American Optical Corporation

DATE: February 2, 1982

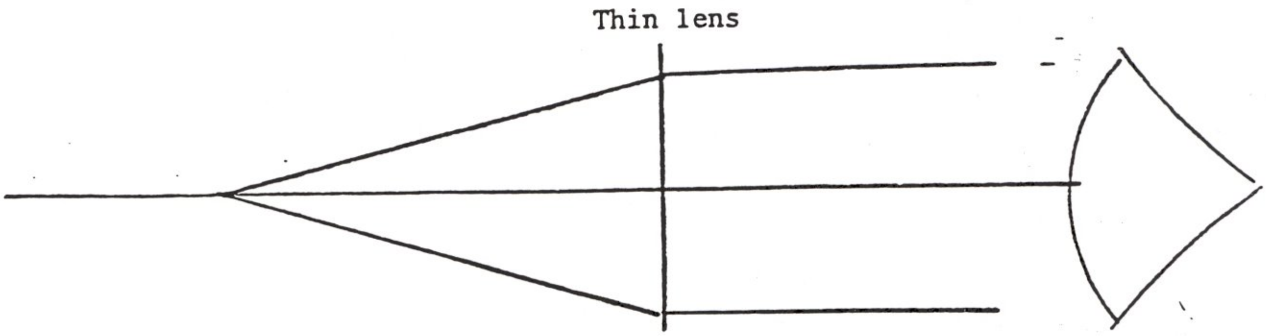
TO: R. B. Whitney

FROM: D. B. Whitney

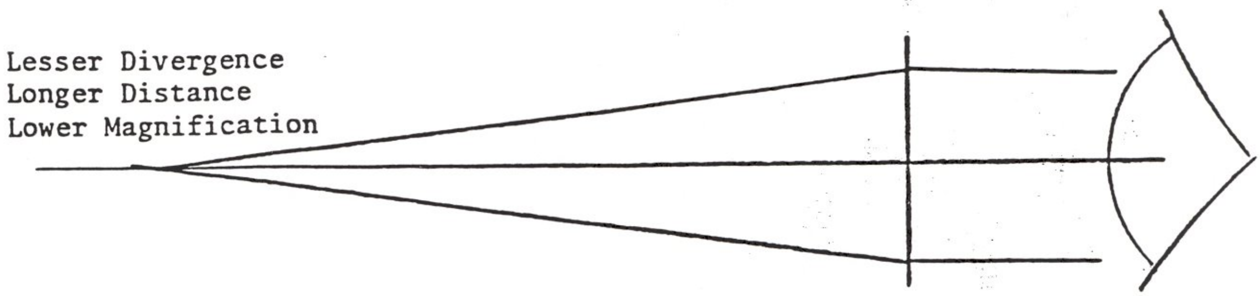
SUBJECT: Magnification of Low Vision Reading Aids

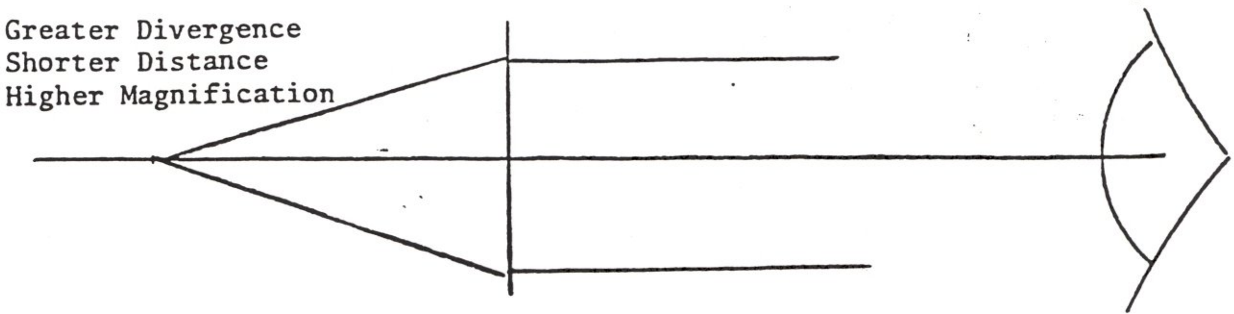
The way in which the magnification of low vision reading aids is designated has long been a matter of confusion and misunderstanding. Though it is generally known that the magnifying power of a reading aid equals its dioptric power divided by four, few realize that the dioptric power involved in this simple calculation is not the power as read on a Lensometer. Rather, it is the "equivalent power" which can be significantly different from the kind of lens power we are used to dealing with.

To better understand the situation, let's consider our reading aid to be an infinitely thin lens, which we can represent by a single line. Light rays diverge from a point on a near object, and are rendered parallel as they enter the patient's eye (this assumes the patient requires no refractive correction - only magnification).

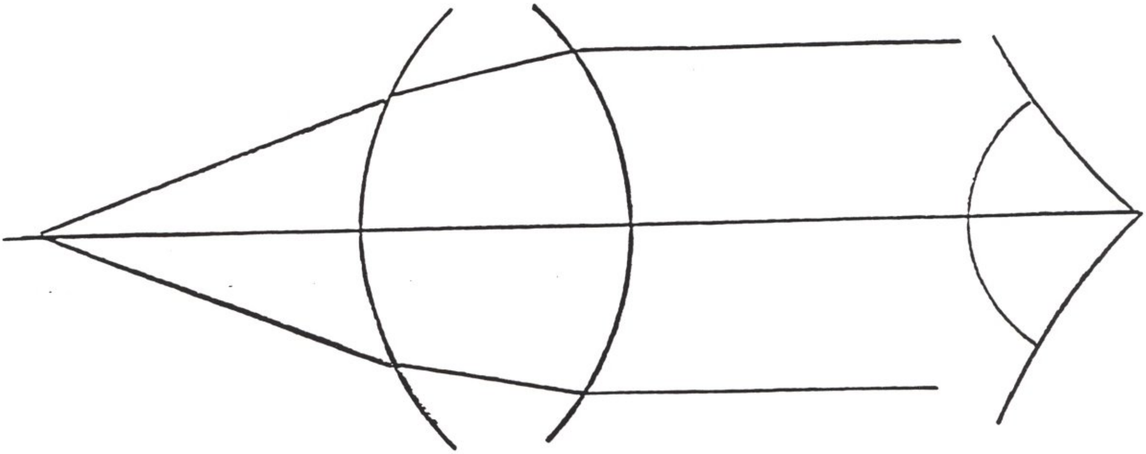


The more the light rays diverge from a point on the object, the greater will be the magnification. Thus, it can be shown that magnification varies inversely with the distance from the object to the thin lens.



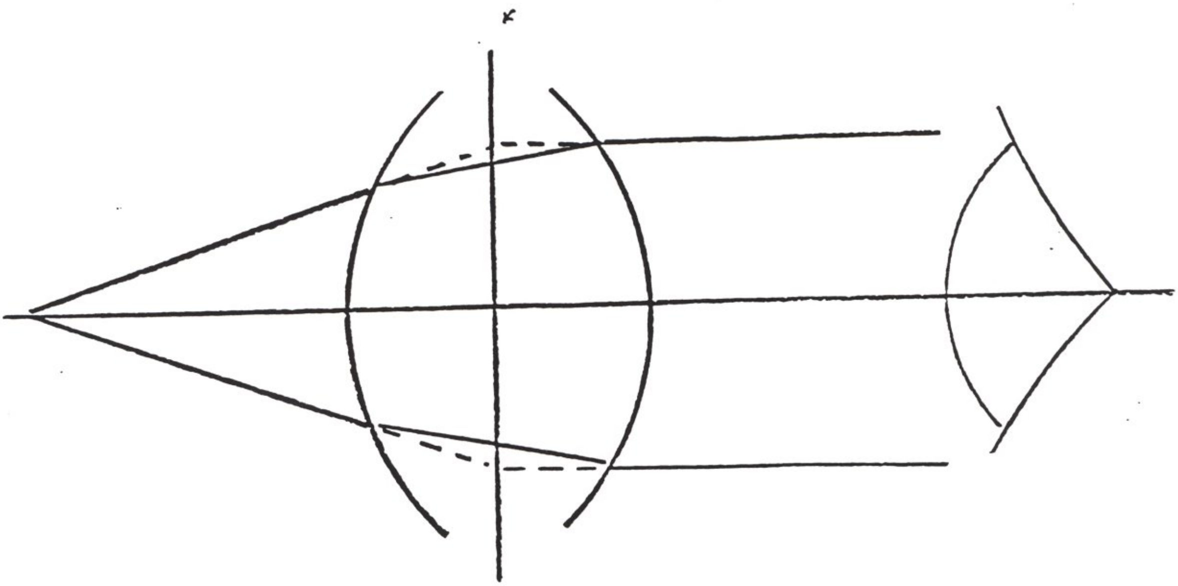


Now let's turn our attention to a lens of finite thickness - the real world situation. Light rays will now be refracted (bent) twice, once at each lens surface.



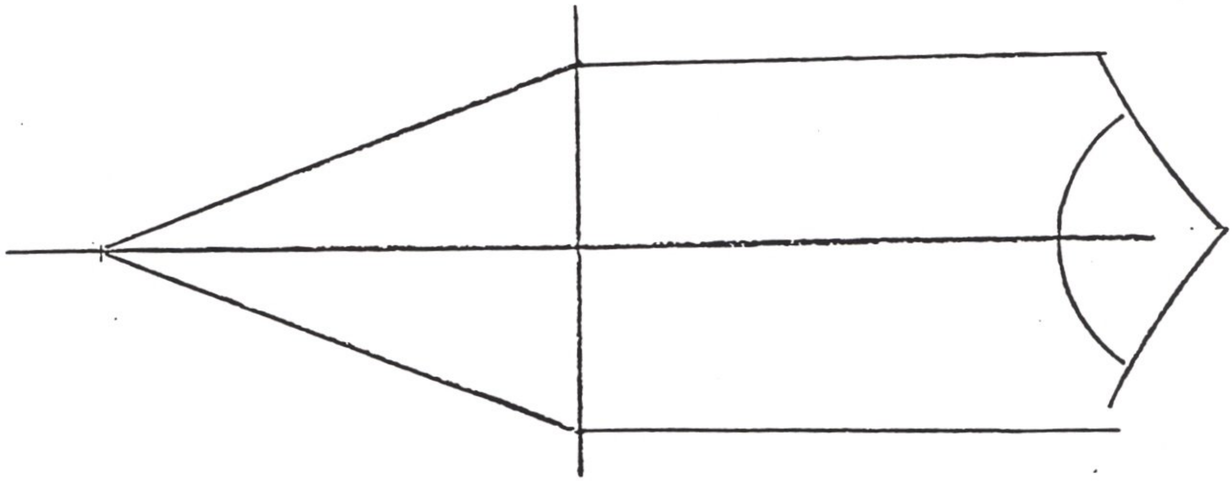
However, if we extend dotted lines from the light rays which are external to the lens, they will intersect at a plane which we call the "1st principal plane".

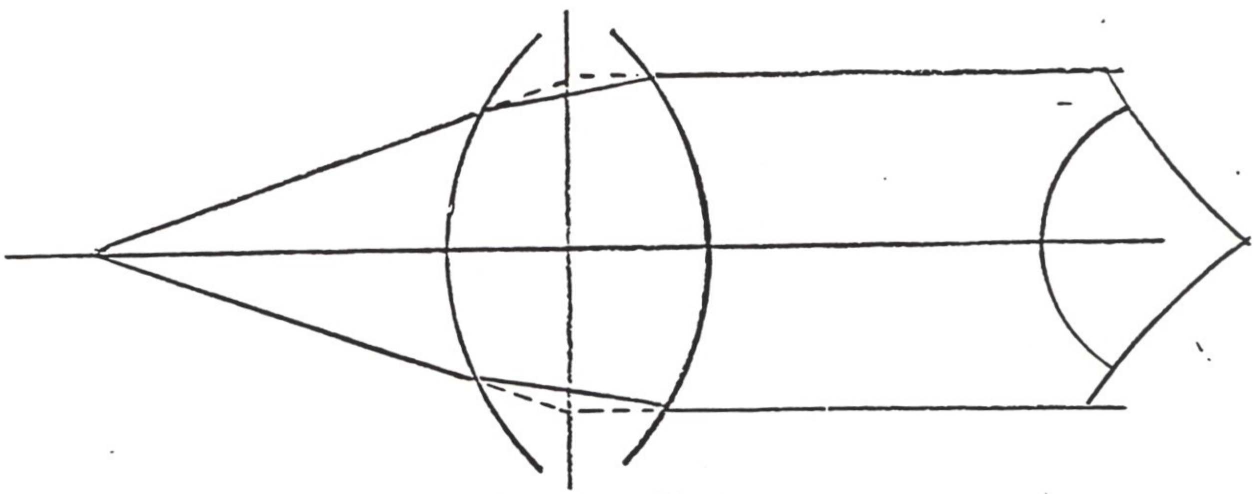
1st Principal Plane



If we allow that magnification as inversely proportional to the distance from the object to a thin lens, then it follows that magnification is inversely proportional to the distance from the object to the 1st principal plane of a thick lens. The divergence of light rays is the same in each case:

Thin Lens





1st Principal Plane

The point of all this is that we cannot determine magnification by referencing to either surface of a thick lens. Thus, a Lensometer power measurement, which must reference to either the front or the rear lens surface, cannot tell us the magnifying power of a lens. A Lensometer measures <u>Effective</u> Power, which is the reciprocal of the distance from the lens <u>surface</u> placed against the instrument stop (or nose) to the focal point. Magnification, on the other hand, is dependent on <u>Equivalent</u> Power, which is the reciprocal of the distance from the principal plane to the focal point.

Since magnification cannot be determined through Lensometer measurement, American Optical provides the following table applicable to its low vision reading aids:

Marked Magnification	Actual Magnification	Back Vertex Power	Front Vertex Power	Equivalent Power	Working Distance
2X	2.0X	8.51D	8.07D	8.17D	124.0mm
4X	4.1	18.49	15.91	16.26	62.8
6X	6.3	29.45	27.23	25.26	36.7
8X	7.9	38.42	34.84	31.80	28.7
10X	10.1	48.35	47.04	40.37	21.3
12X	12.1	58.98	57.86	48.29	17.3

For purposes of verification, the 2X and 4X lenses can be measured on a Lensometer. If measured with the ocular surface against the Lensometer stop (nose), the readings should approximately coincide with those shown in the column labeled "Back Vertex Power". If measured with the anterior surface against the Lensometer stop, the readings should be approximately those shown in the column labeled "Front Vertex Power". The 6X through 12X lenses are too strong in power to be measured on a Lensometer.

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