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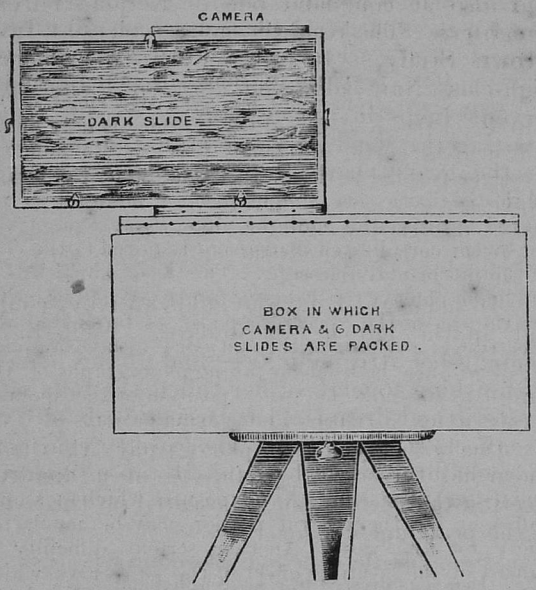
further. If this movement has been to the *left*, the *right* end of the dark slide is inserted, and the view which has previously been carefully focussed taken. The sketch shows the camera in this position, with the dark slide inserted.



The shutter of the dark slide being in two pieces, the exposing of half the plate at a time is not difficult. Now move the camera 1½ inches from the centre to the *right*, and insert the *left* end of the dark slide, and expose, due care being taken that both exposures are the same. Prints from negatives so taken require no transposing, and can be trimmed and mounted without being divided.

Two negatives thus taken are sent by post; it will be seen that prints for these require no transposing.

[These negatives were shown at the last meeting. *Eds.*]

SOLAR PHOTOGRAPHY.

By C. Michie Smith, B.Sc., F.R.S.E., F.R.A.S.

Solar photography is employed mainly for two purposes—for obtaining pictures, day by day, of the spots and faculæ, which are constantly changing, and for recording the phenomena which become visible only on the comparatively rare occasions of total eclipses of the sun. I propose to deal with only the former of these to-night, as the latter will more suitably form the subject of discussion when arrangements are being made to observe our next Indian total eclipse of the sun on January 22nd, 1898.

Before the introduction of photography for the purpose of recording sun-spots, much valuable work had been done by Carrington and others by means of eye observations. The positions of the spots were fixed by actual measurement and the details of the more important spots were sketched in by hand. This work was very laborious, for the details of large spots are usually most complicated, and none but a trained artist need expect to be able to produce a picture of any real value. The sketches are best made from an image of the sun projected on a cardboard disc, and for this purpose any telescope of moderate power can be employed. If we substituted a photographic plate placed in a camera for the screen we would not get a clear photograph, since telescopes intended for visual purposes are not usually corrected for the rays which are most efficient photographically. This is a difficulty which can be got over to a certain extent by finding the actinic focus by experiment and focussing accordingly, and many years ago very fair solar photographs were taken with the 8-inch Troughton and Simms' equatorial of the Madras Observatory during a search for the supposed planet Vulcan. Rutherfurd of New York was probably the first astronomer to make a telescope specially adapted for astronomical photography and he obtained results of a very high class. Rutherfurd's telescope was used simply as a photographic camera with a lens of 13 inches aperture and a focal length of about 16½ feet. But even with this the pictures of the sun were only 1¾ inches in diameter, and it was necessary to enlarge them before the minor details could be seen.

To overcome this difficulty De La Rue, in 1857, designed the instrument known as the "Kew Photoheliograph," of which the instrument which you have seen to-night is the modern form. It is the same in its essential features and hence it is best to describe this form. It consists essentially of a photographic objective of 4 inches aperture and 5 feet focal length and an enlarging lens which throws a magnified image of the sun on the sensitive plate. The lenses and camera are, of course, connected by a tube, and for convenience this tube is mounted equatorially so that it can follow the diurnal course of the sun by a single motion. A driving clock is also provided, which is so adjusted that it would make the telescope turn completely round from east through west to east again in a solar day, and hence if the instrument is pointed to the sun and the clock started it will continue to point to the sun so long as the clock is kept going. This driving clock is by no means essential since the exposures are only a small fraction of a second, but it is a convenience especially in cloudy weather when one has to take advantage of a break in the clouds to get an exposure. In fine weather it is probably best not to use the clock (except when focussing), but to clamp the telescope a little ahead of the sun and make the exposure when the sun reaches the right place. The moment for making the exposure is easily determined by noting where the image of the sun formed by a small lens fixed outside the tube falls on a cross drawn on a piece of paper placed at its principal focus.

To make it possible to determine from the photograph the positions of the spots on the sun it is necessary to have a fiducial line or lines on the plate. In this instrument two spider lines at right angles to each other are stretched across a diaphragm

at the principal focus of the large lens and photographs of these appear on each plate. The exact orientation of these lines can be determined by taking two photographs on the same plate at a short interval of time with the clock stopped. A line joining the two points at which these circles cut each other is evidently at right angles to the direction of motion of the sun's centre on the plate. The direction of the sun's motion is of course known, and hence the directions of the spider lines can be easily determined. Further, the position angle of the sun's axis and the longitude of the sun's centre can be calculated for any given time, and hence if we know the time at which the exposure was made we can, by the help of the lines, place the photograph on the measuring engine with its axis in any required direction, so that the solar latitudes and longitudes of the spots can readily be tabulated.

The shutter used with this instrument is a very rough and, to my mind, unsatisfactory one. It consists of a brass plate in which there is a slit, the width of which can be adjusted by means of a screw. This plate is placed in a slot nearly at the principal focus of the object glass and is actuated by a strong spiral spring. This form of shutter is nearly as old as the instrument and might with advantage be replaced by one of more modern design. Personally I would prefer a shutter which was placed outside the object glass and connected with it only by a black cloth tube which would not conduct the vibration to the instrument. Instruments of the kind I have described are in daily use at Greenwich, Mauritius, and Dehra Dûn, and there are very few days in the year on which photographs of the sun are not obtained at one or other of these places.

Solar photographs are, of course, taken at many other observatories, and at some of these, as at the Lick Observatory, no magnifying lens is used. In such cases it is necessary to have a lens of great focal length if a reasonably large image of the sun is to be obtained. The lens used at the Lick Observatory is of 40 feet focal length, and to simplify the use of such a long camera the arrangements are modified. The telescope, or camera, instead of being mounted on a stand is placed horizontally with what would be the eye end in an ordinary telescope inside a dark room. The image of the sun is reflected into the telescope by what is called a heliostat, which consists of a large plane mirror so mounted and driven by clock-work that the beam of light is reflected in a constant direction. The mirror consists of a disc of unsilvered glass, the two faces being slightly inclined to each other so that the beam of light reflected from the back surface will be thrown quite away from the lens of the telescope. The photograph is in this case taken in the principal focus of the lens and is nearly 4½ inches in diameter. Much is to be said in favour of this form of photo-heliograph, for the magnifying lens is always a source of trouble in the Kew form. The chief difficulty is said to lie in the shutter. Where a narrow slit is used diffraction effects will be produced unless the shutter is placed at the principal focus of the lens. This of course cannot be done exactly with the Lick form of instrument, but a focal-plane shutter might, I think, be so arranged that no sensible injury would be caused to the definition, or a shutter might be used which had a large aperture but moved with a correspondingly high velocity.

For the Kodaikanal Observatory a lens has been ordered of 6 inches aperture and 40 feet focal length. It is proposed to mount it in a somewhat different form from what has been described. The latitude of the Kodaikanal Observatory is only about 10½ degrees north, and hence it is easy to mount a telescope parallel to the earth's axis. The advantage of this is that a very simple form of heliostat is required to direct the sunlight along it, instead of the somewhat complicated instrument required in the case of the horizontal telescope. The Kodaikanal lens is intended chiefly for forming an image of the sun on the slit of the spectroscope so as to enable the spectrum of any part of the sun's disc to be examined, but it will also be used for taking photographs of the sun so as to show the exact position of the spots or faculæ which have been under examination.

One difficulty in solar photography arises from the great difference in brightness between the centre and edge of the sun. An exposure which is amply sufficient for the central portion may be much too short for the rest. Another serious difficulty is caused by the heating effect of the sun's rays which renders the atmosphere unsteady and also changes the focal length and even the shape of the lens. So far as my experience goes, really good solar photographs are very rare though photographs good enough for the measurement of sun-spot areas are common. Personally I am inclined to think that the best photographs will be obtained in the principal focus of a lens of long focal length, but I must say this is by no means the opinion of all astronomers. I hope, however, at Kodaikanal to give both systems a thorough trial under favourable conditions.

I have so far said nothing about the plates to be used, and I regret to say this is a point on which I am not at present able to say anything very definite. At Dehra Dûn and some other places wet plates are still employed, but dry plates are used at Greenwich. The plate to be suitable must be very slow and as fine grained as possible, and it seems probable that some of the plates made for process work would be very suitable The development should be very slow so as to bring out the details of the solar surface, which are numerous and very fine, while the differences of brightness are comparatively small.

OUR HOME LETTER.

Like a hardy annual which appears above the ground, flowers, and dies down again; or like an intermittent spring which now flows with full volume, then diminishes to a gentle trickle only to bubble up again in full force, when least expected, the debate on photography and art is almost always with us in some one of its aspects. There are plenty of men left yet,