FIXATION DISPARITY CURVE STABILITY

AND JUMP VERGENCE FACILITY

By

Scott L. Schomaker

Presented To

Nancy Uniacke, D.O.

April 1, 1987

ABSTRACT

The testing of fixation disparity at near, as of recent, has become a clinically employable indication of the status of one's binocular function. The question at hand, however, is one of fatigue. Do fixation disparity curves change after stressing the oculomotor systems of normal patients? In an attempt to answer this, forty fixation disparity curves were generated as part of routine optometric examinations before and immediately after vergence facility testing. The fixation disparity curves from these twenty patients were carefully analyzed both subjectively and objectively. Subjective inspection indicated a greater number of eso curves than expected, both initially and after vergence facility testing. Visually, the curves indicated a wide range of change, after vergence facility, in amount and type of change. Objectively, via a paired t test, patients with initial normal curves demonstrated fatigue after vergence facility.

It is not the researcher's intent to discuss vergence facility or fixation disparity and ramifications thereof at great length. An overview follows.

Ocular vergence movements are required to shift the eyes from one point of reference to another, nearer or farther in visual space than the original. Thus, vergence movements are rapid, disjunctive, torsional changes in ocular posture such that the end result is a realignment of the visual axes allowing the new target to be singularly visualized.

It has been proposed that vergence shifts are governed through the control system theory. A synopsis of this theory, suggested by Saladin,[1] provides an introduction. For further explanation, the reader is encouraged to study Saladin's work.

When an individual is faced with a vergence demand, disparity detectors in the cortex send a signal to the extraocular muscles. The disparity detectors not only recognize magnitude, but also direction of disparity (crossed, exo, or (+); or uncrossed, eso, or (-)). The vergence process is initiated by the fast vergence adaptor mechanism, also known as the fast neural integrators, that quickly align the visual axes at the desired angle. This innervational component fatigues after a few seconds. At that point, the slow vergence adaptor mechanism or slow neural integrators, take over. This allows for properly sustained ocular posture. The slow vergence adaptor mechanism is also sensitive to eso and exo disparity, as evidenced by Vaegan.[2]

The vergence system is controlled by a negative feedback mechanism. By definition, however, when the feedback output reached zero, the necessary innervation would be lost and the eyes would begin to drift. It has been proposed by Kirshnan and Stark[3] that the slow vergence adaptation mechanism "leaks" innervation to prevent this from occuring. This allows for maintenance of single, clear binocular vision.

Historically, an oft used method of vergence testing is via Risley prisms. However, Risley prisms test sliding vergence movements. This type of movement is used only when a person is following a target toward or away from a point of reference. Jump vergence testing creates a more life-like and, therefore, presumably more accurate measurement of one's convergence and divergence abilities. Furthermore, Risley vergence testing is static, while jump vergence testing is dynamic. Jump vergences are tested by the use of prism flippers. Griffin[4] supports testing using a range of twenty prism diopters.

Fixation disparity is a sensorimotor misalignment under associated viewing conditions. The disparite images of the target fall within Panum's area; therefore, central sensory fusion is achieved. The alignment error resulting in fixation disparity does not usually exceed ten minutes of arc, but may be as much as twenty-five minutes of arc (approximately twenty-five hundredths to seventy-five hundredths of prism diopters on the retina).[5] It has been suggested that fixation disparity is an associated phoria; however, this is a contradiction in terms, since, by definition, a phoria is a disassociated phenomenon. Nonetheless, it is noted that most individuals who are heterophoric show a fixation disparity.

Fixation disparity was first studied at length by Ogle over thirty years ago.[6] Originally, Ogle believed that phorias and fixation disparities were equal. Ogle later found this supposition to be invalid. It is common that the phoria and the fixation disparity for an individual are in the same direction, but such is not always a given, as example, an exophoric patient may have an eso fixation disparity or vice versa. This is the case in approximately twenty-five percent of the population.[6] As in phorias, eso fixation disparity indicates that the individaul is overconverged for the fixation point, while an exo fixation disparity indicates a state of underconvergence.

A fixation disparity curve, also known as an Ogle curve, can be generated through the use of a disparometer. The disparometer (figure 1)[7] is a testing device for fixation disparity based on the principle of polarized vernier lines. This instrument can be either supported by a near point rod or held by the patient at his normal reading distance. To determine horizontal fixation disparity, the patient is instructed to keep the letters on either side of the circle clear (as an accommodative lock) and to turn the knob on the back of the disparometer until the two vertical lines are one above the other. It is best to encourage the patient to bracket. The curve is produced by stressing the system using hand-held prisms in front of either of the patient's eyes and repeating the above. The result, when plotted on a graph, is known as an Ogle curve (figure 2).[5] Four characteristics of a fixation disparity curve should be noted. The first characteristic is the vertical axis intercept, or Y-intercept. This is a measurement of the fixation disparity without any prism in place to produce stress. The horizontal axis intercept, or X-intercept is the second characteristic. This indicates the amount of prism necessary to neutralize the fixation disparity. The third characteristic is the slope of the curve as it crosses the vertical axis. This is an indication of the function of the slow vergence adaptor mechanism. A flat slope indicates proper function. A steep slope (greater than forty-five degree angle) is often associated with symptomatic patients.[8,9] This results from trying to maintain vergence demands by relying on the fast vergence adaptor mechanism. The final characteristic is the curve type. There are four basic types of Ogle curves (figure 3).[5] Type I curves are sigmoid curves with vertical sweeps at either end. Type II curves lack the downward sweep on the base out side. Type III curves lack the upward base in portion. Type IV curves are sigmoid in shape, as are Type I curves; however, the curve terminates with horizontal lines. Saladin and Sheedy[10] determined the following frequency of curve types at near:

Type I	58.2%
Type II	27.6%
Type III	8.2%
Type IV	7.2%

A 1981 study, conducted by A. Jones under supervision of J. James Saladin, O.D. determined that Ogle curves "were very repeatable in subjects with balanced oculomotor systems."[11] This conclusion resulted from studying fixation disparity curves after test intervals of hours, days, weeks, and months.

With this background information in mind, the research that follows was conducted.

METHODS

Data was gathered on twenty patients at the optometry clinic at the Grand Forks Air Base, in Grand Forks, North Dakota. Active duty military personnel as well as dependents were used in the study.

Each patient met the predetermined criteria as follows:

I. No subjective complaints indicating an ocular motility/posture problem.

II. No objective signs indicating the above.

III. Able to achieve thirty seconds on the stereo Reindeer test.

IV. Ortho and/or exophoric at distance and near.

V. None over age thirty.

The following information was gathered on each patient:

I. Patient's initials.

II. Sex.

III. Age.

IV. Visual acuity through both habitual and induced refraction.

  A. At distance; OD and OS.

V. Spectacle prescription.

  A. Habitual and induced.

VI. Forced cover test results to give true angle through habitual prescription.

VII. Risley vergence testing results through induced prescription in phoropter.

A fixation disparity curve was generated by using a disparometer. The patient was instructed to hold the disparometer at his normal reading distance. His attention was drawn to the circle containing the vernier lines used to test for horizontal fixation disparity. The patient education, approximatly ten seconds in duration, included instruction to "align the two lines such that they are one above the other while keeping the letters on either side of the circle clear". Each patient was encouraged to bracket around the point where he thought that the vernier lines were properly positioned. After the patient was allowed to "play" with the disparometer, polaroid glasses were inserted over the patient's habitual near spectacles, and the test was begun with a reiteration to align the lines one above the other and an instruction to spend no more than ten seconds on each setting. Fixation disparity was first measured with no prism in place. Then, it was taken again using hand held loose prisms, in order, of four base in, four base out, six base in, and eight base out. The loose prisms were held by the examiner over the polaroid lens covering the patient's left eye as a matter of practicality determined by the set-up of the examination lane. Each response was recorded, and vergence facility testing was done.

Vergence facility was tested via jump vergences. A short explanation of the procedure was presented to each patient. As before, each patient wore his habitual near correction. The Ohio State near point card, imprinted "Keep these words clear and single", was held by the patient at a measured distance of forty centimeters from the spectacle plane. Each patient was instructed to verbally indicate (for example, by saying "okay" or "clear") when the words on the near point card were clear and single. The prism amounts used were eight base in and twelve base out, keeping in accordance with Griffin's rule of using a twenty prism diopter range.[4] Jump vergences were begun by the examiner first holding the base inside the bar over the patient's eyes. The amount of time necessary to complete ten cycles (twenty turns of the prism bar) was recorded with an L.E.D. stop watch. It should be noted that the time for the examiner to physically make twenty half turns of the prism bar was reported by Schaff to be an average of fifteen and three-tenths seconds.[11]

Upon completion of the above, fixation disparity was again taken. The same procedure was used the second time with the exception of dispensing the original patient educating.

DISCUSSION

Before an actual analysis of the data is approached, a short digression into the possible ways that a curve can change is in order.

There are four basic ways that a curve can breakdown. It can become steeper, overall fixation disparity can increase (a higher Y-axis intercept, therefore more eso), the curve can become wobbly or sporatic, and/or the curve type can change. The base in and base out portions of a fixation disparity curve can fatigue differently.

The possiblity also exists that a fixation disparity curve can improve. That is, change from a curve indicative of an inadequate oculomotor system to one normally associated with well balanced ocular posture.

The obtained data was analyzed two ways. It was subjectively analyzed from a clinical standpoint and also objectively by mathematical means.

Subjective scrutinization was begun by a visual comparison of the forty fixation disparity curves, with added attention directed toward the paired curves from each individual. It was noted that a seemingly abnormal number of eso curves were generated. In a symptom-free population, Saladin[12] suggested that approximately ten percent should demonstrate a fixation disparity opposite of their heterophoria. Because only those with exophorias were included in this study, approximately two eso fixation disparity curves should have been generated. Ten of the twenty subjects tested had eso fixation disparity curves initially. Allowing for two prism diopters deviation as subjective accuracy in aligning the vernier lines, six of the curves were eso. Of the remaining ten curves, four showed an ortho position of zero prism diopters. This also indicates a greater overall shift toward eso than the norm.

In an attempt to explain this, four possibilities were explored.

First, the possibility exists that, for some unknown reason, the sample population simply happened to include more eso fixation disparity curves than expected.

In the second place, because the near heterophoria was obtained by doing a forced cover test, some of the patients classified as being exophoric may have actually been esophoric. When doing a forced cover test, base in prism is held in front of one of the patient's eyes, the patient fuses, and an alternating cover test is done. Neutrality is considered to be one step lower on the prism bar than the prism that objectively indicated an eso eye movement. Base in prism is used to decrease the amount of voluntary convergence due to the convergence accomodation/convergence ratio (CA/C). This effect was probably minimal in the sample population as one's CA/C decreases as one ages. A forced cover test uncovers latency in an exophore due to a bound positive slow vergence adaptation mechanism. This is broken down by the base in prism. A difference of greater than three prism diopters between a cover test and a forced cover test is considered to be clinically significant. In those instances where the above is not the case, it can be assumed that approximately three prism diopters in the exo direction is added to each individual's phoria when doing a forced cover test. Therefore, by subtracting three prism diopters exo from the forced cover test results, it can implied that four esophores were included in the study. Of these four individuals, two had initial eso fixation disparity curves, one was ortho, and the other was exo.

A third possibility also relates to the forced cover test. As mentioned above, the base in prism breaks down the positive slow vergence adaptation mechanism. In doing such, it actually changes the momentum of the system such that the negative slow vergence adaptation mechanism takes over. It is not known how long this momentum continues. Assuming that this tendency is prolonged, it could account for some of those exhibiting eso fixation disparity curves. If this argument is to be plausable, the negative slow vergence adaptation mechanism would have to remain in play for approximately ten minutes, during which time, in the study, near stereopsis was tested and a refraction was completed.

A fourth possibility is related to overall refractive error versus habitual prescription. An undercorrected hyperope or an overcorrected myope may generate and eso fixation disparity curve. The manifest refractions indicated an increase in plus power for two patients. Both of these patients had eso fixation disparity curves. One of these was also included in the group of four individuals who may have been esophoric.

It is of the researchers opinion that the reason for the high number of eso fixation disparity curves cannot be accounted for by a simple explanation, but rather a combination of the above.

A general visual inspection not only revealed more eso fixation disparity curves than expected, but also indicated that overall the second fixation disparity curves was more eso than the first. This was the case in fifteen of the twenty sets of curves.

As reported by Saladin,[13] fixation disparity curves rise (thereby becoming more eso) during vision therapy. The jump vergence testing actually acts as a form of vision therapy in some patients. This is evidenced in those who start out meeting the vergence demand slowly and increase in speed as the test continues. Although no record was kept at the time of the study, the researcher can attest to this phenomena in several patients.

This shift toward eso can also be accounted for by turning to the slow vergence adaptation mechanism once more. The slow vergence adaptation mechanism may be strong enough, but may have a poor time constant. Thus, when stressed, the slow vergence adaptation mechanism is unable to release resulting in a higher curve.

To further analyze the data, the graphs were divided into five groups. This was done by comparing the two fixation disparity curves of each individual. In doing so, the initial curve of each patient was classified as being either normal or abnormal. A curve was labeled normal if the ortho position (that with no prism to produce stress) fell between six eso and six exo and if the slope crossing the Y-axis was forty-five degrees or less. This was determined by the best fitting line between the points corresponding to four base out, ortho, and four base in. If a curve did not meet any or all of the above criteria, it was considered abnormal. Comparing the first curve to the second curve, the following groups were developed: normal - normal, normal - degenerated, normal-seminormal, abnormal - abnormal, and abnormal - improvement. All of the graphs and corresponding classifications are in the addendum (figures 4 - 23) with the intial curve as "#1" and the second curve as "#2".

Those individuals whose fixation disparity curves fell into the normal - normal group were patients with good oculomotor systems. The stress placed on the system from jump vergence facility did not alter the curve in a clinically significant manner.

The normal - degenerated group is composed of those who demonstrated a marked change after jump vergences. These patients had systems which completely broke down.

The normal - seminormal group is comprised of the fixation disparity curves of two individuals who showed a change, but not to the extent of those in the normal - degenerated class. The supposition exists that their slow vergence adaptation mechanisms did not totally collapse, but rather fatigued.

The patients whose fixation disparities were classified as abnormal - abnormal had systems that were inadequate via fixation disparity analysis both before and after jump vergence facility. It should be noted that they had no subjective complaints or objective indications of oculomotor problems as tested.

The final group, abnormal - improvement, is made up of those individuals who actually showed an improvement in their fixation disparity curve after jump vergences. The most likely explanation is that the vergence facility acted as a form of vision therapy. The flipper prisms actually clicked their systems into the proper mode. The slow vergence adaptation mechanisms of these patients were, so to speak, punched into proper function.

The time taken to do jump vergence facility was recorded for each patient. That time ranged from forty-three and five-tenths seconds to one minute, forty-eight and one one-thousandths seconds. (Each patient's time is listed in the addendum with his corresponding Ogle curve after the word "Comments".) Visual inspection implied two trends. Concerning the first trend, the second fixation disparity curve, taken immediately after vergence facility testing, of many of the patients with longer times was steeper than the first curve. The increased slope tells us that the patient is not releasing his system properly. This can be caused by two things: spasm of voluntary convergence or a slow vergence adaptation mechanism with a poor time constant. The second trend is that of overall low time values in the abnormal - improvement group of fixation disparity curves. The shorter time fits well with the abnormal - improvement explanation. While these patients started out slowly, they soon picked up momentum to the point that vergence movements were automatic.

It should be noted that several patients failed the vergence facility test. Because these individuals were excluded from the study, the number was not recorded. To the best of the researcher's recall, the number of individuals who failed the base in and base out side of th flipper prism bar was approximately equal.

After a visual analysis of the data, a statistical comparison was applied to the before and after curves. This was done via a field trial format.

An equation developed by Saladin[12] was used to calculate the shape factor for each curve. The equation is as follows:

$$\text{Shape factor} = |\emptyset - 4BO| + |4BI - \emptyset| + \frac{|4BO - 8BO|}{2} + \frac{|4BI - 6BI|}{2}$$

The number of the minutes of arc on the Ogle curve corresponding to each of the factors in the above equation are used for the computation. Those points on the base in - eso portion of the curve are assigned a positive value, while those on the base out - exo side are negative. For instance, if the ortho point is six eso, a positive six is inserted into each "Ø" position in the equation. If eight minutes of arc exo was obtained with four base out prism diopters in front of the patient's eyes, negative eight would be used in the "4BO" portion of the equation. The higher the number is, the greater the slope.

As an example of the results, patient M.C. (figure 8) of the normal - degenerated group had a calculated shape factor of seven for the initial fixation disparity curve. The shape factor for the second curve is twenty-one. This indicates a significant increase in the overall slope. The shape factors for each patient are tabled in the addendum (Table 1).

Only those patients with an initial curve that was classified as being normal were used in further mathematical analysis. Those individuals with intial abnormal curves were excluded. The reason for this is two fold. First, these patients had an inadequate system, according to fixation disparity curve analysis, to begin with. Second, in some cases the shape factor can give misleading results. For example, patient J.C. of the abnormal - abnormal group, had before and after curves with shape factors of twenty-two and twelve respectively. This would tend to indicate an improvement. In fact, the second curve had completely broken down resulting in a graph composed of points that do not fit any of the four Ogle curve types. Please refer to these two curves in the addendum (figure 18) for further clarification.

A paired t test was run on the eleven patients with normal intial curves. The $\bar{x}$ value was eight and four-tenths for the before curve with a standard deviation of four and seven-tenths. Concerning the after curves, the $\bar{x}$ value was thirteen and eight-tenths with a standard deviation of eight and two-tenths. The t value was negative three and alpha was one-onehundredth. Thus it can be statistically concluded that for patients with inital normal curves the slope worsens after jump vergence facility testing.

CONCLUSION

Fixation disparity curves appear to change after vergence facility testing when objectively analyzed. The amount and type of change ranged from minimal to dramatic and from complete breakdown to overall improvement. Statistically employed measures support that fixation disparity curves fatigue or degenerate after jump vergence factility when the intial Ogle curve is considered normal.

REFERENCES

1. Saladin, J.J., Convergence insufficiency, fixation disparity, and control systems analysis. Presented at the Annual Meeting of the Am. Academy of Optometry., Atlanta, GO 1985; 4-7.

2. Vaegan, Convergence and divergence show large and sustained improvement after short isometric exercise. Am. J. Optm. Physiol. Opt. 1979; 56: 23-33.

3. Krishnan, V.V. and L. Stark, A heuristic model for the human vergence eye movement system. IEEE Trans. Biomed. Egin. 1977; BME-24: 44-49.

4. Griffen, J.R., Binocular Anomalies, Procedures for Vision Therapy. Prof. Press, Inc. Chicago, IL 1982; 15:401.

5. Barry and Barresi, Ocular Assessment. Butterworth Pub. Woburn, MA 1984; 15:141-149.

6. Ogle, K.N., Researches in Binocular Vision, W.B. Saunders. Philadelphia, PA 1950:81-83.

7. Griffen, J.R., Binocular Anaomalies, Procedures for Vision Therapy. Prof. Press, Inc. Chicago, IL 1982 14:342.

8. Sheedy, J.E. and J.J. Saladin, Association of symptoms with measures of oculomotor deficiencies. Am. J. Optom. Physiol. Opt. 1978 55:670-676.

9. Sheedy, J.E. and J.J. Saladin, Phoria, vergence and fixation disparity in oculomotor problems. Am. J. Opt. 54(9); 474-478.

10. Schor, C.M. and K.J. Ciuffreda, Vergence Eye Movements: Basic & Clinical Aspects. Butterworth Pub. Woburn, MA 1983; 15:525.

11. Jones, A., The reliability of the forced vergence fixation disparity curve. Presented at the Annual Meeting of the Am. Academy of Optometry., Chicago, IL 1980; 1.

12. Schaff, S.R., The BI-BO vergence facility test: a probe into the vergence system. Paper on file at Ferris State College of Optometry, 1983:6.

13. Saladin, J.J., information via personal communication, March, 1987.

14. Saladin, J.J., Convergence insufficiency, fixation disparity, and control systems analysis. Presented at the Annual Meeting of the Am. Academy of Optom., Atalanta, GO 1985; 15.

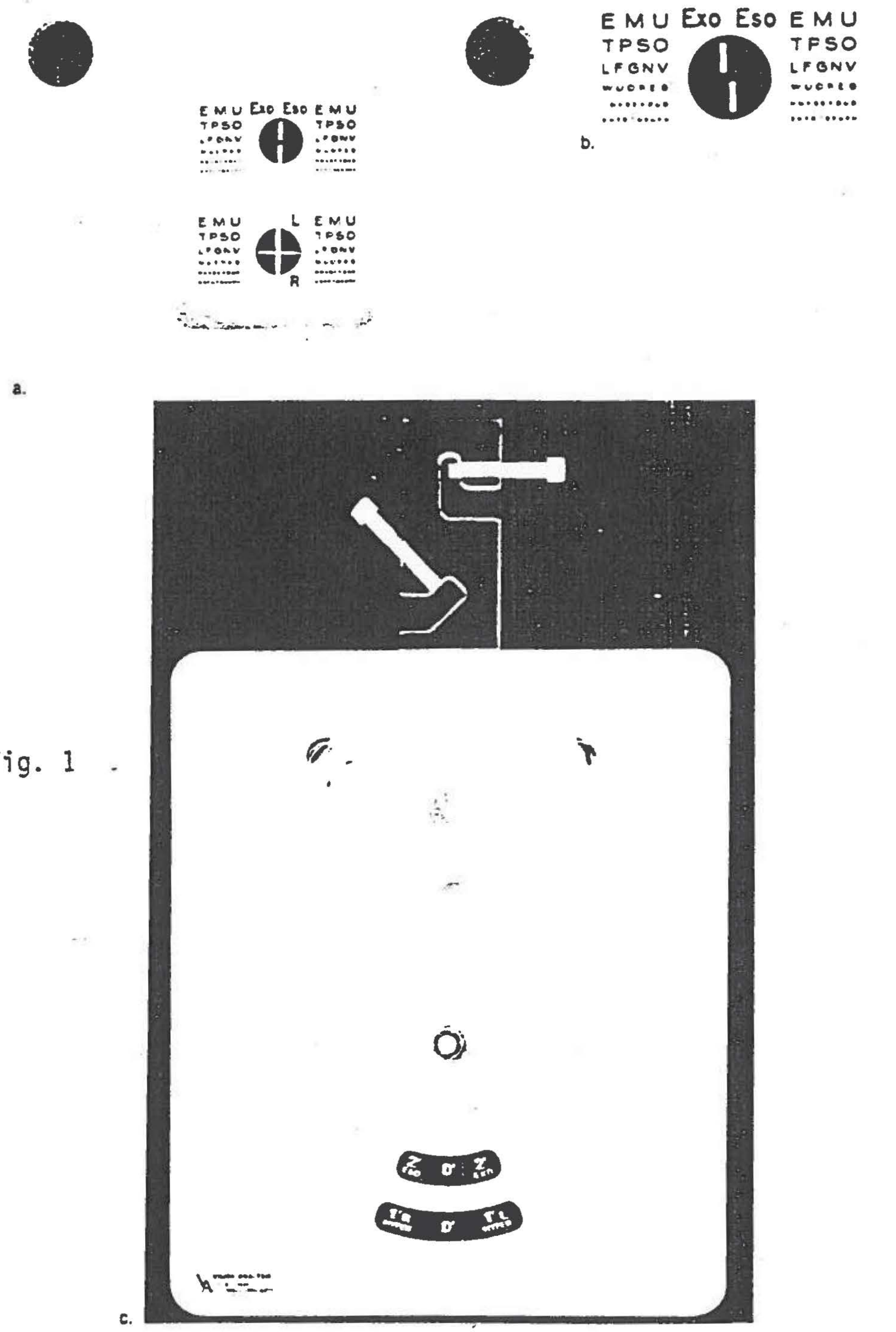


Fig. 1 — Disparometer™ (Courtesy, Vision Analysis). (a) Front view for testing horizontal and vertical fixation disparity. A penlight shone into a circular space illuminates the vernier lines via fiber optics; (b) Vernier offset in measurement of the angle of fixation disparity (angle F); (c) Back view showing fiber optics, which are illuminated from the front of the instrument, the knob to dial varying pre-set disparities, and the dials for reading magnitudes of angle F (in minutes of arc).

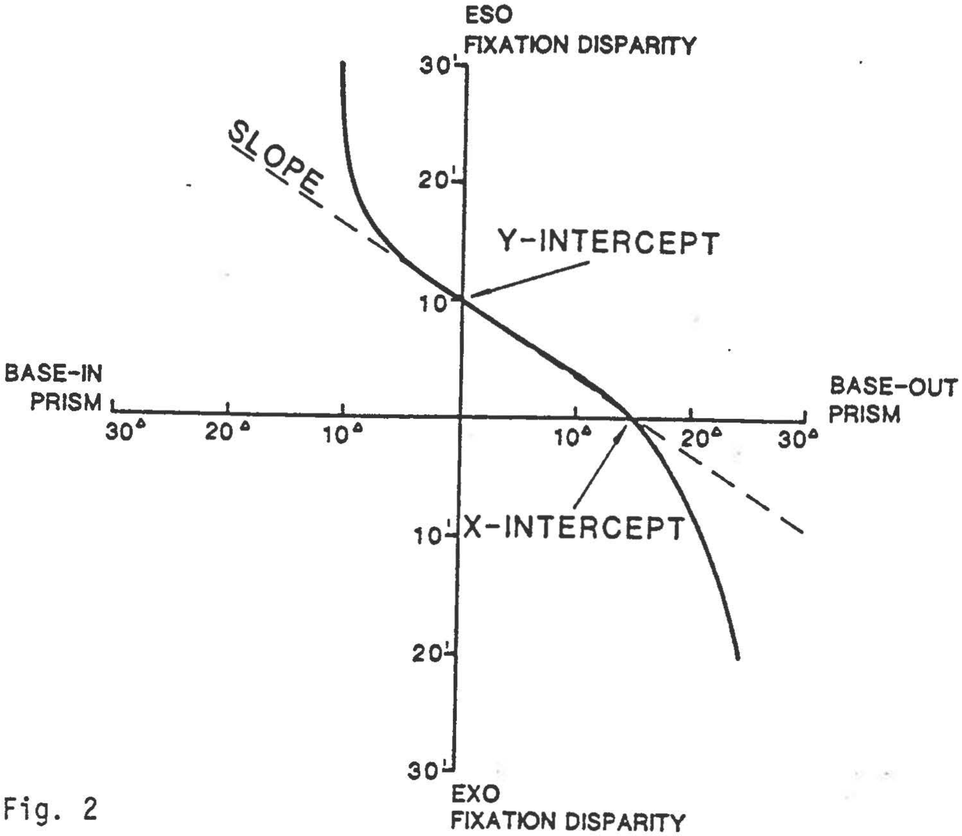


Fig. 2

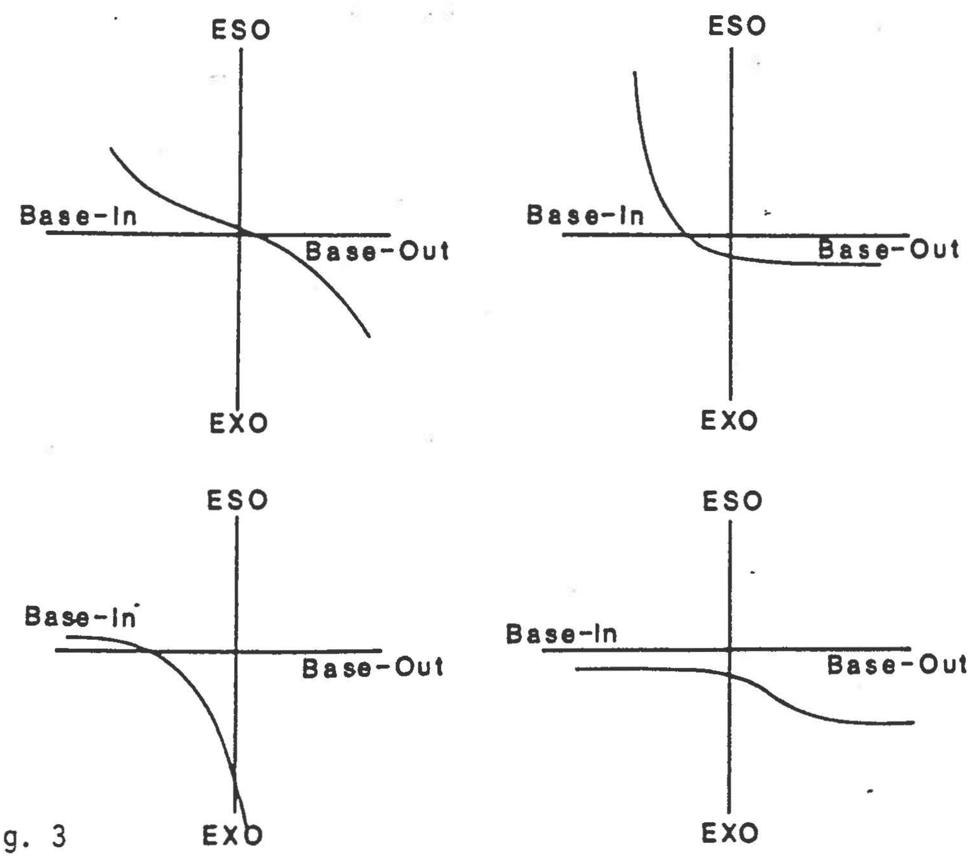


Fig. 3

Four types of fixation disparity curves (Ogle classification): Type I *(upper left)*, Type II *(upper right)*, Type III *(lower left)*, Type IV *(lower right)*.

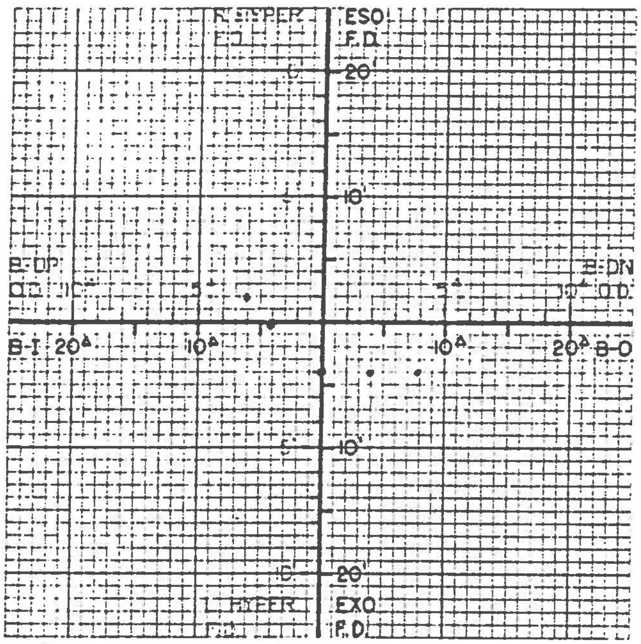
NORMAL - NORMAL

Fig. 4

FIXATION DISPARITY CURVE

#1
NAME P. D.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:
1 min. 15.36 sec.



FIXATION DISPARITY CURVE

#2
NAME P. D.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:

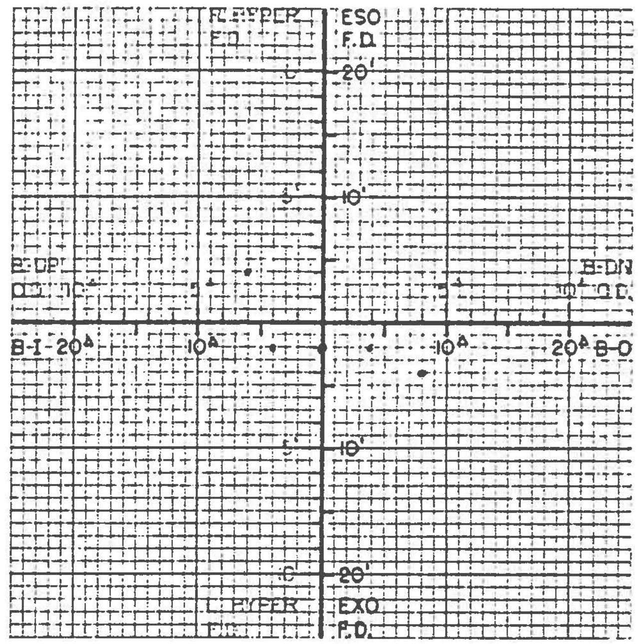
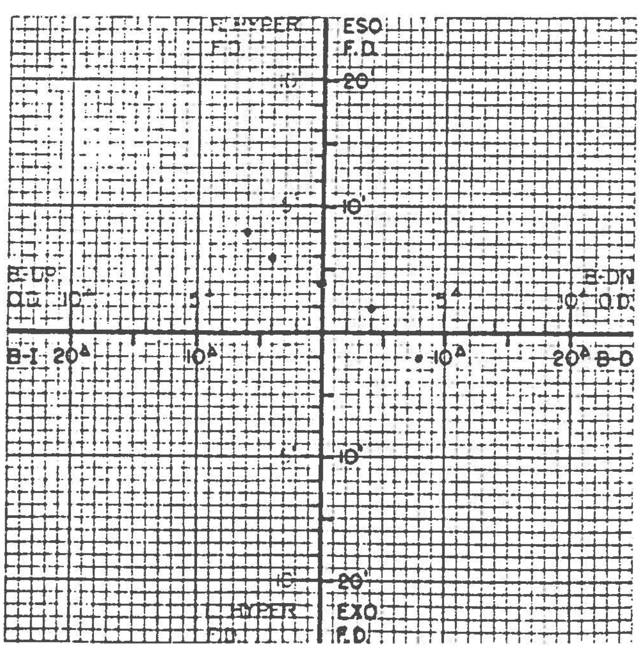


Fig. 5

FIXATION DISPARITY CURVE

#1
NAME A. S.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

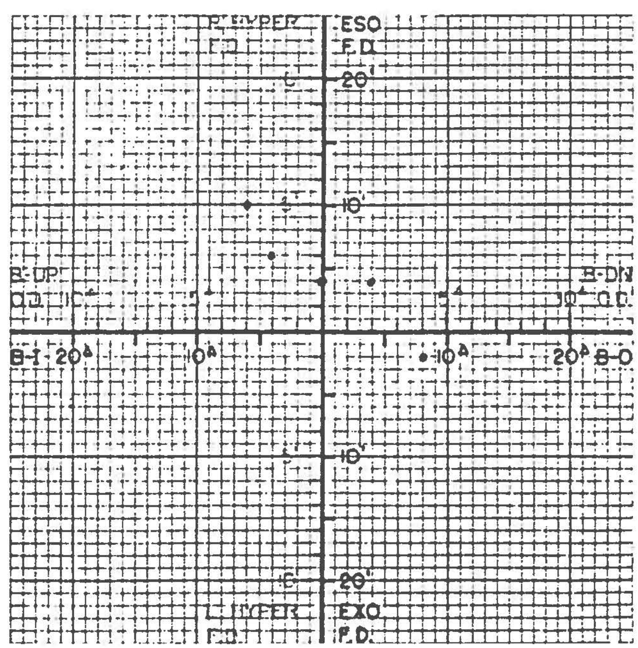
COMMENTS:
1 min. 15.95 sec.



FIXATION DISPARITY CURVE

#2
NAME A. S.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:



NORMAL - NORMAL

FIXATION DISPARITY CURVE

#1
NAME D. A.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:
1 min. 36.24 sec.

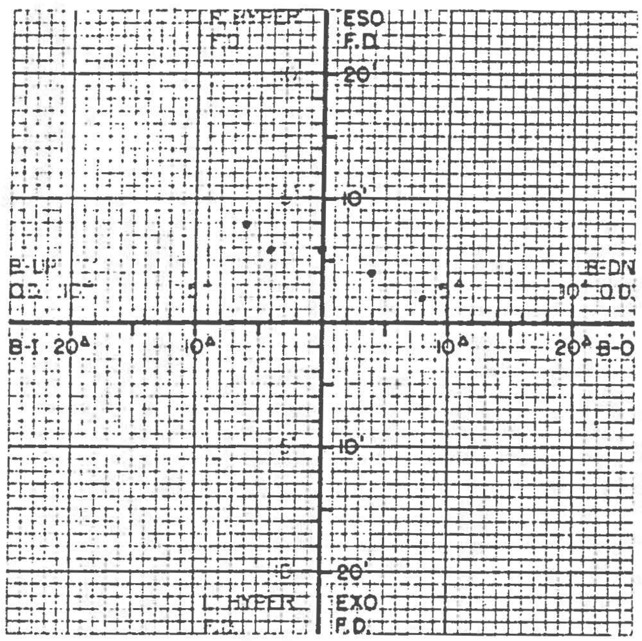
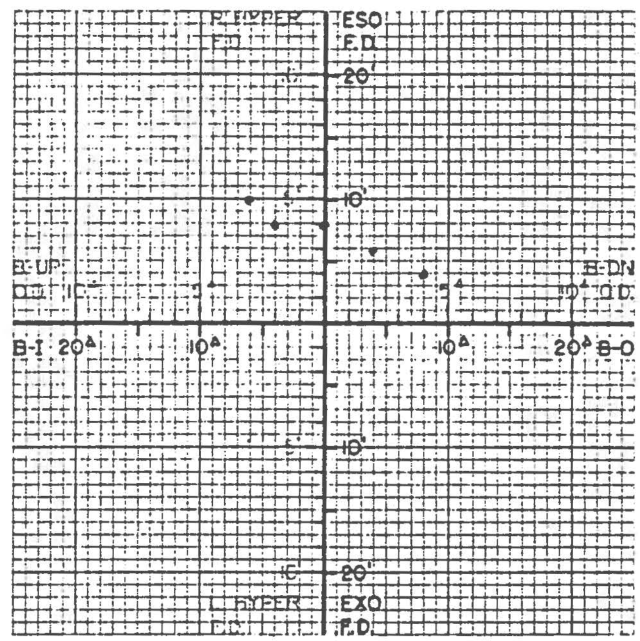


Fig. 6

FIXATION DISPARITY CURVE

#2
NAME D. A.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:



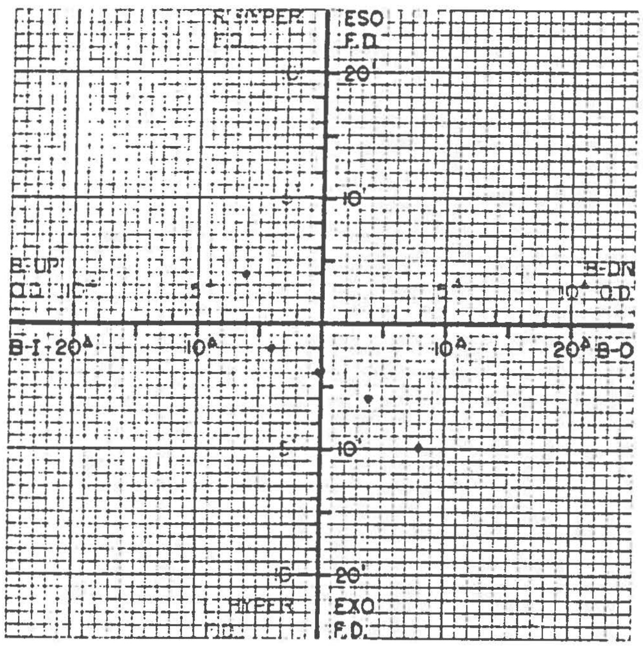
NORMAL - DEGENERATED

Fig. 7

FIXATION DISPARITY CURVE

#1
NAME W. O. S.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS: 1 min. 16.87 sec.



FIXATION DISPARITY CURVE

#2
NAME W. O. S.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:

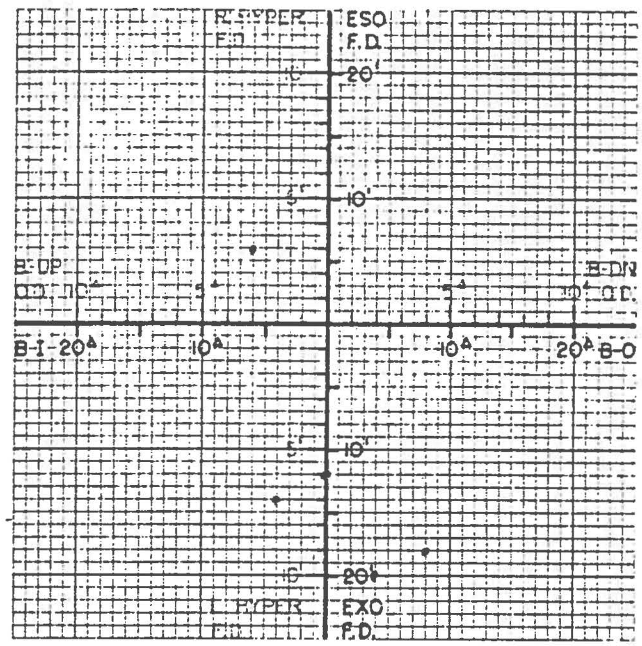
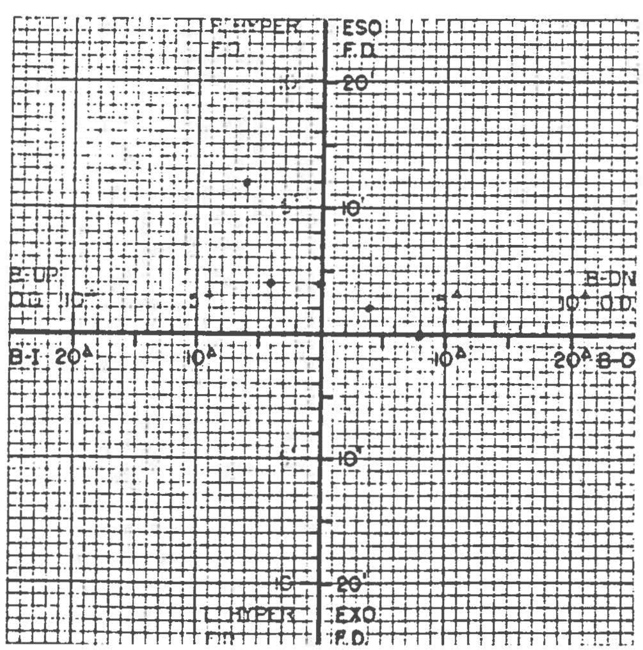


Fig. 8

FIXATION DISPARITY CURVE

#1
NAME M. C.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

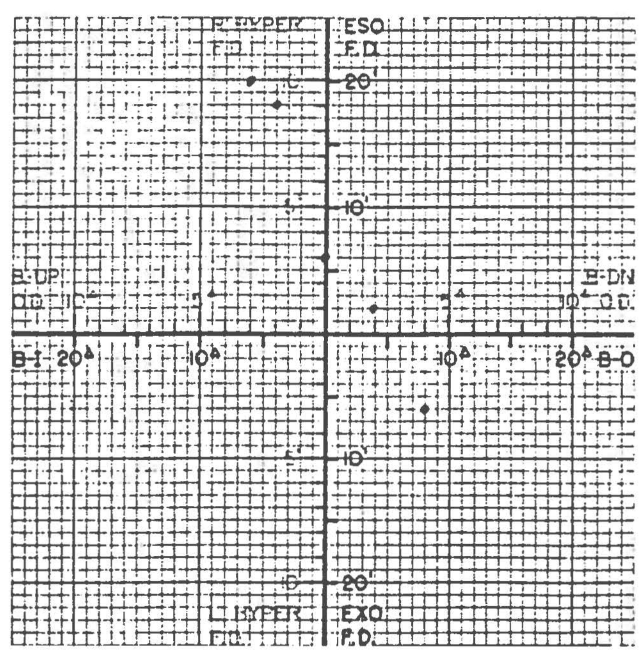
COMMENTS: 1 min. 12.43 sec.



FIXATION DISPARITY CURVE

#2
NAME M. C.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:

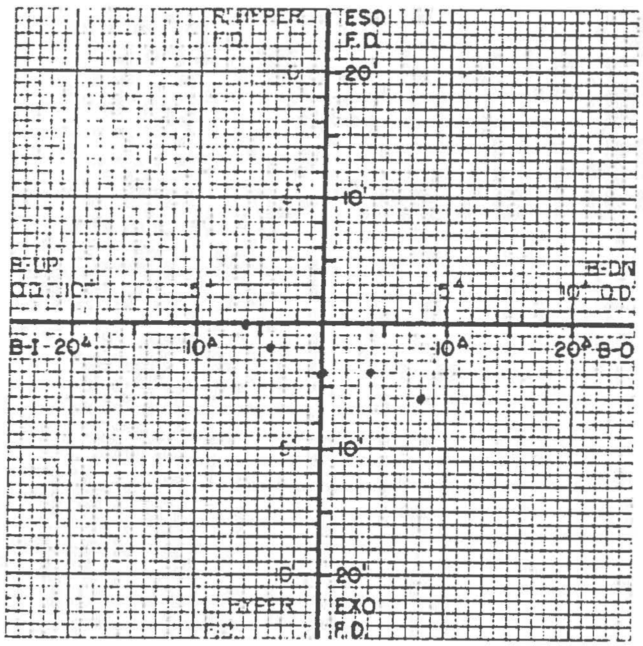


NORMAL - DEGENERATED

FIXATION DISPARITY CURVE

#1
NAME L. P.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:
1 min. 7.64 sec.



FIXATION DISPARITY CURVE

#2
NAME L. P.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:

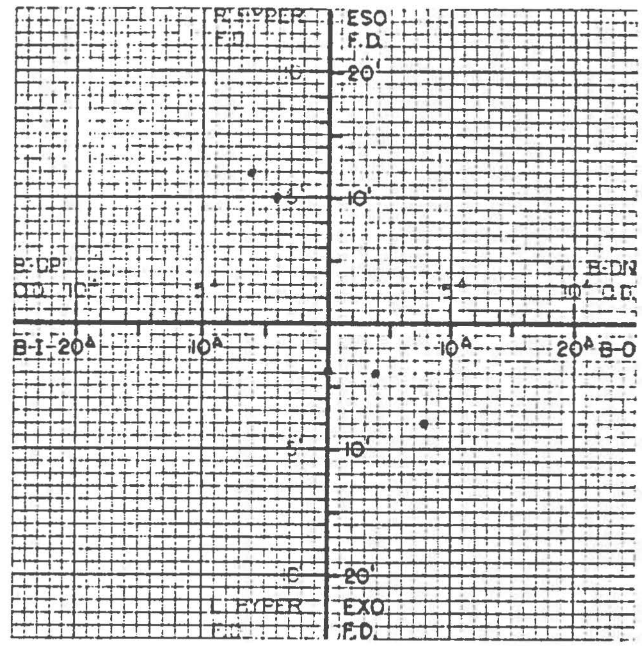
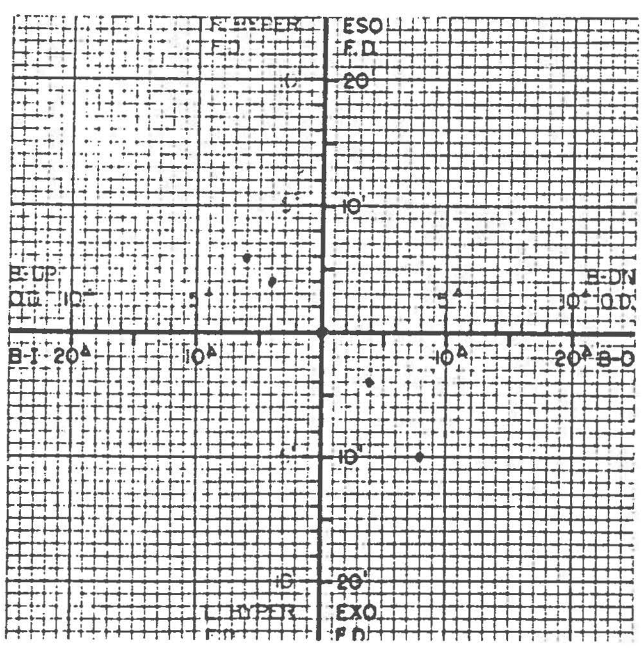


Fig. 9

FIXATION DISPARITY CURVE

#1
NAME M. H.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:
43.5 sec.



FIXATION DISPARITY CURVE

#2
NAME M. H.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:

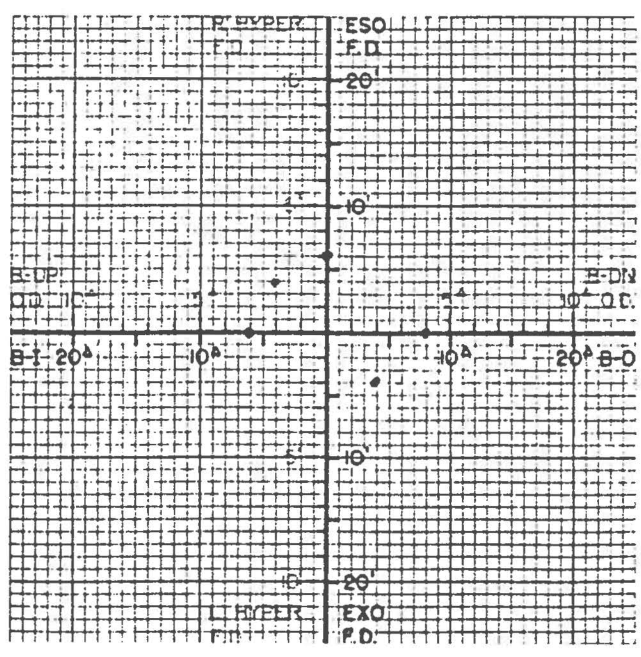


Fig. 10

NORMAL - DEGENERATED

Fig. 11

FIXATION DISPARITY CURVE

#1

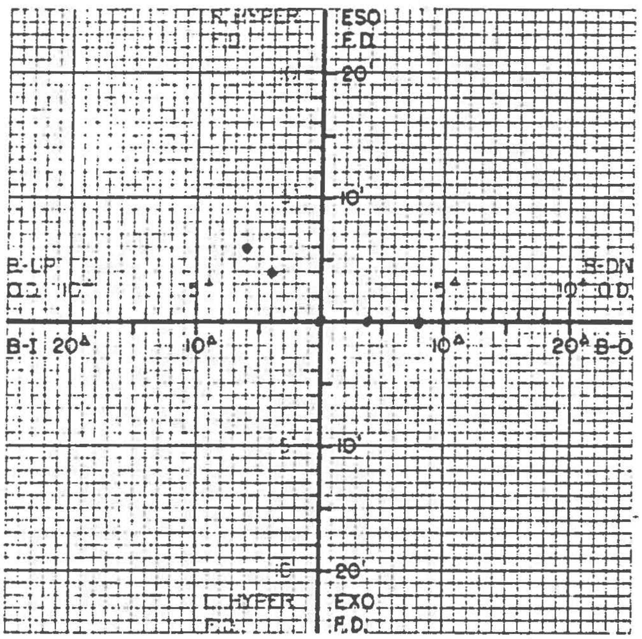
NAME R. P.

DATE

DISTANCE 40 cm

☒ LATERAL ☐ VERTICAL

COMMENTS: 1 min. 11.53 sec.



FIXATION DISPARITY CURVE

#2

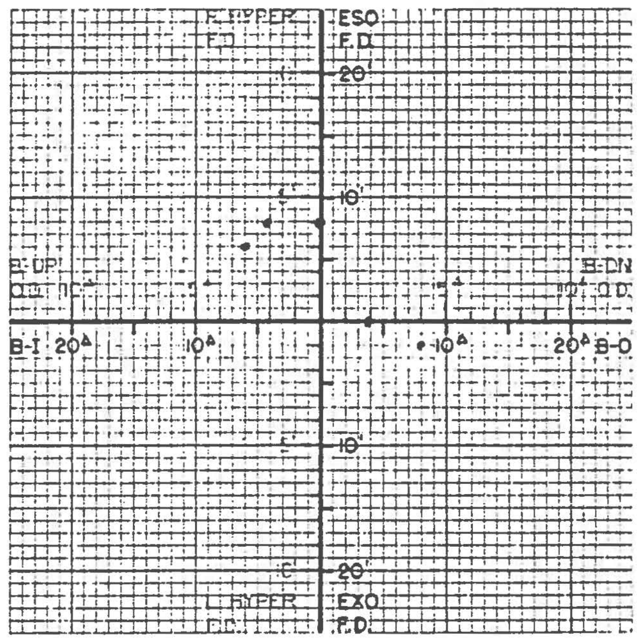
NAME R. P.

DATE

DISTANCE 40 cm

☒ LATERAL ☐ VERTICAL

COMMENTS:



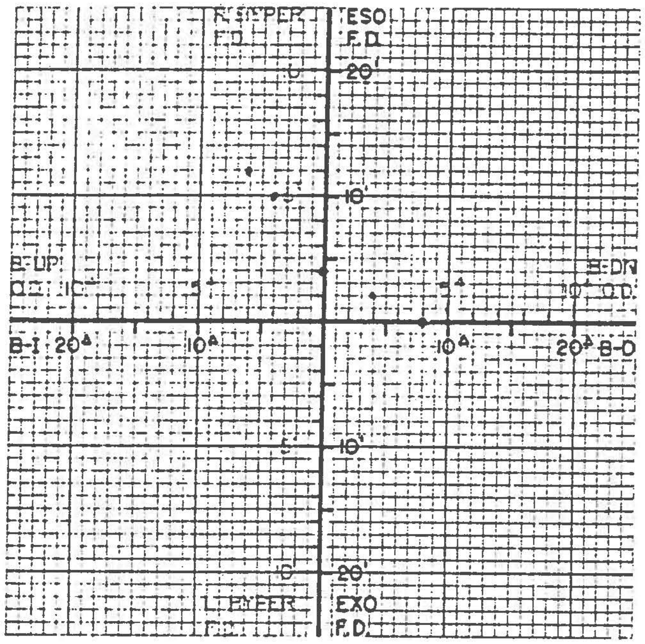
NORMAL - SEMINORMAL

Fig. 12

FIXATION DISPARITY CURVE

#1
NAME H. C.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:
1 min. 48.01 sec.



FIXATION DISPARITY CURVE

#2
NAME H. C.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:

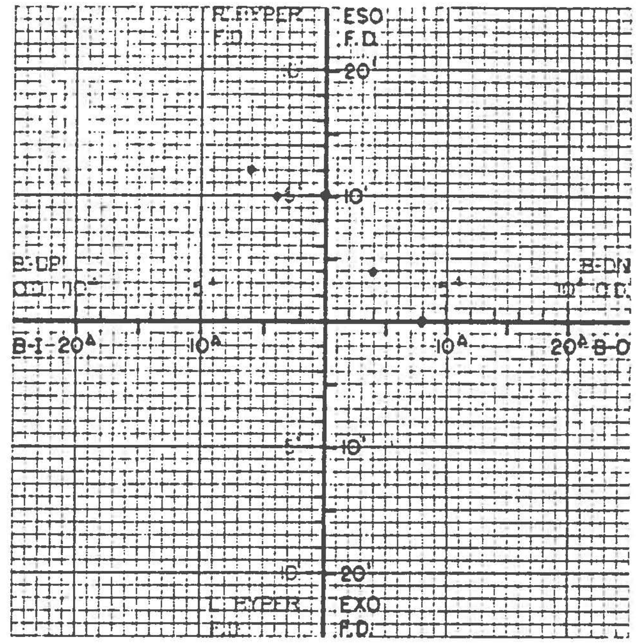
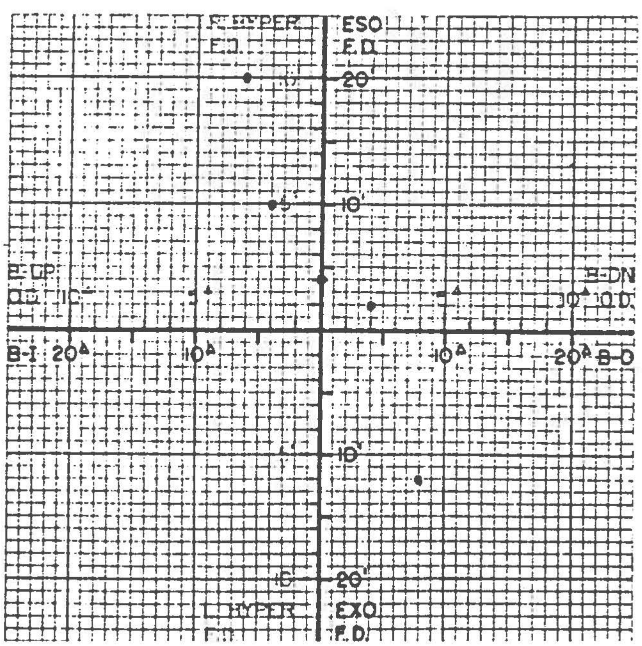


Fig. 13

FIXATION DISPARITY CURVE

#1
NAME K. R.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

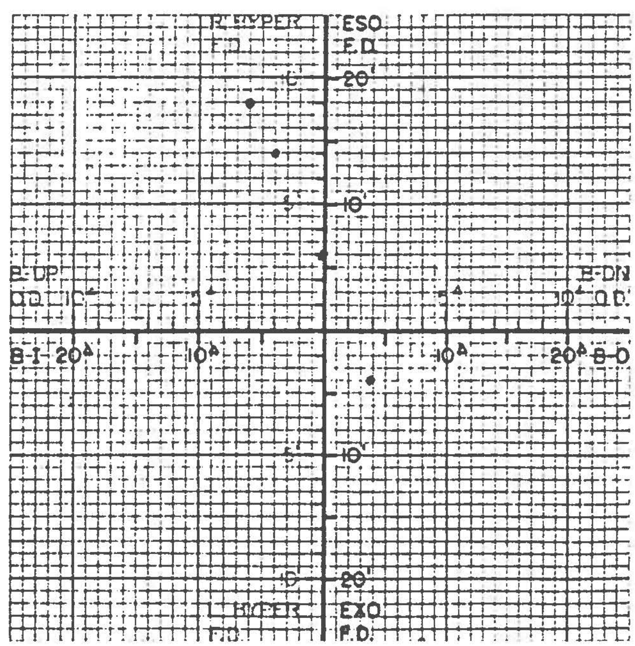
COMMENTS:
1 min. 26.34 sec.



FIXATION DISPARITY CURVE

#2
NAME K. R.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:



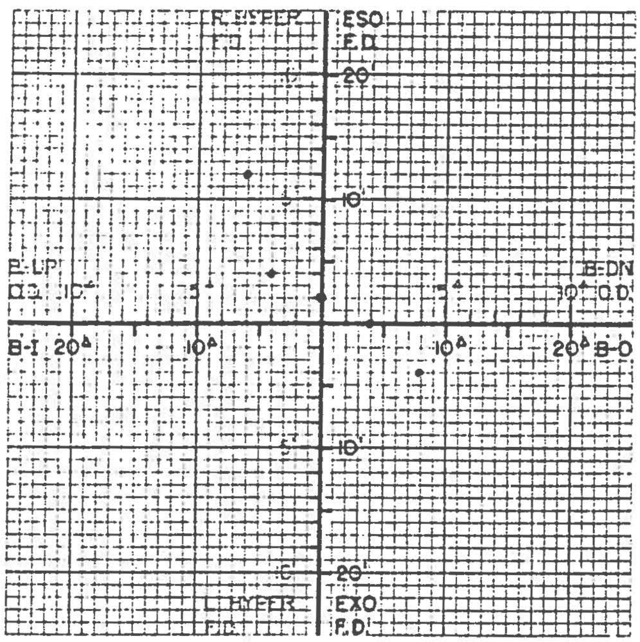
NORMAL - SEMINORMAL

FIXATION DISPARITY CURVE

#1
NAME T. V.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS: 1 min. 22.52 sec.

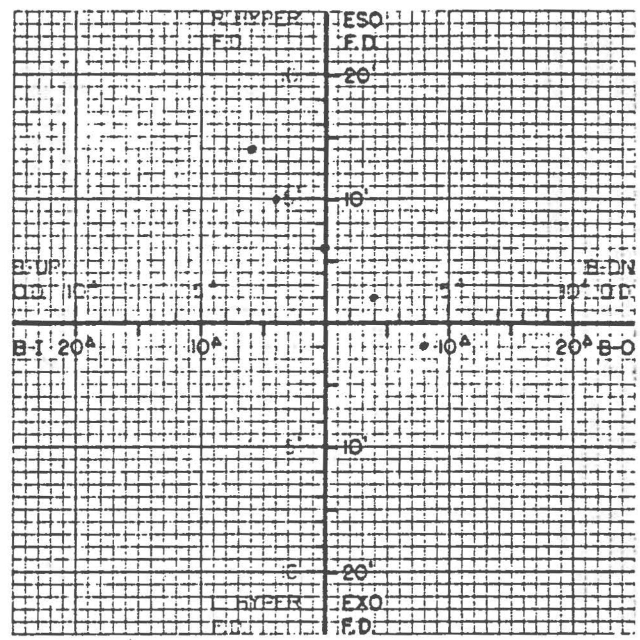
Fig. 14



FIXATION DISPARITY CURVE

#2
NAME T. V.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:



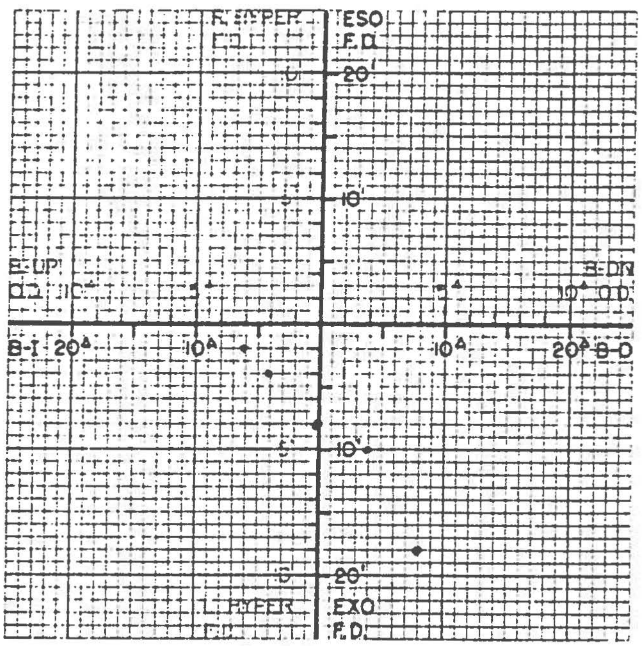
ABNORMAL - ABNORMAL

Fig. 15

FIXATION DISPARITY CURVE

#1
NAME J. S. S.
DATE
DISTANCE 40 cm
X LATERAL ☐ VERTICAL

COMMENTS: 1 min. 17.33 sec.



FIXATION DISPARITY CURVE

#2
NAME J. S. S.
DATE
DISTANCE 40 cm
X LATERAL ☐ VERTICAL

COMMENTS:

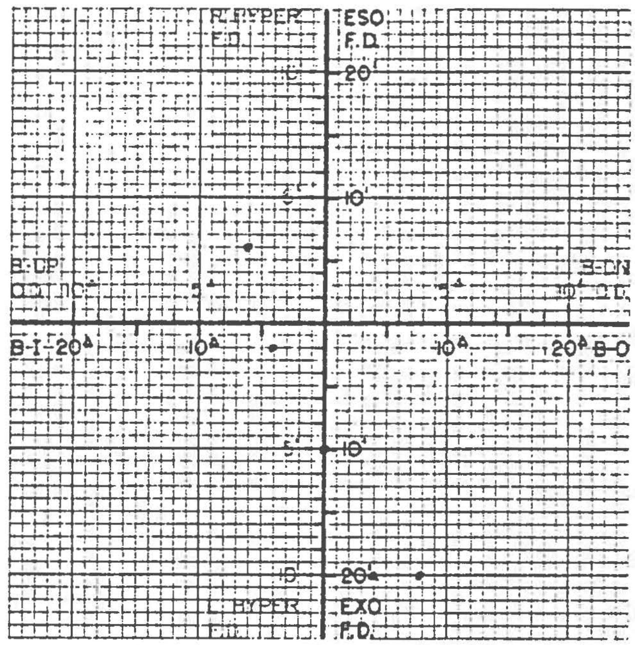
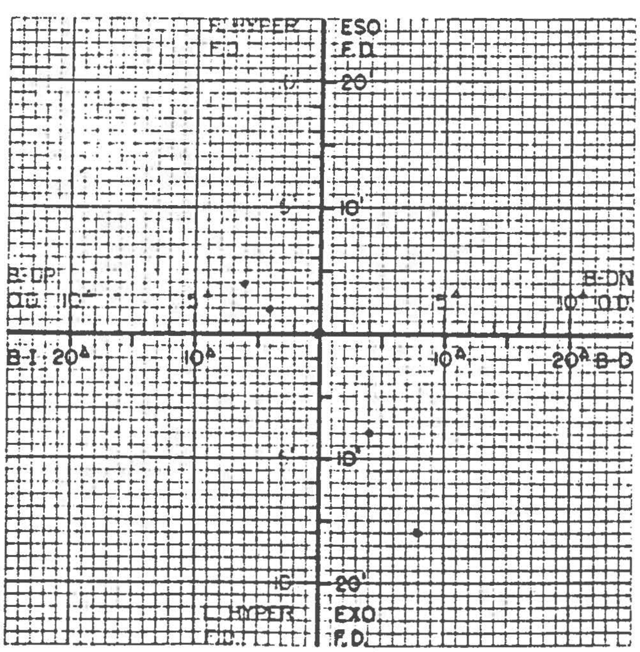


Fig. 16

FIXATION DISPARITY CURVE

#1
NAME J. H.
DATE
DISTANCE 40 cm
X LATERAL ☐ VERTICAL

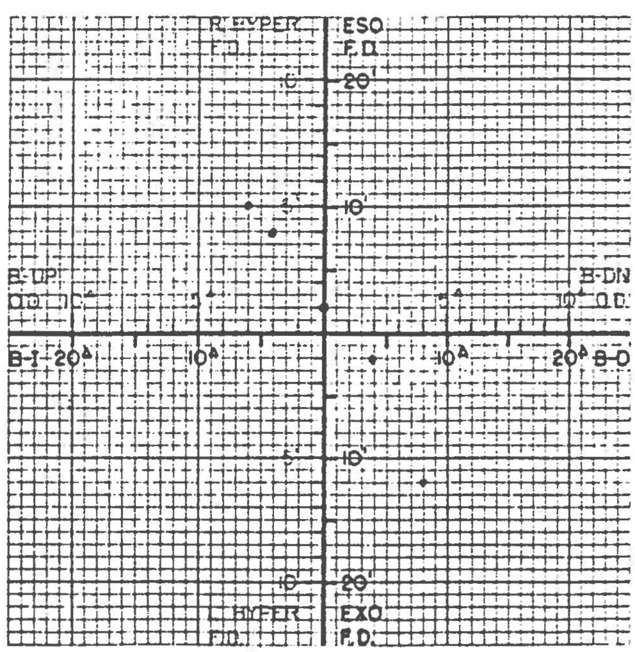
COMMENTS: 1 min. 24.07 sec.



FIXATION DISPARITY CURVE

#2
NAME J. H.
DATE
DISTANCE 40 cm
X LATERAL ☐ VERTICAL

COMMENTS:



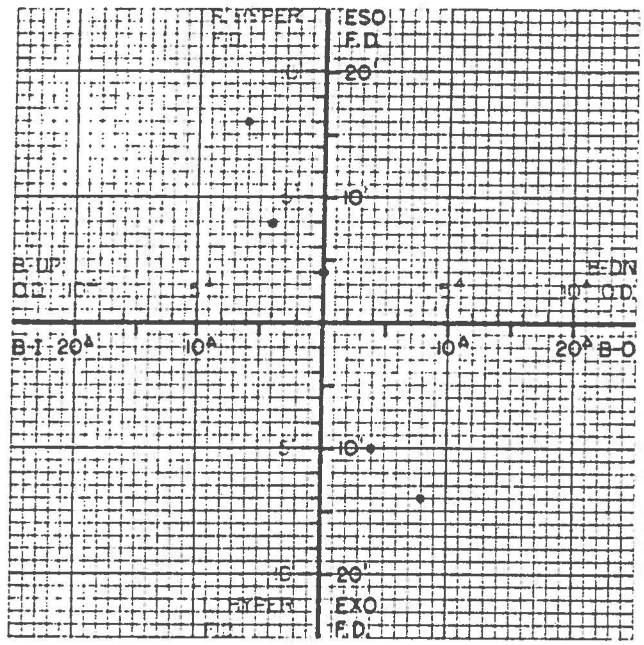
ABNORMAL - ABNORMAL

Fig. 17

FIXATION DISPARITY CURVE

#1
NAME C. H.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS: 1 min. 31.47 sec.



FIXATION DISPARITY CURVE

#2
NAME C. H.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:

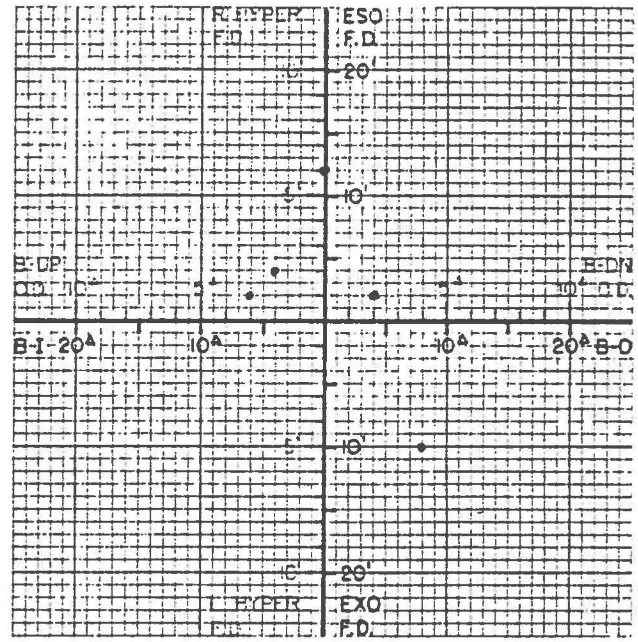
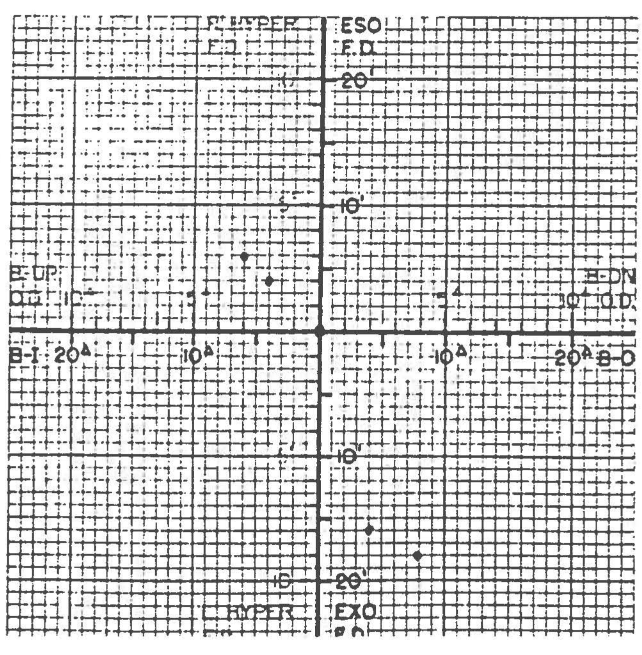


Fig. 18

FIXATION DISPARITY CURVE

#1
NAME J. C.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

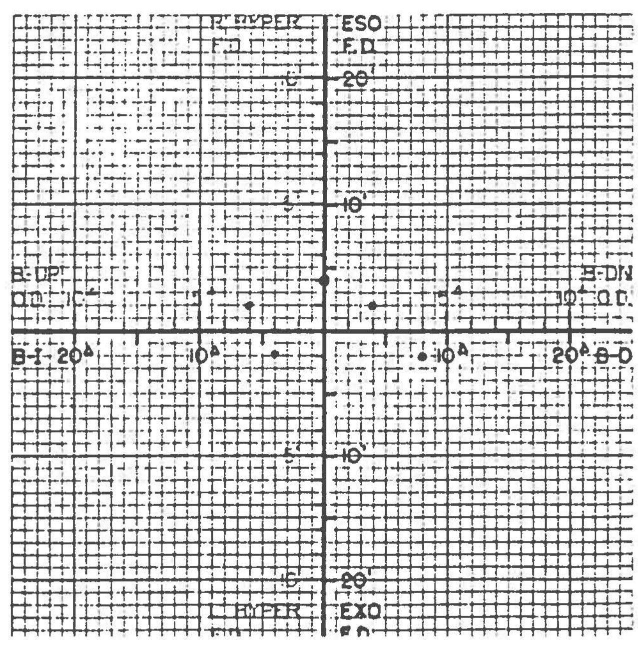
COMMENTS: 1 min. 29.29 sec.



FIXATION DISPARITY CURVE

#2
NAME J. C.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:



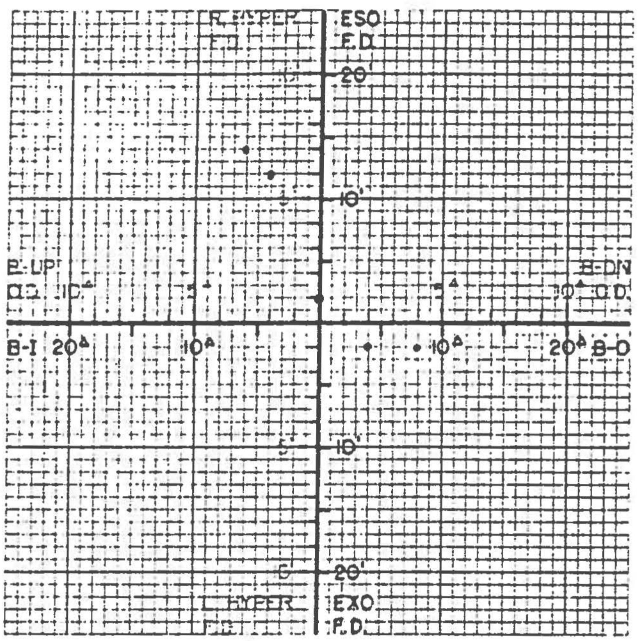
ABNORMAL - ABNORMAL

FIXATION DISPARITY CURVE

#1
NAME J. S.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:
47.27 sec.

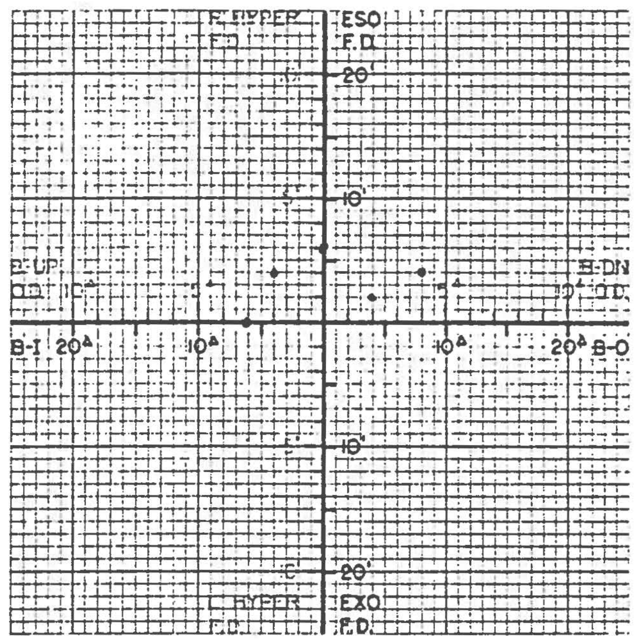
Fig. 19



FIXATION DISPARITY CURVE

#2
NAME J. S.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:

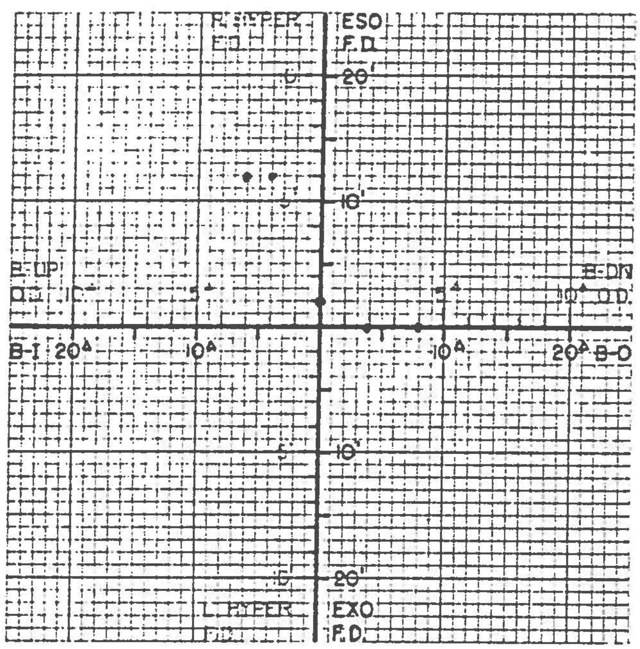


ABNORMAL - IMPROVEMENT

FIXATION DISPARITY CURVE

#1
NAME V. S.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:
53.45 sec.



FIXATION DISPARITY CURVE

#2
NAME V. S.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:

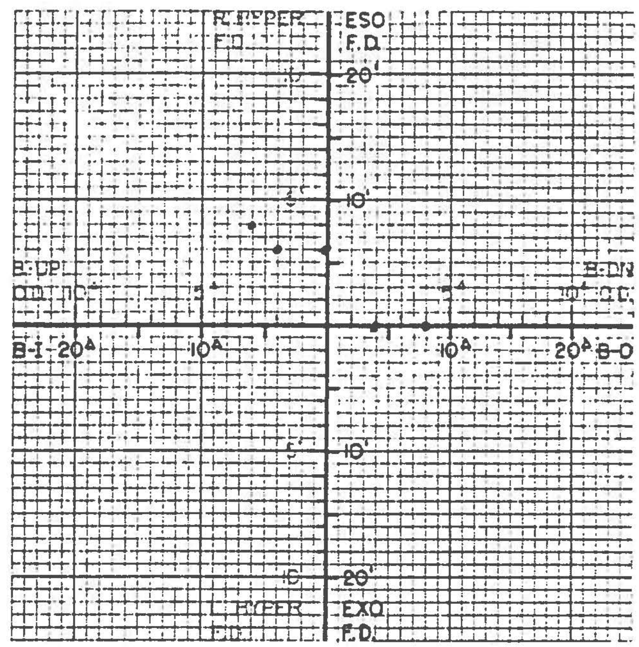
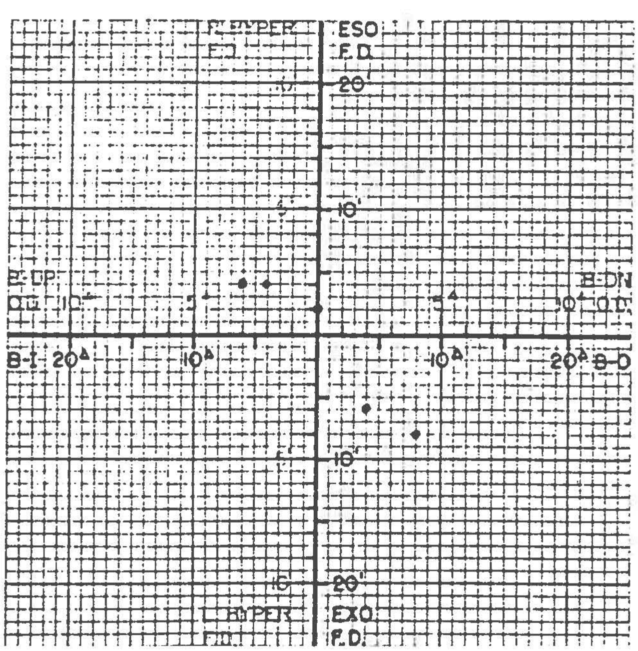


Fig. 20

FIXATION DISPARITY CURVE

#1
NAME W. S.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:
45.09 sec.



FIXATION DISPARITY CURVE

#2
NAME W. S.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:

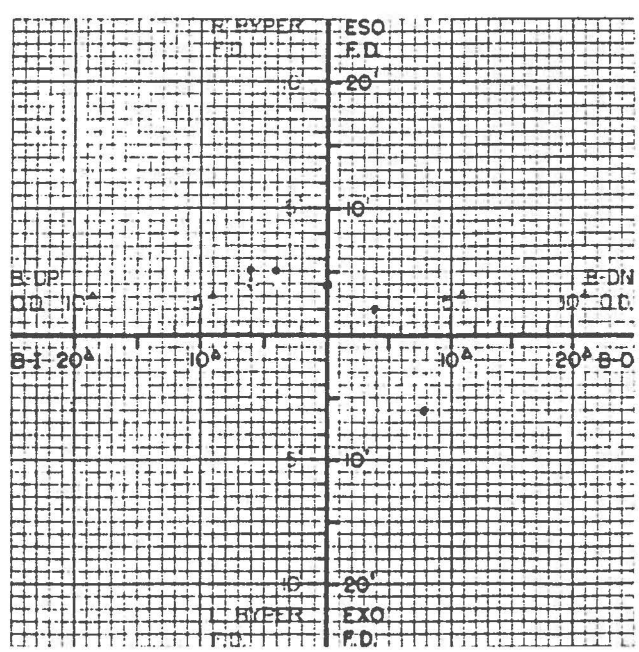


Fig. 21

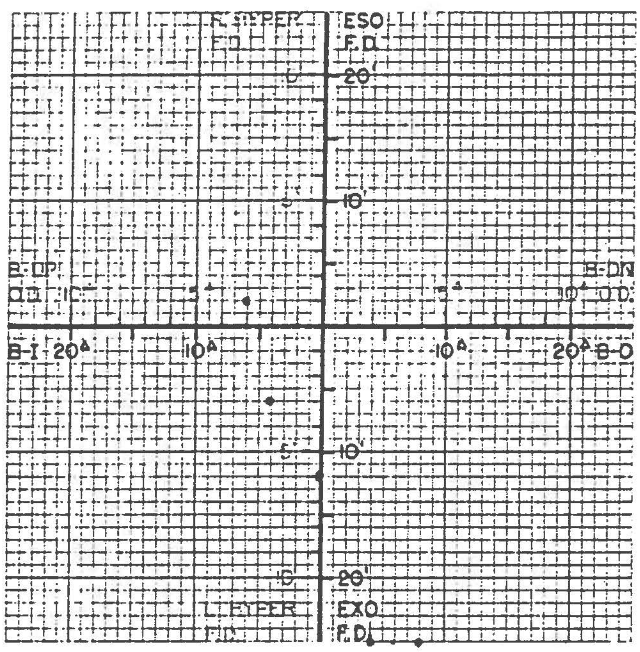
ABNORMAL - IMPROVEMENT

FIXATION DISPARITY CURVE

#1
NAME M. M.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS: 52.2 sec.

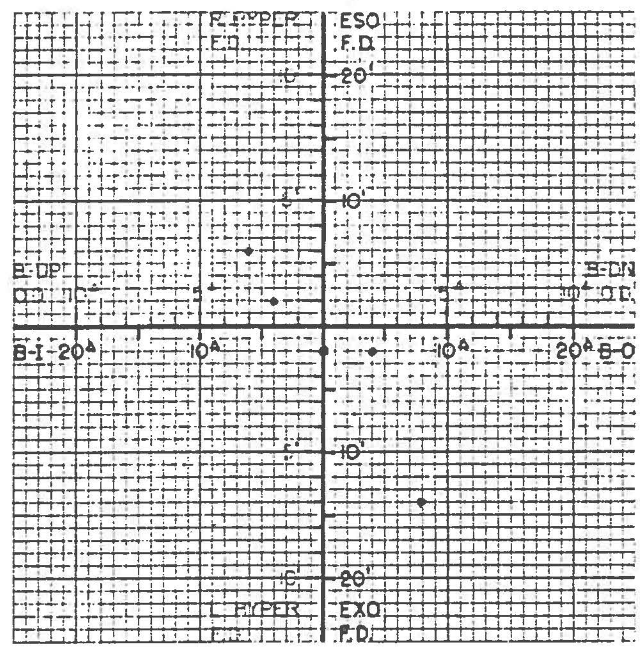
Fig. 22



FIXATION DISPARITY CURVE

#2
NAME M. M.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:

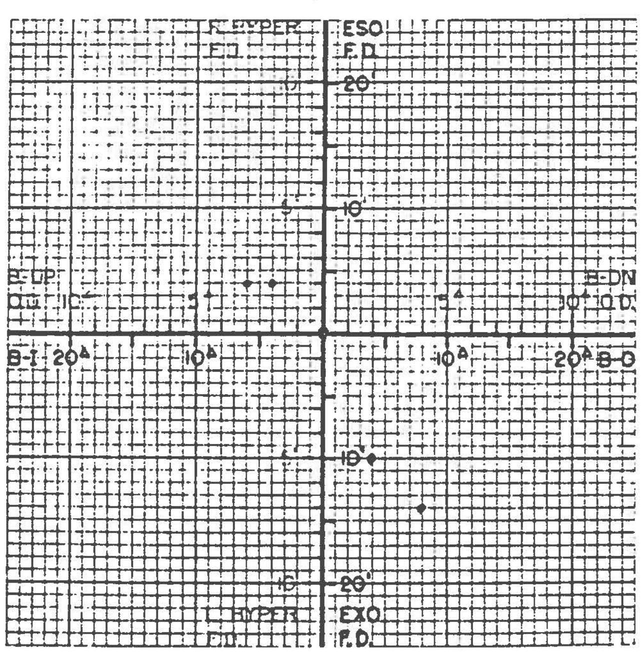


FIXATION DISPARITY CURVE

#1
NAME J. F.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS: 1 min. 2.29 sec.

Fig. 23



FIXATION DISPARITY CURVE

#2
NAME J. F.
DATE
DISTANCE 40 cm
☒ LATERAL ☐ VERTICAL

COMMENTS:

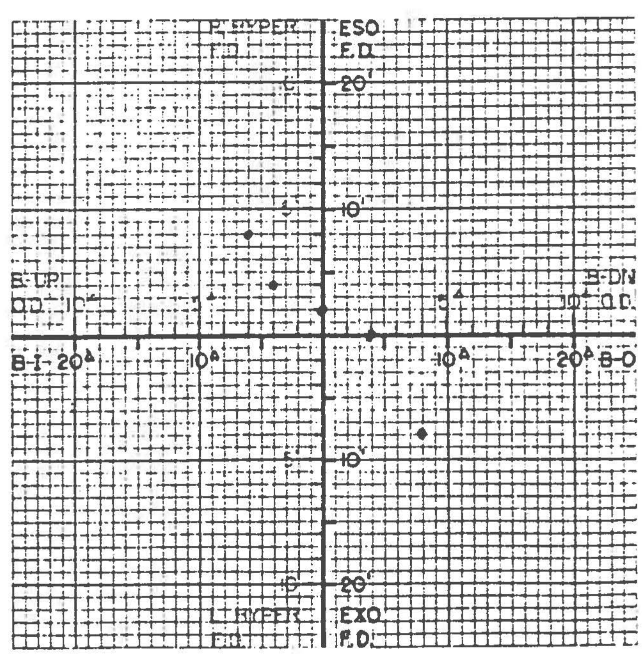


TABLE 1

SHAPE FACTOR RESULTS

Patient	Before Vergence Facility	After Vergence Facility
P.D.	5	4
A.S.	7	7
D.A.	4	4
T.V.	10	12
K.R.	20	30.5
W.O.S	9	21
H.C.	10	9
M.C.	7	21
L.P.	4	17
M.H.	12	16
R.P.	5	10
J.S.S.	11	22
J.H.	15	16
C.H.	24	25
J.C.	22	12
J.S.	15	9
V.S.	12	7
W.S.	11	8
M.M.	23	12
J.F.	16	10