Docketed Mail

Consumers Power Company

General Offices: 212 West Michigan Avenue, Jackson, Michigan 49201 • Area Code 517 788-0550

COPY

November 9, 1976


Mr James G Keppler
Office of Inspection and Enforcement
Region III
US Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, IL 60137

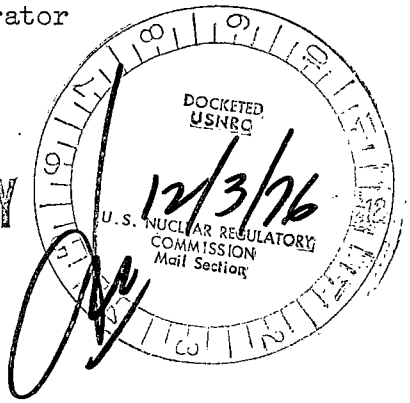
DOCKET 50-255 - LICENSE DPR-20 -
PALISADES PLANT - REACTOR INTERNALS
NOISE MONITORING TEST REPORT

In accordance with the Palisades Technical Specifications (Section 4.13.C.4) this letter transmits a semiannual report. This report is entitled "Palisades Nuclear Plant Reactor Internals Noise Monitoring Tests, October 1976." This report covers the period from May to October 1976.

David A Bixel (Signed)

David A Bixel
Assistant Nuclear Licensing Administrator






12026

NOV 15 1976

CONSUMERS POWER COMPANY

BULK POWER OPERATION

PALISADES NUCLEAR PLANT

# REACTOR INTERNALS NOISE MONITORING TESTS

October 1976

# REACTOR INTERNALS NOISE MONITORING TESTS


## ABSTRACT

Reactor internals noise monitoring test are being conducted on the Palisades core using the power range excore detectors. The tests are conducted in two phases. Phase One measurements include determing the amplitude probability distribution, the standard deviation, and the root mean square value of the measured data. Phase Two measurements require determining the auto-power spectral densities, coherence, and phase relationships of the sensors. Action limits of 0.25% rms and 0.48%rms have been established.

The subject matter of this report covers the period May to October 1976 following a full core reload. During this period the plant was operated at 100% power. The barrel motion is nominally 0.25 mils rms and the rms noise levels are less than those reported for Core 1. At no time were the established action limits exceeded.

## I. INTRODUCTION

Section 4.13 of the Palisades Plant Technical Specifications requires reactor internals vibration analysis to be conducted on the Palisades core. This monitoring program has been required as a result of the core barrel vibration occurring initially in 1972. Two measurement phases are implemented for the analysis. Phase One measurements include the analysis of the power range excore detector signals for gross amplitude of core movement. The analysis is performed by determining the amplitude probability distributions, the standard deviations, and the root mean square values of the measured data. Phase Two measurements require overall noise characteristics to be analyzed including amplitude power distributions, frequency content, and azimuthal relationships of the measured data. This is done by determining the auto-power spectral densities, coherence functions, and phase relationships of the data.

This report represents data taken at stable 100% reactor power. The period covered by this report began with a new core reload so that there was no initial burnup.

## II. SIGNAL CHOICES

Operating power range excore detectors, NI-05 through 10, compromise the primary source of the information used for the analysis of the reactor internals. The power range excore signals are supplemented with the use of incore detector 7-5 and steam generator differential transmitters. Figures 1(a) and 1(b) indicate the locations of the above sensors.

## III. SIGNAL CONDITIONING

Excore signals NI05-08 are processed through a dc "bucking box" which bucks out the dc component of the signal. The signal is then amplified and filtered before being connected to a Hewlett-Packard 5451B Fourier Analyzer. The other sensors are connected as above except the "bucking box" is not used. All signals are high pass filtered at 0.025 hz and low pass filtered depending upon the analysis requirements. The filters have a characteristic roll-off of 24db/octave. Figure 1(c) is a schematic representation of the signal conditioning equipment.

## IV. PHASE ONE MEASUREMENTS

Phase One measurements consist of determining the amplitude probability distribution (APD), the standard deviation (sigma, $\sigma$), and the root mean square (RMS) of the noise component of the power range excore detectors. Representative APD's of the excore detectors are plotted in figures 2, 4, 6, and 8. In addition, the integrals of the APD's (IAPD) are plotted in figures 3, 5, 7, and 9. Since the integral up to a given amplitude is just the probability, a plot of the integral versus the amplitude will form a straight line if plotted on a probability scale, if the APD is gaussian (random data).

Since the majority of the low frequency noise is in the 0-5 hz region, percent RMS is monitored for this range. Data was also collected for 0-2.5 hz so as to compare with data from core 1. The average RMS values for the frequency ranges of interest are listed in Table 1. The RMS value for a given frequency band is calculated by integrating the measured power

spectral density over the band of interest. The percent RMS as a function of time is plotted in figures 10 - 13.

Table 1: Average RMS values, June - October 1976

| Excore Detector | PERCENT RMS 0.025-2.5 hz* | 0.025-5 hz | 2.5-25 hz* | 5-25 hz | 5-50 hz |
|---|---|---|---|---|---|
| NI-05 | 0.070 | 0.064 | 0.028 | 0.0091 | 0.0091 |
| NI-06 | 0.062 | 0.060 | 0.027 | 0.0077 | 0.0079 |
| NI-07 | 0.060 | 0.058 | 0.028 | 0.0087 | 0.0086 |
| NI-08 | 0.063 | 0.061 | 0.028 | 0.0084 | 0.0084 |

*Data from June 1976

In the low frequency region there is high coherence and an out-of-phase relationship between detectors located diagonally across the core in the 0.75 to 3 hz region. Thus, APD's were measured for this region and plotted in figures 14 - 21. The integral of the APD was also determined and plotted on a probability axis as before.

## V. PHASE TWO MEASUREMENTS

Phase Two test measurements consist of determining the power spectral density (PSD) of excore detector signal noise as well as the coherence and phase relationships of the various excore combinations. Figures 22 - 25 are PSD's, normalized with respect to dc voltage, from 0.025 hz to 25 hz. This band was chosen since the frequencies of interest are in this range and better resolution is provided. In any case, PSD's from 0.025 - 50 hz are routinely run to monitor any changes at higher frequencies (figure 26). A 0.025 - 100 hz PSD was measured to look at still wider bands (figure 27).

Coherence and phase relationships for detectors located diagonally across the core are plotted in figures 29 - 32. The results of measured coherences and phases are listed in Table 2 and summarized in figure 39.

## VI. ADDITIONAL MEASUREMENTS

Measurements were taken of incore 7-5 and steam generator differential pressure. Figures 34 -37 are phase and coherence plots of NI05 and NI06 with incore 7-5. Figure 33 is a PSD of incore 7-5 and figure 38 is a PSD of pressure differential transmitter PDT0112B.

## VII. SUMMARY OF FINDINGS AND DATA OBSERVATIONS

### A. Amplitude Probability Distribution (APD)

The APD's are gaussian for both wide band and narrow band frequency ranges, indicating random phenomenon. This is verified by the fact that the IAPD versus amplitude plot is a straight line when plotted on a probability scale. The fact that the data is random and not biased indicates that the core barrel is not coming into contact with the reactor vessel snubbers.

### B. Root Mean Square (RMS) Values

The percent RMS in the 0.025 to 5 hz region has been decreasing with core 2 life as shown in figures 10 - 13. As pointed out later, this drop seems to be primarily due to the 2.3 hz peak decreasing in amplitude with time. As shown in Table 3, the RMS values are less than base line and those reported for end of core 1 (Ref. 2).

### C. Power Spected Densities (PSD)

The 0.25 hz peak is about 5db/hz lower for core 2 than reported for the end of life of core 1. This peak has remained stable throughout core 2 and was the same for 80% power and 100% power.

Table 2: Coherence and Phase for Various Excore Detector Combinations

| Detectors | Frequency (hz) | Coherence (max.) | Phase Angle |
|---|---|---|---|
| NI05/06 | 0.025-5 | .19 | 180° |
| | 11-14.5 | .08 | 0 |
| | 15-17 | .33 | 0 |
| | 17-20 | .37 | 180 |
| NI07/08 | 0.025-5 | .2 | 180 |
| | 11.0-14.5 | .16 | 180 |
| | 15-17 | .46 | 0 |
| | 17-20 | .14 | 180 |
| NI05/09 | 0.025-5.0 | .8 | 0 |
| | 11.0-14.5 | .4 | 0 |
| | 15-17 | .64 | 0 |
| | 17-20 | .30 | 0 |
| NI08/10 | 0.025-5.0 | .75 | 0 |
| | 11-14.5 | .1 | 0 |
| | 15-17 | .65 | 0 |
| | 17-20 | .20 | 0 |
| NI05/07 | 0.025-5.0 | .1 | 180 |
| | 11-14.5 | .39 | 180 |
| | 15-17 | .64 | 180 |
| | 17-20 | .2 | 180 |
| NI05/08 | 0.025-5 | .36 | 0 |
| | 11-14.5 | .4 | 180 |
| | 15-17 | .62 | 180 |
| | 17-20 | .16 | 0 |
| NI06/07 | 0.025-5 | .55 | 0 |
| | 11-14.5 | .35 | 180 |
| | 15-17 | .50 | 180 |
| | 17-20 | .15 | -- |
| NI06/08 | 0.025-5 | .10 | 180 |
| | 11-14.5 | .16 | 180 |
| | 15-17 | .66 | 180 |
| | 17-20 | .48 | 180 |

Table 3: % RMS, 0.025 - 5 hz

| Excore | Prerepair** | Baseline** | End of + Core 1* | Beginning of Core 2 | Core 2 Sept. |
|---|---|---|---|---|---|
| NI05 | 0.80 | 0.079 | 0.120 | 0.072 | 0.061 |
| NI06 | 0.69 | 0.073 | 0.100 | 0.064 | 0.057 |
| NI07 | 0.57 | 0.068 | 0.095 | 0.062 | 0.054 |
| NI08 | 0.70 | 0.080 | 0.117 | 0.067 | 0.056 |

* 80% Power
** Reference 1
\+ Reference 2

D. Coherence and Phase

As for core 1, the coherence in the 0.025 - 5 hz region has decreased with core 2 life from 0.4 to 0.2 nominally. The phase relationship, however, has remained $180^{\circ}$ out of phase.

In the 8 - 10 hz region the coherence has decreased from about 0.12 to negligible values. This loss in coherence occurred along with the loss of amplitude in this region in the PSD's. For the regions around 12.8 hz, 15.5 hz, and 17 hz, the coherence and phase values have been constant and at the same frequency from May through September 1976 (Ref. 2).

## VIII. CONCLUSIONS

High Frequency Barrel Motion

Resonant frequencies for the core barrel have been identified at 12.8 hz, 15.5 hz and 18 hz (Ref. 3). These resonant frequencies are for the core barrel clamped. Since they were prevalent in the data it is indicative that the barrel is indeed well clamped and not loosening.

Low Frequency Battel Motion

In the low frequency region ( $<5$ hz) there is strong coherence and inverse phase relationships in the 0.75 - 3 hz region for excores diagonally across the core. The magnitude of the barrel motion in this frequency range is found through use of the following equation (Ref. 3):

$$\#\text{mils RMS motion} = \frac{100}{.0376}\sqrt{\sqrt{\text{NPSD}_a}\ \sqrt{\text{NPSD}_b}\ (f_2-f_1)\ \gamma}$$

where $\gamma^2$ = coherence

$\text{NPSD}_a$ is the area under the normalized PSD for detector a in the frequency band $f_2-f_1$.

Using run 10-1-76-5 with a $\gamma^2$ of 0.19 a value of 0.25 mils RMS is obtained.

## REFERENCES


1. Consumers Power Company, Reactor Internals Noise Monitoring Test; Completion of Baseline Noise Data, May 22, 1975.

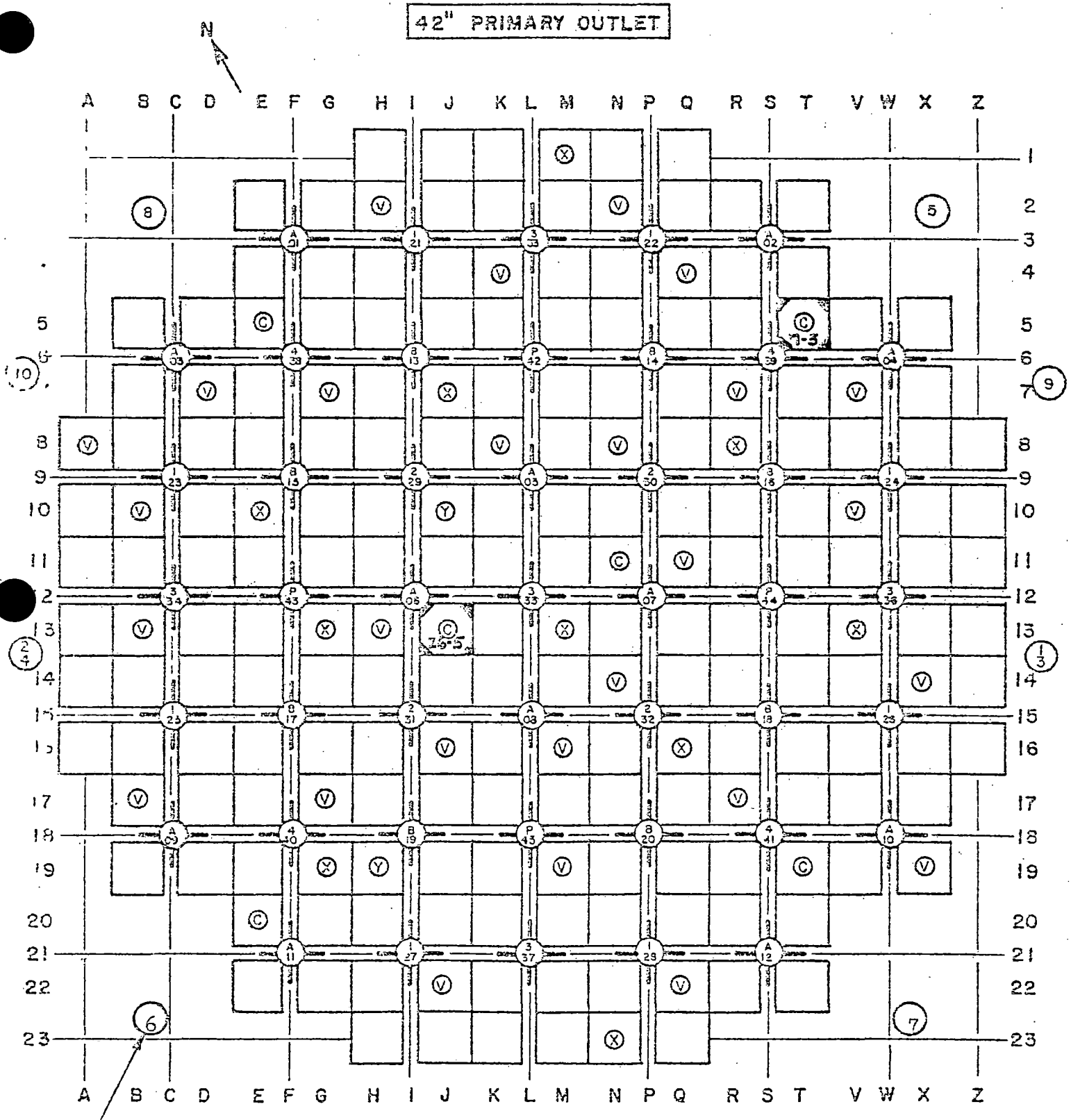
2. Consumers Power Company, Reactor Internals Noise Monitoring Tests, January 9, 1976.

3. Thie, J.A., Neutron Noise Behavior Near End of Fuel Cycle, prepared for Consumers Power Company, December 19, 1975.

4. Exxon Nuclear Company, Inc., Design Report for Palisades Reload Fuel Addendum 2, XN-76-9, April 1976.

FIGURE #1(a)

# Palisades Plant – Reactor Core Plan




In-core Detectors:

- (V) = Full Length Vanadium
- (C) = Full Length Cobalt
- (X) = Long background
- (Y) = Short background

All in-core detectors contain 4 Rhodium detectors and 2 Thermocouples

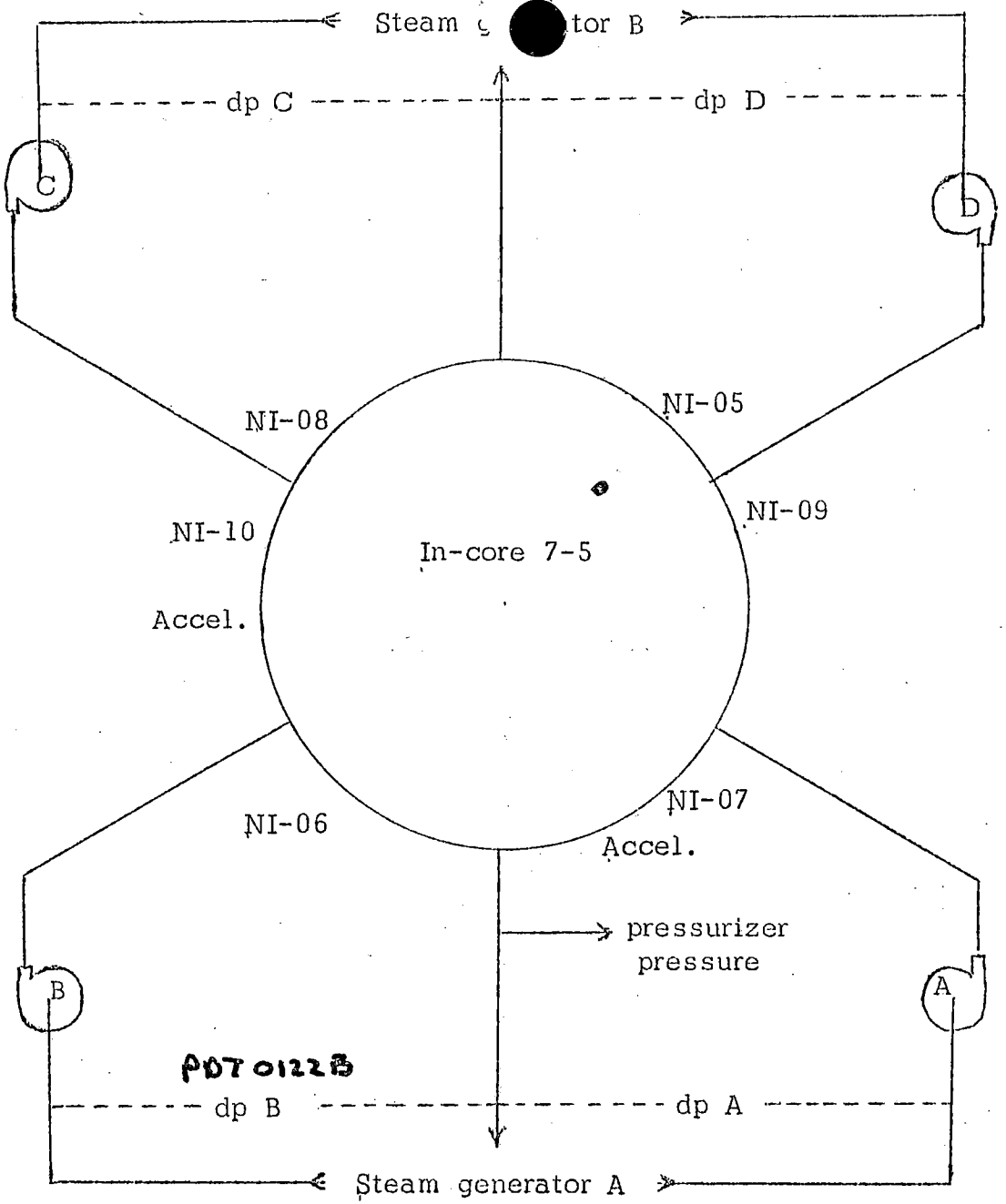
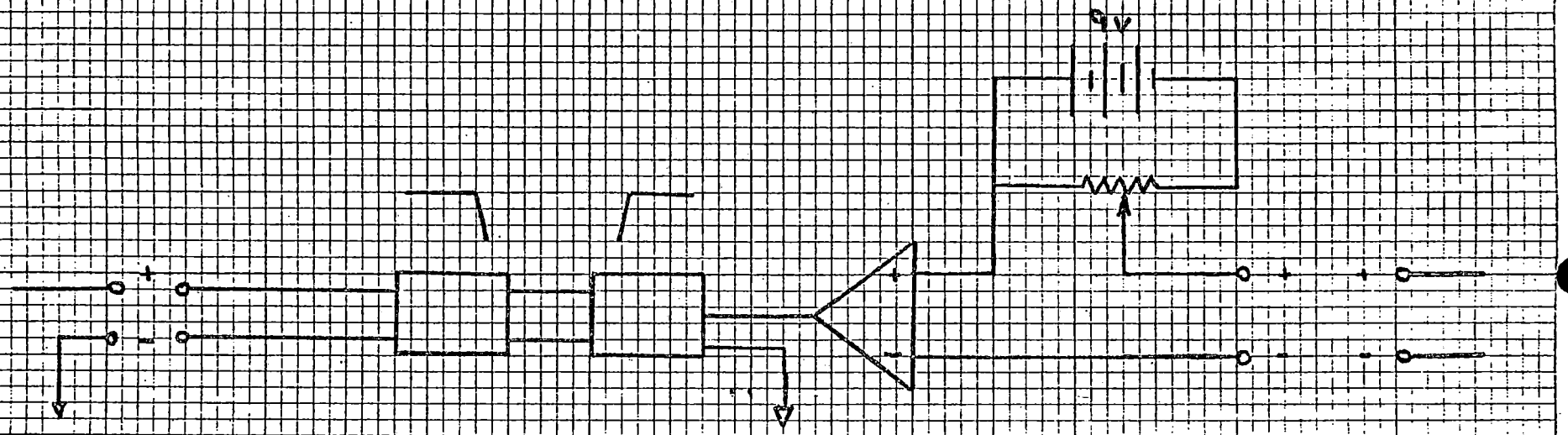



Fig. 1(b) Instrumentation locations for noise tests




INPUT TO SIGNAL ANALYZER HP-5451 B

LOW PASS FILTER 24 DB/OCT.

HIGH PASS FILTER 24 DB/OCT.

OPERATIONAL AMPLIFIER GAIN 1.0 TO 1000

DC BATTERY BUCKING CKT. (Used for NIOS-8)

BUFFERED TEST SIGNAL

FIGURE 1(C)

SIGNAL PROCESSING FOR NOISE ANALYSIS

FIGURE 2

APD EXCORE NI-05

POWER LEVEL: 100%

HP FILTER: 0.025HZ

LP FILTER 20.0HZ

AUGUST, 1976

RUN 8-17-76-1

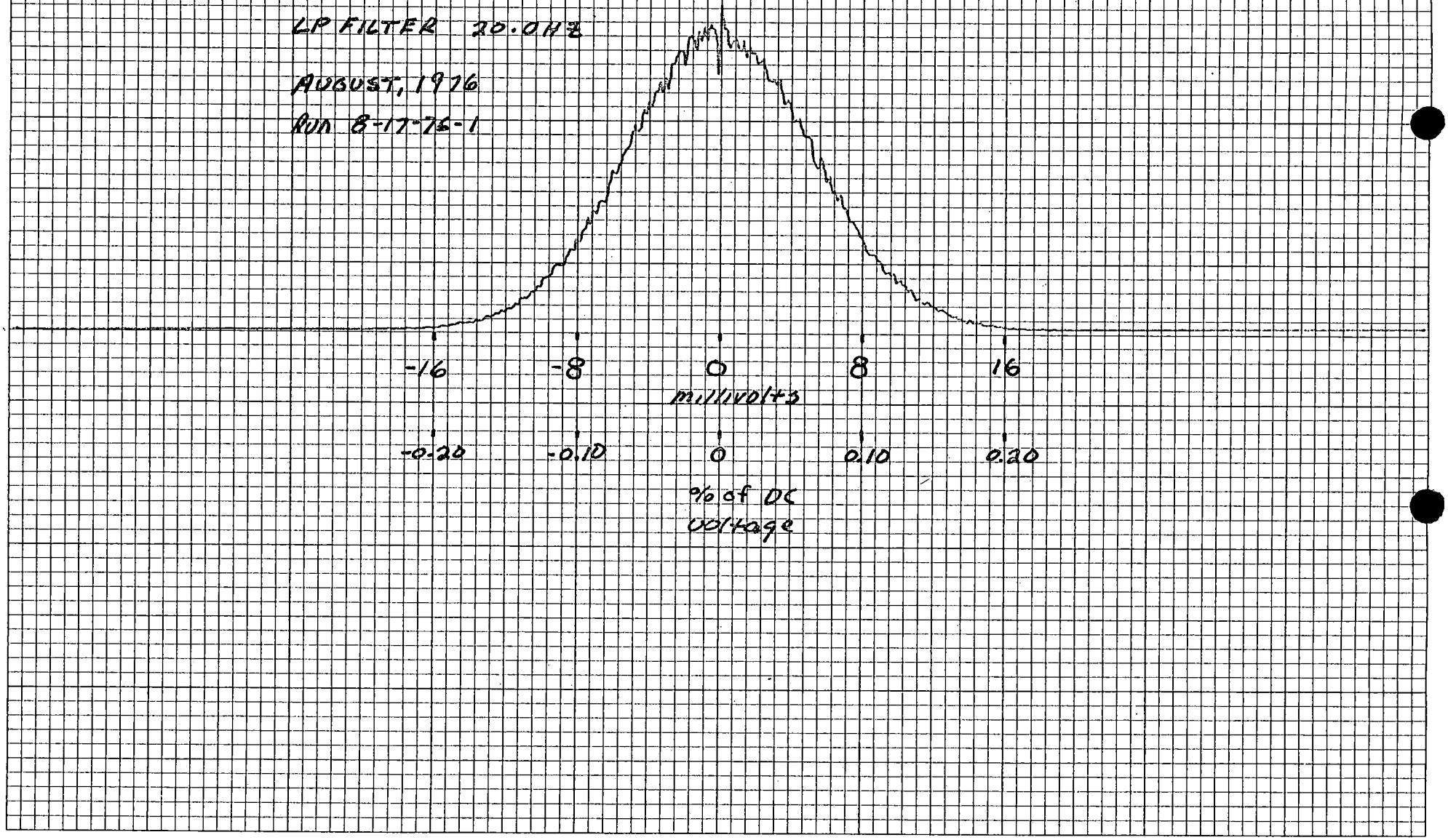


FIGURE 3

IAPD JJI-05

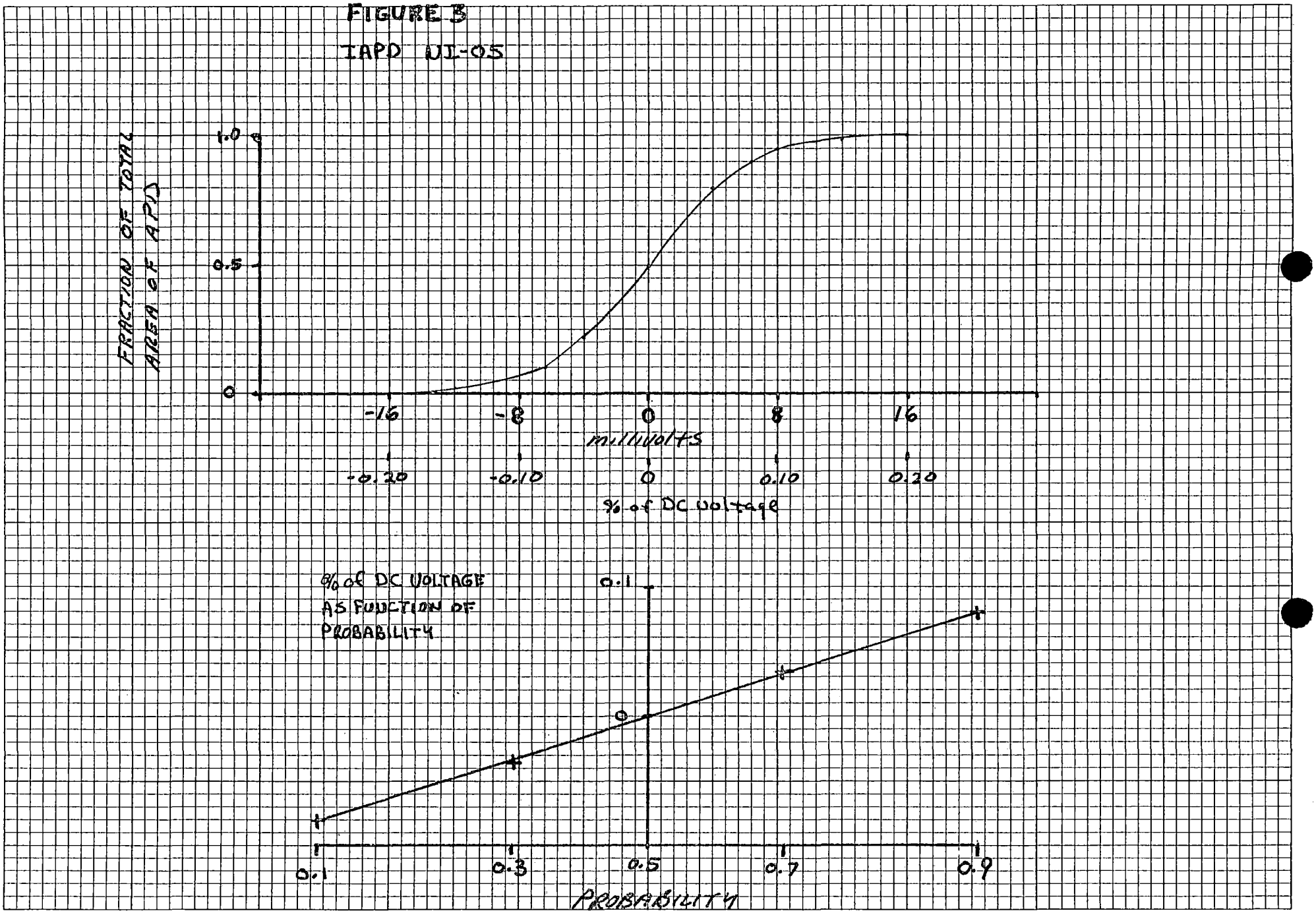


FIGURE 4

APD EXCORE NI-06

POWER LEVEL: 100%

HP FILTER: 0.025 HZ

LP FILTER: 20.0 HZ

AUGUST, 1976

RUN 8-16-76-2

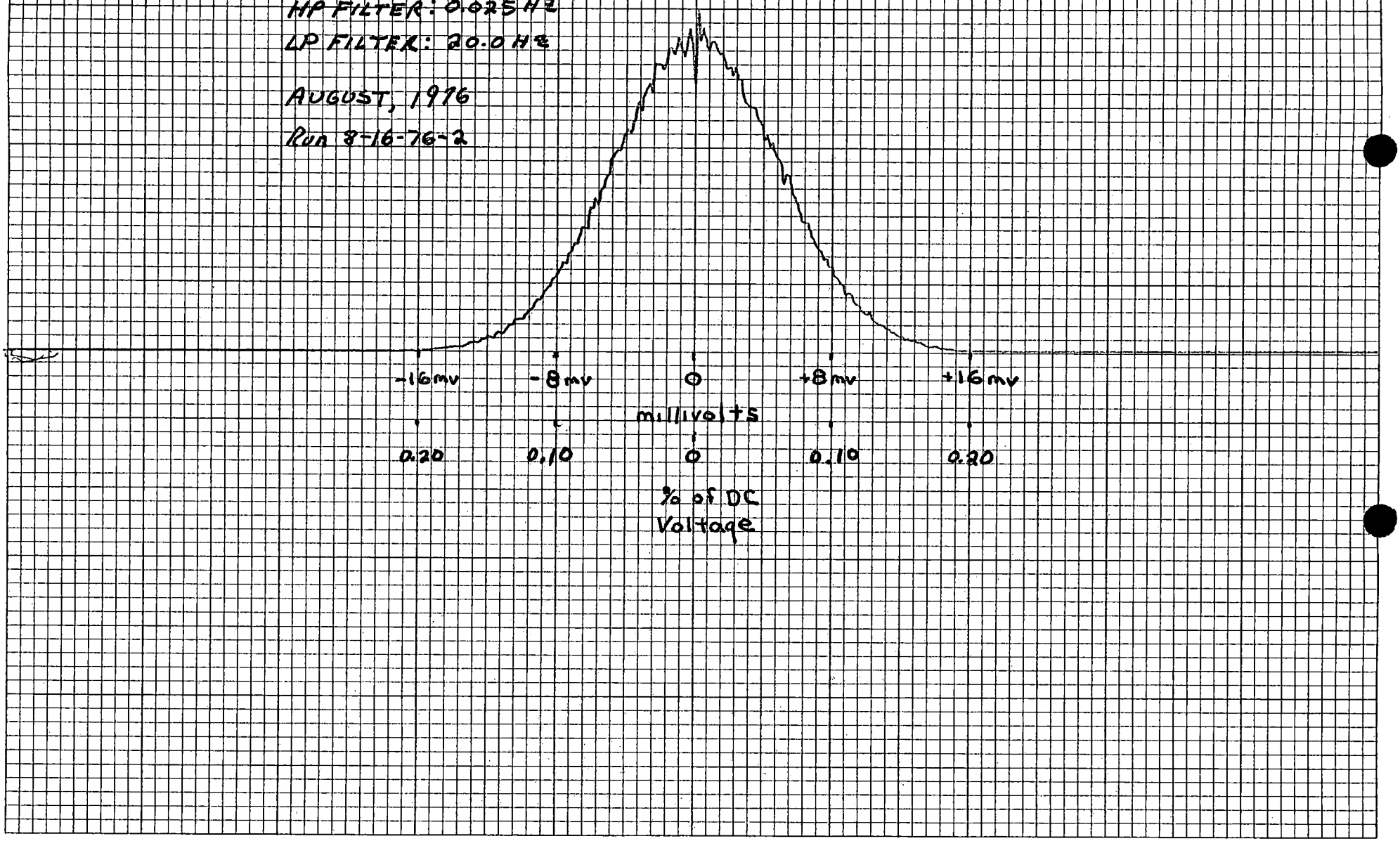


FIGURE 5

IAPD WI-06

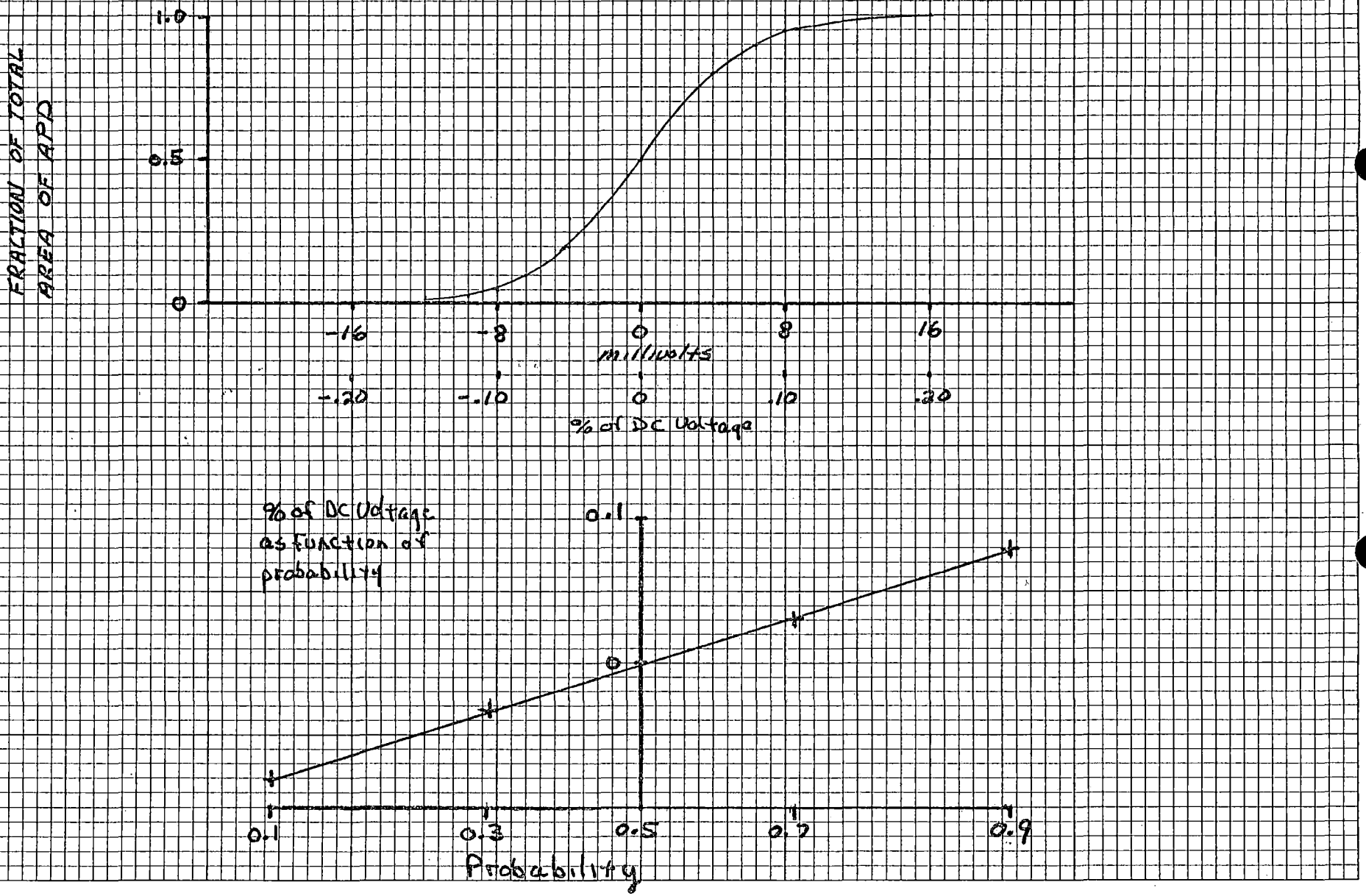


FIGURE 6

APD EXCORE NI-07

POWER LEVEL: 100%

HP FILTER: 0.025Hz

LP FILTER: 20.0Hz

AUGUST, 1976

RUN 8-16-76-2

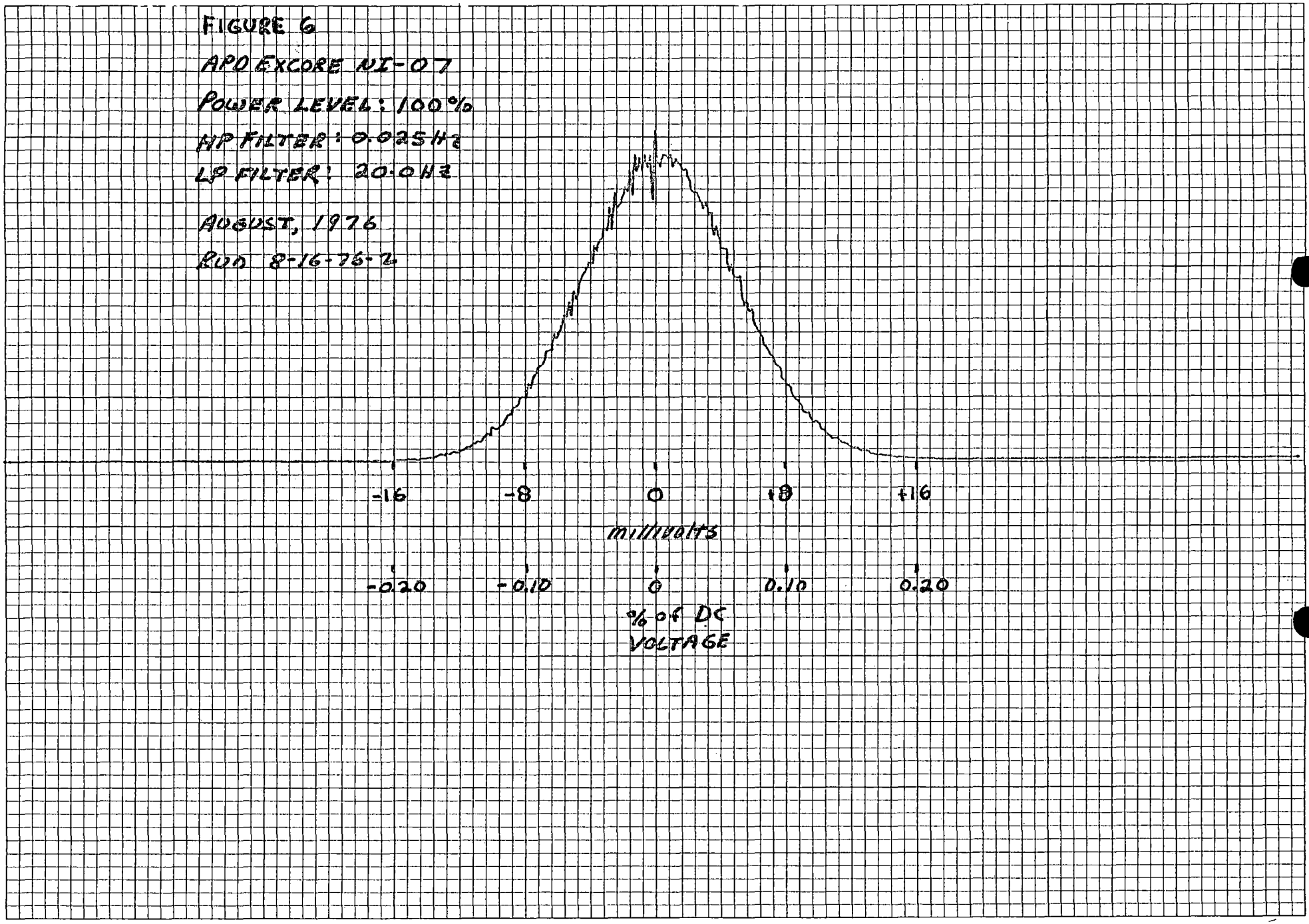
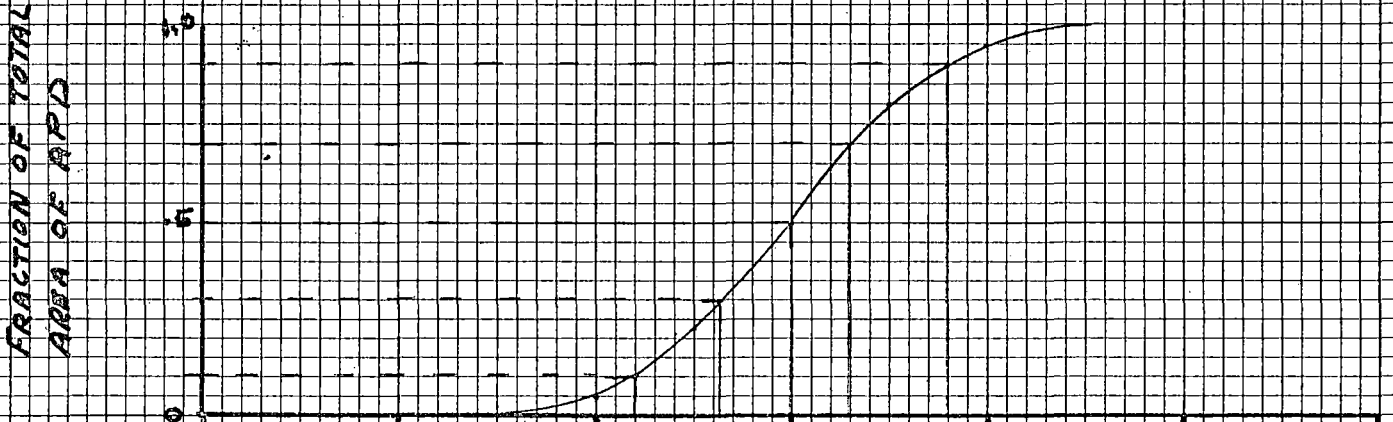


FIGURE 7

IAPD WI-07



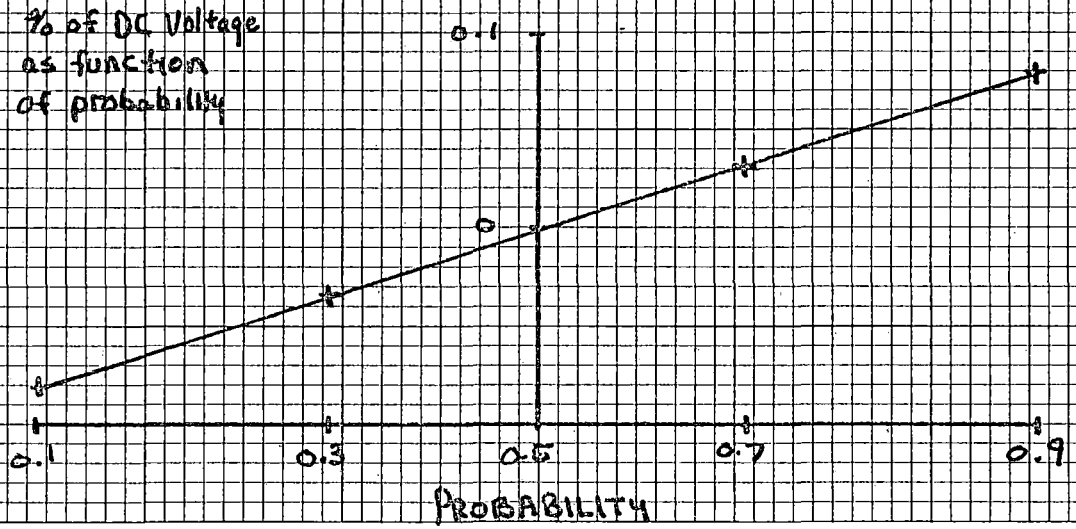



FIGURE 8

APD EXCORE NI-08

POWER LEVEL: 100 %

HP FILTER: 0.025 Hz

LP FILTER: 20.0 Hz

August, 1976

Run 8-17-76-2

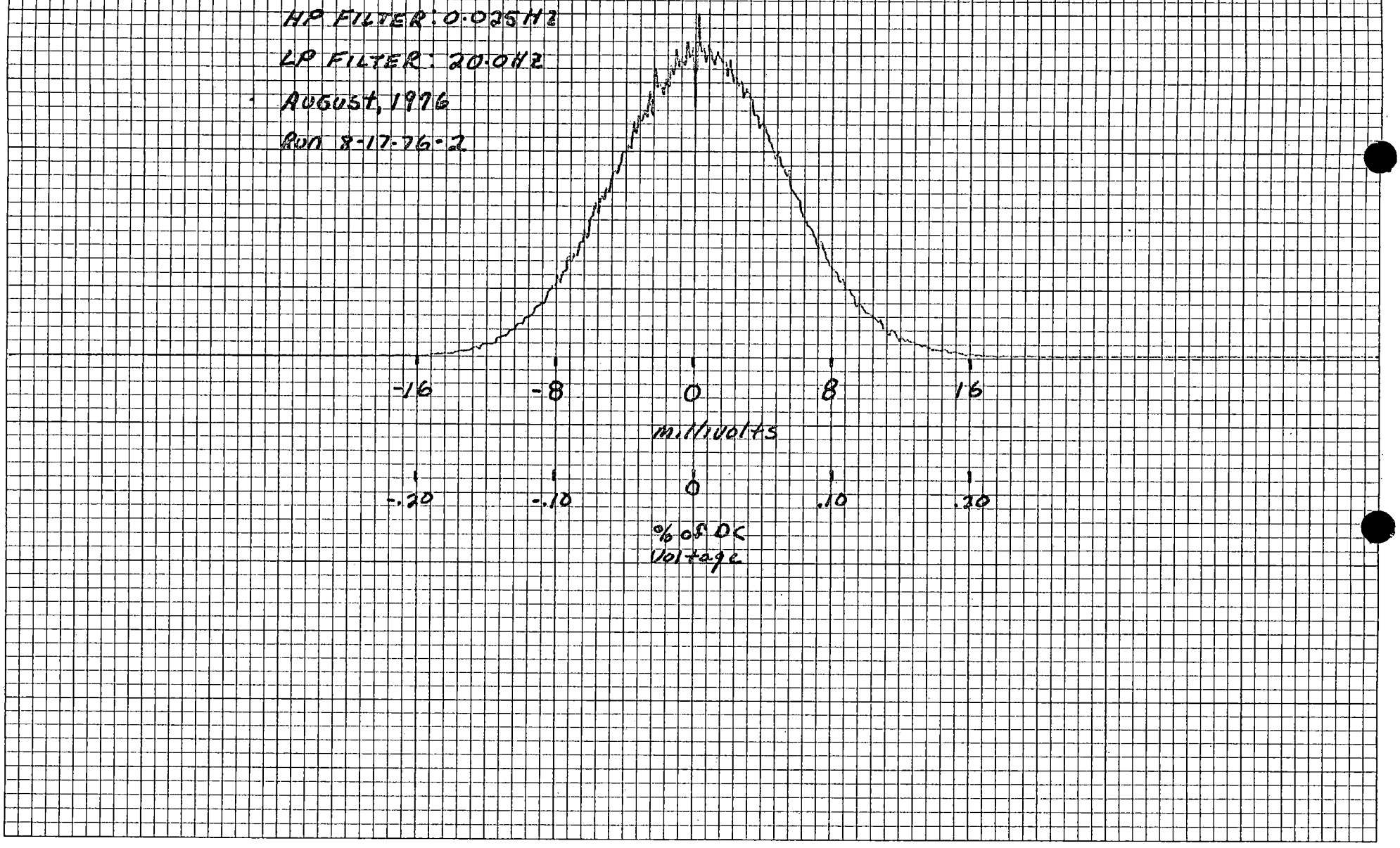
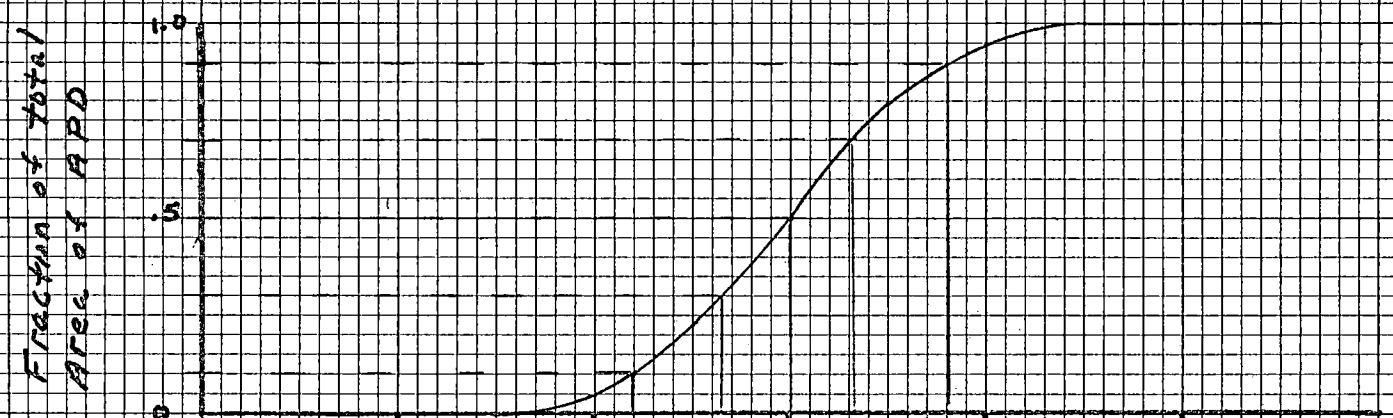


FIGURE 9

IAPD NT-08



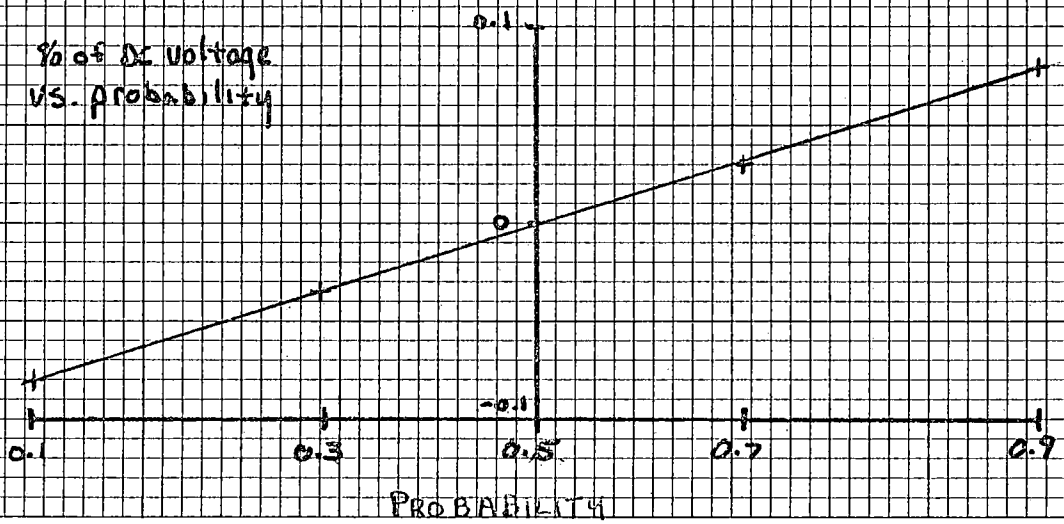



FIGURE 10

# NI-05

## %RMS vs. TIME

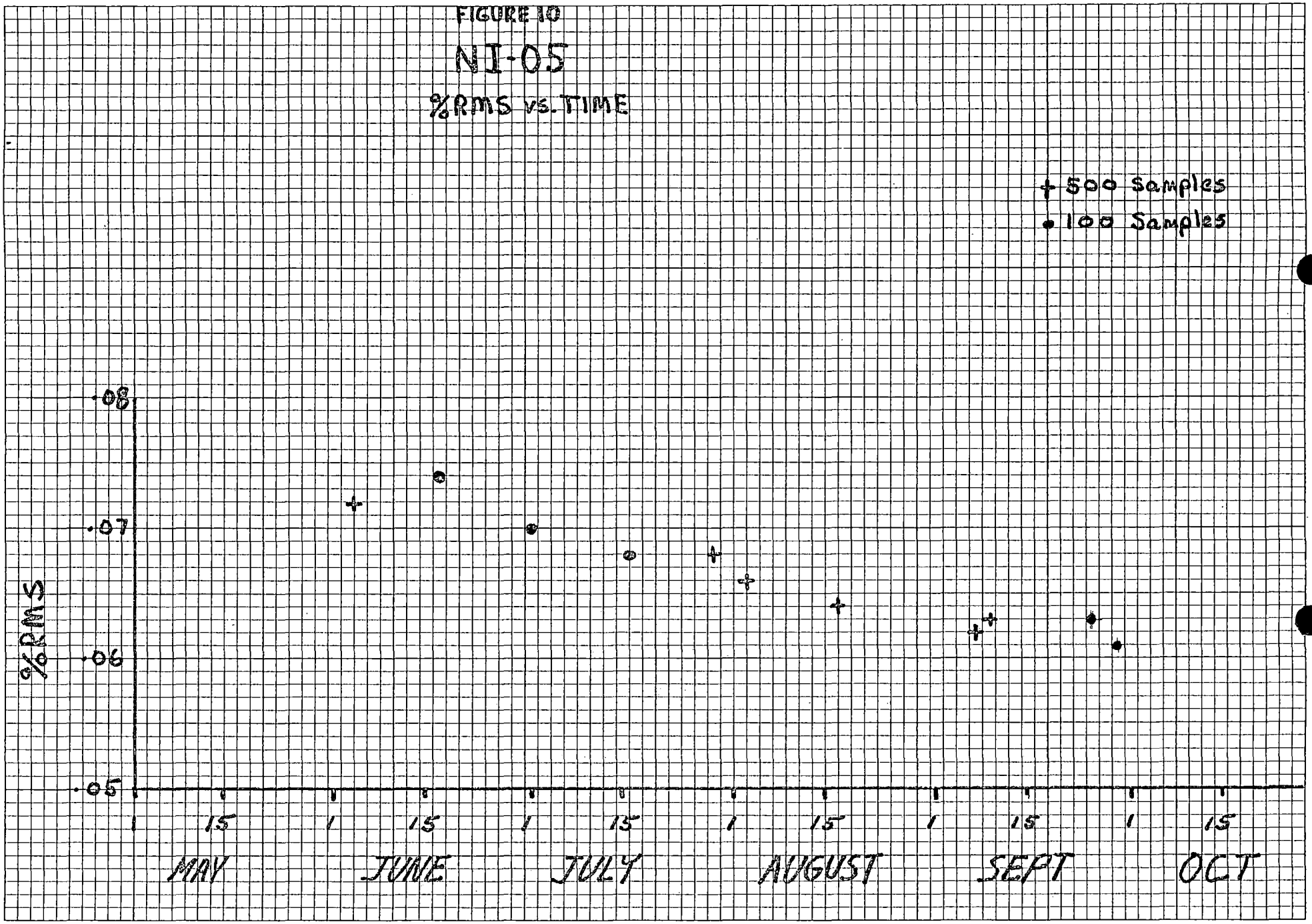


FIGURE 11

# NI-06

## %RMS vs. TIME

+500 Samples

•100 Samples

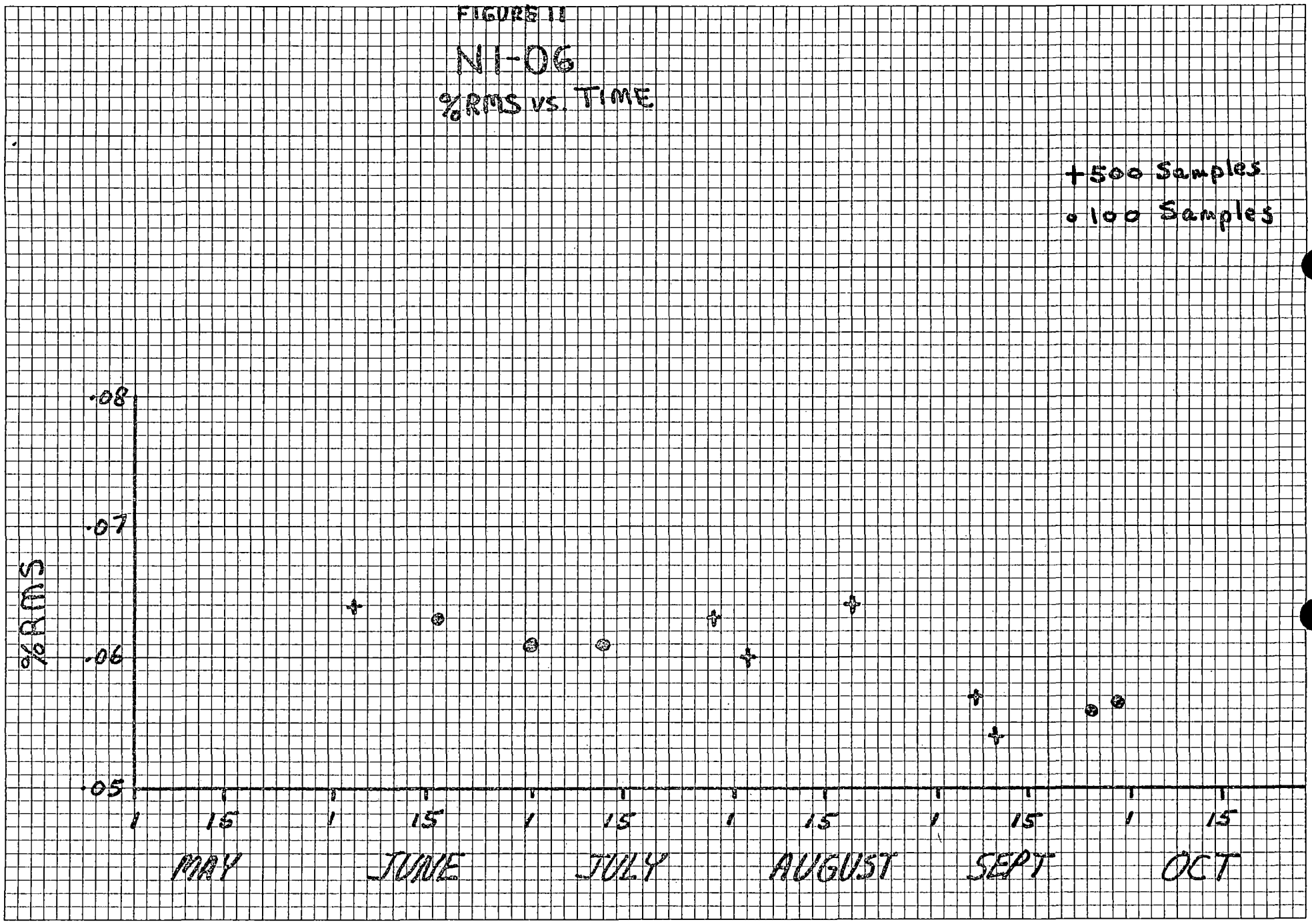


FIGURE 10

# NE-07

## %RMS vs. TIME

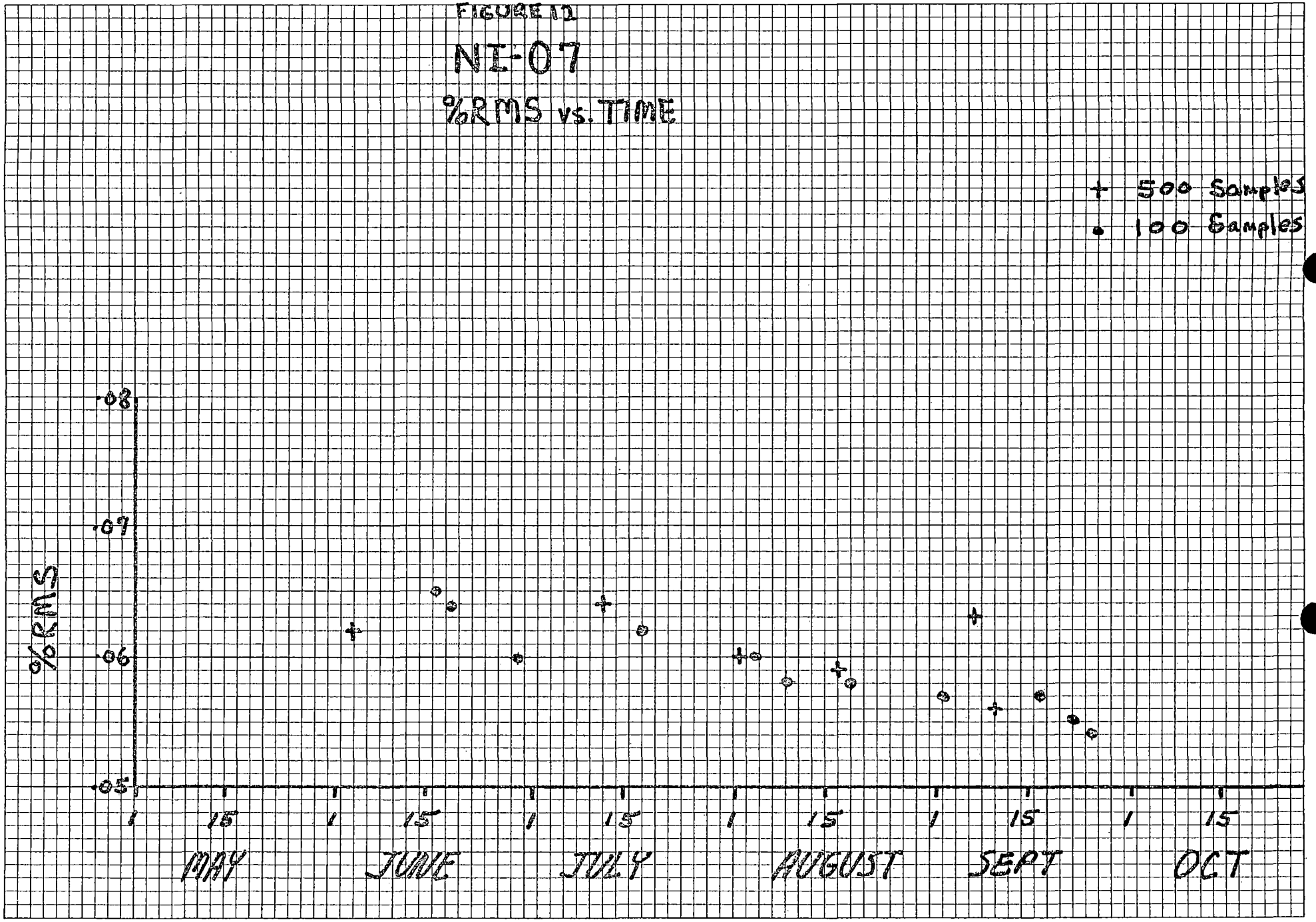


FIGURE 13

# NL-08

## %Rms vs. Time

+ 500 Samples
• 100 Samples

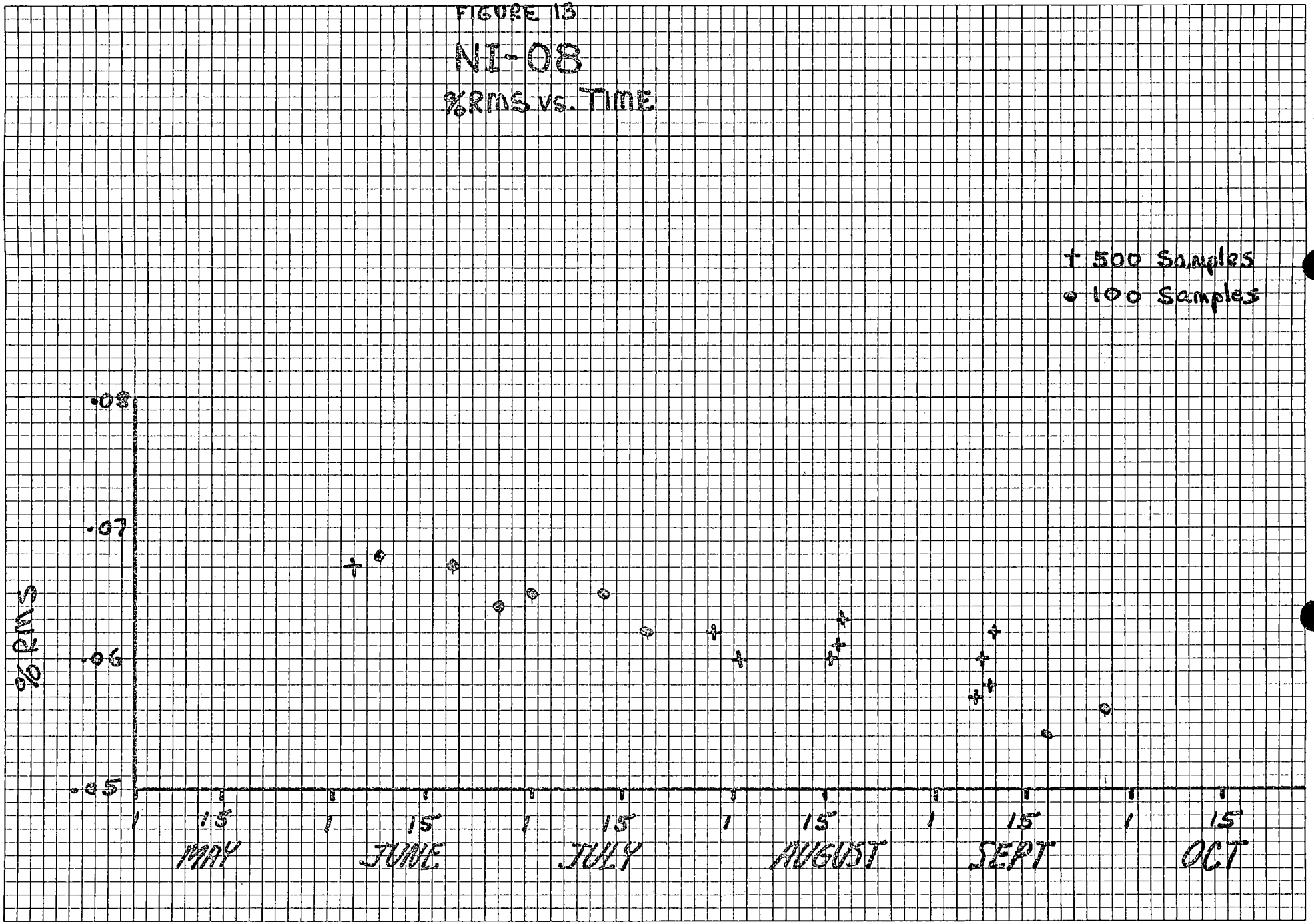


FIGURE 14

APD EXCORE NI-05

POWER LEVEL : 100%

HP FILTER : 0.75Hz

LP FILTER : 3.0 Hz

October, 1976

Run 10-1-76-6

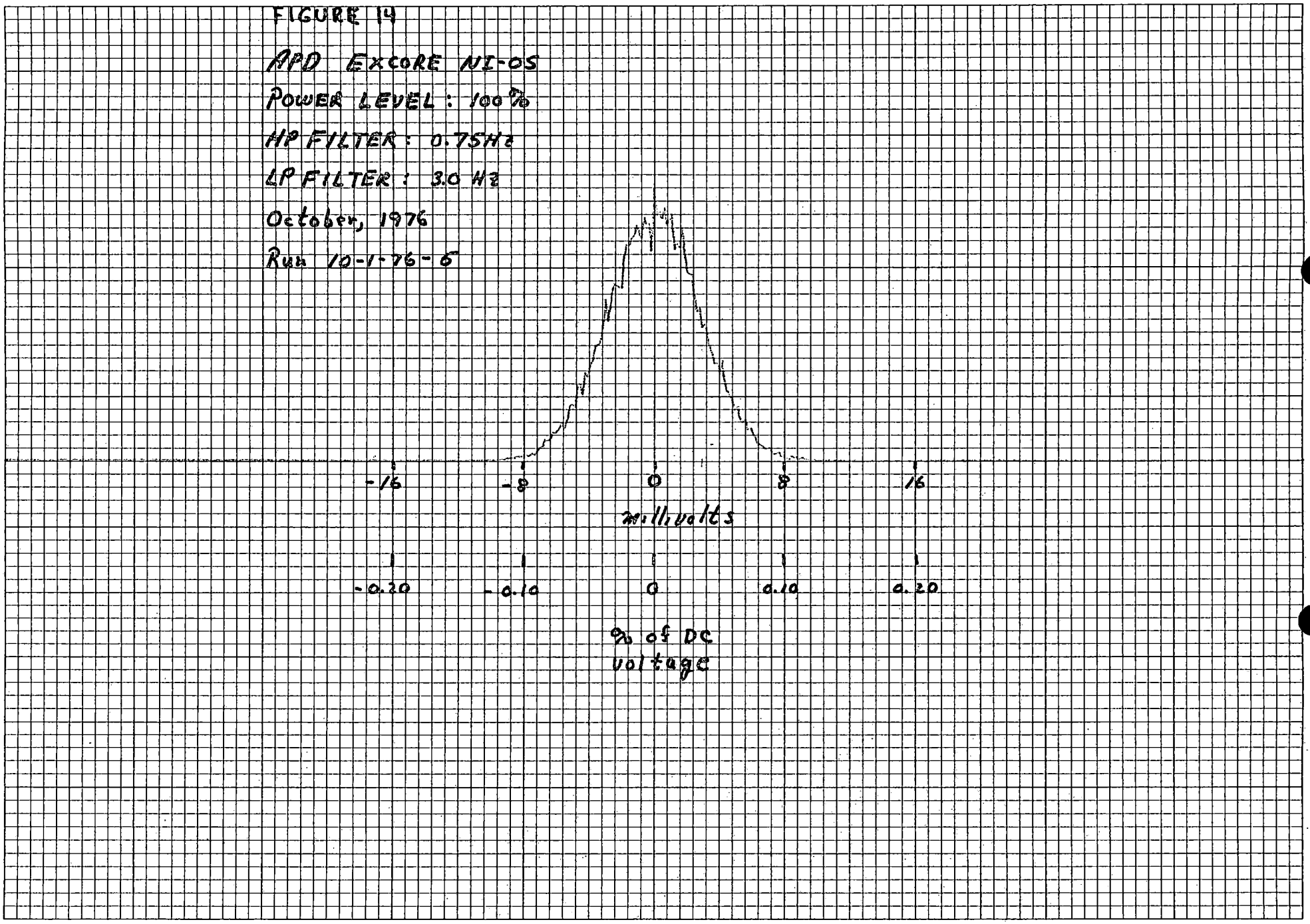


FIGURE 15

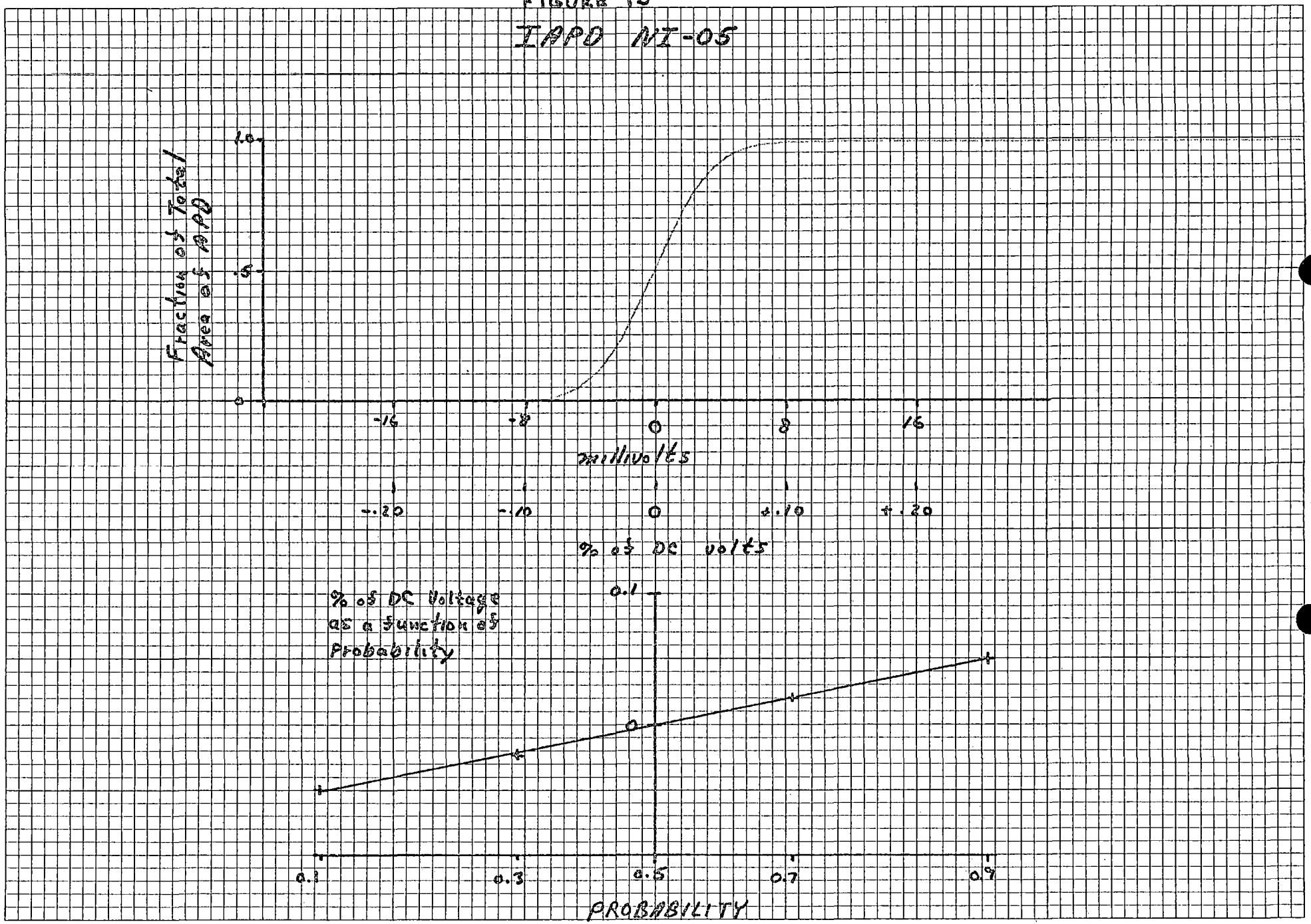


FIGURE 16

ARD EXCORE NI-06

Power Level: 100%

HP FILTER: 0.75 Hz

LP FILTER: 3.0 Hz

October, 1976

Run 10-1-76-5

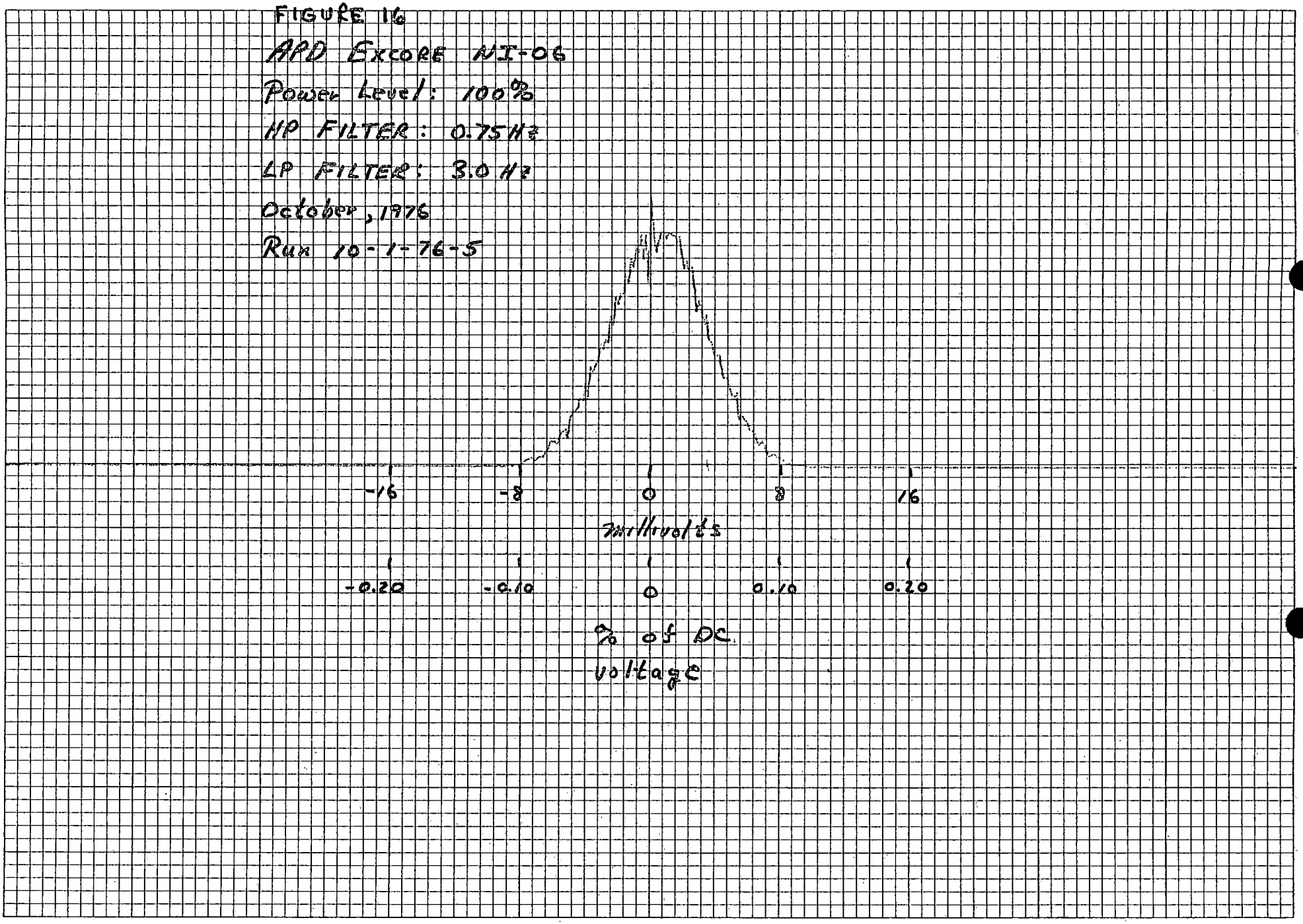


FIGURE 17

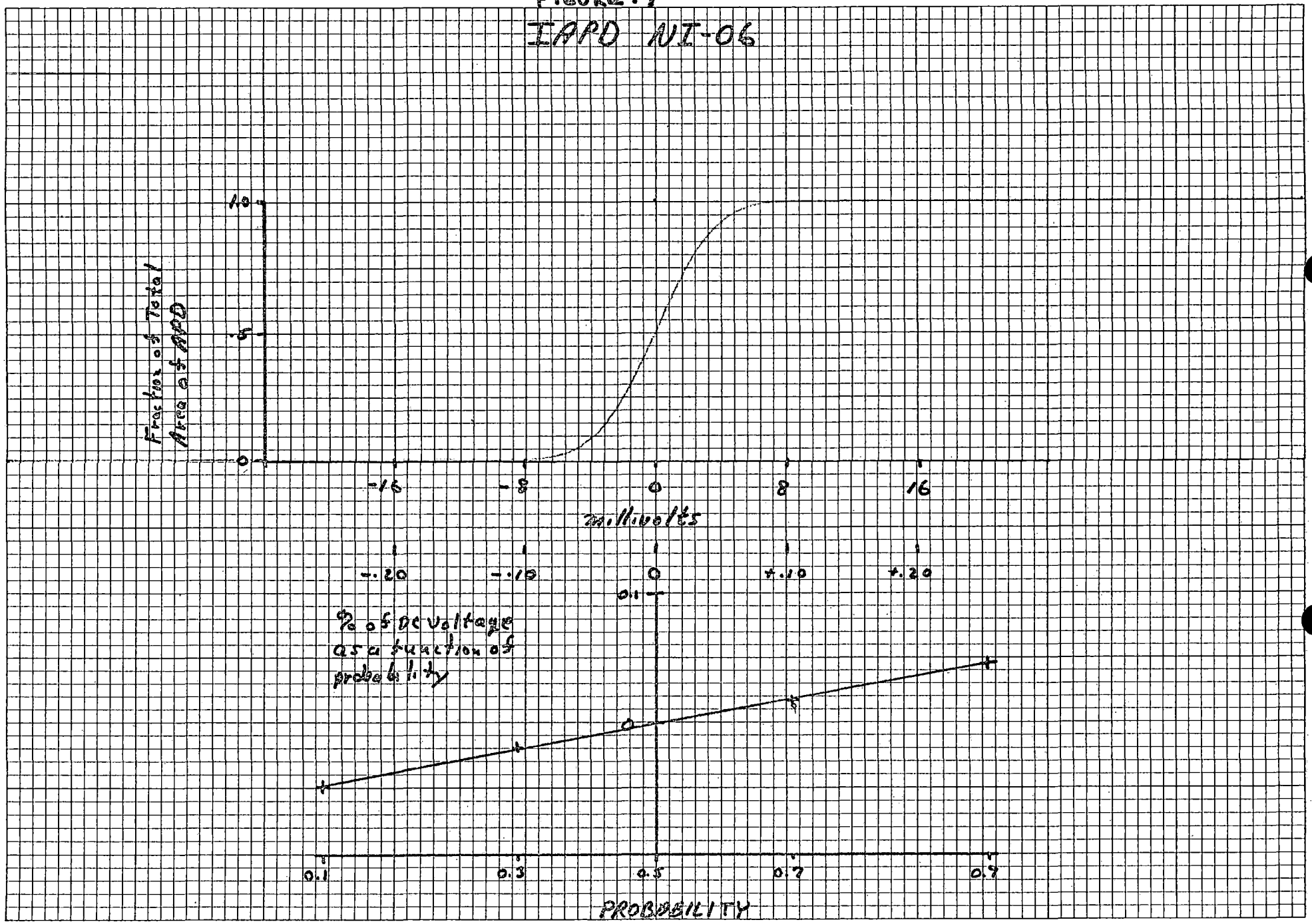


FIGURE 18
APO Excore N107
Power Level: 100%
HP FILTER: 0.75 Hz
LP FILTER: 3.0 Hz
October, 1976
Run 10-1-76-4

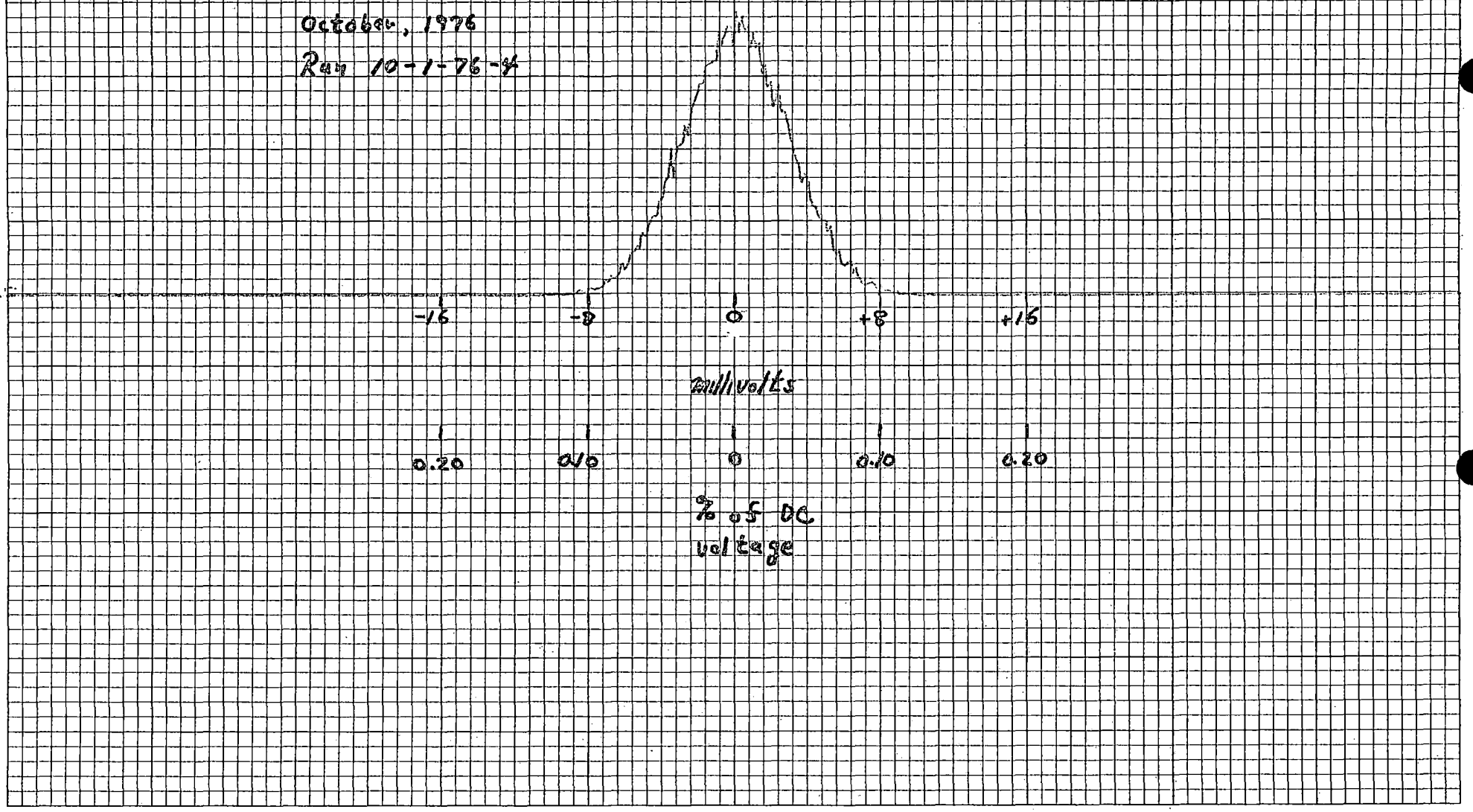


FIGURE 19

IAPD NIT-07

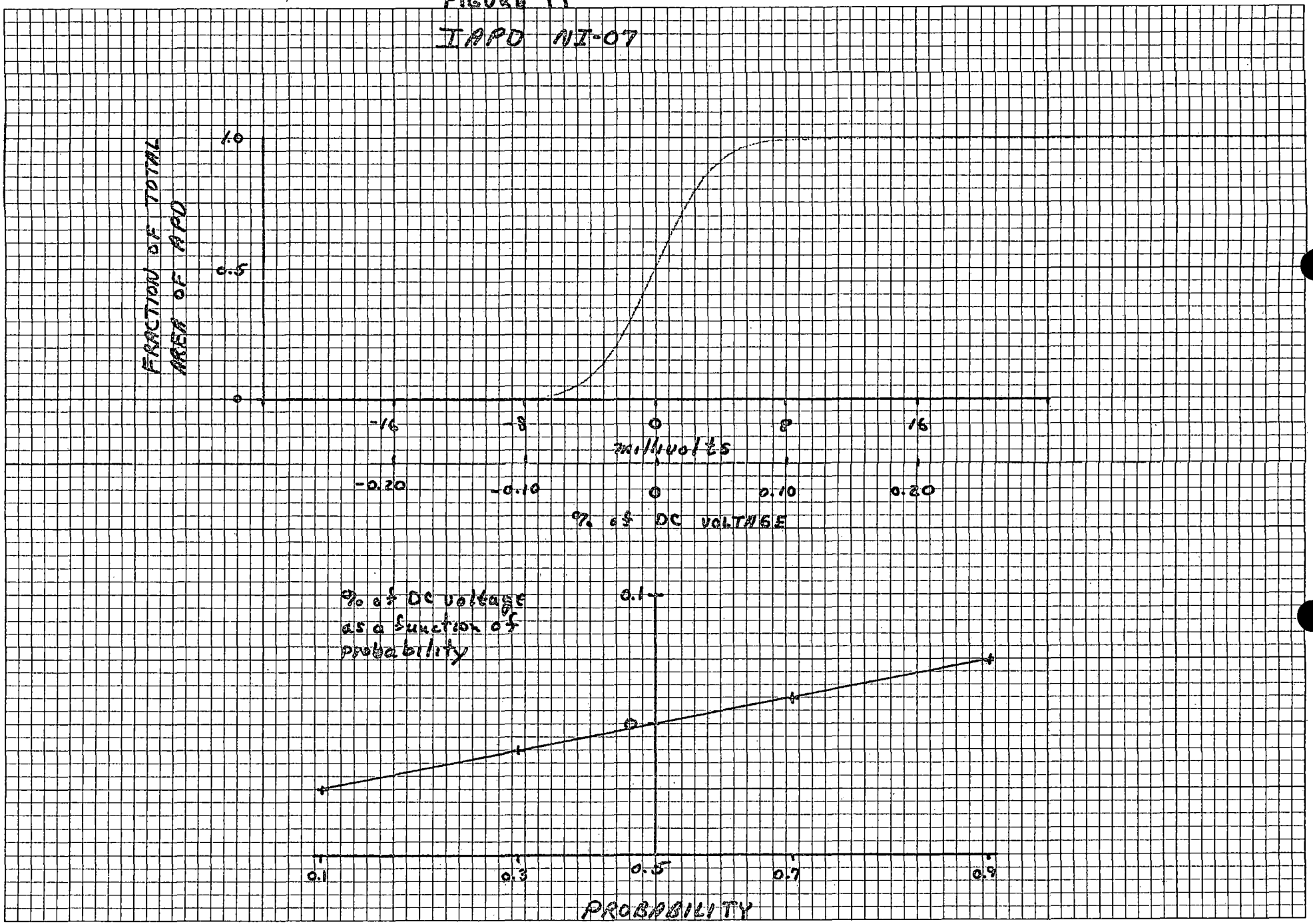


FIGURE 20
APD EXCORE NI-08
POWER LEVEL : 100%
HP FILTER : .075 Hz
LP FILTER : 3.0 Hz
OCTOBER, 1976
RUN 10-1-76-4

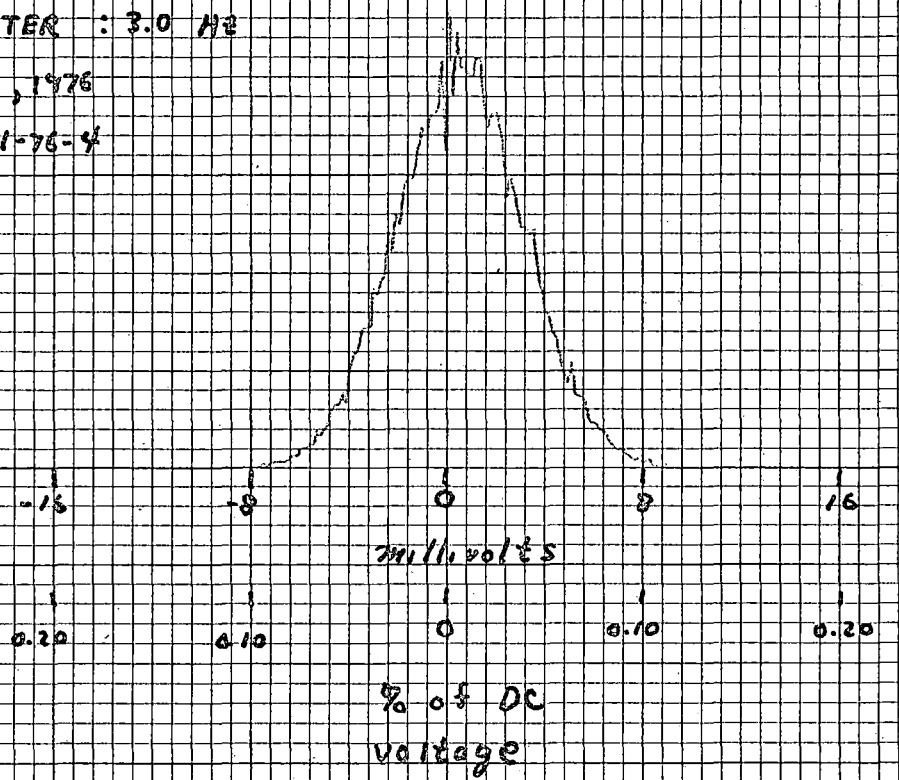
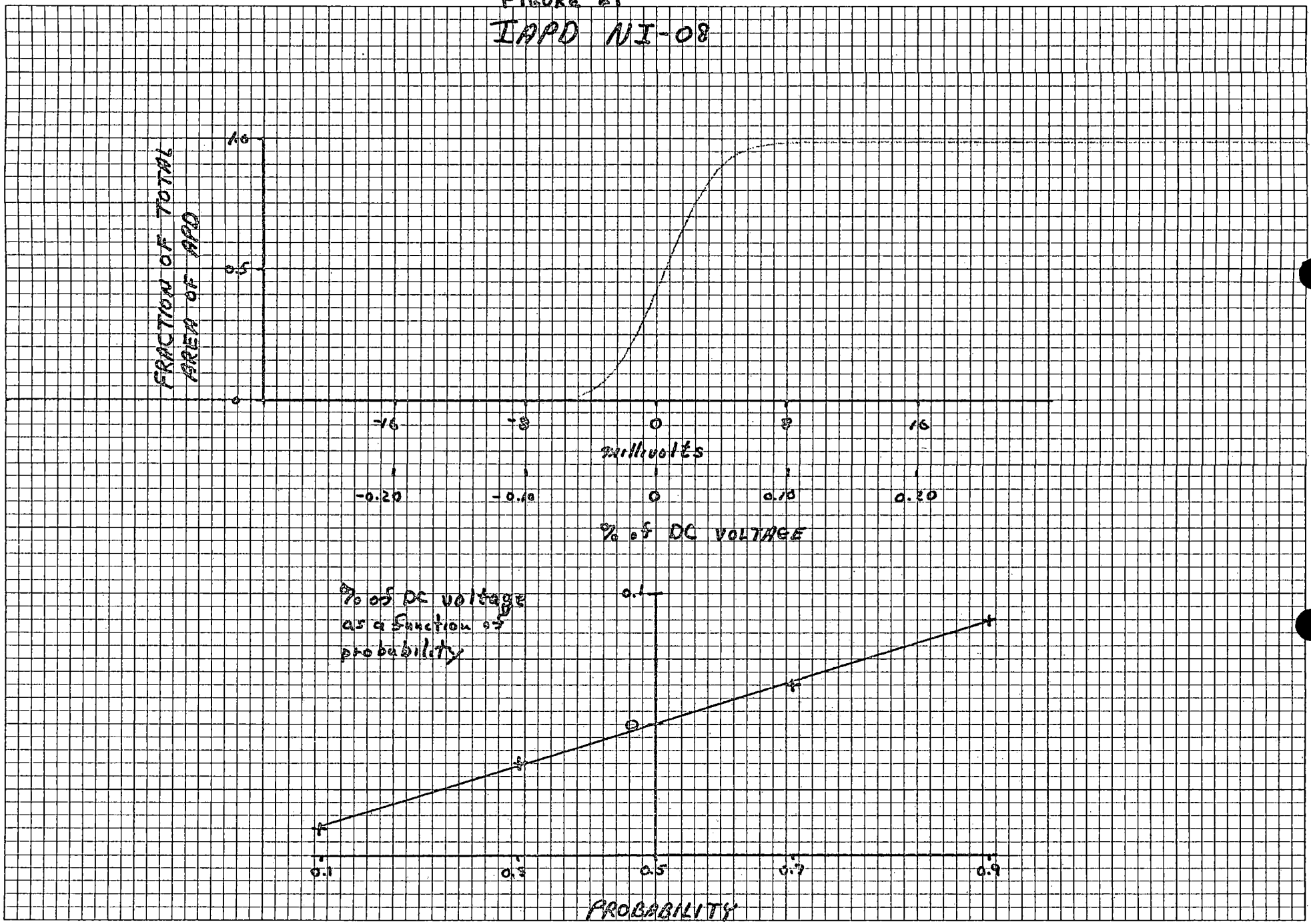
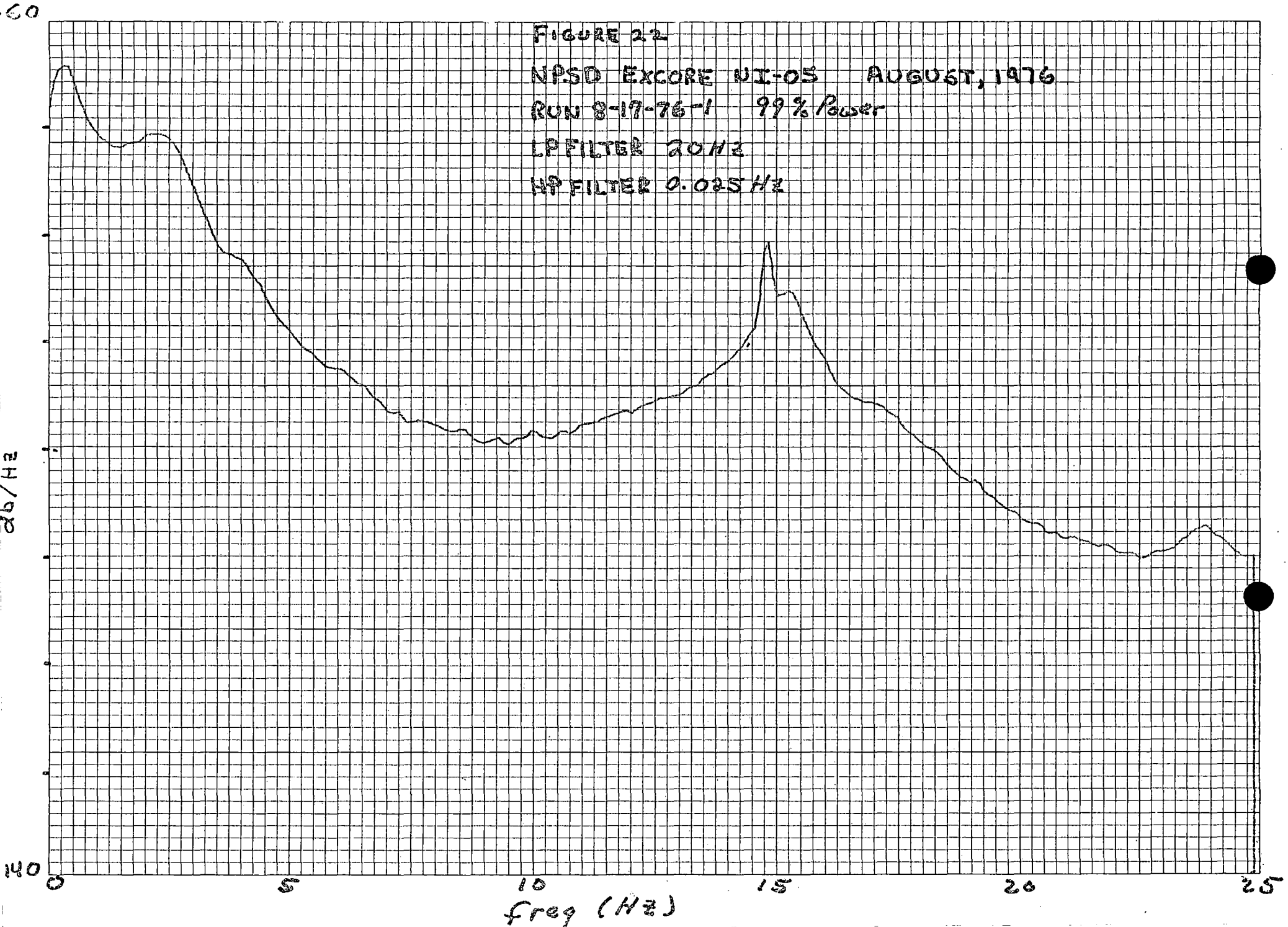


FIGURE 21

IAPD NI-08





(23)

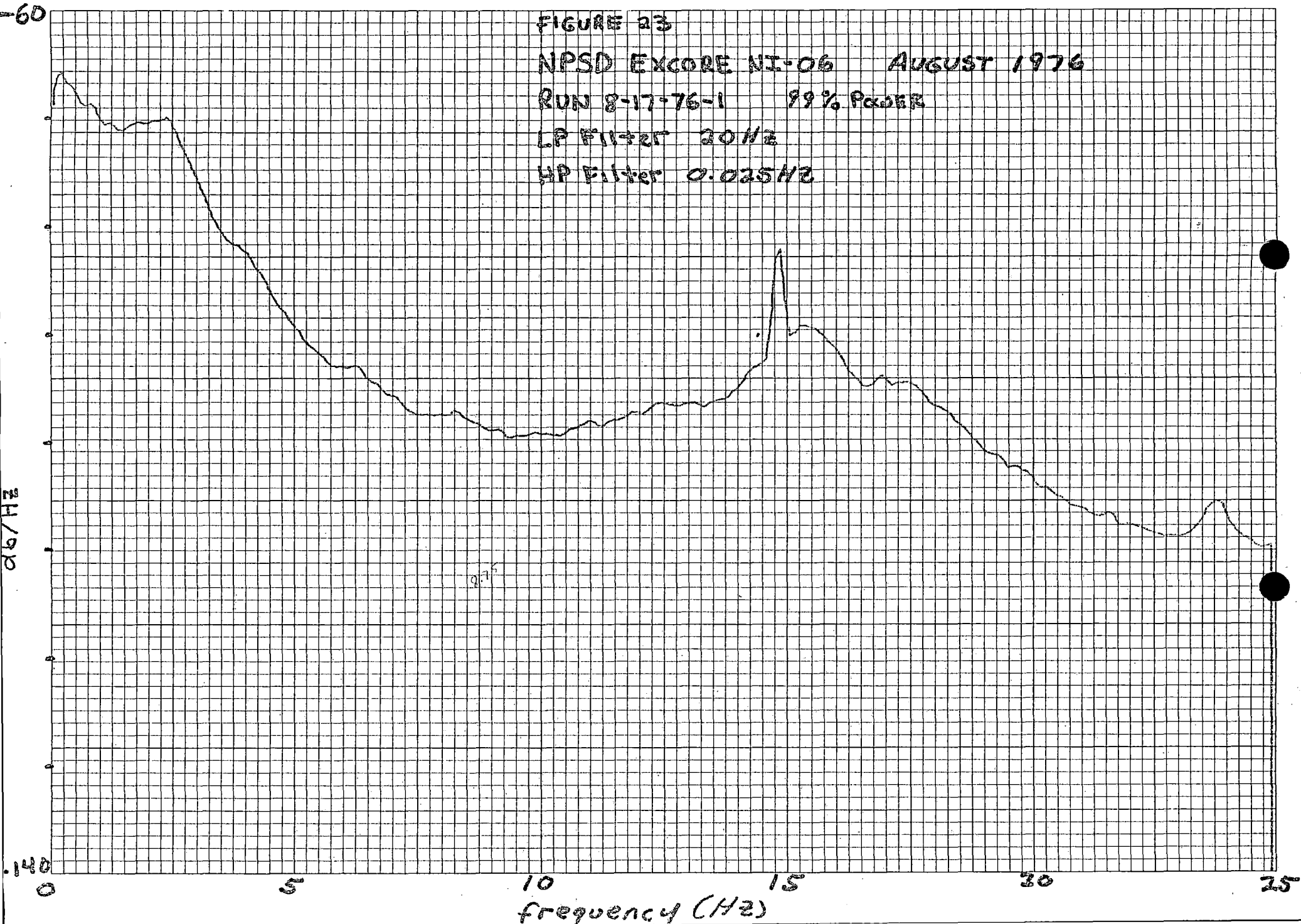
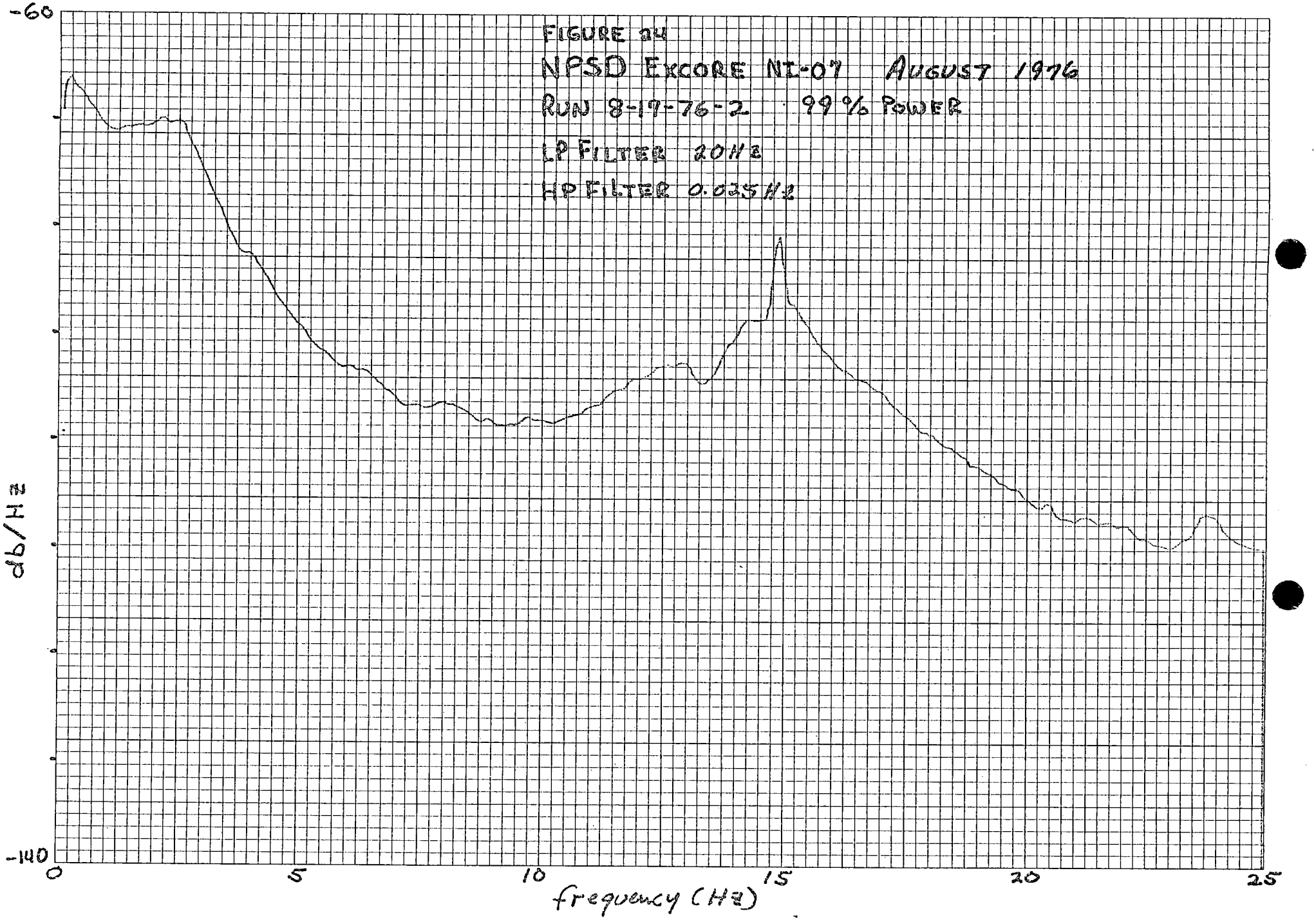
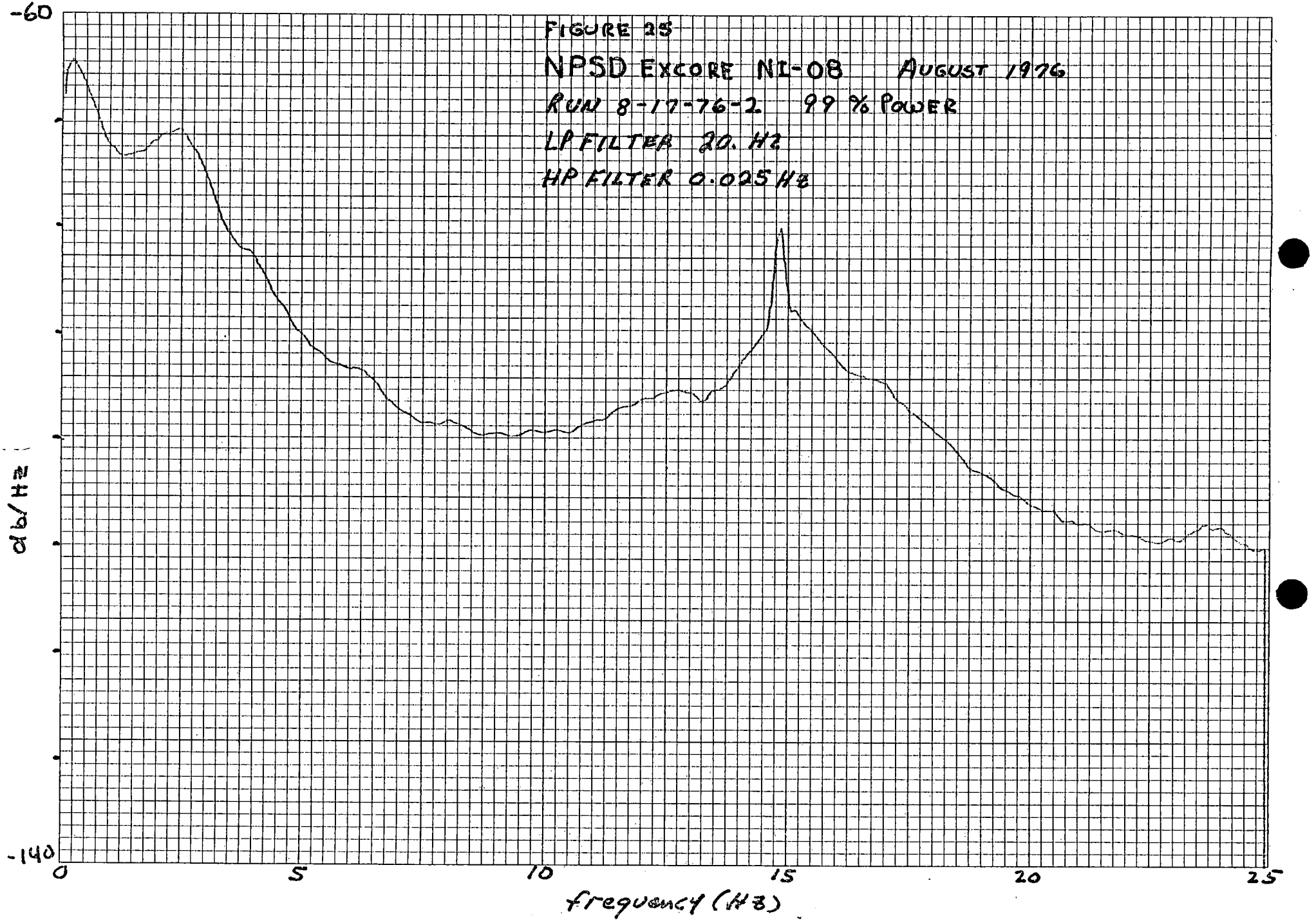
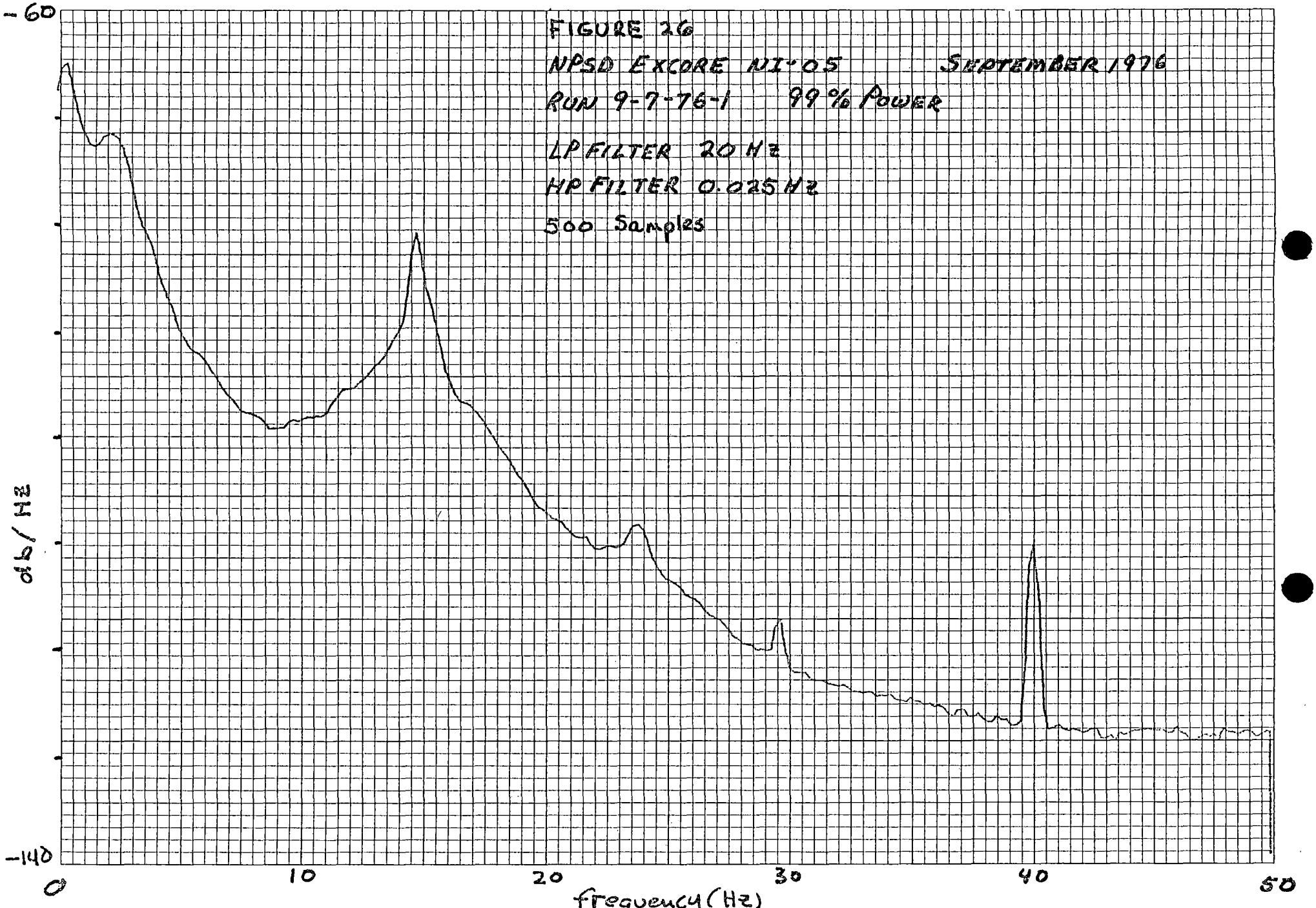



FIGURE 23
NPSD EXCORE NI-06 AUGUST 1976
RUN 8-17-76-1 99% POWER
LP FILTER 30 Hz
HP FILTER 0.025 Hz







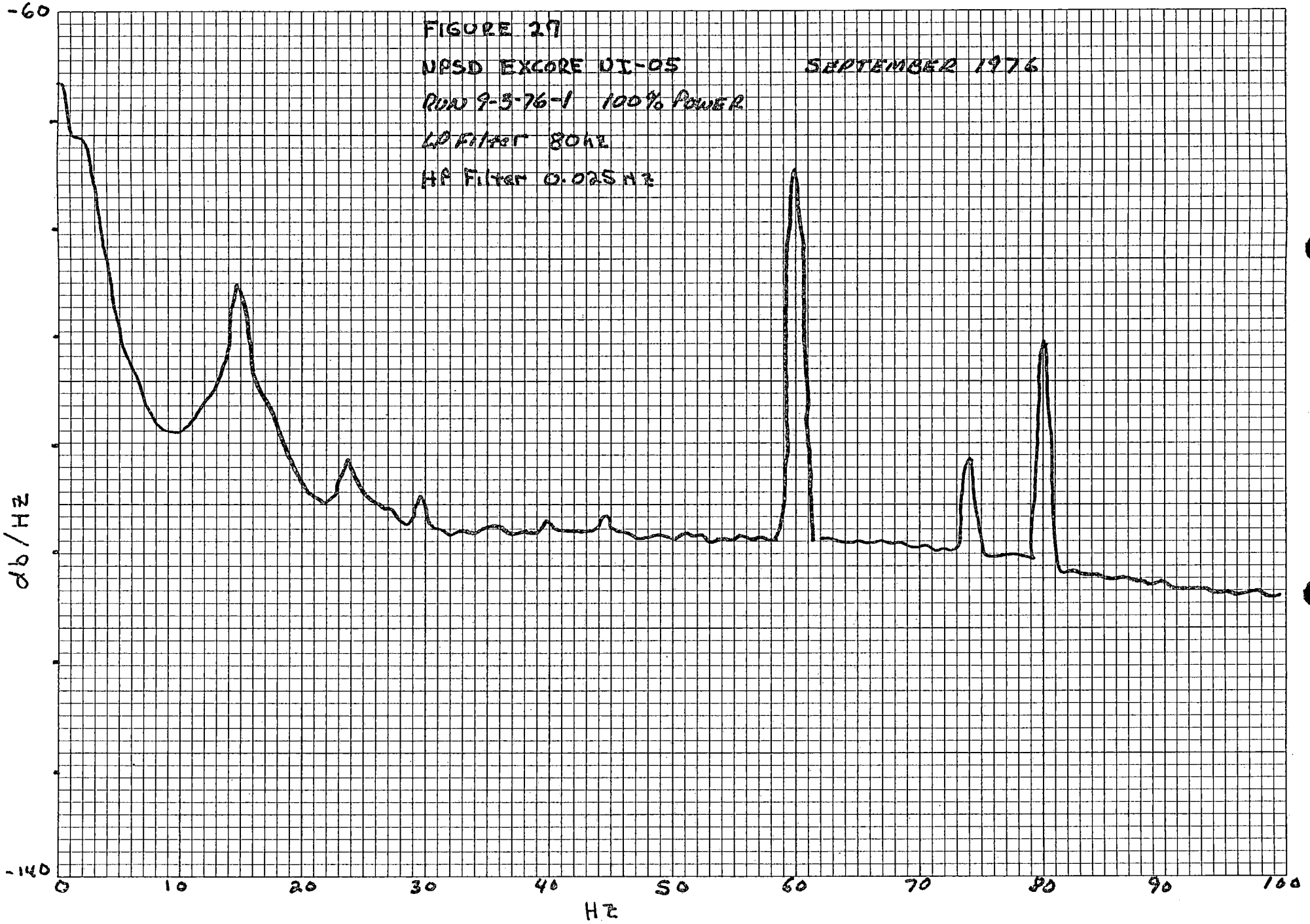
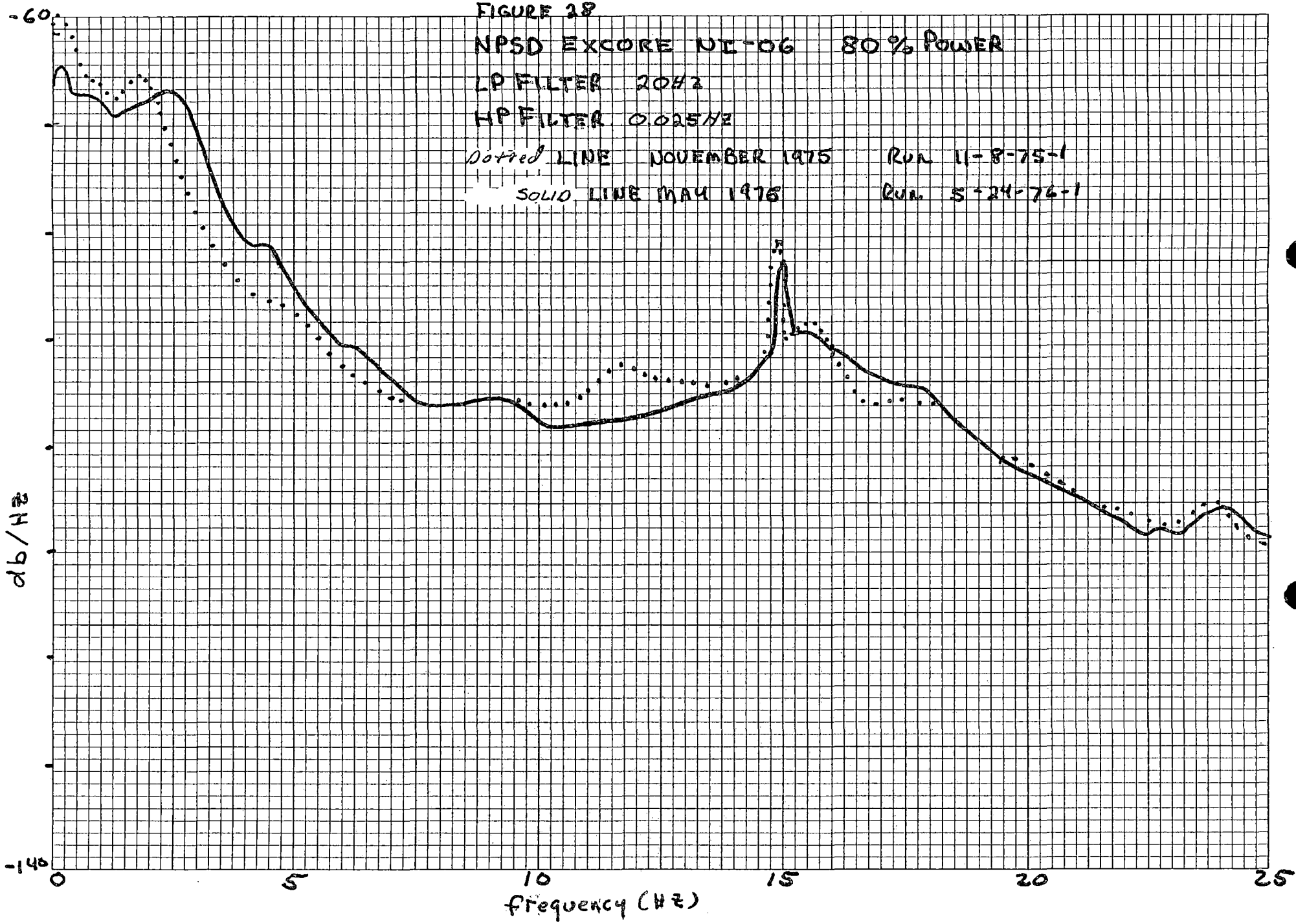


FIGURE 28



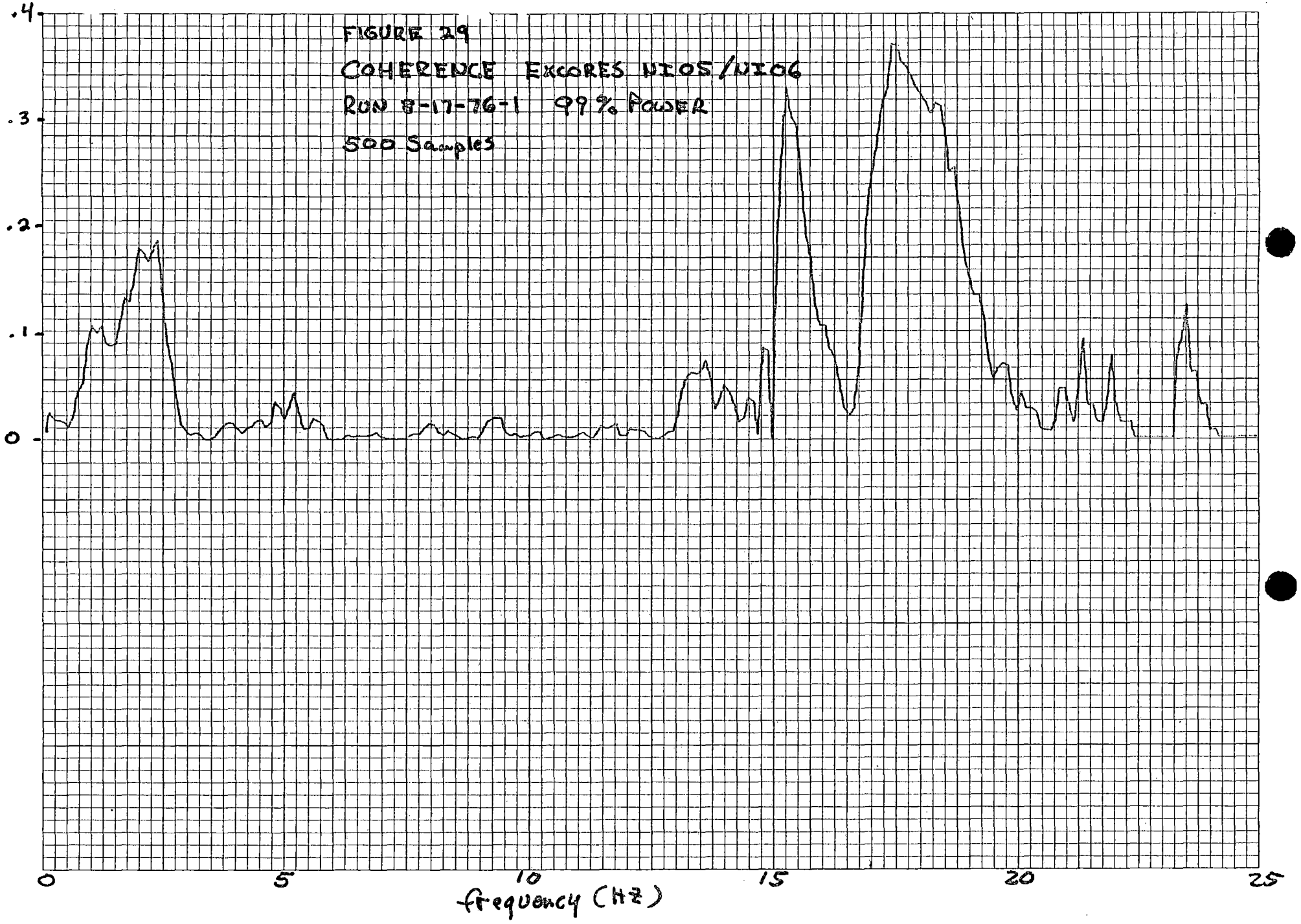
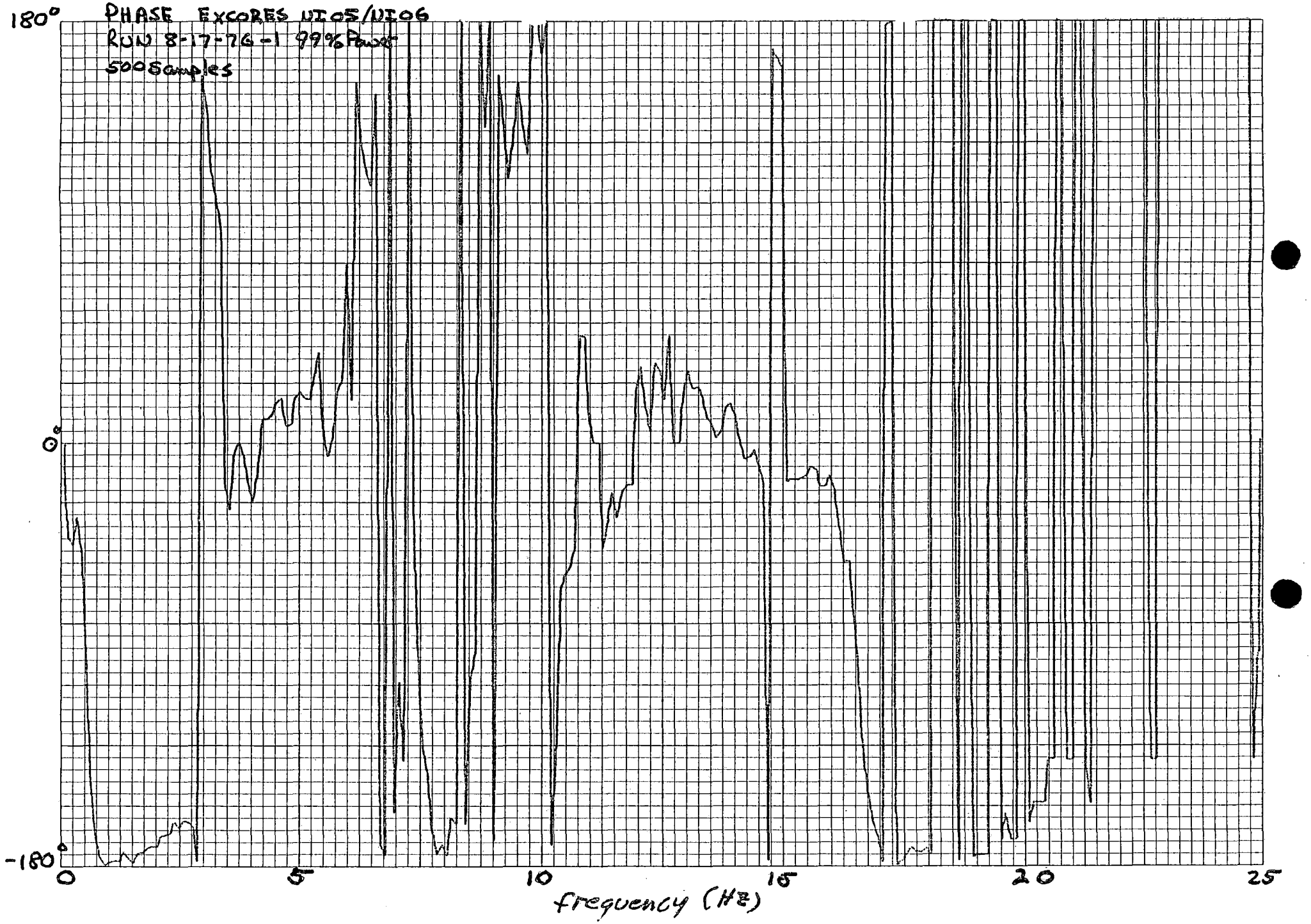
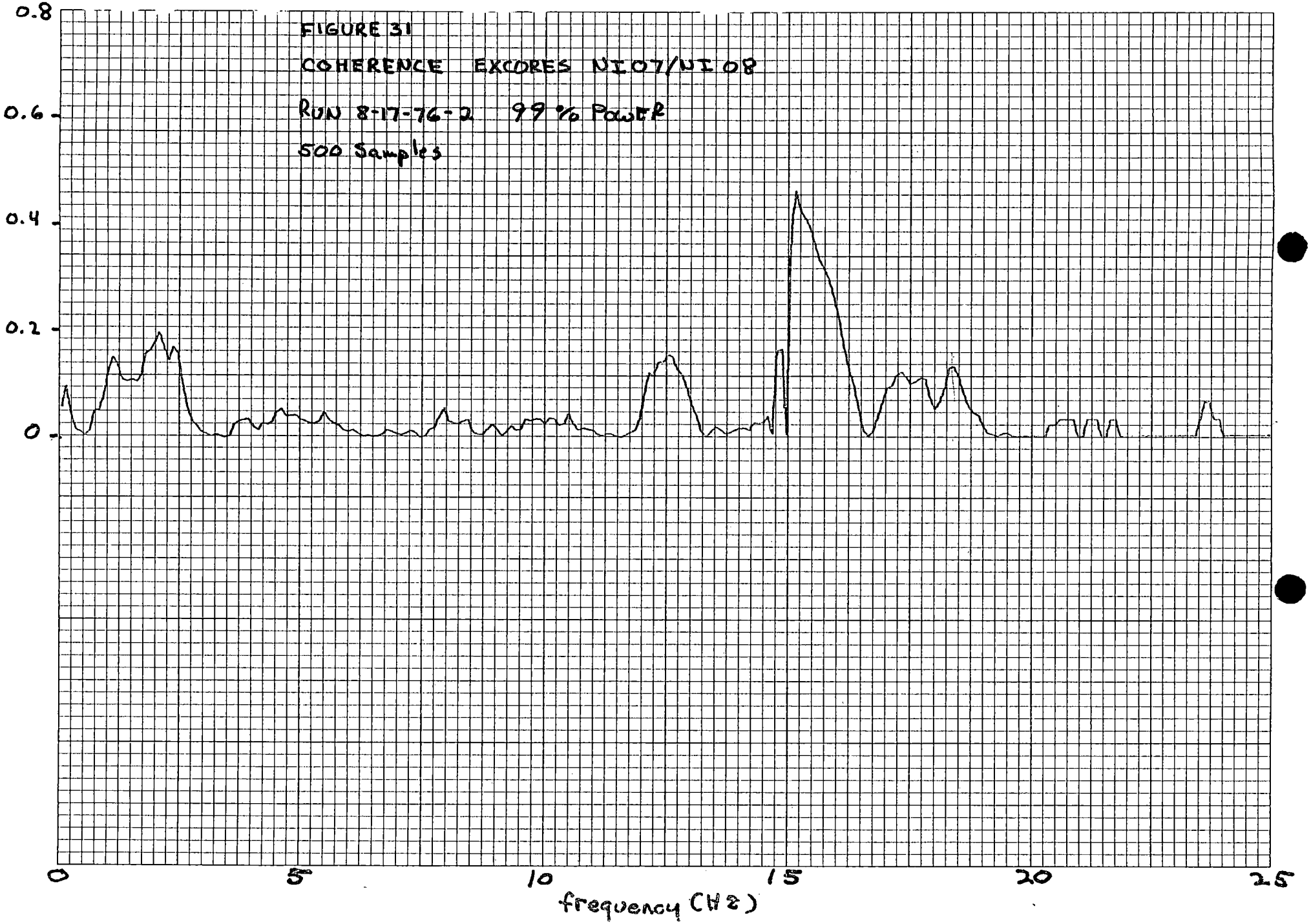


FIGURE 30





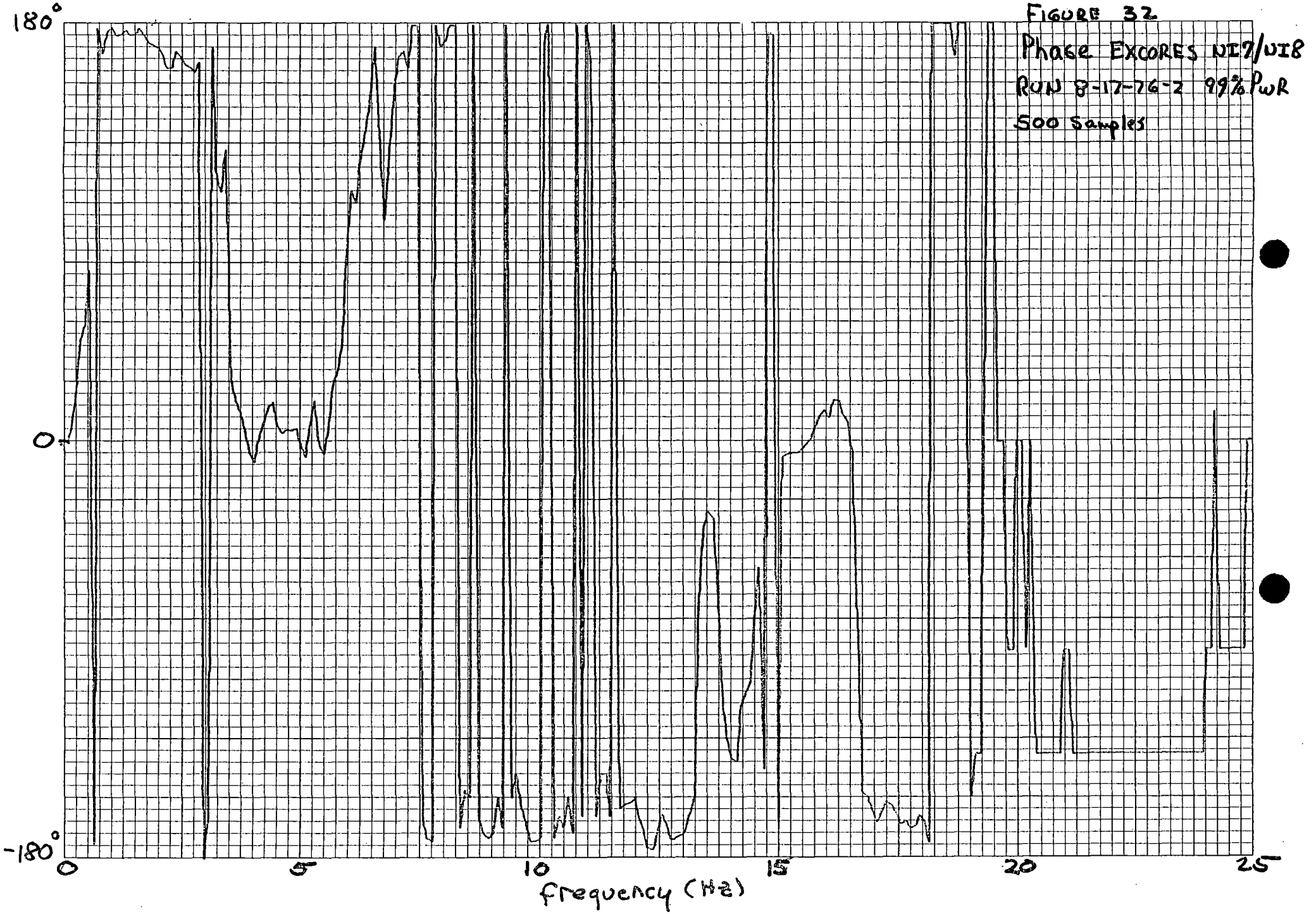



FIGURE 32
PHASE EXCORES NI7/UI8
RUN 8-17-76-2 99% PWR
500 Samples

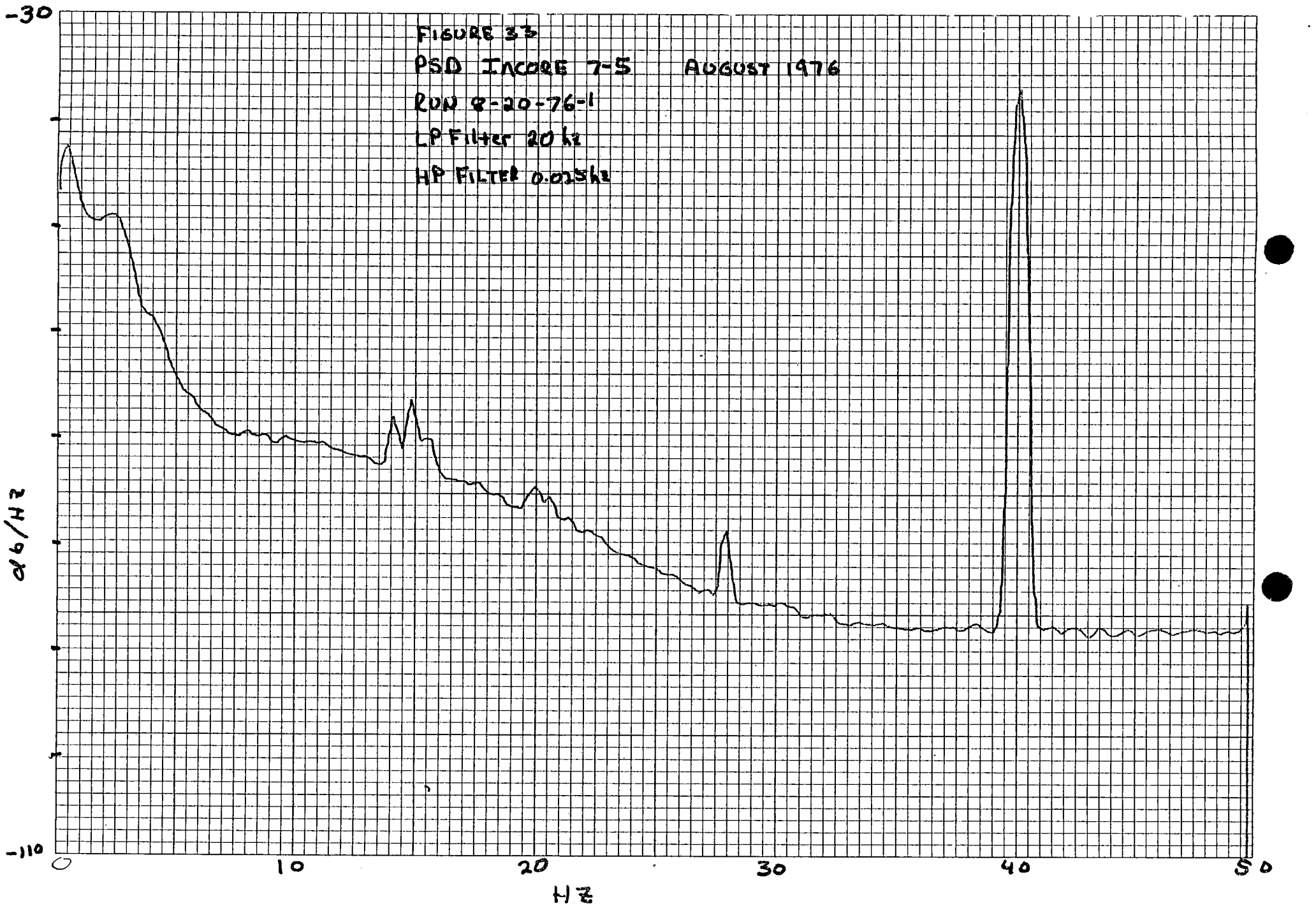
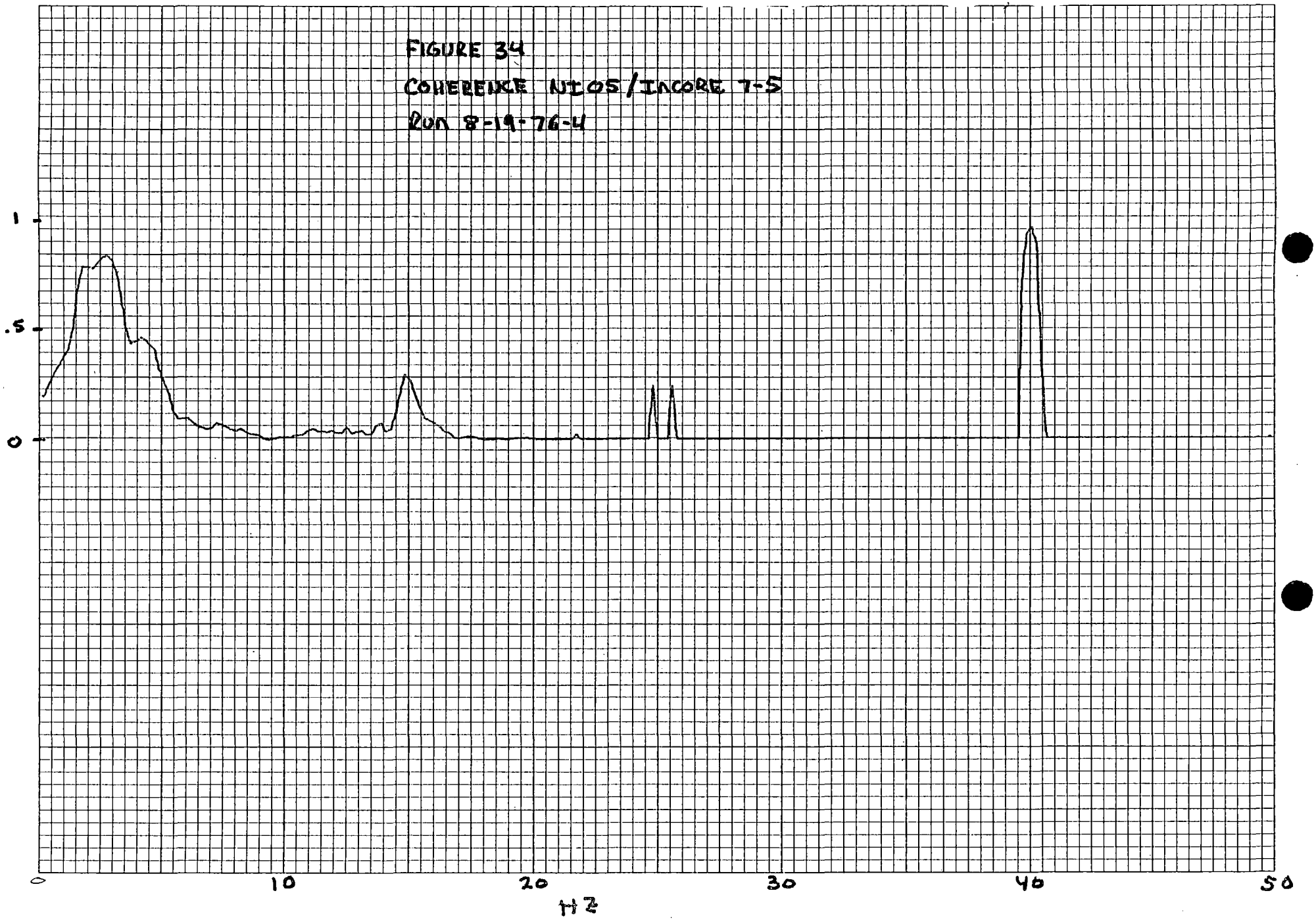
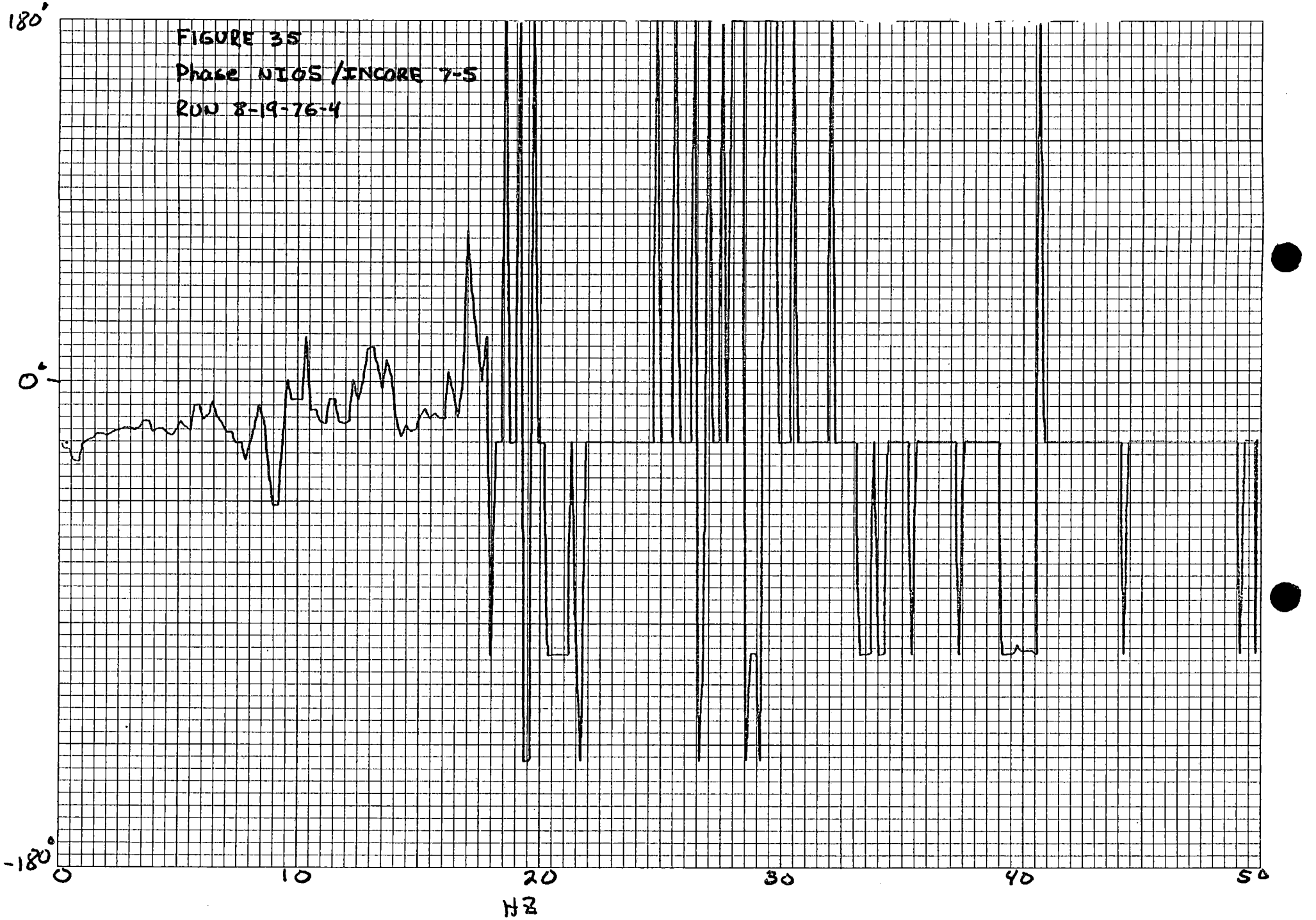
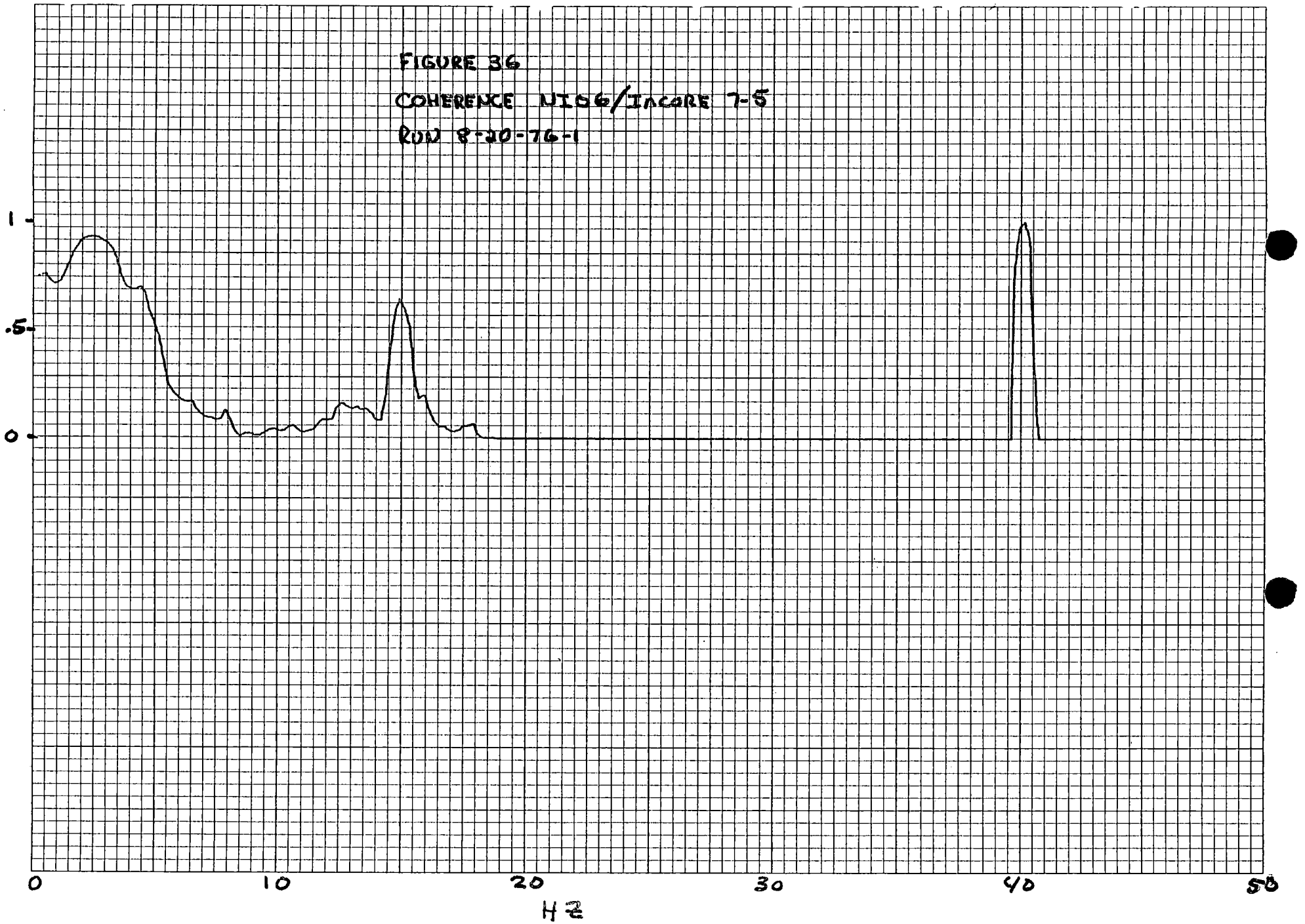


FIGURE 34
COHERENCE NI05/INCORE 7-5
RUN 8-19-76-4







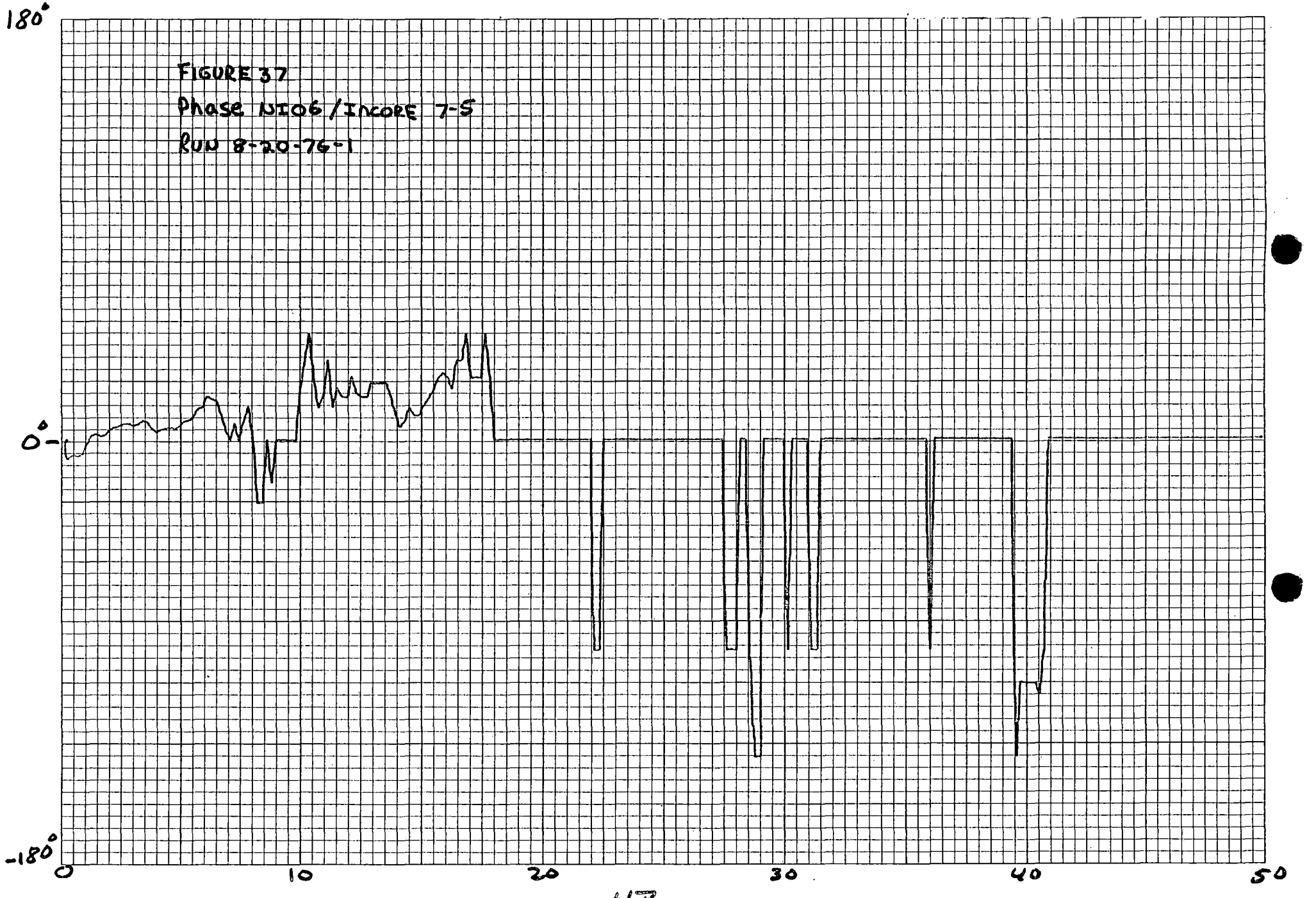



FIGURE 37
Phase NI06/INCORE 7-5
RUN 8-20-76-1

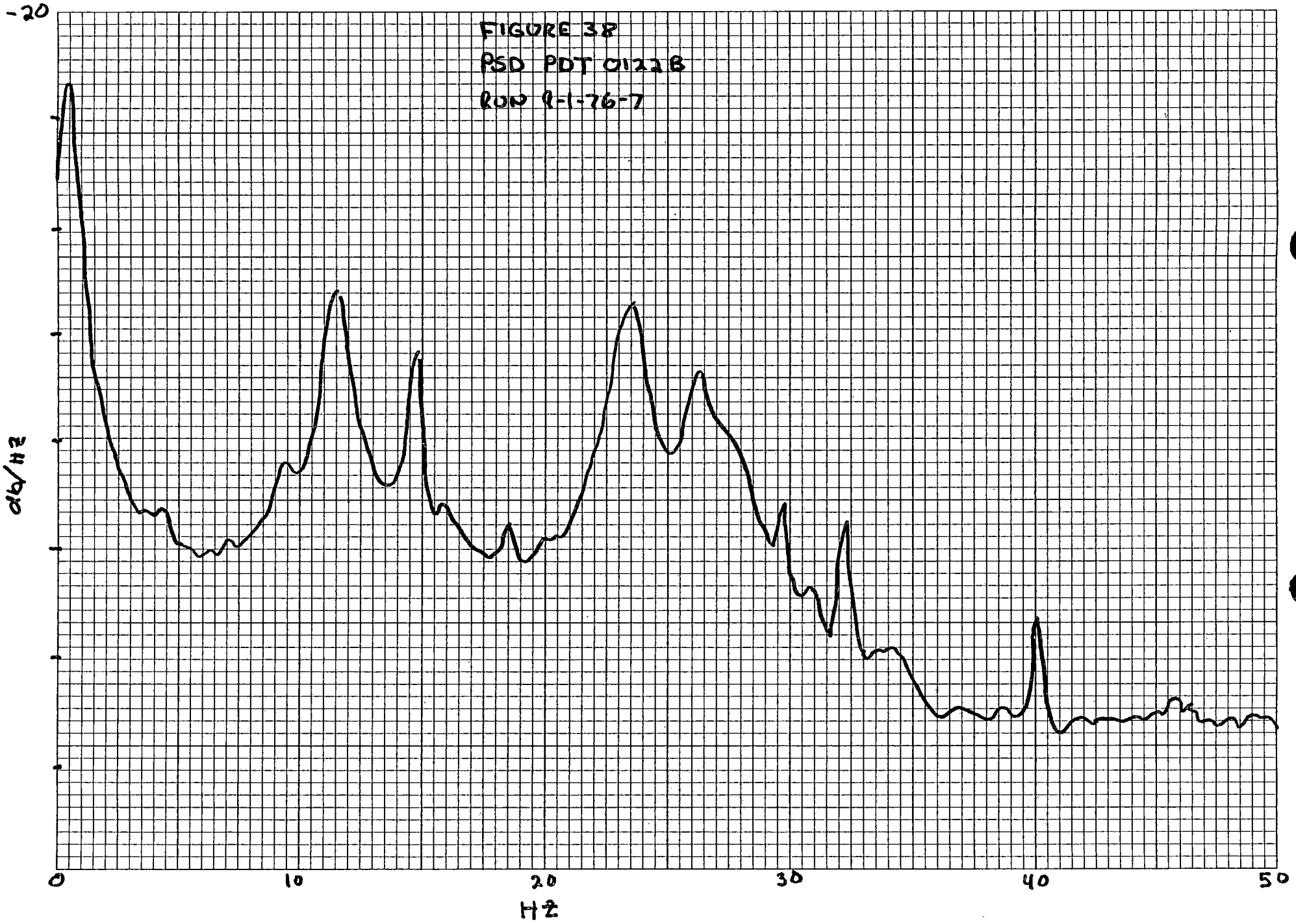
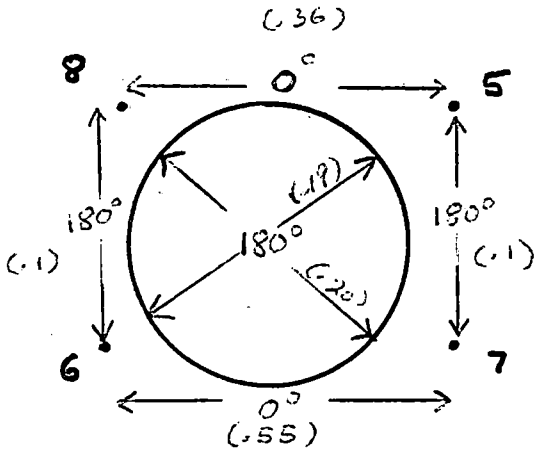
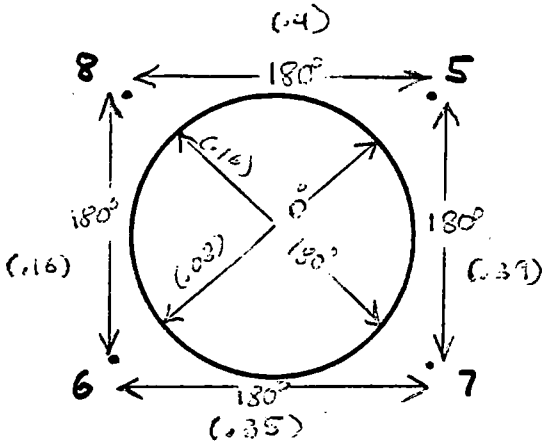


FIGURE 39

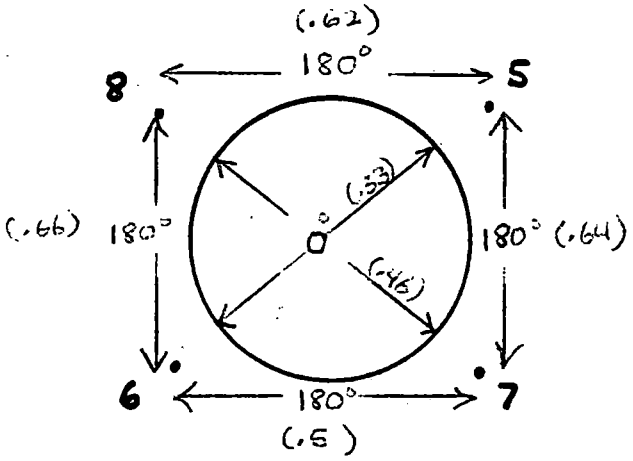
Phase and Coherence* for various frequency bands



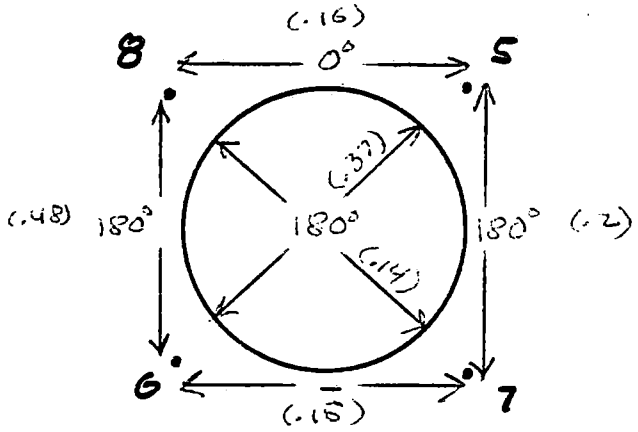

.025 - 5 hz




11 - 14.5 hz




15 - 17 hz




17 - 20 hz

* Number in parenthesis is the measured coherence