mainder running out at the bottom, the equilibrium of the lever is destroyed, and in falling, it disengages a spring which rings a bell sufficiently loud to waken the keeper should he chance to be asleep. It may justly be questioned whe­ther this alarum would not prove a temptation to the keep­ers to relax in their watchfulness and fall asleep. There is another precaution of more importance, which consists in having always at hand in the light-room a spare lamp trimmed and adjusted to the height for the focus, which may be substituted for the other in case of accident. It ought to be noticed, however, that it takes about twenty minutes from the time of applying the light to the wicks to bring the flame to its full strength, which, in order to produce its best effect, should stand at the height of near­ly four inches (10cm∙). The inconveniences attending this lamp have led to several attempts to improve it; and amongst others M. Delaveleye has proposed to substitute a pump hav­ing a metallic piston, in place of the leather valves, which require constant care, and must be frequently renewed. A lamp was constructed in this manner by M. Lepaute, and tried at Corduan ; but was afterwards discontinued until some further improvements could be made upon it. It has lately been much improved by M. Wagner, an ingenious artist whom M. Fresnel employed to carry some of his improvements into effect. In the dioptric lights on the Scotch coast, a common lamp with a large wick is kept constantly ready for lighting ; and in the event of the sud­den extinction of the mechanical lamp by the failure of the valves, it is only necessary to unscrew and remove its bur­ner, and put the reserve-lamp in its place. The height of this lamp is so arranged, that its flame is in the focus of the Icnses, when the lamp is placed on the ring which supports the burner of the mechanical lamp; andas its flame, though not very brilliant, has a considcrable volume, it will answer the purpose of maintaining the light for an hour or two, until the light-keepers have time to repair the valves of the mechanical lamp. No occasion for the use of this reserve-lamp has yet occurred.

The lamp invented by Mr. Oldham of Dublin, appears, from the simplicity of its construction, to be very suitable for the purposes of a lighthouse ; and the writer of this ar­ticle is at present engaged in some experiments to ascertain the possibility of applying the pressure used in Mr. Oldham’s lamp to produce the same regular supply of oil to the con­centric burner, which is at present effected by means of the mechanism of the French lamp.

The divergence of the annular lens is greatly less than that of the parabolic mirror. It may be estimated in the following manner. Let Δ be the angle of divergence of any ray emerging from the lens, *l* the distance of the point **of** incidence from the principal focus of the lens, and *r* the radius of the flame, and we have sin. ∆ = r/l, and when Δ'

is made the angle of the effective divergence of the lens, we have ∆'= 2∆.

Adopting this rule we find the effective divergence of the lens to be about 5° 9,, which does not differ much from the observed divergence.

The manufacture of the dioptric instruments is not dis­tinguished by any peculiarity which requires special notice, the grinding and polishing being performed by means of powders gradually increasing in fineness, successively ap­plied as in the ordinary process of grinding glass. The union of the several zones which compose an annular lens is effected by means of small slips of thin copper, which hav­ing one half passed into a groove in one zone, and the other halt into a corresponding groove in the adjoining zone, pre­vent, in the same manner as a *joggle* in masonry, or a *chock* in carpentry, the one zone from slipping past the other. The pieces are also united by a glue which possesses the

important property of being able to resist the action of con­siderable heat, whilst it is by no means brittle. M. Fresnel intrusted the work of building the first lens to the late M. Soleil, optician to the king of France, to whose zeal and in­telligence he bears ample testimony in the *Memoire* in which he describes the invention.

In order to test the figure of the lenses, moulds carefully made may be applied ; or the lens being mounted on a stand which permits its being set at any angle, the accu­racy of the whole instrument, anil of each portion of it, may be separately tested by the form and size of the spectrum which is formed in the principal focus, by permitting the solar rays to fall upon the lens at right angles. When any particular portion is to be tried, the rest of the surface is co­vered with discs of strong grey paper or pasteboard. Another method may be employed similar to that already described as applicable to reflectors. This method consists in find­ing whether a small object placed in any point of the axis farther from the lens than the principal focus, has its image refracted accurately to a point on a screen placed in the conjugate focus which is due to that distance. The same principle of testing the instrument is also applied when a per­son stationed at a given short distance in front of the lens observes whether its whole surface be completely illuminated by a small flame placed in the conjugate focus corresponding to that distance. All that is necessary, therefore, is to deter­mine these distances by means of formulæ which express the relations of the distances of the object and its image. If δ re­present the distance of the eye from the lens, φ the principal focus, and φ' the distance of the conjugate focus corresponding

to the observer’s distance δ, then we have φ'= δφ/δ-φ

δ—*φ*

If, again, adopting the same notation, we wish to find the distance at which the image of an object placed at a given distance from the lens greater than that of the principal focus, should be accurately impressed on a screen, we have

δ = φφ'/φ-φ

The curved mirrors, as already mentioned, are, strictly speaking, generated by portions of parabolas having their foci coincident with the common flame of the system. In practice, however, they are made portions of a curve sur­face, ground by the radius of the circle which osculates the given parabola, and passes tangentially through the middle of the chord which subtends the arc of the mirror. These mirrors are plates of glass, silvered on the back, and set in flat cases of sheet brass. They are suspended on a cir­cular frame by screws, which are attached to the backs of the cases, and which afford the means of adjusting them to their true position in the lightroom, so that they may re­flect the horizon of the lighthouse to an observer’s eye placed in the focus of the system. In order to test the ac­curacy of the mirrors, recourse may again be had to the for- mulæ of conjugate foci ; thus, if we put *r* equal to the ra­dius of curvature of the mirror, *d* equal to the given distance of any object from the mirror, and *d'* equal to the distance of a moveable screen, which shall receive the true image of the object if the mirror be accurately formed, we shall have

for this latter distance *d'= rd/2d-r.*

The effect of an annular lens may be estimated at mo­derate distances to be nearly equal to that of 3000 Argand flames of about an inch diameter ; that of a cylindric refrac­tor at about 250 ; and that of a curved mirror may perhaps on an average be assumed at about 10 Argand flames.

A beautiful apparatus, which has received the name of the *catadioptric* light, from the compound action by which it is characterised, was another of Fresnel’s applications of