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Cylindrical determinations compared using Jackson Cross Cylinder technique and modified Lebensohn's Arrowhead chart

John E. Kimball
Pacific University

Robert M. Lohr
Pacific University

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Abstract

The purpose of this study is to make a comparison between the Jackson Cross Cylinder technique for determining the axis and power of the far cylinder correction and with the axis and power determination obtained by a subjectively rotated Lebensohn's Arrow-head Figure type astigmatic chart. The question to be resolved is whether the Lebensohn's Arrow-head Figure type chart could be substituted for the Jackson Cross Cylinder test for the determination of both astigmatic cylindrical power and axis.

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Optometry

CYLINDRICAL DETERMINATIONS COMPARED USING JACKSON CROSS CYLINDER TECHNIQUES AND MODIFIED LEBENSOHN'S ARROWHEAD CHART

Submitted to the Faculty of the College of Optometry, Pacific University, in partial fulfilment of the requirements for the degree, Doctor of Optometry, by Jack E. Kimball and Robert M. Lohr

Spring 1969

TABLE OF CONTENTS

PURPOSE

The purpose of this study is to make a comparison between the Jackson Cross Cylinder technique for determining the axis and power of the far cylinder correction and with the axis and power determination obtained by a subjectively rotated Lebensohn's Arrow-head Figure type astigmatic chart. The question to be resolved is whether the Lebensohn's Arrow-head Figure type chart could be substituted for the Jackson Cross Cylinder test for the determination of both astigmatic cylindrical power and axis.

REVIEW OF THE LITERATURE

The Jackson Cross Cylinder technique, as described in Clinical Refraction by Irvin Borish, O.D., is basically the same as that of the rotating cylinder insofar as the optical effects are concerned. The subject determines which of two alternately exposed targets is the blacker and more distinct. A determination of cylinder axis is made first and then the power of the cylinder is refined. The testing is normally preceded by a monocular Red-Green test, the subject being left slightly "in the green" in order to be certain that the Jackson Cross Cylindertest is performed with the patient observing through a spherical lens of maximum acuity.

The Lebensohn's Astigmometer chart is also described in Borish's Clinical Refraction as well as in Tait's Textbook of Refraction and Gettes' two books, Refraction and Practical Refraction. while the basic description found in these texts describes the chart used in this project, it would be well to note certain modifications made to enhance the testing procedure.

Basically, the Lebensohn's Astigmometer chart is an arrow-head figure chart with the obliquety of the arrow-head lines set at 30^{o}, and the arrow-head figure adjacent to one of the cross lines of the target (see picture attached).. If all of the lines of the cross and arrow-head figure are equally black, it can be assumed that no astigmatism exists in the eye being tested. If one line of the cross is blacker, the line with the arrow-head figure is placed in that meridian and the wings of the arrow-head figure compared. When these wings of the arrow-head figure match as to blackness, the correct meridian of astigmatic power has been determined. Once this principal meridian has been determined and the axis of the correcting minus cylinder thus located, the power correction consists simply of increasing minus cylinder power until the contrasted lines of the cross appear equally black. The Lebensohn's type chart used in this project was modified by being:

(1.) Larger; the original Lebensohn's Astigmometer was approximately 14 inches square, the modified chart is approximately 36 inches in diameter.

(2.) More critical; all of the black lines used on the modified Lebensohn's type chart were double lines of 10 minutes subtend (20/40) being separated from each other by a center white space of 10 minutes subtend (20/40).

(3.) Motorized, the entire Lebensohn's type

[3.] Motorized, the entire Lebensohn's type chart was mounted in front of an axis numbered scaling and rotatable in either direction by a control box given to the subject.

TESTING PROCEDURE

The instruments used in this study were the Bausch & Lomb Green's refractor, the Bausch and Lomb Acuity Projector and the remote controlled Lebensohn's type chart.

All testing was done at distance (in a 20 foot room) with illuminations as mentioned below. The subject's farpoint interpupillary distance was measured and the refractor adjusted accordingly.

I. Jackson Cross Cylinder technique:

A. A 20/30 blur was done monocularly with 20 foot candles of illumination. The 20/30 line was blurred with plus spheres until the subject reported the letters just blurred out (could not read any).

B. The clock dial cylinder was also determined monocularly using the same illumination. With the 20/30 blur lens in place, the subject was asked to indicate which line of the clock dial target was the darker and more distinct. The rule of 30 was used to determine the axis of the correcting cylinder and minus cylinder power was added until lines positioned 90^{o} from the darkest lines were of equal darkness.

C. The Red-Green control target of duplicate letters was presented monocularly and under approximately 3 foot candles of illumination. The subject was asked to determine which side of the chart contained the blacker and more distinct letters, the red or green side. If the reply was the red side, the sphere power was reduced in .25 Diopter steps until green was first called.

D. Jackson Cross Cylinder refinement was done monocularly using a 20/40 row of letters. Room illumination was 20 foot candles and the lenses in the refractor were the lenses determined from the Clock Dial and Red-Green test procedures. The axis of the Jackson Cross Cylinder was set so that it bisected the axis of the correcting cylinder, the white dots indicating the plus power and the red dots indicating the minus power. The cross cylinder is flipped so that the powers are reversed and the subject is asked to select the position of best acuity. If one position is preferred, the axis of the minus correcting cylinder is placed 5° closed to the meridian in which the red dots are in the preferred position. The cross cylinder is realigned so that the new axis position bisects it and the test is repeated until a position is found at which no preference is shown for either position of the cross cylinder.

With the axis determination made, the power can be checked by shifting the cross cylinder axis 45°. This places the red and white dots either on axis or 90° off axis. If the preferred position is in agreement with the white dots the power is reduced, if with the red dots the power is increased, until a position of meridional balance is attained. Reduction or addition of power is made in .25 Diopter steps with the spherical equivelant being maintained.

II. Lebensohn's Arrow-head Figure type technique:

A. The previously found 20/30 sphere only determination was used as the starting point. The room illumination was set to approximately 15 foot candles and all testing was done monocularly.

B. The 20/30 blur sphere being in place in the refractor, the subject was asked to observe the Lebensohn type chart. If the crossed sets of black lines and the arrow-head figure were adjudged of equal contrast, no astigmatism was considered present.

C. If there was a subjectively noticable difference in the blackness of either crossed line, the subject was asked to operate a control box containing a bi-directional spring loaded switching mechanism which enabled the subject to rotate the cross and arrow-head figure at will in the desired direction to obtain a balance of blackness in the oblique portions of the arrow-head figure. The balance of these 30° oblique figures coincidental with the appearance of the arrow-head shaft lines being darker than the set of 90° opposing lines, indicated that the correct minus cylinder axis has been found.

The degree reading was made on the non-movable background of the device.

D. When the axis had been determined, the control box was removed from the subject's control and minus cylinder power in .25 Diopter steps was then added until equality or first reversal of cross member darkness was achieved. Spherical equivelances were maintained at all times.

ANALYSIS OF THE DATA

All cylinder powers were separated into their components in the 180 - 90 degree meridians and, separately, into their 135 - 45 degree meridians. For example, if the cylinder determination was - .75 X 115, this could be separated into - .14 X 180 and - .61 X 90. If the 180 degree meridian is called plus and the 90 degree meridian is called minus, this determination reduces to one cylinder determination of - .61 - (- .14) = - .47 D. It is not necessary to include the cylinder meridional notation as the minus sign signifies the 90 degree meridian.

The application of similar methods was used in the determination of the 135 - 45 degree meridians with one significant difference. The axis 45 degress O.D. was made the same sign as the axis 135 degree O.S. to make the O.S. and O.D. determinations comparable and to eliminate cylinder axis as a variable.

This procedure converts the findings into plus and minus values. A series of bar graphs illustrating these values appears later in this paper.

STATISTICAL ANALYSIS OF THE DATA

Computation of the data utilized the following formulaa.

Mean:

$$M = \frac{EX}{N}$$

Where M = the arithmetic mean
X = a score from the data
E = the sum of
N = the total number of scores

Standard Deviation:

$$S_d = \sqrt{\frac{Ex^2}{N - 1}}$$

Where S_d = the standard deviation
E = the sum of
x^2 = the square of the deviation from the mean
N = the total numebr of scores

Standard Error of the Mean:

$$S_{(x_1-x_2)} = \frac{S_d}{\sqrt{N}}$$

Where $S_{(x_1-x_2)}$ = the standard error of the mean
S_d = standard deviation
N = the total number of scores

Statistical analysis of data (continued)

Meridian	Mean	Std. Dev.	Std. error of mean
180 - 90	+.0053 D.	.15 D.	.027
135 - 45	+.065 D.	.21 D.	.037

See tables of data included.

From the above statistics, it can be said, that either of the two tests under discussion is equally valid and reliable when utilized as a far astigmatic cylinder axis and power determination test. The measurement of cylinder axis and or power with either method should give the clinician the same value within the errors of clinical measurement.

Further proof of the interchangability of the two testing procedures under analysis is offered in the following additional statistical analysis.

Correlation Coefficient:

$$r = \frac{Exy}{\sqrt{(Ex^2)\,(Ey^2)}}$$

Where Exy = sum of the products of the deviations of x and y

Ex^2 = sum of the squared deviations in x from M_x

Ey^2 = sum of the squared deviations in y from M_y

r = .94 for axis 180 - 90

r = .90 for axis 135 - 45

JACKSON CROSS CYLINDER

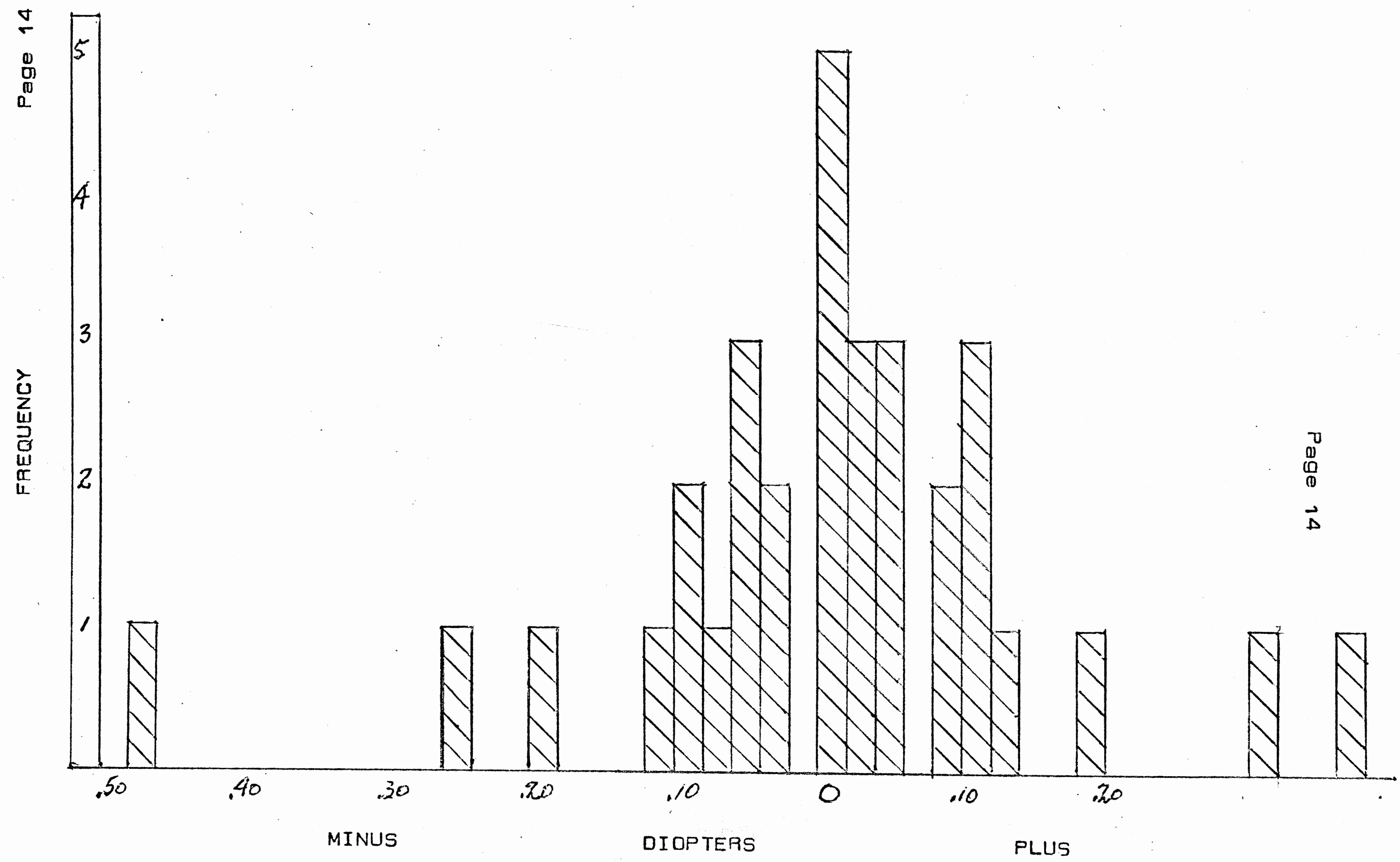
EYE	MINUS CYLINDER	x 90	X 180	X 45	X 135	X 180 - 90	X45 - 135 O.S. 135 - 45 O.D.
1 O.D.	.25 X 45	.12	.12	.25	.00	.00	- .25
1 O.S.	.25 X 160	.03	.22	.04	.21	+ .19	- .17
2 O.D.	.50 X 75	.46	.04	.37	.13	- .42	- .24
2 O.S.	.75 X 105	.70	.05	.19	.56	- .65	- .37
3 O.D.	.25 X 90	.25	.00	.12	.12	- .25	.00
3 O.S.	Plano	.00	.00	.00	.00	.00	.00
4 O.D.	.25 X 150	.06	.19	.02	.23	+ .13	+ .21
4 O.S.	.50 X 30	.12	.38	.47	.03	+ .26	+ .44
5 O.D.	1.75 X 180	.00	1.75	.87	.87	+1.75	.00
5 O.S.	.75 X 75	.70	.05	.56	.19	- .65	+ .37
6 O.D.	.75 X 110	.66	.09	.13	.62	- .55	+ .49
6 O.S.	.75 X 65	.62	.13	.66	.09	- .49	+ .57
7 O.D.	.25 X 175	.00	.25	.10	.15	+ .25	+ .05
7 O.S.	.25 X 60	.19	.06	.23	.02	- .13	+ .21
8 O.D.	1.00 X 90	1.00	.00	.50	.50	-1.00	.00
8 O.S.	.76 X 60	.56	.19	.69	.06	- .37	+ .63
9 O.D.	.25 X 75	.23	.02	.19	.06	- .21	- .13
9 O.S.	1.00 X 75	.93	.07	.75	.25	- .86	+ .50
10 O.D.	.50 X 130	.29	.21	.00	.50	- .08	+ .50
10 O.S.	.25 X 40	.10	.15	.25	.00	+ .05	+ .25
11 O.D.	.50 X 150	.13	.37	.03	.47	+ .24	+ .44
11 O.S.	.50 X 17	.04	.46	.38	.12	+ .42	+ .26
12 O.D.	.25 X 180	.00	.25	.12	.12	+ .25	.00
12 O.S.	.50 x 170	.02	.48	.16	.34	+ .46	- .18
13 O.D.	.12 X 40	.05	.07	.12	.00	+ .02	- .12
*— 14 O.D.	Plano	.00	.00	.00	.00	.00	.00
14 O.S.	.50 X 55	.34	.16	.48	.02	- .18	+ .46
15 O.D.	.25 X 112	.22	.03	.04	.21	- .19	+ .17
15 O.S.	.50 X 50	.29	.21	.50	.00	- .08	+ .50
16 O.D.	.25 X 40	.10	.15	.25	.00	+ .05	- .25
16 O.S.	.25 X 125	.17	.08	.06	.19	- .09	- .13
*13 O.S.	.75 x 40	.34	.44	.75	.00	+ .13	+ .75

LEBENSOHN'S ARROW-HEAD TYPE CHART

EYE	MINUS CYLINDER	X 90	X 180	X 45	X 135	X 180 - 90	X 45 - 135 O.S. 135 - 45 O.D.
1 O.D.	.25 X 55	.17	.08	.24	.01	- .09	- .23
1 O.S.	.25 X 135	.12	.12	.00	.25	.00	- .25
2 O.D.	.50 X 70	.44	.06	.41	.09	- .38	- .32
2 O.S.	.75 X 108	.67	.08	.16	.59	- .59	- .43
3 O.D.	.25 X 64	.20	.05	.22	.03	- .15	- .19
3 O.S.	Plano	.00	.00	.00	.00	.00	.00
4 O.D.	.50 X 135	.25	.25	.00	.50	.00	+ .50
4 O.S.	.50 X 50	.28	.22	.50	.00	- .06	+ .50
5 O.D.	1.75 X 180	.00	1.75	.87	.87	+1.75	.00
5 O.S.	1.00 X 70	.88	.12	.82	.18	- .76	+ .64
6 O.D.	.75 X 115	.61	.14	.09	.66	- .47	+ .57
6 O.S.	.75 X 80	.63	.02	.50	.25	- .61	+ .25
7 O.D.	.25 X 170	.01	.24	.08	.17	+ .23	+ .09
7 O.S.	.25 X 67	.21	.04	.21	.40	- .17	- .19
8 O.D.	.75 X 90	.75	.00	.37	.37	- .75	.00
8 O.S.	.75 X 60	.56	.19	.70	.05	- .37	+ .65
9 O.D.	.50 X 60	.37	.13	.47	.03	- .24	- .44
9 O.S.	.50 X 70	.44	.06	.41	.09	- .38	+ .32
10 O.D.	.50 X 125	.33	.17	.02	.48	- .16	+ .46
10 O.S.	.50 X 35	.17	.33	.48	.02	+ .16	+ .46
11 O.D.	.50 X 152	.10	.40	.05	.45	+ .30	+ .40
11 O.S.	.50 X 18	.05	.45	.39	.11	+ .40	+ .28
12 O.D.	.25 X 175	.00	.25	.10	.15	+ .25	+ .05
12 O.S.	.50 X 175	.01	.49	.21	.29	+ .48	- .08
13 O.D.	Plano	.00	.00	.00	.00	.00	.00
13 O.S.	.50 X 62	.37	.13	.47	.03	- .24	+ .44
14 O.D.	Plano	.00	.00	.00	;00	.00	.00
14 O.S.	Plano	.00	.00	.00	.00	.00	.00
15 O.D.	.25 X 103	.24	.01	.06	.19	- .23	+ .13
15 O.S.	.25 X 112	.22	.03	.04	.21	- .19	- .17
16 O.D.	.12 X 15	.01	.11	.09	.03	+ .10	- .06
16 O.S.	.50 X 135	.25	.25	.00	.50	.00	- .50

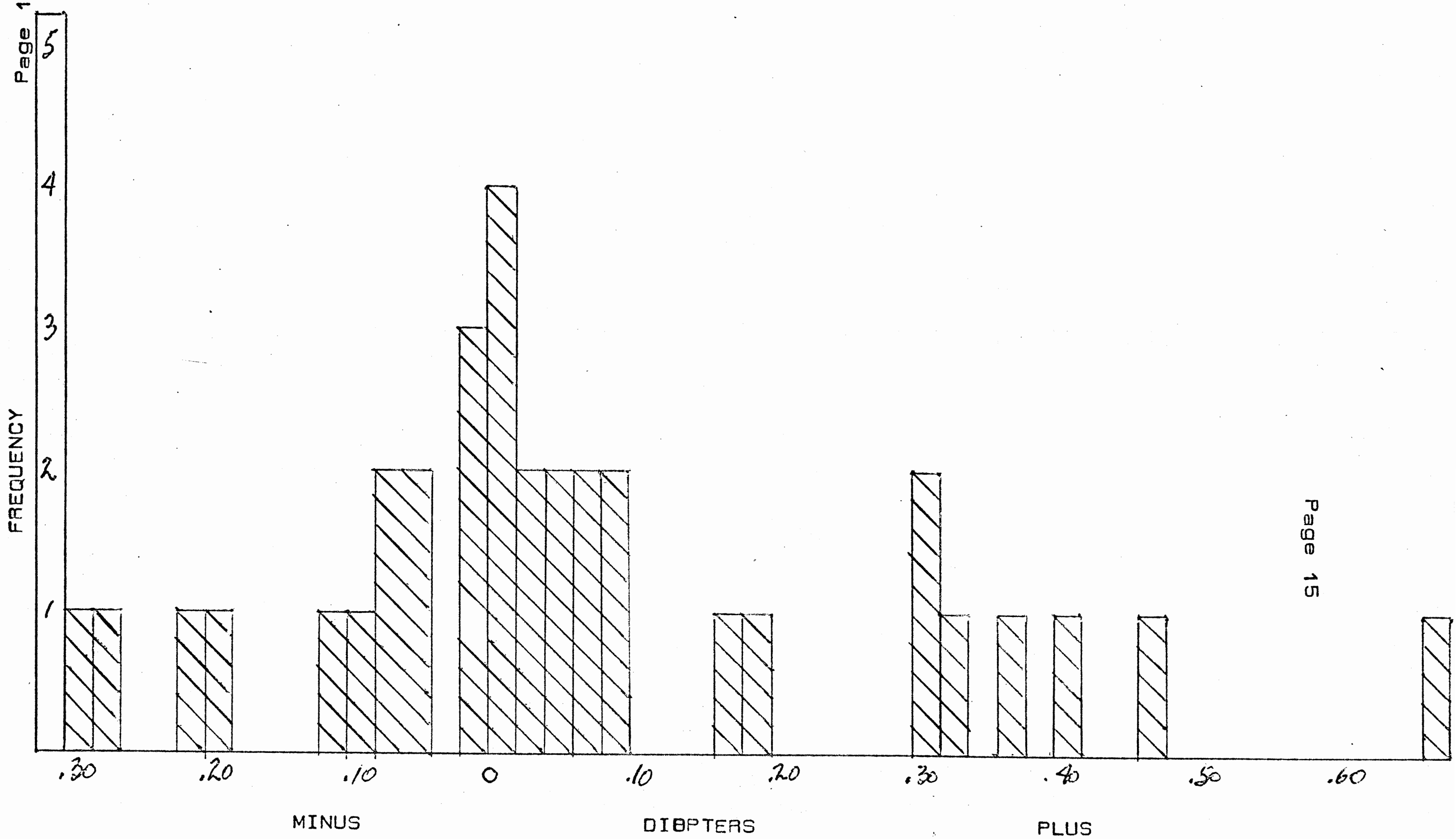
EYE	J.C.C. - LEBENSOHN X 180 - 90	X 135 - 45	X - $\bar{X}$ X180-90	X - $\bar{X}$ X135-45
1 O.D.	+ .09	- .02	+ .085	-.085
1 O.S.	+ .19	+ .08	+ .185	+.015
2 O.D.	- .04	+ .08	- .045	+.015
2 O.S.	- .06	+ .06	- .065	-.005
3 O.D.	- .10	+ .19	- .105	+.125
3 O.S.	.00	.00	- .005	-.065
4 O.D.	+ .13	- .29	+ .125	-.355
4 O.S.	+ .32	- .06	+ .315	-.125
5 O.D.	.00	.00	- .005	-.065
5 O.S.	+ .11	- .27	+ .105	-.335
6 O.D.	- .08	- .08	- .085	-.145
6 O.S.	+ .12	+ .32	+ .115	-.255
7 O.D.	+ .02	- .04	+ .015	-.105
7 O.S.	+ .04	+ .40	+ .035	+.335
8 O.D.	- .25	.00	- .255	-.065
8 O.S.	.00	- .02	- .005	-.085
9 O.D.	+ .03	+ .31	+ .025	+.245
9 O.S.	- .48	+ .18	- .485	+.115
10 O.D.	+ .08	+ .04	+ .075	-.025
10 O.S.	- .11	- .21	- .115	-.275
11 O.D.	- .06	+ .04	- .065	-.025
11 O.S.	+ .02	- .02	+ .015	-.085
12 O.D.	.00	- .05	- .005	-.115
12 O.S.	- .02	- .10	- .025	-.165
13 O.D.	+ .02	- .12	+ .015	-.185
13 O.S.	+ .37	+ .31	+ .365	+.245
14 O.D.	.00	.00	- .005	-.065
14 O.S.	- .18	+ .46	- .185	+.395
15 O.D.	+ .04	+ .04	+ .035	-.025
15 O.S.	+ .11	+ .67	+ .105	+.605
16 O.D.	- .05	- .19	- .055	-.255
16 O.S.	- .09	+ .37	- .095	+.305

J.C.C - LEBENSOHN AXIS 180 - 90

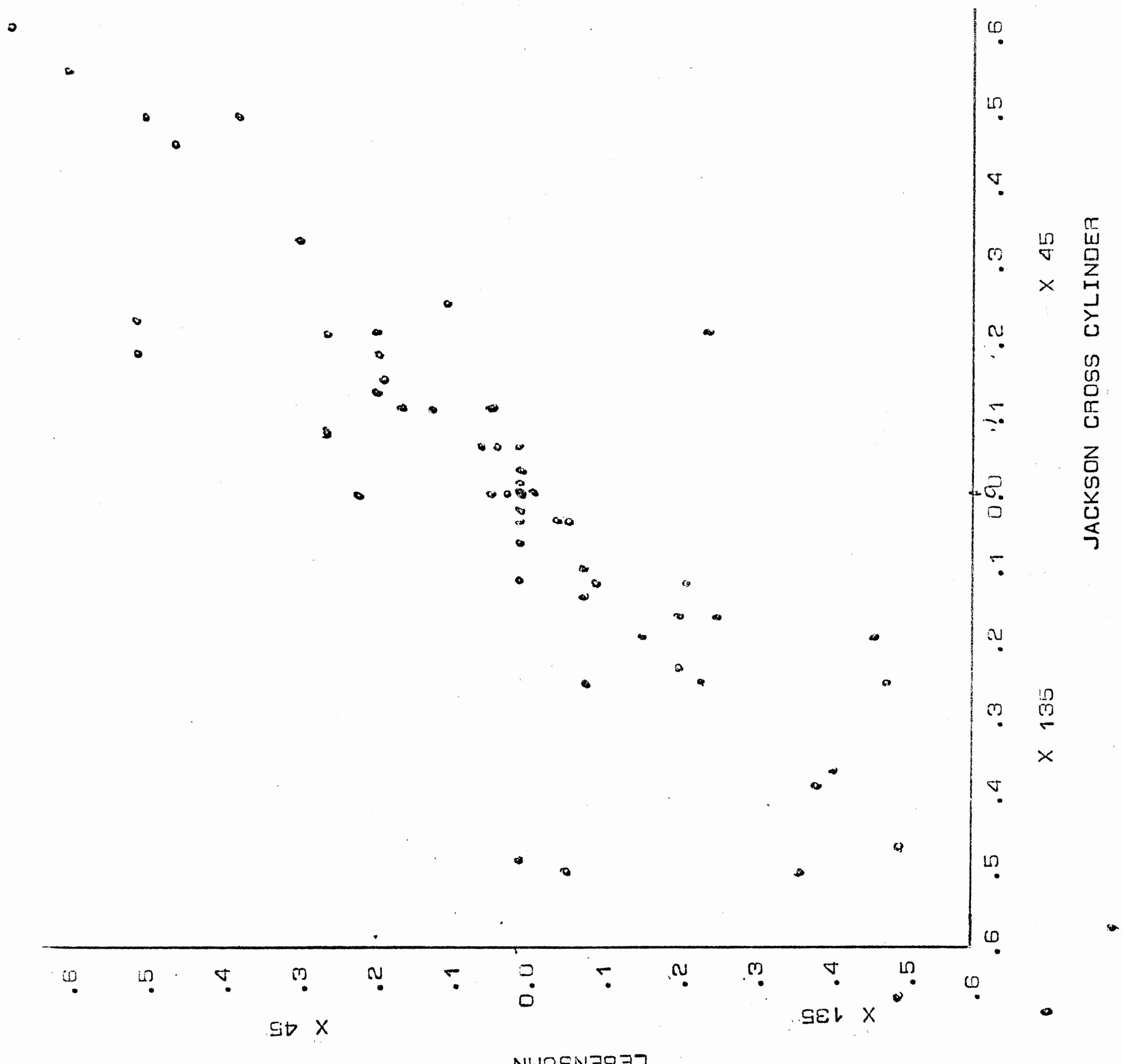


Page 14

J.C.C. - LEBENSOHN AXIS 135 - 45



Page 15


JACKSON CROSS CYLINDER
X 45
X 135
LEBENSOHN
X 45
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.5
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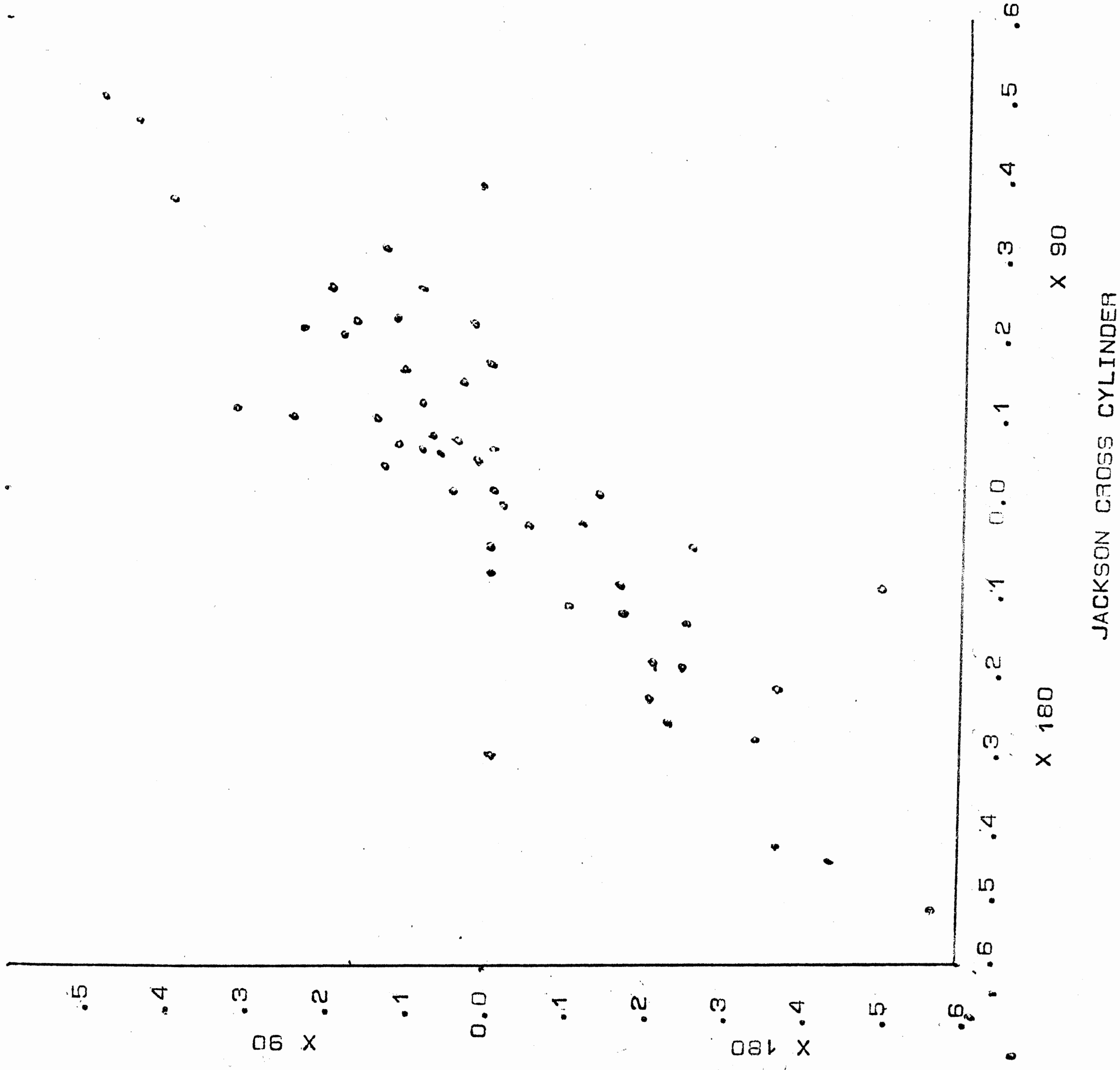

Page 17

VARIABLES, CONTROLLED AND NOT CONTROLLED

Some accounting of variables present in any research must be made, their effects noted and this combination of circumstances used in future projects along these same lines to either duplicate the previous results, or avoid the apparent pitfalls clouding the results.

Contolled variables monitored in this project were:

(1.) The technique of administration of the tests was held as consistent as possible. All instructions to the subject were read from written material so as to be uniform in presentation and quantity.

(2.) The room lighting was found to be very critical during the administration of the Lebensohn's type test. 12 to 15 foot candles of illumination was found to be the level of best response. It was also found, in this test, that a glare factor was present, with a result that a variation in cylinder axis could be elicited. This occured when the Lebensohn's device was placed at such an angle as to reflect the room lights to the subject at a disadvantageous level. To minimize this effect, a matte finished arrow-head chart was tried with negative results and it was discarded. Therefore, the subject to target angle was held constant with the level of illumination.

[3.] All examinations were performed by one clinician so that any idiosyncrasies present is his presentation would be constant. The other clinician operated the acuity projector and controlled the lighting for uniformity in this area.

[4.] The Jackson Cross Cylinder test was always the first test for each subject. The Lebensohn's type test was always the second and was entered into with only sphere power used from previous test results. No clues as to power or axis were given the subject in any manner and his selection of axis was entirely due to his movement of the motorized chart to what he considered the proper location. Minus cylinder power was then subjectively determined by his responses to power additions as described.

[5.] All patients were pre-presbyopes and were not contact lens wearers. Two contact lens wearers were used in the routine, but their lack of consistency in reporting under either technique, negated their usefullness in this investigation.

(6.) All examinations, while not performed in the same examination room, were made utilizing the same type equipment and in the same length rooms. These were: the Bausch and Lomb Green's Refractor and the Bausch and Lomb Acuity projector.

Variables which we were not able to control were:

(1.) While the same size examination rooms were used and the conditions were therefore similar, the illumination was a moderately uncontrolled variable. The designations, as to candle power, on the room rheostats were used to set the illumination to the same level. In checking with a light meter, it was found that these designations were only approximations and that due to color temparature differences between lamps or the age of the lamps, etc., the desired consistent illumination was only approximated.

(2.) It was determined that subjects with high (above - 1.50 D.) cylinder correction and those with very little (+ or - .12 D.) cylinder correction were in many cases more difficult to get an exact response from. However, the responses of a few subject eliciting only a - .25 D. cylinder correction on the Lebensohn's type device were of a very positive nature and would lead one to believe that this amount of cylinder and axis might be very important to this subject.

(3.) All examinations were performed in the afternoon from 3 PM until 5 PM. No attempt was made to determine the possible pre-set of the subject prior to examination.

CONCLUSION

The Jackson Cross Cylinder technique and the Modified Lebensohn's Arrow-head type chart technique can be considered as interchangable in determinations of cylinder power and axis at the far distance. The response of the subjects to the Lebensohn's type device ranged from; "very good, easy to do", to "it is difficult to see the difference".

The conclusion that one testing procedure is as valid as the other is readily seen from the data compiled. The fact that the modified Lebensohn's type equipment is more cumbersome, requires additional expense in aquisition and needs closer attention paid to room illumination and reflective problems, would seem to preclude it being universally adopted.

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In actuality, the subject of astigmatism, its detection and correction, has caused a prolific quantity of investigation to be performed. These investigations, as represented by these thesises, are to be found in the Pacific University Library. Needless to say, the subject appears to have been most completely investigated, and baring the discovery of some new device or method of detection, future optometric investigations should very possibly be directed towards more fertile investigative areas.

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