Powers of Hydrophilic Bifocal Contact Lenses

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INTRODUCTION

One of the new advances in the contact lens field has been the development of hydrophilic bifocal contact lenses There are a number of companies in the research and clinical investigational stage.

Our investigation at the Ferris State College of Optometry concerns itself with a hydrophilic bifocal manufactured by Ciba Vision Care, a division of CIBA-GEIGY Corporation. This lens is currently in the clinical investigation stage The Ciba bifocal lens is of a concentric, progressive power design in that there is an area which contains the distant Rx and a multifocal zone (abbreviated m.z) which progressively increases in plus power as the distance increases away from the optical center of the lens

Four designs were investigated in our study: a spherical base curve lens with a small m.z and one with a large m.z ; and an elliptical base curve lens with a small m.z and large m.z

The lenses with the large m.z. were the first lenses manufactured but later were discontinued in lieu of the small m.z. lenses. Specific parameters of the lenses are not available at this time.

The goals of this investigation were the following: (1) comparing labeled verse measured powers of both the distant R_x and near R_x, (2) determining the rate at which plus power increases in the m.z, (3) to see if the near R_x was found consistantly at a certain point away from the optical center, (4) comparing spherical verse elliptical lenses using data obtained in areas 2 and 3, ~~and~~ (5) comparing large m.z verse small m.z lenses, again using data obtained in areas 2 and 3.

METHODS

A total of 48 lenses were used in the investigation. There were 21 spherical lenses, 17 with a small m.z and 6 with a large m.z. There were 25 elliptical lenses, 19 with a small m.z and 6 with a large m.z

To measure the power at different points within the .m.z several devices using the Scheiner's disk principle were made to fit over the lensometer (photograph 1). These devices consisted of unfinished contact lenses mounted on a polyvinylchloride tubing. We first obtained unfinished plano PMMA lenses with the lathe marks still on them. To use the contact lens for the Scheiner's disc principle it was necessary to drill two apertures, one on each side of the center of the lens and symmetrically separated. To do this a projection magnifier with a metric scale on the screen was used to aid in marking the lenses. The concentric lathe marks on the lenses made this task much easier. The lenses were then drilled at the markings using a 0.35mm drill bit. To allow us to measure the power in the n.z. at 0.5mm intervals seven devices were made. The first had apertures separated by a 0.5mm radius and the last had aperatures separated by a 3.5mm radius from the center of the lens. The back of the stop lenses were then painted to enhance visibility of the Scheiner's disc principle. the contact lenses were then mounted on polyvinylchloride tubing (photograph 2) which then could be placed over the nosepiece of the lensometer as easily as the standard lensometer button. the tubing was designed in such a way so it would be at the correct stop distance on the lensometer.

All contact lenses being measured were masked so no parameters could be seen except for the lot numbers. The lot numbers were used as identification markings when making measurements on the lenses. All lenses were pooled together and randomly selected. Each lens was measured six separate times at each of the seven positions within the m.z. When all lenses had been measured once at each position within the m.z. we would begin the process over again. Standard measurements, without using any Scheiner's disc devices but only a standard button, of the distant and near Rx's were also taken. Six measurements of each lens was made in the same manner as above.

To measure a lens we simply blotted the lens dry, carefully centered it over the device and racked the lensometer back and forth until we saw a singleness of the target which corresponded to the dioptric power ~~(D)~~ at the specific distance from the optical center of the lens.

RESULTS AND DISCUSSION

The first question we investigated concerned itself with comparing the labeled verses actual values of both the distant and near Rx's. We used data obtained from the Scheiner's disc device which had apertures separated by 0.5mm radius as one of our distant Rx values since this was very close to the optical center of the lens. We also used the data from the standard lens measurements as another set of values for the distant Rx. We took the mean of these two values and rounded the answer off to the nearest 0.25D to come up with the actual power of the distant Rx. The labeled powers for both the distant and near Rx's were accepted if the actual powers did not exceed ±0.25D. Only the small m.z lenses were considered since the large m.z lenses are no longer used. The actual verse labeled powers are plotted in figures 1 and 2. The tabulated data is found in tables 1 and 2.

There was only one method used to determine the actual near Rx and these values were obtained by putting the lenses on a standard button and focusing the target which corresponded to the near Rx.

When the data was plotted we saw some interesting results. Lets first consider the distant Rx measurements. Nine out of nineteen (47.4%) of the elliptical lenses had incorrect labeled powers while seven of seventeen (41.2%) spherical lenses had incorrect labeled powers. It is interesting to note that all the lenses which failed the verification had more minus power than what the label read. The elliptical lenses ranged from 0.50D to 0.75D more minus and the spherical lenses had a range of 0.50D to 1.00D more minus. Looking at figures 1 and 2 it can be seen that only one lens out of the 36 investigate had more plus power than what the label indicated. All others were either right on (9), or had more minus power (26) than the labeled power. There appears to be little difference as far as correctly labeled powers when comparing elliptical verse spherical lenses even though the spherical lenses hold a slight edge.

If we now look at the near Rx's we can again see some type of trend. The elliptical lenses had a 36.8% (7 of 19) failure rate on verification while the spherical lenses showed a 29.4% (5 of 17) failure rate. All the lenses, except two which failed the verification had more plus power than the labeled value. This is just the opposite as the distant Rx values. Of the elliptical lenses which failed, one was 1.00D more minus while the other six ranged from +0.50D to 1.00D more plus. Of the spherical lenses which failed, one was 0.75D more minus while the other four were 0.50D more plus. By looking at figures 3 and 4 it can be seen that eight lenses were exactly correct, five had more minus and twenty three had more plus power than what the label ~~had~~ read. Again, there appears to be little difference between the spherical and elliptical lenses when considering verification of the power. But it appears that the near Rx has a better percentage of being correctly labeled than the distant Rx.

Of the nine elliptical lenses which failed the distant power verification 55.6% (5) also had incorrect labeled near Rx's. Of the seven elliptical lenses which had failed the near verification 71.4% (5) had incorrect labeled distant powers. Similar results were observed with the spherical lenses. Of the seven which failed the distant Rx verification 42.9% also failed the near verification. Of the five which failed the near verification 60% (3) also failed the distant Rx verification. Again it can be seen, as in the other comparisons, the spherical lenses were slightly better than the elliptical with respect to correctly labeled lenses. It also appears that if the distant Rx fails the verification there is a good chance the near Rx will be off and vice-versa.

The next part of our investigation concerned itself with determining the rate at which plus power increases within the n.z. and to see if the near Rx was found consistantly at a certain distance away from the optical center

Table III contains data showing where the near Rx was reached with respect to the distance from the optical center. The data was obtained by graphing the increase in plus power as the distance increases from the center of the lens. Lenses were put into groups by near Rx powers and only groups with two or more lenses were considered. This is why Table III contains only 32 lenses instead of the 36 which were investigated. There is a range in ~~which~~ the m.z. where the near Rx occurred, as ~~can be~~ seen in Table III.

We also took the lenses in each group and took the mean at each measured position in the m.z. The range in which the near Rx was found was considerably reduced when compared to the data in Table III. For the spherical lenses the near Rx was found between 2.00 mm ~~to~~ and 3.05 mm from the center of the lens in comparison to the 1.56 mm to 3.52 mm range obtained in plotting single lenses. The elliptical lenses bore similar results, the near Rx occurred between 2.06 mm and 3.58 mm from the optical center in comparison to the 1.08 mm to 4.00 mm range obtained without averaging the lens groups.

Figures 5 and 6 will provide insight into the rate at which the plus power increased in the m.z. The data is again obtained by putting the lenses into groups based on the near Rx and then taking the mean of the values in each group. Theoretically or ideally the power would increase gradually, arrive at the near Rx at a certain point, and then level out at some certain power. The point ~~which~~ at which the near Rx is reached would be the same for all ~~then~~ lenses regardless of the near Rx power. If the near Rx increased then there would be a compensatory increase in the rate at which the plus power increased in the m.z. (see figure 7).

Figure 5 represents the spherical lenses. It can be seen that all groups progressed at essentially the same rate. This accounts for the range of points in the m.z. at which the near Rx is ~~reached~~ found. The groups with the 2.75 to 2.50 diopter adds are ideal in that the ~~adds are~~ near Rx's all found at the same points within the m.z. On the other hand the ~~+~~ 2.75D group increased too fast (near Rx reached @ 2.00 mm from the optical center) while the 3.00 D group increased too slow (near Rx found @ 3.05 mm from the optical center).

Similar results can be seen with the elliptical lenses in figure 6. Both the 2.75 and +3.00 diopter groups reached the near Rx at approximately the same position (2.54 mm and 2.52 mm in the m.z.) while the near Rx in the 2.25 D group didn't increase fast enough and the power increased too fast in the 2.50D group

It appears there are inconsistances in the rate at which the power progresses in the m.z. and this may affect how the patient accepts the lens. If the power increases too fast the patient may be aware of blurred vision due to the too much plus power. On the other hand, if the power doesn't increase enough ~~the the patient may~~ then there may be insufficient power to perform near point tasks. There are other variables which may affect patient acceptance such as what area the patient is using in the m.z. For instance, if the patient is far into the m.z and the power has progressed insufficiently in the m.z. the patient may have no trouble. On the other hand, if the power had progressed too much in the m.z then there may be too much plus power for the particular near point task. Another variable worth mentioning is the fact we have seen that many times there is more plus in the near Rx than what the label read. This too may affect performance if one assumes the lens is correctly labeled.

The last part of the investigation involved comparing lenses with a large m.z. verse lenses with a small m.z. As mention before, the large m.z was used in the first investigational lenses. Patient acceptance was a problem in some cases so the large m.z was replaced with a small m.z. By graphing the data we have come up with ~~an explanation~~ a possible explanation as to why the large m.z lenses failed to work.

Figure 8 represents data containing spherical verse elliptical lenses having large and small multifocal zones. The key here is the ratio of which the power increases in the m.z. The lenses with the small m.z increased at a much faster rate than the large m.z lenses. The power in the large m.z lenses doesn't really start to increase significantly until the distant away from the optical center reaches 1.5.m.m. Some of the patients who were having problems may have been using an area in the m.z. closer to the optical center in which case the large m.z lenses would provide inadequate power. Patients using ~~the~~ an area further from the optical center in the larger m.z. lenses would have less problems because the plus power increases significantly beyond the 2.00 mm mark from the optical center. ~~There there is only a small~~ Other graphs with different near Rx's comparing the large and small m.z. lenses showed similar results as in figure 8.

Summary

The small m.z. is an improvement over the large m.z. lens with respect to the power increase within the m.z. Less patient complaints have been observed in the investigational study at the College since using the small m.z. lenses. There still has been some patient acceptance problems and these problems may be due to some of the results discussed in our investigation.

First there is the problem of receiving the correct lens. Our results indicated little difference between spherical and elliptical lenses with respect to verification of the distant and near Rx's but the spherical lenses held a slight advantage for having more correctly labeled containers. The near Rx was far better for being correctly labeled as compared to the distant Rx. ~~The data also indicated a~~ Even though the near Rx was more frequently labeled correctly than the distant Rx there still was a high failure rate upon verification; 47.4% elliptical and 41.2% spherical lenses failed distant Rx verification ~~and~~ with 36.8% elliptical and 29.4% spherical lenses failing the near Rx verification. The distant Rx showed a trend towards more minus than what was labeled and the near Rx showed a trend towards more plus than what was labeled.

The inconsistency in the rate of progression in the MZ and the different positions ~~at~~ which the near Rx was found in the MZ can also create problems. All these factors can combine to give good results or bad results with respect to patient acceptance. When a patient has a problem with the lenses it becomes hard to determine what parameter of the lens, if any, is at fault.

It is ~~the~~ our hope the information

presented here will provide to the practioner insight into the possible defects in the design of these ~~lenses~~ and similar lenses and ~~possibly explain~~ possible explanations ~~of~~ to why there is failure in patient acceptance.

*TABLE 1

LABELED DISTANT Rx	ACTUAL DISTANT Rx	STANDARD DEVIATION OF ACTUAL Rx DATA	LABELED NEAR RX	ACTUAL NEAR Rx	STANDARD DEVIATION OF NEAR Rx DATA
PLANO	+0.25	0.12	+3.50	+2.75	0.18
+0.25	-0.25	0.15	+2.75	+2.75	0.15
+0.25	-0.25	0.15	+2.50	+2.50	0.13
+0.75	+0.50	0.19	+2.50	+3.00	0.20
-3.25	-3.75	0.20	+2.50	+3.00	0.19
-3.25	-3.75	0.17	+2.50	+3.50	0.16
-1.50	-2.25	0.17	+2.00	+2.25	0.10
PLANO	-0.25	0.17	+2.00	+2.00	0.17
-0.25	-0.75	0.15	+2.00	+1.75	0.19
+3.25	+3.00	0.23	+1.75	+2.25	0.14
-4.00	-4.50	0.17	+2.25	+2.50	0.14
-1.50	-2.00	0.22	+1.25	+1.75	0.11
-0.25	-0.50	0.13	+1.25	+1.50	0.17
PLANO	-0.50	0.13	+1.25	+1.75	0.15
+1.75	+1.75	0.12	+1.25	+1.50	0.19
+0.25	+0.25	0.14	+2.75	+3.00	0.13
+1.25	+1.00	0.11	+2.00	+2.00	0.18
+1.50	+1.00	0.13	+1.75	+2.00	0.11
+0.25	+0.25	0.12	+2.75	+3.00	0.14

*Elliptical lenses - small multifocal zone

*TABLE 2

LABELED DISTACE Rx	ACTUAL DISTANCE Rx	STANDARD DEVIATION OF ACTUAL DATA	LABELED NEAR Rx	ACTUAL NEAR Rx	STANDARD DEVIATION OF NEAR Rx DATA
+2.00	+1.25	0.20	+3.00	+3.50	0.13
+1.25	+0.25	0.25	+2.50	+3.00	0.11
+2.00	+1.00	0.15	+2.60	+2.75	0.16
+1.50	+1.50	0.12	+2.50	+3.00	0.12
+1.75	+1.25	0.16	+2.50	+2.75	0.19
-1.50	-2.25	0.13	+2.00	+2.50	0.21
+2.25	+1.50	0.20	+2.00	+2.25	0.15
+1.25	+1.25	0.13	+4.00	+3.25	0.22
+1.75	+1.75	0.14	+2.75	+2.50	0.12
-1.50	-2.00	0.16	+2.25	+2.25	0.11
+1.00	+0.75	0.12	+2.50	+2.75	0.15
-1.75	-2.00	0.13	+2.25	+2.25	0.15
-1.75	-1.75	0.13	+2.25	+2.25	0.19
-1.75	-2.00	0.12	+2.25	+2.50	0.12
+0.50	+0.50	0.11	+2.50	+2.75	0.12
-1.75	-2.00	0.12	+2.25	+2.00	0.15
+0.50	+0.50	0.12	+2.75	+2.75	0.17

* Spherical lenses - small multifocal zone

TABLE III

DISTANCE FROM THE OPTICAL CENTER AT WHICH THE NEAR ADD WAS PRESENT (IN mm)

SPHERICAL LENSES	ELLIPTICAL LENSES
1.56	1.08
1.56	1.58
2.00	2.02
2.02	2.02
2.08	2.08
2.50	2.08
2.51	2.09
2.51	2.51
2.52	2.54
2.52	2.56
2.55	3.00
3.51	3.04
3.52	3.06
3.52	3.09
	3.52
	4.00
	—*
	—*

* Indicates lenses which did not contain the near add within the 3.5 mm radius which was investigated.

FIGURE 1

DISTANCE POWER - SPHERICAL BASE CURVE

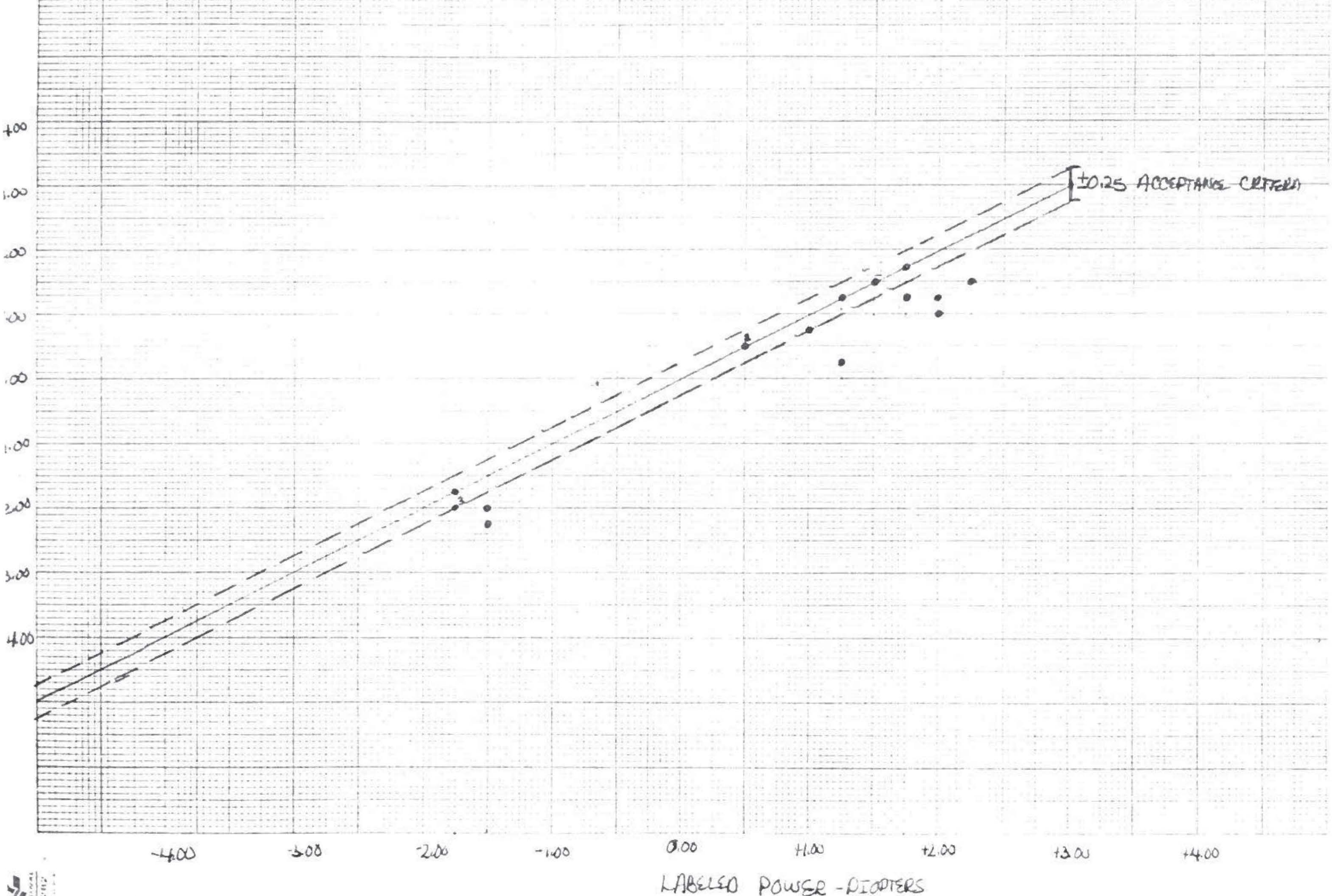


FIGURE 2

DISTANCE POWER - ELLIPTICAL BASE CURVE

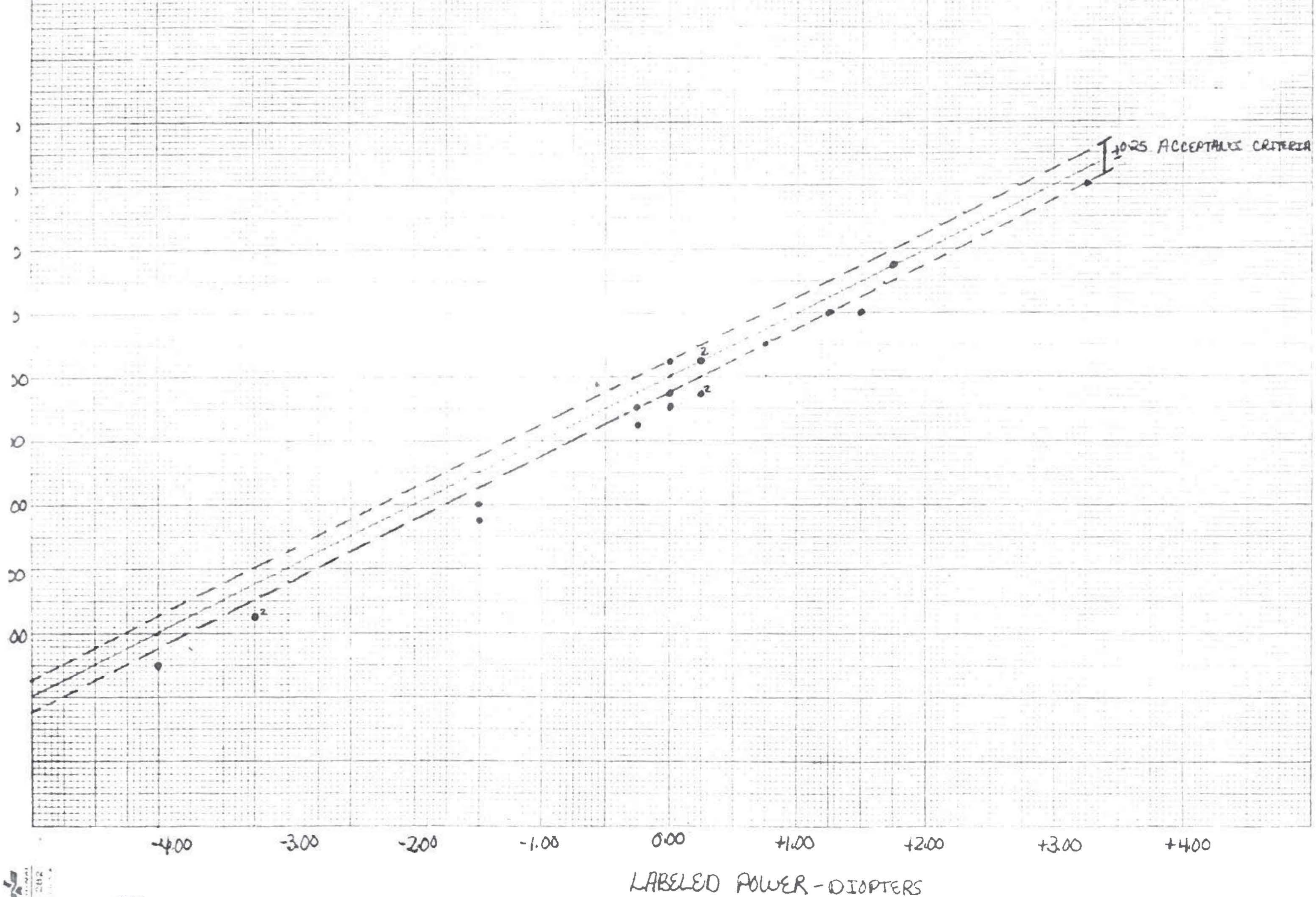


FIGURE 3

NEAR POWER - SPHERICAL BASE CURVES

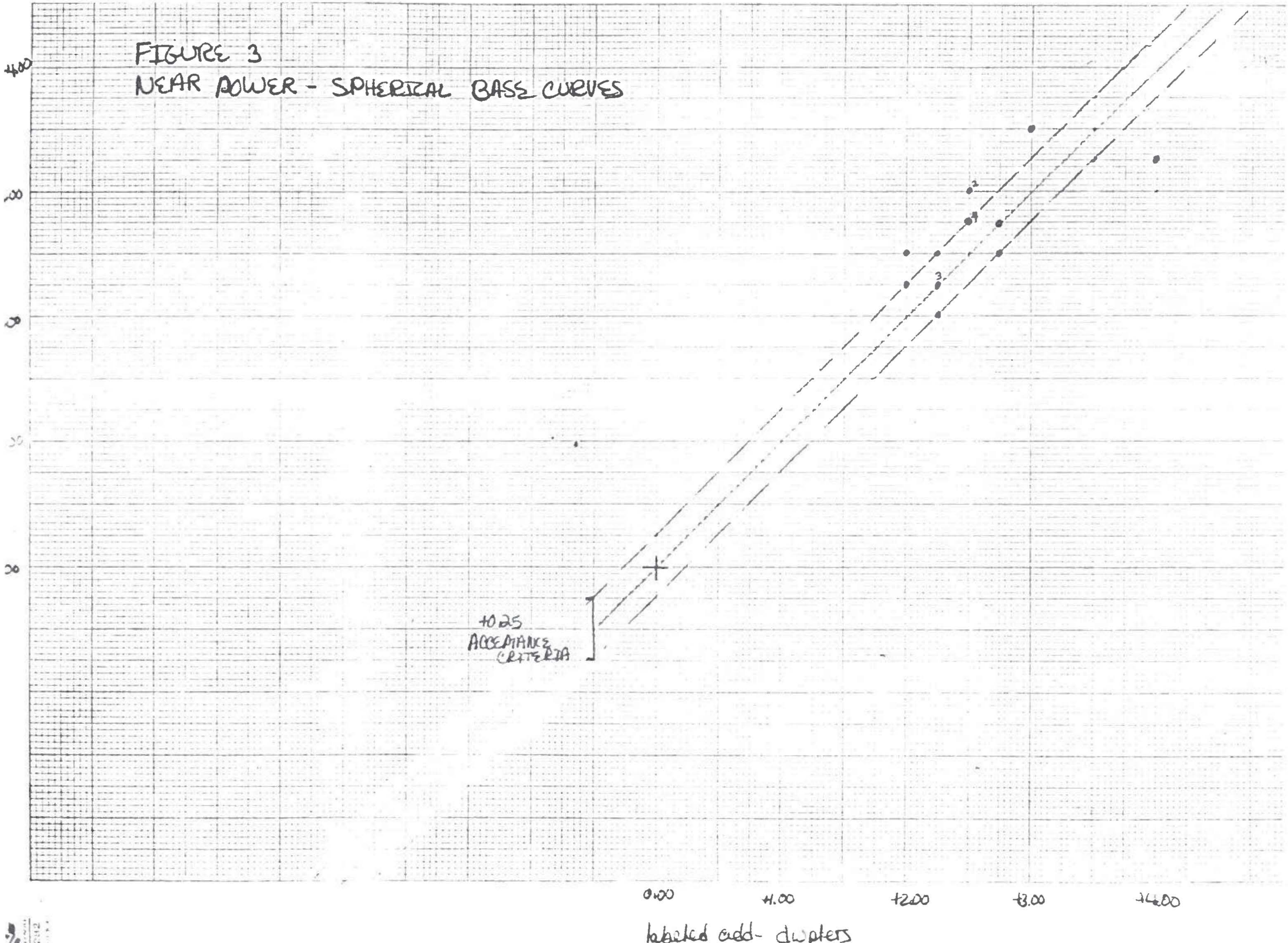
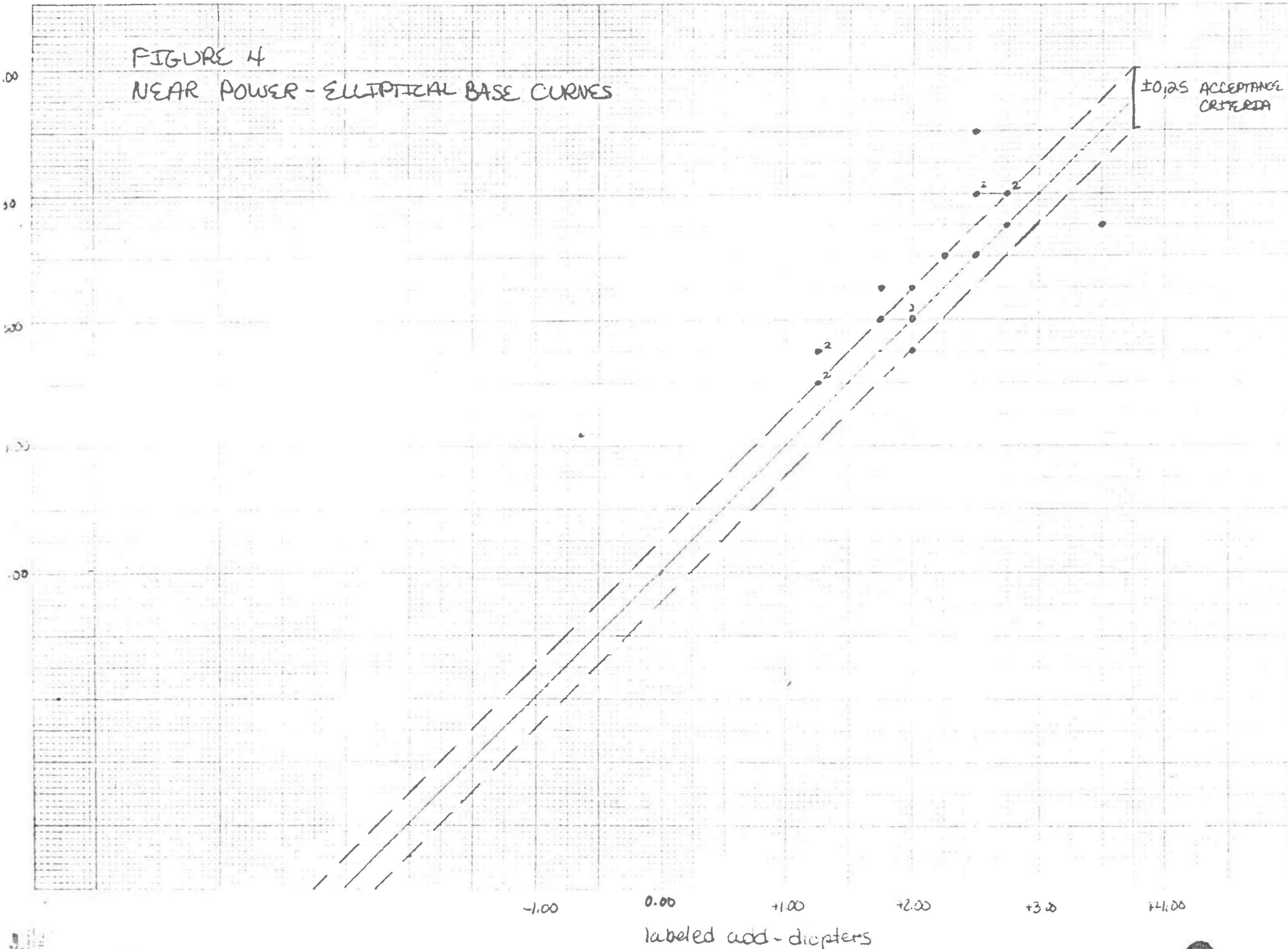


FIGURE 4
NEAR POWER - ELLIPTICAL BASE CURVES



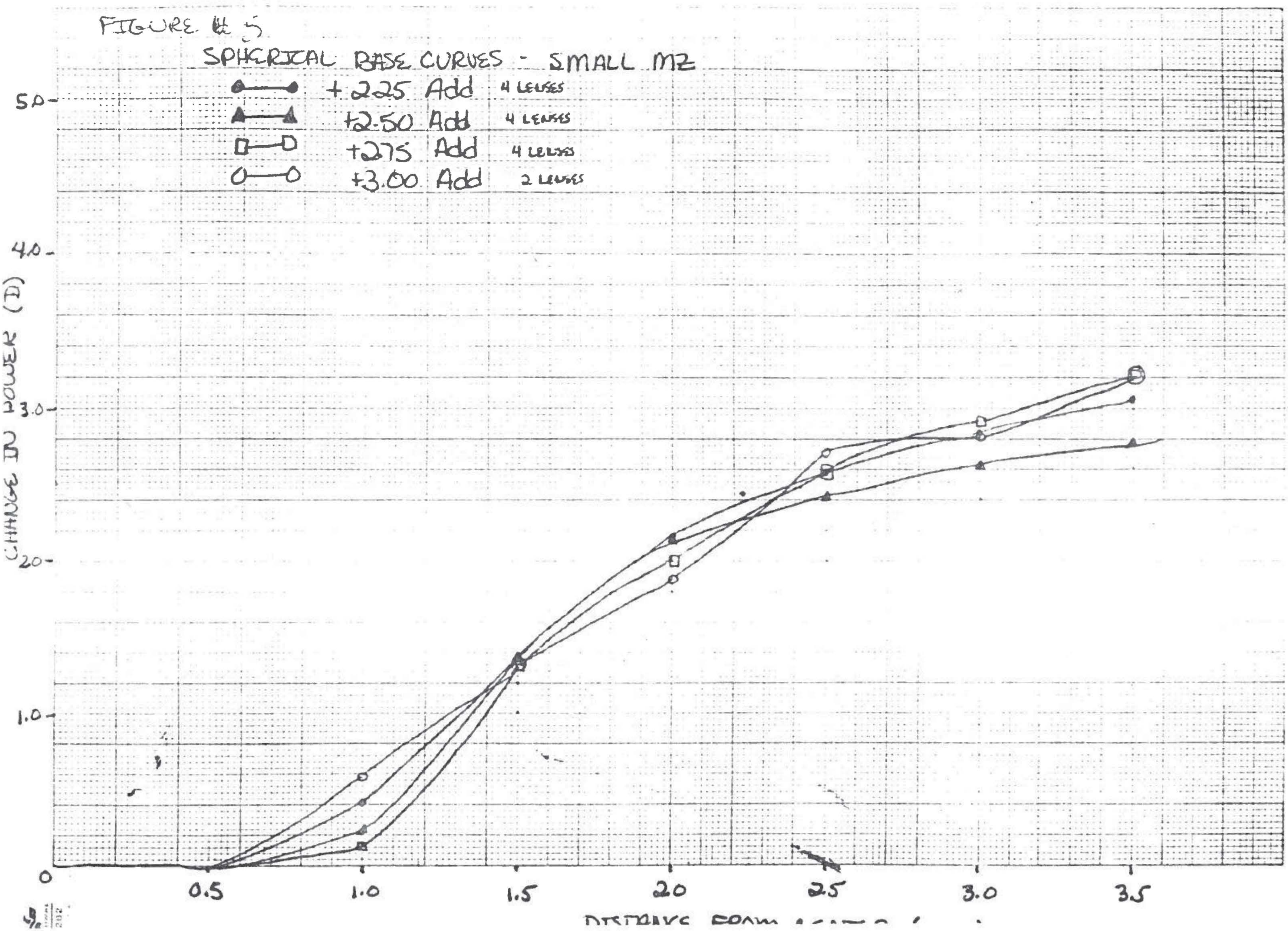


FIGURE # 5
SPHERICAL BASE CURVES - SMALL MZ
+2.25 Add 4 LENSES
+2.50 Add 4 LENSES
+2.75 Add 4 LENSES
+3.00 Add 2 LENSES
CHANGE IN POWER (D)
5.0
4.0
3.0
2.0
1.0
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5

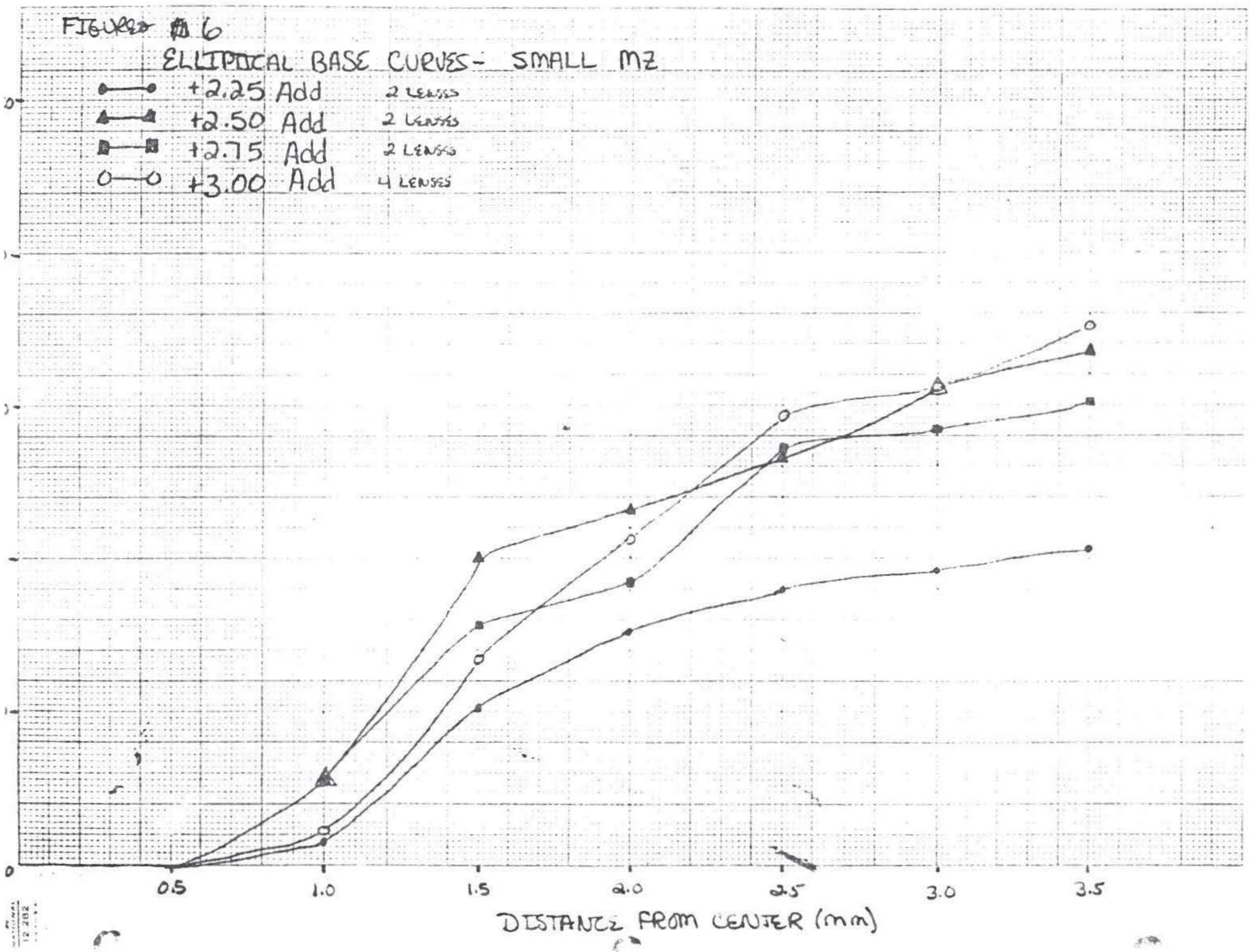


FIGURE #6
ELLIPTICAL BASE CURVES - SMALL MZ
+2.25 Add 2 LENSES
+2.50 Add 2 LENSES
+2.75 Add 2 LENSES
+3.00 Add 4 LENSES
0.5
1.0
1.5
2.0
2.5
3.0
3.5
DISTANCE FROM CENTER (mm)

FIGURE 7

IDEAL OR THEORETICAL RATE AT WHICH THE POWER INCREASES IN THE MULTIFOCAL ZONE

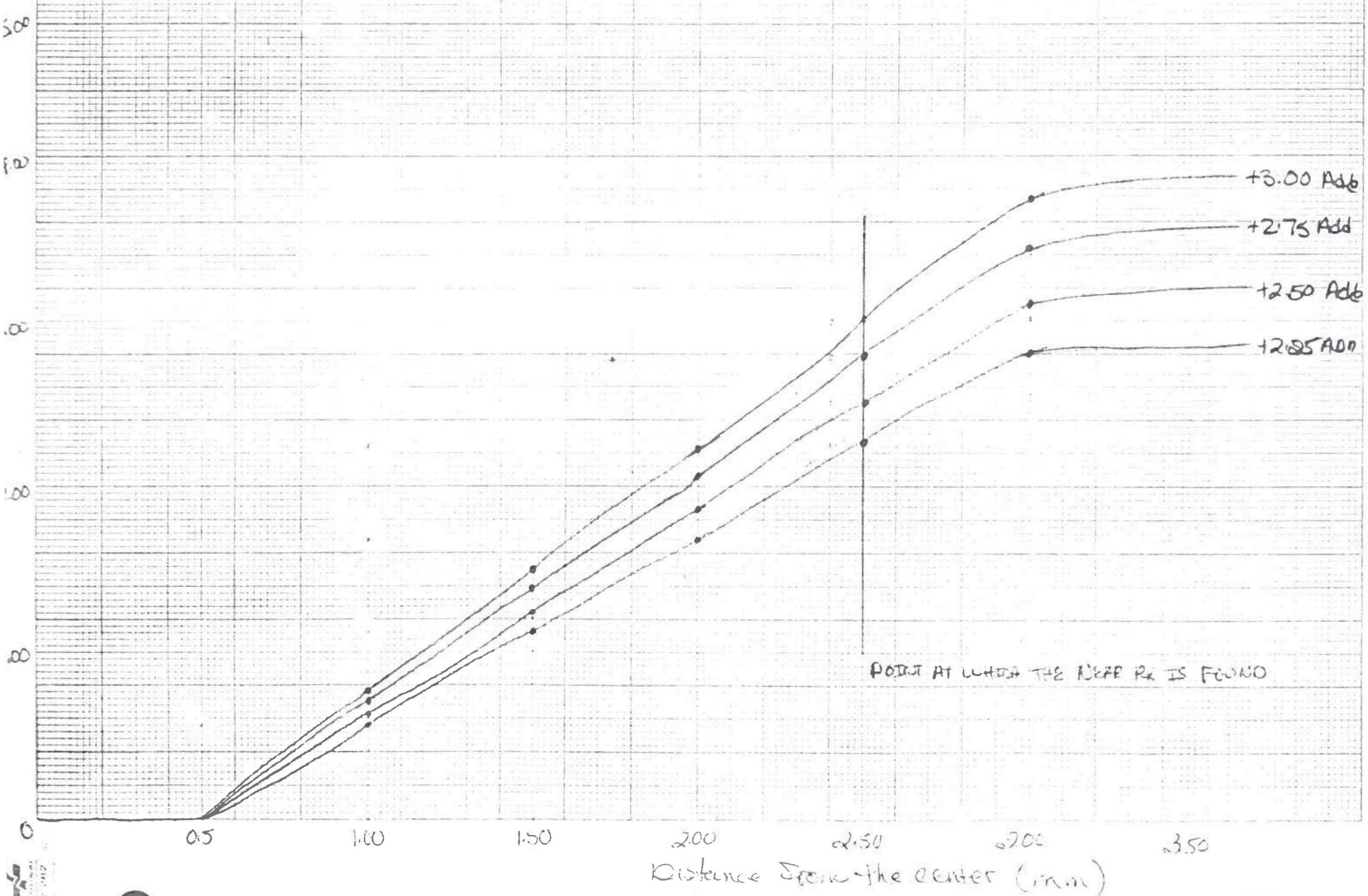
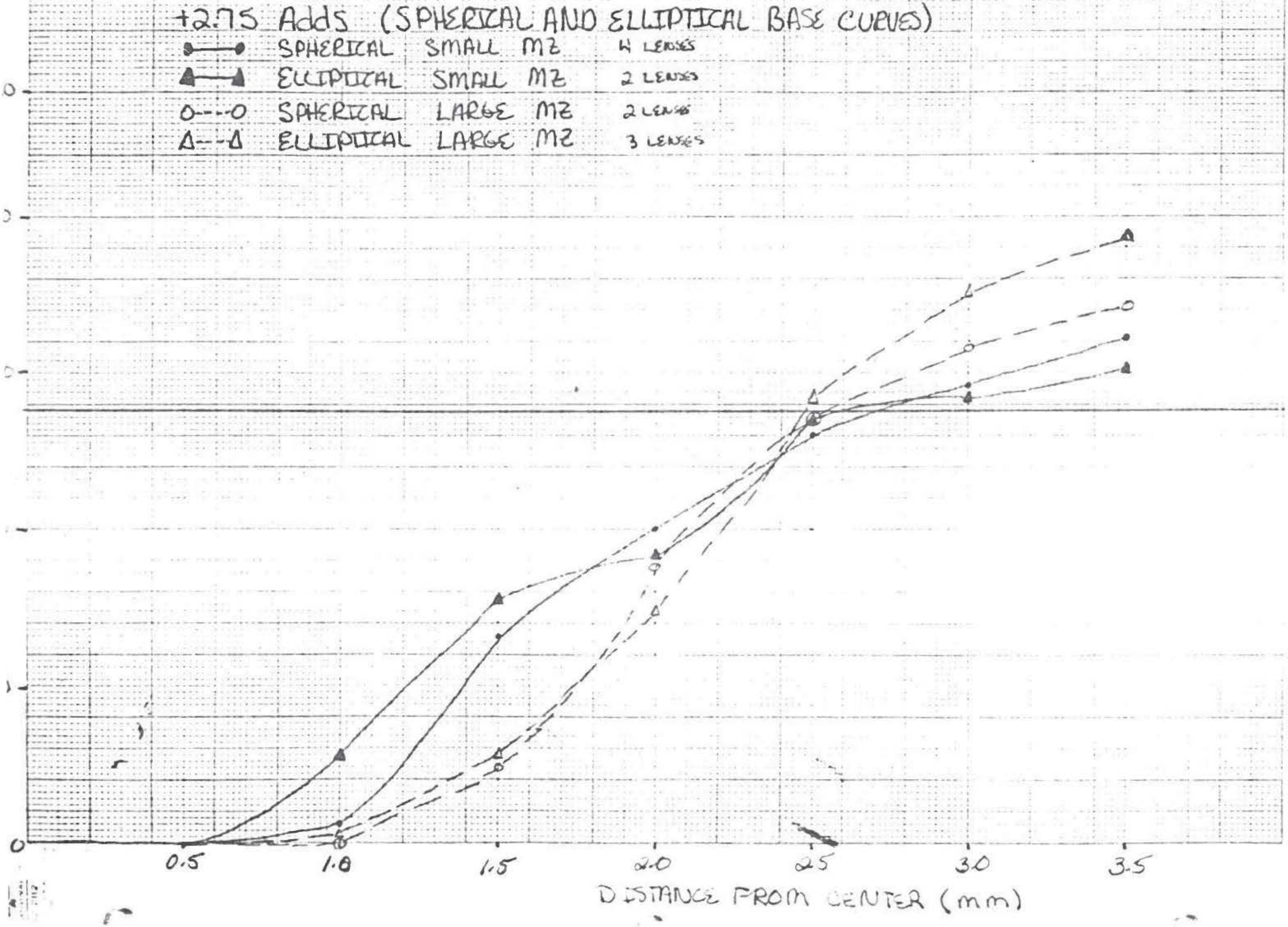


FIG. 8


+2.75 Adds (SPHERICAL AND ELLIPTICAL BASE CURVES)
SPHERICAL SMALL MZ 4 LENSES
ELLIPTICAL SMALL MZ 2 LENSES
SPHERICAL LARGE MZ 2 LENSES
ELLIPTICAL LARGE MZ 3 LENSES
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
DISTANCE FROM CENTER (mm)