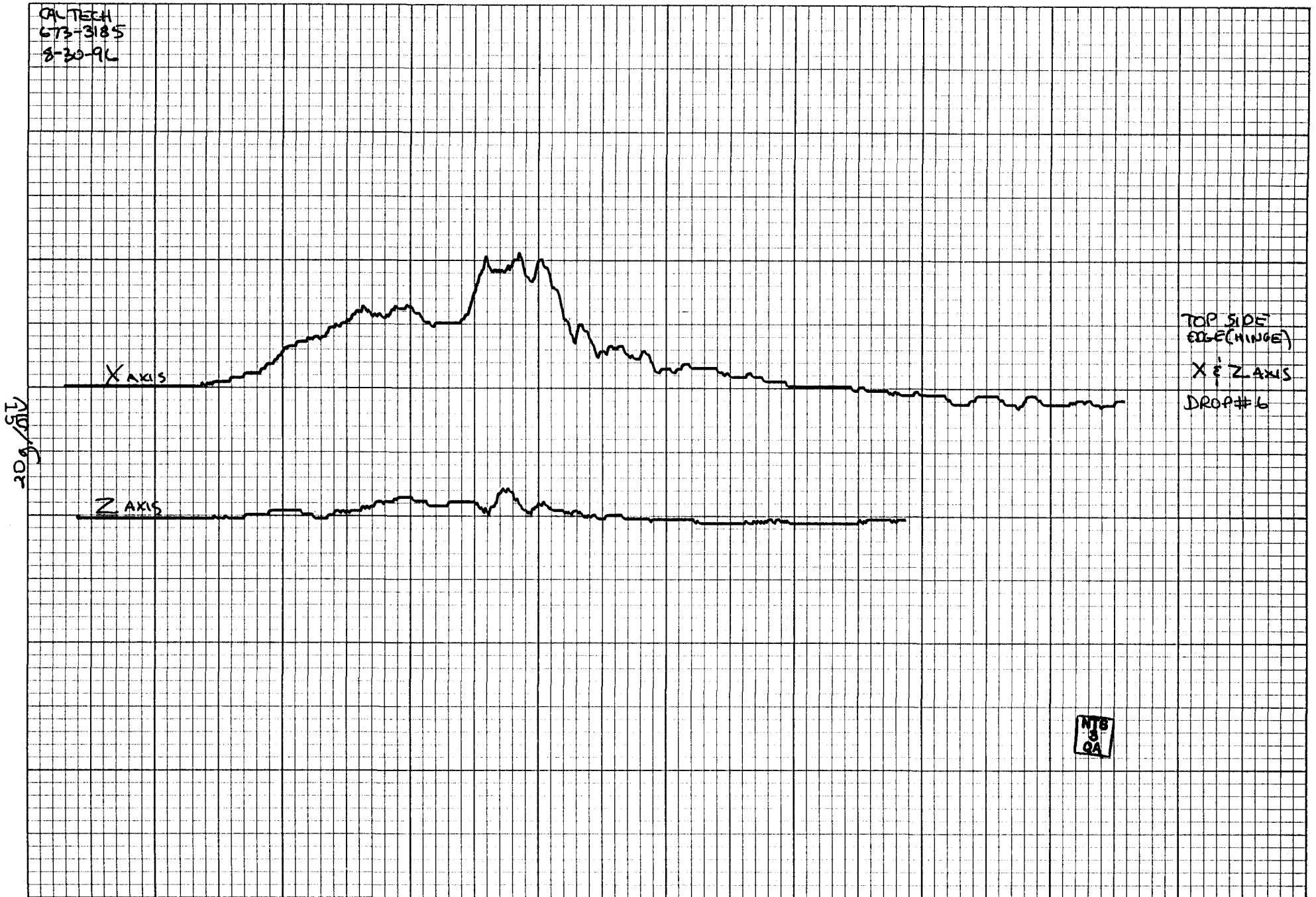
Y AXIS

NTS  
20g  
A

10 ms/DIV



QAL TECH  
673-3185  
8-30-96



20g/div

10ms/div

NIB  
QA

CAL TEL  
673-3185  
8-30-96

50 $\mu$ V/DIV

X AXIS

BOTTOM SIDE  
EDGE (LATCH)  
X AXIS  
DROP # 1

NTS  
3  
GA

10ms/DIV

CAL TECH  
673-3185  
8-30-96

BOTTOM SIDE  
EDGE (LATH)  
DROP# 7

17  
VOLT/60S

Z AXIS

NTS  
3  
PA

10ms/DIV

CAL TECH  
673-3185  
8-30-84

8T  
500 V/IN

Y AXIS

BOTTOM SIDE  
EDGE (LATCH)  
Y AXIS  
DROP # 7

NTS  
3  
QA

10MS/0V

CAL TECH  
673-3185  
8-30-96

50g/div

TOP LEFT CORNER  
(LATCH)  
Y AXIS  
DROFF # 8

LOOSE ACCEL

NTS  
&  
QA

10ms/div



CAL TECH  
673-3185  
8-30-96

X AXIS

ACCEL LOOSE

TOP LEFT CORNER  
(LATCH)  
X AXIS  
DROP # 8

NTS  
&  
PA

10ms/div

20g/div  
50g/div



CAL TECH  
673-3185  
8-30-96

21  
ms/div

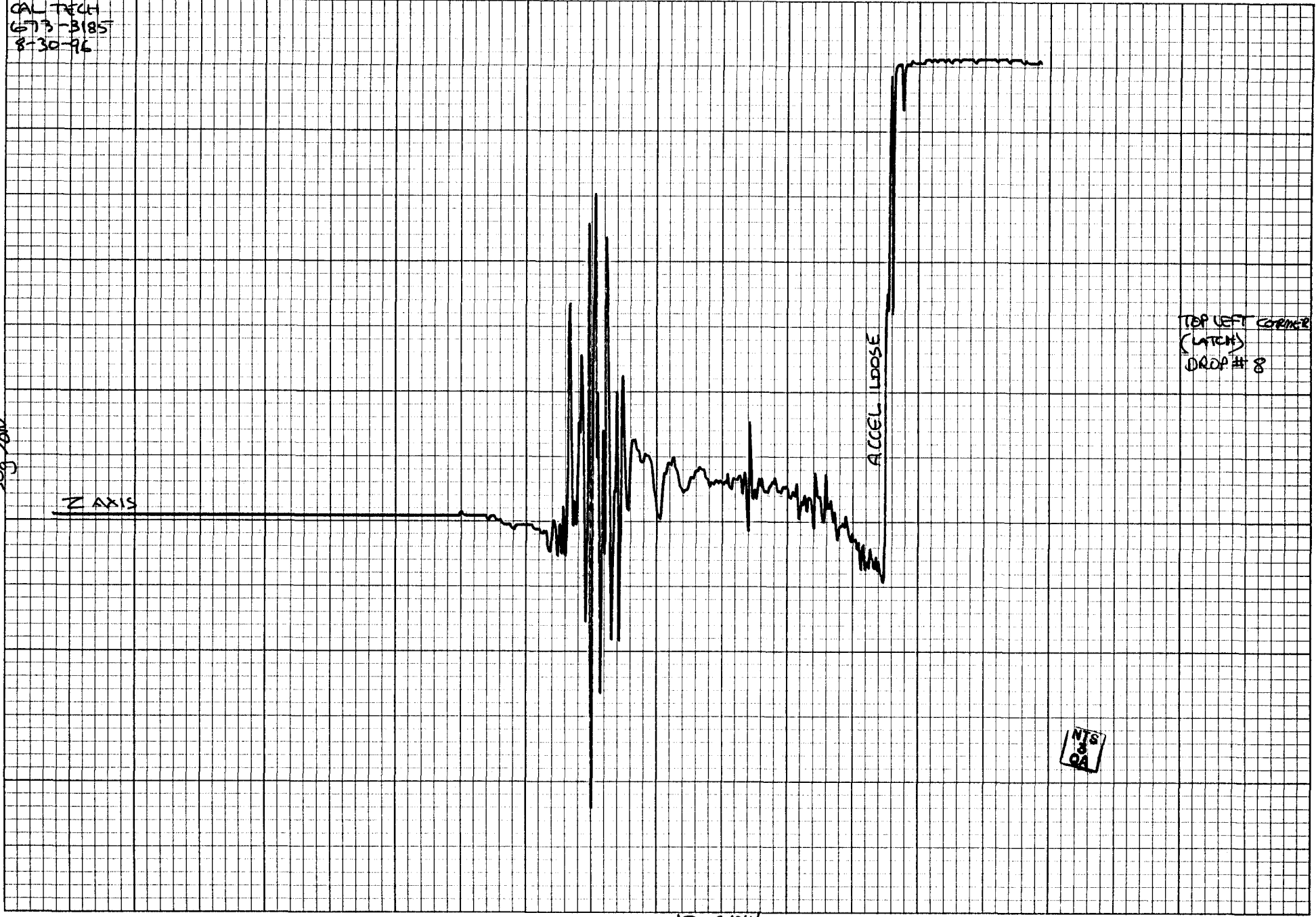
Z AXIS

ACCEL LOOSE

TOP LEFT CORNER  
(LATCH)  
DROP # 8

NTS  
10ms/div

10ms/div





CALTECH  
673-3185  
8-30-96

11/18/805  
22

Z AXIS

BOTTOM LEFT  
CORNER (LATCH  
Z AXIS  
DROFF# 9

NTS  
8  
CA

10ms/DIV

CALTECH  
673-3185  
8-30-96

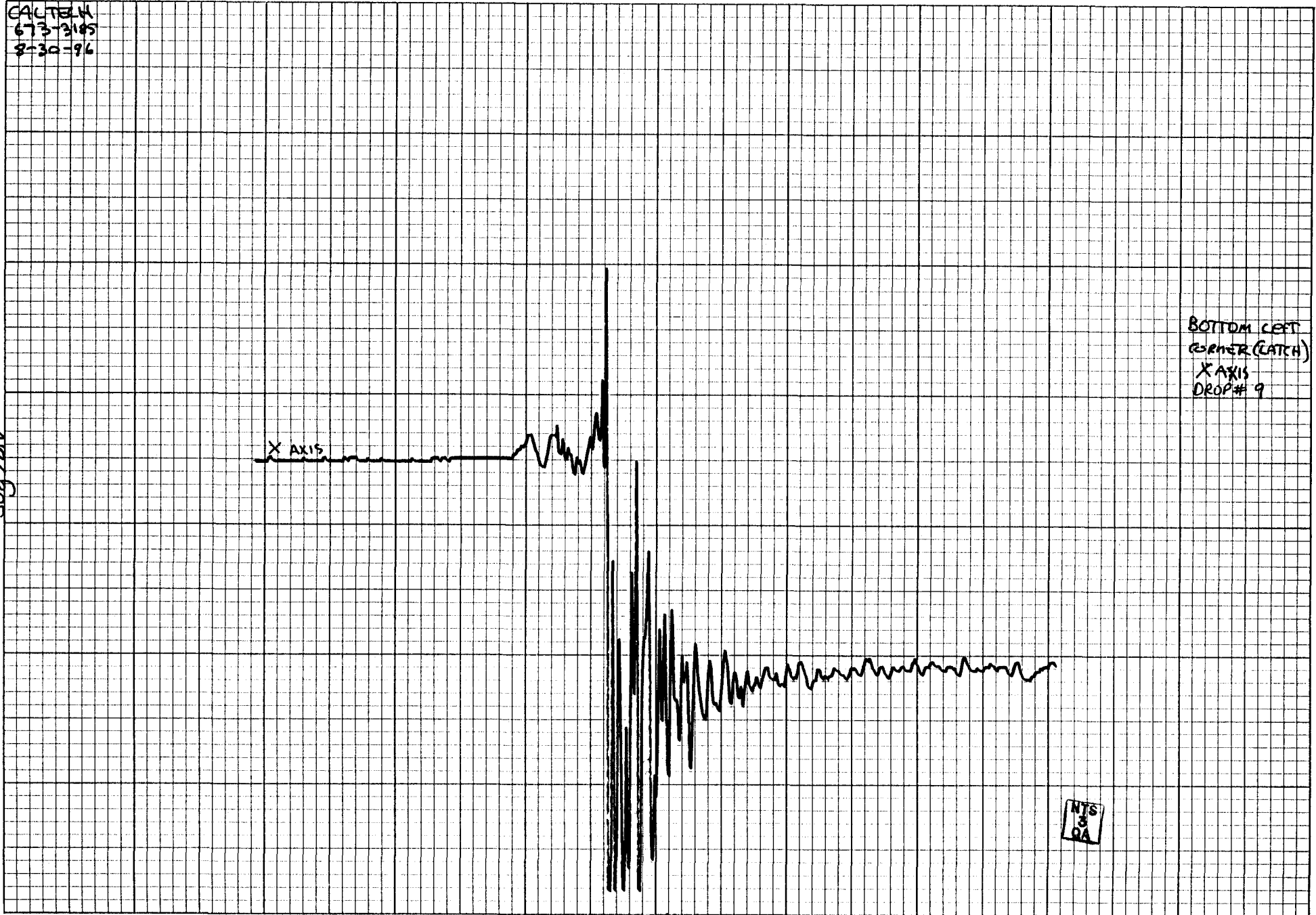
23/10/605

X AXIS

BOTTOM LEFT  
CORNER (CATCH)  
X AXIS  
DROP # 9

10ms/DIV

NIS  
&  
PA



CAL TECH  
675-3185  
8-30-96

IN/CG  
24

Y AXIS

BOTTOM LEFT  
CORNER (LATCH)  
Y AXIS  
DROP# 9

NTS  
3  
QA

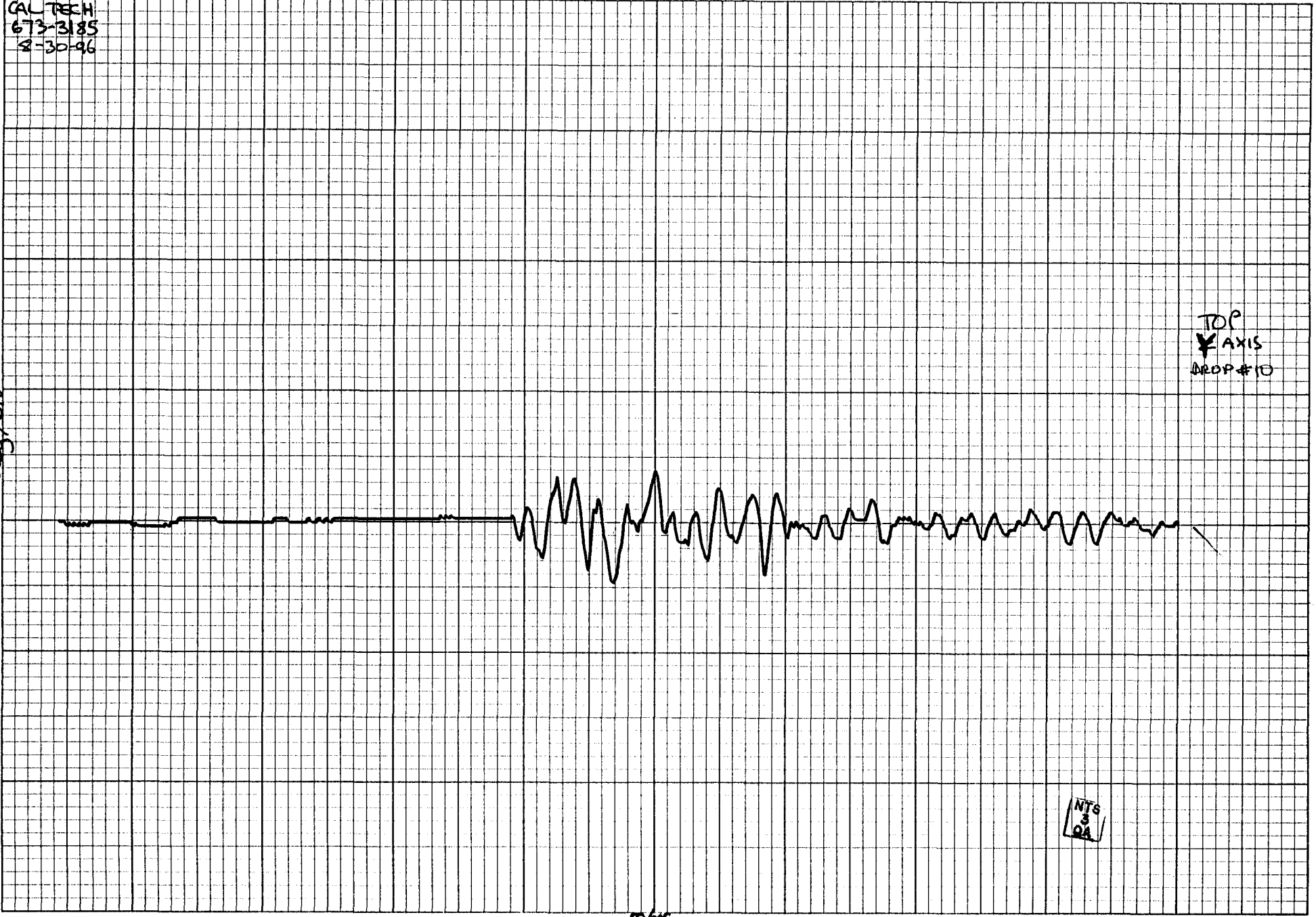
10ms/DIV



CAL TECH  
673-3185  
8-30-96

203/9811

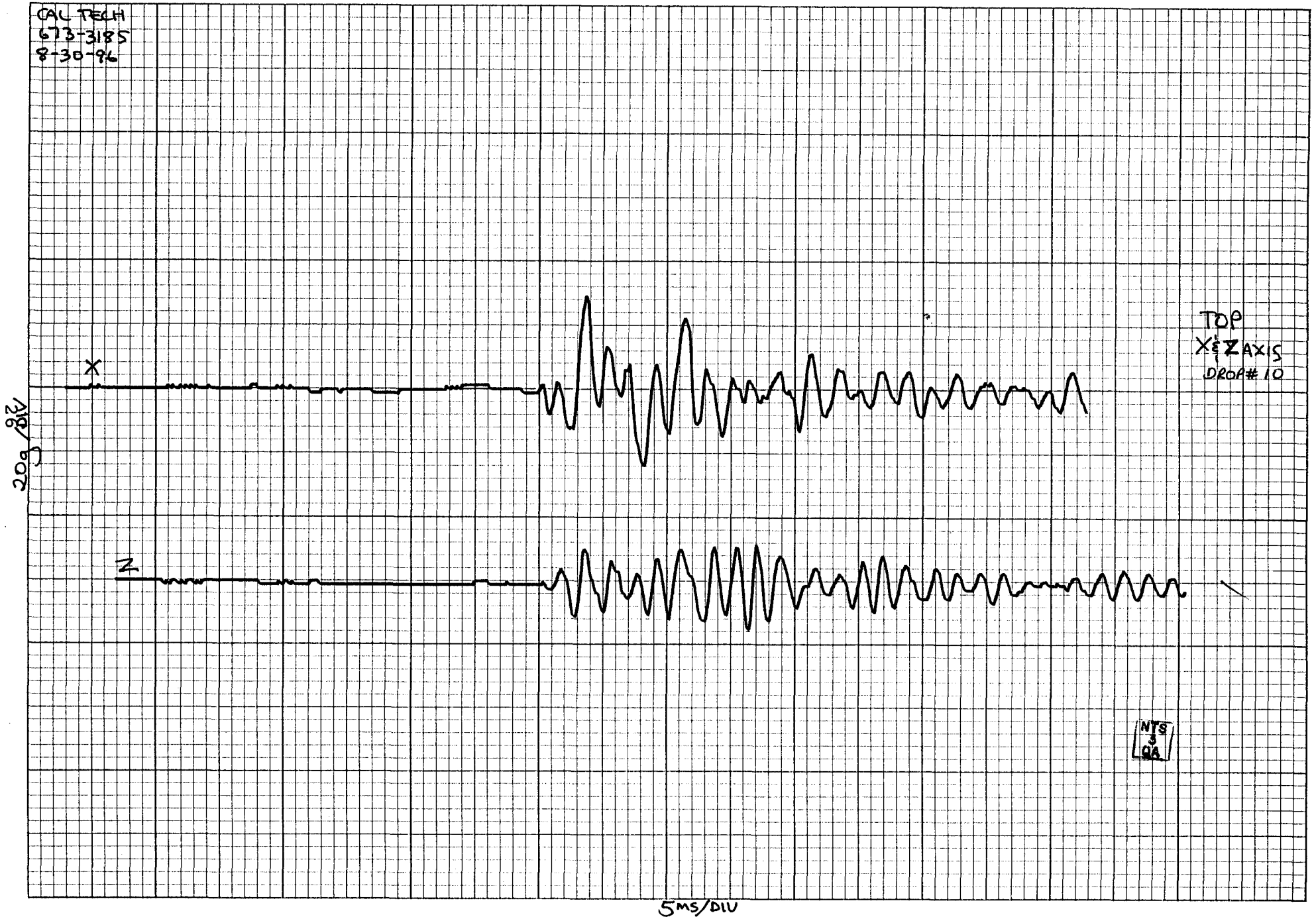
TOP  
AXIS  
DROP #10



NTS  
3  
PA

5/16

GAL TECH  
673-3185  
8-30-96



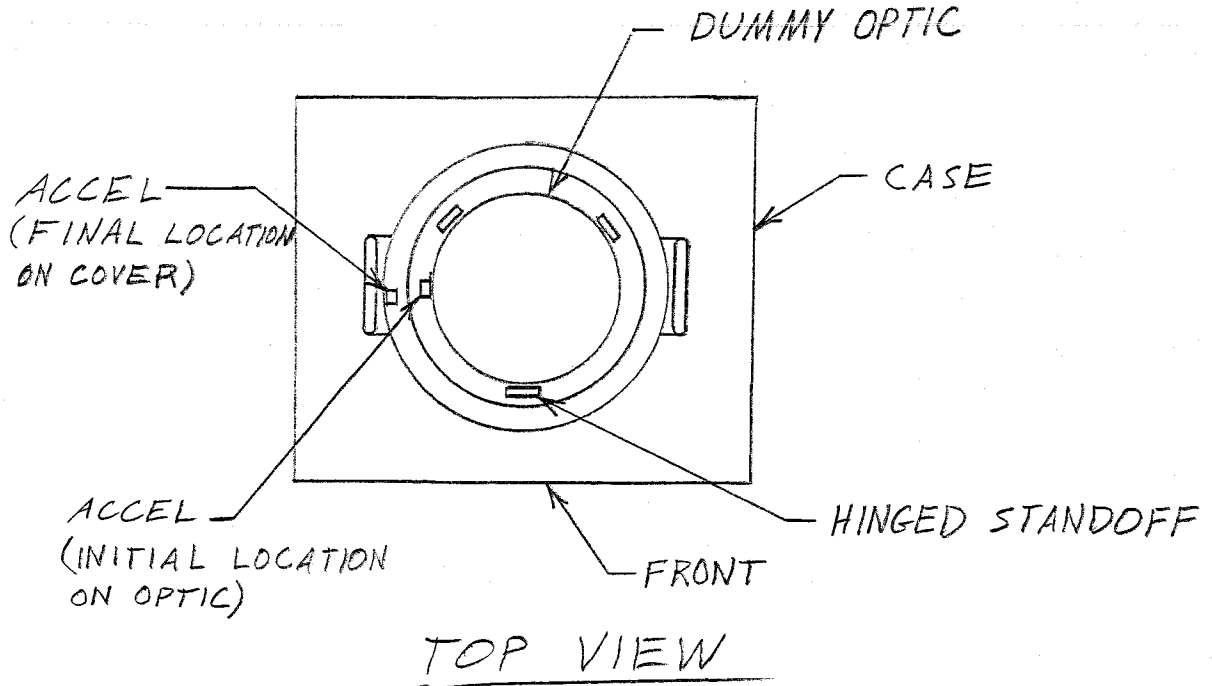
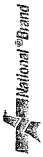
TOP  
X & Z AXIS  
DROP# 10

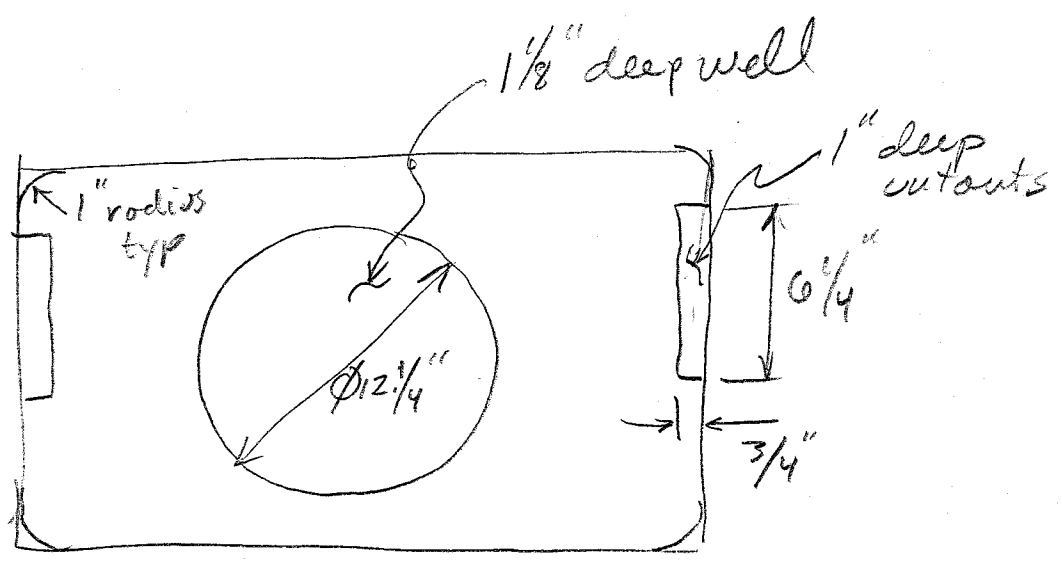
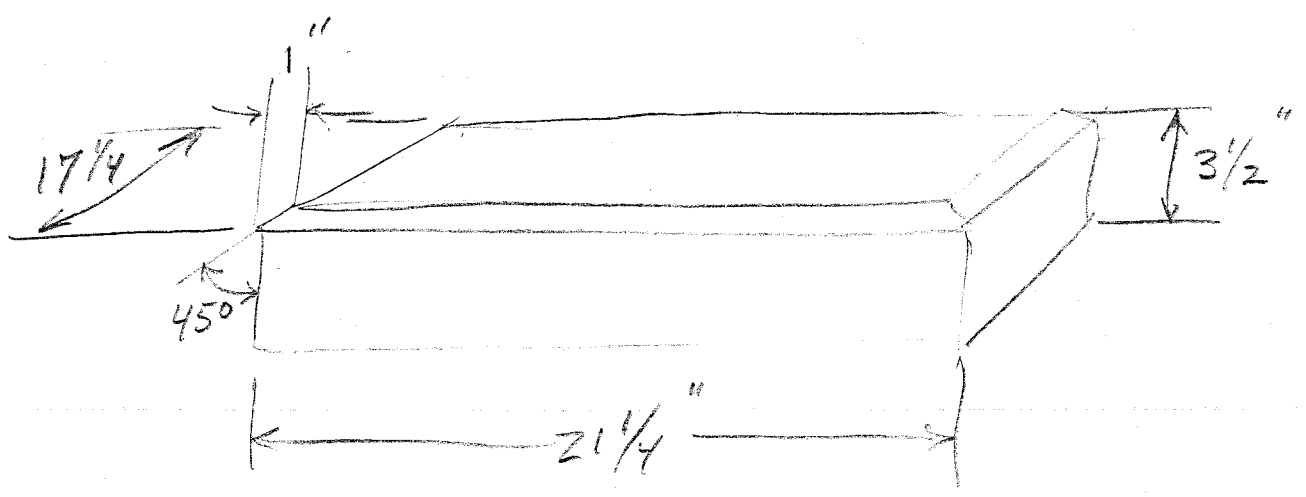


EQUIPMENT LIST

<u>Description</u>	<u>Apparatus</u>	<u>Calibration</u>
<u>SHOCK</u>	Kikusui Digital Oscilloscope, Model 5020A, $\pm 3\%$ , NTS Control No. D-4863-F	6 Months Due 12-6-96
	Kistler Digital Oscilloscope, Model 5020A, NTS Control No. MET-4225-F	6 Months Due 9-8-96
	Kistler Dual Mode Amplifier, Model 5004, NTS Control No. MET-4230-F	6 Months Due 1-15-97
	Kistler Dual Mode Amplifier, Model 5004, NTS Control No. MET-4232-F	6 Months Due 1-15-97
	Kistler Dual Mode Amplifier, Model 5004, NTS Control No. MET-4231-F	6 Months Due 1-2-97
	PCB Accelerometer (Tri-Axial), Model 356A07, NTS Control No. D-5006-F	6 Months Due 2-16-97
	Western Graphtec X-Y Plotter, Model WX1200E, NTS Control No. D-4807-F	6 Months Due 12-7-96

13-782 50 SHEETS, FILLER 5 SQUARE  
12-381 50 SHEETS, EYE EASE, 5 SQUARE  
12-382 100 SHEETS, EYE EASE, 5 SQUARE  
12-389 200 SHEETS, EYE EASE, 5 SQUARE  
12-392 100 RECYCLED WHITE 5 SQUARE  
12-399 200 RECYCLED WHITE 5 SQUARE  
Made in U.S.A.





Circular cutout has  $\approx \frac{1}{4}$ " diametrically ploy around carrier top cover

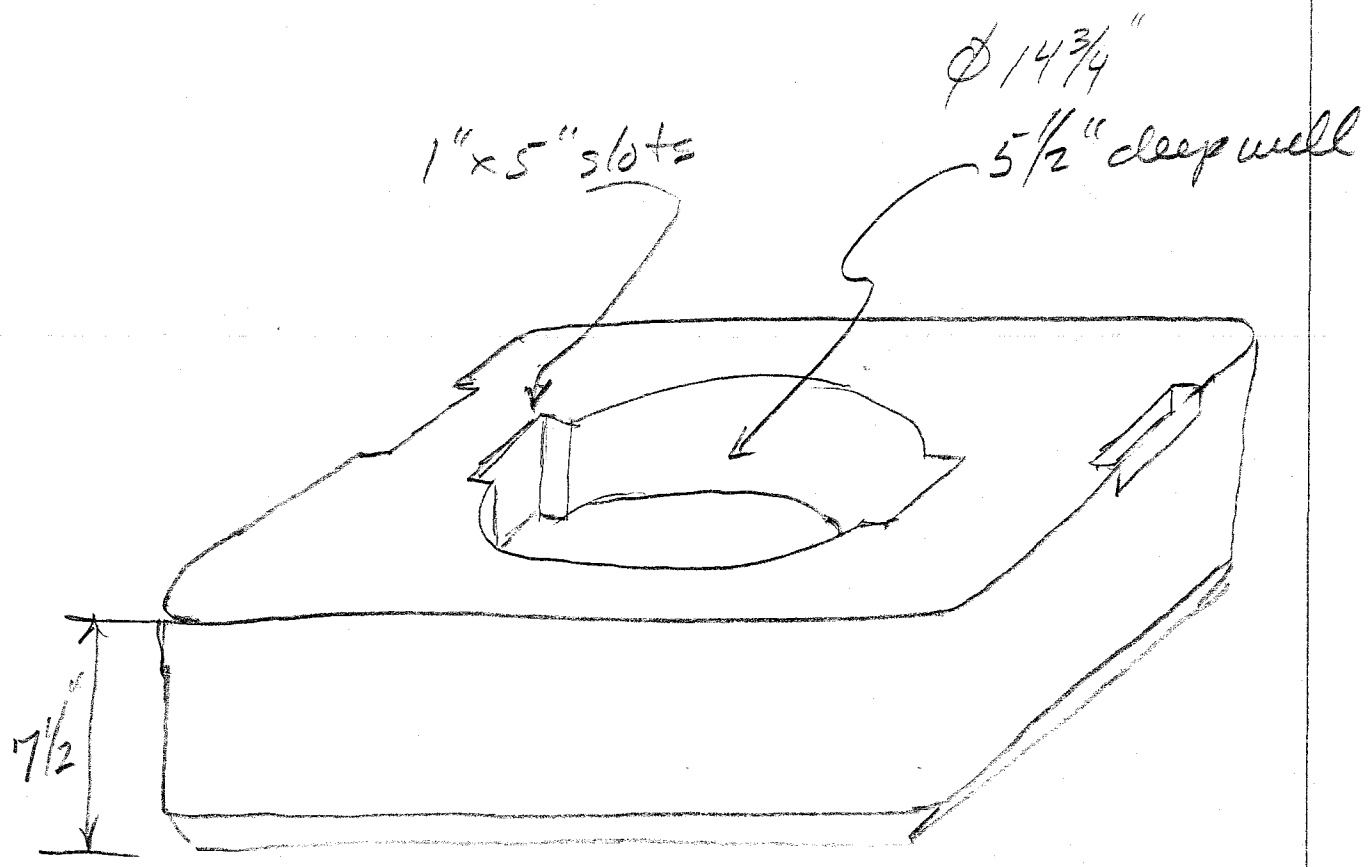
foam insert top

13-792 500 SHEETS, FILLER, 5 SQUARE  
 42-381 60 SHEETS, EYE EASY, 5 SQUARE  
 42-382 100 SHEETS, EYE EASY, 5 SQUARE  
 42-383 200 SHEETS, EYE EASY, 5 SQUARE  
 42-384 100 SHEETS, EYE EASY, 5 SQUARE  
 42-385 100 RECYCLED, WHITE, 5 SQUARE  
 42-386 200 RECYCLED, WHITE, 5 SQUARE  
 Made in U.S.A.





13-782 500 SHEETS, FILLER 5 SQUARE  
 42-391 50 SHEETS, EYE-EASE 5 SQUARE  
 42-390 100 SHEETS, EYE-EASE 5 SQUARE  
 42-389 100 SHEETS, EYE-EASE 5 SQUARE  
 42-388 100 SHEETS, EYE-EASE 5 SQUARE  
 42-387 100 SHEETS, EYE-EASE 5 SQUARE  
 42-386 100 RECYCLED WHITE 5 SQUARE  
 42-385 200 RECYCLED WHITE 5 SQUARE  
 Made in U. S. A.



Circular cutout has  $< \frac{1}{8}$ " diametrical  
 play around the base of the  
 carrier cover, but  $\approx 1 \frac{1}{2}$ " radial play  
 around the top of the carrier cover

foam insert bottom

