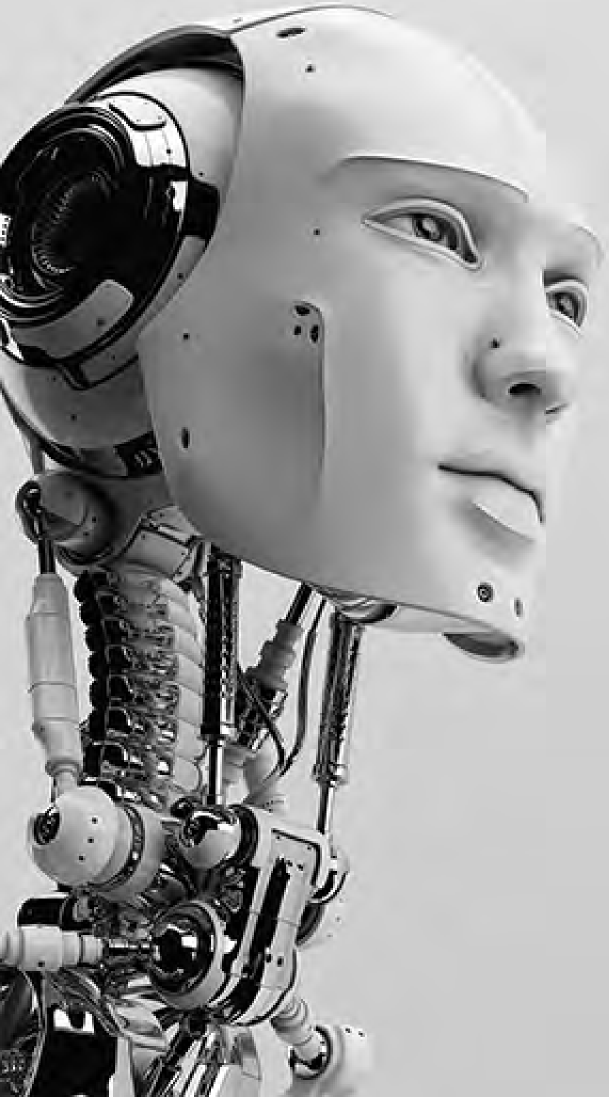
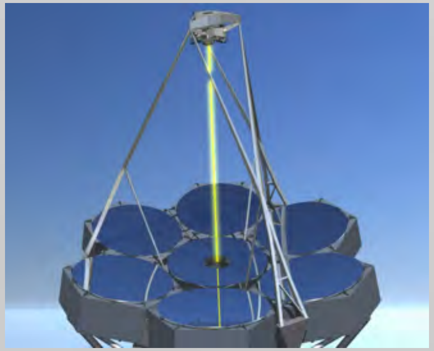
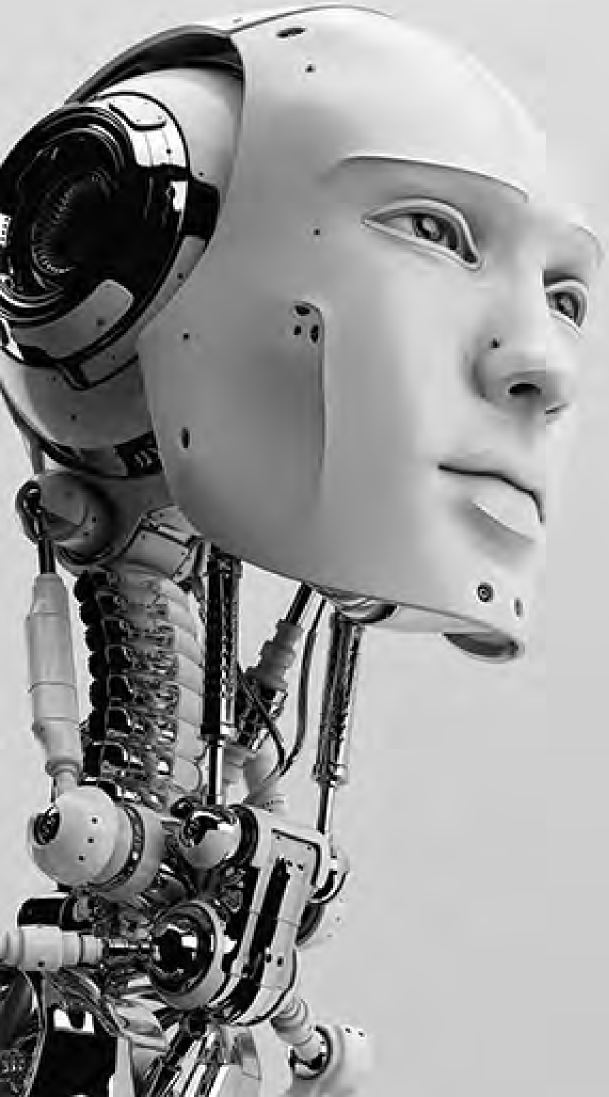


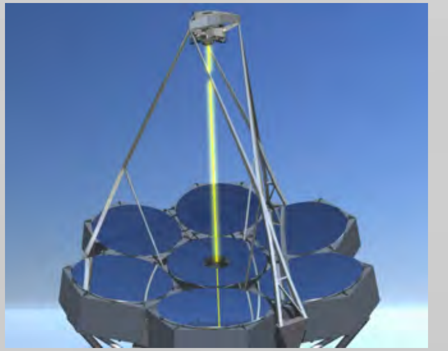
A Brief History of Lenses & Mirrors



THIS PRESENTATION

- WHAT IS A LENS
- SOME HISTORY
- CONSTRUCTION OF A SIMPLE LENS
- SIMPLE LENS TYPES
- LENSMAKERS EQUATION
- KEPLARIAN REFRACTING TELESCOPE
- GALILEAN TELESCOPE
- THE PROBLEM WITH LENS
- DOBSONIAN TELESCOPE
- MIRRORS





WHAT IS A LENS – SIMPLE DEFINITION

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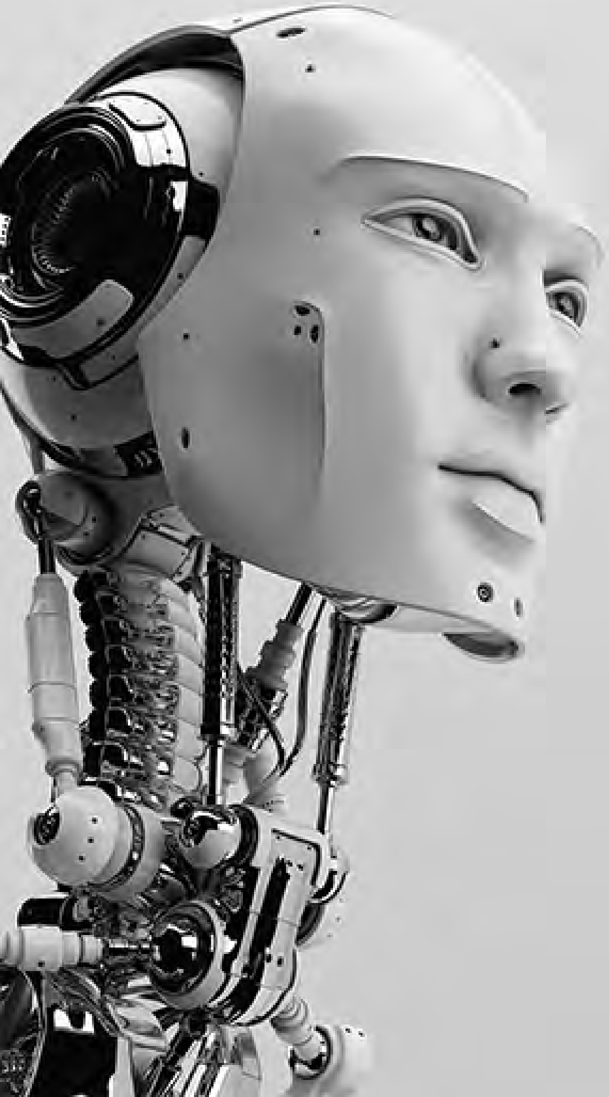

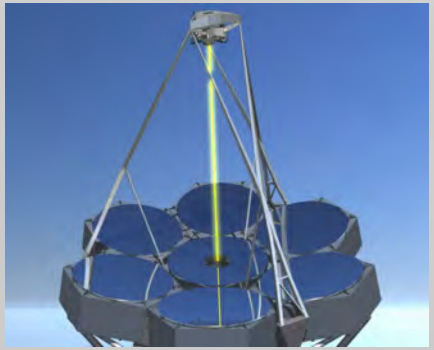

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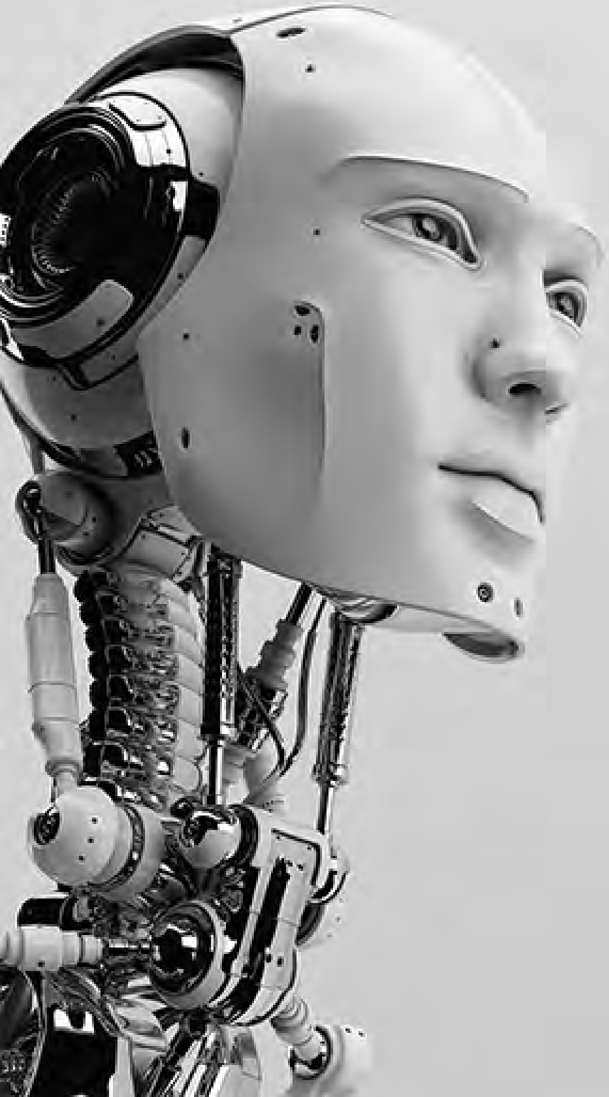

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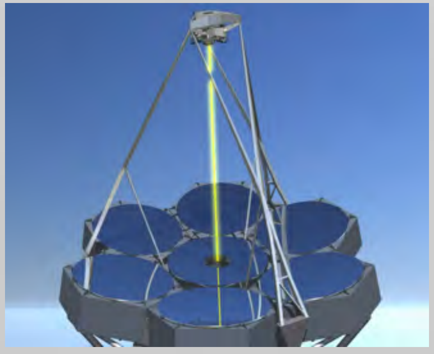

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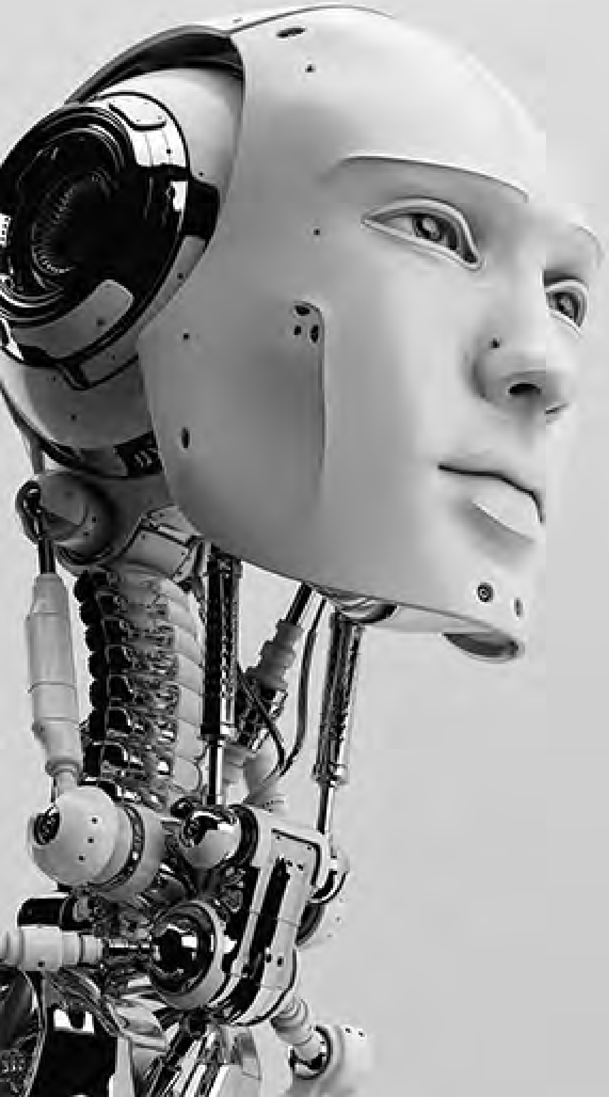

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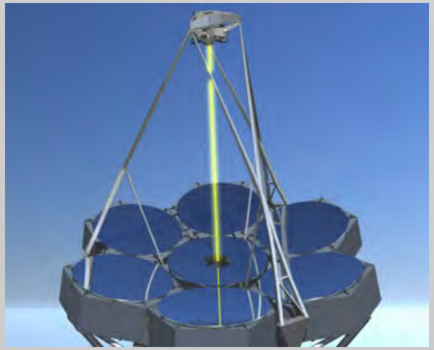

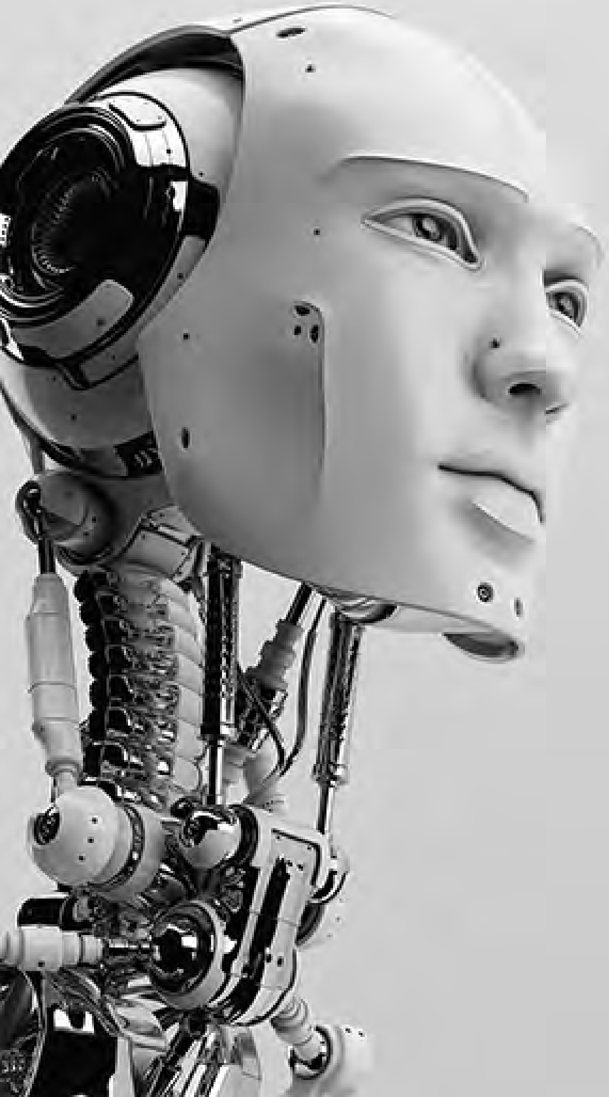

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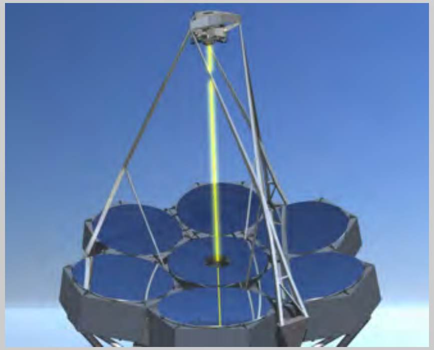
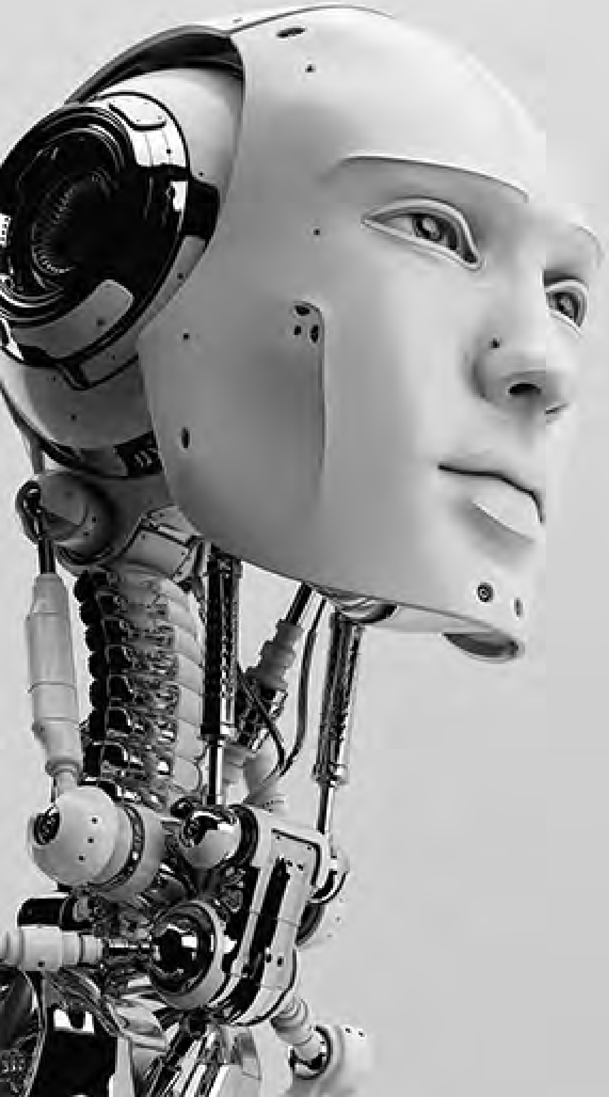
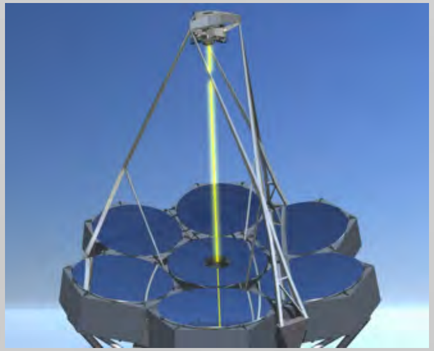
LENSES HAVE A FOCAL LENGTH AND ARE USED IN VARIOUS IMAGING DEVISES SUCH AS TELESCOPES, BINOCULARS, CAMERAS & GLASSES TO CORRECT EYE DEFECTS.



SOME HISTORY

THE WORD LENS IS DERIVED FROM THE LATIN AND IS THE WORD FOR THE SEED OF THE LENTIL PLANT.





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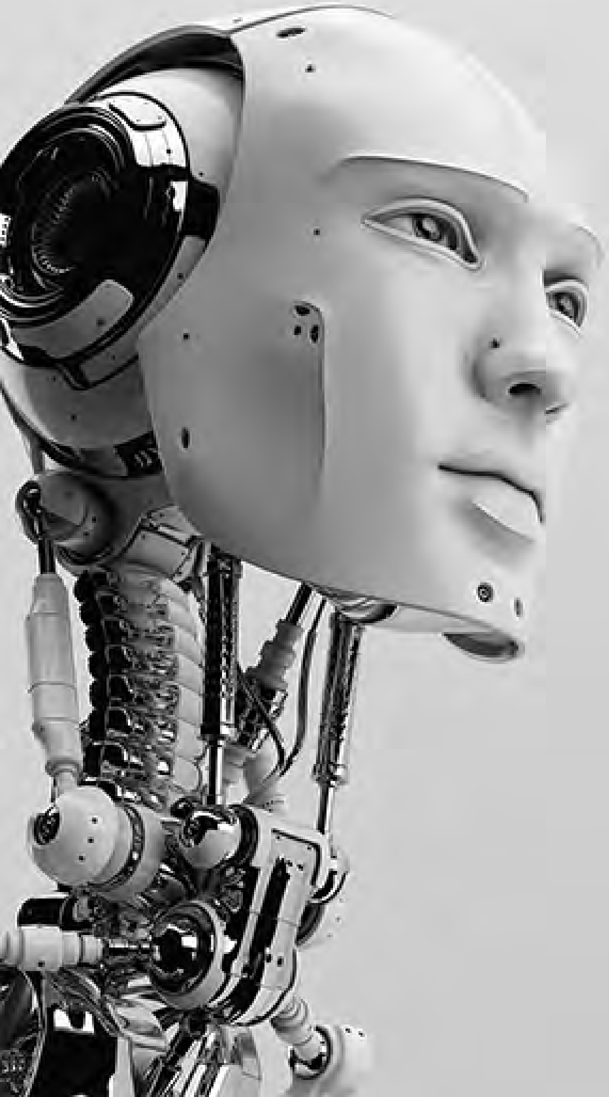

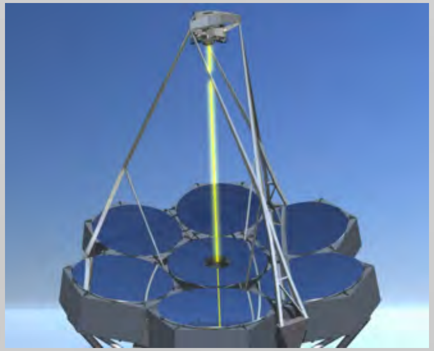

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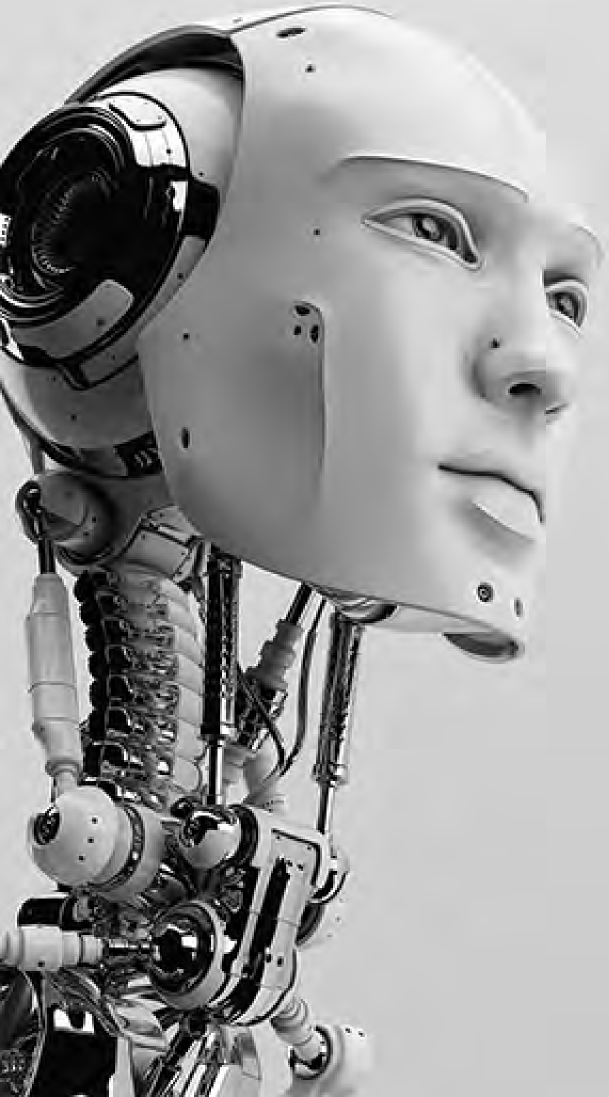

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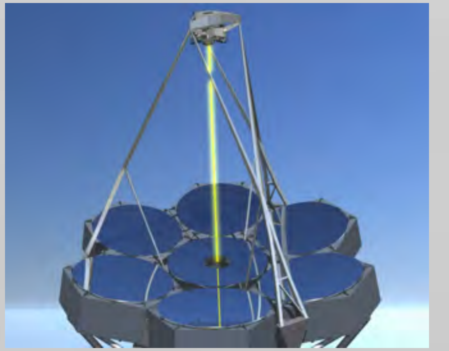

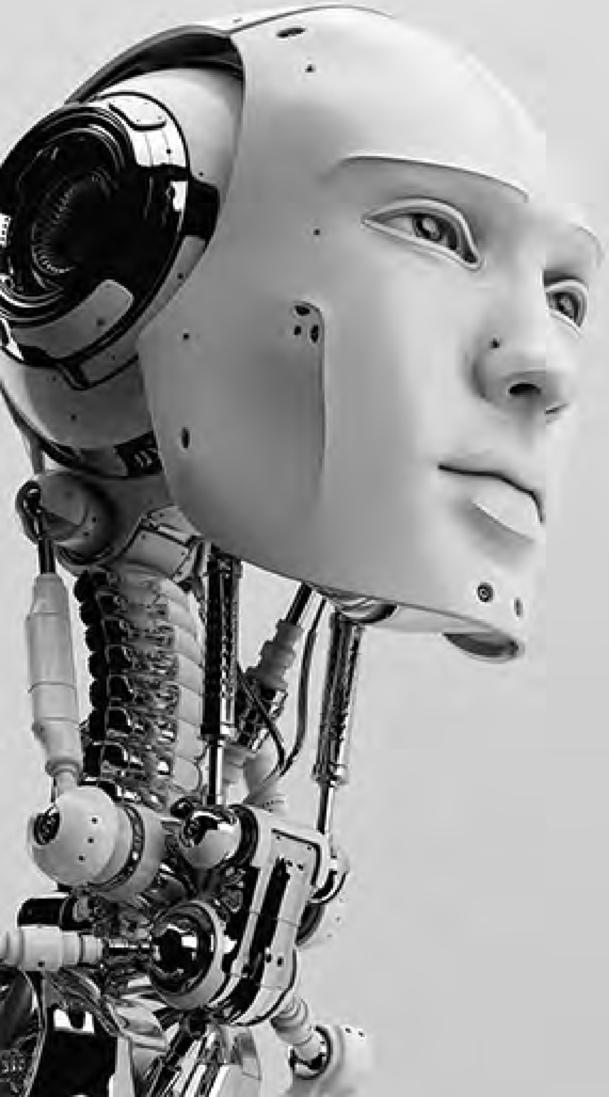

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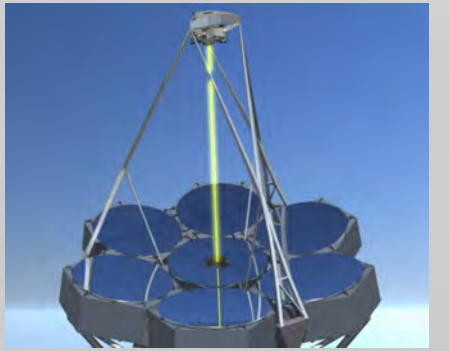
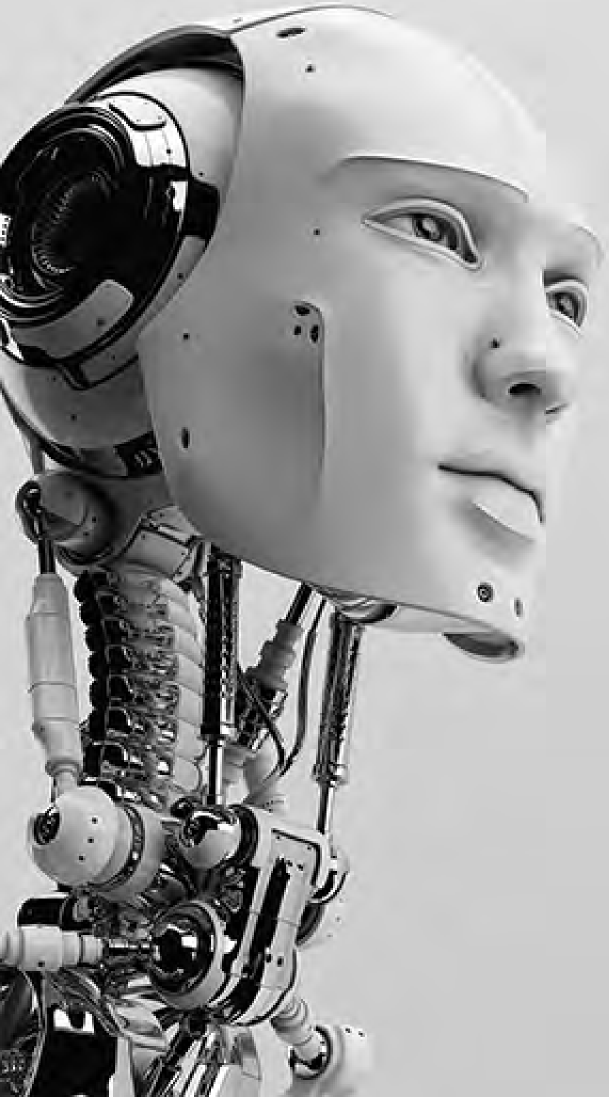
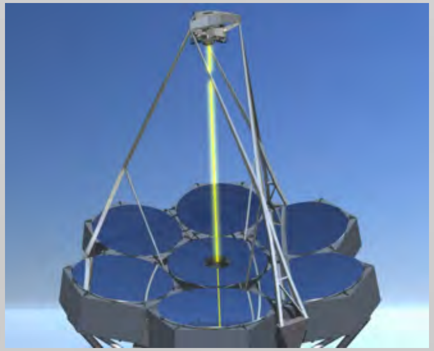
PLINY THE ELDER (1ST CENTURY AD) CONFIRMED BURNING GLASSES WERE USED IN ROMAN PERIODS, HE ALSO SUGGESTED NERO USED LENS TO VIEW GLADIATORIAL MATCHES TO CORRECT HIS NEARSIGHTEDNESS.



CONSTRUCTION OF SIMPLE LENS



MOST SIMPLE LENS ARE SPHERICAL ONES, THE TWO SURFACES BEING SURFACES OF SPHERES. THE LENS SURFACES CAN BE CONVEX, CONCAVE OR PLANAR (FLAT). THE LENS AXIS (THE LINE JOINING THE CENTRES OF THE SPHERES), THE MANUFACTURING PROCESS MEANS THE CENTRE LINE PASSES THROUGH THE LENS CENTRE.



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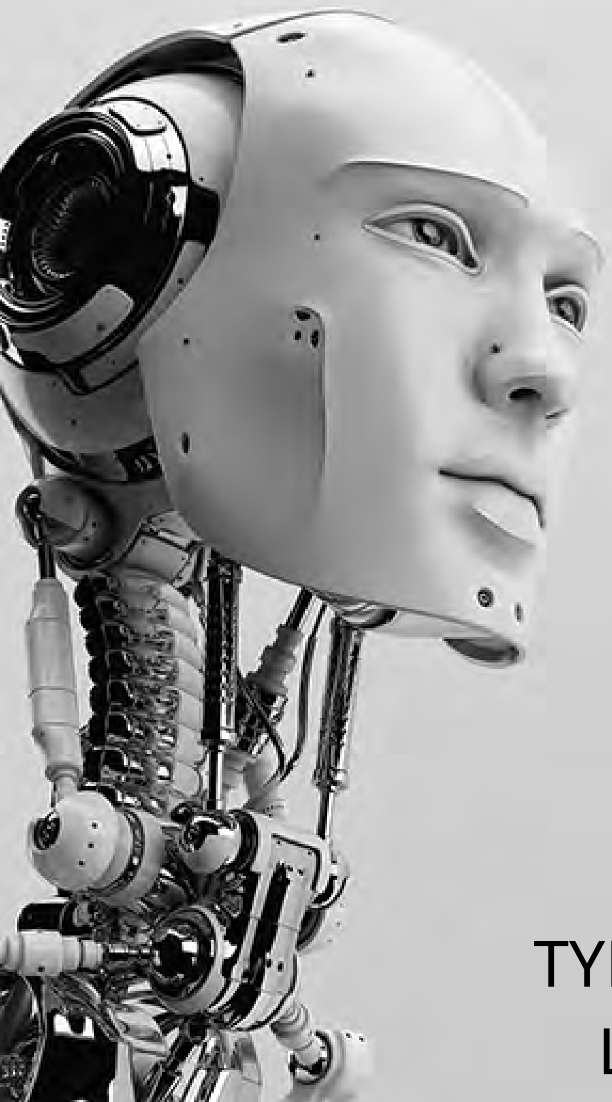


BICONVEX

PLANO CONVEX

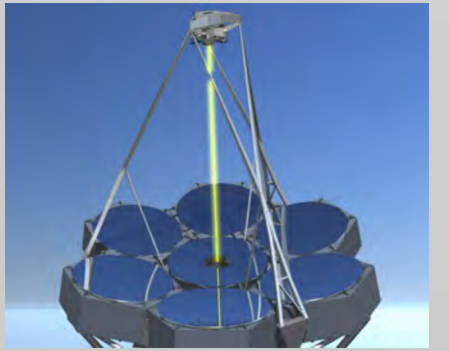
POSITIVE MENISCUS

NEGATIVE MENISCUS

PLANO CONCAVE

BICONCAVE

TYPES OF LENS



SIMPLE LENS TYPES

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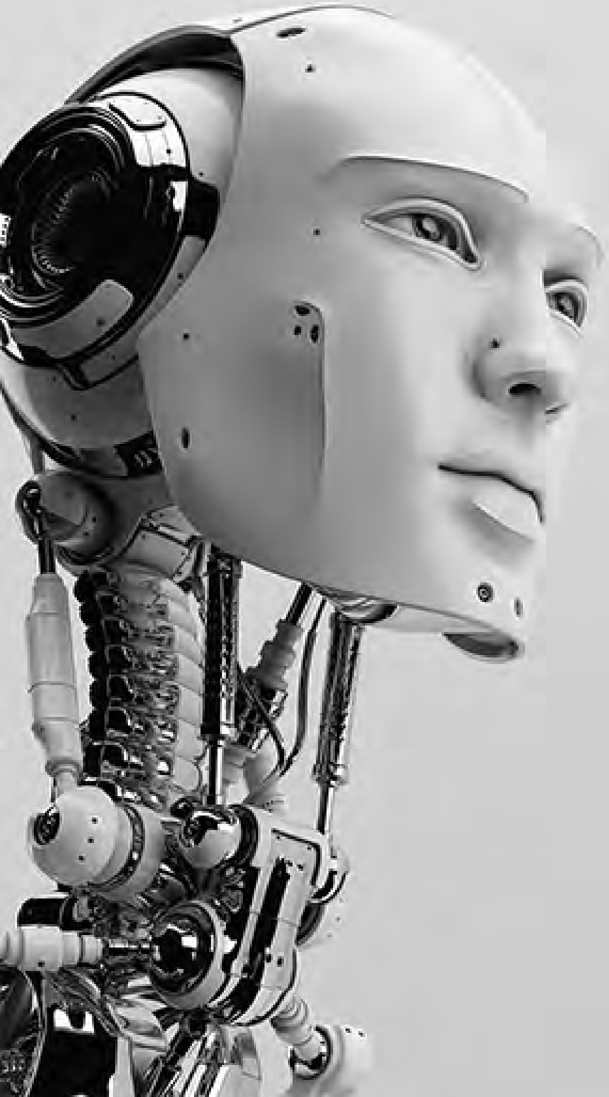
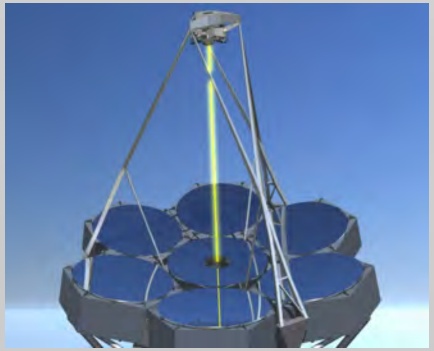
IF BOTH ARE CONVEX IT IS TERMED BICONVEX, IF CONCAVE BICONCAVE.





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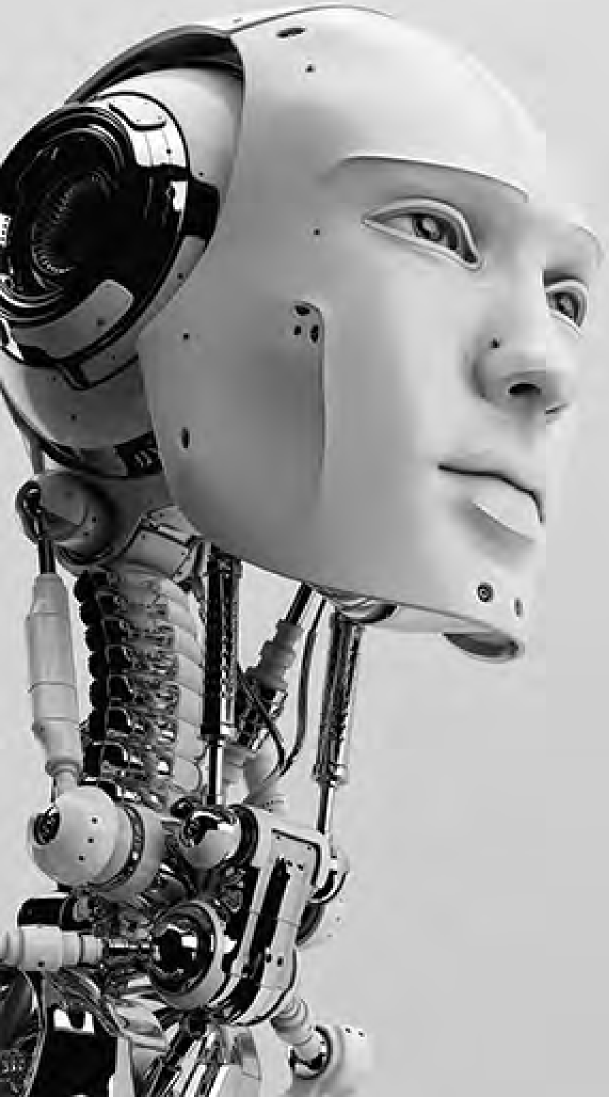

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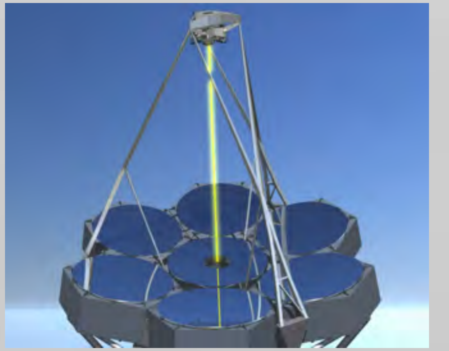
IF BOTH FACES ARE THE SAME CURVATURE THEY ARE TERMED EQUICONVEX OR CONCAVE.



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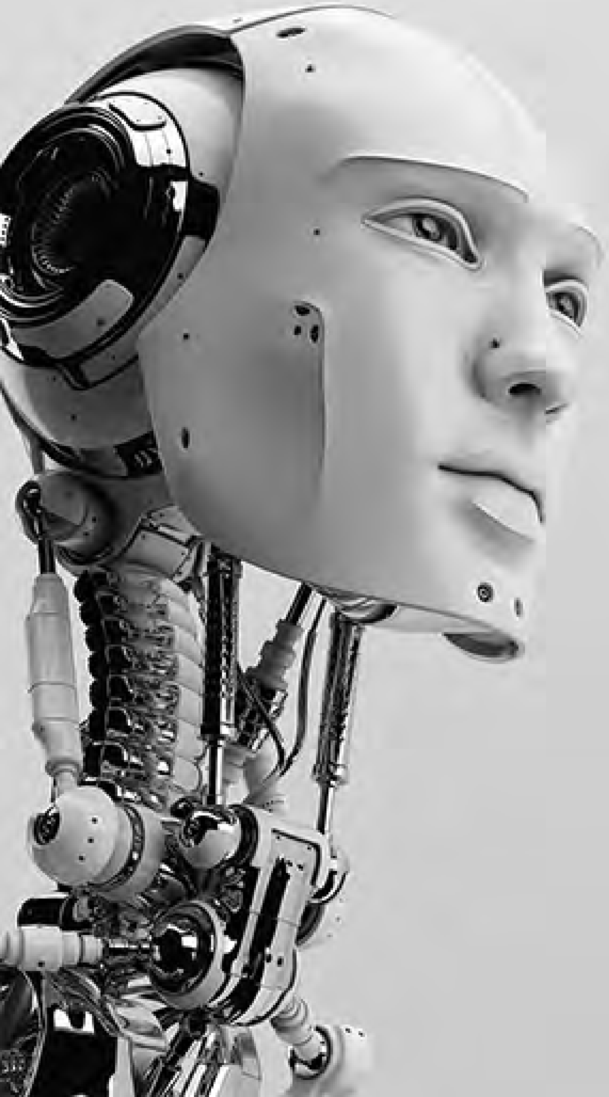

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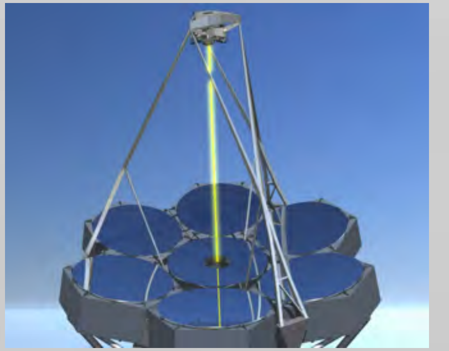
IF ONE SURFACE IS FLAT THEY ARE TERMED PLANO CONVEX OR CONCAVE.



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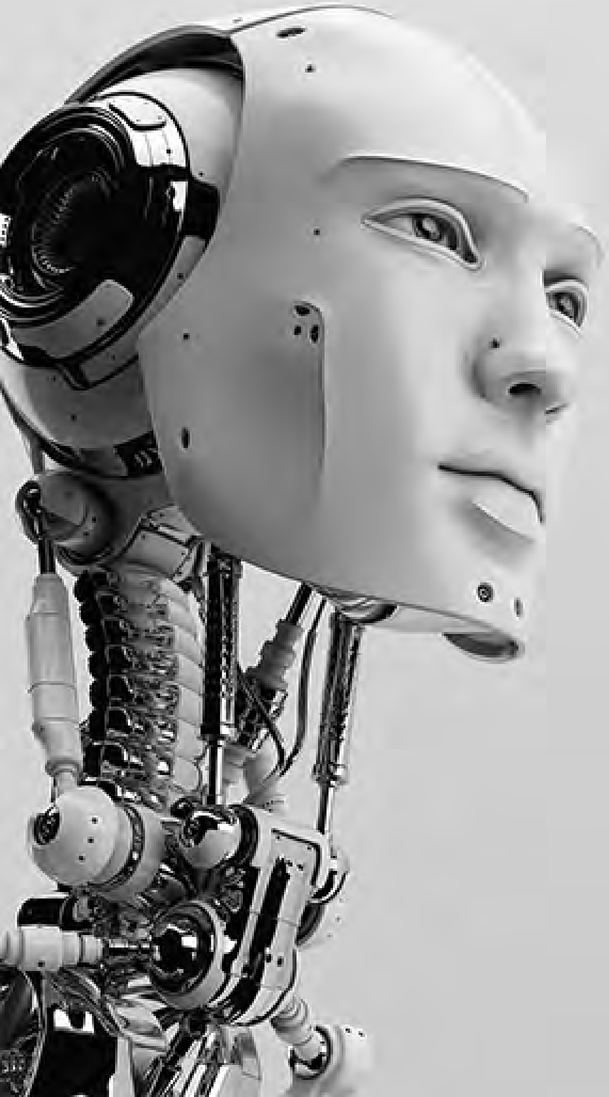

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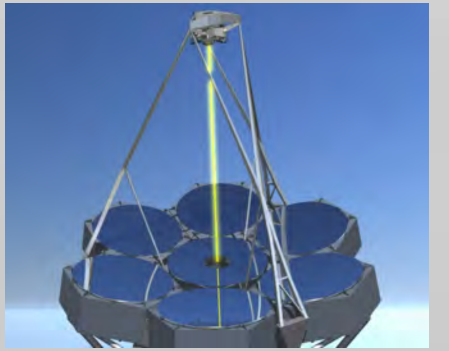
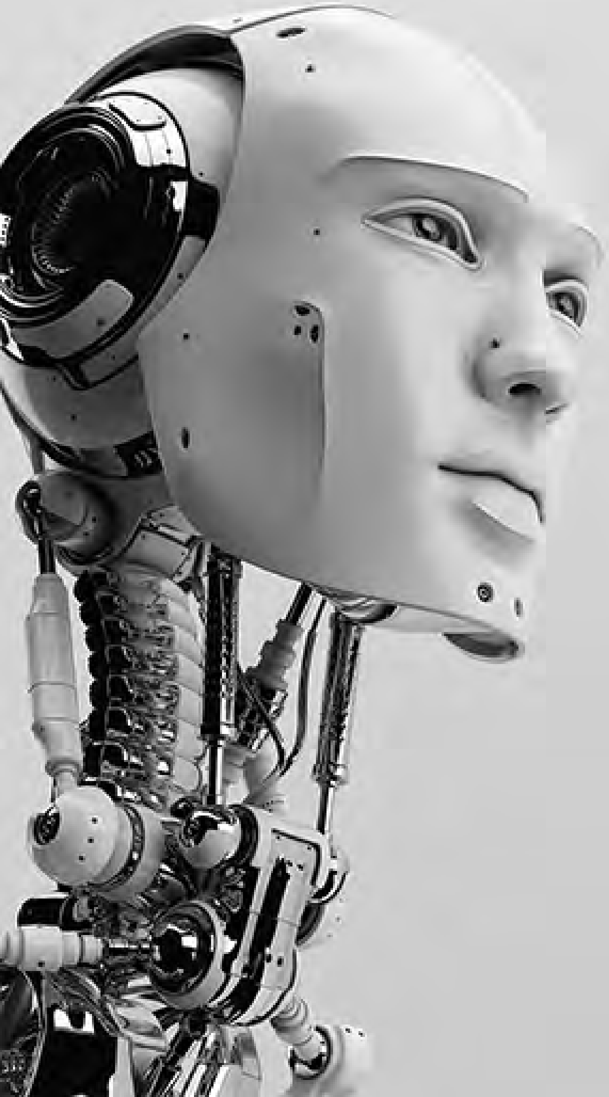
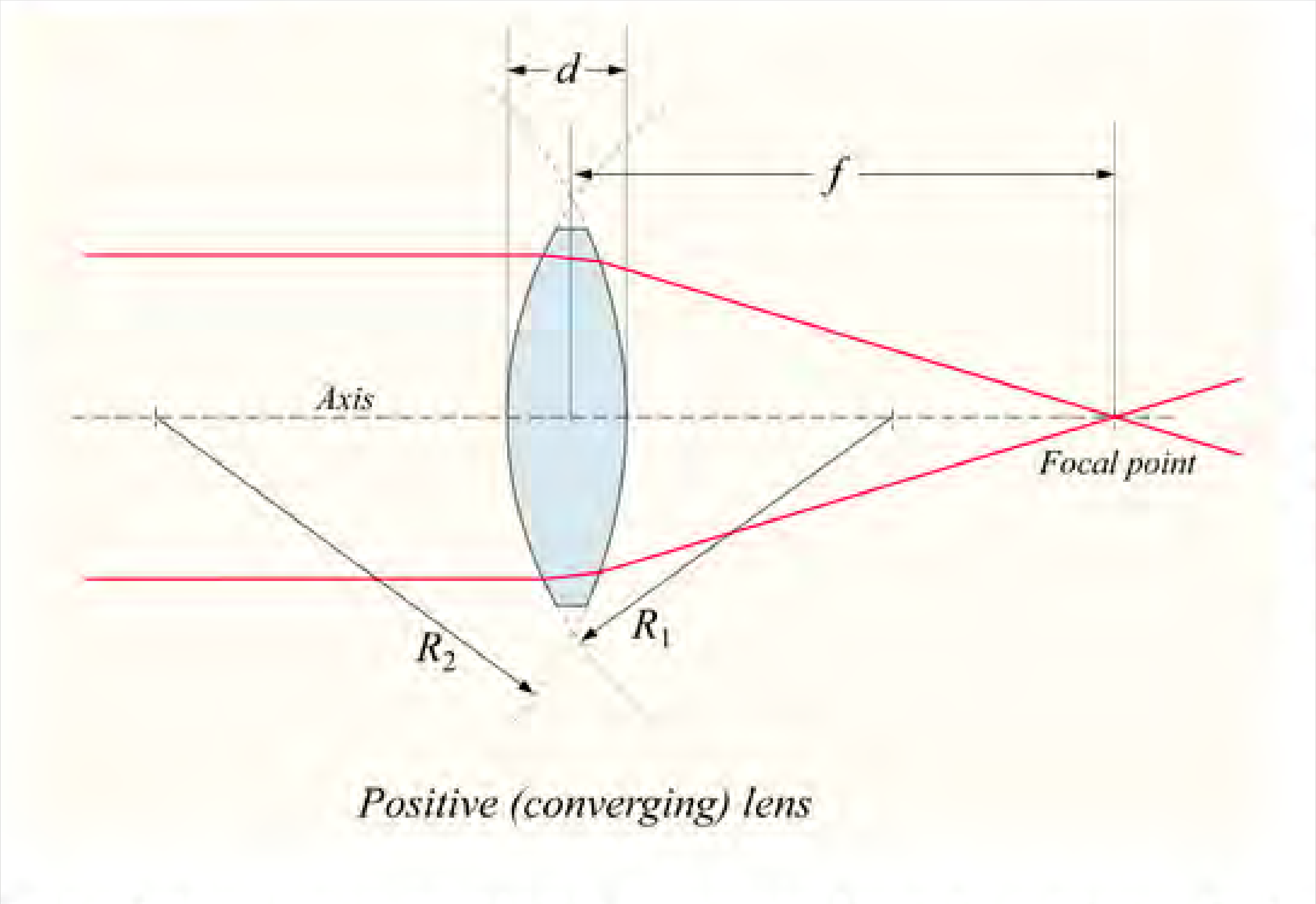
A LENS WITH A CONCAVE AND CONVEX SURFACE IS TERMED MENISCUS.

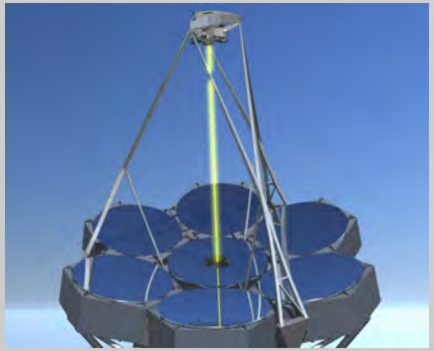




SIMPLE LENS TYPES

IF A COLLIMATED BEAM OF LIGHT PASSES THROUGH A BICONVEX LENS THE BEAM CONVERGES ON A FOCAL SPOT. THIS IS A CONVERGENT LENS.





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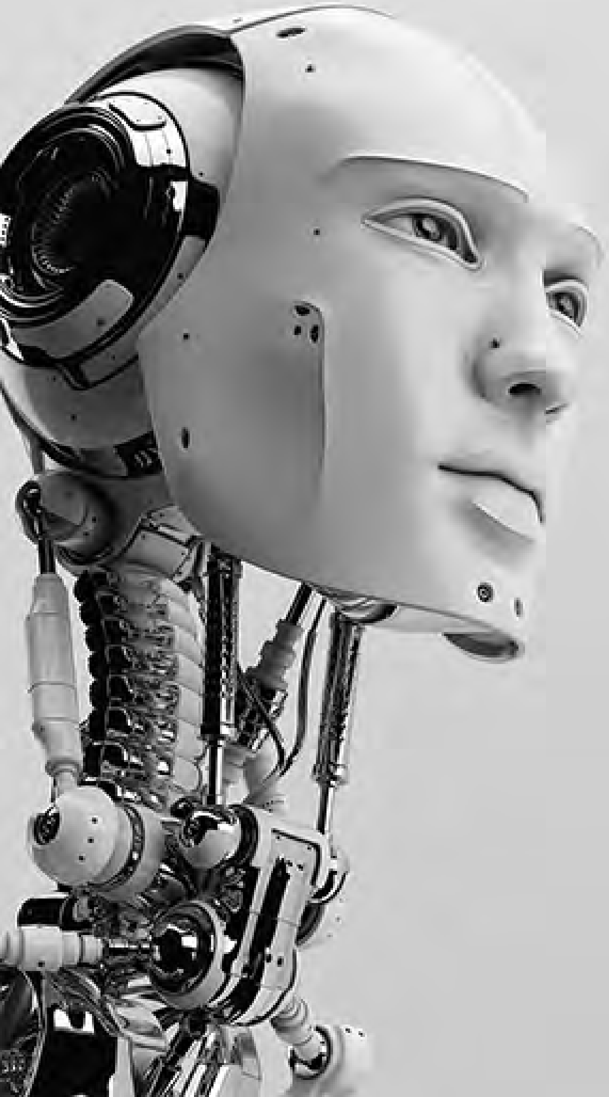
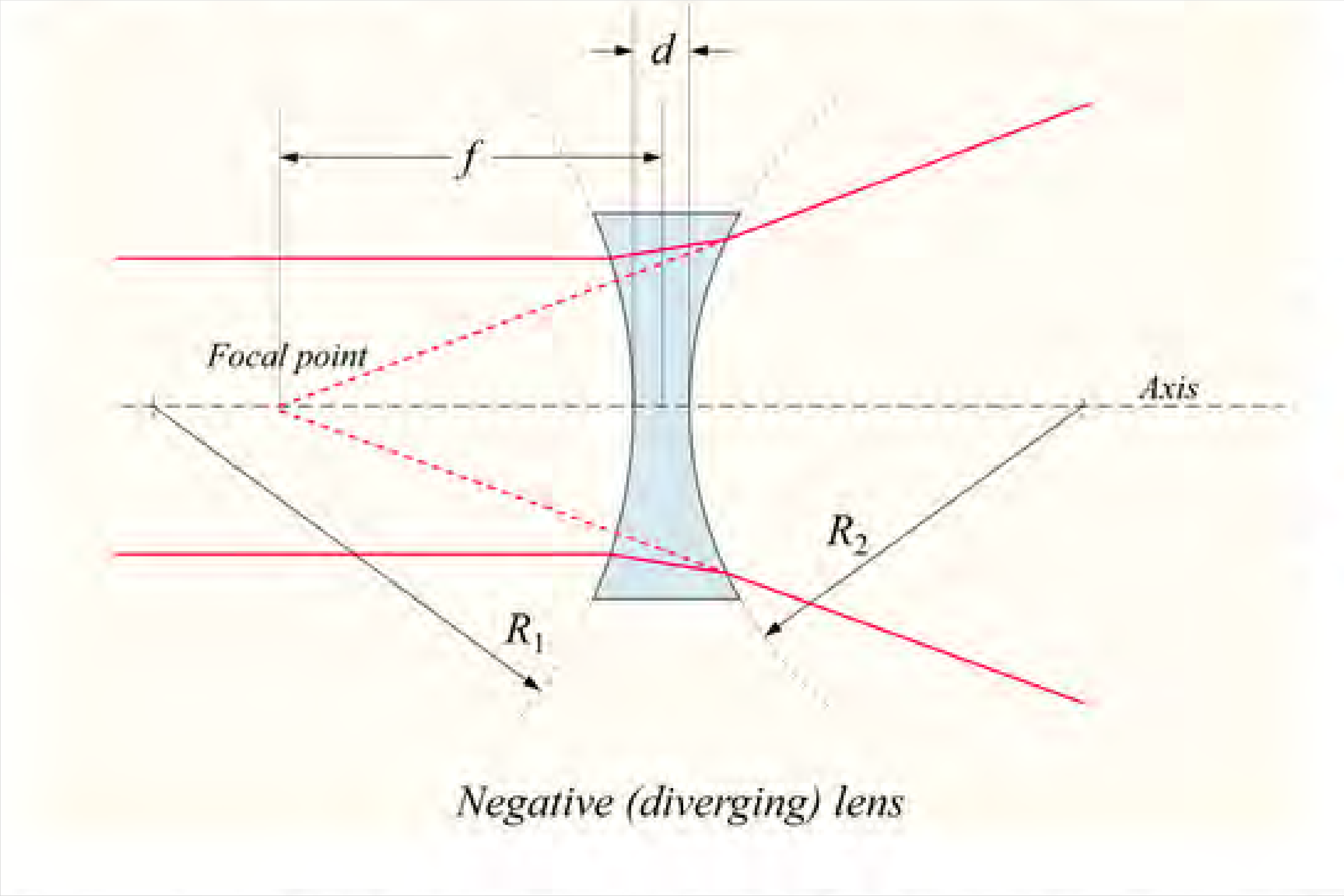
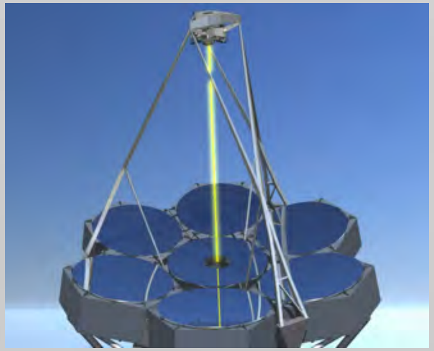
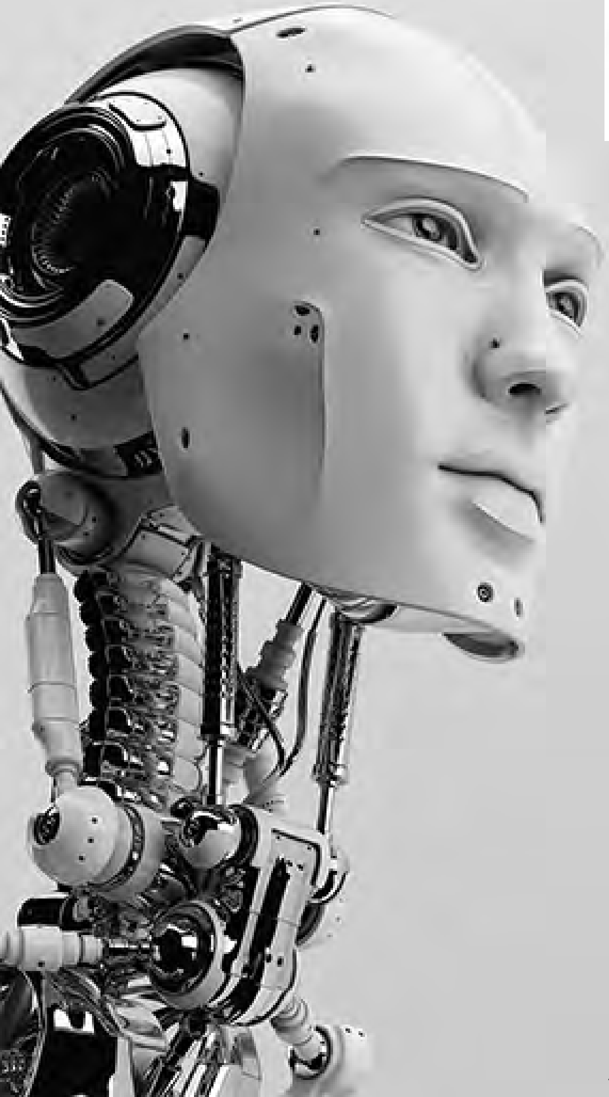






LENS-MAKERS EQUATION



$$\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2} + \frac{(n-1)\,d}{n\,R_1\,R_2}\right]$$

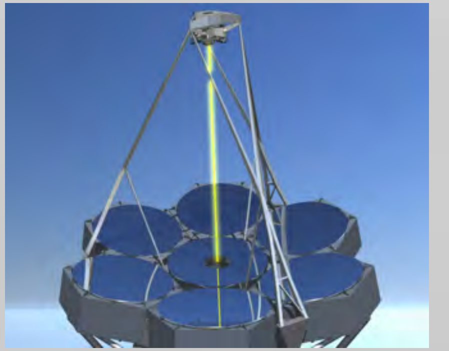
f – EFFECTIVE FOCAL LENGTH.

n - IS THE REFRACTIVE INDEX OF THE LENS.

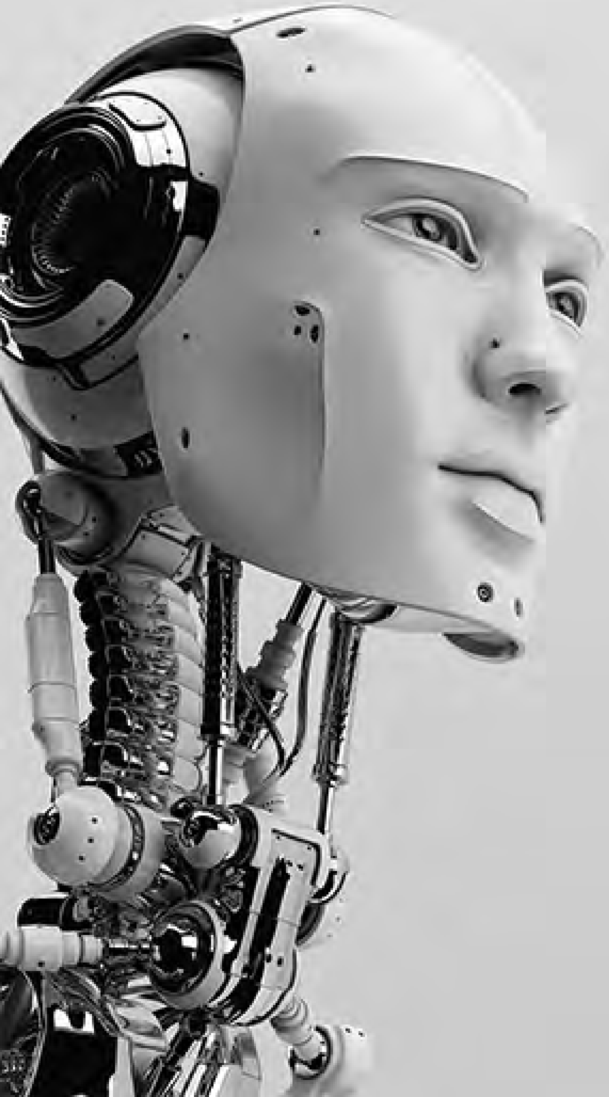
R1 - IS THE RADIUS OF CURVATURE OF THE LENS SURFACE CLOSER TO THE LIGHT.

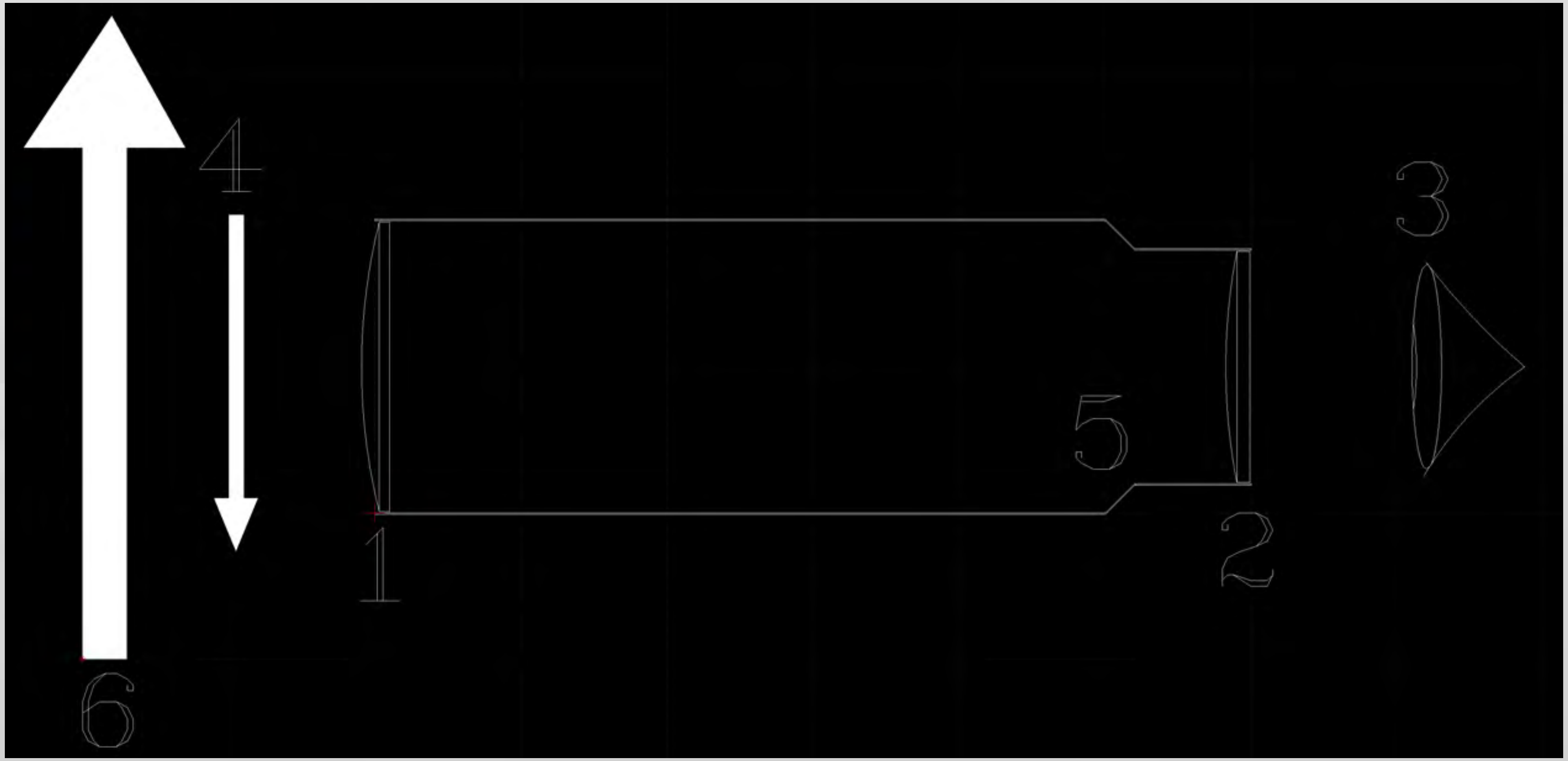
R2 - IS THE RADIUS OF CURVATURE OF THE LENS SURFACE FURTHEST FROM THE LIGHT.

d – IS THE LENS THICKNESS, DISTANCE ON THE LENS AXIS.

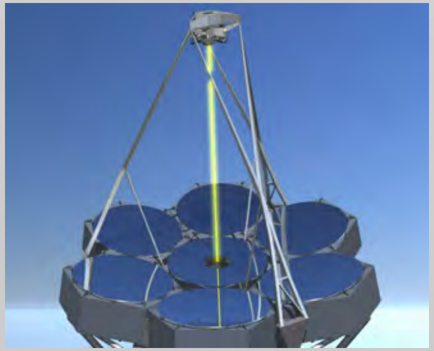


KEPLERIAN REFRACTING TELESCOPE





1. OBJECTIVE LENS.
2. EYEPIECE.
3. OBSERVER.
4. SOURCE IMAGE
5. FOCAL LENGTH LENS 1
6. MAGNIFIED VIRTUAL IMAGE



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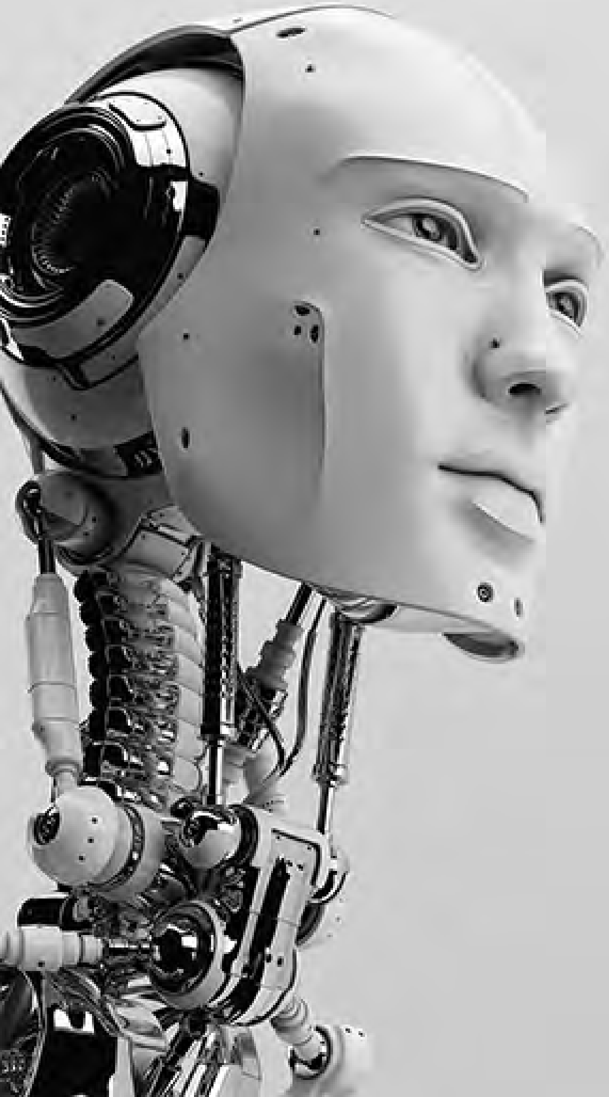

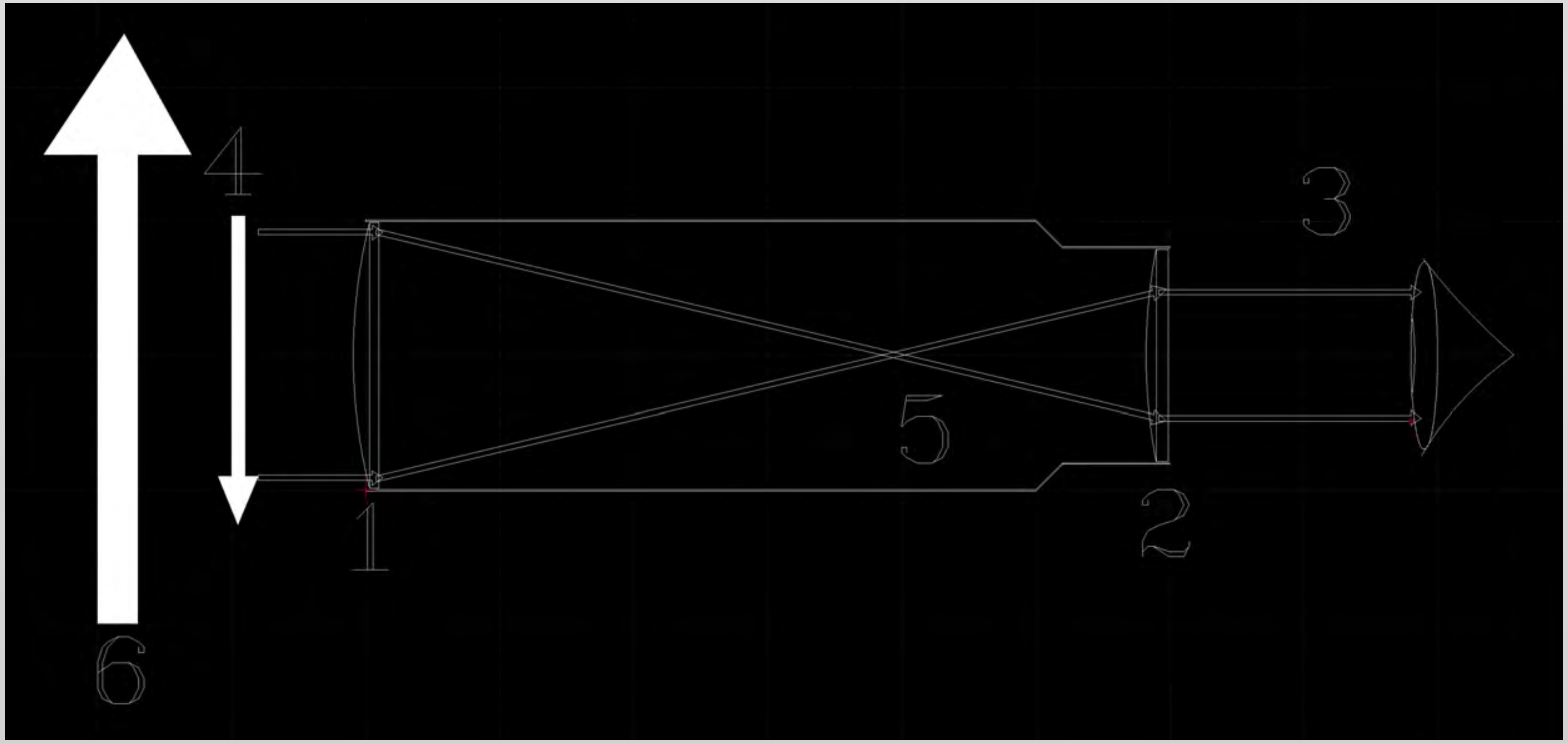

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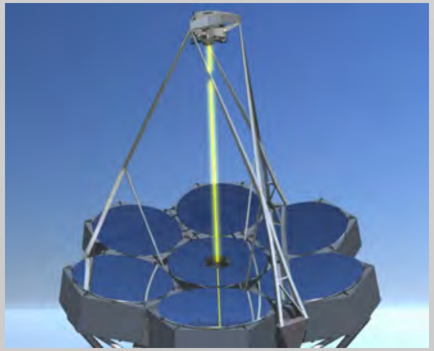

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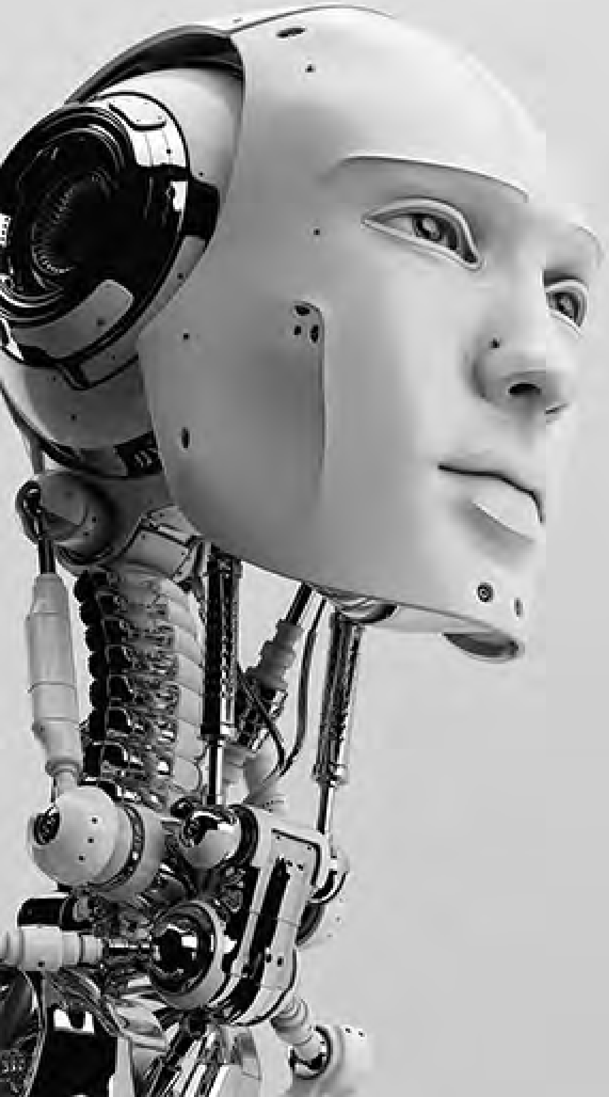

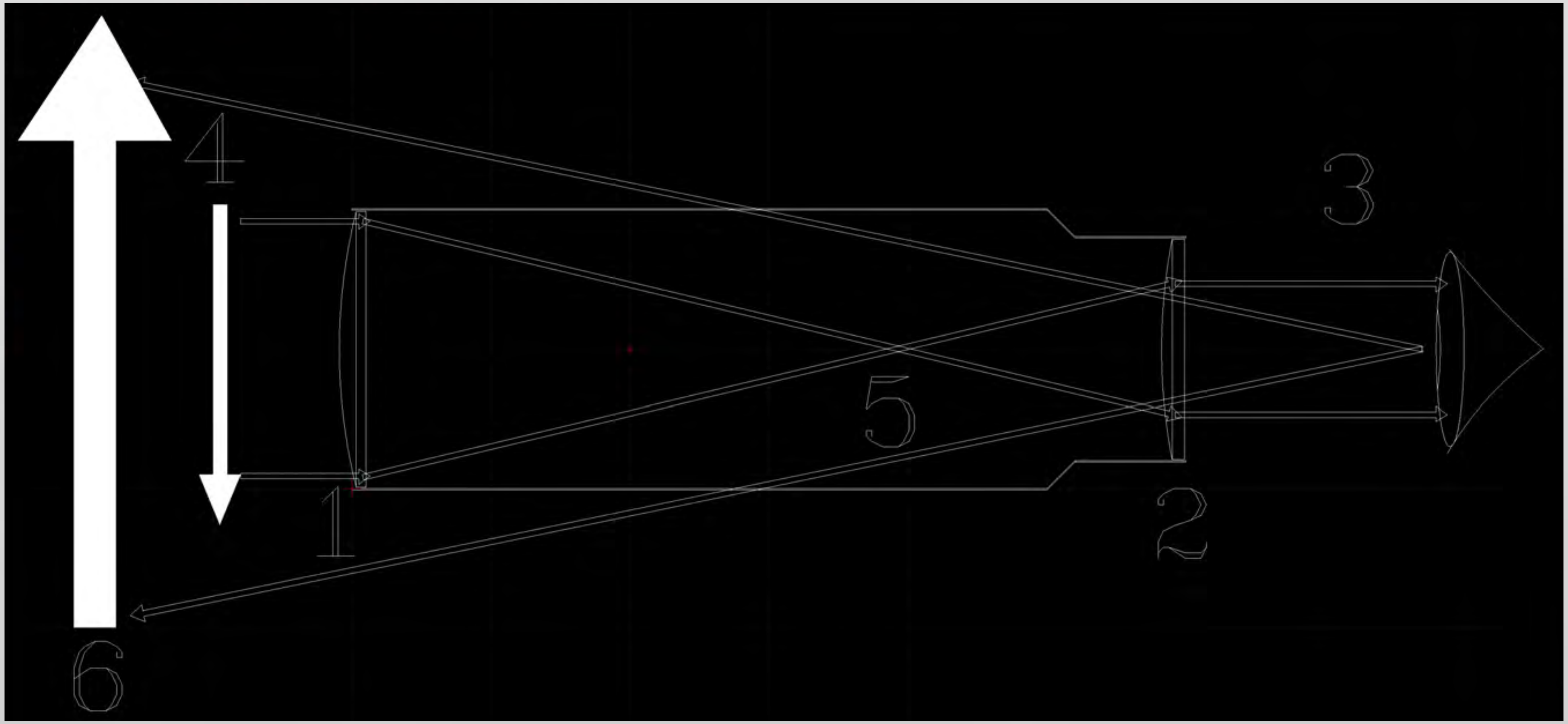

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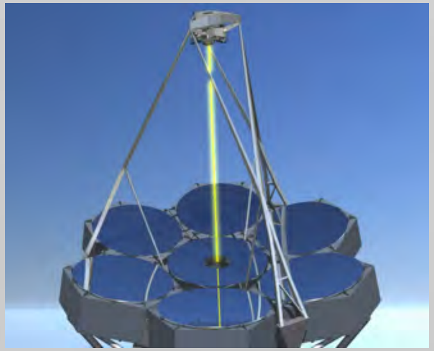

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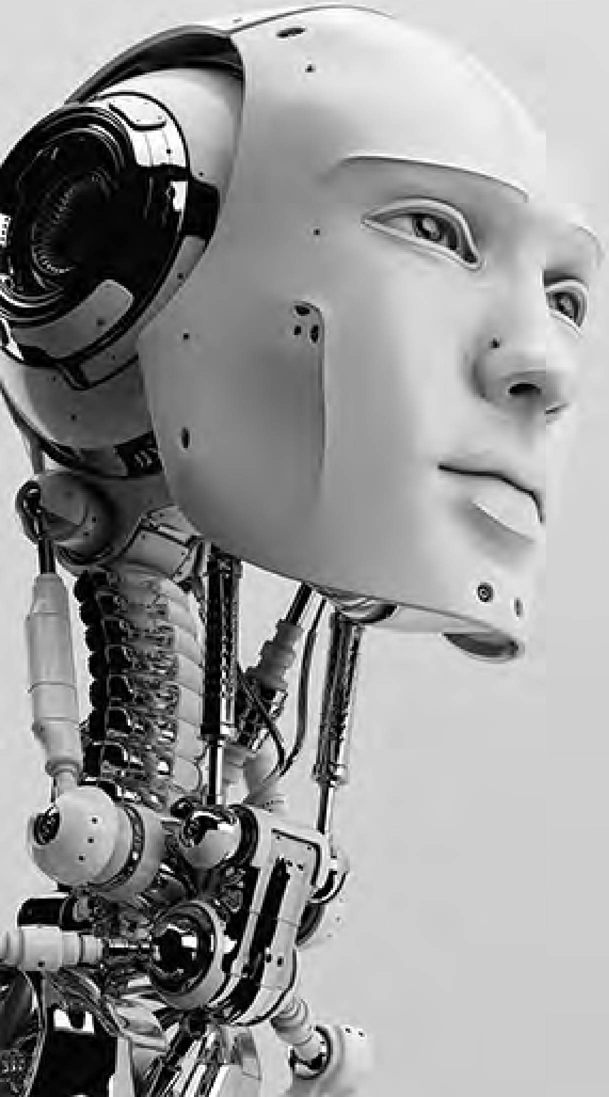
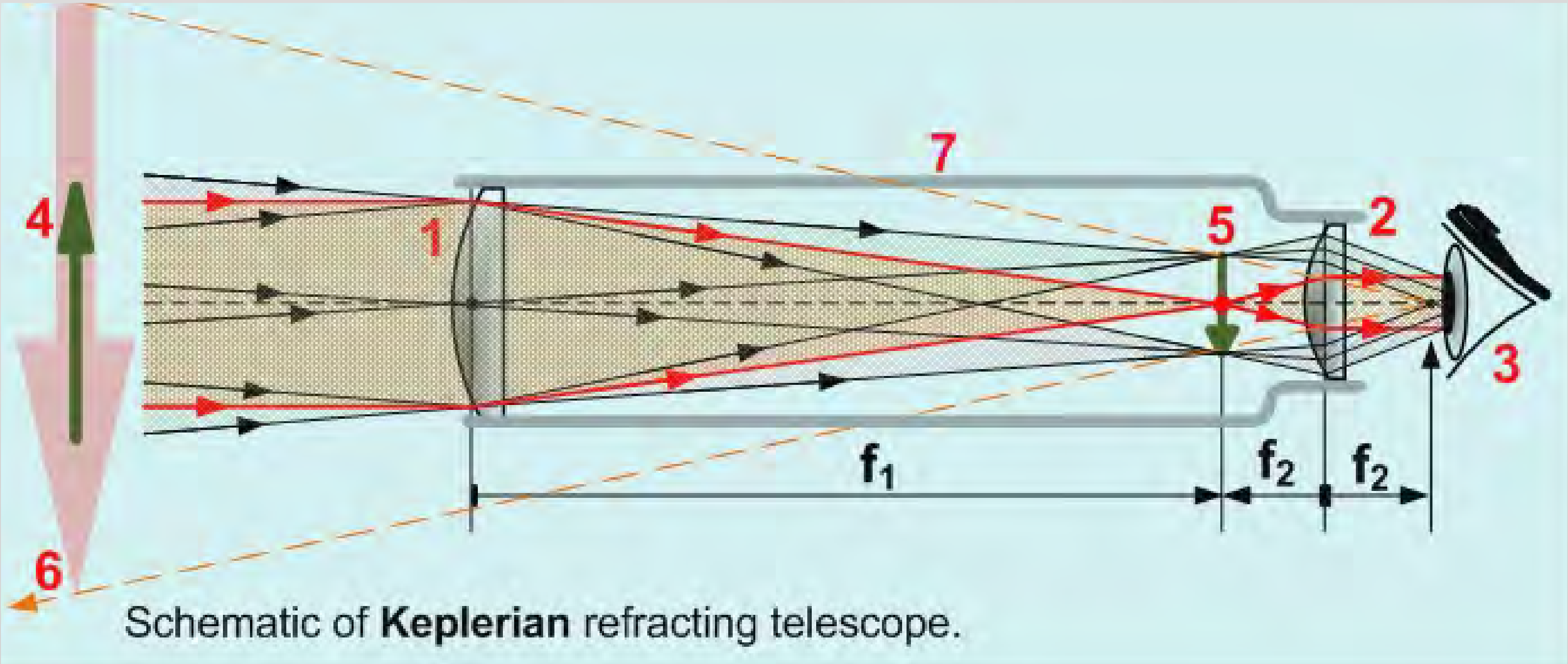
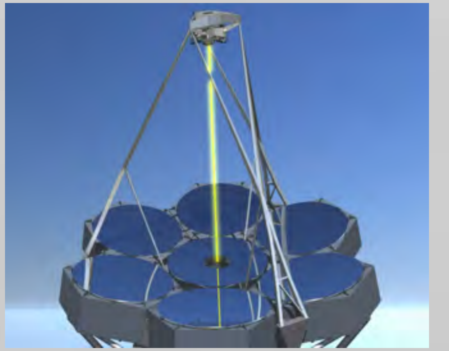
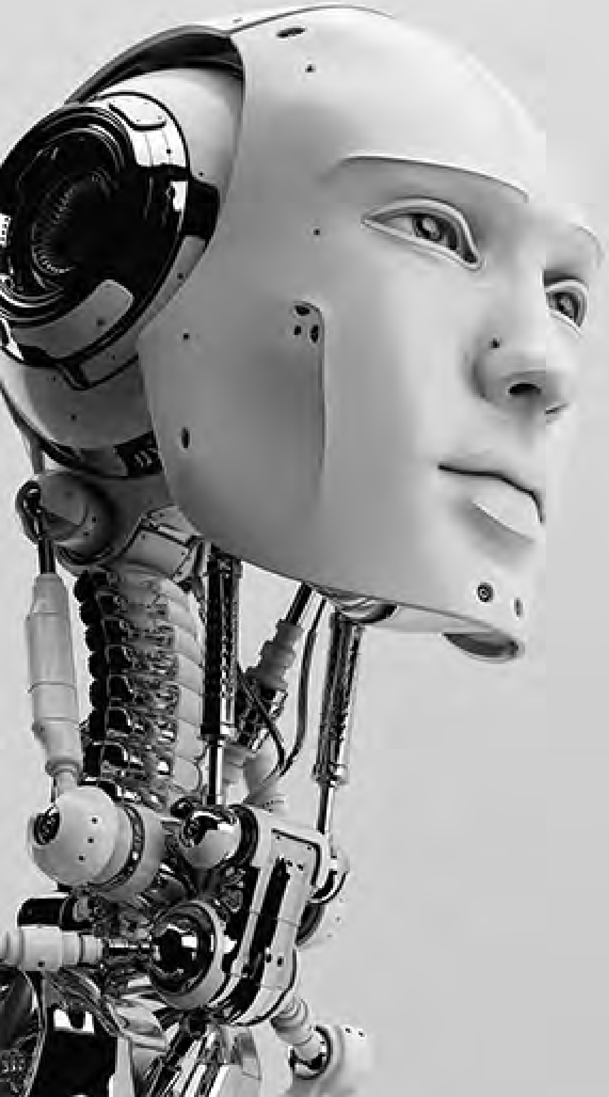


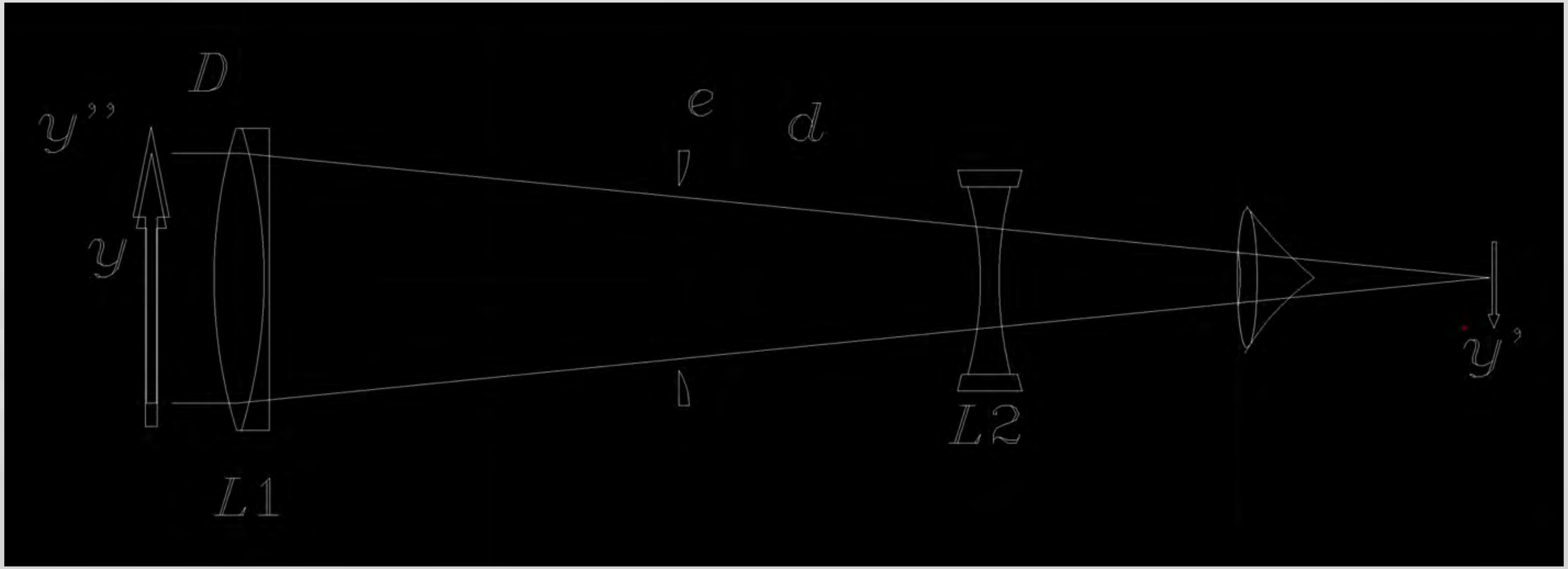


THE COMBINATION OF AN OBJECTIVE LENS I & AN EYEPIECE 2, IS USED TO GATHER MORE LIGHT THAN THE HUMAN EYE ALONE, FOCUS IT 5 & PRESENT IT TO THE VIEWER AS A BRIGHTER, CLEANER AND MAGNIFIED VIRTUAL IMAGE 6.



GALILEAN TELESCOPE





y DISTANT OBJECT

y' IS REAL IMAGE FROM OBJECTIVE

y" MAGNIFIED VIRTUAL IMAGE FROM EYEPIECE

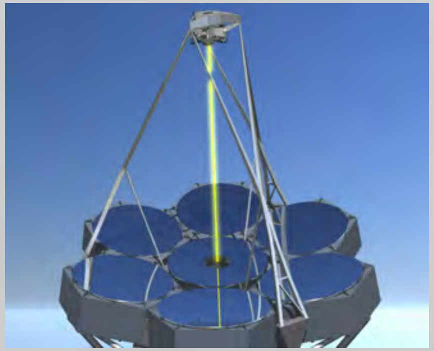
D ENTRANCE PUPIL DIAMETER

d VIRTUAL EXIT PUPIL DIAMETER

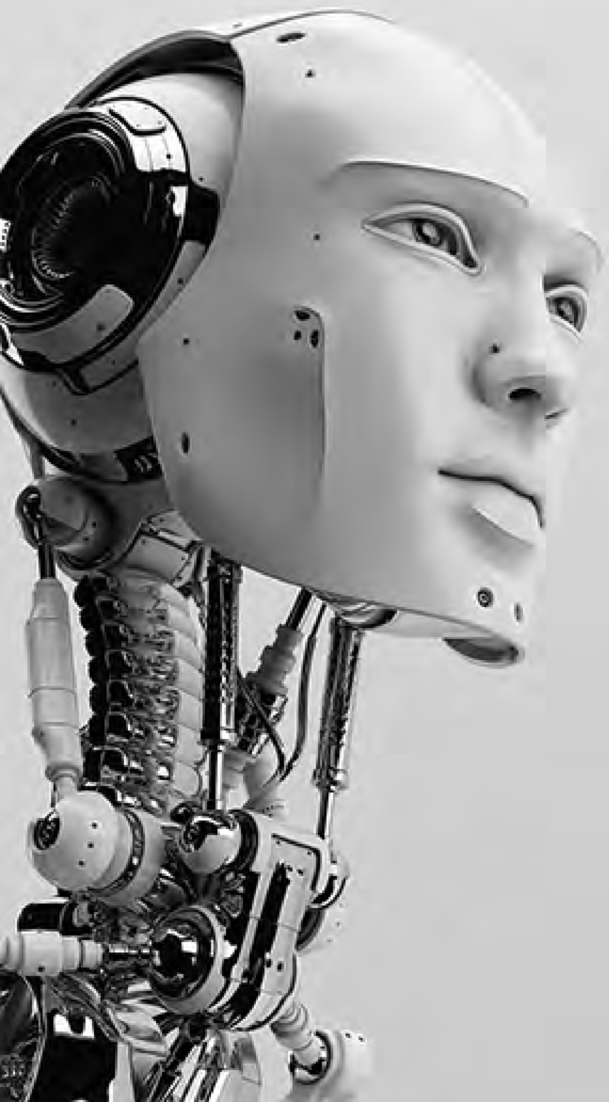
L1 OBJECTIVE LENS.

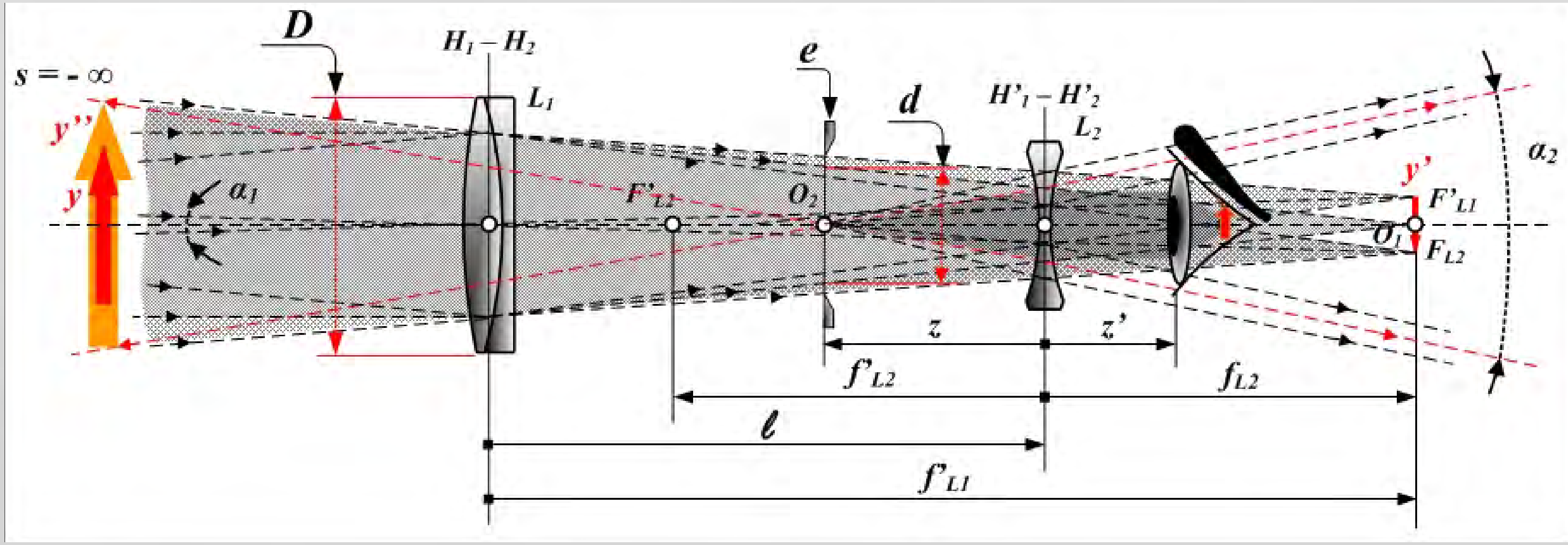
L2 EYEPIECE LENS

e VIRTUAL EXIT PUPIL



GALILEAN TELESCOPE





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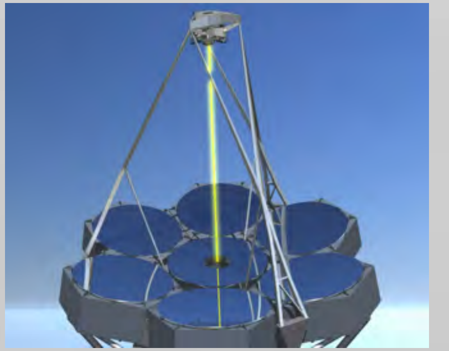
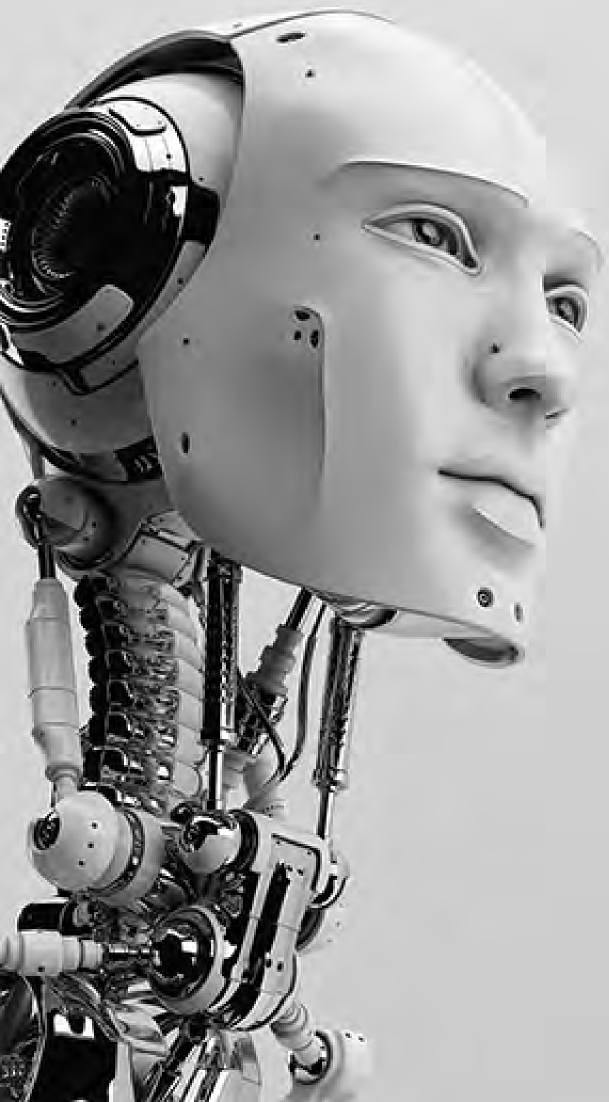


GALILEAN TELESCOPE

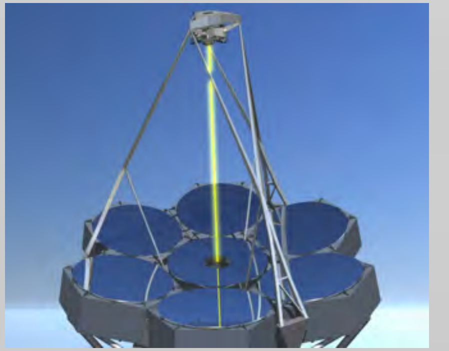


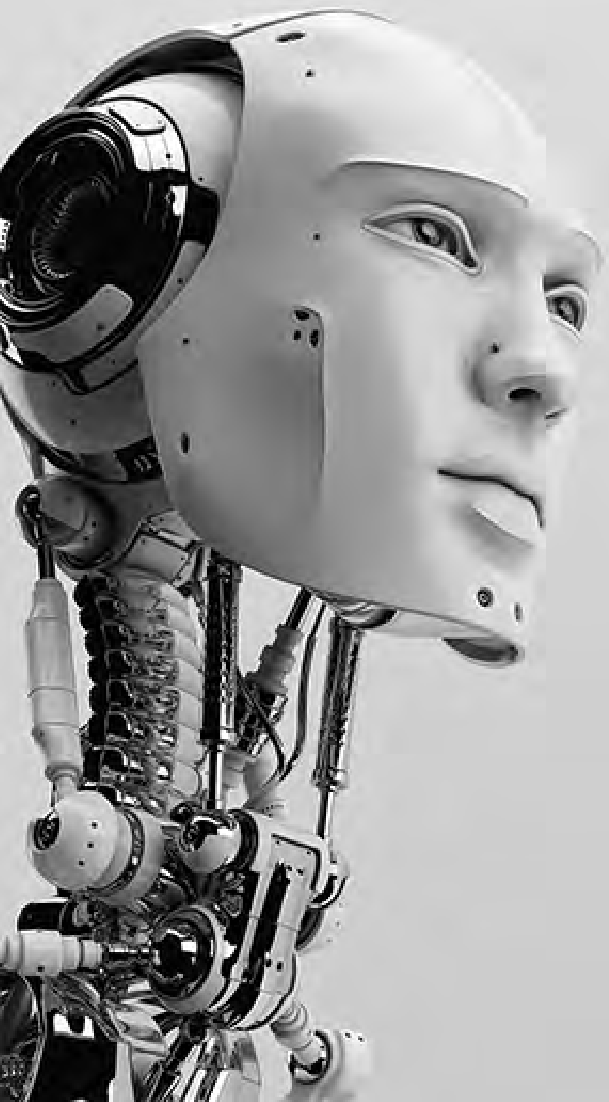
PARALLEL RAYS OF LIGHT FROM AN OBJECT Y ARE BROUGHT TO FOCUS IN THE FOCAL PLANE OF THE OBJECTIVE LENS F’ L1/y.

THE DIVERGENT EYEPIECE L2 LENS INTERCEPTS THESE RAYS MAKING THEM PARALLEL AGAIN.

NON-PARALLEL RAYS FROM THE OBJECT TRAVELING AT AN ANGLE a1 TO THE OPTICAL AXIS, TRAVEL AT A LARGER ANGLE a2 AFTER THEY PASS THROUGH THE EYEPIECE. THIS LEADS TO AN INCREASE IN APPARENT ANGULAR SIZE GIVING A PERCEIVED MAGNIFICATION.

THE FINAL IMAGE y” IS A VIRTUAL IMAGE LOCATED AT INFINITY, THE SAME WAY UP.





THE PROBLEM WITH LENS

WEIGHT- SOLID LENS ARE HEAVY.

REQUIREMENT FOR LENS TO BE PERFECT INTERNALLY – LIGHT HAS TO PASS THROUGH THEM.

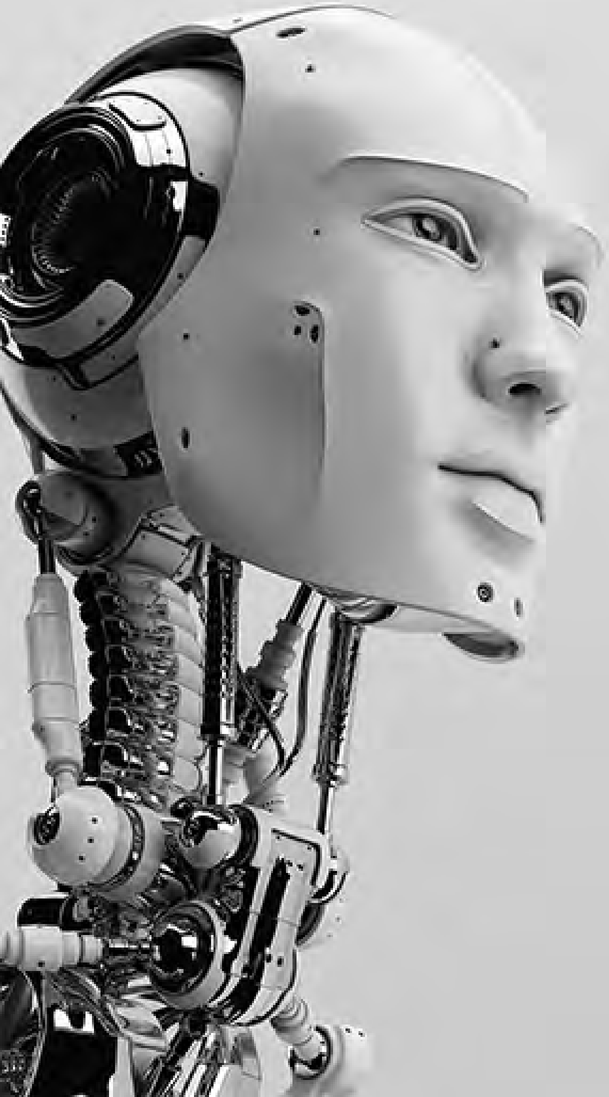
REQUIREMENT FOR TWO, PERFECTLY GROUND LENS FACES.

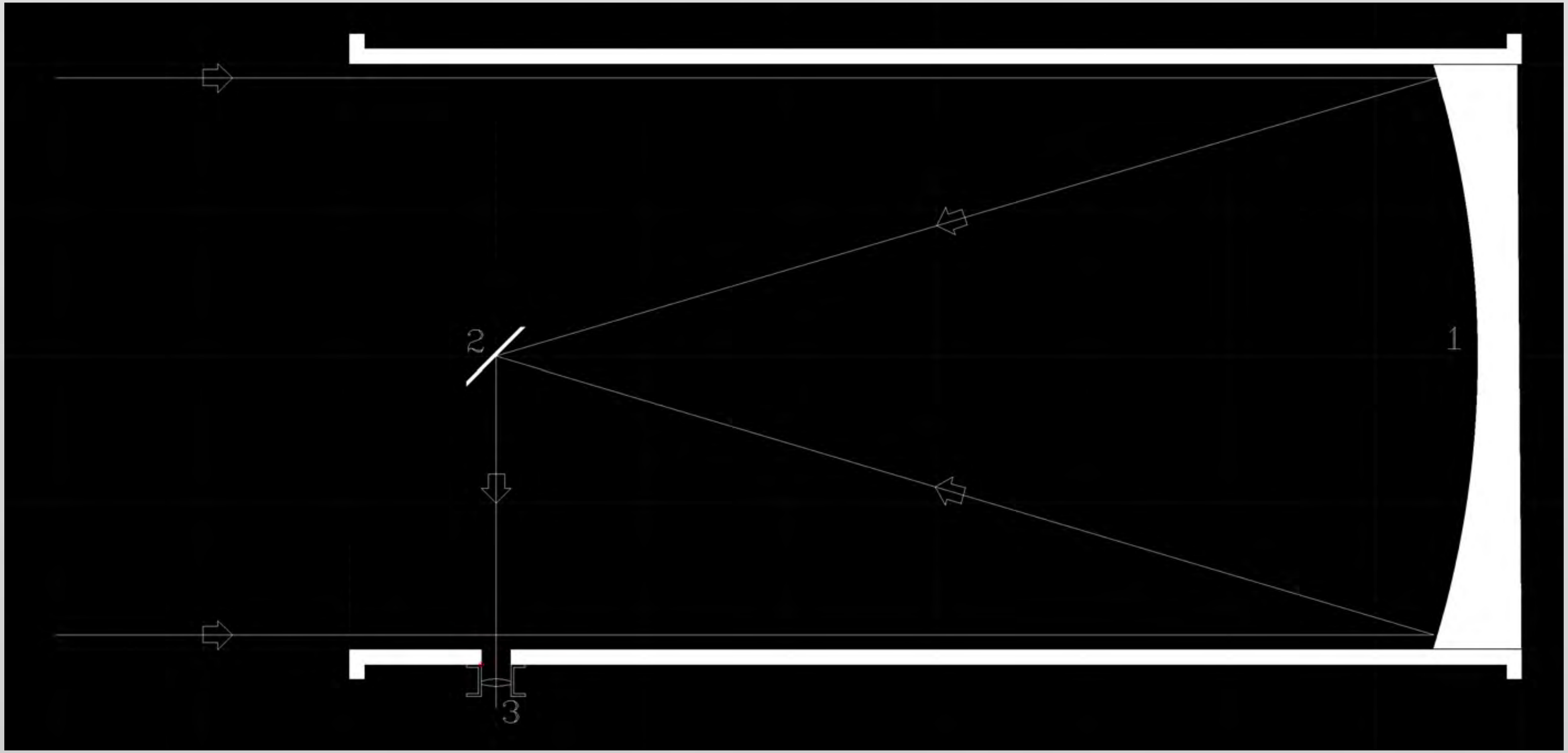
LIGHT HAS A FOCAL LENGTH BASED ON WAVELENGTH, DIFFERING WAVELENGTHS REQUIRE DIFFERENT LENS TYPES TO FOCUS ALL AT ONE SPOT- COMPLEXITY & EXPENSE.

SUPPORT WITH RESPECT TO WEIGHT. LENS THICKNESS INCREASE WITH DIAMETER

THESE FACTORS MEAN THE LARGEST LENS EVER PRODUCED IS I.57 METRE DIAMETER, (LARGE SYNOPTIC SURVEY TELESCOPE LSST).

NEWTONIAN TELESCOPE



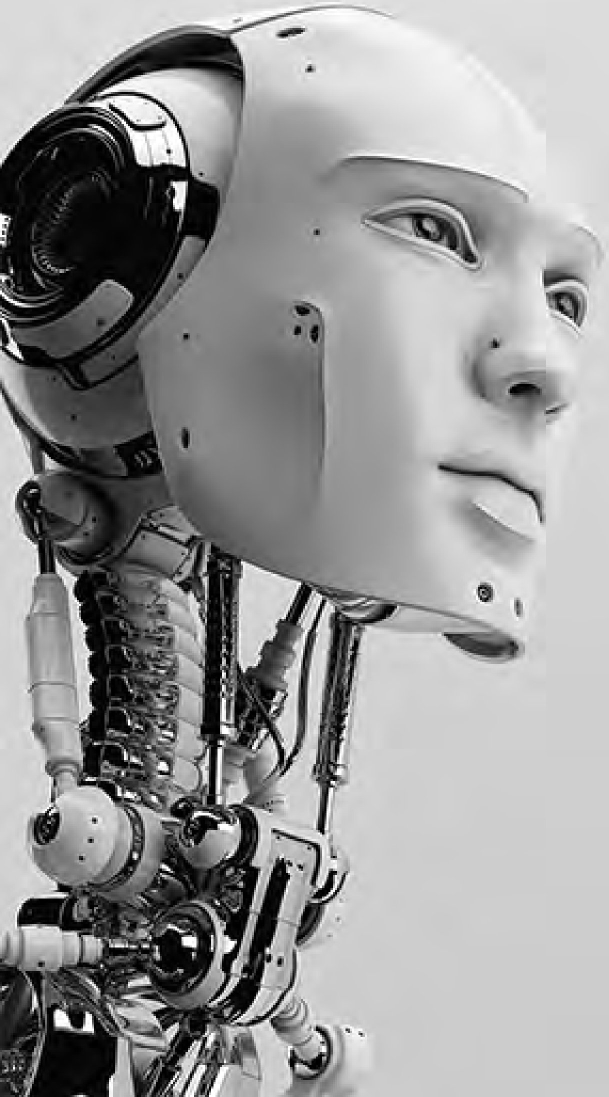


1. PRIMARY MIRROR
2. 45 DEGREE MIRROR
3. FOCUSING LENS

LIGHT PASSAGE THROUGH A DOBSONIAN TELESCOPE

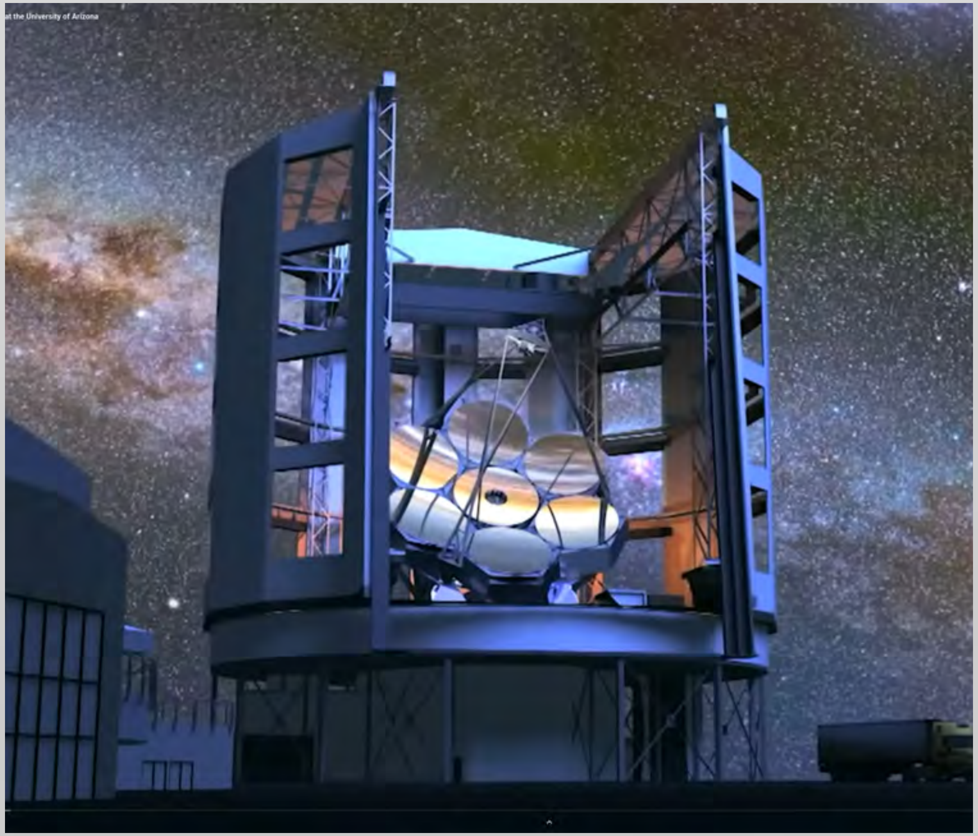
THIS USES TWO MIRRORS & A LENS TO FOCUS THE IMAGE

MIRRORS



MIRRORS OVERCOME THE PROBLEMS OF CASTING AND GRINDING LARGE GLASS LENSES, THIS PART OF THE PRESENTATION DESCRIBES THE MANUFACTURE OF ONE OF THE 8.4m LENSES OF THE GIANT MAGELLIAN TELESCOPE (GMT).

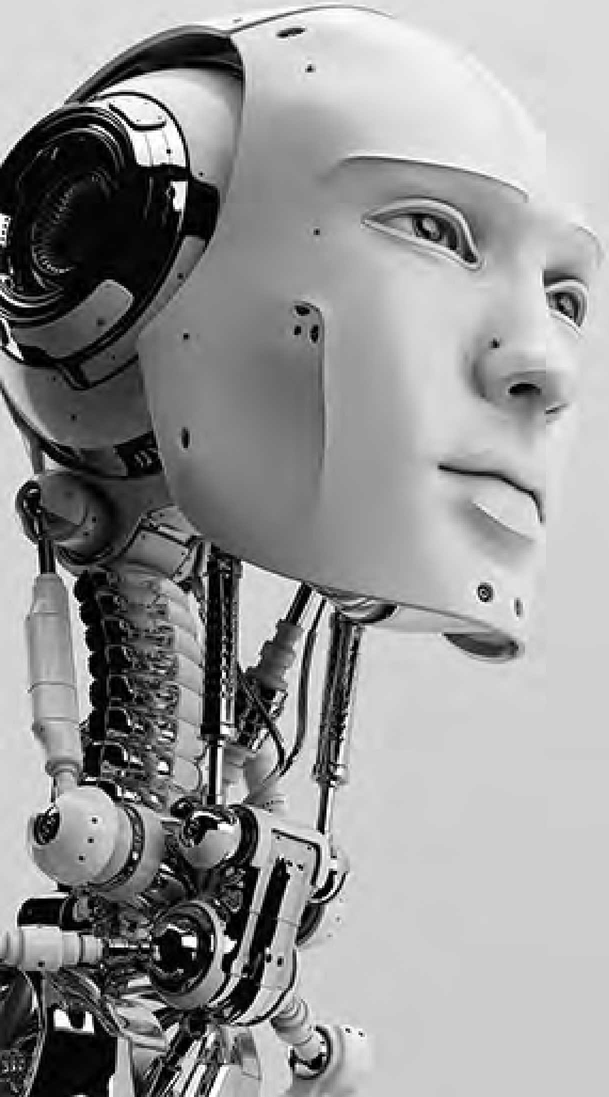
GMT IS ONE OF A SERIES OF LARGE MODERN MIRROR TELESCOPES.



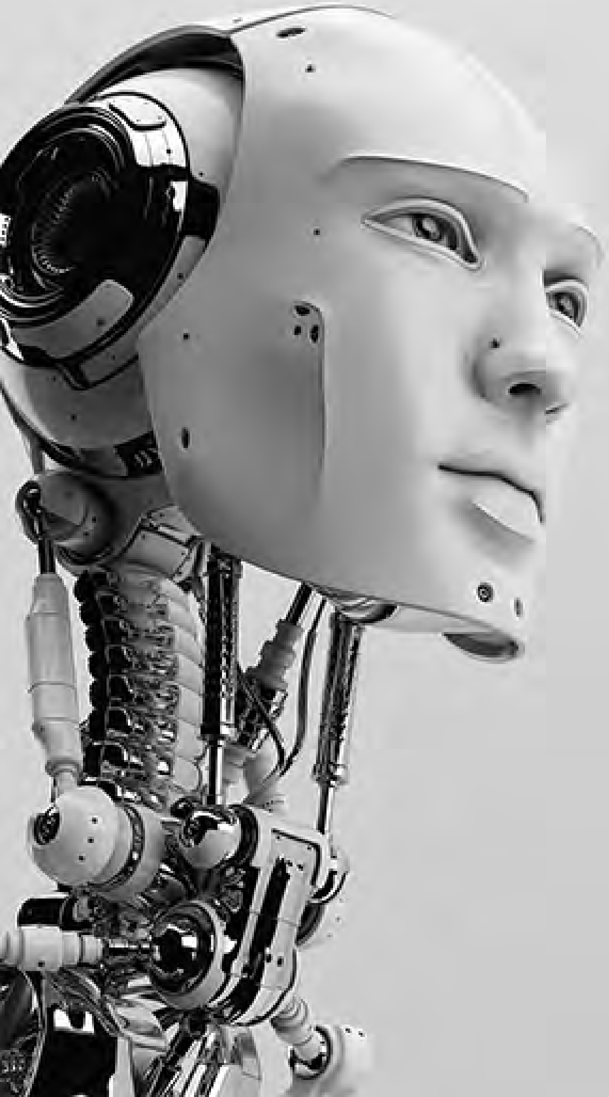
MIRRORS

MANUFACTURE OF THE MIRROR STARTS WITH BUILDING A MOLD.

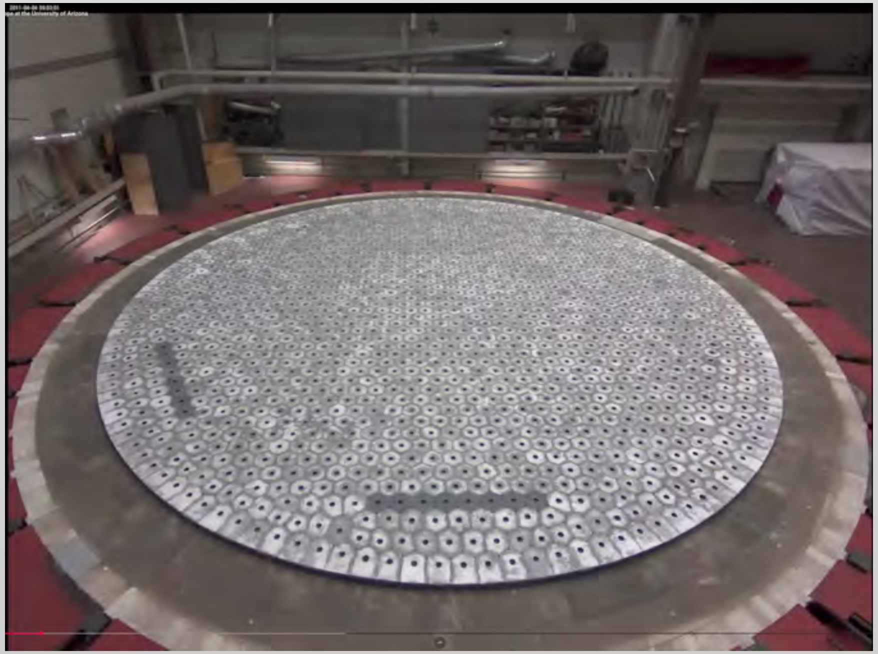
REMOVAL OF THIS MOLD REDUCES THE WEIGHT OF THE FINISHES MIRROR BY 80%.



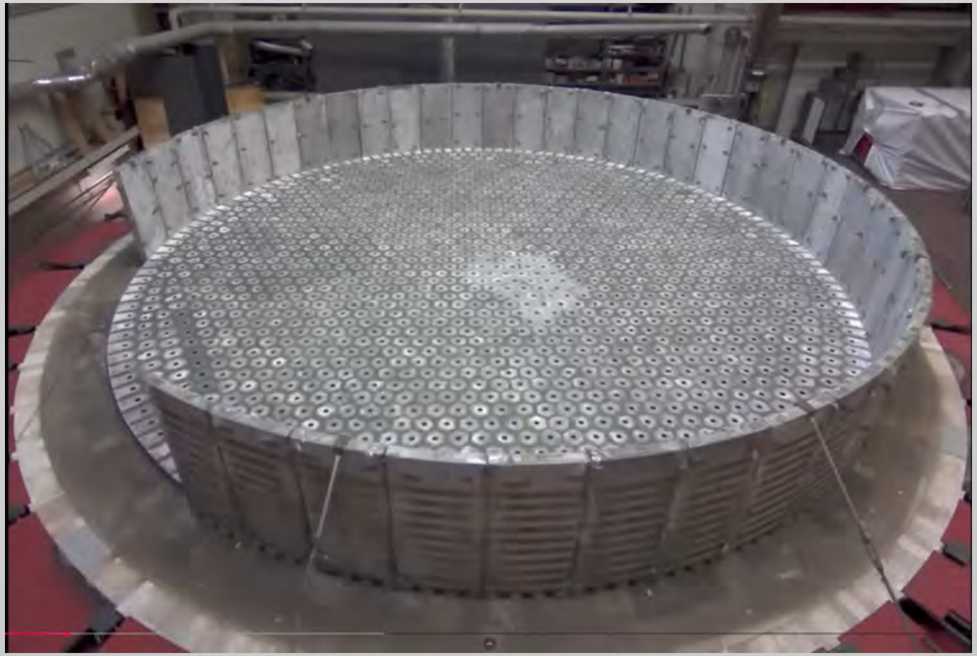
MIRRORS



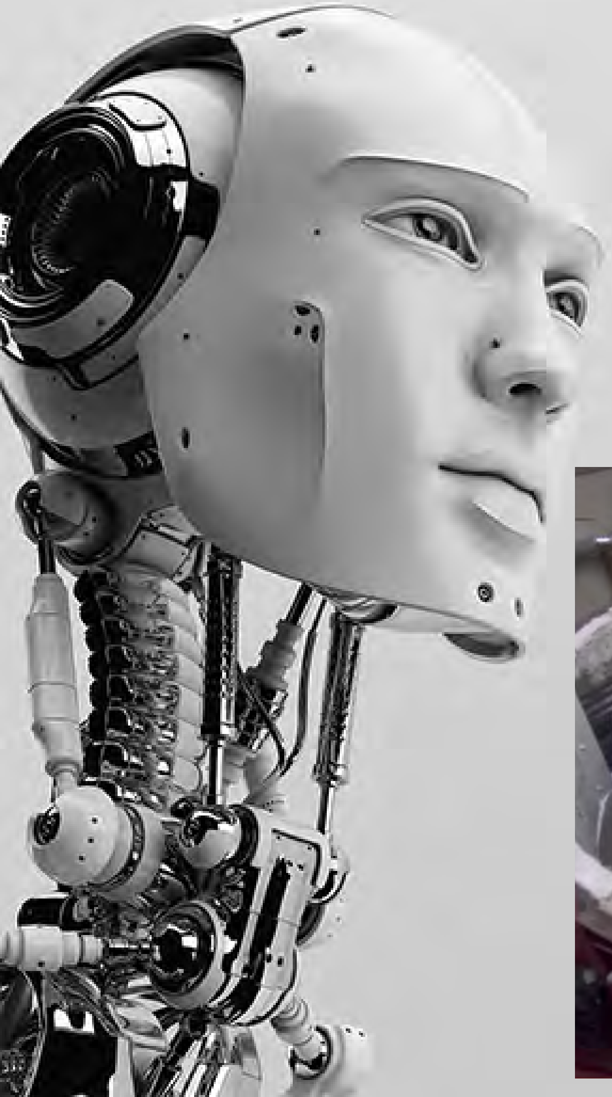
FIRSTLY THE FLOOR IS LAID DOWN.



SECONDLY THE WALLS ARE BUILT.

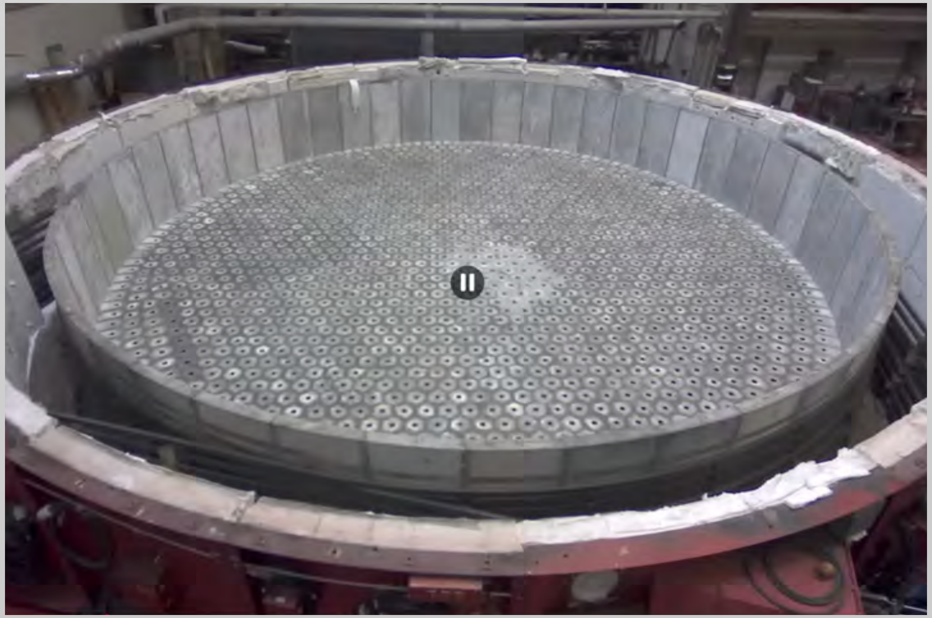


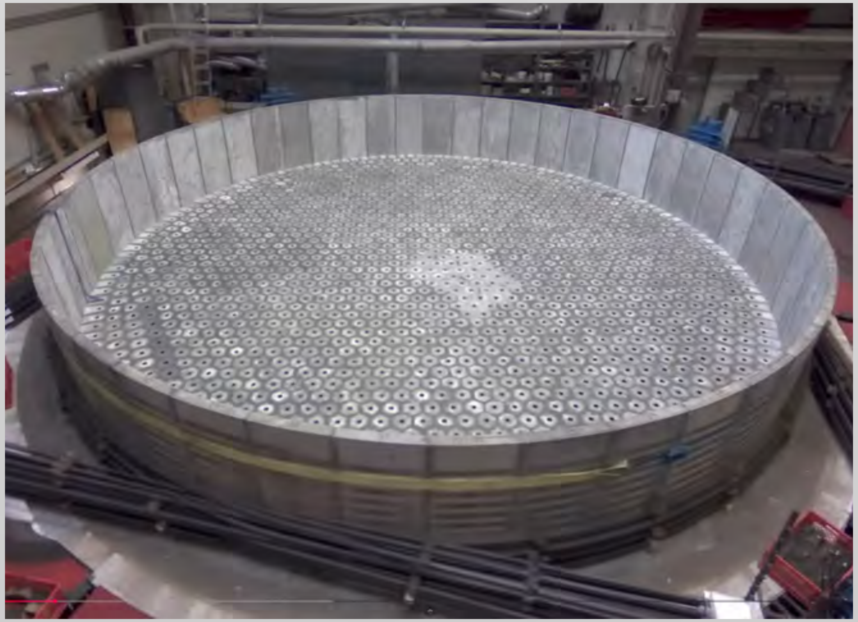
MIRRORS



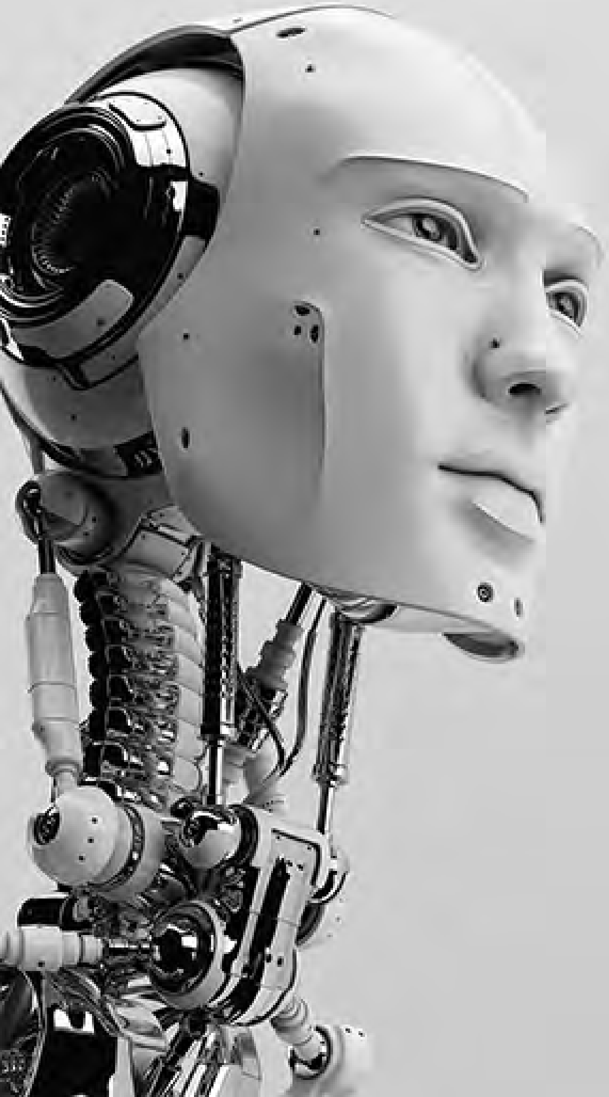
AFTER THE WALLS ARE COMPLETE, THEY ARE BUILT LIKE A WHISKY BARREL WITH METAL WRAPS.

AFTER THIS THE FURNACE WALLS ARE CONSTRUCTED.





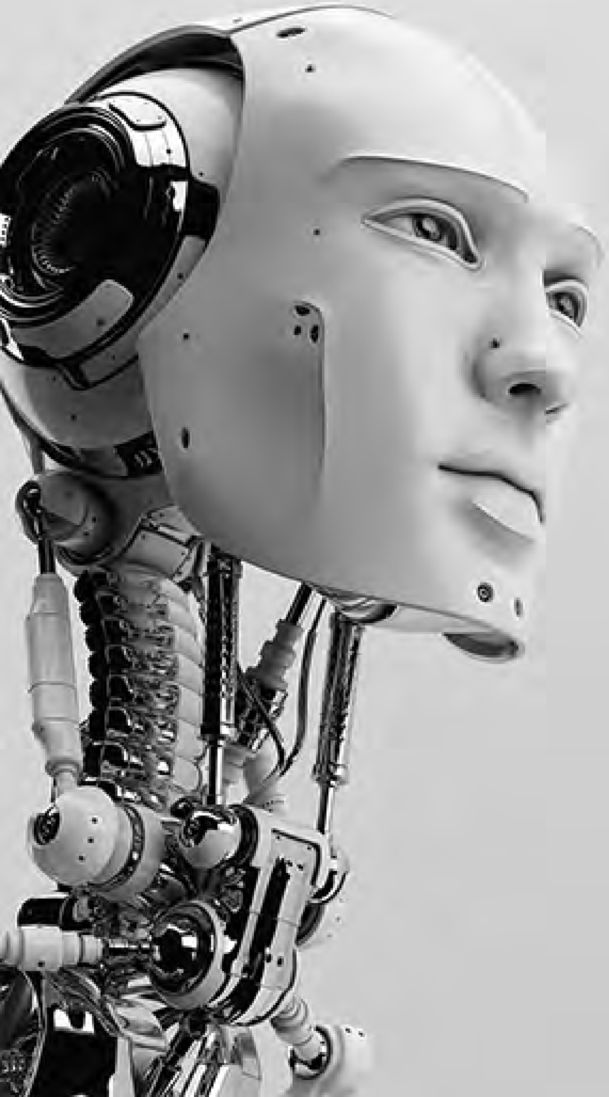
MIRRORS

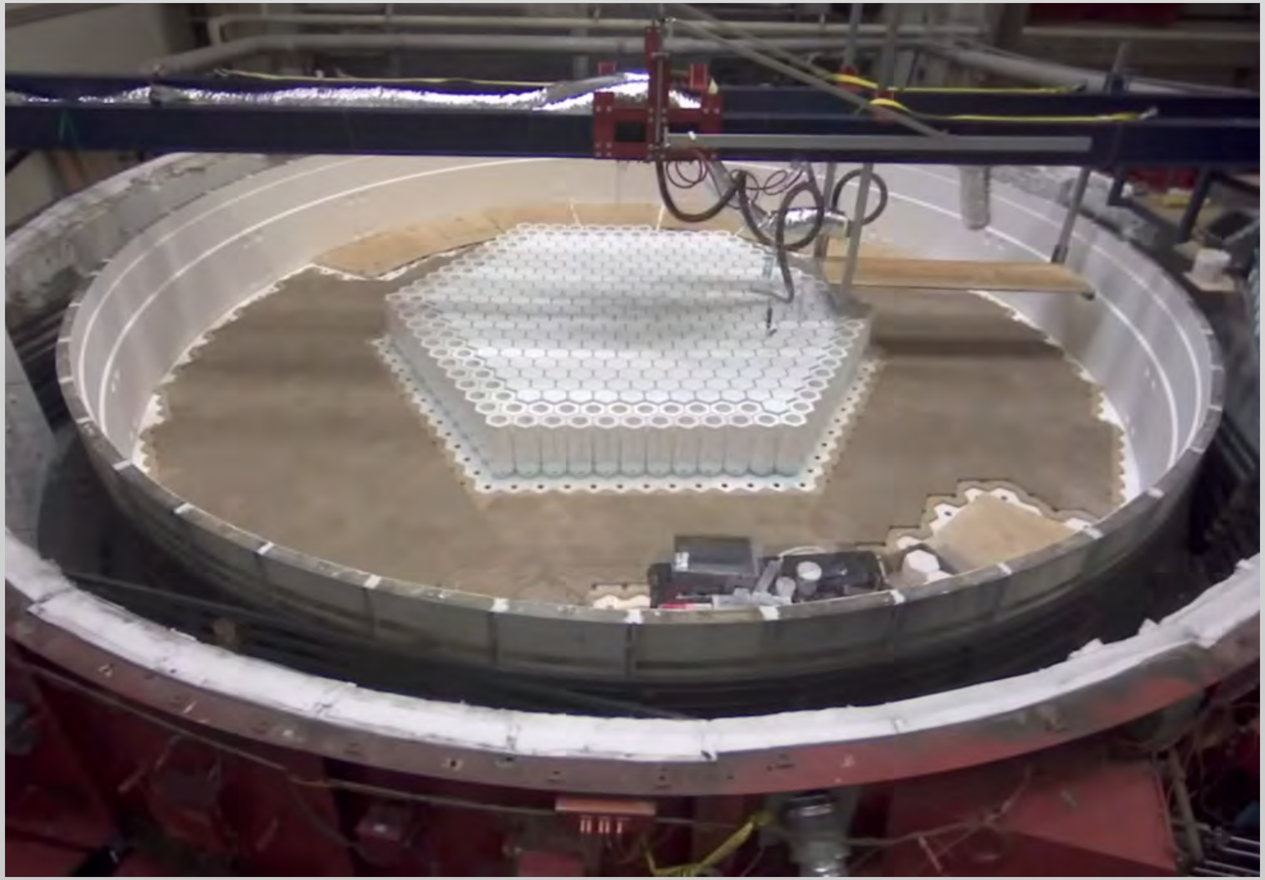


THE FURNACE IS THEN TEST FIRED TO ENSURE CORRECT OPERATION & TO THERMALLY SETTLE THE STRUCTURE

MIRRORS

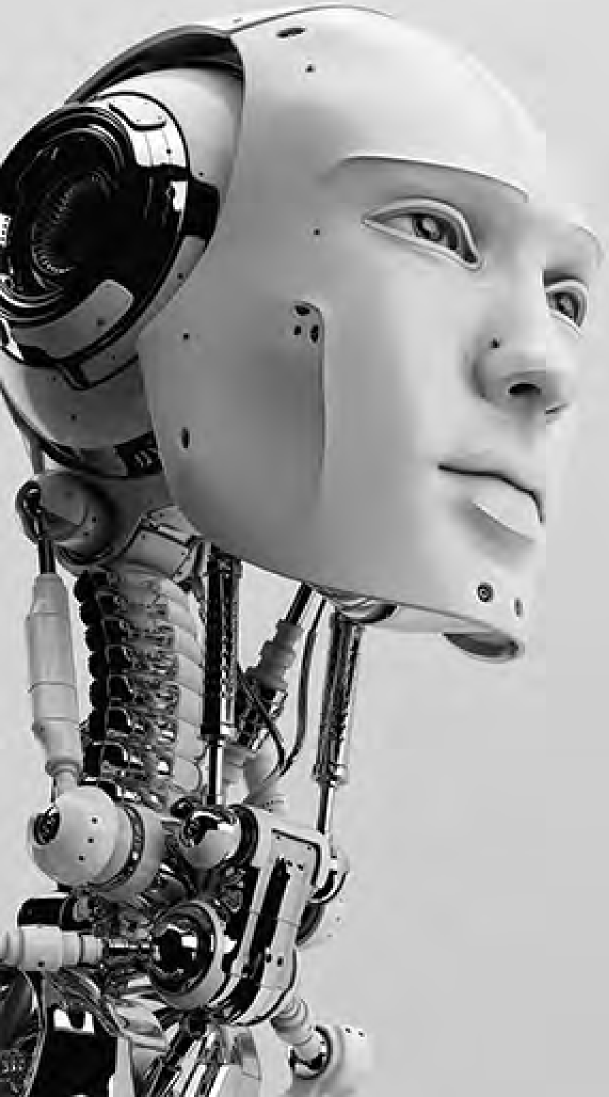
THE FURNACE IS THEN FILLED WITH SILICON HEXAGONS, THAT ARE LATER REMOVED TO REDUCE THE MIRROR WEIGHT, THEY ARE INERT AND DO NOT REACT WITH THE E6 BORON SILICATE MIRROR MATERIAL.

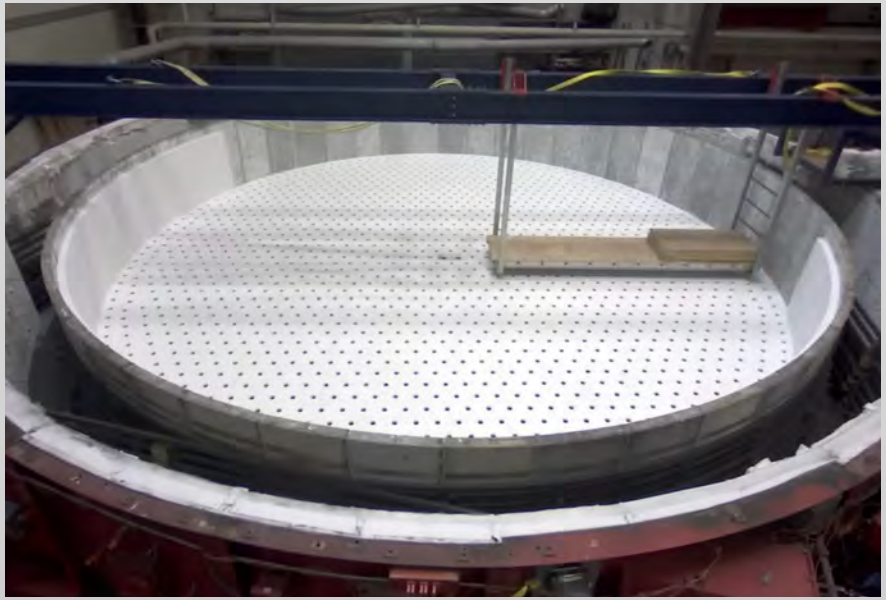




MIRRORS

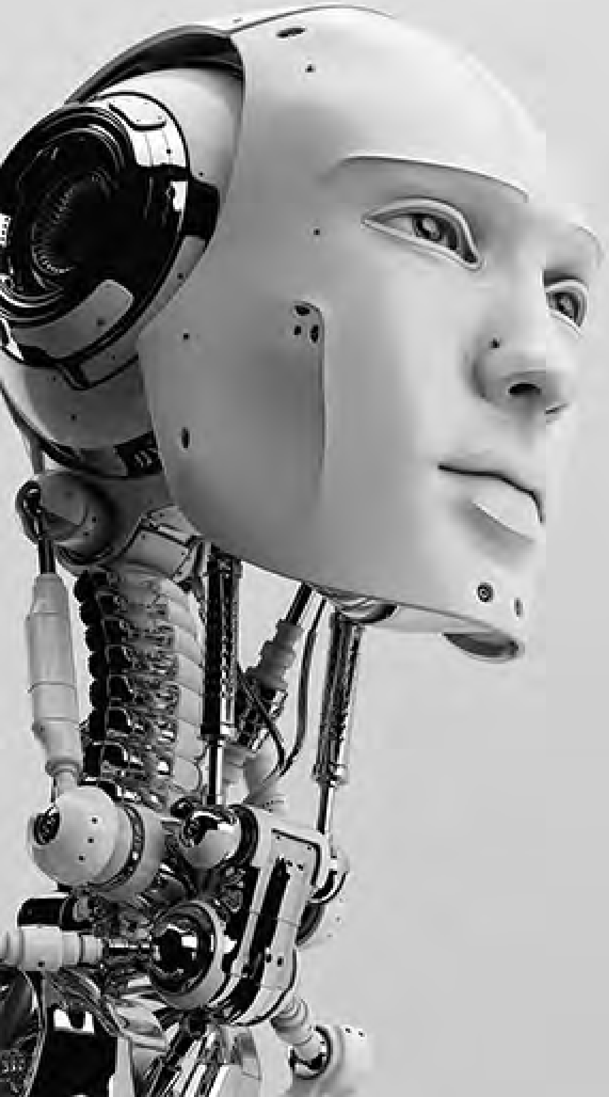
A GANTRY IS USED TO FILL THE SPACE ABOVE THE SILICON HEXAGONS WITH E6 BORON SILICATE PIECES TO A DEPTH OF APPROX 12.5cm.

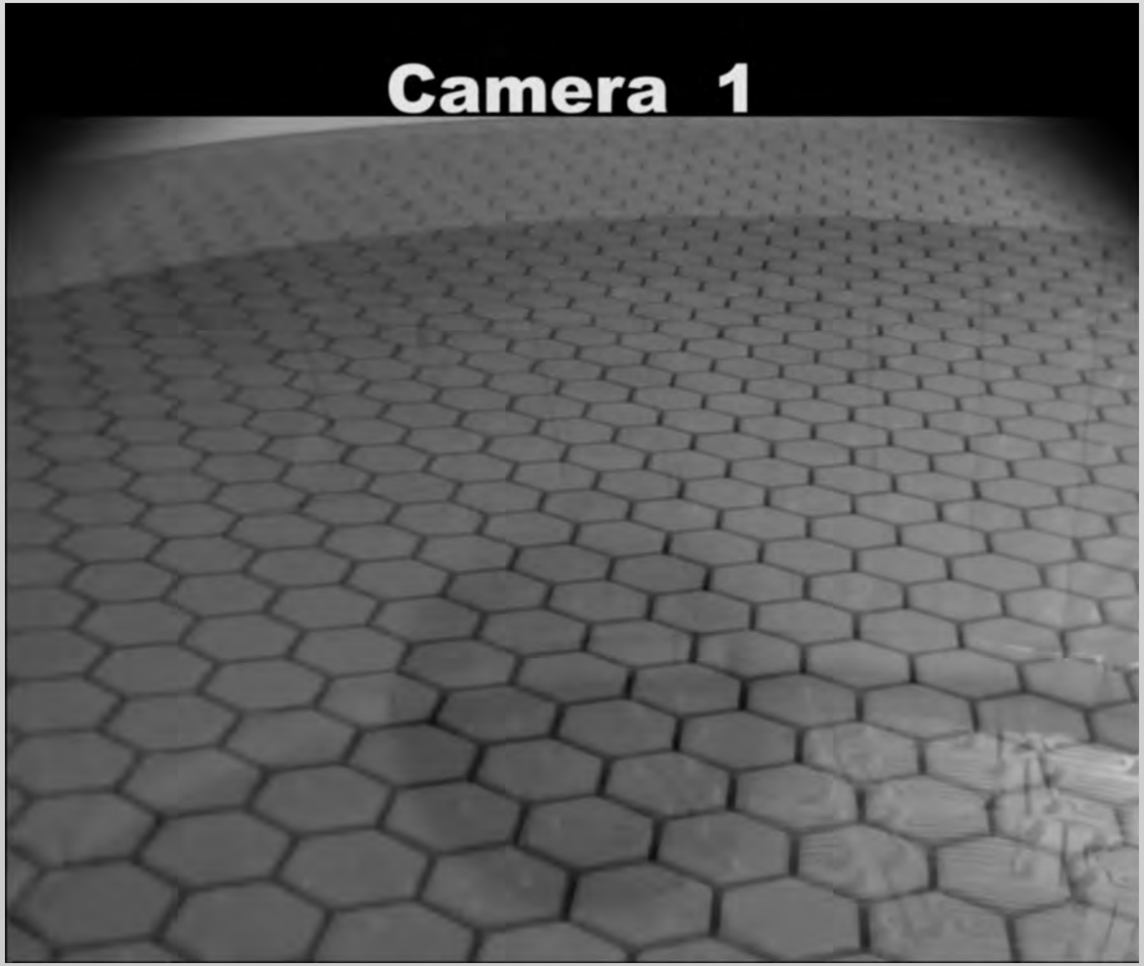




MIRRORS

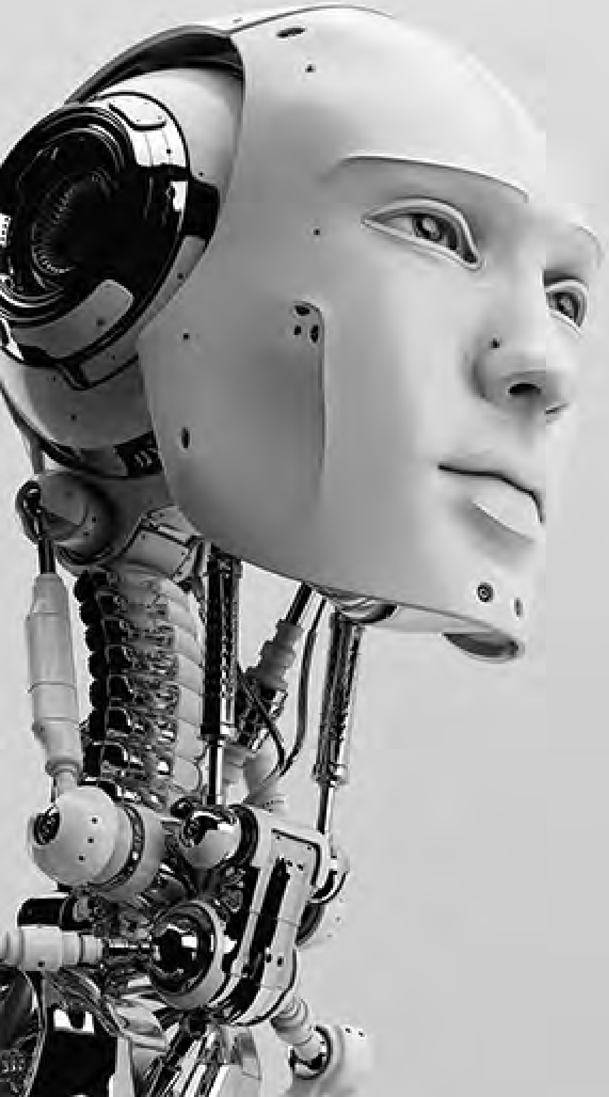
AS THE E6 IS HEATED IT FLOWS BETWEEN THE SILICON MOLD & RELEASES TRAPPED AIR. THE FURNACE IS HEATED TO A TEMP OF 1200 DEG CELSIUS THE GAP BETWEEN THE SILICON HEXAGONS IS 12,5mm

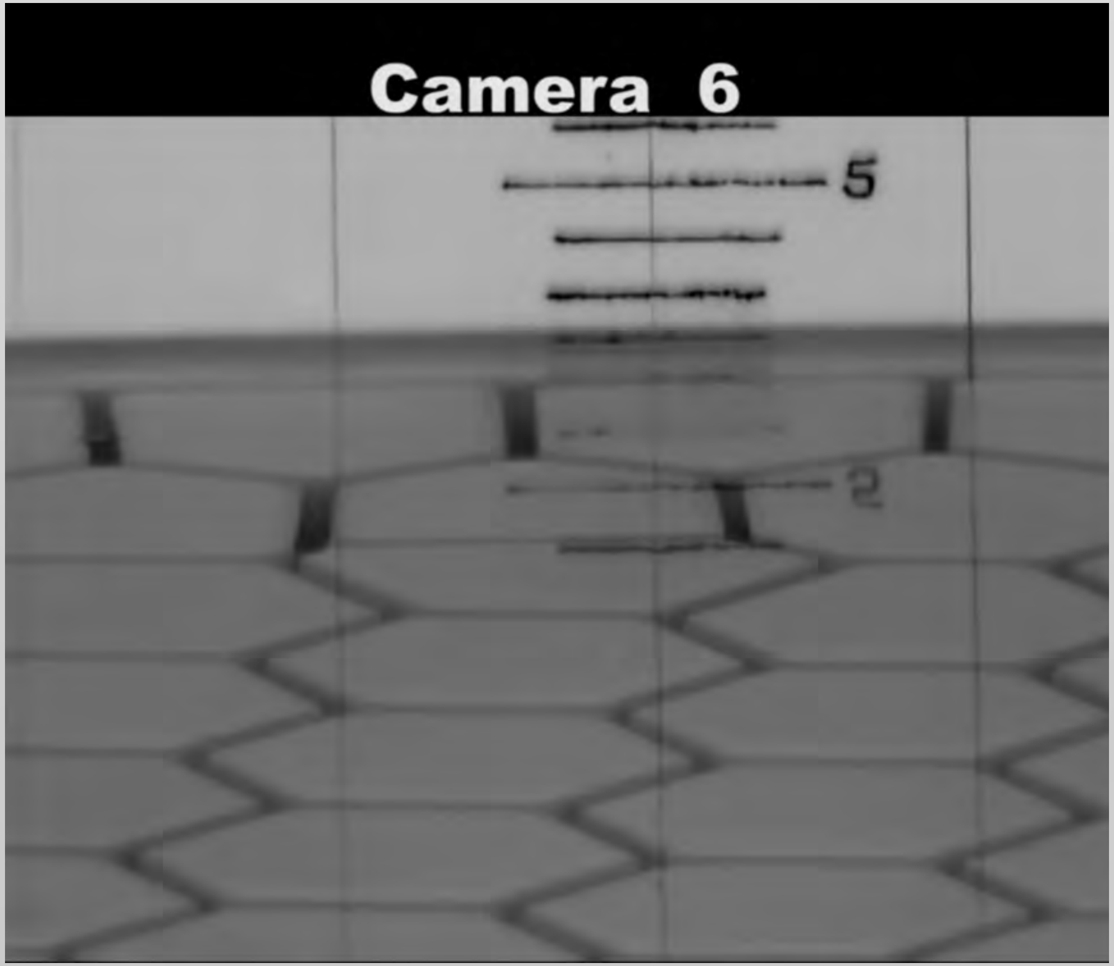




MIRRORS

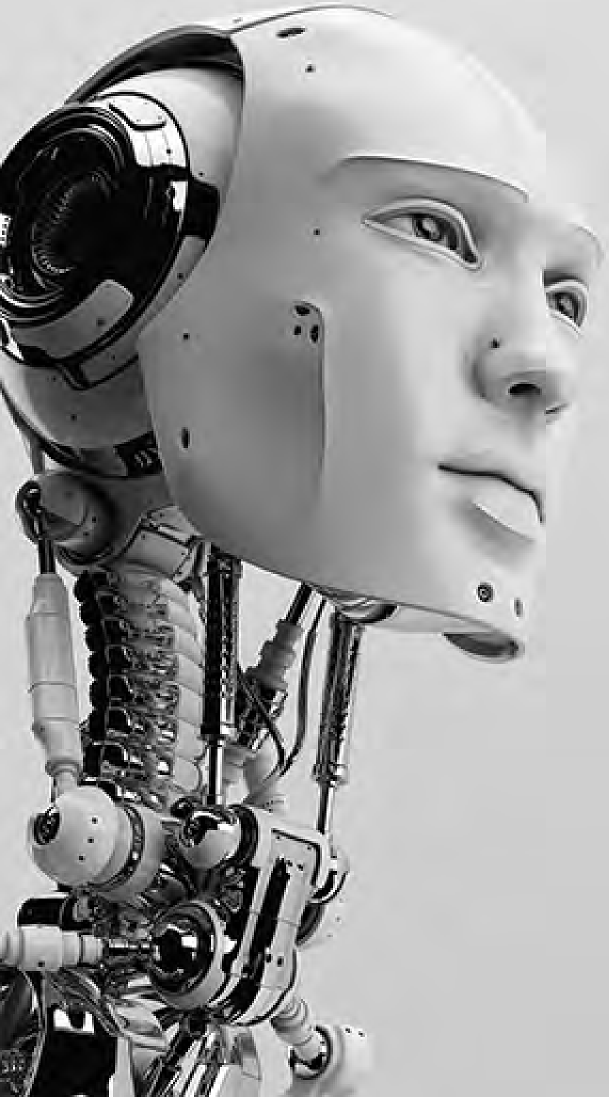
THE E6 SILICATE FORMS AND MELTS TO A DEPTH OF 5cm (2 INCHES).





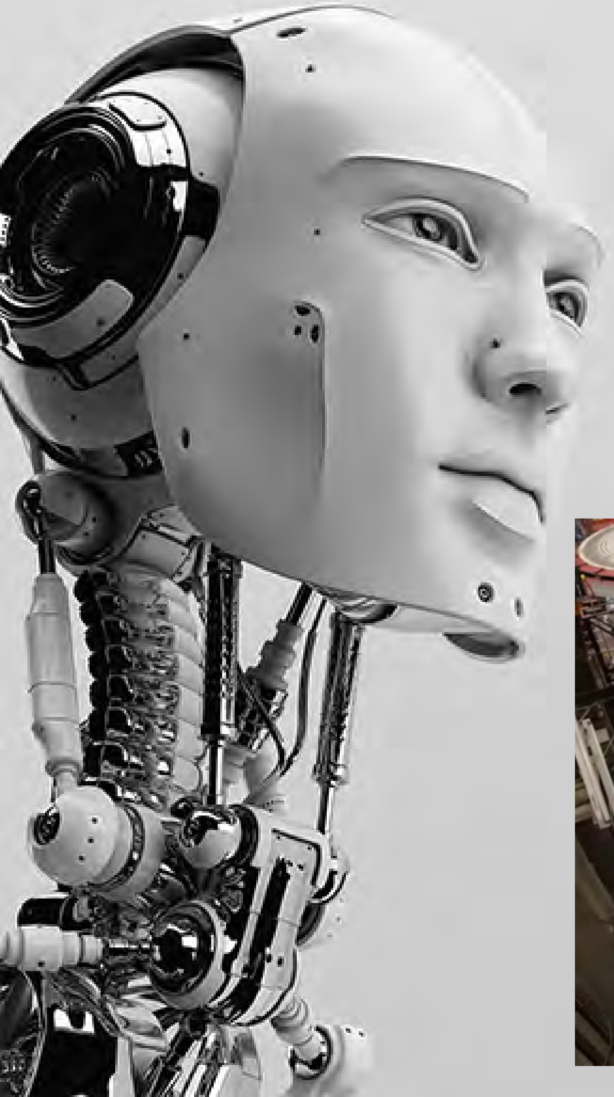
MIRRORS

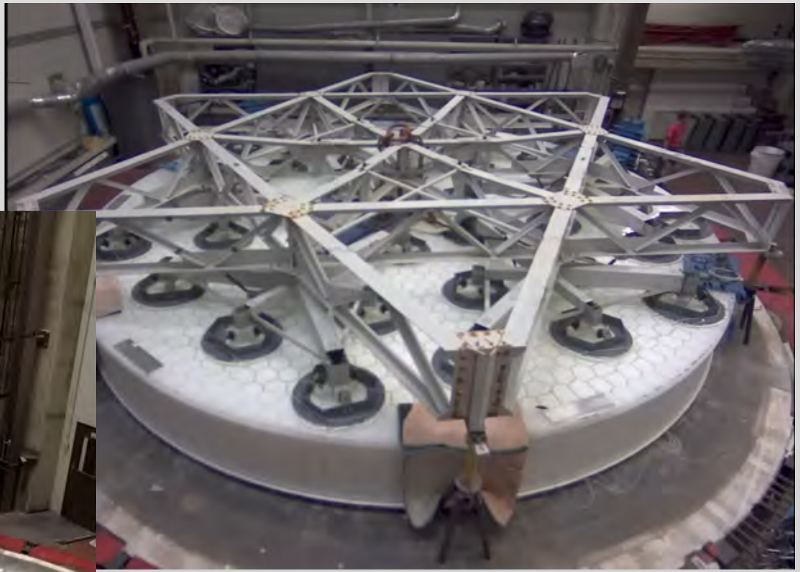
THE INITIAL COOLING IS RAPID TO SET THE MIRROR SHAPE, THE SECOND STAGE (ANNEALING) TAKES 3 MONTHS TO MINIMISE DISTORTION AND CRACKING.



MIRRORS

THE PENULTIMATE PROCESS INVOLVES ATTACHING A LIFTING FRAME TO THE MIRROR BLANK TO STAND IT ON IT’S EDGE TO REMOVE THE MOLD MATERIAL.

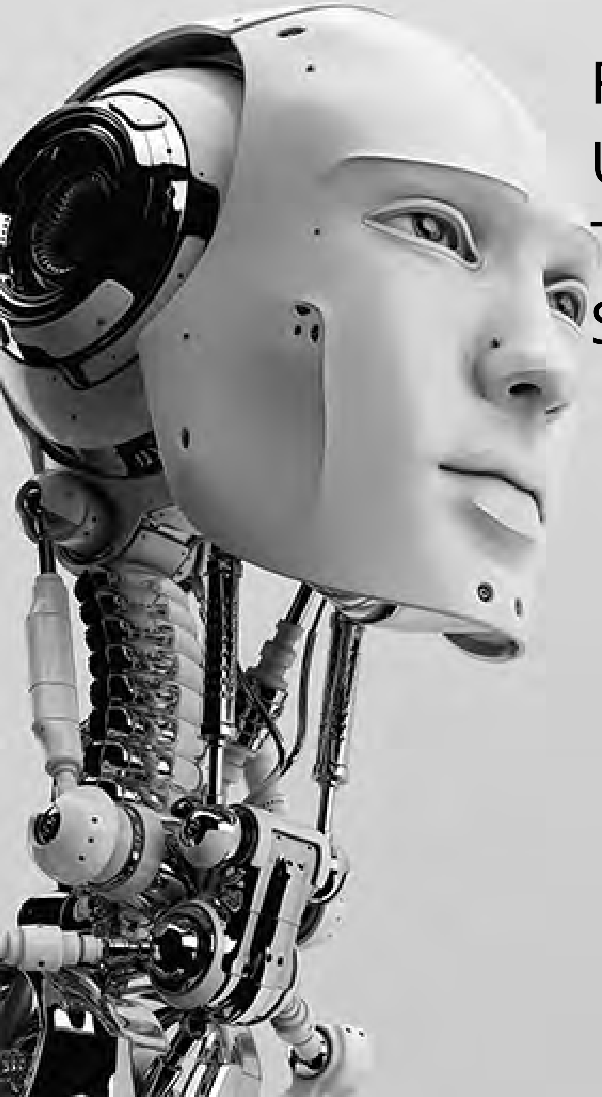


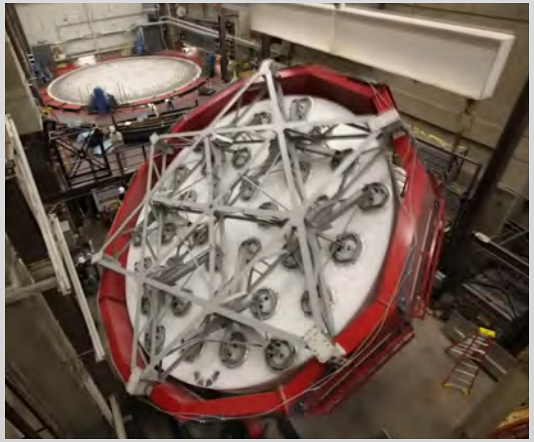


MIRRORS

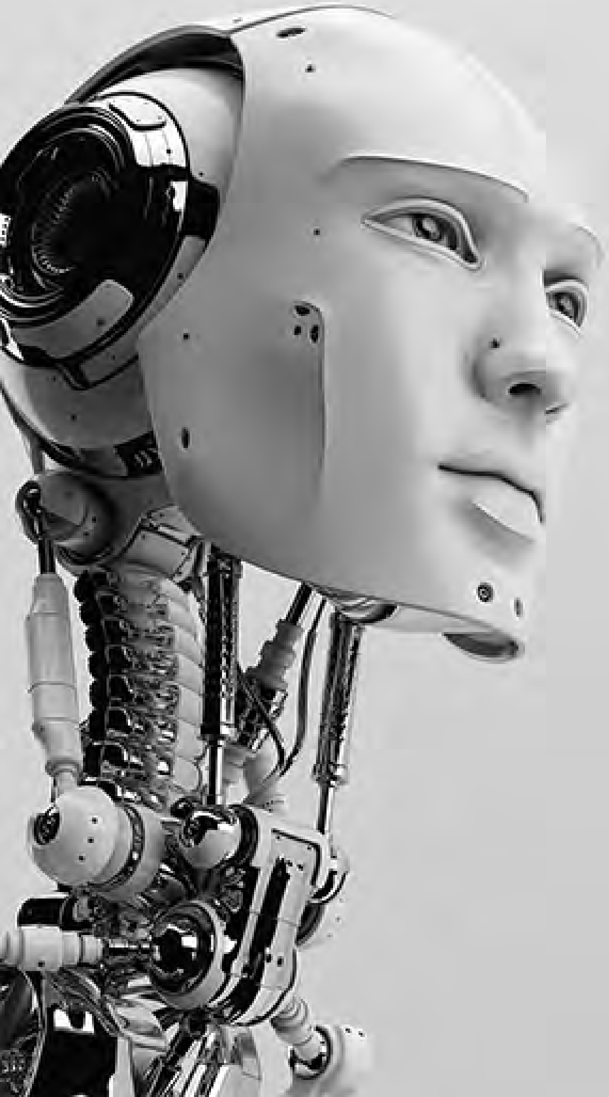
THE MOLD MATERIAL IS REMOVED BY HIGH PRESSURE WATER. THE BLANK NOW TAKES SIX MONTHS TO POLISH TO PROFILE, THE MIRROR IS FINISHED TO NANO-METRE FLATNESS. THE FINISHED BLANK IF SCALED TO THE SIZE OF THE USA WOULD HAVE NO PEAKS HIGHER THAN 3cm.

THE CENTRE MIRROR IS SYMMETRICAL BUT THE SURROUNDING SIX EACH HAVE A UNIQUE PROFILE.





A BRIEF HISTORY OF LENSES & MIRRORS



THANK YOU & QUESTIONS