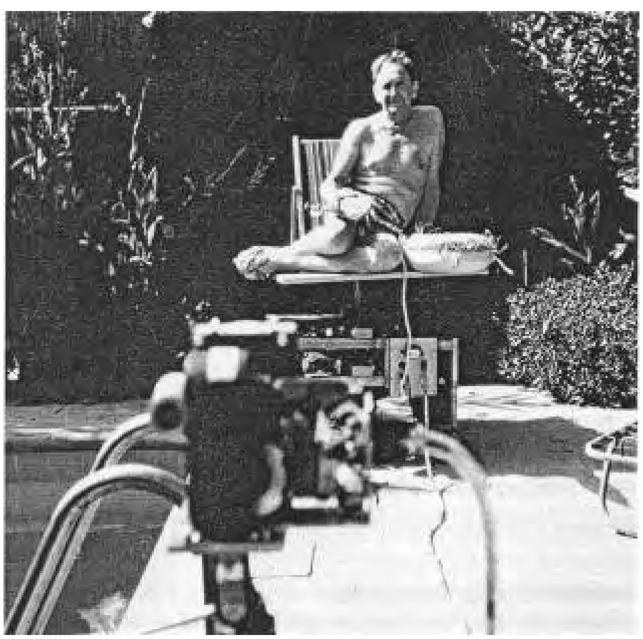
Stereoptiplexer cinema system – "outside-looking-in"

by Walter Funk

Walter Funk has been producing volumetric movies since 1994, pioneering the artistic use of volumetric and autostereoscopic displays for entertainment. His Hologlyphics performances involve volumetric animations and live music performed for an audience. He founded Hologlyphics (http://www.hologlyphics.com), bringing live volumetric entertainment to film and video festivals, art shows, music events, and stereoscopic imaging conferences. Walter studied holography at The Holography Institute, and music at Center for New Music and Audio Technology, UC Berkeley.

The Stereoptiplexer[1,2] is an autostereoscopic cinema system invented by Robert B. Collender. His work in stereoscopic imagery began in 1949, most of it focused on techniques without user-worn viewing aids, with the scene having multiple views. The Stereoptiplexer was improved over many years and various forms of 3D capture and viewing were explored, including the "outside-looking-in" and the "inside-looking-out" varieties. Both allow for unaided viewing of stereoscopic images with 360° freedom of viewer movement, with each position providing the viewer with a separate perspective, the ability to 'look around' images. The "inside-looking-out" variation, first successfully tested in 1960, provides a scene similar to looking out a window, where viewers could see scenes such as landscapes and distant views. In contrast, the "outside-looking-in" version can feature an actor or small object, with the viewer able to walk 360° around the subject, able to see all sides in unaided stereo. This article will highlight the "outside-looking-in" variation.

Collender had several objectives when designing the "outside-looking-in" Stereoptiplexer. The main objective was to provide the ability to view three dimensional images without the use of viewing aids, in which 360° of multiple perspectives can viewed by changing one's position. Slightly modified conventional filming techniques were intentionally used as much as possible. Another objective was to provide a means for reproducing relatively large images with rugged and stable yet practical stereoscopic apparatus. Last but not least, he intended to provide the basis from which autostereoscopic movies could be made practical for the studios and general movie-going public.



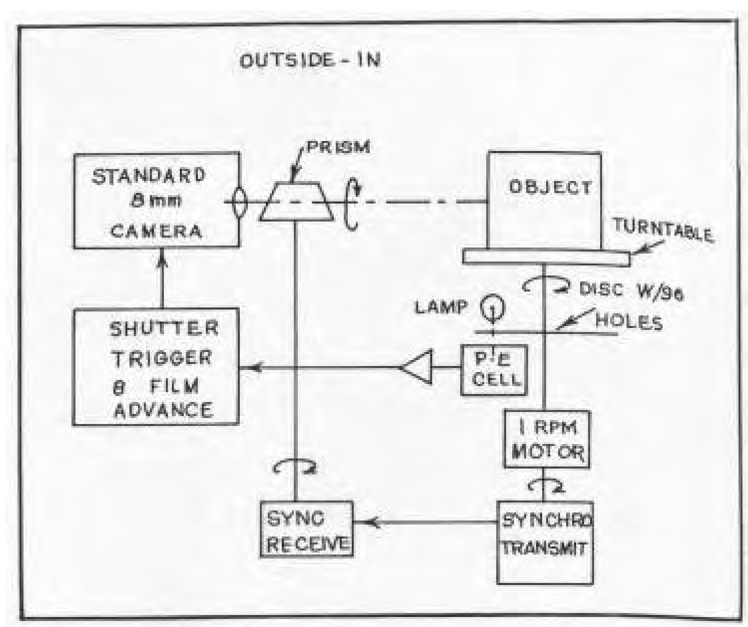


Figure 1: The picture on the left shows a subject on the 3D image capture system rotating turntable with 8mm camera in foreground; the image on the right shows 3D image capture system block diagram

For 3D capture of scenes, a standard 8mm camera is used, viewing the scene through a dove or pechan prism. The subject or object to be captured is placed on a horizontal motorized turntable, with a disk below coupled to the turntable's shaft. The lower disk has 96 holes, with a lamp above the disk and a photo-electric pickup below. Light is either blocked by the disk or shines through one of the 96 holes, and as the subject on the turntable rotates, the azimuth is sensed by the photo-electric pickup. When the photo-electric pickup senses $1/96^{th}$ of a full rotation, it triggers the camera's shutter. The camera's shutter is triggered 96 times per revolution of the subject, and the film is advanced an equal number of times per rotation. The prism in front of the camera is electrically coupled to the rotating turntable, allowing the prism to rotate in sync with the subject, so that the successive images on the film are rotated 360°/96 with respect to an adjacent frame. This correction is necessary so that the later reconstructed 3D image is viewable as upright from any azimuth of view. The 3D capture system is shown in *Figure 1*.

For reconstruction of 3D scenes, the images are viewed inside a revolving drum containing a narrow vertical aperture through which observers could see a scanned 360° reconstruction of the filmed scene. The aperture is $1/96^{th}$ of the closure, resulting in reduction of the screen illumination by a factor of 96. To compensate for the brightness reduction, Collender used a "Fresnel lens-cylindrical lenticule diffuser-sandwich" in place of a translucent screen, to direct all of the light to the vertical slit. Inside the revolving drum is the "Fresnel lens-cylindrical lenticule diffuser-sandwich" used as the projection surface. Using a high speed projector, the scenes captured with the turntable system are projected in succession onto the projection surface inside the drum.

The drum is rotated at least 16 times per second to avoid flicker, and the screen image is always moving parallel to the slit, and a plane passing through the slit always intersects the screen image at right angles. Just as with capture, the projector displays a frame on the projection surface $1/96^{th}$ of a rotation. This is shown in *Figure 2*. Since the observer is viewing the screen image through the vertical slit, at any instant in time, one eye will see a relatively narrow vertical section of the image, and the other eye will see another relatively narrow vertical section of the image. The two vertical sections are spaced from each other. Because the slit is moving, at a later instant in time, the two eyes again see separate portions of the image. The portions of the image viewed by the right and left eye are continually changing, and each eye never sees what the other eye is viewing at the same instant. The two dissimilar views are stereoscopically related and fuse inside the brain into a 3D image.

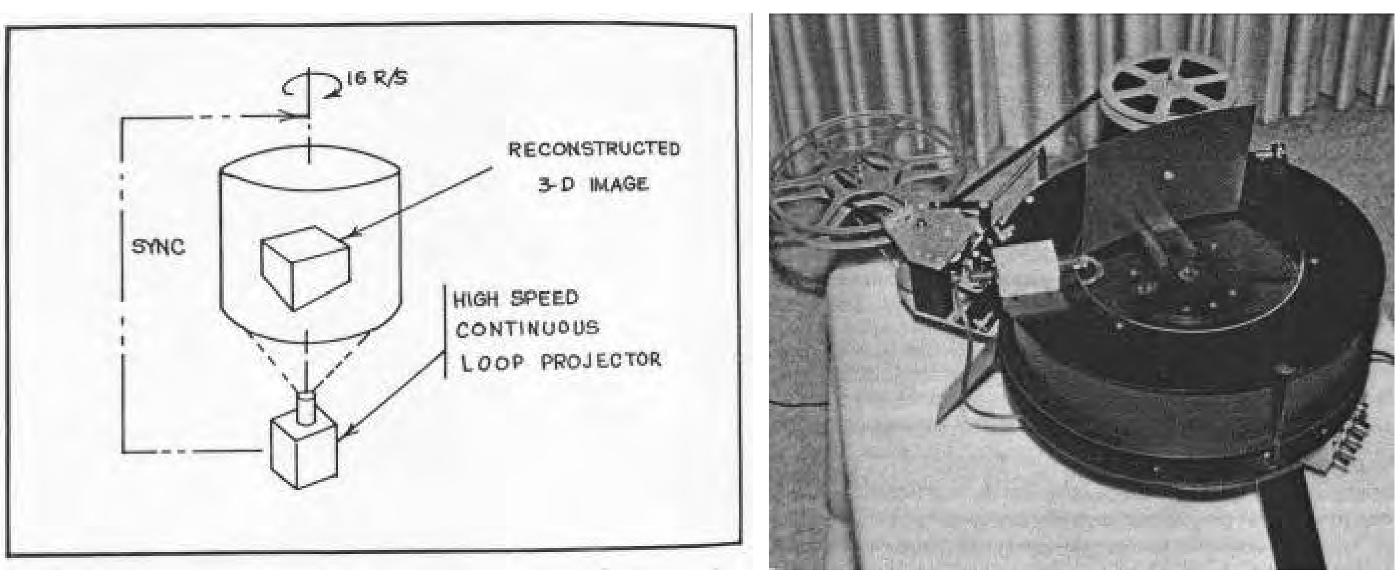


Figure 2: Stereoptiplexer 3D projection system, rotating drum with slit, with screen inside. Left image shows block diagram, right photograph shows 3D projection device

The "outside-looking-in" Stereoptiplexer explored in this article was a direct inspiration for Homer B. Tilton's Parallactiscope[3,4] autostereoscopic CRT display. He adapted the principals behind the Stereoptiplexer to an electronic display. With Tilton's previous work on 3D CRT displays, dating back to the late 1940s, the foundation was in place. The Parallactiscope provides moving electronic images viewed in true stereo without user-worn viewing aids and 90° of motion freedom, with each position providing a separate perspective. In contrast to the Stereoptiplexer using filmed scenes, objects, and images, the Parallactiscope displays synthetically generated scenes, objects, and images. After the first version was built in the late 1960s, many revisions were made. My own artistic work with autostereoscopic and volumetric movies began with a much later version of the Parallactiscope in the early 1990s, and I have added many artistic tools and features to the system, including sound, real-time control, and the adaptation of film and video special effects. Various and extensive content has been produced and shown to live audiences since 1994. All my work and content, know as Hologlyphics[5,6], is based upon the principals explored with the Stereoptiplexer.

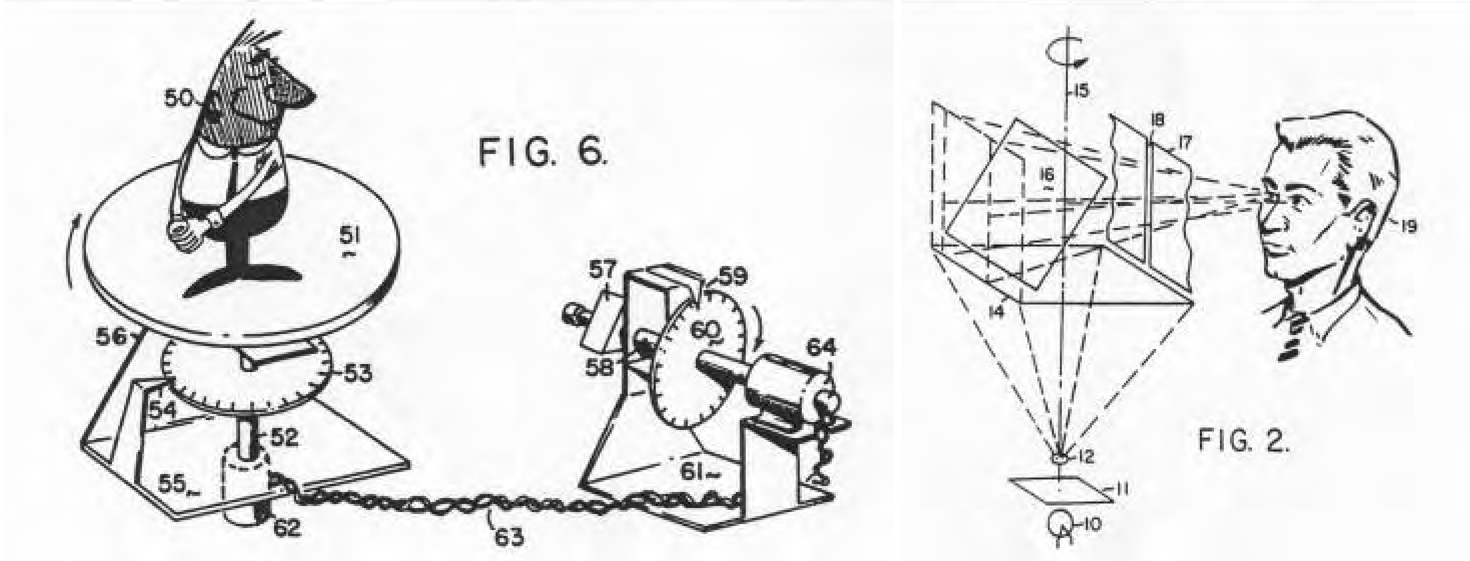
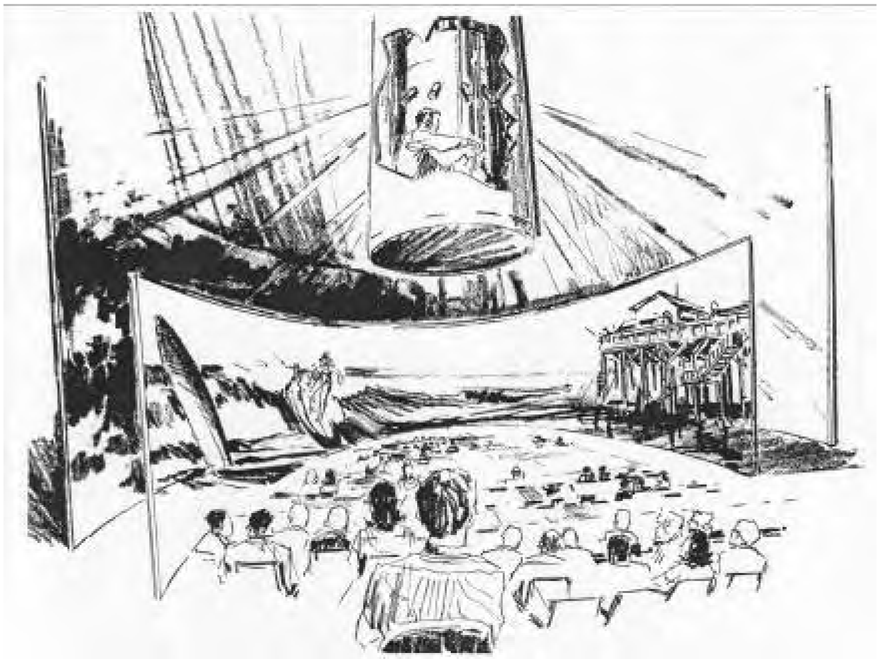


Figure 3. Drawings from Collender's 1965 patent. Patent 3,178,720
Three Dimensional Unaided Viewing Method and Apparatus

Robert Collender went on to make many improvements to the Stereoptiplexer and devised other techniques for the capture and reproduction of true stereoscopic movies without glasses. *Figure.3* shows drawings from a 1965 patent. Later systems made it possible for even larger audiences to view autostereoscopic movies, and he always emphasized minimizing the complexity of the theatre projection equipment as much as possible. In order to reduce film length, he explored image dissection photography techniques, which has the advantage over traditional film in that several very accurately registered superimposed full-frame sized images, on the order of 1000, may be placed on a single frame of film. Later work eliminated the use of moving parts and provided for the content to be stored electronically. In a 1968 article on a new, large screen true 3D movie system[7](*Figure. 4*) with 825 seat capacity and 120° field of view, he asked the following bold question. "What is the big problem? Why can't the audience just sit in the theatre and look through a 100 ft. wide by 50 ft. high bay window and perceive the same impression as if they were transported to the scene and looked through the window – and do this without any sort of optical aid at the eye?" Robert Collender did not just ask this question, he solved many of the roadblocks to delivering highly realistic stereoscopic movies to large audiences without the use of glasses. He even published an article in 1965 for *American Cinematographer*[8] outlining techniques for 3D movies without glasses. Yet, big movie studios and Hollywood have not picked up on any of this work. Times have changed since the 1960s, and I am not suggesting we use techniques not compatible with today's production and projection technology, but Collender's work continued until long after then. Big studios and Hollywood never got on the autostereoscopic movie bandwagon.

With their support, this work could have grown immensely since the late 1960s. The vision, techniques and technology already exist. Currently we hear about many conundrums and squabbles over 3D standards in the theatre, plus news of the digital stereoscopic upgrades the movies houses are undergoing. Yet it is still all about the 3D glasses. With all of the work Collender has done, along with others before and after him, to make high quality true autostereoscopic movies available to the general movie-going public on a practical basis, why are we not there yet? It seems I have to repeat the first part from his question 40 years ago, "What is the big problem?"



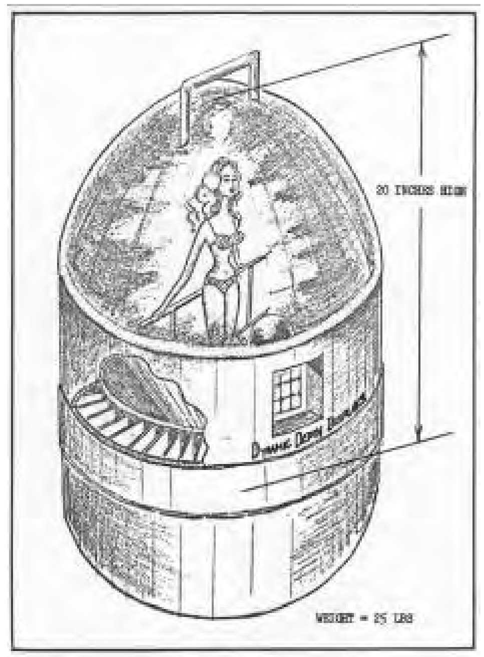


Figure 4: Left shows drawing of Collender's large screen 3D theater system with 825 seat capacity and 120° field of view, the projectionist is at top. Right shows drawing of possible smaller display device.

References

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