L726–8A, are flare stars. It seems that all contracting stars of low mass exhibit the flare phenomenon. Possibly, the flare phenomenon is caused by the fast contraction of the stars of low mass. In conclusion, we may say that all intrinsically faint stars which are very red in colour are most probably degenerate stars of very low mass.

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SILVERING METHODS AT GREENWICH 1900–1956

By E. G. Martin

The installation of a 30-inch reflector on the Thompson Equatorial in 1897 brought into use a large silvered mirror. Prior to this the only large mirror in use was the 24-inch Lassell, and this was a speculum mirror.

When in use, no large mirror would retain its efficiency for much more than nine months. By 1906 a large power station was being built near to the Greenwich meridian, and gradually in other directions, except the South, new and larger power stations emitting smoke and grit came into operation. In addition, the atmosphere received increasing amounts of chemicals which were deleterious to silver coatings. Methods had, therefore, to be devised for rapid resilvering, especially as the 30-inch was also the counterbalance to the 26-inch refractor, and the dismounting of the mirror put the refractor out of commission also.

A trial was made of recoating the mirror by sending it to a local commercial firm who used a spray process, but this was only a partial success. In any case it was accompanied by considerable danger to the mirror, as the staircase from the dome to the ground was very narrow, and no lifting tackle was available. The uncrated mirror weighed 265 lb.

While the reflector was employed on cometary and nebular photography it was only used intermittently, but from 1920 a programme of effective wavelength work was in progress, and in 1926 the work on colour temperatures of stars began; this was continued until the more efficient 36-inch Yapp reflector became available in 1934. During these programmes, both of these large mirrors were silvered twice each year, generally in April and September. The other mirrors requiring recoating were the secondary mirrors of 7 to 11-inch diameter, the smaller ones for the spectrohelioscope, and the 16-inch mirrors for the eclipse coelostats. These smaller mirrors were handled in the photographic darkroom, which was not an ideal place; but no other silvering room existed until one was designed and built as part of the Yapp building.

The preparation of the large mirrors for recoating seems now to have been an extraordinary proceeding. Many things then deemed vital were later discarded and indeed were contrary to the most satisfactory result. It is true that a waxed paper band was tied tightly around the mirror but between the paper band and the mirror there was inserted a thick layer of folded blotting paper, and this was sealed from above with extreme care by running in molten paraffin wax to ensure a complete seal. The central hole of the mirror was plugged with a wooden plug surrounded with crepe rubber. This preparation sometimes took a day or more and was later almost completely discarded with no ill effect. In fact, any leakage which took place allowed sludge to drain away and avoided its deposition on the mirror surface.

There are a number of processes for the silvering of mirrors, and operators are inclined to stick closely to the one they find most successful. Exact measurement of ingredients does not necessarily ensure good results. Brashear tried several methods after a first disastrous attempt, and it is his proved method, with slight modifications, which was used at Greenwich.

The materials required were:

Distilled water	100 c.c.
10 per cent solution Silver nitrate	20 c.c.
10 per cent solution Potassium hydrate (caustic potash)	10 c.c.
25 per cent solution Ammonia 0·880	10 c.c.
Sugar solution	10 c.c.

The sugar solution, which was made up much earlier, was composed of:

Distilled water	2000 c.c.
Loaf sugar	180 c.c.
Nitric acid	8 c.c.
Alcohol	350 c.c.

The nitric acid in the sugar solution appears to be necessary as an activator to start the fermentation process. The alcohol can be obtained in the form of surgical spirit.

When silvering was due to take place, the liquids were mixed as follows. In order to deal with smaller quantities and thus control the chemical reactions, the distilled water was measured out into a separate pail. This enabled the remaining chemicals to be dealt with in a large stoppered bottle, which could be easily shaken and held up for observation of the reactions. Into this bottle was poured the silver nitrate, and any reaction was a detection of impurities in the bottle. Then the ammonia was slowly added until the mixture cleared, avoiding excess with great care. The addition of the potassium hydrate produced heavy fumes and the solution was carefully cleared by the addition of small quantities of ammonia. Finally, a little silver nitrate was added to leave some in suspension, and the resulting solution can be described as straw coloured. This solution, when poured into the distilled water, was ready for silvering, needing only the sugar solution to be poured in at the last moment to cause the precipitation of the silver on to the surface of the mirror.

When silvering was finished, any remaining mixture was carefully handled, heavily diluted and poured away. To retain any was to invite an explosion such as that which took place at Pasadena. At high temperatures an unstable fulminate forms, and the slightest disturbance is liable to set off an explosion.

As experience grew, many improvements were made. In the early days 10,000 c.c. (18 pints) of silvering solution were used to coat the mirror once, whereas later 6000 c.c. only were used to coat the larger 36-inch mirror twice. A trial was once made of treating the cleaned glass surface with stannous chloride, but this process seemed to have no particular advantage and was not tried again. Instead, a very small amount of rouge was used as an indicator that every part of the surface had been cleaned. Warming the surface with warm water immediately before silvering had a good effect on the deposition of silver and was always carried out in cold weather. When the silvering room was available for the 36-inch mirror, the warming up of the room all night previous to silvering was found to be very helpful.

The moment to decide when the coating was thick enough, and to drain off the expended solution was always a tricky one, and depended on experience gained previously. The mirror was then washed clean by swabbing with cotton wool pads, care being taken not to scratch the surface, and then blotted off quickly with clean soft linen cloths. When thoroughly dry, the silver surface was buffed with a clean chamois leather pad stuffed with cotton wool, to smooth the silver into close contact with the glass surface. This revealed also how clean the new surface was, for, if silvering had been carried on too long, the surface would contain a deposit of sludge and would require polishing with a pad impregnated with rouge; this would immediately begin to thin down the silvered surface. It was found that the ideal method of coating was to deposit a thin film of silver, then discharge most but not all of the solution, tip on a fresh solution and continue until a thick deposit was formed but not to carry on silvering until the blue coating turned white. Completely draining off the first solution appeared to stop the process, whereas the retention of a little seemed to make the process continuous.

Failure to obtain a good coating sometimes occurred in the earlier years, but rarely as experience was gained. The principal reasons for failure were too high or too low temperature, an excess of ammonia in the solution and stale or impure chemicals. Purchase of the chemicals through reputable firms resulted in purer supplies. Beakers and other vessels used in silvering were put away after use uncleaned. They were cleaned chemically immediately before a silvering session. The sugar solution was slow in action if made up too recently, and a good stock at least six months' old was always kept in hand.

As silvering was a process dislocating to telescopic observing, it was natural to attempt anything to keep the surface in a good condition. If a mirror became heavily dewed it was no longer efficient; the surface viewed edge-on showed a glittering array of small pieces of silver which had been lifted up by moisture penetrating below. To avoid this the mirror was made as airtight as possible when closed, by having a flexible rubber band around the edge protruding about half an inch, and a plate glass lid which could be closed down upon this to cover the mirror. Also the central hole of the mirror held a container like a plug having within it a desiccator. The mirror was unlikely to dew during observations, being protected by a solid tube for a sufficient distance. It is the variation from air near freezing but dry, to some 20 degrees warmer but very moist, which is so difficult to control in connection with a large solid mass of glass. The 36-inch mirror is 7 inches thick and weighs 650 lb.

A few of the smaller mirrors had their silver surfaces protected by coating with a shellac varnish. This was put on evenly by spinning the mirror on a turntable during varnishing, a process suggested to us by F. J. Hargreaves, but I do not remember any mirror larger than 7 inches in diameter being so treated.

When the Yapp reflector was erected in 1934, a good silvering room was included as part of the building. Large windows gave a good light and the floor was lead-covered, leading away to a drainage sink. The mirror and cell could be lowered from the telescope on to a trolley and pushed into the silvering room. These methods enabled lowering of the mirror and cell on one day, and resilvering and replacement on the telescope on the following day, thus losing only one possible observing night.

After 1945 the process of aluminizing large mirrors, which gave higher reflectivity in ultra-violet light, made the silvering of large mirrors at Greenwich out of date, but the early coatings left much to be desired. In consequence the 36-inch mirror reverted to silvering until 1956. In 1957 the telescope was removed to Herstmonceux where a vacuum chamber was available nearby.

Although the aluminization of mirrors owned by amateurs is now commercially possible, the silvering of their own mirrors at home is still an economic proposition.

The devising of the methods described above was mainly due to C. R. Davidson, F.R.S., when in charge of the Thompson Department up to 1937, assisted by the author who carried on these methods until silvering was no longer done.

ON THE CENTRAL PEAKS OF LUNAR CRATERS

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R. B. Baldwin[1] has noted that many of the so-called "central peaks" are not placed centrally in the lunar craters. He suggests that "this eccentricity is a measure of the angle of impact of the object which produced the crater". We wish to propose a different solution, based largely on the same data.

Baldwin listed ninety-one craters with eccentrically placed interior eminences. Using the *Orthographic Atlas of the Moon*[2] we determined the rectangular coordinates of (*a*) the centre of each crater, with reference to its bounding ringwall, and (*b*) the centre of its interior block. The centre of a complex block was judged by eye. Ten craters were rejected because of poorly determined positions, or because the positions of (*a*) and (*b*) did not differ appreciably.

Lines and arrows were plotted on an orthographic chart (Fig. 1) to indicate the position of a crater and the direction "centre of crater → centre of block", for each of the remaining eighty-one cases. According to the hypothesis of Baldwin, these are the projections on the Moon's surface of the trajectories of the meteorites that produced the craters and central peaks.

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