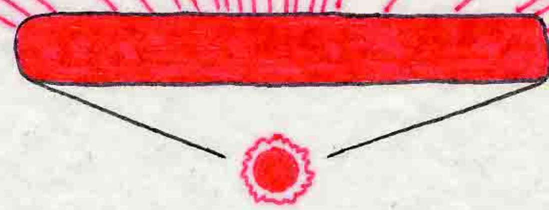
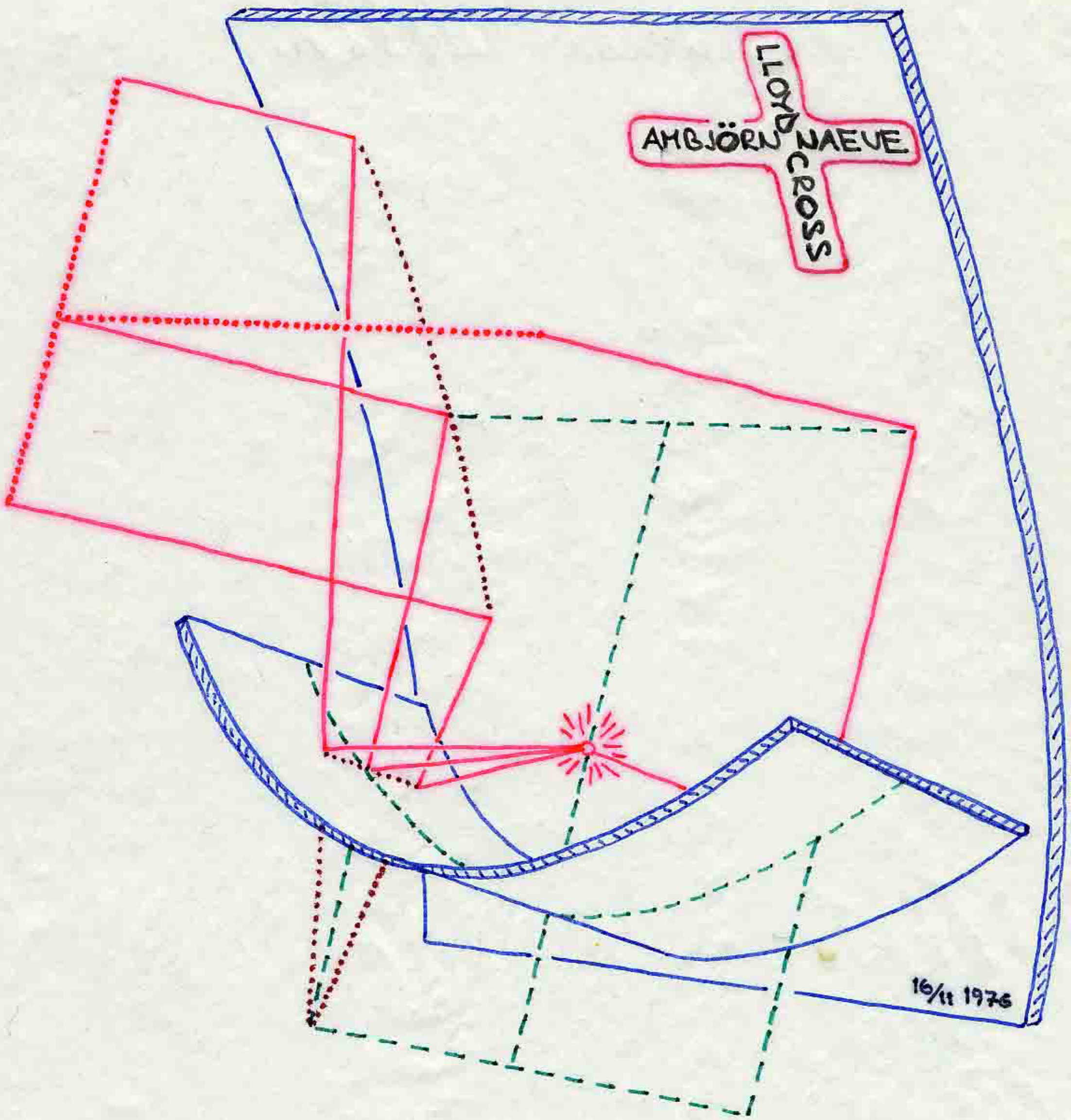
POINTFOCUS





BY

AMBJÖRN NAEVE

The aim of science
is not things themselves
– as the dogmatists in their simplicity imagine –
but the relations between things

Outside those relations
there is no reality
knowable

Poincaré

LET THERE BE

LIGHT

NOBODY KNOWS
WHAT LIGHT IS

THERE ARE
A LOT OF THEORIES AROUND

THEORY
THEORAL
THEORGY

WHAT IS LIGHT ?

THE POOL BALL THEORY
THE VIBRATION THEORY
THE ELECTRIC EEL THEORY
THE CONSCIOUSNESS THEORY

THE POOL BALL THEORY

LIGHT
IS A STREAM OF BALLS
TRAVELING IN STRAIGHT LINES
LIGHTRAYS
EXTENDING OUT
FROM THE SOURCE
IN EVERY DIRECTION
BENDING AND BOUNCING
ACCORDING TO THE RULES OF
THE COSMIC POOL GAME

THE VIBRATION THEORY

LIGHT
IS A VIBRATION
TRAVELING IN CONCENTRICAL BUBBLES
WAVEFRONTS
EXPANDING OUT
FROM THE SOURCE
LIKE CIRCLES ON THE COSMIC POND
BENDING AND BOUNCING
ACCORDING TO THE RULES OF
THE COSMIC BLENDING GAME

THE ELECTRIC EEL THEORY

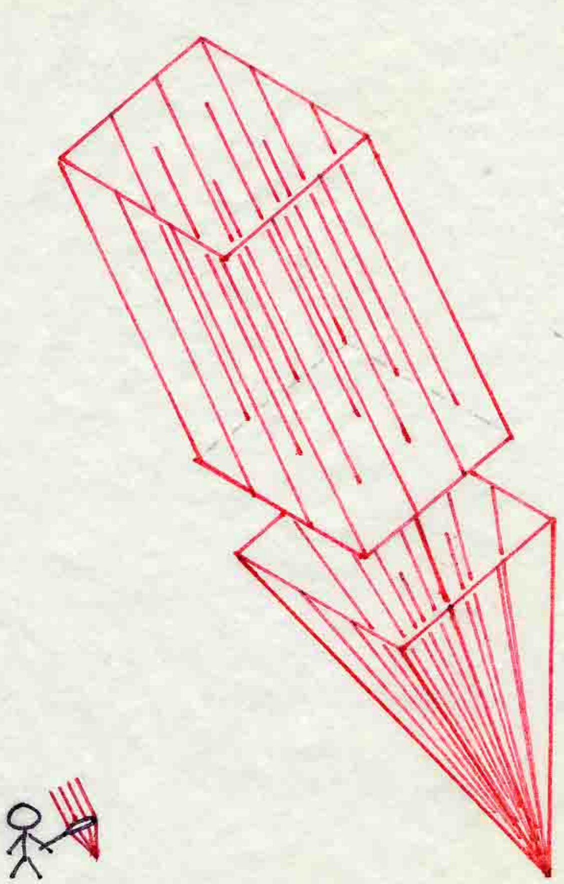
LIGHT
IS A STREAM OF ELECTRIC EELS
PHOTONS
TRANSPORTING AN ENERGY
IN PROPORTION TO THE FREQUENCY
OF THEIR VIBRATION
BEHAVING
SOMETIMES LIKE PARTICLES
SOMETIMES LIKE WAVES
DEPENDING ON THE EXPERIMENT
ACCORDING TO THE RULES OF
THE COSMIC DICE GAME

THE CONSCIOUSNESS THEORY

LIGHT
IS A FIELD OF EXTERNAL CONSCIOUSNESS
COLOURS
BLENDING WITH INTERNAL CONSCIOUSNESS
THROUGH THE RAINBOW CHAKRAS IN
THE HUMAN BODY
CREATING
THE PERSONAL HOLOGRAM
THE EGO EXPERIENCE
REALITY
ACCORDING TO THE RULES OF
THE COSMIC AWARENESS GAME

Have you ever wanted
to focus a lot of sunlight
into a point

I mean
trying to make all the sunrays
within a large area
pass through the same point
in space

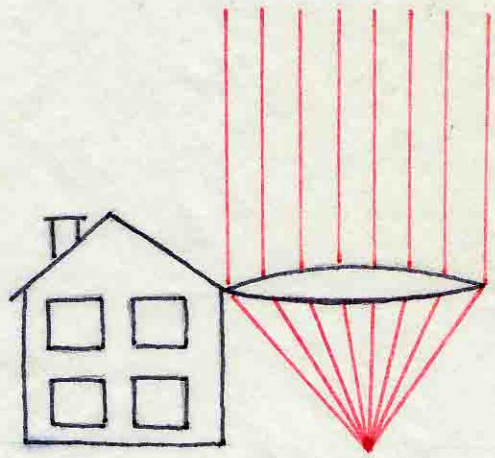


Just like a kid
playing with a burning glass

But bigger

Much bigger

Suppose
that you could gather all the sunlight
that falls in your own back yard
and make it fall
within the palm of your hand



Then
you would have a fistfull
of super concentrated solar energy

A real hot spot

Do you know
what you could do with it

You could make your own solar furnace
hot enough to melt
every material that exists

You could melt some sand
and make silicon cookies
with a boron frosting
to generate an abundance
of dirt cheap solar electricity
without the slightest pollution
of your environment

You could make yourself
all the materials you would ever need
directly from the elements
around you in nature

You could even make diamond
the hardest substance known to man
which gives you power
to work with all the others

ɷ·ɷ

You could become
a 20th century Robinson Crusoe
and live in modern comfort
almost anywhere
on the surface of this planet
without having to buy anything
from anybody

And if you started to wonder about
what to do with your spare time
you could build your own giant telescope
and open up the windows
to the universe around you

ɷ·ɷ

Yes indeed
a big pointfocus machine
could change a lot of things
in your life

Why
are they not being made

Why
don't we see them everywhere
the huge sunburning machines
like we see their oilburning counterparts
all around us

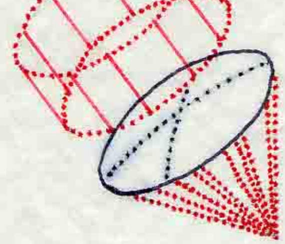
The art
of creating objects
that can focus parallell lightrays to a point
has been practiced by man
at least since the days of Galilei

parallell lightrays
have the same
direction

sunrays
are very close to
parallell

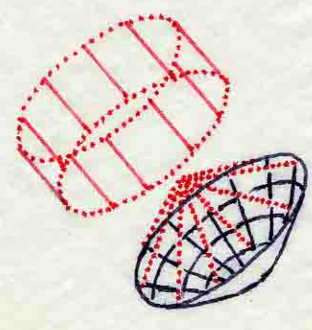
It has so far produced
two different solutions

The convex lense



It bends parallell lightrays
to a point
by letting them refract through
a properly shaped
piece of transparent material

The parabolic disc

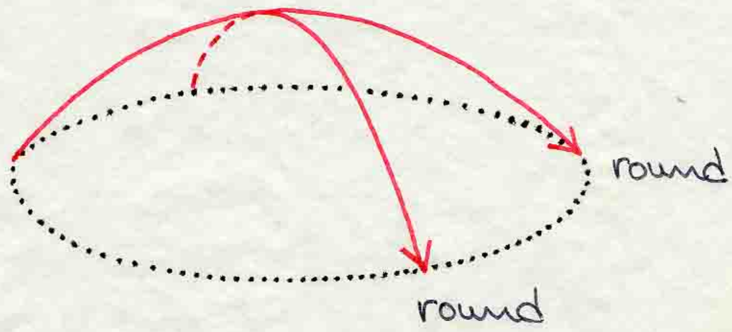


It bends parallell lightrays
to a point
by letting them reflect off
a properly shaped
mirrorized surface

These two solutions
to the pointfocusproblem
have one important thing
in common

They both have a surface
which is curved
in both of its dimensions

A round-round surface



Such a surface
can only be made
by grinding and polishing the material
towards the shape
of mathematical perfection

This
is a very laborious
and expensive
process

Even a small surface
of good pointfocusing quality
is therefore an expensive thing to make
and the cost of a big one
would be astronomical

So
the reason for the lack
of a big pointfocus
is the fact that the two mathematical surfaces
that have the pointfocusing property
are too expensive to approximate physically
in large size

But
what if there was a third way
to do it

I mean
what if there was a third mathematical surface
with the pointfocusing property

And what if the geometry of this surface
was much better adapted
to physical reality

What if it could be easily and cheaply approximated
in large size

~·~

Well
then you would have your giant burning glass
and all the benefits
that come with it

~·~

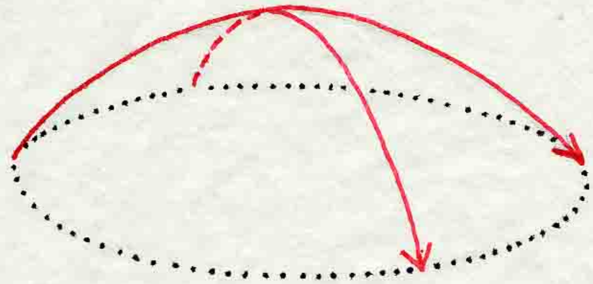
But surely
if such a surface existed
it would have been discovered in mathematics
and communicated to physics
a long time ago

I mean
this surface would solve the energy problem
this surface would create the age of solar power
this surface would open a clear window to cosmos

Surely
such an incredible surface
isn't waiting for you
just around the bend

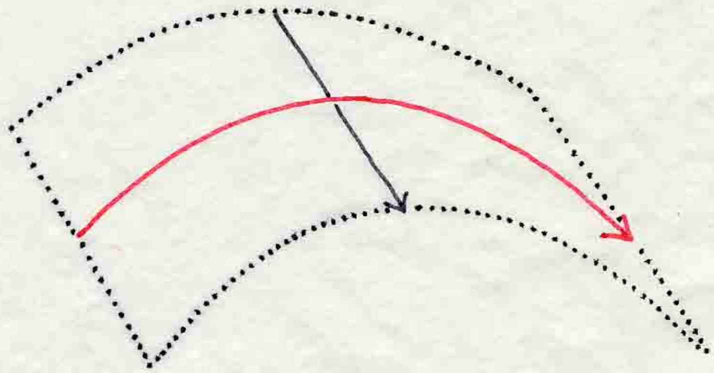
~·~

But
in fact
that is exactly what it does



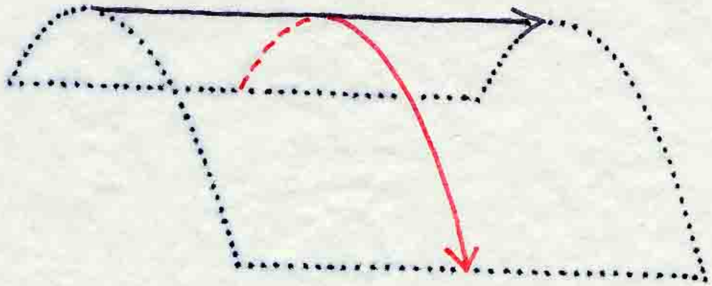
There is a third way
to do it

There is
a third mathematical surface
with the pointfocusing property



And
it has an incredibly simple geometry

It can be
easily and cheaply
approximated
in large size
by bending two flat sheets
of any flexible material



I want to show you
the third way
to do it

The third way
to focus parallell light
to a point

The third way
to focus the energy
from the sun

~ · ~

The way
of focal power

~ · ~

I want to show you
how to understand it
and how to make practical use of it

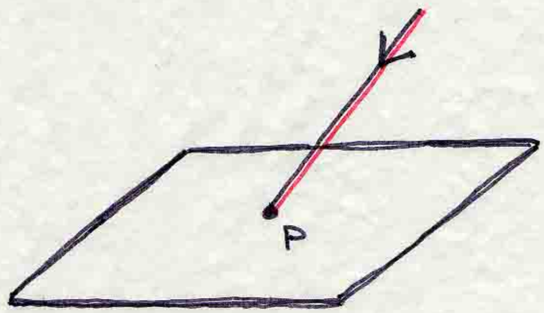
It is so incredibly simple

It only really takes
a piece of plastic
and you can get it
from the hardware store

~ · ~

Take a look
in a plane mirror

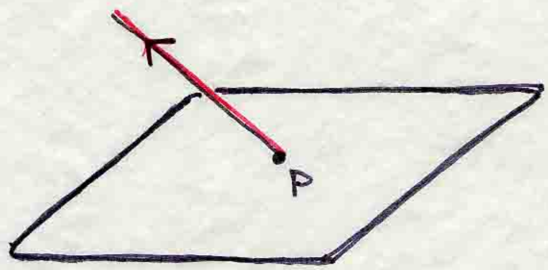
Imagine
a ray of light
that hits the mirror



~ · ~

In which direction
will it bounce back.

Where
is the reflected ray
in relation
to the incoming ray

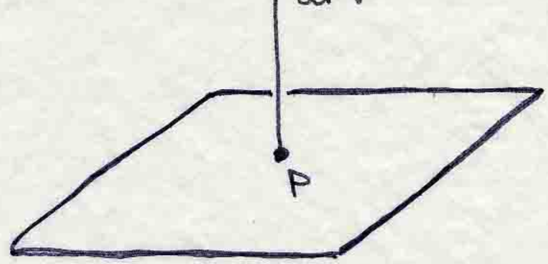


How
does Nature figure out
where to put it
in space.

~ · ~

To each plane
there is a unique direction
which is perpendicular
to it

The normal
at P

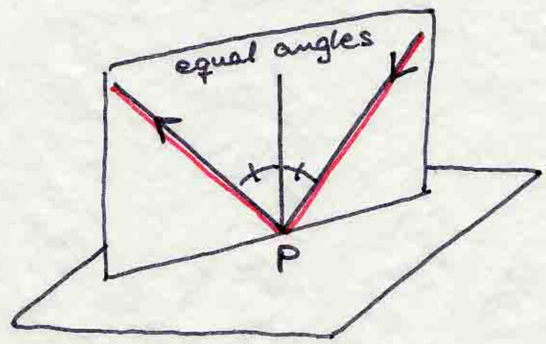


This direction
has a special name
in mathematics

It is called
the normal
of the plane

~ · ~

The reflected lightray
leaves in the plane
that contains
the incoming ray
and the normal
at the point of impact



And the two rays
form equal angles
with this normal

This
is the law of reflection
for a plane surface

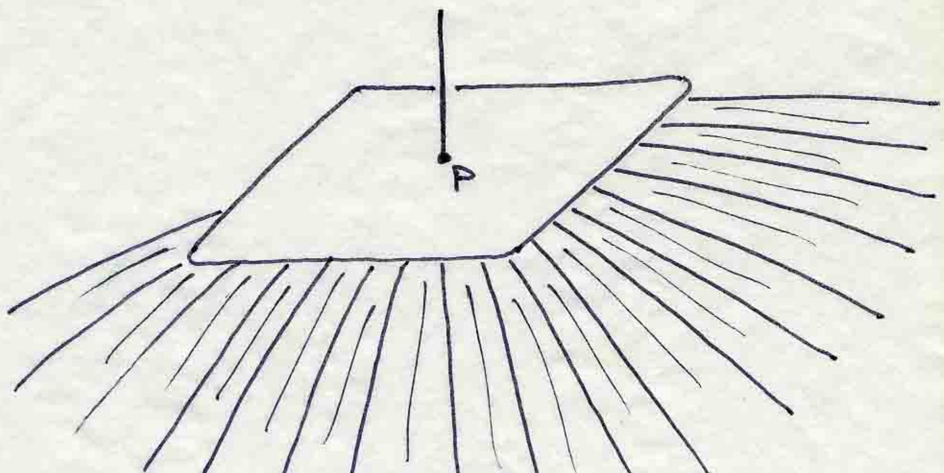
~·~

But
what if
the surface is curved

How
do the lightrays reflect
in a curved mirror

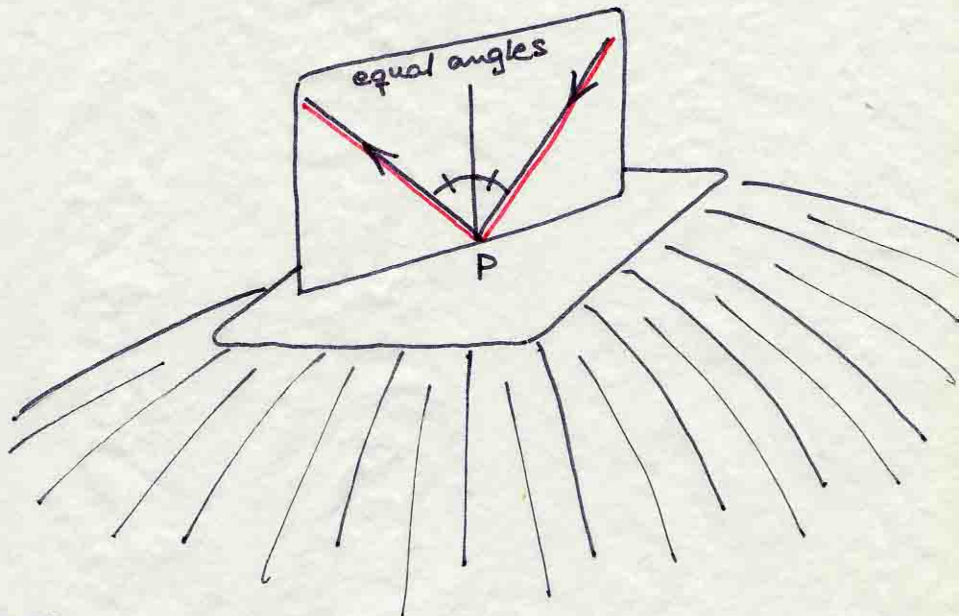
~·~

Each point
on a curved surface
has a "touching plane"



The touching plane
of the point P
is the plane
that touches the surface
at this point

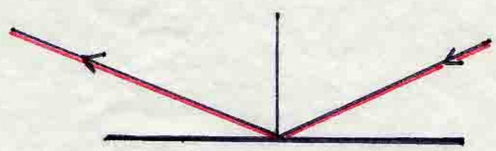
A light ray
that hits a curved mirror
will reflect
in the same direction
as if it were hitting
the touching plane
at the point of impact



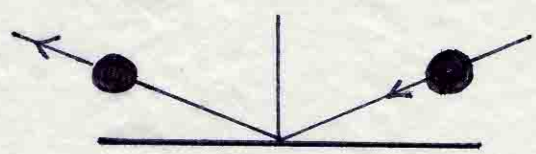
Therefore
the law of reflection
for a plane surface
is true also
for a curved surface
if
we let the word normal
mean
normal to the touching plane

$\sim\cdot\backsim$

A ray of light
reflects
like a ball
on the pool table



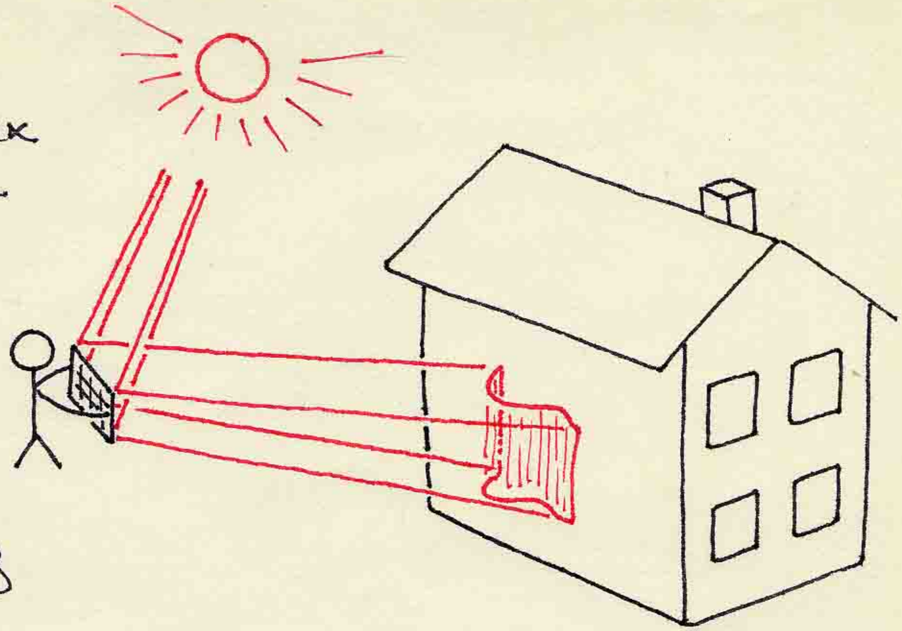
They both
swing a half turn
around the normal
at the point of impact



$\sim\cdot\backsim$

Take a piece of mirrorplex
and aim it at the sun

Bounce the sunlight
onto a wall



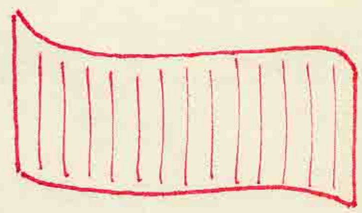
∾ · ∽

Bend the mirror
by squeezing and twisting
the ends

Watch the changes
of the lightshape on the wall

∾ · ∽

When the shape gets larger
the energy is spreading thinner



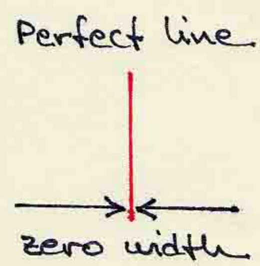
That is why
the shape gets dimmer

When the shape gets smaller
the energy is concentrating

That is why
the shape gets brighter
and hotter

∾ · ∽

How much
can you concentrate the energy

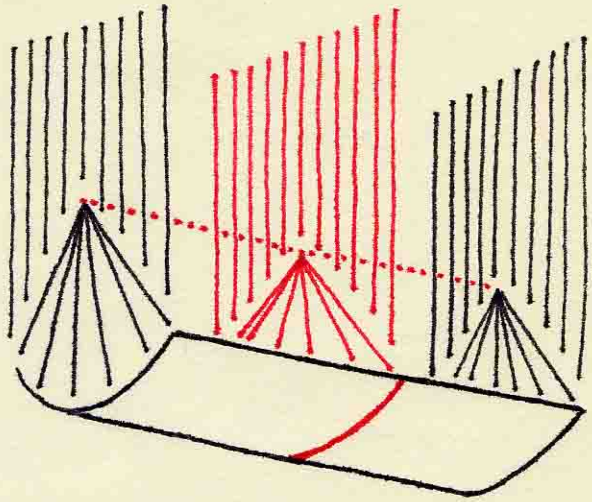


How small
can you make the shape

How close
can you get to a perfect line

∾ · ∽

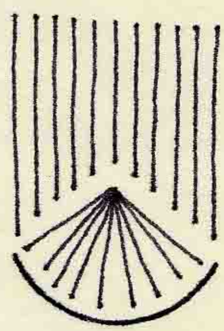
Is there a perfect line
to aim for



This
is a mathematical problem
since a perfect line
is a mathematical concept

We are looking for
the ideal bending curve
for the edge of the mirror

The curve to aim for
when you are bending it



The curve
that would reflect
all the parallell lightrays
of a plane surface
into a single point

Is there
such a curve

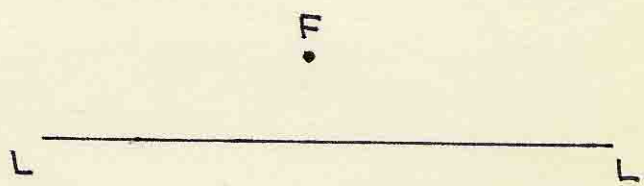
And
if it exists
what does it look like

The answer
to this question
has been known to mathematics
for a long time.

The curve
we are looking for
is called

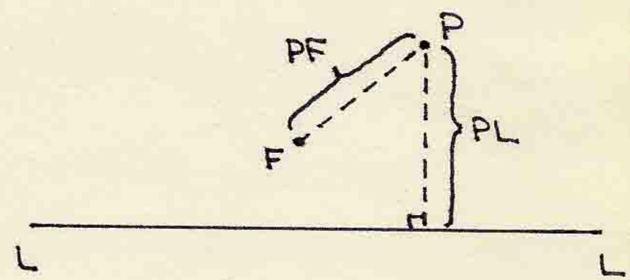
The Parabola

Choose a point (let's call it F)
and a line (let's call it L)
in the plane.



Then
choose another point (let's call it P)

Measure
the distance from P to F (called PF)
and
the distance from P to L (called PL)

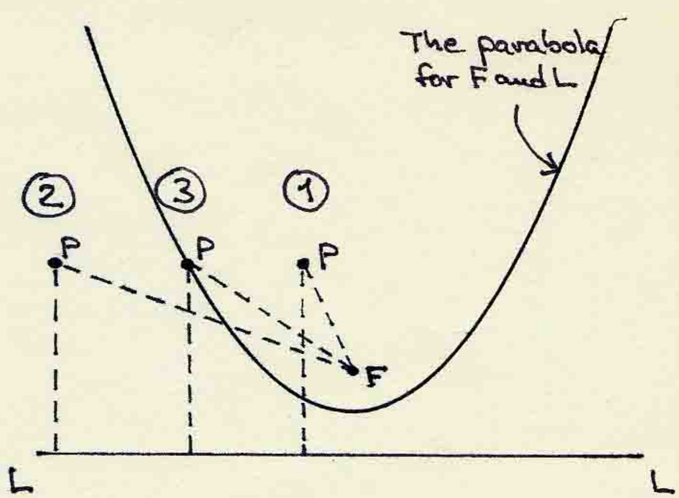


No matter where
you choose the point P
one of these three alternatives
will happen

(1) P is closer to F

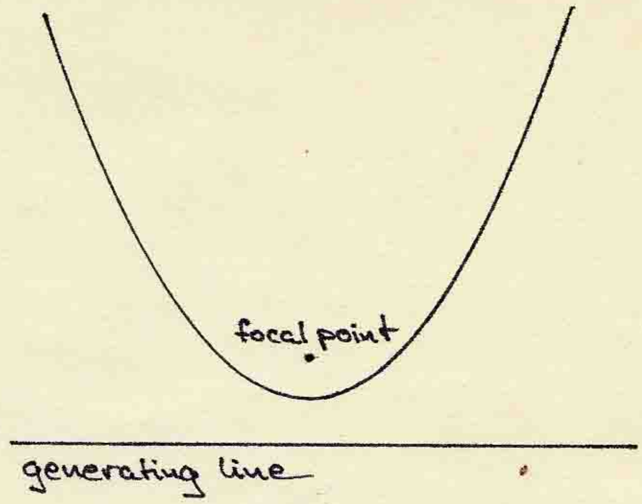
(2) P is closer to L

(3) P has the same distance to both



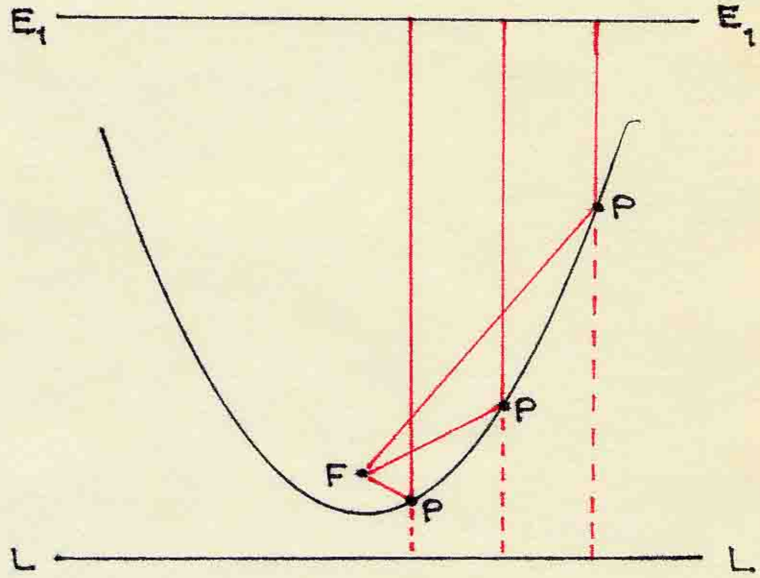
The parabola
determined by F and L
is the curve of all points
that have the same distance
to both F and L

The point F
is called the focalpoint
and the line L
is called the generating line
of the parabola



Draw another line
called E_1
which is parallell to L

Choose a point
called P
on the parabola



Then
the distance from P to F
is equal to
the distance from P to L

Therefore
the sum
of the distance from E_1 to P
and the distance from P to F
is equal
to the distance from E_1 to L

Therefore
the sum is the same
for every point P
on the parabola

This fact can be used
to make
a parabola drawing machine

All you need is
a straight edge
two C-clamps
a right angle
a piece of string
a piece of wood
a nail
and some tape

Tie the string
to the piece of wood
and tape it
to the top of the right angle

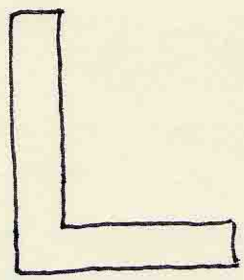
Tie the other end of the string
to the nail
at a distance
equal to the length of the angle

Fasten the straight edge
to the table
with the C-clamps
whereever you want
the generating line

Pin down the nail
wherever you want
the focal point

some tape

a right angle



a straight edge
a ruler
a straight board
a piece of aluminum angle
⋮

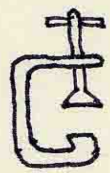
a piece of string

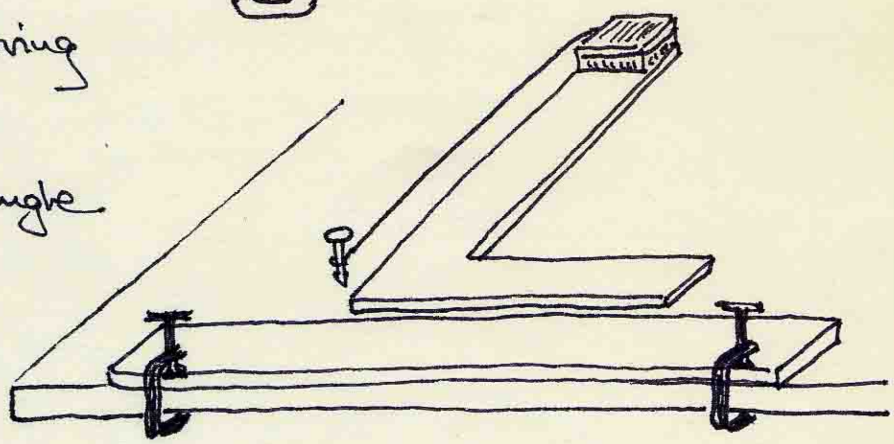
not too elastic

a nail

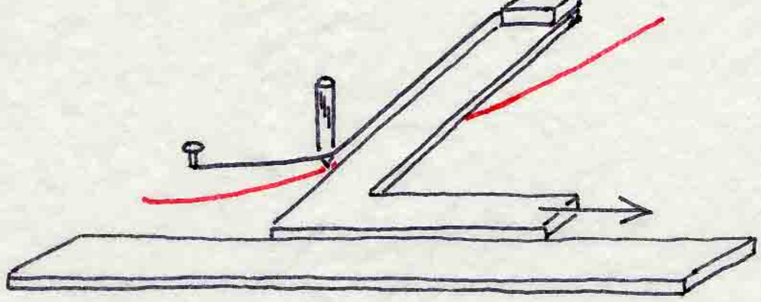
a piece of wood

a C-clamp



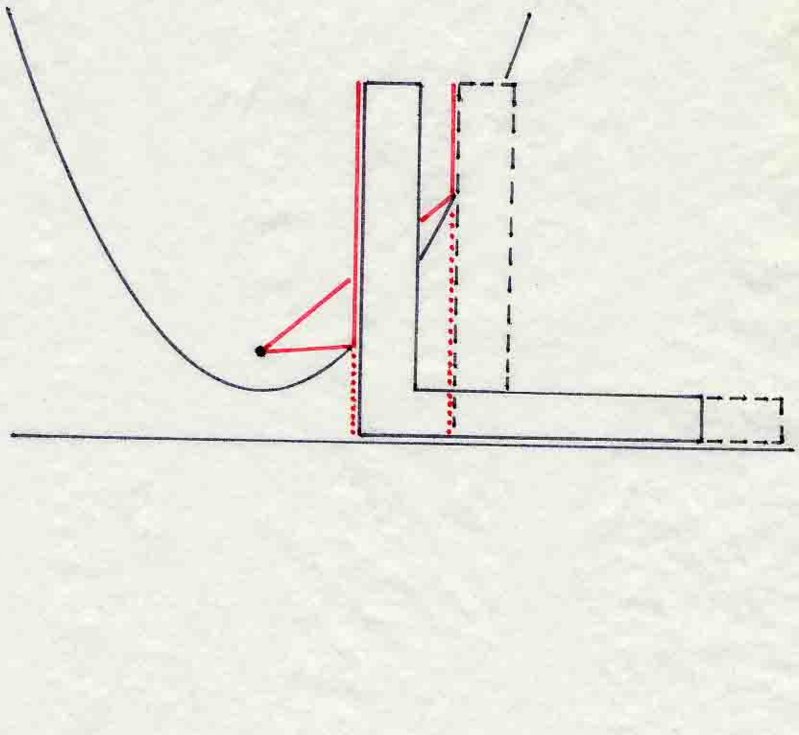


Slide the angle
along the edge
and push the string tight
against the side of the angle
with the tip of your pen



Then
your pen will trace
a parabola
on the table

The edge
is the generating line
and the nail
is the focal point
of this parabola



N.S

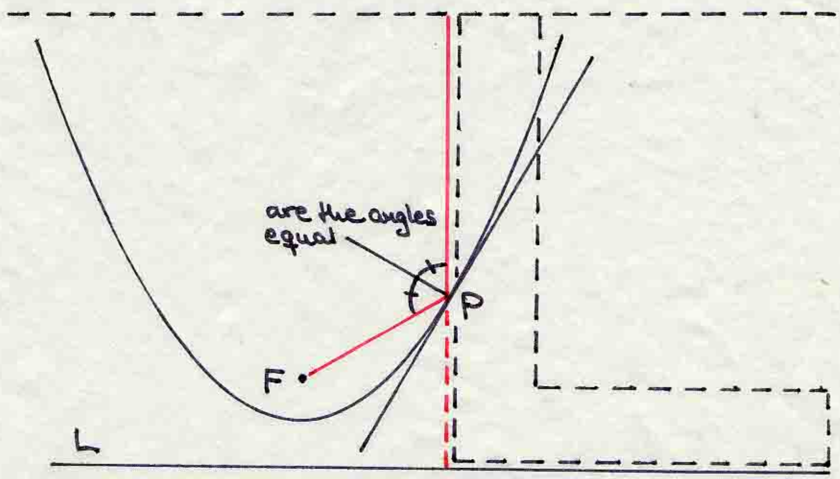
So
now you know
what a parabola is

But
how do you know
that it is in fact
the curve you are looking for

The curve
that will reflect
parallell lightrays
to a point

N.S

Take a look at
the parabola machine



Suppose
that we could prove
that the path of the string
is the same
as the path of a light ray
reflecting
in the parabola

Then
since all the different stringpaths
meet at the point F
so would all the different lightpaths

~ · ~

How
can we prove
that the stringpath
follows the law of reflection
in the parabola

~ · ~

This can be done
with the use of
formulas and equations

It is a standard proof
of high school mathematics
involving
trigonometry
analytical geometry
and a bit of calculus

~ · ~

But
there is a simple
and beautiful
intuitive proof
based on
two fundamental principles
of physics

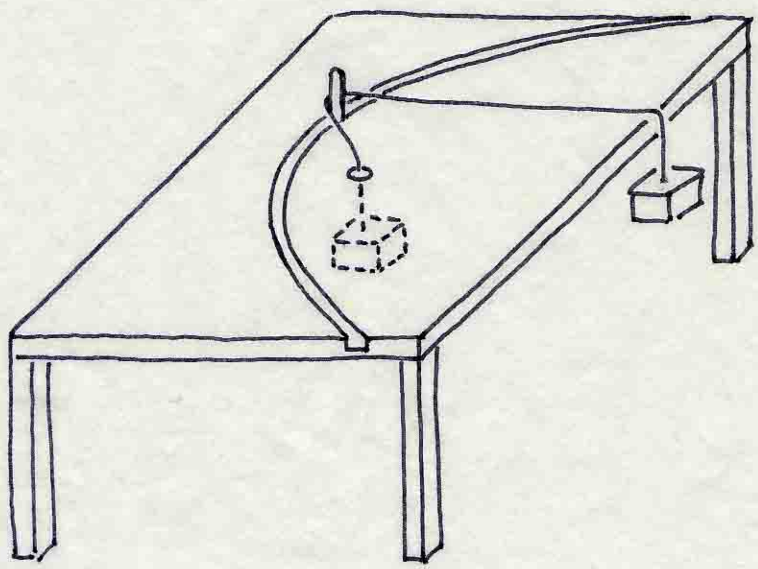
A principle
of energy

and

A principle
of balancing forces

Take a rectangular table

With the edge
as the generating line
cut a parabolic track
in it

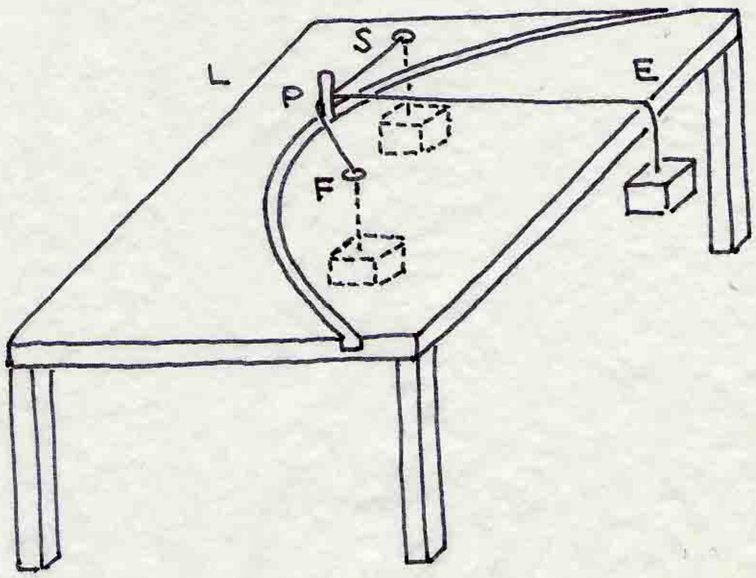


Make a peg
that slides smoothly
in the track

Drill a hole
through the focal point F

Put a string
through the hole
and around the peg
across the edge of the table
and hang a 1 pound weight
from each of its ends

Then
choose a point S
and drill a hole through it

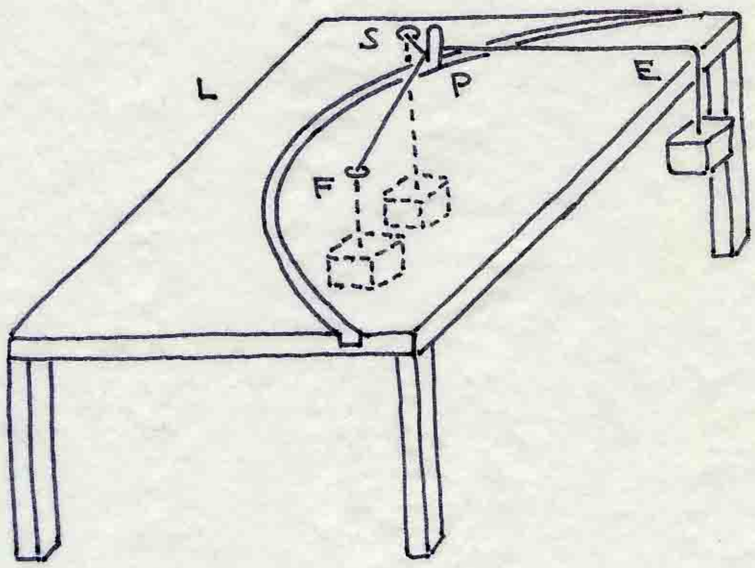


Tie a string to the peg
drop it through the hole
and hang a 1 pound weight
from its other end

Finally
oil the table
with supergrease
to make all motions
frictionless

~ · ~

When the weights
are hanging freely
the position of the peg
will adjust itself
to the point where
the total energy of the weights
is minimal



That is the point
where the weights are
as close to the floor
as they can be

The point
where the total length
of the strings under the table
is as large as possible

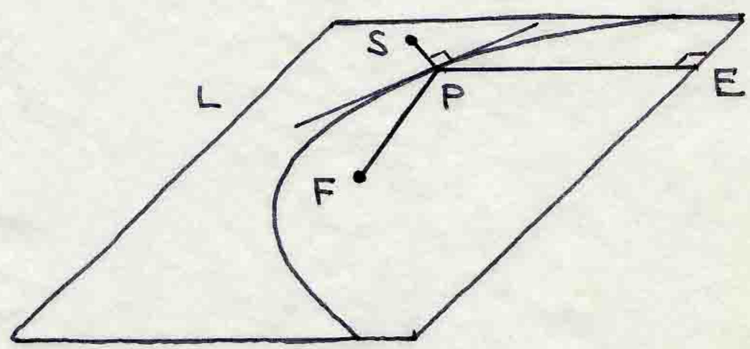
The point
where the total length
of the strings on top of the table
is as small as possible

~ · ~

But
the string FPE
is identical to
the string of
the parabola machine

Therefore
its length is always the same
no matter where the peg is

So
the position of the peg
must be the point
where the string SP
is as short as possible



The point
that is closest to S
on the parabola

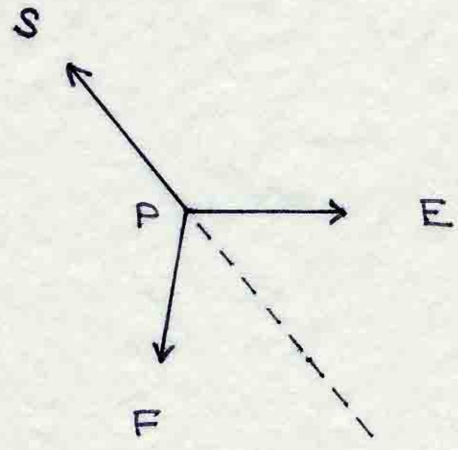
The point
where SP is perpendicular
to the curve

The point
where SP is the normal
to the touching line
of the parabola

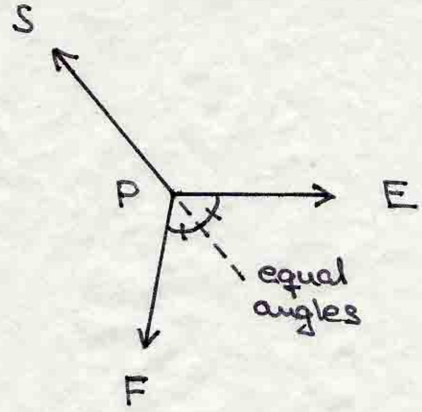
Now
think of the forces
acting on P

The peg is pulled
with equal force
towards F and E

This action is balanced
by a pull towards S

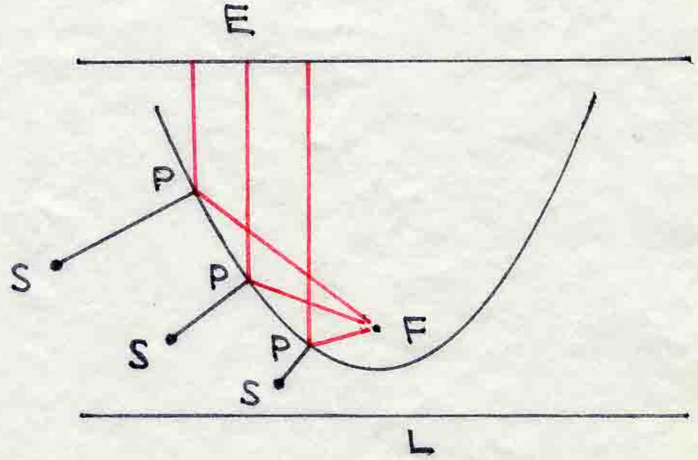


Therefore
the direction SP
must split the angle FPE
in two equal parts



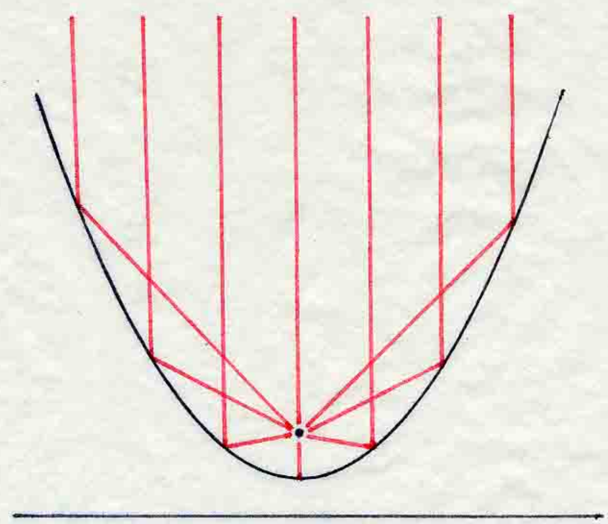
But
SP is the normal direction at P

Therefore
for each choice of the point S
the string FPE
is identical to
the path of a ray of light
reflecting at P



So
we finally arrive at
the conclusion

A mirrorized parabola
will reflect all the parallell lightrays
that are perpendicular
to its generating line
through its focalpoint



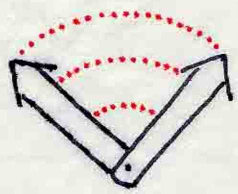
The Parabola
is the curve
of perfect pointfocus
in a two dimensional universe

So
now you have
a two dimensional pointfocus

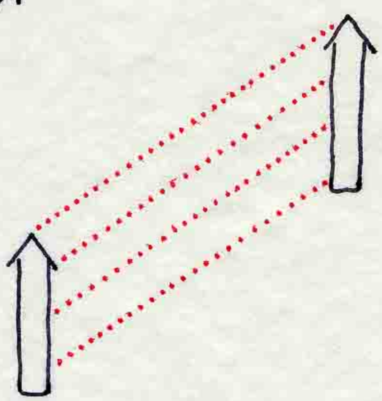
But
how can you focus
threedimensional light
with it

This problem
suggests a motion
of the parabola
in space

Rotation
is the motion of things
in circles

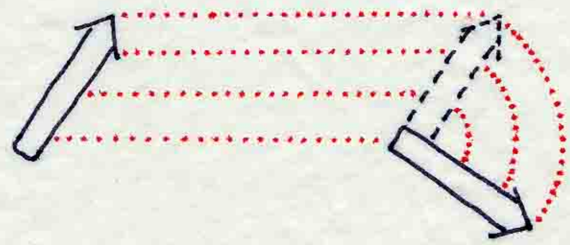


Translation
is the motion of things
in parallell lines



They are
the basic motions
of geometry

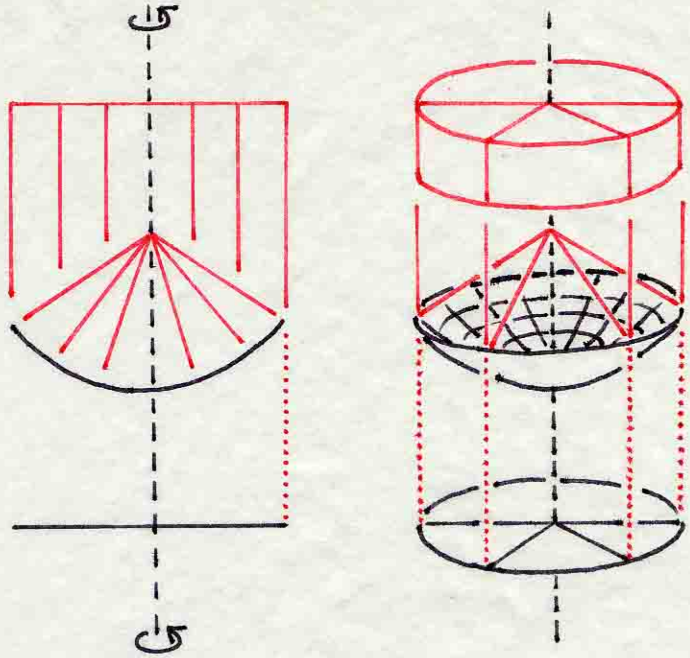
Together
they combine
into all possible motions
of ridgid things



Rotate the parabola
around its axis of symmetry

The trace of the curve
will be a pointfocus
in our universe

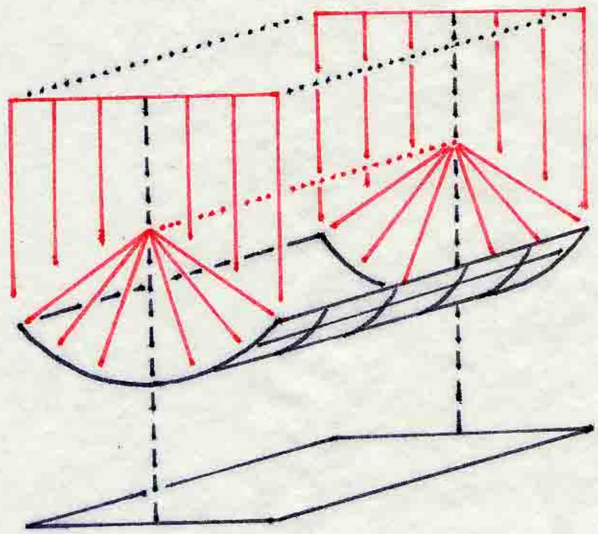
It is called
the parabolic disc
or
the paraboloid of revolution



Translate the parabola
perpendicular to its plane

The trace of the curve
will be a linefocus
in our universe

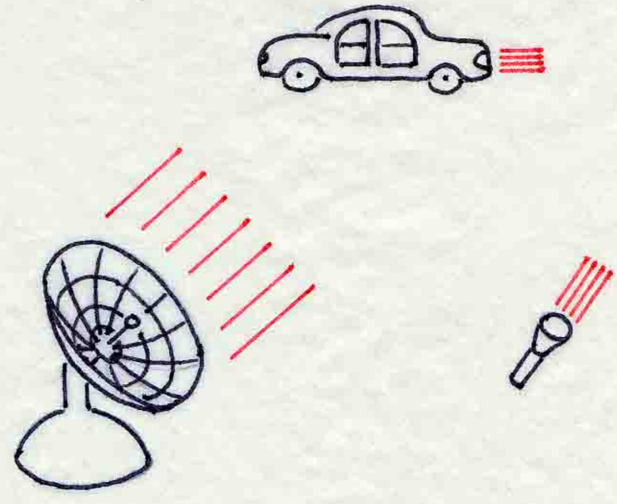
It is called
the parabolic cylinder



The parabolic disc
is a very common surface
on this planet

It is a symbol
of our age

It is the pointfocus
of modern technology



But
the parabolic disc
is not the only way
to do it

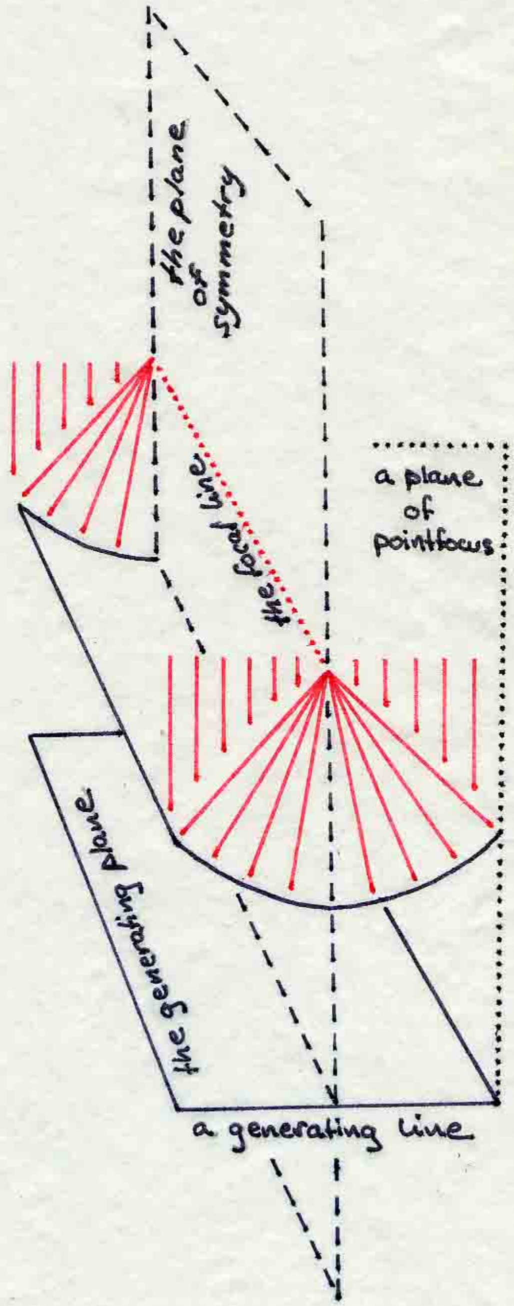
There is a way
to make a pointfocus
with two parabolic cylinders

A parabolic cylinder
has a focal line
and a generating plane

If you slice the cylinder
perpendicular to its focal line
you get
a plane of pointfocus
for the cylinder

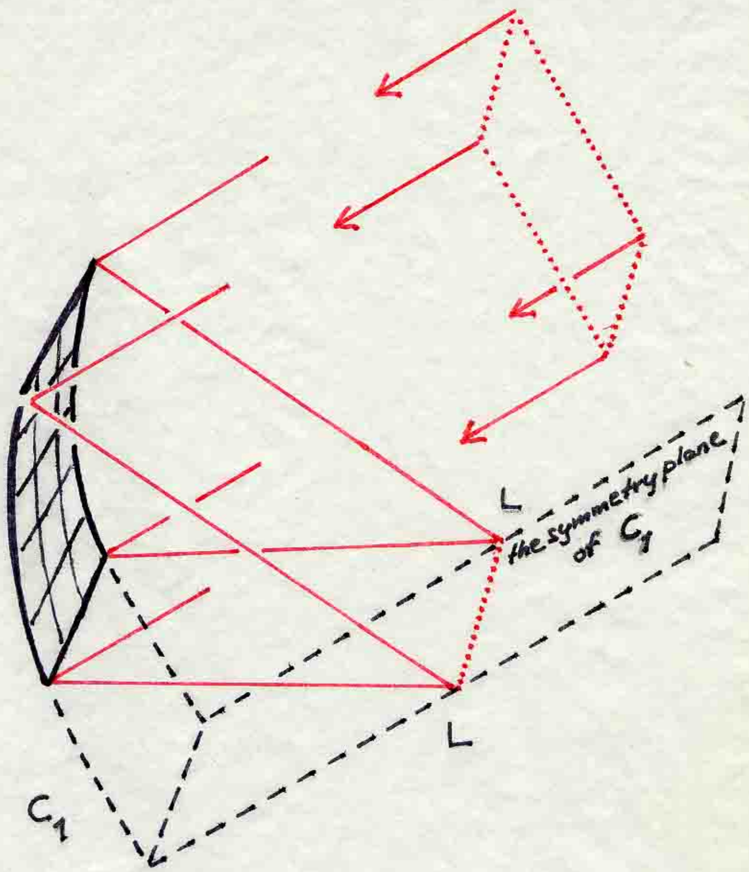
The corresponding cut
in the generating plane
is called
a generating line
for the cylinder

It is
the generating line
of the parabola
which is the corresponding cut
in the cylinder



Take a look
at this parabolic cylinder

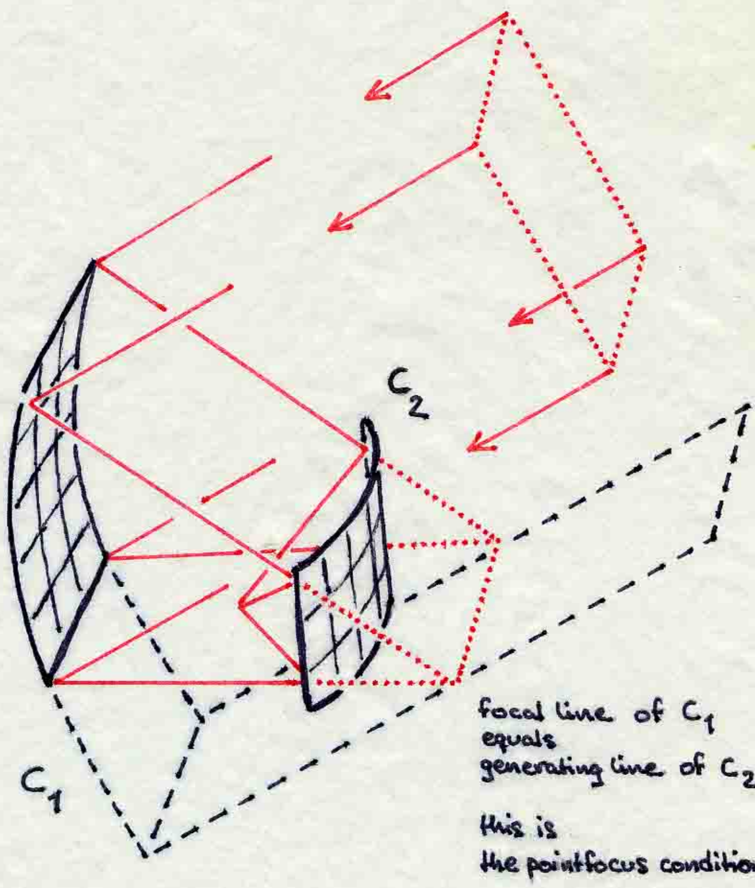
Let's call it C_1



The light
that hits it parallell
to the axis of symmetry
will bounce back
aiming
for the focal line L

Suppose
that we catch the light
with a second
parabolic cylinder C_2

I claim that
if C_2 is placed so that
the focal line of C_1
is identical to
a generating line of C_2
then
the light will come
to a perfect pointfocus



focal line of C_1
equals
generating line of C_2

This is
the pointfocus condition

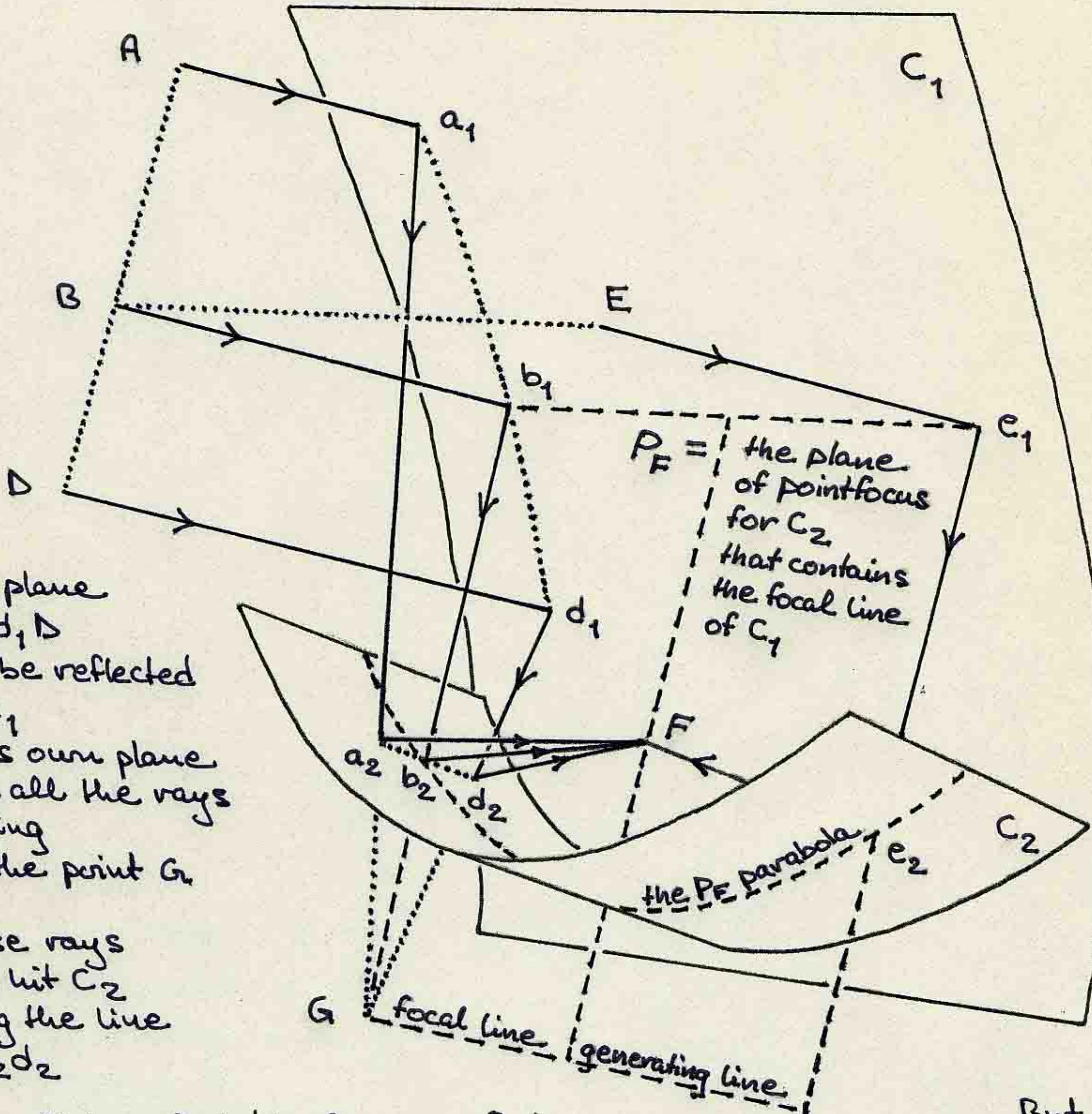
To prove this
look at
the plane P_F

The broken lines
in the figure
are all
in the plane P_F

The plane
of parallell lightrays
that hits C_1
along the line $b_1 e_1$
will be reflected
in the plane P_F
as parallell lightrays
perpendicular to
the generating line
of the P_F parabola

Therefore
this plane of lightrays
will be reflected
by the P_F parabola
to its focal point F

Now look at
the plane of lightrays
$A a_1 d_1 D$
perpendicular to $b_1 e_1$



The plane
$A a_1 d_1 D$
will be reflected
by C_1
in its own plane
with all the rays
aiming
for the point G

These rays
will hit C_2
along the line
$a_2 b_2 d_2$

They will be reflected by C_2
as if they were bouncing
off the plane mirror
that is touching C_2
along that line

So they will all reach
the point which is
the mirror image of G
in this touching plane

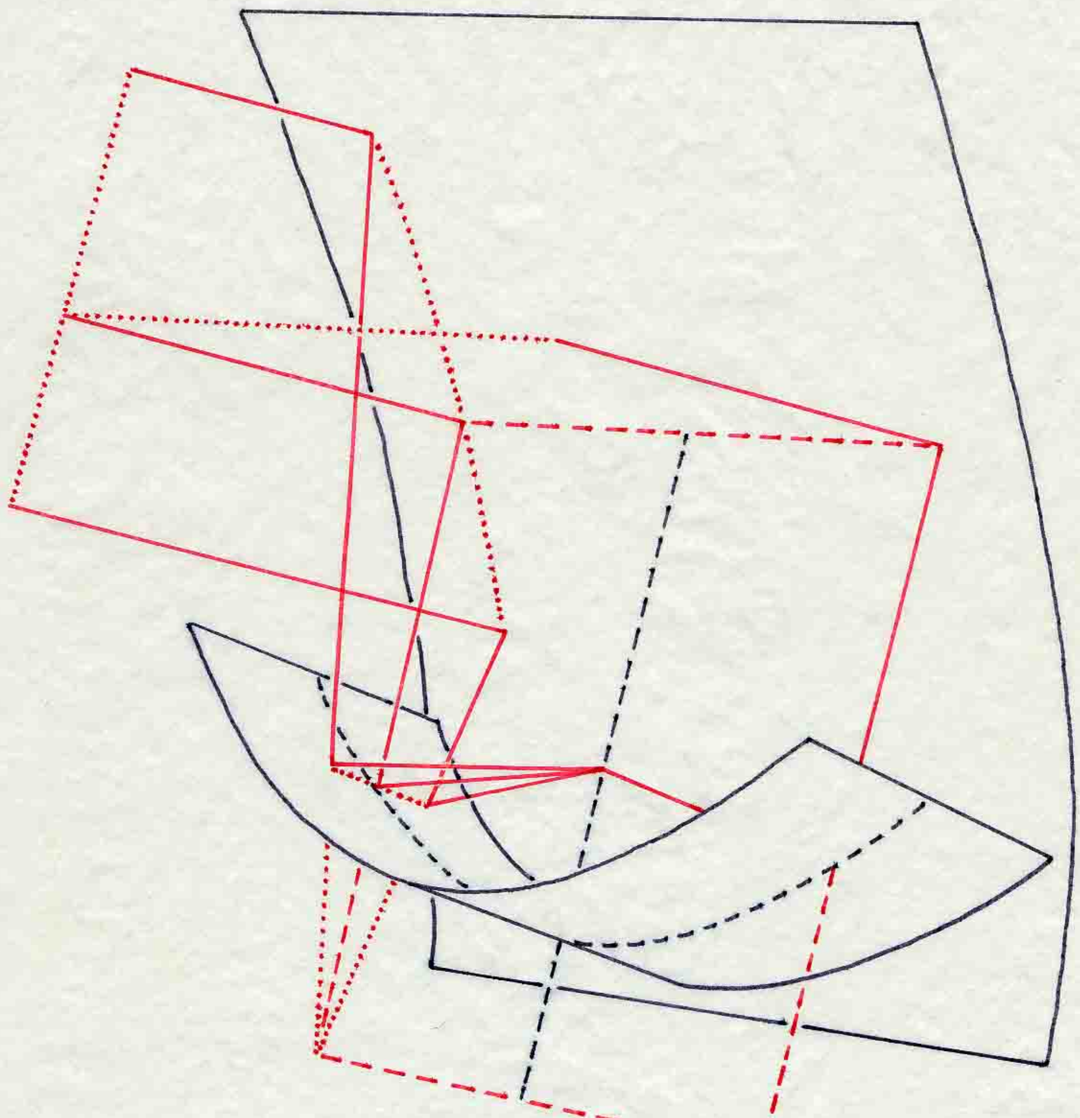
But
the ray $b_1 b_2 G$
is bounced off this plane
into the ray $b_1 b_2 F$

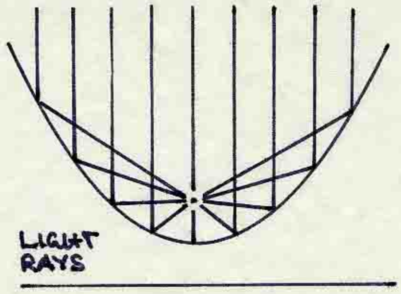
Therefore
the mirror image of G
must be F

So all the lightrays in $A a_1 d_1 D$
will be reflected to F

But
the same argument
is true
for any plane of lightrays
that is parallell to this one

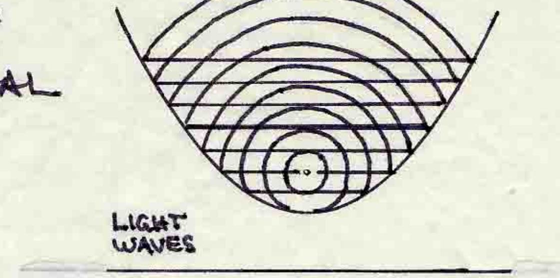
Therefore
they must all be reflected
to the point F
which proves
the pointfocus property





THE PARABOLA

THE 2-DIMENSIONAL
POINTFOCUS
MIRROR



TRANSLATION

THE TWO
FUNDAMENTAL
MOTIONS

ROTATION

SPACE
PACE
ACCELERATION
TRANSLATION

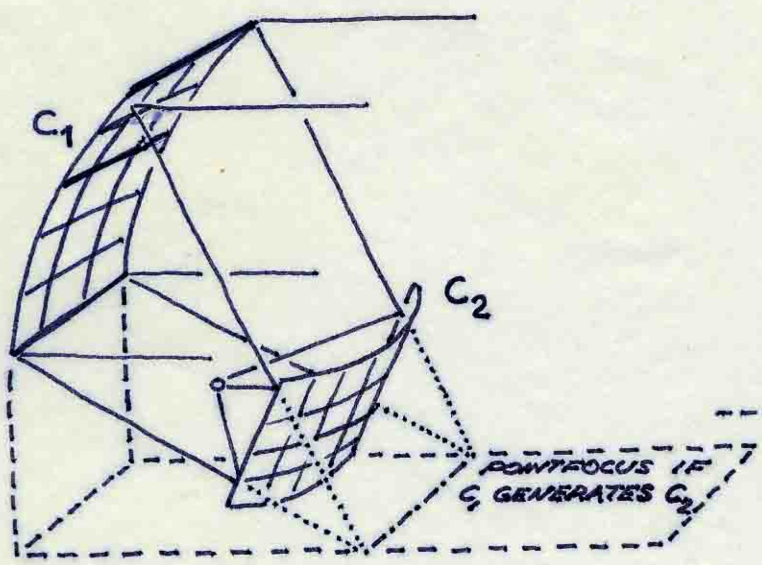
SPACE
ACCELEROTATION
ROTATION

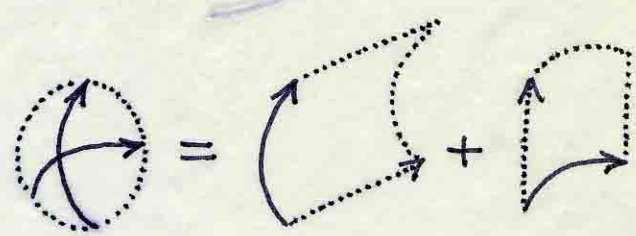
MOTION
IN
LINES

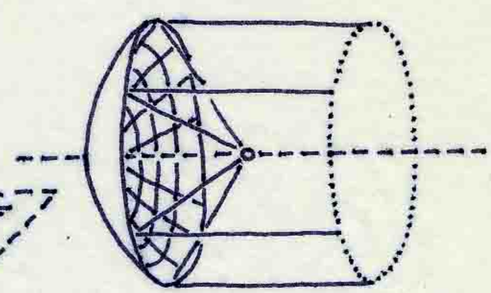
SPACE
PACE

MOTION
IN
CIRCLES

SPACE
PACE

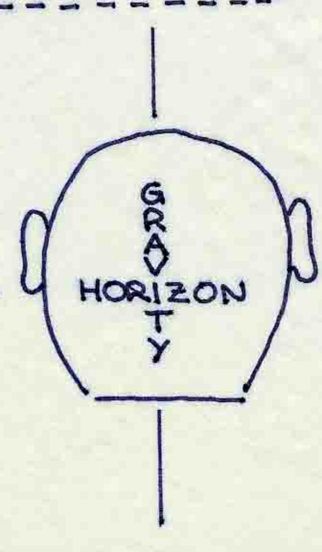






THE NAIVE CROSS
TRANSLATED
PARABOLIC
POINTFOCUS
MIRROR

THE PARABOLOID
ROTATED
PARABOLIC
POINTFOCUS
MIRROR



BEND + BEND
CYLINDRICAL
FLAT SHEETS
CHEAP

GRIND
SPHERICAL
CURVATURE
EXPENSIVE