DR. 938

DOE/JPL/955217-2

DEVELOPMENT OF HIGH EFFICIENCY (14%) SOLAR CELL ARRAY MODULE

Second Quarterly Report, March 15—July 15, 1979

By
P. A. Iles
S. Khemthong
S. Olah
W. J. Sampson
K. S. Ling

MASTER

Work Performed Under Contract No. NAS-7-100-955217

Optical Coating Laboratory, Inc.
Photoelectronics Division
City of Industry, California

U.S. Department of Energy

Solar Energy

DISCLAIMER

DISCLAIMER

Available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161.

Price: Paper Copy $6.00
Microfiche $3.50

DRL No. 82/DRD No. MA-3

Line Item No. 8

DOE/JPL/955217-2
Distribution Category UC-63b

DEVELOPMENT OF HIGH EFFICIENCY (14%) SOLAR CELL ARRAY MODULE

SECOND QUARTERLY REPORT

FOR PERIOD COVERING

15 March 1979 to 15 July 1979

By

P.A. ILES, S. KHEMTHONG, S. OLAH,
W.J. SAMPSON, AND K.S. LING

JPL CONTRACT NO. 955217

OPTICAL COATING LABORATORY, INC.
PHOTOELECTRONICS DIVISION
15251 EAST DON JULIAN ROAD
CITY OF INDUSTRY, CA 91746

"The JPL Low-Cost Silicon Solar Array Project is sponsored by the U. S. Department of Energy and forms part of the Solar Photovoltaic Conversion Program to initiate a major effect toward the development of low-cost solar arrays. This work was performed for the Jet Propulsion Laboratory, California Institute of Technology by agreement between NASA and DOE."

ABSTRACT

Considerable amount was expended in the development of large area, high efficiency P/N solar cells. The best performance achieved to-date on 3" diameter cells is 15.6% at AM1 and 28°C. Factors contributing toward the poor performance have not been identified and isolated. Work is continuing.

Minor modifications have been incorporated in the modular design. The 120 cells will be connected 8 in parallel and 15 in series to enhance the reliability of the modules. As a result of the changes, two junction boxes will be required as the P and N terminals will come out from the opposite sides of the module.

Designs for back contact soldering machine, vacuum pick-up, AR coating tooling, and test fixture have been completed. Fabrication of tooling has begun.

TABLE OF CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

The initial phase of this program is to design and develop 3" diameter, P/N solar cells with the conversion efficiency of 16.5% or better at AM1 and 28°C. Upon completion of the cell development phase, OCLI is to design, fabricate, and deliver six (6) high efficiency modules, approximately 2' x 4', with a minimum output of 90 watts at AM1 and 28°C and with the design goal of 14% overall efficiency.

The second phase of this program is to design and fabricate production tooling for the manufacture of the high efficiency cells and modules. Twenty (20) verification modules are to be fabricated and delivered to JPL.

2.0 TECHNICAL DISCUSSION

Considerable amount of effort has been devoted to the development of high efficiency P/N solar cells. To-date the main causes contributing toward lower power output than that of N/P cells has not yet been identified or isolated. Work is continuing. Minor modifications have been made to the module design. Design of the tooling to be used specifically for this module and the center contact solar cells has been completed.

2.1 Comments on P/N Cell Development

In the previous quarterly report, some promising cells were reported, some with the required efficiency (>16% AM1). However, most of the high output cells were 4 cm^2 area, whereas simultaneous trials applying the same process steps to 3" diameter wafers (45 cm^2 area) did not

give the same efficiency. The repeat series of tests wherein the "best procedure" was repeated using both Czochralski and float-zoned silicon gave similar results, with reduced performance from 45 cm^2 cells.

A small part of this different behavior for larger sizes could be ascribed to the theoretically lower CFF (0.75) for the grid pattern used, compared to a CFF 0.77 for the smaller area cells. This difference arises in resistive losses in the grid patterns. However, this CFF decrease could not explain the major losses in power for the larger P/N cells.

Because the process steps appeared satisfactory as shown by the reasonable yield of good 4 cm^2 cells, the problem was re-examined to see if adverse interactions in the process steps could be responsible, or perhaps differences in a given process when larger slices were used. (Previous work on high efficiency P/N cells had generally been reported for cells <4 cm^2 area.)

Figure 1 repeats the process sequence given in the previous report.

In this sequence several steps can be identified as sensitive to the slice size.

The quality of the diffusion mask used in Steps 3 or 5 could vary, with adverse effects. For eaxmple if diffusants leak through the mask in small areas, some loss in CFF or V_{OC} could result. For the large area slices the masking process could be less effective (and in addition, the probability of failure is increased). Below a test of this hypothesis is described.

FLOW CHART

HIGH EFFICIENCY P+ N N+ CELLS

1. Grow Ingot, N-Type, 7-14 ohm-cm.
2. Prepare Wafers.
3. Apply Diffusion Mask to Front.
4. Diffuse N+ on Back to Form Back Surface Field.
5. Apply Diffusion Mask to Back.
6. Diffuse P+ to Form Junction.
7. Evaporate Back Contact (Al, Ti-Pd-Ag).
8. Apply Front Contact Mask (Photoresist).
9. Evaporate Front Contact (Ti-Pd-Ag).
10. Evaporate AR Coating.
11. Sinter.
12. Electrical Test.

FIGURE 1

Step 6, the boron diffusion used to form the shallow P+ layer involves as a source, boron nitride disks held close to the silicon in a quartz boat. This boat has retaining slots, and these can lead to small areas around the large slice perimeter which are less likely to receive full boron supply. These areas are removed when 4 cm^2 cells are made, but are still present on the 45 cm^2 cells. The cutting experiment described below is intended to show if these edge areas are a problem.

In addition, analysis of the cell losses (in I_{SC}, V_{OC} or CFF) has led to closer scrutiny of some of the processes used.

Some cells show good values of I_{SC}, V_{OC} but the CFF is reduced. No shunting is present, but the series resistance is high. The P+ layer is shallow (sheet resistance >150 ohm/square) but this high sheet resistance does not appear to be the main cause of reduced CFF. There are two possibilities.

(a) Step 7 applies a thin layer of aluminum to the N+ back surface. Al is used because it is a convenient way to obtain a reflecting back contact, and tests have shown that use of the Al can give 2-3% increase in I_{SC}, obtained from the additional pass of unabsorbed long wavelength photons.

This aluminum-silicon contact is not heated above 400°C, and therefore should not tend to form a Schottky rectifying barrier on the highly doped N+ layer. Nevertheless, in some cases if the N+ diffusion was not effective over the whole back surface, or if some boron has penetrated the diffusion mask over the N+ layer, the Al-N+ Si interface could add series resistance (or even decrease V_{OC} slightly).

(b) Some tests have shown that even after careful cleaning, there is a thin transparent layer on the surface of the P+ silicon after boron diffusion. This layer can reduce the AR coating gain and in addition could add series resistance to the cell.

Both (a) and (b) are affected by the sinter steps used; it is clear, however, that high sinter temperatures are not desirable, because they increase the chance of a resistive contact at the back surface or on the other face, could lead to partial penetration of the P+ layer, with increased shunting.

2.1.1 Back-Up Tests

Tests in progress to identify the problems mentioned above are described.

(a) Use of Better Diffusion Masks

Tests wherein a thicker, denser diffusion mask was used to protect the front of the N-silicon during formation of the N+ BSF layer were promising. The shunting effects decreasing CFF were removed, and V_{OC} was adequate. There was still some residual excess series resistance, and tests are in progress to see if this is caused by the thin boron-layer not being completely removed. There was some los of I_{SC}, (reduced diffusion length from heating) but this could be corrected by somewhat reduced temperature in the masking process, and by controlled cooling after the mask is applied.

(b) Cutting Trial

This trial was designed to test the hypothesis that incomplete boron diffusion (or other effects) were occurring at the edge of large

slices. Several 45 cm^2 cells with known poor I-V curves were selected and measured, as selective reduction in cell area was achieved by carefully sawing off edge regions. The resultant cell size approached 4 cm^2. The results of this test can be seen in Table 1. At least 1/4" was removed all around the edges after the second cuts were made. Even the polished cells showed improved CFF, for only one cell (B), and the resultant CFF was still inadequate. No increase in V_{OC} was observed after cutting. It appears that the shunting is not located on the periphery of the cell.

This last test included some P/N cells made with textured front surface, (as discussed in previous monthly reports) used to obtain 2-3% increase in I_{SC}. It has been shown that often textured surfaces have slightly reduced V_{OC} (predictable from the 75% larger surface area) and reduced CFF from shunting effects, so that the textured cells should be less likely to recover after cutting down in size.

2.1.2 Conclusions

The individual process steps, and their combination (and therefore any interactions) can yield satisfactory P/N cells 4 cm^2 in area, but are less successful for 45 cm^2 cells. Tests were described, aimed at reducing this area dependence. Repeat tests with intentional variations in diffusion masks are in progress, using most of the processes found successful for 4 cm^2 cells.

In addition alternate boron diffusion sources are being re-evaluated, and alternate reflecting back contacts are being tested.

TABLE 1

I-V Parameters After Two Successful Cuts
(To Remove Edge Areas)

CELL	SURFACE	START		FIRST CUT		SECOND CUT	
		V_{OC}	CFF	V_{OC}	CFF	V_{OC}	CFF
A	Textured	0.5	0.55	0.485	0.6	0.49	0.62
B	Polished	0.51	0.61	0.5	0.67	0.505	0.67
C	Textured	0.51	0.59	0.5	0.625	0.5	0.55
D	Textured	0.49	0.575	0.48	0.58	0.48	0.565
E	Polished	0.49	0.555	0.475	0.575	0.48	0.555
F	Polished	0.5	0.645	0.49	0.66	0.49	0.65

2.2 Module Design

The module design remains essentially the same as described in the first quarterly report with minor changes after the Design Review Meeting. The detailed design is shown in Figure 1 and Figure 2 (OCLI Drawing Nos. D-202400, and D-202373, Revision B). The changes from the original design will be described in the following paragraphs.

2.2.1 Cell Interconnection

To enhance the reliability of the module, the 120 3" cells will be connected 8 in parallel and 15 in series to alleviate the hot spot problem in the event of a cell being shadowed or damaged. The cells will be cross-strapped every fifth row as shown in Figure 3 (OCLI Drawing No. D-202374, Revision B).

2.2.2 Junction Box

With the modification of cell interconnection, the positve and the negative terminals will be located at opposite ends of the module. Two junction boxes will be required as shown in Figure 1.

2.2.3 White Reflecting Surface

The original plan of applying white paint on Mylar to enhance electrical output was abandoned because no suitable white paint or adhesive could be found that would adhere to the Mylar sheet and maintain its white color after temperature cycling. Sample 36-cell modules have been fabricated using a sheet of 2 mil thick white Tedlar to replace the combination of Mylar and white paint. Mechanically, this approach eliminates one operation. Electrically, the gain after encapsulation remains the same.

2.3 Production Tooling

The design of the following tooling has been completed and modifications have been made after the Design Review. In addition to the drawings shown in this report, detailed drawings for components and subassemblies are available (see Appendix A). Fabrication of tooling has begun.

2.3.1 Back Contact Soldering Machine

The soldering machine as shown in Figure 4 (OCLI Drawing No. D-202458, Sheets 1-3) is semi-automatic. This consists of a phenolic template with 120 3" cavities which accommodate cells with mesh interconnect already soldered to the front contact. A Unitek resistance heating soldering machine mounted on two (2) 1 inch diameter metal rods is used. Indentations at 3.05" apart (3" diameter cell plus .050" spacing between cells) are provided on the rod. The soldering machine is manually moved from cell to cell, a step-repeat process. The fluxing and soldering will be done automatically, with the exception that fluxing during the soldering of the parallel strings will be done manually.

The machine is designed to solder 15 cells in series and 8 cells in parallel. The sequence of solering is as follows:

(a) For Series Connections

Place template against stop on left with "Y" motion in the first hole. Move soldering machine to the right in "X" direction in 3.04" increments until 15 cells are solder-connected in series. Move template to the right against stop which offsets the template by 1.52" and locates

the staggered pattern of the next row. Move "Y" motion to the second hole and proceed with "X" motion to the left. Repeat above procedures until all 120 cells are soldered.

(b) For Parallel Connections

Remove dowel pin from stop on the right hand side and install the pin into the lower hole as appeared in the drawing. Move "X" and "Y" motions to their respective first hole. This will locate the first solder joint for the parallel circuit. A piece of copper mesh cut to the proper length is to be placed on the cells. Proceed to move "Y" motion into the second hole until 8 cells are connected in parallel. Move "X" motion to fifth, tenth, and fifteenth stop and repeat "Y" motion soldering.

2.3.2 Vacuum Pick-Up

To facilitate removal of the 120 cell assembly from the soldering template, a simple vacuum pick-up has been designed as shown in Figure 5 and 6 (OCLI Drawing Nos. D-202475 and D-202473). Two pieces of aluminum honeycomb, spaced 1/16" apart will be edge-sealed. One hundred and twenty (120) soft vacuum cups will be inserted into one side of the honeycomb. Each cup will be positioned over the bare contact of the cell. A vacuum valve will be installed on the opposite side. The in-house central vacuum system will be used to operate the pick-up.

2.3.3 AR Coating Tooling

The evaporator used for applying multi-layer anti-reflective coating has five (5) pie-shaped plates, each holding eleven (11) 3" cells. The

tooling is designed specifically for center contact cells as shown in Figures 7 and 8 (OCLI Drawing Nos. TDD-12333 and TDC-12333-1). Pins inserted into the mounting plate will locate accurately the positions of the cells. An epoxy figerglass template with eleven (11) holes located at the center of each cell will be placed over the mouting plate loaded with eleven (11) cells. Hicorex permanent magnets, 1/4" in diameter, will be dropped inside the holes of the template which will then be removed. The magnets will hold the cells in place against the stainless steel mounting plate.

2.3.4 Test Fixture

The test fixture, as shown in Figure 9 (OCLI Drawing No. TAD-12331), is again designed for testing the center contact cells. Current and voltage probes, electrically isolated, will make contact to the cell. The test fixture has provisions for cooling fluid for temperature control, vacuum hold down, thermocouple, and solenoid to operate the probes. The fixture is capable of testing cells up to 5" in diameter.

3.0 MILESTONE

3.1 The program is behind schedule due to difficulty encountered in developing large area, high efficiency P/N solar cells. A request to change the scope of the contract to allow more time for cell development has been submitted to JPL.

3.1.1 The design of the module has been completed. Modifications as a result of the Design Review Meeting have been incorporated.

3.1.2 Development of high efficiency, P/N cells is continuing. Experiments have been designed to identify the cause of low performance mainly due to low curve fill factors.

3.1.3 Detailed design for the following tooling has been completed. Fabrication has begun.

(a) Back contact soldering machine

(b) Vacuum pick-up

(c) AR coating tooling

(d) Test fixture

3.2 Work Planned for the Next Reporting Period

3.2.1 Continue cell development with increased efforts.

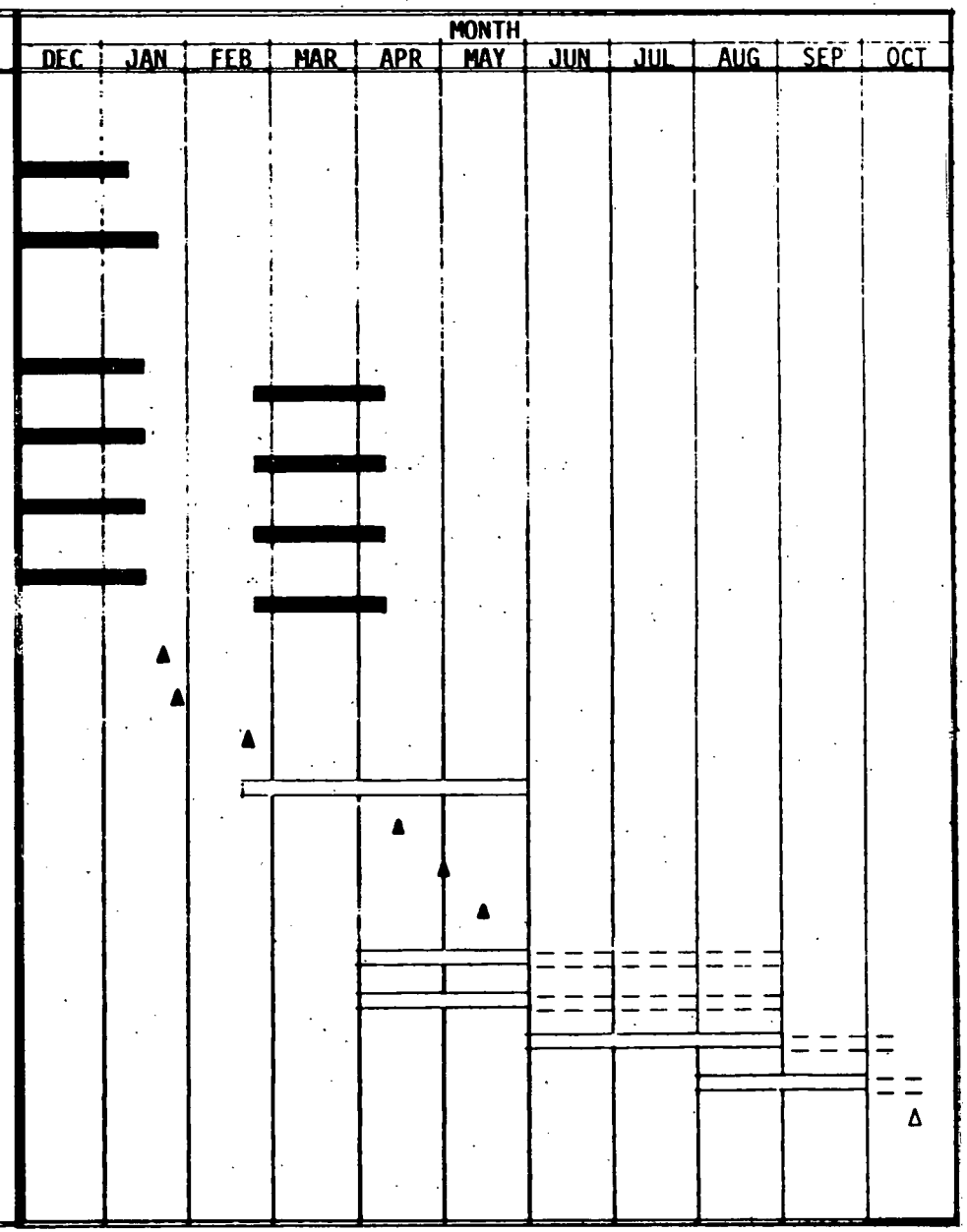
3.2.2 Continue with tooling fabrication.

3.3 A milestone chart is attached.

Revised: 12/22/76

PROGRAM PLAN

TASK
1. DESIGN OF HIGH EFFICIENCY SOLAR CELL
(a) Design of Photomask
Acquisition of Photomask
(b) Design of AR Tooling
Acquisition of AR Tooling
2. DESIGN OF HIGH EFFICIENCY MODULE
(a) Design of Interconnect
Acquisition of Interconnect
(b) Design of N-Contact Soldering Fixture
Acquisition of N-Contact Soldering Fixture
(c) Design of Module Soldering Fixture
Acquisition of Module Soldering Fixture
(d) Design of Module Laydown Tooling
Acquisition of Module Laydown Tooling
3. MODULE DESIGN REVIEW DATA PACKAGE
4. MODULE DESIGN REVIEW
5. RECEIPT OF JPL APPROVAL
6. FABRICATION AND DELIVERY OF SIX (6) MODULES
7. TOOLING DESIGN REVIEW DATA PACKAGE
8. TOOLING DESIGN REVIEW
9. RECEIPT OF JPL APPROVAL
10. FABRICATION OF PRODUCTION TOOLING
11. PREPARATION OF PROCESSING PROCEDURES
12. FABRICATION OF SOLAR CELLS
13. FABRICATION OF TWENTY (20) MODULES
14. PRODUCTION TOOLI ; AND MFACTURING AIDS



PROGRAM PLAN

TASK	MONTH										
	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
15. COST DATA FOR 5, 25, 50 kW										△	
16. COST DATA PER SAMICS											△
17. BASELINE COST ESTIMATE	▲										
18. PROGRAM PLAN	▲										
19. MONTHLY FINANCIAL REPORT	▲		▲	▲	▲	▲	▲	△	△	△	△
20. MONTHLY STATUS REPORT	▲		▲		▲	▲		△	△		
21. QUARTERLY REPORT				▲			▲			△	
22. INTERIM TECHNICAL REPORT	2 WEEKS AFTER RECEIPT OF R&D TESTING DATA FROM JPL										
23. FINAL TECHNICAL REPORT											
(a) Draft	2 WEEKS AFTER RECEIPT OF TESTING DATA FROM JPL										
(b) Final	30 DAYS AFTER RECEIPT OF JPL WRITTEN COMMENTS OF THE DRAFT FINAL REPORT										
24. PARTICIPATION IN TECHNICAL REVIEW ACTIVITIES											
(a) Program Review Meetings	AS REQUIRED										
(b) Program Design Review Meetings	AS REQUIRED										
(c) Project Integration Meetings	AS REQUIRED				▲						
(d) Workshops	AS REQUIRED										

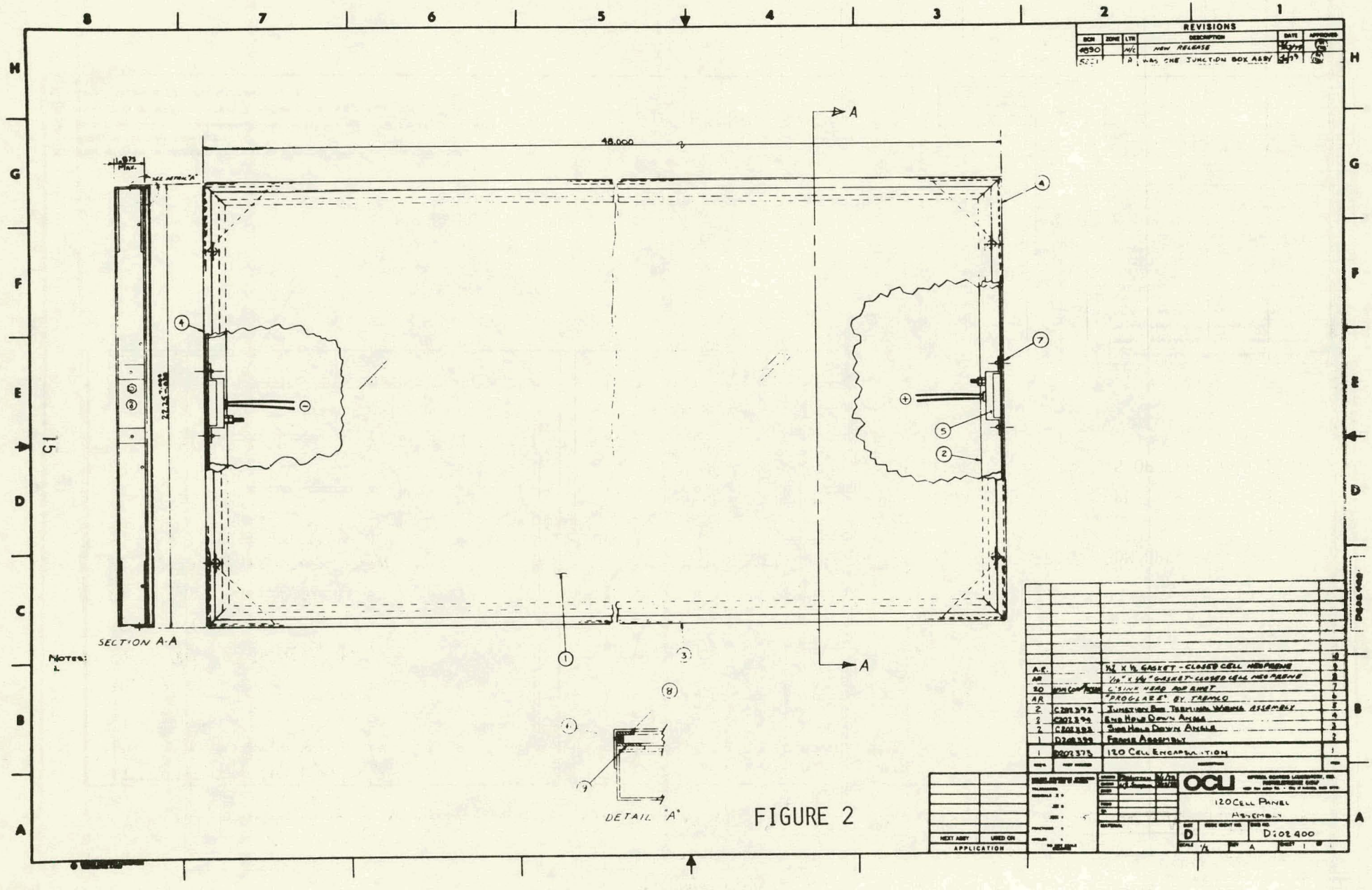
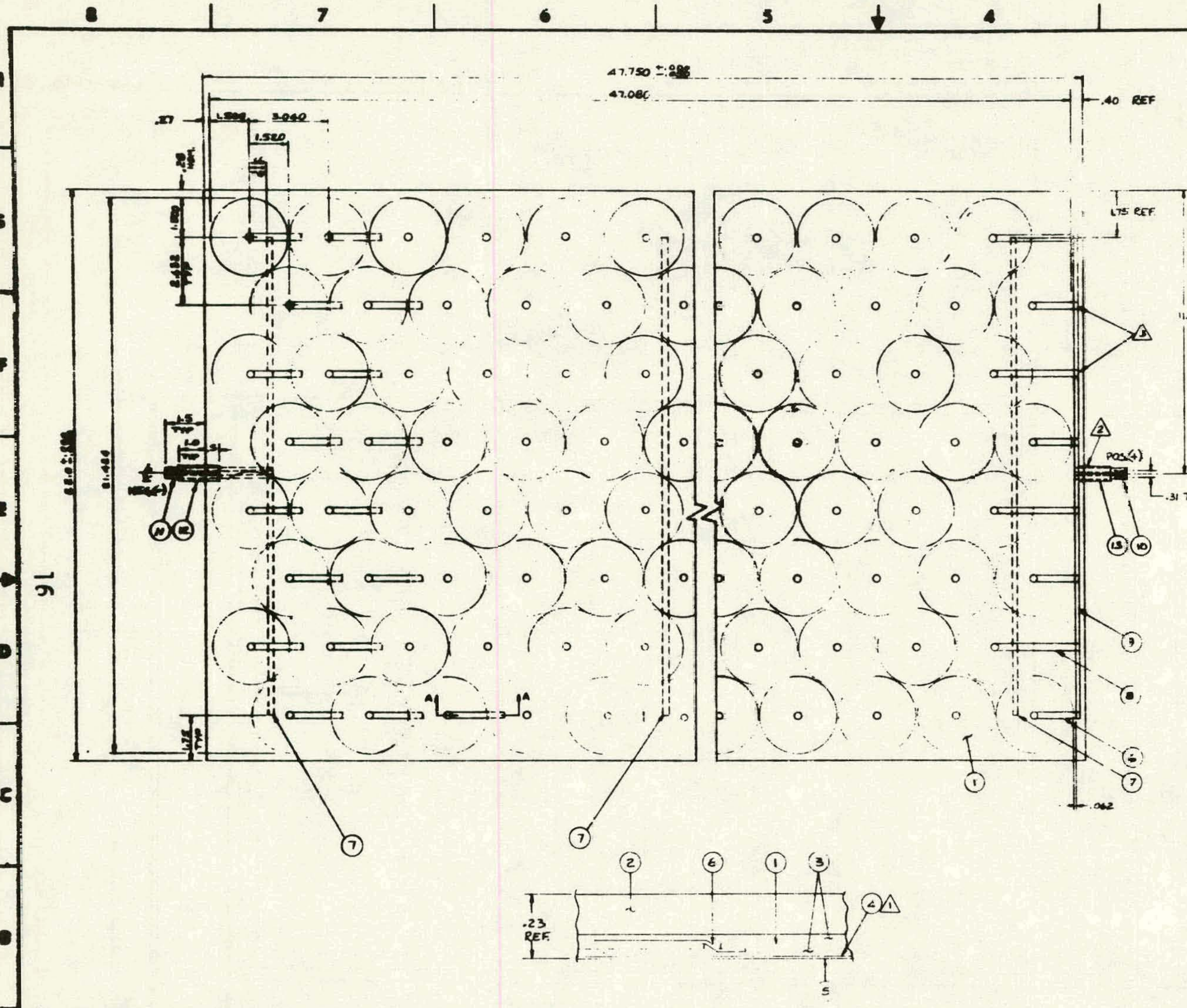

REVISIONS
DCN
ZONE
LTR
DESCRIPTION
DATE
APPROVED
4890
N/C
NEW RELEASE
A
WAS ONE JUNCTION BOX ASSY
48.000
SECTION A-A
DETAIL "A"
NOTES:
1.
A.R.
¼" X ½" GASKET - CLOSED CELL NEOPRENE
AR
1/16" X ½" GASKET - CLOSED CELL NEOPRENE
20
6-SINK HEAD POP RIVET
AR
"PROGLARE" BY TRAMCO
2
C201372
JUNCTION BOX TERMINAL WIRING ASSEMBLY
2
C201394
END HOLD DOWN ANGLE
2
C201393
SIDE HOLD DOWN ANGLE
1
D201373
FRAME ASSEMBLY
1
D201375
120 CELL ENCAPSULATION
OCLI
120 CELL PANEL
ASSEMBLY
D
D102400
NEXT ASSY
USED ON
APPLICATION

FIGURE 2



QTY REQ'D	PART NUMBER	DESCRIPTION	ITEM
2		TEFLON INSULATING TUBING, .008 WALL X 5/32 DIA X 1 1/4	13
2		TEFLON INSULATING TUBING .008 WALL X 5/32 DIA X 1 1/2	12
2		INTERCONNECT, COPPER RIBBON, .009 X .090 X 4	11
2		INTERCONNECT, COPPER RIBBON, .009 X .09 X 1 3/4	10
1		INTERCONNECT, COPPER RIBBON, .009 X .09 X 18 1/2	9
4		INTERCONNECT SOLDER PLATED SN60. COPPER MESH 3/4 X 3 1/2 BCUB - 5/0	8
4		INTERCONNECT SOLDER PLATED SN60. COPPER MESH 3/4 X 18 1/2 BCUB 5/0	7
116		INTERCONNECT, SOLDER PLATED SN60. COPPER MESH 3/4 X 2 BCUB - 5/0	6
1		MYLAR, WHITE .005 X 22 X 47 3/4	5
A.R.		PRIMER ADHESION PROMOTER GE # 4120	4
2		PVB, SR-11, .015 X 22 X 47 3/4 (MONSANTO)	3
1		3/16 X 22 X 47 1/4 SUNADEX GLASS, ANNEALED & SEAMED (ASG)	2
120	A202337	3" DIA SOLAR CELL	1

REVISIONS

ECN	ZONE	LTR	DESCRIPTION	DATE	APPR
5803		A	REVISED & REDRAWN	3-9-77	
5432		B	REVISED & REDRAWN	7-24-79	

NOTES:

1. ITEM NO 7 TO BE SOLDERED AT EVERY CELL ACROSS WITH A (4) FOUR ROW SKIP BETWEEN EACH INTERCONNECT.
2. AFTER MAKING SOLDER CONNECTIONS OF ITEMS 6 & 8 TO ITEM 9, TRIM 6 & 8 FLUSH.
3. PUSH ITEM 13 AGAINST ITEM 9 DURING SHRINKING OPERATION.
4. APPLY PRIMER TO THIS SIDE OF MYLAR.

OCLI OPTICAL COATING LABORATORY, INC. PHOTOELECTRONICS GROUP

120 CELL ENCAPSULATION

SIZE D | DWG NO D202373 | SCALE 1/2 | REV B | SHEET 1 OF 1

FIGURE 3

REVISIONS					
DCN	ZONE	LTR	DESCRIPTION	DATE	APPROVED
4802		N/C	NEW RELEASE	2-9-79	
5217		A	OUTPUTS WERE AT ONE END	5/1/79	
5433		B	REVISED & REDRAWN	7/24/79	

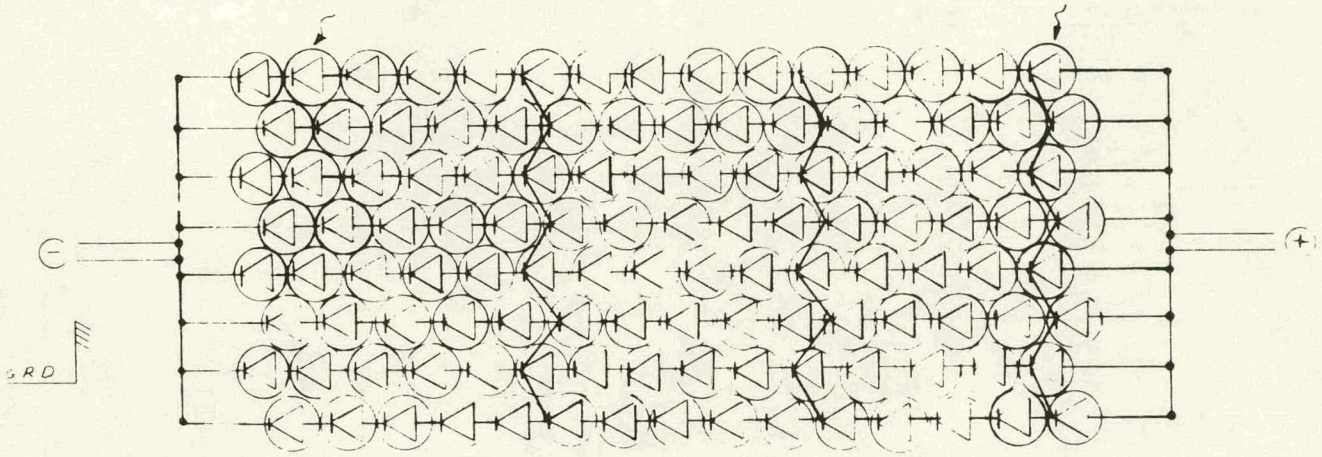


FIGURE 4

		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	DRAWN	TTALP	7-2-79	OPTICAL COATING LABORATORY, INC. PHOTOELECTRONICS GROUP 15251 Don Julian Rd. • City of Industry, Calif. 91746
		TOLERANCES	CHECK			
		DECIMALS X ±	ENGR			WIRING DIAGRAM
		XX ±				100 CELL PANEL
		XXX ±	PROD			
		FRACTIONS ±	QA			
		ANGLES ±	MATERIAL			SIZE B · CODE IDENT NO. · DWG NO. B20237A
NEXT ASSY	USED ON	DO NOT SCALE DRAWING				SCALE NONE · REV B · SHEET 1 OF 1
APPLICATION						

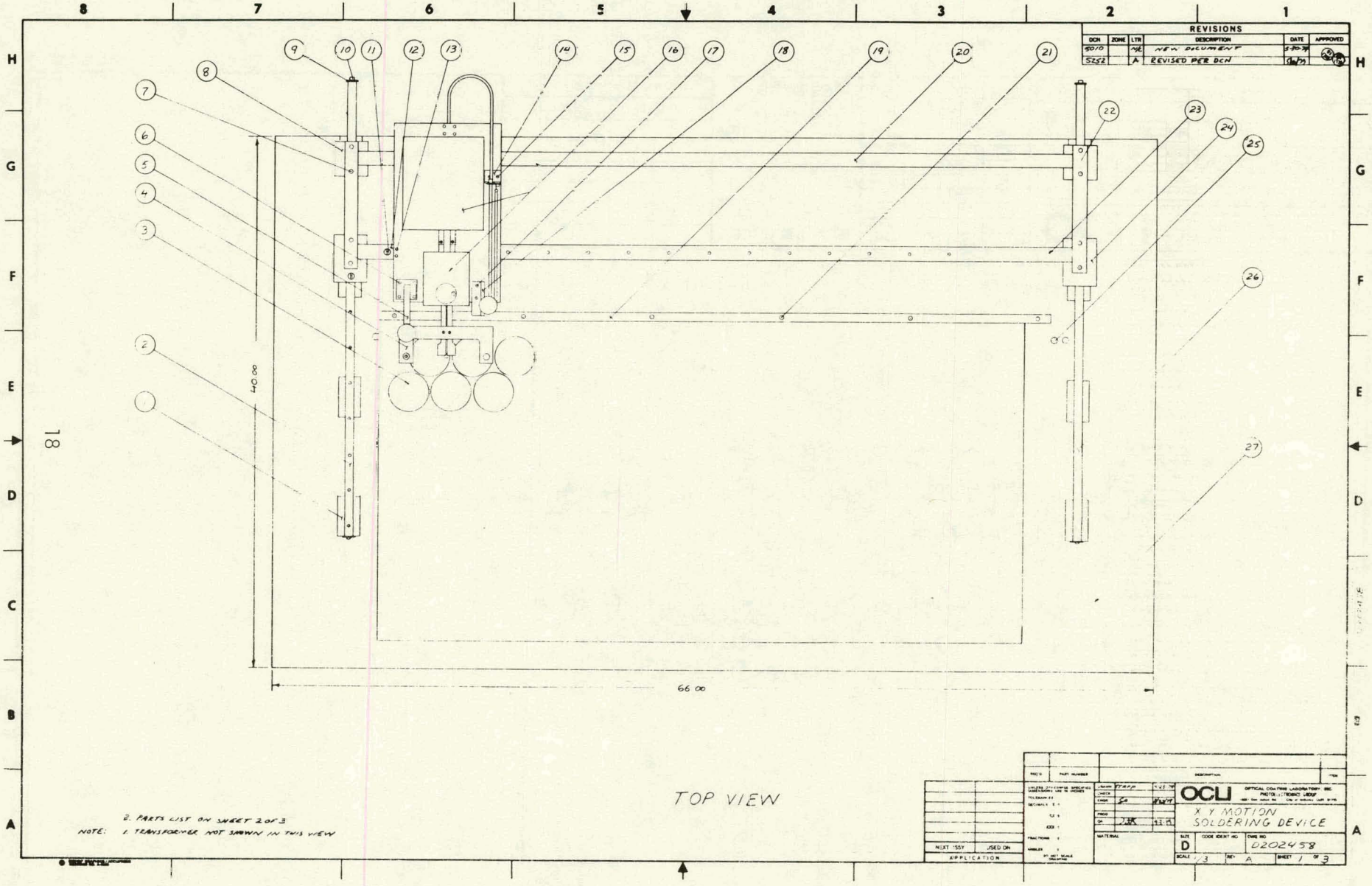

REVISIONS
DCN ZONE LTR DESCRIPTION DATE APPROVED
9010 NEW DOCUMENT 4-30-79
5252 A REVISED PER DCN 6-6-79
40.00
66.00
TOP VIEW
NOTE: 1. TRANSFORMER NOT SHOWN IN THIS VIEW
2. PARTS LIST ON SHEET 2 OF 3
OCLI
X Y MOTION SOLDERING DEVICE
D202458
SCALE 1/3
SHEET 1 OF 3

FIGURE 5-1

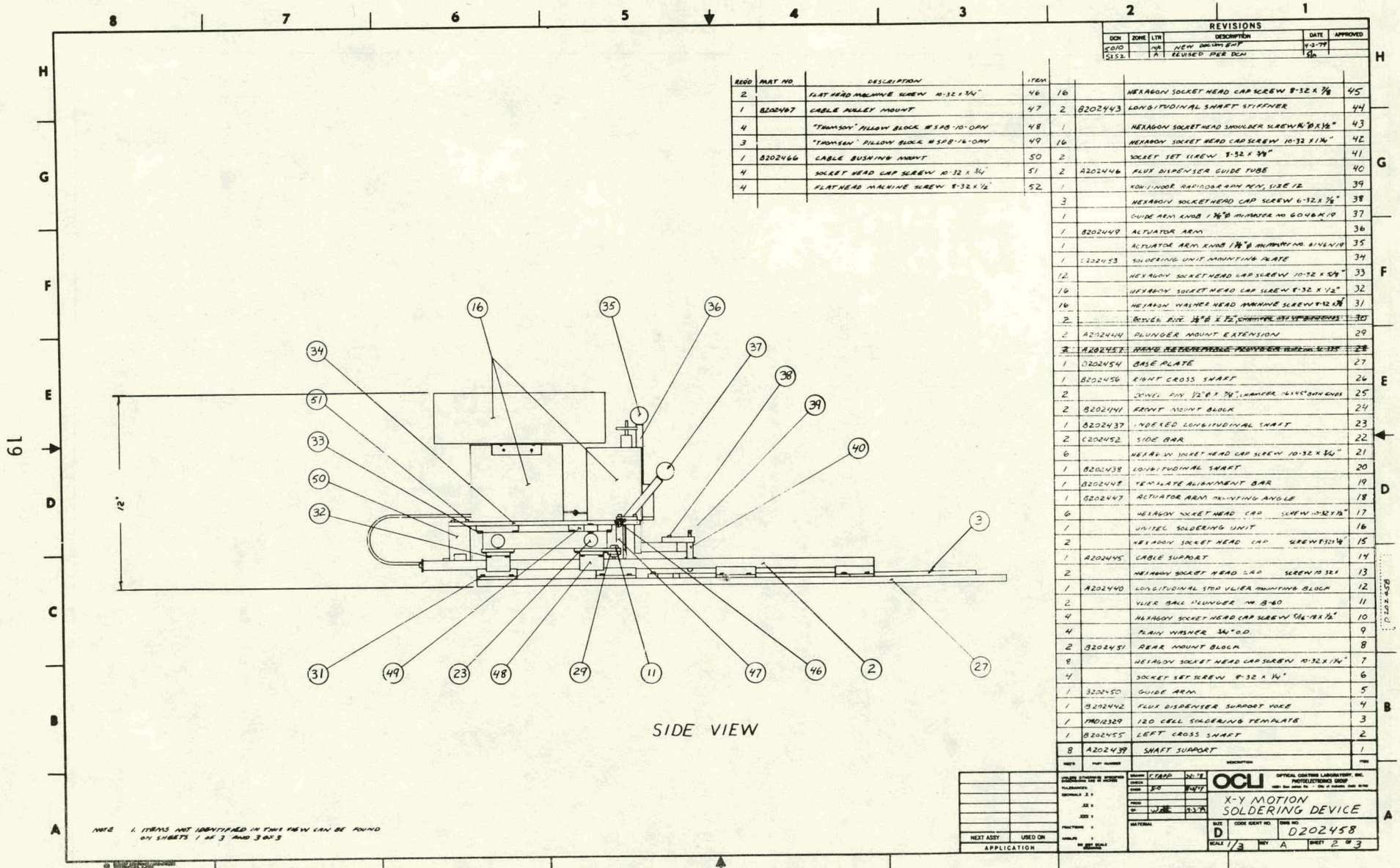

REVISIONS
DCN ZONE LTR DESCRIPTION DATE APPROVED
5010 n/a A NEW DRAWING RELEASED 4-3-79
5152 REVISED PER DCN 5/a
REQD MAT NO. DESCRIPTION ITEM
2 FLAT HEAD MACHINE SCREW 10-32 x 3/4" 46
1 8202467 CABLE PULLEY MOUNT 47
4 "THOMSON" PILLOW BLOCK #SBB-10-OPN 48
3 "THOMSON" PILLOW BLOCK #SPB-16-OPN 49
1 8202466 CABLE BUSHING MOUNT 50
4 SOCKET HEAD CAP SCREW 10-32 x 3/4" 51
4 FLAT HEAD MACHINE SCREW 8-32 x 1/2" 52
16 HEXAGON SOCKET HEAD CAP SCREW 8-32 x 3/8 45
2 8202443 LONGITUDINAL SHAFT STIFFNER 44
1 HEXAGON SOCKET HEAD SHOULDER SCREW 5/8"Ø X 1/2" 43
16 HEXAGON SOCKET HEAD CAP SCREW 10-32 X 1/4" 42
2 SOCKET SET SCREW 8-32 x 3/8" 41
2 A202446 FLUX DISPENSER GUIDE TUBE 40
1 KOH-I-NOOR RAPIDOGRAPH PEN, SIZE 12 39
3 HEXAGON SOCKET HEAD CAP SCREW 6-32 X 3/8" 38
1 GUIDE ARM KNOB 1 3/8"Ø MCMASTER NO. 6046K19 37
1 8202449 ACTUATOR ARM 36
1 ACTUATOR ARM KNOB 1 3/8"Ø MCMASTER NO. 6046K19 35
1 C202453 SOLDERING UNIT MOUNTING PLATE 34
12 HEXAGON SOCKET HEAD CAP SCREW 10-32 x 5/8" 33
16 HEXAGON SOCKET HEAD CAP SCREW 8-32 X 1/2" 32
16 HEXAGON WASHER HEAD MACHINE SCREW 8-32 X 3/8" 31
2 DOWEL PIN 3/8"Ø X 1 1/2" CHAMFER .03 X 45° BOTH ENDS 30
2 A202444 PLUNGER MOUNT EXTENSION 29
1 A202457 HEAD ASSEMBLY, PLUNGER 28
1 D202454 BASE PLATE 27
1 8202456 RIGHT CROSS SHAFT 26
2 DOWEL PIN 1/2"Ø X 3/4" CHAMFER .03 X 45° BOTH ENDS 25
2 8202441 FRONT MOUNT BLOCK 24
1 8202437 KEYED LONGITUDINAL SHAFT 23
2 C202452 SIDE BAR 22
6 HEXAGON SOCKET HEAD CAP SCREW 10-32 X 3/4" 21
1 8202438 LONGITUDINAL SHAFT 20
1 8202448 TEMPLATE ALIGNMENT BAR 19
1 8202447 ACTUATOR ARM MOUNTING ANGLE 18
6 HEXAGON SOCKET HEAD CAP SCREW 10-32 X 1/2" 17
1 UNITEC SOLDERING UNIT 16
2 HEXAGON SOCKET HEAD CAP SCREW 8-32 X 1/4" 15
1 A202445 CABLE SUPPORT 14
2 HEXAGON SOCKET HEAD CAP SCREW 10-32 X 3/8" 13
1 A202440 LONGITUDINAL STOP VLIER MOUNTING BLOCK 12
2 VLIER BALL PLUNGER NO. B-60 11
4 HEXAGON SOCKET HEAD CAP SCREW 5/16-18 X 1/2" 10
4 PLAIN WASHER 3/4" O.D. 9
2 8202451 REAR MOUNT BLOCK 8
8 HEXAGON SOCKET HEAD CAP SCREW 10-32 X 1/4" 7
4 SOCKET SET SCREW 8-32 x 1/4" 6
1 3202450 GUIDE ARM 5
1 8202442 FLUX DISPENSER SUPPORT YOKE 4
1 MD2329 120 CELL SOLDERING TEMPLATE 3
1 8202455 LEFT CROSS SHAFT 2
8 A202439 SHAFT SUPPORT 1
QTY DESCRIPTION ITEM NO. PART NUMBER
SIDE VIEW
12"
16 35 36 34 37 38 51 39 33 40 50 32 3 31 49 23 48 29 11 47 46 2 27
NOTE 1. ITEMS NOT IDENTIFIED IN THIS VIEW CAN BE FOUND ON SHEETS 1 of 3 AND 3 of 3
NEXT ASSY USED ON
APPLICATION
OCLI OPTICAL COATING LABORATORY, INC. PHOTOELECTRONICS GROUP
X-Y MOTION SOLDERING DEVICE
SIZE D CODE IDENT NO. DWG NO. D202458
SCALE 1/3 REV A SHEET 2 OF 3
D202458

FIGURE 5-2

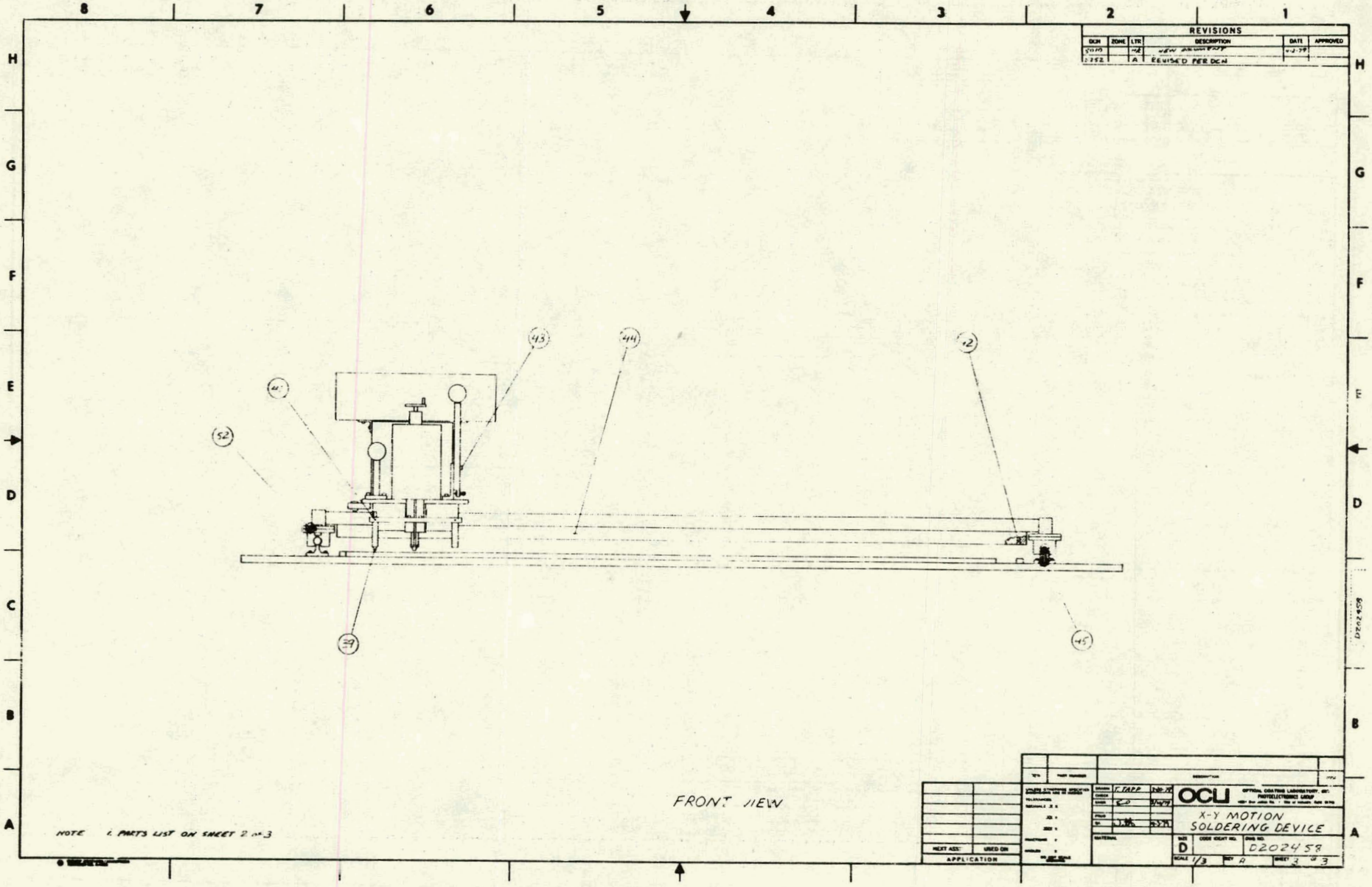
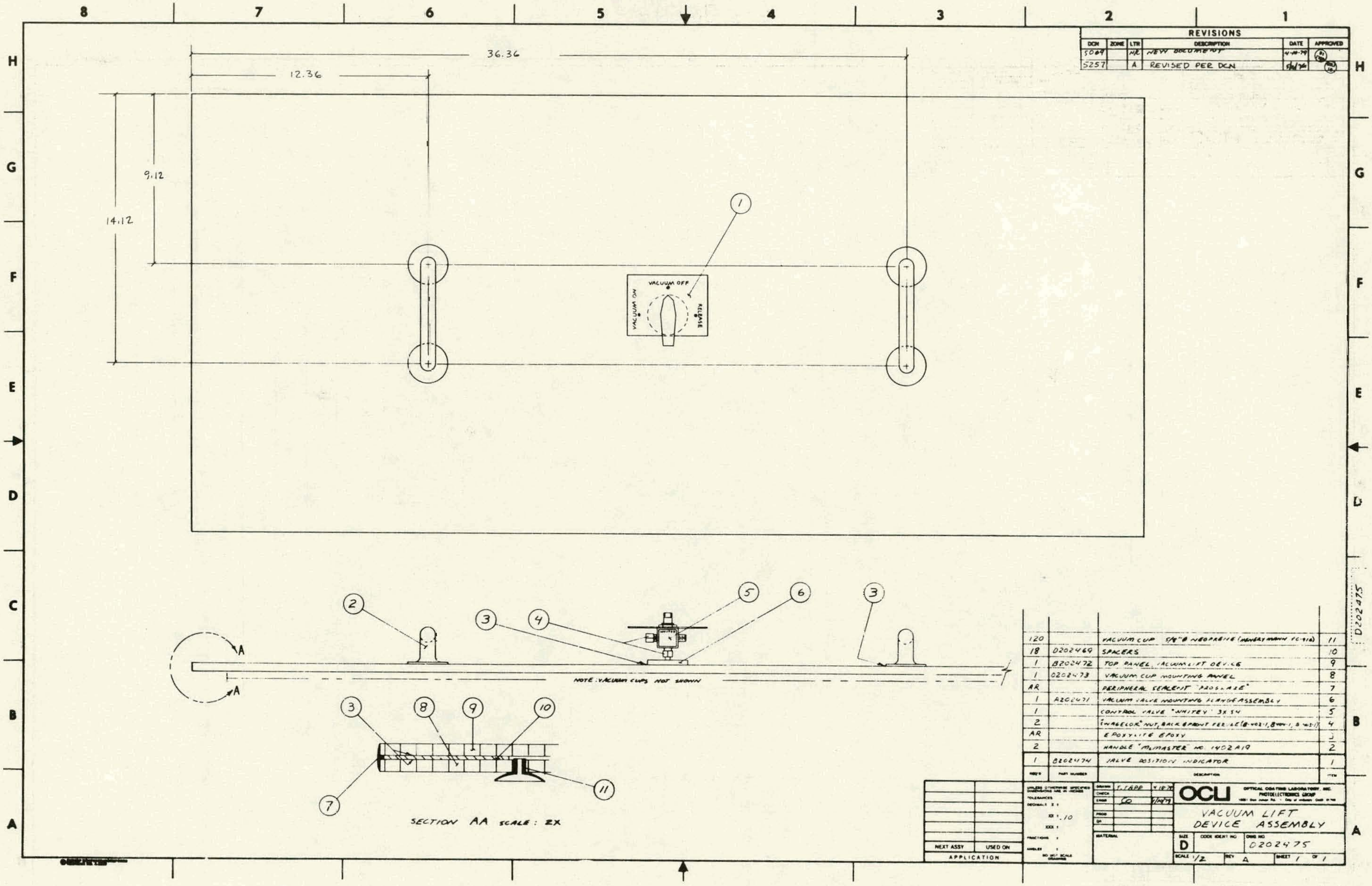

REVISIONS
DESCRIPTION
DATE
APPROVED
REVISED PER ECN
FRONT VIEW
NOTE 1. PARTS LIST ON SHEET 2 OF 3
X-Y MOTION
SOLDERING DEVICE
D202458

FIGURE 5-3



REVISIONS
DCN ZONE LTR DESCRIPTION DATE APPROVED
5069 NR NEW DOCUMENT 4-10-79
5257 A REVISED PER DCN
36.36
12.36
9.12
14.12
VACUUM OFF
VACUUM ON
RELEASE
NOTE: VACUUM CUPS NOT SHOWN
SECTION AA SCALE: 2X
120 VACUUM CUP 5/8" Ø NEOPRENE (HENDRYMANN FC-910) 11
18 D202469 SPACERS 10
1 B202472 TOP PANEL, VACUUM LIFT DEVICE 9
1 D202473 VACUUM CUP MOUNTING PANEL 8
AR PERIPHERAL SEALANT "PROSEALE" 7
1 A202471 VACUUM VALVE MOUNTING FLANGE ASSEMBLY 6
1 CONTROL VALVE "WHITEY" 3X54 5
2 "SWAGELOK" NUT, BACK & FRONT FERRULE 4
AR EPOXYLITE EPOXY 3
2 HANDLE "McMASTER" NO. 1402A19 2
1 B202474 VALVE POSITION INDICATOR 1
REQ'D PART NUMBER DESCRIPTION ITEM
NEXT ASSY USED ON
APPLICATION
OCLI
OPTICAL COATING LABORATORY, INC.
PHOTOELECTRONICS GROUP
VACUUM LIFT DEVICE ASSEMBLY
D 202475
SCALE 1/2 REV A SHEET 1 OF 1

FIGURE 6

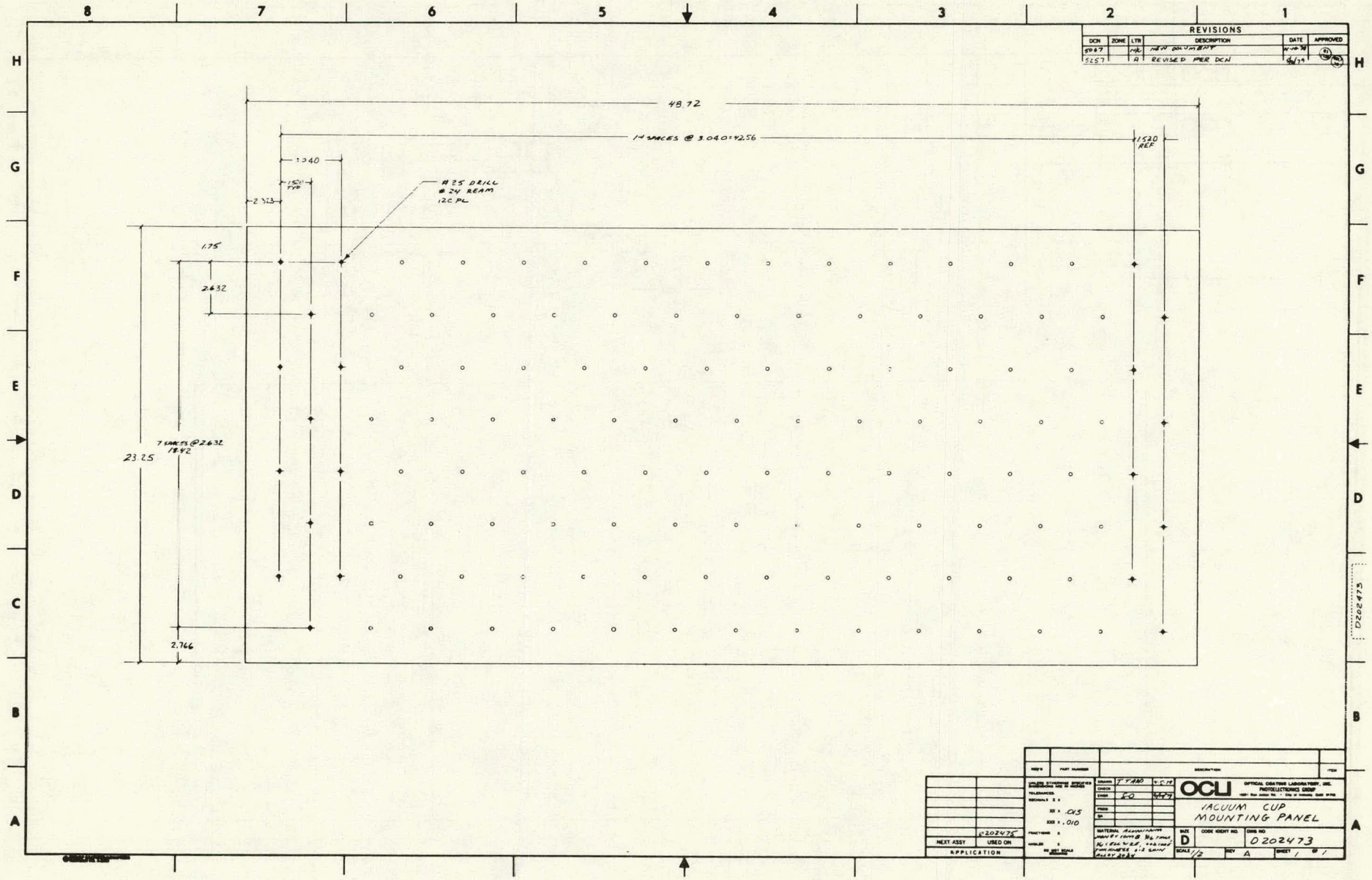

REVISIONS
DCN | ZONE | LTR | DESCRIPTION | DATE | APPROVED
5067 | | NIL | NEW DOCUMENT | 4-10-78
5157 | | A | REVISED PER DCN | 5/79
48.72
14 SPACES @ 3.040 = 42.56
1.520 REF
3.040
1.520 TYP
2.363
#25 DRILL
#24 REAM
12C PL
1.75
2.432
7 SPACES @ 2.632 = 18.42
23.25
2.766
T. TAO
K.Q.
OCLI
OPTICAL COATING LABORATORY, INC.
PHOTOELECTRONICS GROUP
VACUUM CUP
MOUNTING PANEL
0202475
NEXT ASSY
USED ON
APPLICATION
SIZE
D
CODE IDENT NO.
DWG NO
0202473
SCALE 1/2
REV A
SHEET 1 OF 1

FIGURE 7

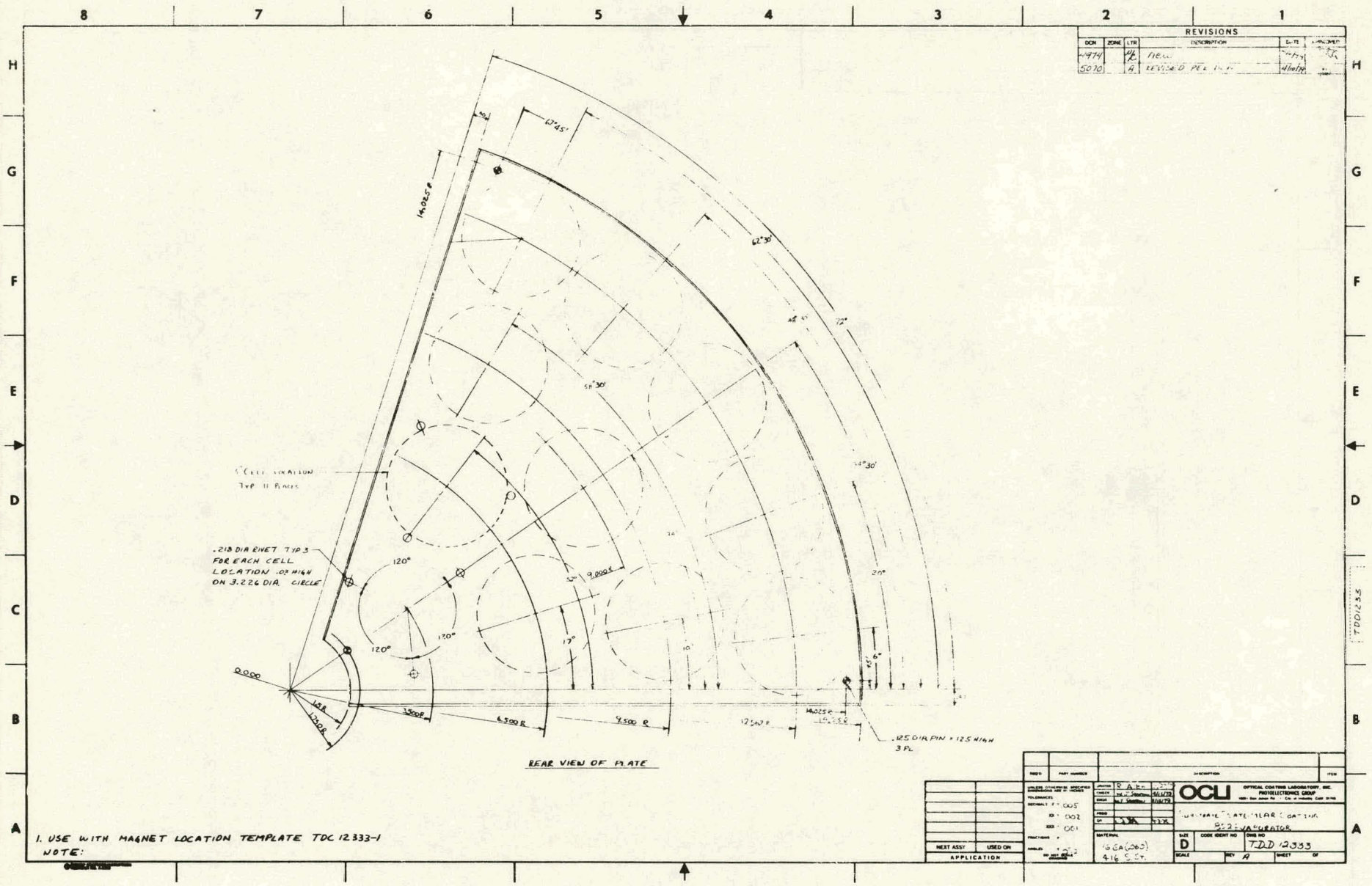

REVISIONS
REAR VIEW OF PLATE
.218 DIA RIVET TYP 3 FOR EACH CELL LOCATION .03 HIGH ON 3.226 DIA. CIRCLE
.125 DIA PIN x .125 HIGH 3 PL
1. USE WITH MAGNET LOCATION TEMPLATE TDC 12333-1
NOTE:
OCLI
TDD12333

FIGURE 8

REVISIONS					
DCN	ZONE	LTR	DESCRIPTION	DATE	APPROVED
5088		N/C	RELEASE		

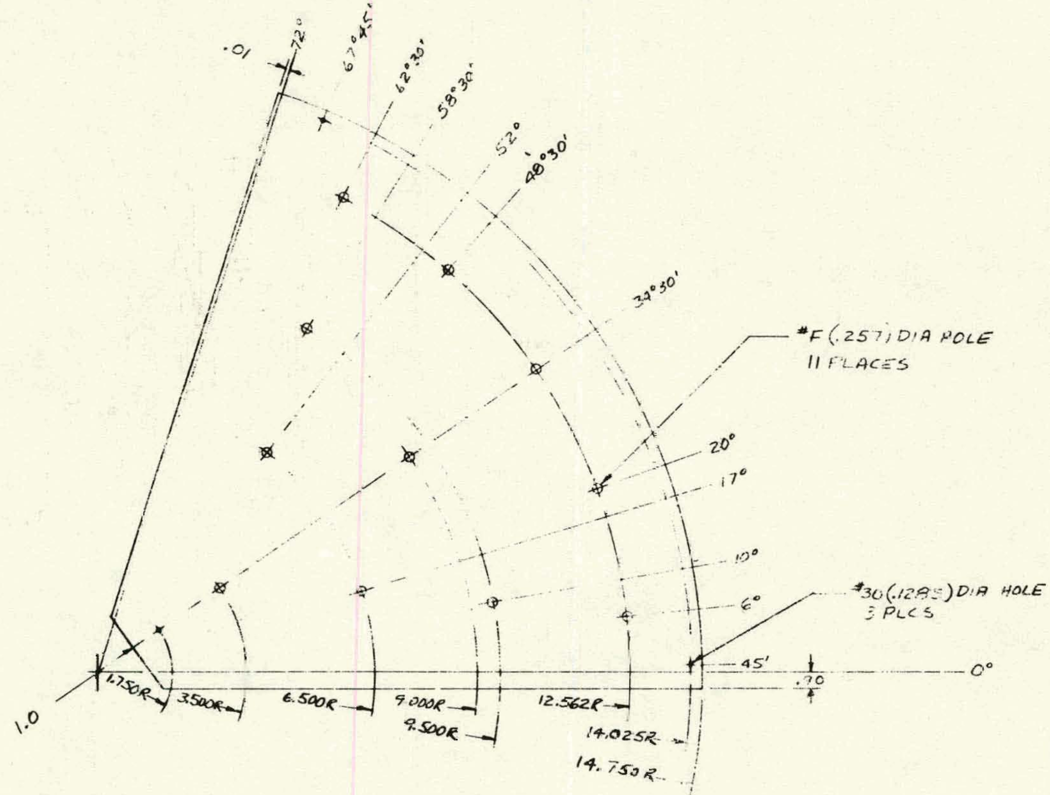


FIGURE 9

REQ'D	PART NUMBER	DESCRIPTION	ITEM

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMALS X ±
.XX ± .015
.XXX ± .005
FRACTIONS ±
ANGLES ± 1°
DO NOT SCALE DRAWING

NEXT ASSY | USED ON
APPLICATION

DRAWN 4/11/79
CHECK 4/12/79
ENGR 4/12/79
PROD
QA

MATERIAL
EPOXY GLASS
1/16 THICK
G-10 OR EQUIV.

OCLI
OPTICAL COATING LABORATORY, INC.
PHOTOELECTRONICS GROUP
15251 Don Julian Rd. • City of Industry, Calif. 91746

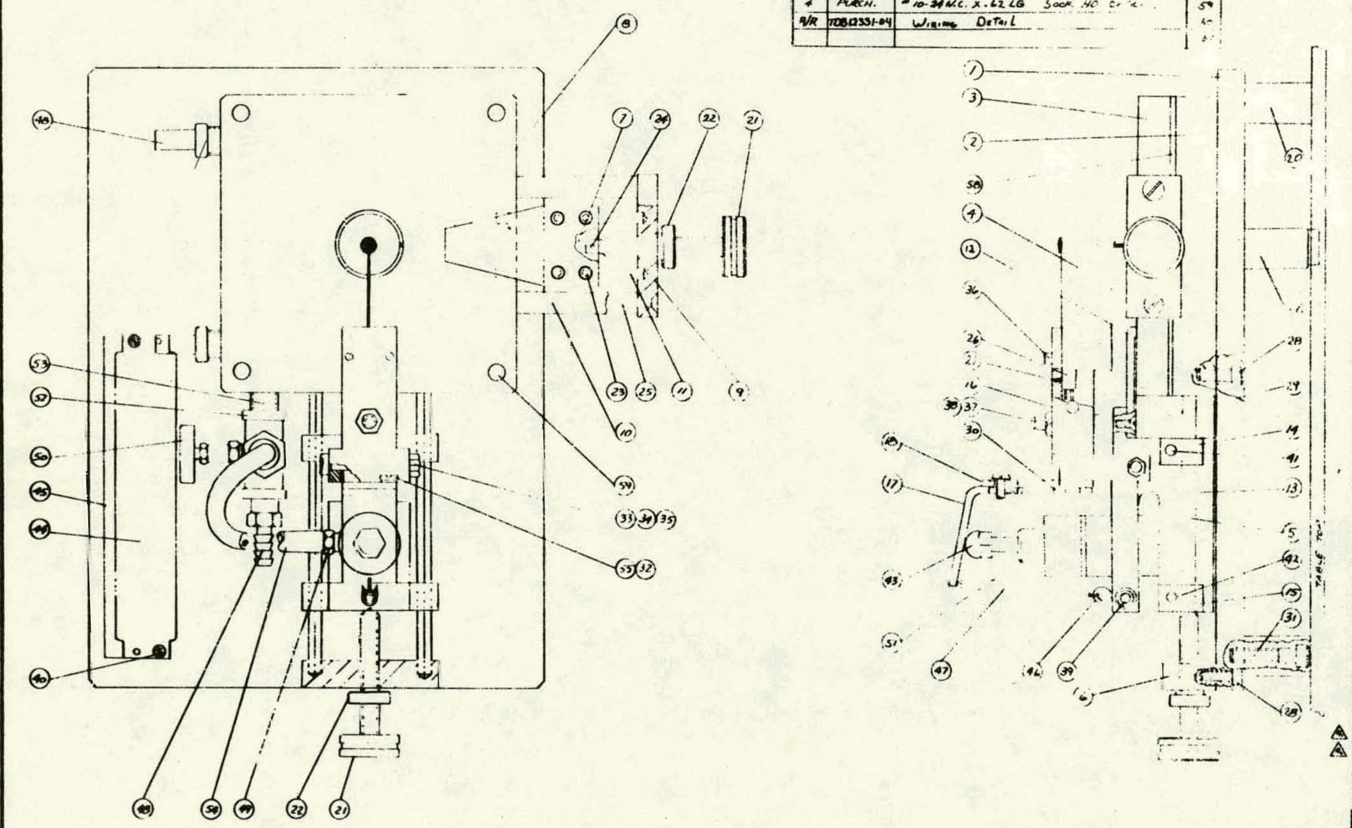
MAGNET LOCATION TEMPLATE

SIZE C | CODE IDENT NO. | DWG NO. TDC 12333-1
SCALE 1/2 | REV N/C | SHEET | OF

TDC 12333-1

REQD.	PART NO.	DESCRIPTION	ITEM
1	PURCH.	F-208 PNEUTROL FLOW CONTROL VALVE	50
1	PURCH.	MODEL 090.5-D BIMBA CYLINDER	51
1	PURCH.	1/4 I.P.S. TEE BRASS	52
2	PURCH.	1/4 I.P.S. CLOSE NIPPLE	53
AR	PURCH.	1/4 I.D. x 3/8 O.D. CLEAR TYGON TUBING	54
2	PURCH.	#8 EXTERNAL TOOTH LOCK WASHER	55
2	PURCH	1/8 I.P.S. BRASS PIPE PLUG	56
1	PURCH.	#008 O'RING	57
1	PURCH.	#159 O'RING	58
4	PURCH.	#10-24 N.C. X .62 LG SOCK. HD [illegible]	59
A/R	TDB12331-04	WIRING DETAIL	[illegible]

REVISIONS					
DCN	ZONE	LTR	DESCRIPTION	DATE	APPROVED
5012			NEW	3-30-79	
5333	3B	A	TDB12331-05 Was -06	5-31-79	
5333	3B	A	TDB12331-06 Was -05	5-31-79	



1	PURCH.	#404 AMFLO HOSE CONNECTOR	49
4	PURCH.	#401 AMFLO HOSE CONNECTOR	48
1	PURCH.	#179A TENSION SPRING	47
1	PURCH	1/16 O. WIRE "S" HOOK	46
1	PURCH.	#364-12-R-010 MARKER STRIP (TRW-CINCH JONES)	45
1	PURCH.	#354-11-12-001 BARRIER TERM BLK. (TRW-CINCH JONES)	44
1	PURCH	5/16-24NF ACORN NUT	43
1	PURCH.	.187 DIA. X 1.00 LG DOWEL PIN	42
1	PURCH	.187 DIA X .75 LG DOWEL PIN	41
2	PURCH	#[illegible]-32 [illegible] X .50 LG BINDER HD MACH SCREW	40
1	PURCH.	1/4-20 N.C. X 1.50 SOCK HD CPSCR.	39
1	PURCH.	1/4-20 N.C HEX NUT	38
1	PURCH.	1/4-20 N.C X 1.50 LG SOCK. SET SCREW	37
2	PURCH	1/4-20 N.C X .50 LG SOCK. HD. CPSCR	36
2	PURCH.	#5612-38 31 WASHER (SEASTROM MFG. CO.)	35
1	PURCH.	#10-24 N.C HEX NUT	34
1	PURCH.	1/4 DIA. X [illegible] SHOULDER BOLT	33
2	PURCH.	#8-32 N.C. X .37 LG BUTTON HD. MACH. SCREW	32
6	PURCH	1/4-20 N.C X 1.25 LG SOCK HD CPSCR	31
2	PURCH.	#6-32 N.C. X .37 LG SOCK HD CPSCR	30
2	PURCH	8-32 N.C X .37 LG FLT. HD. MACH. SCREW	29
6	PURCH	#10-24 N.C X .62 SOCK. HD. CPSCR	28
1	PURCH.	#2-56 N.C. X .62 FLT HD MACH. SCREW	27
2	PURCH	#JF2525 RECEPTACAL (WINCHESTER ELECTRONICS)	26
2	PURCH	#10-24 N.C. X 3.00 LG FLT. HD. MACH. SCREW	25
4	PURCH.	#6-32 N.C. X .37 LG SOCK. SET SCREW	24
4	PURCH.	#8-32 N.C. X .25 LG SOCK HD CPSCR.	23
2	PURCH	#T-1034-CN CHECK NUT (A.M.R. ENG. CORP.)	22
2	PURCH.	#SCH-336 SWIVEL PAD CLAMP (VLIER ENG. CORP.)	21
4	TDB12331-18-1	FOOT	20
2	TDB12331-18-2	LOCATOR	19
1	TDC12331-17-1	SLIDE, ADJUSTABLE	18
1	TDC12331-17-2	BRACKET, PIVOT	17
1	TDB12331-16	LEVER	16
2	TDB12331-15	BEARING SLIDE ~ REAR	15
2	TDB12331-14	BEARING SLIDE ~ FRONT	14
1	TDB12331-13	SLIDE PIVOT BLOCK	13
1	TDB12331-12	LOCATOR	12
2	TDB12331-11	GUIDE ROD	11
2	TDB12331-10	SPACER	10
1	TDB12331-09	GUIDE	9
1	TDB12331-08	STOP	8
1	TDB12331-07	SLIDER	7
1	TDB12331-05	BLOCK GUIDE ROD	6
2	TDB12331-06	GUIDE ROD	5
1	TAB12332	PROBE ASSY	4
1	TDD12331-03	COOLING PLATE	3
1	TDC12331-02	VACUUM BASE	2
1	TDD12331-01	BASE PLATE	1

OCLI — OPTICAL COATING LABORATORY, INC. — PHOTOELECTRONICS GROUP

Terrestrial Solar Cell Test Fixture

Size: D — Dwg. No. TAD 12331 — Rev: A

NEXT ASSY — USED ON — APPLICATION

FIGURE 10

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

BACK CONTACT SOLDERING MACHINE

Drawing No.	Title
D-202458	X-Y Motion Soldering Device (3 pages)
D-202454	Base Plate
C-202453	Soldering Unit Mounting Plate
C-202452	Side Bar
C-202456	Right Cross Shaft
B-202442	Flux Dispenser Support Yoke
B-202451	Rear Mount Block
B-202447	Actuator Arm Mounting Angle
B-202449	Actuator Arm
B-202466	Cable Bushing Mount
B-202448	Template Alignment Bar
B-202437	Indexed Longitudinal Shaft
B-202443	Longitudinal Shaft Stiffner
B-202438	Longitudinal Shaft
B-202455	Left Cross Shaft
B-202450	Guide Arm
B-202441	Front Mount Block
B-202467	Cable Pulley Mount
A-202445	Cable Support
A-202440	Longitudinal Stop Vlier Mounting Block
A-202457	Hand Retractable Plunger
A-202444	Plunger Mount Extension
A-202439	Shaft Support
A-202446	Flux Dispenser Guide Tube

VACUUM PICK-UP

Drawing No.	Title
D-202475	Vacuum Lift Device Assembly
D-202473	Vacuum Cup Mounting Panel
D-202469	Spacer Details and Location
B-202472	Top Panel Vacuum Lift Device
B-202474	Vacuum Position Indicator
A-202470	Vacuum Valve Mounting Flange
A-202471	Vacuum Valve Mounting Flange Assembly

TEST FIXTURE FOR CENTER CONTACT CELL

Drawing No.	Title
TAD-12331	Terrestrial Solar Cell Test Fixture
TDD-12331-01	Base Plate
TDC-12331-02	Vacuum Base
TDD-12331-03	Cooling Plate
TDB-12331-04	Wiring Detail
TDB-12331-05	Block - Guide Rod
TDB-12331-06	Guide Rod
TDB-12331-07	Slider
TDB-12331-08	Stop
TDB-12331-09	Guide
TDB-12331-10	Spacer
TDB-12331-11	Guide Rod
TDB-12331-12	Locator
TDB-12331-13	Slide Pivot Block
TDB-12331-14	Bearing, Slide-Rear
TDB-12331-15	Bearing, Slide-Rear
TDB-12331-16	Lever
TDC-12331-17	Actuator
TDB-12331-18	Feet, Alignment
TAD-12332	Robe Assembly
TDB-12332-01	Post
TDB-12332-02	Block
TDB-12332-03	Arm

ANTI-REFLECTIVE COATING TOOLING

Drawing No.	Title
TDD-12333	Substrate Plate - MLAR Coating, 852 Evaporator
TDC-12333-01	Magnet Location Template

U.S. GOVERNMENT PRINTING OFFICE: 1980—640-258/1976