Stand Magnifier Strategies

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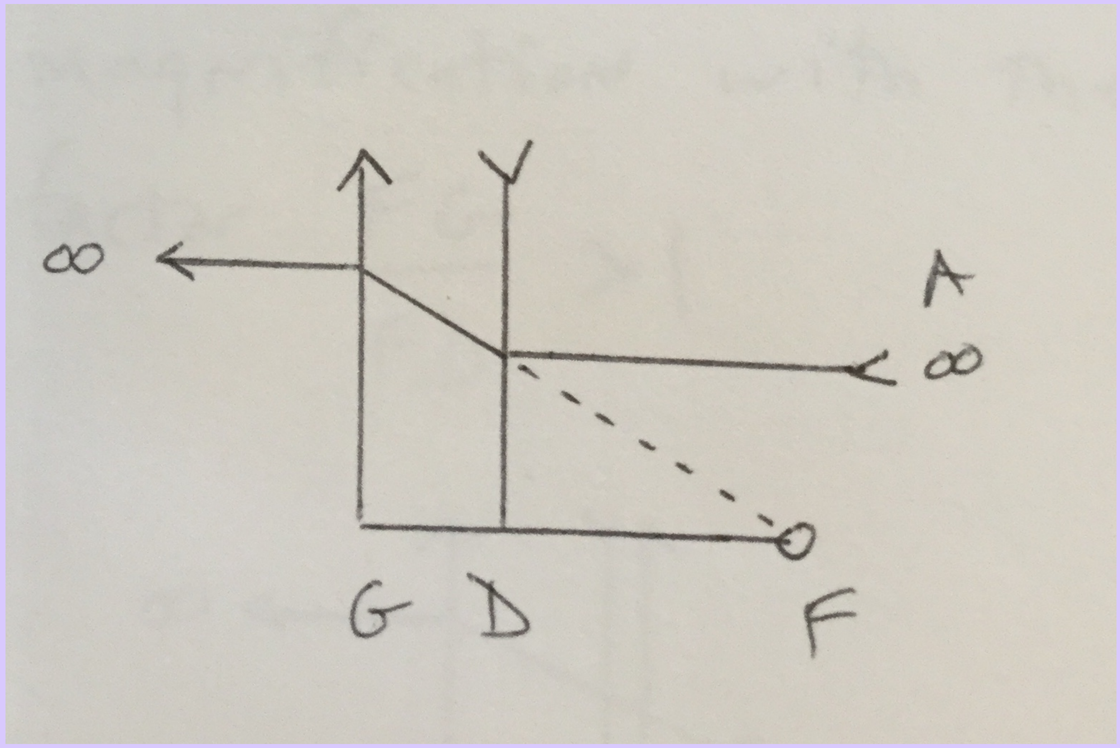
RETINAL IMAGE SIZE MAGNIFICATION OR MINIFICATION

Retinal image size magnification or minification is an eye's retinal image size relative to that produced by a standard eye. Only when intra-ocular variables are relevant must a standard eye have intra-ocular components. Therefore, when considering magnification from extra-ocular lenses, the eye can be considered a single refracting surface. When the arbitrary standard retinal image size is factored out with a second known eye, the result has meaning as a comparison of two known eyes.

AFOCAL ANGULAR MAGNIFICATION OR MINIFICATION

Afocal angular magnification or minification results from two separated refracting elements that together focus a distant object at infinity. A Galilean telescope is a well known example of such a system. When its diverging “eyepiece” lens is closer to the observer than its converging “objective” lens, it produces afocal angular magnification. When the telescope is reversed, (or when the lenses are interchanged), it produces afocal angular minification.

MYOPIC DISTANCE CORRECTION

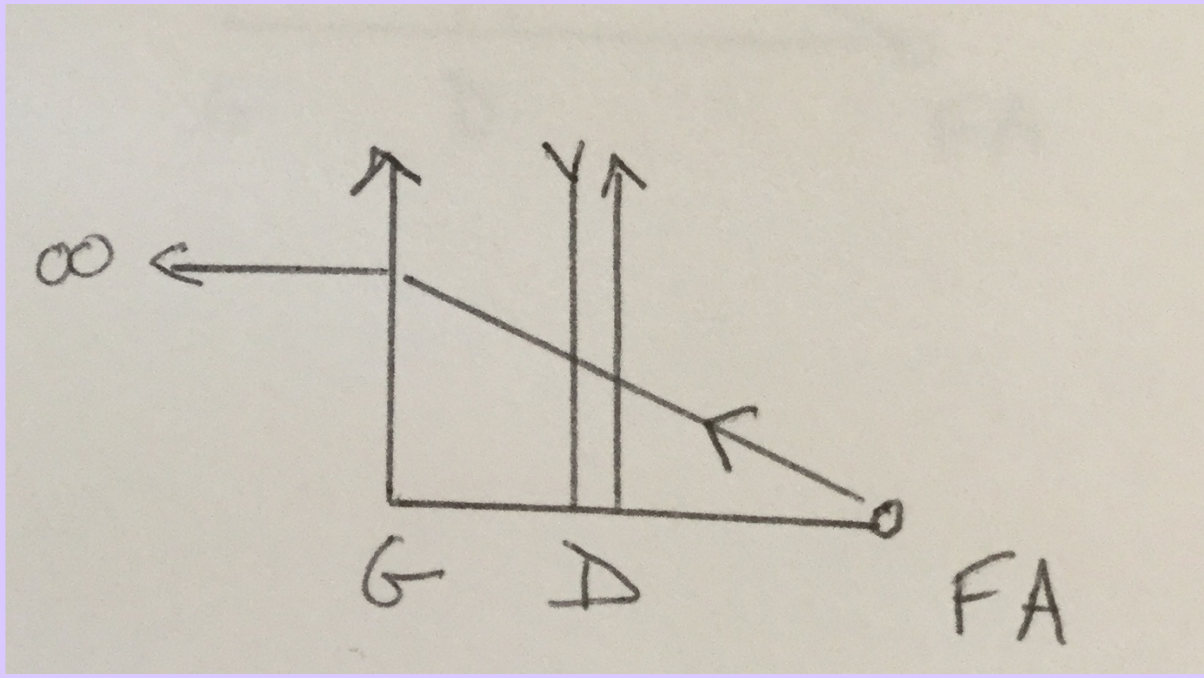


With distance “myopic” refractive error at G, the focused distance myopic correction at D creates afocal angular minification:

$$\frac{FD}{FG} < 1$$

This is relative to both the myopic eye focused with object A at the myopic eye's front focal point F, as well as the emetropic eye focused with object A at distance.

MYOPIC DISTANCE CORRECTION REMOVAL

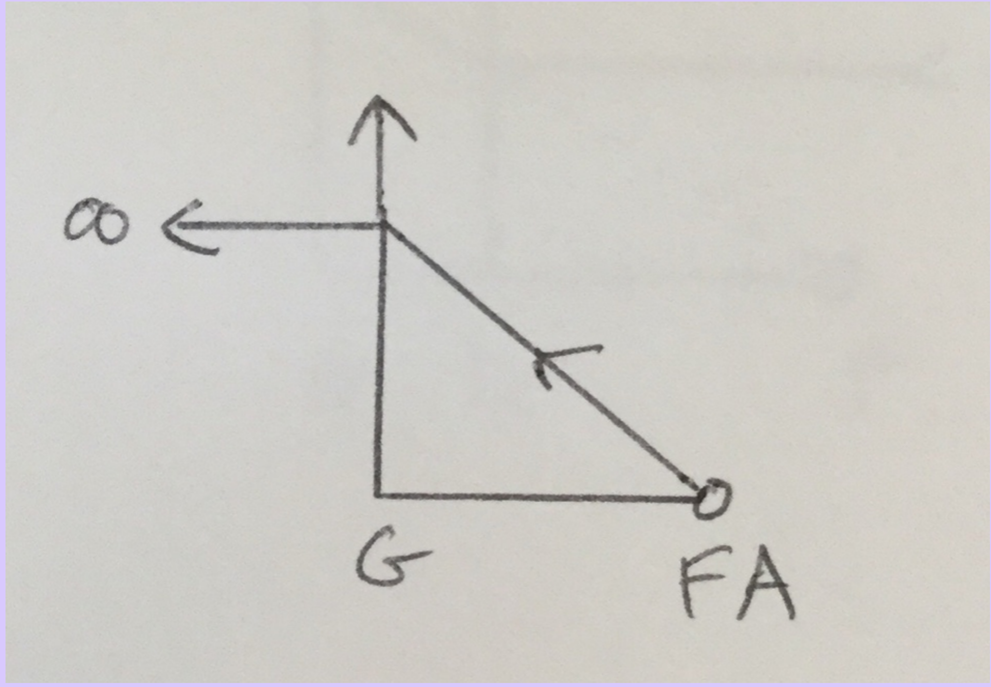


Removing the myopic distance correction at D with a converging lens at D removes this afocal angular minification with the factor:

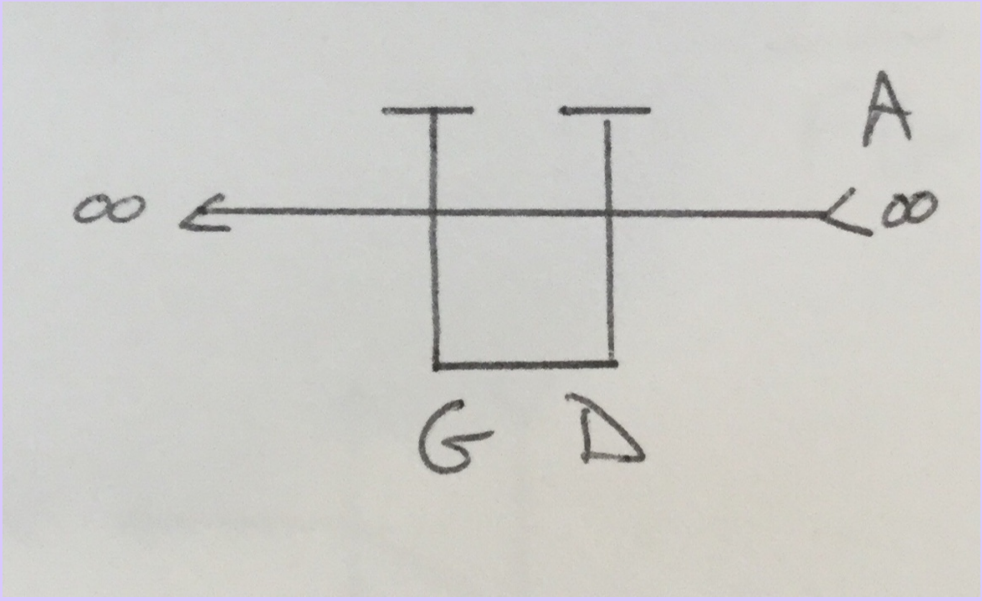
$$\frac{FG}{FD} > 1$$

and this magnification of near correction is relative to the distance corrected myope.

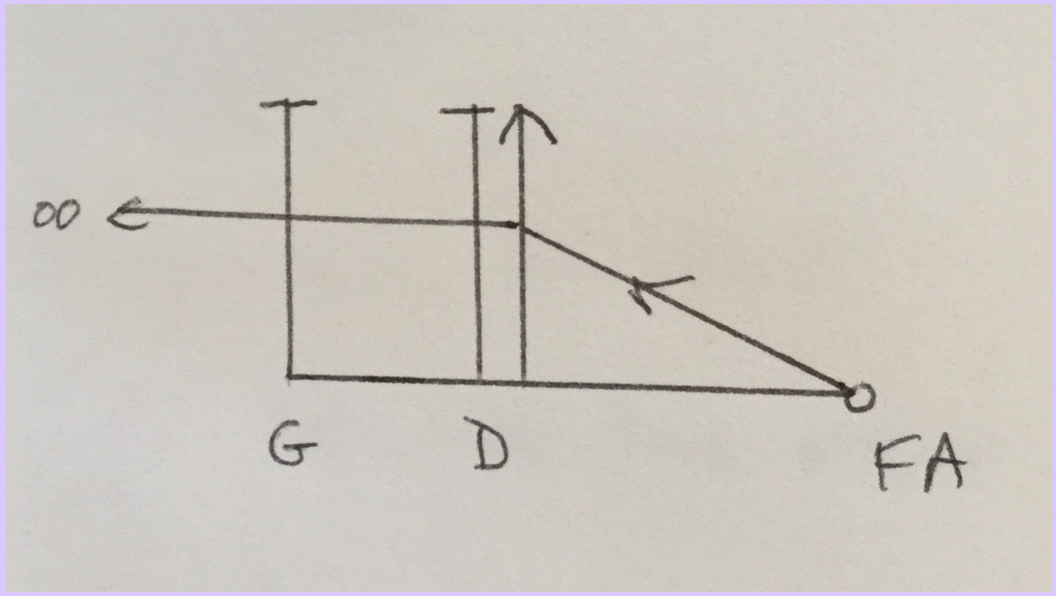
It is not relative to either the myope:



or an emetrope:



If additional converging power is added to the converging lens so that the near focal point is in focus for an emetropic eye, rather than the myopic eye, the afocal angular minification removed with the factor:



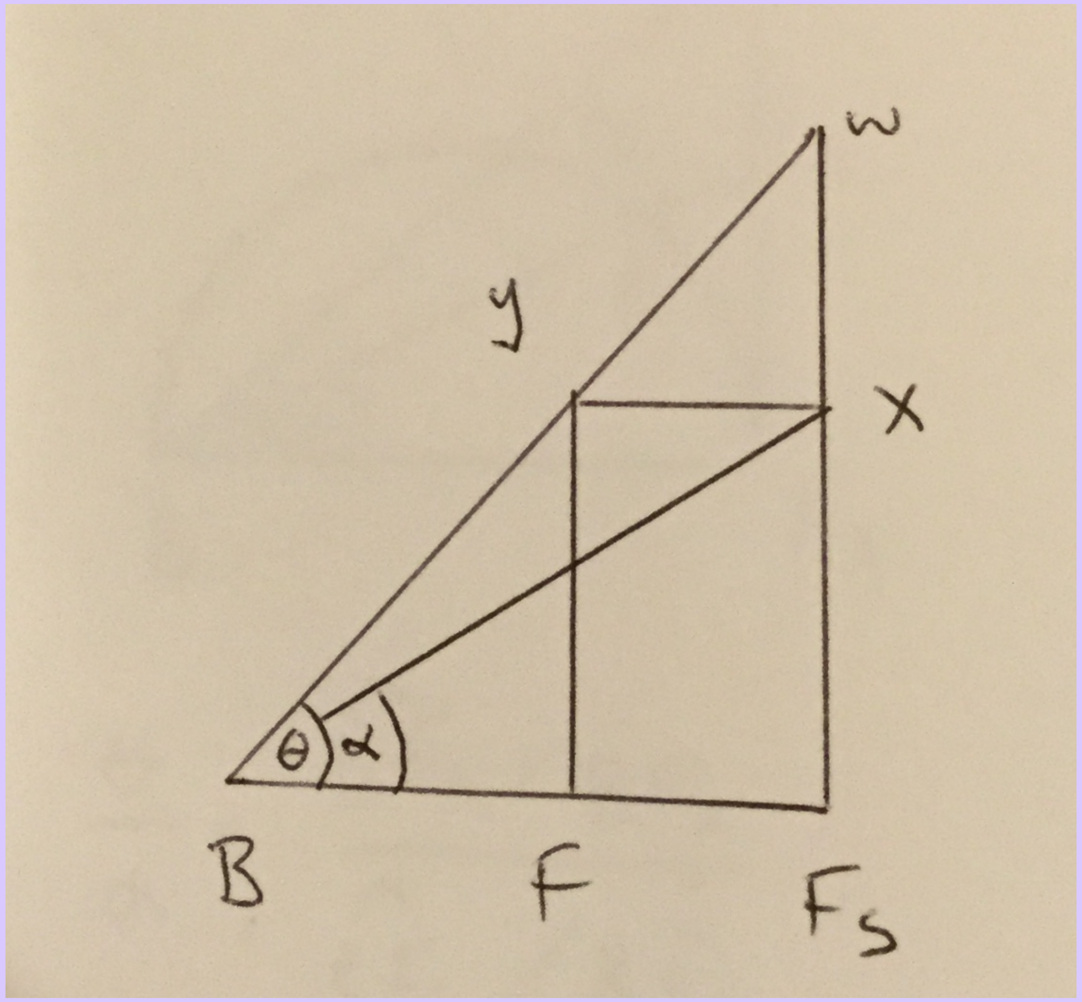
$$\frac{FG}{FD} > 1$$

remains the same when the reference eye is emetropic.

Therefore the focused near magnification of any converging lens, (either a spectacle lens or a handheld magnifier), is the inverse of the afocal angular minification produced by a diverging nearsighted correcting lens at the same location when the hypothetical near sighted eye has a front focal point at the position of the focused object.

NEAR OBJECT ANGULAR SUBTENSE MAGNIFICATION OR MINIFICATION

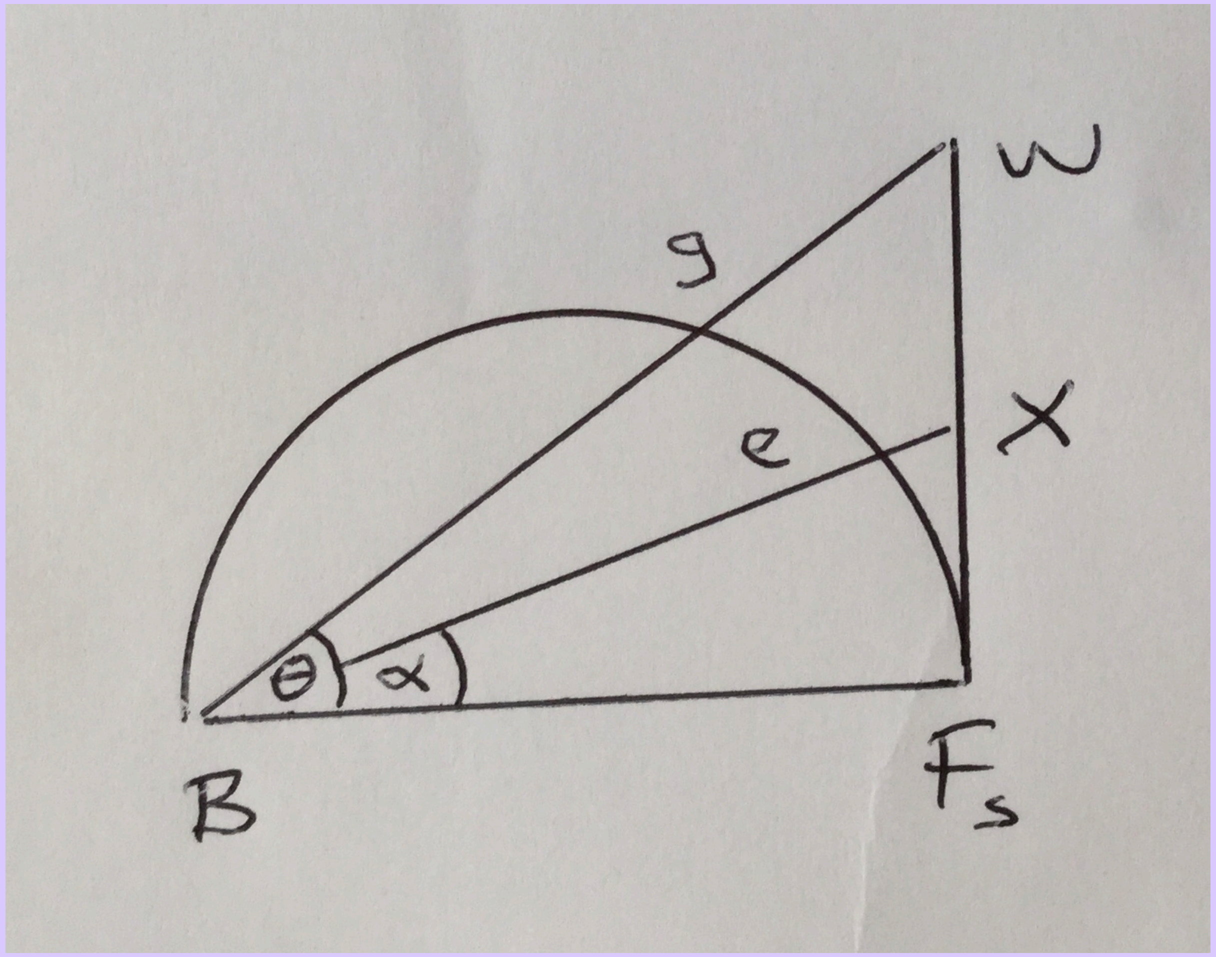
Any near object location involves a near object angular subtense magnification or minification ratio when referenced to an arbitrary standard near object distance.



When referenced to an eye's front surface at B, if an object at a standard distance BFs is moved to F, the near angular subtense magnification equals:

θ/α

Since an angle equals its intercepted arc divided by the arc's diameter:



$$\theta/\alpha = \frac{\sim gFs/BFs}{\sim eFs/BFs}$$

Since as the angles become axial, or approach zero, the angles become small enough to be represented as tangent ratios, and since the object's height is constant, this tangent ratio becomes an inverse object distance ratio as measured from the eye:

$$\theta/\alpha \Rightarrow \frac{wFs}{xFs} = \frac{wFs}{yF} = \frac{BFs}{BF}$$

Therefore, the near object axial angular subtense magnification or minification equals the reference distance to the eye, divided by the object's actual distance to the eye.

COMBINING NEAR OBJECT AXIAL ANGULAR SUBTENSE MAGNIFICATION OR MINIFICATION WITH NEAR MAGNIFICATION DUE TO REMOVAL OF AFOCAL AXIAL ANGULAR MINIFICATION

In order to be seen clearly while using a distance correction without focusing the eye, (without ocular accommodation), any near object requires either a pinhole correction or a converging lens with its front focal point at the near object. When a pinhole is used, all light is axial, and there is no magnification from an optical near correction. Therefore, magnification is simply the near object axial angular subtense magnification or minification.

When a converging lens is used with its front focal point at the near object, parallel light leaves the converging lens from the object, and the image size is therefore the same regardless of the object-to-eye distance.

The ratio describing near object axial angular subtense magnification or minification:

$$\frac{BFs}{BF}$$

when combined with the ratio describing near magnification due to a converging lens producing parallel light for an emmetropic eye:

$$\frac{FG}{FD}$$

produces a ratio product which factors out the object's actual distance to the eye BF = FG.

BF equals FG because the near magnification due to a converging lens producing parallel light for an emmetropic eye is found by calculating the afocal axial minification associated with a corresponding myopic error at G. This hypothetical myopic error at G lies at the eye’s presumed single refracting surface B, because we have decided in advance to limit our consideration of magnification to extra-ocular components, and ignore all intra-ocular factors.

The combined factors equal the reference distance to the eye divided by the object's distance to the converging lens:

$$\frac{BFs}{FD}$$

confirming that when parallel light leaves a converging lens from an object, the image size is the same regardless of the object-to-eye distance.

VIRTUAL IMAGE ENLARGEMENT

When a converging lens has an object closer than its focal point, it has a virtual image beyond that focal point which is larger than the object. An additional converging lens, (represented as ocular accommodation, uncorrected myopia, or a spectacle add), must then produce parallel light rays from the virtual image to maintain clarity. This describes the optics involved with stand magnifier magnification.

STAND MAGNIFIER CONSTANTS

The two optically significant constants associated with a particular stand magnifier are its, “enlargement factor,” and its lens to virtual image distance.

ENLARGEMENT FACTOR

A stand magnifier’s converging lens always has its object at a constant distance inside its focal point, and therefore has a virtual image at a constant distance beyond its focal point. This results in the virtual image being enlarged by a constant factor.

As long as the power of a spectacle add producing a clear image is not changed, adding a stand magnifier, (and moving the object so its new virtual image lies at the previous object distance), does nothing to magnification other than multiply it by the particular stand magnifier's constant enlargement factor. Therefore, a stand magnifier's enlargement factor equals the magnification it produces with a specific spectacle add, divided by the magnification produced by the spectacle add alone.

LENS TO VIRTUAL IMAGE DISTANCE

The focal length of a spectacle add that produces a clear image with a stand magnifier’s lens at the spectacle plane specifies the stand magnifier’s constant lens to virtual image distance. Since the virtual image can not be brought closer, this spectacle add is also the stand magnifier’s maximum usable spectacle add, and it provides the stand magnifier’s maximum magnification.

CALCULATION OF THE ENLARGEMENT FACTOR WITH THE STAND MAGNIFIER LENS AT THE SPECTACLE PLANE

If we use aspheric trial lenses to determine the high plus spectacle add that produces the same apparent magnification as the stand magnifier at the spectacle plane with its maximum usable spectacle add, the ratio of magnification from that high plus spectacle add to that from the stand magnifier's maximum usable spectacle add without the stand magnifier equals the stand magnifier's constant enlargement factor.

Since the magnification produced by any spectacle add equals the reference distance divided by the object to spectacle plane distance, (or the reference distance times the power of the spectacle add), the reference distances can be factored out of the magnification ratio determining the enlargement factor, which then becomes simply a ratio of spectacle adds producing the same apparent magnification, one without the stand magnifier, and one with the stand magnifier at the spectacle plane.

CALCULATION OF THE ENLARGEMENT FACTOR WITH THE STAND MAGNIFIER LENS FURTHER THAN THE SPECTACLE PLANE

When a stand magnifier is used with a spectacle add that is less than its maximum usable spectacle add, the stand magnifier's virtual image, (and therefore the stand magnifier's object and lens), must be moved away from the spectacle plane to produce a clear image.

Magnification is then reduced due to the lower powered spectacle add. Multiplying the magnification from the lower-powered spectacle add by the stand magnifier's constant enlargement factor specifies the magnification of the combined stand magnifier and new spectacle add.

EQUIVALENT POWER

Since reference distances can be factored out when comparing magnifications, multiplying the lower powered spectacle add by the stand magnifier's constant enlargement factor specifies the hypothetical spectacle add required to provide the same magnification as the stand magnifier and spectacle add combination. This hypothetical spectacle add is known as the, "equivalent power," of the combination, and clinicians sometimes talk in terms of this. However, near magnification remains a comparison requiring a reference distance.

CHANGING REFERENCE DISTANCES

If a particular stand magnifier and spectacle add combination produces 4X magnification when compared with an object at a reference distance of 25cm, and we wish to consider a 50cm reference distance instead, we simply multiply 4X by 50/25, for a value of 8X.

NON-LIGHTED STAND MAGNIFIERS

The following table lists commonly prescribed non-lighted stand magnifiers. The table includes the maximum usable spectacle adds, (which were determined with stand magnifier lenses at the spectacle plane), and the resulting apparent magnifications, (which were measured and bracketed using aspheric high-plus spectacle adds for comparison). The fields of view were specified by the numbers of newsprint letters seen, “n”, or by the centimeters of text seen, "cm." The Reizen "6x" stand is the "hollow dome" model.

Peak “15x”	+5 max ⇒ 15X/6n
Peak “10x”	+5 max ⇒ 10X/12n
Coil 4212	+2 max ⇒ 10X/12n
Coil 4210	+2 max ⇒ 8X/16n
Agfa “8x”	+4 max ⇒ 8X/12n
Coil 5123	+3 max ⇒ 7X/16n
Coil 5428	+7 max ⇒ 6X/20n
Coil 4206	+1 max ⇒ 5X/20n
Reizen “6x”	+5 max ⇒ 5X/24n
Coil 5214	+1 max ⇒ 3X/9cm
Coil 5213	+4 max ⇒ 3X/9cm

Peak “10X” & “15X”

Coils 4210 & 4212

Agfa “8X” Loupe

Coil 5123

CE
COIL
Stand Magnifier
5123
MODEL
EQUIVALENT POWER
MAGNIFICATION F/4+1
EFFECTIVE LENS SIZE
5123
24.0D
7.0X
36mm Diam.
loupe sur pied

Coil 5428


CE
COIL
Stand
Magnifier
5123
MODEL | EQUIVALENT POWER | MAGNIFICATION F/4+1 | EFFECTIVE LENS SIZE
5123 | 24.0D | 7.0X | 36mm Diam.
loupe sur pied

Coil 4206

Reizen “6X”

Tiltable Coils:

5213
&
5214

STAND MAGNIFIER DEFOCUSED IMAGE QUALITY

A stand magnifier's image quality is determined in part by the deviation of its virtual image location from the focal point of the spectacle add used. Moving the object and stand magnifier so that the virtual image lies further beyond the spectacle add focal point has much less dioptric effect on image quality when the spectacle add focal point is relatively far away. Therefore, with stand magnifiers requiring relatively low maximum spectacle adds, the field of view can become the factor limiting usefulness at distances longer than indicated by the spectacle add, rather than image quality.

To illustrate that, consider the following table of stand magnifiers used with their maximum usable spectacle adds, which lists the distances the stand magnifier lenses must be moved from the spectacle plane before producing noticeable blur, and the visual fields at those distances. When a reduced visual field is listed as one newsprint letter, (1n), it is the factor that limits the stand magnifier’s useful distance, rather than image quality.

Peak “15x”	0cm/6n
Peak “10x”	1cm/10n
Coil 4212	18cm/1n
Coil 4210	15cm/1n
Agfa “8x”	8cm/8n
Coil 5123	10cm/12n
Coil 5428	6cm/20n
Coil 4206	20cm/1n
Reizen “6x”	6cm/24n
Coil 5214	60cm/2cm
Coil 5213	12cm/8cm

The table's determinations where made with a distance refraction, "just noticeable difference," of +/-0.25D. For those patients with reduced vision and larger, "just noticeable differences," blur would not be noticed as quickly if the stand magnifier lens were moved away from the spectacle plane, and visual fields would more often be the factor limiting the stand magnifier's useful distance.

REDUCING THE SPECTACLE ADD WHEN USING A FOCUSED STAND MAGNIFIER

When spectacle add power is reduced linearly and object distance is increased to maintain clarity, the object angular subtense magnification and the magnification of near correction, (which when combined equals the reference distance multiplied by the add power), is also reduced linearly.

When the spectacle add power used with a stand magnifier is reduced linearly, and the stand magnifier is moved further from the eye to maintain clarity, the resulting rate of magnification reduction remains linear, but is multiplied by the stand magnifier's constant enlargement factor. Three non-lighted stand magnifiers will be discussed to illustrate this effect.

FOR THE FOLLOWING TWO “PEAK” STAND MAGNIFIER TABLES

The resulting magnification with each spectacle add was directly measured and bracketed using magnification with aspheric high plus spectacle adds. The required distance of the stand magnifier's lens from the spectacle plane was calculated by subtracting the focal length of the stand magnifier's maximum usable spectacle add from that of the reduced spectacle add, for each spectacle add used. The resulting field associated with each spectacle add was specified in newsprint letters, "n," at the distance calculated. Enlargement factors were calculated for each spectacle add.

PEAK "15X”

+5 max ⇒ 0cm/15X/6n	E = (15X)/(5/4) = 12
+4 ⇒ 5cm/12X/3n	E = (12X)/(4/4) =12
+3 ⇒ 13.3cm/9X/1n	E = (9X)/(3/4) = 12

PEAK "10X”

+5 max ⇒ 0cm/10X/12n   E = (10X)/(5/4) = 8

+4 ⇒ 5cm /8X/6n   E = (8X)/(4/4)= 8

+3 ⇒ 13.3cm /6X/4n   E = (6X)/(3/4) = 8

FOR THE FOLLOWING REIZEN (HOLLOW DOME) "6X" STAND MAGNIFIER TABLE

For the following Reizen (hollow dome) "6x" stand magnifier table, the resulting magnification with each spectacle add was directly measured and bracketed using magnification with aspheric high-plus spectacle adds. For each spectacle add, the required distance of the stand magnifier's lens from the spectacle plane was directly measured in order to obtain the clarity range, (with a distance refraction, "just noticeable difference," of +/-0.25D). The fields were then measured at the midpoint of the clarity range produced by each spectacle add. Enlargement factors were calculated for each spectacle add.

REIZEN "6X" HOLLOW DOME

+6 max ⇒ 0cm/5X/24n E = (5X)/(6/4) = 3.3

+5 ⇒ 0-4cm/5X/24n E = (5X)/(5/4) = 4

+4 ⇒ 4-12cm/4X/24n E =(4X)/(4/4) = 4

+3 ⇒ 8-24cm/3X/16n E = (3X)/(3/4) = 4

CHOOSING THE MAXIMUM SPECTACLE ADD FOR STAND MAGNIFIER CALCULATIONS

A +6 add was the maximum spectacle add producing central clarity when a Reizen (hollow dome) "6x” lens was at the spectacle plane. However, clarity with an add occurs over a range, and since with a +6 add, small separations from the spectacle plane created blur, the add was at the high end of that range. As expected, this combination underestimated the enlargement factor. A better criteria for choosing the maximum add for clarity with the stand magnifier lens at the spectacle plane is to choose one that produces no more peripheral aberrations than the aspheric high-plus spectacle add producing the same magnification.

THE OBJECT ANGULAR SIZE/CENTRAL SCOTOMA CROSS-SECTION RATIO

As an object is brought closer, the cross-section size of an affecting central scotoma decreases in a linear fashion, since it represents the base of an isosceles triangle with its constant vertex angle located at the eye, and its axis along the optical axis. As a separate function, as an object is brought closer, its angular subtense at the eye is increased exponentially, since it represents the vertex angle of an isosceles triangle with a constant base moving toward the eye along its axis, which is also the optical axis. Therefore, as an object is brought closer, its object angular size/central scotoma cross-section ratio increases exponentially.

Determining the best distance refraction for a low vision patient can be difficult due to a large optical, “just noticeable difference,” which represents the diopter change required to produce a subjective change in vision. With adults, this can sometimes be addressed by performing the distance refraction at 1 meter using a large target, and optically compensating by subtracting +1 diopter. This takes advantage of the increase in the object angular size/ central scotoma cross-section ratio as a target is moved closer to the eye. This exponential increase can be even more useful when using a Coil #4206 stand magnifier, which produces its image 1 meter away, yet uses an object only centimeters from the eye.

COMPARING REQUIRED MAGNIFICATION

The magnification required to meet a near visual goal when simply using a high plus spectacle add is usually the magnification required when using a stand magnifier with a much lower powered spectacle add, if the object distance is approximately the same, regardless of the location of the enlarged virtual image.

STAND MAGNIFIER LENS ABERRATIONS

Although stand magnifiers with maximum spectacle adds consistent with standard bifocals can be convenient, they have more aberrations than stand magnifiers producing the same magnification with higher maximum spectacle adds. This is because stand magnifiers with higher maximum spectacle adds have a lower proportion of their magnification produced by image enlargement, and a greater proportion produced by proximity of the image.

When a hand magnifier is pulled away from an object, its image enlarges and moves toward infinity. This increases power (spherical and astigmatic) aberrations, and therefore increases power differences across the surface of the lens, resulting in an increase in the variability of magnification across the surface of the lens. For the same reason, stand magnifiers with lower maximum spectacle adds exhibit higher variability of magnification across the surface of their lenses than stand magnifiers with higher maximum spectacle adds.

Variable magnification across the surface of a stand magnifier lens can cause letters in text to move relative to one another when a stand magnifier is moved across the surface of a page. The patient's subjective reaction can range from indifference to nausea. Although an aspheric lens design minimizes this, it does not eliminate it altogether, and cannot address the problem at all viewing distances.

Different levels of variable magnification across the surface of a stand magnifier lens can be illustrated by comparing the non-lighted Coil 4206, producing a maximum of 5X with its maximum spectacle add of +1, with the non-lighted Coil 5428, producing a focused 5X with a spectacle add of +6. In order to illustrate the difference, these stand magnifier/ spectacle add combinations should be held in focus and moved across a line of text.

COIL 5850 "BRIGHT," AND COIL 5428 COMBINATION

When the Coil 5850 "Bright" paperweight magnifier is placed under the Coil 5428 non-lighted stand magnifier, the combination produces a subjective maximum of 12X with a maximum spectacle add of +5D at the spectacle plane. Subjective magnification observations with lower adds indicate that +5 is the high end of the clear spectacle add range, since it predicts a lower enlargement factor. The following tables illustrate that this combination is fairly equivalent to the Peak “15X” non-lighted stand magnifier, but provides a much larger field.

COIL 5850/COIL 5428 COMBINATION:

+5 max ⇒ 0cm/12X/10n — $E = (12X)/(5/4) = 9.6$

+4 ⇒ 5cm/12X/10n — $E = (12X)/(4/4) = 12$

+3 ⇒ 13.3cm/9X/7n — $E = (9X)/(3/4) = 12$

PEAK 15X:

+5 max ⇒ 0cm/15X/6n — $E = (15X)/(5/4) = 12$

+4 ⇒ 5cm/12X/3n — $E = (12X)/(4/4) =12$

+3 ⇒ 13.3cm/9X/1n — $E = (9X)/(3/4) = 12$

Additionally, the double lens system of the combination provides for minimal aberrations, and the Coil 5850 paperweight magnifier has light-gathering characteristics. It is therefore possible that when a Peak 15X provides adequate magnification, but inadequate fields at usable working distances, a Coil 5850/Coil 5428 combination will suffice.

LOW MAXIMUM SPECTACLE ADDS

A stand magnifier with a maximum spectacle add of +1 can sometimes be used with a distance correction to increase the available working distance. In these cases, adding distance magnification with a 2X “TV Max” clip allows for a stand magnifier with half the power and twice the field. However, since these stand magnifiers produce relatively high levels of aberrations, and because aspheric lens designs only reduce aberrations at one viewing distance, this is not always an effective strategy.

HIGH MAXIMUM SPECTACLE ADDS

A stand magnifier with a high maximum spectacle add has a virtual image that lies relatively close to the back of its lens. Due to the relatively low level of aberrations resulting from this, it can be successfully used with lesser spectacle adds to increase the working distance. A second pair of high-plus reading lenses can then provide for especially high magnification nearer the spectacle plane.

LIGHTED STAND MAGNIFIERS

Lighted stand magnifiers generally use handles with either bright or dim LED lights, or handles with incandescent lights. Due to the enhanced contrast produced, bright LED lighted stands are normally preferred, unless glare is a significant factor.

Bright LED-Lighted Stand Magnifier Constants:

PowerMag "5X"	+5 max ⇒ 5X	E = 5X/(5/4) = 4
PowerMag "8X"	+4 max ⇒ 8X	E = 8X/(4/4) = 8
ILA "4X"	+4max ⇒ 4X	E = 4X/(4/4) = 4
ILA "5X"	+6 max ⇒ 5X	E = 5X/(6/4) = 3.3
ILA "6X"	+4 max ⇒ 6X	E = 6X/(4/4) = 6
ILA "7X"	+5 max ⇒ 7X	E = 7X/(5/4) = 5.6
ILA "8X”	+2 max ⇒ 8X	E = 8X/(2/4) = 16
ILA "10X"	+2 max ⇒ 10X	E = 10X/(2/4) = 20

Dim LED or incandescent-lighted Stand Magnifier Constants:

Coil "4.7X" LED	+4 max ⇒ 4.5X	E = 4.5X/(4/4) = 4.5
Coil "5.4X" LED	+3 max ⇒ 5.5X	E = 5.5X/(3/4) = 7.3
Coil "7.1X" LED	+4 max ⇒ 7X	E = 7X/(4/4) = 7
Coil "8.7X" LED	+2 max ⇒ 8X	E = 8X/(2/4) = 16
Coil "10.1X" LED	+2 max ⇒ 10X	E = 10X/(2/4) = 20
Coil "12.0X" LED	+3 max ⇒ 12X	E = 12X/(3/4) = 16
Coil "14.7X" LED	+2 max ⇒ 15X	E = 15X/(2/4) = 30
Peak "10X"	+5max ⇒ 10X	E = 10X/(5/4) = 8
Peak "15X"	+5 max ⇒ 15X	E = 15X/(5/4) = 12

Lighted stands from Independent Living Aids, (ILA), are examples of bright LED stands. According to my measurements, these have the same optical constants as "Besser" bright LED stands. They have optically equivalent non-lighted stands as indicated in the following chart.

OPTICALLY EQUIVALENT STANDS			
NON-LIGHTED	BRIGHT LED	DIM LED	INCANDSCENT
REIZEN "6X" (+5 MAX ⇒ 5X)	ILA "4X" (+4 MAX ⇒ 4X)		
COIL 5428 (+7 MAX ⇒ 6X)	ILA "5X" (+6 MAX ⇒ 5X)		
COIL 5123 (+3 MAX ⇒ 7X)	ILA "7X" (+3 MAX ⇒ 7X)		
AGFA "8X" (+4 MAX ⇒ 8X)	POWERMAG "8X" (+4 MAX ⇒ 8X)		
COIL 4210 (+2 MAX ⇒ 8X)	ILA "8X" (+2 MAX ⇒ 8X)	COIL "8.7X" (+2 MAX ⇒ 8X)	COIL "8.7X" (+2 MAX ⇒ 8X)
COIL 4212 (+2 MAX ⇒ 10X)	ILA "10X" (+2 MAX ⇒ 10X)	COIL "10.1X" (+2 MAX ⇒ 10X)	COIL "10.1X" (+2 MAX ⇒ 10X)
PEAK "10X" (+5 MAX ⇒ 10X)			PEAK "10X" (+5 MAX ⇒ 10X)

The preferred stand lighting can be chosen using just readable font with the following optically equivalent lighted stand/add combinations.

BRIGHT LED	**ILA "8X"/+2 ADD (MAX)**
DIM LED	**COIL "8.7X"/+2 ADD (MAX)**
INCANDESCENT	**COIL "8.7X"/+2 ADD (MAX)**

If magnification in the range of 4X to 7X is preferred, and if dim LED or incandescent lighted stands are preferred, available non-lighted stands do not help with selection. In these cases, the following table can be useful.

FOCUSED MAG	COIL "4.7X"	COIL "5.4X"	COIL "7.1X"
3X	+2.7 ADD		
4X	+3.5 ADD		
4.5X	+4 ADD (MAX)	+2.5 ADD	
5X		+2.7 ADD	+2.9 ADD
5.5X		+3 ADD (MAX)	+3.1 ADD
6X			+3.4 ADD
7X			+4 ADD (MAX)

IN CONCLUSION

Stand magnifiers produce focused magnification that is dependent on the spectacle add used with them. Each stand magnifier has a maximum spectacle add that will produce a clear image. This add will require the stand magnifier to be held at the spectacle plane, and will produce the maximum magnification possible with that particular stand magnifier. Stand magnifiers with higher maximum spectacle adds produce less aberrations, but provide less range of focus, and are less often usable with standard bifocals.