

LXVIII. *A Method of working the Object
Glasses of Refracting Telescopes truly spheri-
cal.* By the late Mr. James Short,
F. R. S.*.

Read Jan. 25,
1770.

PREPARE two plates or tools of brass, the one convex, and the other concave, being both portions of a sphere of the same radius as the focal length of the object glass you want to have, or rather of a radius somewhat longer than the focal length you want, for a dioptrical reason; let these plates or tools be between two and three times the breadth of the object glass desired; or, in long focal lengths, twice the breadth will be sufficient: let these tools be of a sufficient thickness in proportion to their breadth or diameter, and let them be ground with fine emery exactly true to one another, working them alternately, the one above the other, to preserve the same focal length; or, if it is desired longer, you must work the convex above the concave; or, if desired shorter, you must grind the concave above the convex.

After this, you prepare another brass-plate or tool, of the same breadth and thickness as the two former,

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and of the same radius of concavity ; its being truly turned on a lathe will be sufficient for this purpose ; which tool is to serve afterwards for the polishing of the two surfaces of your object glass, and therefore called the polishing tool.

Prepare a piece of straw-coloured glass, of the plate glass kind, of the proper diameter for the object glass you desire, which ought always to be broader than the proper aperture for that length ; let this piece of glass be ground flat, in another tool, on both sides, and as nearly parallel as may be, and somewhat polished, in order to discover whether there are any veins or flaws in the glass. When you are satisfied of the goodness of the glass, you are then to prepare a handle to fasten your glass to. Great care must be taken in this, for fear of bending your glass by the handle ; my method is this ; I take a flat piece of brass, or rather of the concavity of the sphere, to which the glass is to be ground ; this piece of brass should not be thicker than $\frac{2}{3}$ of the thickness of the glass, of a circular form, less in breadth somewhat than the glass itself, and having sides of the same form, at right angles to the flat piece of brass, and these sides ought to be of such a shape as that the fingers may easily apply to it in working, and these sides should be as low as may conveniently be, and no thicker than about $\frac{2}{3}$ of the glass. This handle is to be fastened to the glass, by warming the glass and handle gently before a fire, and laying some pitch upon the glass thus warmed, till it becomes soft like melted wax ; and then laying your brass handle, a little heated, on the pitch, you press it a little, till you are sure there is nothing between the
glass

glass and handle but pitch ; you then lay down the glass and handle upon something flat, taking care that the handle is in the middle of the glass, till it is entirely cold. It is very material to know, that the pitch, to be used for fastening the handle to the glass, must be soft pitch, that has never been used, nor melted ; for any other pitch will infallibly bend the glass.

You then grind your glass in the concave tool with emery, and give it the proper figure and smoothing for the last polish, in the common manner.

In order to give your glass the last polish, which is the most difficult part of the whole work, you are to prepare some pitch for covering the before mentioned polishing concave tool, which is done in this manner : Take some pitch, and melt it in an iron ladle, and let it boil for a quarter of an hour or thereabouts ; by this boiling, the pitch, when cold, will become hard and brittle ; or you may shorten this operation, by melting equal quantities of pitch and rosin, and then there is no occasion to let it boil so long. Your pitch being thus prepared, you again melt it, and take it off the fire, and let it stand till the pitch becomes pretty cold, or of a thickish consistence ; and having warmed the polishing tool a little, to make the pitch stick to it, you pour out of the ladle upon the polishing tool as much of the pitch as you judge will cover the whole tool, when spread out, to about the thickness of $\frac{1}{8}$ of an inch ; you then invert this tool with the pitch upon it, and press it upon the convex tool, which must be quite dry, clean, and cold, in order to give it the figure of the convex tool ; in case it has not spread out so as to cover the whole surface
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of the polishing tool, you warm the pitch by holding it before the fire, and pressing it upon the convex tool, as before, till it has entirely covered the surface of the polishing tool ; you then plunge it into cold water, till the brass is quite cold.

N. B. In order to know if your pitch is hard enough, you press the edge of the nail of your thumb upon it, and if it receives an impression, the pitch is not hard enough.

You then proceed to prepare this polishing tool, for the last polish of your glass, by grinding this polishing tool upon the convex tool with pretty coarse emery, and a small quantity of water, in the common way that tools are ground one upon another ; but this must be done only for a small space of time, and the polishing tool must have no other pressure than its own weight, for fear of some of the emery sticking in the pitch, and you must never allow the emery to grow dry ; when you have ground the pitch so as to be all over of the same colour, you then wash the pitch from all the emery with a brush and clean water ; after this you take a bottle of water, and holding the pitch tool in a sloping position, you pour water out of the bottle so as to fall upon every part of its surface.

You then place the polishing tool in a horizontal position, and you put upon it some putty, washed from all its gritty particles, but it need not be the finest washing, and you put a good deal of water upon your polishing tool, mixing the putty and it together, and you polish your glass upon this pitch polisher in the common manner of polishing glasses.

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After you have polished your glass about ten minutes, you again grind your polisher upon the convex tool with emery, as before, for fear the pitch has, by working, lost any of its proper figure; and the oftener you do this, the truer will be the figure of your glass; and in this manner you proceed till the glass is quite polished.

You then take your glass off its handle, by holding it before the fire, till it is so warm that you can slide the handle off the glass; and whilst the glass is warm, you take off as much of the pitch as you can with the sharp edge of a knife; you then lay the glass down to cool, and, when quite cold, you drop some spirits of wine upon it; and this, with a cloth, will wipe off the rest of the pitch.

You then examine the center of the surfaces of your glass; and if it lies to one side of the center of your glass, mark that place with a spot of ink, and then put on your handle as before, upon the side that is now polished, with its center over the spot of ink, and grind your glass as before, till the circular remaining part of the glass to be ground is as much distant from the center of the glass on the other side from the spot as the spot was from the center of your glass; you then by heat return your handle to the center of the glass, and proceed to grind and polish this side of the glass as before.

N. B. The concave and convex tools should be ground with fine emery, after you have done one side of your glass; for the oftener these are ground together, you will be the more sure of having your figure true.