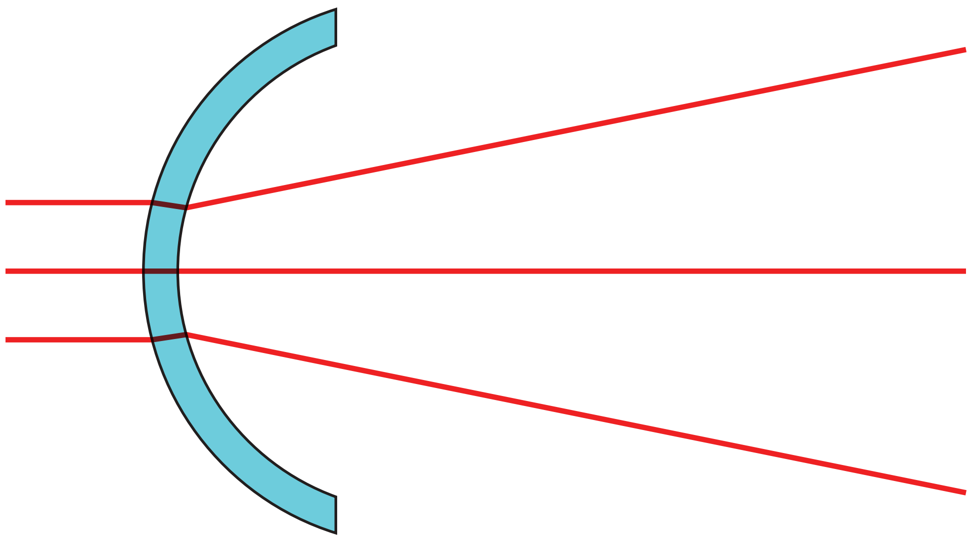

FIGURE 1(A)

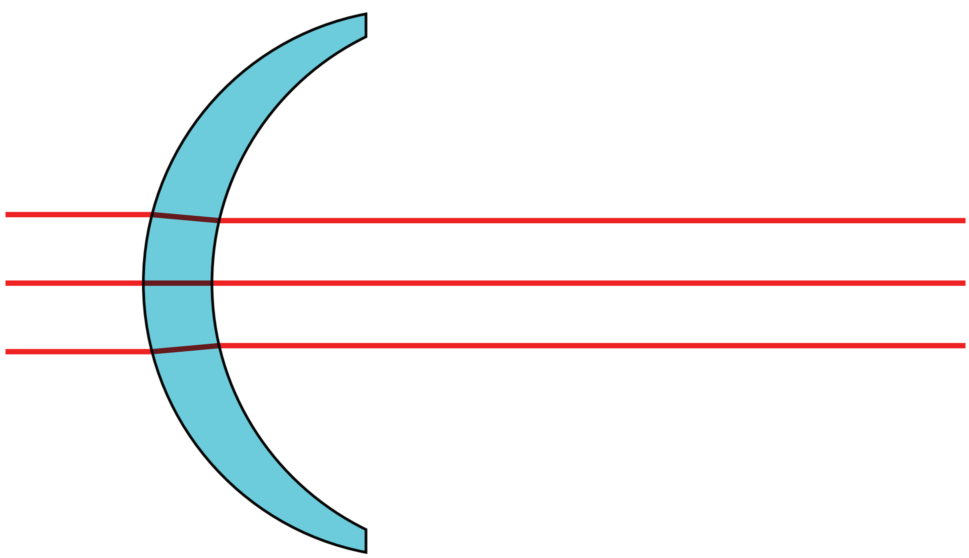

FIGURE 1(B)

ABSTRACT

This application discloses an apparatus for minimizing the optical effects of domes. Herein, the inner surface of the dome is designed to correct for any optical effect of the outer surface of the dome.

We claim:

1. An apparatus for the correction of dome aberrations comprising a dome having a shell with two concentric spherical surfaces, one on an outside surface and one on an inside surface, wherein the outside surface of the shell comprises a radius R, wherein the inside surface of the shell comprises a radius $R-t + t/n$, wherein the shell comprises a thickness t, and wherein the shell comprises a refractive index n.

2. A method for correcting dome aberrations comprising designing two concentric spherical surfaces of the dome, one on an outside surface and one on an inside surface, wherein the outside surface of the dome comprises a radius R, wherein the inside surface of the dome comprises a radius $R-t + t/n$, wherein the dome comprises a thickness t, and wherein the dome comprises a refractive index n.

REDUCING THE OPTICAL EFFECTS OF DOMES

TECHNICAL FIELD

This application is directed to an apparatus and method that corrects for the optical effect of domes. In particular, this application describes designing the curvature of the inner surface of a dome to correct for the lensing effects or aberrations of the outer dome.

BACKGROUND

Many devices, such as missiles, aircraft, and moving cameras, use a dome to protect the optical components. These domes almost always affect the light passing through them in negative ways. The optical correction of domes has been a topic of significant research in recent years but there has not been any practical and successful solutions to date.

The main negative affect of most domes is a lensing affect, which is normally seen as a diverging lens, one with a negative focal length. For example, if the dome is composed of two concentric spherical surfaces, the outside having radius R, the shell having thickness t, and the shell material having the refractive index n, the focal length at the center of the dome is $f = -nR(R - t)/[(n - 1)t]$. This has a significant effect on an optical system within the dome. The focal length of any transparent dome varies with the distance from the center so that some domes may produce a negative lensing effect at the center and a positive lensing effect some distance away.

Some attempts to correct for the effects of domes have used additional optical elements besides the dome, which technique is not desirable because of added complication and cost. For example, one attempt at remediation was the use of an additional high-order Fresnel lens that corrects for the optical effects of the dome over a fairly wide portion of the dome width. This attempt, however, is limited in the range of wavelengths it can be used for, and is less effective if the imaging system is gimbaled. Another way to attempt to correct for the effects of domes is to put an additional optical element between the imaging optics and the focal plane. This attempt requires very high precision in manufacturing. Also, the additional optical element would need to be redesigned for each implementation involved (combination of dome, imaging system, and wavelength range), which is costly and time-consuming. Yet another way to attempt to correct for the effects of domes is to refocus the system before the focal plane. This is likely to be necessary for any attempted correction. Focusing corrections, however, may need to be large if the dome's optical effects are not corrected, which situation is obviated in the present application. Thus, there exists a need for an effective solution to the problem of the optical effect of domes, which the present apparatus addresses.

BRIEF SUMMARY

The present application is directed to an apparatus for the correction of dome aberrations comprising a dome having a shell with two concentric spherical surfaces, one on an outside surface and one on an inside surface, wherein the outside surface of the shell comprises a radius R, wherein the inside surface of the shell comprises a radius $R-t + t/n$, wherein the shell comprises a thickness t, and wherein the shell comprises a refractive index n.

Another embodiment of the present application is a method for correcting dome aberrations comprising designing two concentric spherical surfaces of the dome, one on an outside surface and one on an inside surface, wherein the outside surface of the dome comprises a radius R, wherein the inside surface of the dome comprises a radius $R-t + t/n$, wherein the dome comprises a thickness t, and wherein the dome comprises a refractive index n.

The dome correction apparatus of this application has several benefits and advantages. One benefit is that the dome manufacturing process will not require large changes in design due to different imaging systems or wavelength ranges. Another benefit is that additional parts or components are not required which promotes simplicity of manufacture, ease of use, and controls manufacturing cost.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates an apparatus for correcting the optical effect of a dome wherein (A) shows the concentric dome uncorrected and (B) shows the same dome that has been corrected.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

The present application relates to an apparatus and a method for mitigating the overall lensing effect of a dome. The correction of these aberrations can be done by shaping the inner surface of the dome so that the overall lensing effect of the outer dome is eliminated. For example, a spherical dome whose thickness at the center is t, has no lensing effect if the radius of the inner surface is $R - t + t/n$, which is the value t/n larger than the concentric value but is still less than the radius of the outer surface. This comparison is shown in Figure 1.

As stated above, the effective focal length of the dome varies with off-axis distance. It is possible to create an interior surface figure that corrects over the entire width of the dome. More likely, it will be sufficient to correct exactly at one or two off-axis distances, resulting in a mostly corrected dome. For two spherical surfaces, as discussed here, it is only possible to correct exactly at one distance off-axis.

This correction is easy to add to the dome manufacturing process and will not need large changes in design due to different imaging systems or wavelength ranges, but rather will be a single solution for each dome. It will be capable not only of fixing the focus shift caused by the dome, but versions of it can also correct for some of the optical aberrations (in particular, defocus and spherical aberration).

The apparatus described herein is beneficial for use in short-range missiles, and can be very helpful when implemented in the forward dome of an aircraft. Anytime a dome is used to protect a camera or other imaging system, the present apparatus can reduce or eliminate the optical effects of that dome.

Alternative embodiments of the subject matter of this application will become apparent to one of ordinary skill in the art to which the present invention pertains without departing from its spirit and scope. It is to be understood that no limitation with respect to specific embodiments shown here is intended or inferred.