



# ISTITUTO E MUSEO DI STORIA DELLA SCIENZA

## How to make a Galileian Telescope

### I. THE BASICS – THE PRINCIPLES OF OPTICS

A Galileian telescope uses just two lenses. The objective lens is *convergent* (plano-convex), the ocular lens is *divergent* (plano-concave). The ocular lens is placed on the optical axis so that its focal point coincides with that of the objective lens (**see Figure 1 – Optical Diagram**).

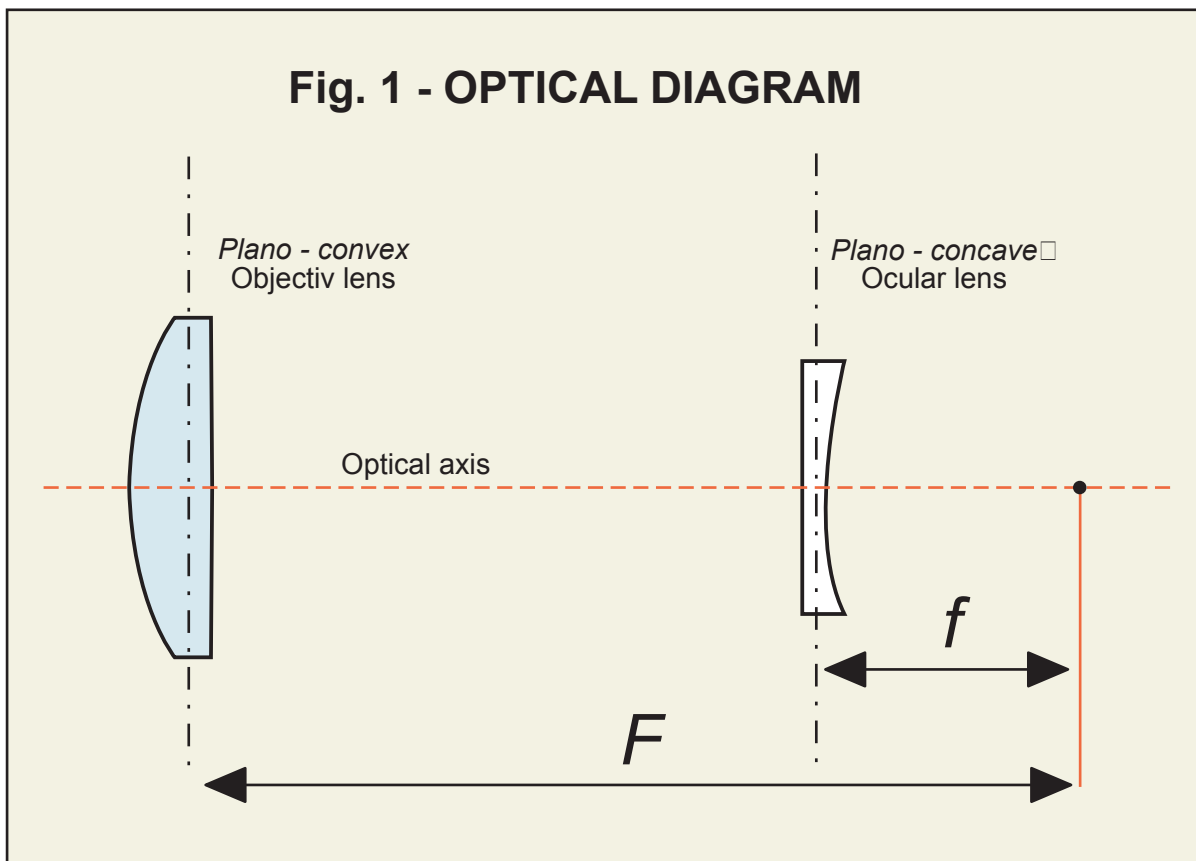
The image produced by the telescope of a faraway object is:

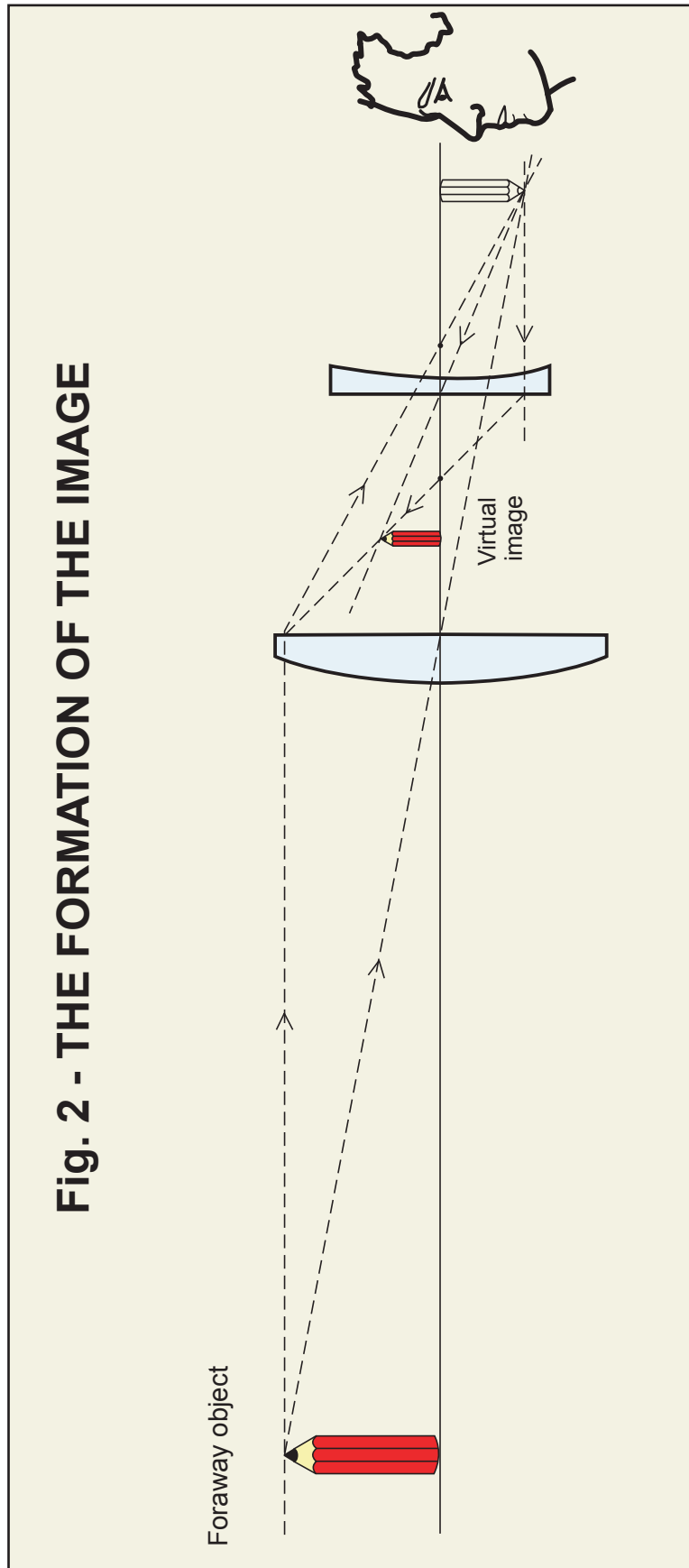
- *magnified* in proportion to the relationship between the focal length  $F$  of the objective lens and the focal length  $f$  of the ocular lens;
- *the right way up*, because the upside-down image produced by the convergent objective lens is turned the right way up by the divergent ocular lens;
- *virtual*, in so far as, in the optical diagram, the image comes from the other side of the ocular lens than where the eye is. The image is only able to be viewed because the observer has an eye to put against the eyepiece. The lens of the eye – which makes a third (convergent) lens – completes the optical system of the telescope (**see Fig. 2 – The Formation of the image**).

To make a Galileian telescope with easily available lenses instead of plano-convex and plano-concave lenses, you can use ordinary concave-convex spectacle lenses (one convergent for long-sightedness and one divergent for shortsightedness). While this option cuts costs, it will also reduce the optical

power of the telescope, both for magnification and the quality of the image, which will be distorted by spherical and chromatic aberration.

The telescope will not be of much use for astronomical observation: you'll be able to look at the moon and, if you're lucky you may get to see the satellites of Jupiter. **YOU SHOULD NEVER POINT IT AT THE SUN, AS THE CONCENTRATION OF ITS RAYS BY THE LENSES WILL DAMAGE THE EYE, AND EVEN MAKE YOU GO BLIND!** But the telescope can be put to use for non-astronomical observations.





## II. WHAT YOU NEED

### **2 spectacle lenses of 60mm diameter:**

- the first of +0.75 diopters (convergent, focal length about 133 cm);
- the second of –5 diopters (divergent, focal length –20 cm).

You can find these lenses easily in any shop that makes, rather than sells, spectacles.

### **2 cardboard tubes about 5 mm thick**

- the first with an internal diameter of at least 60 mm and length of 90 cm;
- the second with an external diameter of less than 60 mm and length of 60 cm.

With a little patience and luck, tubes like this can be found for free (using the insides of rolls of fabrics or household paper towels, etc).

### **1 piece of card about 1 mm thick.**

These materials will let you make a Galileian telescope which will magnify 6 or 6.5 times. The instrument will be about 81 cm long, telescoping out to about 120 cm.

## III. MAKING THE PIECES

With a hacksaw (or a good knife) cut the first tube into the following six pieces:

**A : *the body of the telescope*** – a piece 75 cm long;

**B : *the eyepiece*** – 6 cm long;

**C1, C2 and C3 : *ring pieces*** – three pieces 1 cm long. As they have to be put inside the *body of the telescope* A or in the *eyepiece* B, each *ring piece* needs to have a segment around three times the thickness of the tube cut out (for example, if the tube is 5 mm thick, roughly 15 mm needs to be taken out to reduce the diameter of the *ring piece* by 5 mm) (see Fig. 3 – **The Ring Piece**);

**D** : *eyepiece support* – 2 cm long. As the *eyepiece support* has to go inside the *eyepiece B*, it too must have a section removed like the *ring pieces C1, C2* and *C3*.

The second tube is ready as it is:

**E** : *sliding tube*.

Cut the card with scissors into the following pieces:

**F** : *objective lens diaphragm* – a circular ring with an external diameter of 6 cm and internal diameter (the opening) of 4 cm;

**G** : *ocular lens diaphragm* – a circular ring with an external diameter of 6 cm and internal diameter (the opening) of 1 cm;

**H1, H2, H3**, etc.: *strengtheners* – as many rectangles (2 cm × 30 cm) as you need.

(See Figure 4– The parts of the Telescope)

**Note:** If you're lucky enough to find a second tube that fits exactly into the first, and slides inside easily, you don't need to make pieces **D, H1, H2, H3**, etc.

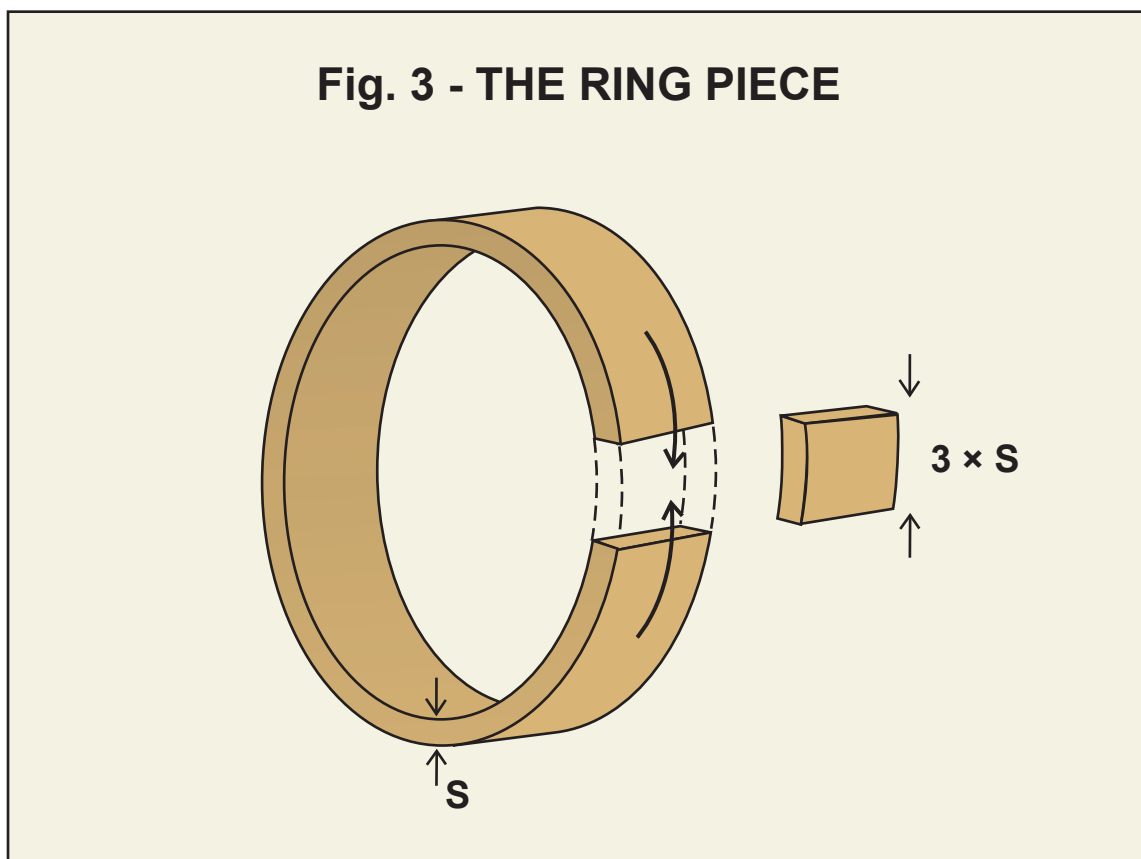
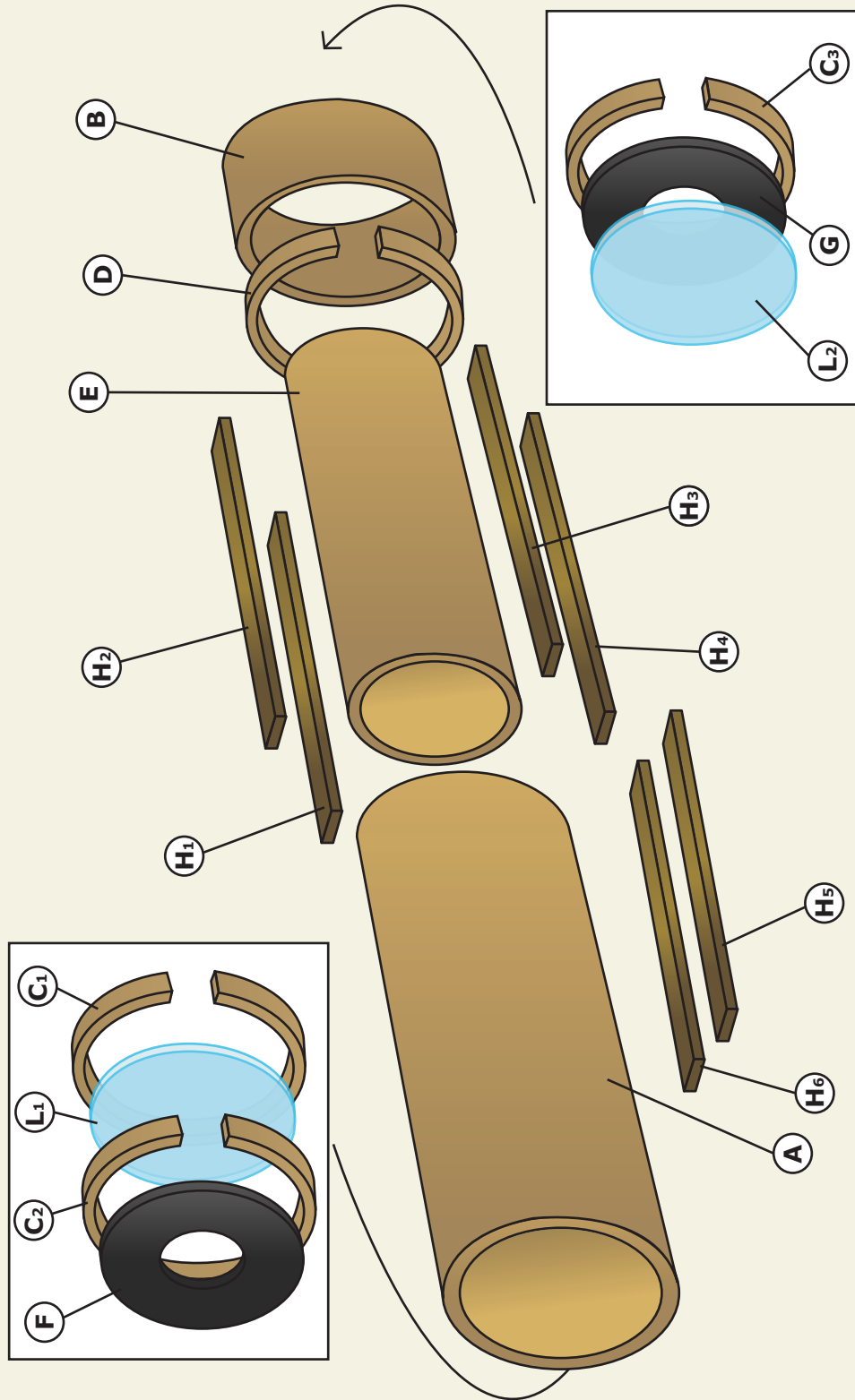




Fig. 4 - THE PARTS OF THE TELESCOPE



#### IV. ASSEMBLING THE PIECES

(see Fig. 5 – Cutaway view of the telescope)

##### **The main body of the telescope:**

Glue the *ring piece C1* inside the *body of the telescope A*, about 4 cm from one end. Then put the *objective lens L1* in, so that the convex side is on the outside. Secure the *objective lens L1* by gluing the *ring piece C2* inside the *body of the telescope A*. Glue the *objective lens diaphragm F* onto the *ring piece C2*.

##### **The sliding part of the telescope:**

Glue the *eyepiece support D* at the end of the *eyepiece B*. Glue the *sliding tube E* into the *eyepiece support D*. If the *sliding tube E* doesn't fit, file the *eyepiece support D* to make it larger. Conversely, if the *sliding tube E* goes in too freely, glue one or more bits of thin card, about 2 cm wide to its end, until you get a perfect fit.

Put the *ocular lens L2* into the *eyepiece B* so that the concave side is on the outside. Put in the *ocular lens diaphragm G*. Secure both the *ocular lens L2* and the *ocular lens diaphragm G*, gluing the *ring piece C3* into the *eyepiece E*.

Glue lengthwise the strengtheners *H1*, *H2* and *H3*, with the same amount of distance between them, at the end of the *sliding tube E*.

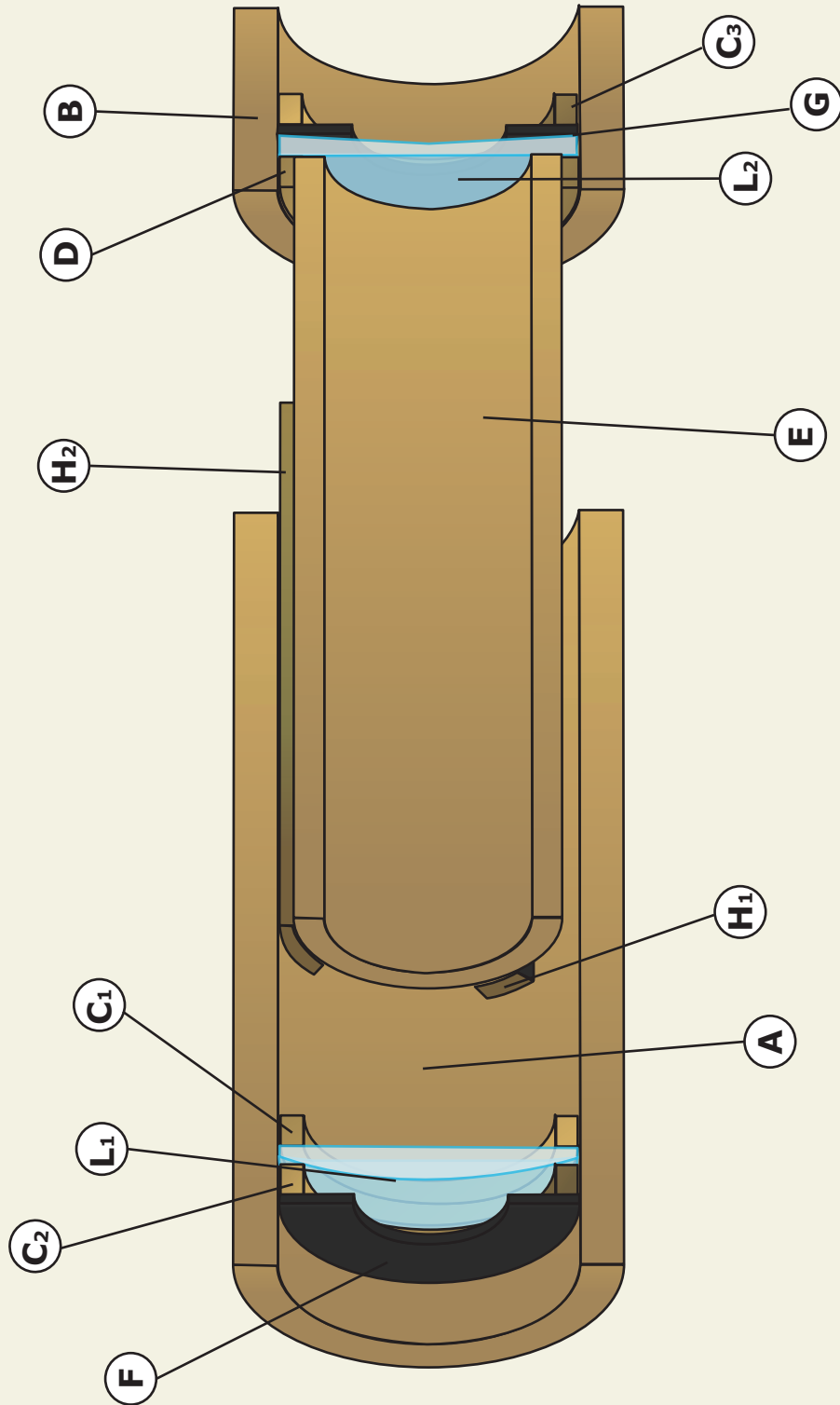
##### **Putting the telescope together:**

Check that the *sliding part* goes into the *main body* of the telescope. If it goes in too freely, glue on more *strengtheners H4*, *H5*, *H6*, etc., placing them exactly over the *strengtheners H1*, *H2* and *H3* that you've already glued there, until the two parts slide easily without too much play

**Nota:** If you're lucky enough to have the second tube fitting exactly into the first, glue the *sliding part E* into the *eyepiece support D*, pushing it in about 2 cm. To prevent the air trapped in the telescope from stopping you closing or extending it, put a little hole (for air release) into the first tube, just behind the *ring piece C1*.



**Fig. 5 - CUTAWAY VIEW OF THE TELESCOPE**







ISTITUTO E MUSEO  
DI STORIA DELLA SCIENZA

If you've followed these simple instructions, the telescope should now be complete. You can point it at a far-off object and pull out the *sliding part* from the *main body* until you get a clear and magnified image.

If the image does not appear clearly because of the poor lens quality of spectacle lenses, you could try to change the *objective lens diaphragm F* (4 cm opening), with a smaller aperture (down to 2 cm). The image will come out less bright, but more distinct.

Have fun!