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Comparison between the method of determining the power and axis of the cylinder by the Jackson cross cylinder technique and the bi-cross cylinder method as re-developed by Robert Vaughn

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Abstract

The purpose of this study is to compare two methods of determining the axis and power of the far cylinder: the Jackson Cross cylinder and the Bi-Cross cylinder techniques, in an effort to determine if the Vaughn Bi-Cross cylinder technique could be substituted for the Jackson Cross cylinder test.

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COMPARISON BETWEEN THE METHOD OF DETERMINING THE POWER AND AXIS OF THE CYLINDER BY THE JACKSON CROSS CYLINDER TECHNIQUE AND THE BI-CROSS CYLINDER METHOD AS RE-DEVELOPED BY ROBERT VAUGHN

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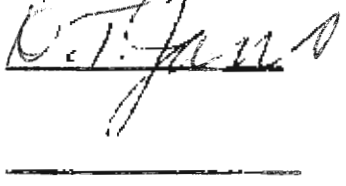
Approved 

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PURPOSE

The purpose of this study is to compare two methods of determining the axis and power of the far cylinder: the Jackson Cross cylinder and the Bi-Cross cylinder techniques, in an effort to determine if the Vaughn Bi-Cross cylinder technique could be substituted for the Jackson Cross cylinder test.

REVIEW OF THE LITERATURE

Matsuura's Auto-Cross[1] and Vaughn's Bi-Cross cylinder[2] are similar in that both instruments employ monocular diplopia to determine the existence of astigmatism; its axis and its power in that respective order.

The Matsuura Auto-Cross article boasts of "hundreds of successful cases pertaining to astigmatism regardless of their magnitude."

The optical principles of the Matsuura Auto-Cross were not included in the article; however, the Vaughn Bi-Cross cylinder optics are as follows:

> The Bi-Cross cylinder testing device makes use of two lenses:
>
> A. Maddox prism.
>
> B. Bi-Cross cylinder lens.
>
> The Maddox prism produces the monocular diplopia necessary for the successful use of this instrument.
>
> The Bi-Cross cylinder lens is so constructed and arranged in this instrument that the two images produced by the Maddox prism are viewed in such a manner as to be similar to the two positions considered when using the JCC (Jackson Cross cylinder) technique. The lens is mounted so it may be placed in one of two positions; axis determination or power determination.[3]

PROCEDURE

Fifty subjects were tested in all; one examiner ran the complete testing procedure on all fifty subjects.

The instruments used in the testing were a Green's phoropter and the Bi-Cross cylinder.

The testing procedure was as follows with all findings at far: (1) PD (2) 20/30 blur, (3) clock dial, and (4) Red-green. The control for this experiment was the clock dial cylinder and the red-green sphere.

First, the exact power and axis of the cylinder correction was determined by the standard J.C.C. technique.

Second, the original clock dial cylinder and red-green sphere were replaced in the phoropter, the Bi-Cross cylinder was put into place. The exact procedure was as follows: (1) occlude left eye; (2) a 20/30 acuity letter (O) was projected in a refraction room with approximately 7ft/cd illumination; (3) monocular diplopia was experienced by the subject; (4) the subject was asked which of the two letters appeared clearer and more distinct; (5) if for example the lower letter appeared the better, the axis of the instrument was rotated counter-clockwise until the top letter was reported best;

(6) now the instrument's axis was rotated clockwise until the lower letter was reported best; (7) the mid-point between (5) and (6) was recorded and placed in the phoropter as the final axis; (8) the handle of the instrument was rotated to the cylinder position: (9) the subject was asked which of the two letters appeared clearer and more distinct; (10) if for example, the top letter was reported better, cylinder power was reduced until both letters were reported equal; (11) on the other hand if the lower letter was reported better, cylinder power was increased until equality was achieved; (12) axis and power have now been determined for the right eye and now the procedure is repeated on the occluded eye.

ORGANIZATION OF THE DATA

Fifty subjects from ages 10 to 69 were tested. The distribution by age groups is as follows:

AGE BRACKET	NUMBER OF SUBJECTS
0 - 10 years	1
11 - 20 years	8
21 - 30 years	35
31 - 40 years	2
41 - 50 years	3
51 - 60 years	0
61 - 70 years	1

Of the fifty subjects tested, 9 were females and 41 were males.

Table I, page 6, is a tabulation of the raw data.

Table II, page 8, is a comparison of the power of the right eye as done by the J.C.C. and Bi-Cross cylinder.

Table III, page 9, is a comparison of the power of the left eye as done by the J.C.C. and Bi-Cross cylinder.

Table IV, page 10, is a comparison of the axis of the right eye as done by the J.C.C. and Bi-Cross cylinder.

Table V, page 11, is a comparison of the axis of the left eye as done by the J.C.C. and Bi-Cross cylinder.

TABLE I

CASE NO.:	AGE:	SEX:	J.C.C. O.D.	J.C.C. O.S.	Bi-Cross cylinder O.D.	Bi-Cross cylinder O.S.
1.	10	M	-1.00 x 84	-.50 x 100	-1.12 x 85	-.50 x 98
2.	11	M	- .37 x 93	-.37 x 87	- .50 x 92	- .37 x 89
3.	11	F	- .25 x 07	plano	- .37 x 05	- .12 x 180
4.	15	F	-1.12 x 105	-.37 x 53.	-1.25 x 106	- .50 x 55
5.	19	M	- .37 x 95	-.37 x 175.	- .25 x 93	- .50 x 175
6.	19	F	- .25 x 20	-.25 x 90	- .37 x 22	- .25 x 91.
7.	19	F	- .25 x 65	-.50 x 85.	-.25 x 68	- .37 x 90
8.	20	M	-1.50 x 20	-1.87 x 175	-1.50 x 21	-1.87 x 175.
9.	20	M	-.37 x 12	- .25 x 125.	- .37 x 14	- .25 x 128
10.	21	M	- .37 x 100	plano	- .37 x 105	plano
11.	21	M	-1.00 x 05	-1.00 x 172	- .75 x 05	- .75 x 175
12.	21	M	- .50 x 100	- .37 x 50	- .62 x 90	- .50 x 55
13.	21	M	-.12 x 52	- .12 x 02	- .12 x 51	- .25 x 03.
14.	21	M	-1.37 x 90	- .87 x 103	-1.25 x 88	- .75 x 95.
15.	22	M	- .75 x 95.	-1.00 x 80.	- .62 x 97	- .75 x 85.
16.	22	F	- .62 x 95	- .50 x 82	- .62 x 92	- .62 x 80.
17.	22	M	plano	- .12 x 178	plano	- .12 x 175.
18.	22	M	- .12 x 20	- .25 x 22	plano	- .25 x 23.
19.	22	F	- .12 x 165	- .62 x 172.	- .12 x 165	- .62 x .70
20.	22	M	- .25 x 90	- .50 x 90	- .25 x 85	- .50 x 100.
21.	22	M	- .50 x 95	- .25 x 45	- .37 x 100	- .25 x 50.
22.	22	M	plano	- .37 x 127	plano	- .37 x 127
23.	23	M	- .50 x 10	- .50 x 175	- .75 x 14	- .75 x 175
24.	23	M	- .75 x 25	- .75 x 170	- .62 x 22	- .75 x 172
25.	23	M	- .62 x 82	- .50 x 95	- .62 x 96	- .37 x 89
26.	23	M	- .62 x 83	- .12 x 15	- .37 x 83	- .12 x 10
27.	23	M	-1.50 x 87	-1.50 x 97	-1.50 x 88	-1.50 x 93
28.	23	M	- .28 x 105	- .25 x 115	- .37 x 100	- .25 x 120
29.	24	M	- .87 x 105	- .50 x 109	-1.00 x 105	- .25 x 107

TABLE I (CONTINUED)

CASE NO.:	AGE:	SEX:	J.C.C. O.D.	J.C.C. O.S.	Bi-Cross cylinder O.D.	Bi-Cross cylinder O.S.
30.	24	M	- .37 x 82	- .62 x 85	- .25 x 89	- .25 x 90
31.	24	M	- .50 x 90	plano	- .37 x 95	plano
32.	25	M	- .87 x 101	-1.12 x 92	- .75 x 95	-1.12 x 95
33.	25	M	-1.62 x 89	-1.50 x 88	-1.62 x 88	-1.37 x 88
34.	25	M	-1.00 x 15	- .37 x 175	-1.12 x 15	- .50 x 180
35.	25	M	- .62 x 22	- .62 x 180	- .75 x 20	- .50 x 180
36.	26	M	- .50 x 100	- .62 x 75	- .50 x 97	- .50 x 75
37.	26	M	- .25 x 10	- .50 x 37	- .25 x 10	- .50 x 38
38.	26	F	plano	plano	- .25 x 89	plano
39.	27	M	- .25 x 17	- .50 x 162	- .25 x 18	- .37 x 170
40.	28	M	-1.37 x 5	-1.67 x 165	-1.12 x 5	-1.37 x 177
41.	28	M	- .25 x 20	- .25 x 27	- .25 x 20	- .25 x 27
42.	29	M	- .12 x 12	- .62 x 93	- .12 x 22	- .50 x 94
43.	30	M	- .25 x 32	plano	- .37 x 31	plano
44.	30	M	-1.00 x 17	- .75 x 147	- .75 x 19	- .62 x 147
45.	31	M	plano	-1.75 x 157	plano	-1.87 x 158
46.	31	M	- .62 x 127	- .50 x 72	- .62 x 127	- .62 x 71
47.	41	M	- .37 x 07	- .25 x 160	- .37 x 10	- .25 x 165
48.	41	M	- .50 x 110	- .50 x 65	- .50 x 111	- .37 x 67
49.	49	F	- .62 x 95	-1.12 x 83	- .62 x 95	-1.25 x 82
50.	69	M	-1.25 x 125	-1.25 x 75	-1.25 x 123	-1.25 x 76

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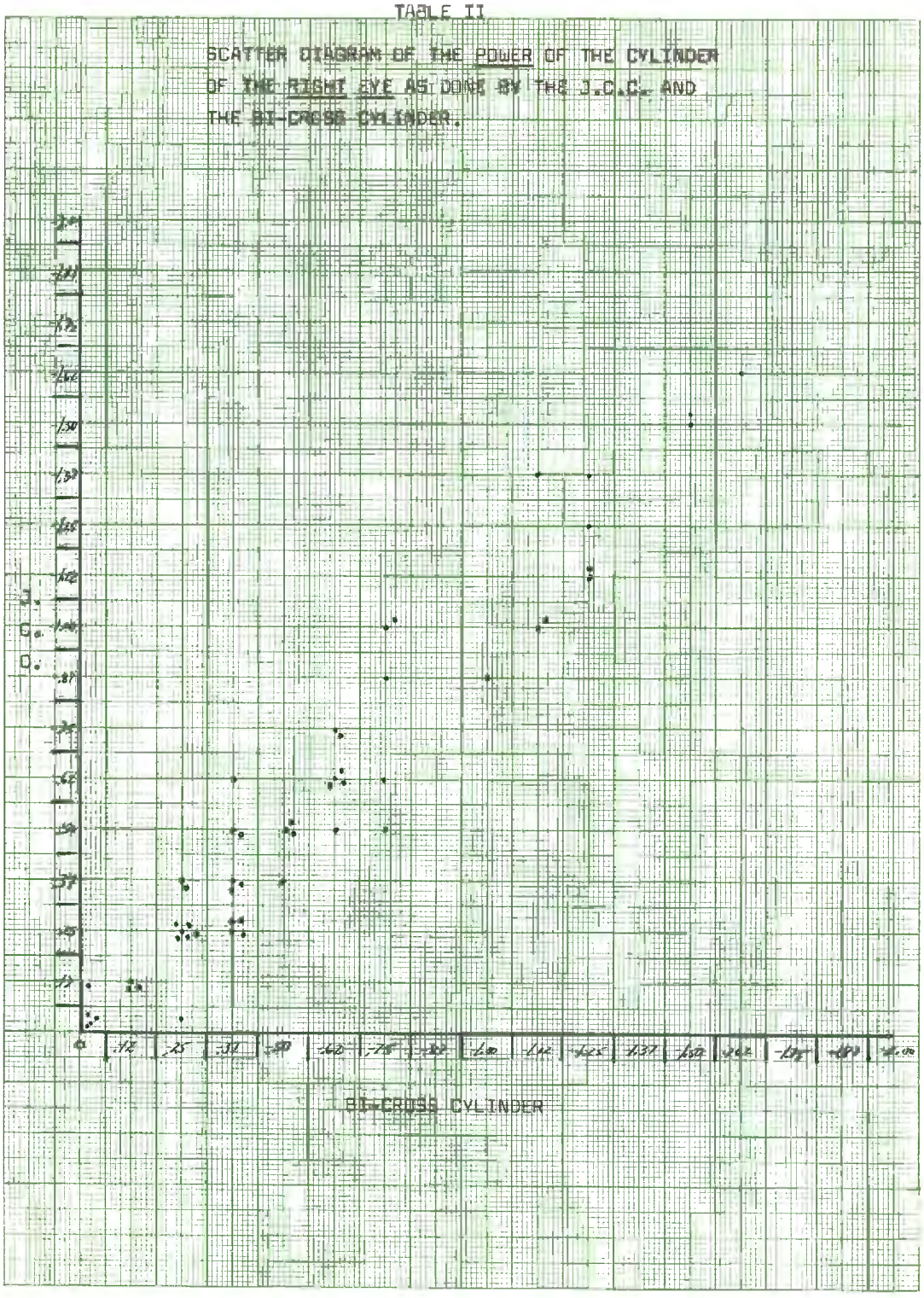
TABLE II

SCATTER DIAGRAM OF THE POWER OF THE CYLINDER OF THE RIGHT EYE AS DONE BY THE J.C.C. AND THE BI-CROSS CYLINDER.



10 Millimeters to the Centimeter

TABLE III

SCATTER DIAGRAM OF THE POWER OF THE CYLINDER OF THE LEFT EYE AS DONE BY THE J.C.C. AND THE BI-CROSS CYLINDER.

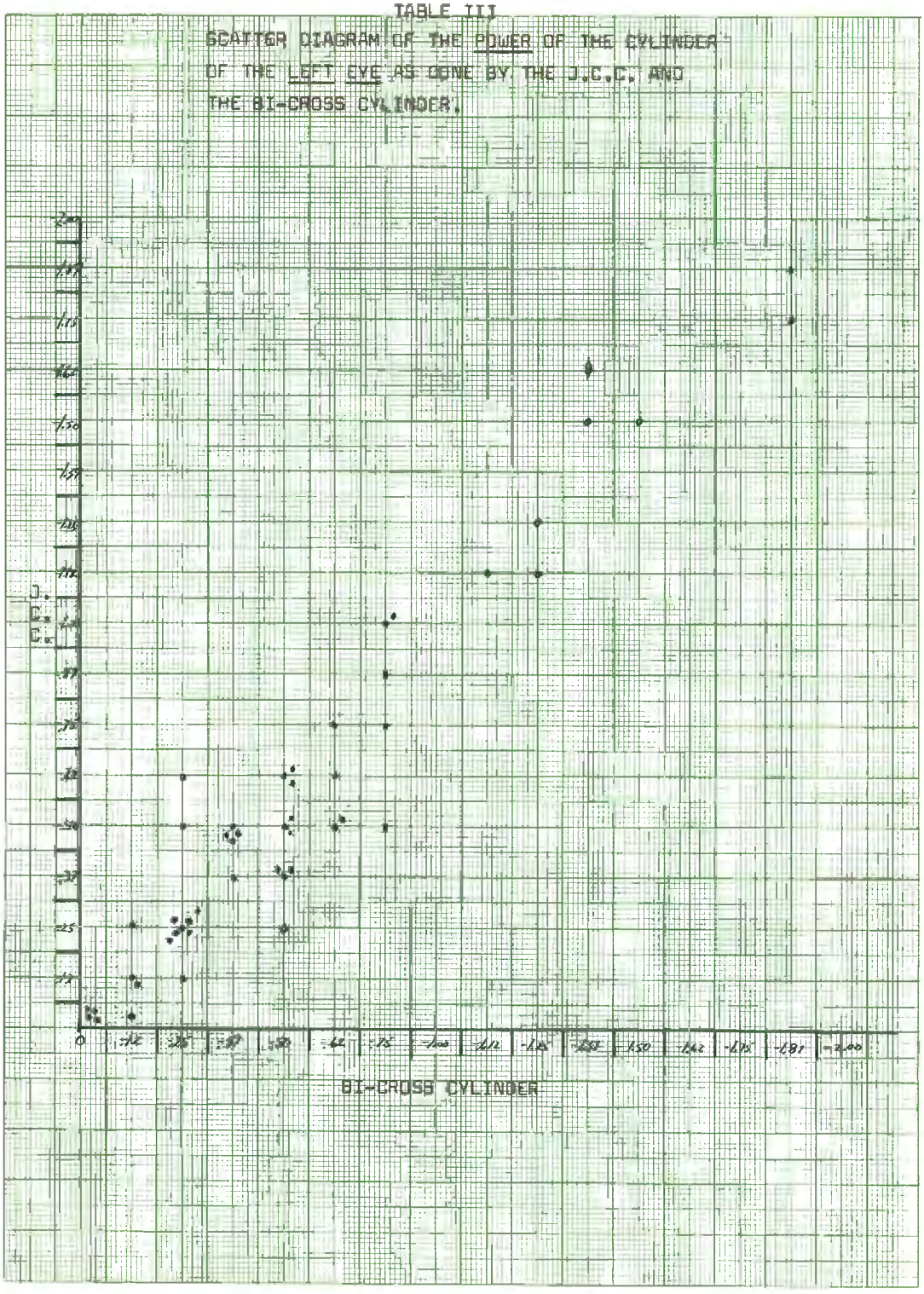
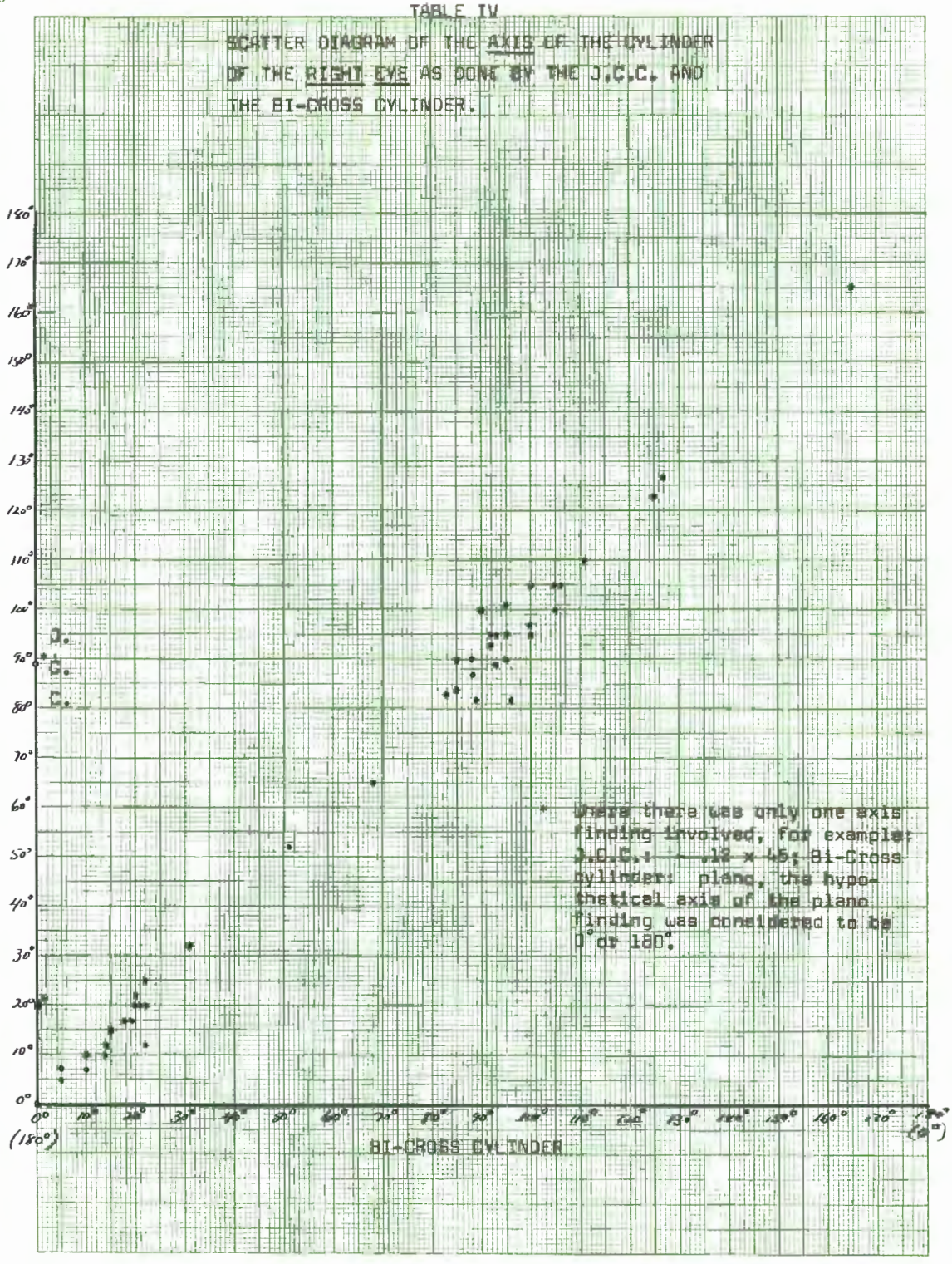


TABLE IV

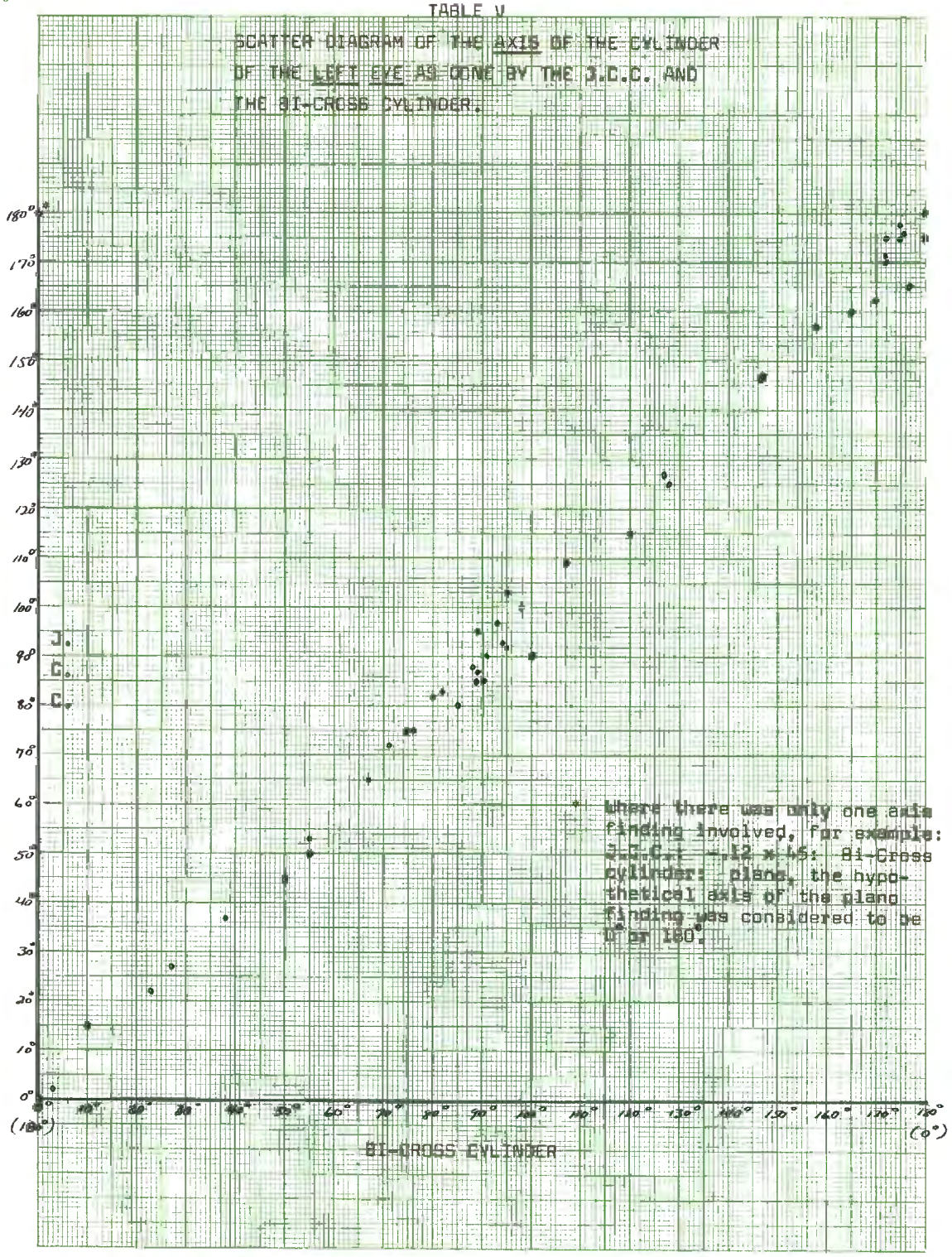
SCATTER DIAGRAM OF THE AXIS OF THE CYLINDER OF THE RIGHT EYE AS DONE BY THE J.C.C. AND THE BI-CROSS CYLINDER.



* Where there was only one axis finding involved, for example: J.C.C.: ~~ ×12 × 45; Bi-Cross cylinder: plano, the hypothetical axis of the plano finding was considered to be 0° or 180°.

TABLE V

SCATTER DIAGRAM OF THE AXIS OF THE CYLINDER OF THE LEFT EYE AS DONE BY THE J.C.C. AND THE BI-CROSS CYLINDER.



Where there was only one axis finding involved, for example: J.C.C. -.12 x 45; Bi-Cross cylinder: plano, the hypothetical axis of the plano finding was considered to be 0° or 180°.

STATISTICAL ANALYSIS

Formulae used in the statistical analysis of the data are as follows:

Mean:

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

where M = the arithmetic mean
X = a score or other measure
N = the number of scores
E = denotes "sum of"[4]

Standard Deviation:

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

where S = standard deviation
x^2 = the square of a deviation from the mean
E = denotes "sum of"
N = number of cases[5]

Correlation Coefficient:

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

where Exy = sum of the products of deviations 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 [6]

Results of the statistical analysis are as follows:

Means:

Power of the cylinder

	J.C.C.	Bi-Cross cylinder
O.D.	.590	.560
O.S.	.580	.620

Axis of the cylinder

	J.C.C.	Bi-Cross cylinder
O.D.	59.62	61.62
O.S.	89.94	97.30

Standard Deviations:

Power of the cylinder

	J.C.C.	Bi-Cross cylinder
O.D.	.432	.387
O.S.	.469	.450

Axis of the cylinder

	J.C.C.	Bi-Cross cylinder
O.D.	47.10	42.80
O.S.	57.02	57.90

Correlation Coefficient:

1. power O.D. = .96
2. power O.S. = .94
3. axis O.D. = .94
4. axis O.S. = .99

SUMMARY AND CONCLUSION

The data was correlated in several different ways. 1. The power and axis means of the J.C.C. findings for one eye (right eye then left eye) were compared directly with the power and axis mean of the Bi-Cross cylinder. By comparing the respective means of the two types of testing, there is little if any difference, but this one comparison does not prove the reliability of the Bi-Cross cylinder. 2. Further, the standard deviations resulted in a minimum change for both power and axis, therefore proving that the J.C.C. and the Bi-Cross cylinder would be adequate for the majority of the subjects involved and also could be predicted to be adequate for the simple majority of the "population." 3. According to correlation coefficients for power and axis there appears to be no significant difference. 4. By examination of the graphs, the values for power and axis are practically linear with some slight exceptions.

The opinion of the authors of this paper, is that the correlation coefficient is adequate to allow free substitution of one procedure for the other.

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