Magic Test-tube

This experiment uses a test-tube filled with water to create an optical illusion.

You will need:-

A large test tube (boiling tube)
A short length of thin wire (e.g. 6cm long and 1mm in diameter)
Rubber bung to fit the test-tube
A printed copy of the word lists on page 2.

Method

1). Boil some water to remove any dissolved gases and allow the water to cool until you can comfortably put your hands in it.

2). Fill the boiling tube completely with the cooled, boiled water and insert the rubber bung. This can be quite difficult to do and is most easily achieved by:-
   (a) carefully pouring the water into a container which is large enough for the test-tube to lie flat with the rubber bung at the end
   (b) lie the test-tube horizontal in the container and allow it to completely fill with the warm water
   (c) hold the wire next to the bung and carefully insert the bung into the test-tube. (Fluids are almost incompressible and the wire creates a gap between the bung and the test-tube and so allows some of the water to leave the test tube as the bung is inserted.)
   (d) When the bung has been pushed in to the test-tube as far as possible, carefully pull the wire out from between the bung and the test-tube.

   As the water in the test-tube cools to room temperature, it will contract and pull the bung slightly further into the tube.
   The test-tube filled with water will now act as a cylindrical lens.

3). Place the test-tube flat on the word lists, so that words from both columns can be seen through the test-tube.
   Words from both columns should appear magnified and may be distorted.

4). Now lift the test tube away from the word list until the words in the right hand column are seen upside down.
   However, words in the left hand column are not inverted!

How does the test-tube manage to invert the right hand column of words but not the left??

Explanation

The test-tube filled with water acts as a cylindrical lens. When objects which are at least twice the focal length of the lens away from the lens are viewed through a cylindrical lens, they are inverted. So both columns of words are inverted. However, the words on the left hand side have been especially chosen so that they are the same whether viewed upside down or normally.

A normal (spherical) lens will not work in this manner since it will also laterally invert the object as well (swap left and right, as well as top and bottom)

BED	BAD
BEE	BELL
BECK	BLUR
BEDECK	BOSS
BIKE	BILL
BOB	BOY
BOOK	BLUE
BOOKED	CAB
BOX	CABLE
COB	CABIN
COD	CADET
CODE	CADRE
CODED	COLD
COED	CAKE
COOK	COOL
DIOXIDE	DREAM
EBB	ENTER
ECHO	ENTIRE
HIKE	HOPE
ICE	IDOL
KICK	KERNEL
OH	OAR
OK	OAK
OX	OAT
OXIDE	OUTER