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The Refractor

The Bulletin of the Eastbay Astronomical Society
Founded in 1924 at Chabot Observatory, Oakland, California

Volume 79
Number 11
July 2002

This month's meeting will be:

Special Member's Sci-Fi Review Night

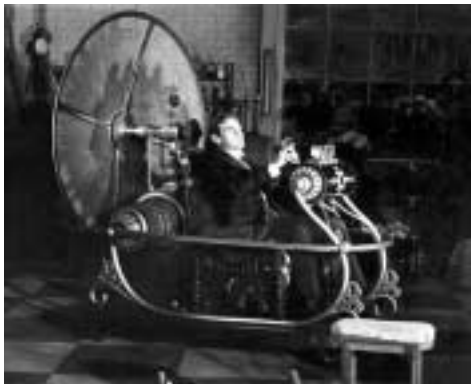
"Best Science Fiction Films of All Time"

Saturday, July 20, 2002

Physics Lab, 2nd Floor, Spees Bldg
Chabot Space & Science Center, Oakland

- Presentation – 7:30 pm
- Club Business afterwards

We don't have a speaker this month, so we thought we'd do something fun and a little different. We're putting together a panel of "experts" to debate the merits (or lack thereof) of our favorite science fiction films, complete with snippets from the films being discussed. If you've got a favorite sci-fi film, bring a copy of it to the meeting (if it's a video tape, line it up ahead of time to the clip you think is the film's best representative sequence; if it's a DVD, find the exact time of the clip and write it down so we can go right to it). **Due to the limited amount of time we have to do this, we ask that you a) keep your clip under 5 minutes in length, and b) you pre-register your nomination with Don Saito – first come, first served.** We should be able to fit around 6 – 8 nominations, including clips and discussion, inside of a two-hour meeting. We'll show them to the audience, and you can tell us why you liked it. We'll then take any comments that might come from the peanut gallery. If you don't have a copy of it, check with Don (he's got a fair collection of videos and DVDs of some of the more popular films), and you might be able use one of his. Otherwise, you can just rent the video/DVD from your favorite video store. Contact Don at: donsaito@pacbell.net, or (510) 482-2913. ✯



◂ *Rod Taylor in* The Time Machine

Carter's composite shot of the annular solar eclipse from central Mexico and a flamingo in flight. A pretty lucky shot, considering it was cloudy most of the day.

The Optical History of Rachel (Chabot's 20-inch telescope)

By Robert Schalck

INTRODUCTION:

The 20-inch telescope is a refractor (lens type) telescope. The Hubble Space Telescope is a reflective (mirror type) telescope. The term 20-inch is used to describe the diameter of the lens or mirror of a telescope. The larger the lens or mirror, the more light the telescope gathers, the better it resolves distant objects in space.

The Optical History

The 20-inch lens is made from two different glass mate-

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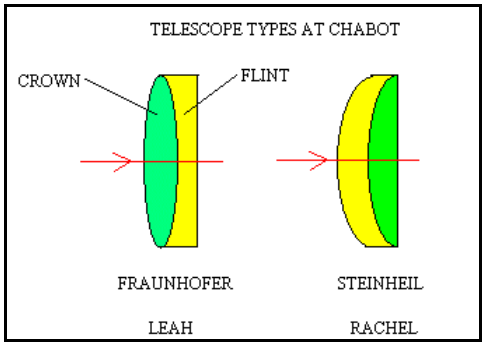
DINNER WITH THE SPEAKERS
5:30 pm
Saturday, July 27, 2002
HUNAN YUAN
4100 Redwood Rd #11
(next to Safeway)
Oakland
(510) 531-1415
Please call Betty Neall at 510/533-2394 by Friday, July 26 to confirm your place.

Inside This Issue:

rials. One called "Crown" and the other "Flint". The two glass materials are needed to improve the optical performance. As the light is bent by the first lens, it breaks the light into colors, just like a prism. The second lens is used to bring two colors into focus. When you look though a refractor, you see a ring of colors around the image of a star or planet. A mirror-type telescope does not have this problem since all colors come into focus. This is one of the many reasons why mirror telescopes are used today. The 20-inch telescope was one of the last large refractors built for a major observatory.



The John Brashear company ordered the glass blanks in January 1914. They ground and polished the lens. The *Jenaer Glaswerk Schott & Gen.* of Jena, Germany (they are now called Schott Glass Technologies) manufactured the glass for the lens.

The John Brashear Company was located in Pittsburgh, Pennsylvania (they are still in business today as Brashear LP). John Brashear was a very well known and respected Master Optician of his time. His son-in-law, James McDowell, was also a Master Optician, and it's our understanding that he was the person who ground and polished the 20-inch lens.

The glass blanks were ready to be shipped in August 1914, however this was during the outbreak of W.W.I and there was a possibility that they would not be shipped. The glass was finally allowed to leave Germany in November 1914, through Holland.

A sample of the two glass types was sent to Professor Charles S. Hastings of Yale University. In 1914, he was one of the world's authorities on mathematical optics. He would determine all the optical properties of the samples, and then compute the curves for the set of lenses made from that particular piece of glass. The design was carried out by hand, using log tables and optical formulas to determine where the light rays in different colors would come to the best focus possible. In most refractor designs the red - blue colors are the ones used for this correction.

Using the new glass materials from Jena gave Hastings a chance to design a very good lens. The final design has the "Flint" glass forward, called a Steinheil design.

The 8-inch Clark telescope "Leah" was designed with the "Crown" forward, called a Fraunhofer design. See glass design figures.

The 3-inch and 5-inch finder scopes on the 20-inch may have been used as models of the new design. Models were used to prove the design before the curves were cut into the large blanks. The 3-inch scope has curves slightly different from the 5-inch scope. The 5-inch scope appears to be the better design of the two. It was just a matter of scaling up the design to 20 inches.

The Polishing and Testing Process.

The preferred method of testing a telescope in 1914 was to use a star image. The optician would bring the star in and out of focus. If the star image was the same size and shape, in and out of focus, then the lens was considered done. McDowell had to polish a lens surface and then place both lenses into a cell, then mount the cell into a test fixture. The Brashear Company was known for making very precise optical flats. McDowell may have used an artificial star and a flat to test the lens after polishing. This task was performed as many as a hundred times to be assured that the polishing was complete and produced a perfect lens.

A final test may have been made outside by mounting the cell into the large telescope tube attached to a pier. McDowell would locate a bright star near the zenith (straight up), and focus the star image to assure that the polishing was complete.

There is little information about what method the Brashear Company may have used. They were always willing to share knowledge of their work; however, there are always a few company secrets that an optical company would want to keep to themselves.

A Lens Cleaning Was Needed

In 1989, we decided to clean and test the lens. The old observatory dome leaked during the winter rainy season for a few years and some of the water had entered the tube. There was a concern that rain water may have damaged the lens.

We were able to get permission to test and repair the lenses at Tinsley Laboratories in Richmond, California. Tinsley is one of the best optical companies in the world; they are known for making the camera optics used in various spacecraft that traveled to the planets. It was also the company who made the correction optics to solve the problem with the Hubble Space Telescope, thus saving it from being useless.

A team was assembled to test, assess the damage, clean, reassemble and retest the lens. The volunteers were made of two Master Opticians, two Optical Engineers and a Mechanical Engineer from different companies located here in California. They were experts in polishing and cleaning glass, optical testing and design. All the time and equipment was donated. It took over 200 man-hours to complete the task.

The first test for the lens was to look for stress in the glass using Polaroid filters. No stress was observed, other than the normal amount from the annealing process. Using a 1,000 - watt lamp, we looked for any cracks or grazing on the optical surfaces that may have occurred from exposure to the moist air. None was found. The lenses are very clear and free from surface and internal glass defects.

The next test for the lens was to check its optical performance. The method the team used is called laser interferometry. Unlike the star test, there is no need to wait until nighttime to test the lens. The laser interferometer uses a Helium Neon laser (it produces light at the 632.8 nm wavelength) and two perfect reference mirrors. The interferometer can measure the lens

Editor's News and Views

by Don Saito

We've now had two **Members Only view nights**; Monday May 13th, and Sunday June 16th and they've both been really fun. I'm telling ya: not having to contend with the weekend crowds is a real treat! This last one; we saw the crescent Moon "early" in the evening through Leah (well, if you call 9:30 pm, *early*), and when it got dark enough, we viewed the milk (Milky Way), spilt sugar (globular clusters M13, M5), and the Ghostly Cheerio (Ring Nebula – M57). This must have made astronomers hungry for breakfast, working late and into the wee hours of the morning. All that was lacking: the Pancake Galaxy, and the Sausage Cluster, to make a complete meal! (Sorry.)

Ann and Frank Creese are continuing to hold regular library work parties – the next one is on Saturday, June 29 from 2-5pm. There's still a lot of work that needs to be done, so if you can spare a few hours of your time, it would be for a uniquely worthy cause!

Chabot Space and Science Center will open their newest exhibit: **The Liberty Bell 7 Space Capsule** that was plucked from the bottom of the Atlantic Ocean a few years ago, having been lost on the bottom of the sea since 1961(!) A Smithsonian travelling exhibit; ought to be way cool! ✯

MEMBERSHIP RENEWALS

The last two months of the Eastbay Astronomical Society's fiscal year are July and August. Consequently, members must renew their membership before the end of August to ensure uninterrupted delivery of *The Refractor*. Please use the form on Page 5 to renew your membership before the end of August. Thank you!

⇨ ⇨ ⇨ ⇨ UPCOMING EVENTS ⇨ ⇨ ⇨ ⇨

SHINGLETOWN STAR PARTY – July 10-15

For the past eight years the SF Bay Area internet observers group *The Astronomy Connection* (TAC) has been hosting star parties at Mt. Lassen Volcanic National Park. The dark skies and wonderful daytime sights have made this an increasingly popular event.

This year, in conjunction with TAC, TAC-SAC (Sacramento) and Shasta County, the Shingletown Activities Council is proud to host the inaugural Shingletown Star Party for 5 days and nights at the Shingletown Airport, which is located approximately 40 miles east of Redding off of Hwy 44 in Shingletown, CA. The dates are from noon on Wednesday, July 10th through Monday at noon on July 15, 2002. The airport will be officially closed to air traffic during our stay, so we will be able to camp on site and leave our equipment set up on the paved runway.

This star party is open to all amateur astronomers. Come and join the fun at a real dark sky event.

More details and a sign-up form can be found at: http://www201.pair.com/resource/resource-intl/ssp.html or contact Jim Ster by e-mail (sterjf at ecs.csus.edu) or telephone (916 278-5624 /voicemail) or Mark Wagner by e-mail (mgw@resource-intl.com) or phone (408 356-1125).

View from Barcroft by Carter Roberts

TRI-VALLEY/EAS BARCROFT HIGH-ALTITUDE STAR PARTY August 8-13

The cost for Barcroft is $50 per person per night, and there is room for 20 people (participants must be 17 years of age or older). All meals are covered. They've got bunk bed dorms, showers, and flush toilets; you should bring your own sleeping bag. It is at 12,400 feet. We acclimate at the Grandview campground at about 8,000 feet the day and night before (Thursday). Carter likes to spend the previous day in Mammoth at the Swiss Ski Chalet so as to get an extra day acclimatizing, and that seems to help him. Dress *VERY* WARMLY! Three sets of long underwear is not overdoing it. You are much more sensitive to cold when your body can't metabolize as well, and at 12K+ feet, the lack of oxygen impedes metabolism. Some people even bring survival suits. There are a small number of suits up there but don't rely on that. Bring at least three sets of long underwear, a warm hat, or even better, a balaclava, warm gloves, and warm boots. Remember, you are half-way into space! There is an oxygen tank in the dining room for emergencies. This Barcroft trip ought to be especially memorable as the Perseids peak the Monday/Tuesday night when we're up there! For more info, contact Dave Rodrigues at (510) 483-9191, day or night. ✯

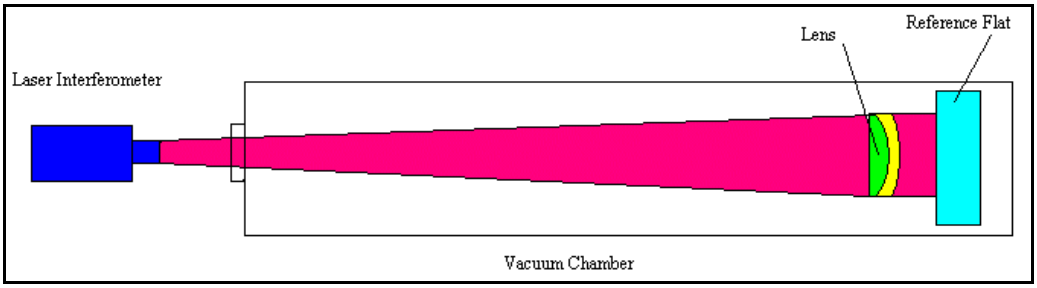
SPARE SHOTS

Alan Fischer demonstrates the Levitron, which floats a spinning magnet in the air. An excellent device to get kids interested in science!

The partial eclipse of the sun on June 10th as imaged by Ellis Myers using his Nikon Coolpix 995 digital camera and Jim Scala's 5.5-inch Takahashi (with 28mm William Optics eyepiece. Nice shot!

Cont'd from Page 2
performance to 1/20 of the wavelength of the laser light.

The testing system consisted of an interferometer, a 40 foot long vacuum chamber with an entrance window, and a 24 inch diameter reference mirror inside the chamber. (See the test system drawing.) The interferometer was positioned at the chamber window (that would be the eyepiece end of the telescope). The lens was placed inside the chamber near the large reference mirror. The interferometer was aligned towards the lens.



Inside the interferometer, half the light is sent to a small reference mirror, the other half is sent towards the lens. The laser light enters the chamber though the window and travels towards the lens located 28 feet away. The light passes though the lens and continues until it hits the large reference mirror. The light bounces back from the large reference mirror and once again passes though the lens. It continues back towards the interferometer and is refocused. The two beams are recombined inside the interferometer. The two reference mirrors are optically perfect so any defects seen in the laser light must be in the lens. The combining light from the lens and the mirror produces what is called interference fringes. By tilting the reference mirror inside the interferometer, we change the spacing of the fringes. The shape and straightness of the fringes is what is measured.

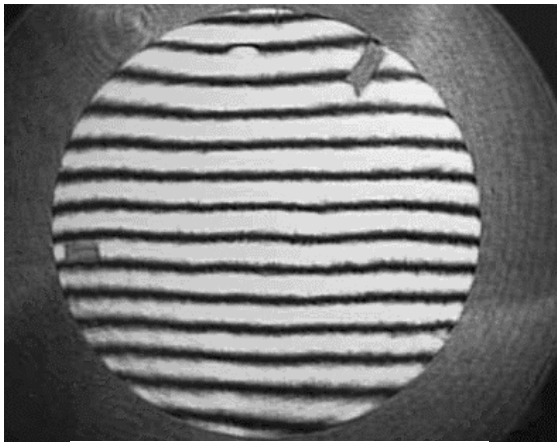
The first result had a slight but adjustable defect. We took the lenses apart and over a period of a few weekends we were able to clean most of the rust stains from the edge and the surfaces. We measured the mechanical dimensions of each of the lenses, the radius of curvatures, center thickness and the diameters.

The lens cell was sent to a repair shop that specializes in restoring rusted metal. The rust was removed and the cell was painted and sealed with a special baked on paint. The paint will keep the cell from rusting again and it should last 75 to 100 years.

The alignment of a refractor lens is very important. During grinding a slight wedge is produced between the surfaces. The optician marks the edge of the two lenses and maintains this alignment during polishing and testing. It is important to keep the wedge always aligned in the same position throughout the polishing and testing stage. If any defect is seen, the optician will know it is on one of the surfaces and not caused by the wedge in the glass. The optician did not mark the 20-inch lens very clearly, either by a line on the edge or using an internal defect in the glass, like a bubble or seed.

The lens cell repair took about a month. During that time, the team reviewed the first results and decided to run a series of tests to find the best alignment of the lenses. We placed the lenses back into the cell. The outside surfaces were marked with masking tape. The clocked positions were recorded. The lens was loaded into the chamber. We used the interferometer as a guide to find the perfect alignment. The crown element was the best choice to rotate. This was done by hand, just like the hour hand on a clock. The fringe changes were observed and recorded at each position. After a few hours of rotating, we discovered a position that gave us the best optical performance.

We locked the lens in this position and removed the air in the chamber using the vacuum pump. Air currents inside the chamber disturb the fringes and we were not able to see the small defects in the lens. The best way to describe this effect is like seeing the hot air rising from a heated road or what makes the stars twinkle at night. The hot air causes waves that distort the image between you and what is ahead. That is why telescopes need to be on high mountain tops or in space. The lens was tested under the best possible conditions.



"...we were amazed to see near perfect straight interference fringes. This was the signature of a great lens."

The vacuum pump took a few hours to remove all the air inside the chamber. As the air became thin, we were amazed to see near perfect straight interference fringes. This was the signature of a great lens.

The Final (technical) Result

The lens's overall performance (shape of the wavefront) is <1/3 wave Peak to Valley over 20 inches and <1/10 wave P-V over 18 inches. The smallest defect (smoothness) is < 1/20 wave RMS. With a Strehl Ratio of .93 See the interferograms.

Using these values, does the lens have the resolving power to meet the Rayleigh limit and the Airy disc requirements? These are calculated values used by an optical designer and an astronomer to describe the best possible performance of any telescope. The Rayleigh value is a number of how close two stars could be resolved and the Airy disc value is how much star light can be focused into the small *Cont'd on Page 5*

est possible diameter.

The 20-inch lens is slightly better than both these limits. In other words, if the air is clear and steady you would see the very fine details on any object. Using today's standards, a lens with a Strehl Ratio higher than .80 is a very good lens.

To meet the Rayleigh limit, 68% of the light from a star must focus inside the Airy disc. The 20-inch can focus about 75% of the starlight inside the Airy disc. This lens is capable of resolving objects to .28 arc seconds. However, the best conditions here at Chabot are rarely better than 1 arc second. An example of how good the 20-inch lens is, under perfect conditions you would be able to read a headline of a newspaper just over 3 miles away. Knowing that this lens was tested by eye, using a simple but effective star test, shows the great optical skill that Jim McDowell and John Brashear had.

I think the two quotes in a letters from John Brashear to Charles Burckhalter describe it best. "The lens is very valuable, no astigmatism, transparency is excellent, and absolutely free of striae" (a glass defect from manufacturing) "So splendid correction for spherical aberration (a design or polishing defect) certainly puts your lens in a high class, and as I telegraphed you, I believe it is equal to any 24-inch or 25-inch ever made. But "the proof of the pudding is in the eating" and that you can tell after you have tried it out."

If you have a chance to look though the 20-inch telescope on a very clear and steady night, you can see for yourself how good the lens is. Over the years we have seen many of the rings around Saturn, details of the clouds on Jupiter, close double stars that look like fine diamonds and a number of comets with fine details. The best of all are the ooh's and ahh's from people, who look though the scope, and sometime say, "It looks just like the pictures you would see in an astronomy book."✯

◂*Bob Schalk inspects and cleans Leah's 8-inch front element.*

Eastbay Astronomical Society

MEMBERSHIP APPLICATION FORM

(Please print clearly)

*Name:*_____

*Address:*_____

*City:*_____

*State/Zip:*_____

*Email:*_____

*Day Phone:*_____

*Eve Phone:*_____

☐ *Do not print address in Membership Directory listing*

MEMBERSHIP CATEGORIES:

☐ *Regular $24*
☐ *Family.....$36*
☐ *Contributing $40*
☐ *Sustaining .....$60 or more*
☐ *Student (digital newsletter only)...$10*

Optional discounted magazine subscription:
☐ *Sky & Telescope.....$29.95*
☐ *Astronomy.....$29.00*

Optional tax deductible donations:
☐ *Burns Library .....$_____*
☐ *General Fund .....$_____*

Total Enclosed: .....$_____

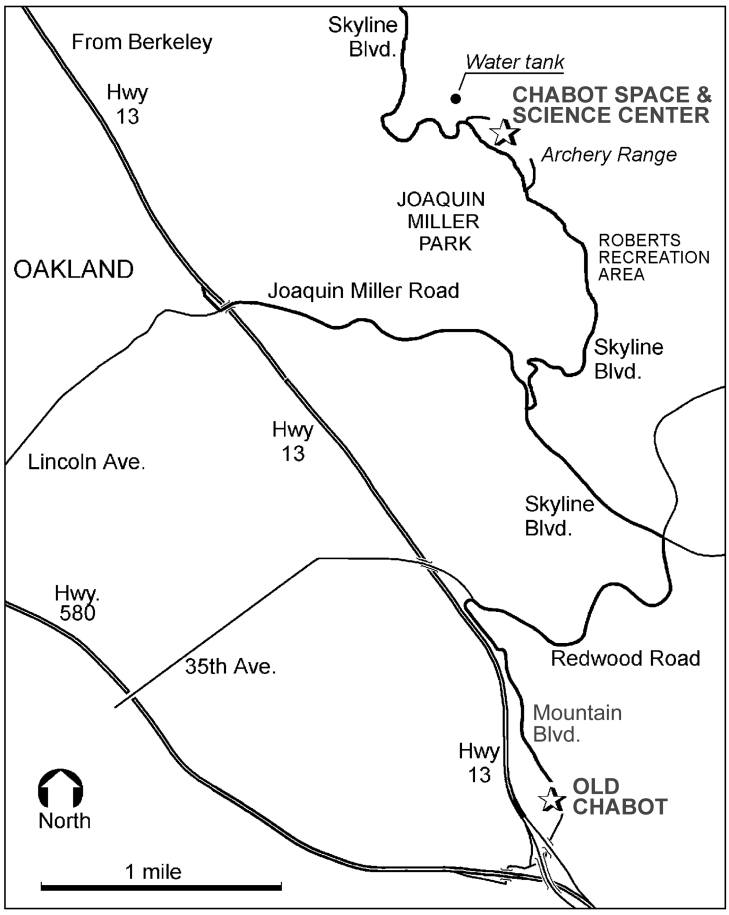
☐ *To help save the club money, I prefer to receive the newsletter in digital format.*

Please mail this form and your check or money order payable to:
Eastbay Astronomical Society
19047 Robinson Road
Sonoma, CA 95476-5517

For more information, contact Treasurer Don Stone at:
(707) 938-1667, or ddcstone@earthlink.net, or the address above.

Eastbay Astronomical Society

At Chabot Space & Science Center
10000 Skyline Boulevard, Oakland, CA 94619
July 2002



FUTURE CONJUNCTIONS

June 29 2-5pm EAS Library work party
July 10-15 Shingletown Star Party
12 7:30pm EAS Board Meeting, Chabot
20 7:30pm EAS Meeting, Chabot
Aug 8-13 Tri-Valley/EAS Barcroft High Altitude Star Party
17 7:30pm EAS Meeting, Chabot
(No EAS Board Meeting this month)

Eastbay Astronomical Society

President:	Carter Roberts	(510) 524-2146
		cwroberts@earthlink.net
Vice President:	Phil Crabbe II	(510) 655-4772
Treasurer, Membership:	Don Stone	(707) 938-1667
		ddcstone@earthlink.net

Articles and photos for *The Refractor* are encouraged. Deadline for the August issue is August 7, 2002. Items may be submitted by mail to the editor, Don Saito, 3514 Randolph Avenue, Oakland, CA 94602-1228. Internet email address: donsaito@pacbell.net. Day: (510) 587-6052 Eve: (510) 482-2913.

Join the Eastbay Astronomical Society

❑ Regular, $24/year
❑ Contributing, $40/year
❑ Sustaining, $60/year or more
❑ Family, $36/year
❑ Student, $15/year (digital newsletter, only

Contact: Don Stone, EAS Membership Registrar
Telephone: (707) 938-1667 Email: ddcstone@earthlink.net
Mail: 19047 Robinson Road, Sonoma, CA 95476-5517