View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by CommonKnowledge

5-12-1975

Meridional variations in contrast sensitivity for human subjects

Jeff Anderson
Pacific University

Terry Gustafson
Pacific University

Larry Steinmetz
Pacific University

Robert Trumm
Pacific University

Recommended Citation

Anderson, Jeff; Gustafson, Terry; Steinmetz, Larry; and Trumm, Robert, "Meridional variations in contrast sensitivity for human subjects" (1975). *College of Optometry*. 396.
https://commons.pacificu.edu/opt/396

This Thesis is brought to you for free and open access by the Theses, Dissertations and Capstone Projects at CommonKnowledge. It has been accepted for inclusion in College of Optometry by an authorized administrator of CommonKnowledge. For more information, please contact CommonKnowledge@pacificu.edu.

Meridional variations in contrast sensitivity for human subjects

Abstract

Meridional variations in contrast sensitivity for human subjects

Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

Subject Categories

Optometry

This thesis is available at CommonKnowledge: https://commons.pacificu.edu/opt/396

Copyright and terms of use

If you have downloaded this document directly from the web or from CommonKnowledge, see the “Rights” section on the previous page for the terms of use.

If you have received this document through an interlibrary loan/document delivery service, the following terms of use apply:

Copyright in this work is held by the author(s). You may download or print any portion of this document for personal use only, or for any use that is allowed by fair use (Title 17, §107 U.S.C.). Except for personal or fair use, you or your borrowing library may not reproduce, remix, republish, post, transmit, or distribute this document, or any portion thereof, without the permission of the copyright owner. [Note: If this document is licensed under a Creative Commons license (see “Rights” on the previous page) which allows broader usage rights, your use is governed by the terms of that license.]

Inquiries regarding further use of these materials should be addressed to: CommonKnowledge Rights, Pacific University Library, 2043 College Way, Forest Grove, OR 97116, (503) 352-7209. Email inquiries may be directed to:.copyright@pacificu.edu

MERIDIONAL VARIATIONS IN CONTRAST SENSITIVITY FOR HUMAN SUBJECTS

by
Jeff Anderson
Terry Gustafson
Larry Steinmetz
Robert Trumm

Senior Thesis
May 12, 1975

PACIFIC UNIVERSITY LIBRARY
FOREST GROVE, OREGON

Ⓐ

Frank Thor

Introduction

In people who have had deprivation of their visual system, there is often a lowered sensitivity to subsequent stimuli even after the deprivation has ended. Among other things, deprivation can be based upon deficiencies in the outside world or upon deficiencies of the optics of the eye.

In a study using minimum discriminable visual threshold for square wave gratings, Freeman, Mitchell and Millodot[1] found that most normal subjects had a reduced sensitivity to oblique gratings while the sensitivity to horizontal gratings was nearly always similar to the sensitivity for vertical gratings. They hypothesized that this was due to the low occurrence of oblique lines in the visual environment. Annis and Frost[2], in a similar study on Cree Indians raised in tepees, found no significant reduction in sensitivity to gratings at any orientation. They hypothesized that the cause was the more uniform occurrence of lines at each orientation in the Indians' visual environment.

It has been thought for some time that deficiencies in the optics of the eye can cause reduced sensitivity. Freemen, Mitchell, and Millodot also found in their study that the presence of high astigmatism caused reduced sensitivity to gratings in some orientations even after correction of the astigmatism. Since the orientations with the least sensitivity corresponded to the orientations of gratings that were most blurred when the person was uncorrected, they hypothesized that the lowered sensitivity was due to the deprivation by blur. They also found that this meridional amblyopia did not occur in subjects with high astigmatism. They hypothesized that these subjects reduced deprivation by blur before they wore a correction by either focusing or using various viewing distances.

One explanation for the existance of low sensitivity for only some orientations is that there may be some indepentent processing of information in the different orientations. This would allow deprivation to reduce sensitivity to gratings at one orientation and not at another. In a study using visual evoked response amplitudes, Campbell and Maffei[3] found that such independent processing in different orientations does exist in some respects. They found that the amplitude of the visual evoked response for gratings tilted fifteen degrees apart was similar to the amplitude for two gratings. For gratings tilted closer than fifteen degrees, the amplitude of the response was reduced toward the amplitude for one grating. Blakemore, Nachmias and Sutton[4], in a study using adaptation to test grating, found results that lend support to the view of some independent processing of information at different orientations.

In the study by Campbell and Maffei and the study by Blakemore et al, the results indicated that there is also some independent processing of information at different spatial frequencies. Campbell and Maffei found that the amplitude of the visual evoked response to two gratings at the same orientation was similar to the amplitude for two gratings if there was one octave[5] difference in frequency between the gratings. Blakemore et al found that adaptation to a grating of one spatial frequency had little effect on a grating of one-and-a-half octaves higher spatial frequency or of two octaves lower spatial frequency. Hubel and Wiesel[6], in single-cell work on cats, found cells in the visual cortex that were most sensitive to lines at one orientation and of one width. This supports the hypothesis that in the visual system there is some independent processing of information at different orientations and at different spatial frequencies. Some investigators have made a model involving "channels" in the visual system to account for the independent processing.

If modification by deprivation occurs and if independent channels exist, then meridional amblyopia will not necessarily be the same for all spatial frequencies. Freeman[7] investigated this possibility using contrast sensitivity and found cases where meridional amblyopia existed in spatial frequencies to as low as about one cycle per degree visual angle. He found normal subjects that had reduced sensitivity to obliques for spatial frequencies to only as low as about five cycles per degree. This present study is similar to the study by Freeman. In undertaking it, we wished to determine the effect of known deprivation both upon channels that should be affected by the deprivation and upon channels that should not be affected. We also hoped to find some cases that gave evidence of deprivation where no deprivation was suspected to have occurred.

Method

The stimuli used in this study consisted of sinusoidal components with spatial frequencies of 20, 6.75, 2.25, and 0.75 cycles per degree. The various sinusoidal gratings were generated by a standard wave generator and presented on an oscilloscope situated 10 feet (304 cm) in front of the subject. Dots were placed on the face of the oscilloscope to control accommodation. The contrast of the gratings was controlled by adjusting the intensity of the wave generator. Measurement of the gratings was on a standard voltage indicator. The various orientations, 180°, 90°, 45°, and 135°, of the gratings were achieved through the use of a Dove prism suspended in front of the eye being tested.

Subjects for this study were picked according to the type of refractive anomaly they had. Emmetropes of no more than ½ diopter of sphere and ¼ dioptor of cylinder correction and astigmats of a significant amount were used for this study. The best correction possible as determined from standard analytical testing was worn during the testing of the astigmats while the emmetropes were tested without any correction in place.

Each subject was positioned behind the Dove prism and instructed to look at the oscilloscope and keep the dots clear. Contrast was increased for the gratings so that the subject could see the pattern being presented. The contrast was then reduced to a point where the gratings could no longer be seen. The subject was then instructed to say "now" when he was sure he saw the grating again. Contrast was then increased to this point. The subject was then instructed to report "now" when he could no longer see the grating. Contrast was reduced until no grating was seen. Then the contrast was increased again until the subject was sure he saw the grating again. Measurements were taken from the second time the subject was sure that he saw the grating. This procedure was performed five times for each frequency at the four orientations.

Each eye was tested twice. The sequence of presenting the frequencies was to start with 20 cycles/degree, 6.75 cycles/degree, 2.25 cycles/degree, and 0.75 cycles/degree. For each frequency orientations of 180°, 45°, 90°, and 135° were given and in that order. When the eye was tested again the sequence of presenting orientations was reversed.

Results and Discussion

Several different results can be seen by looking at the data and the graphs. For one, the relative sensitivities to different frequencies for each meridian tested (90^{o}, 180^{o}, 45^{o},135^{o}) varied for each patient and also varied differently between subjects. On the graphs this is shown by the crossing over of the lines between the frequencies. For any given subject this "crossing over" could be caused by the lack of consistancy in his response from trial to trial. Another possibility is one that would indicate that there is little or no difference in the sensitivities of the different meridians at the various frequencies and that they cross over because the responses of the subject cannot be exact. The "crossing over" could also be due to the fact that each channel has a different sensitivity for each frequency and these channels have developed independently of each other.

Another result is that for most normal subjects tested, the vertical meridian was more sensitive that the other three meridians tested , as shown in figure 6. This can best be explained by the fact that contours orientated in the vertical are more predominant in the environment than any other given meridian.

For most subjects, the middle two frequencies elicited the highest sensitivities, especially the 2.25 cycles per degree of visual angle. The two extreme frequencies used (20 and .75 cycles) exhibited the least sensitivity. In figures 4, 7, and 8 even though the subjects' visual acuity was 20/15, no response could be obtained even at a maximum contrast. The reason for this might be explained by the way the visual system is tuned generally more toward the two middle frequencies and therefore more receptive or sensitive to these frequencies. The reason no response for the highest frequency was obtained is because a high enough contrast was not available.

One of the expected results would be that the 135° and 45° meridians would be similar in sensitivity, especially in subjects that have "with the rule" astigmatism and "against the rule" astigmatism and in the normals. This tended not to be the case. In fact, in figure 4, one oblique meridian was more sensitive than either the 90 or 180 and the other oblique was less sensitive. In several cases (mostly normals) where the vertical meridian was most sensitive, the obliques and the horizontal meridian tended to be similar in their sensitivities as shown in figures 5 and 6. One explanation for this result might be that many of the contours in the environment that are orientated in the horizontal are not really projected onto the retina horizontally; ie., the corner of a building.

One of the more interesting results foumd was that in several normal cases (figures 4,5, and 6) sensitivities in the different meridians tended to be nearly equal in the lower frequencies and more spread apart in the higher frequencies. However, in several cases of astigmats (figures 1,2, and 8) the sensitivity the sensitivity difference between the four meridians kept the same interval throughout the entire frequency spectrum. Whether the interval was small or great had little effect on this phenomenon.

At the lower frequencies we can expect the sensitivites of the different meridians to be pretty much the same because at those lower frequencies the optics of the eye would not play much of a role in any meridional amblyopia from deprivation. This was borne out in the results of the normals tested. However, in many of the astigmats this result was not obtained. There was quite a bit of difference in the sensitivities of the different meridians at the lower frequencies. This would lead us to believe that there is more than optics alone that affects the sensitivity.

In figures 1 and 2, a high astigmat x 180 with nearly the same refractive error in both eyes, the subject exhibited a meridional amblyopia in one eye (more sensitivity in all frequencies to the vertical meridian over the horizontal meridian) but in the other eye there was a crossing over of the sensitivities of the vertical and horizontal at the different frequencies. This is an unexpected result because one would expect the same type of results from each eye because of the similar refractive errors and because both eyes should have had the same environmental exposure.

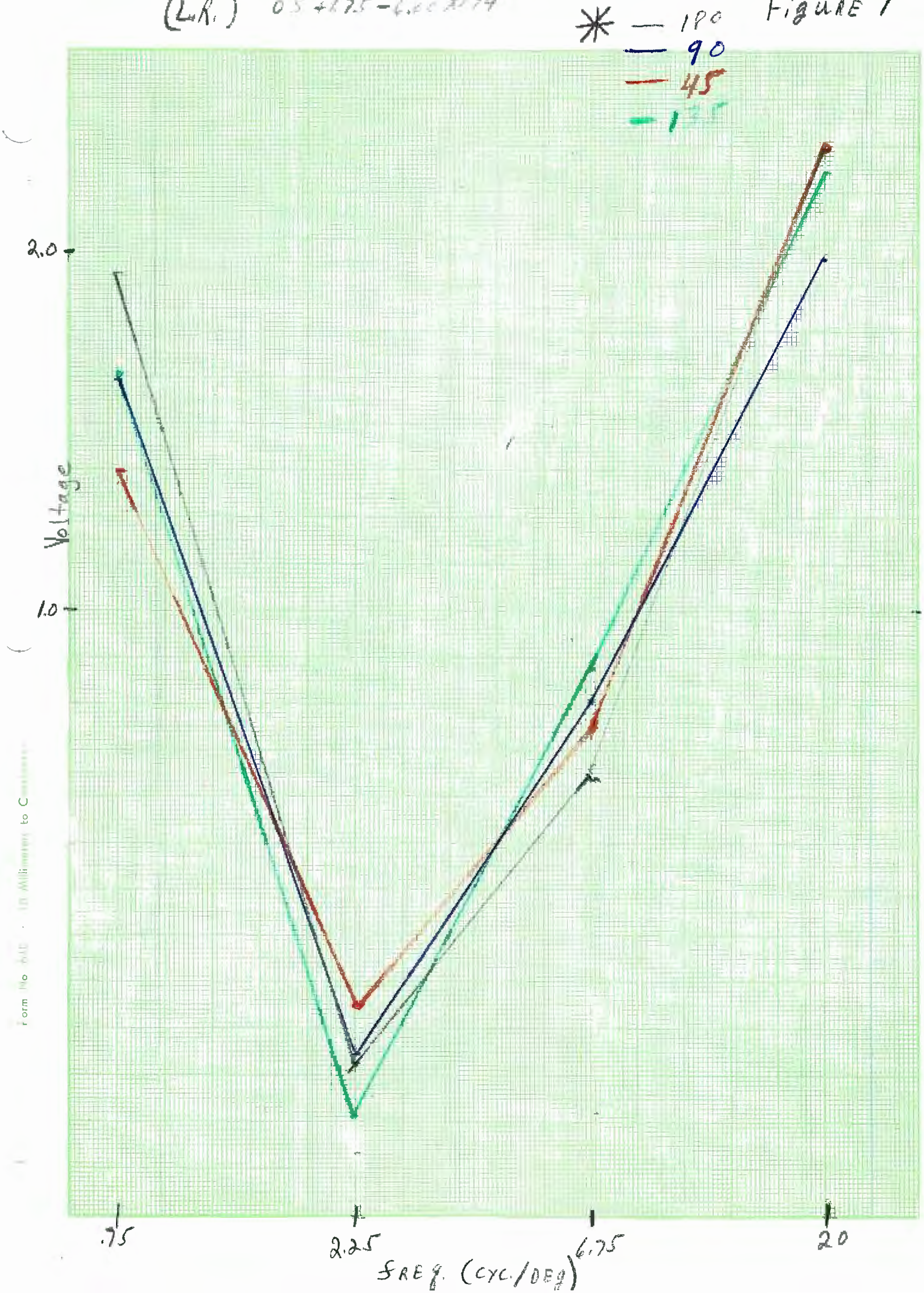
Graphs

On the following graphs is plotted the results of our study. A single graph contains the results of all of the testing for one subject. Each data point on a graph represents the average of two trials, each of which contained five contrast threshold measurements. This average of the two trials is plotted on the "y" axis in cycles per degree visual angle on a logarithmic scale. The data points for the four orientations, 180, 45, 90, and 135 are plotted on each graph and the lines labelled. On each graph the refractive error of the eye tested is noted. On the graphs of the astigmats, the orientation that is most blurred when the subject is uncorrected is marked with a star.

For each trial of five threshold measurements, the mean and standard deviation can be found on the tables following the graphs.

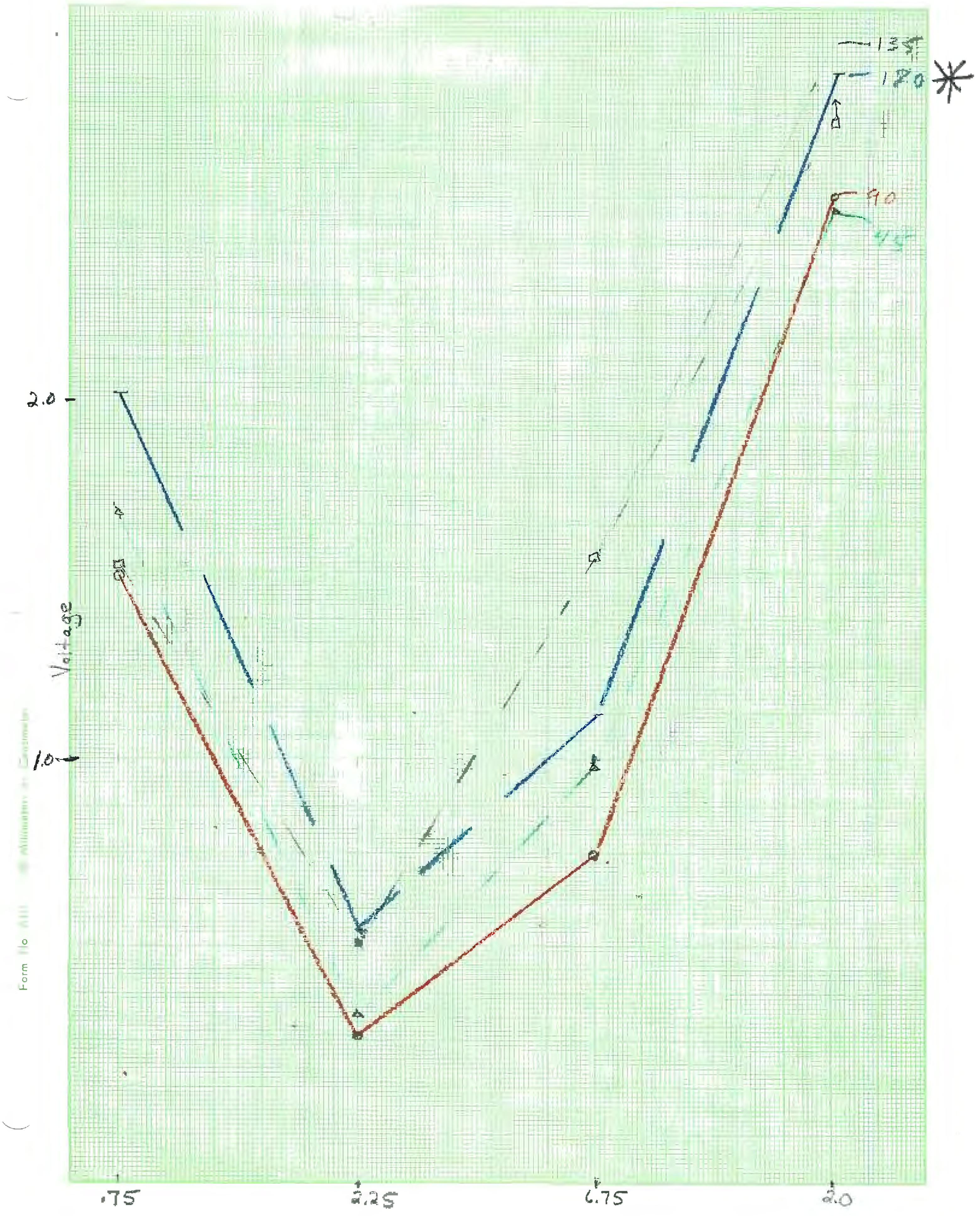
(L.R.) OS +2.75 -6.00 X174

Figure 1



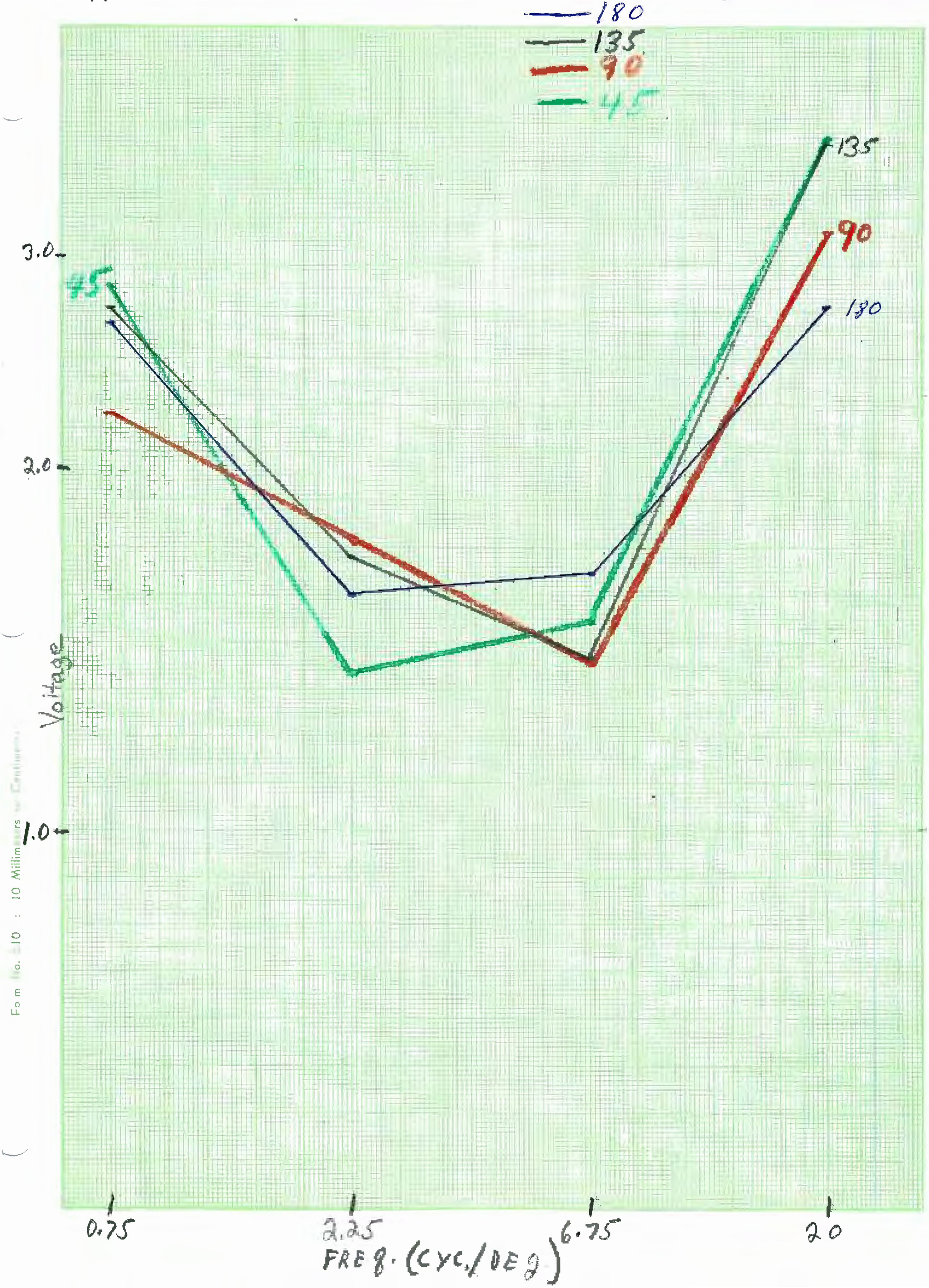
(LR) OD: +1.50 -5.50x180

Figure 2



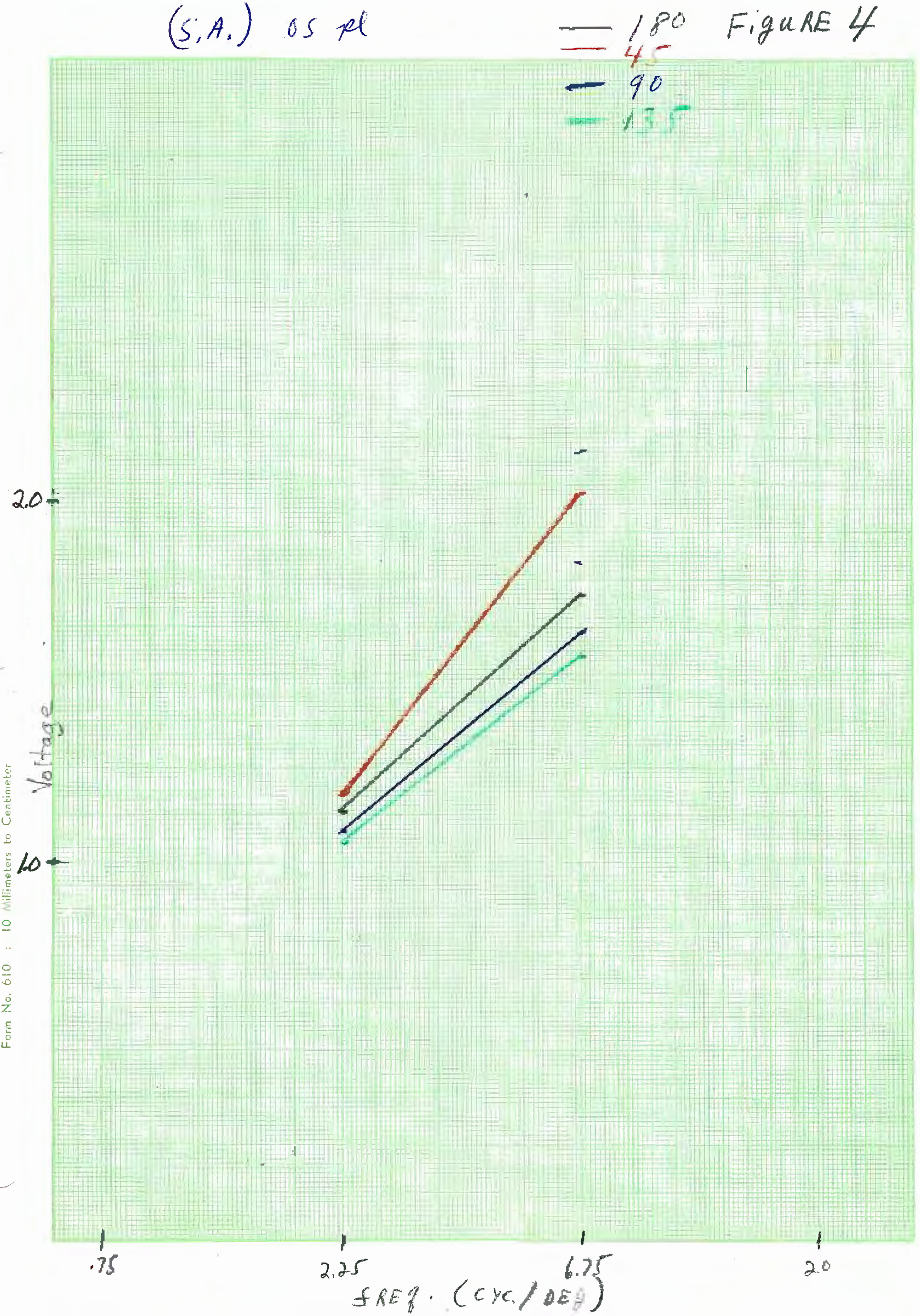
K.T. -.25-.12X15

FIGURE 3



(S.A.) OS pl

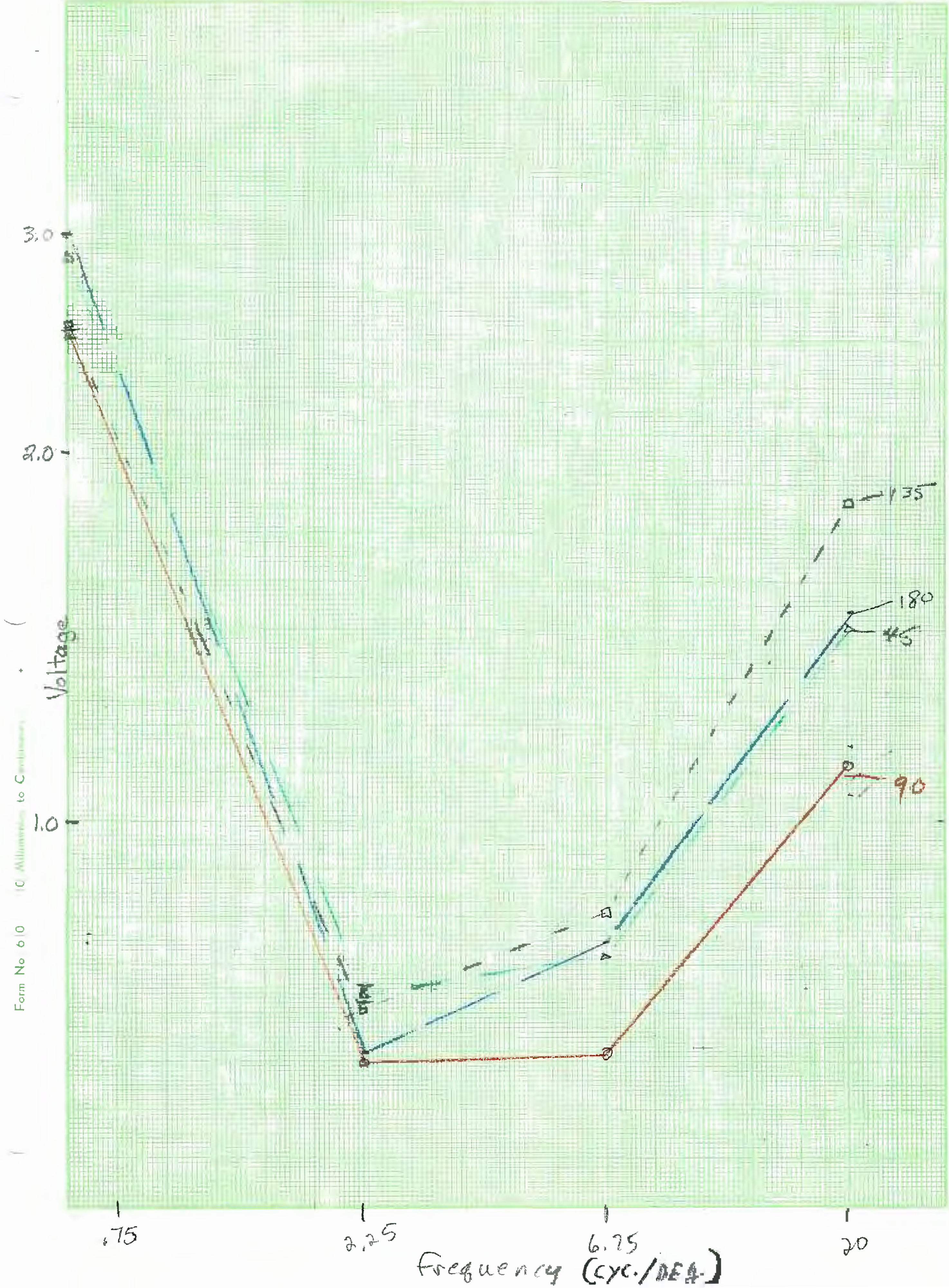
FIGURE 4



Form No. 610 : 10 Millimeters to Centimeter

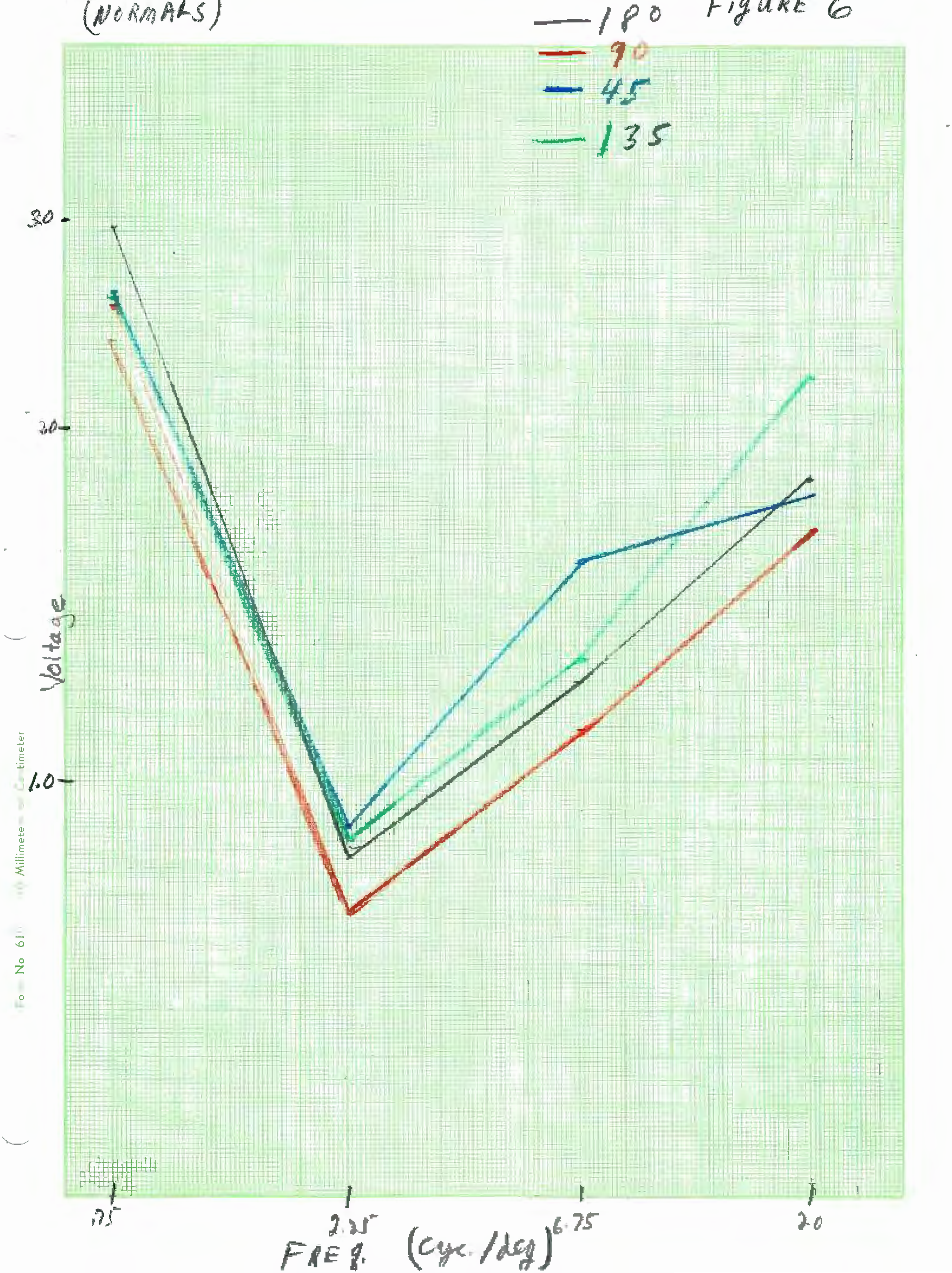
B.H.

FIGURE 5


3.0
2.0
1.0
Voltage
.75
2.25
6.75
20
Frequency (cyc./DEG.)
135
180
45
90
Form No 610
10 Millimeters to Centimeter

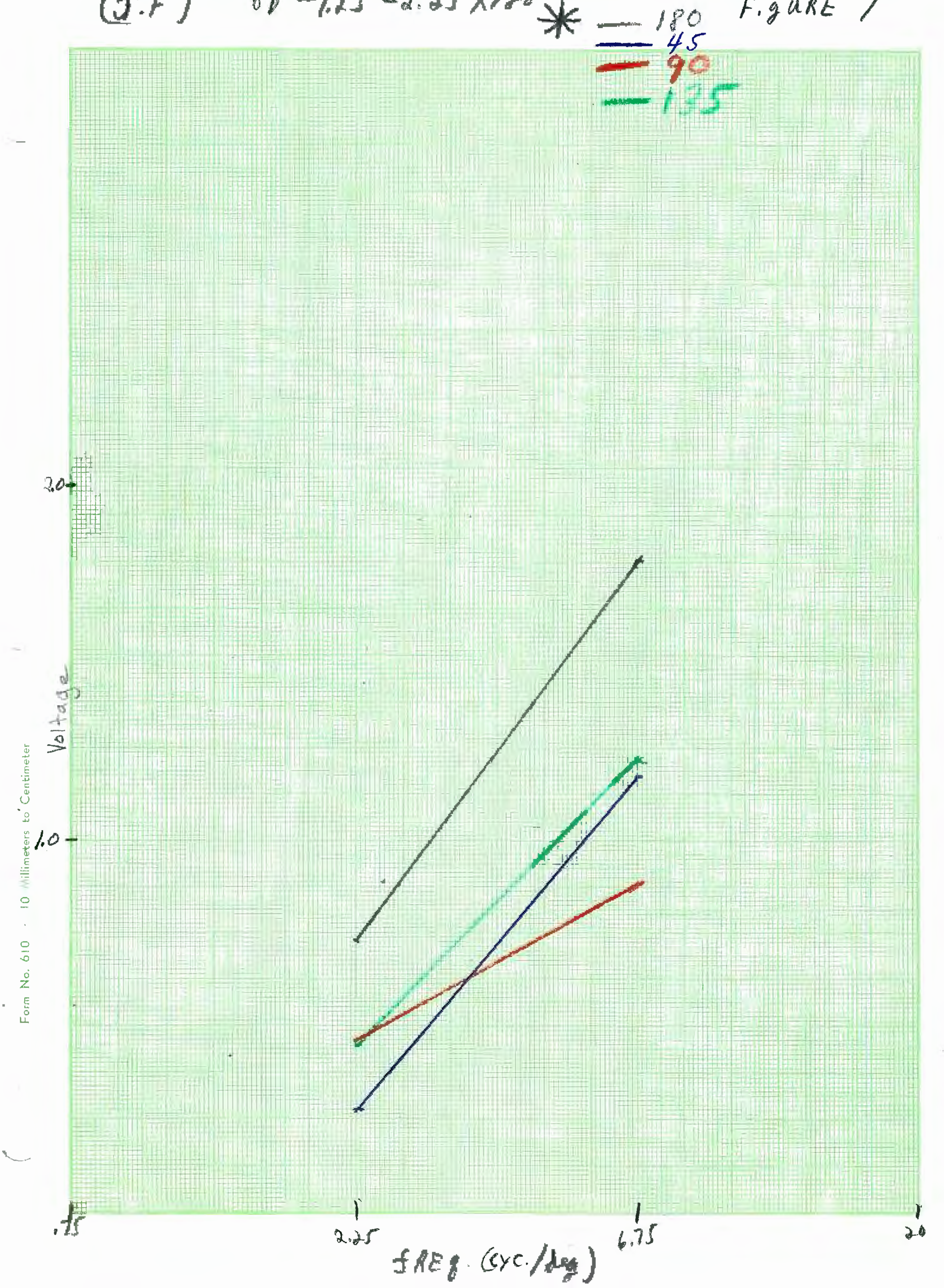
(NORMALS)

FIGURE 6



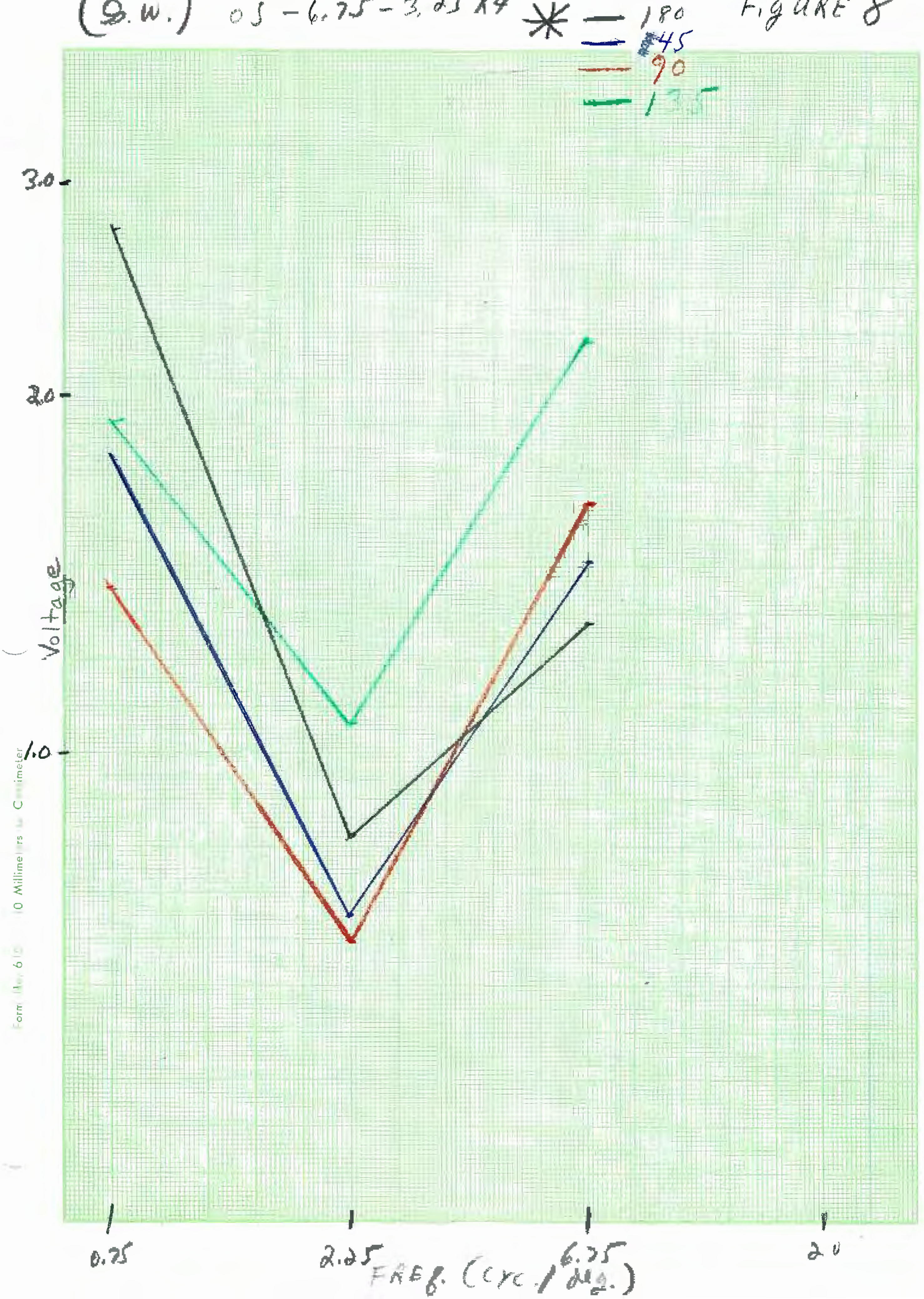
Fo… No 61… Millimeter… Centimeter

(J.F) OD -1.25 -2.25X180 Figure 7



(S.W.) OS -6.75 -3.25 X4

FIGURE 8



Form No. 615 10 Millimeters to Centimeter

(R.M.) OD pl

Figure 9

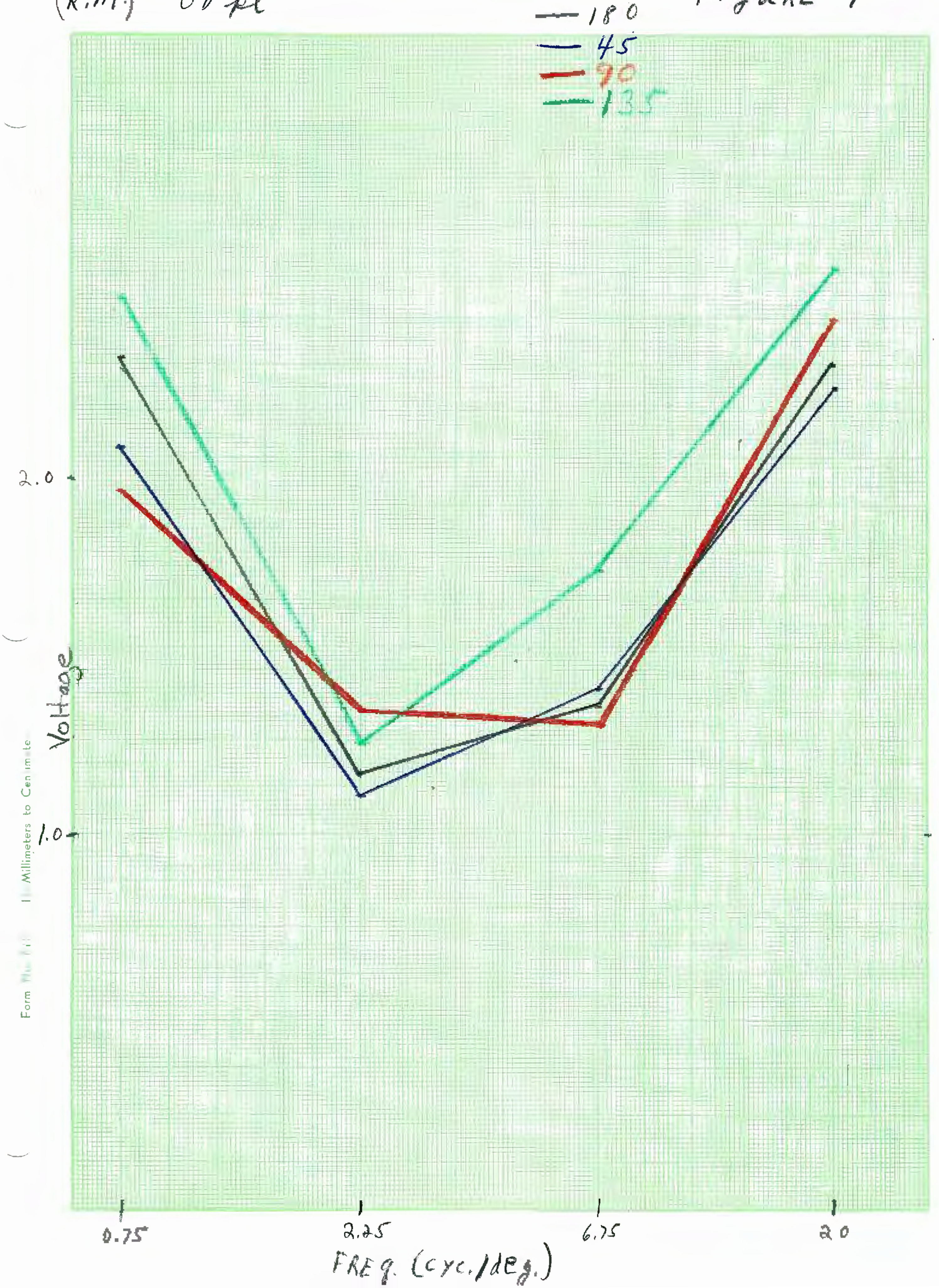
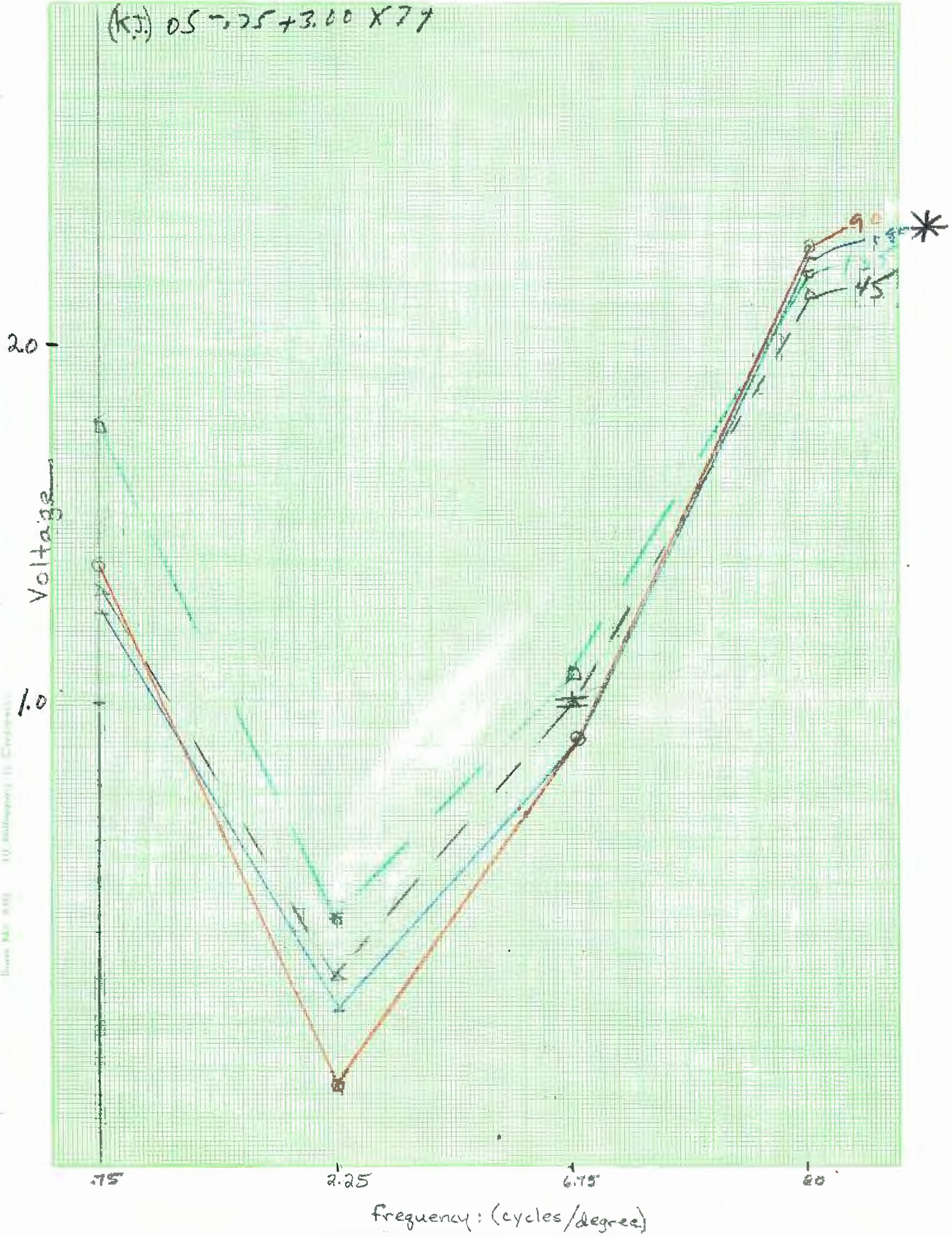


FIGURE 10


(KJ) OS −.25 +3.00 X 77
Voltage
2.0
1.0
.75
2.25
6.75
20
Frequency: (cycles/degree)
90
180
135
45

20 cyc./deg.	180	45	90	135
1. L.R.(OD)	3.72+/-.11 can't see	can't see 1.96+/-.22	2.60+/-.22 3.26+/-.48	3.08+/-.57 can't see
2. L.R.(OS)	2.96+/-.23 1.92+/-.08	3.06+/-.33 1.86+/-.34	2.26+/-.50 1.70+/-.20	2.40+/-.28 2.30+/-.29
3. K.J.(OS)	1.50+/-.44 3.27+/-.31	1.42+/-.23 3.00+/-.64	1.38+/-.22 3.46+/-.40	1.64+/-.38 2.98+/-.25
4. K.T.(OS)	2.64+/-.40 1.50+/-.24	3.8+ 1.48+/-.33	3.12+/-.78 0.84+/-.09	3.78+/-.15 1.80+/-.001
5. B.H.(OD)	1.7+/-.17 1.28+/-.08	1.64+/-.11 1.26+/-.09	1.36+/-.05 0.88+/-.08	2.18+/-.15 1.50+/-.12
6. M.P.(OS)	1.88+/-.13	3.7+	3.7+	3.12+/-.18
7. R.M.(OS)	2.46+/-.21 can't see	2.38+/-.15 can't see	2.70+/-.40 can't see	2.98+/-.25 can't see
6.75 cyc./deg.				
1. L.R.(OD)	1.22+/-.15 0.98+/-.27	0.63+/-.05 1.35+/-.41	0.88+/-.08 0.78+/-.10	2.39+/-.56 0.58+/-.13
2. L.R.(OS)	0.61+/-.11 0.84+/-.13	0.71+/-.19 0.88+/-.12	0.67+/-.23 1.01+/-.15	0.73+/-.12 1.06+/-.12
3. K.J.(OS)	0.76+/-.04 1.10+/-.12	0.80+/-.18 1.20+/-.20	0.55+/-.12 1.30+/-.04	0.66+/-.12 1.46+/-.12
4. S.A.(OS)	1.88+/-.08 1.47+/-.03	2.05+/-.22 2.03+/-.06	1.82+/-.07 1.30+/-.06	1.54+/-.09 1.43+/-.05
5. K.T.(OS)	1.82+/-.43 1.04+/-.39	1.42+/-.55 1.55+/-.31	2.16+/-1.05 1.14+/-.18	1.48+/-.59 1.30+/-.16
6. B.H.(OD)	0.78+/-.39 0.82+/-.05	0.71+/-.04 0.84+/-.05	0.45+/-.03 0.85+/-.12	0.83+/-.08 0.88+/-.05
7. J.F.(OD)	2.06+/-.29 1.39+/-.08	1.25+/-.05 1.02+/-.08	0.87+/-.10 0.99+/-.11	1.48+/-.23 0.86+/-.13
8. G.W.(OS)	1.32+/-.13 1.76+/-.17 0.78+/-.75	1.38+/-.19 2.11+/-.11 0.87+/-.002	1.60+/-.12 1.94+/-.24 1.35+/-.10	1.91+/-.15 2.73+/-.41 2.03+/-.13
9. M.P.(OS)	1.03+/-.15	1.12+/-.07	1.01+/-.55	0.98+/-.11
10.R.M.(OD)	1.14+/-.18 1.42+/-.18	1.08+/-.13 1.57+/-.11	0.90+/-.10 1.59+/-.04	1.69+/-.20 1.63+/-.11

2.25 cyc./deg.	180	45	90	135
1. L.R.(OD)	0.61+/-.07 0.84+/-.39	0.45+/-.04 0.78+/-.19	0.47+/-.04 0.71+/-.17	0.61+/-.05 0.82+/-.14
2. L.R.(OS)	0.25+/-.06 0.58+/-.07	0.34+/-.11 0.58+/-.03	0.28+/-.05 0.56+/-.07	0.29+/-.04 0.46+/-.03
3. K.J.(OS)	0.40+/-.08 0.23+/-.05	0.43+/-.06 0.74+/-.01	0.44+/-.06 0.50+/-.12	0.47+/-.05 0.84+/-.14
4. S.A.(OS)	1.12+/-.05 1.08+/-.09	1.19+/-.07 1.10+/-.06	1.17+/-.06 0.96+/-.06	1.04+/-.08 1.04+/-.12
5. K.T.(OS)	1.56+/-.50 1.59+/-.25	1.38+/-.22 1.35+/-.60	2.04+/-.40 1.28+/-.21	1.30+/-.19 2.00+/-.89
6. B.H.(OD)	0.57+/-.02 0.73+/-.06	0.62+/-.07 0.82+/-.04	0.53+/-.07 0.75+/-.04	0.62+/-.38 0.78+/-.07
7. J.F.(OD)	0.91+/-.09 0.70+/-.05	0.61+/-.06 0.58+/-.04	0.74+/-.08 0.62+/-.02	0.74+/-.07 0.61+/-.05
8. G.W.(OS)	0.64+/-.05 1.19+/-.05 0.72+/-.01	0.56+/-.04 0.92+/-.08 0.73+/-.05	0.50+/-.01 0.96+/-.09 0.64+/-.07	1.34+/-.06 1.09+/-.20 0.77+/-.08
9. M.P.(OS)	0.80+/-.08	0.67+/-.03	0.66+/-.05	0.58+/-.03
10.R.M.(OD)	0.83+/-.07 1.31+/-.08	0.84+/-.09 1.33+/-.09	1.11+/-.07 1.44+/-.09	0.99+/-.06 1.39+/-.05
0.75 cyc./deg.				
1. L.R.(OD)	1.78+/-.16 2.30+/-.25	1.24+/-.17 2.00+/-.37	1.08+/-.08 1.80+/-.12	0.84+/-.05 2.08+/-.37
2. L.R.(OS)	2.40+/-.43 1.46+/-.25	1.70+/-.44 0.94+/-.05	2.22+/-.28 .094+/-.23	2.34+/-.25 .084+/-.05
3. K.J.(OS)	0.82+/-.08 1.56+/-.15	0.61+/-.10 1.86+/-.09	0.58+/-.04 2.06+/-.09	0.94+/-.17 2.48+/-.18
4. K.T.(OS)	2.92+/-.70 4.94+/-1.57	2.90+/-.53 5.76+/-.84	2.38+/-.65 4.26+/-1.02	3.14+/-.59 4.82+/-1.41
5. B·H.(OD)	2.56+/-.17 3.56+/-.13	2.18+/-.08 3.62+/-.04	1.66+/-.06 3.40+/-.07	1.64+/-.06 3.46+/-.09
6. G.W.(OS)	2.78+/-.20	1.78+/-.15	1.38+/-.08	1.90+/-.30
7. M.P.(OS)	1.52+/-.15	1.74+/-.27	1.60+/-.16	1.44+/-.05
8. R.M.(OD)	2.86+/-.08 2.14+/-.15	2.14+/-.29 2.08+/-.28	1.94+/-.09 1.94+/-.17	2.58+/-.29 3.04+/-.22

References and Notes

1. Ralph D. Freeman, Donald E. Mitchell, and Michel Millodot: A Neural Effect of Partial Visual Deprivation in Humans, Science 175; 1384, 1972.

2. Robert C. Annis and Barrie Frost: Human Visual Ecology and Orientation Anisotropies in Acuity, Science 182: 729, 1973.

3. F.W. Campbell and L. Maffei: Electrophysiological Evidence of the Existence of Orientation and Size Detectors in the Human Visual System, Journal of Physiology 207: 635, 1970.

4. Colin Blakemore, Jacob Nachmias, and Peter Sutton: The Perceived Spatial Frequency Shift: Evidence for Frequency-Selective Neurones in the Human Brain, Journal of Physiology, 210:727, 1970.

5. An octave is a doubling of spatial frequency, eg. three cycles per degree visual angle to six cycles per degree visual angle.

6. D.H. Hubel and T.N. Wiesel: Receptive Fields, Binocular Interaction and Functional Architecture in the Cats' Visual Cortex, Journal of Physiology 160: 196, 1962.

7. R.D. Freeman. Contrast Sensitivity in Meridional Amblyopia, Invest. Opthalmology 14: 78, 1975.