N82-23268

NASA CONTRACTOR REPORT
FINAL REPORT 165871

WOVEN GRAPHITE EPOXY COMPOSITE TEST SPECIMENS WITH GLASS BUFFER STRIPS

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NASA
National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665

ABSTRACT

Woven unidirectional graphite cloth, with bands of fiberglass replacing the graphite in discrete lengthwise locations, was impregnated with epoxy resin and used to fabricate a series of composite specimens. This effort was accomplished in the Materials & Process Engineering Laboratory under NASA Contract NAS1-16677. The finished panels, with the fiberglass buffer strips, were delivered to NASA, Langley Research Center for test. This report covers details of the fabrication process.

FOREWARD

This document is the final report which describes the details of manufacture of graphite epoxy composite test specimens with glass, fiber buffer strips for Contract NAS1-16677. The work was conducted from July 1981 to December 1981. John M. Kennedy of Langley Research Center, Hampton, Virginia, was the NASA Technical Monitor of the contract.

Mr. R. J. Palmer of the Douglas Aircraft Company, Materials & Process Engineering, was the Program Manager and directed the technique of fabrication. Principal contributors to the Douglas activities were G. R. Bonnar, R. C. Wade, and D. L. Crouch of Materials & Process Engineering. In addition, special acknowledgment is expressed to the J. Brochier & Fils Company in Villerubanne, France, for their interest and help in developing the weaving processused to make the woven cloth used in this program.

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I

INTRODUCTION

The use of glass buffer strips in graphite epoxy panel construction has been previously shown to offer effective crack propagation control. Fabrication of these panels has previously entailed cutting strips of graphite and fiberglass epoxy prepreg tape and manually locating alternate graphite and fiberglass material side by side to form the glass buffer strip construction. This report details the low-cost fabrication process used for manufacture of a series of buffer strip panels to NASA design requirements.

The buffer strip panel design configurations required that S-1014 glass fibers be woven in the warp direction of the unidirectional woven Thornel 300 graphite cloth, as shown in Figure 1. Three woven glass fiber configurations (See Figures 2, 3 and 4) on 2.5 inch centers, were required (1) 0.50 inch wide, 1 ply of glass thick, (2) 0.25 inch wide, 2 plies of glass thick, and (3) 0.125 inch wide, 4 plies of glass thick. Fracture and tensile coupon panels were designed to use uniwoven S-1014 glass cloth and uniwoven T-300 graphite cloth in different ply configurations. Custom weaving was involved to obtain this type of woven buffer strip material. The specimens were fabricated using a dry lay-up technique. The woven cloth was layed on the 5208 resin film and impregnated and cured in one operation.

Panels were bagged and cured in sets of similar configuration whenever possible. Cured panel quality was checked by C-scan, X-ray and resin and void determination. The various panel configurations that were fabricated are shown in the Engineering drawings (See Appendix A) and in Table I.

The use of commercial products or names of manufacturers in this report does not constitute official endorsement of such products or manufacturers, either expressed or implied, by the National Aeronautics and Space Administration.

TABLE I

SPECIMEN DESIGN CONFIGURATIONS

SPECIMEN	CONFIGURATION	GLASS/ PLIES	GLASS WIDTH	PANEL SIZE	NUMBER OF PANELS
LB-921963-WC1	$[45/0/-45/90]_{2S}$	0°	0.50"	12" X 34"	3
-WD1	$[45/0/-45/90]_{2S}$	0°	0.25"	12" X 34"	3
-WG1	$[45/0/-45/90]_{2S}$	0°	0.125"	12" X 34"	3
LB-921964	$[45/0/-45/90]_{6S}$	0°	0.50"	12" X 42"	3
LB-921965	$[45/0/-45/90]_{2S}$	+45,0,-45,90	0.50"	12" X 34"	3
LB-921966	$[\pm 45]_{4S}$	+45, -45	0.50"	20" X 20"	3
	$[+45/0/-45/90)_{2S}$	+45, -45	0.50"	20" X 20"	3
LB-921967	$[45/0/-45/90]_{2S}$	-	-	12" X 46"	1
	$[45/0/-45/90]_{2S}$	0° S-1014 Cloth		24" X 24"	1

II

MATERIALS

Four types of materials were used in the specimen fabrication and were purchased from the following companies:

2.1 J. Brochier et Fils
70 Cours Tolstoi
Villeurbanne 69605 France

° Graphite cloth 95% uniwoven Thornel 300 (.006"/ply cured laminate thickness

° Graphite cloth 95% uniwoven Thornel 300 with S-1014 glass strips

(a) Fiberglass 0.50" X .006" Figure 2
(b) Fiberglass 0.25" X .012" Figure 3
(c) Fiberglass 0.13" X .024" Figure 4

2.2 Narmco Materials, Inc.
600 Victoria Street
Costa Mesa, California 92627

° 5208 resin "B" stage film, .020 lbs/ft^2

2.3 Fabric Development
10 South Main Street
Quaker Town, Pennsylvania 18951

° Uniwoven "S" glass cloth .006"/ply cured laminate thickness)

III

PROCEDURE

All specimens were fabricated using the same technique and procedure, except as where noted. Panels were made oversize to allow for a one-inch perimeter trim. The fabrication method was as follows:

3.1 Resin Layup

(a) The Narmco 5208 resin film was removed from cold storage (0°F) and allowed to warm to room temperature before being opened.

(b) The required plies of 5208 resin film were cut to specimen size.

(c) A cured panel fiber volume fracture of .60 $\pm$ .05%, required 22 plies of resin film for every 16 plies of graphite/glass fabric.

(d) Narmco 5208 resin film is sandwiched between a paper separator and polyethylene film separator. The polyethylene film was removed from the sheet of resin, leaving the paper separator in place.

(e) A second resin sheet after its polyethylene film was removed was placed on the exposed resin film. (See Figure 5.)

(f) The two sheets were squeegeed together to remove all air bubbles.

(g) The layup was turned over and squeegeed once more before the paper separator was removed.

(h) This process was repeated until the desired number of plies of resin were obtained.

3.2 Laminate Plies

(a) Templates were made for the various ply patterns to insure that the glass buffer strips of similar ply patterns were aligned correctly. Clear mylar was cut to panel size for the different ply patterns and marked for correct buffer strip alignment.

(b) The mylar template was layed on the woven cloth, and masking tape was placed around the perimeter of the template on the uniwoven cloth. (See Figure 6.) Masking tape was used to minimize the tendency for the cloth to fray.

(c) Each ply was cut down the center of the masking tape.

3.3 Laminate Fabrication

(a) A scratch free caul sheet was prepared for laminate fabrication by taping one sheet of nylon film to the surface followed by one sheet of Armalon release film.

(b) The paper separator was removed from the stacked 5208 resin and the resin positioned on the prepared plate.

(c) The precut graphite plies were layed on the resin in the ply pattern configuration. (See Figure 7.)

(d) The correct alignment and stacking of the buffer strips was obtained by use of a mylar template as each ply was taped in position. (See Figure 8.)

The LB-921963 - WDI and -WGI configuration called for 2-ply and 4-ply glass buffer strips. The equal volume glass, (width x thickness = constant volume) was woven into the cloth. The thicker buffer strips required a smooth surface in the doubler area of the specimen. This surface condition was accomplished by placing preimpregnated uniwoven graphite (1 ply for LB-92193-WDI, 3 plies for LB-932963-WGI between the buffer strips. (See Figure 9.) In this buildup area, the uniwoven graphite was impregnated prior to layup by placing 1 ply of uniwoven cloth on 2 plies 5208 resin. This material was sealed under a vacuum bag and placed in an oven for 15 minutes at 150°F to obtain resin impregnation into the cloth.

3.4 Laminate Bagging and Cure

(a) Each laminate was prepared for vacuum bagging by placing 1 ply of Armalon on the surface followed by 1 ply of Mockburg bleeder per 4 plies of uniwoven cloth. (See Figure 10.)

(b) A ply of nylon film was securely taped over the prepared laminate to prevent excess resin bleed. For LB-921963-WDI and WGI metal plates were taped in position over the nylon film in the doubler area to insure a flat surface.

(c) Two plies of 181 glass were placed over the prepared laminate and vacuum bagged using nylon bagging material. The bag was sealed using vacuum bag sealant.

(d) The complete bagged assembly was placed in a cold autoclave and 25 inches minimum vacuum pressure drawn on the vacuum bag.

(e) The temperature was raised to 250°F, while under vacuum pressure, and heat-up rate was calculated by the following equation:

$$\text{HEAT-UP RATE} = \frac{\text{220°F - PART ENTERING TEMPERATURE}}{\text{TIME IN MINUTES TO REACH 220°F}}$$

(f) The assembly was allowed to dwell at 250°F, dependent upon heat-up rate, as noted in Table II.

(g) Autoclave pressure was raised to 100 ± 10 psi, and the vacuum bag was vented to the atmosphere when pressure reached 25 psi.

(h) Then the temperature was raised to 350°F and held at 350 ± 10°F and 100 ± 10 psi for a minimum of 2 hours after the lowest thermocouple reached 340°F.

(i) The assembly was cooled below 150°F, the pressure was reduced, and the part was removed from the autoclave.

TABLE II

CURE CYCLE PARAMETER SETTINGS

HEAT-UP RATE (°F/MINUTES)	PRESSURE APPLICATION TEMPERATURE (°F)	250° DWELL TIME VACUUM (MINUTES)	TIME AT 350°F (MINUTES)
0.4	225	0	120
0.5	235	0	
0.6	245	0	
0.7	250	0	
0.8		10	
0.9		20	
1.0		30	
1.1		35	
1.2		40	
1.3		45	
1.4		45	
1.5		50	
1.6		50	
1.7		55	
1.8		55	
1.9		60	
2.0		60	
2.5		65	
3.0		70	
4.0		75	
5.0		75	
6.0		80	
7.0		80	
8.0		80	
9.0	250	80	120

3.5 Procedure for Preparing of Aluminum Doublers for Bonding

(a) Contaminants were removed from aluminum surfaces with methyl ethyl ketone (MEK).

(b) The details were immersed in alkaline cleaner for 15 $\pm$ 2 minutes, rinsed in tap water, immersed in chromate acid solution for 12 to 15 minutes, and spray rinsed in tap water.

(c) A final spray rinse was made in deionized water for 2 to 3 minutes.

(d) All details were dried at a maximum temperature of 200°F for at least 15 minutes until dry.

3.6 Bonding of Metal Doublers

(a) Prior to the bonding of the aluminum doublers, each panel was submitted to Nondestructive Inspection to determine the quality of the laminates. C-scan and X-ray inspection were performed by the McDonnell Douglas Nondestructive Test Laboratory.

(b) Oversize aluminum 7075-T6 doublers were prepared for bonding per paragraph 3.5.

(c) The specimen bond area was grit blasted and followed by MEK wipe prior to bonding.

(d) The aluminum doublers were positioned and bonded to the specimen using HYSOL EA 934 two-part room temperature setting adhesive.

3.7 Machining and Drilling

(a) Holes were drilled per requirements for each panel.

(b) Each panel was cut to size, and samples were taken from the trim area and submitted for resin, fiber volume, and void content.

(c) Panels were deburred and the excess adhesive removed.

(d) The panels were packaged and shipped to NASA Langley Research Center.

IV

DISCUSSION AND RESULTS

(a) The results for the nondestructive testing are shown in Appendix B for C-scan and Appendix C for X-ray. The X-ray photography required multiple shots that were spliced together to produce one photograph. This method accounts for some of the X-ray photographs that appear to have buffer strips that appear to be crooked.

(b) The results of the resin and void determination are shown in Table III.

(c) Specimen LB-921965 Panel 1 was the first specimen to be fabricated. Some problems arose in maintaining alignment of the buffer strips on top of one another. These problems were resolved and all other specimens were fabricated as disclosed in this report.

(d) The poor C-scan result for Z921964-2 panel is a result of higher void content (1.06%) and visual surface porosity. The panel was accepted with noted variance for the test program.

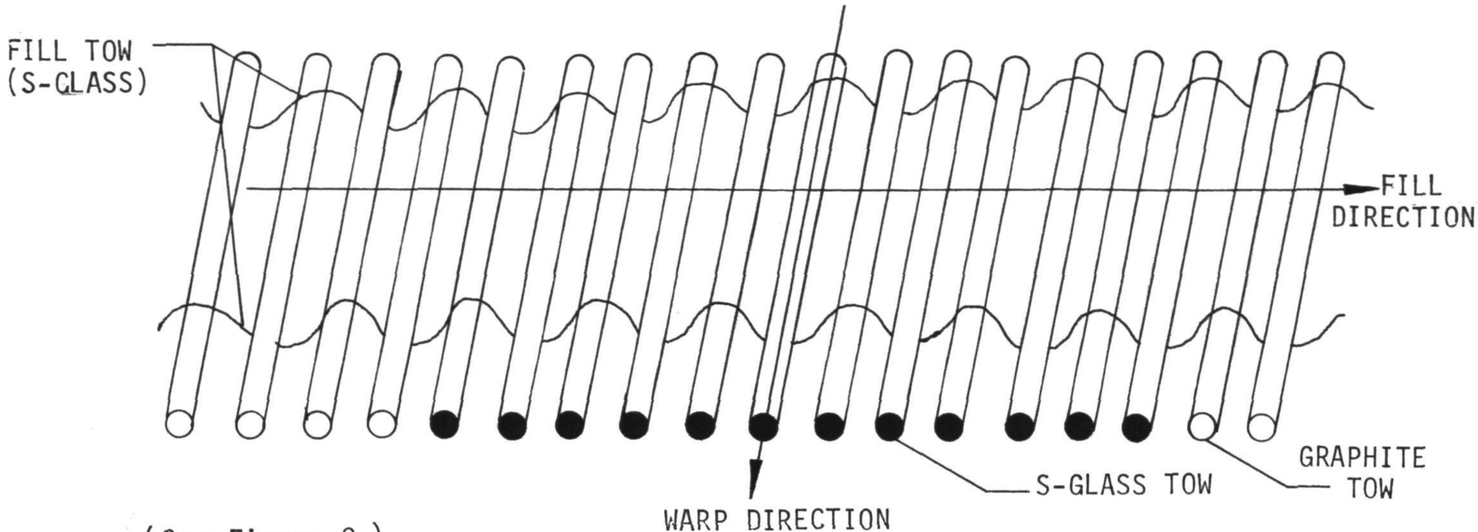
TABLE III

RESIN CONTENT RESULTS

SPECIMEN	AVERAGE % RESIN CONTENT *	AVERAGE % FIBER VOLUME *	AVERAGE % VOID CONTENT *
LB-921963-WC1-1	28.74	64.46	+ 0.05
-2	30.18	62.86	0.05
-3	29.09	64.07	0.05
LB-921963-WD1-4	34.09	58.44	+ 0.03
-5	35.98	56.39	+ 0.06
-6	35.72	56.65	+ 0.10
LB-921963-WG1-7	36.66	56.75	+ 0.02
-8	36.40	55.94	+ 0.08
-9	38.09	54.36	0.05
LB-921964 -1	27.09	66.21	0.05
-2	29.54	62.78	+ 1.06
-3	31.60	61.08	+ 0.13
LB-921965 -1	31.71	62.26	0.05
-2	28.77	62.03	0.05
-3	28.30	66.82	0.05
LB-921966 -1	30.66	63.29	0.05
-2	31.74	61.62	0.05
-3	31.67	62.60	0.05
LB-921966 -4	33.59	59.14	0.05
-5	34.78	57.92	0.05
-6	32.48	60.29	0.05
LB-921967-WGR	30.98	61.72	+ 0.02
LB-921967-WC1	34.43	61.02	+ 0.31

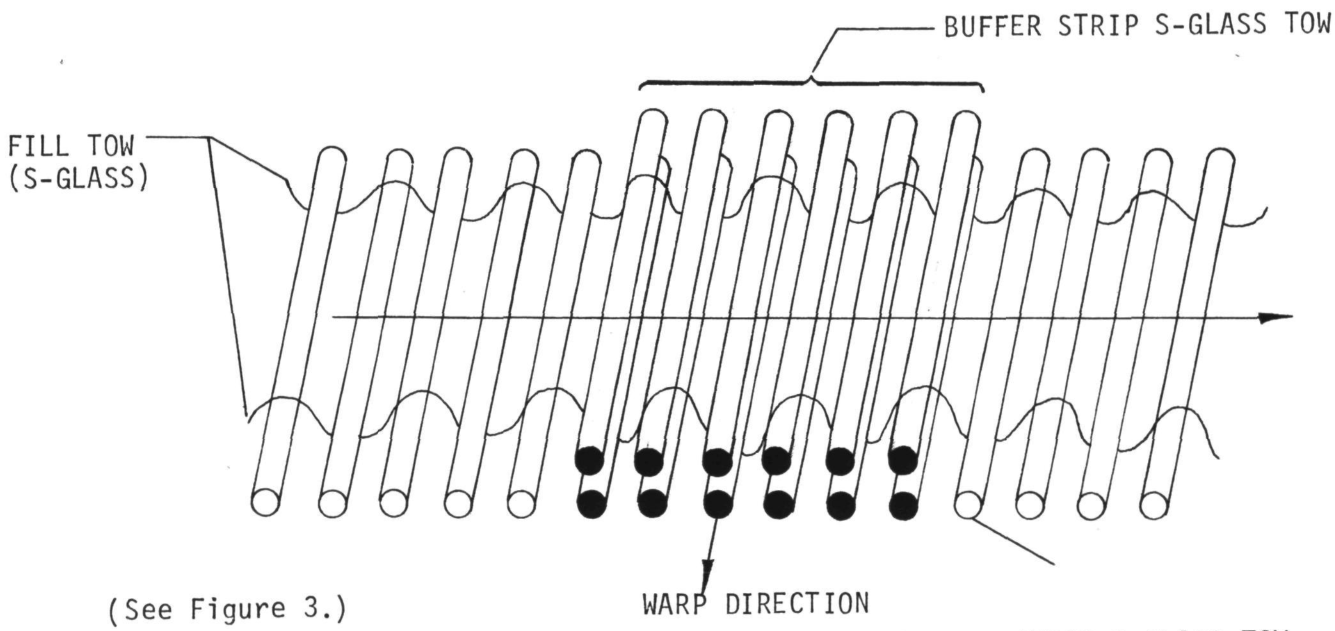
* Average of 3 or more test results.

ONE LAYER S-GLASS BUFFER STRIP PLY



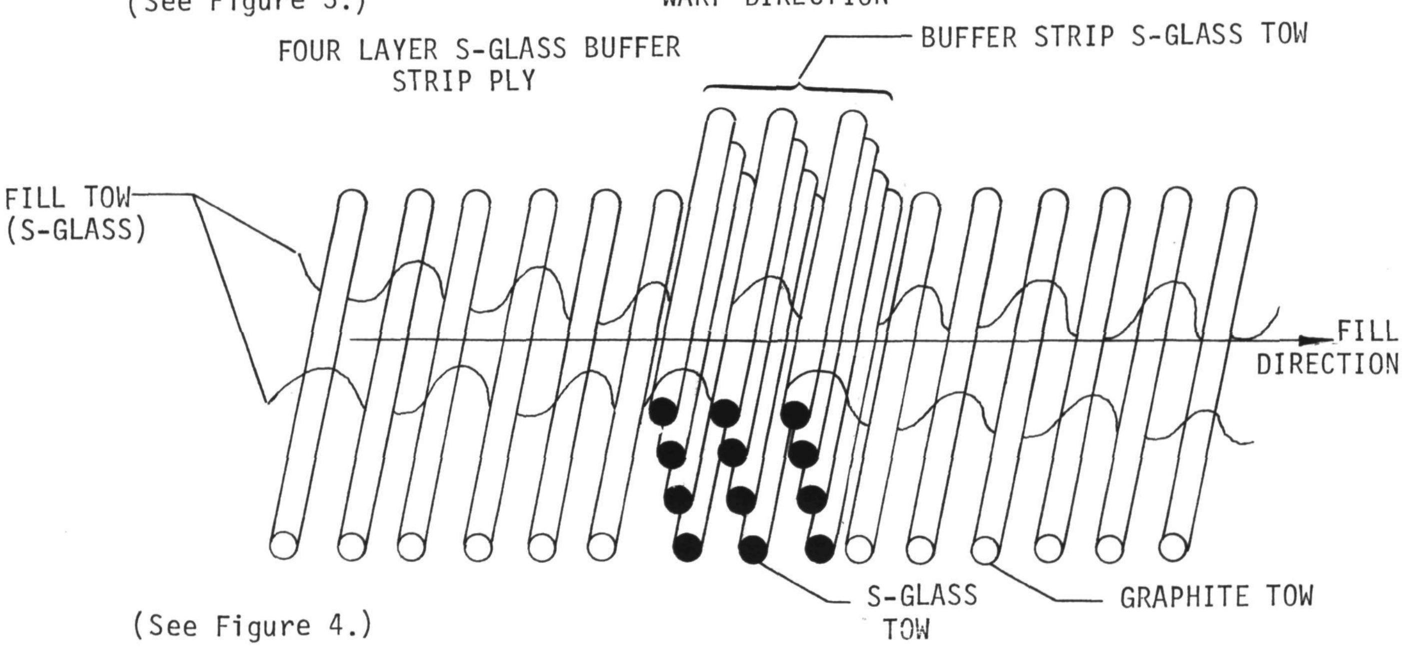
(See Figure 2.)

TWO LAYER S-GLASS BUFFER STRIP PLY



(See Figure 3.)

FOUR LAYER S-GLASS BUFFER
STRIP PLY



(See Figure 4.)

FIGURE 1. SKETCHES OF BUFFER STRIP PLIES

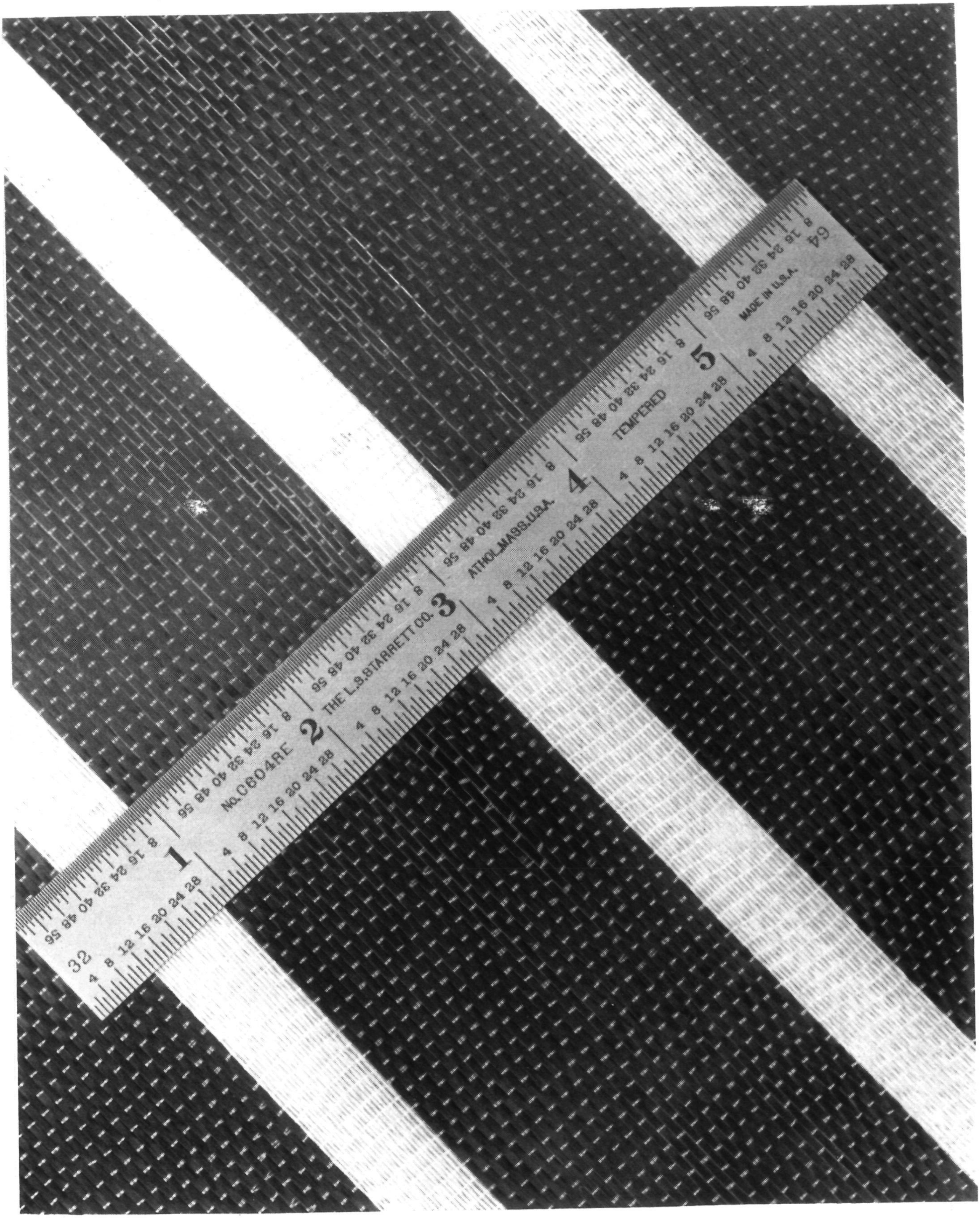


FIGURE 2. UNIWOVEN THORNEL 300 GRAPHITE (.006" THICK) WITH S-1014 GLASS (.50" WIDE AND .006" THICK)

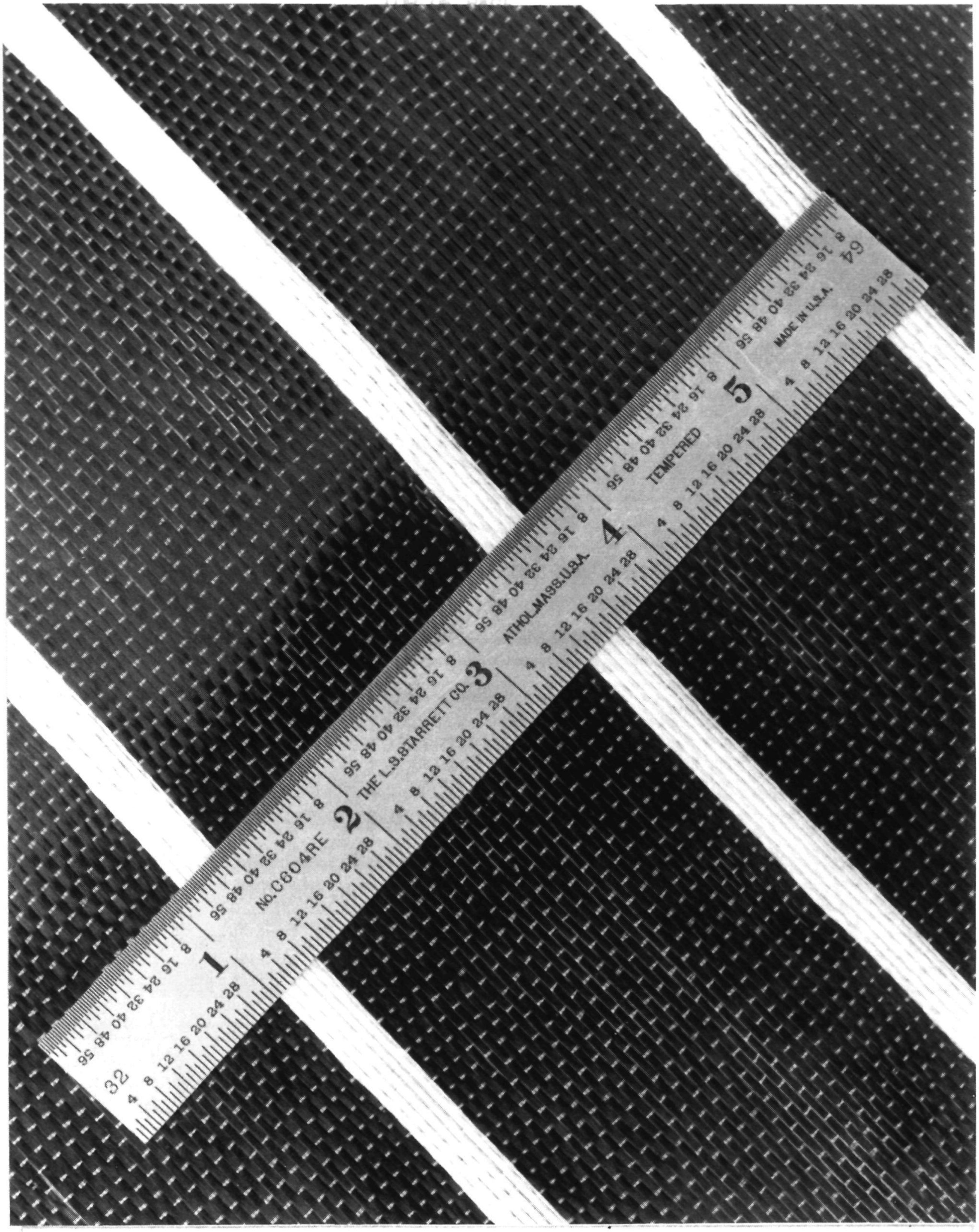


FIGURE 3. UNIWOVEN THORNEL 300 GRAPHITE (.006" THICK) WITH 2 PLIES S-1014 GLASS (.25" WIDE AND .012" THICK)

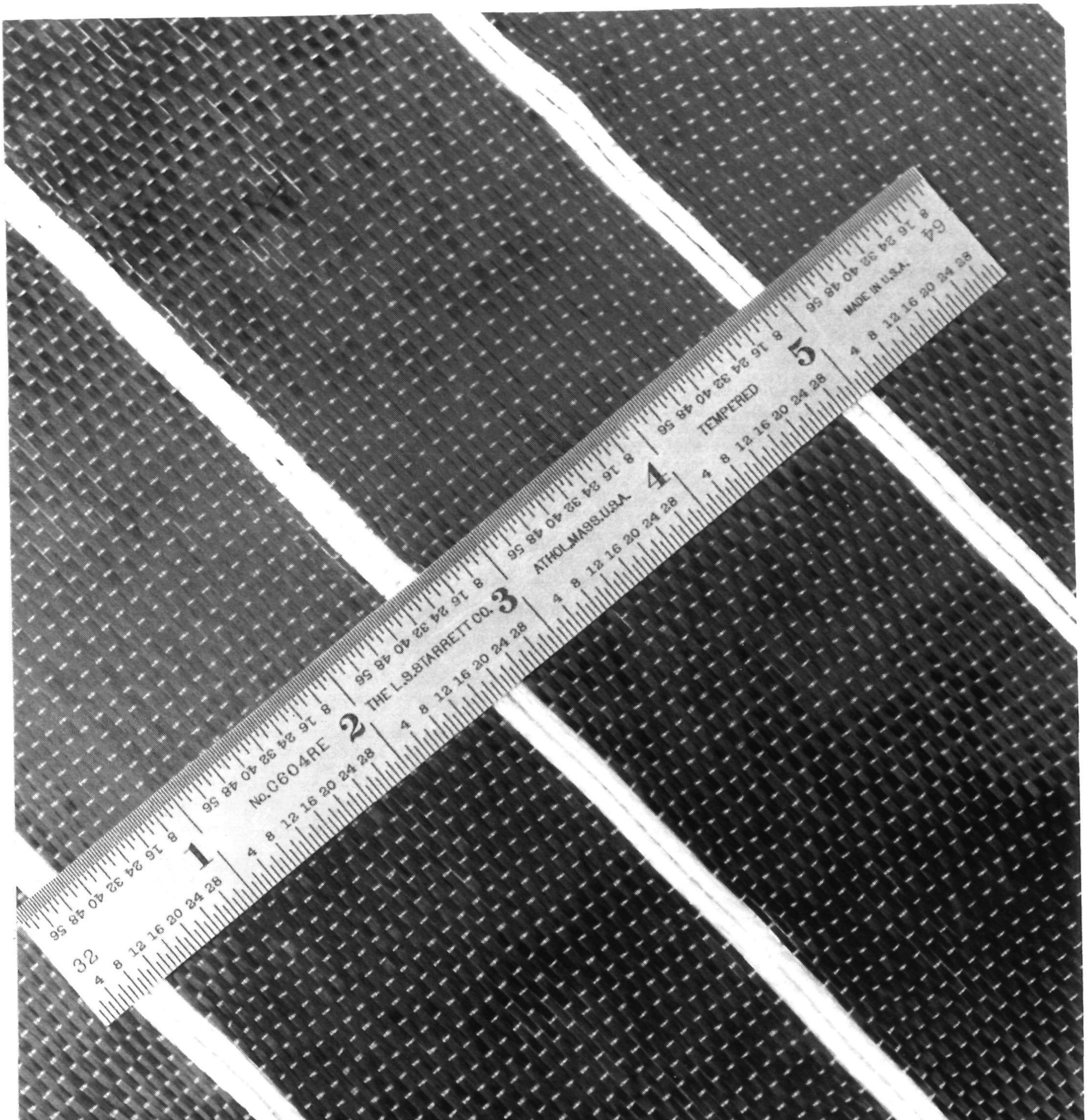


FIGURE 4. UNIWOVEN THORNEL 300 GRAPHITE (.006" THICK) WITH 4 PLIES S-1014 GLASS (.125" (3.18mm) WIDE AND .024" THICK)

FIGURE 5. LAYUP OF THE 5208 RESIN FILM

TOP OF PAGE
ONE PER PAGE (SIZE 6½ X 8)

FIGURE 6. ALIGNMENT OF TEMPLATE ON 0° PLY PATTERN

FIGURE 7. LAYUP OF THE UNIWOVEN CLOTH PLIES

FIGURE 8. ALIGNMENT AND TAPING IN POSITION OF BUFFER STRIP PLIES USING MYLAR TEMPLATE

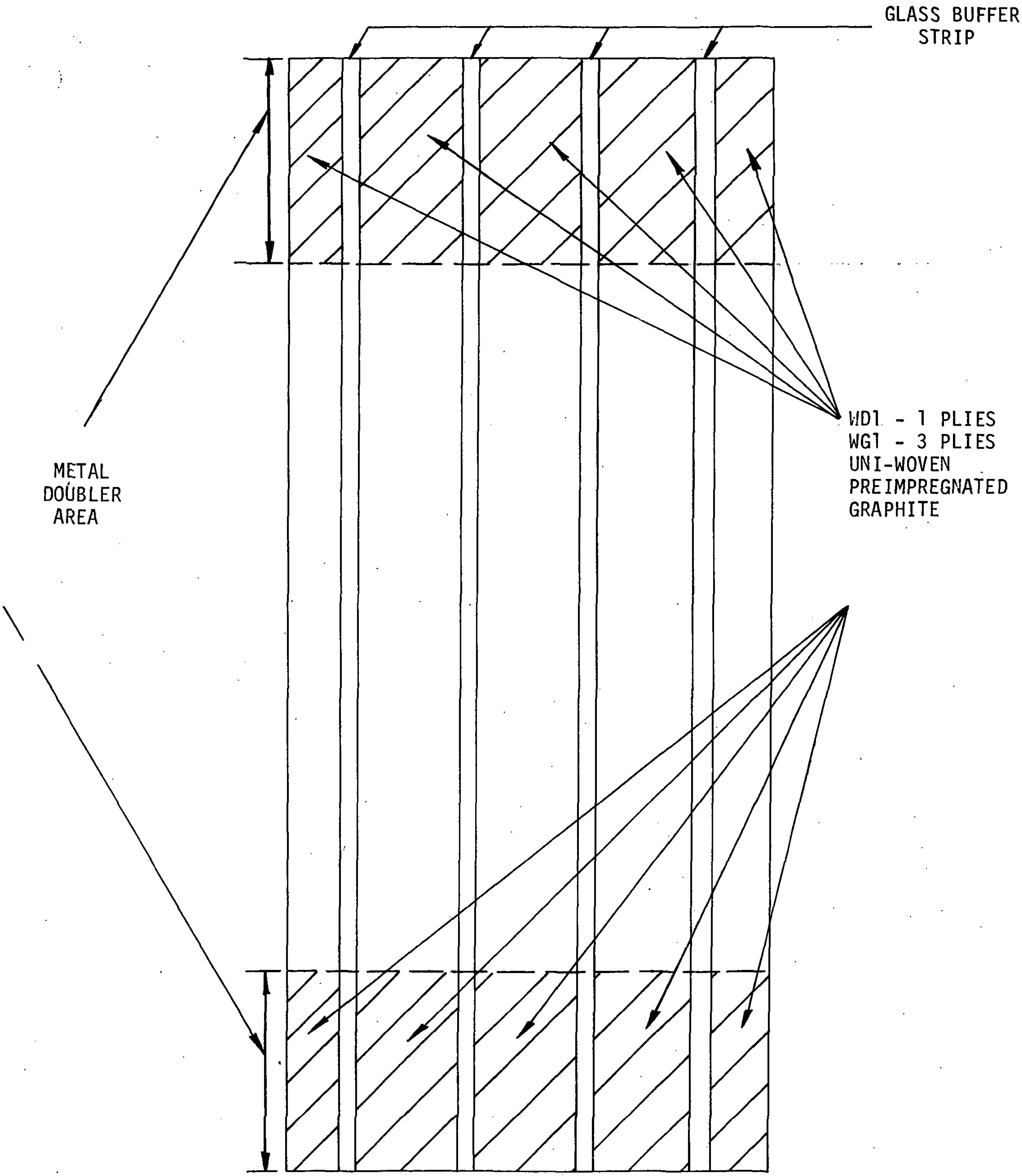


FIGURE 9. PLACEMENT OF PREIMPREGNATED GRAPHITE PLIES FOR METAL DOUBLER BUILDUP FOR LB-921963-WD1 AND WG1

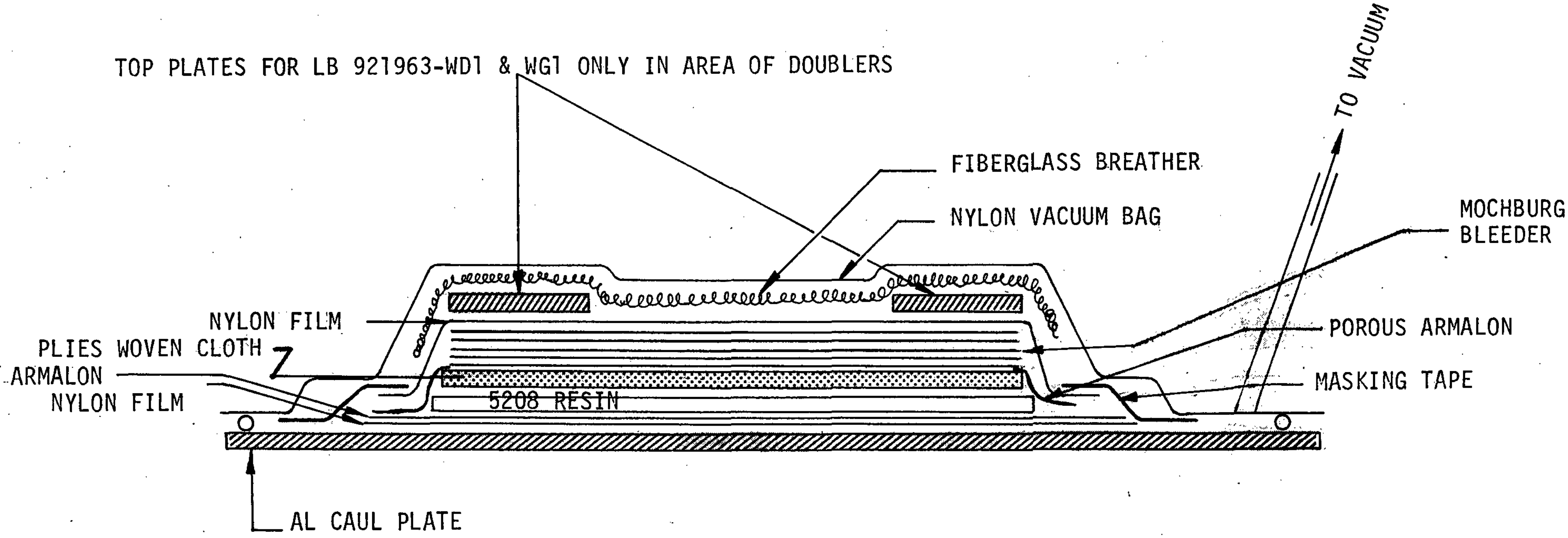
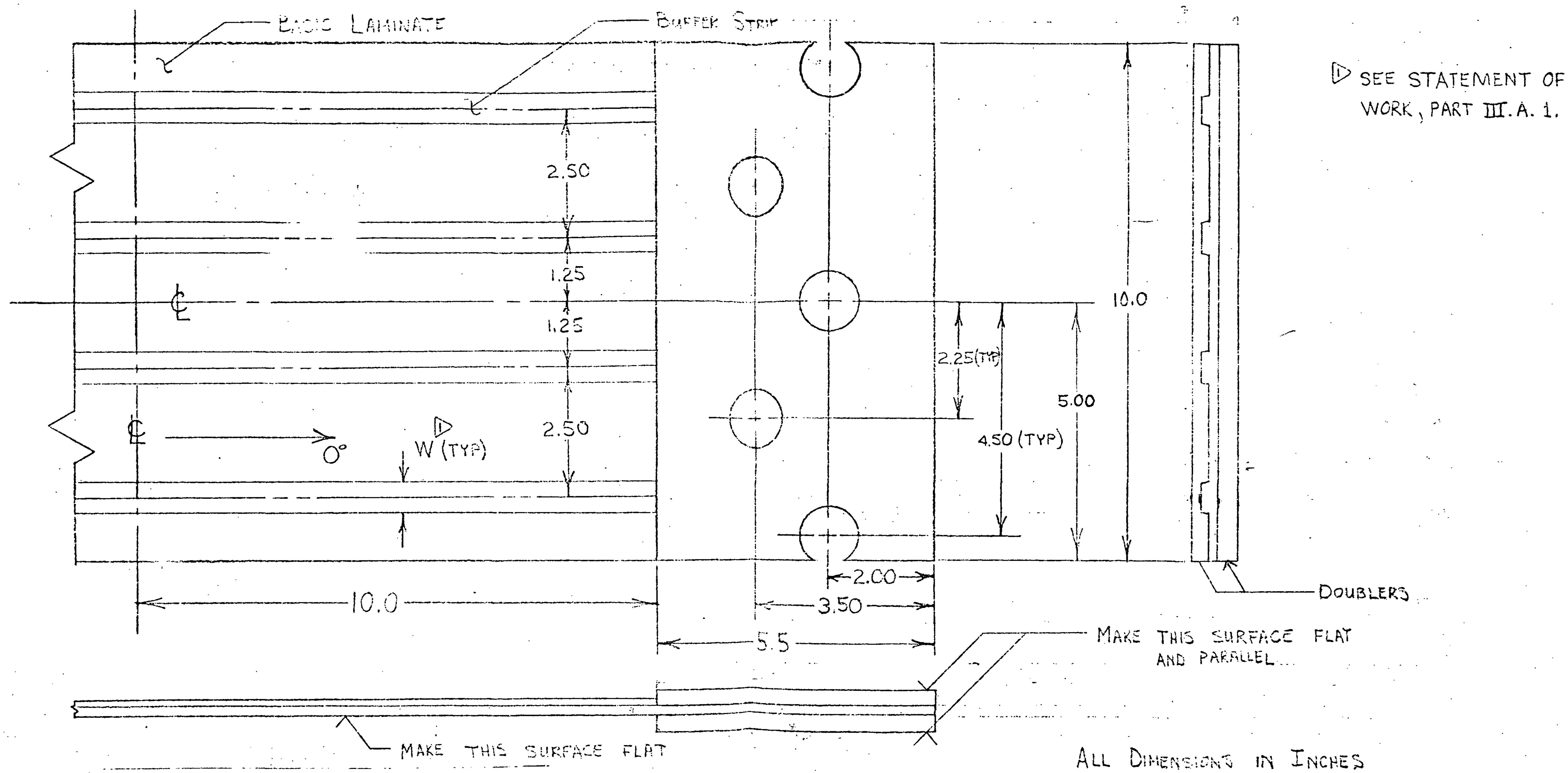


FIGURE 10. VACUUM BAGGING OF SPECIMENS

APPENDIX A

SPECIMEN CONFIGURATION DRAWINGS

A-1	LB-921963	Woven Composite Buffer Panels Constant Area Buffer Strips
A-2	LB-921964	Woven Composite Buffer Panels Thick Buffer Strip Panel
A-3	LB-921965	Woven Composite Buffer Panels Every Ply Buffer Strips
A-4	LB-932966	Woven Composite Buffer Panels Shear Panel
A-5	LB-921967	Woven Composite Buffer Panels Tensile and Fracture Coupons



DATE	LET	FREQ.	REVISIONS	BY	CK.	APPD.

MATERIAL: Gr/Ep & S-Gl/Ep

SCALE: 1/2

TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: X.X (1 DECIMAL PLACE) ± .1; X.XX (2 DECIMAL PLACES) ± .02; X.XXX (3 DECIMAL PLACES) ± .005; ANGULAR ±

SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE

EST. FIN. WEIGHT

DR. [illegible] 12/1980 | STRESS

DES. | APPD.

CHK. [illegible] 1-5-81 | APPD.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA 23665

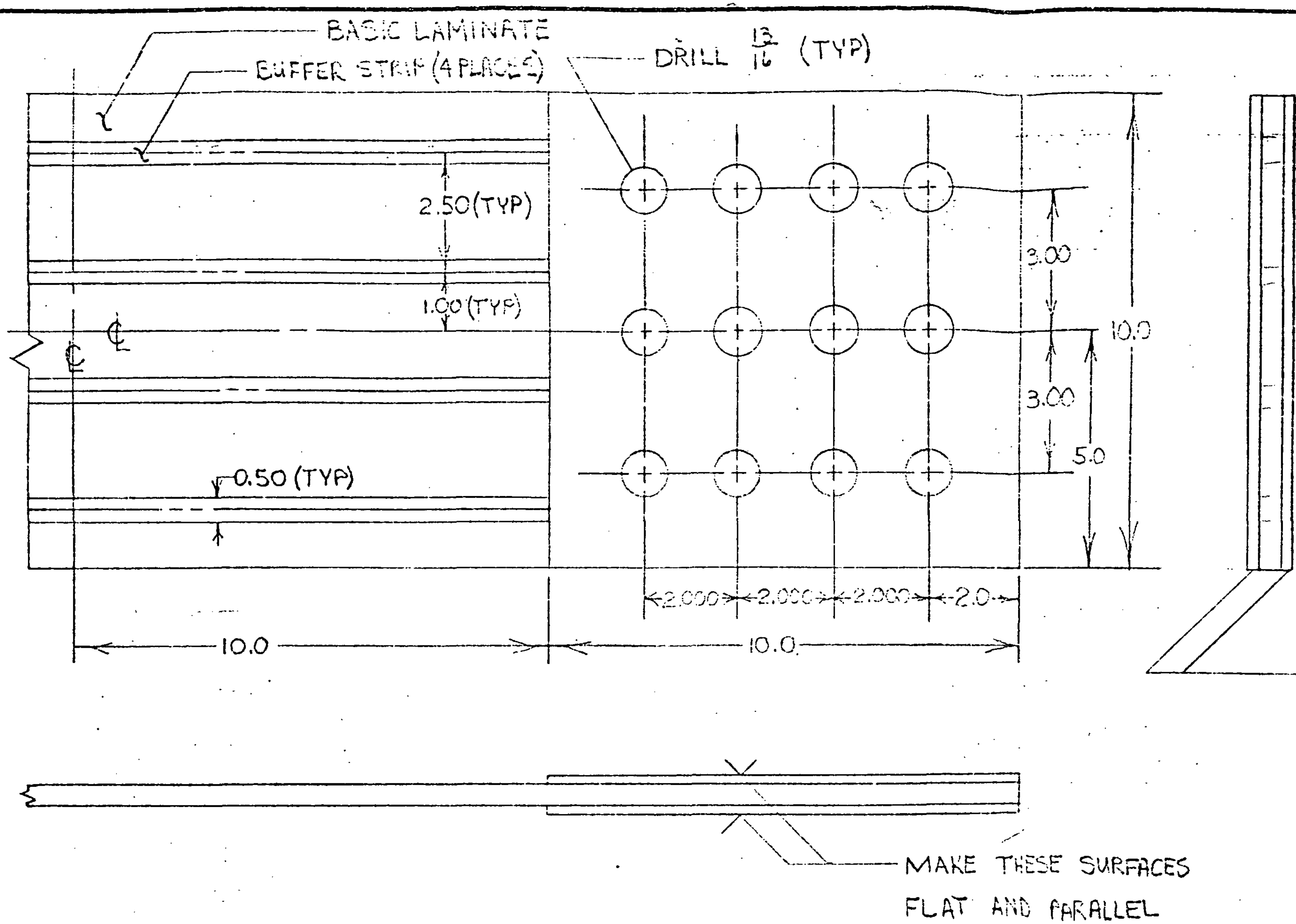
PROJECT TITLE: WOVEN COMPOSITE BUFFER PANELS

DRAWING TITLE: CONSTANT AREA BUFFER STRIPS

PROJECT NO. | BLDG. NO.

JOB ORDER NO. | SHEET NO. 1 OF 1

LB-921963
DRAWING NO.



NOTES

- BASIC LAMINATE IS $[45/0/-45/90]_{6S}$ UNIDIRECTIONAL WEAVE 5208/T300 GR/EP. BUFFER MATERIAL IS S-1014 GLASS.
- BUFFER MATERIAL SHALL BE WOVEN INTO EACH 0° PLY REPLACING THE GRAPHITE; BUFFER STRIP IS $[45/0_{S-GL}/-45/90]_{6S}$.
- MAKE 3 PANELS

DATE	LET	FREQ.	REVISIONS	BY	CK.	APPD.

MATERIAL: T300/5208, S-1014/5208

SCALE: 1 - 3

TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: X.X (1 DECIMAL PLACE) ± .1; X.XX (2 DECIMAL PLACES) ± .02; X.XXX (3 DECIMAL PLACES) ± .005; ANGULAR ±

SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE ✓

EST. FIN. WEIGHT

DR. JFK 12/17/80 | STRESS
DES. | APPD.
CHK. | APPD.

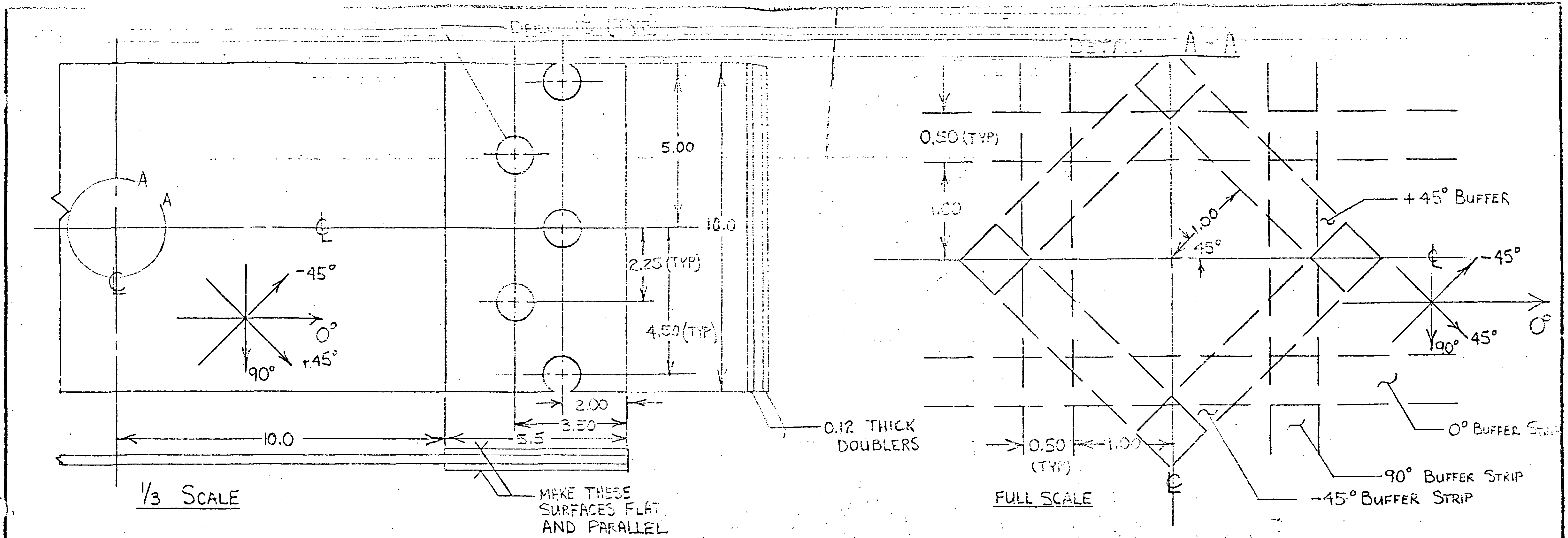
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA 23665

PROJECT TITLE: Woven Composite Buffer Panels

DRAWING TITLE: Thick Buffer Strip Panel

PROJECT NO. | BLDG. NO.
JOB ORDER NO. | SHEET NO. 1 OF 1

LB-921964 DRAWING NO.



NOTES

- BASIC LAMINATE IS $[45/0/-45/90]_{2S}$ MADE FROM UNIDIRECTIONAL WEAVE CLOTH, 5208/T300 GRAPHITE EPOXY
- S-GLASS BUFFER STRIPS ARE TO BE WOVEN INTO EACH PLY. THE BUFFER STRIPS ARE ONE FOR ONE REPLACEMENT, 0.50 INCHES WIDE ON 2.50 INCH CENTERS.
- DETAIL A-A GIVES LOCATION OF BUFFER STRIPS RELATIVE TO THE CENTERLINES.
- MAKE 3 PANELS

DATE	LET	FREQ.	REVISIONS	BY	CK.	APPD.

MATERIAL: T300/5208, S-1014/5208

SCALE: AS NOTED

TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: X.X (1 DECIMAL PLACE) ± .1; X.XX (2 DECIMAL PLACES) ± .02; X.XXX (3 DECIMAL PLACES) ± .005

ANGULAR ±

SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE ✓

EST. FIN. WEIGHT

DR.	JFK 12/17/80	STRESS	
DES.		APPD.	
CHK.	CCP 1-5-81	APPD.	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA 23665

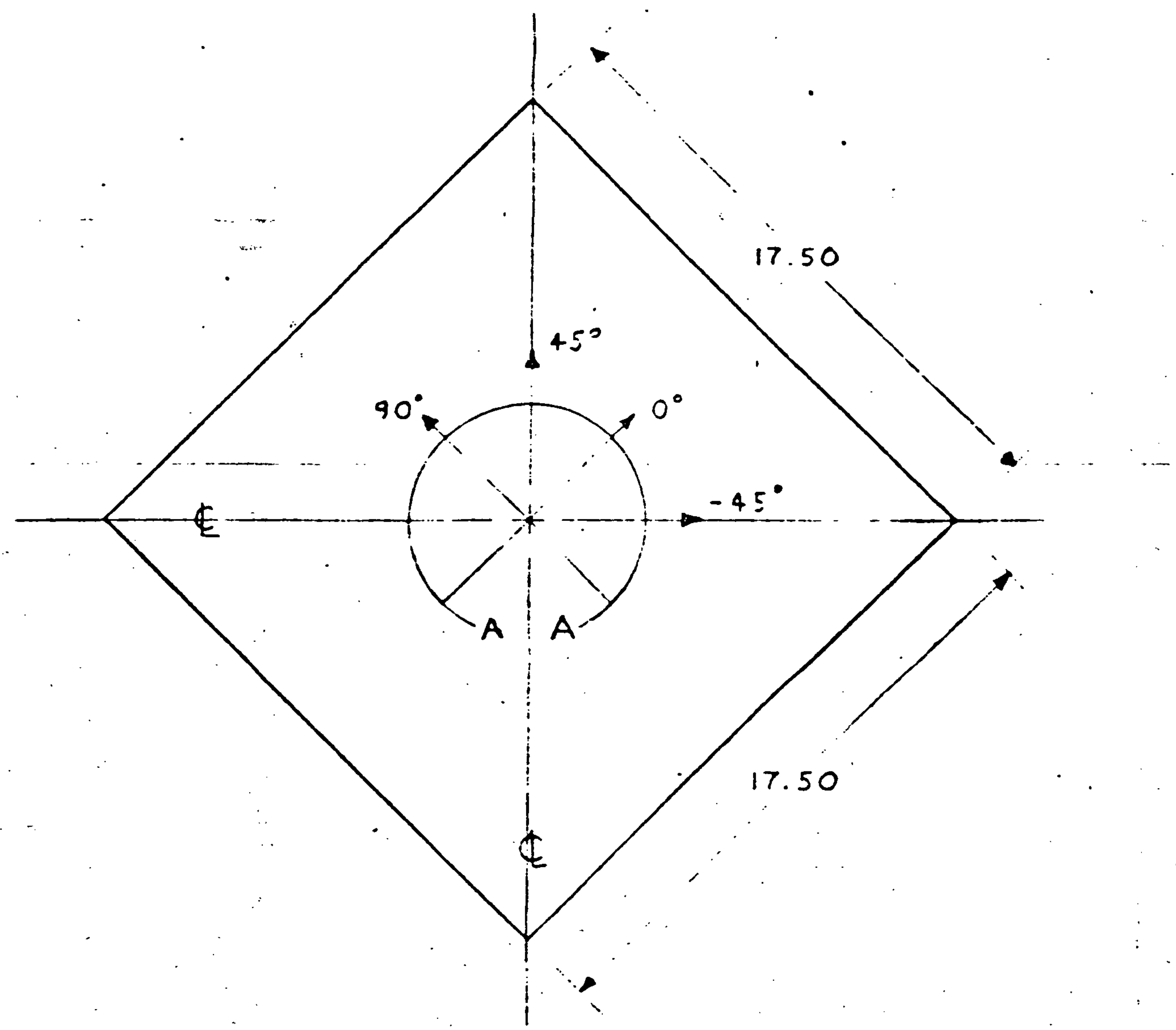
PROJECT TITLE: WOVEN COMPOSITE BUFFER PANELS

DRAWING TITLE: EVERY PLY BUFFER STRIPS

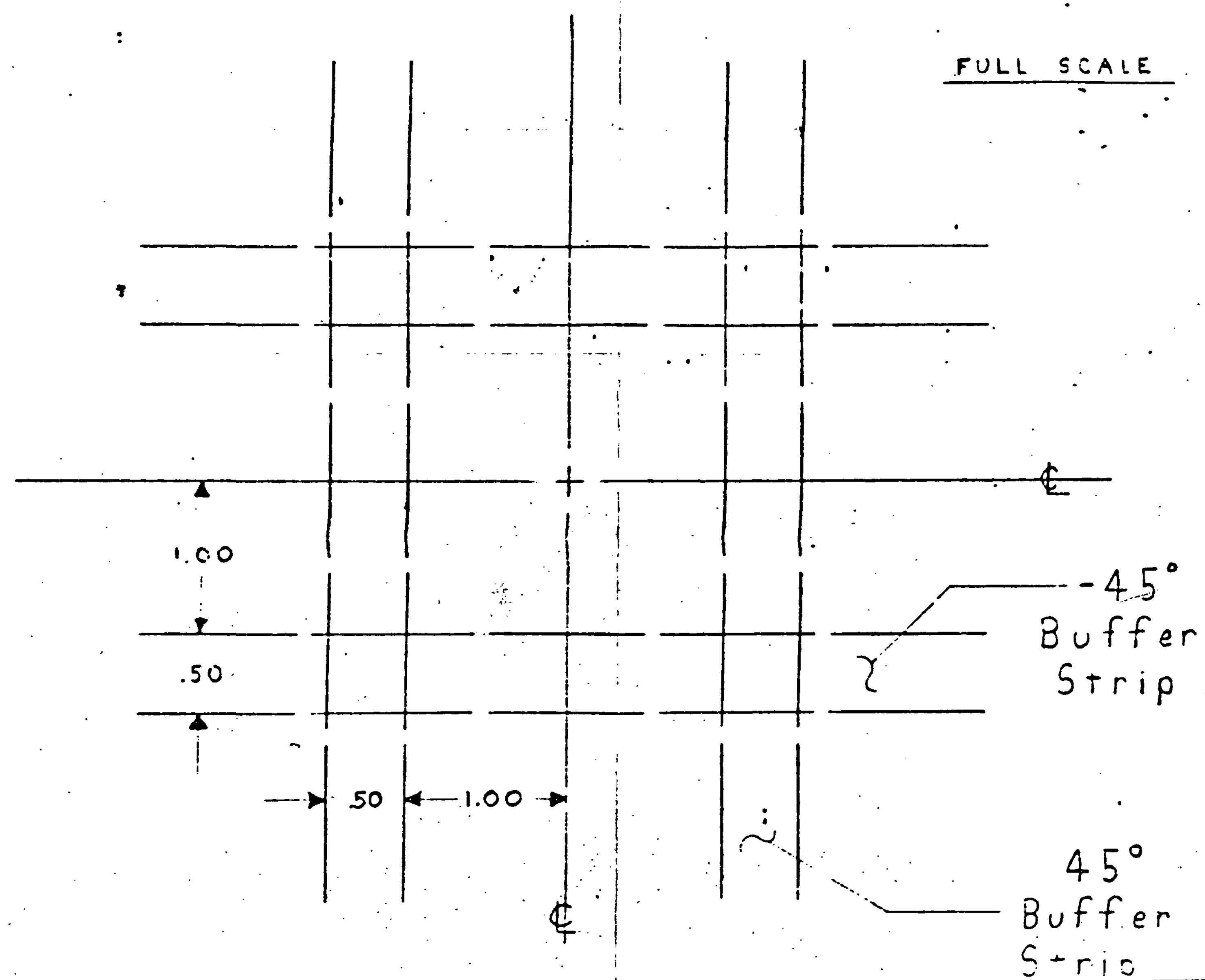
PROJECT NO. | BLDG. NO. | JOB ORDER NO. | SHEET NO. 1 OF 1

LB- 921965
DRAWING NO.

Shear Panel



Detail A-A



DATE	LET	FREQ.	REVISIONS	BY	CK.	APPD.

MATERIAL: T300/5208 ; S-1014/5208

SCALE: As Noted

TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: X.X (1 Decimal Place) ±.1; X.XX (2 Decimal Places) ±.02; X.XXX (3 Decimal Places) ±.005

ANGULAR =

SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE

EST. FIN. WEIGHT

DR.	STRESS
DES.	APPD.
CHK. SAK 9/2/81	APPD.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA 23665

PROJECT TITLE: Woven Composite Buffer Panels

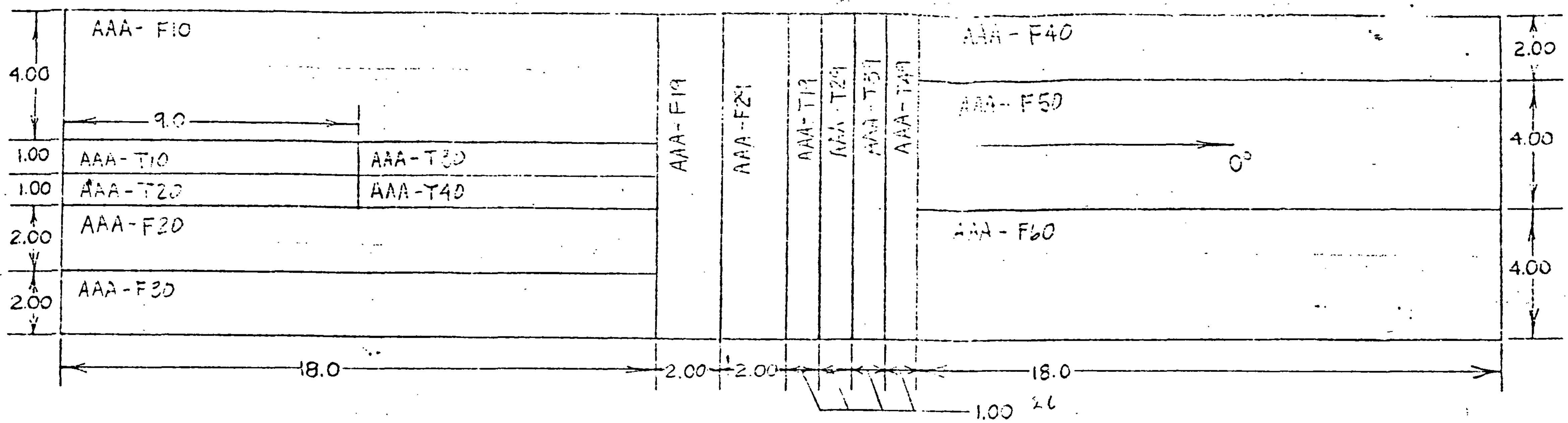
DRAWING TITLE: Shear Panel

PROJECT NO. | BLDG. NO.

JOB ORDER NO. 22 | SHEET NO. of

LB- 921966-A

DRAWING NO.



ALL DIMENSIONS IN INCHES

NOTES

- MAKE ONE PLATE OF EACH LAMINATE NUMBER LARGE ENOUGH TO CUT OUT ALL SPECIMENS
- PUT SPECIMEN NUMBERS ON SPECIMENS. REPLACE AAA WITH APPROPRIATE LAMINATE NUMBER
- RESIN SYSTEM IS 5208
- T300 IS TYPE OF GRAPHITE FIBER. S-1014 IS TYPE OF S-GLASS FIBER
- USE UNIDIRECTIONAL WEAVE CLOTH FOR EVERY PLY

LAMINATE NUMBER	LAMINATE CODE	MATERIAL 0°	±45°	90°
WGR	$[45/0/-45/90]_{2S}$	T300	T300	T300
WC1	$[45/0_{S-GL}/-45/90]_{2S}$	S-1014	T300	T300

DATE	LET	FREQ.	REVISIONS	BY	CK.	APPD.

MATERIAL: AS NOTED
SCALE: 1/4

TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: X.X (1 DECIMAL PLACE) ± .1; X.XX (2 DECIMAL PLACES) ± .02; X.XXX (3 DECIMAL PLACES) ± .005
ANGULAR ±

SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE: √

EST. FIN. WEIGHT

DR. EFK 12/10/80 | STRESS
DES. | APPD.
CHK. | APPD.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA 23665

PROJECT TITLE: WOVEN COMPOSITE BUFFER PANELS

DRAWING TITLE: TENSILE AND FRACTURE COUPONS

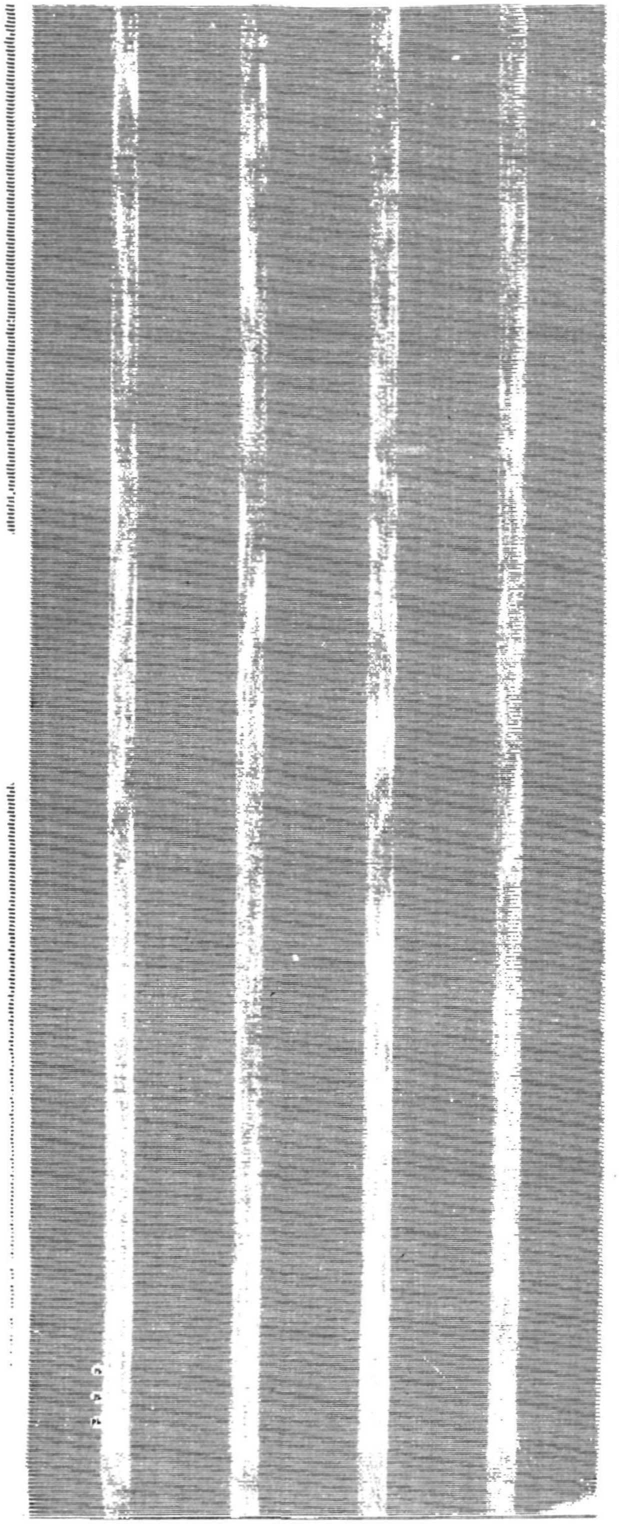
PROJECT NO. | BLDG. NO.
JOB ORDER NO. | SHEET NO. 1 OF 1

LB- 421967
DRAWING NO.

APPENDIX B

C-SCAN NONDESTRUCTIVE INSPECTION

B-1	LB-921963	WCI	Panel 1
B-2	LB-921963	WCI	Panel 2
B-3	LB-921963	WCI	Panel 3
B-4	LB-921963	WDI	Panel 4
B-5	LB-921963	WDI	Panel 5
B-6	LB-921963	WDI	Panel 6
B-7	LB-921963	WGI	Panel 7
B-8	LB-921963	WGI	Panel 8
B-9	LB-921963	WGI	Panel 9
B-10	LB-921964	-	Panel 1
B-11	LB-921964	-	Panel 2
B-12	LB-921964	-	Panel 3
B-13	LB-921965	-	Panel 1
B-14	LB-921965	-	Panel 2
B-15	LB-921965	-	Panel 3
B-16	LB-921966	-	Panel 1
B-17	LB-921966	-	Panel 2
B-18	LB-921966	-	Panel 3
B-19	LB-981966	-	Panel 4
B-20	LB-921966	-	Panel 5
B-21	LB-921966	-	Panel 6
B-22	LB-921967	No Glass	Panel 1
B-23	LB-921967	With Glass	Panel 1



Z921963 PNL #1

WC -1

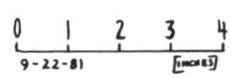
NDE INSPECTION METHOD - ULTRASONICS THROUGH TRANSMISSION

TRANSDUCERS: PULSER - 10MHZ 0.5" M F/L

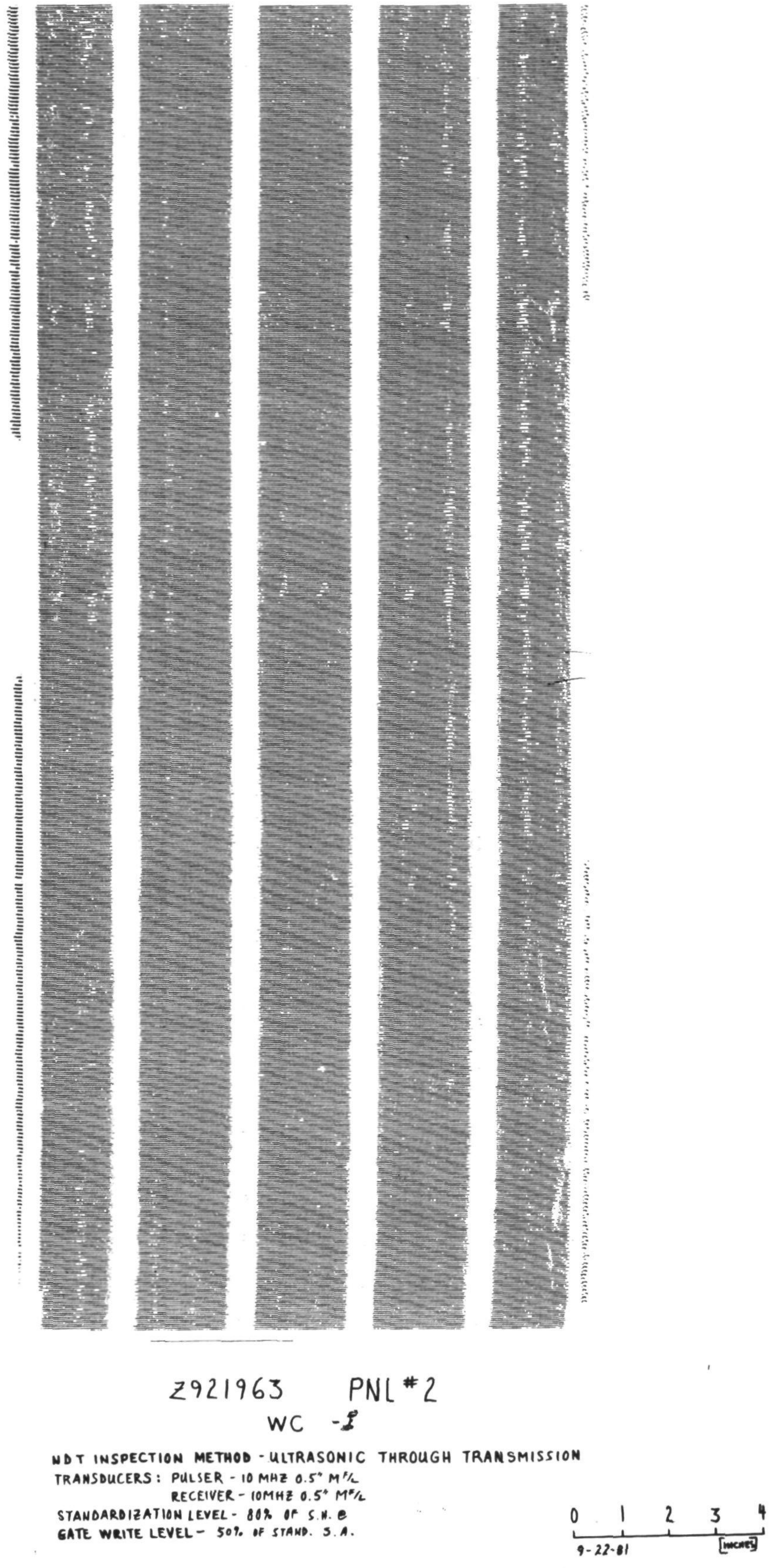
RECEIVER - 10MHZ 0.5" M F/L

STANDARDIZATION LEVEL - 80% OF S.H.

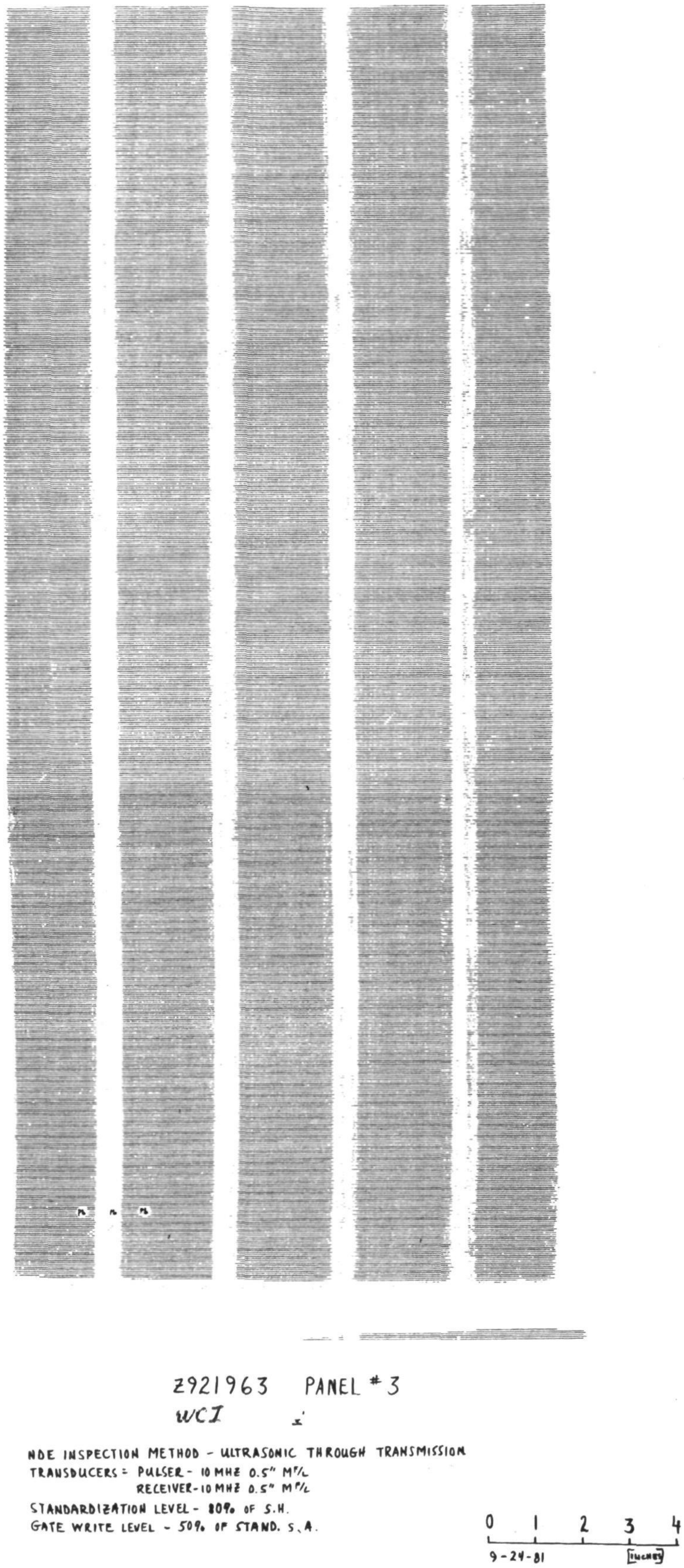
GATE WRITE LEVEL - 50% OF STANDZN. S.A.



B-1 C-SCAN RESULTS LB 921963 WCI - PANEL 1

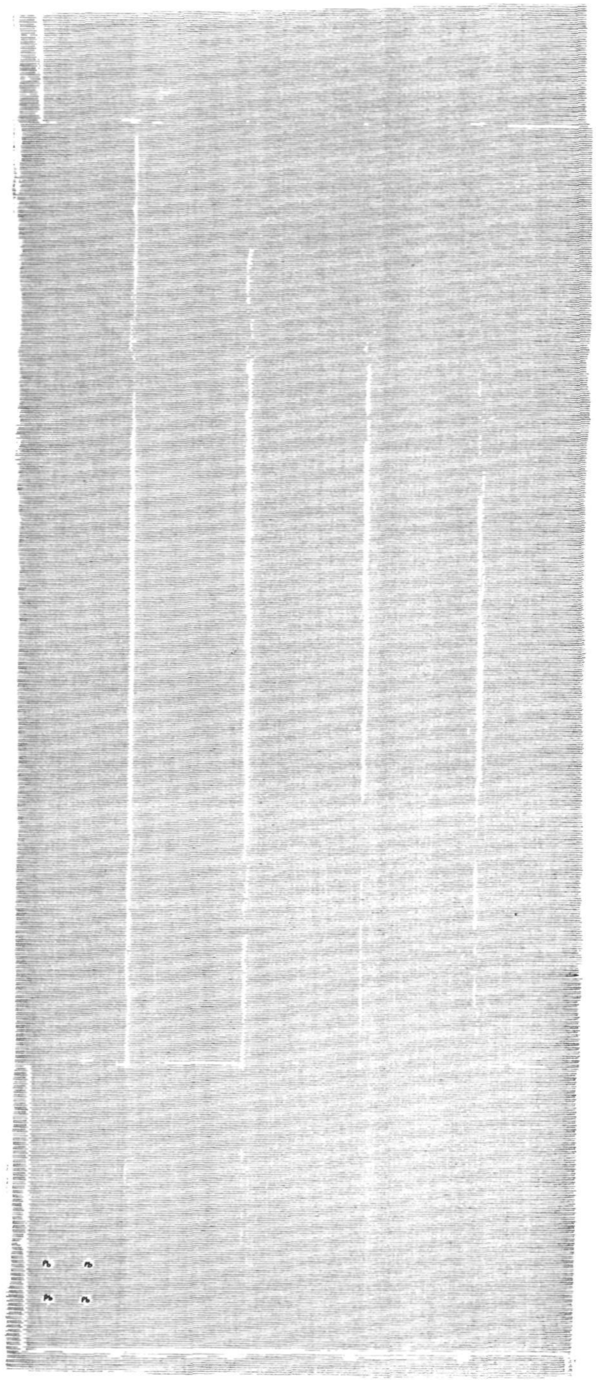


B-2. C-SCAN RESULTS LB 921963 WCI PANEL 2



B-3. C-SCAN RESULTS LB 921963 WCI - PANEL 3

TOP OF PAGE
ONE PER PAGE (SIZE 6½ × 8)



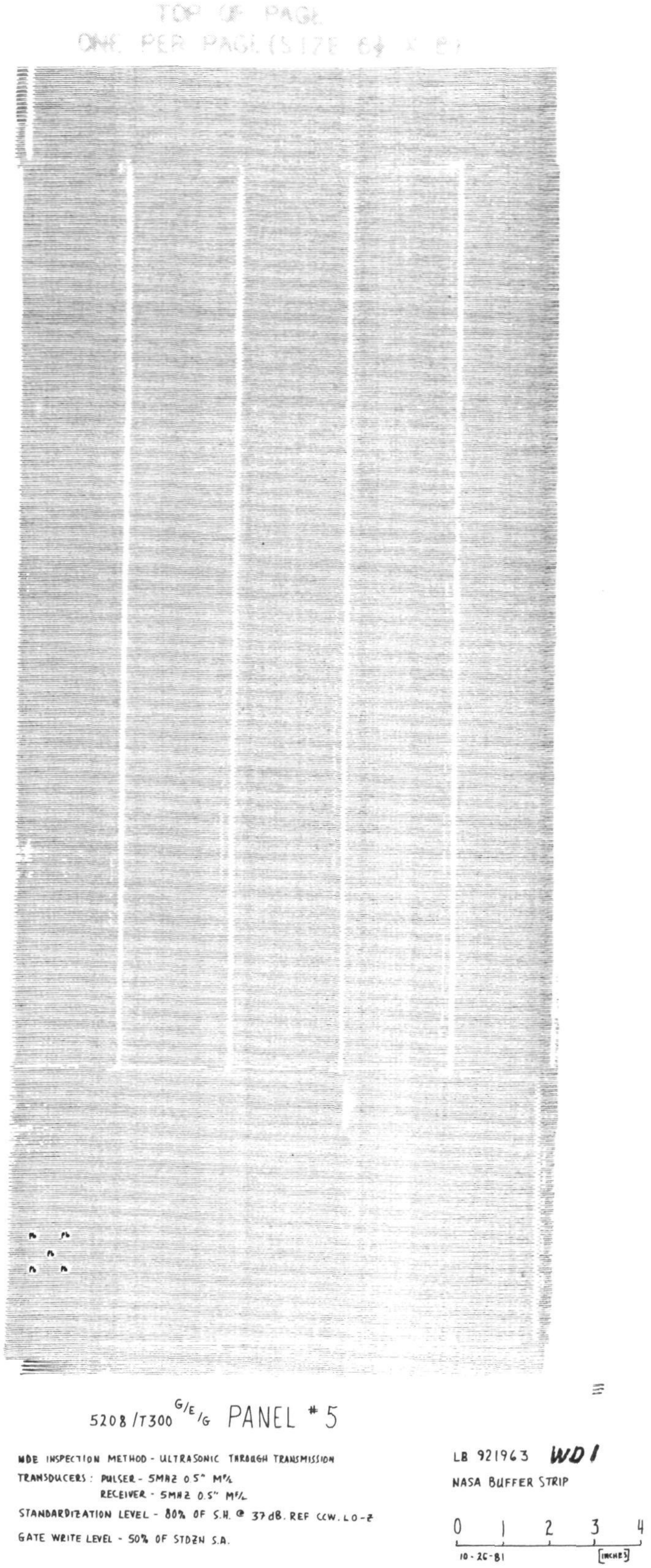
5208/T300 G/E/G PANEL # 4

NDE INSPECTION METHOD - ULTRASONIC THROUGH TRANSMISSION
TRANSDUCERS: PULSER - 5MHZ 0.5" M F/L
RECEIVER - 5MHZ 0.5" M F/L
STANDARDIZATION LEVEL - 80% OF S.H. @ 37dB, REF CCW, LO-Z
GATE WRITE LEVEL - 50% OF STDZN. S.A.

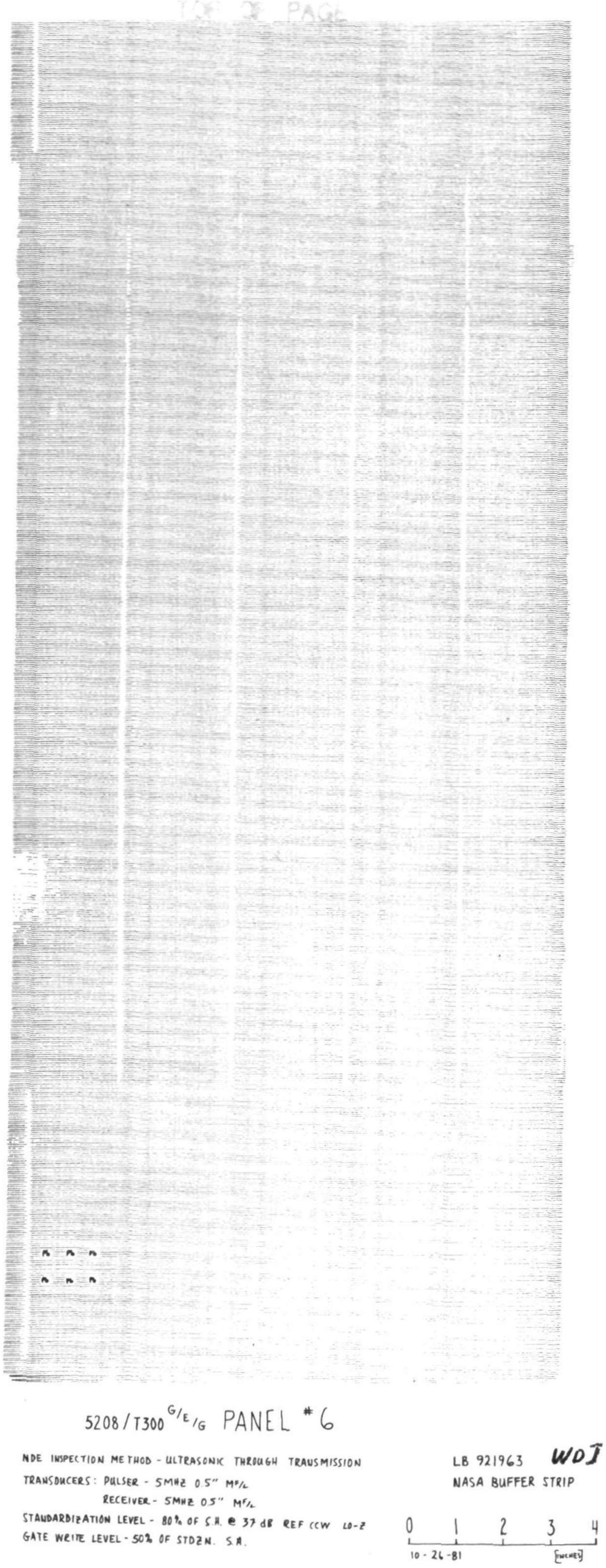
LB 921963 WDI
NASA BUFFER STRIP

0 1 2 3 4
10-27-81 (INCHES)

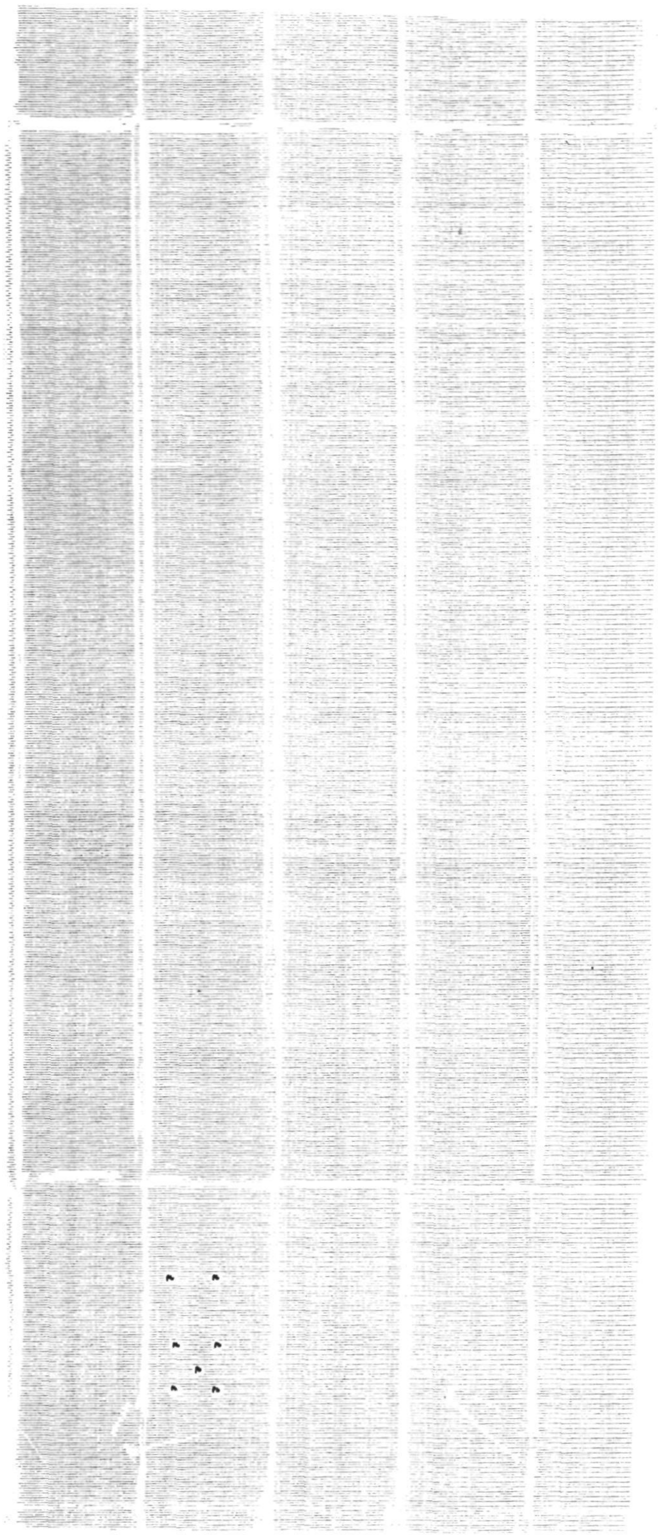
B-4. C-SCAN RESULTS LB 921963 WDI - PANEL 4



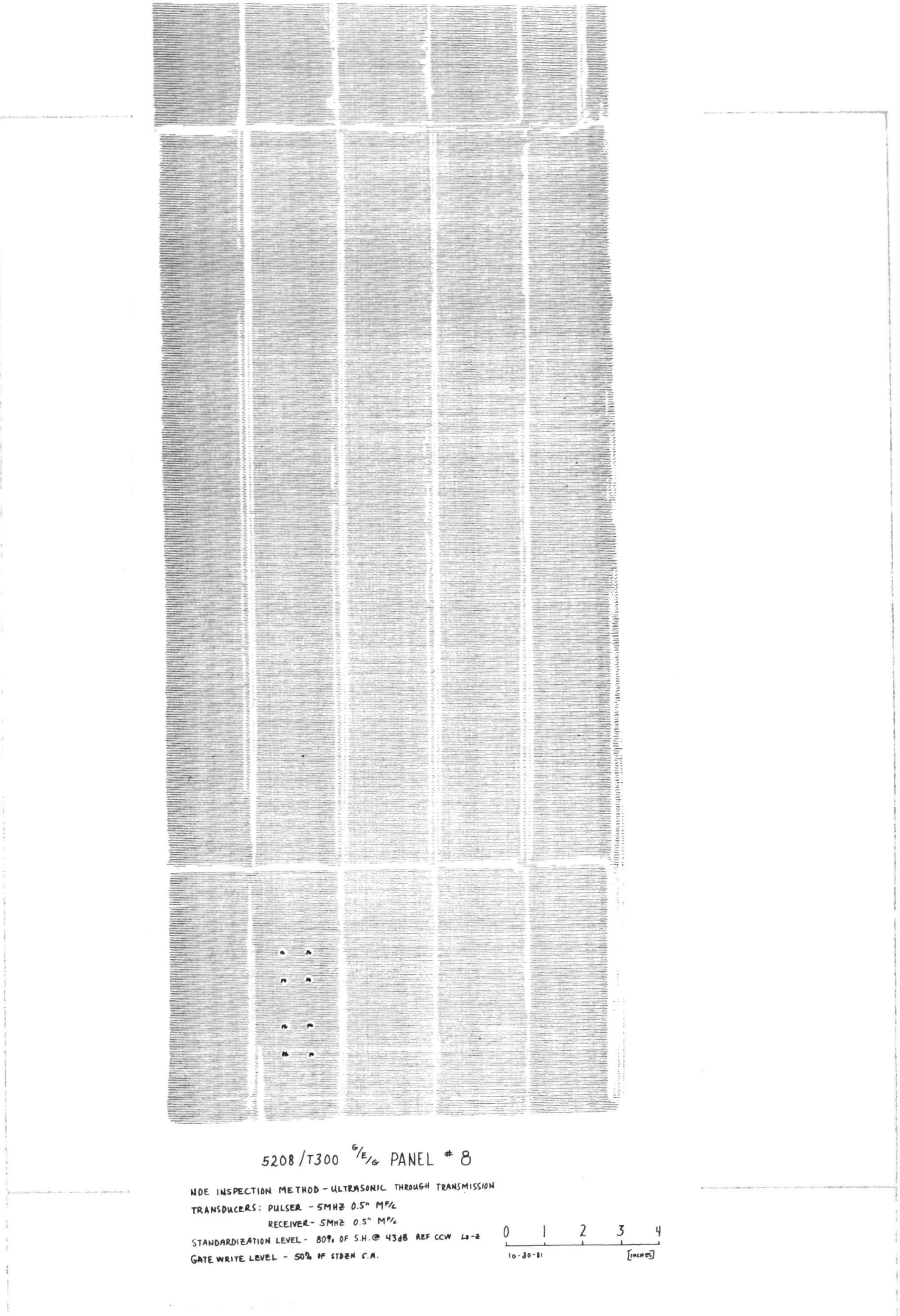
B-5. C-SCAN RESULTS LB 921963 WDI - PANEL 5



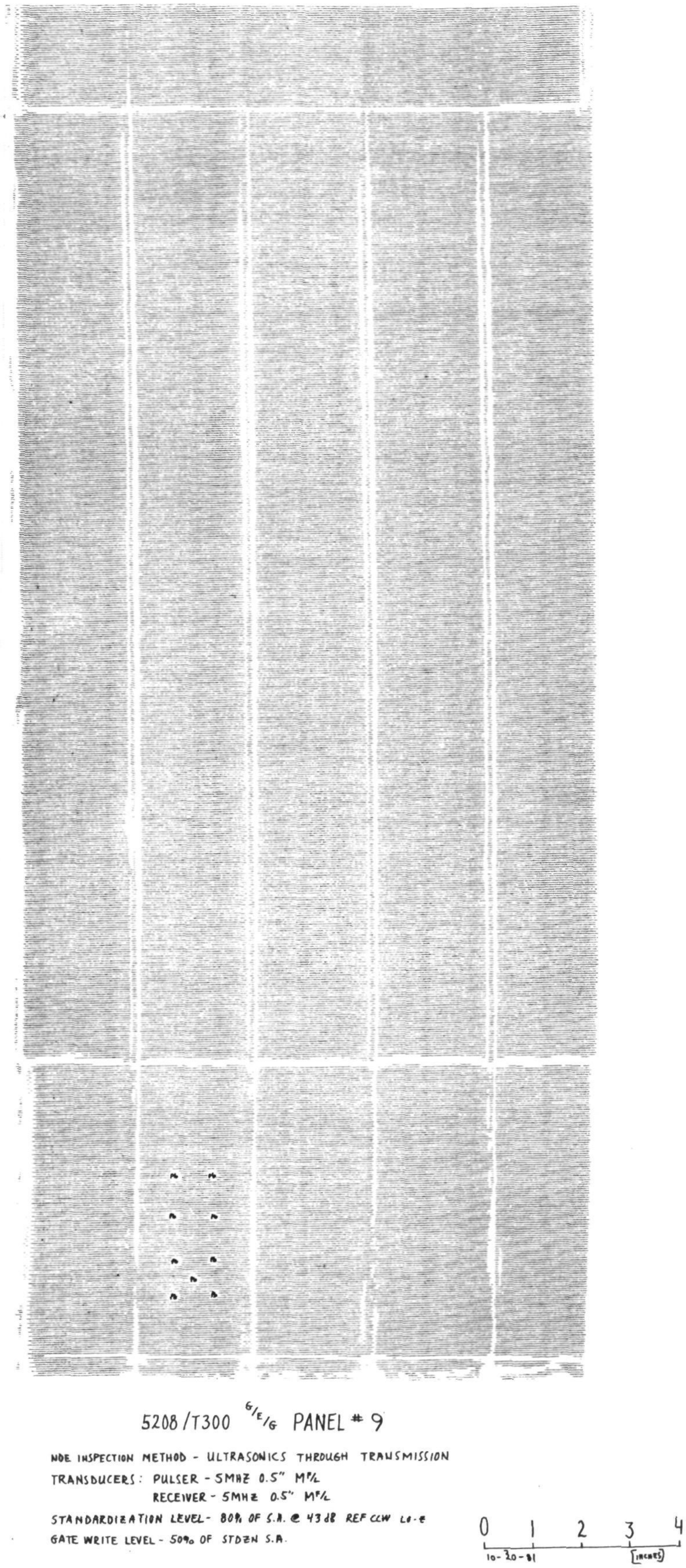
B-6. C-SCAN RESULTS LB 921963 WDI - PANEL 6



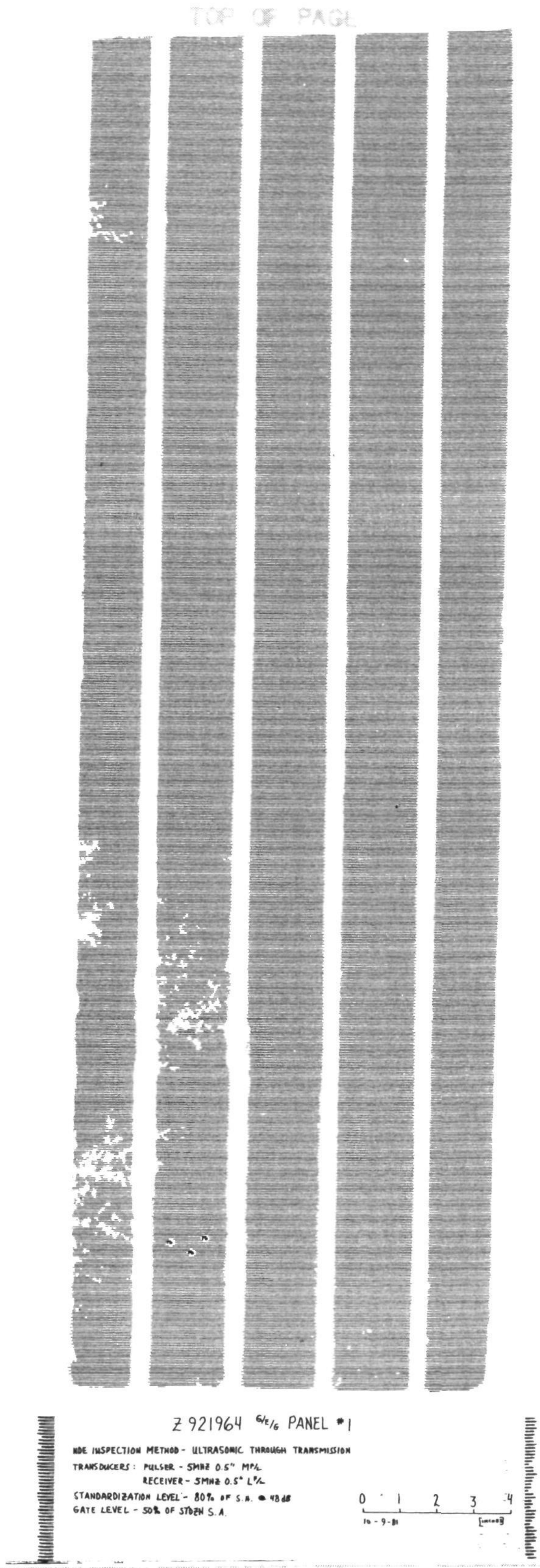
B-7. C-SCAN RESULTS LB 921963 WGI - PANEL 7



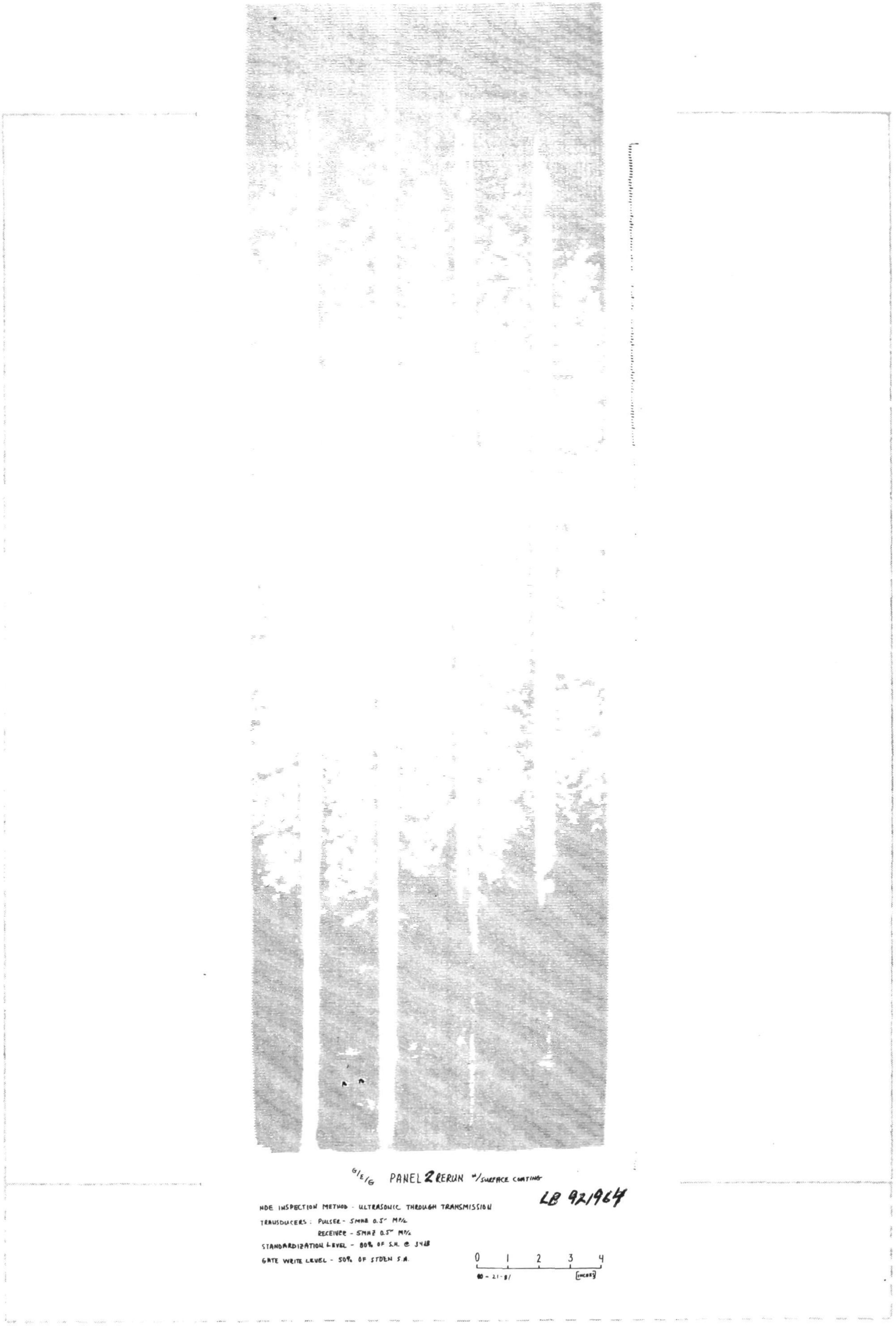
B-8. C-SCAN RESULTS LB 921963 WGI - PANEL 8



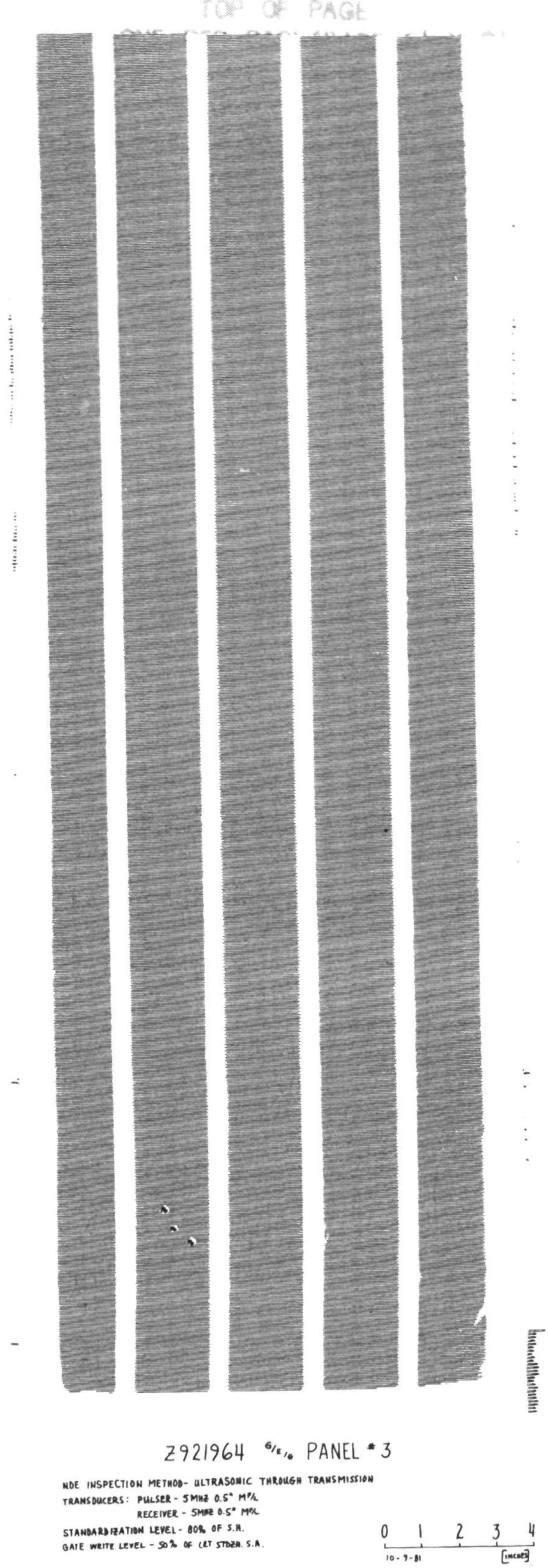
B-9. C-SCAN RESULTS LB 921963 WGI - PANEL 9



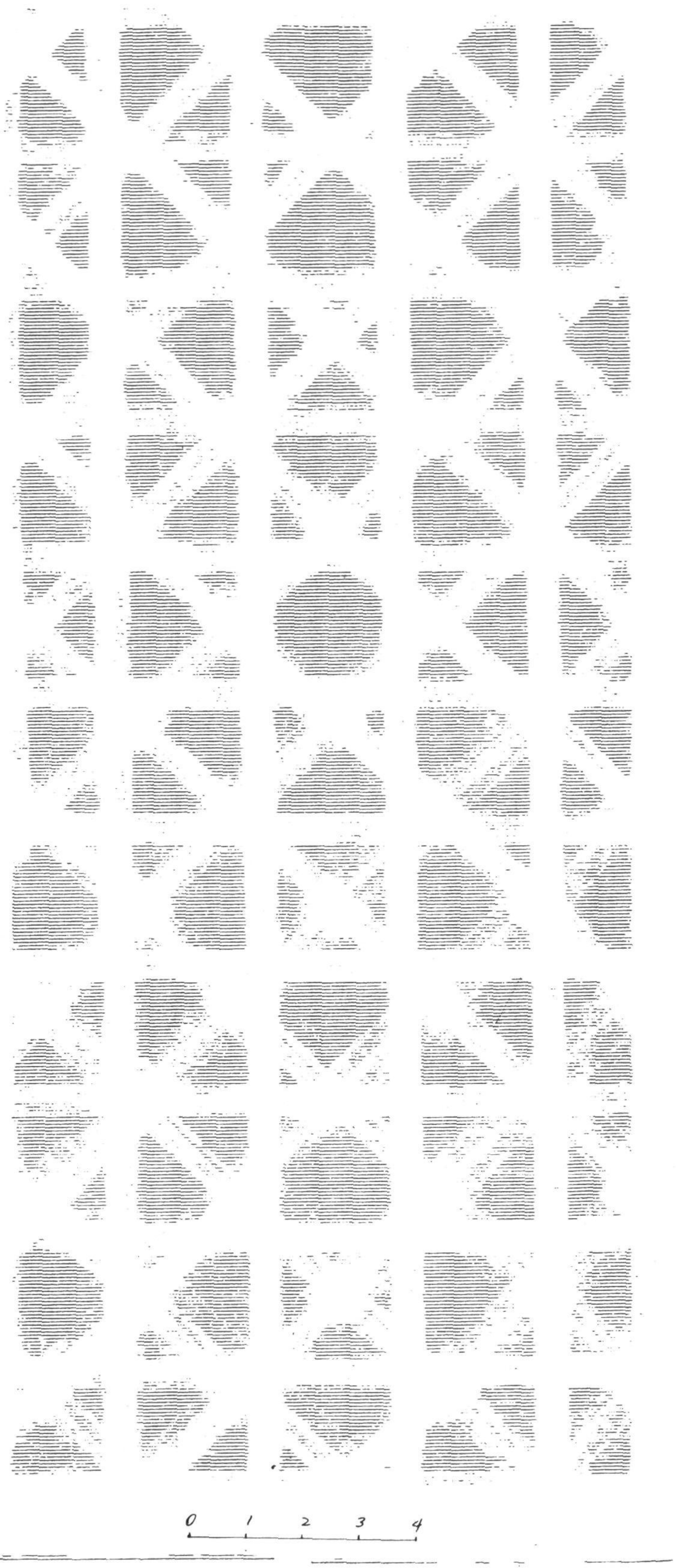
B-10. C-SCAN RESULTS LB 921964 - PANEL 1



B-11. C-SCAN RESULTS LB 921964 - PANEL 2



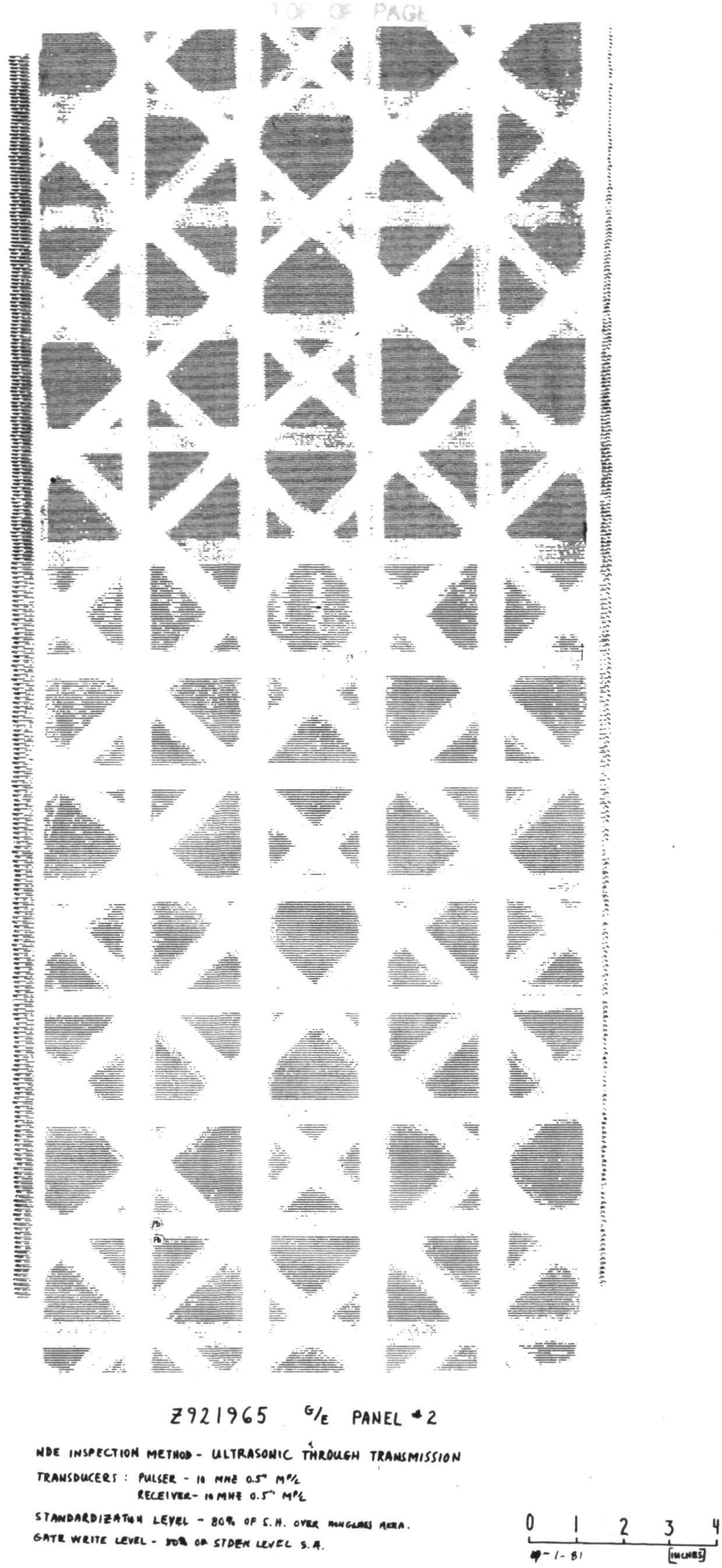
B-12. C-SCAN RESULTS LB 921964 - PANEL 3



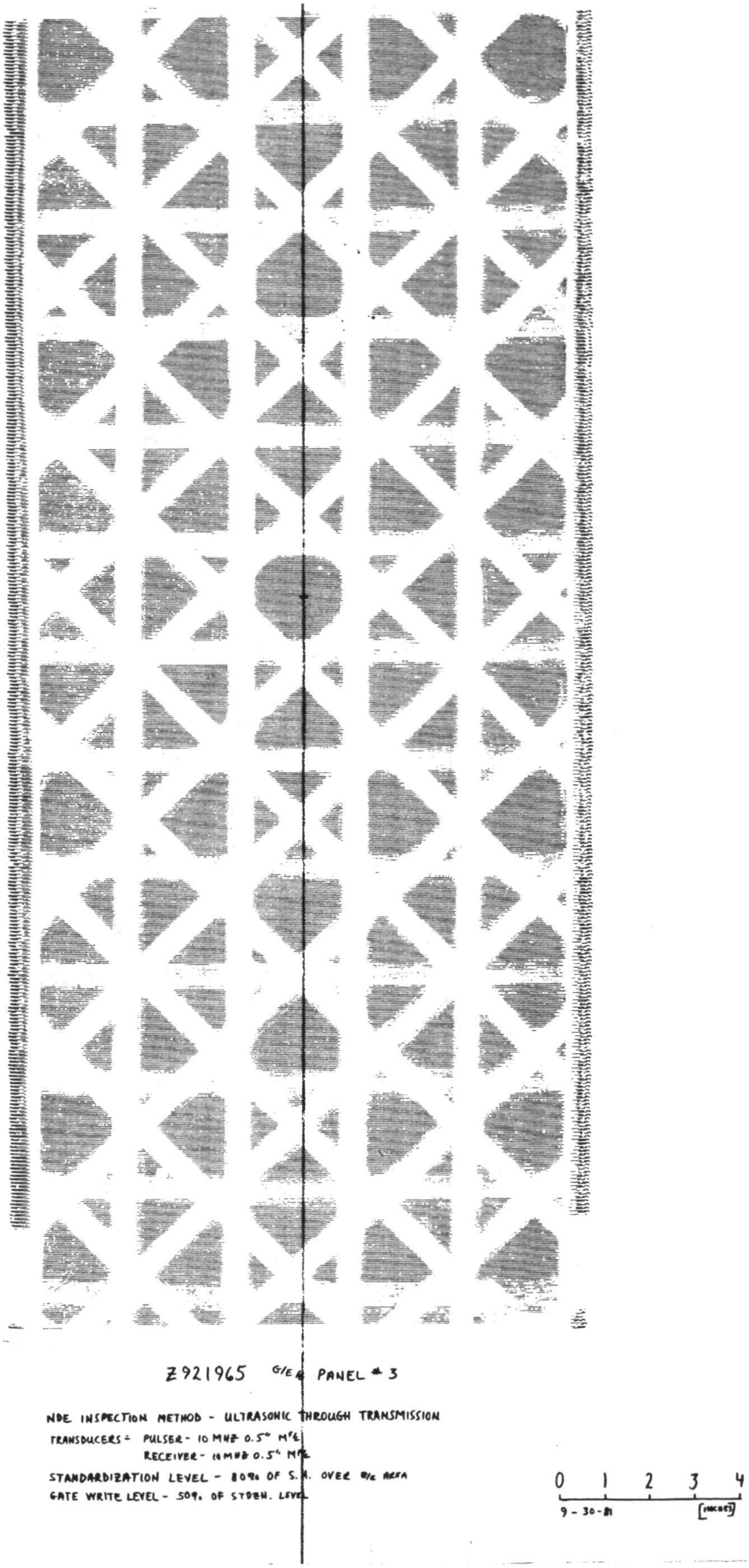
921965 PANEL #1

9/16/84

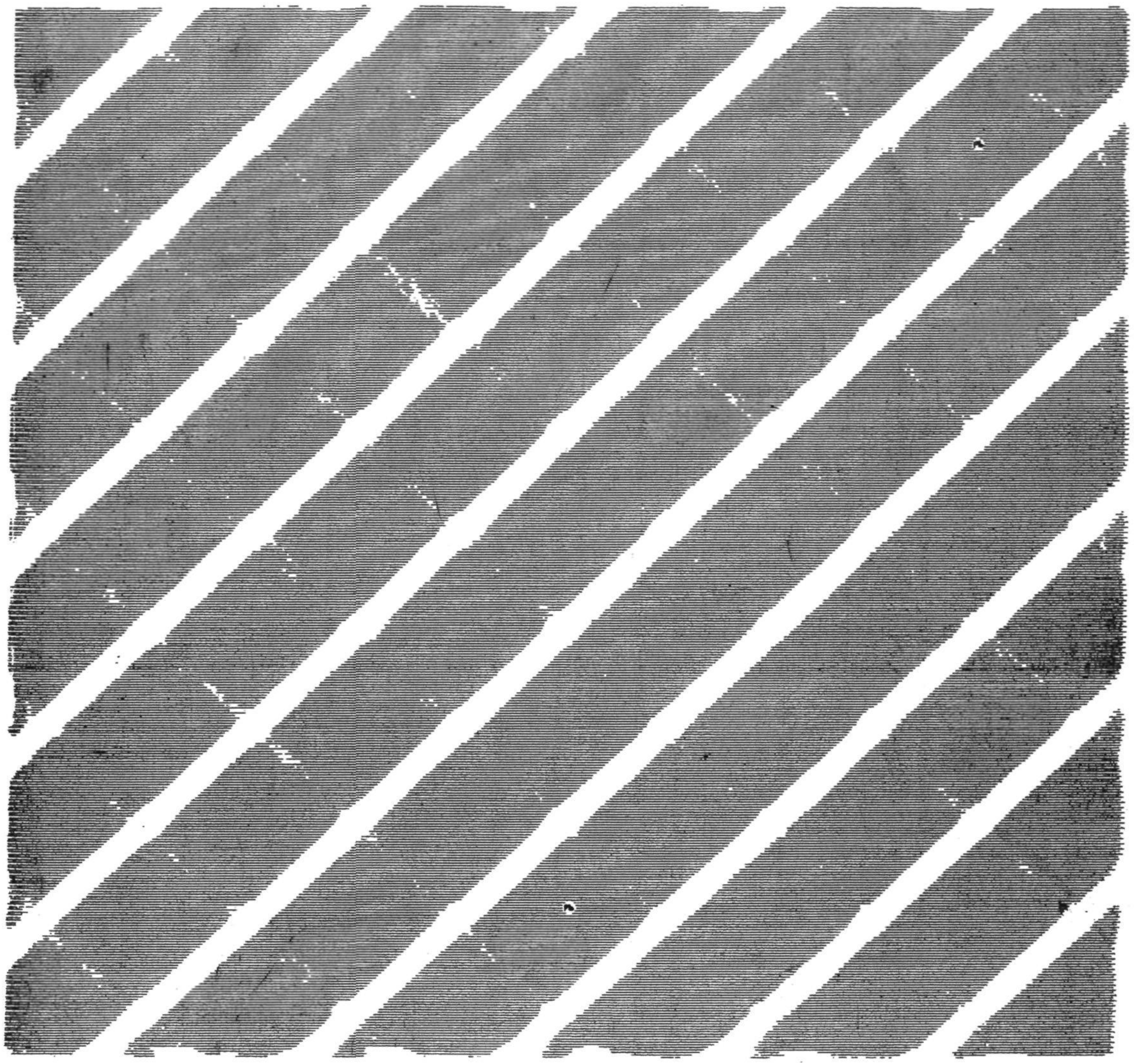
B-13. C-SCAN RESULTS LB 921965 - PANEL 1



B-14. C-SCAN RESULTS LB 921965 - PANEL 2

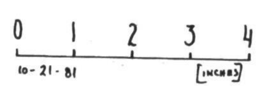


B-15. C-SCAN RESULTS LB 921965 - PANEL 3

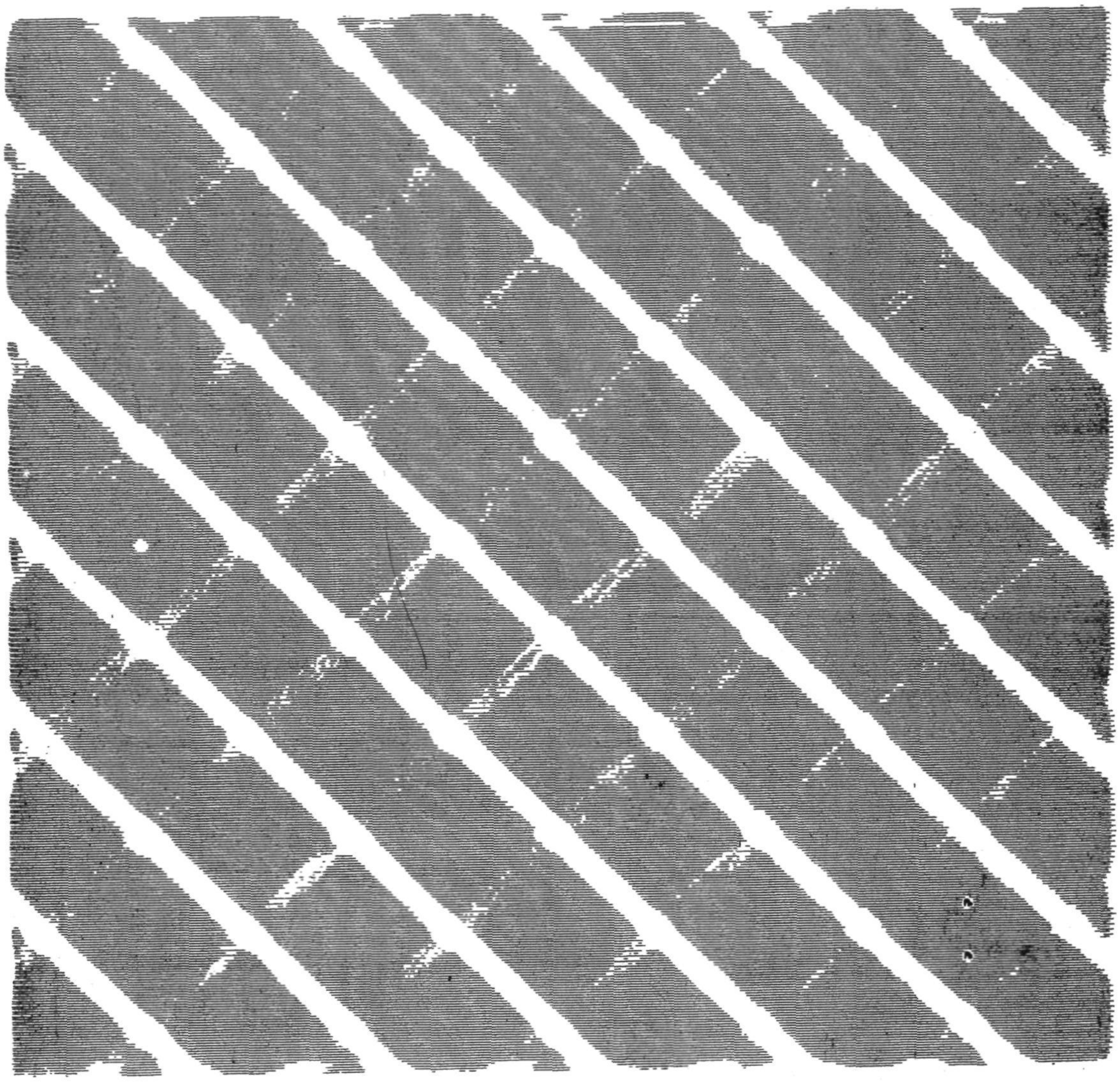


G/E/G PANEL #1

NDE INSPECTION METHOD - ULTRASONIC THROUGH TRANSMISSION
TRANSDUCERS: PULSER - 5MHZ 0.5" MF/L
RECEIVER - 5MHZ 0.5" MF/L
STANDARDIZATION LEVEL - 80% OF S.H. @ 65dB
GATE WRITE LEVEL - 50% OF STDZN S.A.



B-16. C-SCAN RESULTS LB 921966 [± 45]$_{4s}$ - PANEL 1



G/E/G PANEL #2

NDE INSPECTION METHOD - ULTRASONIC THROUGH TRANSMISSION

TRANSDUCERS: PULSER - 5MHZ 0.5" M F/L

RECEIVER - 5MHZ 0.5" M F/L

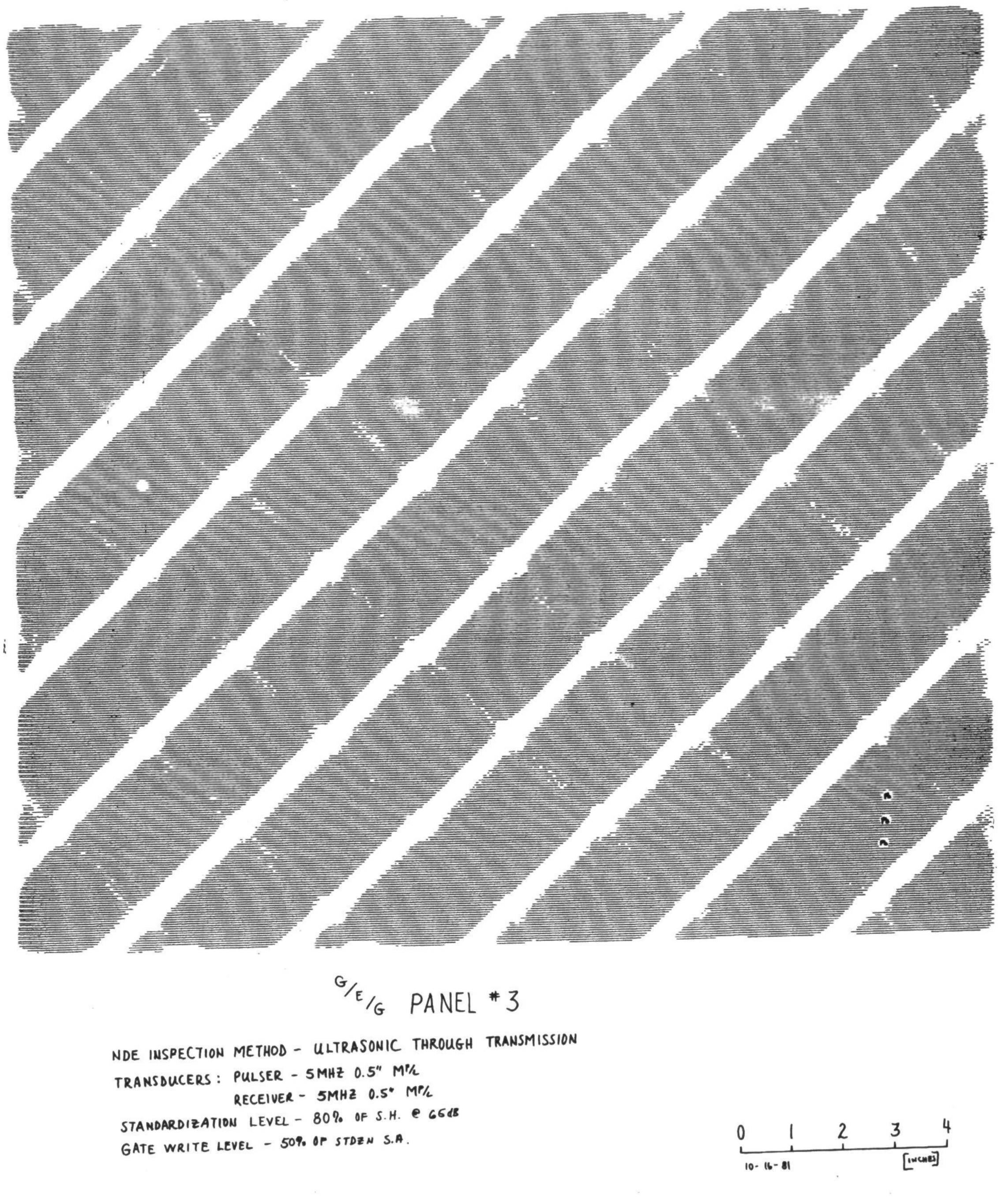
STANDARDIZATION LEVEL - 80% OF S.H. @ 65dB

GATE WRITE LEVEL - 50% OF STDZN S.A.

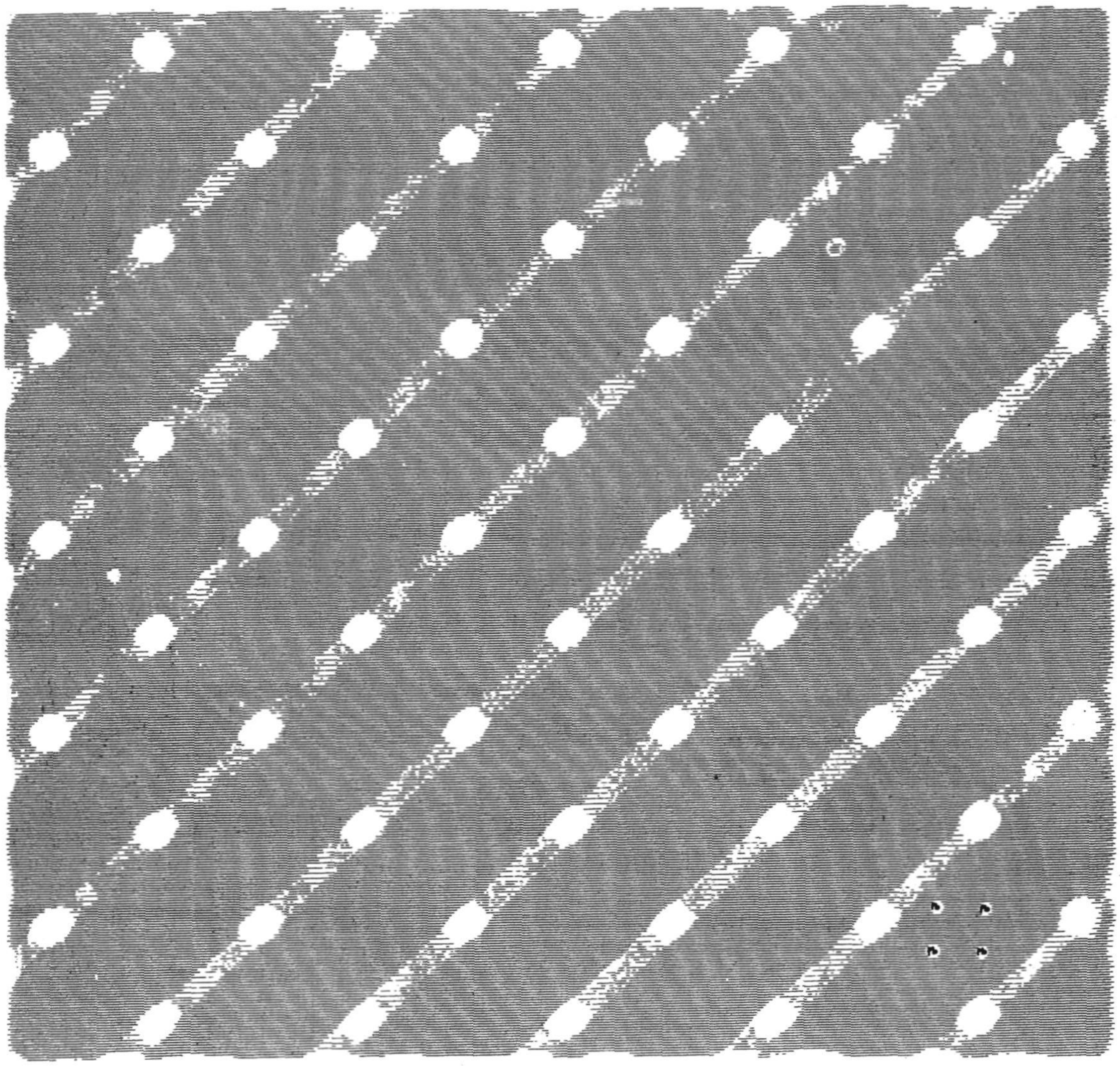
0 1 2 3 4

10-26-81 [INCHES]

B-17. C-SCAN RESULTS LB 921966 [$\pm$ 45]$_{4s}$ - PANEL 2



B-18. C-SCAN RESULTS LB 921966 [$\pm$ 45]$_{4s}$ - PANEL 3



G/E/G PANEL #4

NDE INSPECTION METHOD - ULTRASONIC THROUGH TRANSMISSION

TRANSDUCERS: PULSER - 5MHZ 0.5" MF/L

RECEIVER - 5MHZ 0.5" MF/L

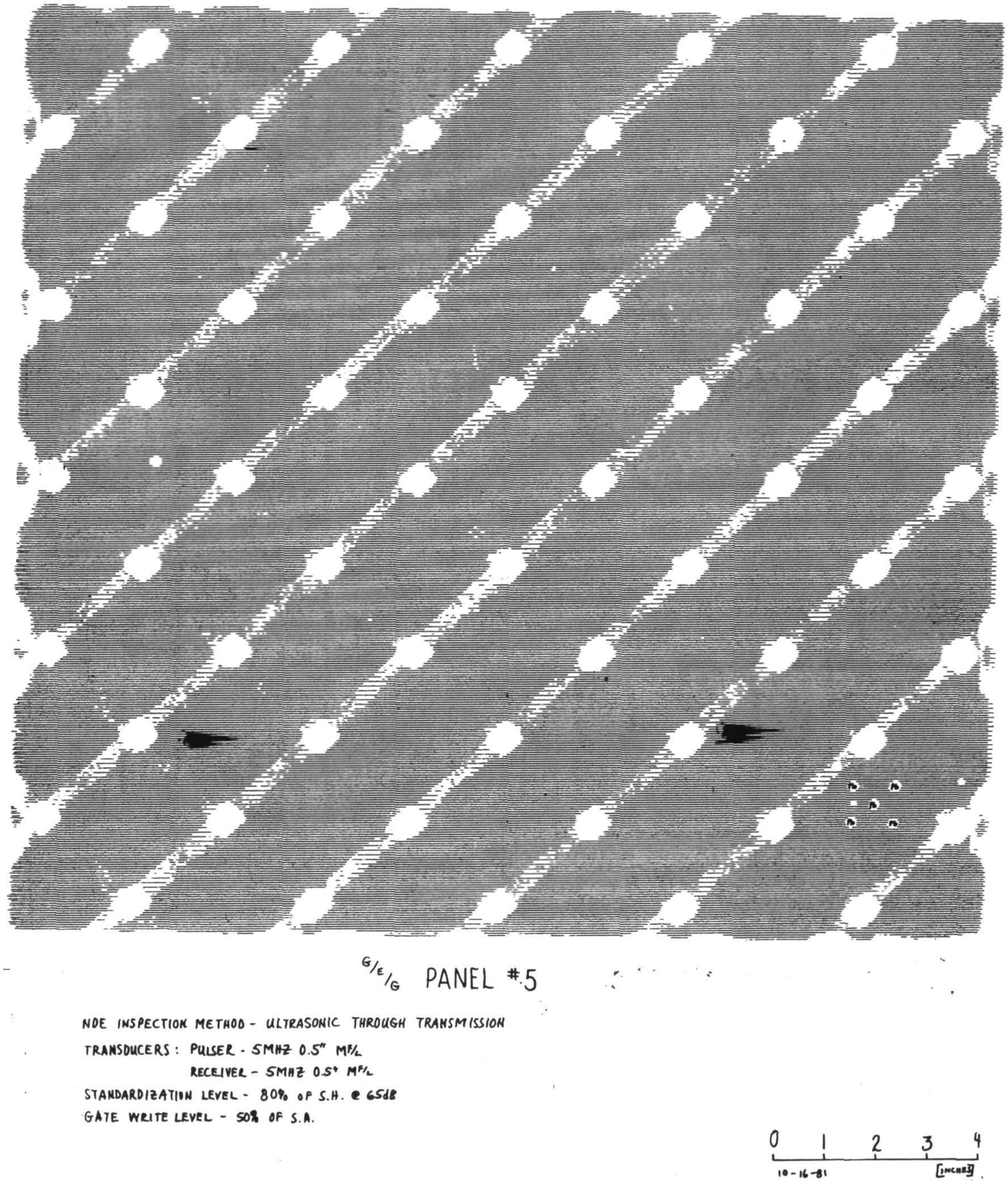
STANDARDIZATION LEVEL - 80% OF S.H. @ 65dB

GATE WRITE LEVEL - 50% OF STDZN S.A.

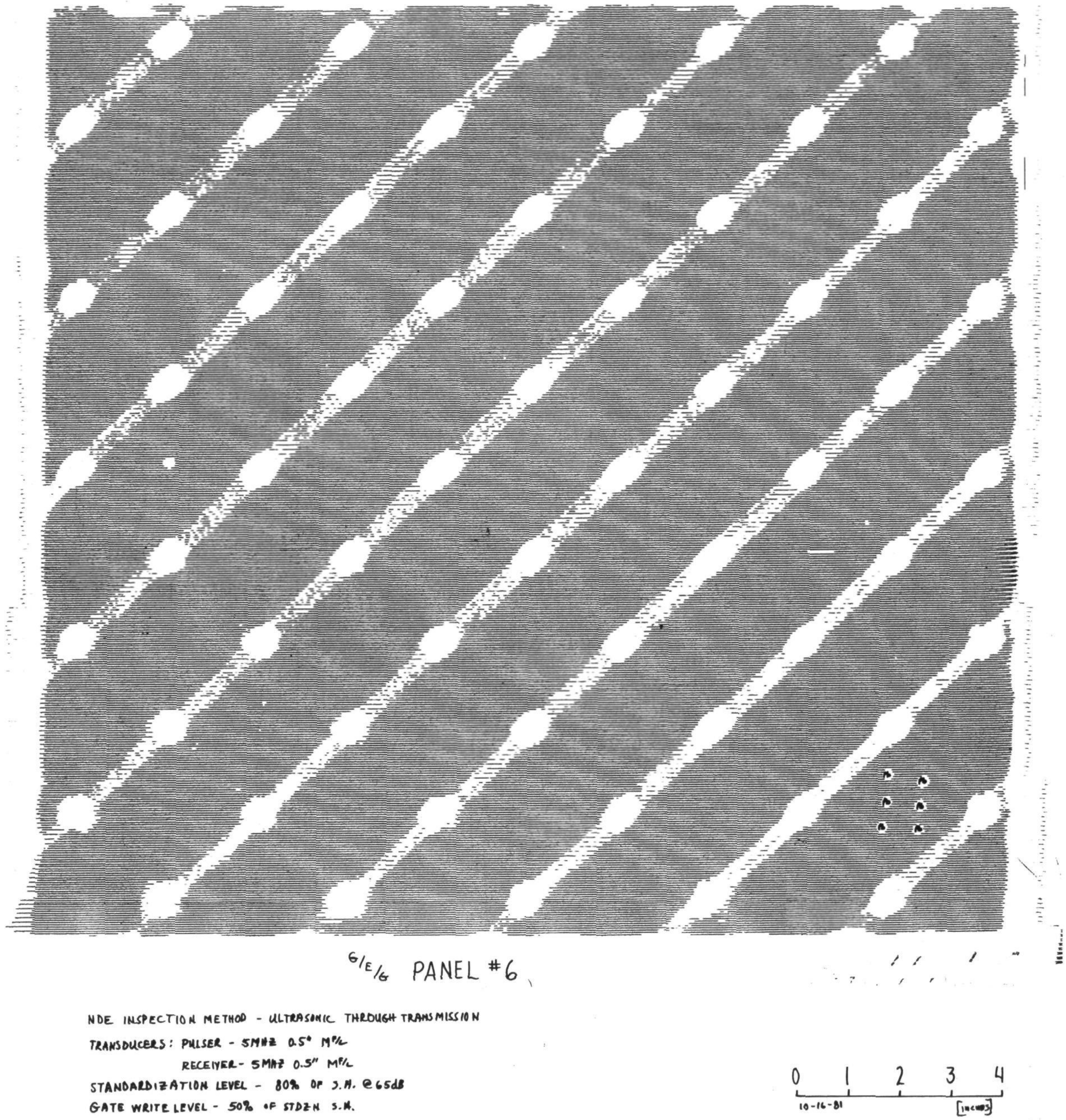
0 1 2 3 4

10-16-81 [INCHES]

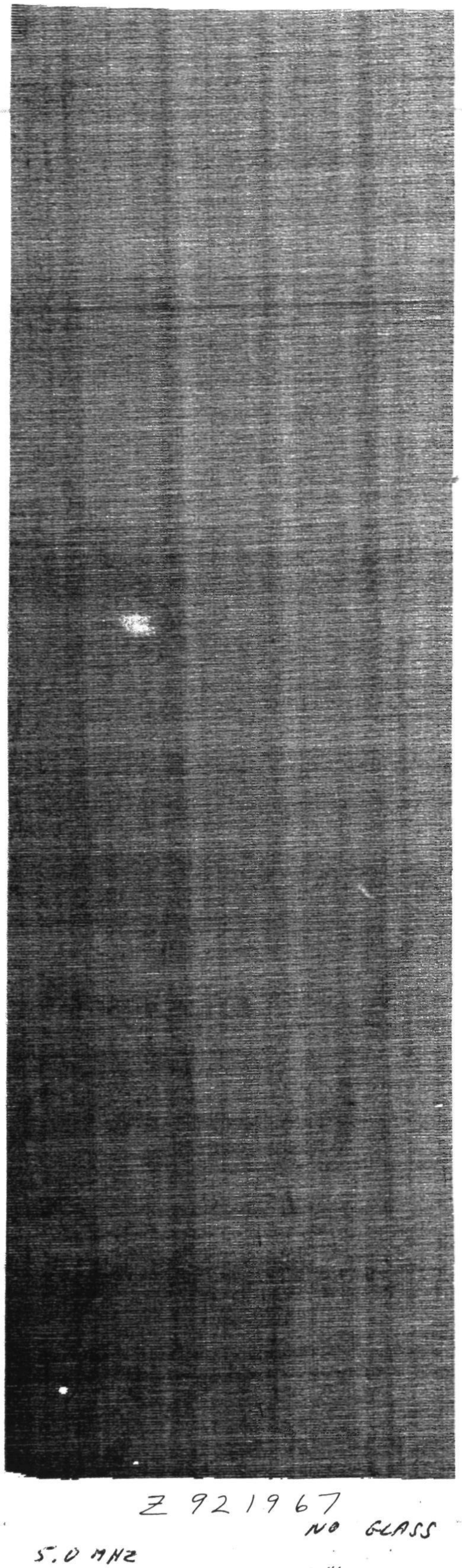
B-19. C-SCAN RESULTS LB 921966 $[+45, 0, -45, 90]_{2s}$ - PANEL 4



B-20. C-SCAN RESULTS LB 921966 $[+45, 0, -45, 90]_{2s}$ - PANEL 5



B-21. C-SCAN RESULTS LB 921966 $[+45, 0, -45, 90]_{2s}$ - PANEL 6

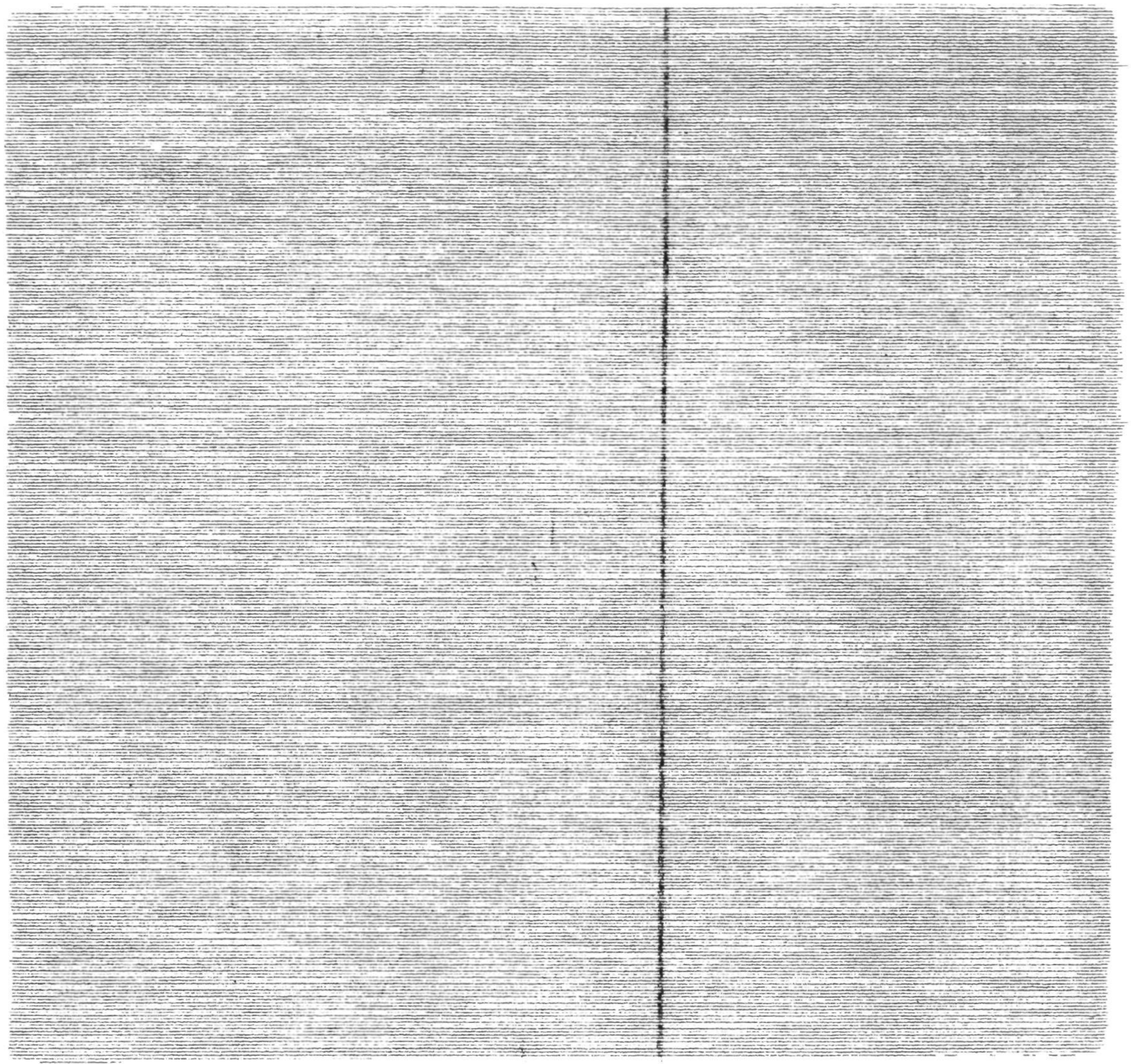


Z 921967 NO GLASS

5.0 MHZ
THRU-TRANS

0 1 2 3 4

B-22. C-SCAN RESULTS LB 921967 - NO GLASS - PANEL 1



0°

5208 / T300 W/0° GLASS

WCI LB9121967

NDE INSPECTION METHOD - ULTRASONIC THROUGH TRANSMISSION

TRANSDUCERS: PULSER - 5MHZ 0.5" MF/L

RECEIVER - 5MHZ 0.5" MF/L

STANDARDIZATION LEVEL - 80% OF S.H. @ 42dB, REF CCW, LO-Z

GATE WRITE LEVEL - 50% OF STDZN. S.A.

0 1 2 3 4

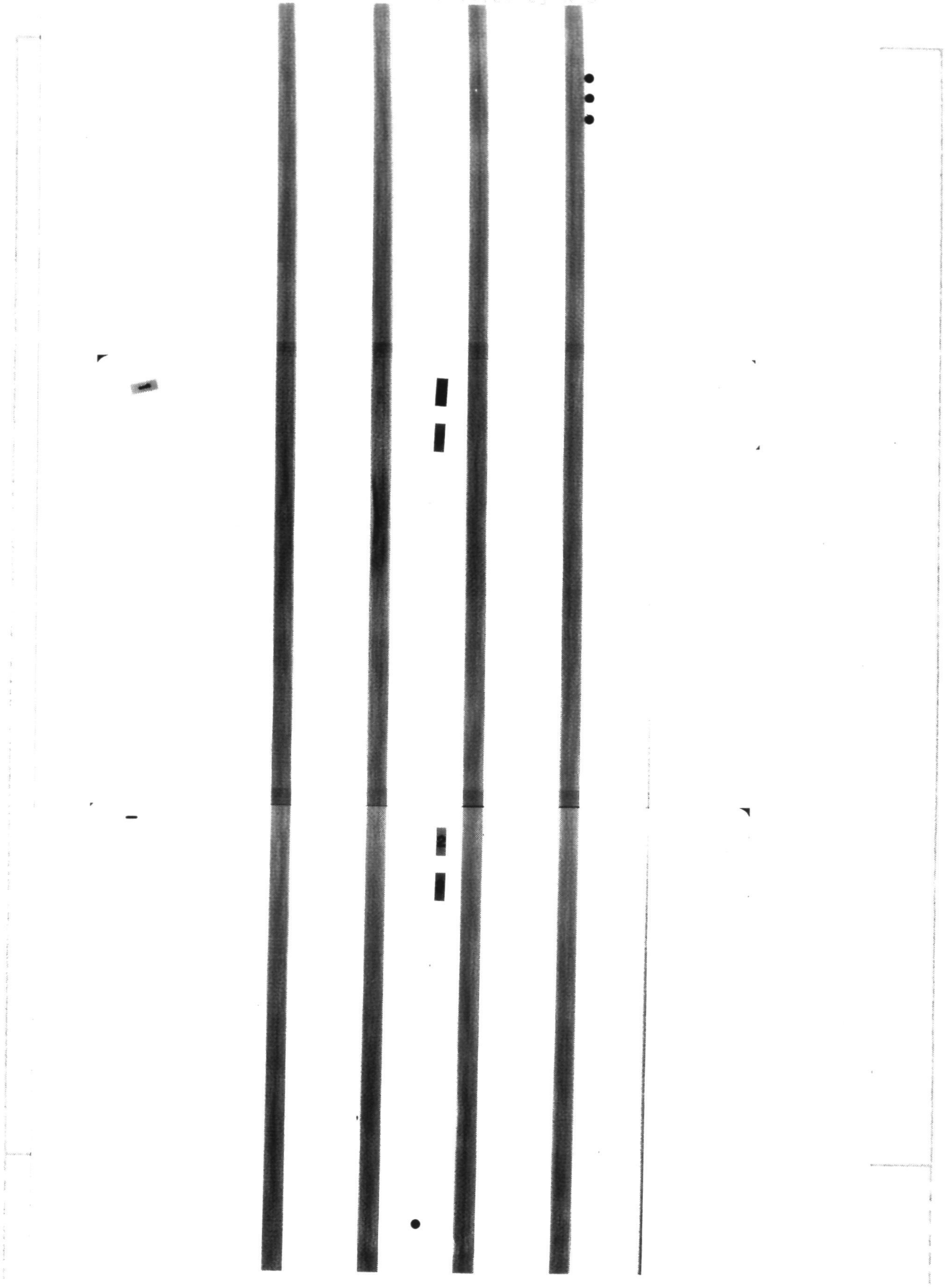
11-25-81 [INCHES]

B-23. C-SCAN RESULTS LB 921967 0° UNIWOVEN GLASS CLOTH

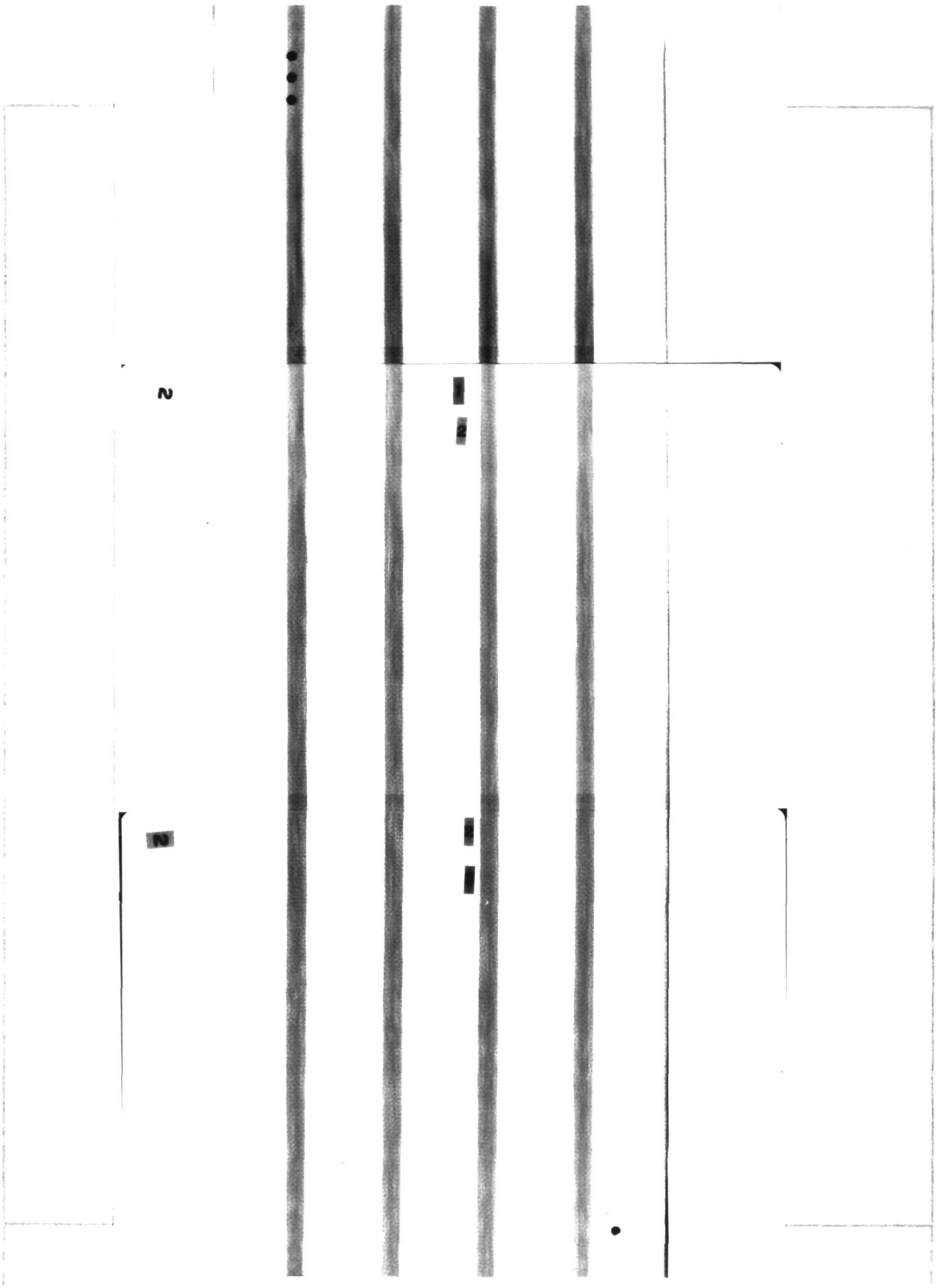
APPENDIX C

X-RAY NONDESTRUCTIVE INSPECTION

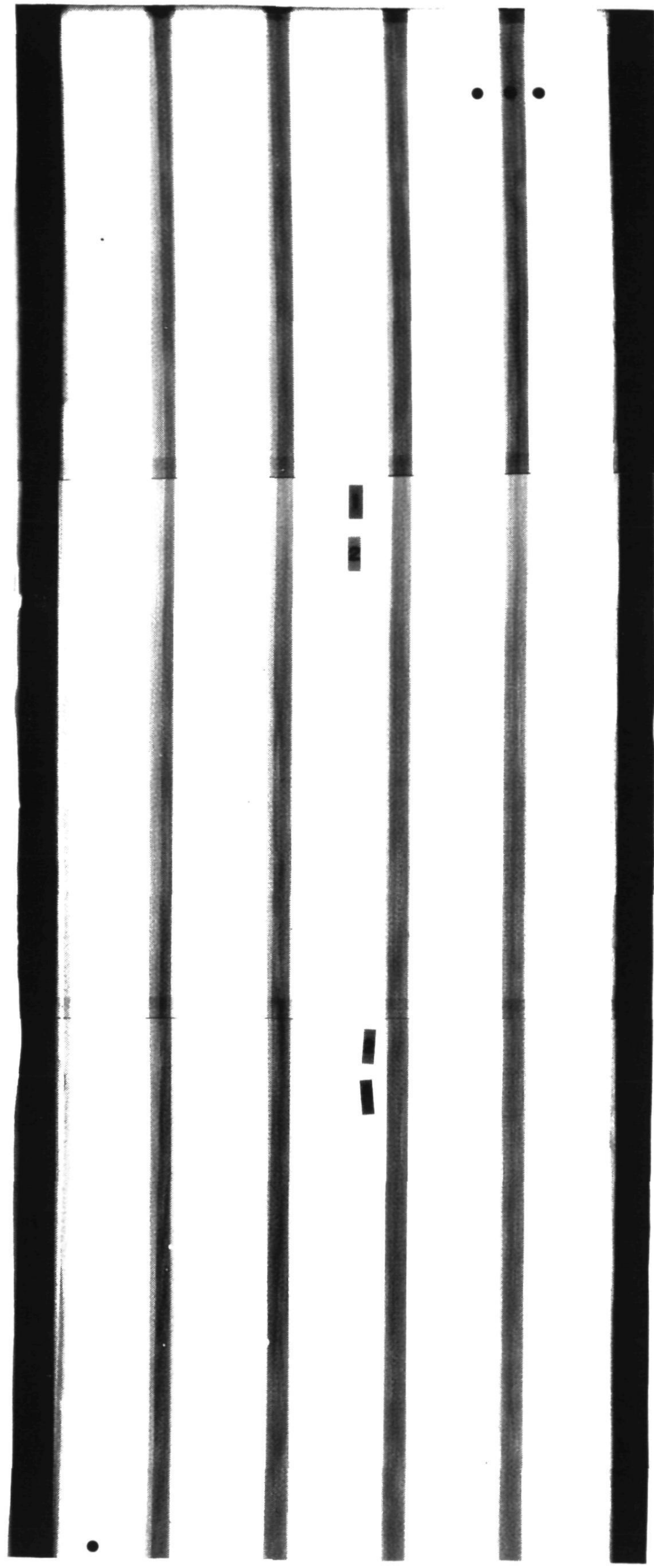
C-1	LB-921963	WCI	Panel 1
C-2	LB-921963	WCI	Panel 2
C-3	LB-921963	WCI	Panel 3
C-4	LB-921963	WCI	Panel 4
C-5	LB-921963	WDI	Panel 5
C-6	LB-921963	WDI	Panel 6
C-7	LB-921963	WGI	Panel 7
C-8	LB-921963	WGI	Panel 8
C-9	LB-921963	WGI	Panel 9
C-10	LB-921964	-	Panel 1
C-11	LB-921964	-	Panel 2
C-12	LB-921964	-	Panel 3
C-13	LB-921965	-	Panel 1
C-14	LB-921965	-	Panel 2
C-15	LB-921965	-	Panel 3
C-16	LB-921966	-	Panel 1
C-17	LB-921966	-	Panel 2
C-18	LB-921966	-	Panel 3
C-19	LB-921966	-	Panel 4
C-20	LB-921966	-	Panel 5
C-21	LB-921966	-	Panel 6



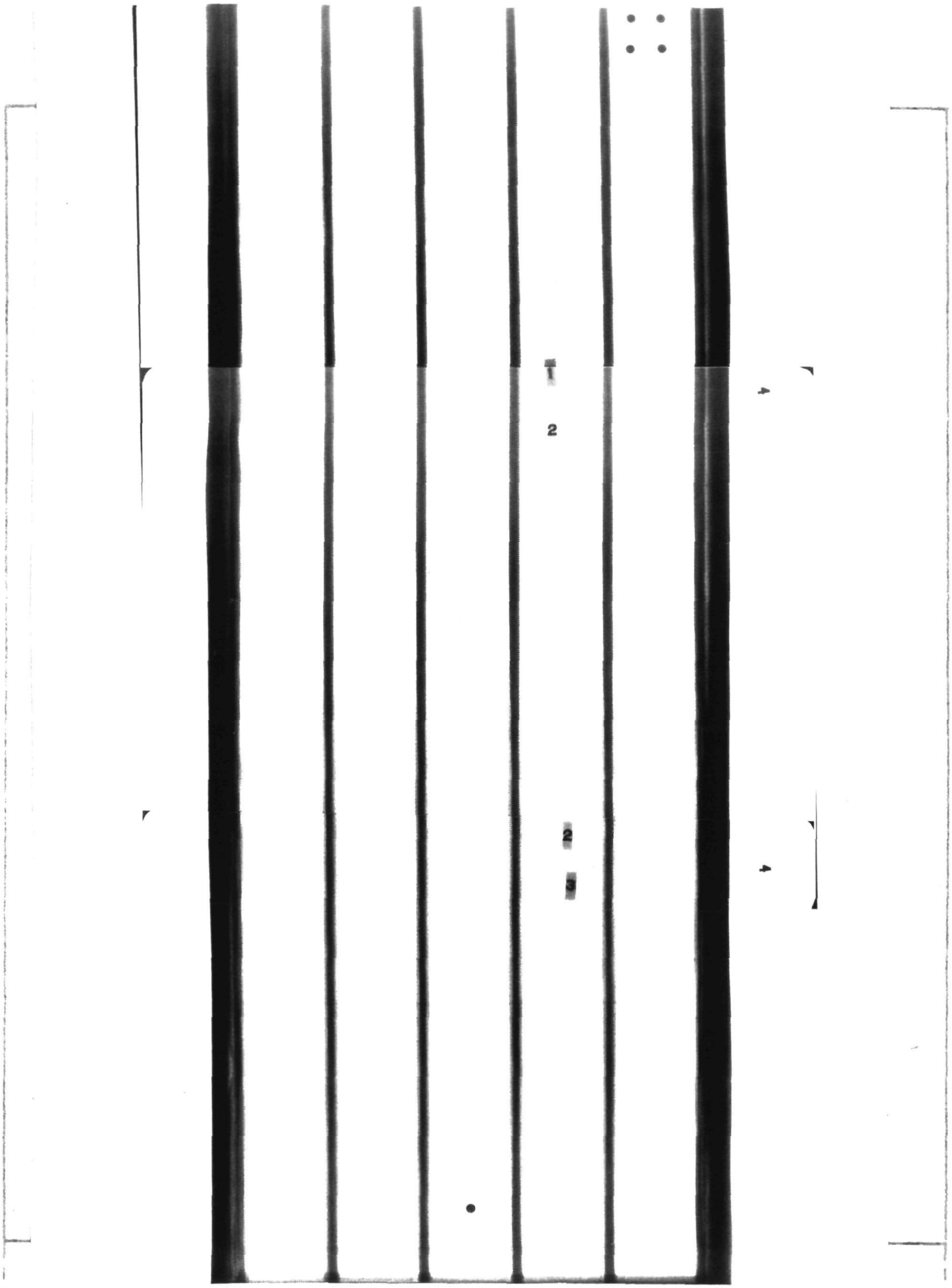
C-1. X-RAY RESULTS LB 921963 WCI - PANEL 1



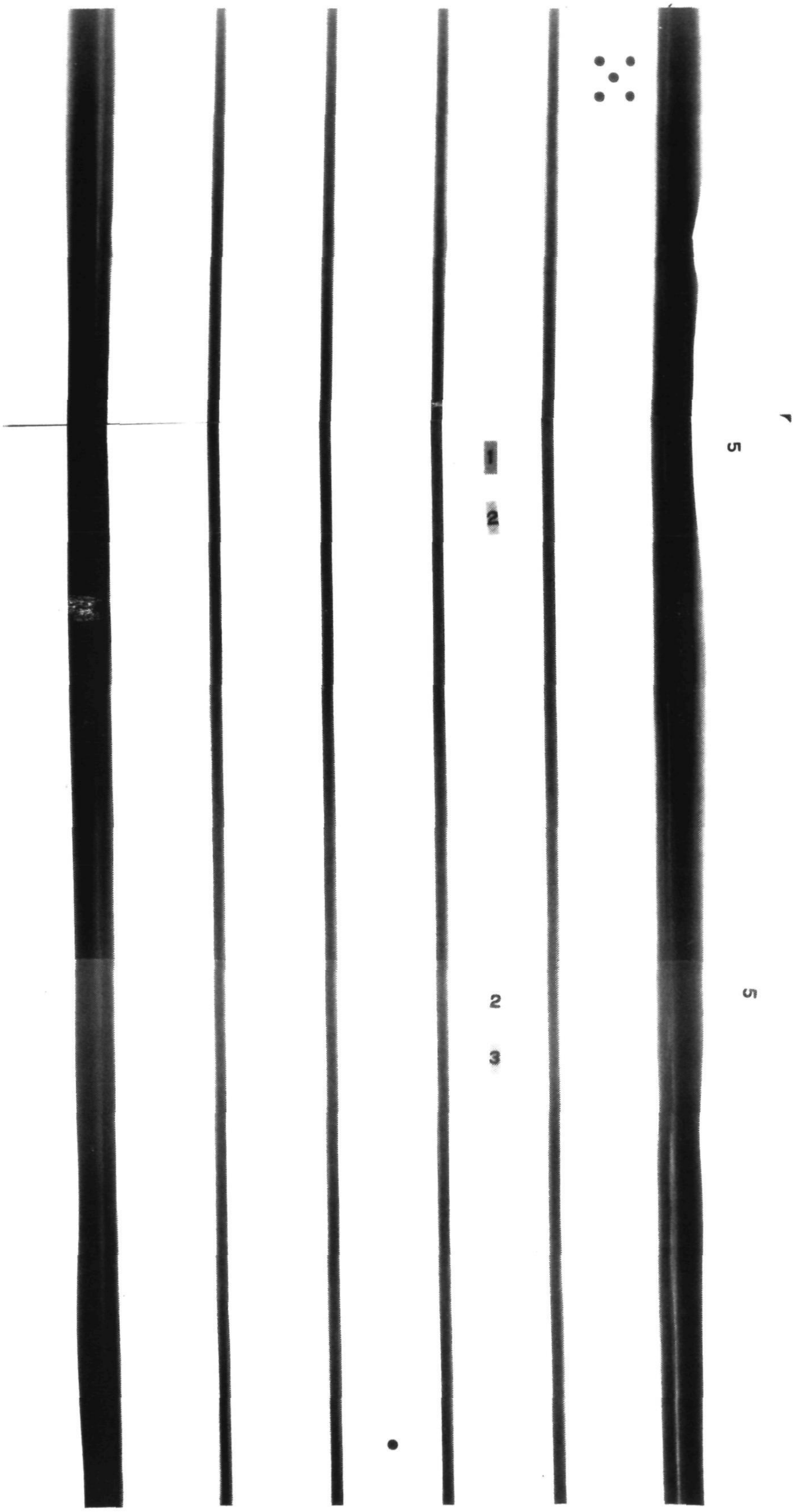
C-2. X-RAY RESULTS LB 921963 WCI - PANEL 2



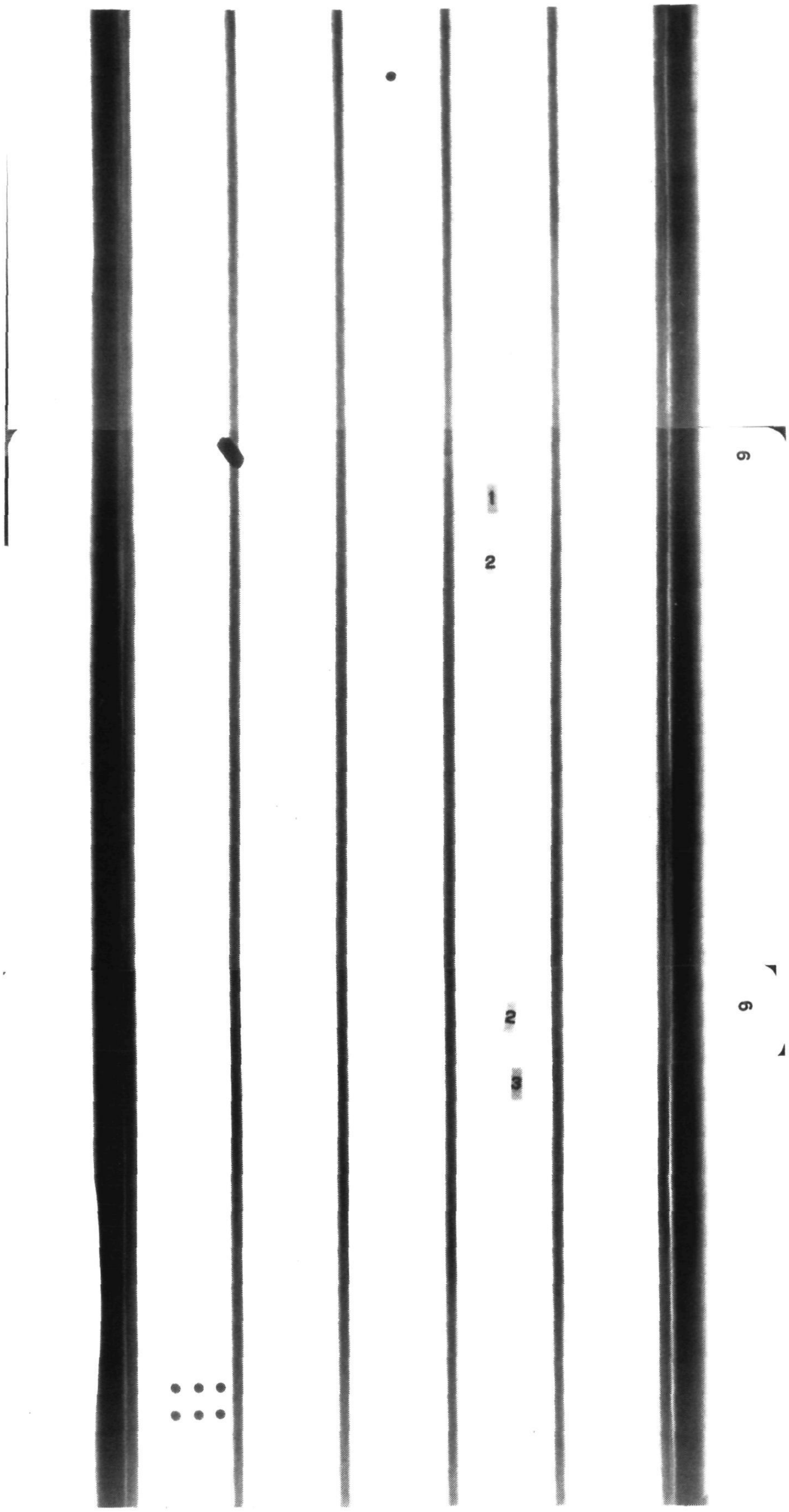
C-3. X-RAY RESULTS LB 921963 WCI - PANEL 3



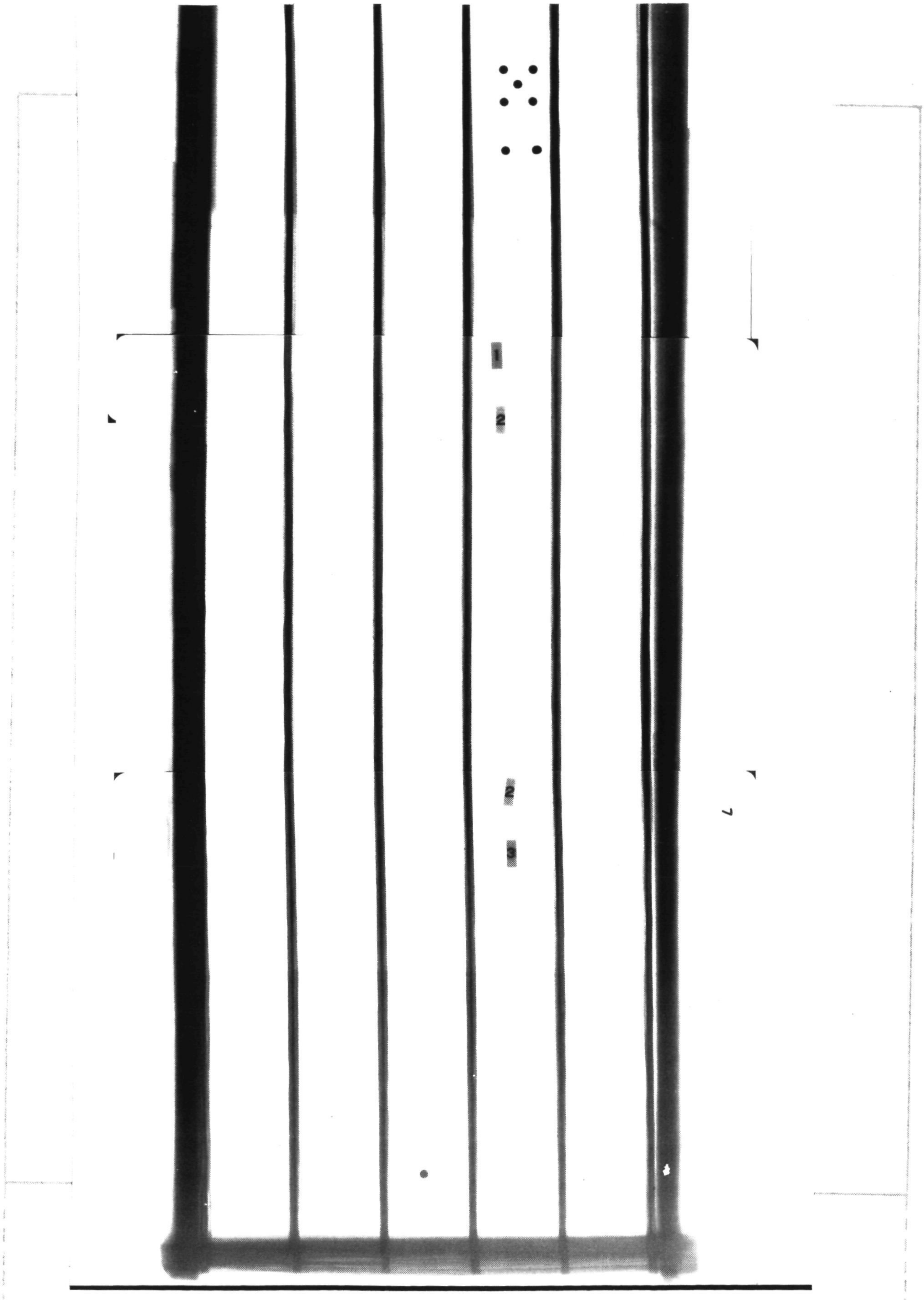
C-4. X-RAY RESULTS LB 921963 WDI - PANEL 4



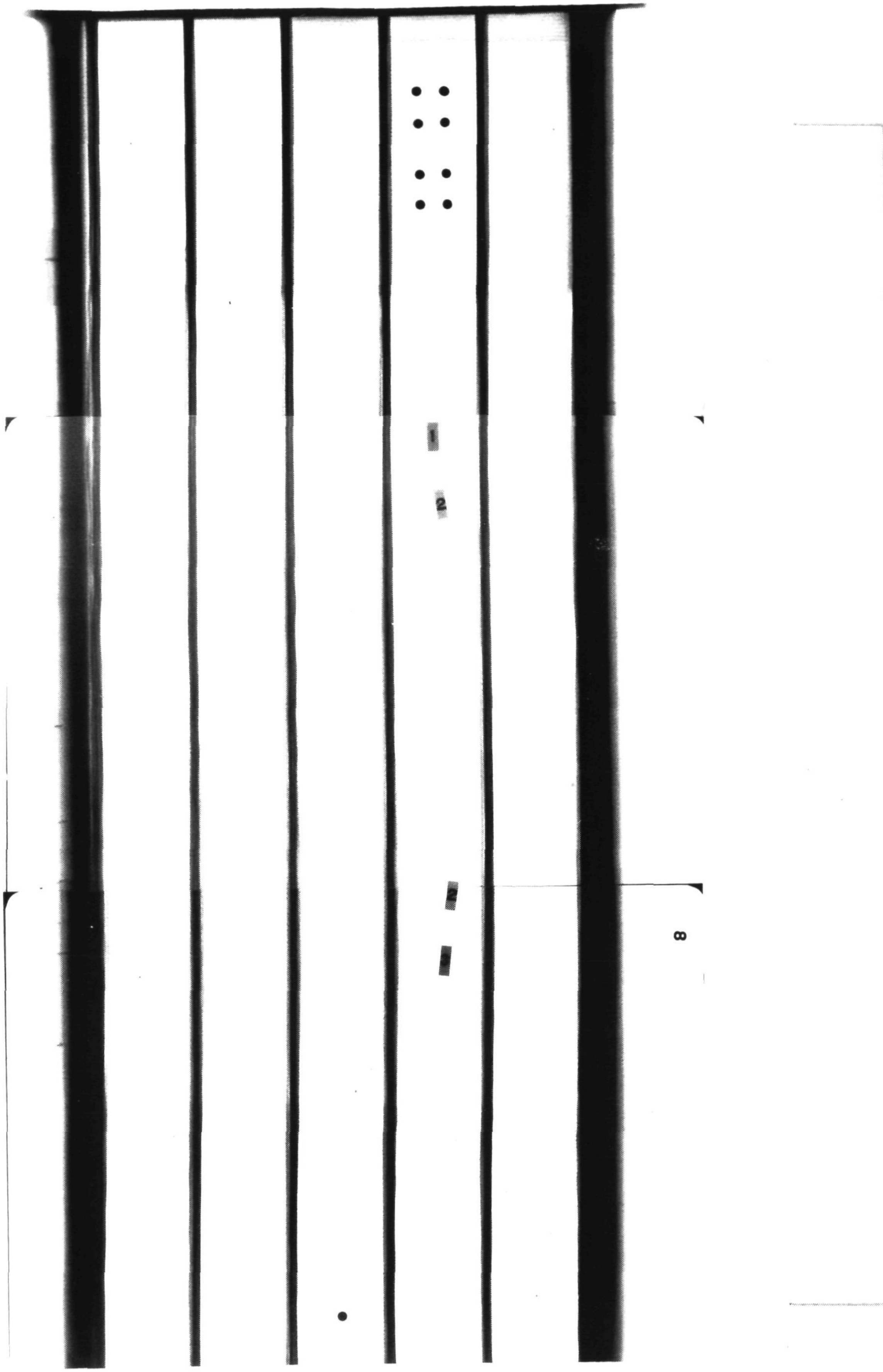
C-5. X-RAY RESULTS LB 921963 WDI - PANEL 5



C-6. X-RAY RESULTS LB 921963 WDI - PANEL 6

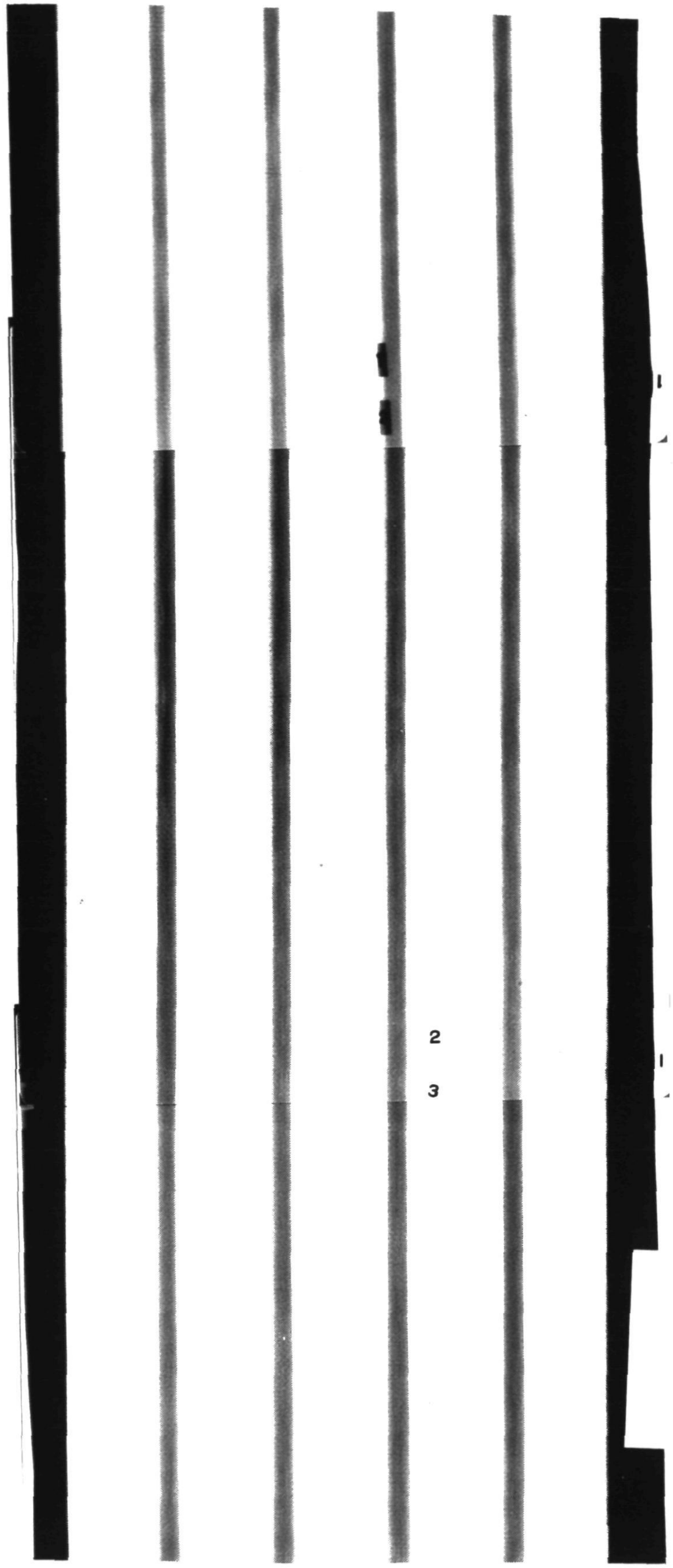


C-7. X-RAY RESULTS LB 921963 WG1 - PANEL 7



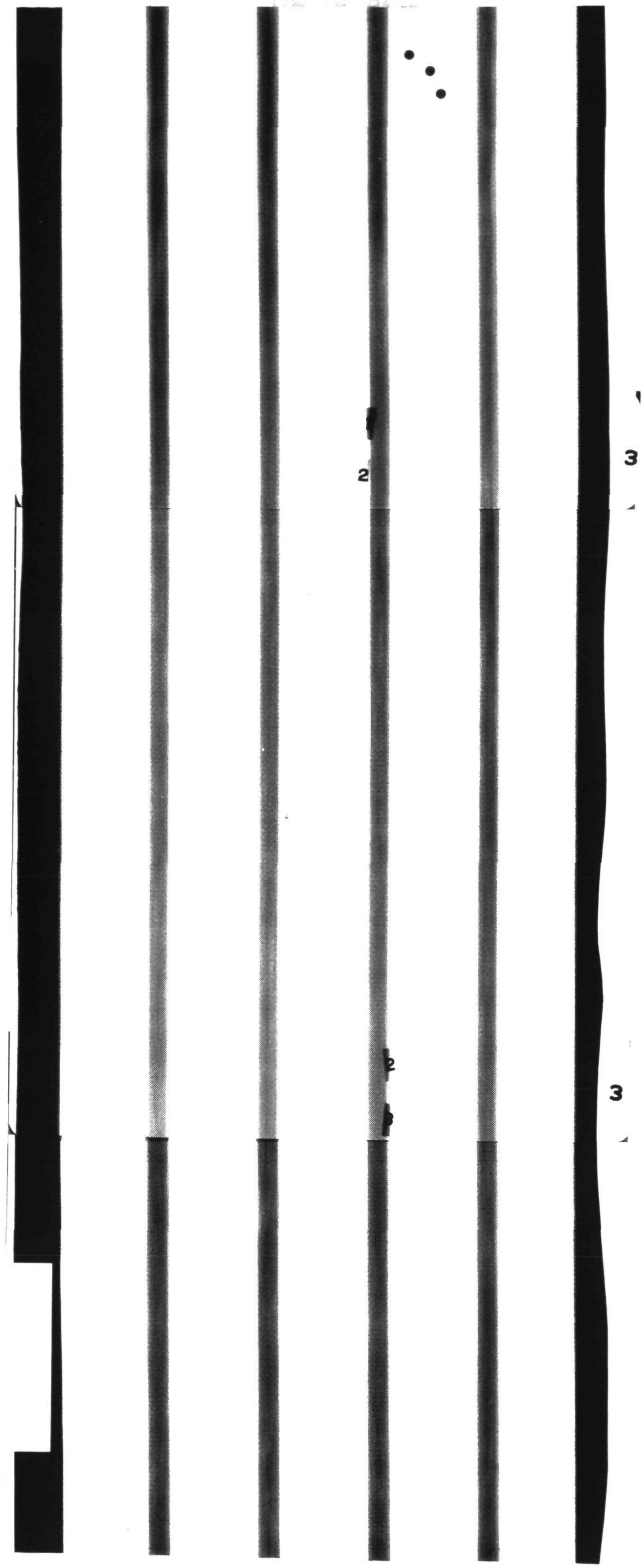
C-8. X-RAY RESULTS LB 921963 WG1 - PANEL 8

C-9. X-RAY RESULTS LB 921963 WG1 - PANEL 9

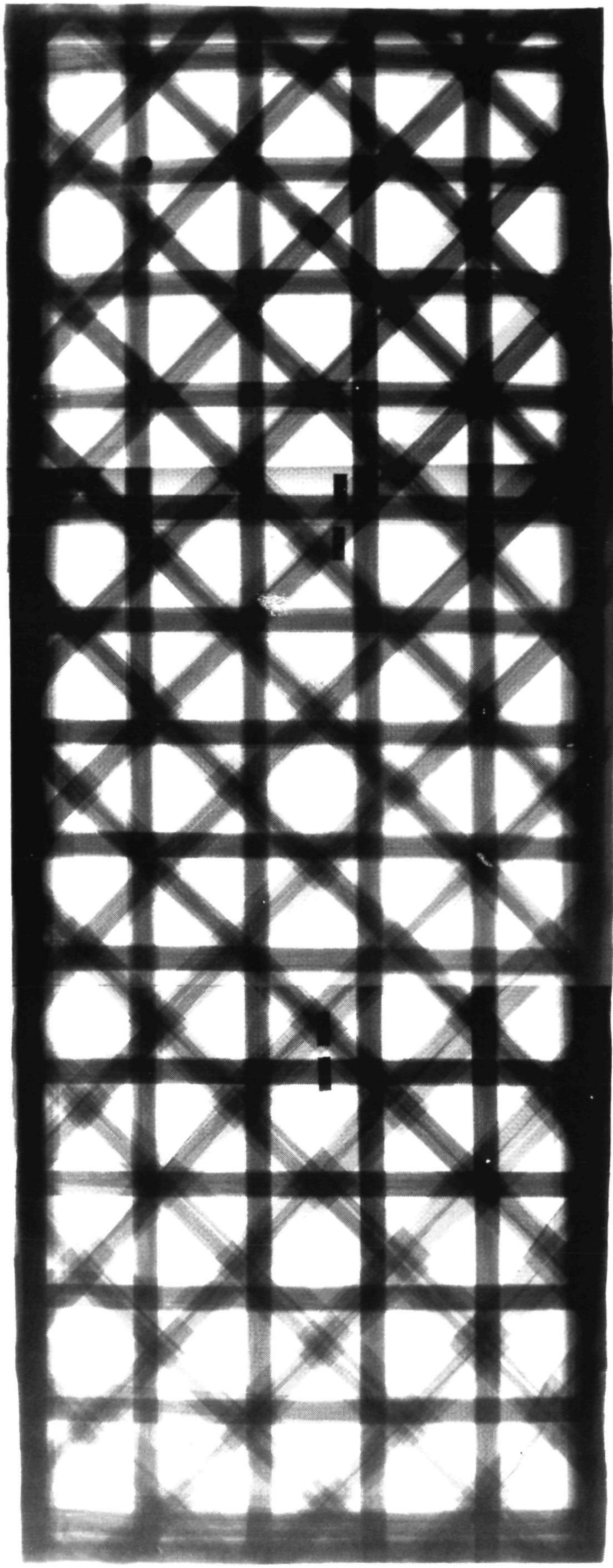


C-10. X-RAY RESULTS LB 921964 - PANEL 1

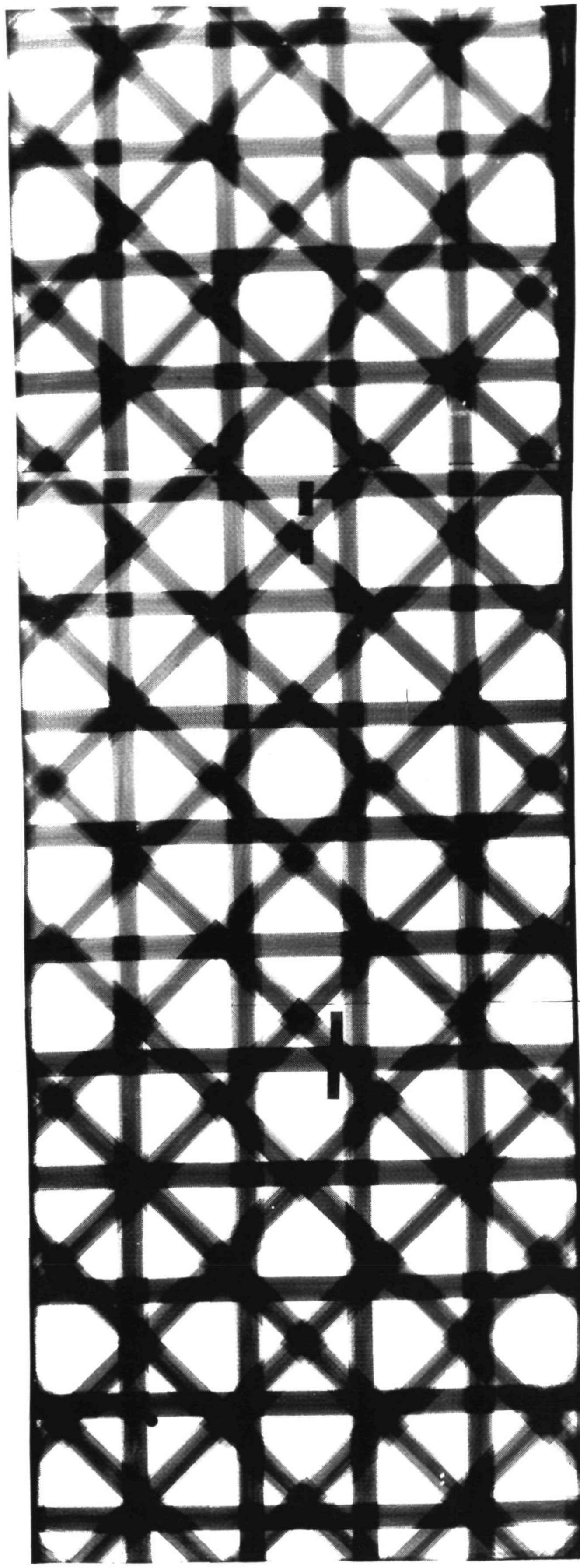
C-11. X-RAY RESULTS LB 921964 - PANEL 2



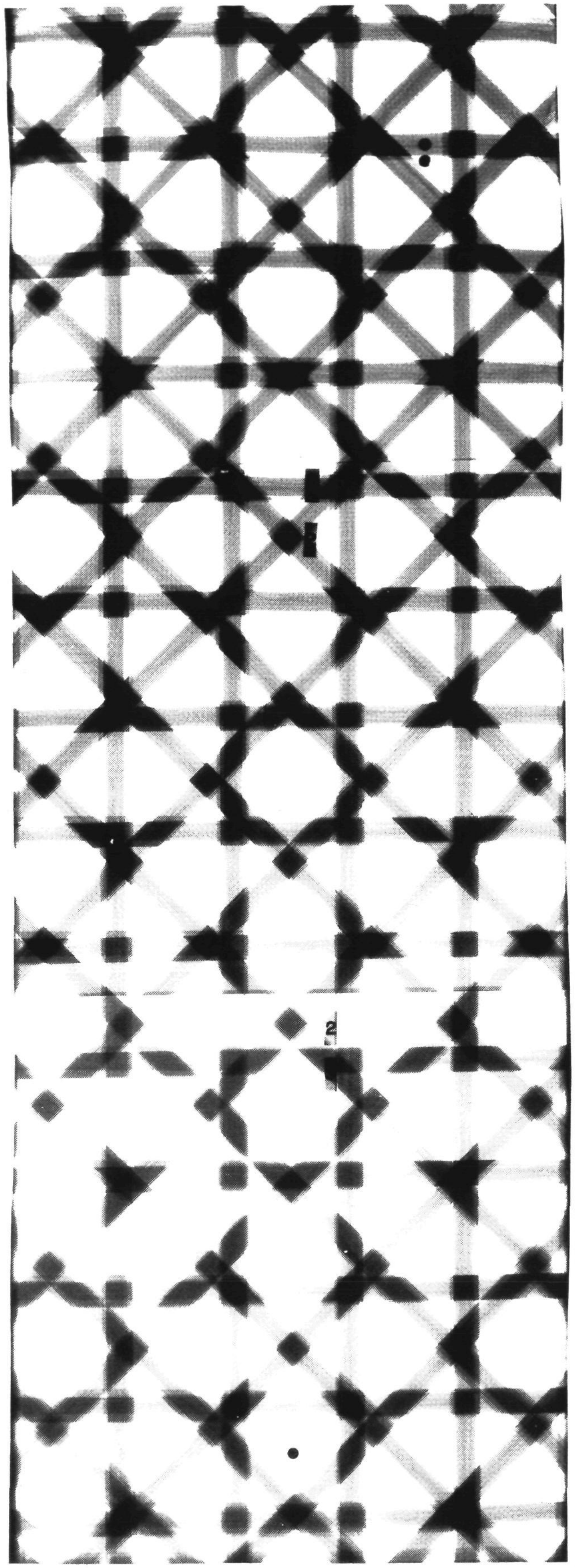
B-12. X-RAY RESULTS LB 921964 - PANEL 3



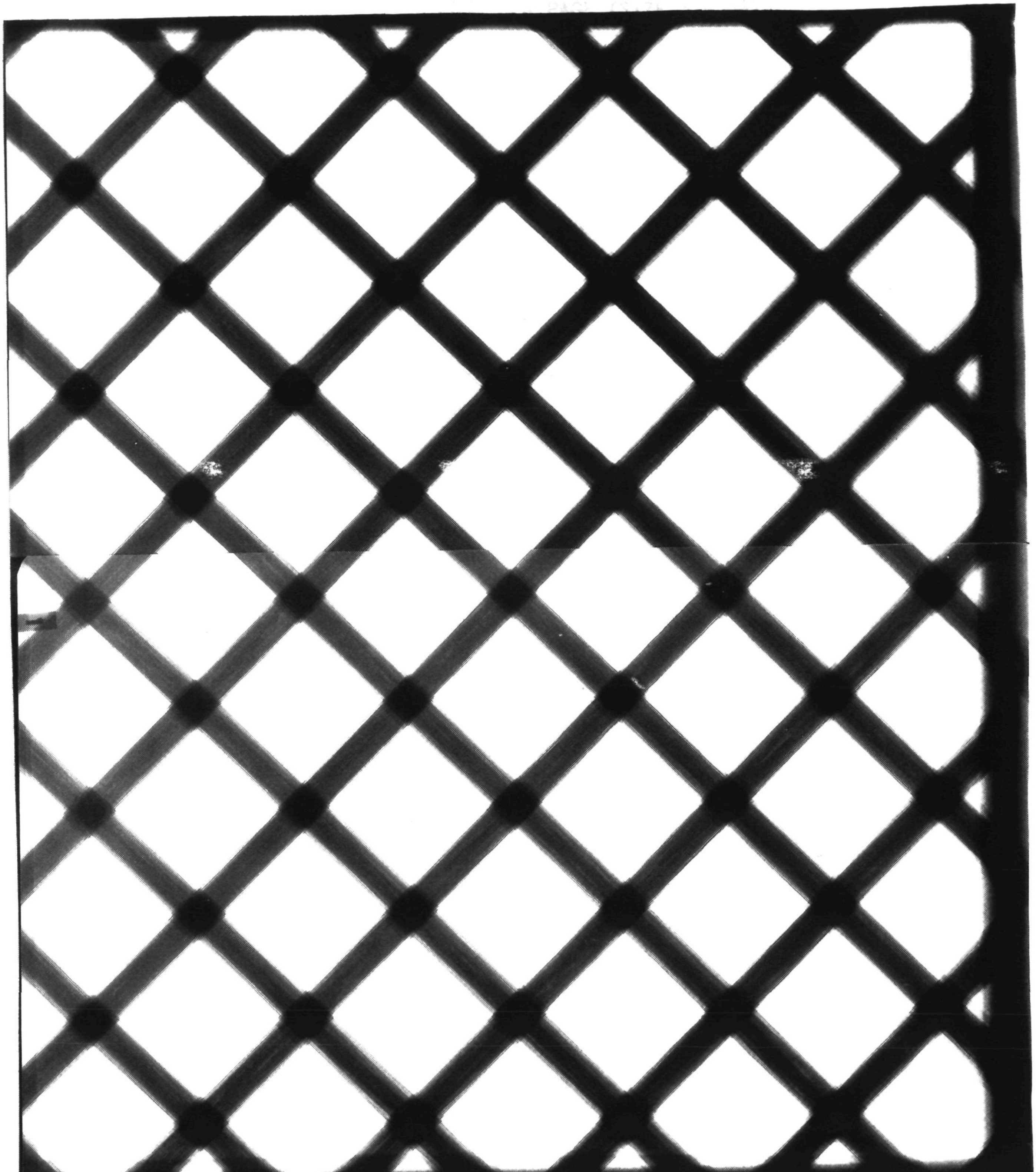
C-13. X-RAY RESULTS LB 921965 - PANEL 1



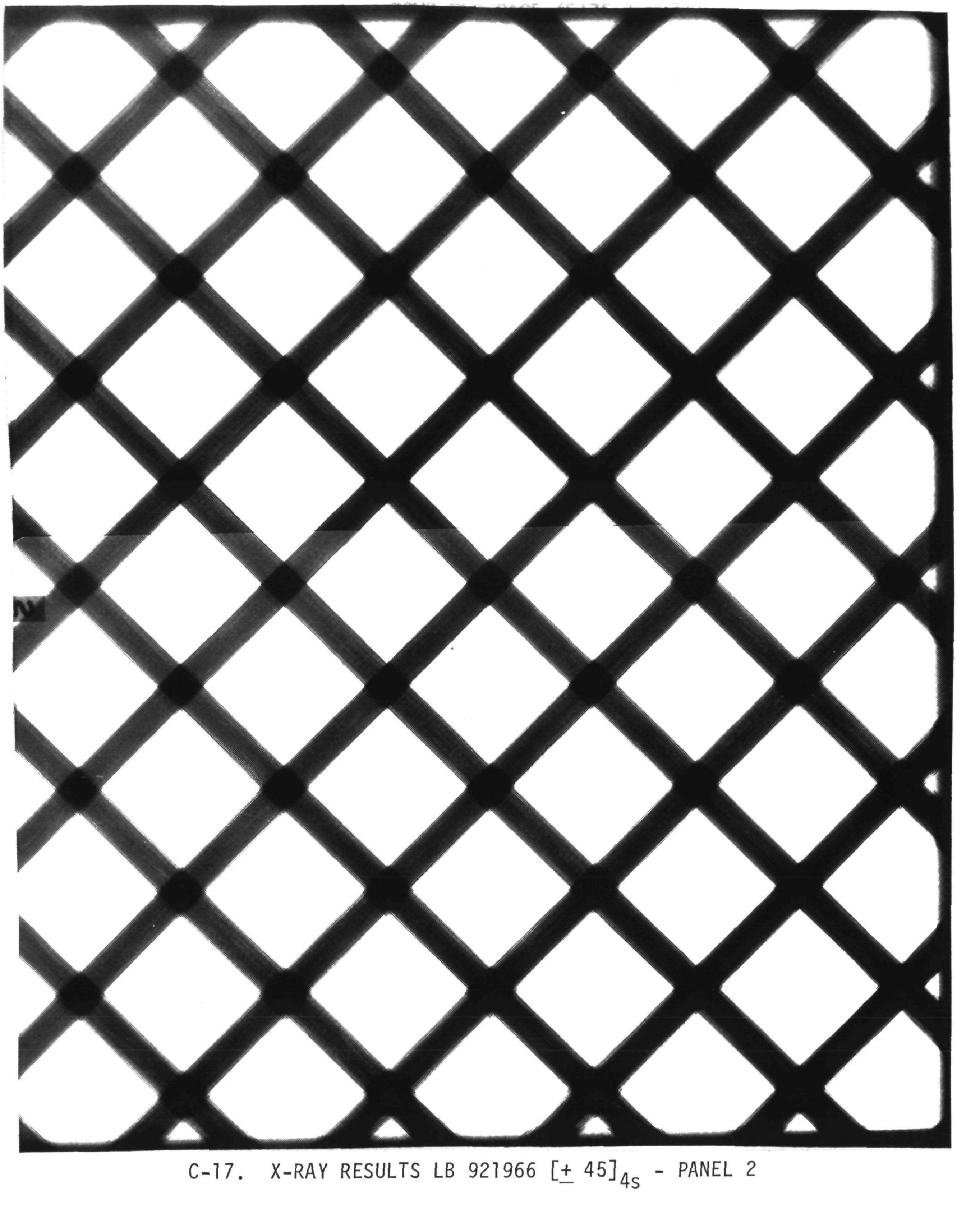
C-14. X-RAY RESULTS LB 921965 - PANEL 2



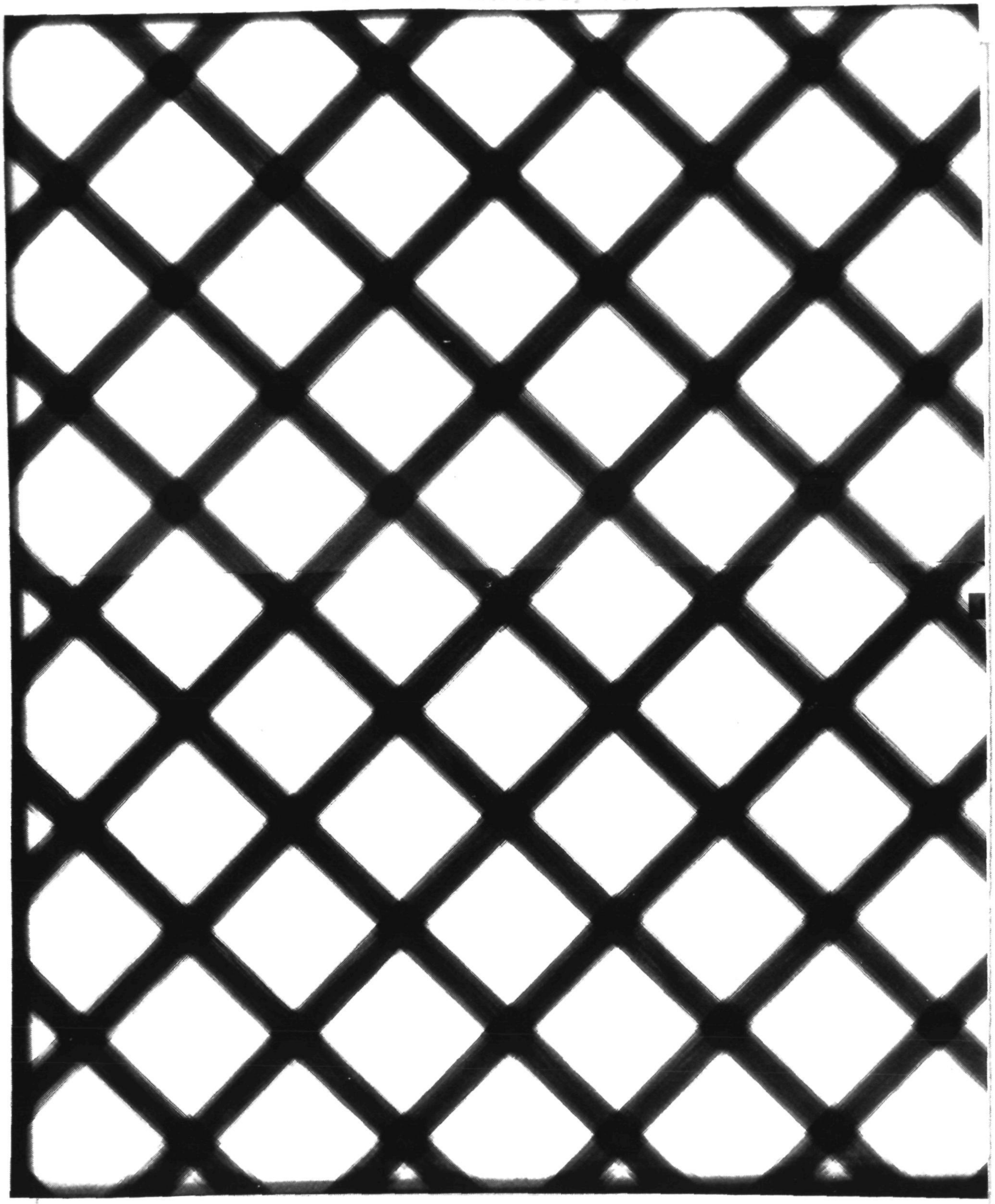
C-15. X-RAY RESULTS LB 921965 - PANEL 3



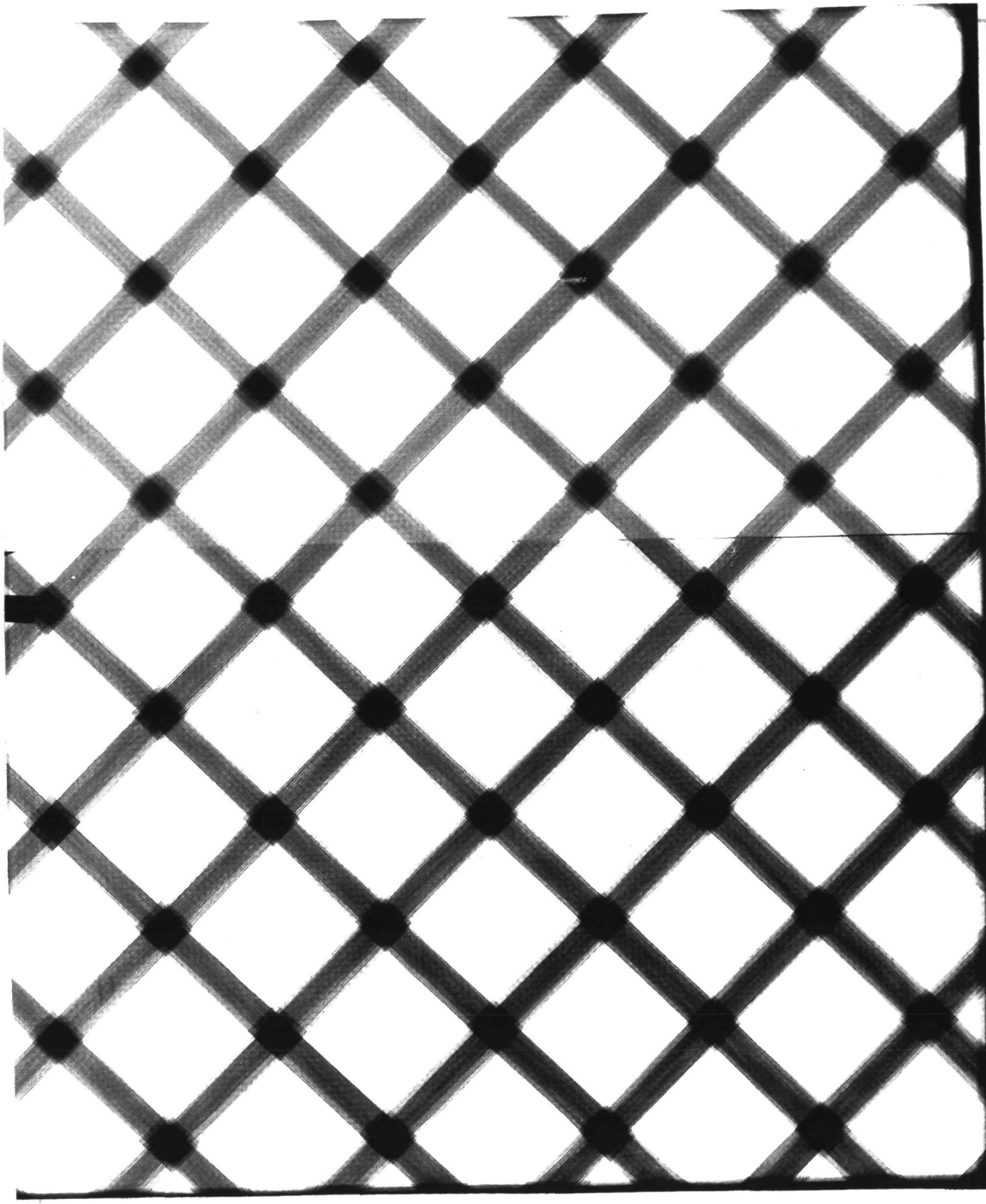
C-16. X-RAY RESULTS LB 921966 $[\pm 45]_{4s}$ - PANEL 1



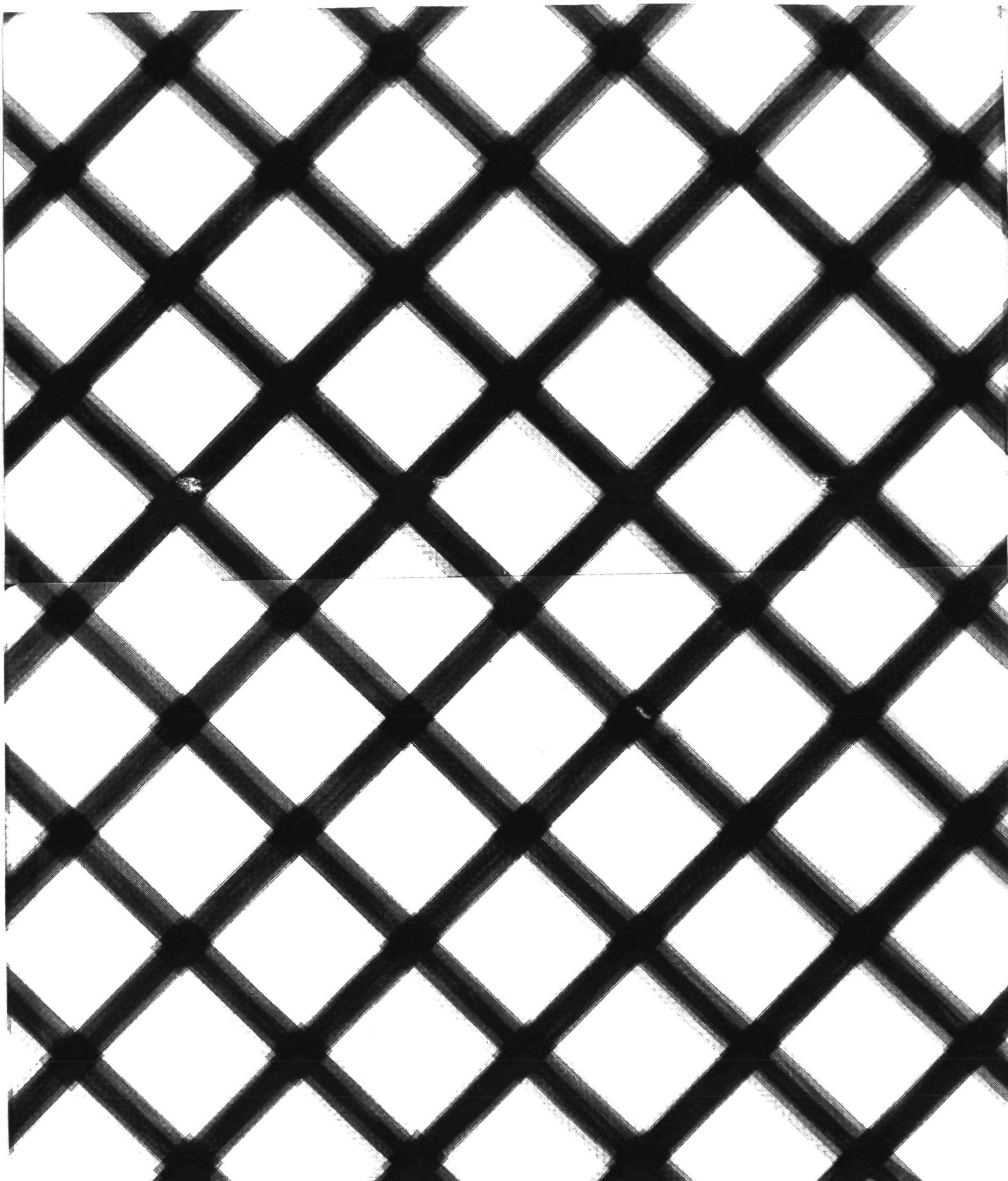
C-17. X-RAY RESULTS LB 921966 [$\pm$ 45]$_{4s}$ - PANEL 2



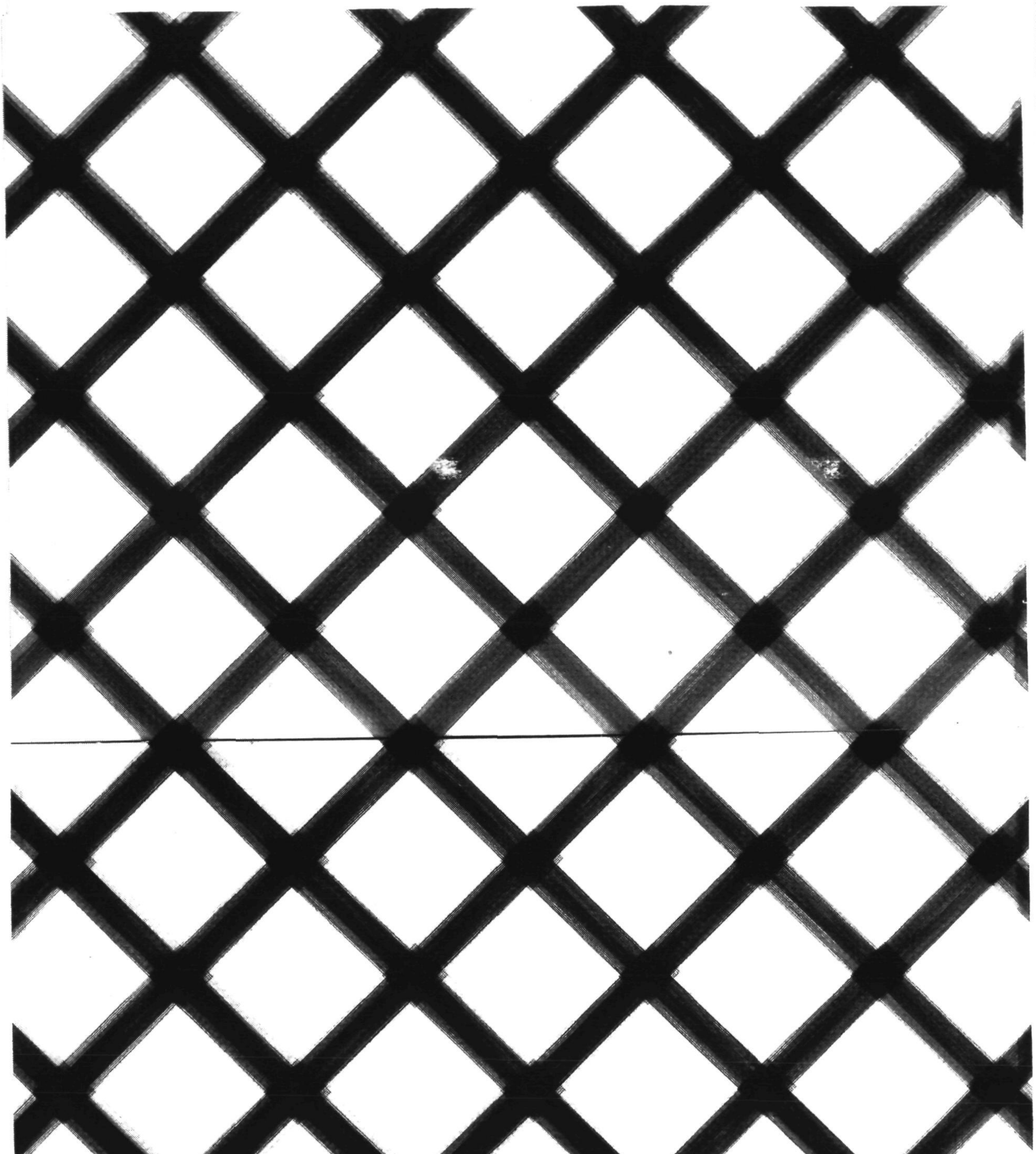
C-18. X-RAY RESULTS LB 921966 $[\pm 45]_{4s}$ - PANEL 3



C-19. X-RAY RESULTS LB 921966 $[+45, 0, -45, 90]_{2S}$ - PANEL 4



C-20. X-RAY RESULTS LB 921966 [+45, 0, -45, 90]$_{2s}$ - PANEL 5



C-21. X-RAY RESULTS LB 921966 $[+45, 0, -45, 90]_{2s}$ - PANEL 6

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CR 165871		

4. Title and Subtitle	5. Report Date
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	6. Performing Organization Code
7. Author(s) G. R. Bonnar and R. J. Palmer	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address McDonnell Douglas Corporation Douglas Aircraft Company 3855 Lakewood Blvd. Long Beach, CA 90846	11. Contract or Grant No. NASI 1-16677
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546	13. Type of Report and Period Covered Contrator Report
	14. Sponsoring Agency Code

15. Supplementary Notes
Langley Technical Monitor: John M. Kennedy
Final Report

16. Abstract

Woven unidirectional graphite cloth with bands of fiberglas replacing the graphite in discrete lengthwise locations was impregnated with epoxy resin and used to fabricate a series of composite tensile and shear specimens. The work was accomplished in the Materials & Process Engineering Laboratory under NASA Contract NASI-16677. The finished panels, with the fiberglass buffer strips, were delivered to NASA, Langley Research Center for test. This report covers details of the fabrication process.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Composite, Graphite/Epoxy, Fabrication; Buffer Strips	Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	69	-

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