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Zachary C. Berk
Pacific University

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Abstract

The VER will be in widespread use in optometric clinics within the near future. The VER, in the experimental laboratory, is showing itself to be a valuable tool in precise objective measurements in the visual analysis of an individual. The VER will not only be able to do refractions, but will be able to take phorias, ductions, measure fixation disparity, color vision defects, visual acuity, and check on the cause of amblyopia. In doing refraction, the sinusoidally presented checkerboard has proven to be the best visual stimulus. This paper deals with trying to determine the optimum checkerboard parameters in doing clinical refraction. These parameters include pattern rate and relative contrast..

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Frank Thorn

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DETERMINATION OF THE PROPER
CHECKERBOARD TARGET FOR V.E.R. REFRACTION

Zachary C. Berk

May 14, 1974

Frank Thon

I would very much like to thank Dr. Frank
Thorn and William Dunn for their invaluable
assistance in making this thesis possible.

A handwritten signature in cursive script, appearing to read "Rachel D. L.", with a long, sweeping tail extending downwards and to the left.

ABSTRACT

The VER will be in widespread use in optometric clinics within the near future. The VER, in the experimental laboratory, is showing itself to ^{be} a valuable tool in precise objective measurements in the visual analysis of an individual. The VER will not only be able to ^{do} refractions, but will be able to take phorias, ductions, measure fixation disparity, color vision defects, visual acuity, and check on the cause of amblyopia.

In doing refraction, the sinusoidally presented checkboard has proven to be the best visual stimulus. This paper deals with trying to determine the optimum checkboard parameters in doing clinical refraction. These parameters include pattern rate and relative contrast.

V.E.R. investigations have been around for over forty years. The techniques for measuring the V.E.R. have basically been similar in character, but have varied only in the technology used to measure and record the brain waves. Since the VER is small in magnitude, in comparison to the "noise" that is picked up by the detecting electrodes, an averaging system must be used to factor out the electrical potentials that are not stimulus related and leave only the stimulus dependent VER. Originally, the averaging was accomplished by setting the oscilloscope down so low that a single sweep could not be detected visually. After many sweeps of the oscilloscope, only the non random signals would overlay sufficiently to trace out a visually detected function - this was the VER. Today, this averaging is done by high speed computer.

The type of target that the patient views is ^avery critical factor in the type of VER produced. This is logically so because the VER is stimulus dependent and the character of the response (VER) is directly related to the stimulus character.

The standard target used has been the checkboard pattern, because it has been shown that the magnitude of the VER is dependent on the relative contrast and the number of borders composing the target. Empirically, it has been shown that

the checkerboard is the most visually stimulating pattern there is.

The tests of clinical functions involve the analysis of neural activity evoked by specific visual stimuli. The activity set off by a visual stimulus is highly variable and is often obliterated by much larger spontaneous activity (alpha rhythm). Therefore, the stimulus must be repeated at least twenty times and the VER averaged. Traditionally, pulse stimuli have been used in these tests. The VER's that result are complex and vary from subject to subject, and last up to one-half of a second. The stimulus must not be presented more frequently than once every two or three seconds, or the size and shape of the VER will systematically change during the session.

The best electrophysiological correlates of stimulus strength are simply latency and amplitude of VER. Complex analysis of these complex VER's add little if anything to these correlations. Thus, most of the information inherent in a complex VER is wasted. Also, extended repetition of stimuli at slow rates is time consuming and boring to the patient.

Within the past few years, sinusoidally modulated stimuli have been used in VER studies. If the stimuli are presented at a rate of 8-16 Hz. VER potential is roughly sinusoidal. With this type of presentation, two seconds are needed to generate a VER. The phasic shift, amplitude, integral of the VER, and the Fourier analysis of the VER function are

all excellent predictors of stimulus strength and are more easily measured than the analogous measurements of complex pulse evoked VER's.

In comparing the pulse stimulus presentation to the sinusoidally presented stimuli- the pulse technique which allows for tremendous variability in VER trace. The sinusoidal presentation almost eliminates the personal character and simplifies the data. The Modulated stimulus is so powerful in its stability that when a subject concentrates his amplitude of response is less than if he relaxes and lets his mind wander. The implications of this phenomenon in clinical use are fantastic. Now the clinician will no longer have to worry about the attentiveness of his patient, because increased attention will only interfere with the results.

The sinusoidal modulated checkerboard is also interesting in its inherent properties. The modulating contrast is an ongoing stimulus which allows the space average luminance to remain constant. In this manner it is possible to detect the functional properties of the mechanisms responsible for the transmission of spatial signals in isolation from complicating factors such as light and dark adaptation.

The V.E.R. has been proposed for the testing of the following:

1. a) Refractive state for distant vision
b) Amplitude of accommodation
2. a) Visual acuity
b) Organic and functional amblyopia
3. Monocular fixation points
4. Binocular eye movement coordination
 - a) Strabismus
 - b) Accommodative - convergence interaction
(Heterophoria)
 - c) Fusional vergence amplitudes
 - d) Fixation disparity

Therefore, the V.E.R. has potential for conducting most of the twenty-one point visual analysis and strabismic testing. The purpose of this study is to try to determine the optimum check size and contrast necessary for clinical work.

The literature related to this study includes the following: Spehlman, 1965; Harter and White, 1968, 1970; Ludlam and Meyers, 1972; Duffy and Rengstorff, 1971; Dawson et al, 1972. These papers have shown that amplitude of the V.E.R. is largest and the latency shortest when the briefly illuminated checkerboard pattern which evokes it, is in focus. Spekreijse, 1966, Cobb et al, 1967, and Tweel et al (1970) have also shown this with pattern movement as a stimulus. Copenhaver and Perry (1964) and Lifshitz (1966) have shown it with other stimulus con-

figurations. Harter and White (1968, 1970), Ludlam and Meyers (1971) , Duffy and Rengstorff (1971) , and Dawson et al (1972) have used this information to perform clinical refractions. Most studies show excellent agreement between V.E.R. and subjective refractions.

Millidot and Riggs (1970) introduced an innovation whereby they performed a V.E.R. refraction with the checkerboard pattern. This technique had more reliability than subjective testing.

This study is largely based upon one article, Campbell and Maffei (1970).

If the V.E.R. is to be used in a clinic, there should be two checkerboard targets, one a particular pattern rate (cycles per angle) which would be sensitive to refraction for non-amblyopic eyes, the other a coarse pattern that would be insensitive to small lens changes, which would be useful for amblyopic refractive and qualitative tests. Both of these targets should evoke a V.E.R. that has a high signal to noise ratio.

In Fig.#1 a graph of VER amplitude vs. log contrast of a checkerboard stimulus is drawn. The values that are indicated on the graph are only put in for illustration only, experiments following this one will be necessary to determine those values. As can be seen in Fig. #1, there is a direct, straight-line relationship between VER magnitude

and log contrast until a certain contrast is reached and the VER amplitude levels off. At the plateau, for the various functions, an increase in contrast of the stimulus does not result in an increase in VER.

According to the modulated transfer function (MTF) for the visual system, there are two patterned rates ($C/^\circ$) for each VER vs log contrast functions except the optimum pattern rate. All rates and contrast combinations, besides the optimum, have two rates that will coincide on the graph. This is because the eye when it is exposed to targets finer than the ideal condition progressively lose sensitivity to the target due to a subthreshold acuity level. A similar function is true on the coarse side of the optimum rate. As the checks of the stimulus get coarser and coarser the number of corders are reduced, thus reducing visual stimulation and cutting down on the VER magnitude.

The pair of rates/function is convenient for the desire to have one standard testing function composed of two check sizes for amblyopic and non-amblyopic eyes as mentioned previously.

The ideal pair is the one which will:

- (1) increase, for each level of contrast, a maximum VER
- (2) a maximum signal/noise ratio
- (3) a function within normal range of contrasts which do not plateau within the working range. When there is

a loss of information.

Procedures:

Two subjects were used; S.T. was a 36-year-old emmetrope and Z.B. was a 26 year old 1.00 D. hyperope. Three electrodes were used to record the VER. One electrode was placed 2.5 cm. above theinion along the midline and the other two were attached to the two earslobes. An averaging computer was used to tease out the stimulus dependent VER. The checkboard stimulus was placed a distance of twenty feet from the subjects. The checkboard was generated by a television screen. The T.V. screen was designed and built by William Dunn under Dr. Thorn's guidance. The T.V. can generate any size checks, at any contrast level, and modulate at any Hz. Eleven lens changes were made for each VER trial. Whenever a trial was made the computer would average and display the information on the oscilloscope in four different functions; the mean; the standard deviation; the mean plus the standard deviation; and the mean minus the standard deviation. The graph represented a total time period of 142 milliseconds which included 71 individual time bins. Within each 2 millisecond time bin 60 trials were taken. The teletype machine also made up a punched tape to be used to run the X-Y plotter for recording all data.

Between each trial the patient swung a cardboard shield in front of his eyes to prevent a long visual exposure to the

flashing checkboard. This was done to prevent the cortical neurons from becoming exhausted and reducing the VER amp. The right eye was used for each trial(an arbitrary decision) and a black occluder, that fit into the trial frame, was used to block off exposure to the left eye.

The checkboard screen was a circular 3.3° visual angle stimulus. The room lights were turned off at all times during the experiment.

Two series were attempted. One was a high contrast stimulus and the other was a low contrast stimulus viewed through the series of eleven different lenses.

Data:

Subject- S.T. High Contrast Series
Contrast- 85%
Mean Luminance-67 ft. lamberts
Pattern Rate- 1 cycle/degree visual angle

| <u>Lens</u> | <u>VER Amplitude(arbitrary values)</u> |
|-------------|--|
| pl | 214 |
| +6.00 | 159 |
| +2.00 | 149 |
| +1.00 | 236 |
| + .50 | 257 |
| + .25 | 341 |
| pl | 371 |
| - .25 | 333 |
| - .50 | 358 |
| -1.00 | 289 |
| -2.00 | 378 |
| -6.00 | 347 |
| pl | 367 |

Subject- Z.B. Low Contrast Series

Contrast- 20.7%

Mean Luminance- 77.6 ft. lamberts

Pattern Rate- 1 cycle/degree visual angle

| <u>Lens</u> | <u>VER Amplitude</u> |
|-------------|----------------------|
| +1.00 | 380 |
| +7.00 | 311 |
| +3.00 | 254 |
| +2.00 | 313 |
| +1.50 | 390 |
| +1.25 | 354 |
| +1.00 | 282 |
| + .75 | 272 |
| + .50 | 298 |
| p1 | 365 |
| -1.00 | 336 |
| -5.00 | 320 |
| +1.00 | 287 |

Subject- Z.B. High Contrast Series

Contrast-72%

Mean Luminance- 82.4 ft. lamberts

Pattern Rate- 1 cycle/°

| <u>Lens</u> | <u>VER Amplitude</u> |
|-------------|----------------------|
| +1.00 | 399 |
| +7.00 | 198 |
| +3.00 | 261 |
| +2.00 | 381 |

Amplifier broke down!

Concentration vs. No Concentration

Subject- Z.B. Same stimulus values as low contrast series.

| | |
|------------------|-----|
| -3.00 (conc.) | 283 |
| -3.00 (no conc.) | 320 |

Also, included in the thesis are the actual X-Y plots completely drawn by the computer.

Discussion:

S.T.'s high contrast trial went very well but when the low contrast trial was attempted the results were not significant. A further time was set aside for a repeat on the low contrast but the amplifier broke down and the completion of S.T.'s data could not be done before the deadline of this thesis.

Z.B.'s low contrast trial went well but the high contrast trial could only be partially completed because of the same amplifier breaking down.

The graphs show a low V.E.R. amplitude on the plus lens side of the lens series due to the blurring of the checkboard. As the + lenses reduced in value relative to the subject's refractive error, determined subjectively, the amplitude of the V.E.R. rose to a maximum.

The only variation in response between S.T. and Z.B. was in the minus lens series (increased accommodative stimuli). S.T. kept a high V.E.R. magnitude throughout the minus lens series, where Z.B.'s amplitude fell off quite a bit. These differences may be associated with Z.B.'s accommodative problem, which has been demonstrated in the clinic.

Comparing Z.B.'s low contrast to Z.B.'s high contrast V.E.R. amplitudes it is obvious that the high contrast evokes a higher V.E.R. potential. This is consistent with

the work done by Campbell and Maffei (1970). The work that must be done to determine the optimum check size for clinical work will necessitate many more trials with many different stimulus conditions, in which check size is varied in relation to the checkboard contrast.

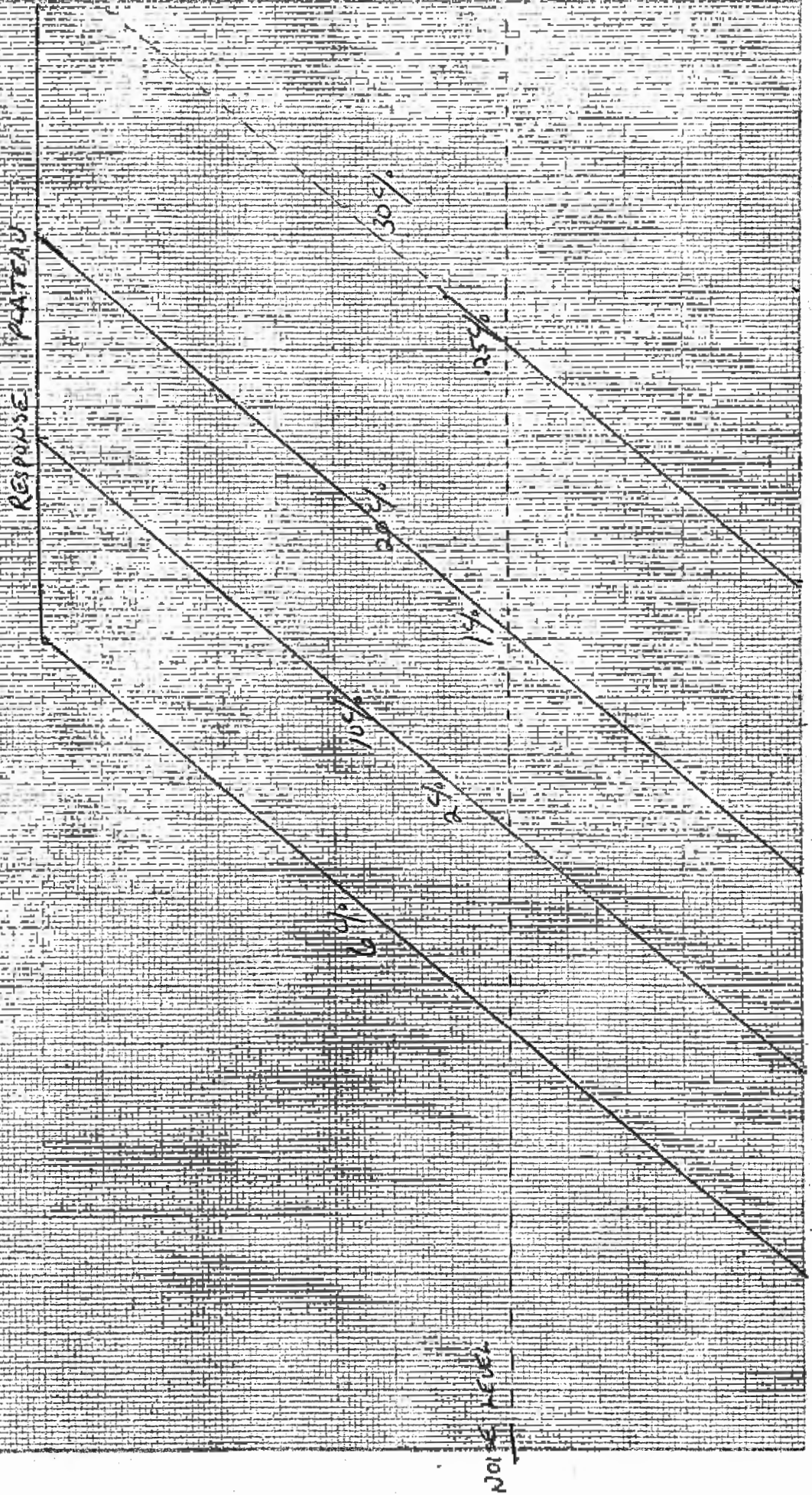
Conclusion:

This study is the beginning of a search for the optimum parameters needed for clinical V.E.R. refraction. This paper outlines the procedures and format for future research.

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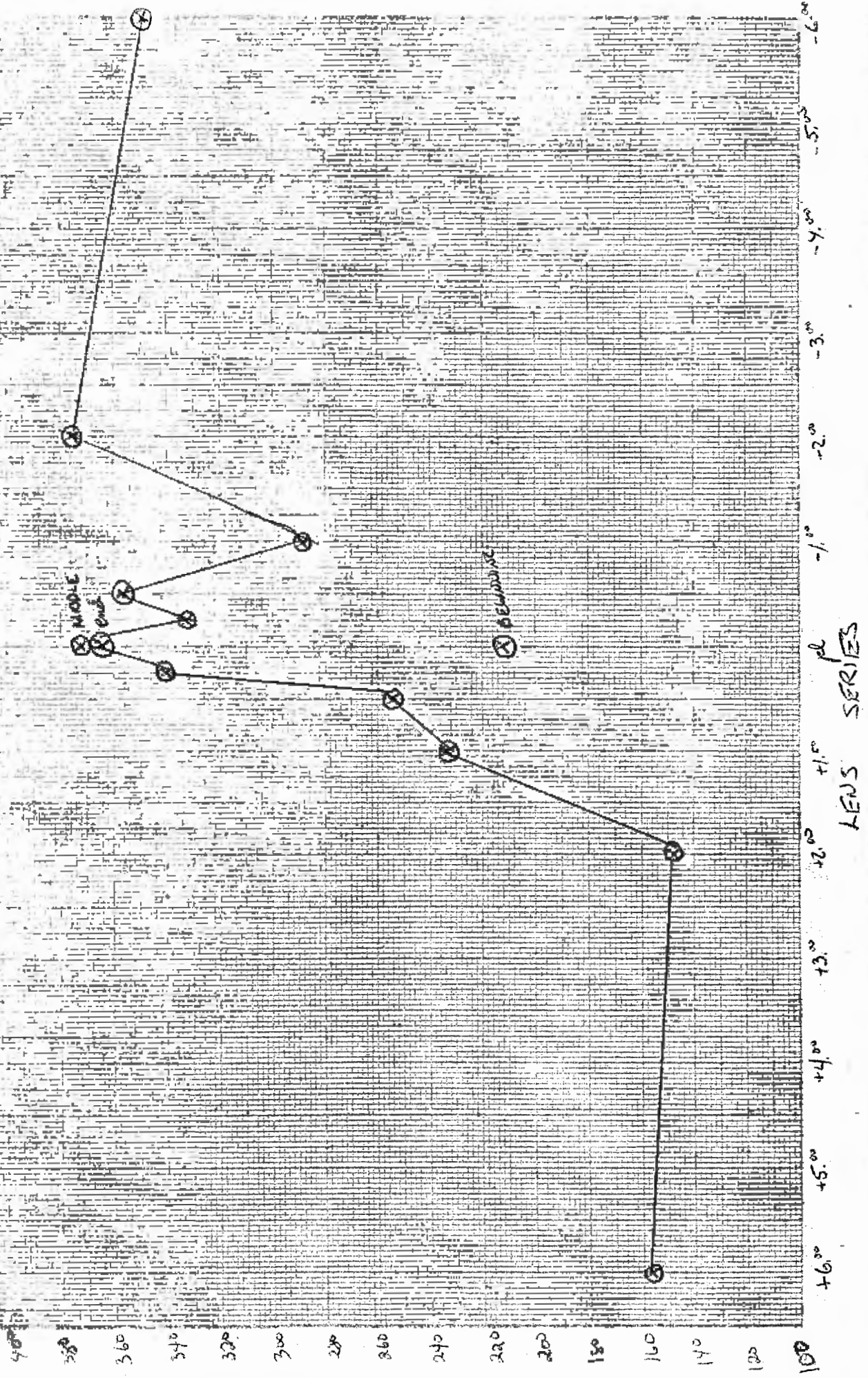
Fig. 1



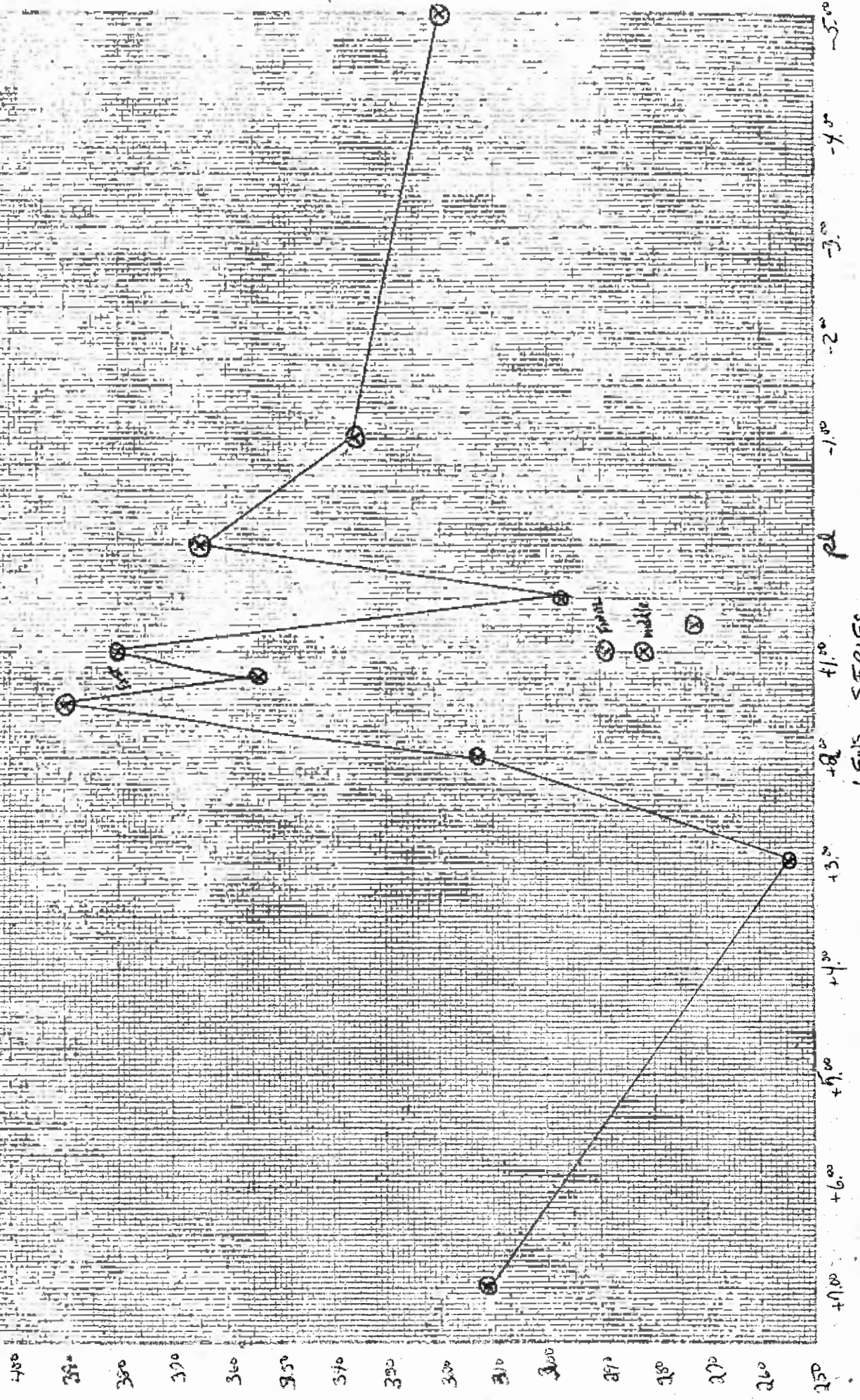
VER AMPLITUDE

10
13
LOG CONTRAST

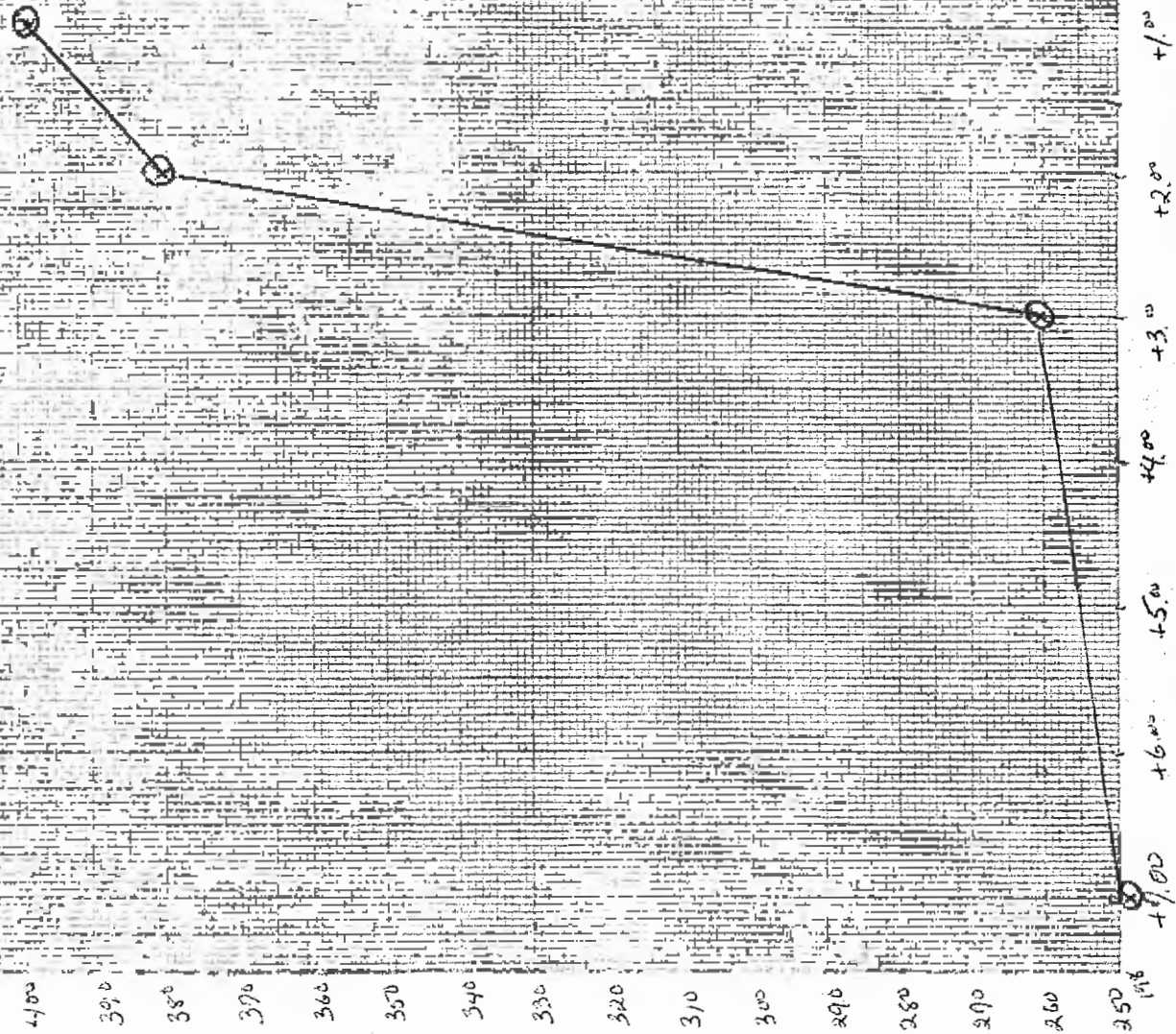
SUBJECT S.T.
H.I. CONTRAST



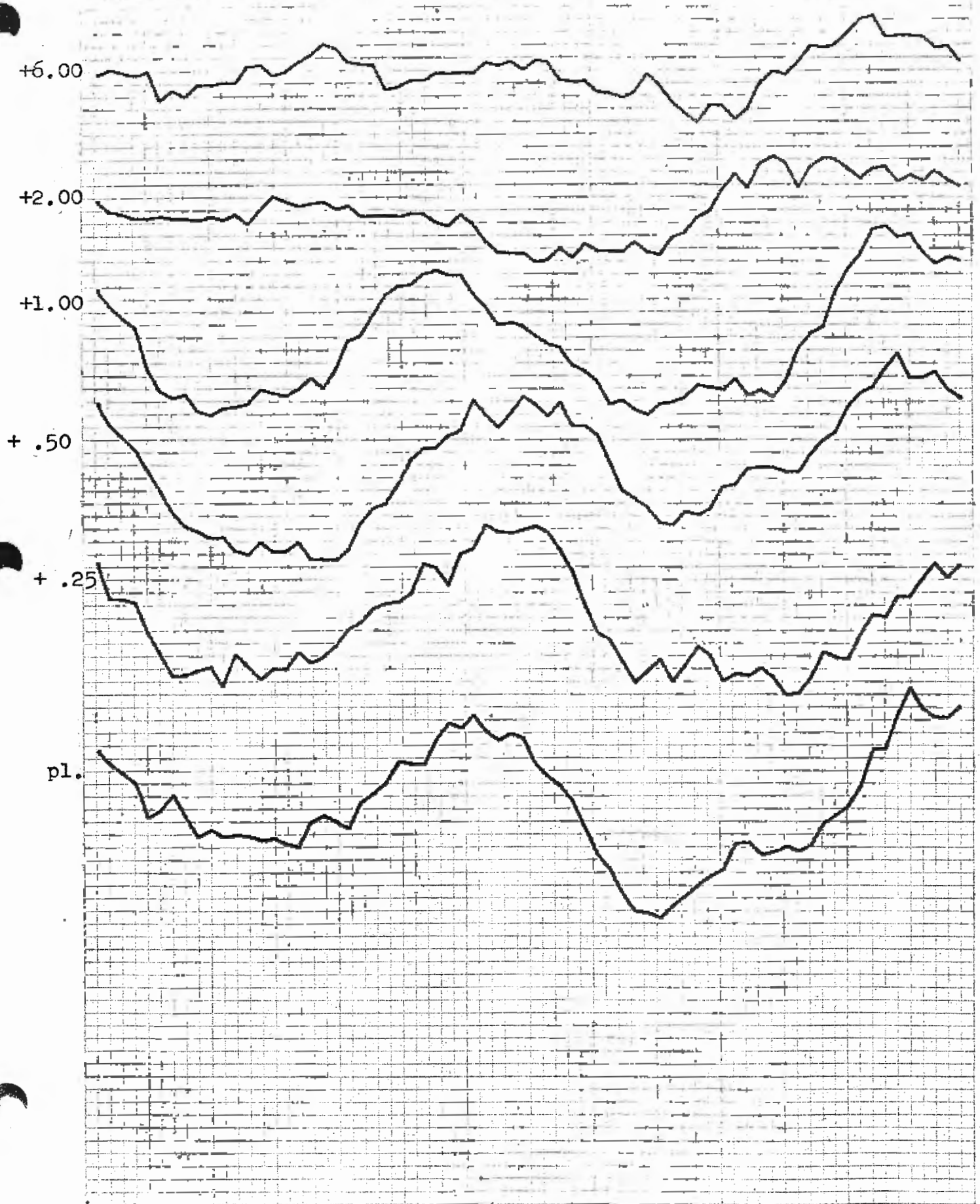
SUBJECT - 2.6
LO CONTRAST



SUBJECT Q B
H I CONTRAST SERIES

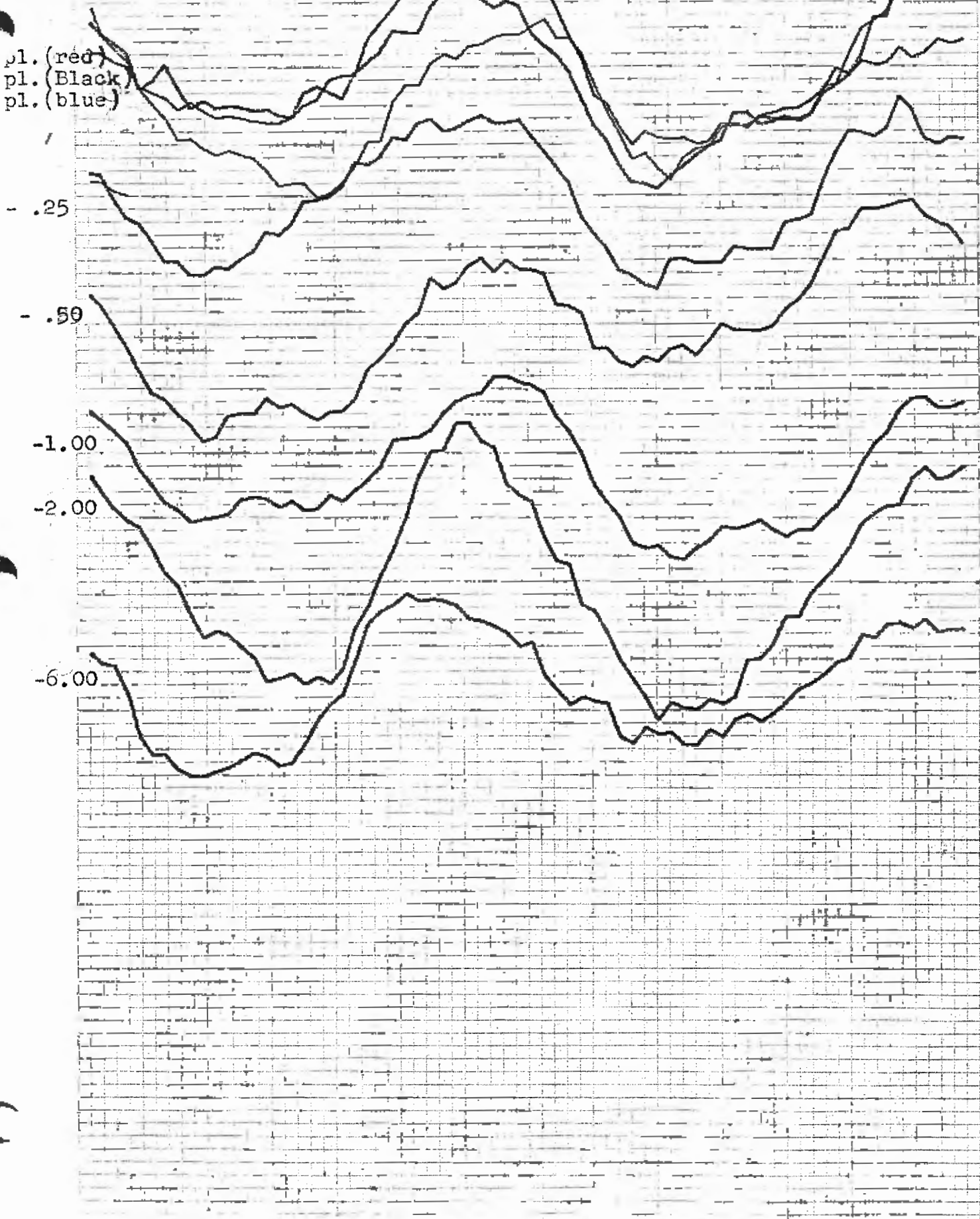


Subject; S.T. High Contrast



Subject: S.T. High Contract Series

1st pl. (red)
2nd pl. (Black)
3rd pl. (blue)



+1.00 (Blue) 1st
+1.00 (Black) 2nd

Subject: Z.B. Low Contrast

+1.00 (Red) 3rd

+ .75

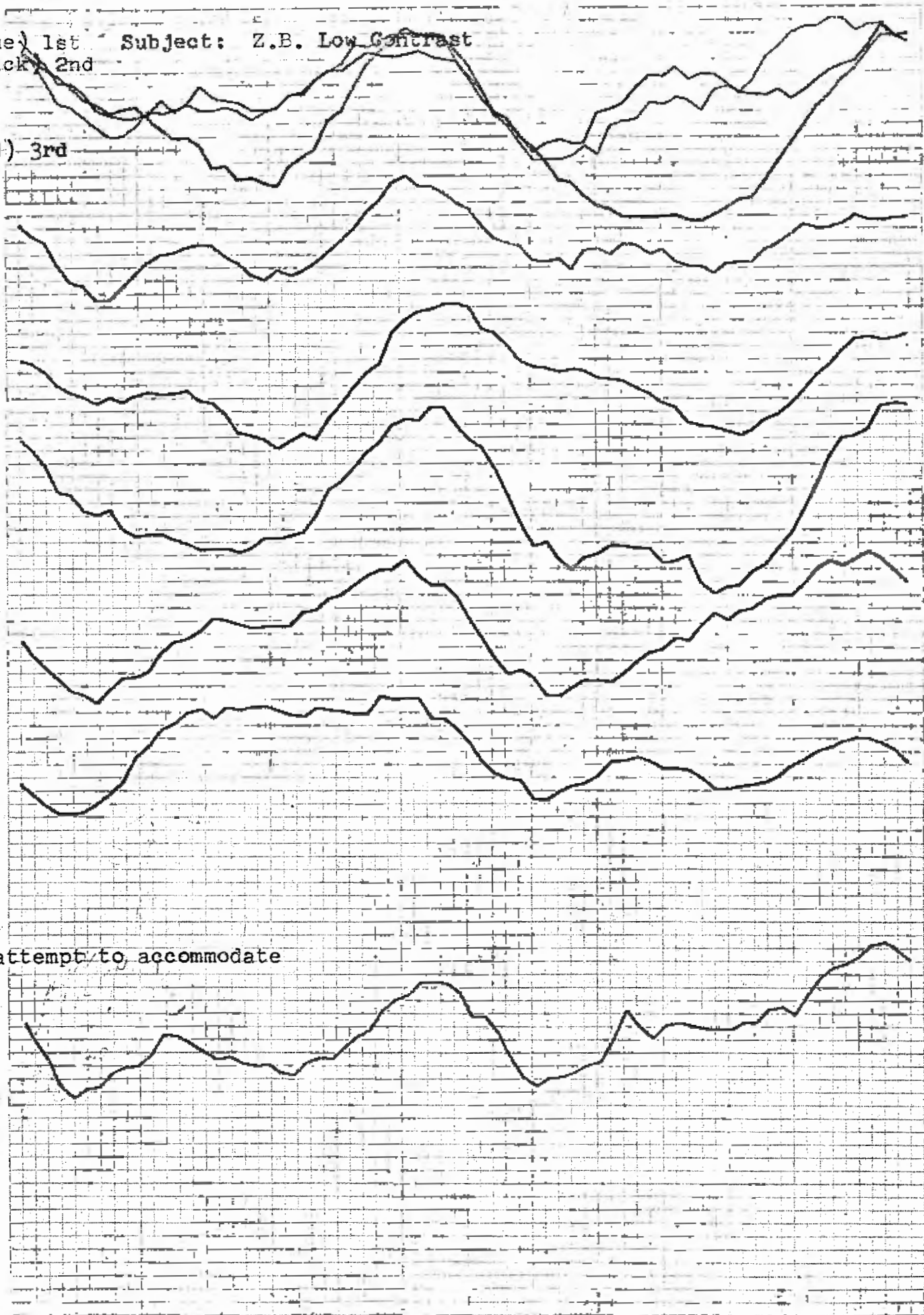
+ .50

pl.

-1.00

-3.00

-3.00 attempt to accommodate



Subject: Z.B. Low Contrast

+7.00

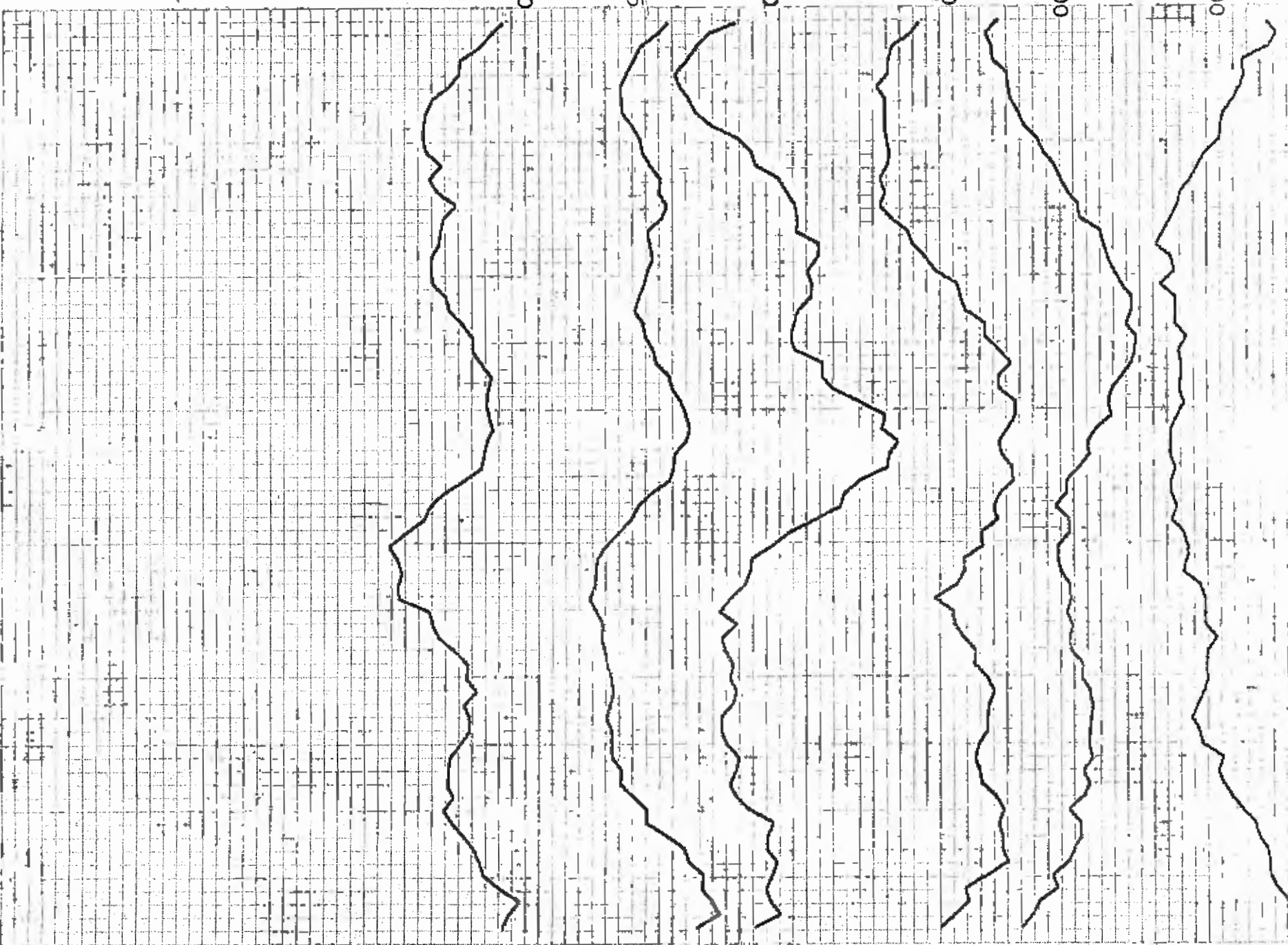
+3.00

+2.00

+1.50

+1.25

+1.00



Subject: Z.B. High Contrast Series

+7.00

+3.00

+2.00

+1.00

