VERIFICATION OF POWER OF BACK SURFACE ASPHERIC CONTACT LENSES

by
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INTRODUCTION

Aspheric bifocal contact lenses for correction of presbyopia is increasing in popularity. With an increase in usage, a simple and efficient means of verification of power of these lenses must be achieved. The problem with conventional lensometry of aspheric bifocal contact lenses is the measuring of the peripheral portion of the contact lens where the extra plus add is located. This study will show a technique for measuring the approximate add at different intervals from the center of the contact lens. In the study, nineteen back surface aspheric contact lenses were used.

The design of a back surface aspheric lens is different from a conventional spherical lens with multi peripheral curves. The aspheric lens gradually changes curvature compared to an abrupt change with spherical multicurve lenses. The cornea gradually flattens from apex to periphery. With the aspheric lens gradually changing, it fits the contour of the cornea more precisely. This should enable a better fitting contact lens.

The radius of curvature of a back surface aspheric lens gradually increases from the center of the lens to the periphery. This progressive flattening of the posterior lens surface establishes an increase in plus power or decrease in minus power from apex to edge of the lens. This increase of plus or decrease of minus gives an effective add.

The amount of flattening of apical curve in the periphery is known as the eccentricity of the lens. There are two principal peripheral curves generated in a back surface aspheric contact lens. These curves are equal at the apex, but change in the periphery. Diagram 1 shows these two curves. The two curves are known as the sagittal and tangential radii. The sagittal radius has one end point on the lens and the other intersects and lies on the apical axis. In Diagram 1, the sagittal radius or Rs at point D is $\overline{DE}$. Sagittal curve contains the three dimensional arc SDS. The Rs at point G on the lens is $\overline{GH}$.

The tangential radius or Rt is the radius of the curve perpendicular to the tangent at a point on the lens. Rt in Diagram 1 at D is $\overline{DF}$. Rt for point G is $\overline{GI}$. The tangential and sagittal radius at point A is $\overline{AX}$ which is the apical radius.

The equation for the sagittal radius is: $Rs = Ro^2 + e^2y^2$. This is derived from the general equation of a conic section where:

Ro = apical radius
e = eccentricity
y = distance from center of lens[1]

The equation for the tangential radius is: $Rt = \frac{Rs^3}{Ro^2}$.

The tangential radius is related to the tangential power by the equation: $Pt = \frac{N_2 - N_1}{Rt}$. The tangential power was measured in the periphery using a lensometer and the Schieners principle.

PROCEDURES AND TESTING

Conventional lensometry will not work to find the power of a peripheral point on the lens because the image of a majority of points on the lens is read at one time. The power cannot be determined because the peripheral point on the lens that is being measured is unknown. In other words, with all the points having different powers, it is unsure what points are being tested by using the conventional lensometer.

Using the Schieners principle overcomes this problem. The Schieners principle is a device in which the power of a lens is found using two small pinholes that are separated by a known distance. Two images are seen except at the point of focus. Diagram 2 illustrates the principle of Schiener.

Diagram 2 shows that at plane B one image is seen. Plane B is also the focus point of the lens. Plane A and C have two images on them, this means that they are not in focus. A lens focuses a point source of light at a point. Using the Schieners principle in this system gives two points of light at any place other than the focus point of the lens.

This principle can be used in verifying peripheral points on aspheric contact lenses. New lensometer stops were made which incorporated the Schieners principle. P.V.C. tubing was cut and drilled out to imitate lensometer stops. A contact lens was glued to the top of the plastic tubing. Holes were drilled in the contact lenses using a three-fourths millimeter drill bit. Two holes were drilled, each at one millimeter from the center of the lens, giving a total separation distance of two millimeters between the holes. This was also done for distances of 1.5, 2.0, 2.5, and 3.0 millimeters from the center of the lens. Diagram 3 illustrates the 2.0 millimeter lens.

All of the made lensometer stops were of equal height, which was the same as the height of the original lensometer stop. A permanent ink marker was used to darken the contact lenses on the lensometer stops. This enabled light to pass only through the drilled holes. An American Optical lensometer was used for the lensometry readings.

Nineteen VFL II lenses were used, consisting of six plus lenses and thirteen minus lenses. The lenses, chosen at random, were mounted on the lensometer stops using double faced tape and were centered before measuring. Each lens was measured at the 1.0, 1.5, 2.0, 2.5, and 3.0 settings. Every setting was measured six different times for all nineteen lenses.

RESULTS

After the power of each lensometry reading was recorded, the mean and standard deviation was tabulated for each power. The central power, using a 1.5 millimeter central hole, was also recorded. The largest standard deviation for the lensometry readings was 0.27 D, which was found at the three millimeter reading for lens number seven. The mean standard deviation for all the readings was 0.13 D, with 0.00 D being the lowest standard deviation.

Graph number one compares the six plus lenses. Each lens was rated at a power of +2.00 D with an eccentricity of 1.10. The manufacturer does not specify the amount of add in the periphery, only the eccentricity of the lenses. These lenses were found to have an average power of +1.87 D with a standard deviation of 0.09 D. The lenses had slightly less plus centrally than the manufacturer specified. As the distance from the center of the lens increases, the readings in the peripheral portion of the lens show increased average plus and an increase in the standard deviation. At 3 millimeters out from the center, the standard deviation is 1.06 D. This illustrates that the power between two lenses at a point 3 millimeters away from the center can vary greatly.

Graph number two compares the power of the thirteen minus lenses. The manufacturerlisted all powers to be a -3.00 D centrally with a 1.10 eccentricity. The lenses were found to have an average central power of -3.20 D with a standard deviation of 0.11 D. The lenses had slightly more minus than was specified. The readings in the peripheral portion illustrate that as the distance from the lens center increases, there is a decrease in minus power and an increase in standard deviation. At the 3 millimeter reading, a standard deviation of 0.84 D was found.

Graph number three compares the change in power for the different distances for both plus and minus lenses. This illustrates that the plus lenses generally have a greater increase in the change of power as compared with the minus lenses. The plus and minus lenses standard deviations are nearly equal for all testing distances.

Graph number four is a comparison of the steepest and flattest base curve of the plus lenses. The steepest base curve shows a higher increase in the change of plus compared to the flattest base curve. This change in power due to base curve differences can account for the large standard deviations in the periphery on graph number one. Using graph number four, if two people with the same prescription were fit with the VFL lenses, one having a very steep cornea and the other a flat cornea, the patient with the steep cornea may be over plussed at near while the patient with a flat cornea may be under plussed at near.

Graph number five compares the steepest and flattest base curves of the minus lenses tested. The change in power is noted more on the graph of the minus lenses than on the plus lenses. This can partially be accounted for by the base curves plotted. The steepest and flattest plus base curves are 7.3 and 7.8 respectively. The steepest and flattest minus lenses base curves are 6.93 and 8.14 respectively. The minus lenses tested have a wider range of base curves than the plus lenses, which is why the separation seems so much greater. The analogy for plus lenses of the patients with steep and flat corneas will also fit for the minus lenses.

Graph number six demonstrates the decrease in power from the steeper to flatter base curves at the 2 millimeter distance. It should be noted that the reading for the 7.5 base curve seems out of place. This is most likely due to manufacturing error. The 7.5 reading is 1.07 D above the mean and is 1.73 D standard deviations away from the norm. If the 7.5 base curve lens is dropped from the calculations, the plus lens average at the 2 millimeter testing distance is 1.54 D compared to 1.75 D, and the standard deviation drops to 0.37 D compared to 0.62 D. These irregularities of the 7.5 base curve lens are also found at other testing distances.

Graph number seven shows, at the 2 millimeter testing distance, the decrease in the change of power going from a steeper base curve to a flatter base curve. At the 2 millimeter distance, lens number 17, which has a base curve radius of 7.33, is 1.10 D higher then the mean of 1.42 D which is 1.82 D standard deviations away from the norm. Lens number 5, which has a base curve of 7.68, is 0.58 D above the mean which is 0.95 D standard deviations away from the norm. These two points stand out compared to the rest when graph number seven is viewed. These two lenses are probably poorly manufactured and are easily seen to be that way to an observer when viewing graph seven.

CONCLUSION

The power of back surface aspheric contact lenses can be measured using a lensometer stop that incorporates the Schieners principle. This system can be used to measure the progressive add of an aspheric lens at different distances from the center of the lens. At a given distance from the center of many lenses, a range of values for different base curves can be found. A practitioner can measure a lens, then refer to tables of various base curves and eccentricities to find how a verified lens compares to normal values. If the finding is off by 1.0 or 1.5 standard deviations, the optometrist could reorder the lens. If the doctor would want more accuracy in the lenses, he could reorder them until what he receives is 0.5 standard deviations from the mean.

The optometrist could compare his findings with theoretical tables that have the power change for different base curves and eccentricities at a certain distance from the center of the lens. These tables have already been computed.[2]

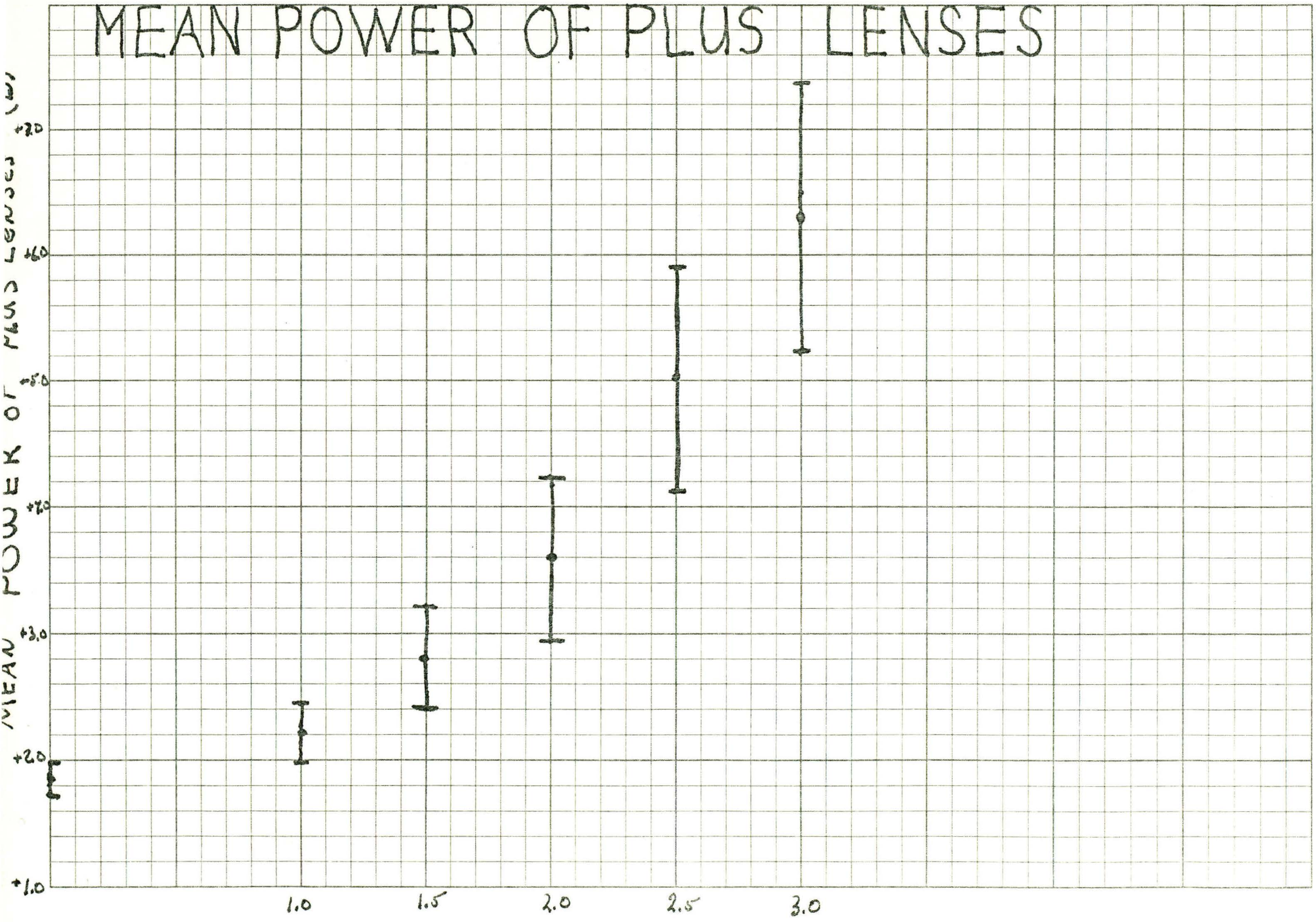
A doctor who uses aspheric lenses should know what he is receiving from the lab. This fast and easy system will identify a lens that is manufactured incorrectly or a lens that is not what was specifically ordered.

REFERENCES

1. Bennett, A.G., Aspherical Contact Lens Surfaces - Part Two, The Ophthalmic Optician, 8: 1299, 1968.

2. DeFazio, Anthony J., Back Surface Aspheric Contact Lenses, Masters Thesis.

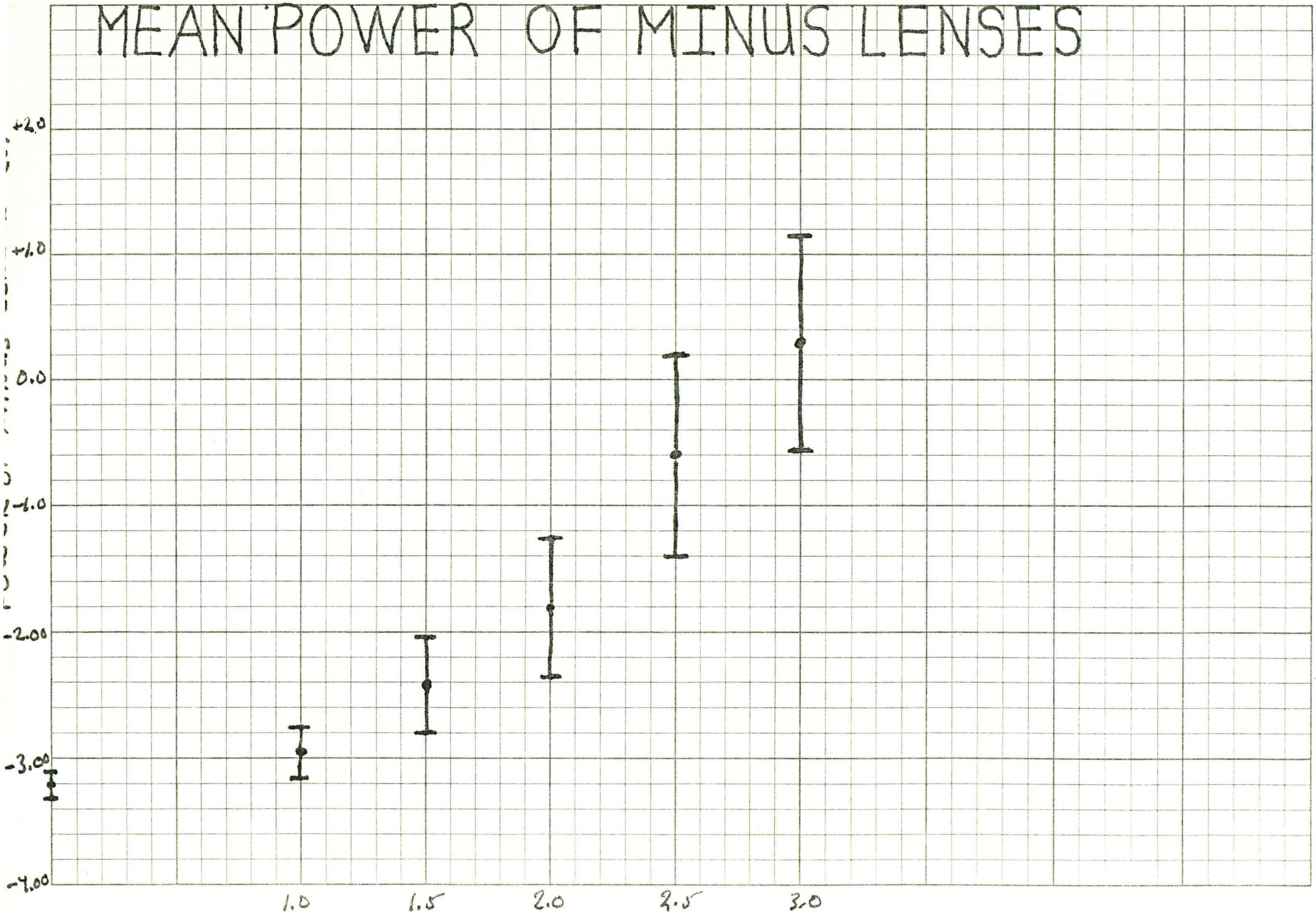
GRAPH # 1



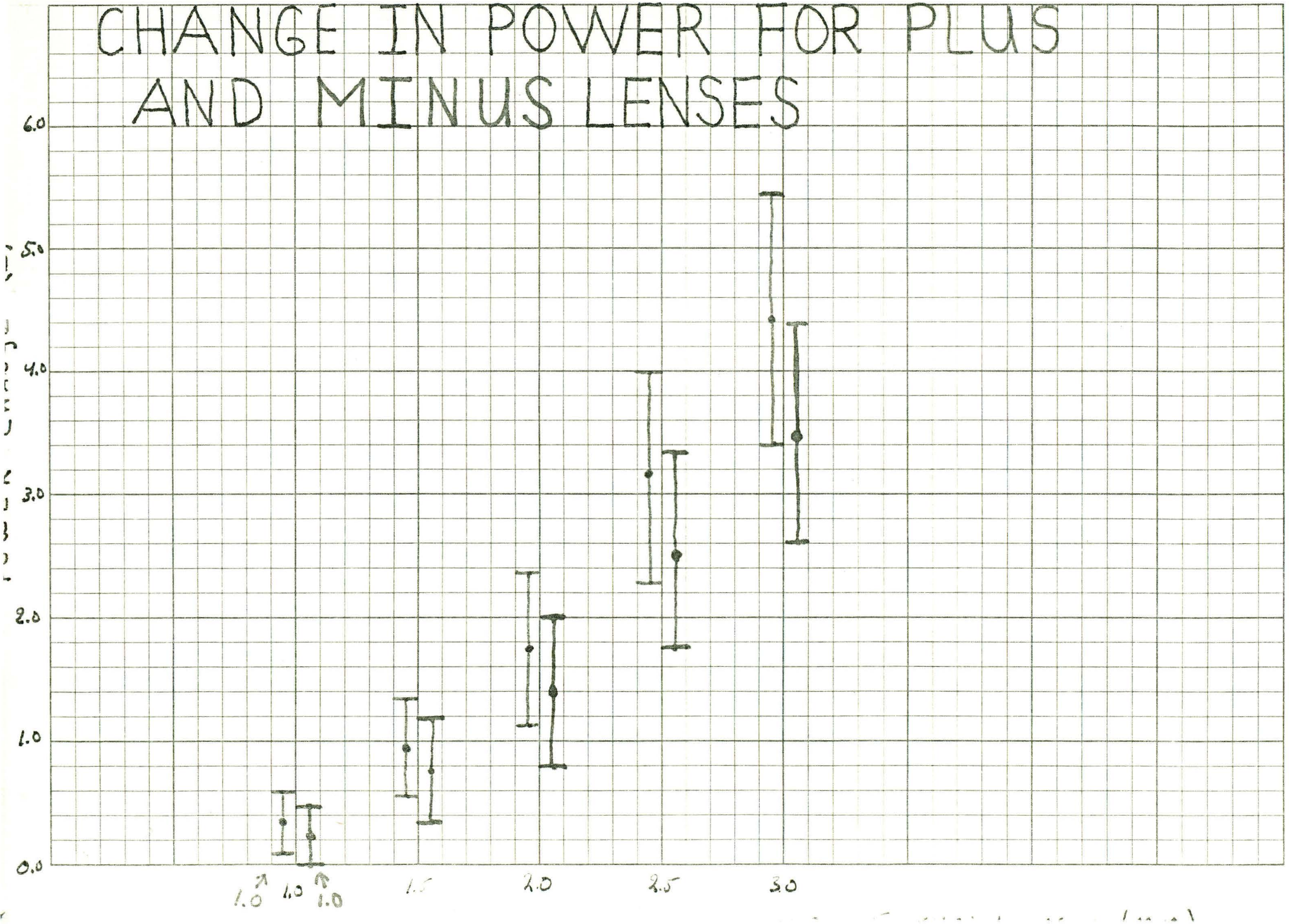
MEAN POWER OF PLUS LENSES

GRAPH #2

MEAN POWER OF MINUS LENSES

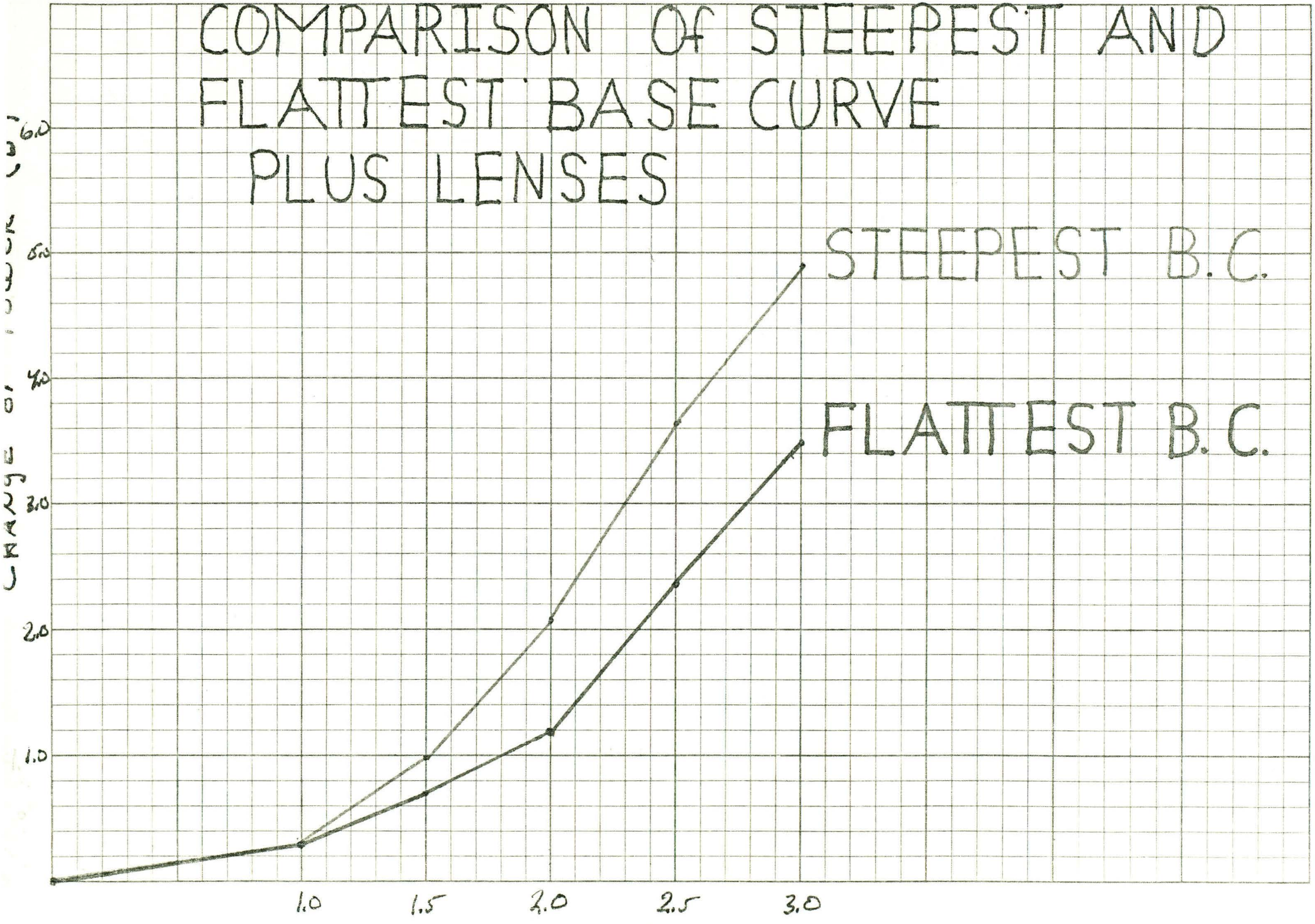


GRAPH # 3



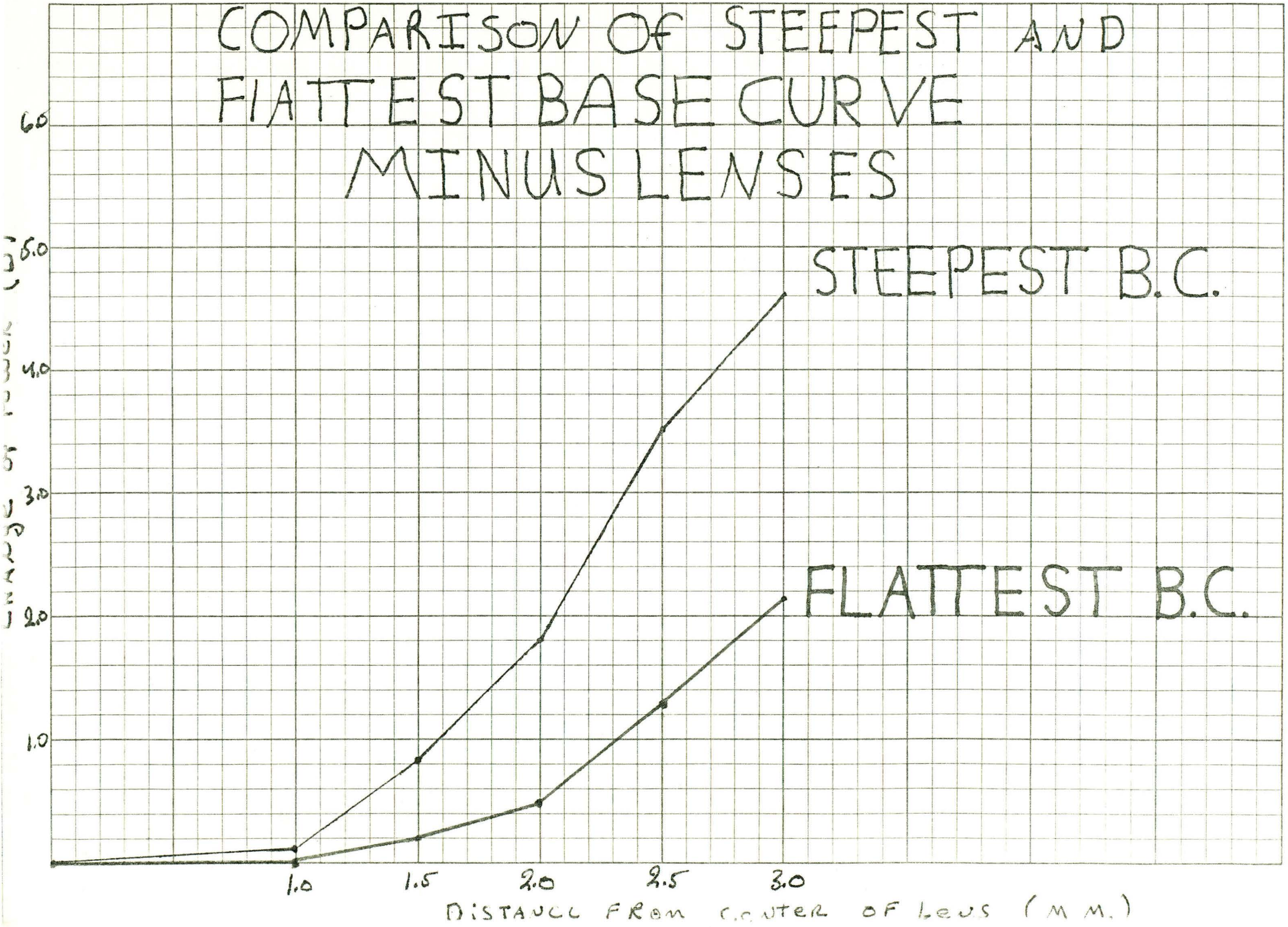
CHANGE IN POWER FOR PLUS AND MINUS LENSES

GRAPH # 4



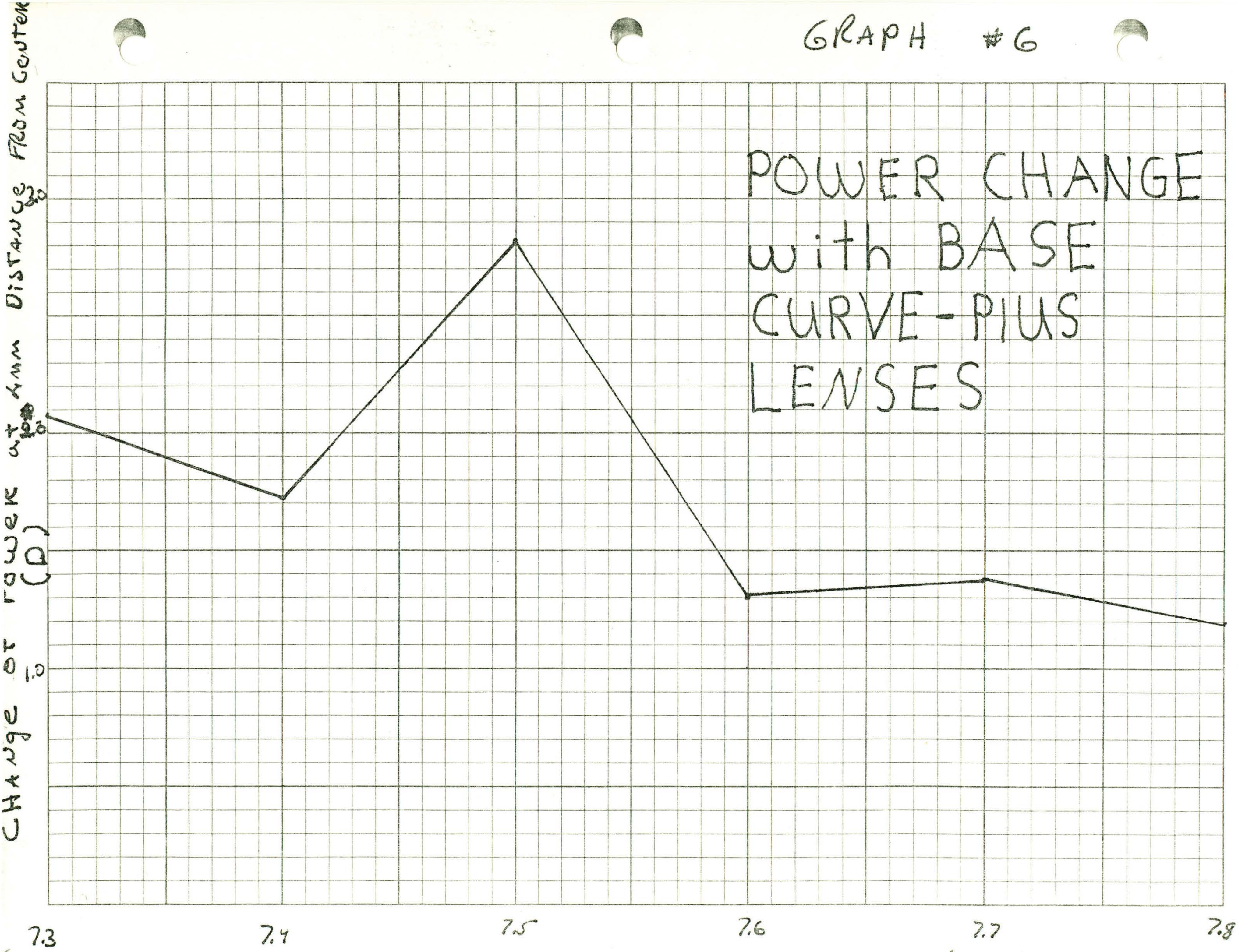
COMPARISON OF STEEPEST AND FLATTEST BASE CURVE PLUS LENSES

GRAPH #5

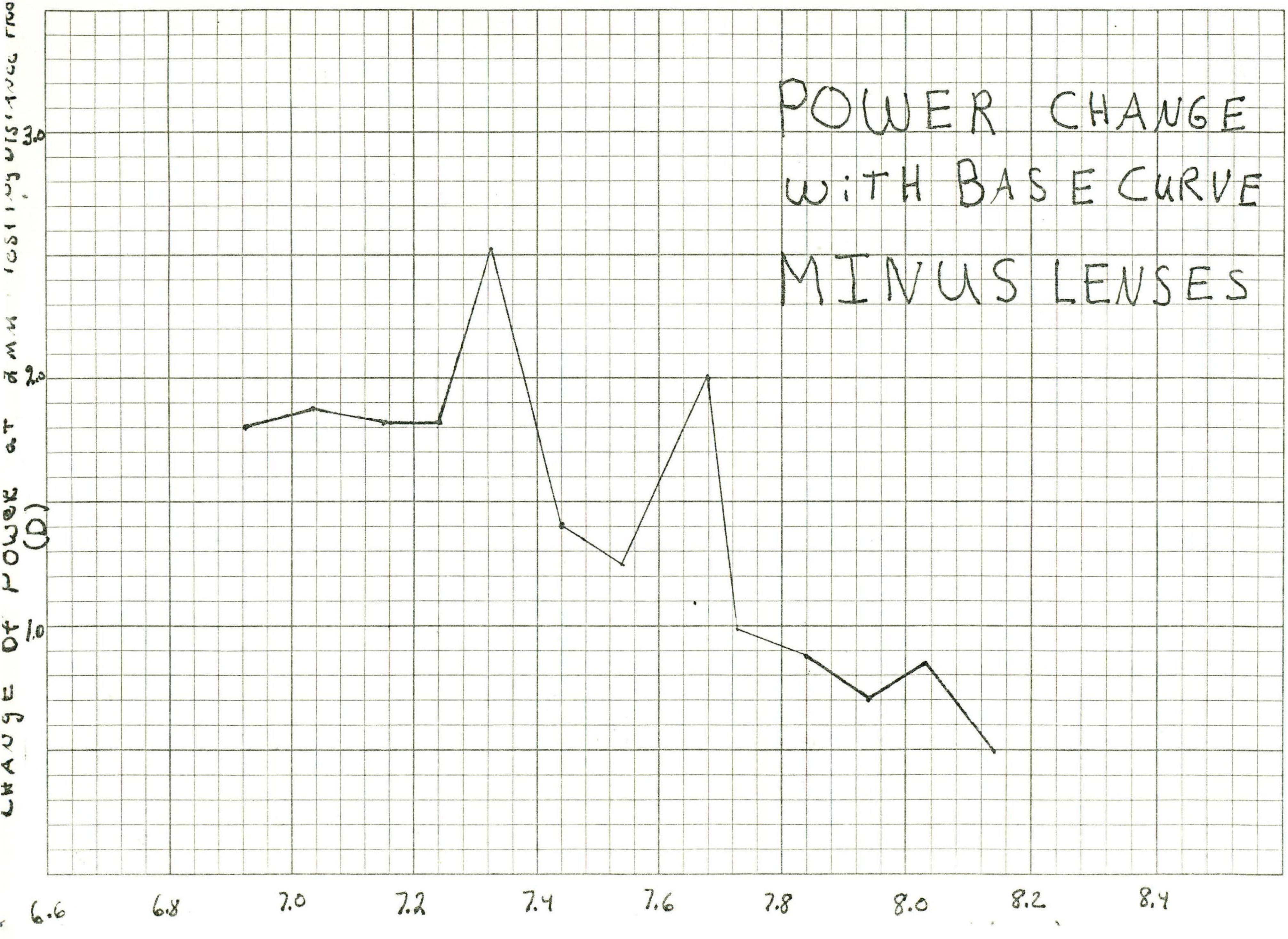


COMPARISON OF STEEPEST AND FLATTEST BASE CURVE MINUS LENSES

GRAPH #6

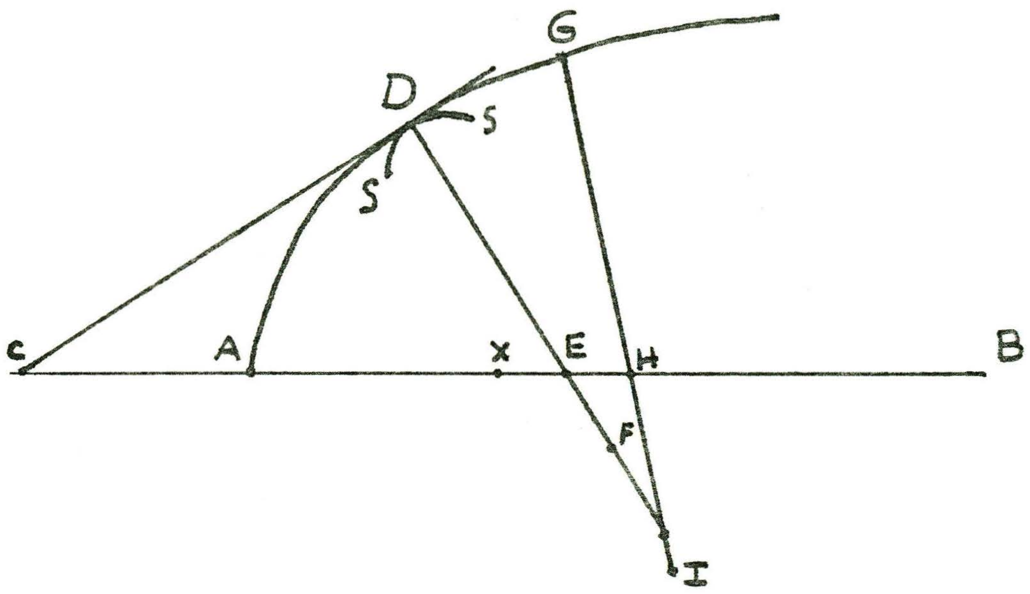

POWER CHANGE
with BASE
CURVE-PIUS
LENSES
CHANGE OF POWER at 4mm DISTANCE FROM CENTER
(D)
3.0
2.0
1.0
7.3
7.4
7.5
7.6
7.7
7.8

GRAPH #7



POWER CHANGE
WITH BASE CURVE
MINUS LENSES

DIAGRAM # 1



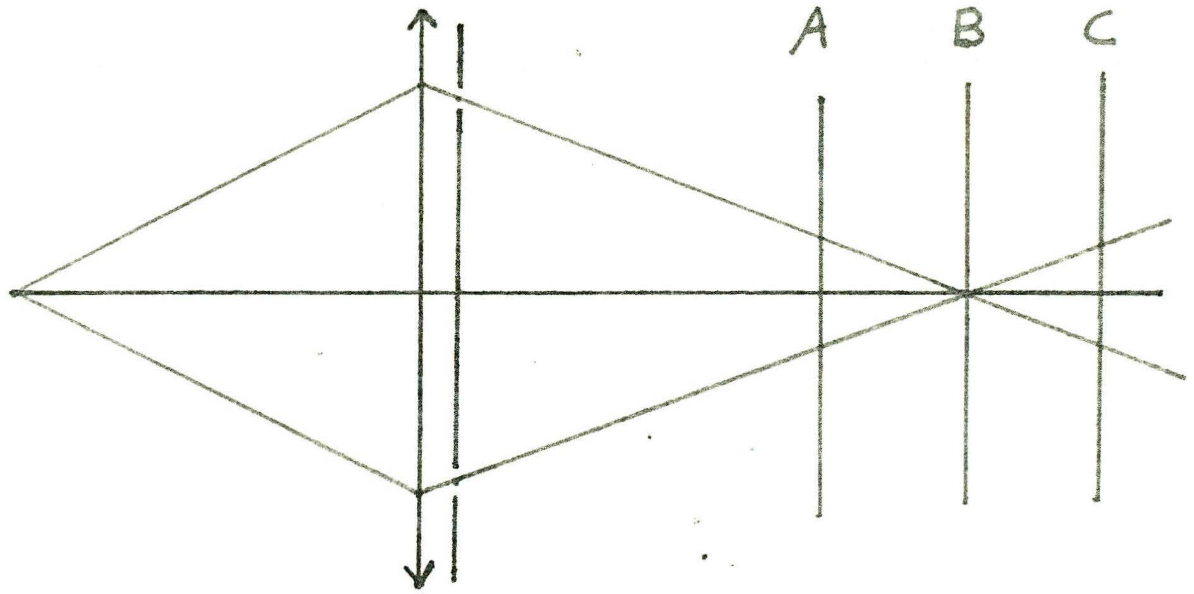


DIAGRAM # 2

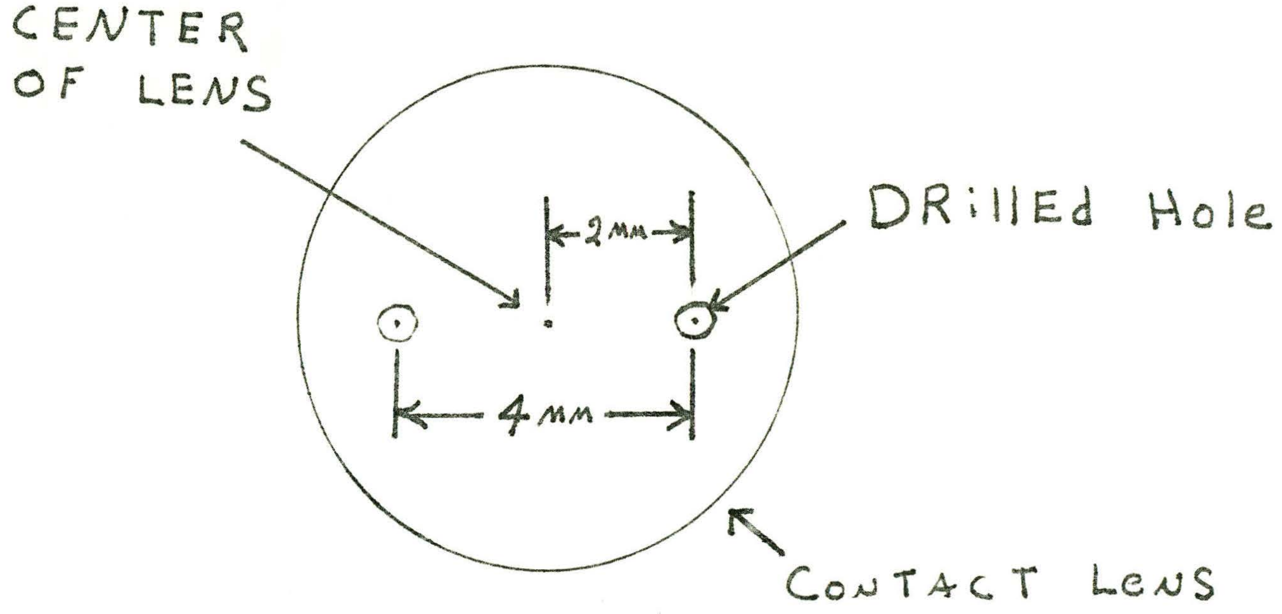


DIAGRAM # 3