EUROPEAN SOUTHERN OBSERVATORY

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral

Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

VLT PROGRAMME

VERY LARGE TELESCOPE

INSTRUMENTATION DIVISION

MACAO TECHNICAL SPECIFICATIONS AND STATEMENT OF WORK FOR THE TWO MICRO LENSLET ARRAYS

Doc. No. VLT-SPE-ESO-11640-2460
Issue: 1.0
Date: 02.02.2001

Prepared: J. Farinato, M. Kasper, B. Delabre
Name Date Signature

Approved: R. Arsenault, H. Bonnet
Name Date Signature

Released: N. Hubin
Name Date Signature

CHANGE RECORD

ISSUE	DATE	SECTION/PAGE AFFECTED	REASON/INITIATION DOCUMENTS/REMARKS
1.0	Feb 02 2001	All	First Issue

TABLE OF CONTENTS

1 ACRONYMS

AD	Applicable Document
AIT	Assembly, Integration and Tests
AO	Adaptive Optics
APD	Avalanche Photo Diode
BOB	Broker Of Observation Blocks
CWFS	Curvature Wavefront Sensor
CPS	Counts Per Second
DM	Deformable Mirror
ESO	European Southern Observatory
FOV	Field of View
HO	High Order
HW	Hardware
ICD	Interface Control Document
IR	Infrared (1.0-2.2μm)
LOS	Line of Sight, the seeing in the direction that the scope is looking
MACAO	Multiple Applications Curvature Adaptive Optics
Mas	Milli arcsec on the sky
ND	Neutral Density filter
NGS	Natural Guide Star (a point source < 0.2” in size)
OB	Observation Block
OS	Observing Software
OSS	Observing Support Software
PSF	Point Spread Function
RD	Reference Document
SOS	Super OS
STRAP	System for Tip-tilt Removal with Avalanche Photodiodes
SW	Software
TBC	To Be Confirmed
TBD	To be determined
UT	Unit Telescope (8.2-m diameter)
VLT	Very Large Telescope
VLTI	VLT Interferometer (1 – 13 μm)
WFS	WaveFront Sensor
WRT	with respect to

2 SCOPE

This document describes the technical specifications for the designing, manufacturing and testing of the two micro lenslet arrays that will be used for the MACAO WFS Lenslet Arrays required for the ESO-VLT MACAO Systems.

3 Principle of proposed solution

The general view of the system, presented in Figure 1, consists of two lenslet arrays. The first lenslet array is used to extract subapertures of a keystone geometry typical for curvature sensors. The second array images the lenslets of the first array onto the fibers, creating micropupils.

It is required that the vertex maps of both lenslet arrays correspond as specified later in this document.

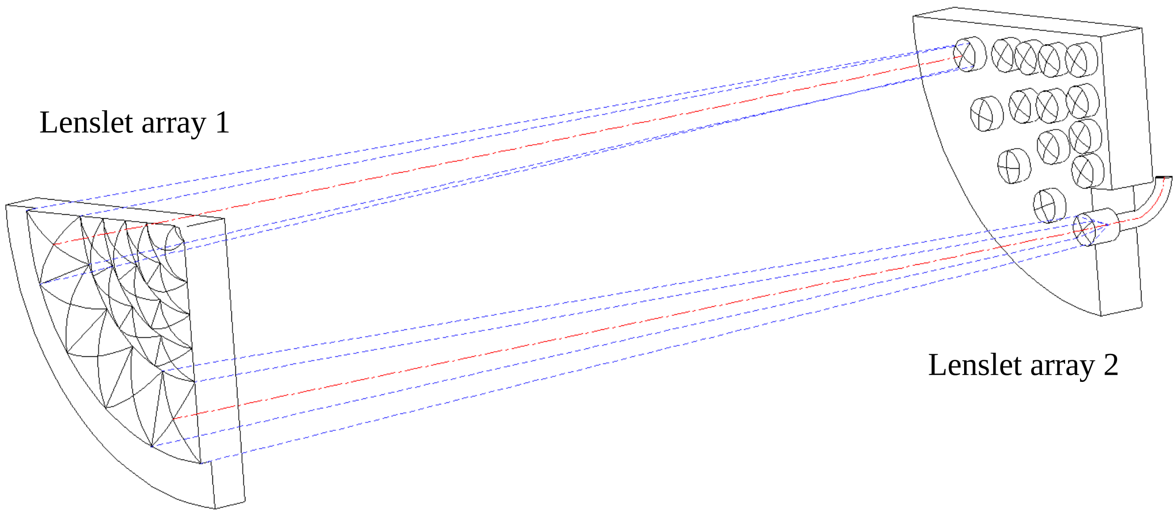


Figure 1: Schematic view of the proposed lenslet array unit

Figure 2 displays an edge-on view of the proposed lenslet array unit. For the sake of clarity, only one lens of each lenslet array is drawn.

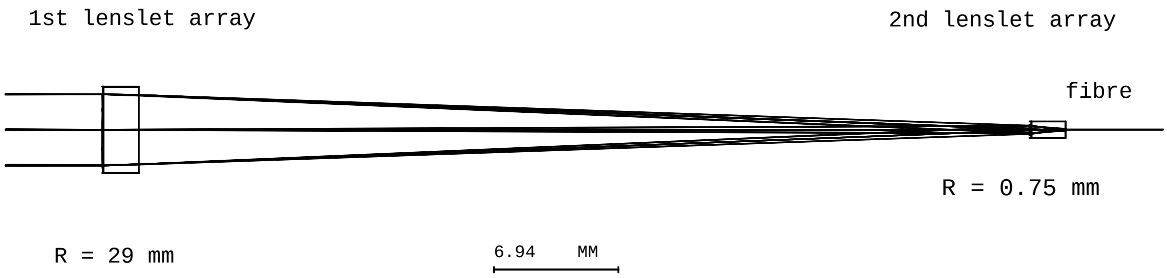


Figure 2. Edge-on view of the two lenslet array solution. The first lenslet is imaged by the second lenslet onto the fiber entrance.

4 Lenslet arrays technical specifications

In the following sections we give the technical specifications of the two lenslet arrays, both from the optical and mechanical points of view. For both arrays, the use of Fresnel lenses is acceptable.

4.1 First lenslet array optical specifications

The dimensions and the geometry of the lenslet array shall be according to the technical drawing of the first lenslet array attached to this document (hereafter called LA1), where are outlined the five different lenslet shapes, one per ring plus one external ring. All the sizes are in millimeters.

The radial location of the lenslet vertexes is indicated with small circles in LA1. This will give also the final position of the centres of the 60 spots created by the lenslets. In Table 2 the lenslet vertexes are reported in terms of angles and radial distances (starting from the spot #1 in counter-clock-wise).

The external ring (8.75 mm < R < 11.50 mm, see LA1) must be flat (better or equal than 300nm rms) and has no optical purpose.

The lenslet array shall fulfil the optical specifications outlined in Table 1.

Wavelength range	450-950nm
Overall transmission	>95% in the wavelength range 450-950nm, goal 97%
Temperature range	[-10º,30º]
Lenses Curvature Radius	29mm ± 0.3mm (for n=1.55, to be adapted for other n)
Encircled energy	90% in a 100 µm aperture at 550 nm wavelength
Coatings	AR coatings of the lenslets on both sides, with R<1% in the range 450-950nm

Table 1: First lenslet array optical specifications

Spot #	Angle (deg)	Radius (mm)	Spot #	Angle (deg)	Radius (mm)	Spot #	Angle (deg)	Radius (mm)	Spot #	Angle (deg)	Radius (mm)
1	45	1.265	2	135	1.265	3	225	1.265	4	315	1.265
5	22.5	2.635	6	67.5	2.635	7	112.5	2.635	8	157.5	2.635
9	202.5	2.635	10	247.5	2.635	11	292.5	2.635	12	337.5	2.635
13	15	3.865	14	45	3.865	15	75	3.865	16	105	3.865
17	135	3.865	18	165	3.865	19	195	3.865	20	225	3.865
21	255	3.865	22	285	3.865	23	315	3.865	24	345	3.865
25	11.25	5.115	26	33.75	5.115	27	56.25	5.115	28	78.75	5.115
29	101.25	5.115	30	123.75	5.115	31	146.25	5.115	32	168.75	5.115
33	191.25	5.115	34	213.75	5.115	35	236.25	5.115	36	258.75	5.115
37	281.25	5.115	38	303.75	5.115	39	326.25	5.115	40	348.75	5.115
41	9	7.245	42	27	7.245	43	45	7.245	44	63	7.245
45	81	7.245	46	99	7.245	47	117	7.245	48	135	7.245
49	153	7.245	50	171	7.245	51	189	7.245	52	207	7.245
53	225	7.245	54	243	7.245	55	261	7.245	56	279	7.245
57	297	7.245	58	315	7.245	59	333	7.245	60	351	7.245

Table 2: Lenslet vertexes

4.2 First Lenslet array mechanical specifications

Reference crosses

Three reference crosses shall be located on the front side of the first lenslet array as depicted in LA2.

Labels

Each lenslet array should be labelled with a unique identifier (eg. AO1a, AO1b,…)

4.3 Second lenslet array optical specifications

LA2 is also a technical drawing of the second lenslet array (hereafter called LA2). The 2nd lenslet array is essentially flat with small circular lenslets of 0.7 mm diameter placed hat the positions of the vertexes of the first lenslet array (see Table 2). All lenslets of this array are identical.

Table 3 lists the optical specifications for the second lenslet array.

Table 3: Optical specifications for 2nd lenslet array

Wavelength range	450-950nm
Overall transmission	>93% in the wavelength range 450-950nm, goal 95%
Temperature range	[-10º,30º]
Lenslet diameter	≥ 0.7 mm
Lenses radius of curvature	0.75mm ± 0.02mm (for n=1.55, to be adapted for other n)
Encircled energy	90% in a 20 μm aperture at 550 nm wavelength
Thickness of support	1.85 mm ± 0.01 mm
Coatings	AR coating of the lenslets on front (lenses) side, with R<1% in the range 450-950nm

4.4 Second lenslet array mechanical specifications

Reference crosses

Three reference crosses shall be located on the front side of the second lenslet array as depicted in LA1.

Labels

Each lenslet array should be labelled with a unique identifier (eg. AO2a, AO2b,…).

5 Environmental specifications

All specifications shall be fulfilled in the following conditions:

- Functional air temperature range: -10°C to +30°C
- Operational air temperature range: 0°C to +15°C
- Typical air temperature gradient at night: -0.4°C/hour
- Operating altitude: 0-2700m a.s.l.
- Humidity: <95% non condensing

6 Statement of work

6.1 Unit testing

The supplier shall propose a **test procedure** demonstrating the conformance to the presented specifications. This procedure shall be submitted to ESO for approval. The acceptance test shall be performed at the contractor premises. Optical and mechanical specifications shall be measured and checked.

The contractor shall perform **thermal cycling tests** to demonstrate the lenslet units are still meeting all the specifications after the following cycle:

- Ramp between ambient temperature and –10°C
- 3 hours at –10°C
- ramp between –10°C to 30°C at a rate of 5°C per hour
- 3 hours at 30°C
- ramp between 30°C to ambient temperature

6.2 Supplies

6.2.1 Hardware

The elements to be supplied by the contractor are:

- 12 1st lenslet arrays and 12 2nd lenslet arrays with option to order some more later.
- Re-usable transport boxes for each unit. The units will be transported by plane a number of times, thus the transport boxes shall be able to withstand the environmental loads during the transport and protect the equipment.

6.2.2 Documentation

The following documentation shall be delivered :

- Design Report , describing the overall unit design
- Test procedure report
- Test report for each unit
- “As built” drawings

All the documents shall be in English.

7 Project definition

- Phase 0: Delivery of test procedure for both lenslet arrays.
- Phase 1: manufacturing and testing of the 2nd lenslet array.
  During this phase, the supplier shall manufacture and test the first unit of the 2nd lenslet array.
  This phase ends with an acceptance test at the supplier premises attended by ESO.
  Only after ESO approval, the supplier shall continue with phase 2.
- Phase 2: manufacturing and testing of the 1st lenslet array.
  During this phase, the supplier shall manufacture and test the first unit of the 1st lenslet array.
  This phase ends with an acceptance test at the supplier premises attended by ESO.
  Only after ESO approval, the supplier shall continue with phase 3.
- Phase 3: manufacturing and testing of the remaining lenslet arrays.
  During this phase, the supplier shall manufacture and test the remaining lenslet arrays.

This phase ends with the acceptance test at the supplier premises of the entire set of lenslet arrays, tested one by one.

- Phase 4: supplies delivery
  During this phase, all the hardware and the full documentation shall be delivered to ESO.
  This phase ends with the provisional acceptance of the units at ESO.
- Phase 5: final acceptance
  The final acceptance is performed after the guarantee period of 1 year.

8 Time schedule

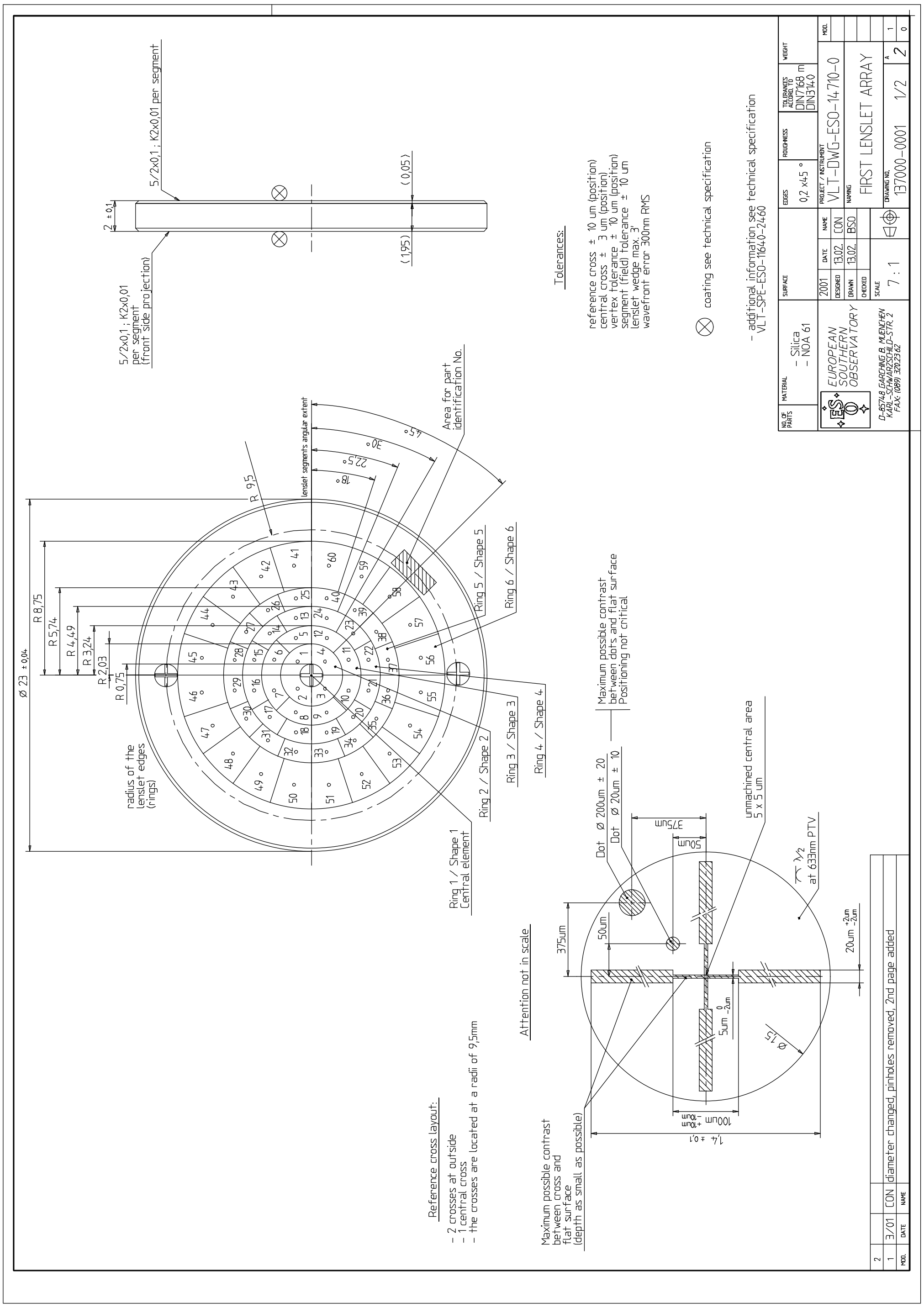
Naming t_0 the date of the signature of the contract, the following milestones have to be met:

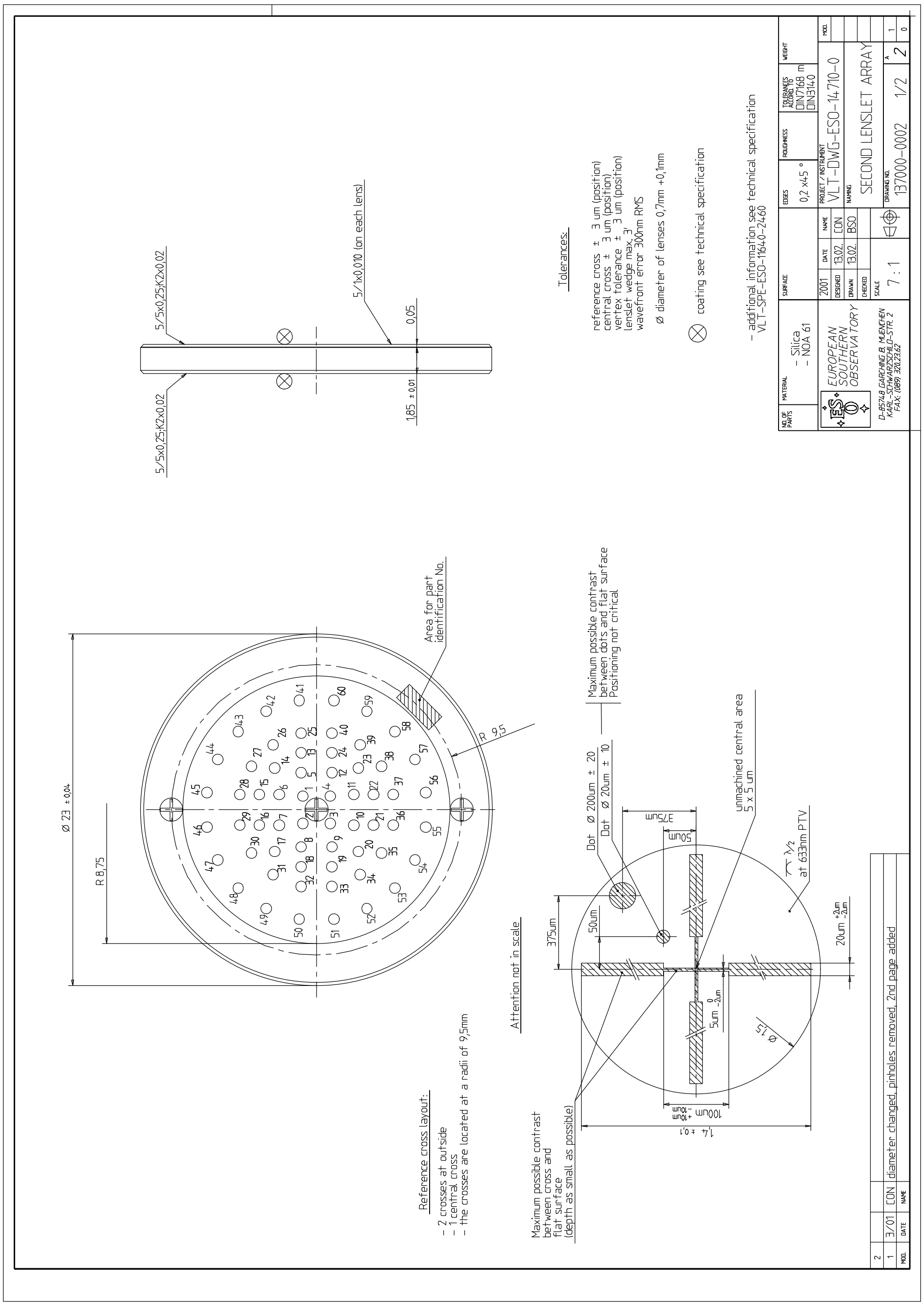
- At t_0 + 1 months: phase 0
- At t_0 + 2 months: phase 1
- At t_0 + 4 months: phase 2
- At t_0 + 6 months: phase 3
- At t_0 + 7 months: phase 4
- At t_0 + 18 months: phase 5

9 Offer replies

The offer replies shall contain:

- A technical proposal describing the design and manufacturing process for the lenslet arrays.
- A bid for 12+12 lenslet arrays and, as an option:
- A bid for additional units
- If part of the work is expected to be sub-contracted, the sub-contractors shall be mentioned in the reply
- The delivery schedule
- Duration of the warranty


Tolerances:
reference cross ± 10 um (position)
central cross ± 3 um (position)
vertex tolerance ± 10 um (position)
segment (field) tolerance ± 10 um
lenslet wedge max. 3'
wavefront error 300nm RMS
coating see technical specification
- additional information see technical specification VLT-SPE-ESO-11640-2460
Reference cross layout:
- 2 crosses at outside
- 1 central cross
- the crosses are located at a radii of 9,5mm
Attention not in scale
Ring 1 / Shape 1 Central element
Ring 2 / Shape 2
Ring 3 / Shape 3
Ring 4 / Shape 4
Ring 5 / Shape 5
Ring 6 / Shape 6
Area for part identification No.
radius of the lenslet edges (rings)
Maximum possible contrast between dots and flat surface
Positioning not critical
unmachined central area 5 x 5 um
Maximum possible contrast between cross and flat surface (depth as small as possible)
- Silica
- NOA 61
EUROPEAN SOUTHERN OBSERVATORY
VLT-DWG-ESO-14710-0
FIRST LENSLET ARRAY
137000-0001
7 : 1
3/01 CON diameter changed, pinholes removed, 2nd page added


Tolerances:
reference cross ± 3 um (position)
central cross ± 3 um (position)
vertex tolerance ± 3 um (position)
lenslet wedge max. 3'
wavefront error 300nm RMS
Ø diameter of lenses 0,7mm +0,1mm
coating see technical specification
- additional information see technical specification VLT-SPE-ESO-11640-2460
Area for part identification No.
Maximum possible contrast between dots and flat surface
Positioning not critical.
Reference cross layout:
- 2 crosses at outside
- 1 central cross
- the crosses are located at a radii of 9,5mm
Attention not in scale
Maximum possible contrast between cross and flat surface (depth as small as possible)
unmachined central area 5 x 5 um
Dot Ø 200um ± 20
Dot Ø 20um ± 10
λ/2 at 633nm PTV
Silica
NOA 61
EUROPEAN SOUTHERN OBSERVATORY
VLT-DWG-ESO-14710-0
SECOND LENSLET ARRAY
137000-0002
7 : 1
diameter changed, pinholes removed, 2nd page added