

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

- LIGO -

CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

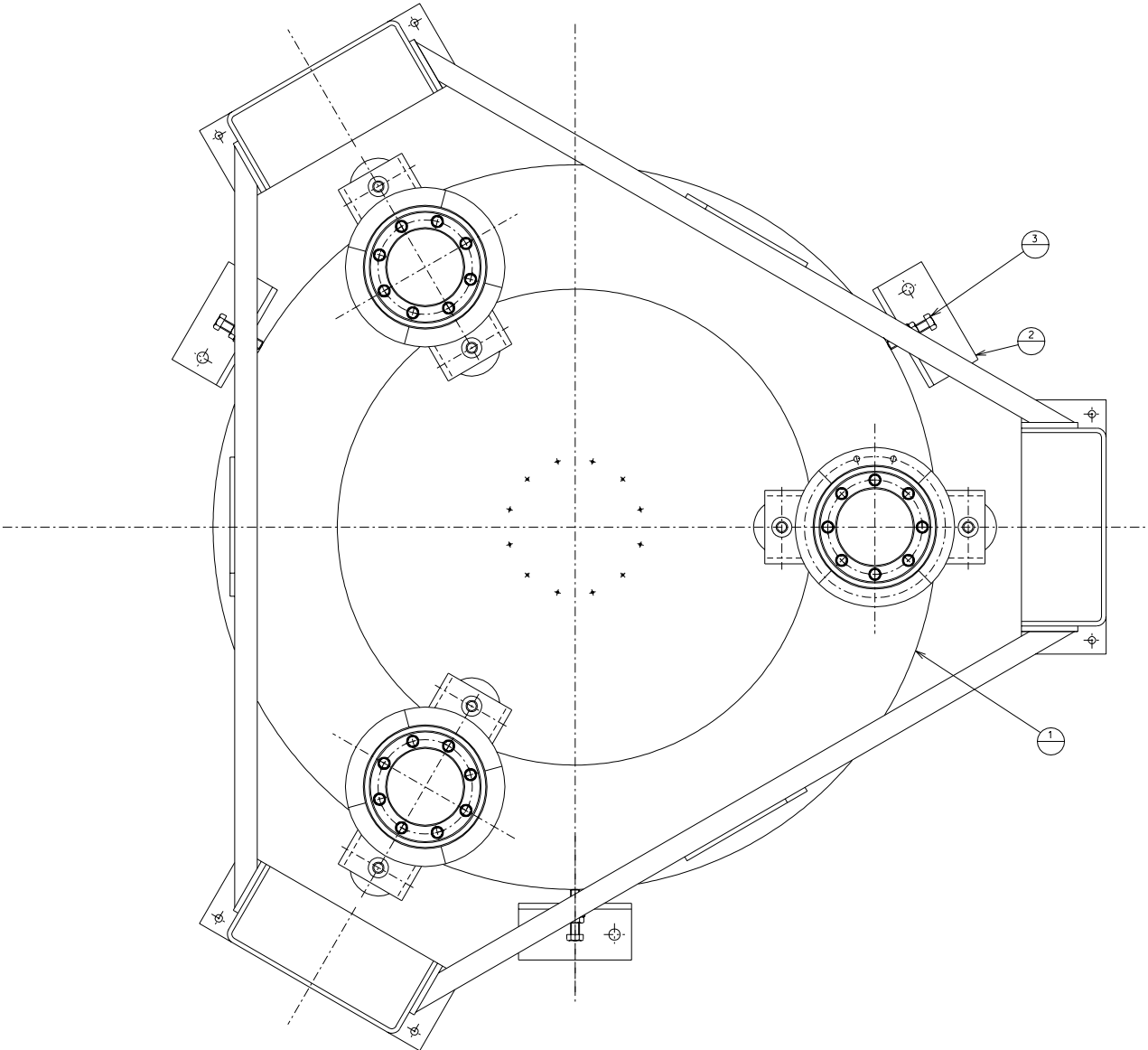
Document Type Technical Note	DCC Number LIGO-D010240-00-R	Date 30 th October 2001
LIGO-II Seismic Attenuation System (SAS) test tower Inverted Pendulum Mechanical drawings		
Gianni Gennaro, Tatiana Zelenova (PROMEC), Riccardo DeSalvo (LIGO)		

Distribution of this draft: TBD
This is an internal working note
of the LIGO Project.

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
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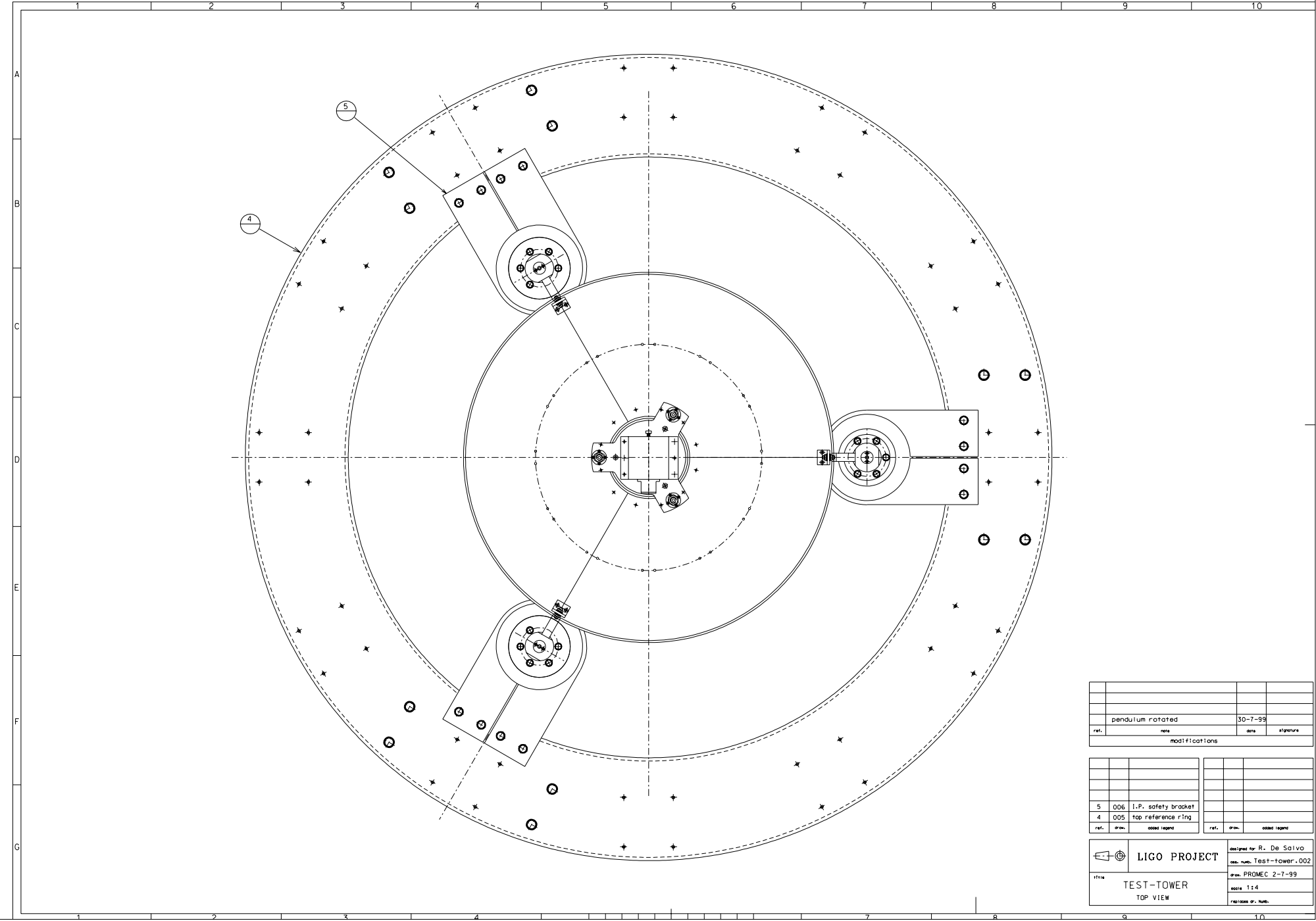
www: <http://www.ligo.caltech.edu/>



ref.	desc.	date	signature
	pendulum rotated	30-7-99	
modifications			

ref.	desc.	added legend	ref.	desc.	added legend
3	006	base tuning screw			
2	006	base tuning bracket			
1	004	base disk			

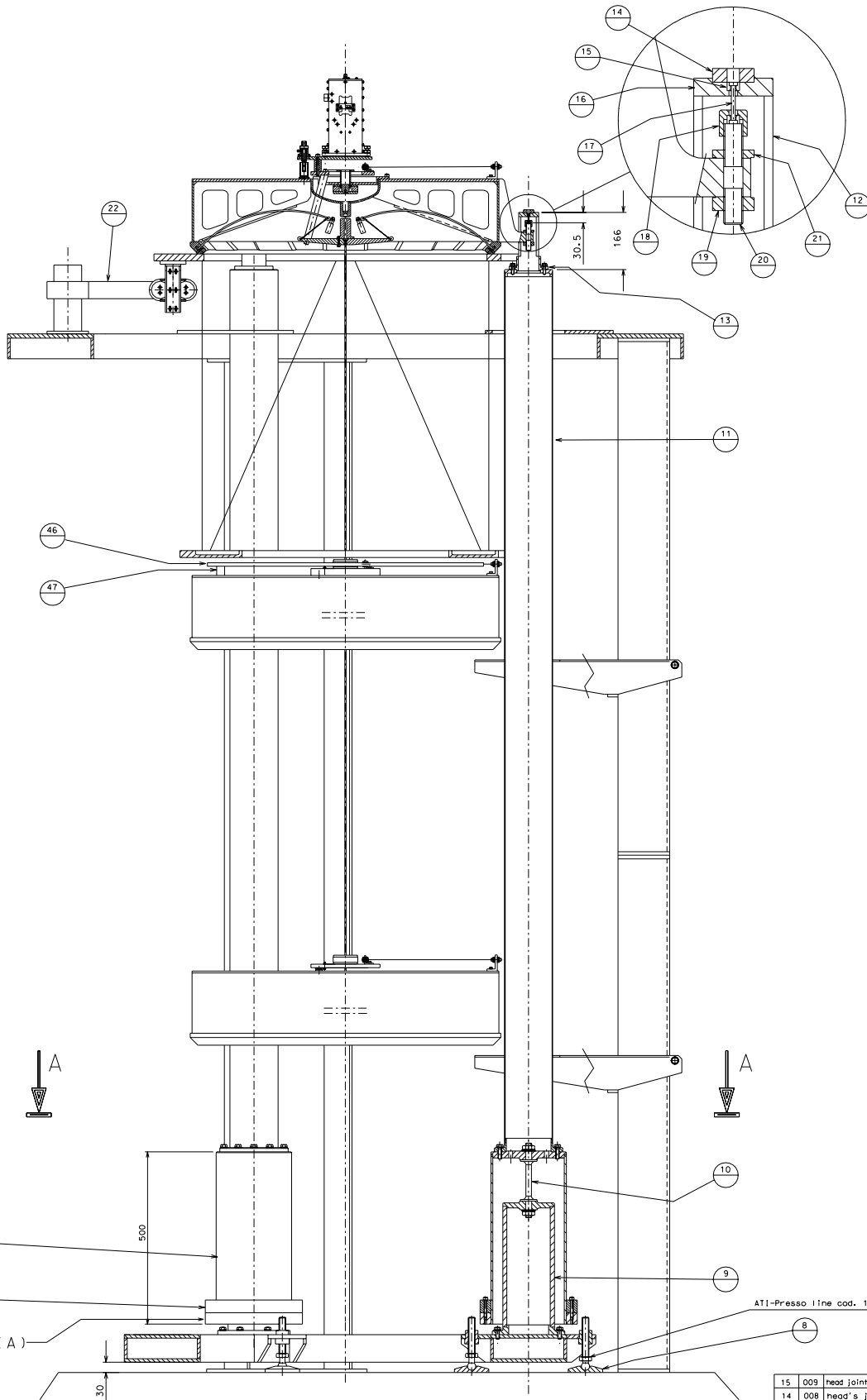
	LIGO PROJECT	designed for R. De Salvo
	TEST-TOWER SECTION A-A	des. num. Test-tower-001 draw. PROMEC 2-7-99 scale 1:4 ref. issue or. Num.



ref.		pendulum rotated		30-7-99	
	note			date	signature
modifications					

5	006	I.P. safety bracket			
4	005	top reference ring			
ref.	draw	codes legend	ref.	draw	codes legend


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		des. num. TEST-tower.002
		draw. PROMEC 2-7-99
		scale 1:4
TEST-TOWER		ref/codes or. houb.
TOP VIEW		



ATI-Presso line cod. 175139 N°6 pieces

15	009	head joint 1/2 cup	47	026	copper plate
14	008	head's joint cap	46	026	spacer
13	008	leg's head retention disk	22	013	peripheral magnets
12	008	leg's head	21	009	height tuning c/nut
11	008	main leg	20	009	height tuning rod
10	009	elastic joint	19	009	height tuning nut
9	007	base column	18	009	height tuning cap
8	008	footing	17	009	head's flex joint
7	007	bell	16	008	leg's head top disk
6	008	counterweight			

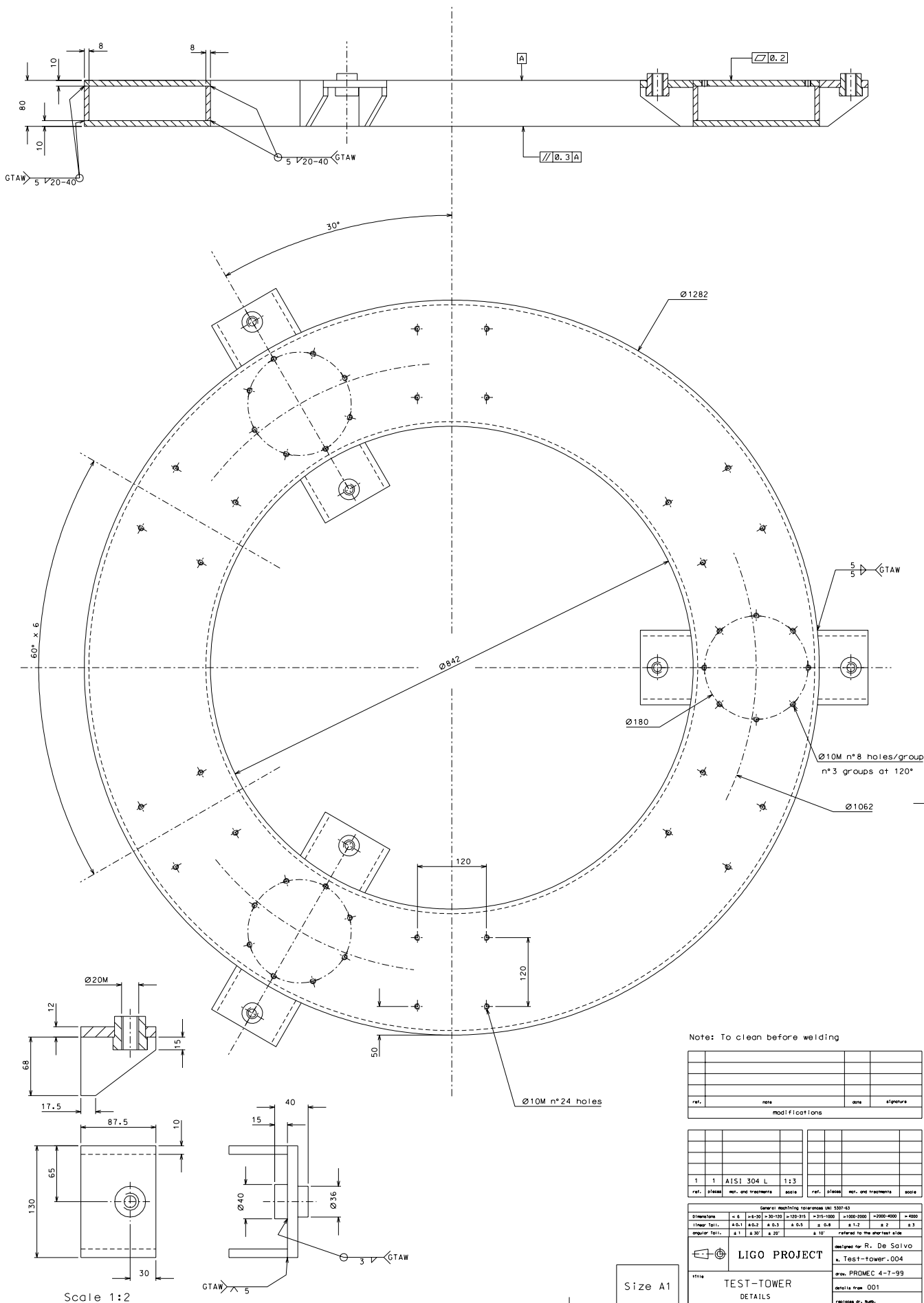
ref.	draw.	name	date	signature
A		welded ring	3-5-00	
		pendulum rotated	30-7-99	
modifications				


LIGO PROJECT

TEST-TOWER
 LATERAL VIEW

scale 1:6
 author: R. De Salvo
 des. num. TEST-tower.003
 draw. PRGMEC 2-7-99

Size A1



Note: To clean before welding

rev.	note	date	signature

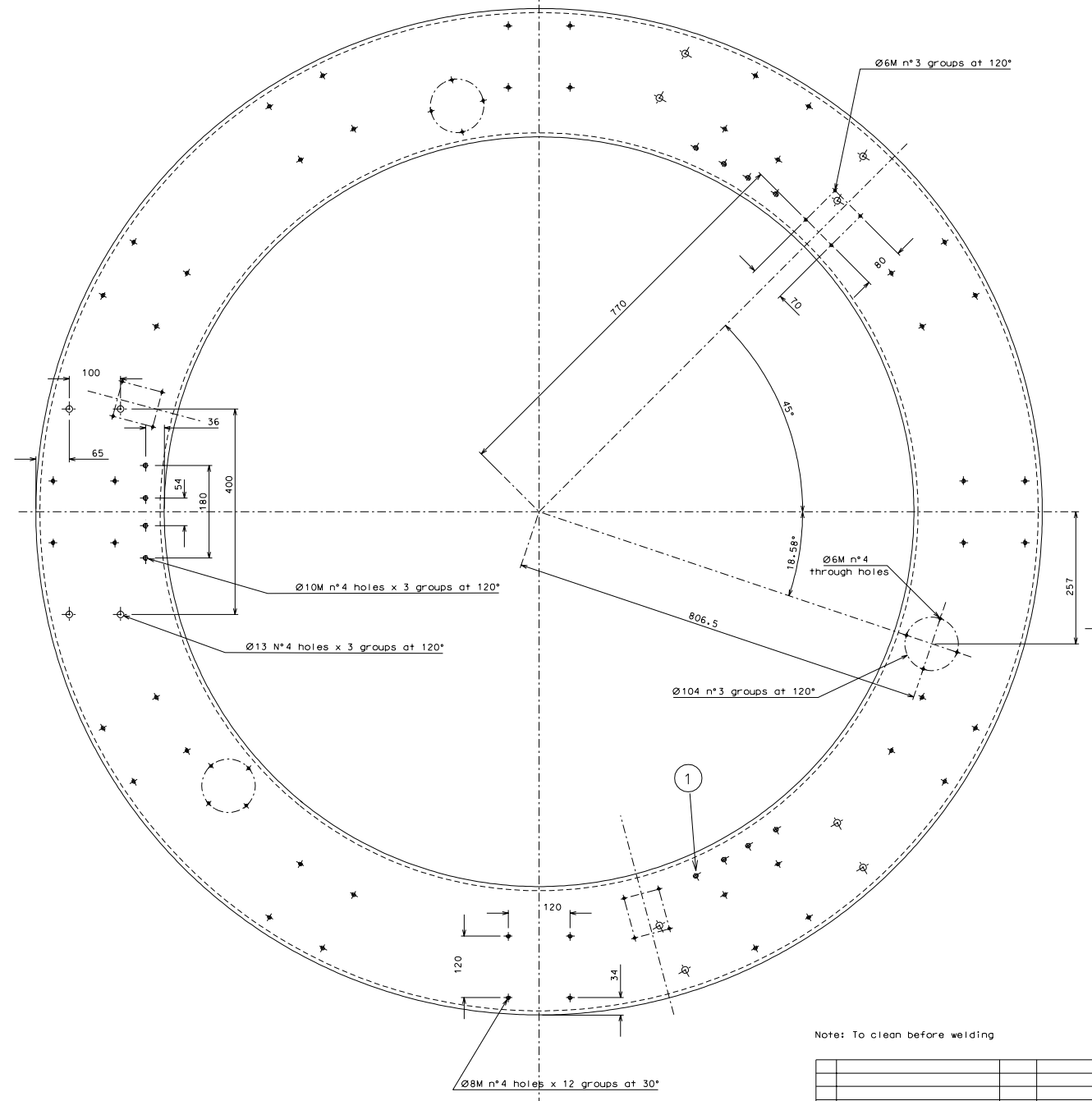
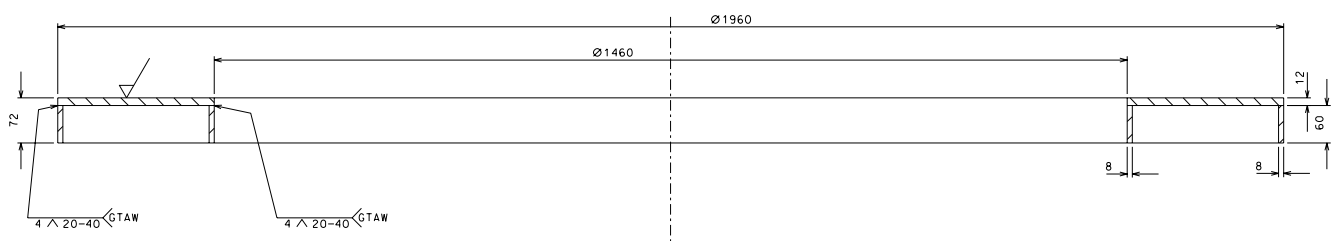
1	1	AISI 304 L	1:3	ref.	class	rev.	and	treatment	scale

General machining tolerances UNI 5201-63										
Dimensione	< 6	6-30	30-120	120-315	315-1000	1000-2000	2000-4000	> 4000		
Tolleranza	± 0.1	± 0.15	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 2	± 3	related to the smallest size
Superficie	± 0.1	± 0.15	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 2	± 3	related to the smallest size

LIGO PROJECT designed by R. De Salvo
 n. Test-tower.004 draw. PRGMEC 4-7-99
 TEST-TOWER details from 001
 DETAILS realized by: Nuff.

Size A1

Scale 1:2

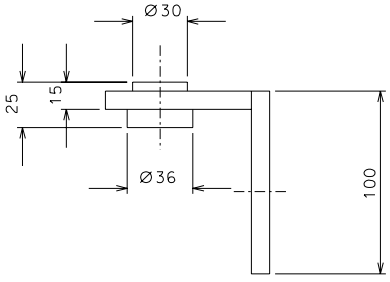
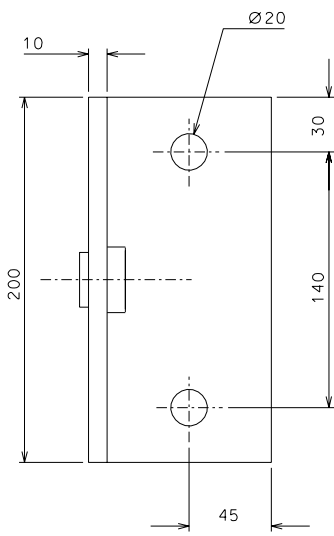
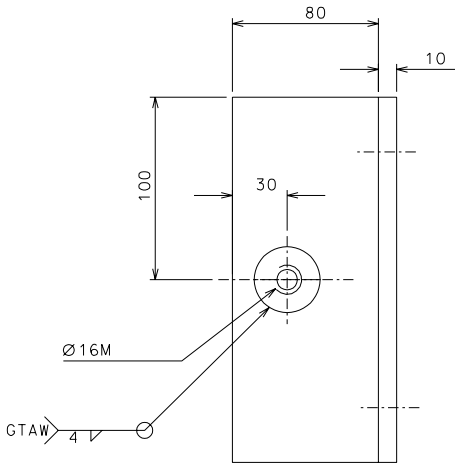


Note: To clean before welding

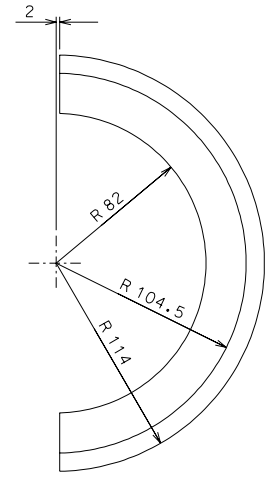
1	holes moved	30-7-99	
ref.	note	date	signature
modifications			

4	1	AISI 304 L	1:4				
ref.	pieces	mat. and treatment	scale	ref.	pieces	mat. and treatment	scale

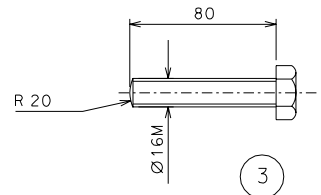
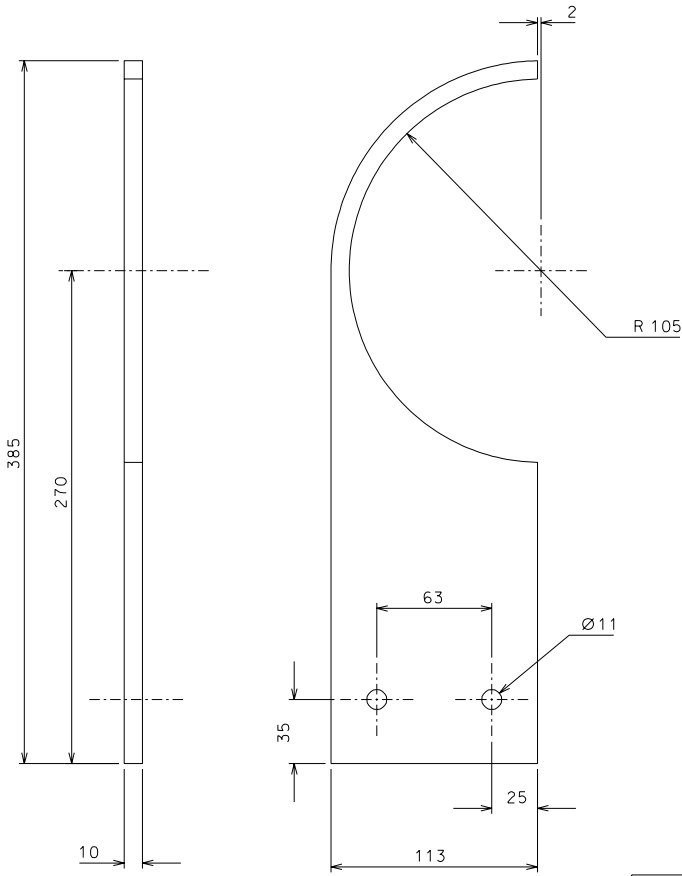
General machining tolerances UNI 5201-63								
Dimensione	< 6	6-30	30-120	120-315	315-1000	1000-2000	>2000-4000	> 4000
Forma	±0.1	±0.15	±0.2	±0.3	±0.5	±0.8	±1.2	±2
Angolo	±1	±1.5	±2	±3	±5	±8	±12	±20
	refered to the external side							±3
LIGO PROJECT								designer for R. De Saivo n. Test-tower.005
TEST-TOWER								draw. PRGMEC 4-7-99
DETAILS								details from 002
Size A1								realized by: null.



2



5.1




3

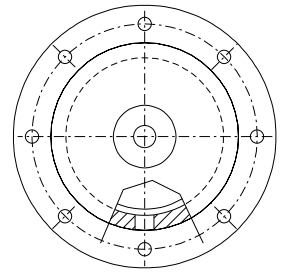
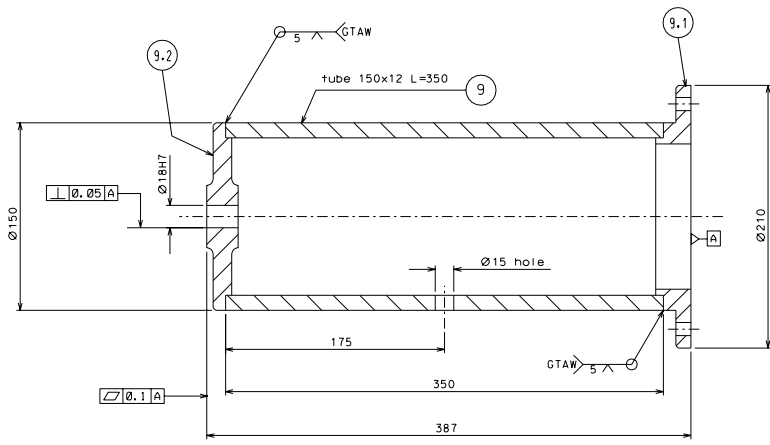
ref.	note	date	signature
modifications			

5.1	6	Al alloy	1:2				
5	6	AISI 304	1:2				
3	3	steel	1:2				
2	3	AISI 304 L	1:2				
ref.	pieces	mat. and treatments	scale	ref.	pieces	mat. and treatments	scale

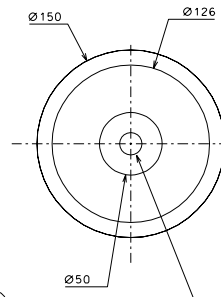
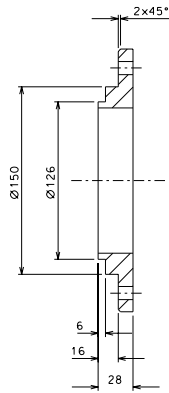
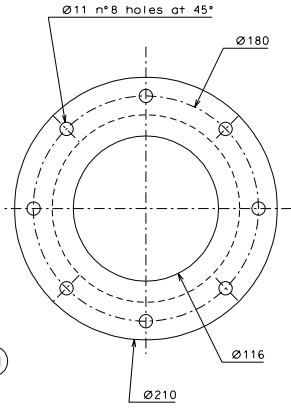
General machining tolerances UNI 5307-63								
Dimensions	< 6	>6-30	>30-120	>120-315	>315-1000	>1000-2000	>2000-4000	>4000
linear Toll.	± 0,1	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2	± 2	± 3
angular Toll.	± 1'	± 30'	± 20'	± 10' referred to the shortest side				


LIGO PROJECT
 designed for R. De Salvo
 N. Test-tower.006
 draw. PROMEC 5-7-99
 details from 001-002
 replaces dr. Num.

Size A2

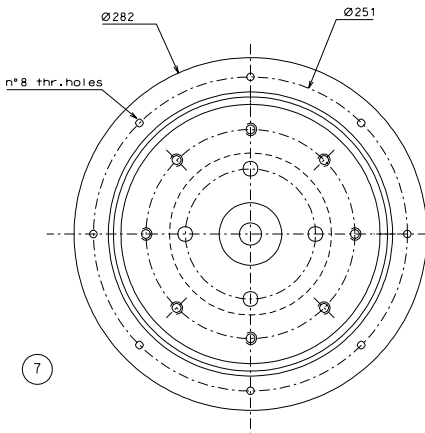


9

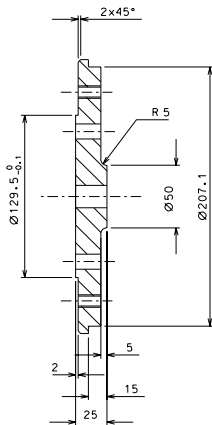
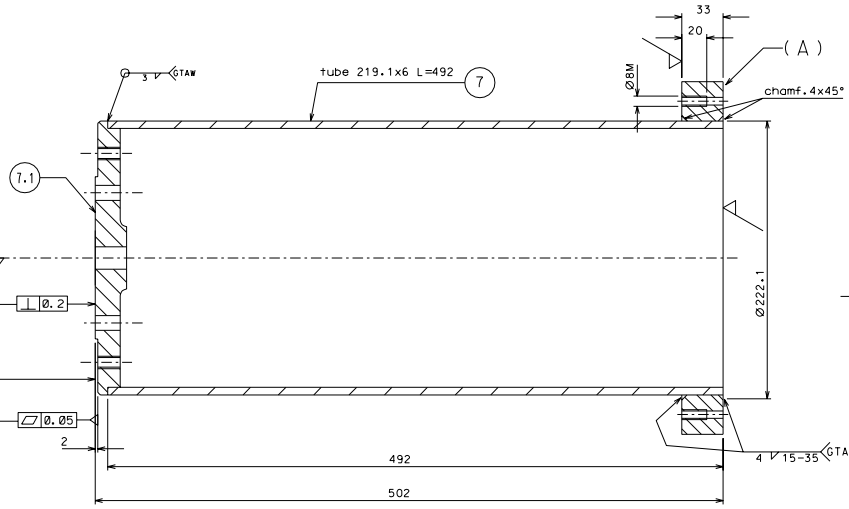


9.2

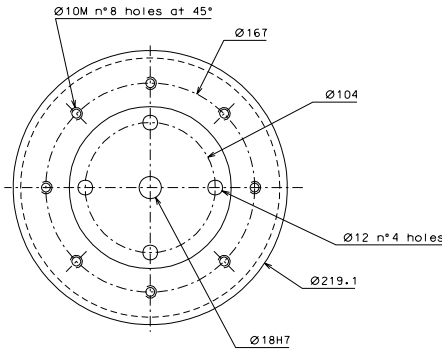
mashing after welding



7



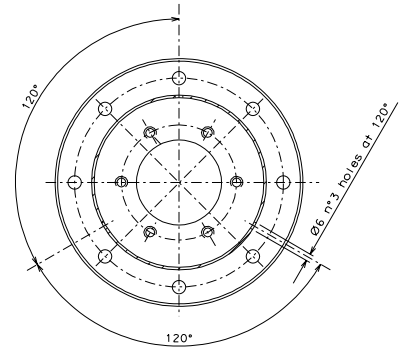
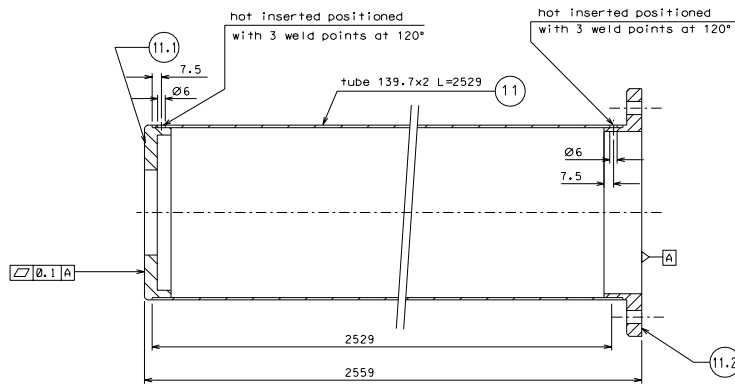
7.1



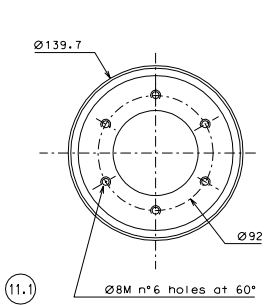
ref.	description	date	signature
A	welded ring	3-5-00	
modifications			
9.2	3	AISI 304 L	1:2
9.1	3	"	1:2
9	3	"	1:2
7.1	3	"	1:2
7	3	"	1:2
ref. class	ref. and treatment	scale	ref. class
General machining tolerances UNI 5107-63			
Dimension	< 6	6-30	> 30-120
Linear Tol.	±0.1	±0.2	±0.3
Angular Tol.	±1'	±30'	±20'
refered to the external side			
designed for R. De Salvo			
n. Test-Tower-007			
draw. PRIMEC 8-7-99			
details from 003			
realized by: Sutti.			

Size A1

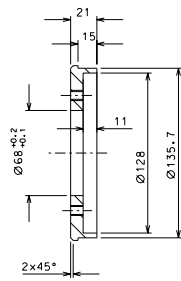
LIGO PROJECT
TEST-TOWER
DETAILS



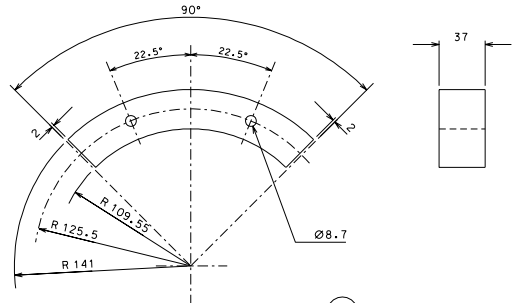
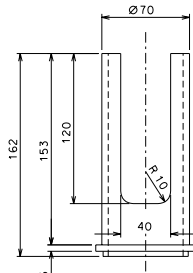
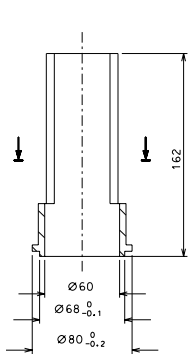
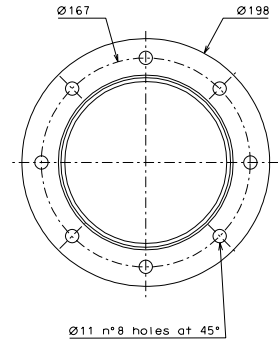
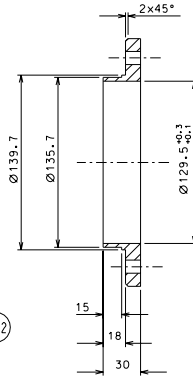
11



11.1

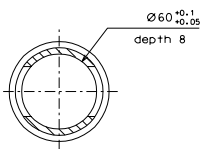


11.2

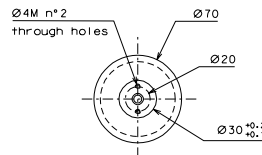
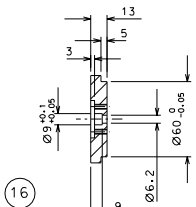


6 (A)

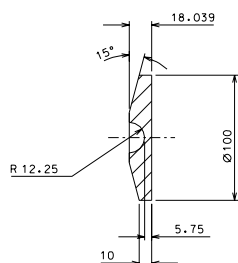
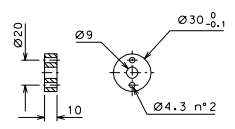
12



16

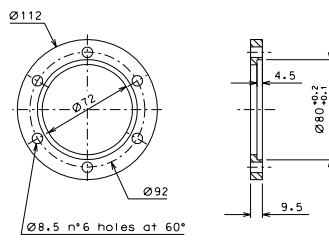


14



8

13

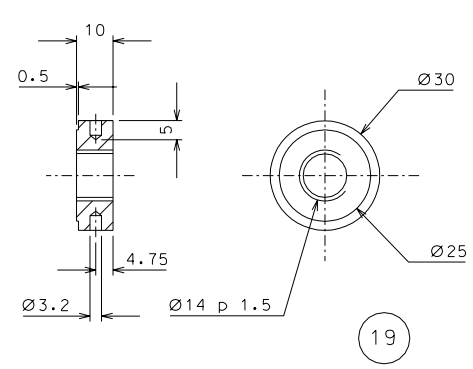
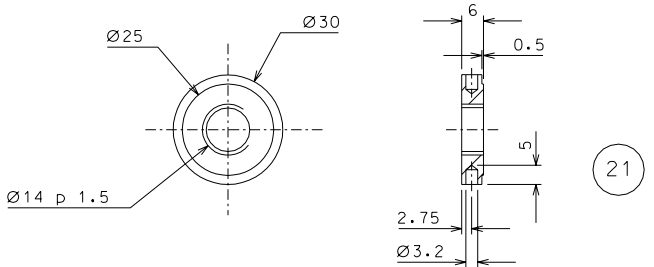
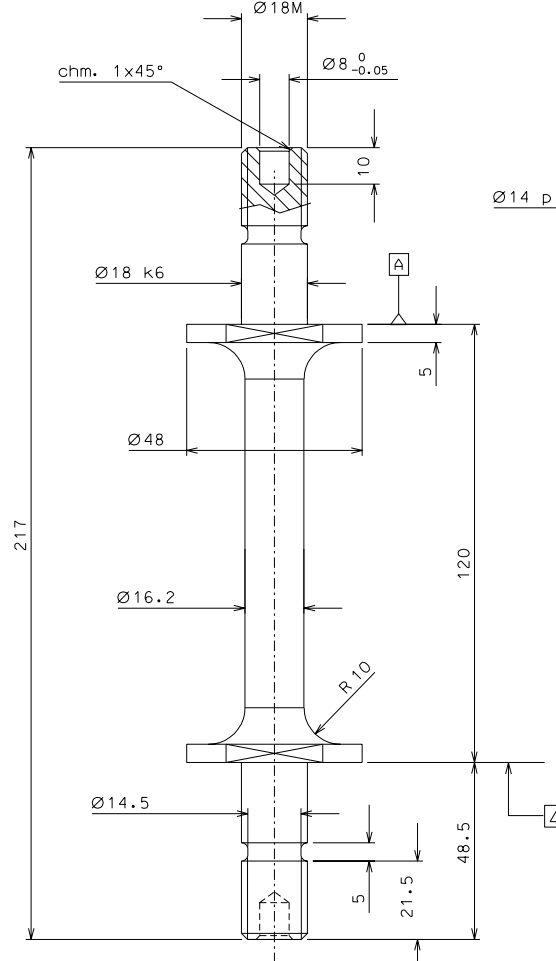
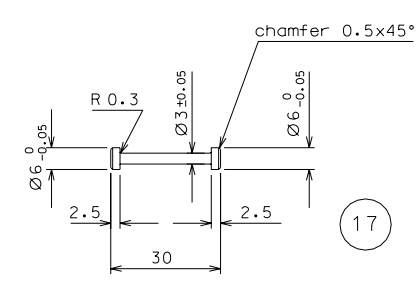
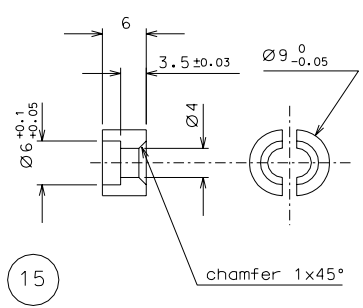
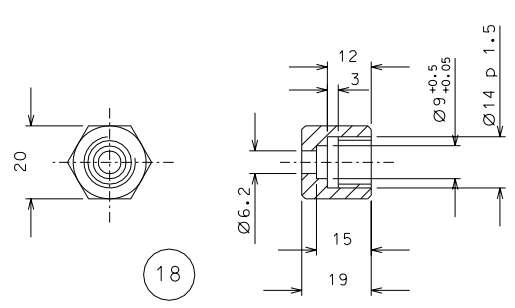
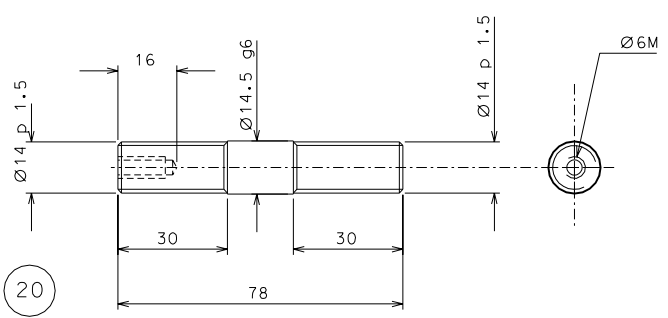


A new version		3-5-00	
ref.	date	signature	signature
modifications			
11.2	3	AISI 304 L	1:2
11.1	3	"	1:2
11	3	"	1:2
8	6	StSteel	1:2
6	12	AISI 304	1:2
6	12	AISI 304	1:2
6	12	AISI 304	1:2
6	12	AISI 304	1:2
ref.	date	ref.	date

General machining tolerances UNI 5107-63										
Dimension	< 6	6-30	30-120	120-315	315-1000	1000-2000	2000-4000	> 4000	refered to the nearest size	
Linear dim.	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±1.8	±3		
Angular dim.	±1'	±30"	±20"	±10"						

LIGO PROJECT		designed for R. De Salvo	
		n. Test-Tower-008	
Title		PRIMEC 8-7-99	
		details from 003	
		realized by: Nullo.	

Size A1



(A) Nickel flash 0.0003

ref.	note	date	signature
A	modification num. pieces	26-10-00	
modifications			

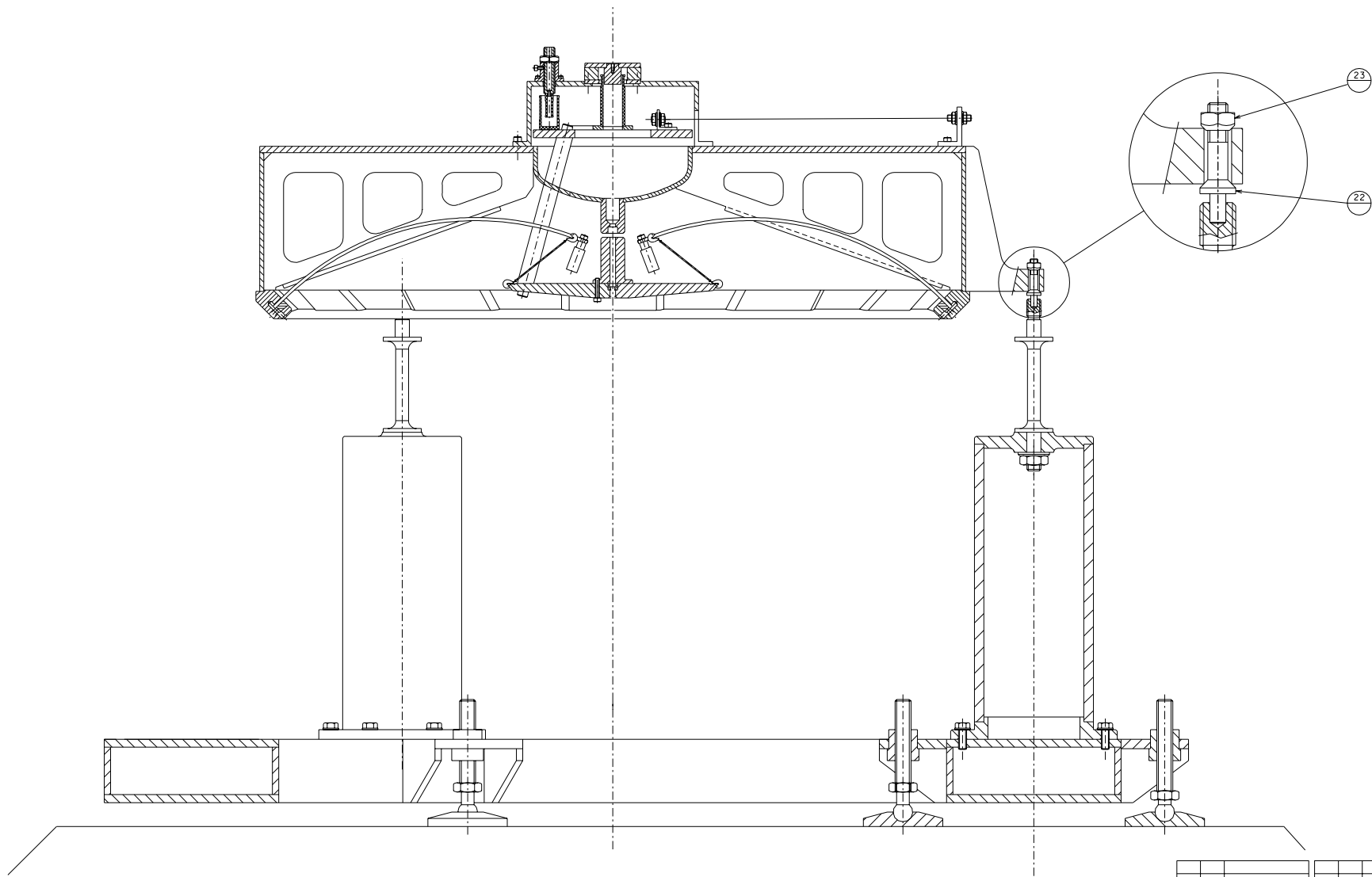
19	3	AISI 304	1:1				
18	3	"	1:1				
17	30	maraging A	1:1				
15	6	" A	2:1	21	3	AISI 304	1:1
10	3	" A	1:1	20	3	"	1:1
ref.	pieces	mat. and treatments	scale	ref.	pieces	mat. and treatments	scale

General machining tolerances UNI 5307-63							
Dimensions	< 6	> 6-30	> 30-120	> 120-315	> 315-1000	> 1000-2000	> 2000-4000
linear Toli.	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 2
angular Toli.	± 1	± 30'	± 20'	± 10' referred to the shortest side			

LIGO PROJECT
 designed for R. De Salvo
 N. Test-tower.009
 draw. PROMEC 10-7-99
TEST-TOWER
 DETAILS
 details from 003
 replaces dr. Num.

10 symmetric on both sides

Size A2



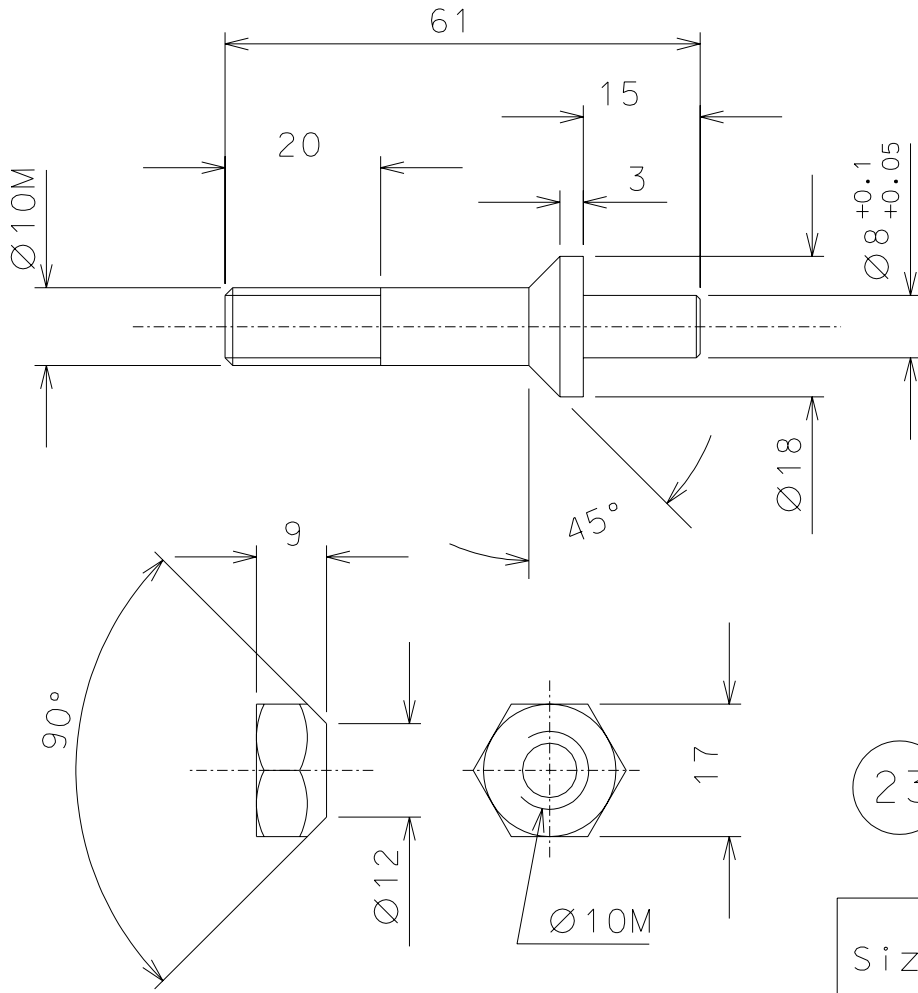
Assembly note: Use Filter_0 with reference to align base column (9) on base disk (1)

23	011	nut			
22	011	alignment			
ref.	qty.	descr.	notes	ref.	qty.

Size A1

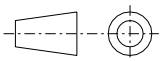
ref.	note	date	signature
modif / cat / rev			

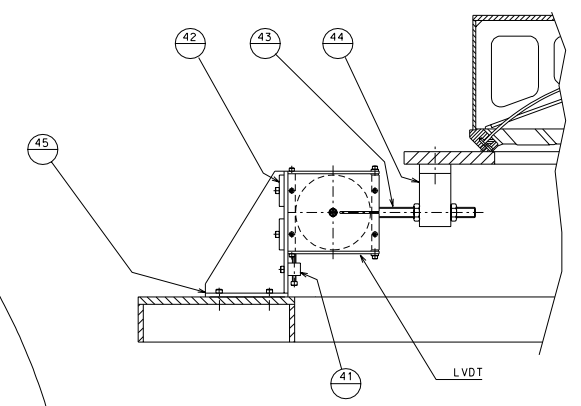
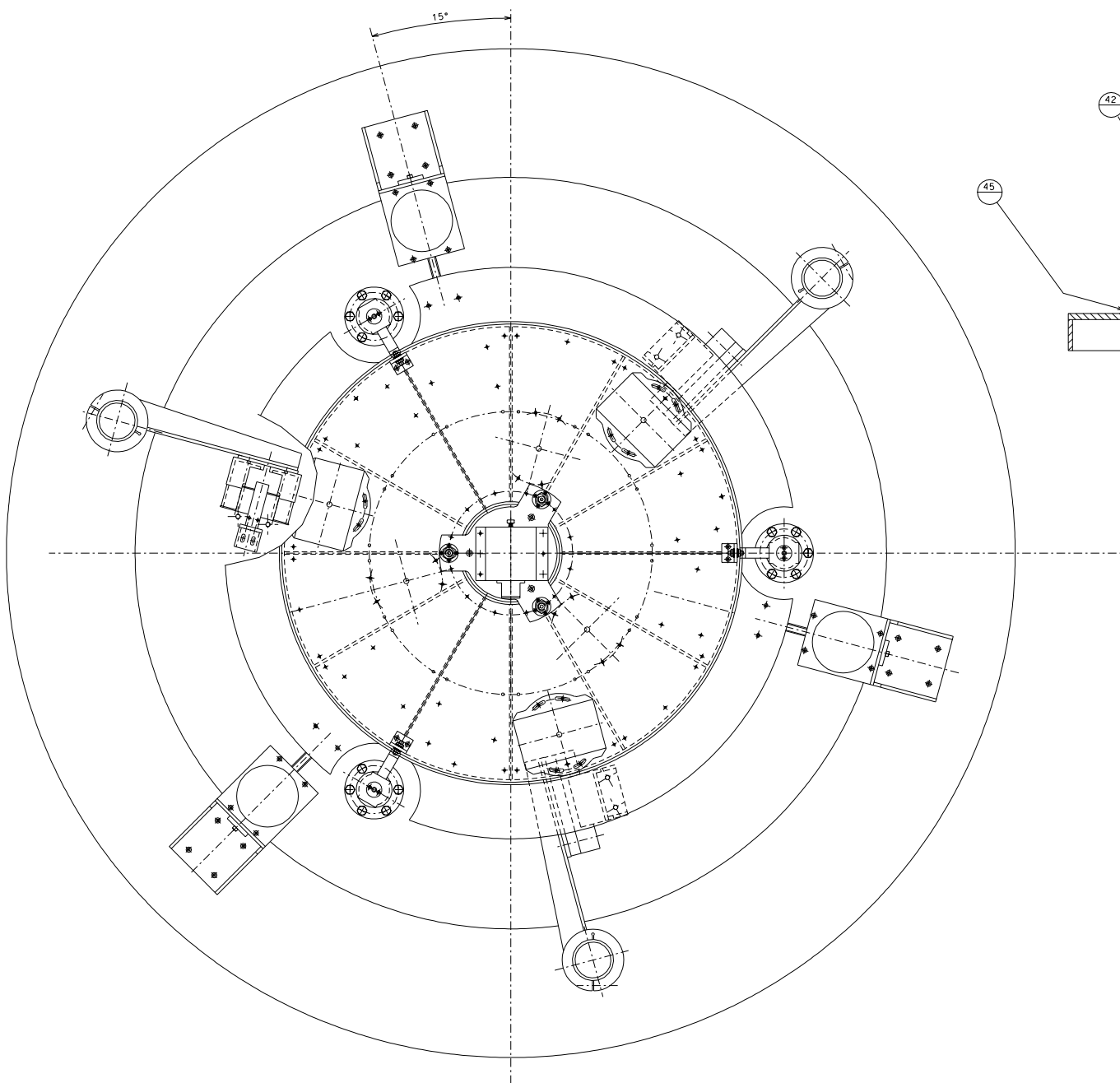
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	TEST-TOWER ASSEMBLY	ass. num. Test-tower-010
1116		des. PROMEC 16-7-99
		scale 1:2.5
		ref / issue or. Num.



23	3	steel	1:1
22	3	steel hardened	1:1
ref.	pieces	mat. and treatments	scale

ref.	pieces	mat. and treatments	scale

General machining tolerances UNI 5307-63								
Dimensions	< 6	> 6-30	> 30-120	> 120-315	> 315-1000	> 1000-2000	> 2000-4000	> 4000
linear Toll.	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 2	± 3
angular Toll.	± 1	± 30'	± 20'	± 10' referred to the shortest side				
	LIGO PROJECT				designed for R. De Salvo			
					N. Test-tower.011			
title	TEST-TOWER TOOLS				draw. PROMEC 10-7-99			
					details from 010			
					replaces dr. Numb.			

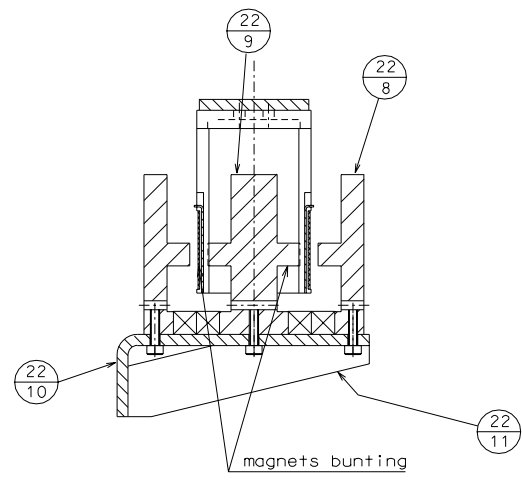
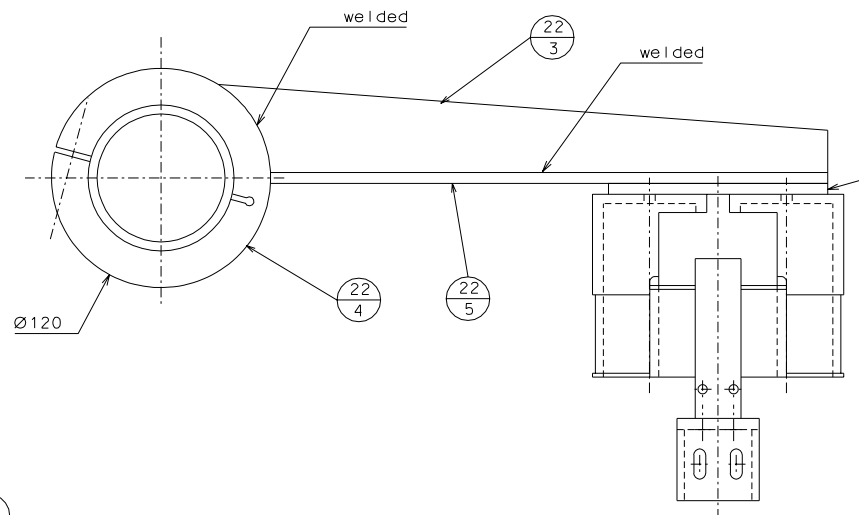
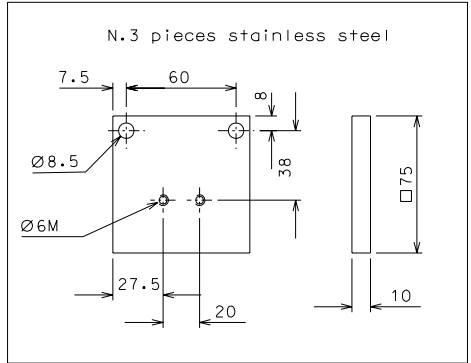
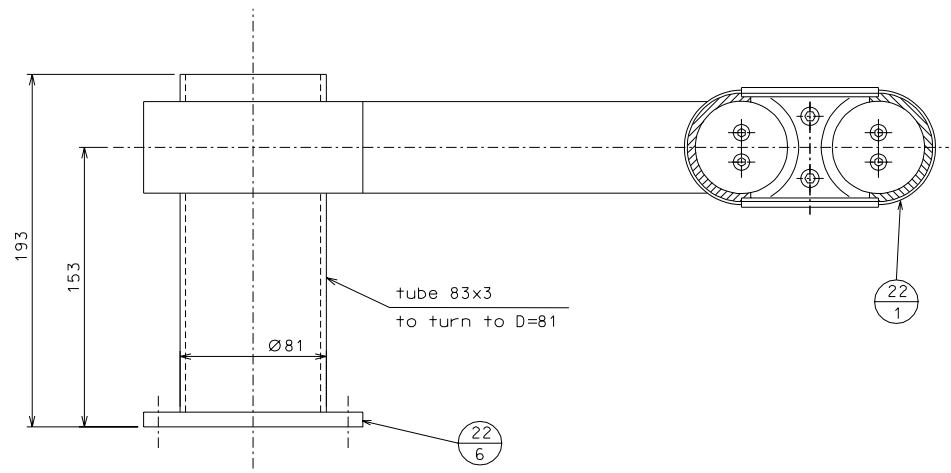


modified		24-9-99	
ref.	note	date	signature
modifications			

45	025	plate					
44	025	plate support					
43	025	plate					
42	025	guide bushing					
41	025	plate					
ref.	draw.	date	legend	ref.	draw.	date	legend

	LIGO PROJECT	designed for R. De Salvo
	TEST TOWER TOP WITH SENSOR	des. num. TEST-TOWER-012 draw. PROMEC 12-9-99 scale 1:4 ref. / rev. or. Num.

Size A1

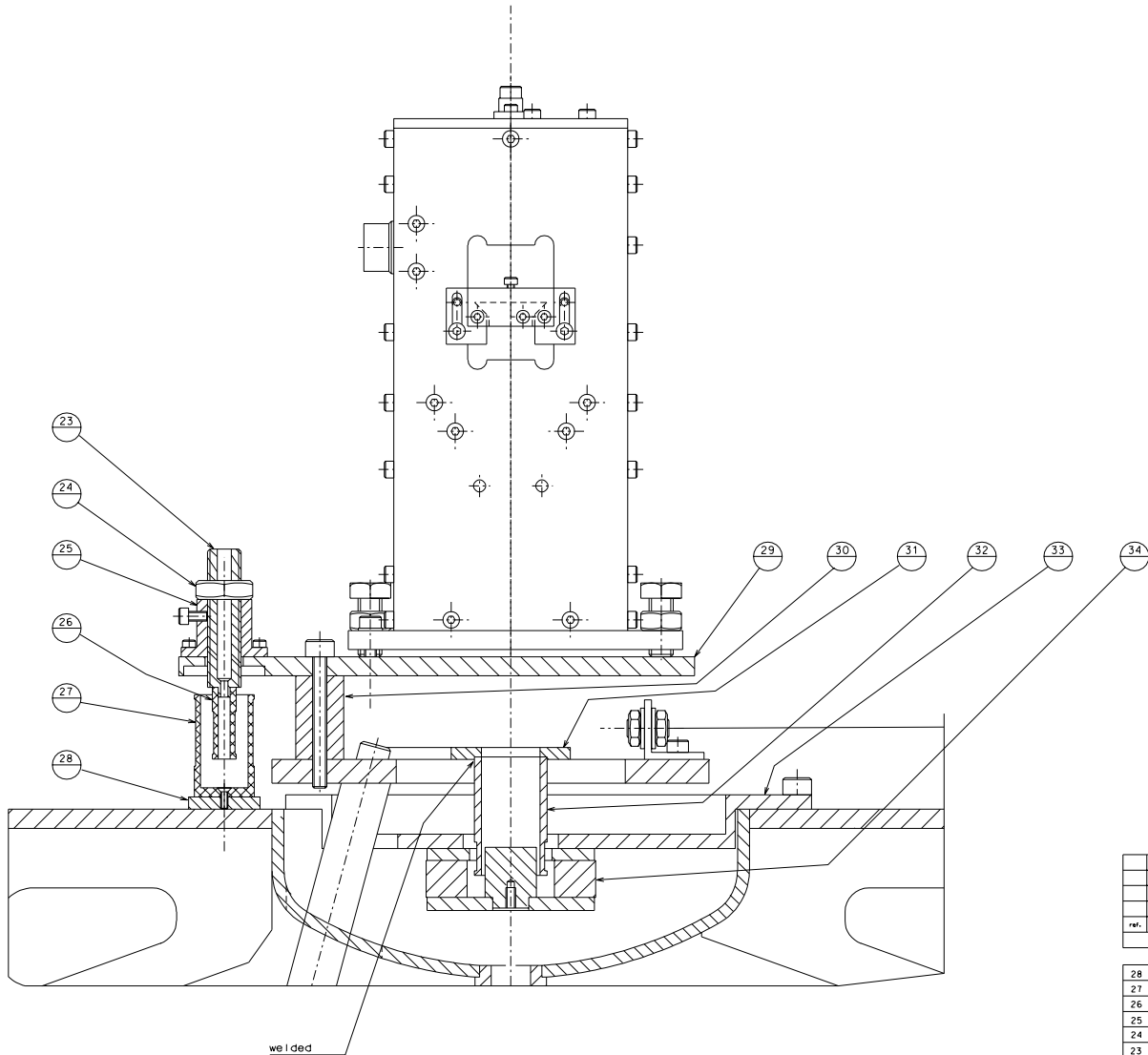


22.6	018				
22.5	019				
22.4	019		22.11	023	
22.3	019		22.10	023	
22.2	023		22.9	018	
22.1	018		22.8	018	
ref.	draw.	added legend	ref.	draw.	added legend

ref.	note	date	signature	
modifications				

Size A2

	LIGO PROJECT	designed for R. De Salvo
		ass. numb. Test-tower.013
title		draw. PROMEC 16-9-99
TEST-TOWER TANGENTIAL MAGNET		scale 1:2
		replaces dr. numb.

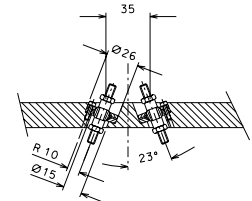
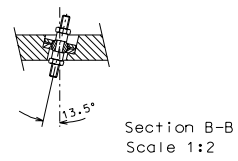
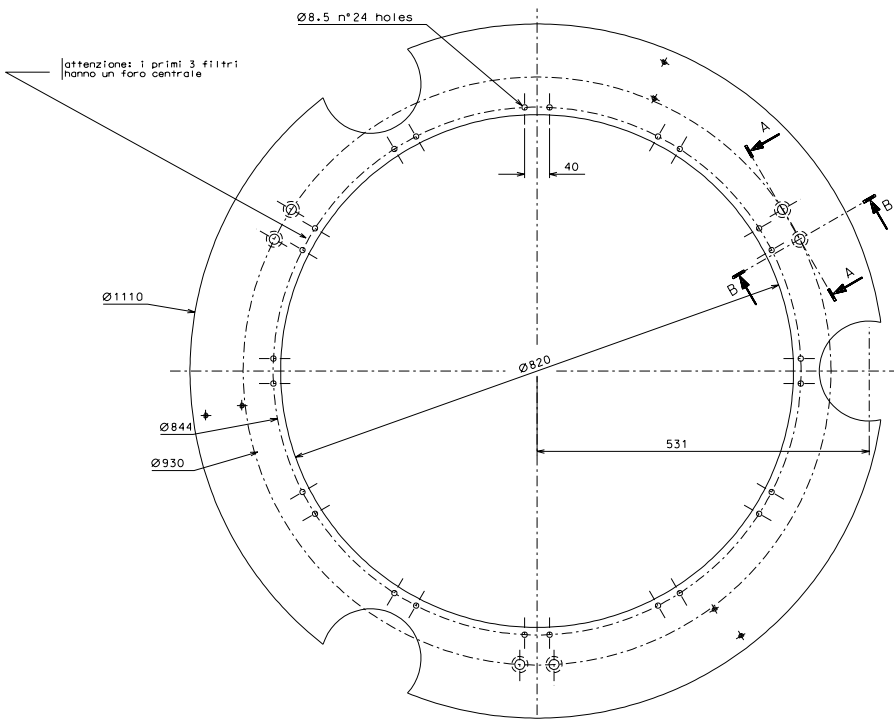


ref.	note	date	signature
modifications			

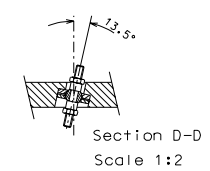
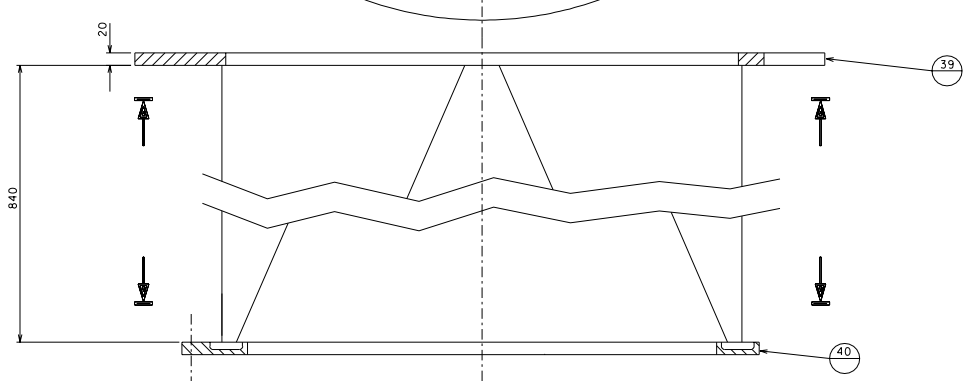
28	020	plate	34	022	magnet
27	020	coil	33	022	magnet support
26	020	coil	32	020	coil
25	020	slide	31	021	coil support
24	020	nut	30	020	space
23	020	screw	29	021	accelerometer base
ref.	draw.	object legend	ref.	draw.	object legend

	LIGO PROJECT	designed for R. De Salvo
	TEST TOWER DAMPER	ass. num. Test-tower-014
title	scale 1:1	draw. PROMEC 12-9-99
		ref. / draw. / object legend

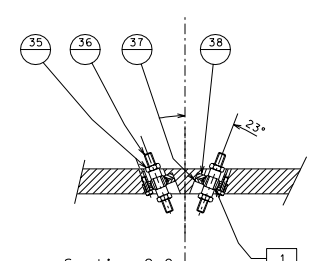
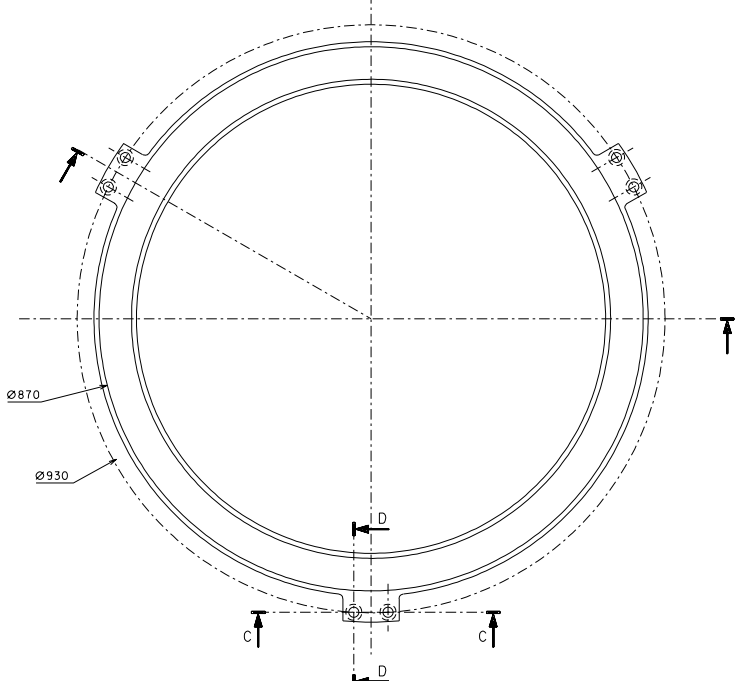
Size A1



Section A-A
Scale 1:2



Section D-D
Scale 1:2



Section C-C
Scale 1:2

ref.	draw.	date	signature
modified		24-9-99	
modifications			

ref.	draw.	added	removed	ref.	draw.	added	removed
40	017						
39	016						
38	024						
37	024						
36	024						
35	024						

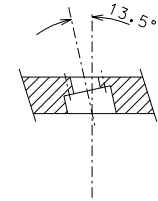
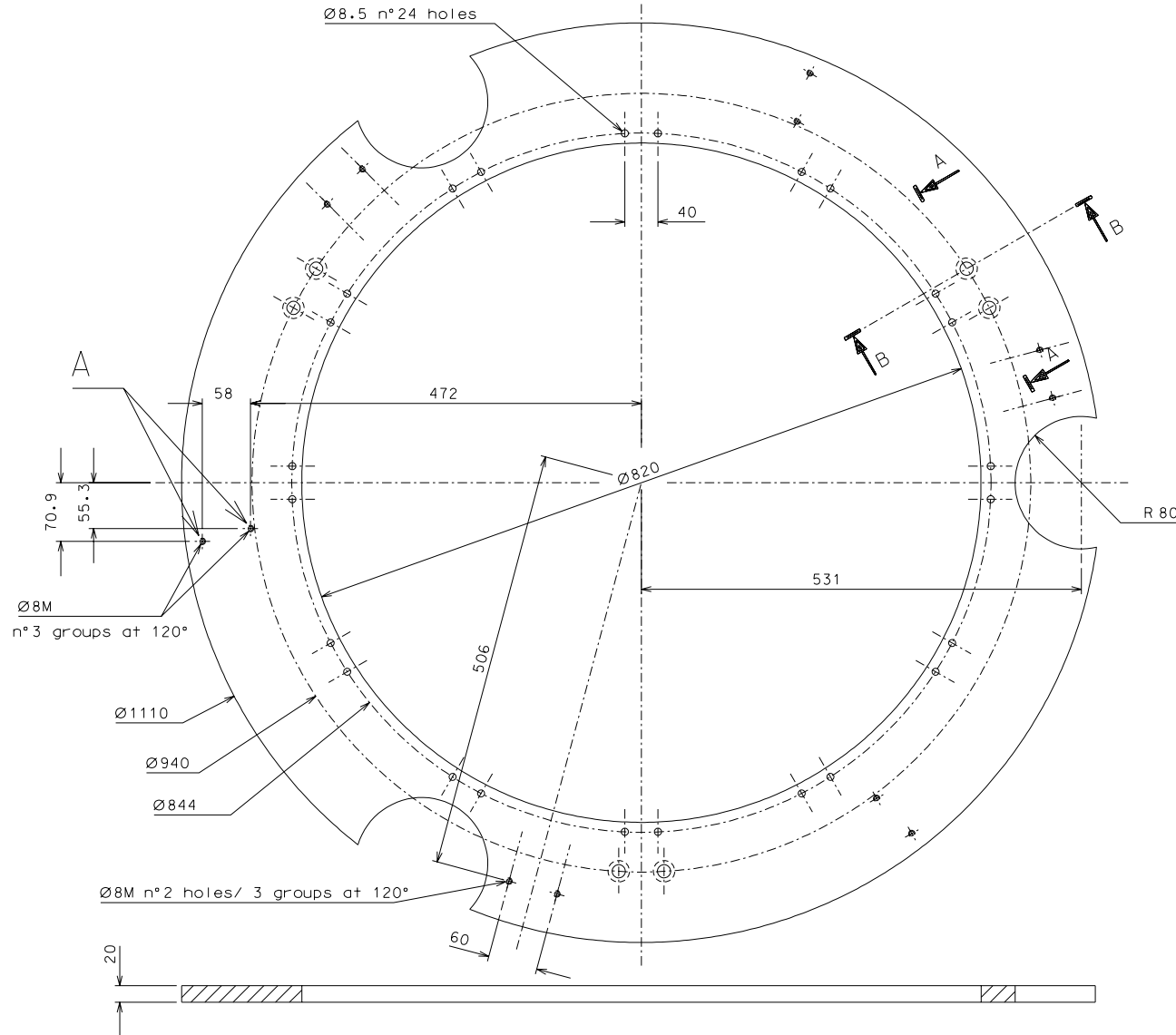
For to buy
1 - AT1, JBS 6, n°12 pieces

LIGO PROJECT designed for R. De Saivo
ass. num. TEST-TOWER-015

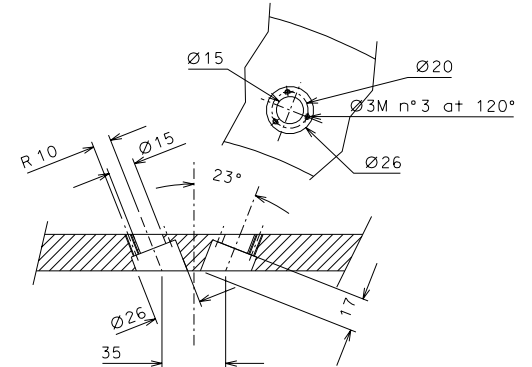
TEST-TOWER scale 1:4

ESAWIRE ref. / draw. or. num.

Size A1



Section B-B
Scale 1:2



Section A-A
Scale 1:2

n°3 couples of holes at 120°

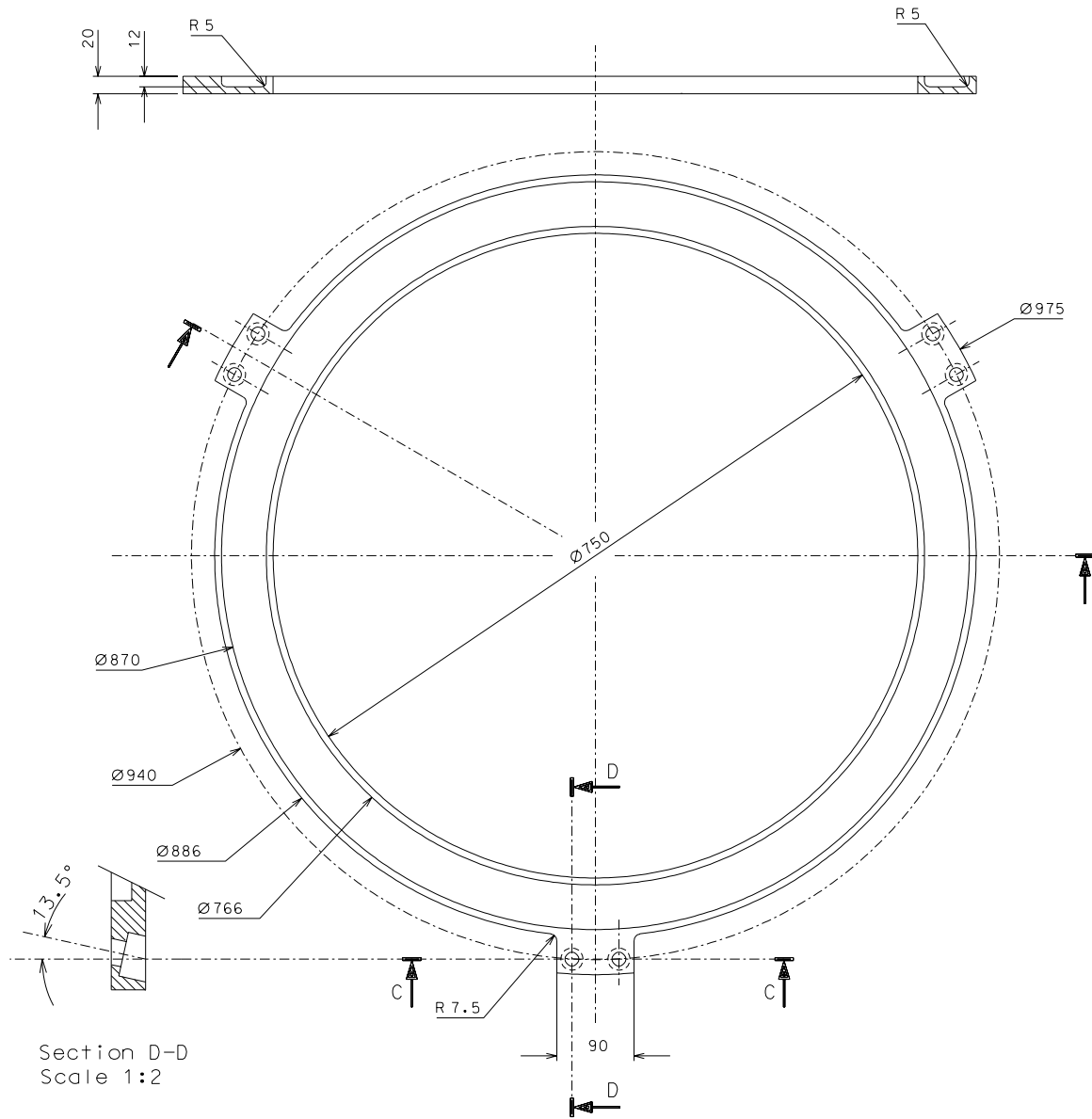
modified		24-9-99	
ref.	note	date	signature
modifications			

39	1	AISI 304	1:4		
ref.	pieces	mat. and treatments	scale	ref.	pieces
				mat. and treatments	scale

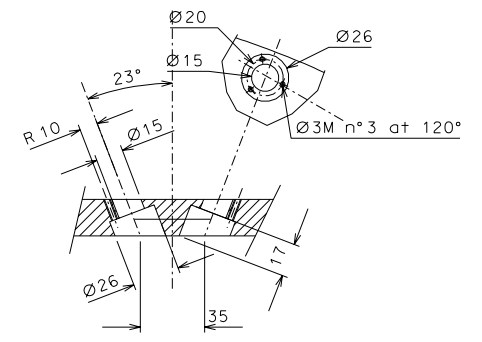
General machining tolerances UNI 5307-63							
Dimensions	< 6	> 6-30	> 30-120	> 120-315	> 315-1000	> 1000-2000	
Linear Tol.	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	
angular Tol.	± 1'	± 30'	± 20'	± 10' referred to the shortest side			

	LIGO PROJECT	designed for R. De Salvo
		N. Test-tower.016
title	TEST-TOWER	draw. PROMEC 16-9-99
	DETAIL	details from 015
		replaces dr. Num.

Size A2



Section D-D
Scale 1:2



Section C-C
Scale 1:2
n°3 couples of holes at 120°

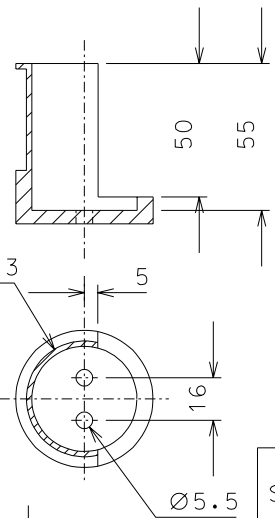
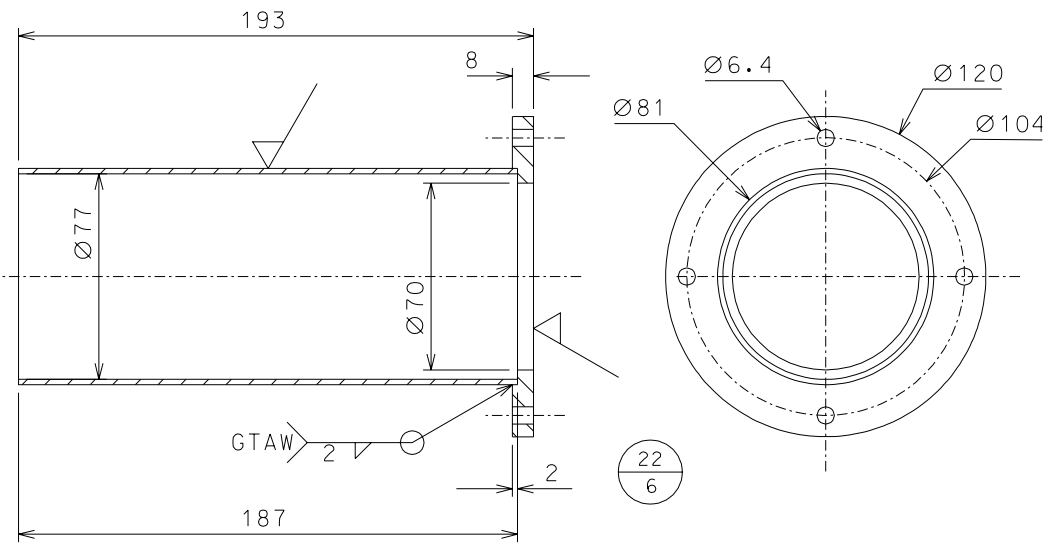
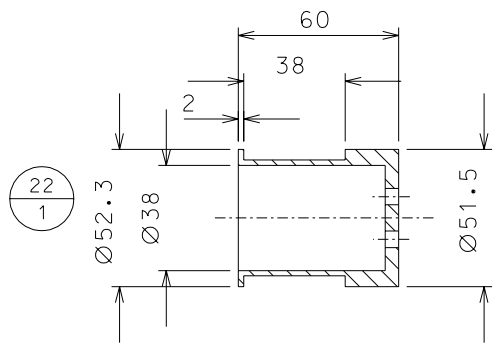
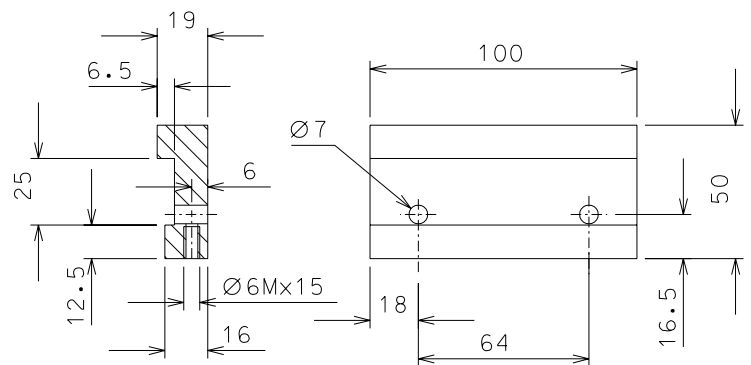
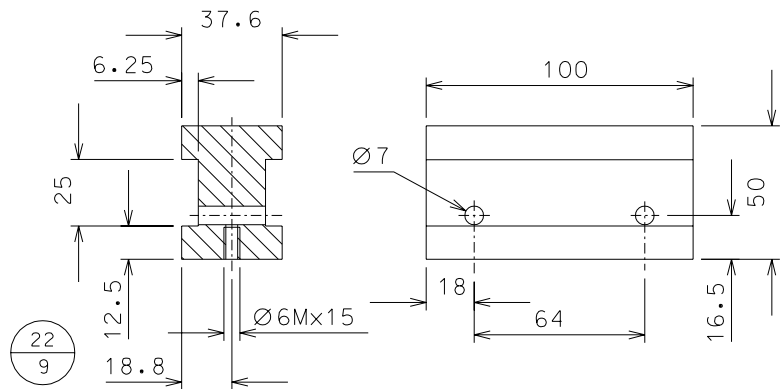
modified		24-9-99	
ref.	note	date	signature
modifications			

40 1 nickel plated ARMCO 1:4			
ref.	pieces	mat. and treatments	scale

General machining tolerances UNI 5307-63							
Dimensions	< 6	> 6-30	> 30-120	> 120-315	> 315-1000	> 1000-4000	> 4000
Linear Toll.	± 0,1	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2	± 3
angular Toll.	± 1	± 30'	± 20'	± 10' referred to the shortest side			

	LIGO PROJECT		designed for R. De Salvo
	TEST-TOWER DETAIL		N. Test-tower.017
			draw. PROMEC 16-9-99
title			details from 015
			replaces dr. Num.

Size A2



Size A3

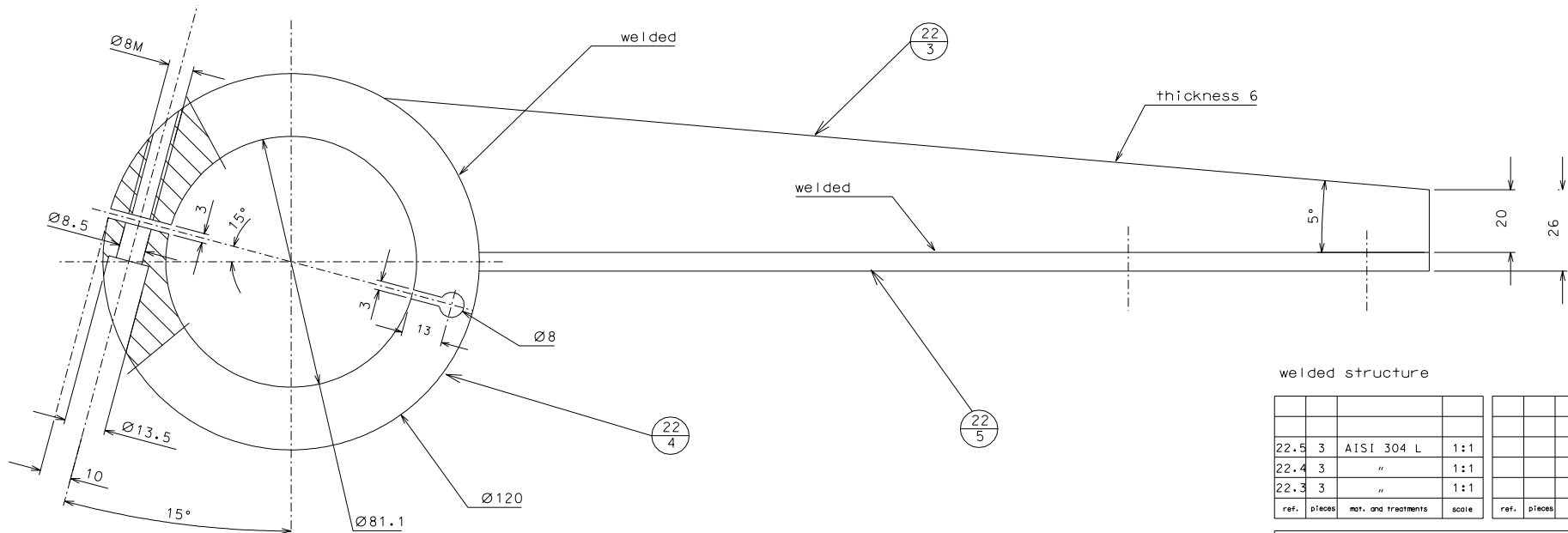
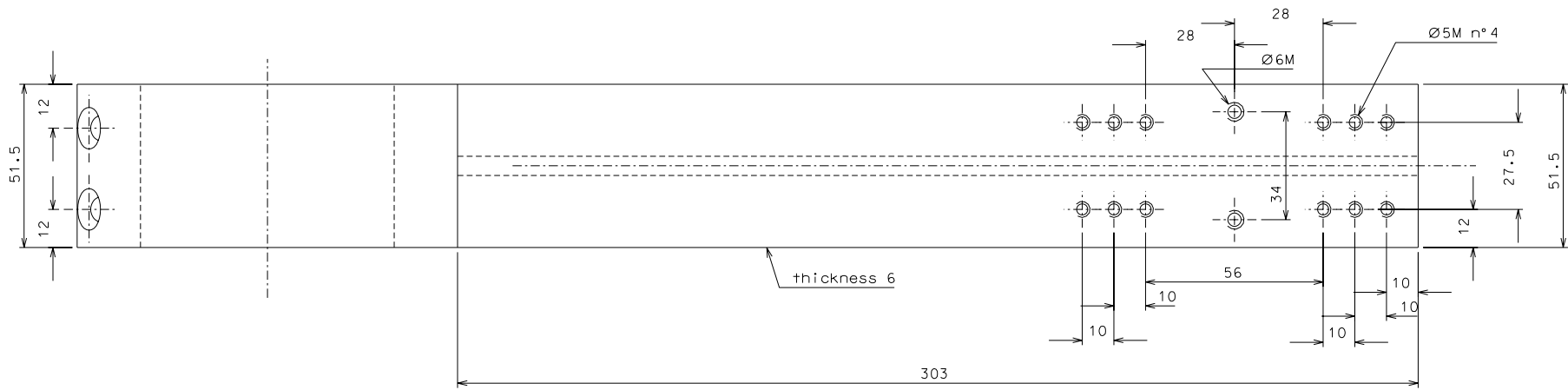
ref.	note	date	signature
modifications			

22.6	3	AISI 304 L	1:2
22.1	6	AISI 304	1:2
ref.	pieces	mat. and treatments	scale

22.9	3	nickel plated ARMCO	1:2
22.8	6	"	1:2
ref.	pieces	mat. and treatments	scale

General machining tolerances UNI 5307-63								
Dimensions	< 6	>6-30	>30-120	> 120-315	> 315-1000	>1000-2000	>2000-4000	> 4000
linear Toll.	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 2	± 3
angular Toll.	± 1	± 30'	± 20'	± 10' referred to the shortest side				

	<h1>LIGO PROJECT</h1>	designed for R. De Salvo
		N. Test-tower.018
<h2>TEST-TOWER DETAILS</h2>	draw. PROMEC 17-9-99	
	details from 013	
	replaces dr. Numb.	



welded structure

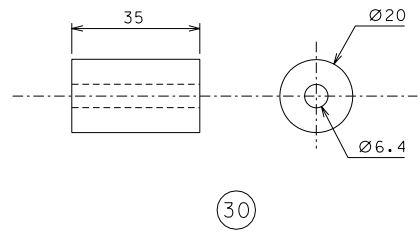
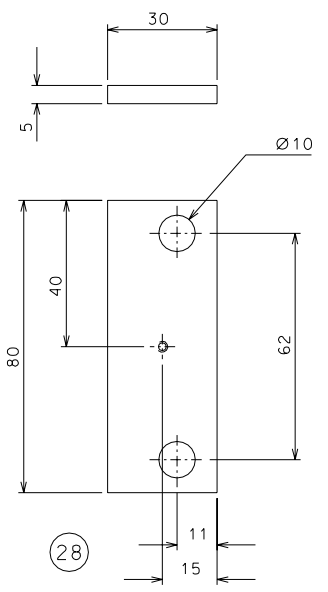
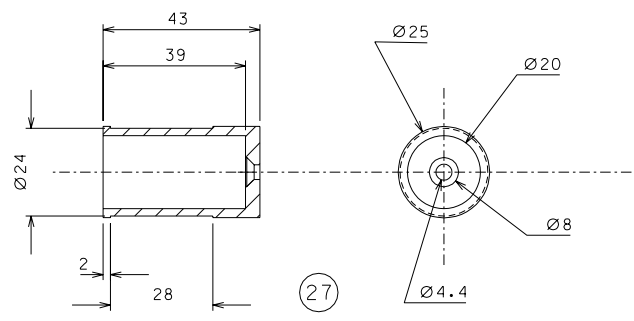
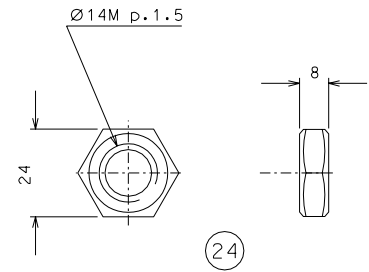
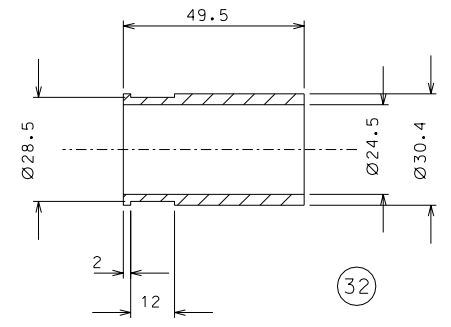
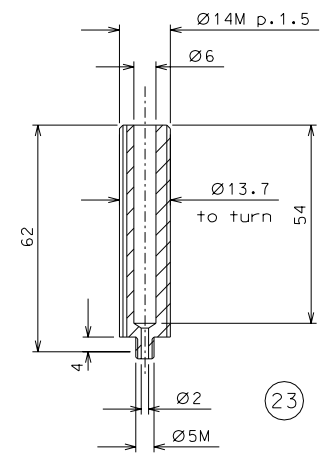
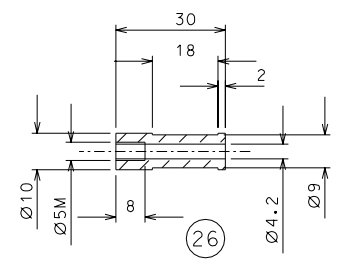
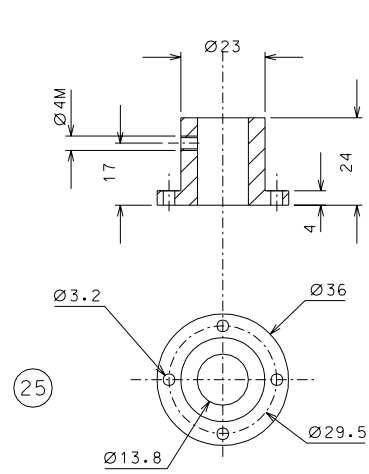
ref.	pieces	mat. and treatments	scale	ref.	pieces	mat. and treatments	scale
22.5	3	AISI 304 L	1:1				
22.4	3	"	1:1				
22.3	3	"	1:1				

General machining tolerances UNI 5307-63							
Dimensions	< 6	> 6-30	> 30-120	> 120-315	> 315-1000	> 1000-2000	> 2000-4000
Linear Toli.	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 3
angular Toli.	± 1'	± 30'	± 20'	± 10' referred to the shortest side			

Size A2

ref.	note	date	signature
modifications			

	<h3>LIGO PROJECT</h3>	designed for R. De Salvo N. Test-tower.019
	<h3>TEST-TOWER DETAILS</h3>	draw. PROMEC 18-9-99 details from 013 replaces dr. Numb.



LVDT courtesy of VIRGO

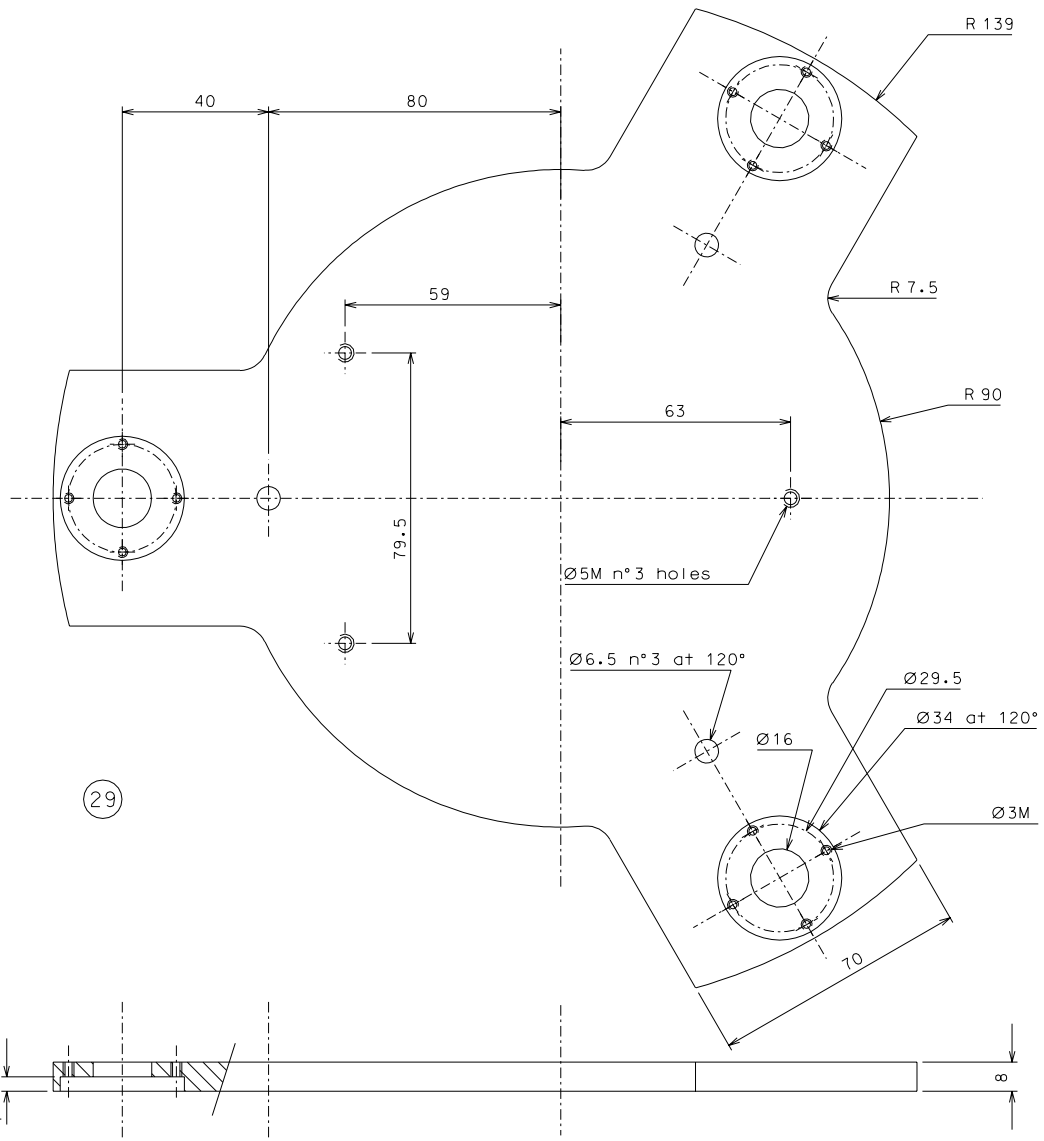
ref.	note	date	signature
modifications			

27	3	ertalon	1:1				
26	3	perspex	1:1				
25	3	bronze B14	1:1	32	1	bronze B14	1:1
24	3	"	1:1	30	3	Al alloy	1:1
23	3	stainless steel	1:1	28	3	stainless steel	1:1
ref.	pieces	mat. and treatments	scale	ref.	pieces	mat. and treatments	scale

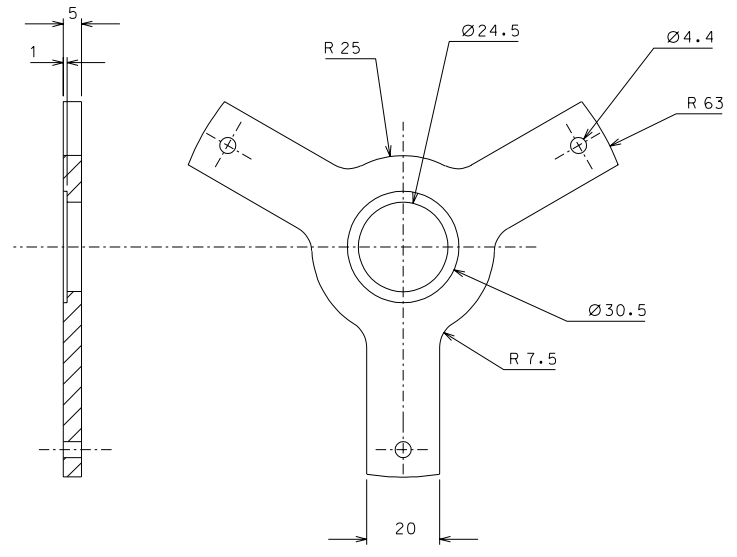
General machining tolerances UNI 5307-63							
Dimensions	< 6	> 6-30	> 30-120	> 120-315	> 315-1000	> 1000-2000	> 2000-4000
Linear Toli.	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 3
Angular Toli.	± 1'	± 30'	± 20'	± 10' referred to the shortest side			

	LIGO PROJECT		designed for R. De Salvo
	TEST TOWER DETAILS		N. Test-tower.020
title		draw. PROMEC 14-9-99	
		details from D14	
		replaces dr. Num.	

Size A2



29



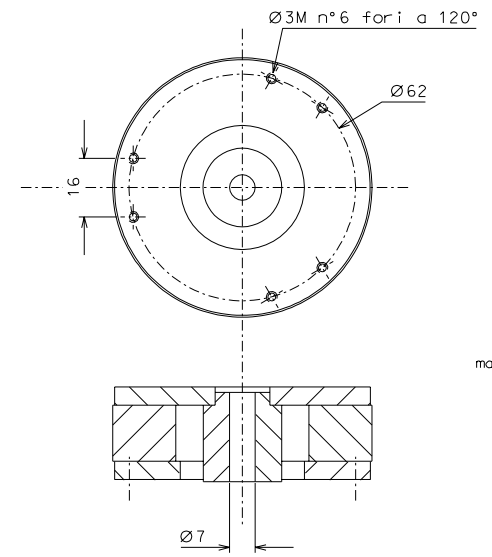
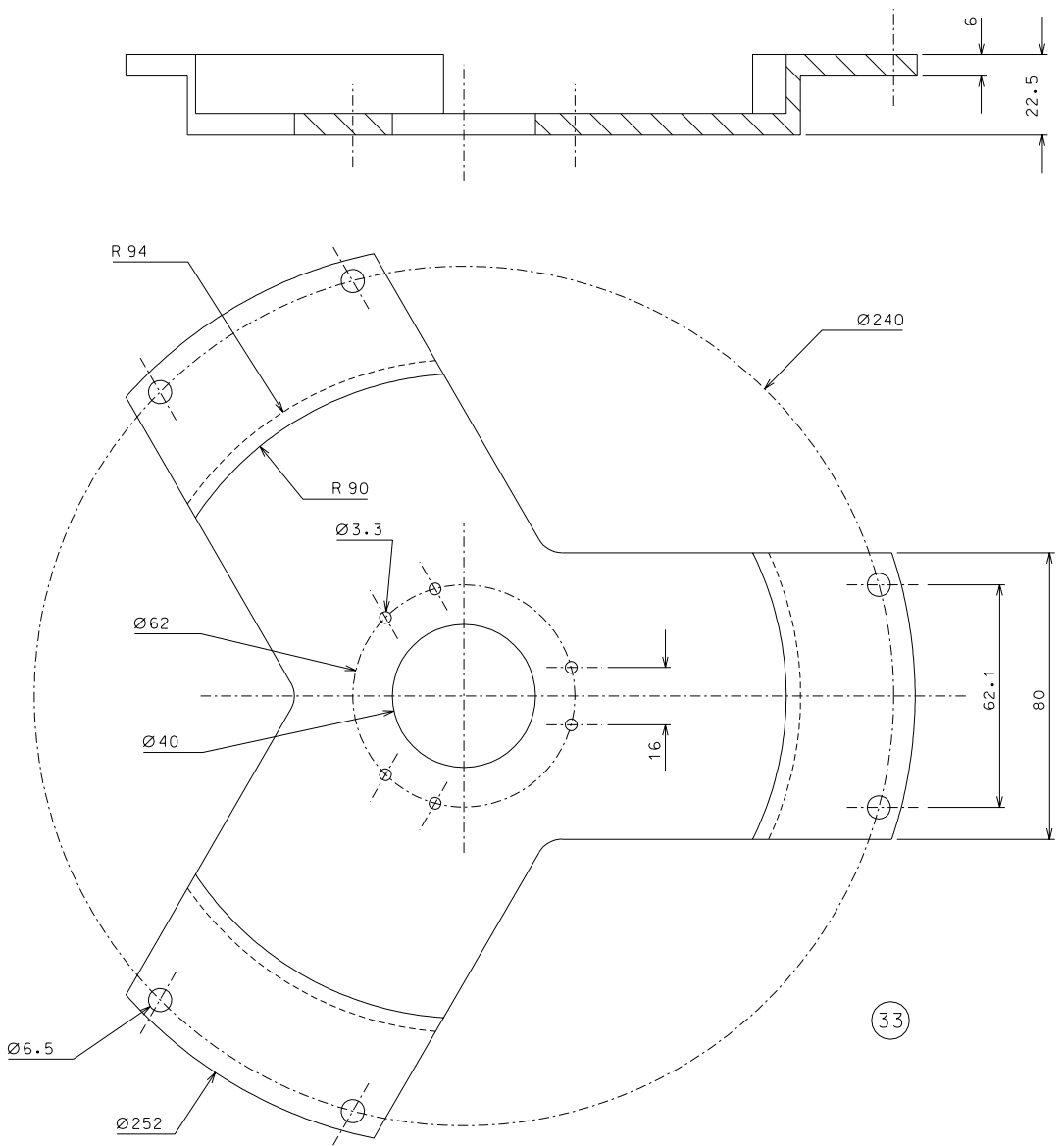
31

ref.	note	date	signature
modifications			

31	1	stainless steel	1:1				
29	1	"	1:1				
ref.	pieces	mat. and treatments	scale	ref.	pieces	mat. and treatments	scale

General machining tolerances UNI 5307-63								
Dimensions	< 6	> 6-30	> 30-120	> 120-315	> 315-1000	> 1000-2000	> 2000-4000	> 4000
Linear Toli.	± 0,1	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2	± 2	± 3
angular Toli.	± 1'			± 30'	± 20'	± 10'		

	LIGO PROJECT		designed for R. De Salvo
	TEST TOWER		N. Test-tower.021
DETAILS		draw. PROMEC 14-9-99	
Size A2		details from 014	
		replaces dr. Num.	



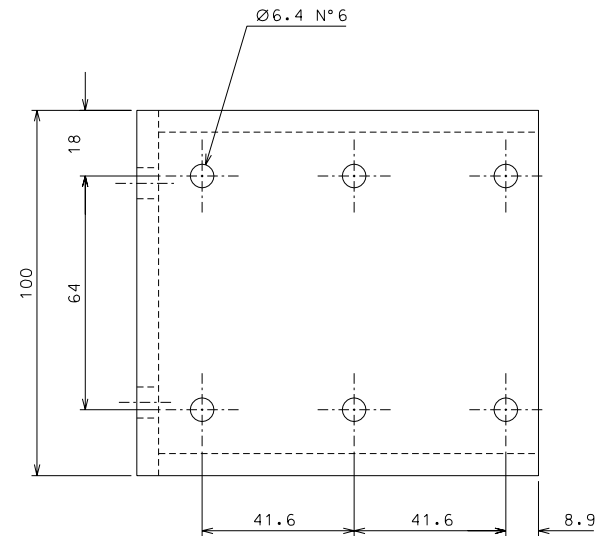
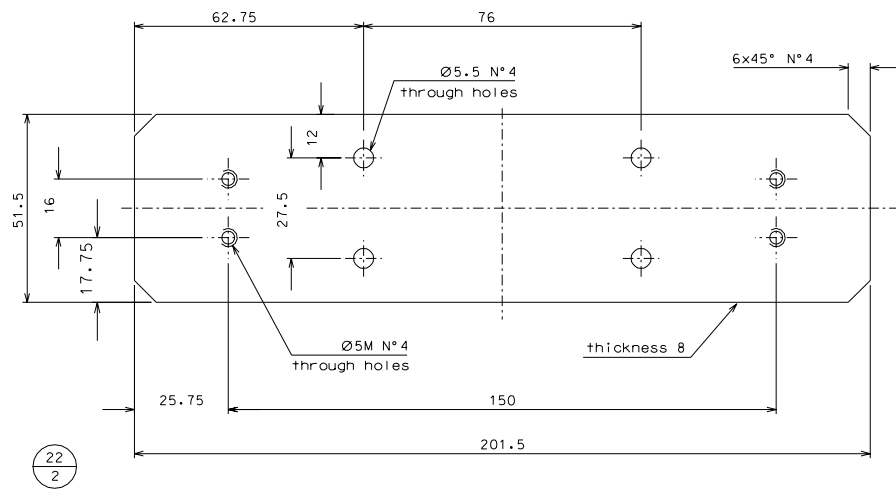
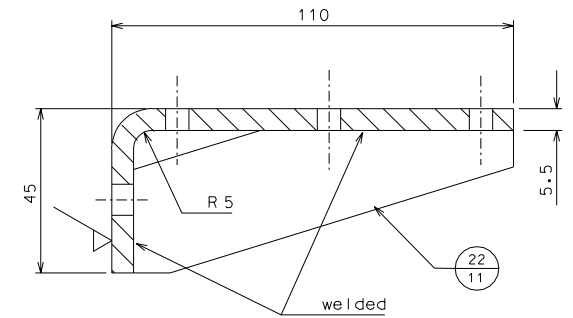
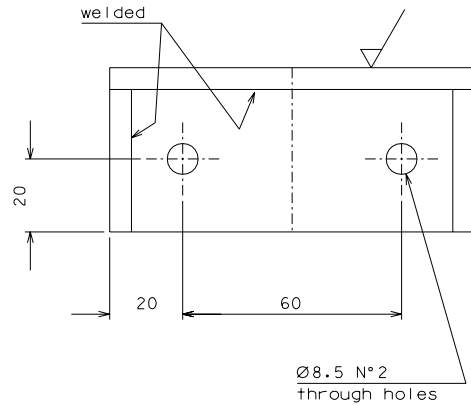
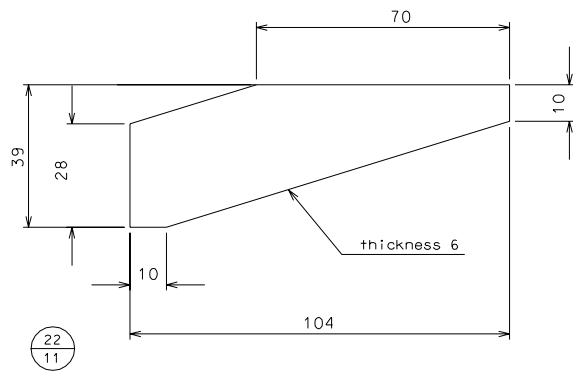
(34)
magnet, cut with water

ref.	note	date	signature
modifications			

34	1		1:1			
33	1	stainless steel	1:1			
ref.	pieces	mat. and treatments	scale	ref.	pieces	mat. and treatments
			scale			

General machining tolerances UNI 5307-63							
Dimensions	< 6	> 6-30	> 30-120	> 120-315	> 315-1000	> 1000-4000	> 4000
Linear Toli.	± 0,1	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2	± 3
angular Toli.	± 1'	± 30'	± 20'	± 10' referred to the shortest side			
LIGO PROJECT				designed for R. De Salvo N. Test-tower.022 draw. PROMEC 14-9-99 details from 014 replaces dr. Num.			
title TEST TOWER DETAILS							

Size A2



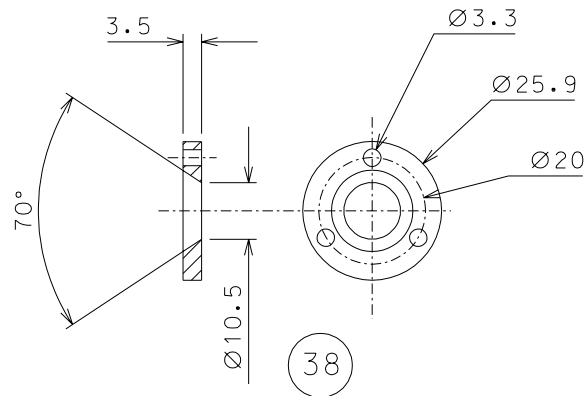
22.11	6	AISI 304	1:1				
22.10	3	"	1:1				
22.2	3	"	1:1				
ref.	pieces	mat. and treatments	scale	ref.	pieces	mat. and treatments	scale

General machining tolerances UNI 5307-63							
Dimensions	< 6	> 6-30	> 30-120	> 120-315	> 315-1000	> 1000-2000	> 2000-4000
Linear Toli.	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 3
angular Toli.	± 1'	± 30'	± 20'	± 10' referred to the shortest side			

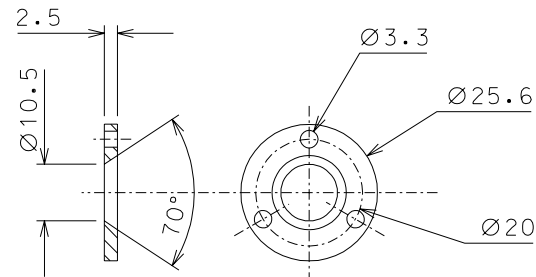
Size A2

ref.	note	date	signature
modifications			

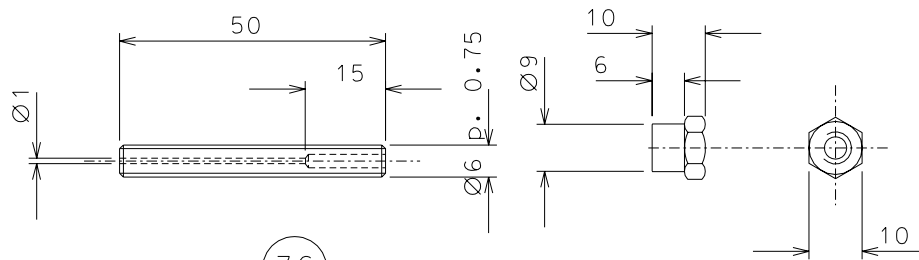
	LIGO PROJECT		designed for R. De Salvo
	TEST-TOWER DETAILS		N. Test-tower.023
title		draw. PROMEC 18-9-99	
		details from 013	
		replaces dr. Num.	



38



37

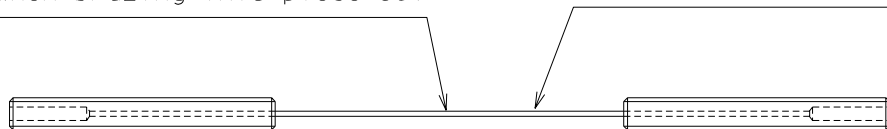


36

35

piano wire 0.8 minimum length 1100
(to be trimmed to desired length
when brazing into piece 36)

length to be determined by
length of suspension wire



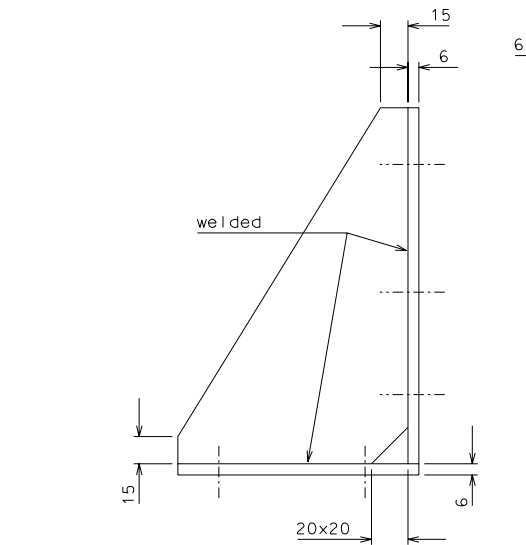
silver braze in oven under argon atmosphere

Size A3

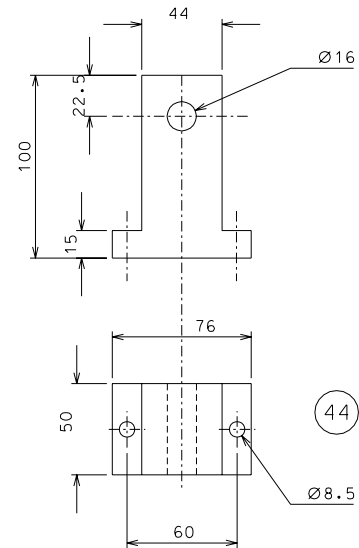
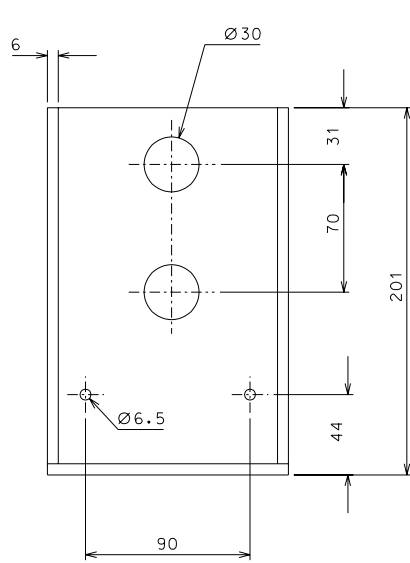
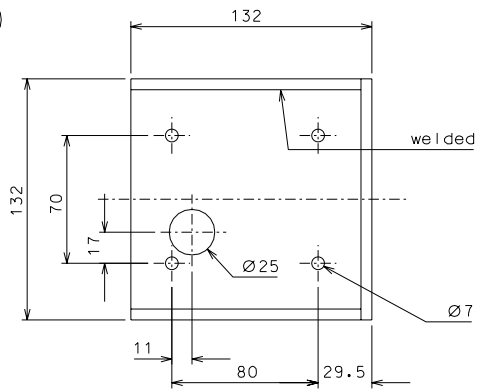
	modified	24-9-99	
ref.	note	date	signature
modifications			

38	12	bronze	1:1				
37	12	"	1:1				
36	12	"	1:1				
35	24	stainless steel	1:1				
ref.	pieces	mat. and treatments	scale	ref.	pieces	mat. and treatments	scale

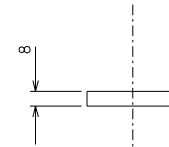
General machining tolerances UNI 5307-63									
Dimensions	< 6	>6-30	>30-120	> 120-315	> 315-1000	>1000-2000	>2000-4000	> 4000	
linear Toll.	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 2	± 3	
angular Toll.	± 1	± 30'	± 20'	± 10'				referred to the shortest side	
				LIGO PROJECT				designed for R. De Salvo	
				TEST-TOWER				N. Test-tower.024	
title				DETAILS				draw. PROMEC 21-9-99	
								details from 012	
								replaces dr. Numb.	



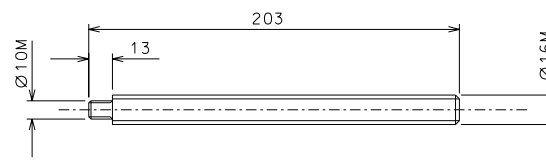
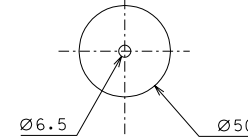
45



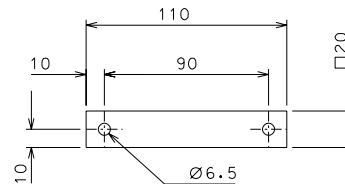
44



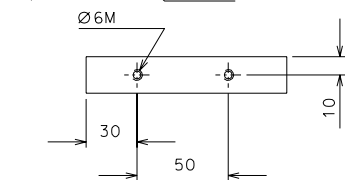
42



43



41



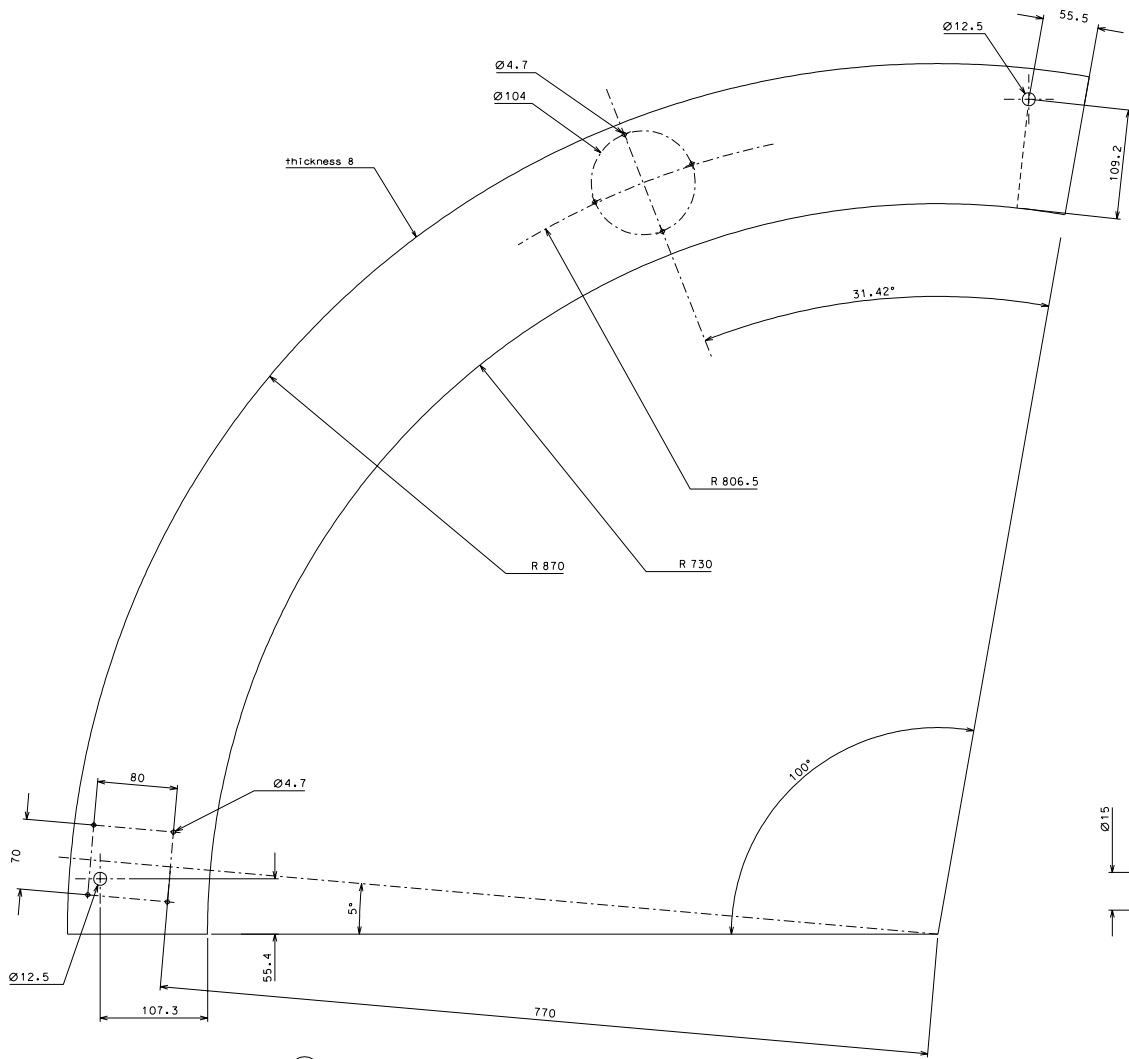
ref.	note	date	signature
modifications			

45	3	AISI 304 L	1:2				
44	3	Al alloy	1:2				
43	3	stainless steel	1:2				
42	6	"	1:2				
41	3	"	1:2				
ref.	pieces	mat. and treatments	scale	ref.	pieces	mat. and treatments	scale

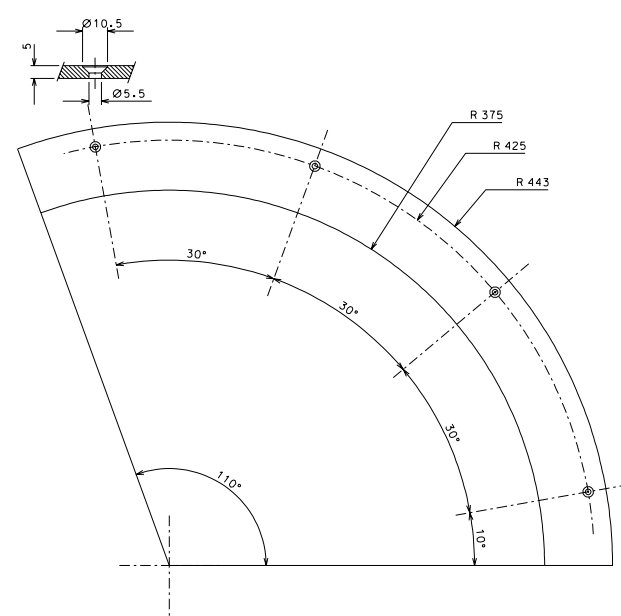
General machining tolerances UNI 5307-63							
Dimensions	< 6	> 6-30	> 30-120	> 120-315	> 315-1000	> 1000-2000	> 2000-4000
Linear Toli.	± 0,1	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2	± 3
angular Toli.	± 1'	± 30'	± 20'	± 10' referred to the shortest side			

	LIGO PROJECT		designed for R. De Salvo
			N. Test-tower.025
title TEST-TOWER DETAILS		rev. PROMEC 19-9-99	
		details from 012 replaces dr. Num.	

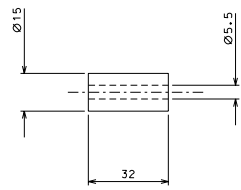
Size A2



A



46



47

(*) N°3 pieces of nickel plated iron ARMCO n°6 of copper type DHFC

ref.	desc	date	signature
modifications			

47	12	AL alloy	1:1				
46	9	*	1:2.5				
A	1	AL alloy	1:2.5				
ref.	piece	mat. and treatments	scale	ref.	piece	mat. and treatments	scale

General machining tolerances UNI 5007-63							
Dimension	< 4	4-30	30-100	100-315	315-1000	1000-4000	> 4000
linear fall.	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 2
angular fall.	± 1'	± 30"	± 20"	± 10"	related to the smallest size		

LIGO PROJECT
 designed for R. De Salvo
 n. TEST-tower.026
 area. PROMEC 26-9-99
 details from 003
 replace or. Num.

Size A1