grees) is employed. No radius should be admitted which is much less than one third of the focal distance.

This process will be made plain by an example.

Experiments have shown, that in common crown-glass the sine of incidence is to the sine of refraction as 1∙526 is to 1, and that in the generality of flint-glass it is as 1∙604 to 1. Also that *dm*/*dm'* = 0∙6054 = *u*. Therefore *m —* 1 *dm'*

= 0·526 ; *m'-* 1 = 0∙604 ; *c =* \* = 0∙87086. By

m — 1

these numbers we can compute the co-efficients of our final equation. We shall find them as follows :

A=2∙0l2, B= 3∙529, C = 1’360, D = — 0·526, E=l∙8659.

The general equation (p. 155, col. 1, line 16), when sub­jected to the assumed coincidence of the internal surfaces, is Aj∑lS'-L+dT^-2.c + E + D — C = 0. A — C is *a- a , 1*

= 0·652, B + D — 2C is = 0·283, and E + D — C is = — 0·020 ; and the equation with numerical co-efficients is *—~τ~ —* ~~θ ~ ∙^~~~ — 0∙020 = 0, which corresponds to the

equation *px2* + *qx + r =* 0. We must now make *s ~-*

= = 0∙434, and *t = - ≡* = 0∙0307. This

0∙652 *p* 0∙652

1 0’434

gives us the final quadratic equation —, 00·0307

= 0. To solve this, we have —1/2*s* = 0·217, and 1/4s2 = — 0·0471. From this take *t,* which is = —0∙0307 (that is, to 0∙047l add 0∙0307), and we obtain 0∙0778, the square

root of which is = 0∙2789. Therefore, finally, 1/*a* = 0·2170 *a*

± = 0∙2789, which is either 0∙4959 or — 0·0619. It is plain that the first must be preferred, because the second gives a negative radius, or makes the first surface of the crown- glass concave. Now as the convergence of the rays is to be produced by the crown-glass, the other surface must be­come very convex, and occasion great errors in the com­puted aberration. We therefore retain 0·4959 for the

value of -, and *α = —* s≡ 2Ό166.

*a* 0∙49o9

To obtain *b,* use the equation ·£ = “ — 1, which gives

v = — 0∙5041, and therefore a convex surface. Therefore *b*

s=⅛⅛ι = 1∙9897∙

*a'* is the same with *b,* and -, = — 0∙5041.

*a*

To obtain *b',* use the equation -i- = — 4. u. Now ∕∕ α,

*u —* 0∙6054, and — — — 0∙5041. The sum of these is *<1*

0·1013 ; and since it is positive, the surface is concave. 4=τ⅛>=8β,2∙

Lastly, p = m — 1 — *u* (*m'* — 1) = 0∙1603, and P

= ÔÜ6Ô3 ~ 0·2383

Now to obtain all the measures in terms of the focal dis­tance P, we have only to divide the measures already found by 6∙2383, and the quotients are the measures wanted.

\_. . 2∙0166 „

Therefore *a =* = 0∙32325,

4=≡S=-°si79β∙

α'= -- =-0∙3l798,

\*=≡= P= -- = 1∙

If it be intended that the focal distance of the object­glass shall be any number *n of* inches or feet, we have only to multiply each of the above radii by n, and we have their lengths in inches or feet.

Thus we have completed the investigation of the con­struction of a double object-glass. Although this was in­tricate, the final result is abundantly simple for practice, especially with the assistance of logarithms. The only troublesome thing is the preparation of the numerical co-ef­ficients A, B, C, D, E of the final equation. Strict atten­tion must also be paid to the positive and negative signs of the quantities employed.

We might propose other conditions. Thus it is natural to prefer for the first or crown-glass lens such a form as shall give it the smallest possible aberration. This will require a small aberration of the flint-glass to correct it. But a little reflection will convince us that this form will not be good. The focal distance of the crown-glass must not ex­ceed one third of that of the compound glass ; these two being nearly in the proportion of *dm' — dm* to *dm'.* There­fore if this form be adopted, and *a* be made about 1/6th of *b,* it will not exceed 1/5th of P. Therefore, although we may produce a most accurate union of the central and marginal rays by opposite aberrations, there will be a considerable aberration of some rays which are between the centre and the margin.

It is absolutely impossible to collect into one point the whole rays (though the very remotest rays are united with the central rays), except in a very particular case, which cannot obtain in an object-glass ; and the small quantities which are neglected in the formula which we have given for the spherical aberration, produce errors which do not follow any proportion of the aperture that can be ex­pressed by an equation of a manageable form. When the aperture is very large, it is better not to correct the aberra­tion for the whole aperture, but for about 5/6ths of it. When the rays corresponding to this distance are made to coincide with the central rays by means of opposite aberrations, the rays which are beyond this distance will be united with some of those which are nearer to the centre, and the whole diffusion will be considerably diminished. Dr Smith has illustrated this in a very perspicuous manner in his theory of his Catoptric Microscope.

But although we cannot adopt this form of an object-glass, there may be other considerations which may lead us to prefer some particular form of the crown-glass, or of the flint-glass. We shall therefore adopt our general equation A B C D 1 r, „

— = ; + E = 0 to this condition,

α, *a* a∙i *a'*

Therefore let *h* express this selected ratio of the two radii of the crown-glass, making = *h* (remembering always that *a* is positive and *b* negative in the case of a double convex, and /1 is a negative number).

With this condition we have ∙τ = -. But when we make *b a*

*n* the unit of our formula of aberration, -7 = -—1. There- *o a*

1 Ä 1 1

fore 1 = , and - ≡ ι. Now substitute this for

*α a a* 1 — *h*

- in the general equation, and change all the signs (which still preserves it = 0), and we obtain