# Against the Hockney-Falco thesis: Glass and metal mirrors of the 15th century could not project undistorted images

**Sara J. Schechner**

*David P. Wheatland Curator, Collection of Historical Scientific Instruments, Department of the History of Science, Harvard University*
*1 Oxford Street, Cambridge, MA 02138; Telephone: 617-496-9542; Fax: 617-496-5932; E-mail: schechn@fas.harvard.edu*

**Abstract:** Inspection of surviving mirrors and related objects shows that they were too crude to offer the early Renaissance painter an optical short-cut to a naturalistic image of his subject. The craftsmanship of mirror makers was independent of and inferior to the quality of theories of image formation of the day.

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In a recent book, website, and public appearances, artist David Hockney and physicist Charles Falco have claimed that master painters, such as van Eyck, in the 15th century used glass or metal mirrors to project images onto canvas where they could be easily traced to give lifelike detail [1,2]. Their thesis is problematic on three grounds: (1) optical knowledge in the late Middle Ages and early Renaissance; (2) material culture from the same period; (3) alleged historical re-enactments of the technique.

(1) *Optical knowledge.* Although medieval optical texts show that scholars were deeply interested in light, vision, mirrors, and reflection, Falco is mistaken when he claims that passages from Witelo, Bacon, Grosseteste, or Ibn al-Haytham offer evidence of the study of projected images from concave mirrors. Proper historical reading of these texts show that the scholars were concerned with the geometrical points of reflection and the location of images in flat, spherical, cylindrical, conical, concave, and convex mirrors. Ibn al-Haytham, who is referenced as Jean de Meun's source in *Le Roman de la Rose*, never discusses image projection from concave mirrors, and a reading of the allegorical dream in the 13th century French verse offers no conclusive proof of image projection, in spite of Falco's claims to the contrary [3].

(2) *Material culture*. Whatever the state of medieval optical theory, there was a gap between theory and practice. Knowing how to design an optical system is distinct from being able to carry it out. Surviving medieval and early Renaissance mirrors are plagued by distortions arising from the process of fabrication. In general, medieval metal mirrors were small, dark, and convex. Reflectivity was limited because they were rough cast of an alloy of copper and tin, and hand-polished. Burning mirrors, although concave, had very short foci and did not require high reflectivity or the uniform curvature needed for image formation. Contemporary glass was dark green or brown and filled with air bubbles. The old broad technique produced a thick, almost opaque, uneven sheet of glass. The reflection off its surface was much distorted. The crown technique developed around 1330 produced thin, furrowed disks of glass, which could not be "silvered." Crude spheres were easier to form than plate glass, and their interiors could be metal-coated while still on the blowpipe. These spheres were the source of the convex glass mirrors that appear in Renaissance paintings. The reflected image from these mirrors was distorted because the glass was imperfectly shaped, striated, and bubble-filled. Hockney's assertion that convex mirrors could be reversed in their frames in order to serve as concave mirrors is false. The metal-coated interior would not be smooth or shiny, nor it could it stand up to polishing. No method existed to coat the outer surface of the sphere. This is why no concave converging glass mirrors are known from this period [3].

(3) *Problem of re-enactments.* Hockney and Falco have demonstrated how modern, store-bought or homemade, long-focal-length concave mirrors can project images, but such "re-enactments" are misleading when there is no historical evidence (documentary or material) to back them up. Even if one were to cast and grind a mirror using period materials and methods, one will never fully recreate historical conditions. Moreover, the availability of production materials in the past does not imply that they were used then in the same way a person today might think of using them. For instance, no one produced steady electric current before Volta's "pile" in 1800, even though coins of dissimilar metals, cloth, saltwater, and wire had existed since antiquity.

**References:**

[1] D. Hockney, *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters* (Viking Studio, 2001).
[2] C. Falco, "Frequently Asked Questions," http://www.optics.arizona.edu/ssd/faq.html (29 March 2004).
[3] S. Schechner, "Between Knowing and Doing: Making Mirrors in the Fifteenth Century," *Optics, Optical Instruments, and Painting* (European Science Foundation, forthcoming 2004).