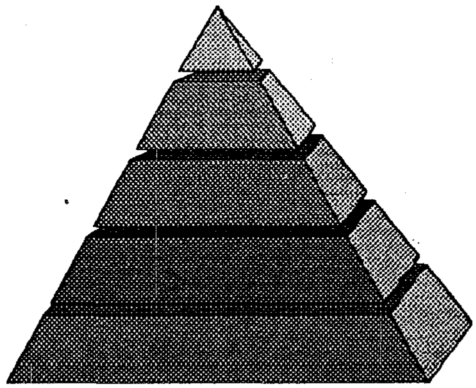
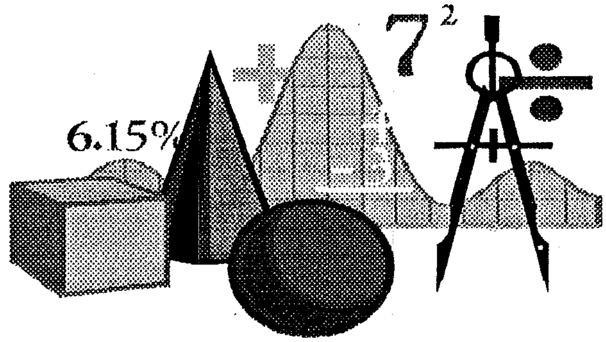


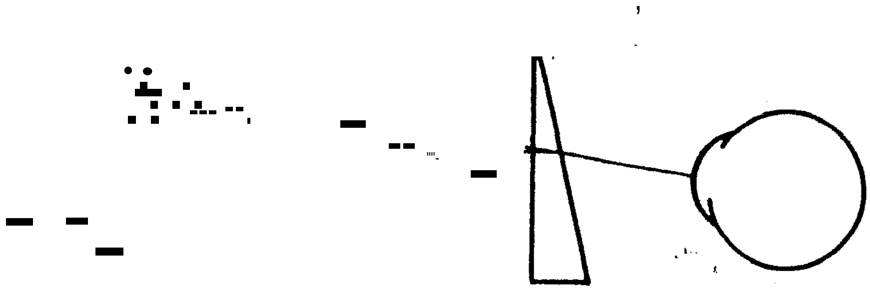
"Advanced Prismatic Calculations"

Prismatic Effects and Vertical Imbalance In
Oplirthalmic Lenses

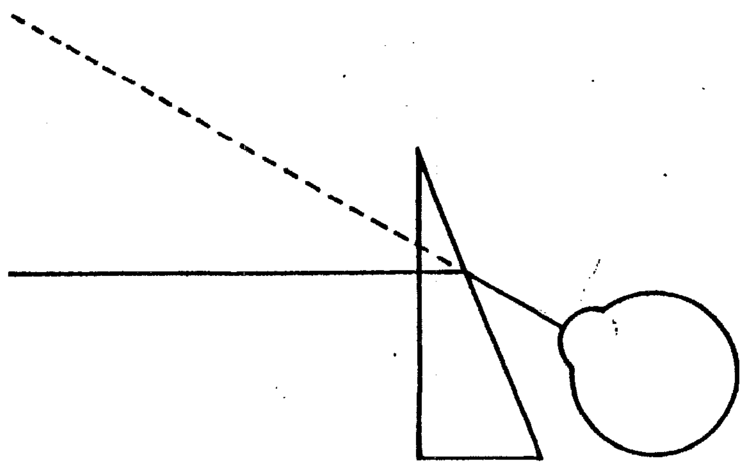


Prepared for: Ophthalmic Personnel of Atlantic Canada
Continuing Education Program
April 28, 1995

Presented by: Susan E. Feltmate,
. Dispensing Optician



When a *prism is placed before*  *the eye, the deviated* ray *enters the eye. The eye cannot perceive that the* ray *has been deviated; it simply appears to be coming from another direction. The object viewed appears to be displaced; of course, the object hasn't moved, the eye is seeing* a *displaced image.*



In practical application, prism meW be used in an eyeglass prescription to aid in binocular function. For example, if an eye turns upward, a *prism may be placed with its base down before that eye, thus displacing images upward. The images the deviant eye sees with then correspond with the position* of *the eye. Both eyes receive* a *clear, retinal image* of *the object; the eyes* are *now working* as a *"team".*

PRISM is defined as being:

- a wedge-shaped, non-parallel transparent material (glass or plastic) that alters the direction of incident light

- a transparent object that produces or divides a spectrumof light

- an optical device, triangular in shape, that bends but does not focus light rays toward the posltion of its base.

PRISM DIOPTER:

Prism deviates light by bending it toward the base. The amount of deviation is quantified in Prism Diopters: A = *cm/m*

One Prism Diopter deviates a ray of light one centimeter from the position it would otherwise strike, at a point one metre away from the prism.

When indicated in an optical prescription, prism is expressed with a dioptric value and a base direction: up, down, in or out. ex: **2.A 81** Prism direction may also be expressed in degrees 0 - 360, making use of the Cartesian Coordinate system.

Although not commonly used, prism power may be expressed in degrees instead of diopters: 1 degree of Prism = 1.75^{11} and *1A* = .57 degrees.

Image Displacement:

Light travelling through a prism is bent in the direction of its base; images seen through a prism are displaced in the direction of its apex. Thus, when the eye views an object through a prism, it appears to have "moved" from its original location. What the eye is seeing is a displaced image of the object, caused be the deviation of the light ray travelling through the prism. The amount and direction of deviation is a function of the power and base direction of the prism, and can be prescribed to achieve a desired result.

FRESNELL PRESS·ON PRISMS

The top view of a lens with Fresnell press-en prism is depicted in Figure 3- 8, while the front view of such a lens iEI depicted in Figure 3-9.

Figure 3-8
A comparison of a lens with Fresnell Press-on Prisms and a Regular Prism.

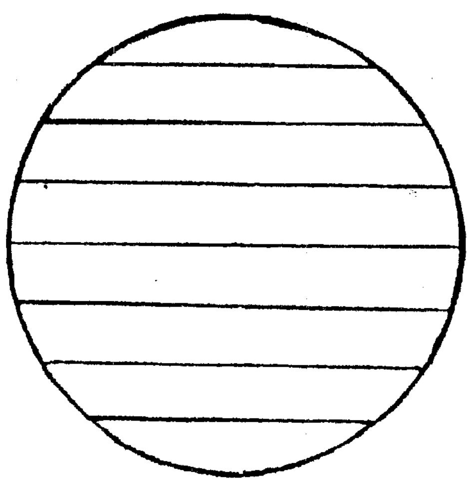
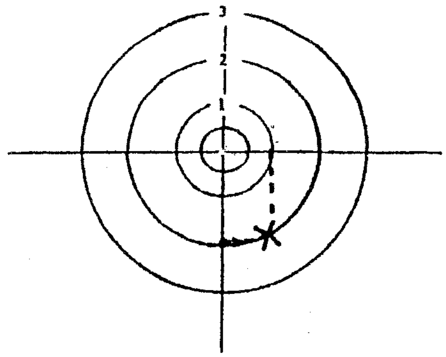


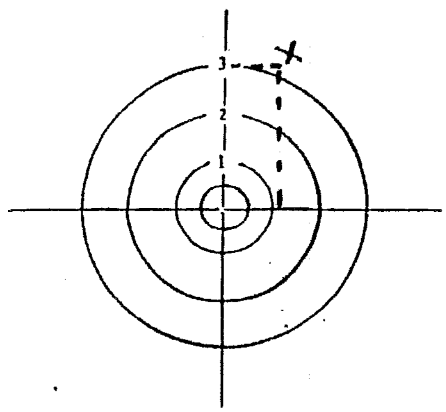
Figure 3-9
The front view of a lens with Fresnell Press-on Prisms arranged horizontally.

4.

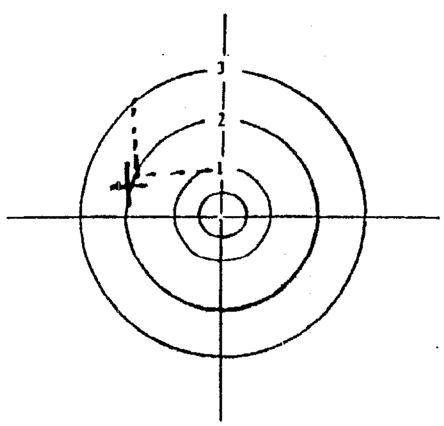
b) 1~ base in and 2~ base down on



c) 1.5~ base out
and 3~ base up OS



d) 2~ base in and
1~ base up OS



OPHTHALMIC LENSES AND PRISMATIC EFFECTS:

Ophthalmic lenses are constructed by a series of prisms placed either base to base (plus lenses) or apex to apex (minus lenses). Because prisms bend light in the direction of the base, these lenses can be designed to either converge or diverge light, and bring it to a point of focus. The amount of convergence or divergence of a lens can be predicted and controlled; ophthalmic lenses are thus able to correct refractive errors, by allowing light to 'focus on the retina.

The optical center of a lens is the point at which the prisms meet (base to base, or apex to apex), assuming that prism is not prescribed. This is the point at which incident light is most clearly focused, and the *eye* receives optimum vision. In most cases, this point of the lens is co-incident with the pupil (depending on the lens type and prescription); in this case, the lens is considered to be "centered". If prism is being prescribed, the area of the lens directly in front of the pupil is known as the major reference point. Prism power is verified at this point, and as the optical center of the lens has now "moved" from its place before the eye, the lens is now considered to be "decentered".

Prismatic effects occur every time we view objects through our glasses at a point other than the optical center. These prismatic effects occur often, as our eyes move through our lenses, 'and the amount of prism encountered is usually insignificant, especially in low-powered lenses. The amount of prism (either prescribed or unwanted) can be calculated by using Prentice's Rule:

Prism = decentration (in centimeters) multiplied by the lens power A =
c F

Prism may occur in a lens by error; for example, an incorrect PO (pupillary distance measurement) will affect the positioning of the optical centers of the lenses, resulting in the wearer looking through unwanted prism:

Ex. 0.0. + 3.00 anatomical PO 60mm
Problem: The finished glasses are found to have a PO of 65mm

A = cF A = .5 x 3 Prism = 1.5 BO

This amount of prism is well beyond accepted industry tolerances, and would cause discomfort to the wearer.

The "severity" and therefore the importance of a prismatic effect is directly related to lens power. Using the same scenario, we substitute the power of the lens to +0.25. Using Prentice's Rule, we see that a lens of-this small amount of power can be moved 40mm before it generate 1 diopter-of prism."

5.

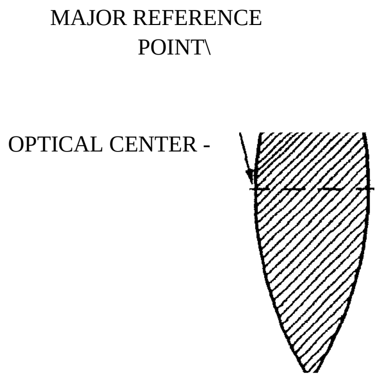
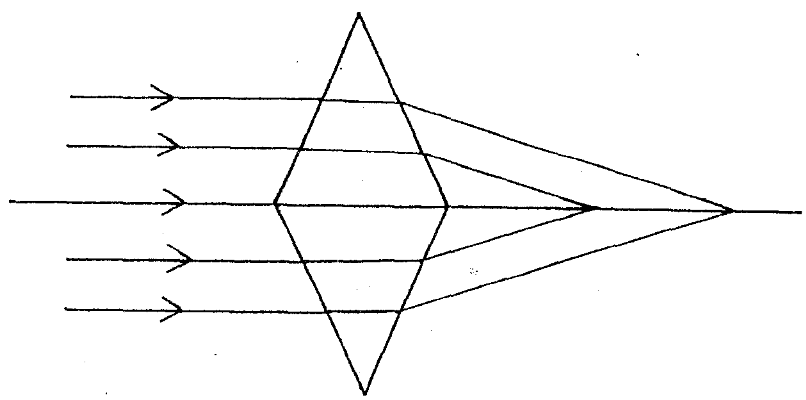


Figure XVIII-l If the optical center of a lens is purposely decentered from its position in front ofthe eye. that point on the lens in front of the eye containing the correct amount of prismatic effect is the *major reference point* of the lens.

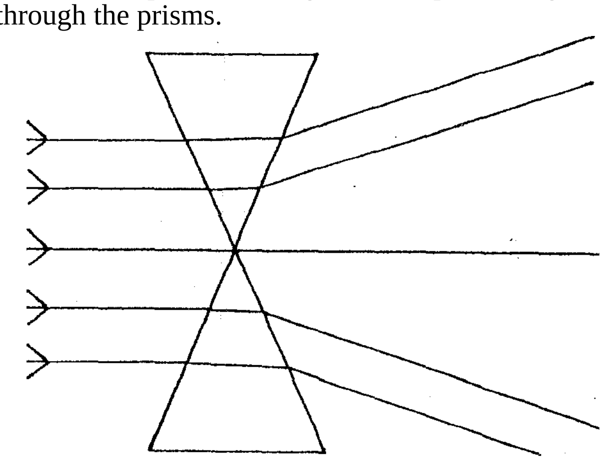
If we place two prisms base to base, then parallel light will pass through them and converge to a point.

EXAMPLE I



If we place two prisms with their apices touching, then the parallel light will diverge after passing through the prisms.

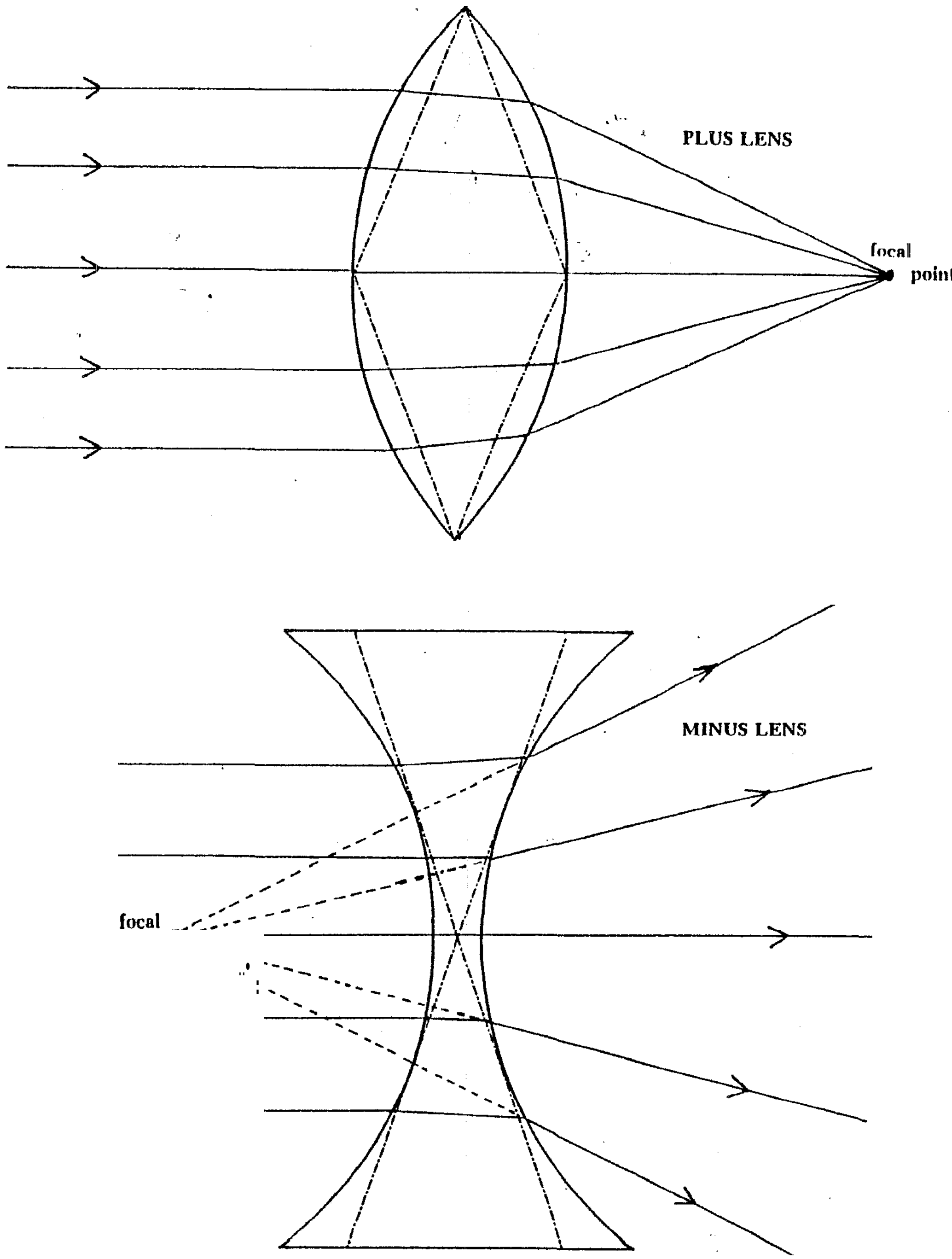
EXAMPLE II



7..

DIAcnAM 1.12

point ~:.:--_



Prismatic Effects at the Reading Level- Myopes vs. Hyperopes:

In our discussion of Image Jump, we have seen how the location of the optical center in a bifocal can influence the amount of prismatic effect present in the lens. If we consider a bifocal segment to be a miniature "plus" lens, we can see that a bifocal with a low optical center (such as a round-top 22) would result in Base Down prism at the reading level, while a bifocal with a high optical center (such as as. T. 25) would result in Base Up prism at the reading level. Images seen through a (BD) round-top 22 lens would be displaced upward, while images seen through a (8U) S.T. 25 lens would be displaced downward. In terms of convergence, the Base Up effects of the high-centered seg would be preferable, as the eyes would be "encouraged"
to look downward into -the reading area of the lens.

When we consider that the Hyperope is looking through a (distance) lens consisting of prisms base to base, we see that he is already looking through Base Up prism, which enhances his ability to look "down and in". A Base Down segment at near will counteract this effect.

The Myope, however, is looking through a lens consisting of prisms placed apex to apex; a Base Down segment will compound the Base Down effect he is already looking through, thus making it more difficult for him to converge.

Because of these prismatic effects, it is recommended that myopes be fit with bifocal segs having high optical centers, such as the S. T. 25, 28, 35, 40, and Executive, to counteract the Base Down effect of a minus lens.

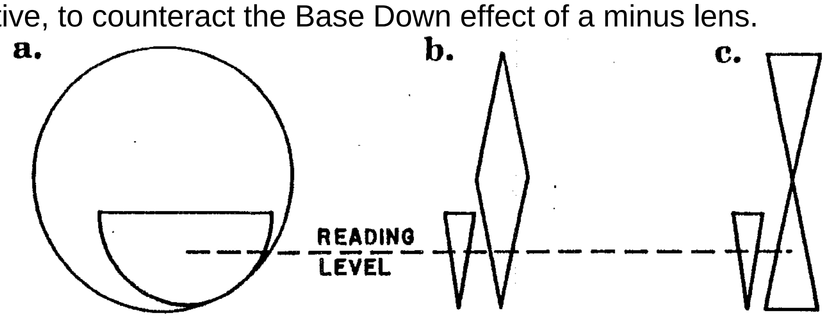
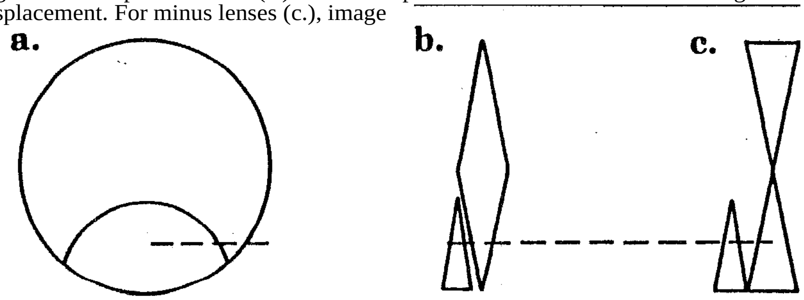


Figure XIX-19 Segs with high optical centers (a.) produce a base up effect at the reading level which causes an increased vertical prismatic effect (and hence an increased image displacement) when used in combination with plus lenses. This is shown in b. When used with minus lenses, as in c. the image displacement is reduced.

READING
LEVEL

Figure XIX-20 Segs with low optical centers (a.) counteract prismatic effects at the near reading level for plus lenses (b.) reducing image displacement. For minus lenses (c.), image displacement is increased.



Calculation of Prismatic Effects

Spheres:

Horizontal and vertical decentration of spheres may be determined through Prentice's Rule: Δ = cF

Example: A -5.000 lens is decentered 3mm downward, What is the prismatic effect? (amount and direction)

Solution: - 5.00 x ,3 = 1.50 Δ BU

NOTE: minus lenses that are decentered result in base directions that are OPPOSITE to the direction of decentration.

- Example: An Rx calls for 2 Δ 81 on a right lens of + 5.00. What is the amount and direction of decentration required?

Solution: c = Δ *IF,* therefore c = 2/5.00 so c = .4cm decentered inward

NOTE: plus lenses that are decentered result in base directions that are the SAME as that of the decentration.

Cylinders:

To calculate the prismatic effects of cylindrical lenses, we must first find the TOTAL POWER of the cyl (or spherocyl) in the direction of decentration.

Example: PI - 2.50 x 180 lens is decentered inward 5 mm. What are the prismatic effects?

Solution: The power meridian of a cylinder is 90 degrees away from its axis meridian; at 180 degrees this lens has no power (full power is at 90), therefore lateral decentration has no effect on this lens.

Solving for decentration along major meridians is fairly straightforward:

If axis is 90 - calculate power for horizontal decentration
If axis is 180 - calculate power for vertical decentration

If axis is 135 or 45 - the cylinder is at *50%* power

Decentration of Obliquely-Oriented Cylinders

To find the total power of the cylinder in the desired meridian (i.e. the direction of decentration) , three methods may be used:

10. Graphical Method - results in "effective decentration" ("c" in.A = cF)
11. Mathematical Method - De = Dv cos - - Dh sln-,
12. Approximate Method - Ft = F sph +(F cyl sin 2theta)

This course requires use of the Approximate method only:

Ft-	total power of the lens at a given meridian
F sphF	sphere power
cyl-	cylinder power
theta	angle between the given meridian and the desired meridian

Example: 00 - 4.75 X 35 lens is decentered down 5mm What is the prismatic effect?

Solution:

We must first find the power of the lens along the meridian of decentration; in this case, 90 degrees:

F 90 = F cyl sin 21theta

4.75 (sin 2 55)

= -4.75(671)
= -3.187

= cF   A = (.5) (3.00)   A = 1.5.A BU

Using Sphero-cyls:

Example: + 4.00 -1.25 X 65 00 lens decentered in 4mm
What is prismatic effect?

Solution: F 180 = F sph + (F cyl sin 2~
= +4.00 +(-1.25sin2 115) =
+4.00 + (-1.026)
= + 3.00

.A = cF   ıı = (.4) (3.00)   A = 1.2 81

Prismatic Effects at the Near Vision Point

Near Vision Point: The point on a lens through which the patients line of sight passes when feading.

To Calculate:

1. Determine the vertical distance from the N.V.P. to the N.O.C. (near optical center)
2. Use Prentice's Rule to calculate the vertical and horizontal prismatic effects of the distance portion of 'lens
3. Use Prentice's Rule to calculate the vertical and horizontal prismatic of the near portion of the lens (seg)
4. Algebraically add the two vertical prismatic effects
5. Algebraically add the two horizontal prismatic effects

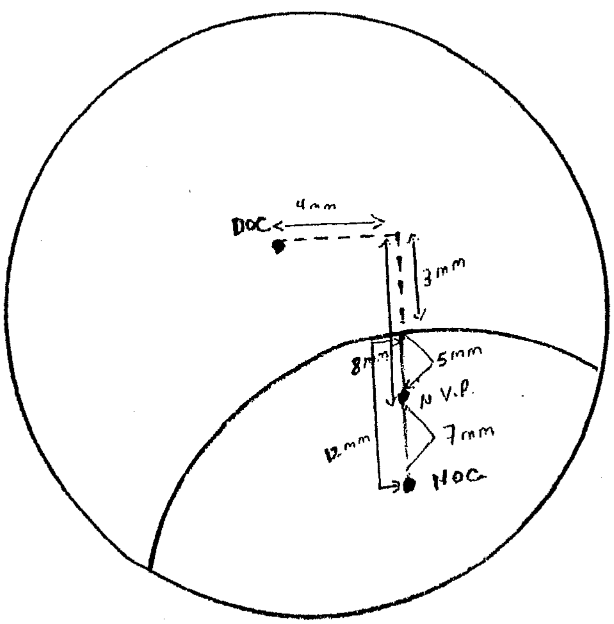
Example: 0.0. + 2.25 round-top 24mm
Add + 2.00 seq drop 3mm inset 4mm

NVP 8mm below DOC
NVP 4mm in from DOC

-DOC to top of seg = 3mm
-DOC to NVP = 8mm

Therefore:

-top of seg to NVP = Smm
-top of seg to NOe = 12mm
-dist, from NVP to NOe = 7mm



Given:

Vertical prismatic effects of distance portion - fl. =; cF +2.25 X .8 = 1.8 SU
Horizontal prismatic effects of distance - fl d cF . +2.25 X .4 = .980

Vertical prismatic effects of near portion -
Horizontal prismatic effects of near -

Vertical .4 Bu
Horizontal .9BO

COMBINED PRISMATIC EFFECTS:
A = cF +2.00 x.7 = 1.4 SD
fl = cF no horizontal decentration

Vertical Imbalance

Prismatic effects are present at all points of a lens except for the optical centers. If the lenses are of a similar power, when looking away from the optical center, very little prismatic effect is induced. However, when there is a significant difference in the powers of the right and left lens, the wearer will experience imbalance; the extent of which is dependent on how far away he or she is looking from the optical center.

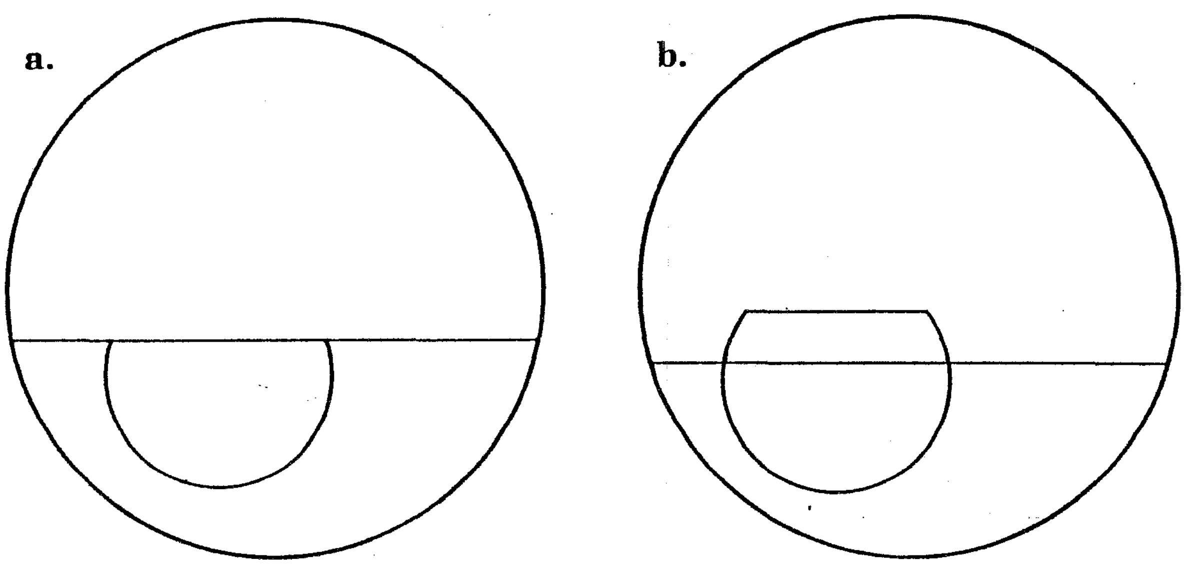
Vertical Imbalance occurs when the eye experiences differing prismatic effects at a point below the optical center. It is not a problem for the single-vision patient, as the eyes tend to remain central in the lens"; however, the bifocal wearer who is an anisometrope may experience vertical imbalance, as the NVP may be 8 - 10 mm away from the DOC. This will cause difficulty in reading.

To determine if vertical imbalance is present, we must first determine the prismatic effects of eac:h lens, by finding the total power at 90 degrees, and then using Prentice's Rule; next, we must establish which lens has the imbalance, and use the appropriate correction. Three methods of correction may be used:

1. Dis-similar segs (if imbalance is 1- 1.50)
2. R - Compensated Segs " " ..
3. Bicentric Grind (slab-off) (if imbalance is over 1.50)

Vertical imbalance of less that 1.00 is usually not corrected.

Slab-off Prism:	Glass-	Base Up	Most Minus
Reverse Slab :	Plastic	Base Down	Most Plus



Flgur@ XI~-8 Slsboff pri!!m produce!! A thin line elli!!i1y concealed by li flAt·top !leg. The wider the !!eg is, the more inconspicuous the line will be. In a., a blfocal lens is shown, while b. shows the correct position (or slab-off prism on R flat-top trifocal. The procedure for a trifocal bicentric 81rind is done (rom the back in a manner similar to that shown in Figure XIX·9 for the plestlc lens.

Bicentric Grinding - Slab-Off and Reverse Slab-Off Prism

Bicentric Grinding is laboratory process by which prism is generated on a lens as a means of correction for a vertical imbalance .

. When bicentric grinding is done on a glass lens, it will always result in base up prism being created in the lower section of the lens. Because of this result, the bicentric will always be used on the.most m,~us\or least plus lens. \. ..

For example: Rx OD –2.00 ,
O.S. –4.00 + 2.00 add ..

- ,-

Assuming the near point to be 10mm below the optical center, the above prescription would have a vertical imbalance of 21\ B.D. in the left lens.

Because bicentric grinding on a glass lens creates base up prism at near, the slab-off prism would be done on the left (most minus) lens.

Conversely, if the above Rx were in Plus form, the resulting vertical imbalance would be 2" B. U. in the left lens. The bicentric would then b~ done on the right lens (most minus); both lenses would then have an equal amount of base up prism. .

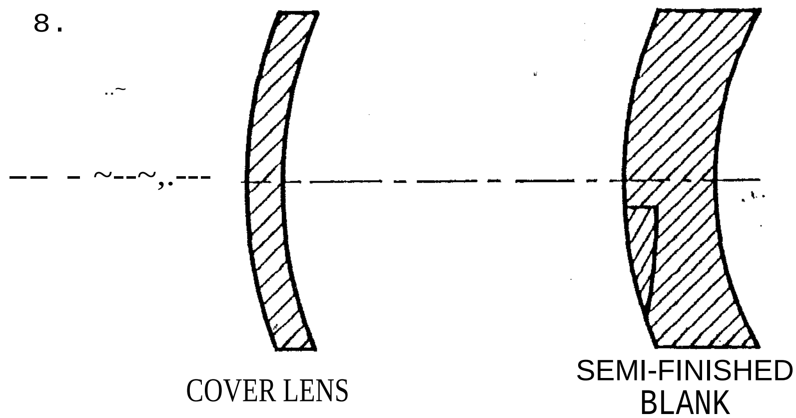
When bicentric grinding is done on a plastic lens, the opposite lens is used; the bicentric will be done on the most plus or least minus lens. Bicentric grinding on a plastic lens is known as reverse slab-off, and consists of base down prism being generatetl in the lower section of the lens. Because of the popularity of plastic lenses, laboratories now have available semi-finished lens blanks with base down prism already generated; since these lens blanks have base down prism only, they would have to be used on an Rx where B.D~ prism is required to correct an imbalance at near point.

For example: Rx OD. + 2.00
O.S. + 4.00 Add + 2.00

Assuming the near point to be 10mm below the optical centers, the resulting imbalance would be 2" BU in the left lens. A bicentric lens blank with 2" BD moulded into it would be used on the left (most plus) lens to correct this imbalance. If the above Rx were in minus powers, the imbalance would be 2"BD on the left lens; the correction would then be done on the right (least minus) lens, resulting in equal amounts of base down prism in each lens.

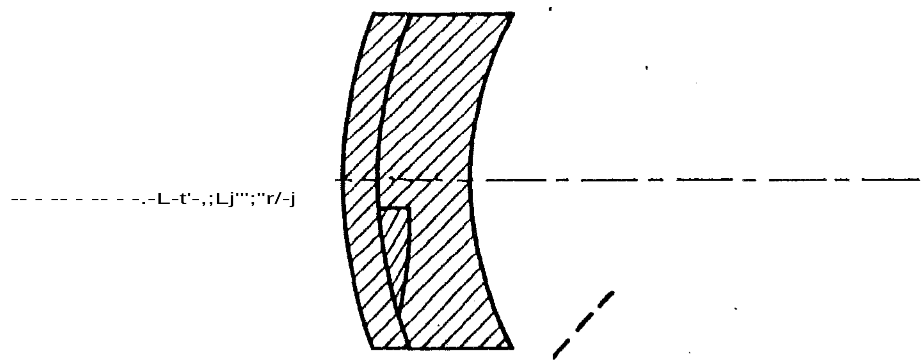
13.

8.



14.

b.



c.

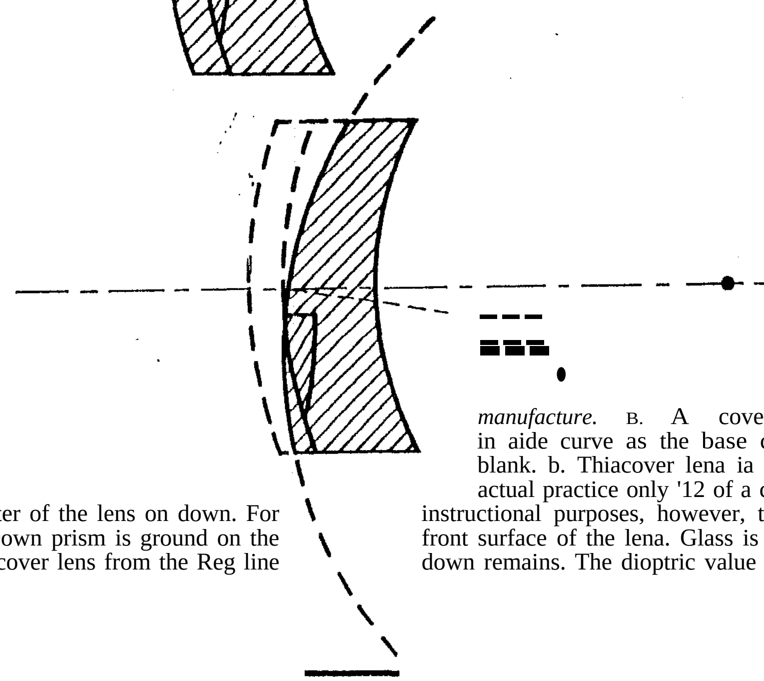
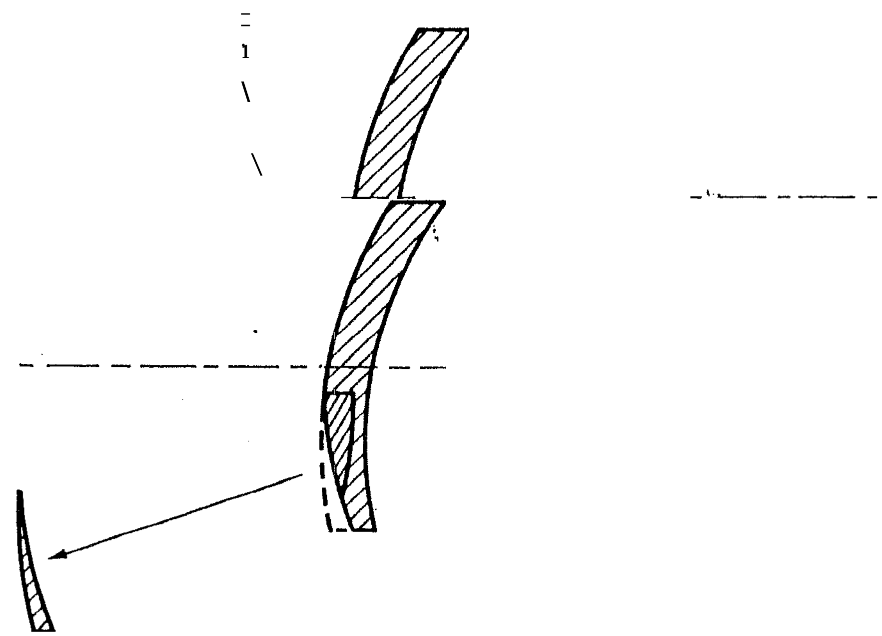


Figure XIX-7 *Slab-off prism manufacture.* B. A cover lena ia manufactured to have the same in aide curve as the base curve of the required semifinished lena blank. b. Thiacover lena ia cemented to the aemifiniahed blank. (In actual practice only '12 of a cover lens ill required, covering from the center of the lens on down. For instructional purposes, however, the complete cover lena is shown.) c. Base Down prism is ground on the front surface of the lena. Glass is surfaced off until only the lower half of the cover lens from the Reg line down remains. The dioptric value of the prism iR d



equal to the prescribed amount needed for compensation. d. If no further steps were taken, a prismatic effect would be induced in the entire lens. Therefore compensating prism Base Up is ground on the bock surface at the same time the 'distance power is being surfaced on. Now the entire lens is once again without prism. e. Lastly the remaining portion of the cover lens is removed. This wedge-shaped portion is a Base Down prism whose value equals that surfaced, as was shown in c. The net effect is the addition of Base Up prism to the lens from the sell' downward.

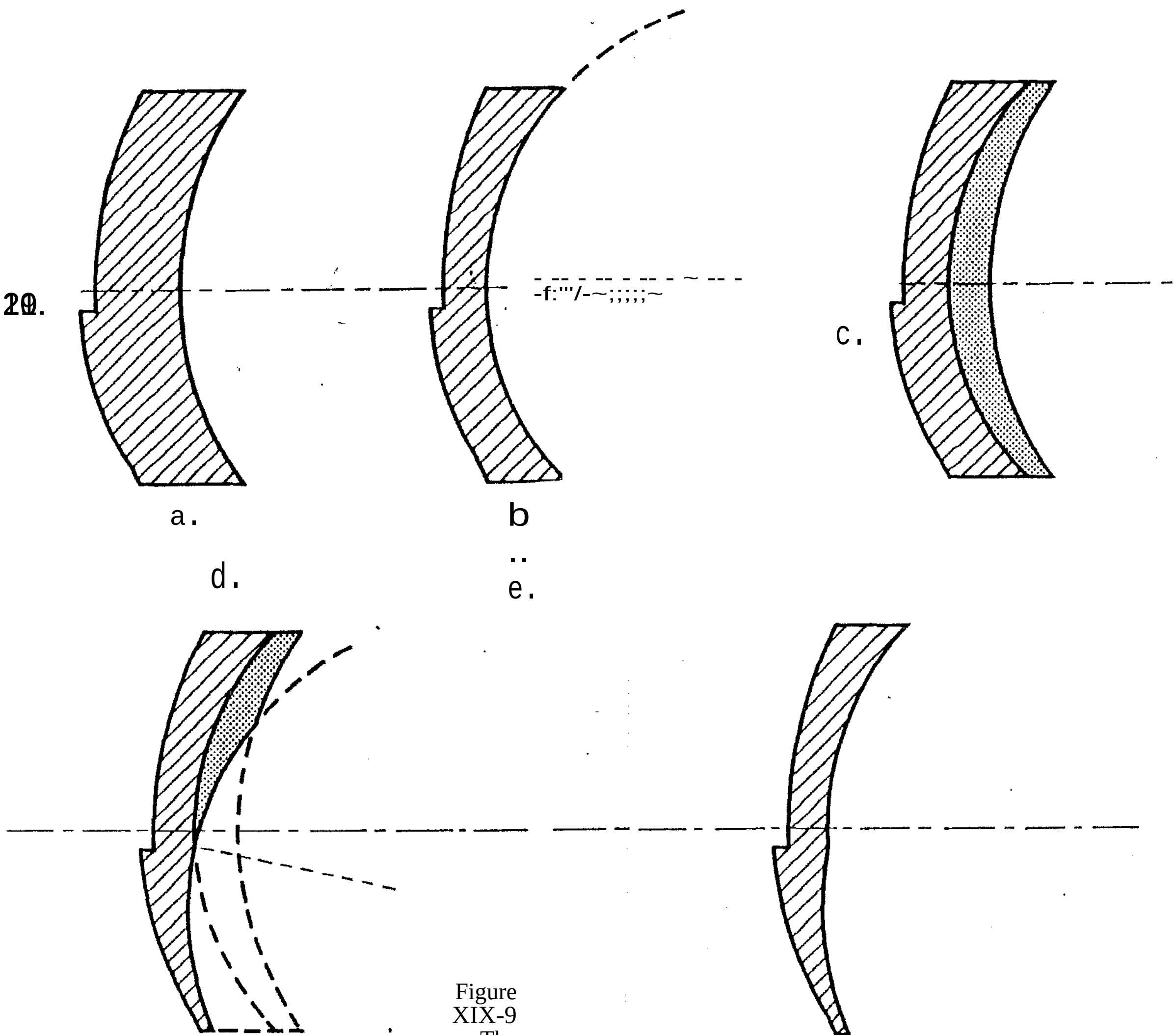


Figure XIX-9

The process of bicentric grinding on a plastic lens must be carried out entirely on the rear surface, as the front surface contains the one-piece construction bifocal segment area. A semifinished lens as shown in a. is surfaced to the required prescription, (b.), exclusive of the desired prism at near. A liquid resin material is poured into the concave rear surface and allowed to dry. This resin, shown in c. serves the same purpose as the cover lens served for the glass lens technique. The lens is then re-surfaced at an angle (shown in d.) Surfacing a lens at an angle serves to grind on prism. The surfacing tools used are the same as were used in b. so that correct power is maintained. The near portion now contains the proper amount or prism Base Up, and the correct power. Lastly the lens is chilled to cause the remaining resin to break away. The upper portion had not been changed since originally surfaced. The completed lens is shown in e. It will be noted that with bicentrically ground plastic lenses, the slab line is on the rear surface, instead of the front.

Compounding Prism

Two prisms (horizontal and vertical) are combined in power and orientation, to form one prism that is the equivalent of both:

Example: OD3BI 2^ABU

Graphical Method:

- plot the prisms as vectors on a graph
- complete a parallelogram
- draw the resultant prism; measure - this is power
- using protractor, measure angle - this is base direction

Mathematical Method: (using trig. functions)

Formula used - $R^2 = V^2 + H^2$

Horizontal component is H
Vertical component is V
Resultant Prism is R
Base Direction is theta

To Find Power of Prism:

$R^2 = 4 + 9$

$R^L = /13 =$
3.61

To Find Base Orientation:

·

Tan theta.-= V/H (tangent = opp. over adj.)

Tan theta = 2/3 Tan theta= .666

Tan = 33.69

Solution: New Prism is 3.61diopters prism axis 34

Resolving Prism

One prism having an oblique axis is resolved into horizontal and vertical components:

Example: OD 2.00 Δ 30^{o}

Graphical Method:

- draw to scale on graph paper as a vector
- horizontal and vertical lines are dropped at 180 and 90 degrees and measured
- a parallelagram is constructed (in reverse)
- base directions are determined through cartesian co-ordinate system

Mathematical Method:
Formula used - V (vertical) = P(power) x sin theta

H(horizontal) = P(power) x cos theta

'theta = base orientatio

H = 2 cos 30 =
2 x.866 = 1.73

Solution:

V = 2 Sin 30 =
2 x 0.5 =
1.00

Base direction is evident from orientation of original prism; 30' degrees is "up" and"in"

1.7 BI 1BU final solution

Definitions of Ophthalmic Terms

Anisometropia: The condition in which the eyes have an unequal refractive error of at least one diopter

Approximate Formula: The formula used to determine the power of a cylindrical or sphere-cylindrical lens at any given meridian: F = F sphere + F cylinder (sin 2 '6-)

Bicentric Grind: The process in which a second optical center is ground on a portion of the Iens to create vertical prism at near, thus correcting vertical imbalance.

Compounding Prism: The process ot combining two prisms (with both horizontal and vertical components) in power and base direction to form one prism that is the equivalent of both.

Decentration: The displacement, or movement of a lens so that its optical center is at a point away from the wearers line of sight, for the purpose of creating a prismatic effect.

Major Reference Point: The point on a lens where the prism equals the amount prescribed; the point at which prism is measured.

Near Vision Point: The point on a lens where the patients line of sight passes when reading.

Prism Diopter: The unit of measurement that quantifies prism power: 11\ = *cm/m:* One prism diopter deviates a ray of light one centimeter from the position it would normally strike at a distance of one meter away from the prism.

Resolving Prism: The process of taking a prism with an oblique axis and expressing it as two prisms oriented perpen- dicularly to each other, having their own power and . base direction.

Vertical Imbalance: The condition caused by the difference in prismatic effects of lenses of unequal power; occurring when the wearer looks at a point below the optical center of the lens.