Mechanical Design for the Time of Flight System of the STAR Detector

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1 Introduction

The physics goals of STAR, particularly for complete particle identification, demand a comprehensive TOF system. The requirements for this system are to cover the pseudorapidity range $-1 < \eta < 1$ subtended by the barrel surface of the TPC, to identify pions with $0.3 < p_t < 1.5$ GeV/c; kaons with $0.3 < p_t < 1.5$ GeV/c and proton/antiprotons with $0.3 < p_t < 2.3$ GeV/c, and to provide a fast trigger sensitive to charged particle multiplicity in the central region.

The technical requirements posed by the above goals are challenging and the timing resolution needed is sigma < 100 ps. This requires a highly segmented cylindrical counter of 2.05 meter inner radius and about 4.5 meter long which is able to operate in a 5 kG magnetic field. The necessity of minimising secondary particles particularly photon conversions is the reason for putting the TOF system inside the solenoidal coil and the cryostat.

2 TOF System Design

The baseline design for the TOF system is the shingle design consisting of tiling the cylinder with 7776 single ended scintillators arranged in 216 trays (108 in $+Z$; 108 in $-Z$ direction). Figure 1 shows 108 trays arranged outside the TPC surface of radius 205 cm. Each tray contains 36 scintillators and covers about 3.3 degree in ϕ as shown in Fig.2. Each tray is about 11.8 cm wide and 2.25 meters long. They can be individually inserted onto the rails mounted on the outside surface of the TPC. The detailed dimensions of the tray base and cover are shown in Figs 3-5.

Due to budget constraints a descoped version will at first be used. This will consist of implementing $16 + 16 = 32$ trays which will cover approximately $53°$ in ϕ. The rest of the cylinder will be implemented with 368 double ended TOF slats. These slats will be used as a trigger device for mid-rapidity region and to provide lower resolution but still useful TOF data.

3 Fabrication, Assembly and Installation

Each shingle counter will consist of a 1 inch diameter 15 stage R3432-01 Hamamatsu Proximity Mesh Dynode phototube optically coupled to a scintillator with a plexi-glass light guide. The scintillator will be Bicron BC404 1.5 cm $\times$ 2.6 cm $\times$ 23.5 cm with diamond cut edges. Using a fish tail design, the light guides will be used to couple the 1.6 cm diameter active area of the phototube to the 2.6 cm $\times$ 1.5 cm area of the scintillator. The light guides will be machined from thick acrylic sheets with all machined edges flame polished.

The phototubes will be glued to the light guides and the light guides glued to the scintillators. The calibration fibers will also be glued to the scintillators. Each counter will then be wrapped in aluminized mylar and taped. The tube bases will then be attached and the system will be checked for possible light leaks and useable pulse height. Then the 36 shingle counters will be mounted four abreast and 9 along the Z direction in a tray and all cabling hooked up.

Each slat counter will consist of two R3432-01 phototubes optically coupled to a BC408 1.5 cm $\times$ 5.2 cm $\times$ 200 cm scintillator with a plexi-glass light guide. The scintillators will have diamond cut edges and as usual the plexi-glass will be shaped to couple the active area of the scintillators and the phototubes. The phototubes will be glued to the light guides and the light guides glued to the scintillators. The calibration fibers will also be glued to the scintillators. Each counter will then be wrapped in aluminized mylar and taped. The tube bases will then be attached and the system will be checked for possible light leaks and usuable pulse heights. The slat counters will then be mounted two abreast in the module tray and all cabling hooked up.

The module tray parts are fabricated out of extruded plastics. These are considered expandable items during repairs. Therefore a larger number of spares will be needed. The trays will have following parts: Tray base, Tray covers, Blank and Perforated End Plates. Each group of four shingle counters or two slats will be supported inside the tray by a molded foam wedge or block and secured by two extruded plastic restraint struts. A copper heat conductor will join each group of four(two) tube electronics to the aluminum support rail to provide cooling. There will also be tube retainers which will be used to hold the tubes. The preliminary engineering drawings for these are shown in Figs 6-9.

The mechanical support system will consist of 216 aluminum rails, 2.25 meter long, which will be fabricated and bolted to the TPC outer frame. The rails are shown in Fig. 10. Each module tray, holding 36 shingle counters, or two slat counters will be inserted into the slots formed by the support rails. Trays will be inserted from each end of the STAR detector. Power and signal cables, calibration fibers as well as cooling air will be run inside the module trays, the details of which will be worked out later on. An assembly unit will be used to support a loaded tray module while it is being inserted into the STAR detector.

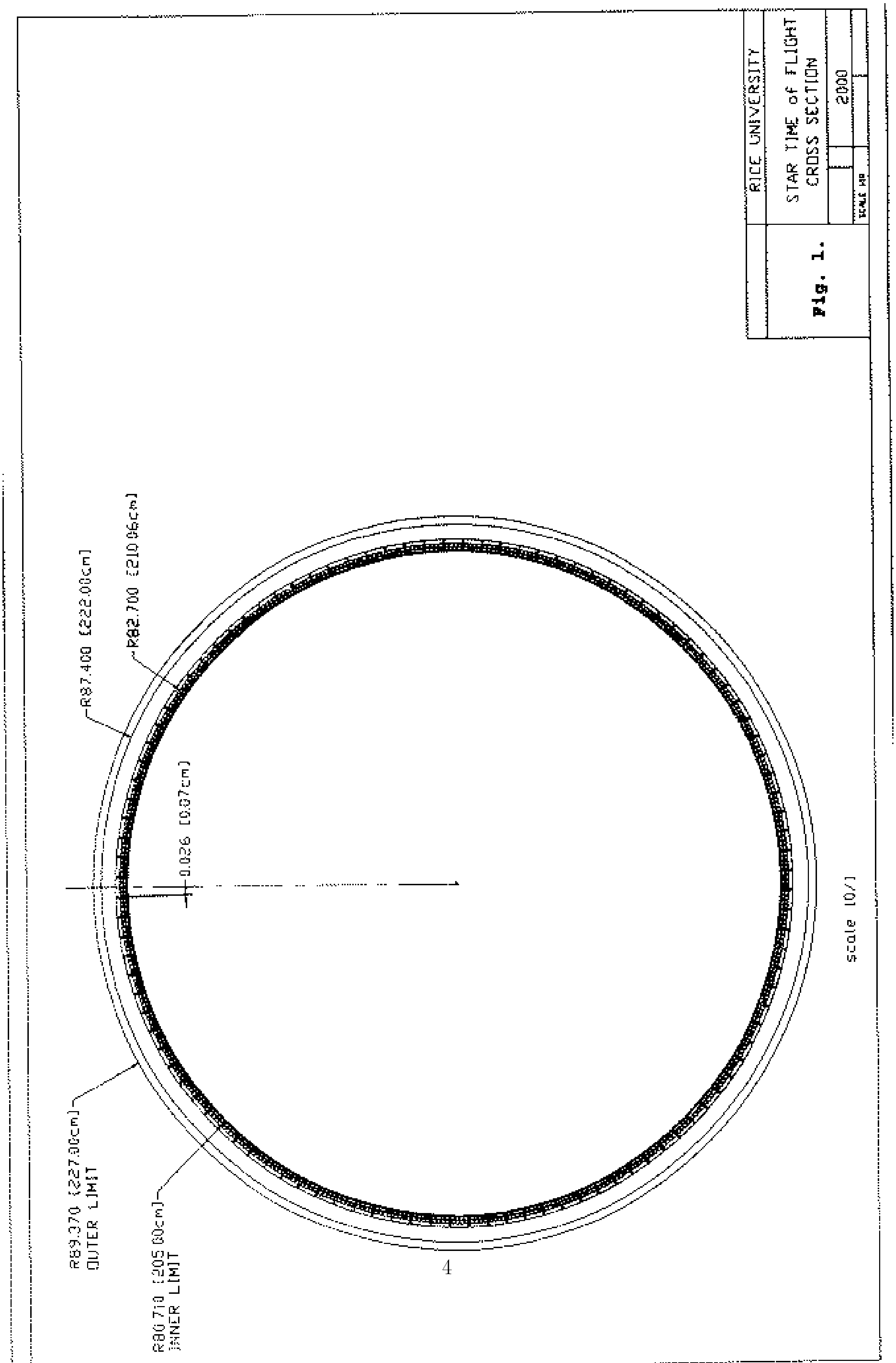
Trays containing scintillators and the phototubes will then be installed one by one. We will need a clear space of about 2.5 meter from the end cap to install the trays. Once all of them are installed, one will check the performance of the system by putting high voltage and checking the phototube signals.

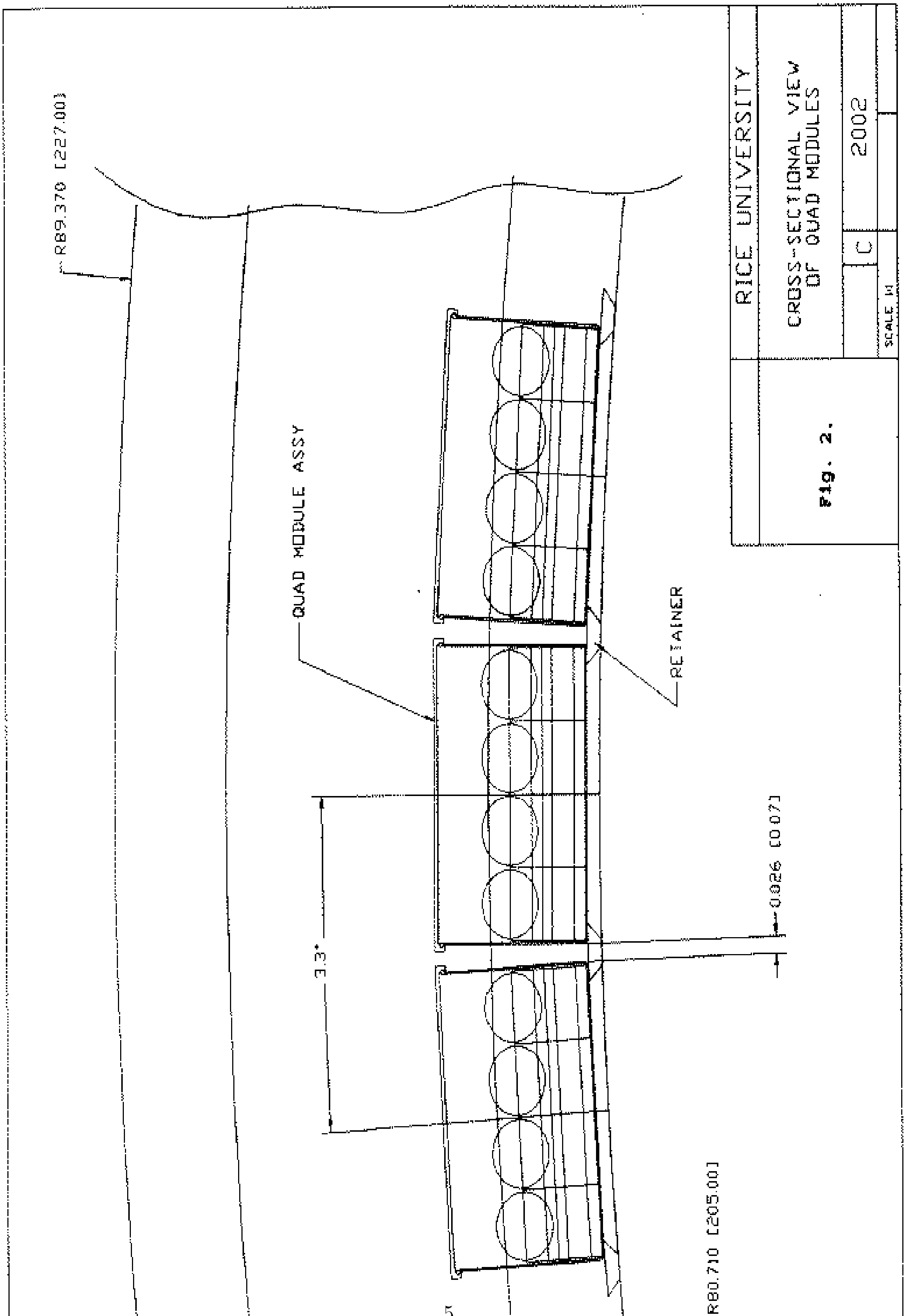
4 Maintenance and Servicing

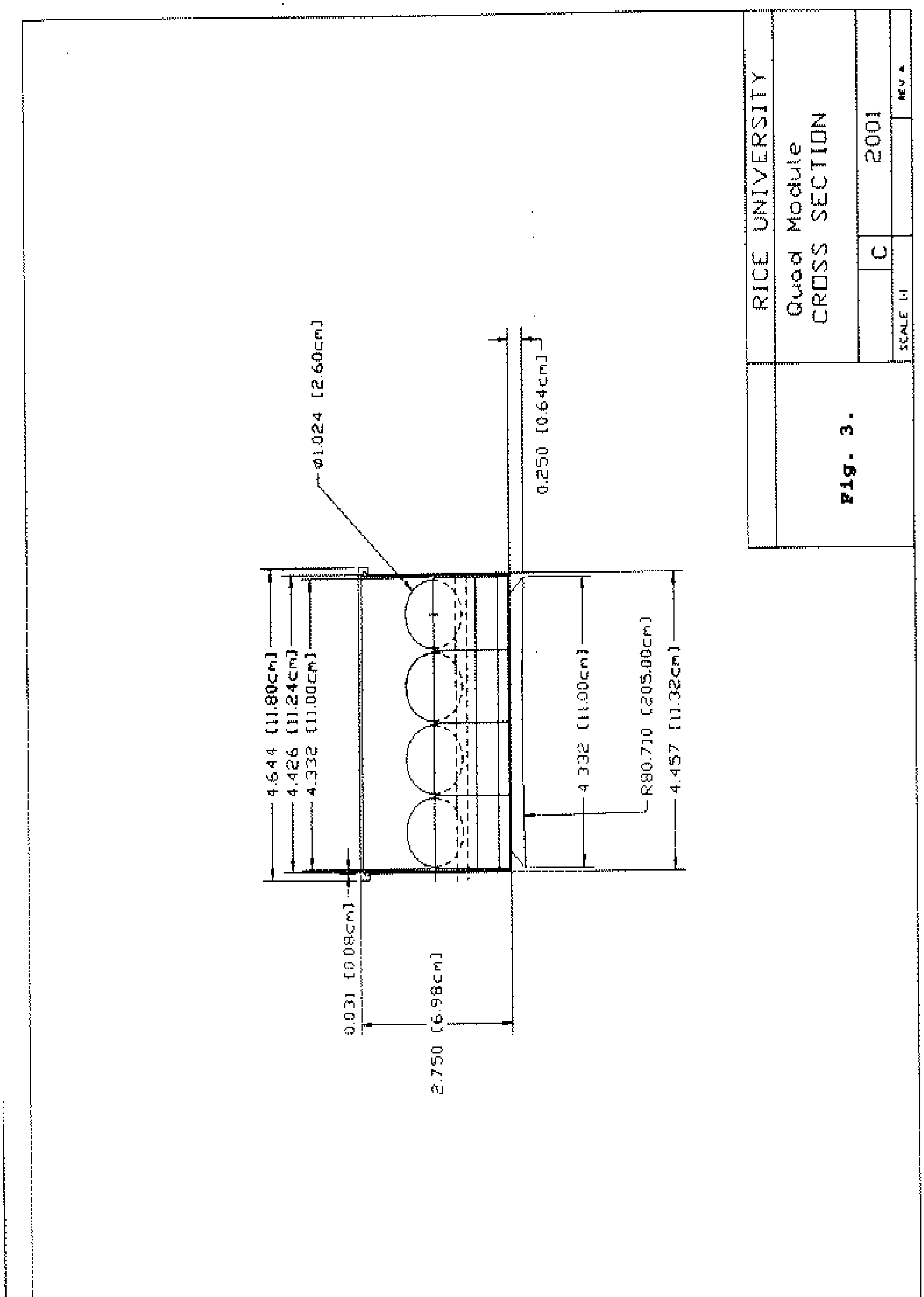
Once the TOF system is totally debugged and working one will not need to change anything on a regular basis. If a phototube dies while running we will perhaps ignore fixing it. If several phototubes die at a time and a reason is known, we will perhaps try to fix that problem. Such maintanence may not require a large disassembly of the system and will not require a major maintenance access. Servicing of the entire TOF system once a year should be adequate and sufficient.

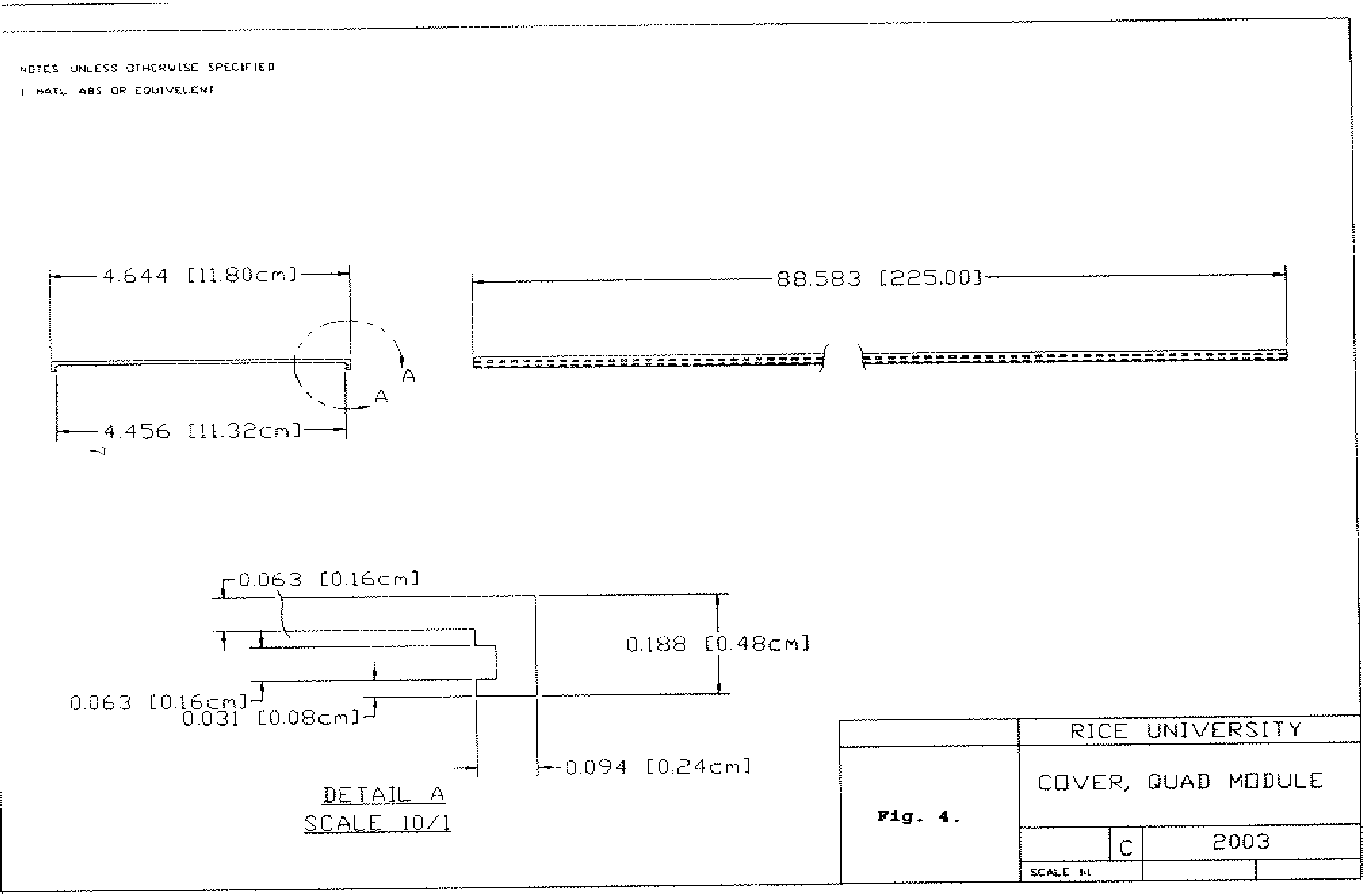
5 Acknowledgement

We would like to thank the LBL/STAR integration engineering group for providing us uptodate information regarding the dimensions of the entire STAR detector design. We would also like to thank H. Huang, G. Rai, R. Scharenberg and M. Tincknell for initiating the idea of the TOF system which we discussed in this note.


RICE UNIVERSITY
STAR TIME of FLIGHT
CROSS SECTION
2000
Fig. 1.
R87.400 [222.00cm]
R82.700 [210.06cm]
0.026 [0.07cm]
scale 10/1
R89.370 [227.00cm]
OUTER LIMIT
R80.710 [205.00cm]
INNER LIMIT


R89.370 [227.00]
QUAD MODULE ASSY
RETAINER
3.3°
0.026 [0.07]
R80.710 [205.00]
RICE UNIVERSITY
CROSS-SECTIONAL VIEW
OF QUAD MODULES
C
2002
Fig. 2.

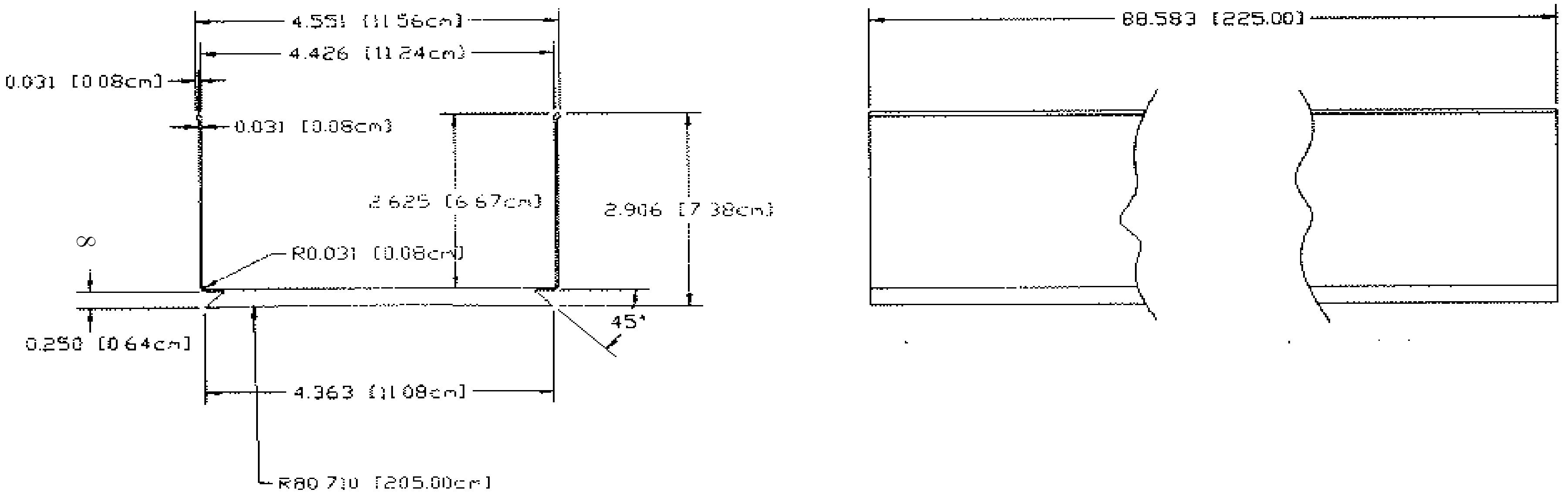

RICE UNIVERSITY
Quad Module
CROSS SECTION
C
2001
SCALE 1:1
REV A
Fig. 3.
Ø1.024 [2.60cm]
0.250 [0.64cm]
4.644 [11.80cm]
4.426 [11.24cm]
4.332 [11.00cm]
4.332 [11.00cm]
R80.710 [205.00cm]
4.457 [11.32cm]
0.031 [0.08cm]
2.750 [6.98cm]



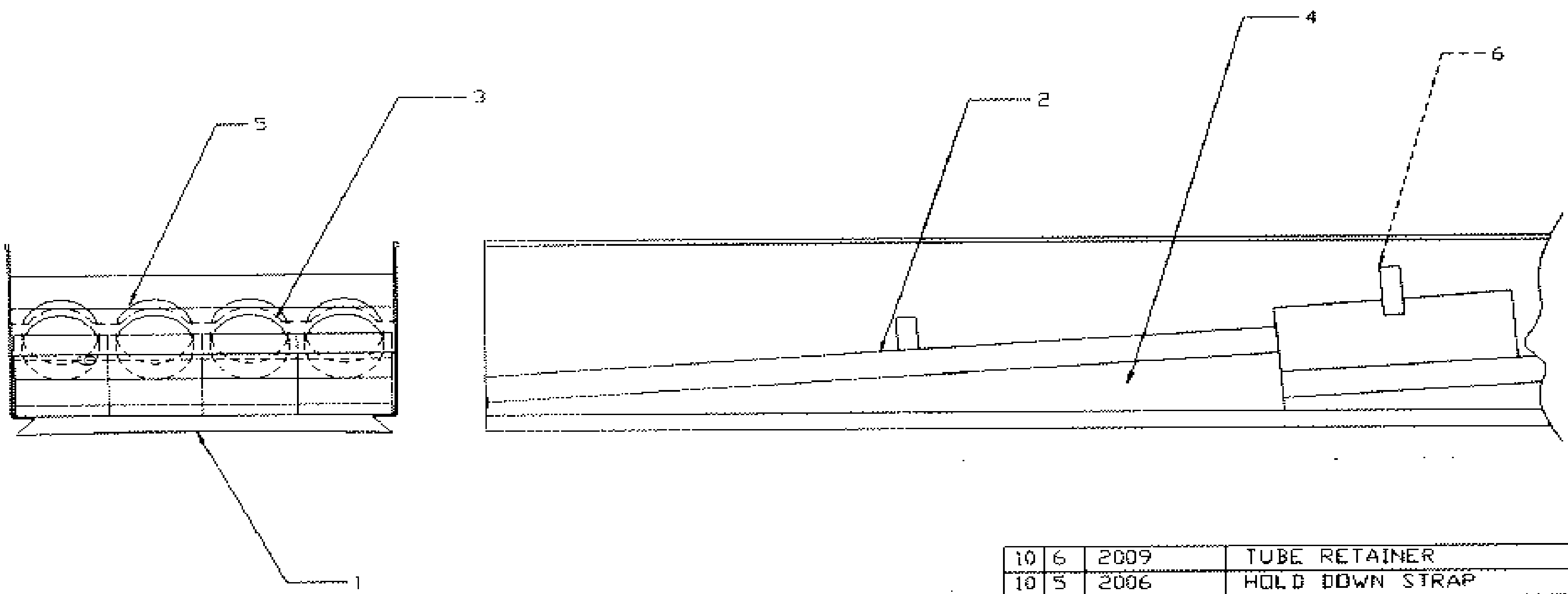
NOTES UNLESS OTHERWISE SPECIFIED
1 MATL ABS OR EQUIVELENT
4.644 [11.80cm]
4.456 [11.32cm]
A
A
88.583 [225.00]
0.063 [0.16cm]
0.188 [0.48cm]
0.063 [0.16cm]
0.031 [0.08cm]
0.094 [0.24cm]
DETAIL A
SCALE 10/1
RICE UNIVERSITY
COVER, QUAD MODULE
C
2003

Fig. 4.

NOTES: UNLESS OTHERWISE SPECIFIED
1 MATL. ABS OR EQUIVELENT



	RICE UNIVERSITY
Fig. 5.	BASE, QUAD MODULE
	C 2004
	SCALE 1:1



10	6	2009	TUBE RETAINER
10	5	2006	HOLD DOWN STRAP
10	4	2008	PAD
40	3		SCINTILLATOR/PHOTOTUBE
40	2	BC420	SCINTILLATOR SLAT
1	1	2004	BASE

RICE UNIVERSITY

SCINTILLATOR ASSY

C 2007

SCALE 1:1

Fig. 6.

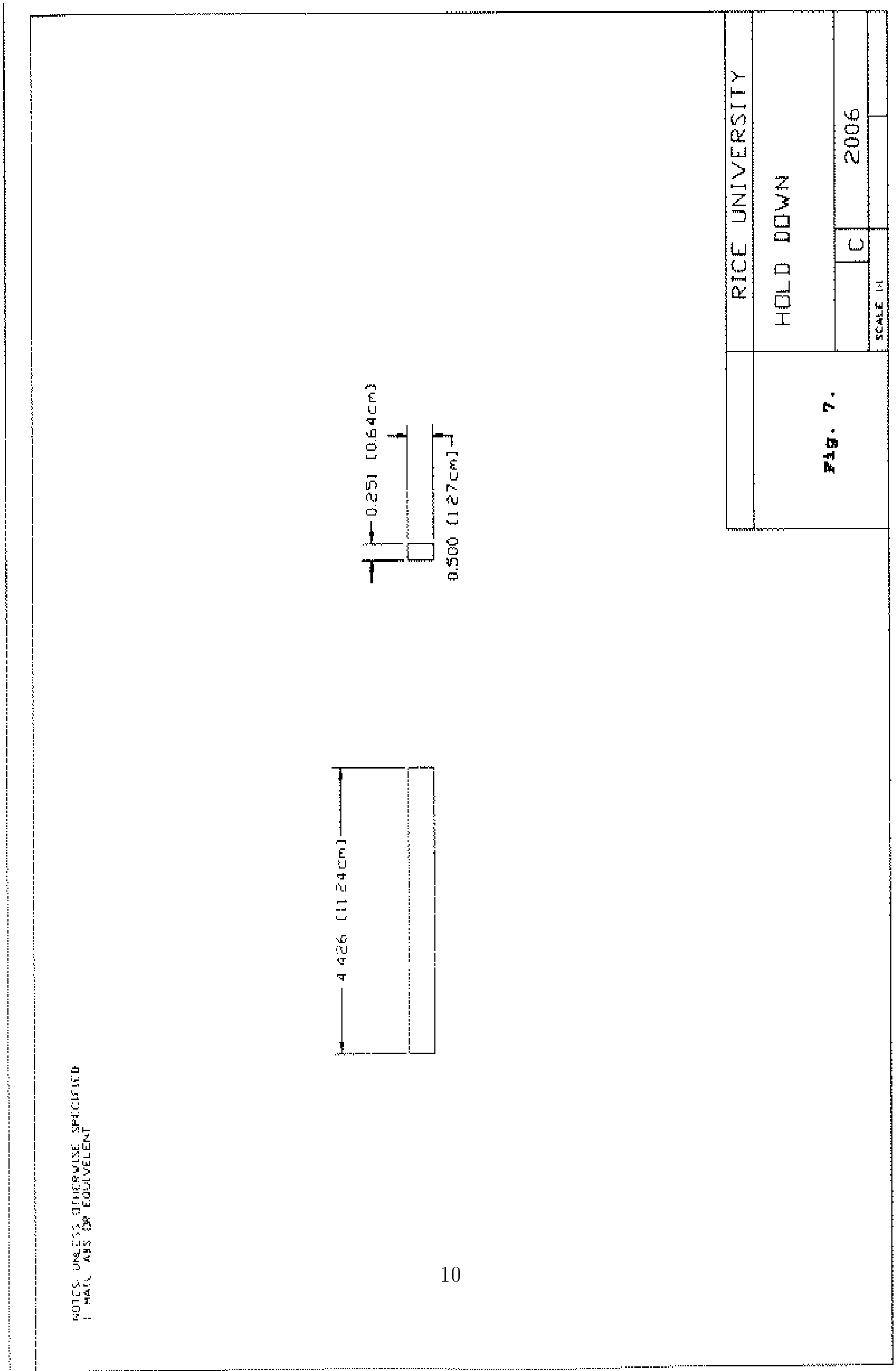

RICE UNIVERSITY
HOLD DOWN
C
2006
SCALE 1:1
0.251 [0.64cm]
0.500 [1.27cm]
4.426 [11.24cm]
NOTES: UNLESS OTHERWISE SPECIFIED
1 MATL ABS OR EQUIVELENT

Fig. 7.

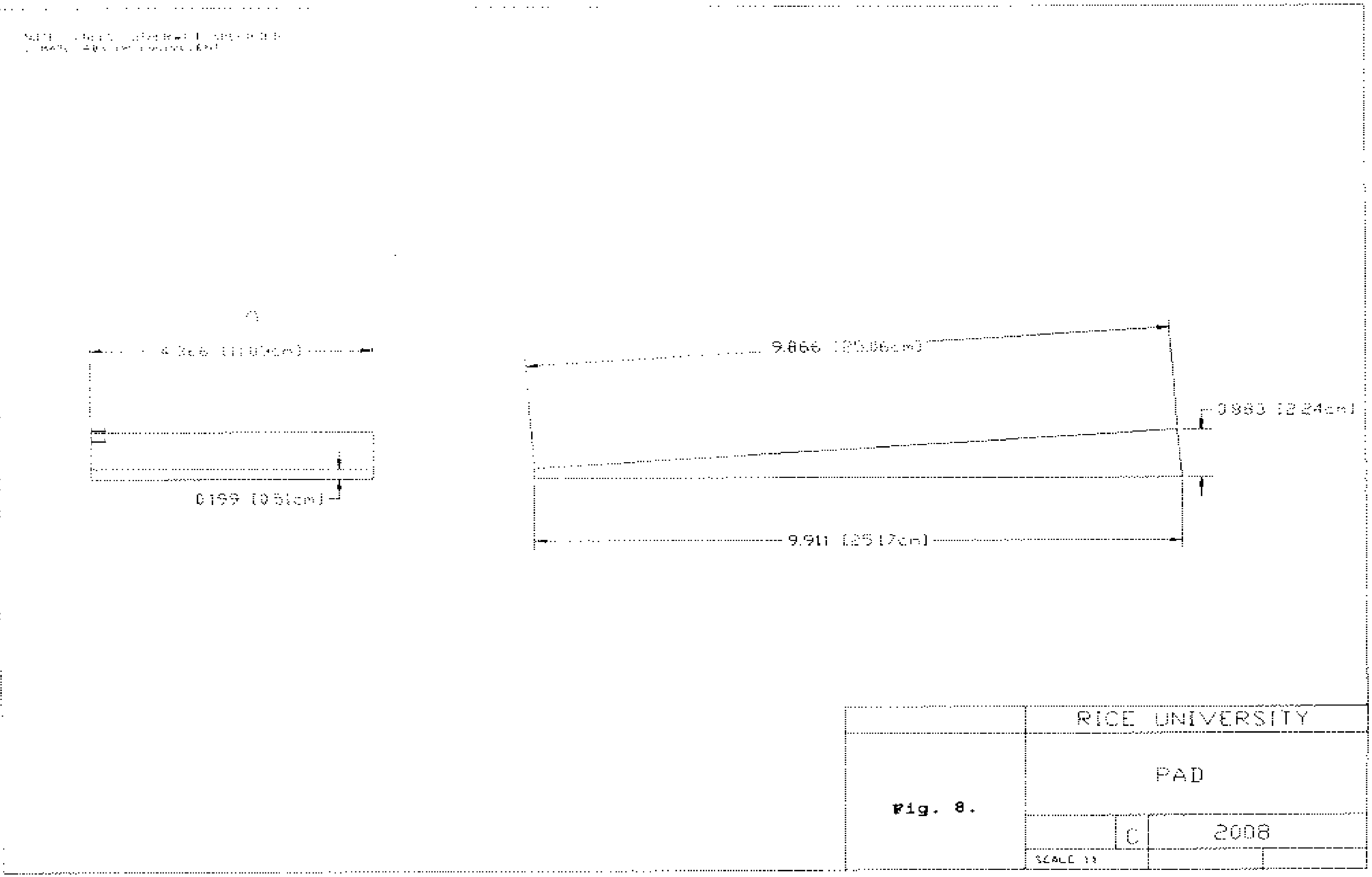


Fig. 8.

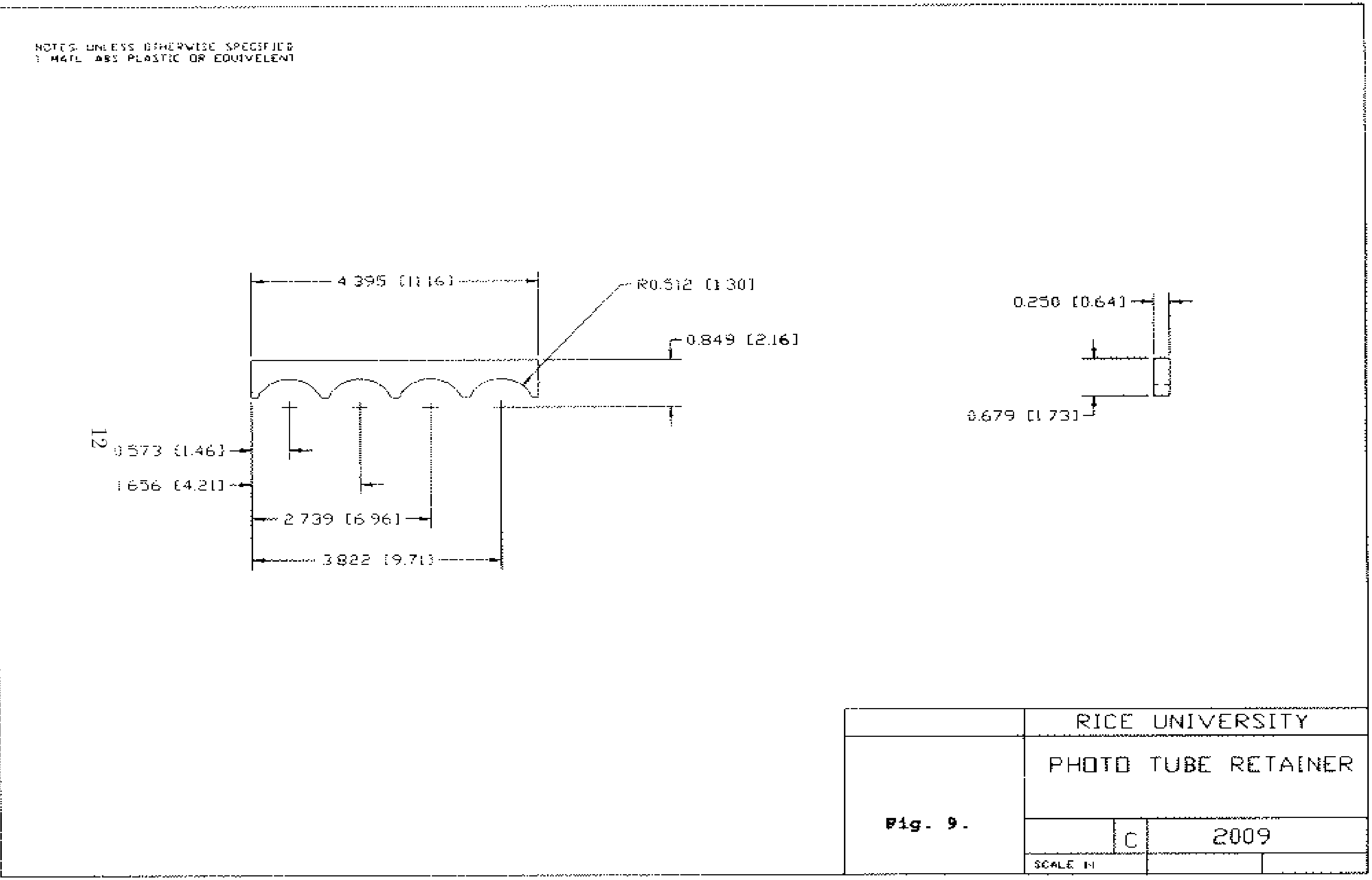

NOTES: UNLESS OTHERWISE SPECIFIED
1 MAT'L ABS PLASTIC OR EQUIVELENT
4.395 [11.16]
R0.512 [1.30]
0.849 [2.16]
0.573 [1.46]
1.656 [4.21]
2.739 [6.96]
3.822 [9.71]
0.250 [0.64]
0.679 [1.73]
RICE UNIVERSITY
PHOTO TUBE RETAINER
C
2009
SCALE

Fig. 9.

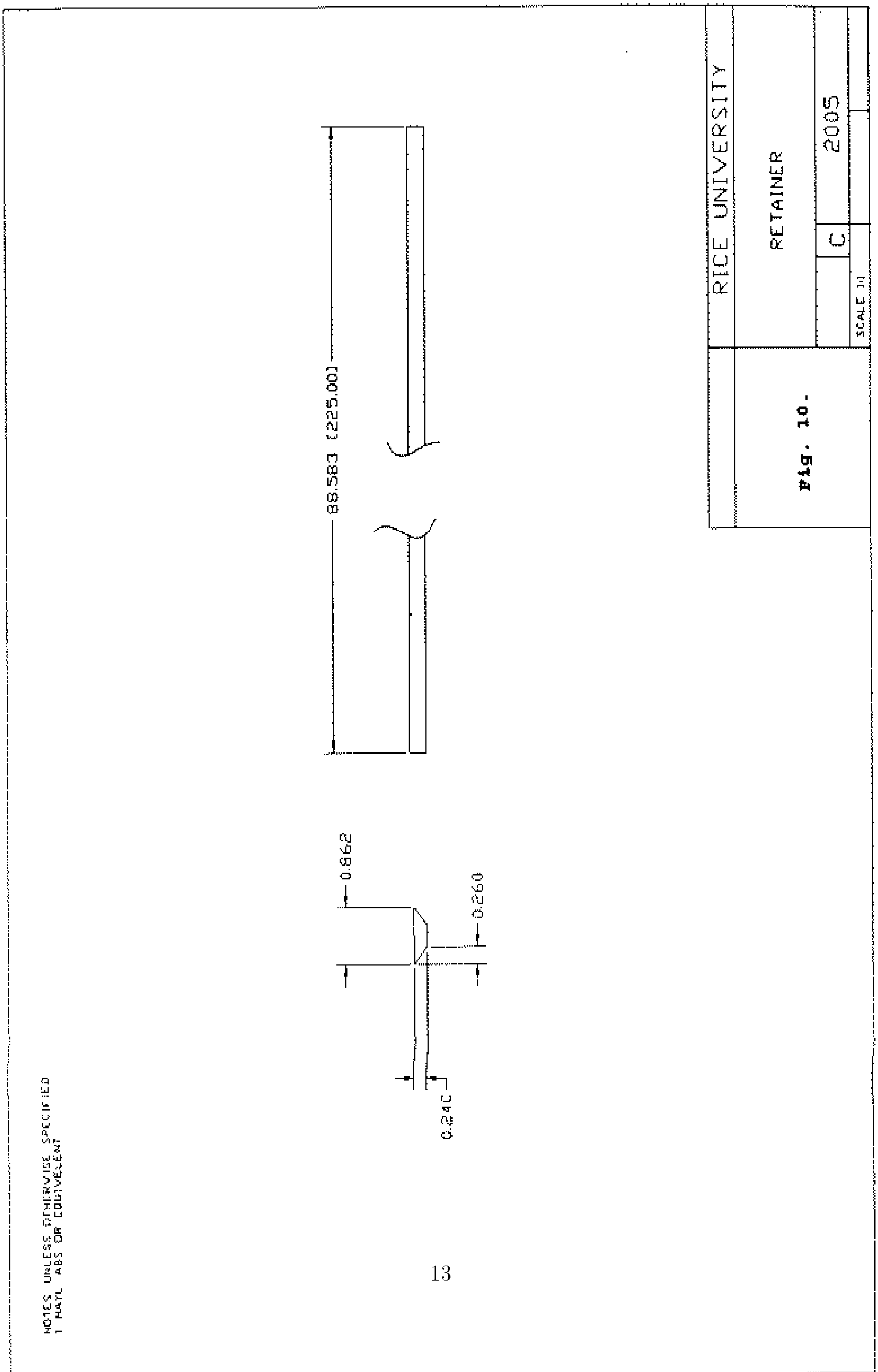

RICE UNIVERSITY
RETAINER
C
2005
SCALE
88.583 [225.00]
0.862
0.260
0.240
NOTES UNLESS OTHERWISE SPECIFIED
1 MATL ABS OR EQUIVALENT

Fig. 10.