

TABLE OF CONTENTS

Volume 1

- I Introduction
- II Executive Summary
- III Study Design
- IV Introduction, Results of Exposure Evaluations
 - A. Physical Testing of Coating Systems
 - B. KTA-Tator Laboratory Exposure
 - C. NASA-Johnson Space Center Facility Exposures
 - D. Tables of Exposure Evaluation Results
 - 1. Simulated Pool Evaluation Results
 - 2. KTA-Envirotest Exposure Evaluation Results
 - 3. QUV (ASTM G53) Exposure Evaluation Results
 - 4. Laydown Area Exposure Evaluation Results
 - 5. Rotunda Exposure Evaluation Results
 - 6. WETF Pool Exposure Evaluation Results
 - 7. Repair System Exposure Evaluation Results
 - 8. Cathode Panel Exposure Evaluation Results
- V Discussion of Results
- VI Conclusions and Recommendations

Appendices

Volume 2

- A. Coating System, Surface Preparation and Application Data
- B. Coating Material Infrared Spectra

Volume 3

- C. Test Panel Photographs
- D. Methods and Procedures
- E. Application Equipment Costs
- F. Solicitation of Candidate Coating Systems

APPENDIX C

Photographic Appendix

Test panels subject to exposure are presented by System for each of the exposure environments included in the study. Control panels are included with exposed panels for comparison. This appendix is divided into subsections by exposure environment.

| | |
|-----------------------------|------------|
| Simulated Pool Exposure | 2000 hours |
| QUV-Weatherometer Exposure | 2000 hours |
| KTA Envirotest Exposure | 2000 hours |
| WETF Pool Exposure | 3200 hours |
| WETF Pool Repaired System | 3000 hours |
| WETF Pool Zinc Anode System | 3200 hours |
| Laydown Area Exposure | 3700 hours |
| Rotunda Exposure | 3700 hours |

All test panels employed in the study were identified with tag numbers. The numbering scheme employed separated each coating system into a block of numbers. Within each coating system the numbers were further separated into consecutive series for each substrate. The numbers assigned are presented below.

| TEST PANEL NUMBERS BY SYSTEM AND SUBSTRATE | | | | | | |
|--|----------------------------------|-----------------|----------|-----------|---------|---------------|
| System # | Coating | Stainless Steel | Aluminum | Coupled** | CPVC | Physical Test |
| 1 | PF112 | 1-22 | 23-44 | 45-58 | 59-76 | 77-82 |
| 2 | NSP 120 | 83-104 | 105-126 | 127-140 | 141-158 | 159-164 |
| 3 | Devran 230 | 165-186 | 187-208 | 209-222 | 223-240 | 241-246 |
| 4 | Carbomastic 15/ Carboline 890 | 247-268 | 269-290 | 291-304 | 305-322 | 323-328 |
| 5 | SW Hi-Solids Catalyzed Epoxy | 329-350 | 351-372 | 373-386 | 387-404 | 405-410 |
| 6 | UTPlast Super | 411-432 | 433-454 | 455-468 | 469-486 | 487-492 |
| 7 | UTPlast | 493-514 | 515-536 | 537-550 | 551-568 | 569-574 |
| 8 | Elite 8844 | 575-596 | 597-618 | 619-632 | 633-650 | 651-656 |
| 9 | Plasite 7122 | 657-678 | 679-700 | 701-714 | 715-732 | 733-738 |
| 10 | Aquatapoxy A6 | 739-760 | 761-782 | 783-796 | 797-814 | 815-820 |

** When viewing Coupled panels, the full aluminum panel face in on the "nut" side of the fastener, the full stainless steel face on the "bolt head" side.

The presentation of panel photographs includes a representation of test panel layouts for each exposure environment preceding the photographs for that environment. The layout indicates the substrate of the panels shown. Note from the numbers above, that for any series of photographs the lowest set of numbers are stainless steel panels, followed by aluminum, coupled then CPVC panels.

APPENDIX C
Photographic Presentation of Panels

Simulated Pool Panels

Right Hand Page:

2000 hrs

| |
|-----------------|
| Stainless Steel |
| Aluminum |

| |
|-----------------|
| Stainless Steel |
| Aluminum |

Left Hand Page:

| |
|------------|
| CPVC |
| Coupled-SS |

| |
|------------|
| CPVC |
| Coupled-AL |

One System per page

800 hrs

| |
|-----------------|
| Stainless Steel |
| CPVC |

| |
|----------|
| Aluminum |
| Coupled |

Simulated WETF Pool, 2000 hrs.

System 1

12

14

Simulated WETF Pool, 2000 hrs.

System 1

34

36

Simulated WETF Pool, 2000 hrs.

System 1

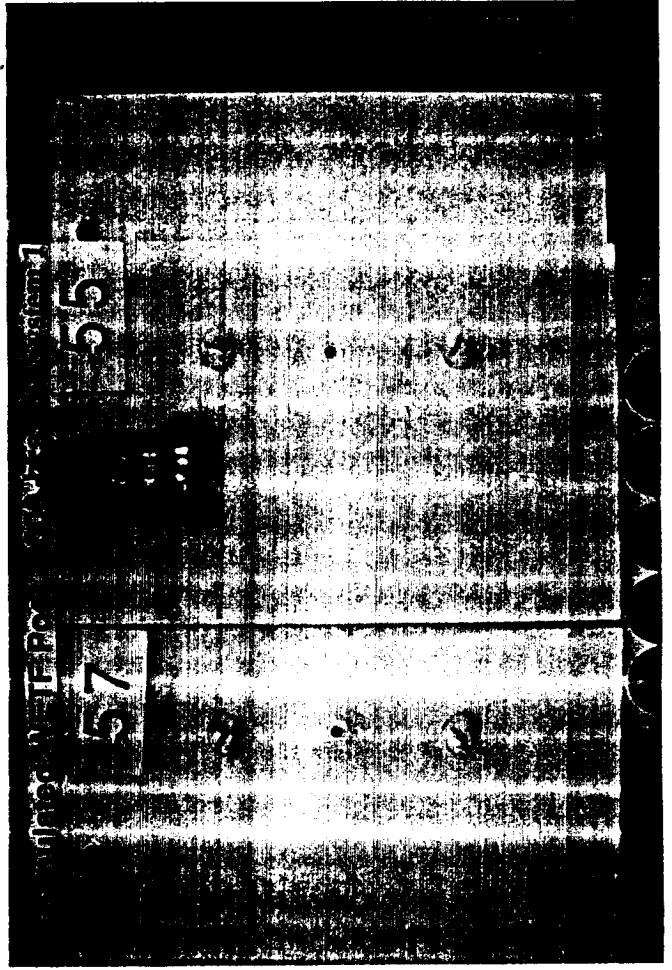
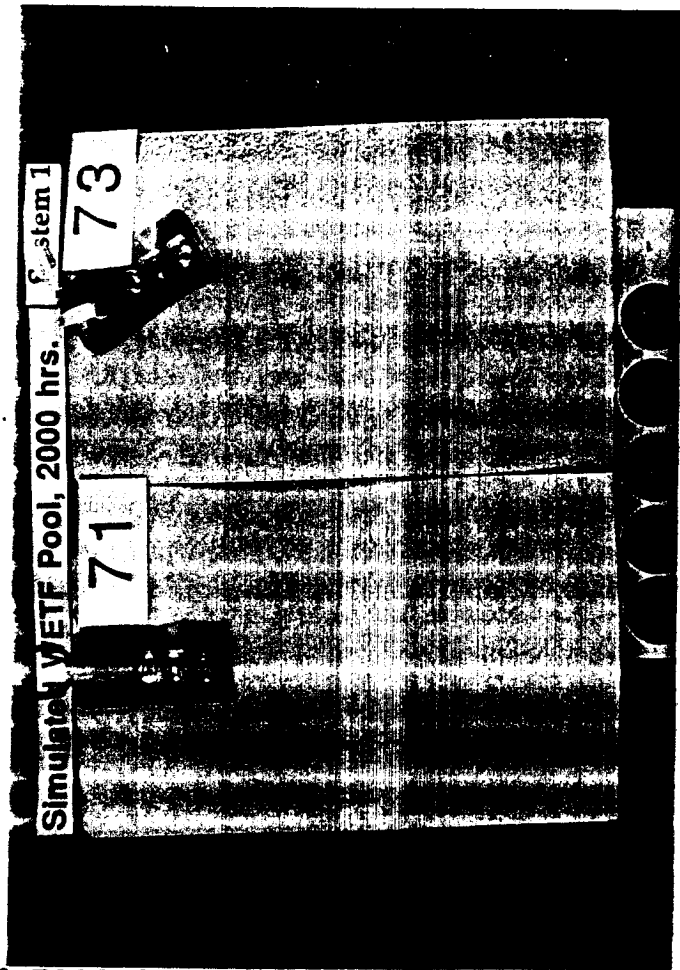
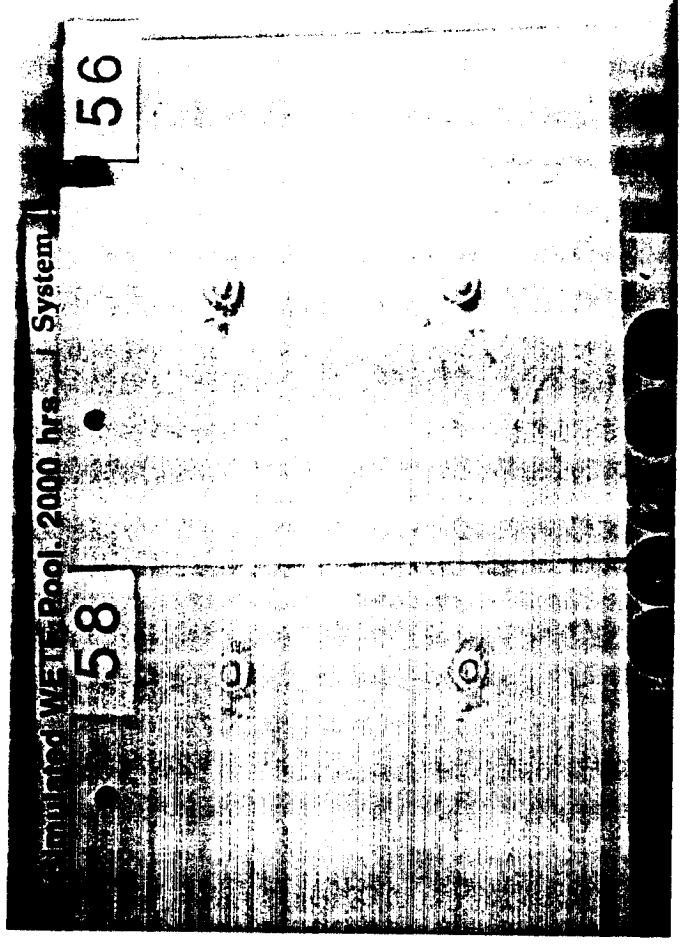
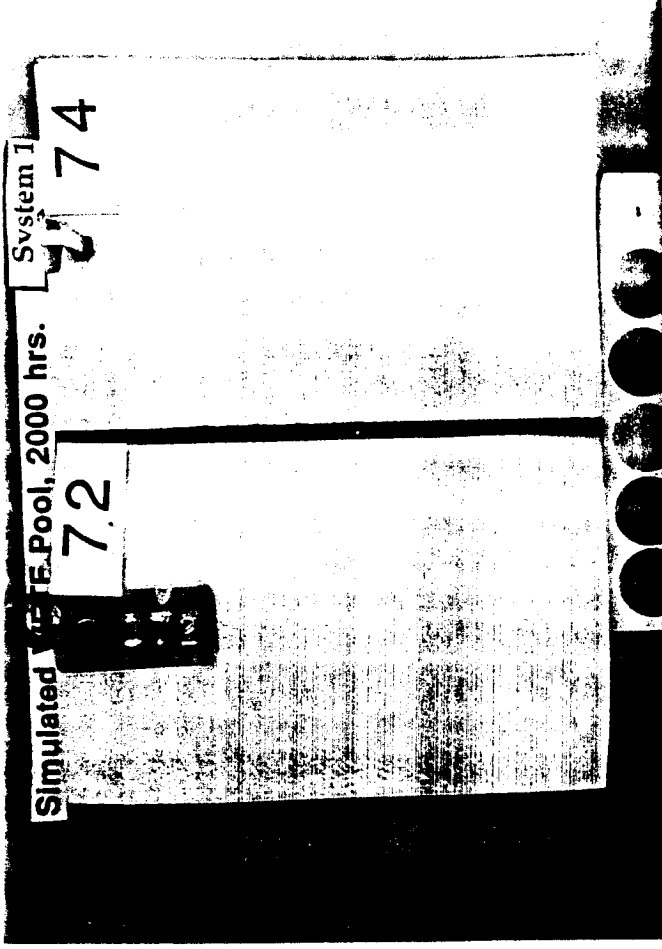
11

13

Simulated WETF Pool, 2000 hrs.

System 1

35



ORIGINAL PAGE IS
OF POOR QUALITY

System 2

Simulated WETF Pool, 2000 hrs.

94

96

System 2

Simulated WETF Pool, 2000 hrs.

116

118

System 2

Simulated WETF Pool, 2000 hrs.

93

95

System 2

Simulated WETF Pool, 2000 hrs.

115

117

Simulate WETF Pool, 2000 hrs

System 2

151

153

Simulate WETF Pool, 2000 hrs

System 2

152

154

Simulate WETF Pool, 2000 hrs

System 2

137

139

Simulate WETF Pool, 2000 hrs

System 2

138

140

Simulated WEJF Pool, 2000 hrs.

System 3

177

180

Simulated WEJF Pool, 2000 hrs.

System 3

178

179

Simulated WEJF Pool, 2000 hrs.

System 3

199

201

Simulated WEJF Pool, 2000 hrs.

System 3

200

202

Simulated WEF Pool, 2000 hrs.

233

System 3

237

Simulated WEF Pool, 2000 hrs.

236

System 3

238

Simulated WEF Pool, 2000 hrs.

221

219

Simulated WEF Pool, 2000 hrs.

222

System 3

220

System

Simulated F Pool, 2000 hrs.

262

260

System 4

Simulated F Pool, 2000 hrs.

284

282

System 4

Simulated F Pool, 2000 hrs.

261

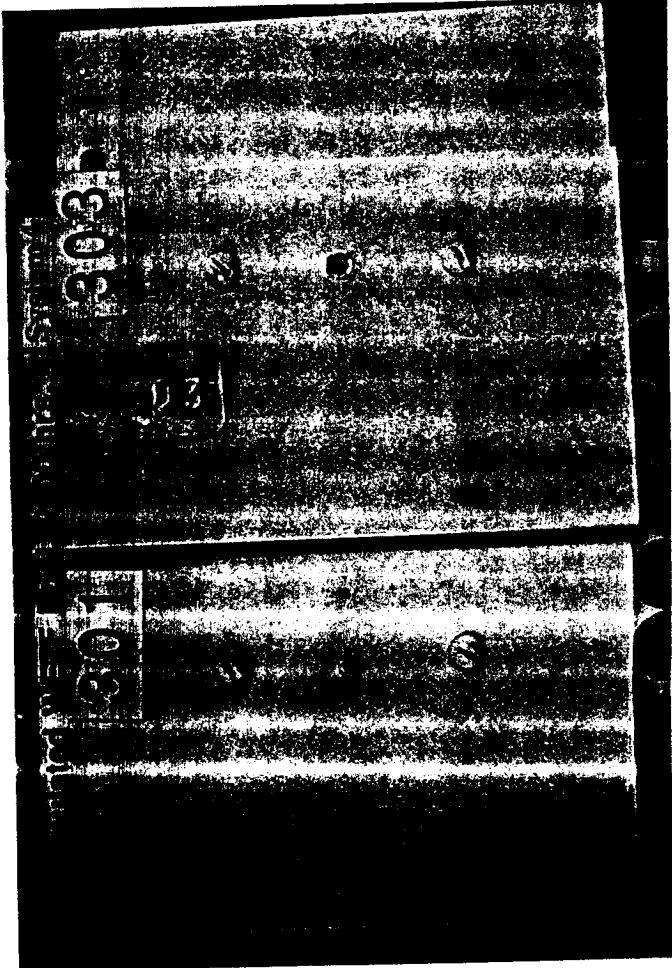
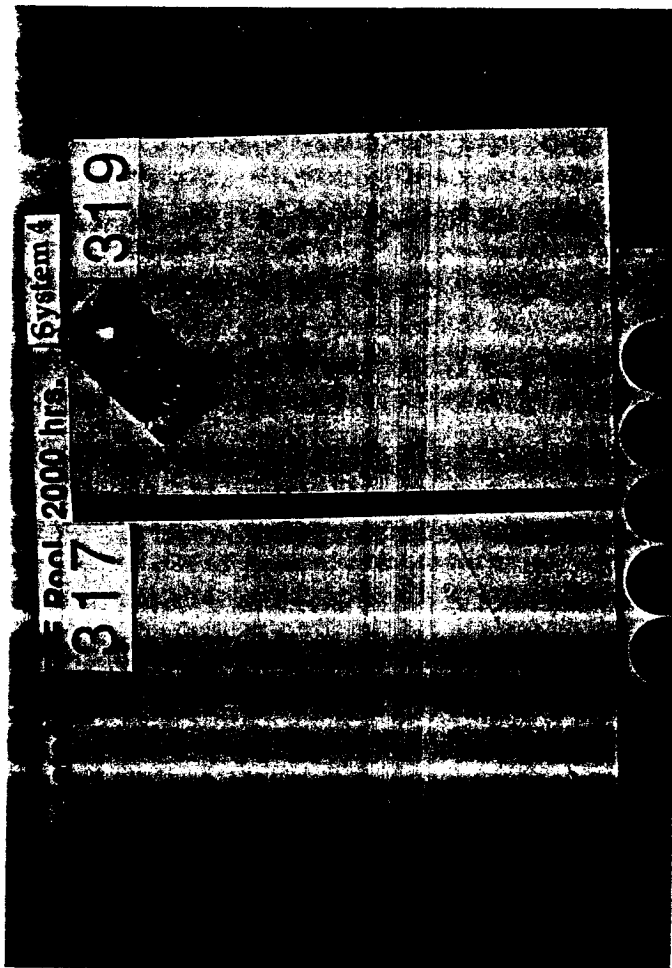
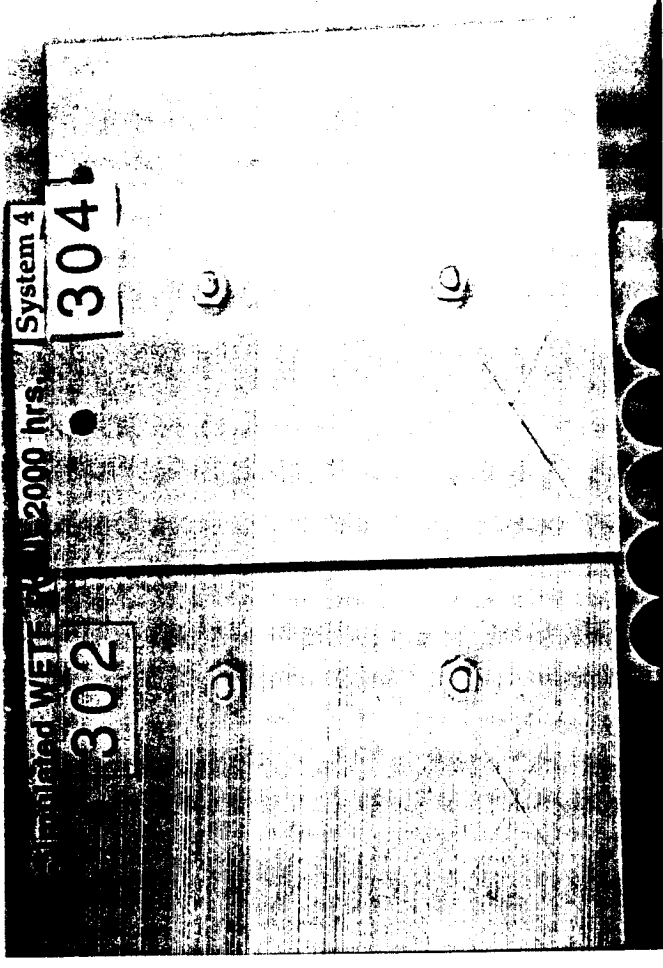
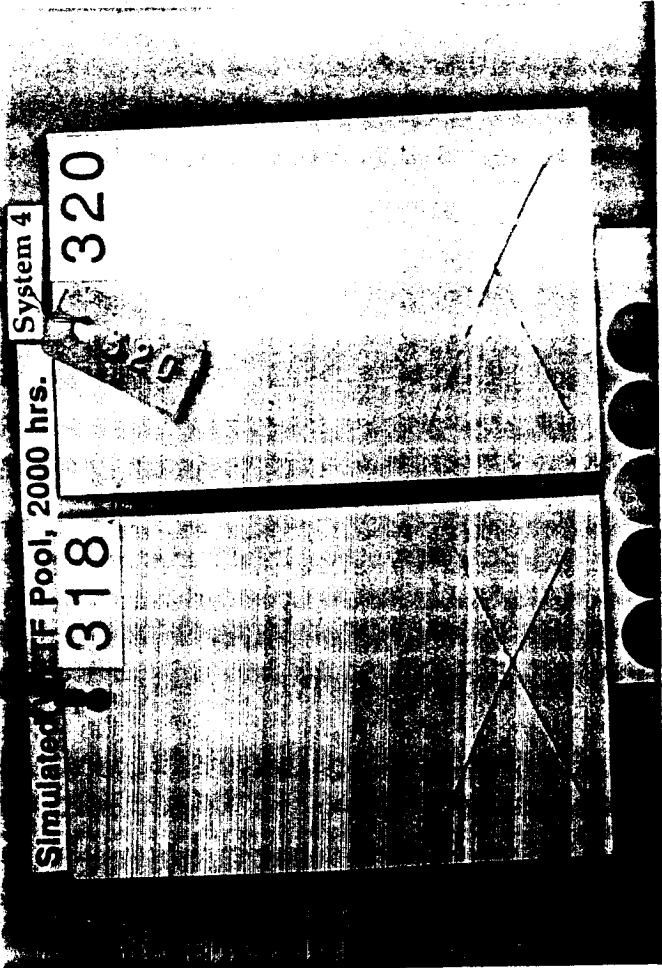
259

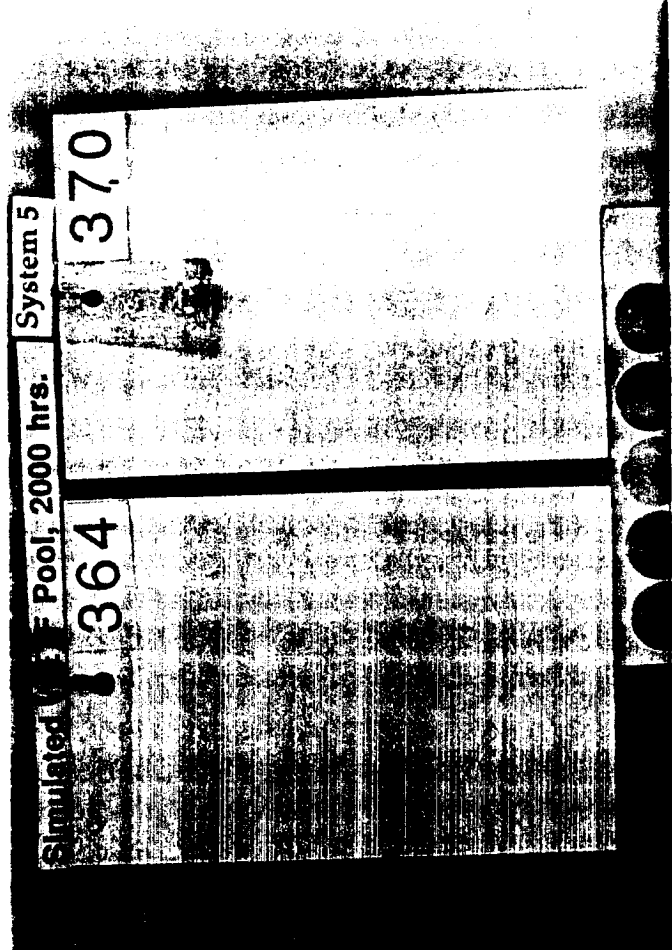
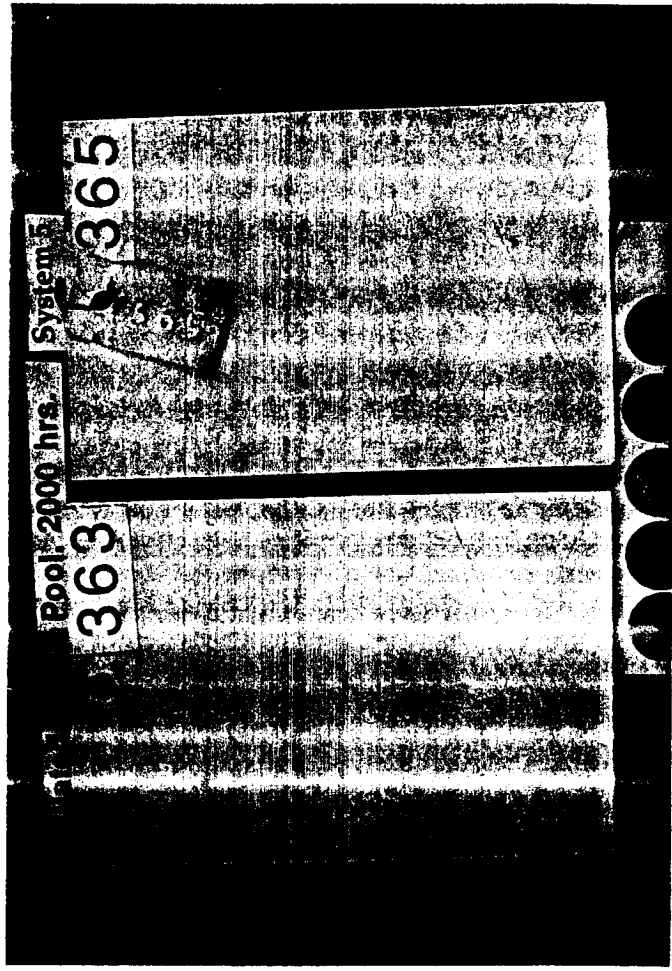
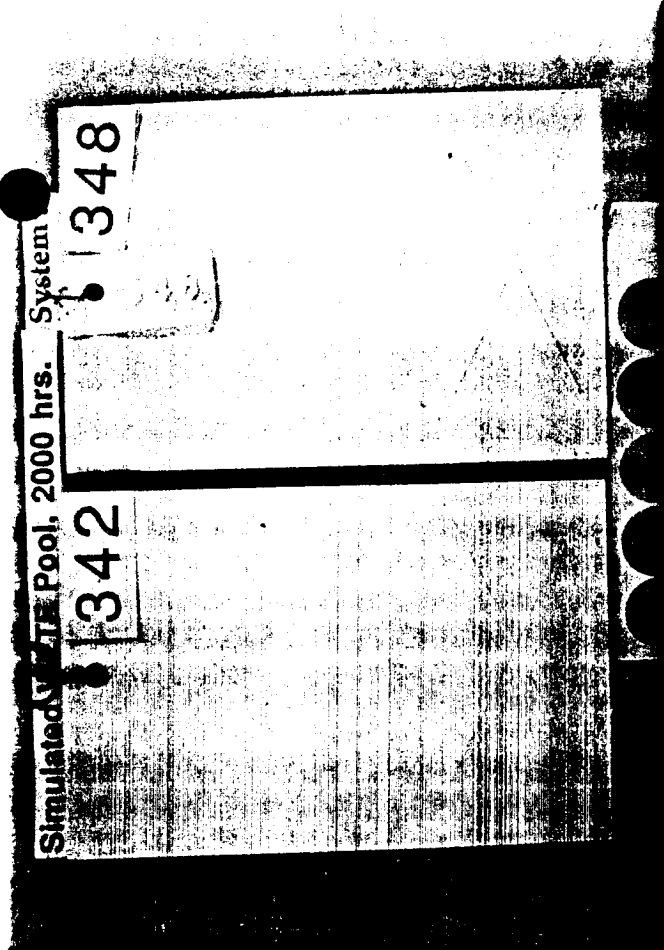
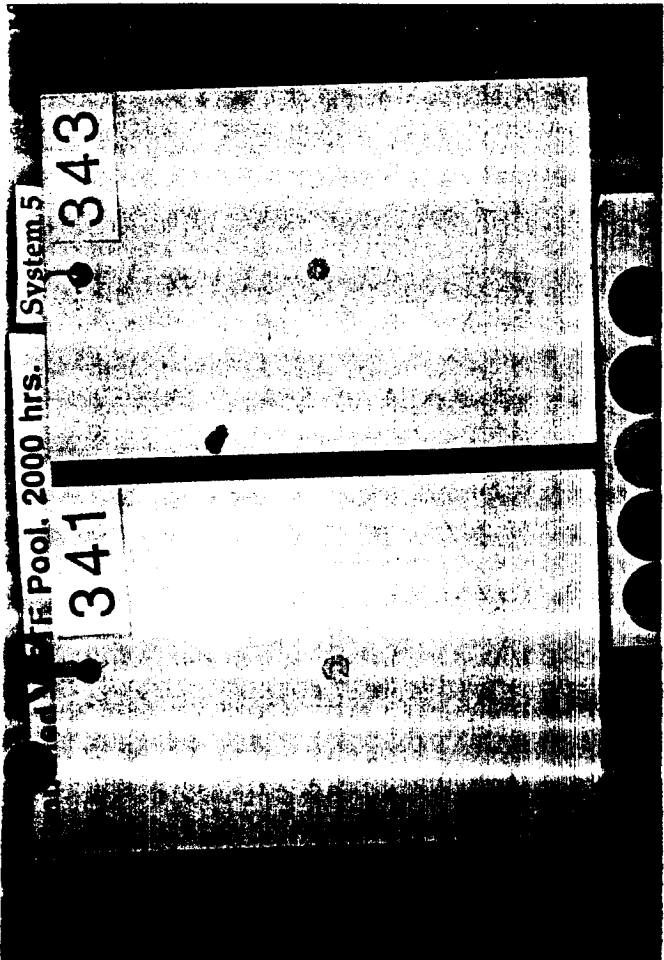
System 4

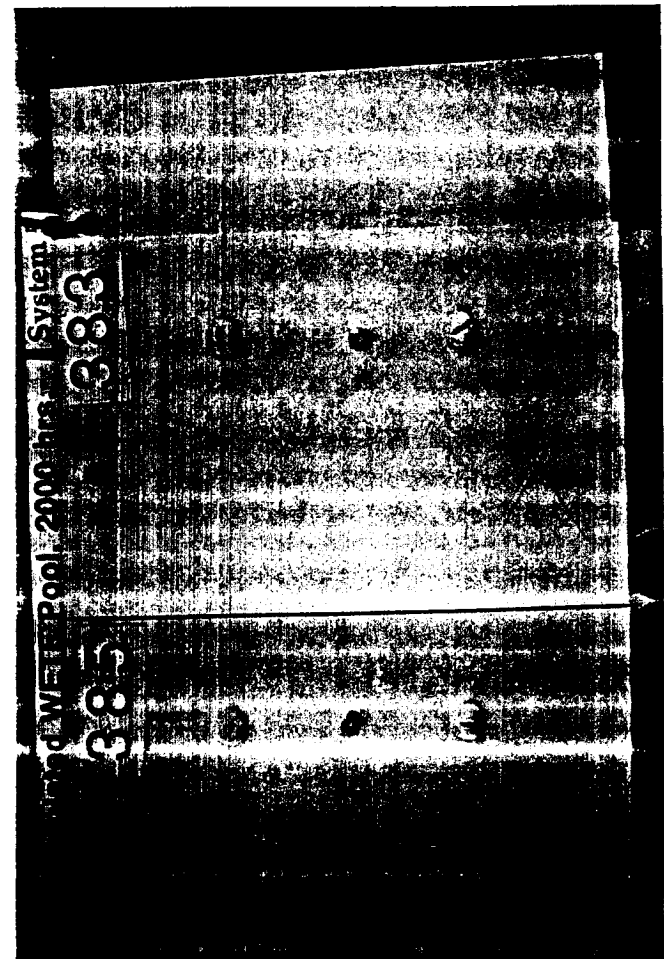
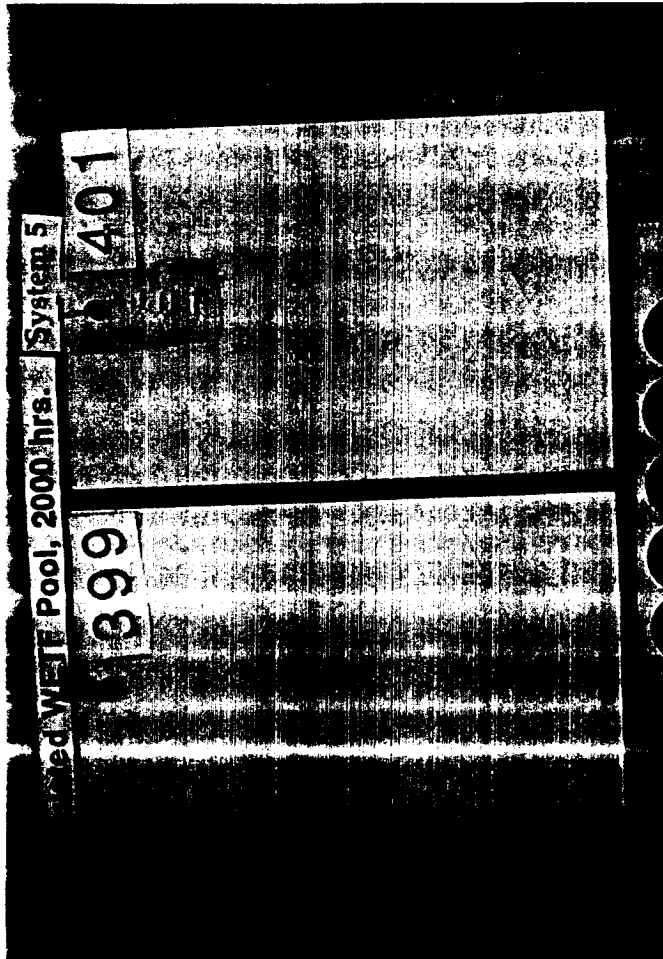
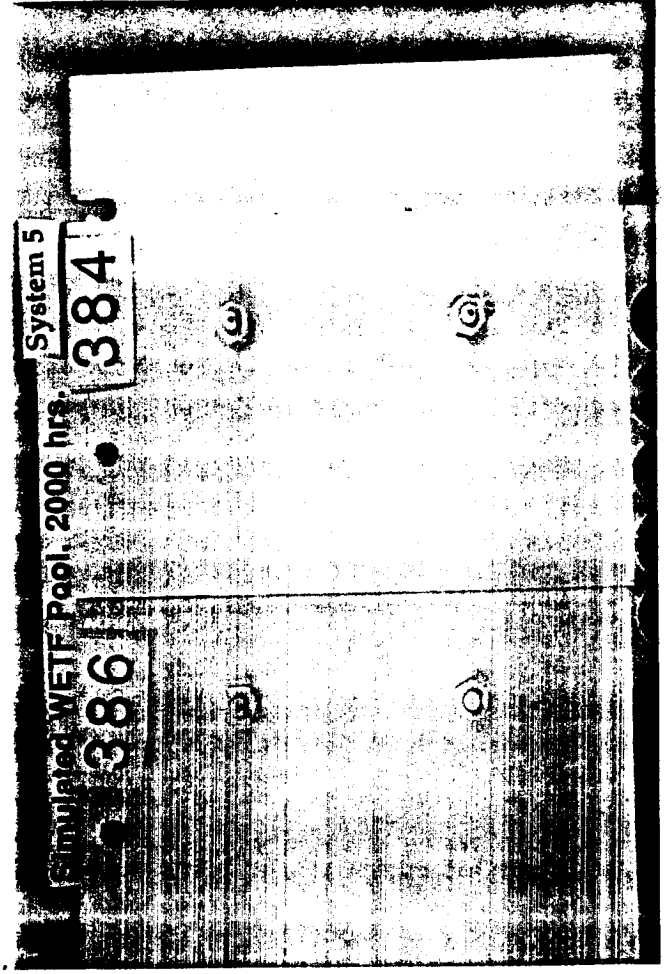
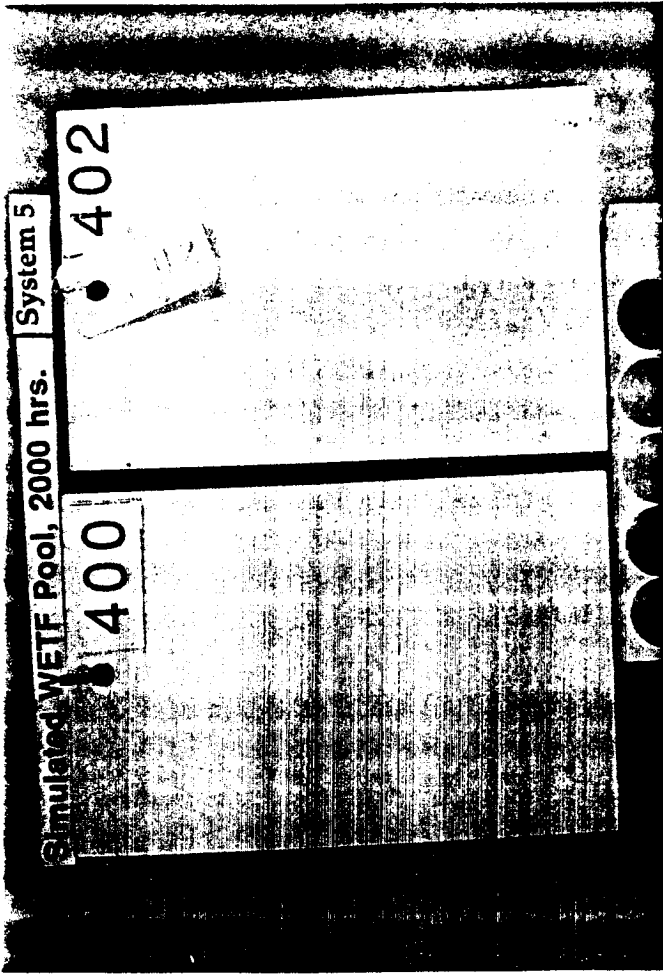
Simulated F Pool, 2000 hrs.

283

281







Simulated WETF Pool, 2000 hrs.

System 6

423

425

Simulated WETF Pool, 2000 hrs.

System 6

424

426

Simulated WETF Pool, 2000 hrs.

System 6

445

447

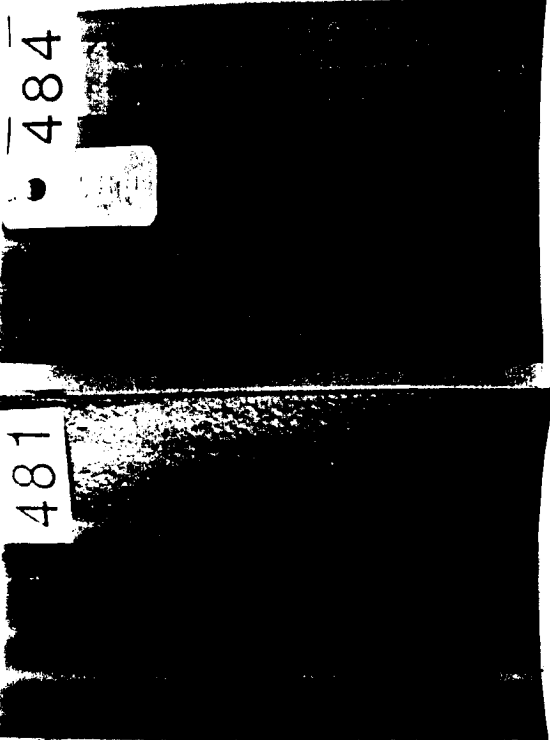
Simulated WETF Pool, 2000 hrs.

System 6

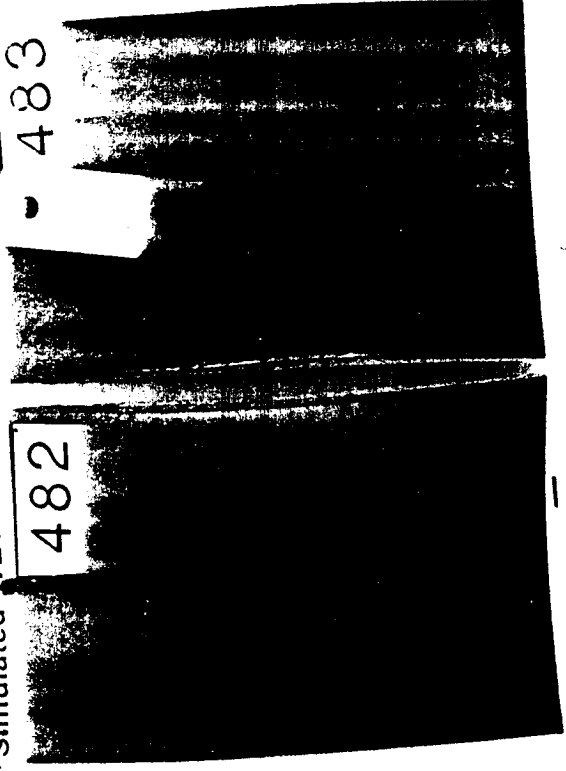
446

448

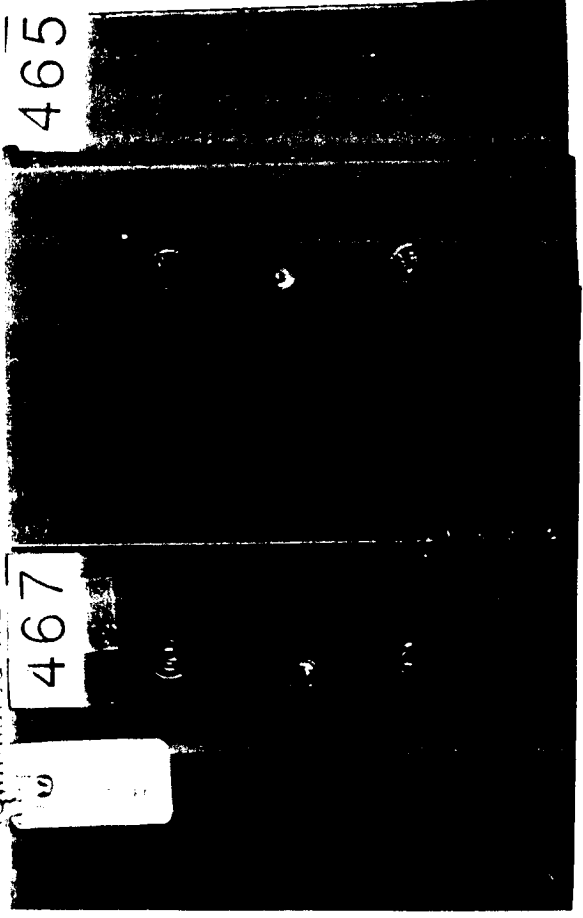
Simulated WETF Pool, 2000 hrs. System 6



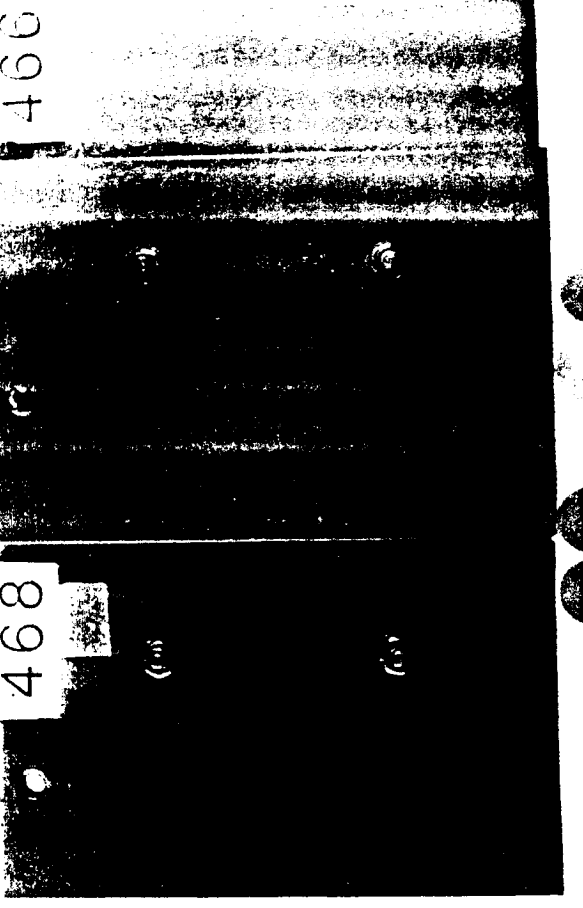
Simulated WETF Pool, 2000 hrs. System 6



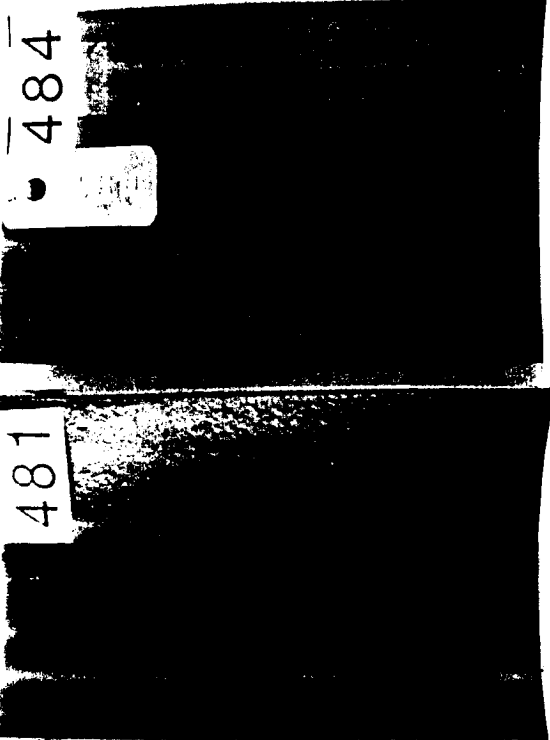
Simulated WETF Pool, 2000 hrs. System 6



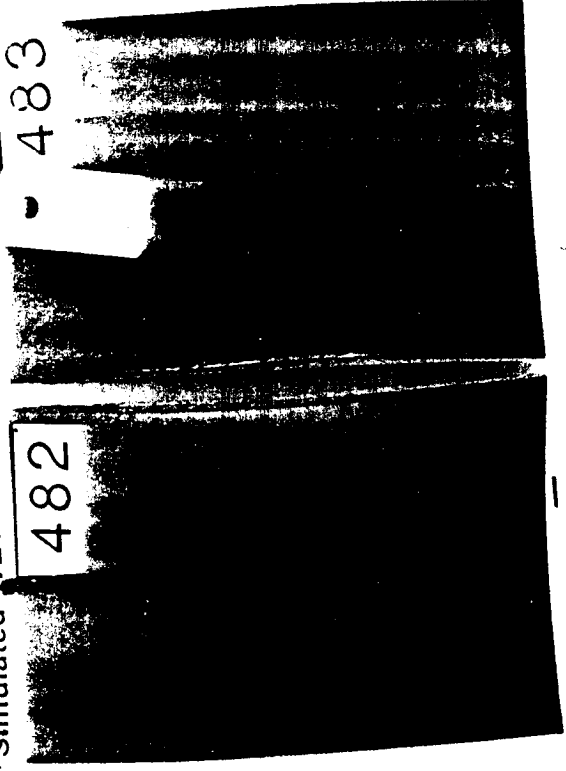
Simulated WETF Pool, 2000 hrs. System 6



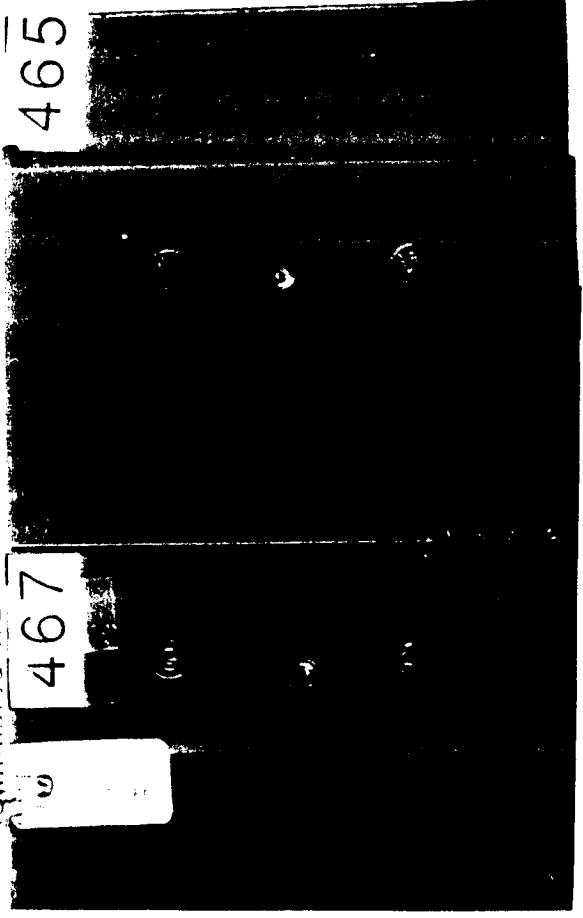
Simulated WETF Pool, 2000 hrs. System 6



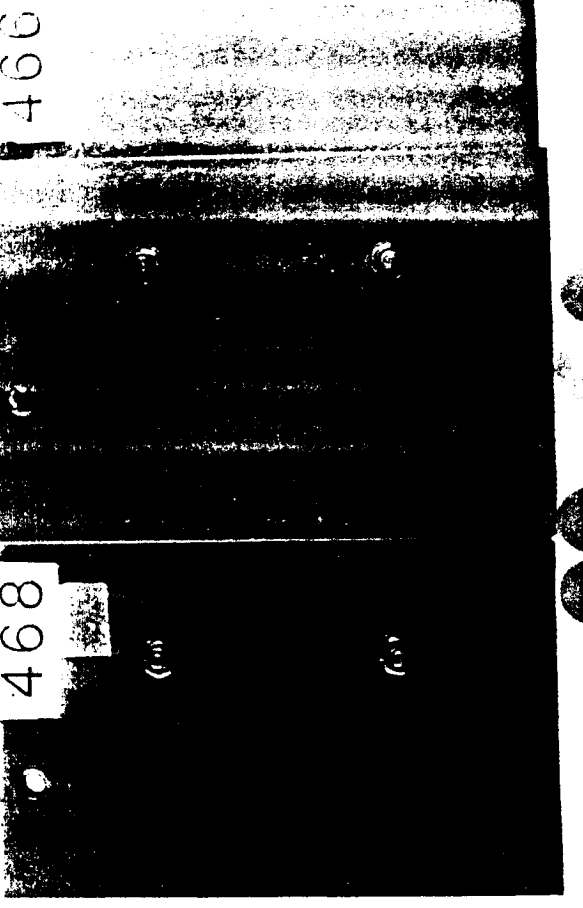
Simulated WETF Pool, 2000 hrs. System 6



Simulated WETF Pool, 2000 hrs. System 6



Simulated WETF Pool, 2000 hrs. System 6



ORIGINAL PAGE IS OF POOR QUALITY

Simulated WETF Pool, 2000 hrs.

System 7

505

507

Simulated WETF Pool, 2000 hrs.

System 7

506

508

Simulated WETF Pool, 2000 hrs.

System 7

527

529

Simulated WETF Pool, 2000 hrs.

System 7

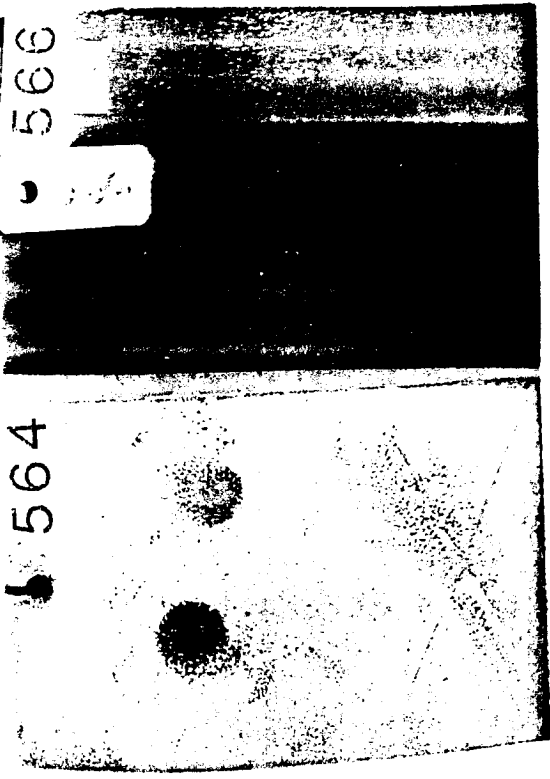
528

530

ORIGINAL PAGE IS
POOR QUALITY

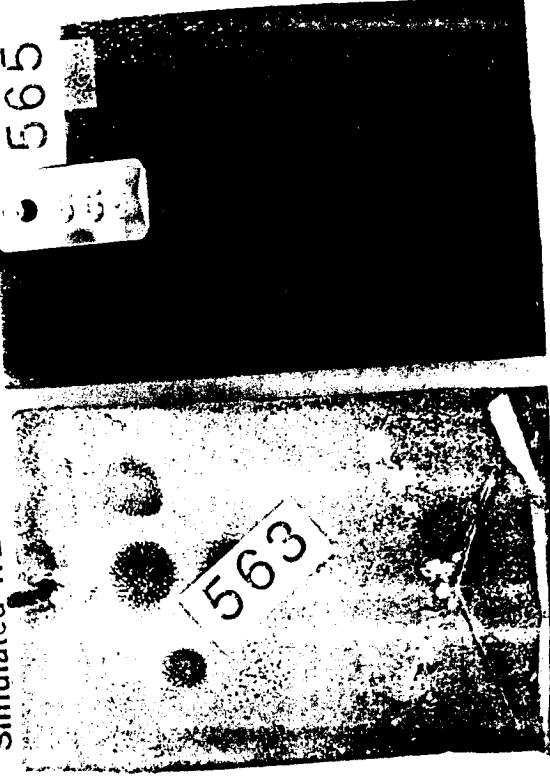
System 7

Simulated WETF Pool, 2000 hrs.



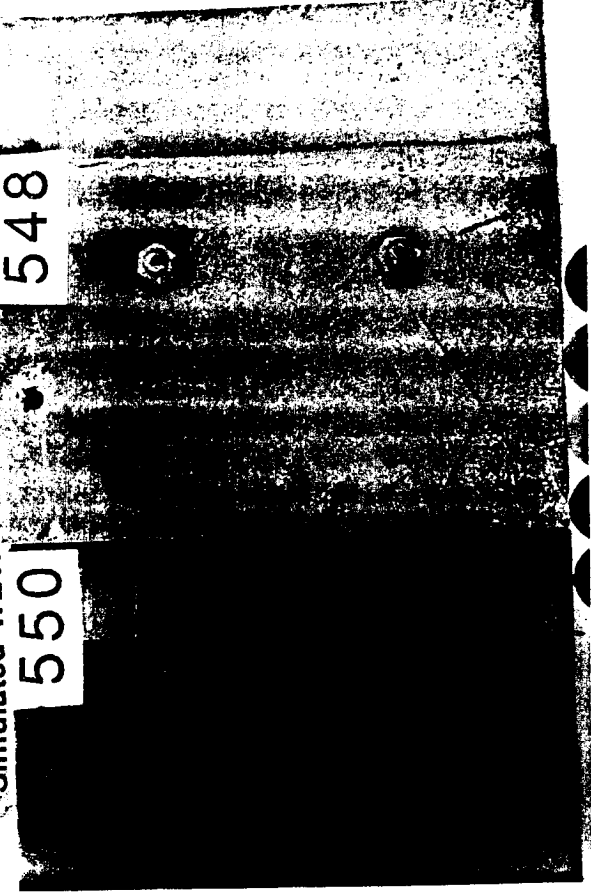
System 7

Simulated WETF Pool, 2000 hrs.



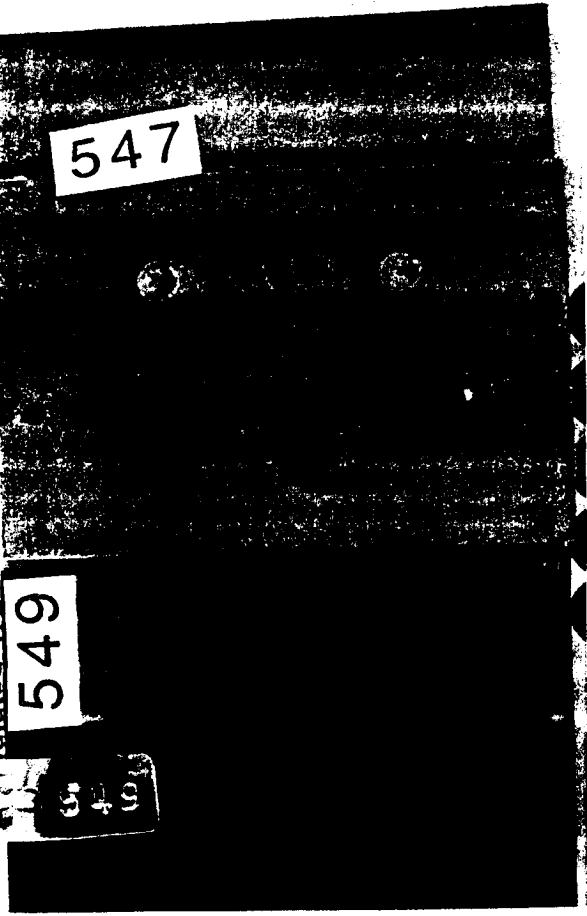
System 7

Simulated WETF Pool, 2000 hrs.



System 7

Simulated WETF Pool, 2000 hrs.



Simulated WETF Pool, 2000 hrs.

587

System 8

589

Simulated WETF Pool, 2000 hrs.

588

System 8

590

Simulated WETF Pool, 2000 hrs.

609

System 8

611

Simulated WETF Pool, 2000 hrs.

610

System 8

612

Simulated WEIF Pool, 2000 hrs.

643

System 8

645

Simulated WEIF Pool, 2000 hrs.

644

System 8

646

631

629

Simulated WEIF Pool, 2000 hrs.

632

System 8

630

System 9

Simulated WETF Pool, 2000 hrs.

672

699

System 9

Simulated WETF Pool, 2000 hrs.

671

668

System 9

Simulated WETF Pool, 2000 hrs.

694

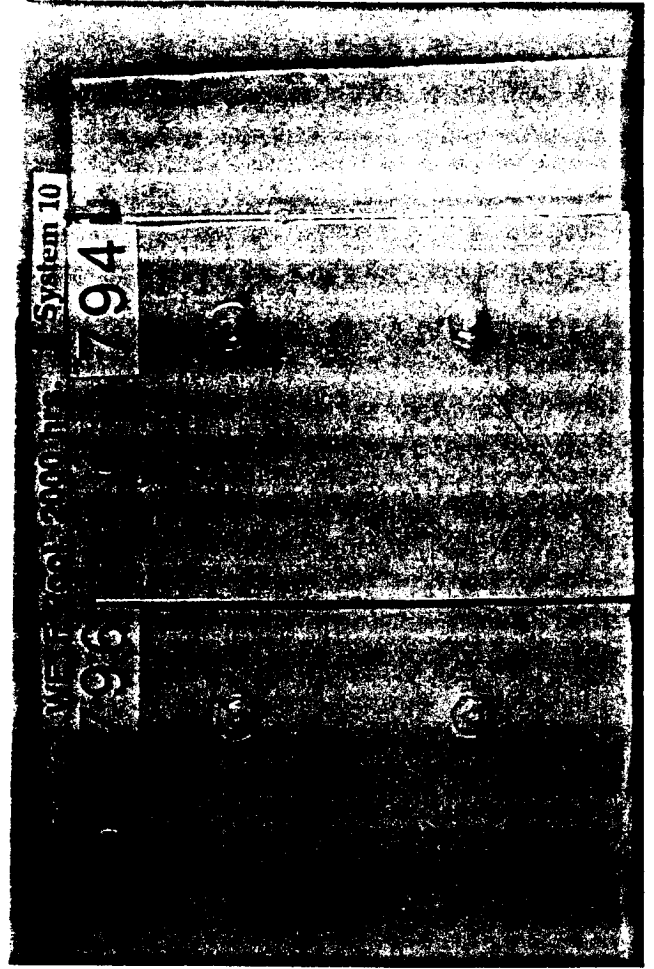
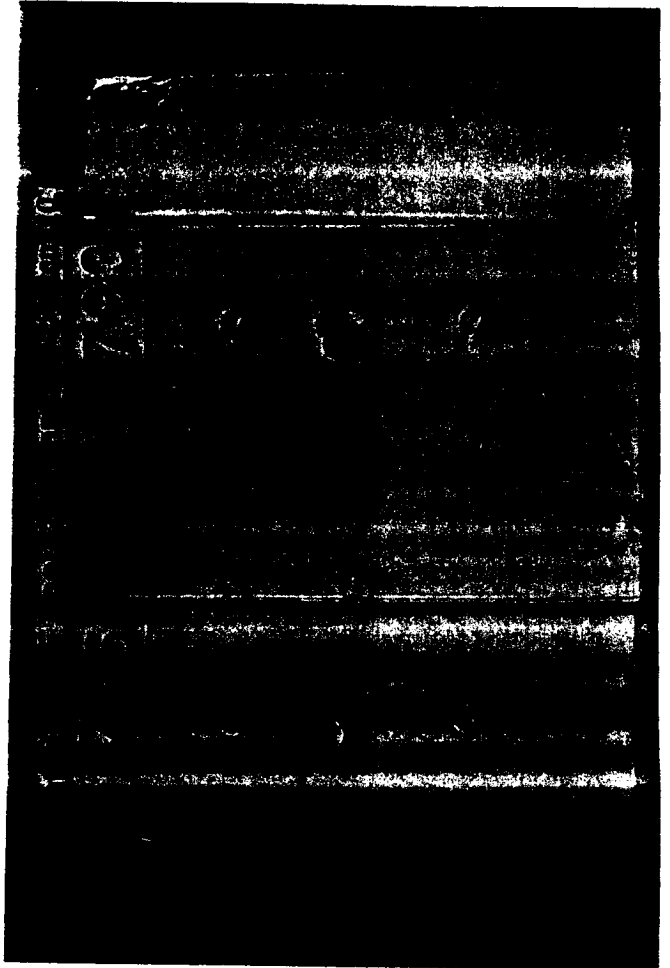
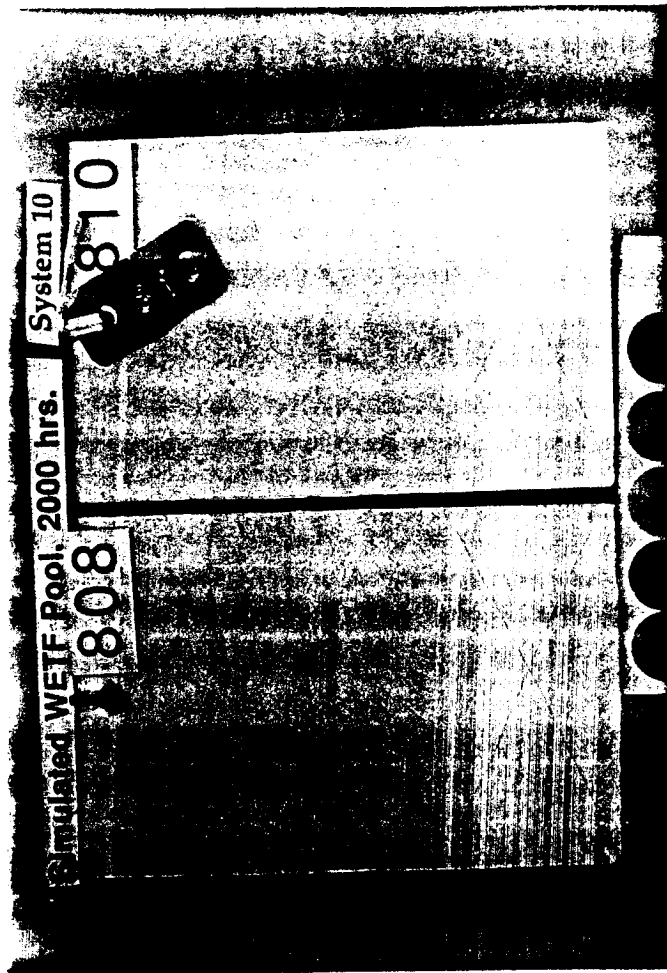
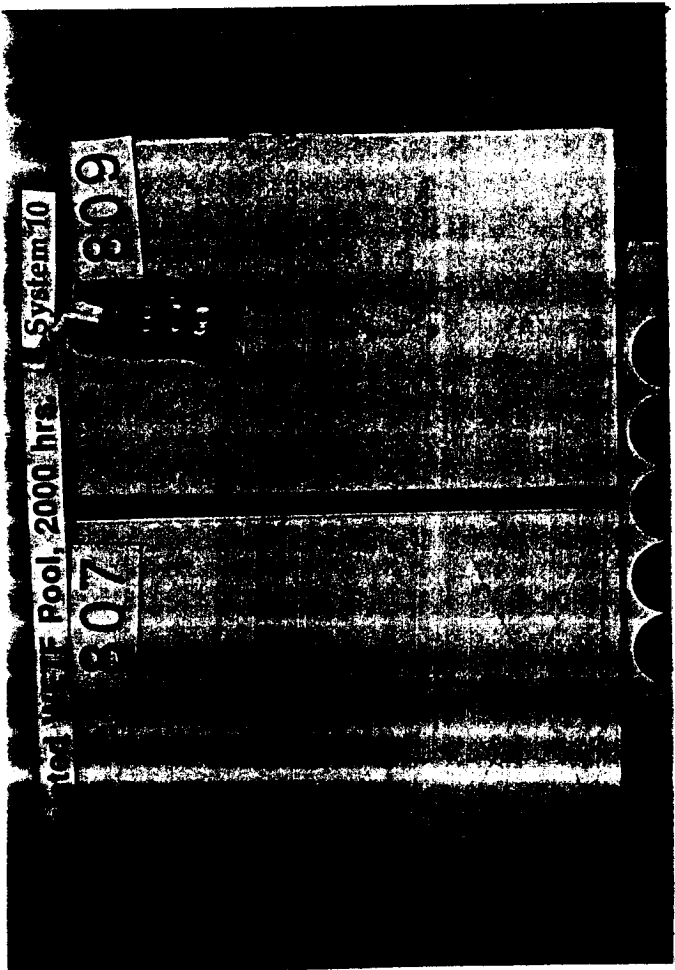
692

System 9

Simulated WETF Pool, 2000 hrs.

695

691



750

752

Simulated WETF Pool, 2000 hrs. System 10

774

773

System 10

Simulated WETF Pool, 2000 hrs.

753

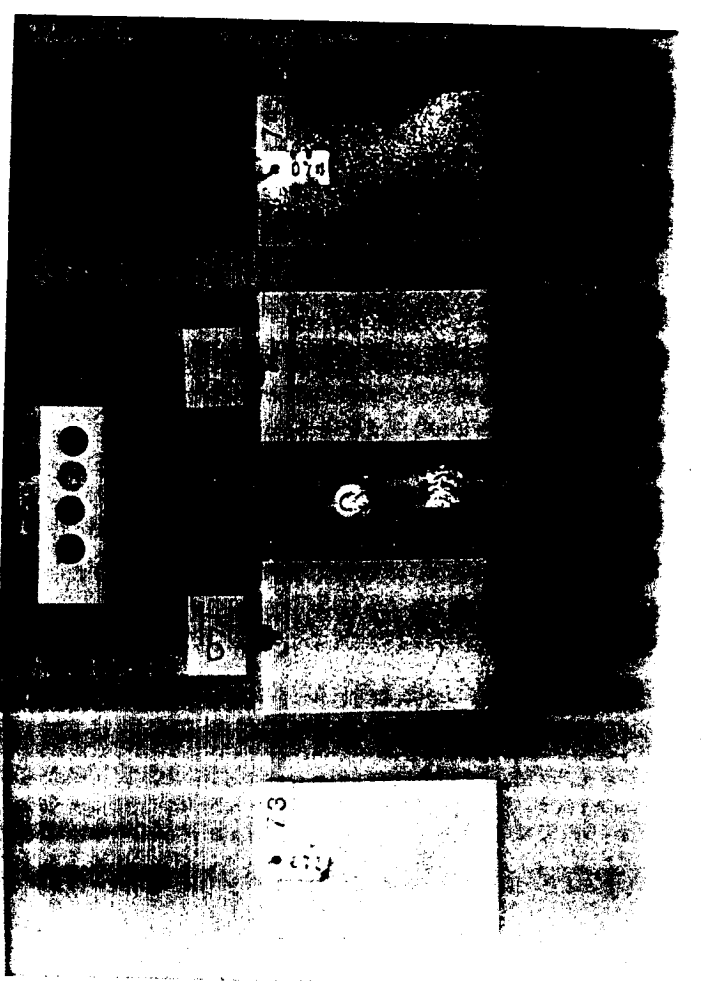
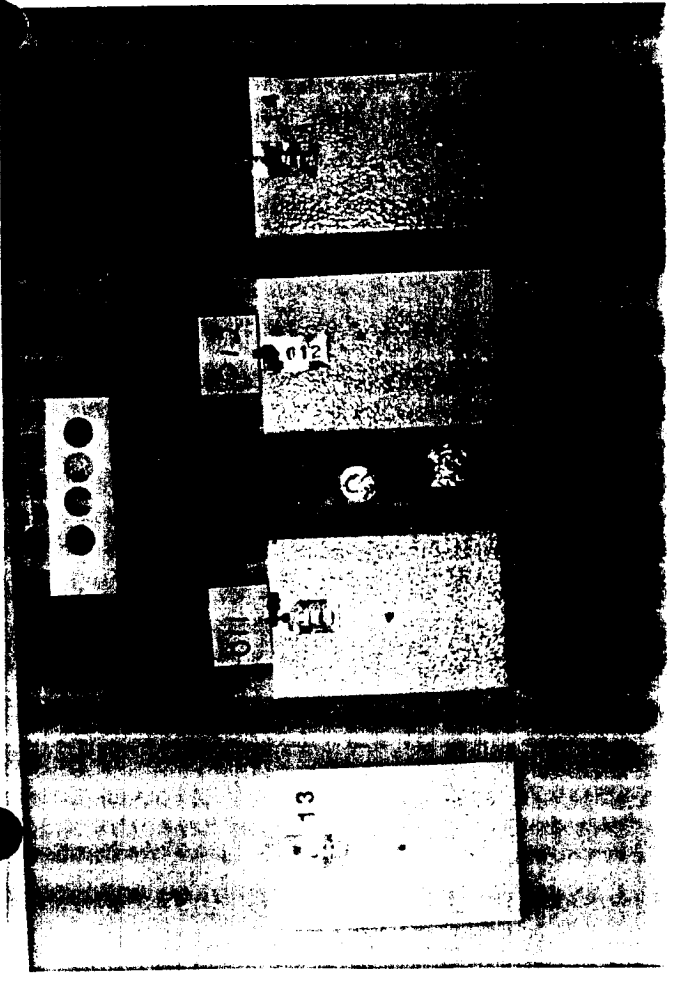
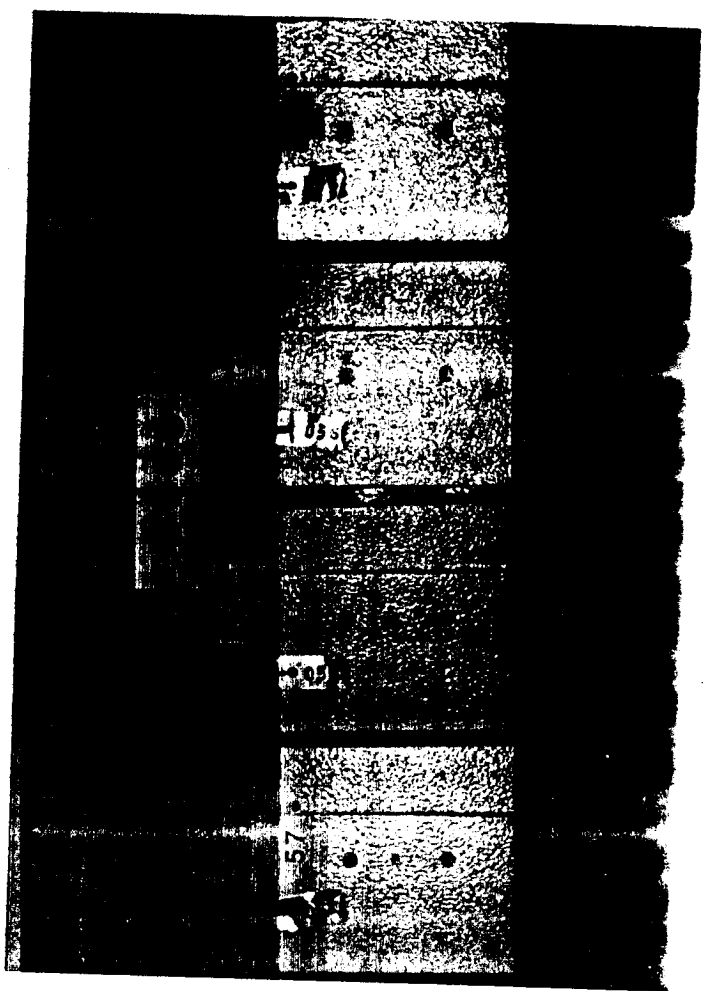
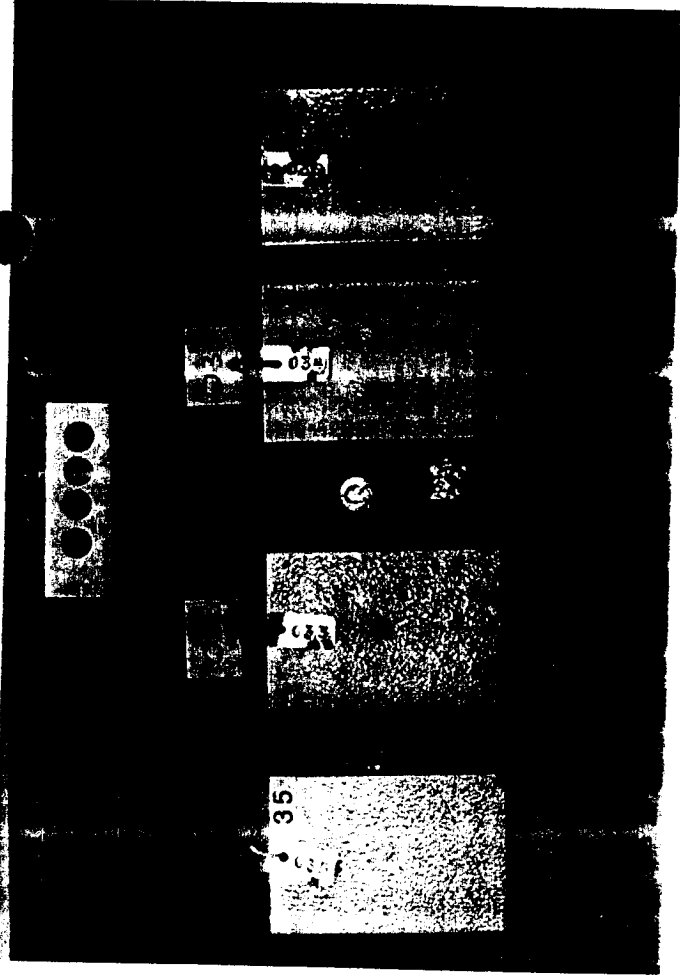
751

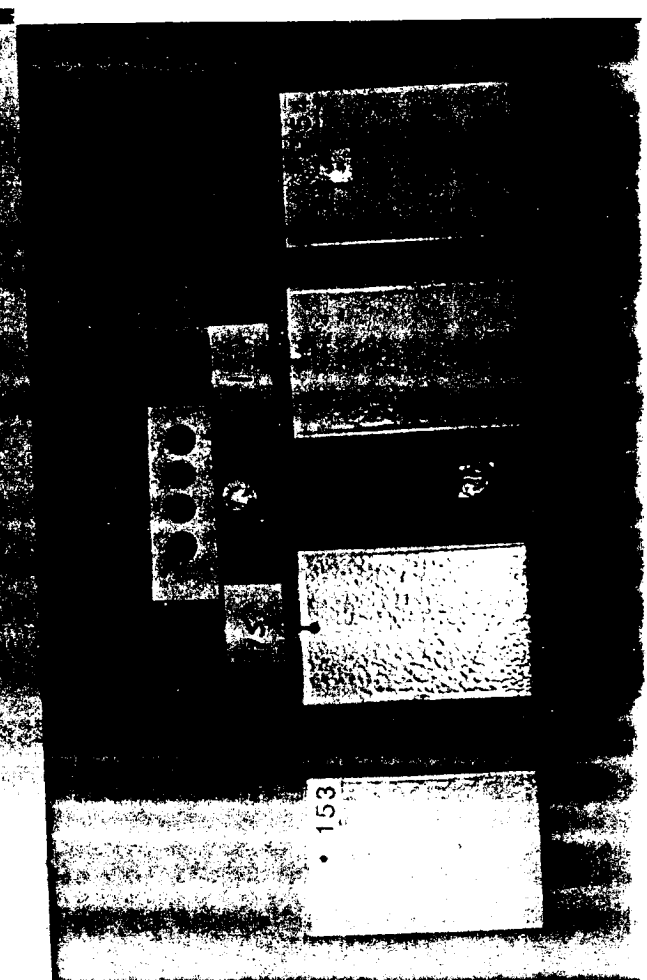
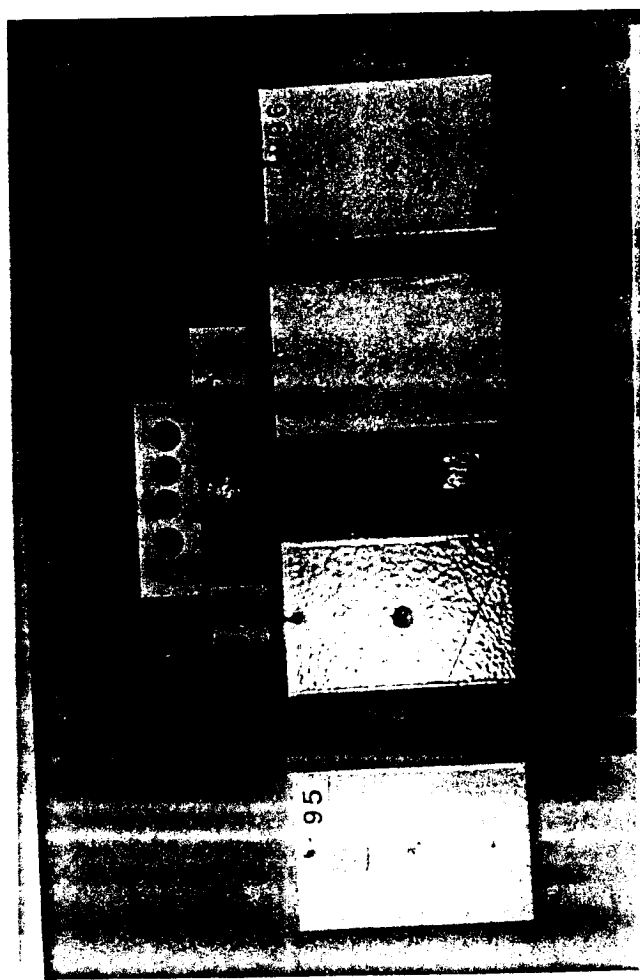
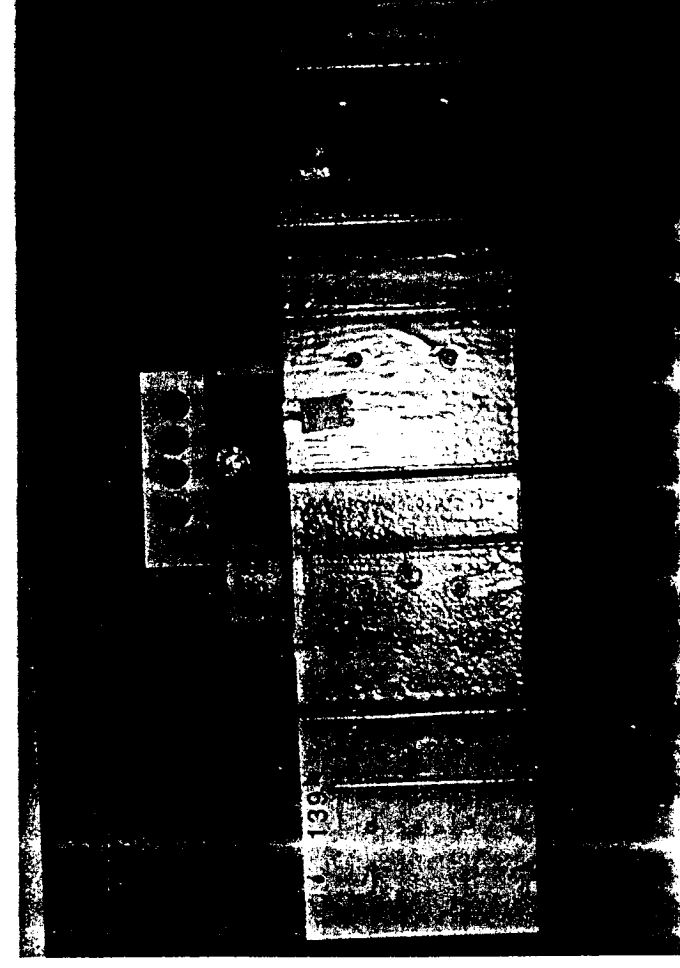
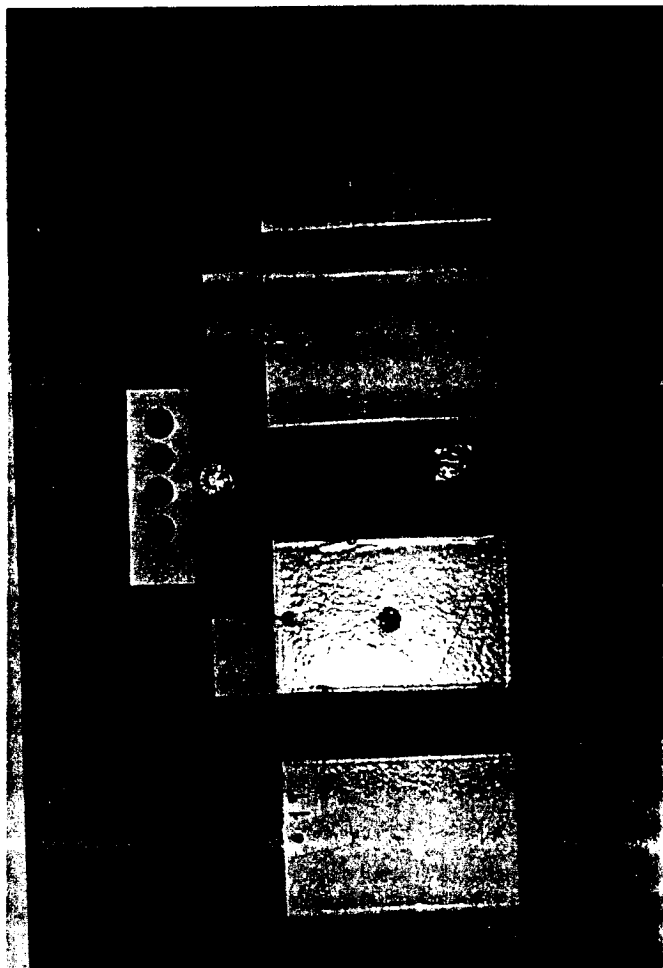
System 10

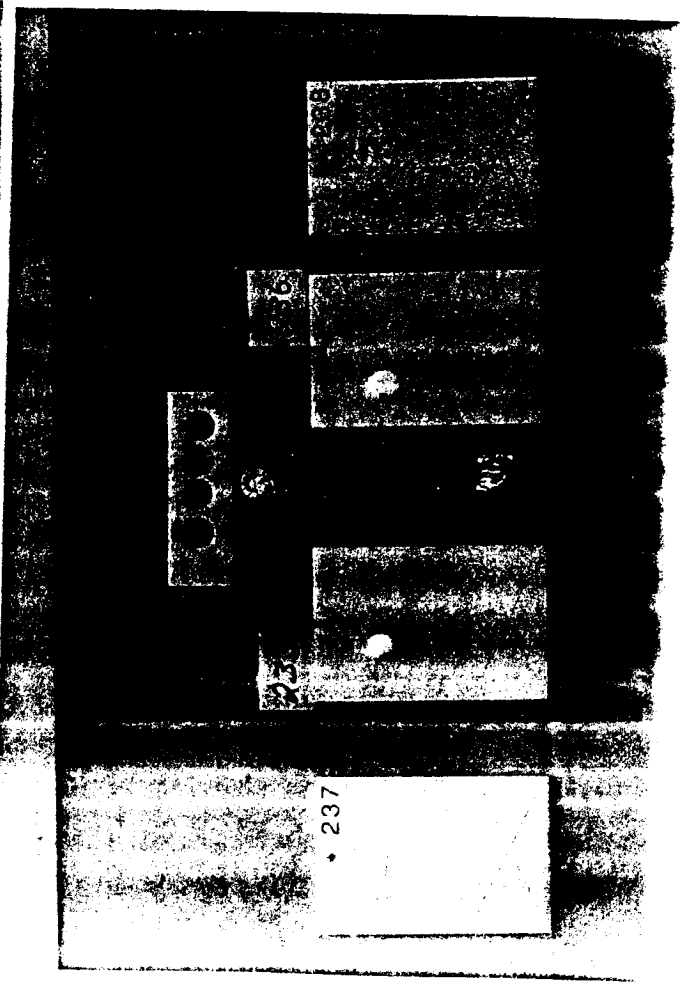
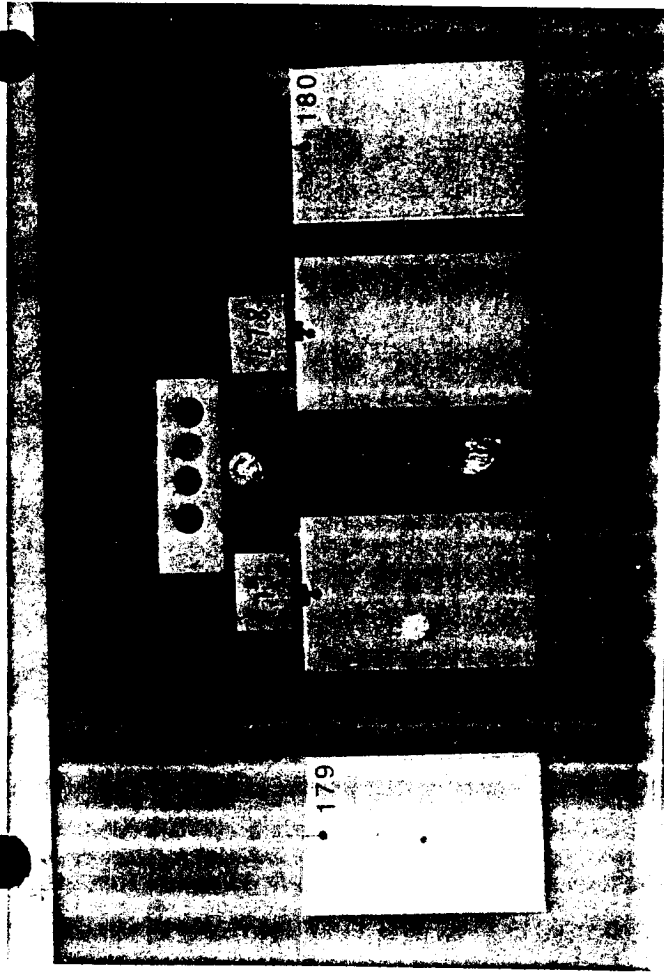
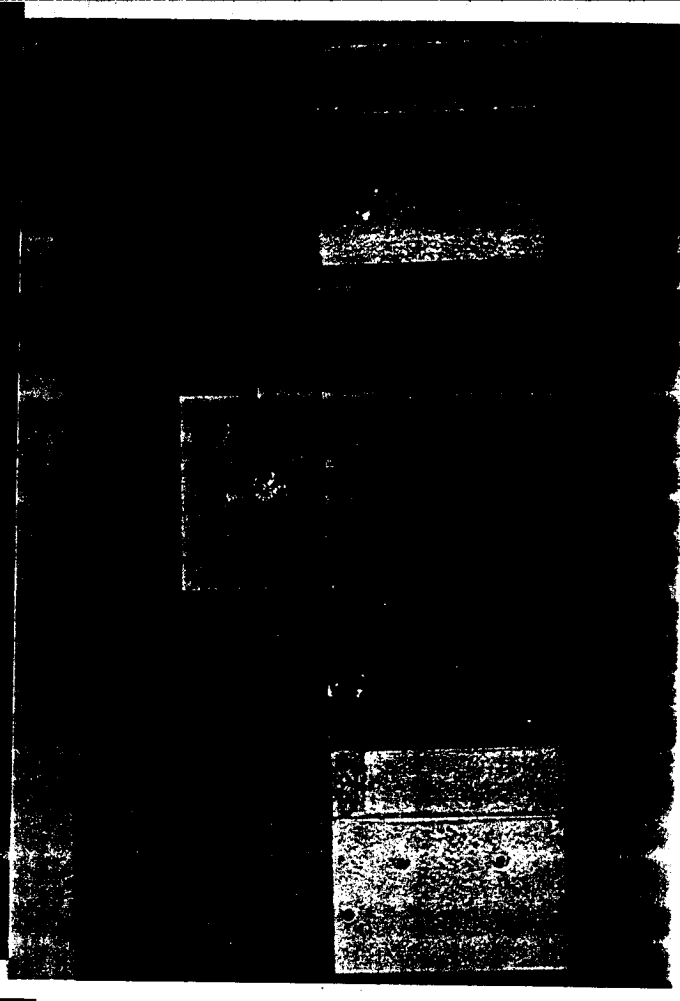
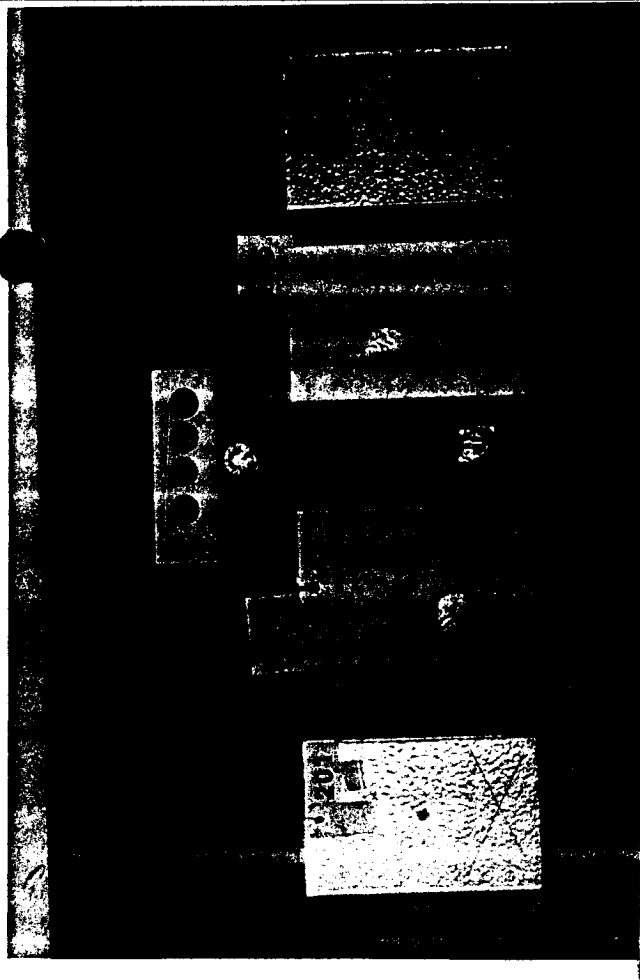
Simulated WETF Pool, 2000 hrs.

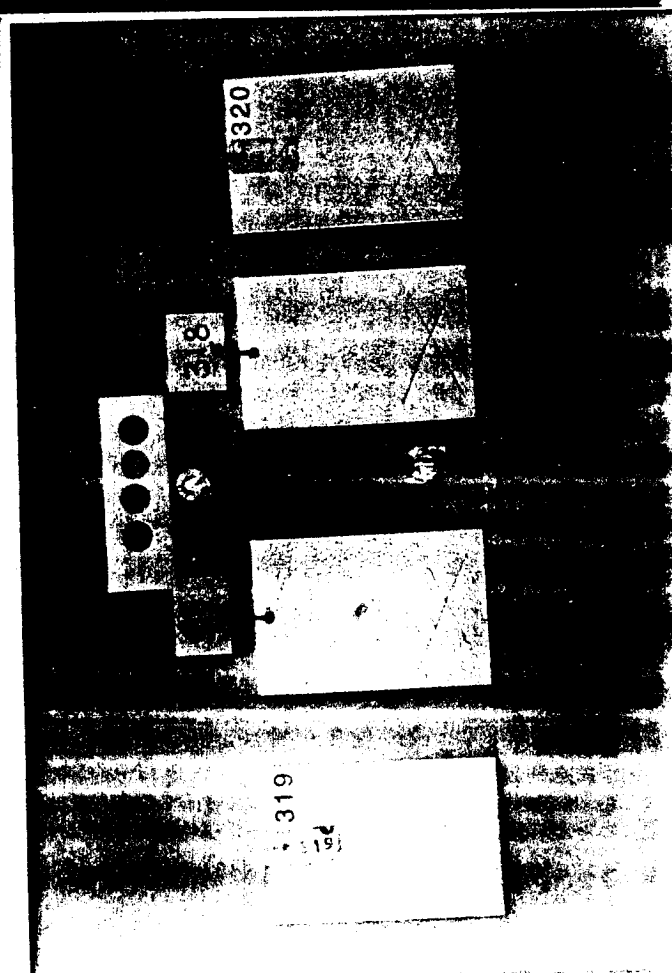
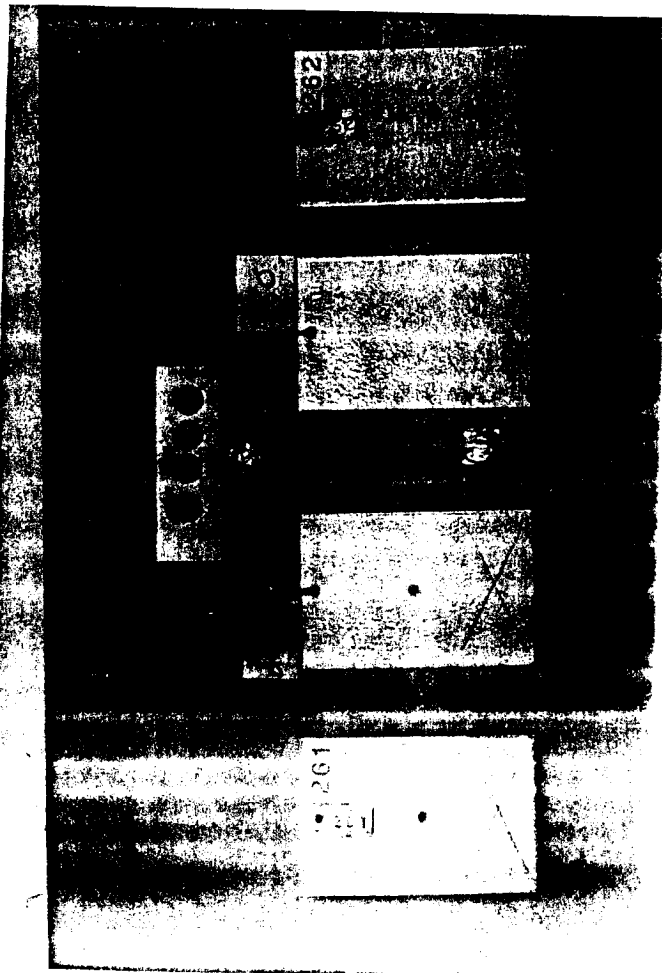
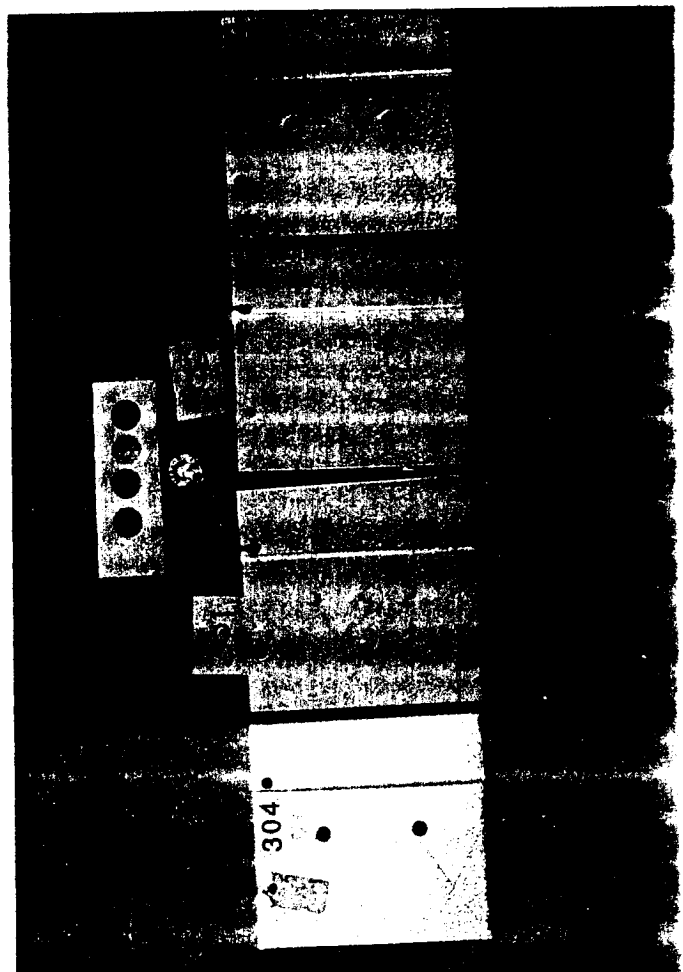
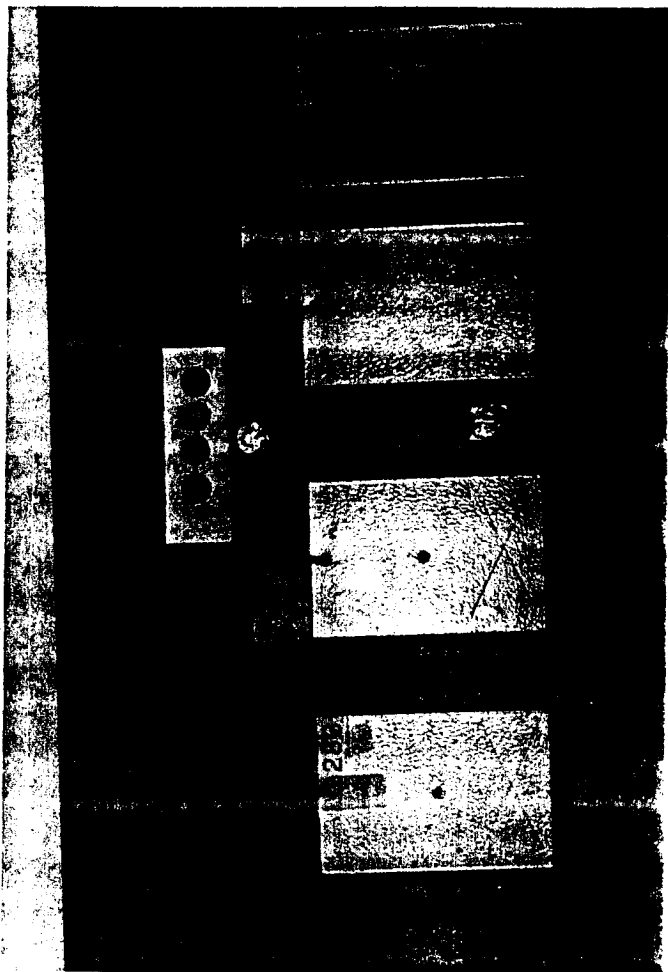
776

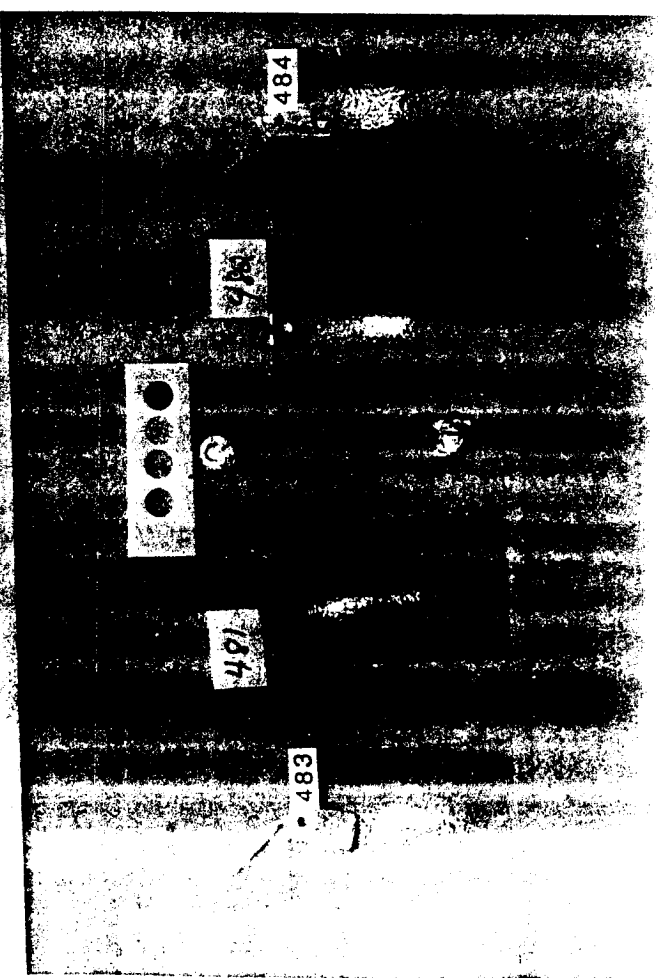
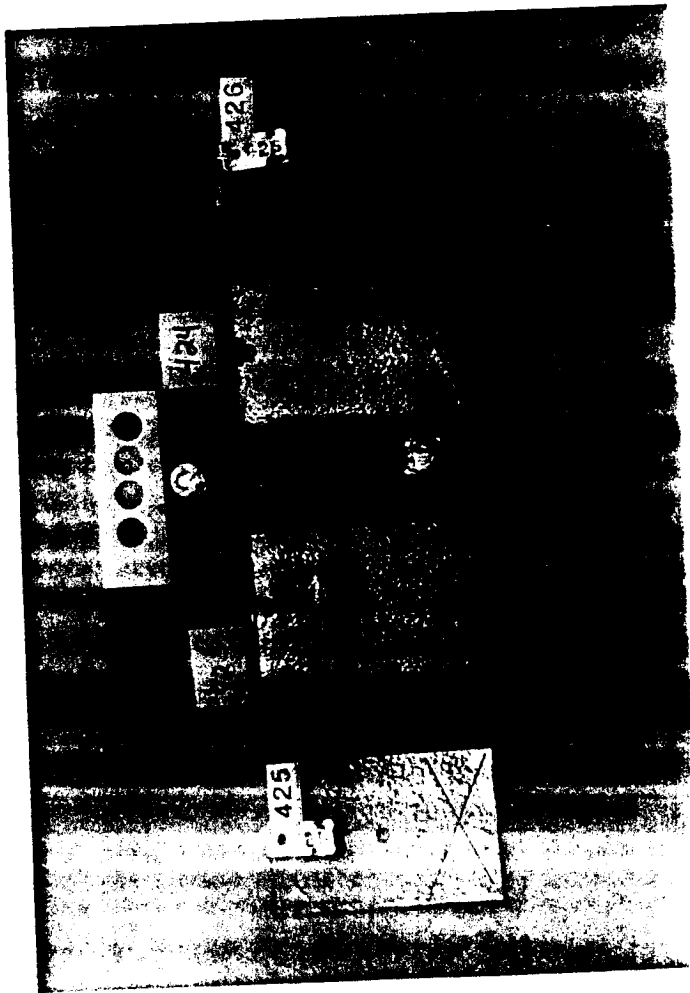
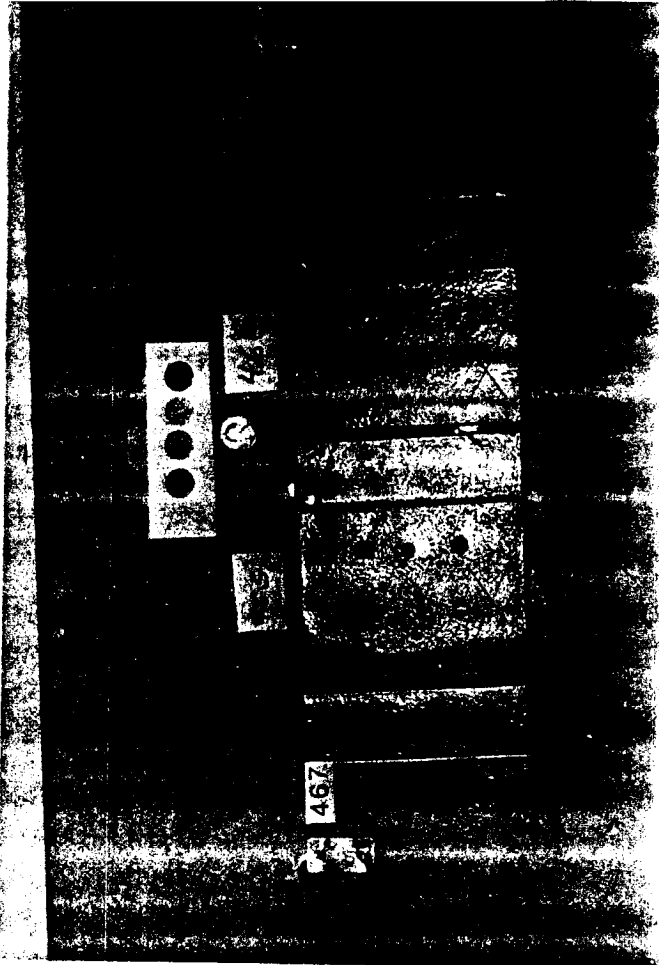
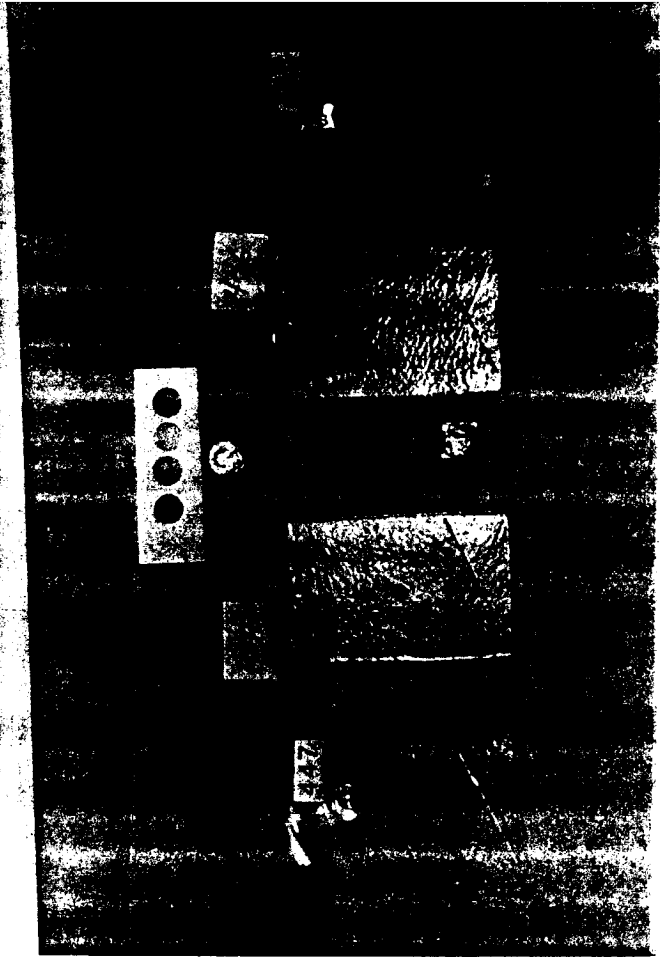
772

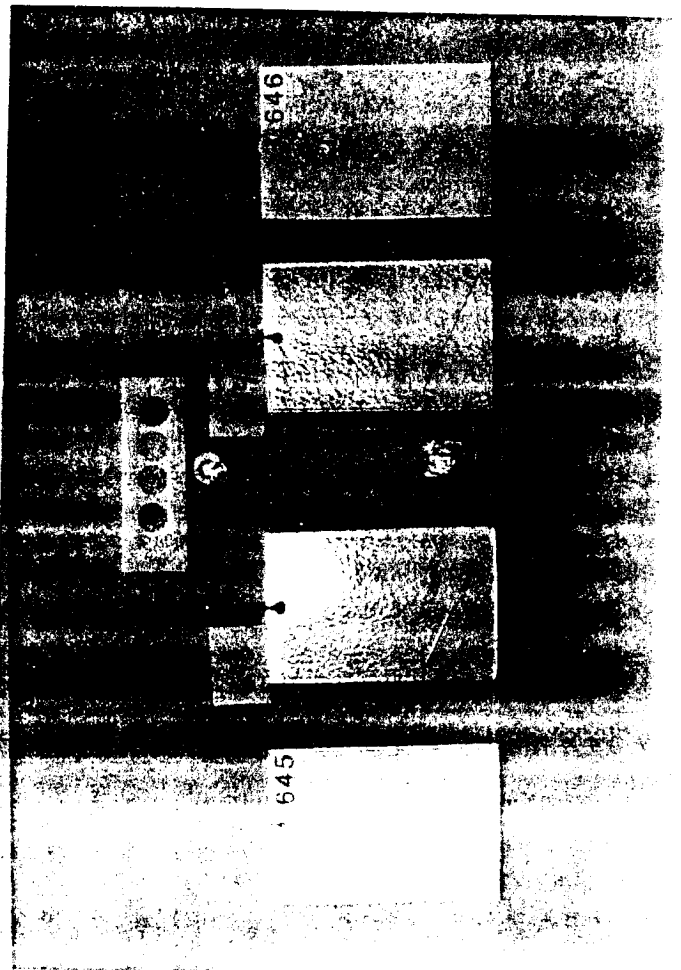
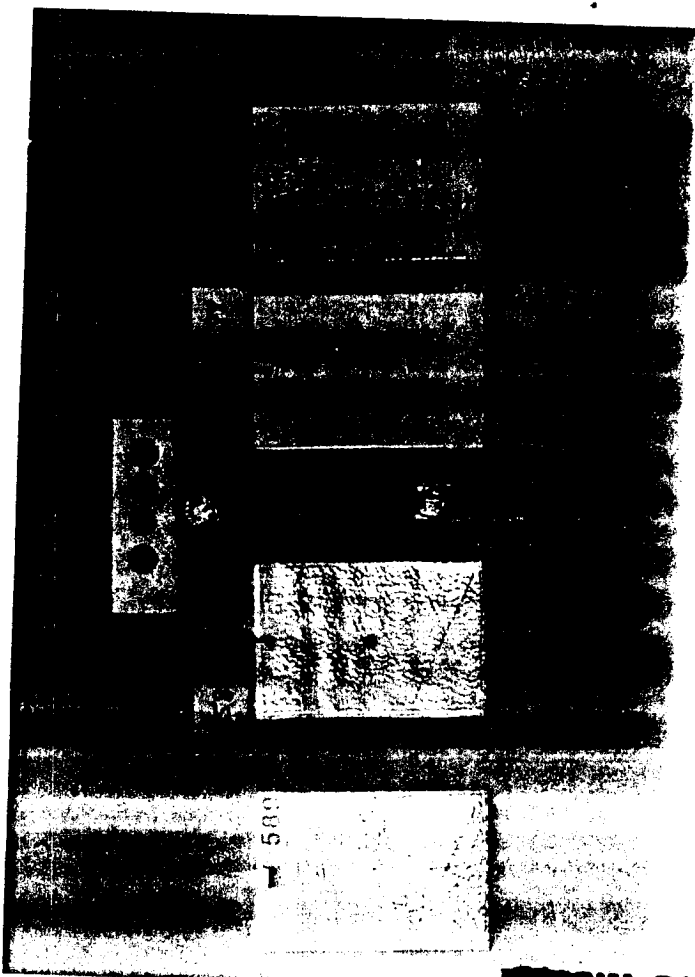
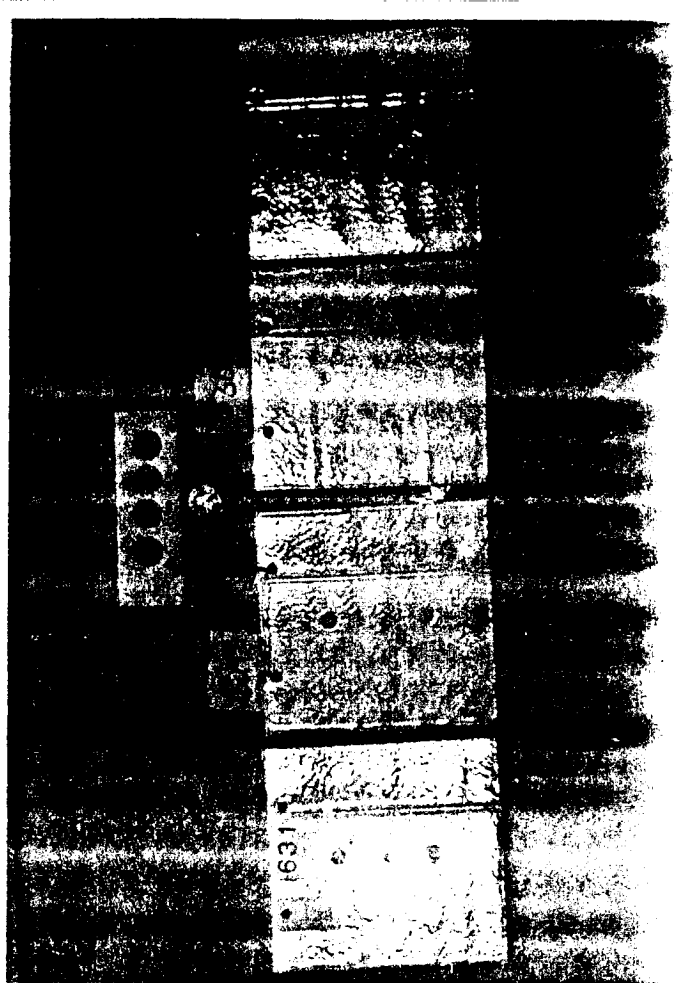
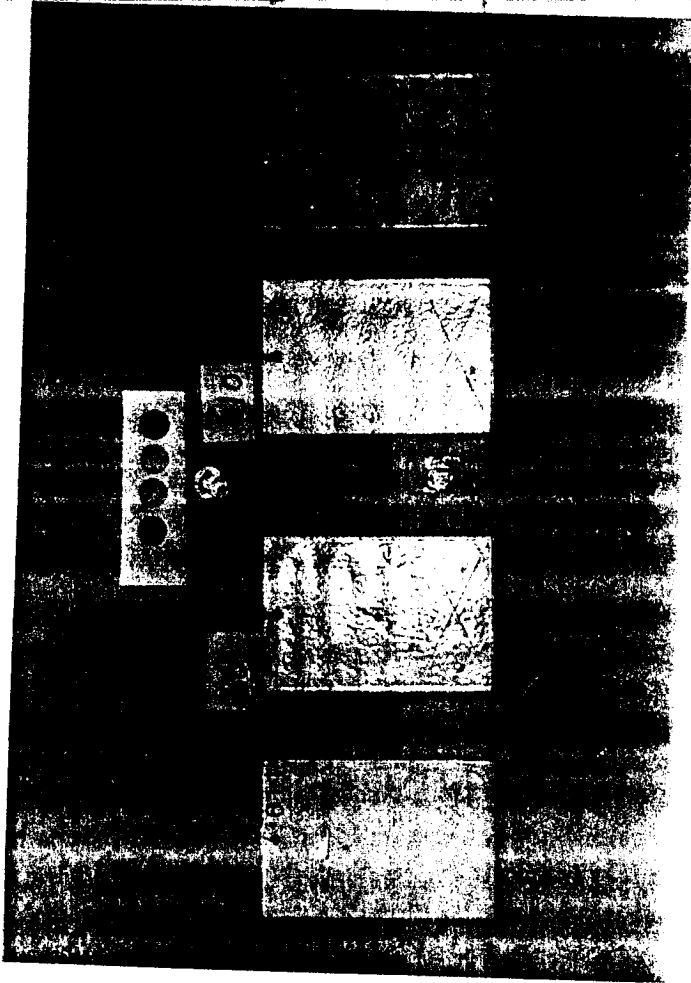




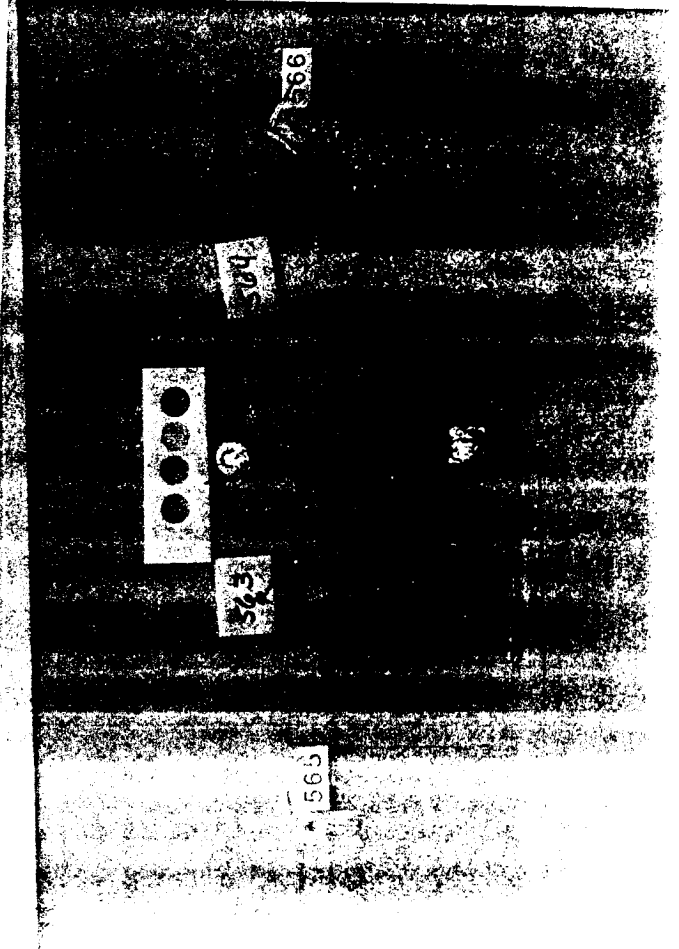
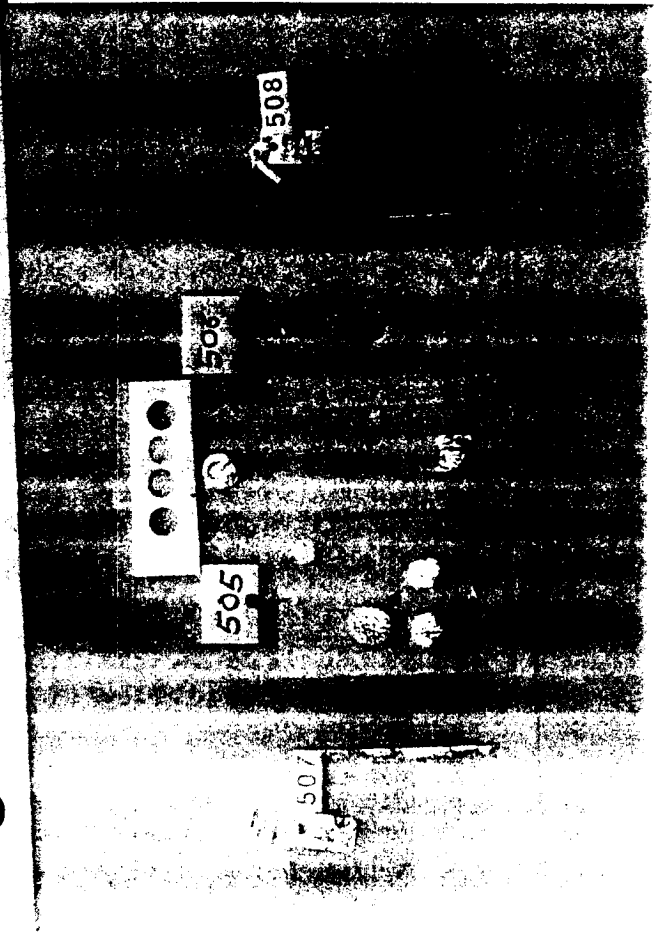
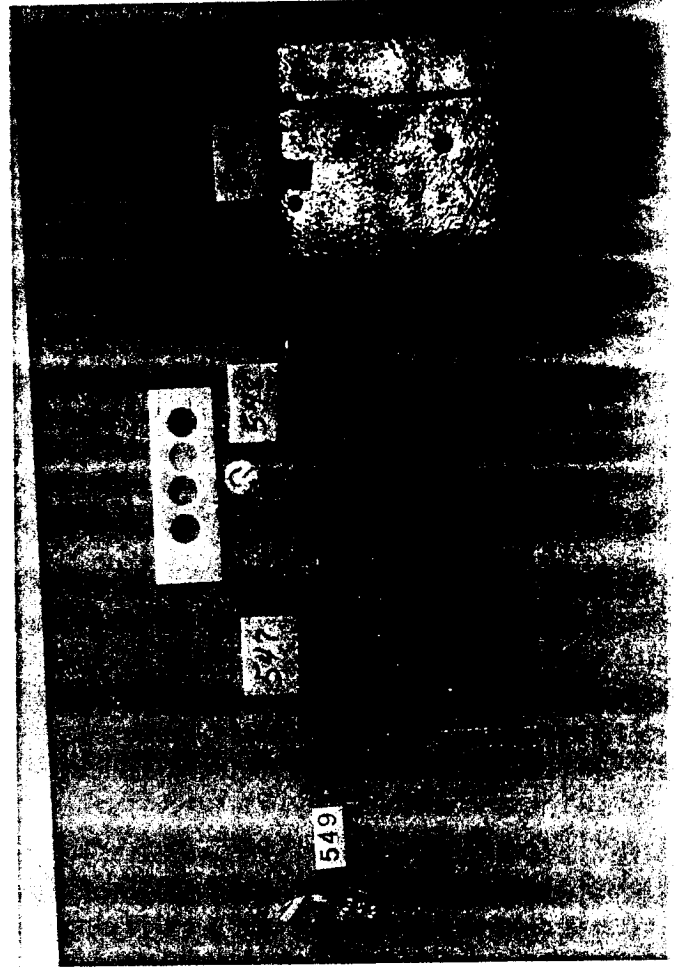
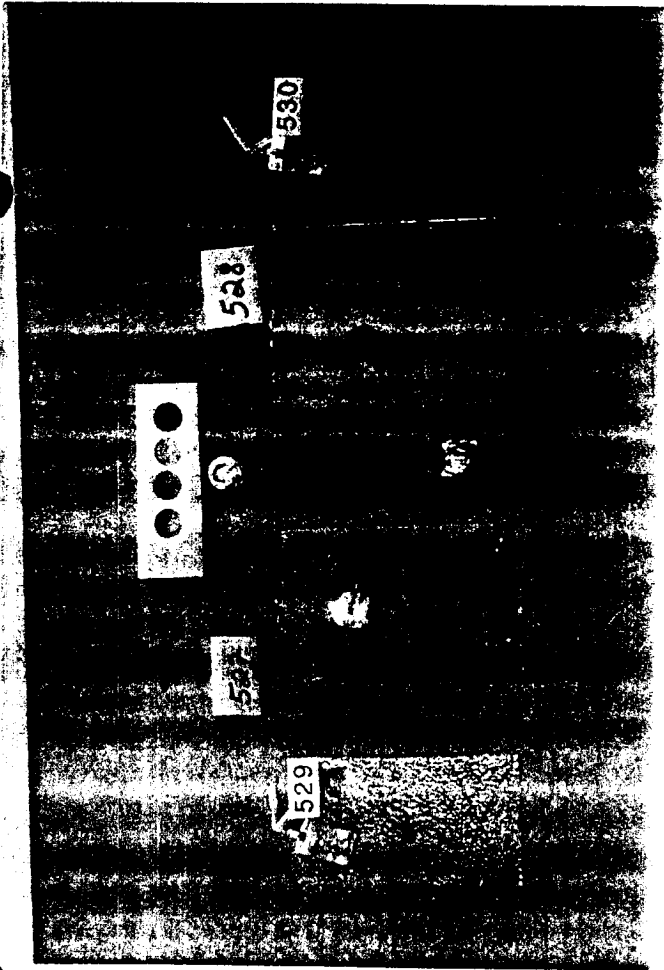


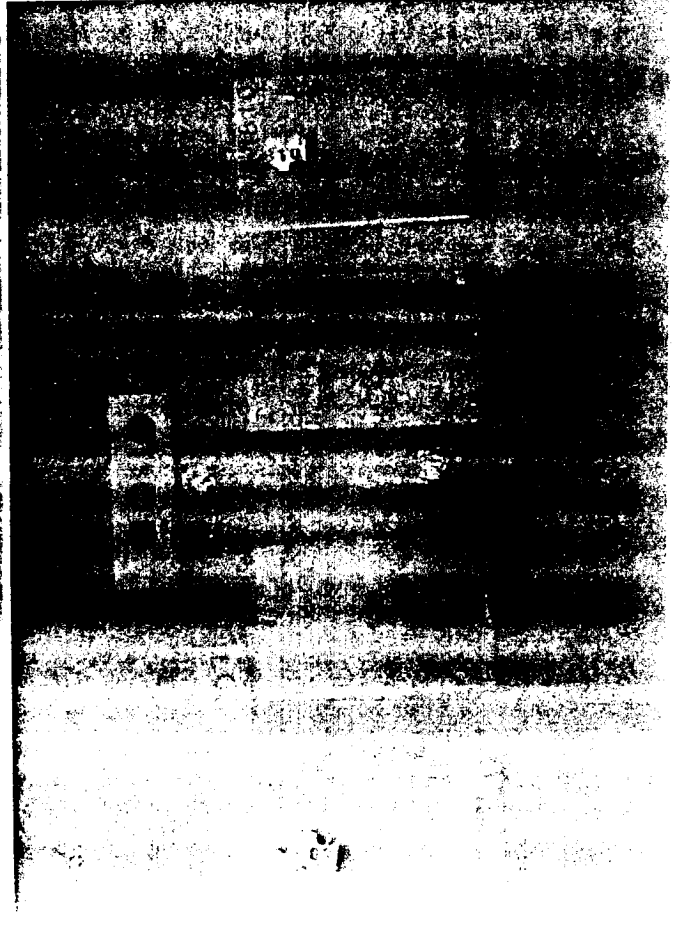
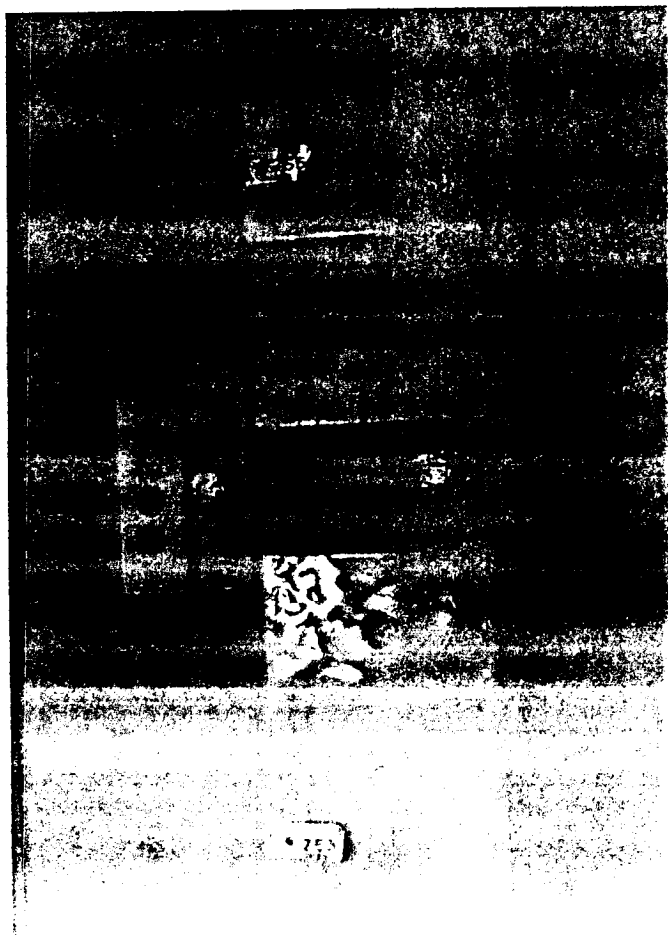
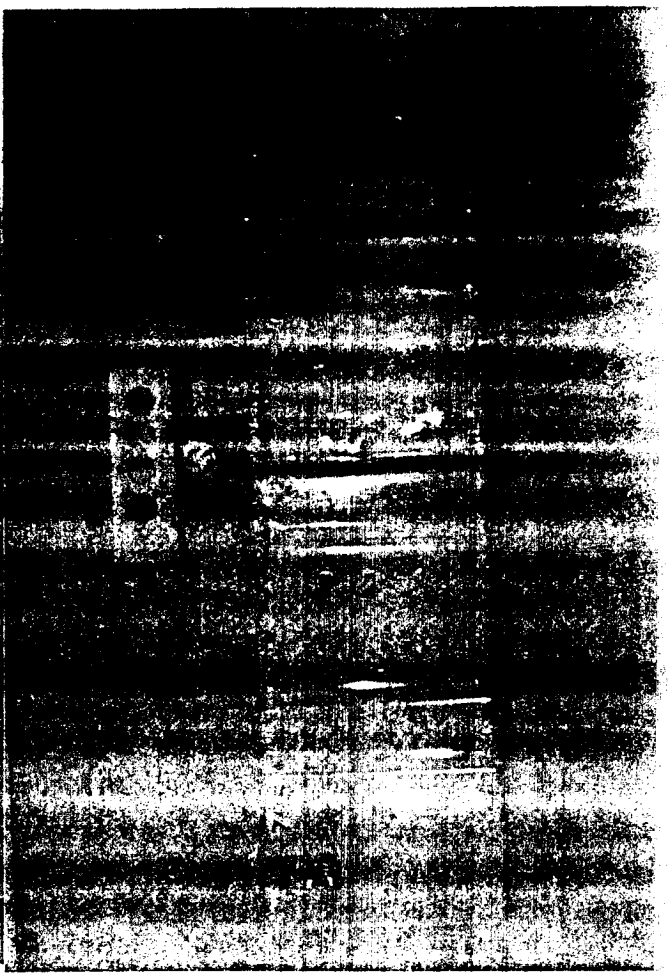
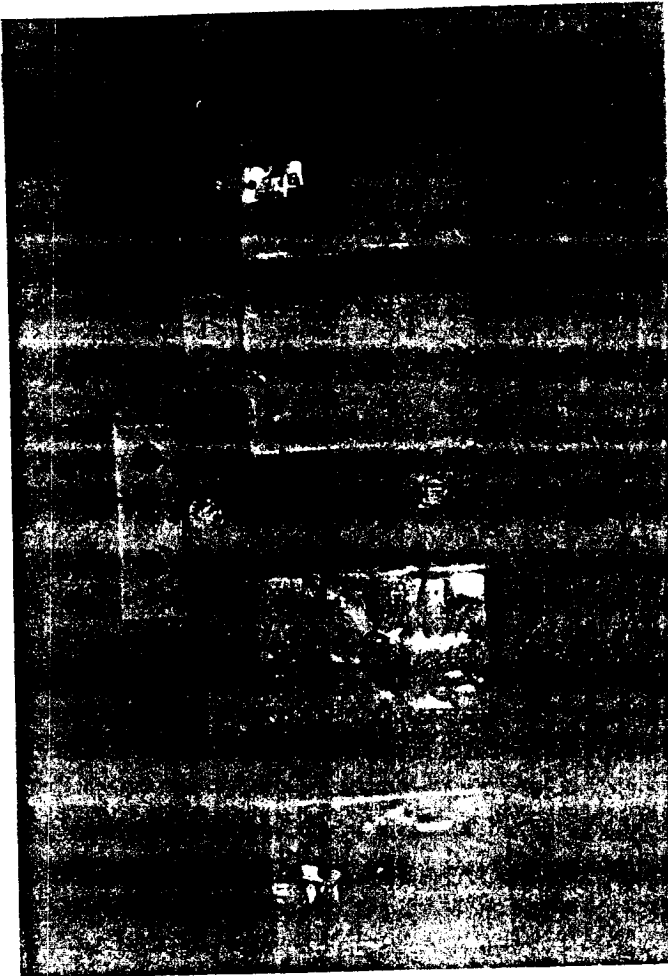


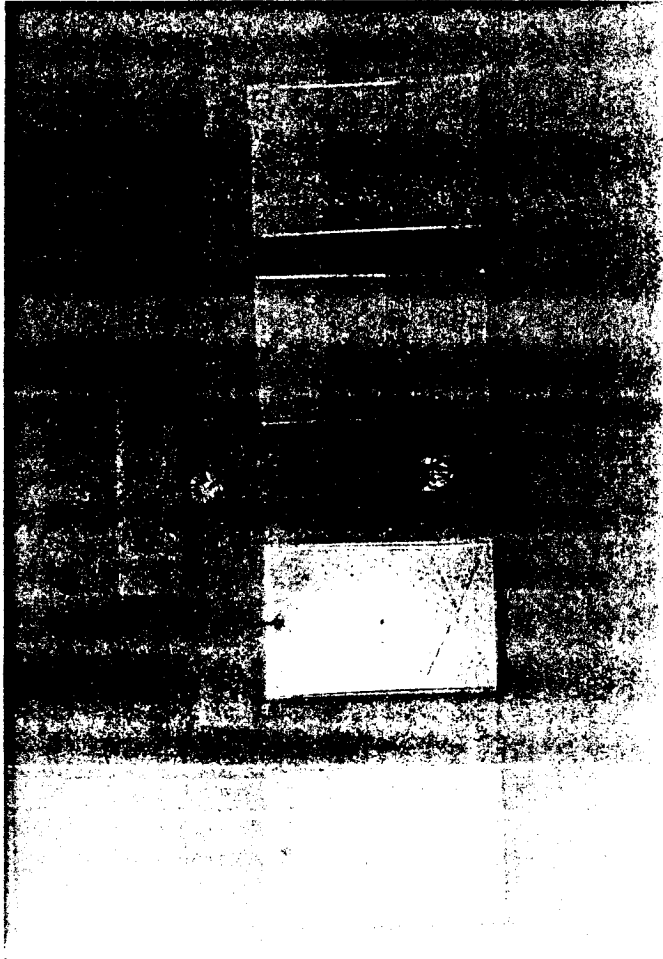
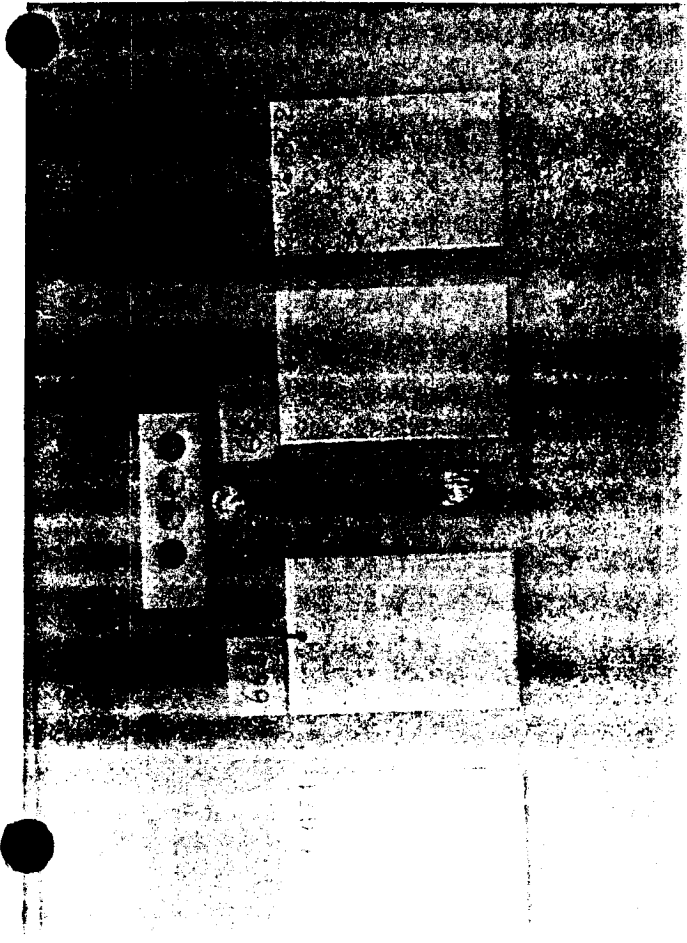
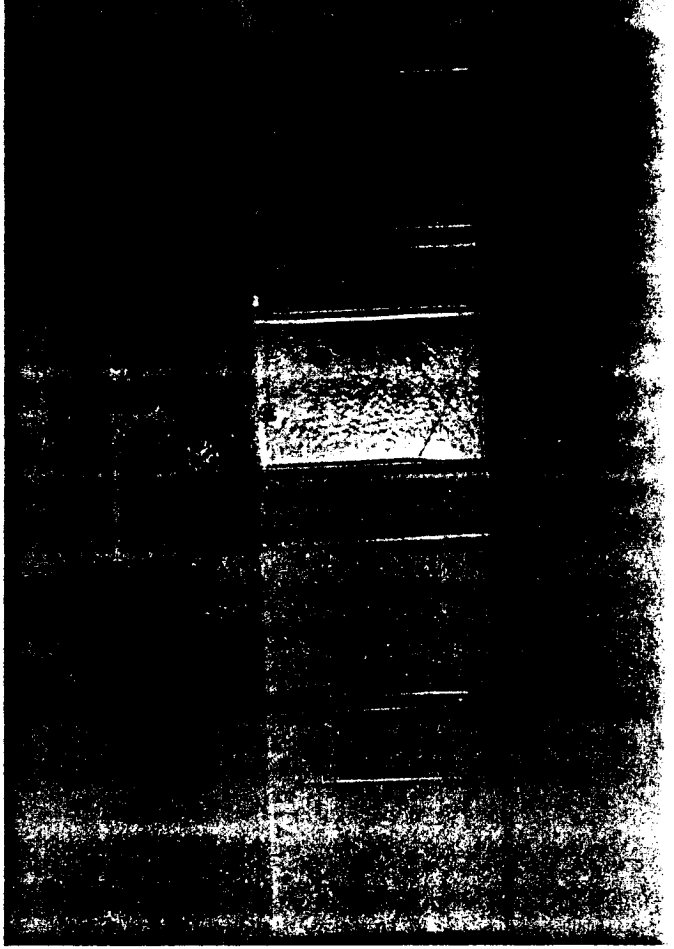
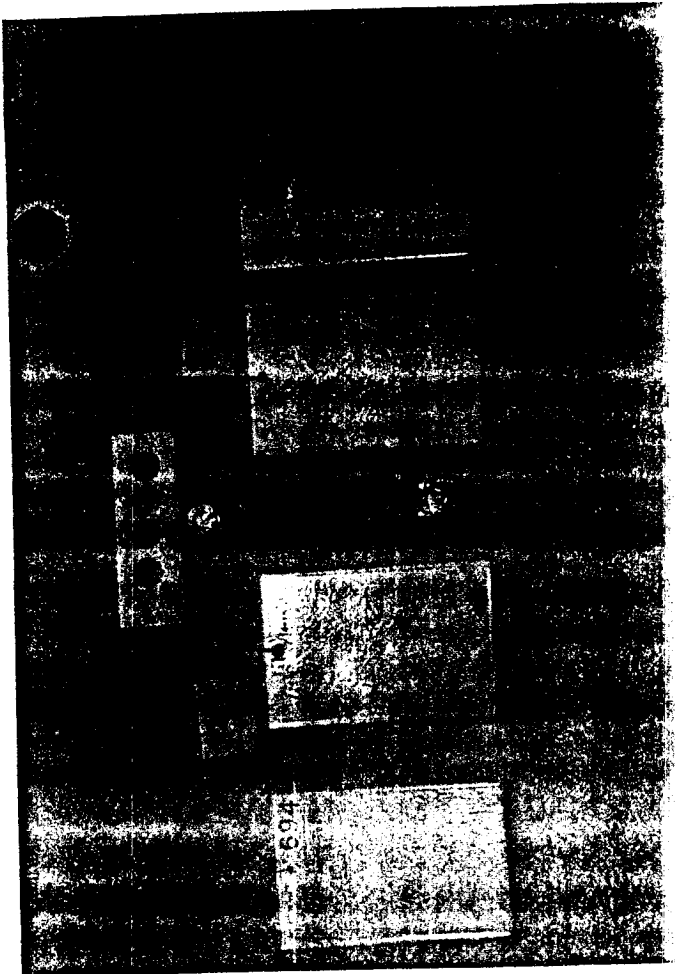




ORIGINAL PAGE IS
OF POOR QUALITY







ORIGINAL PAGE IS
OF POOR QUALITY

APPENDIX C
Photographic Presentation of Panels

QUV-Weatherometer Panels

Right Hand Page:

2000 hrs

| |
|-----------------|
| Stainless Steel |
| Aluminum |

| |
|-----------------|
| Stainless Steel |
| Aluminum |

Left Hand Page:

| |
|------------|
| CPVC |
| Coupled-SS |

| |
|------------|
| CPVC |
| Coupled-AL |

One System per page

800 hrs

| |
|-----------------|
| Stainless Steel |
| CPVC |

| |
|----------|
| Aluminum |
| Coupled |

ORIGINAL PAGE IS
OF POOR QUALITY

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 1

9

13

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 1

10

14

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 1

31

35

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 1

32

36

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 1

74

70

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 1

73

69

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 1

54

58

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 1

53

57



QUV-Weatherometer (ASTM G-53), 2000 Hours

System 2

149

153

QUV-Weatherometer (ASTM G-53), 2000 Hours

System 2

150

154

QUV-Weatherometer (ASTM G-53), 2000 Hours

System 2

139

135

QUV-Weatherometer (ASTM G-53), 2000 Hours

System 2

140

136

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 3

175

179

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 3

176

180

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 3

197

201

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 3

198

202

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 3

231

237

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 3

232

238

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 3

221

217

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 3

222

218

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 4

257

261

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 4

258

262

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 4

279

283

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 4

280

284

ORIGINAL FILED OF POOR QUALITY

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 4

315

319

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 4

316

320

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 4

303

299

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 4

304

300

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 5

397

401

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 5

398

402

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 5

386

382

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 5

385

381

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 5

339

343

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 5

340

348

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 5

361

365

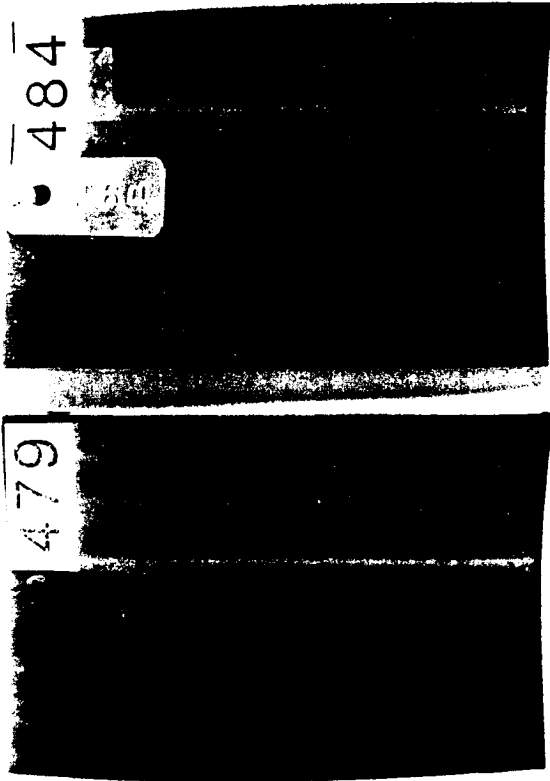
QUV-Weatherometer (ASTM G-53), 2000 Hours
System 5

362

370

ORIGINAL COPY IS
OF POOR QUALITY

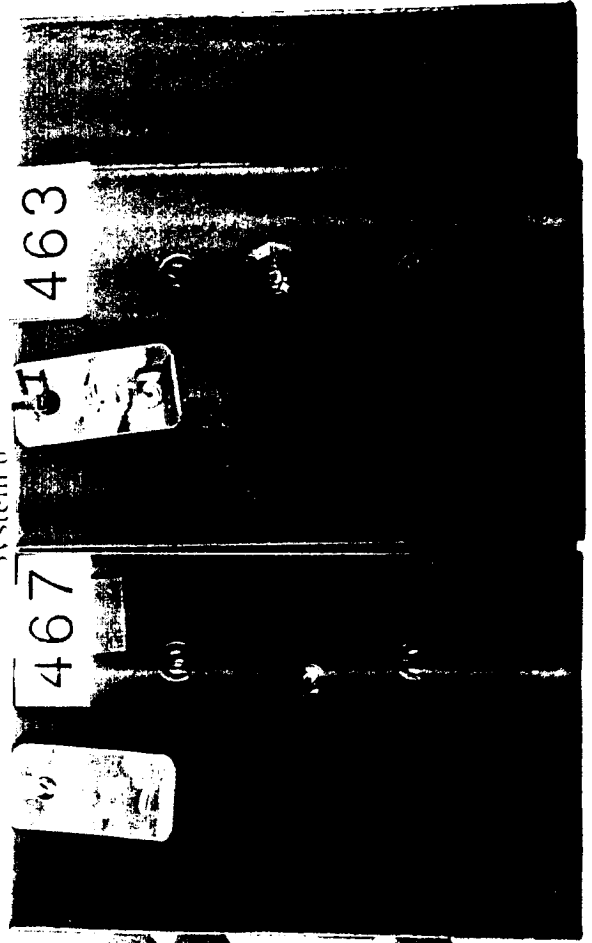
QUV-Weatherometer (ASTM G-53), 2000 Hours
System 6



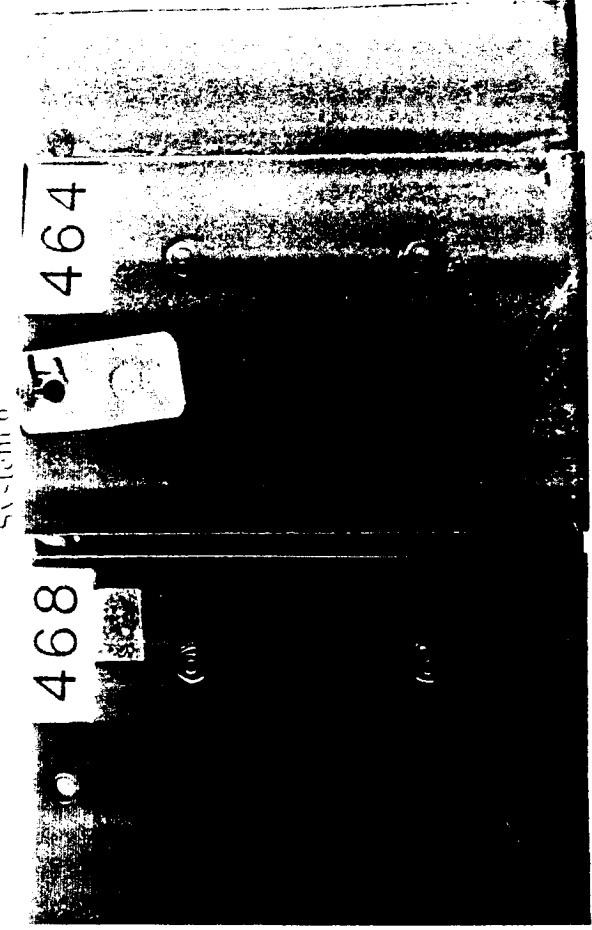
QUV-Weatherometer (ASTM G-53), 2000 Hours
System 6



QUV-Weatherometer (ASTM G-53), 2000 Hours
System 6

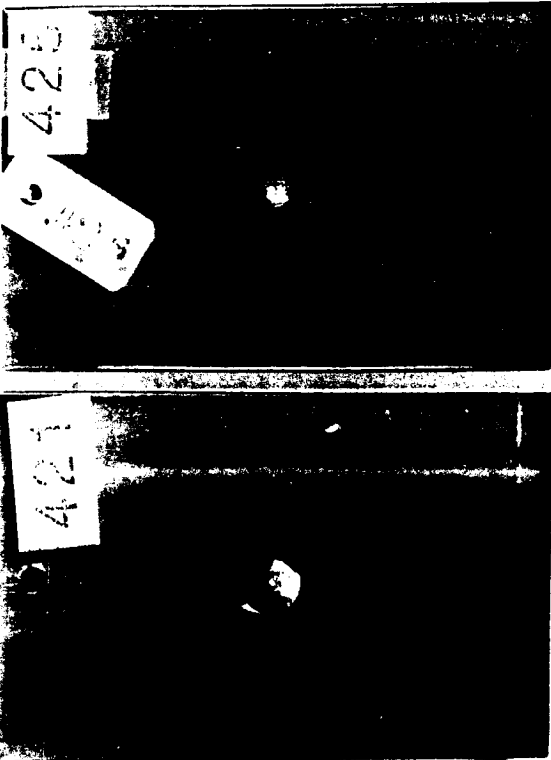


QUV-Weatherometer (ASTM G-53), 2000 Hours
System 6



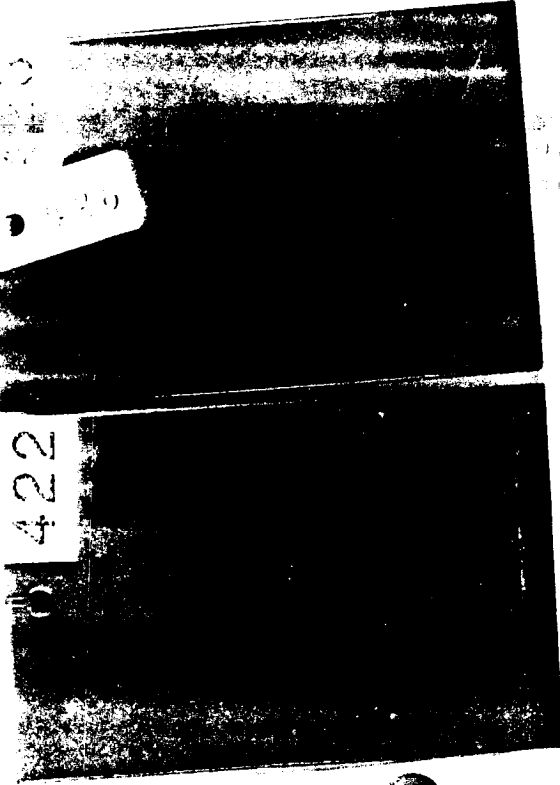
QUV-Weatherometer (ASTM G-53), 2000 Hours

System 6



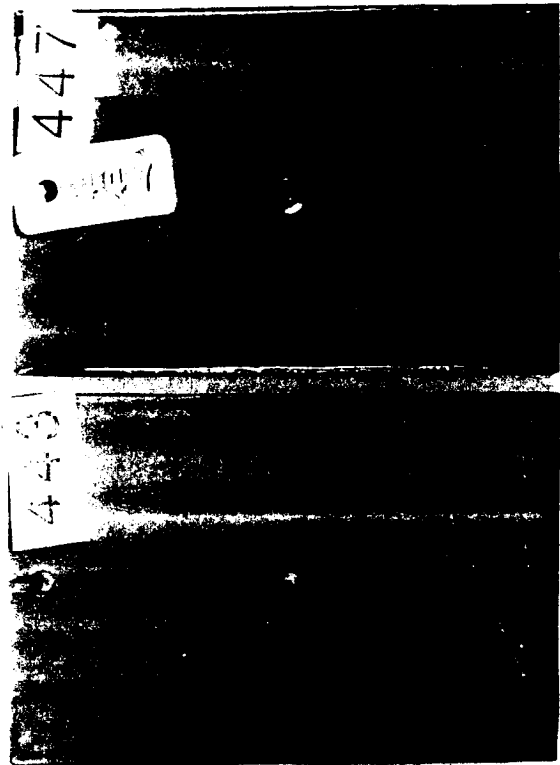
QUV-Weatherometer (ASTM G-53), 2000 Hours

System 6



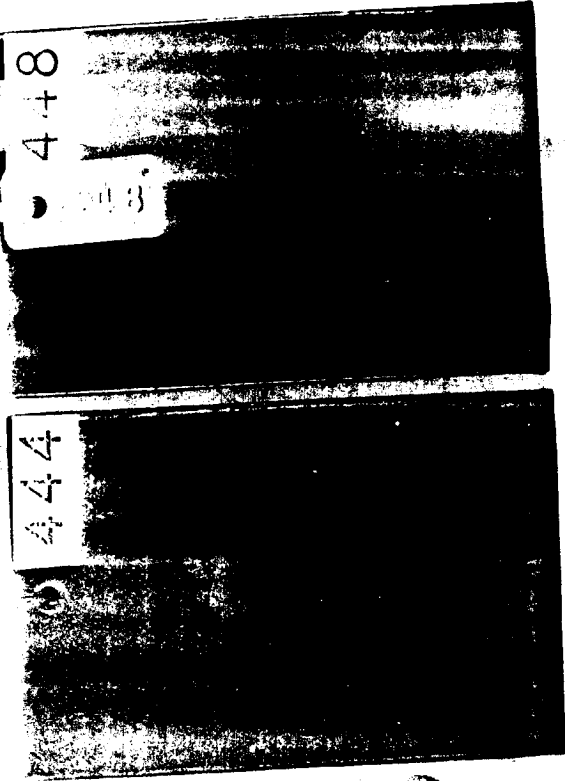
QUV-Weatherometer (ASTM G-53), 2000 Hours

System 6

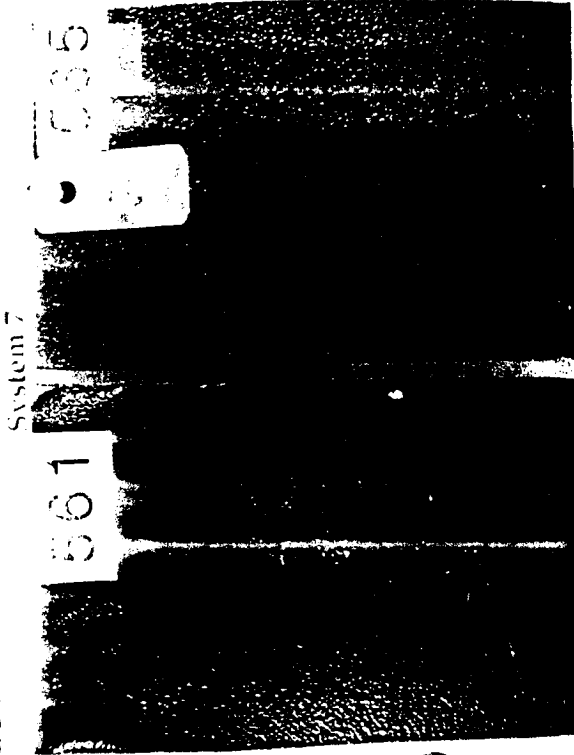


QUV-Weatherometer (ASTM G-53), 2000 Hours

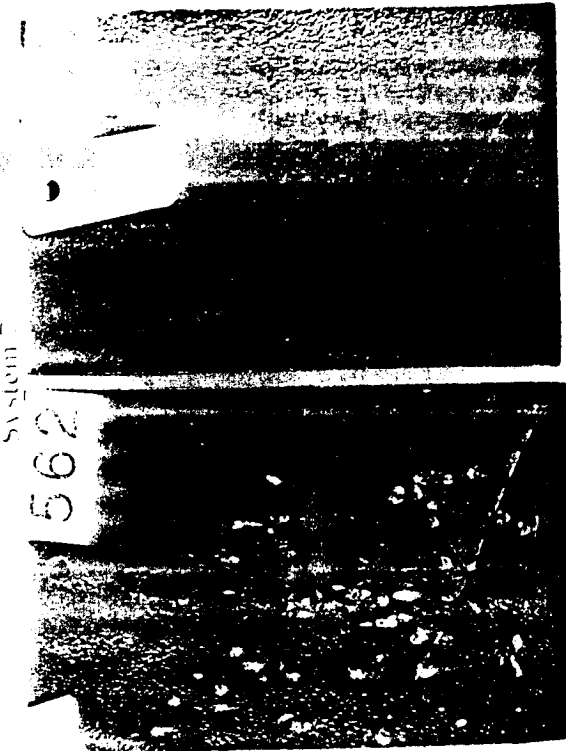
System 6



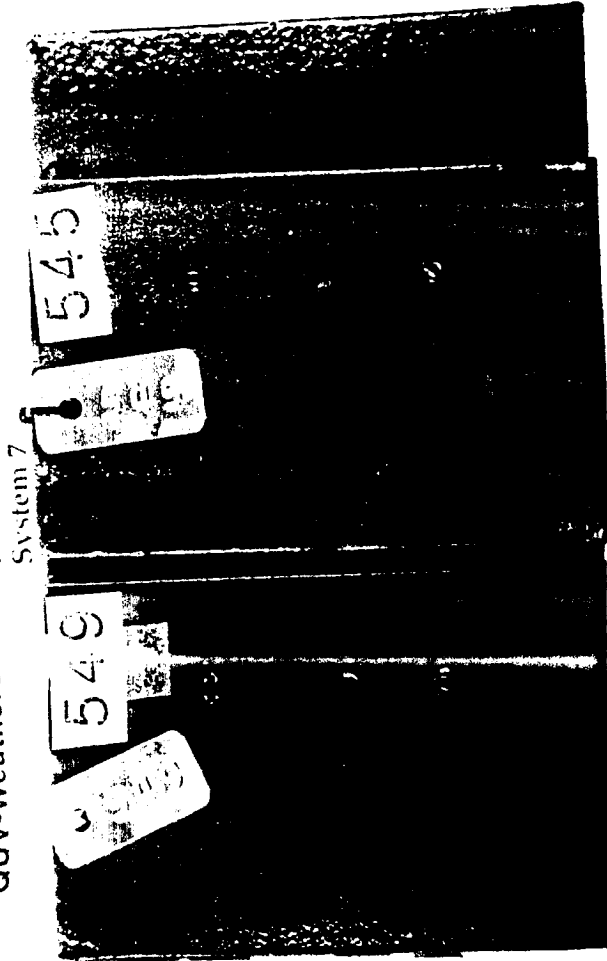
QUV-Weatherometer (ASTM G-53), 2000 Hours



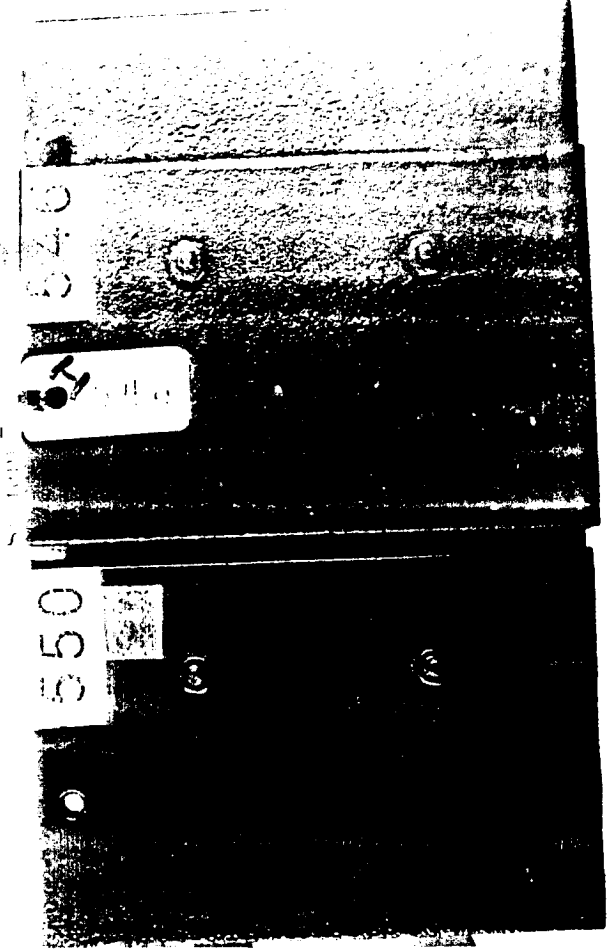
QUV-Weatherometer (ASTM G-53), 2000 Hours



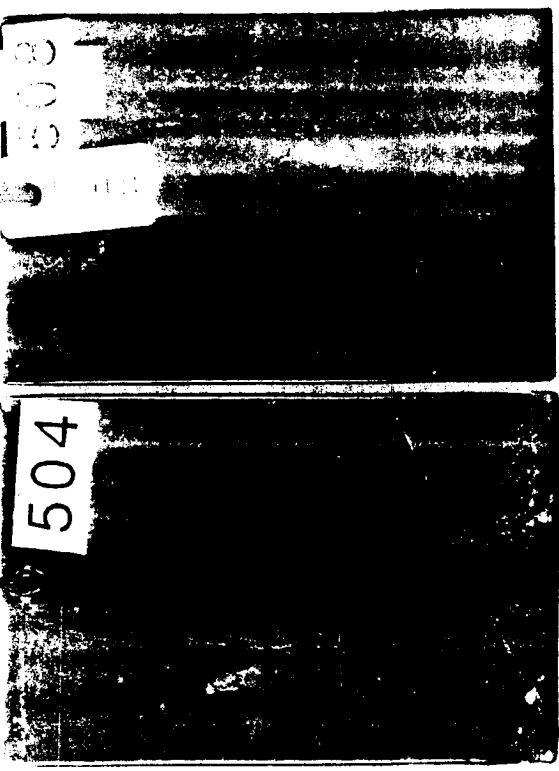
QUV-Weatherometer (ASTM G-53), 2000 Hours



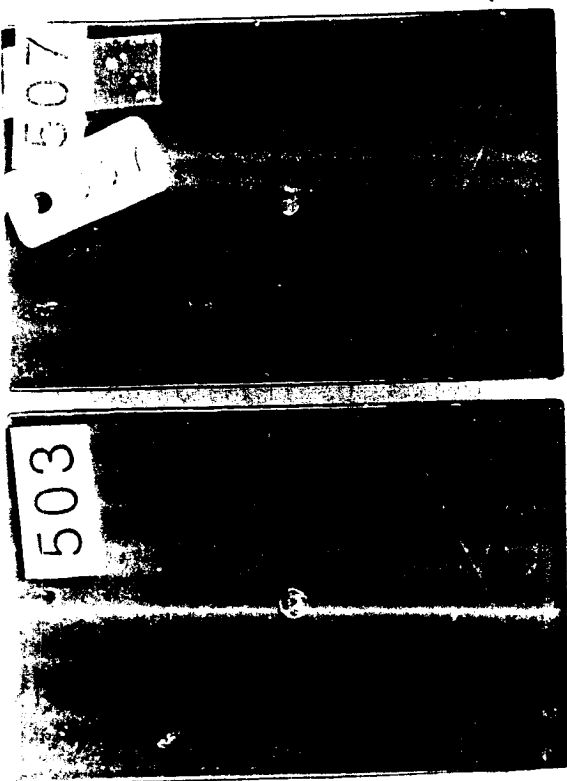
QUV-Weatherometer (ASTM G-53), 2000 Hours



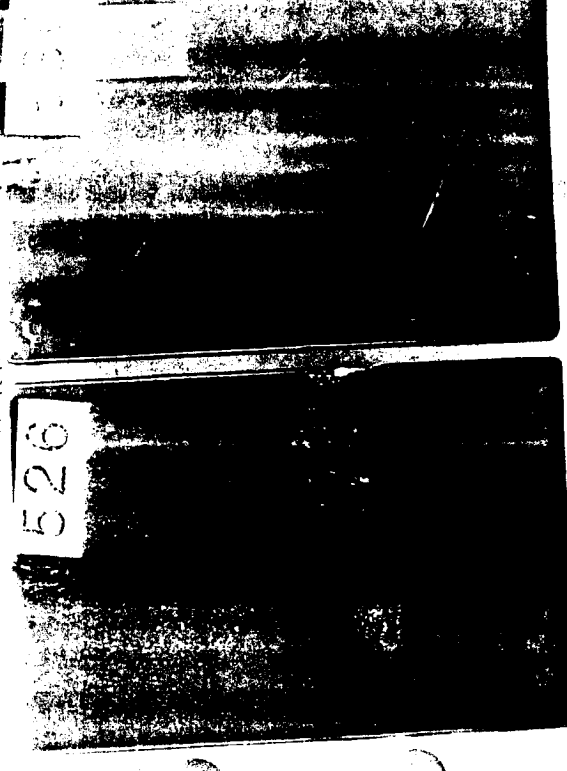
QUV-Weatherometer (ASTM G-53). 2000 hours
System 7



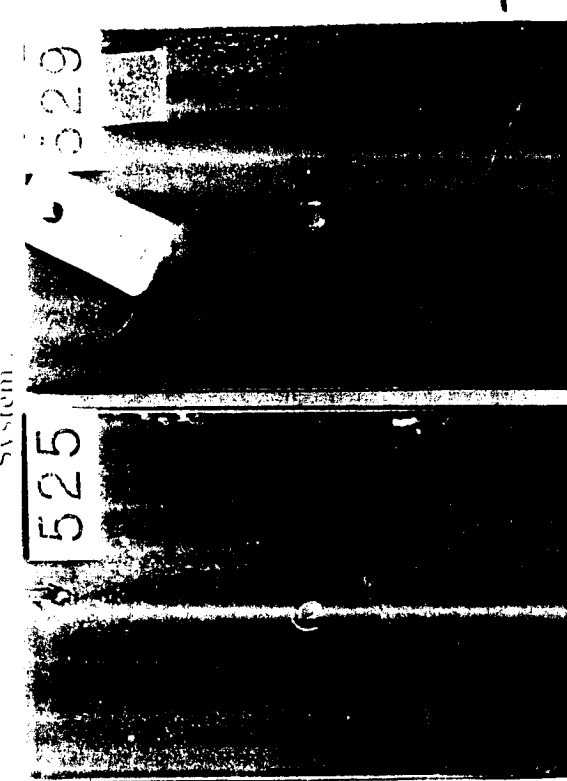
QUV-Weatherometer (ASTM G-53). 2000 hours
System 7



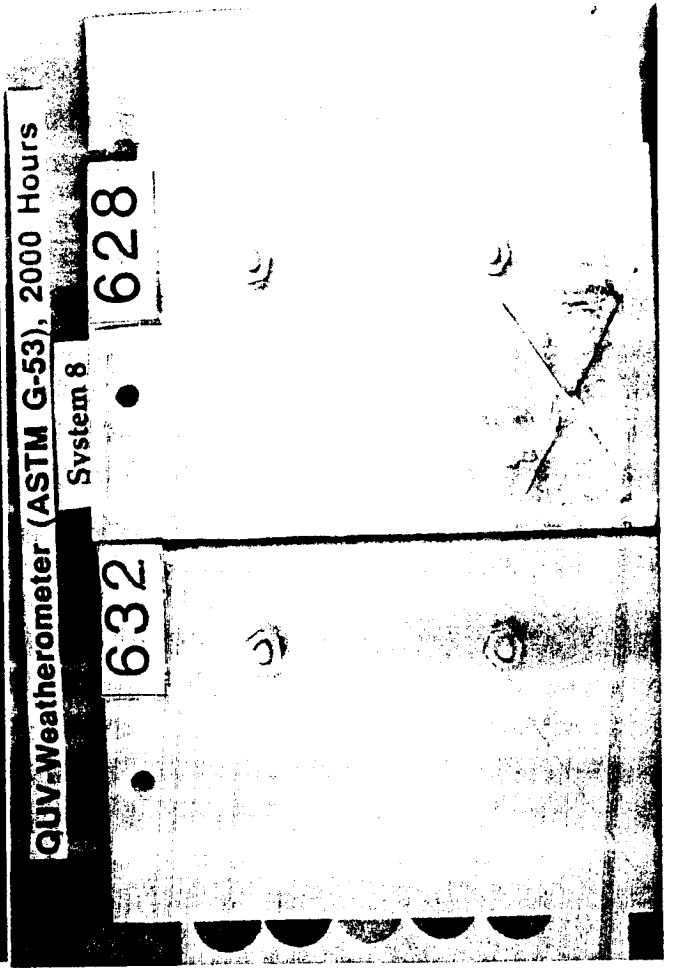
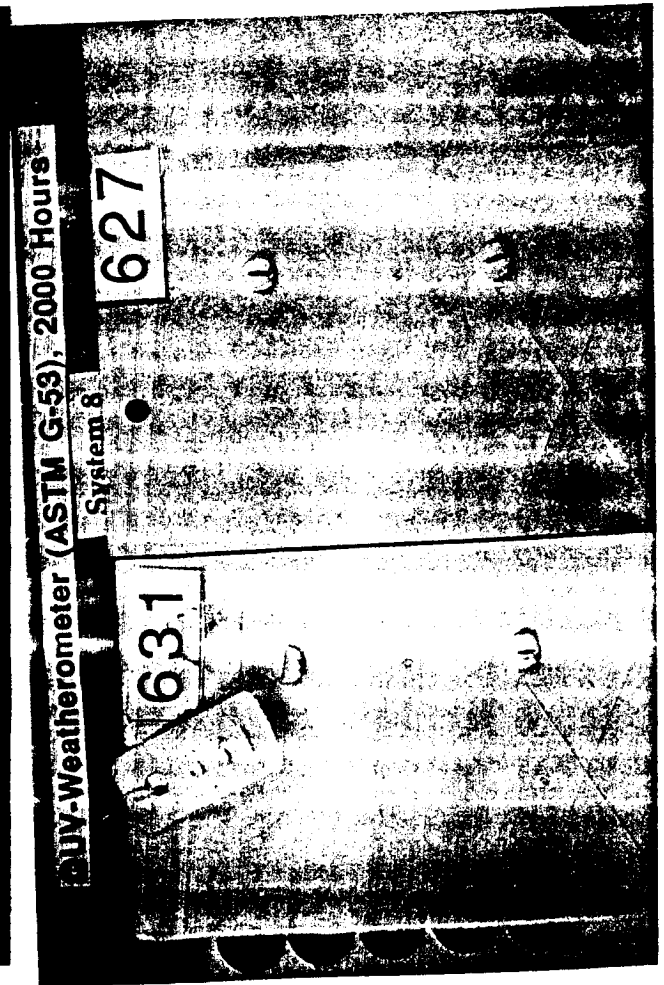
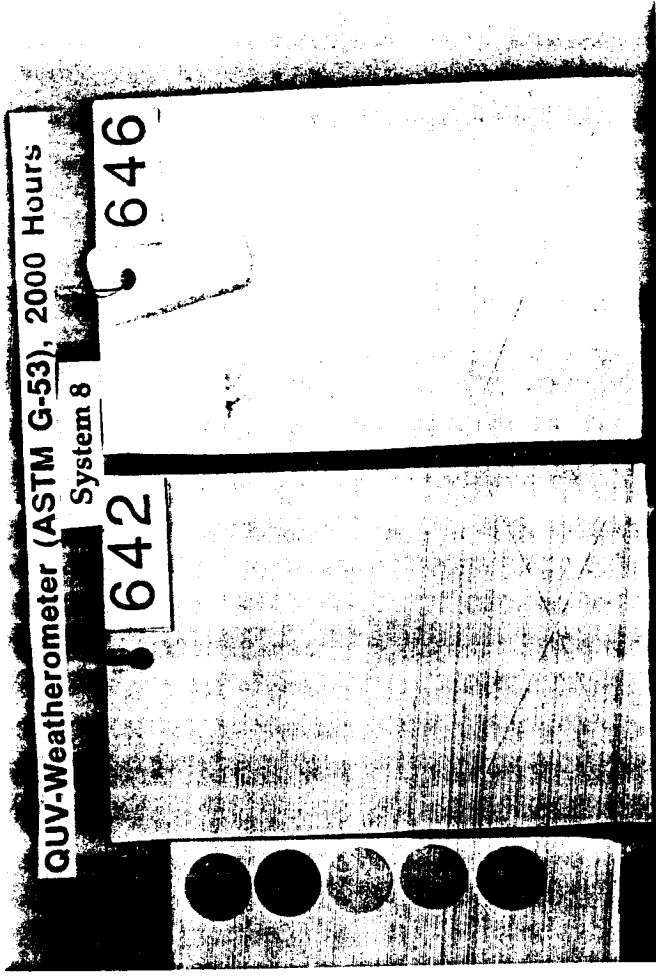
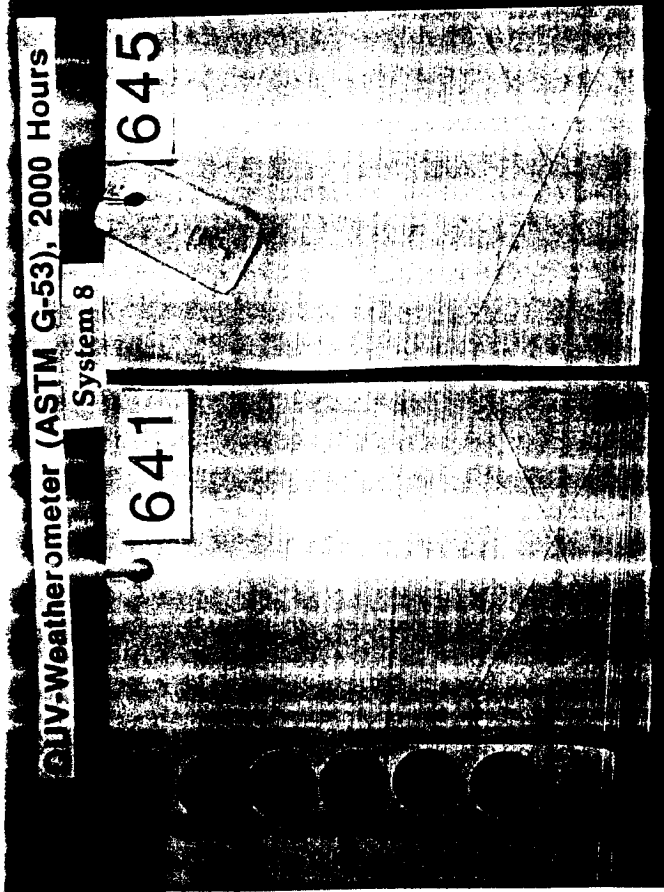
QUV-Weatherometer (ASTM G-53). 2000 hours
System 7



QUV-Weatherometer (ASTM G-53). 2000 hours
System 7



ORIGINAL PAGE IS
OF POOR QUALITY



QUV-Weatherometer (ASTM G-53), 2000 Hours

System 8

585

610

QUV-Weatherometer (ASTM G-53), 2000 Hours

System 8

586

589

QUV-Weatherometer (ASTM G-53), 2000 Hours

System 8

607

611

QUV-Weatherometer (ASTM G-53), 2000 Hours

System 8

608

612

612

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 9

723

727

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 9

724

728

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 9

713

709

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 9

714

710

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 9

665

671

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 9

666

672

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 9

688

695

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 9

690

694

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 10

805

809

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 10

806

810

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 10

795

791

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 10

796

792

OF POOR QUALITY

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 10

749

753

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 10

750

755

QUV-Weatherometer (ASTM G-53), 2000 Hours
System 10

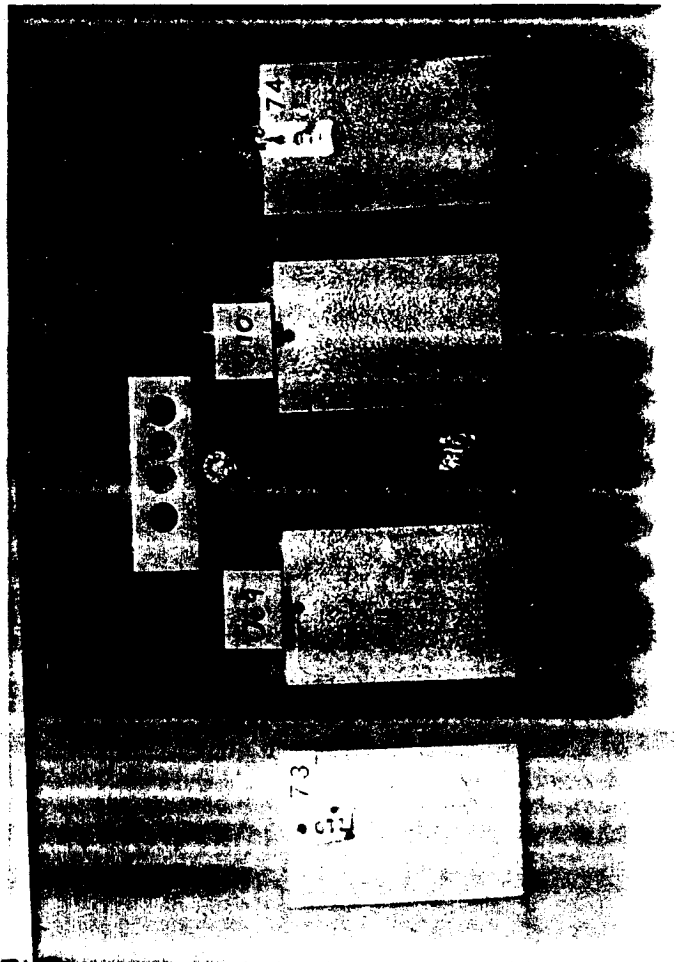
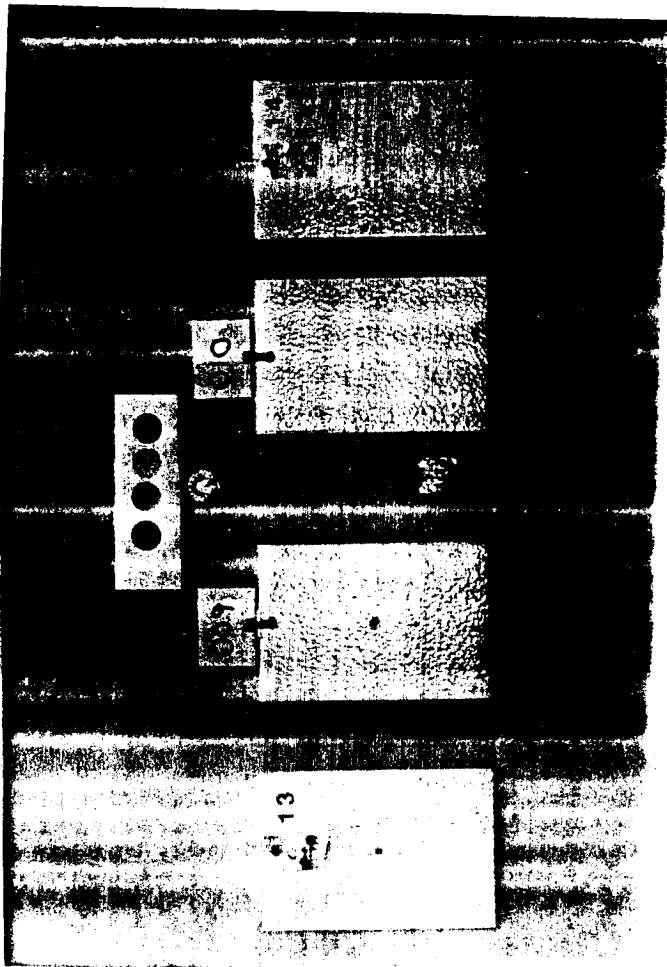
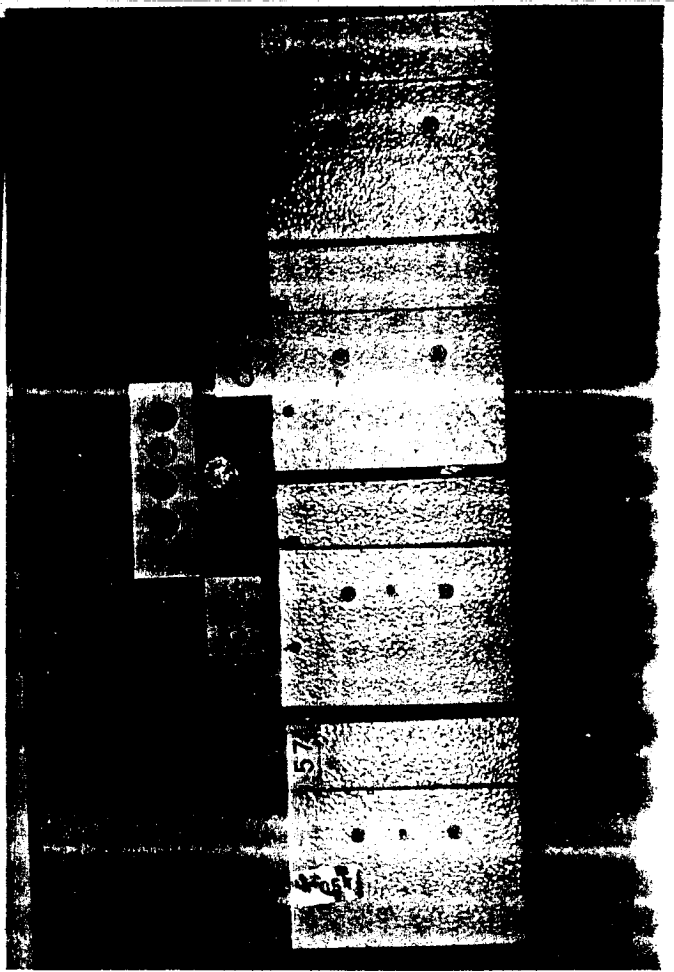
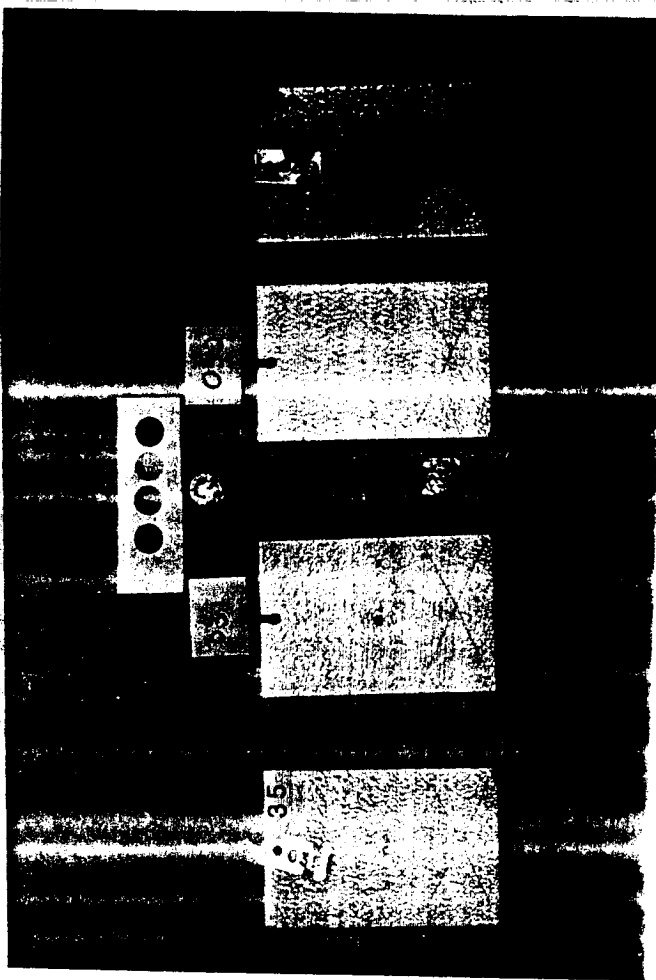
770

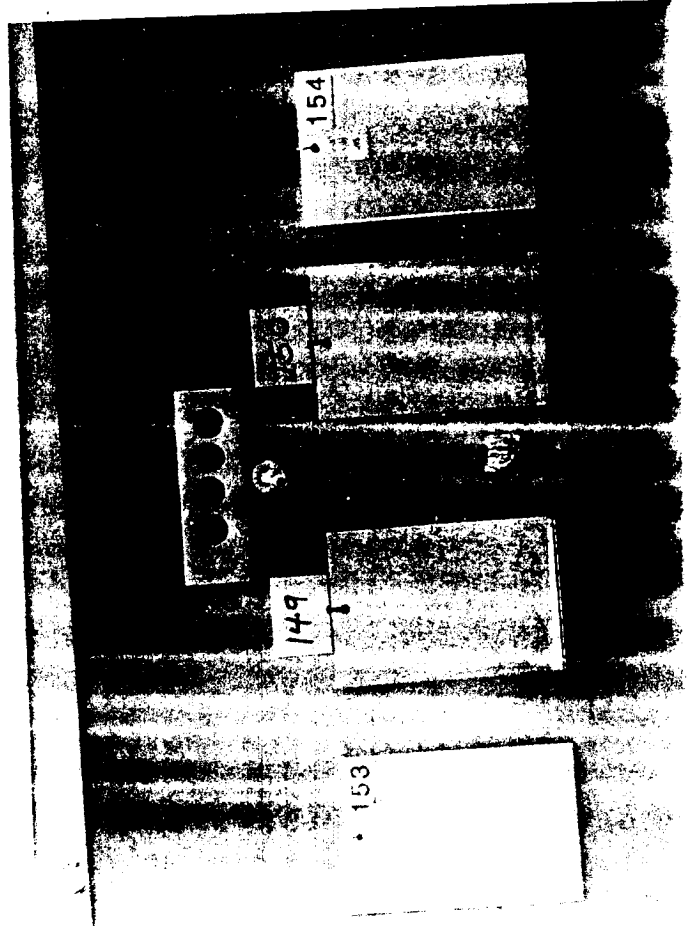
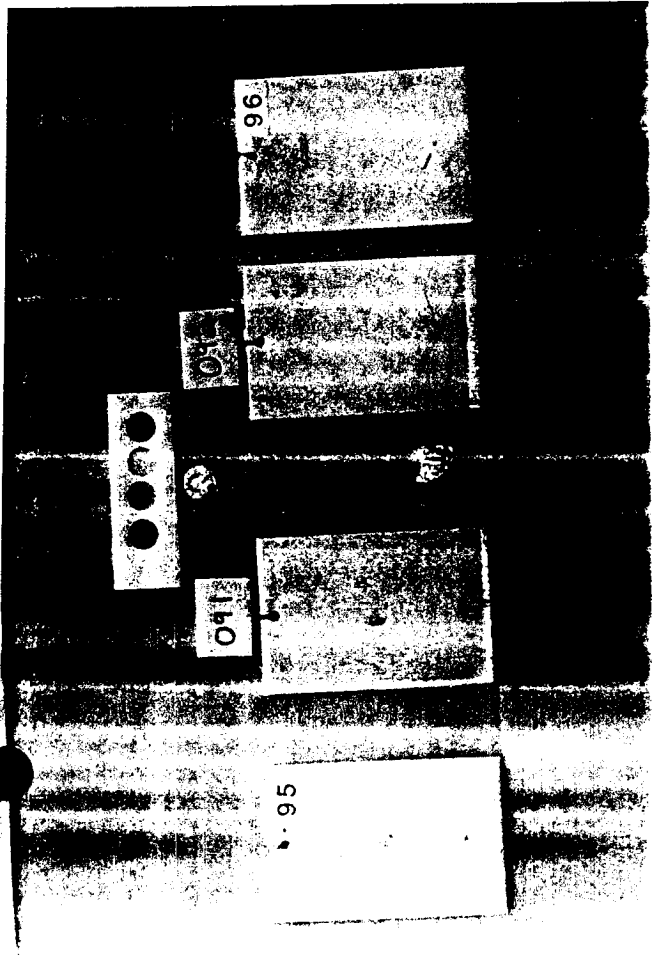
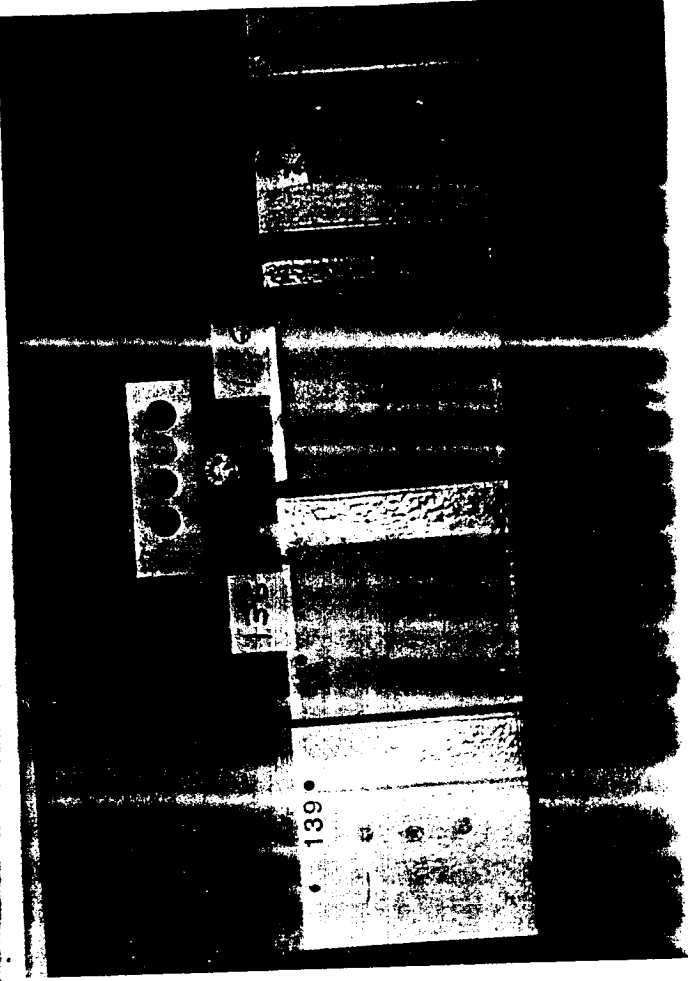
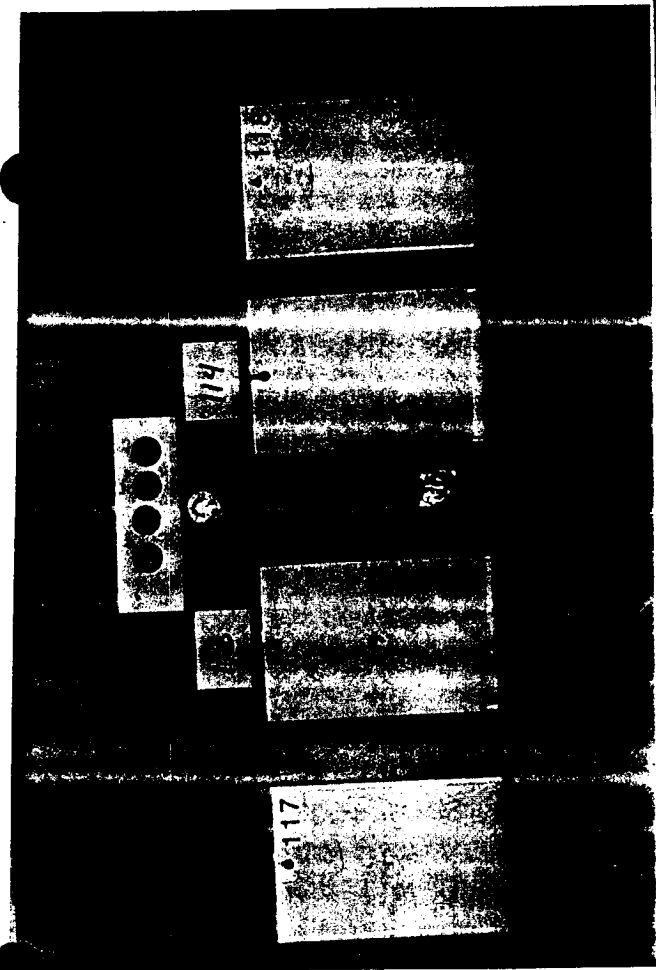
776

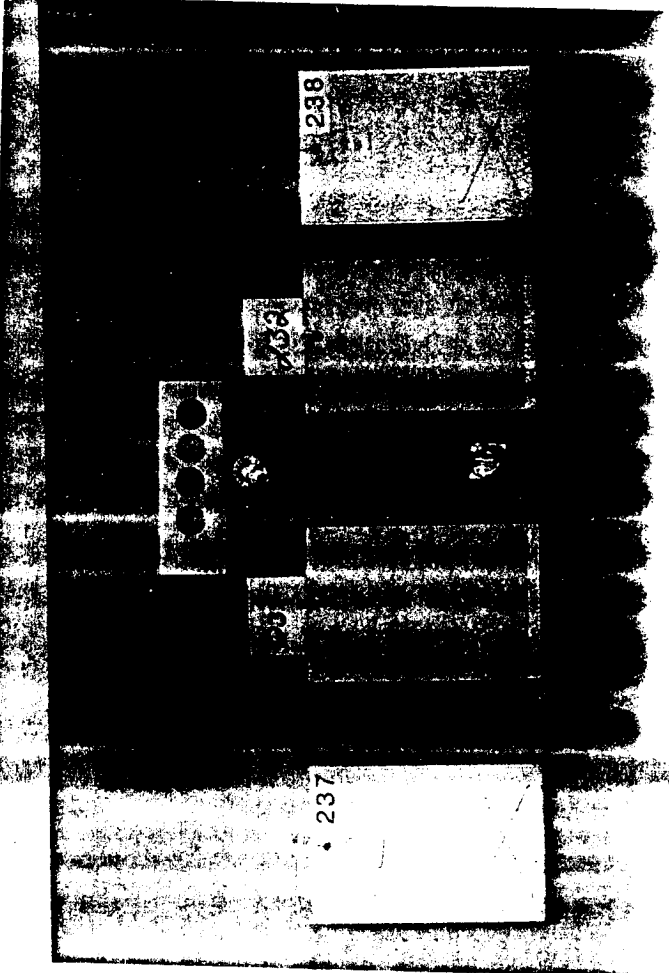
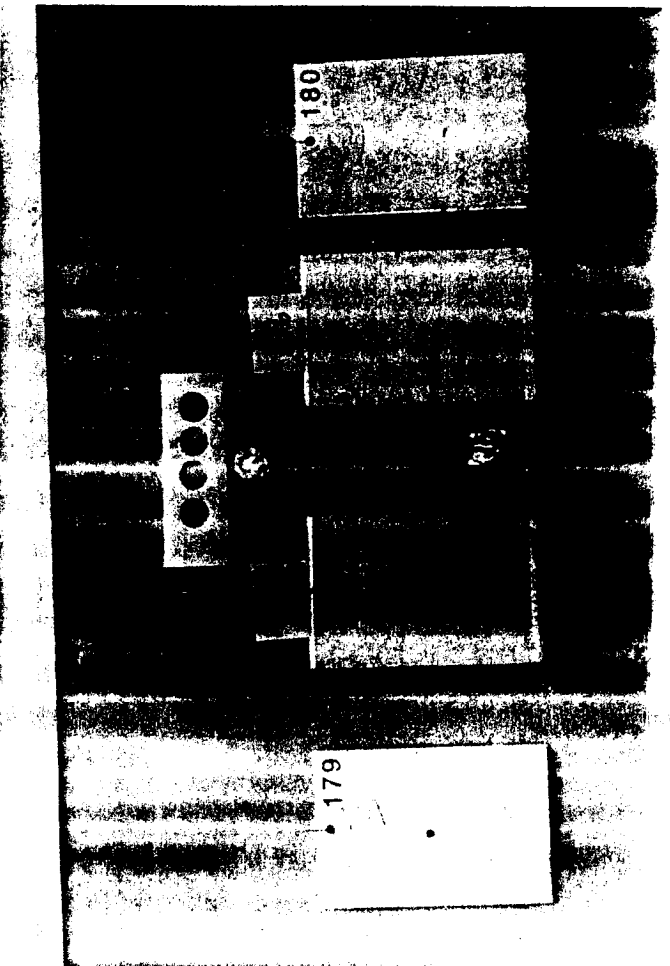
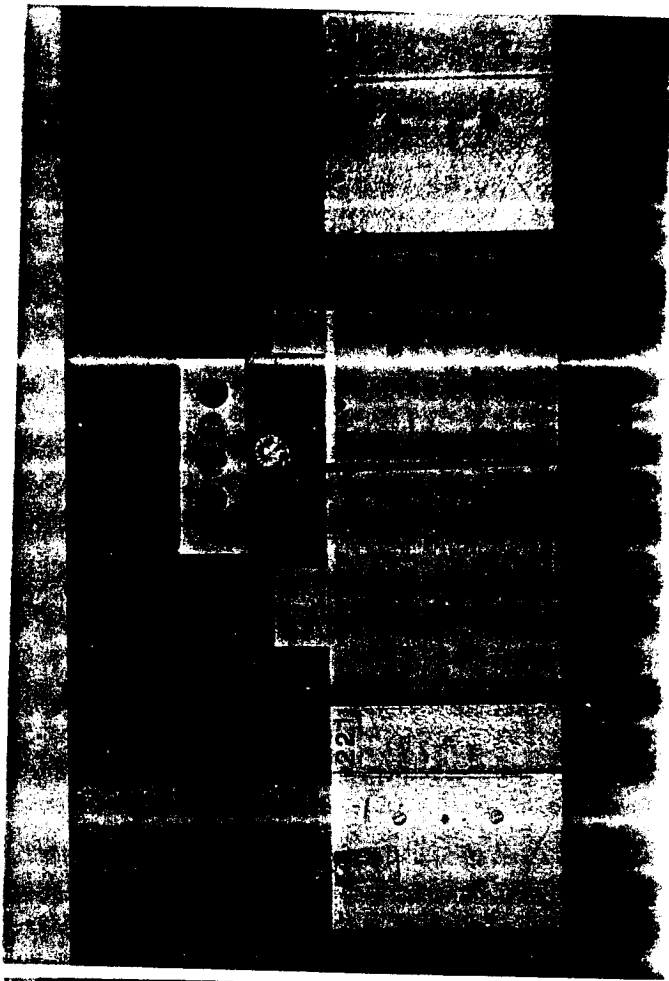
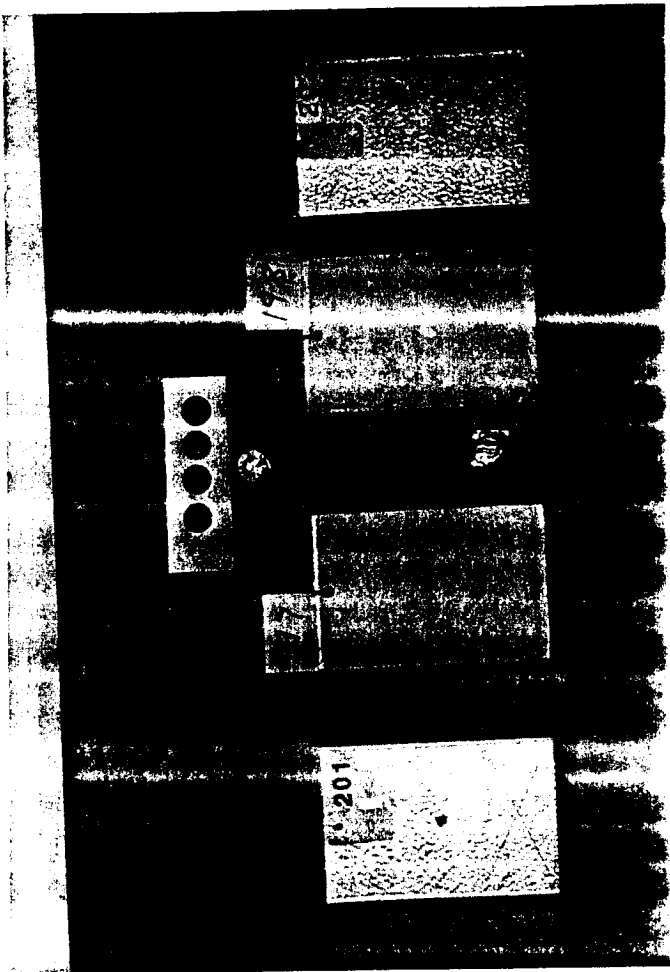
QUV-Weatherometer (ASTM G-53), 2000 Hours
System 10

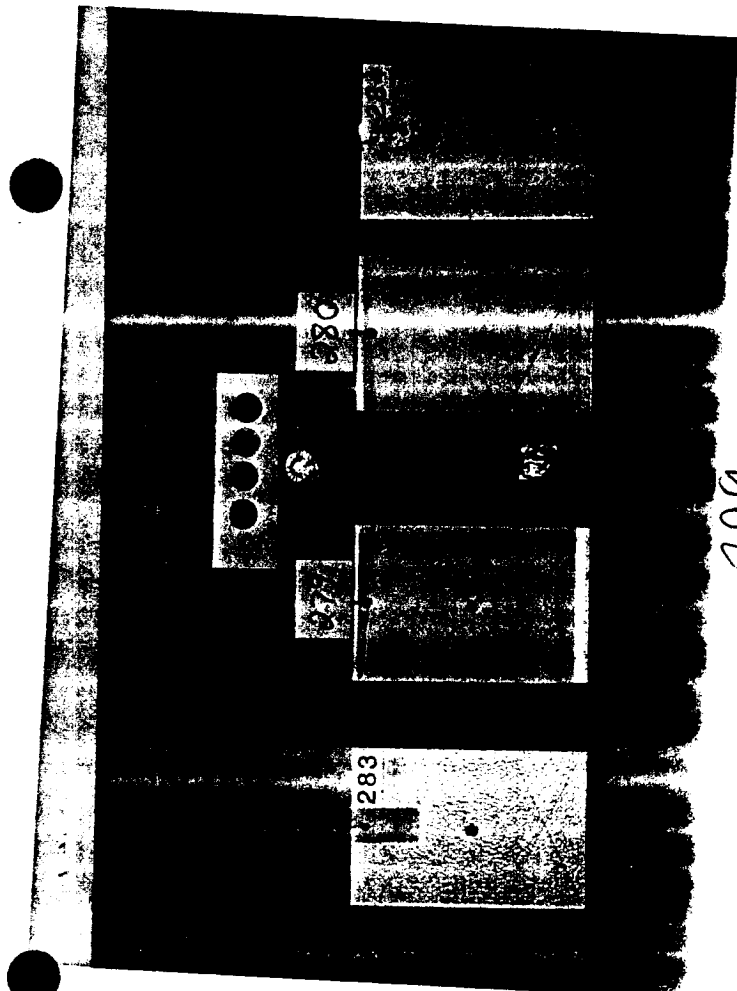
771

774

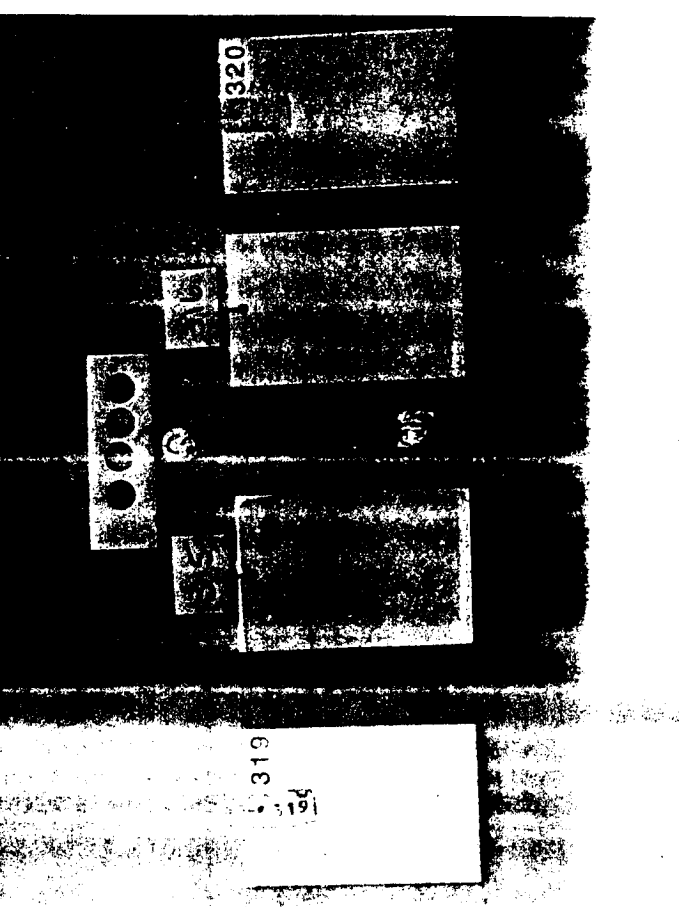
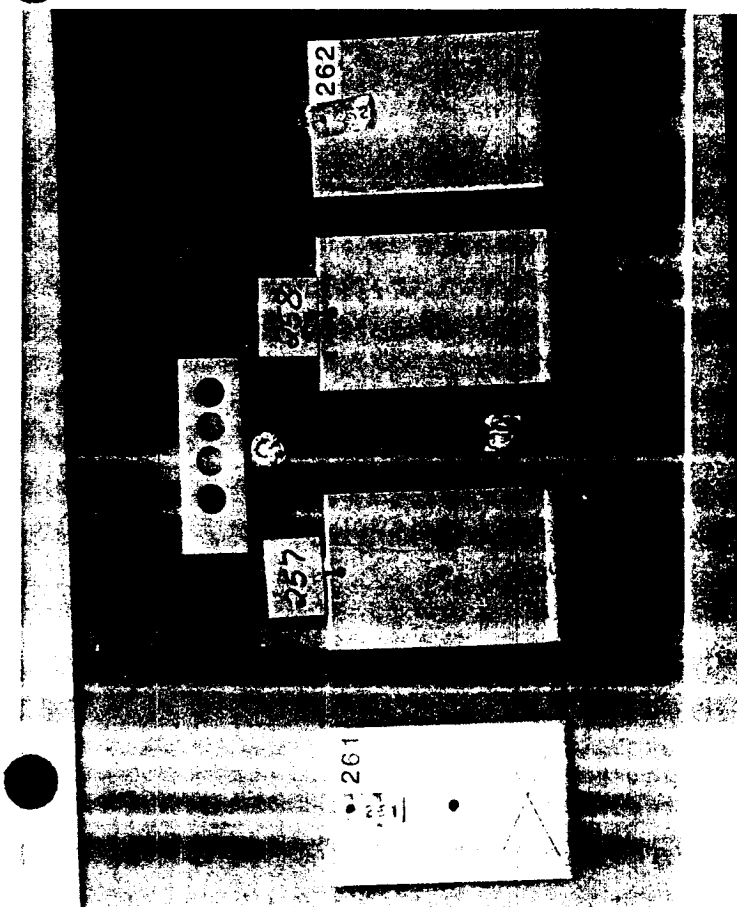
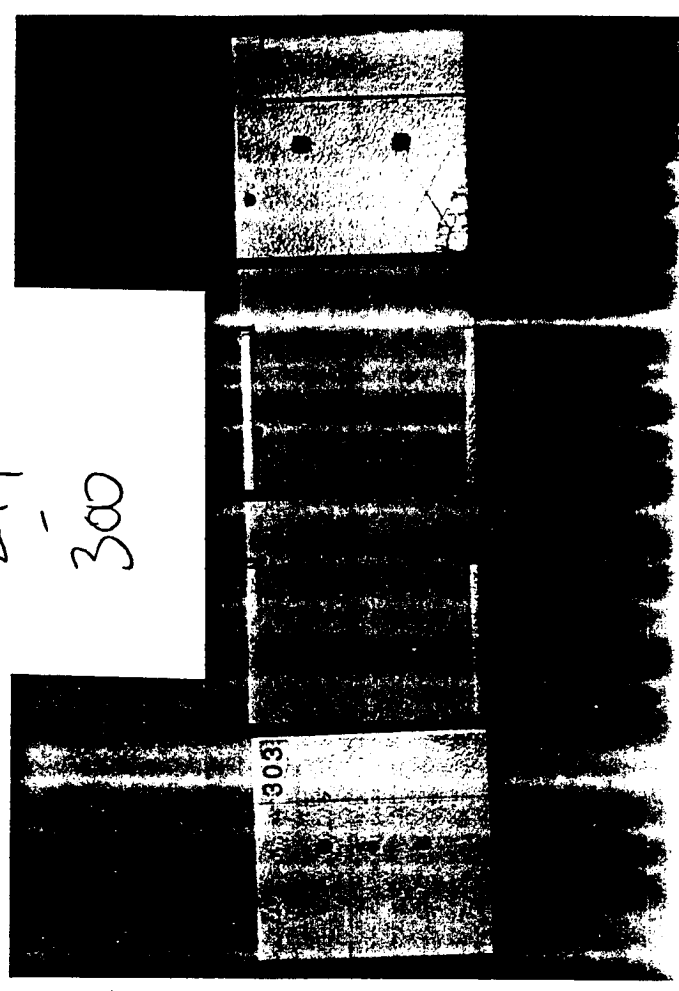




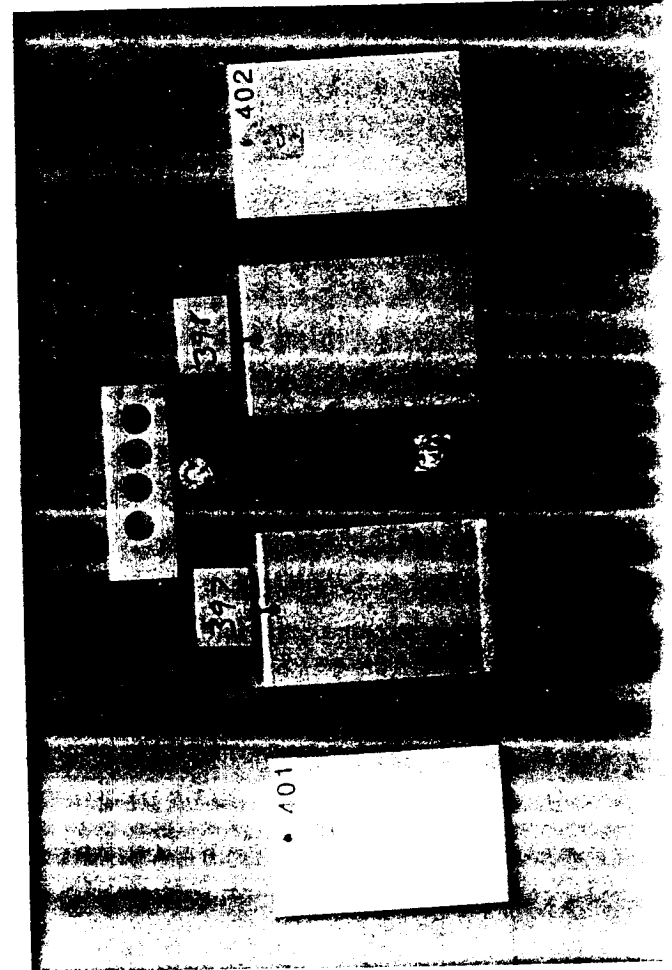
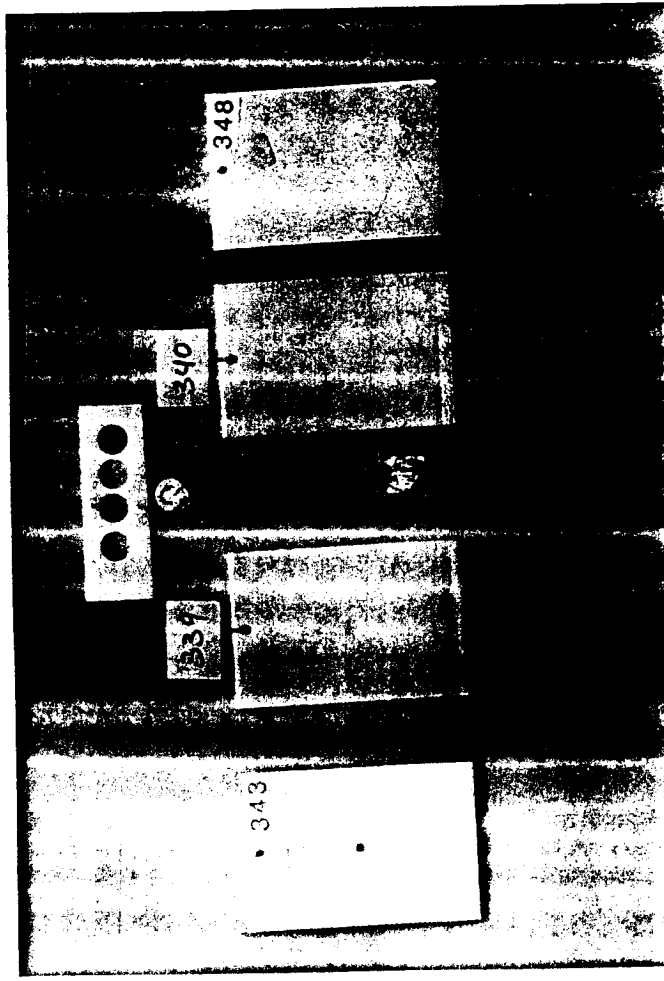
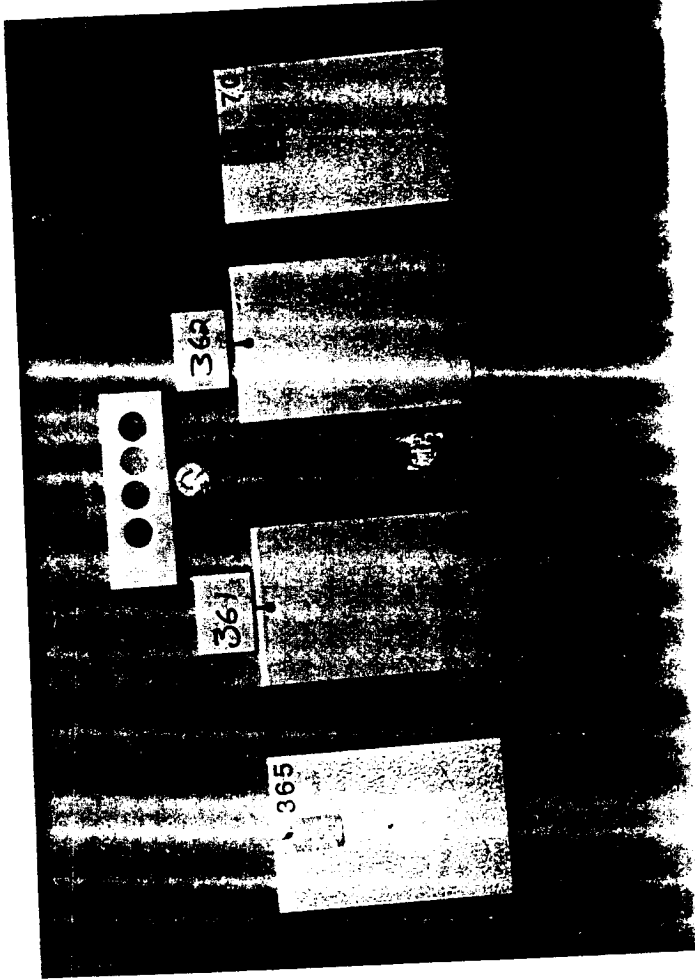




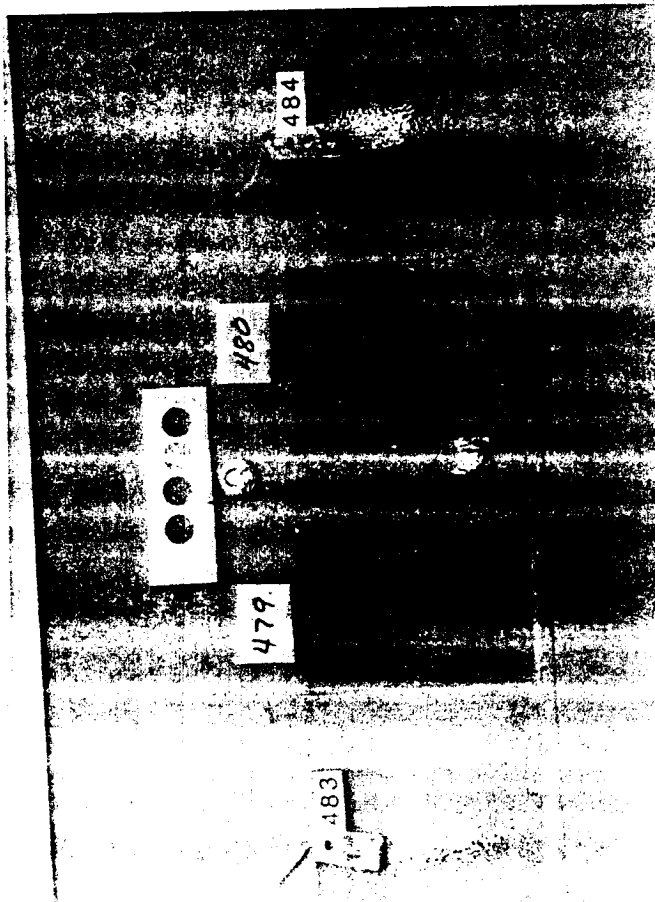
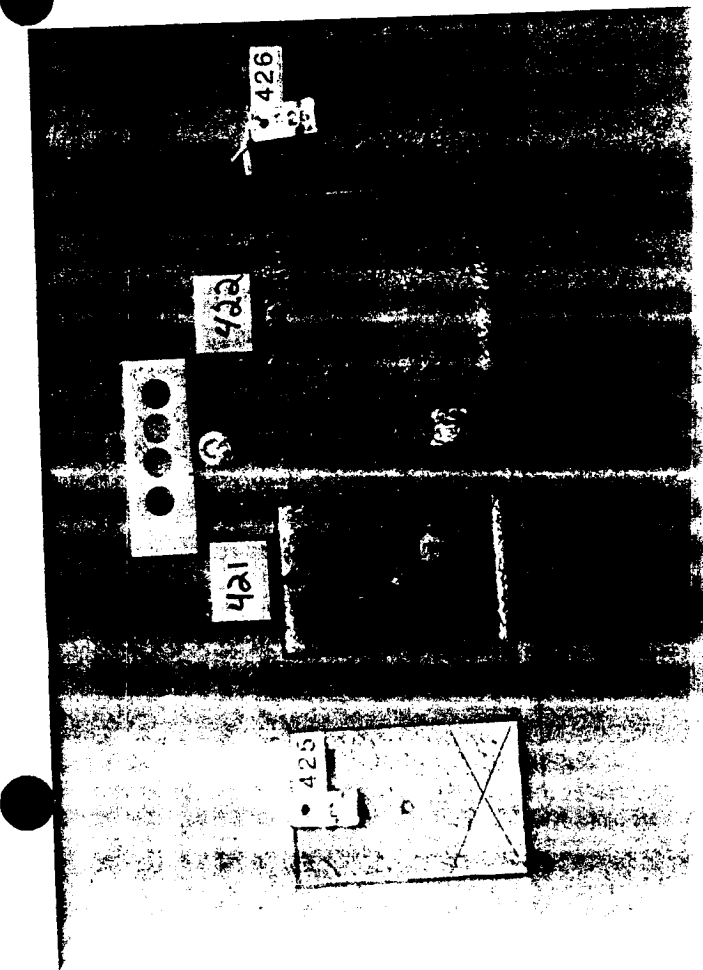
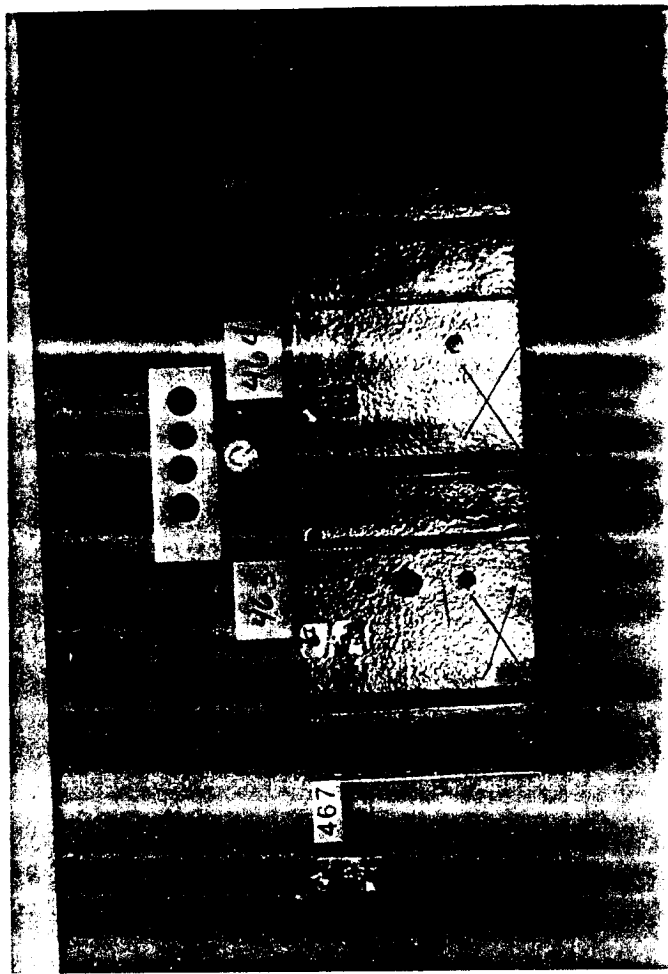
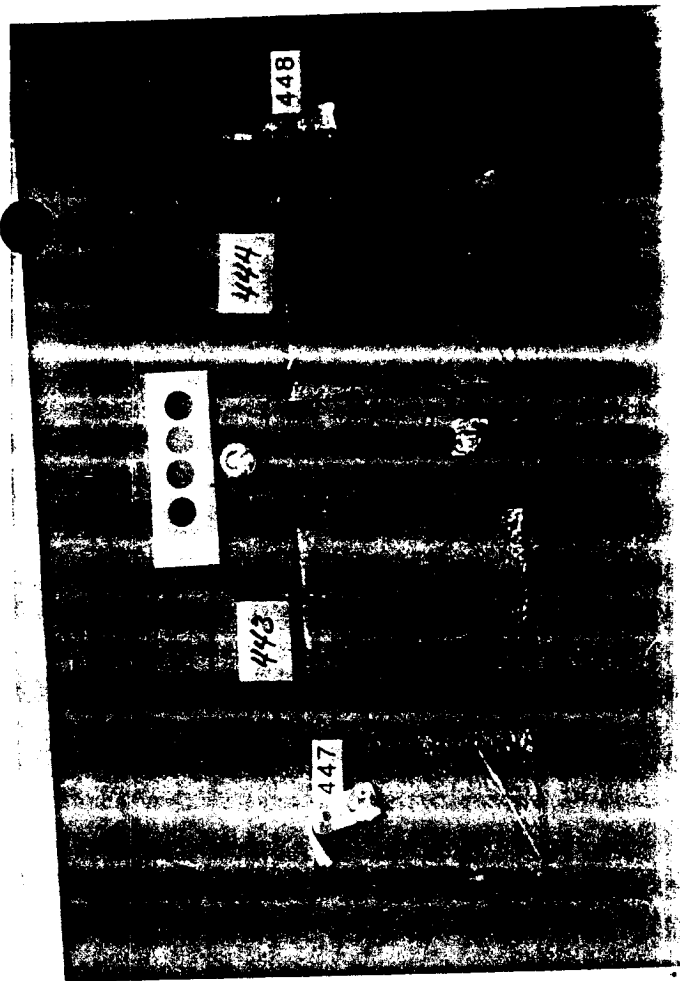
299
-
300

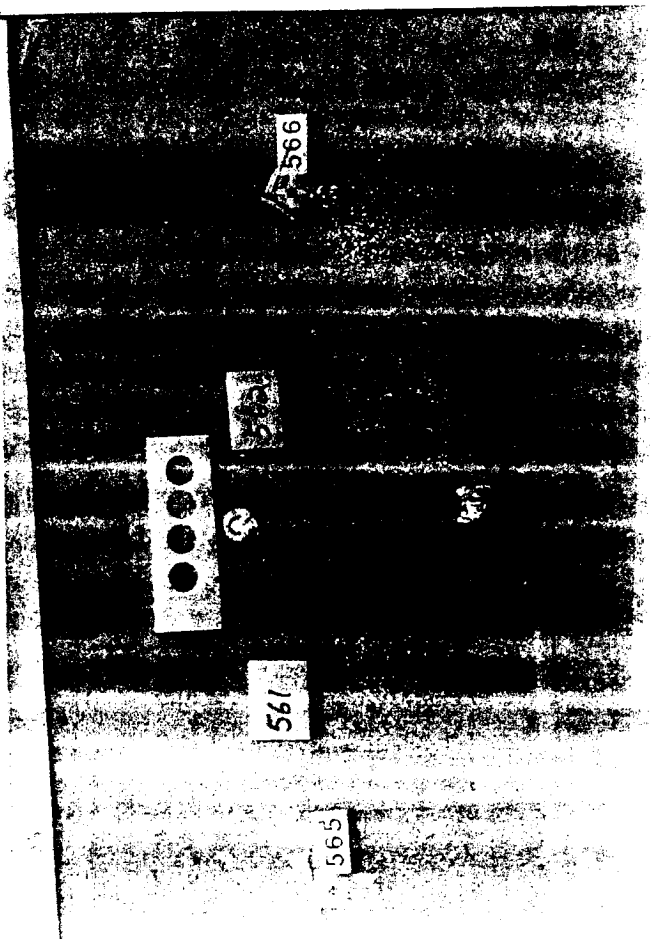
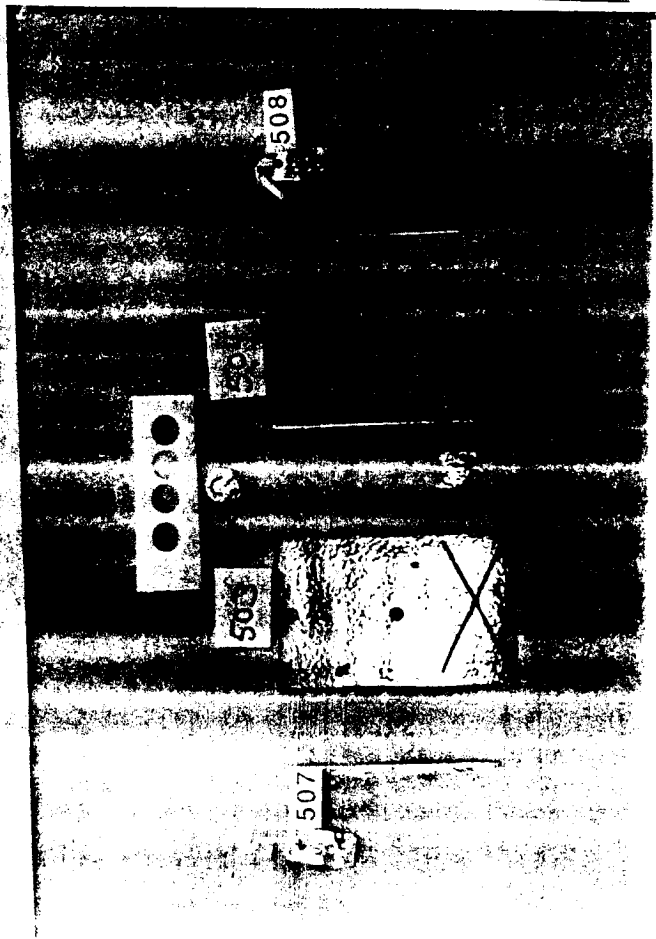
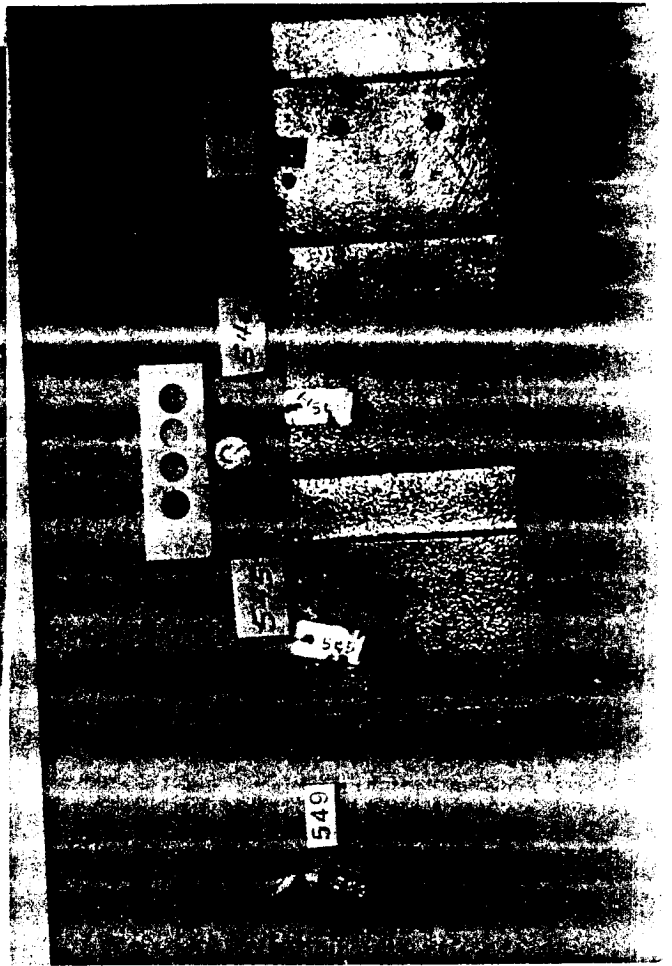
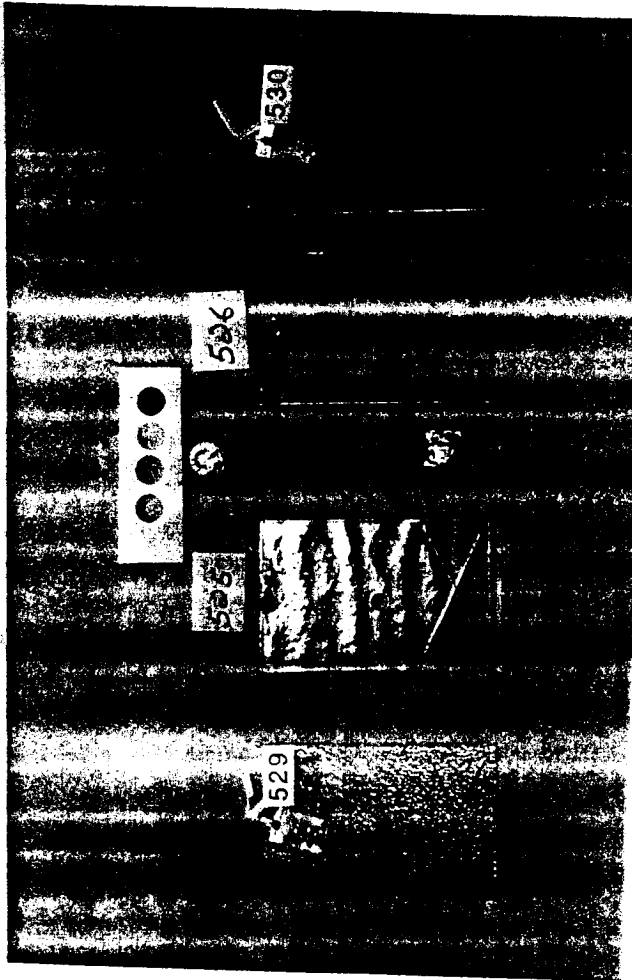


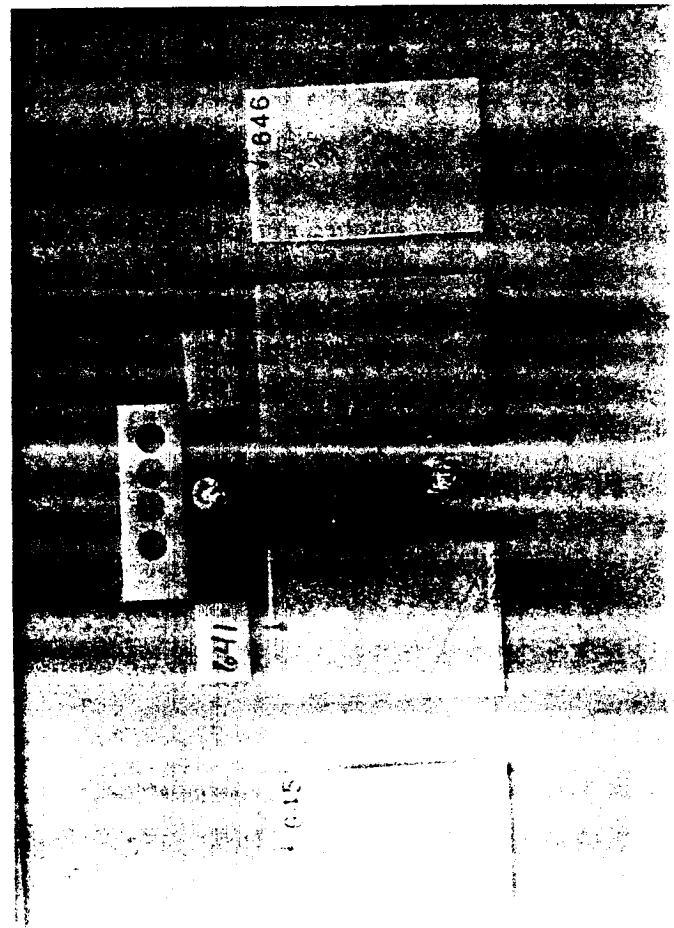
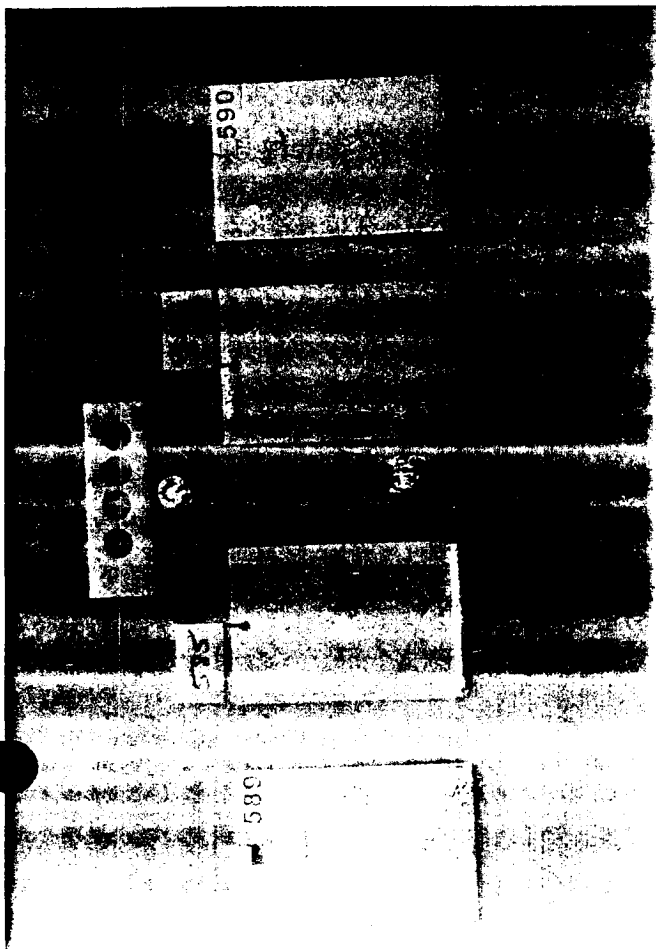
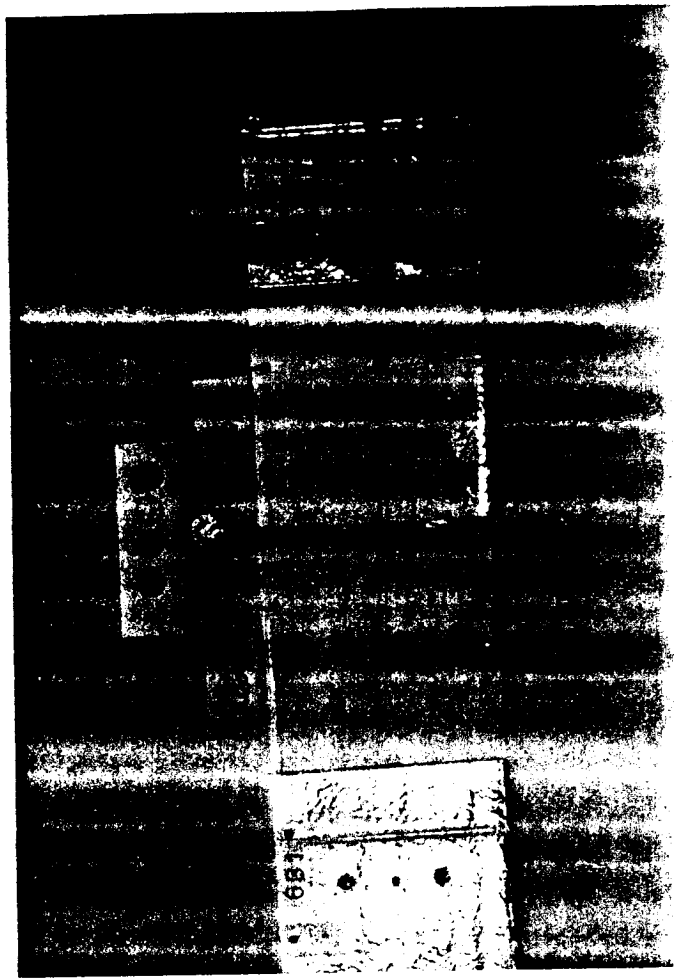
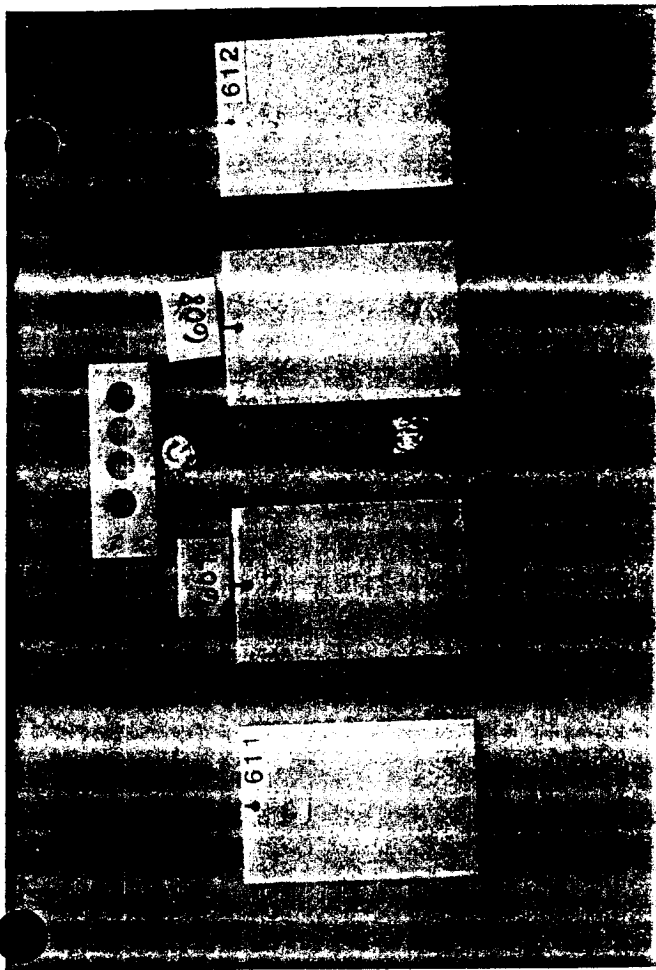
ORIGINAL PAGE IS
OF POOR QUALITY

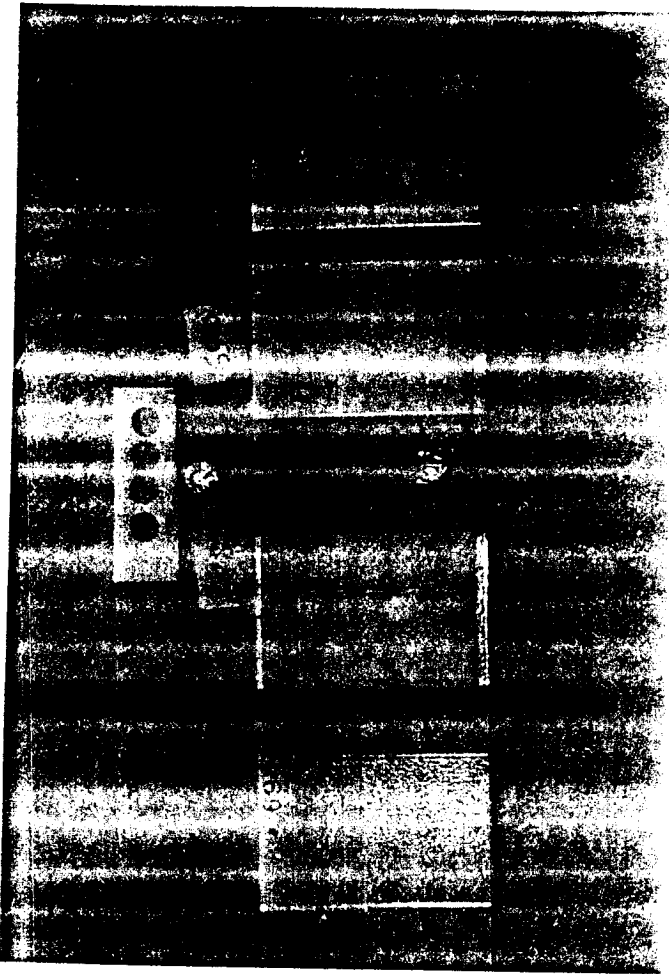


38/-
382

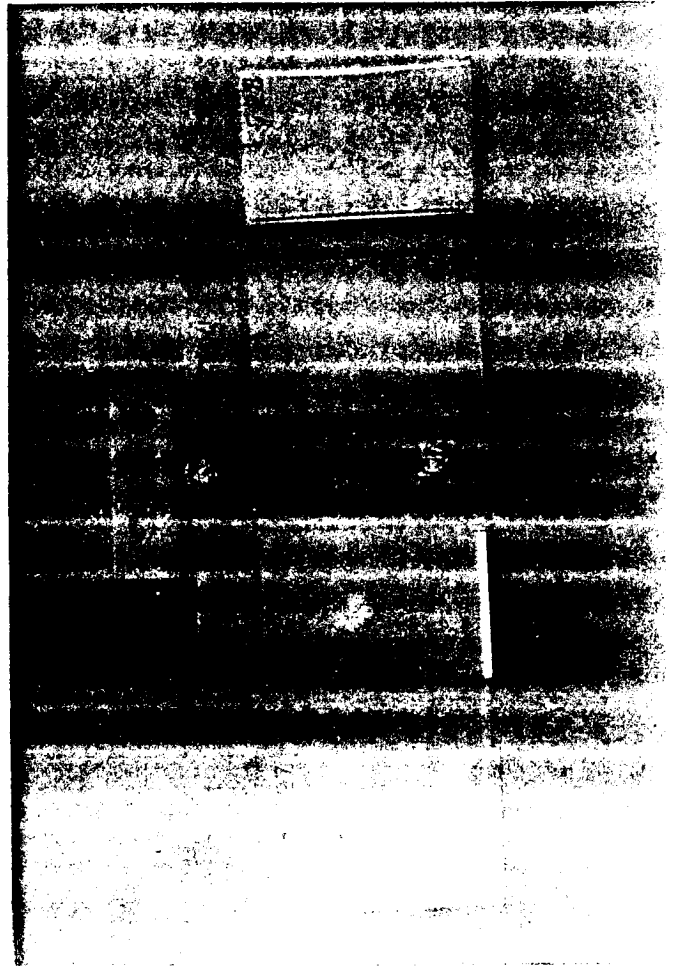
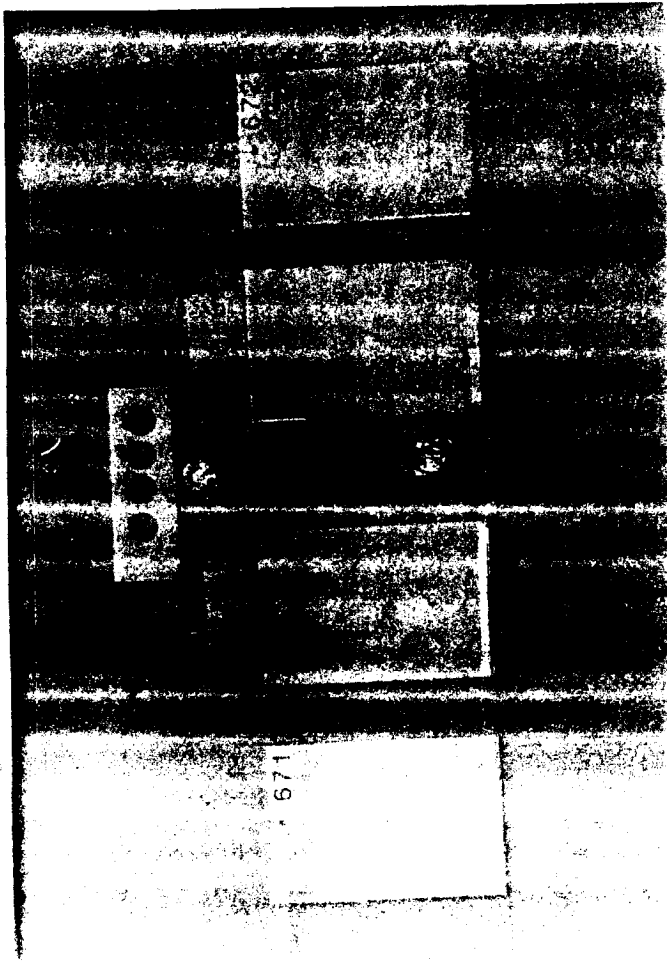




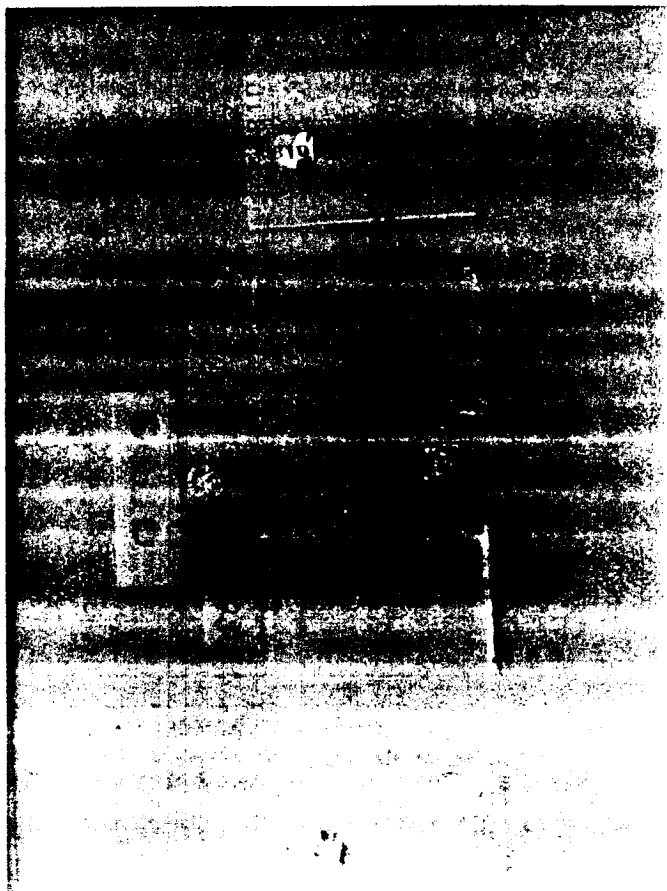
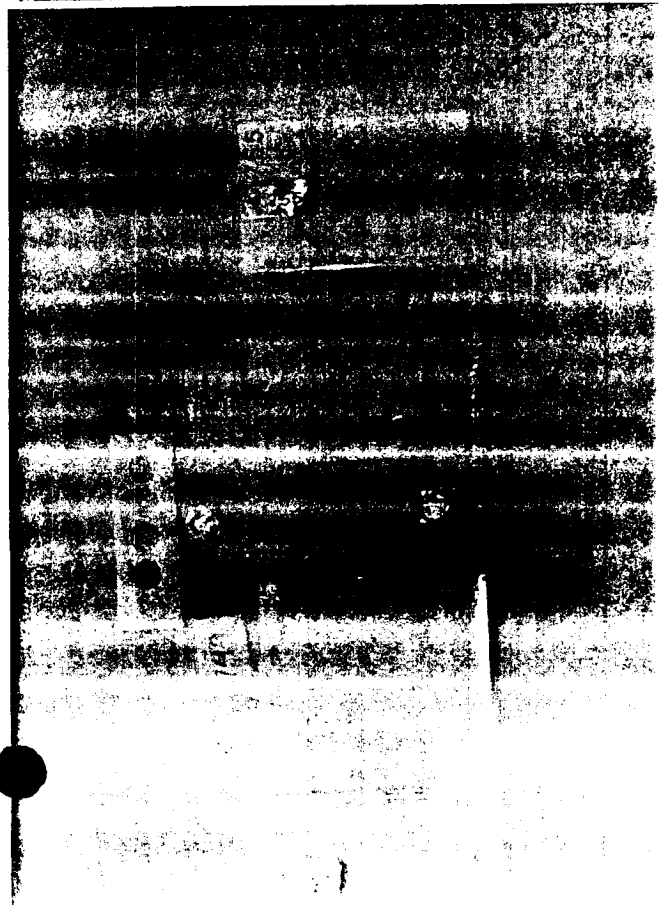
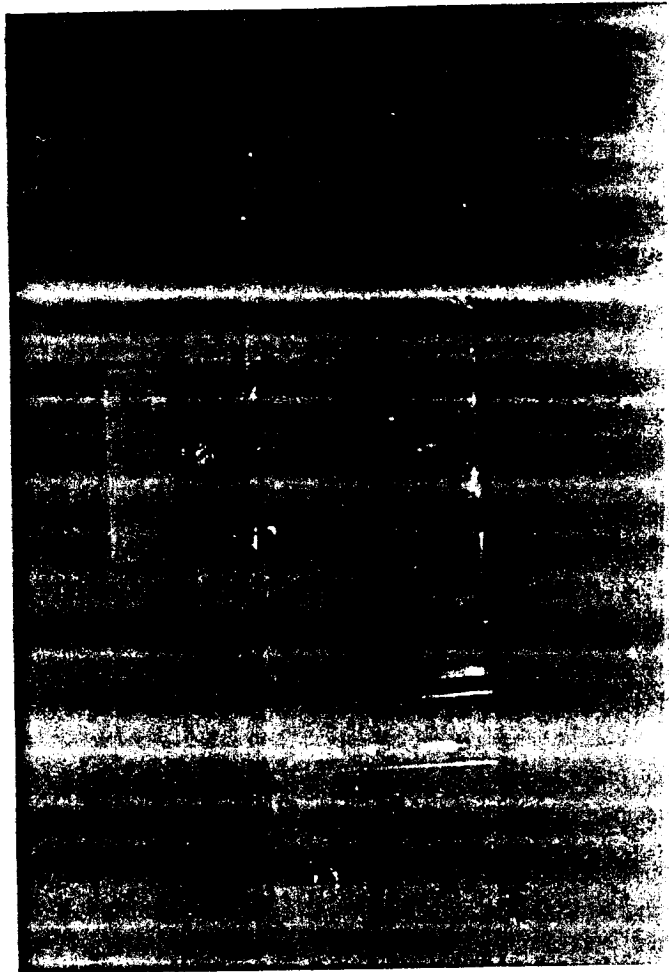
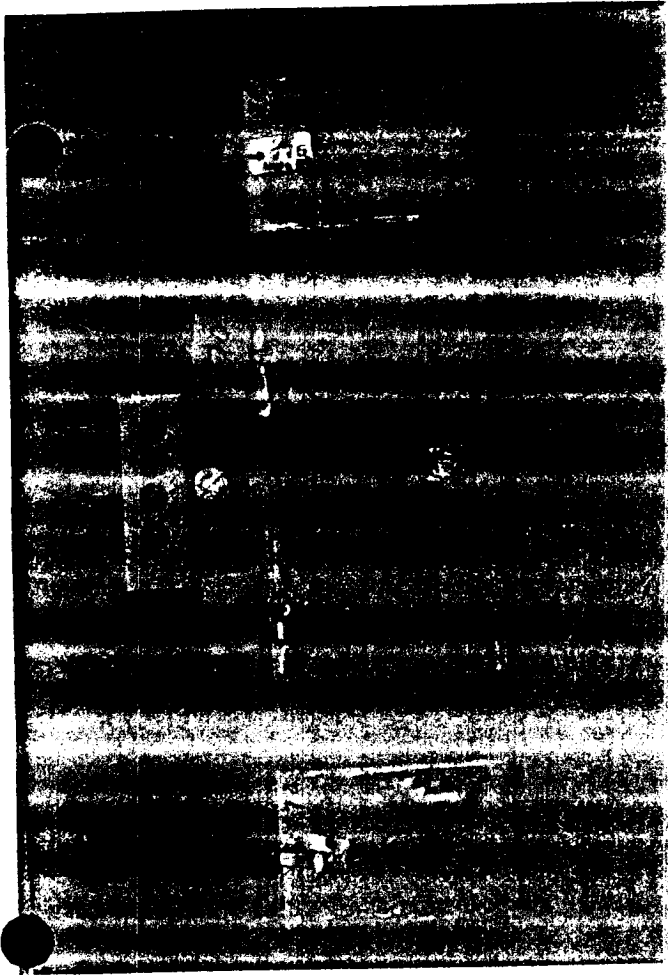




709
710



ORIGINAL PAGE IS
OF POOR QUALITY



System 1 KTA-Envirotest, 2000 Hours.

74

67

System 1 KTA-Envirotest, 2000 Hours.

74

68

System 1 KTA-Envirotest, 2000 Hours.

57

51

System 1 KTA-Envirotest, 2000 Hours.

58

52

System 1 KTA-Envirotest, 2000 Hours.

13

7

System 1 KTA-Envirotest, 2000 Hours.

14

8

System 1 KTA-Envirotest, 2000 Hours.

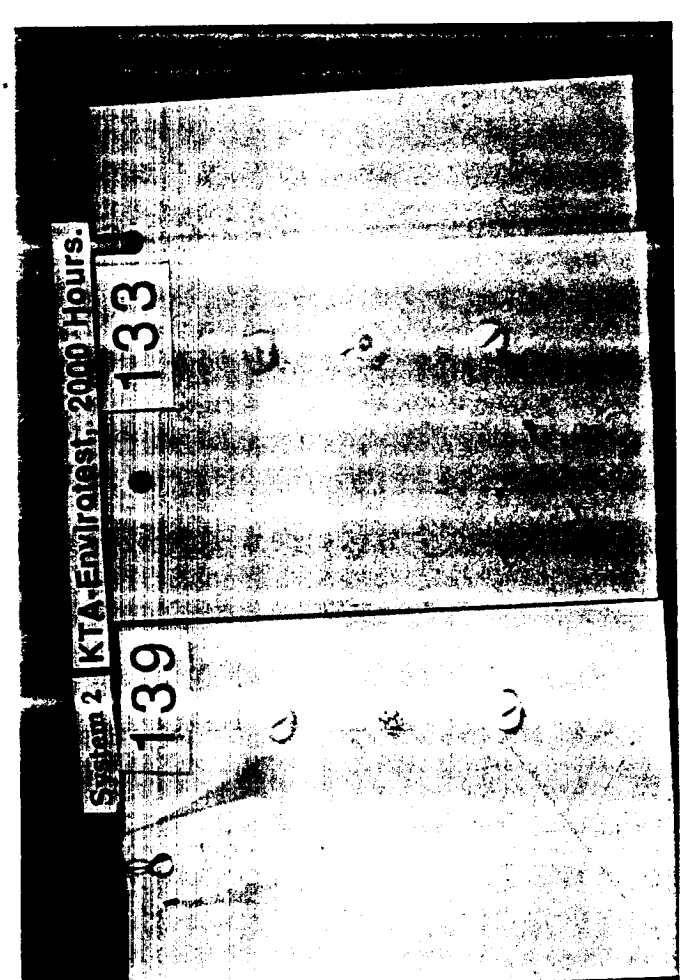
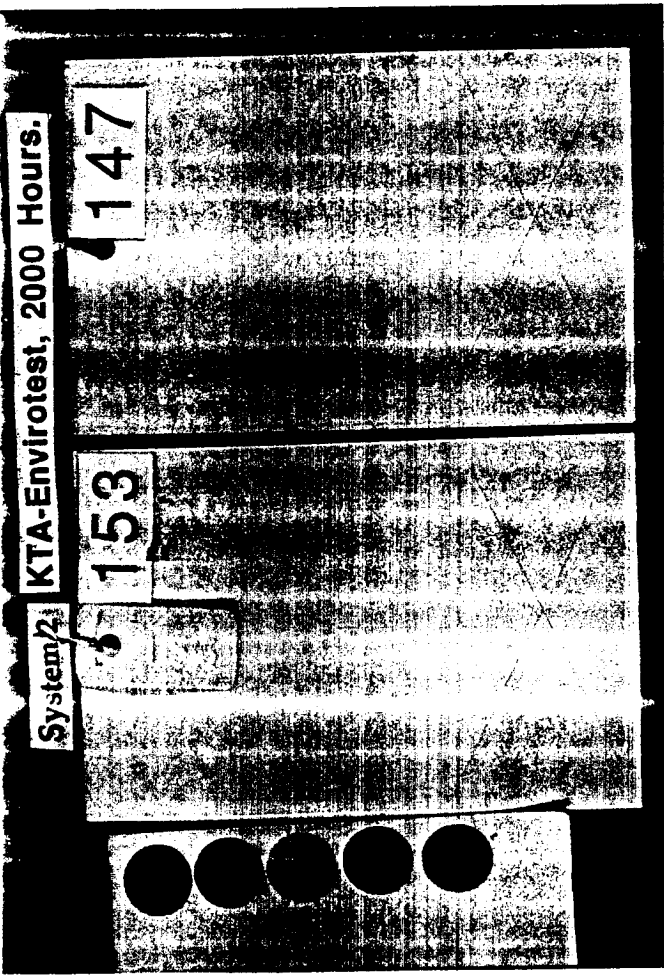
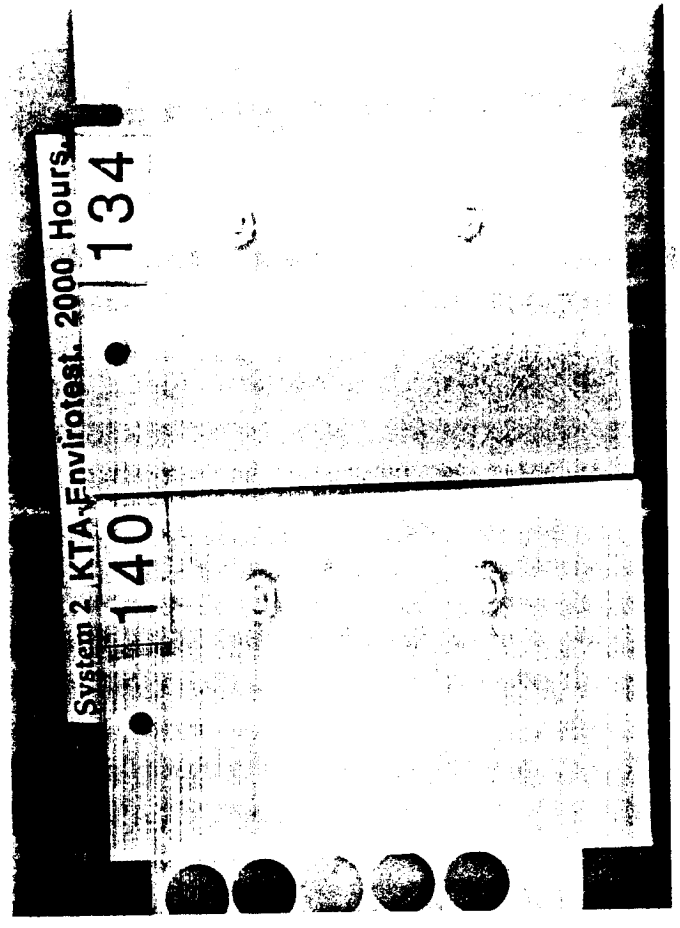
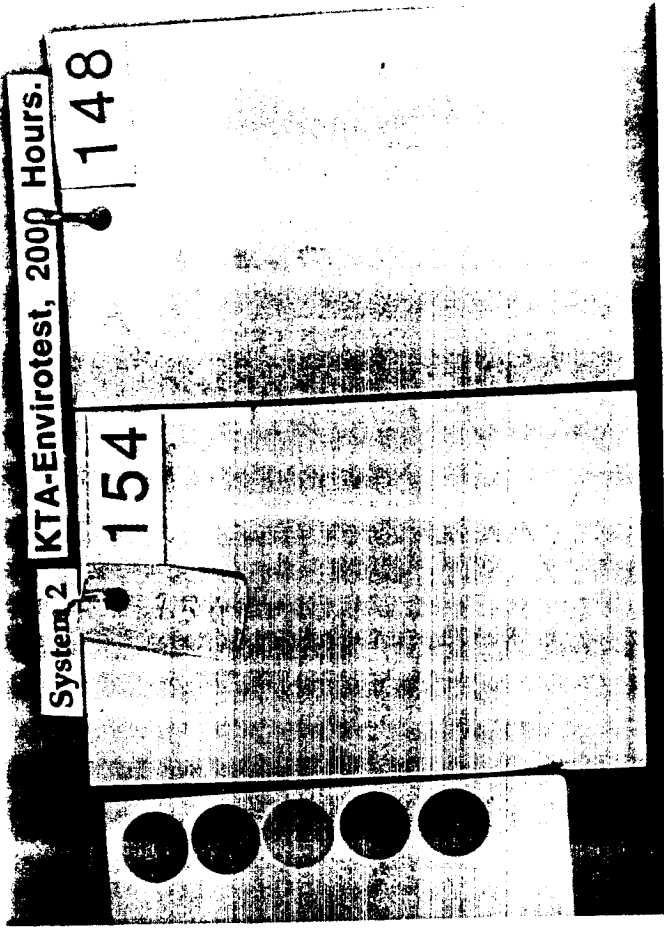
35

29

System 1 KTA-Envirotest, 2000 Hours.

35

30



ORIGINAL PAGE IS
OF POOR QUALITY

System 2 KTA-Envirotest, 2000 Hours.

90

96

System 2 KTA-Envirotest, 2000 Hours.

89

95

System 2 KTA-Envirotest, 2000 Hours.

112

118

System 2 KTA-Envirotest, 2000 Hours.

111

117

System 3 | KTA-Envirotest, 2000 Hours.

179

173

System 3 | KTA-Envirotest, 2000 Hours.

180

174

System 3 | KTA-Envirotest, 2000 Hours.

221

215

System 3 | KTA-Envirotest, 2000 Hours.

222

216

System 3 KTA-Envirotest, 2000 Hours.

201

195

System 3 KTA-Envirotest, 2000 Hours.

202

196

System 3 KTA-Envirotest, 2000 Hours.

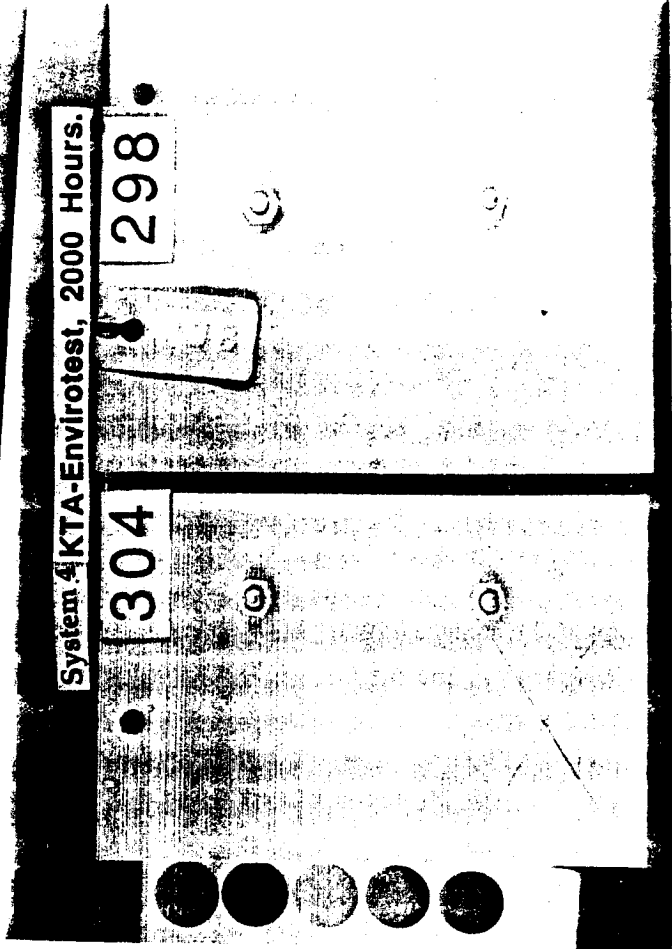
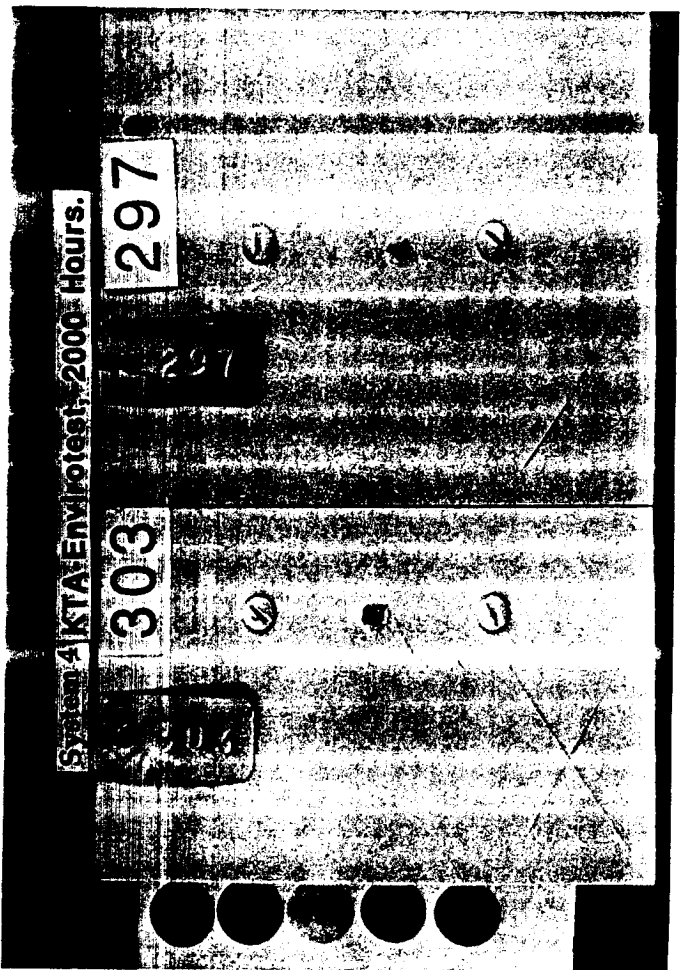
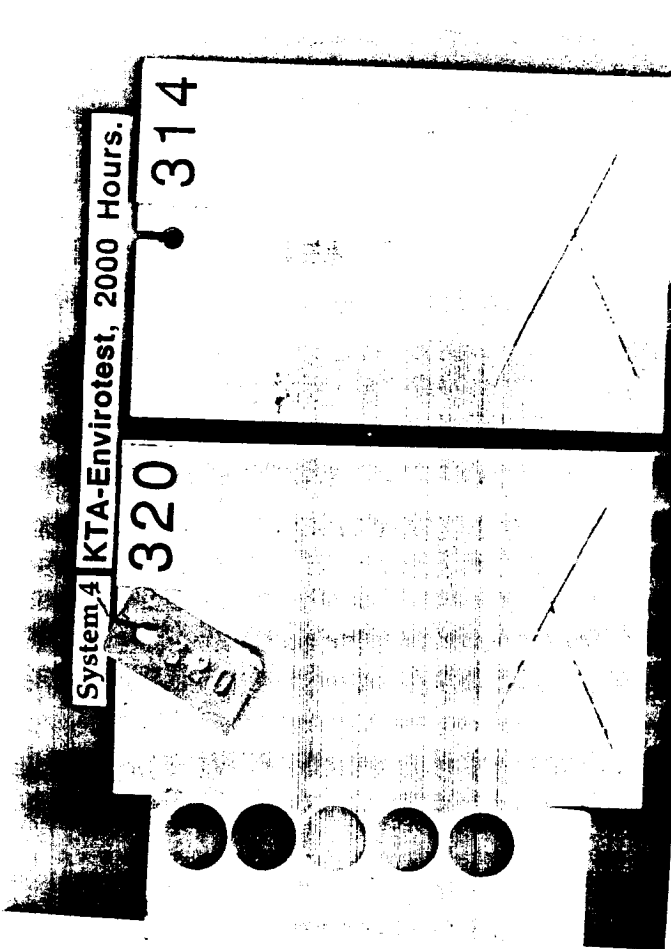
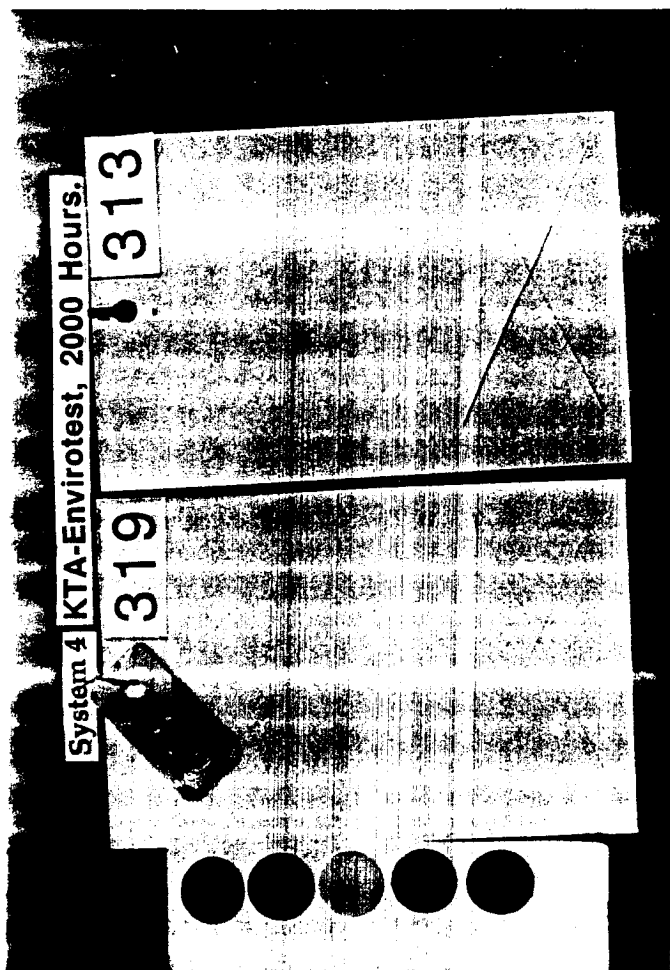
237

229

System 3 KTA-Envirotest, 2000 Hours.

238

230

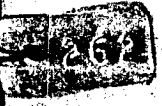


System 4 KTA-Envirotest, 2000 Hours.

256

262

System 4

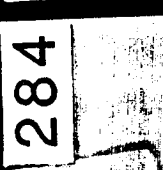


System 4 KTA-Envirotest, 2000 Hours.

278

284

System 4

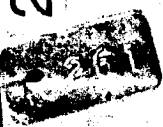


System 4 KTA-Envirotest, 2000 Hours.

255

261

System 4

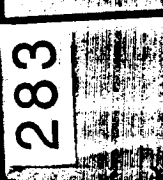


System A KTA-Envirotest, 2000 Hours.

277

283

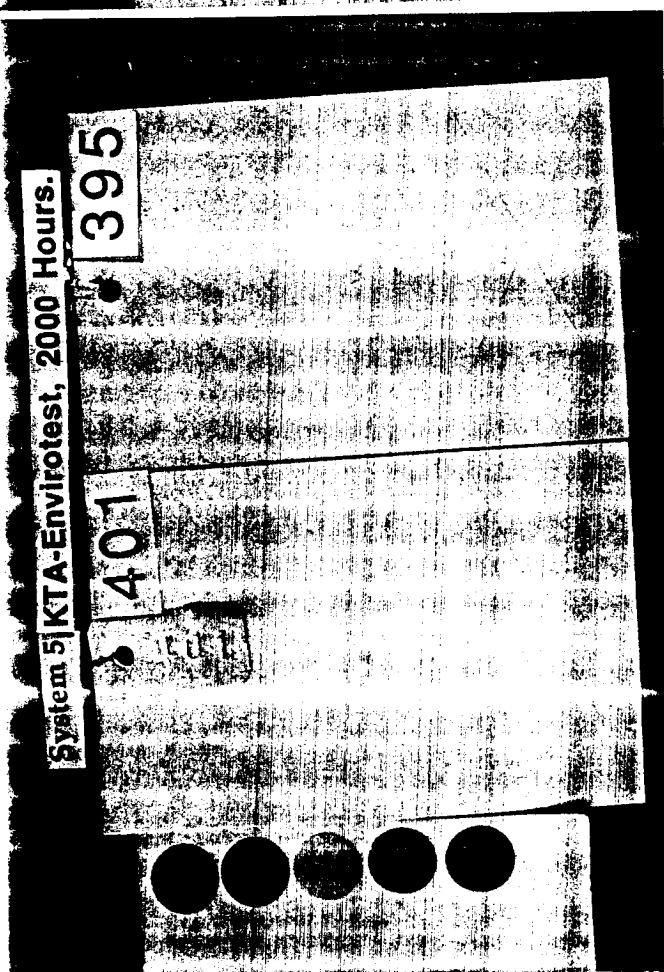
System A



System 5 KTA-Envirotest, 2000 Hours.

395

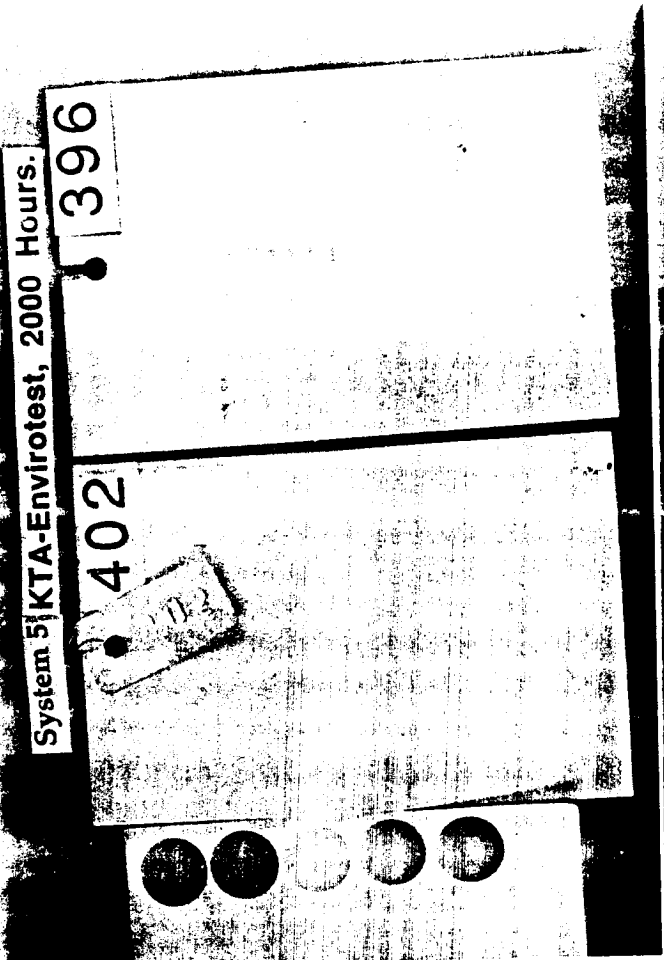
401



System 5 KTA-Envirotest, 2000 Hours.

396

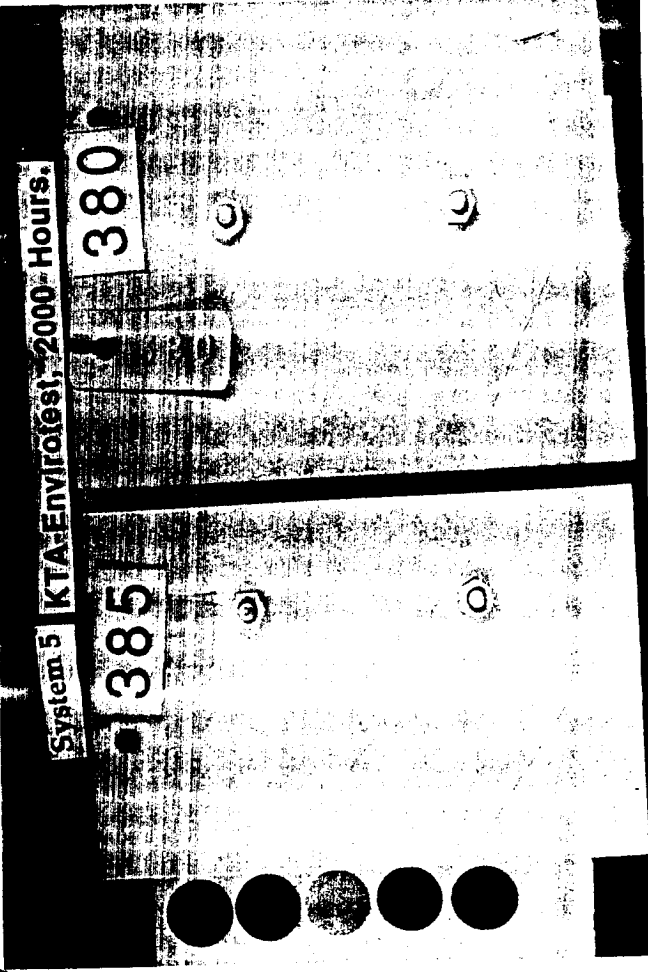
402



System 5 KTA-Envirotest, 2000 Hours.

380

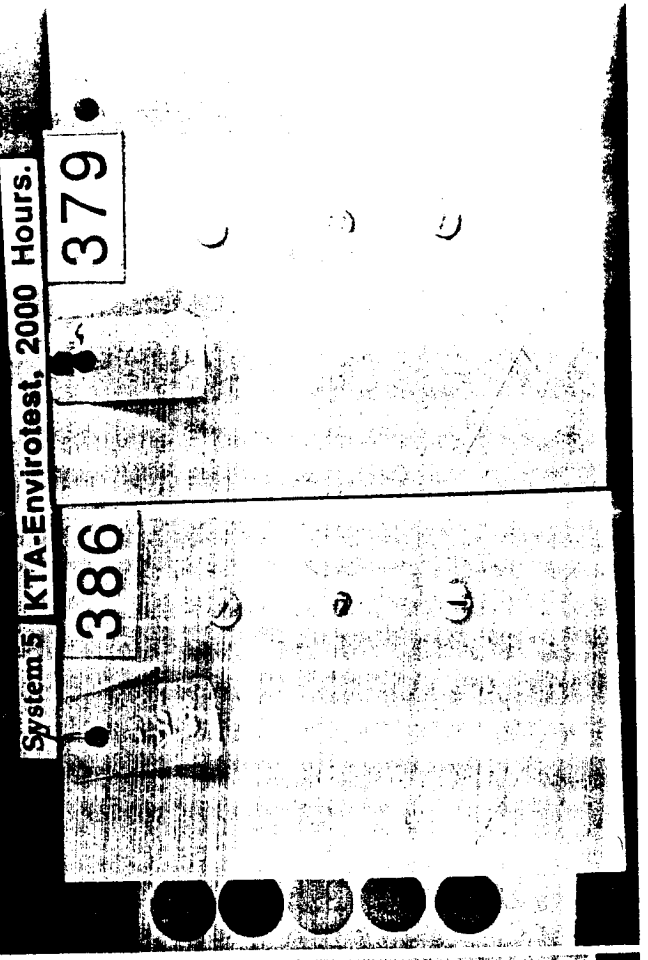
385



System 5 KTA-Envirotest, 2000 Hours.

386

379



System 5 KTA-Envirotest, 2000 Hours.

338

348

System 5 KTA-Envirotest, 2000 Hours.

360

370

System 5 KTA-Envirotest, 2000 Hours.

337

343

System 5 KTA-Envirotest, 2000 Hours.

359

365

System 6 KTA-Envirotest, 2000 Hours.

426

420

System 6 KTA-Envirotest, 2000 Hours.

425

419

System 6 KTA-Envirotest, 2000 Hours.

448

442

System 6 KTA-Envirotest, 2000 Hours.

447

441

System 6 KTA-Envirotest, 2000 Hours.

483

486

System 6 KTA-Envirotest, 2000 Hours.

484

485

System 6 KTA-Envirotest, 2000 Hours.

467

461

System 6 KTA-Envirotest, 2000 Hours.

468

462

System 7 KTA-Envirotest, 2000 Hours.

565

551

565

566

560

566

System 7 KTA-Envirotest, 2000 Hours.

549

543

549

544

550

544

550

System 7 KTA-Envirotest, 2000 Hours.

507

501

508

System 7 KTA-Envirotest, 2000 Hours.

508

502

System 7 KTA-Envirotest, 2000 Hours.

529

523

530

System 7 KTA-Envirotest, 2000 Hours.

530

524

System 8 KTA-Envirotest, 2000 Hours.

589

583

System 8

KTA-Envirotest, 2000 Hours.

590

584

System 8 KTA-Envirotest, 2000 Hours.

631

625

System 8

KTA-Envirotest, 2000 Hours.

632

625

System 8 KTA-Envirotest, 2000 Hours.

612

606

System 8 KTA-Envirotest, 2000 Hours.

611

605

System 8 KTA-Envirotest, 2000 Hours.

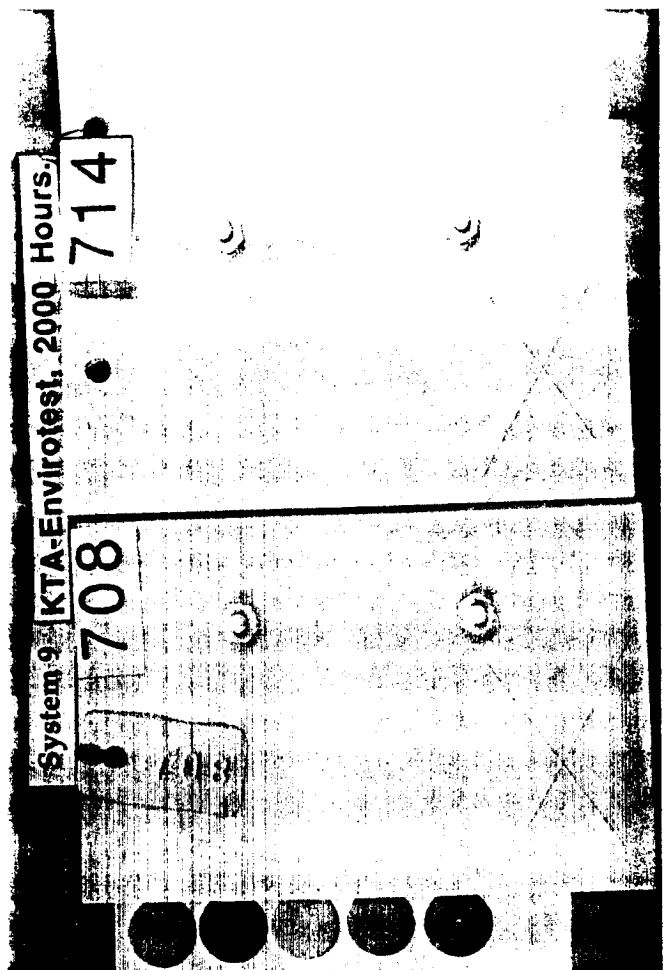
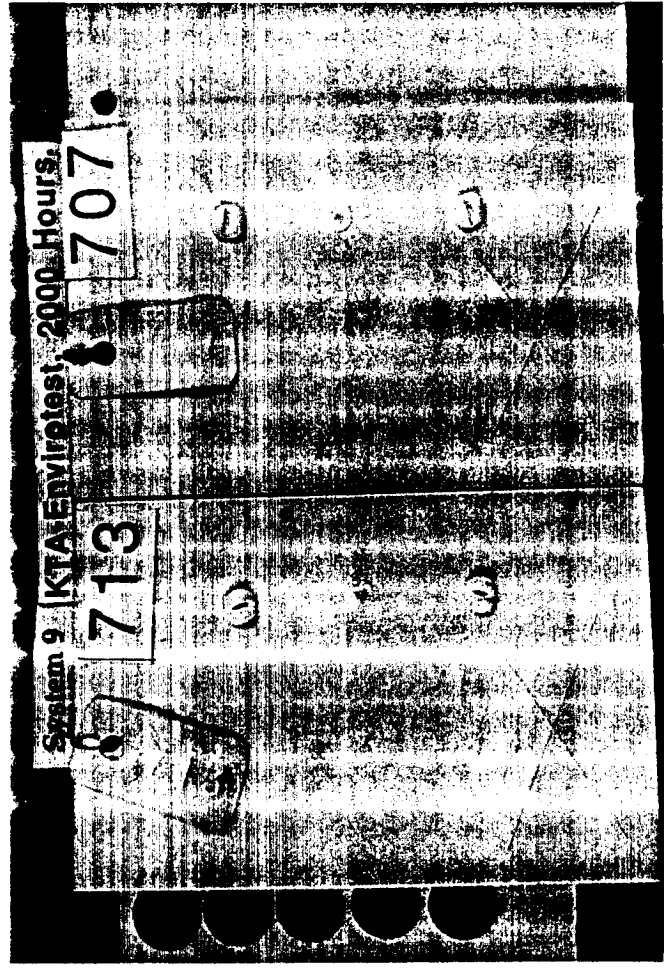
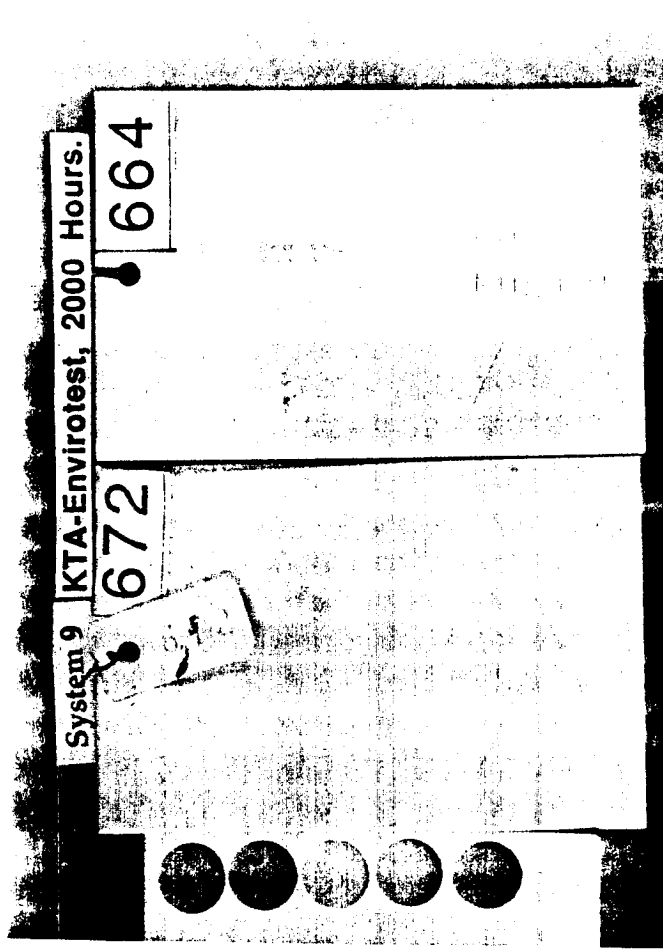
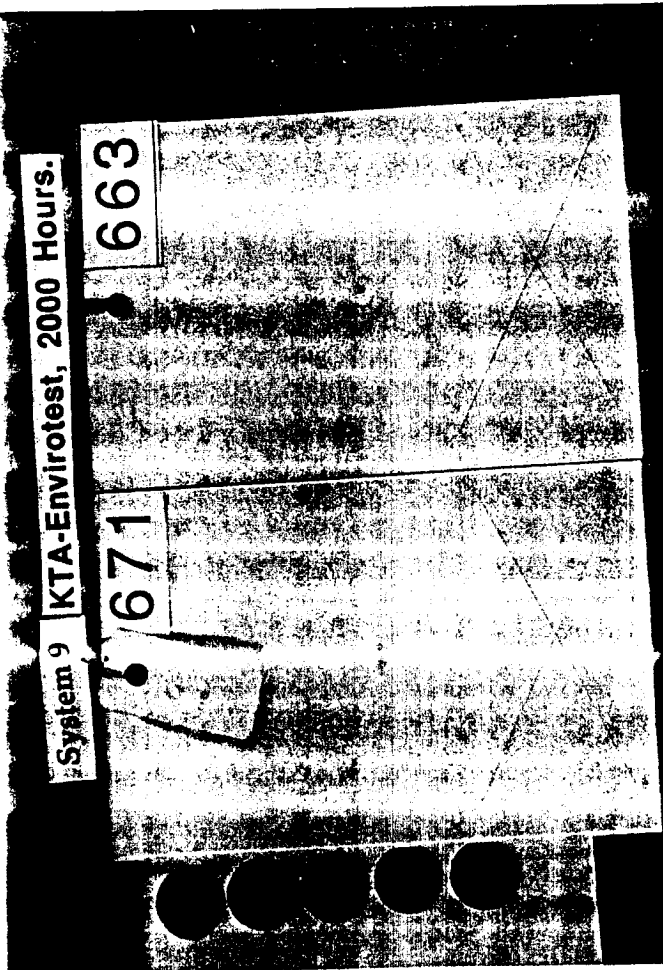
646

640

System 8 KTA-Envirotest, 2000 Hours.

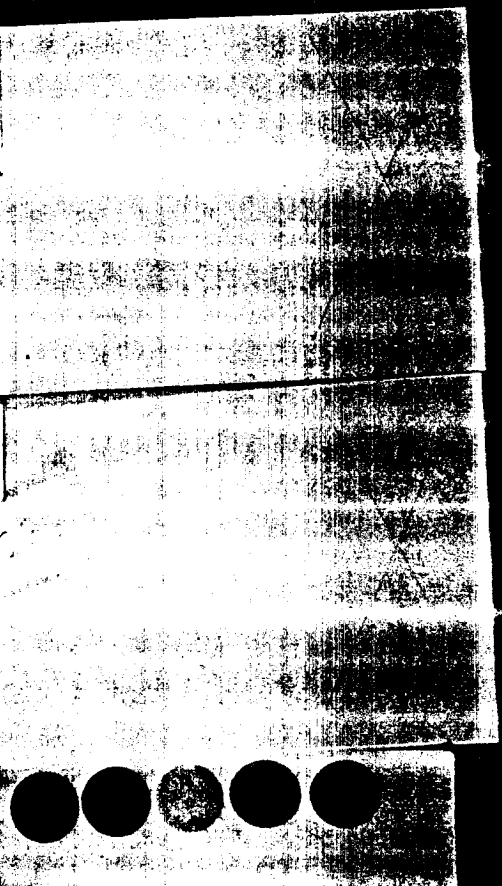
645

639



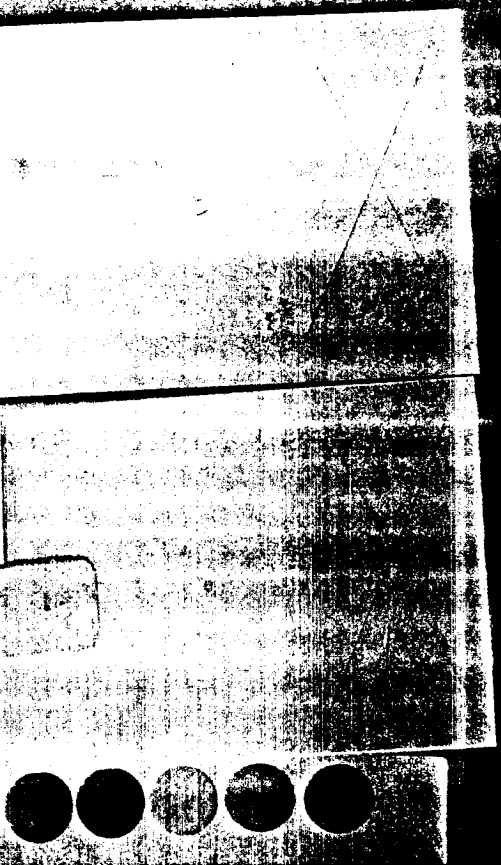
System 9 KTA-Envirotest, 2000 Hours. 687

694



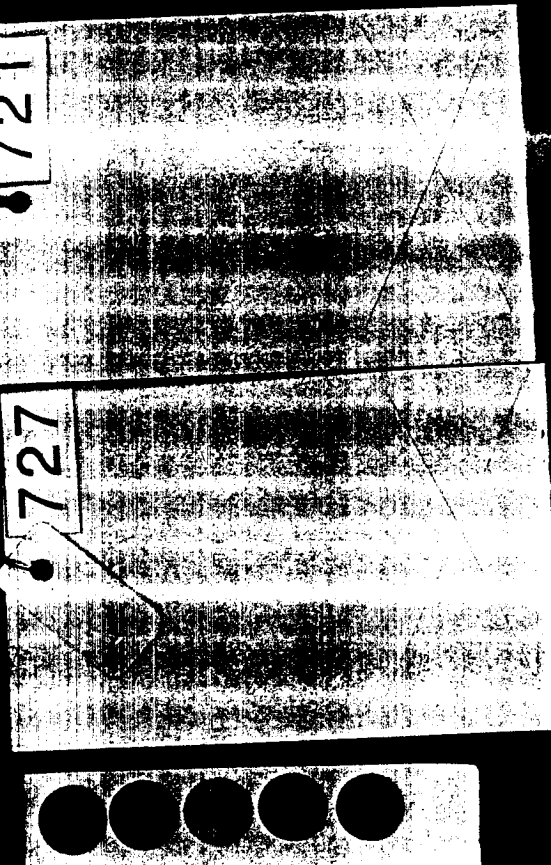
System 9 KTA-Envirotest, 2000 Hours. 686

695



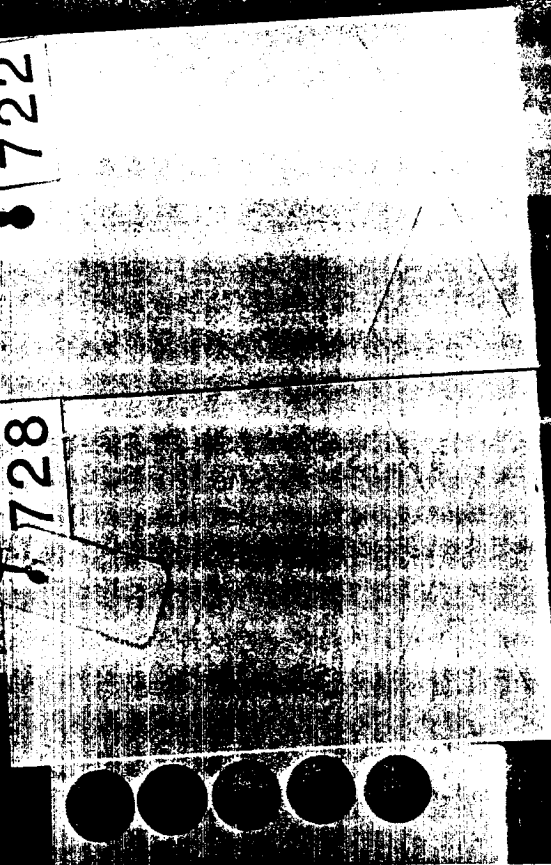
System 9 KTA-Envirotest, 2000 Hours. 721

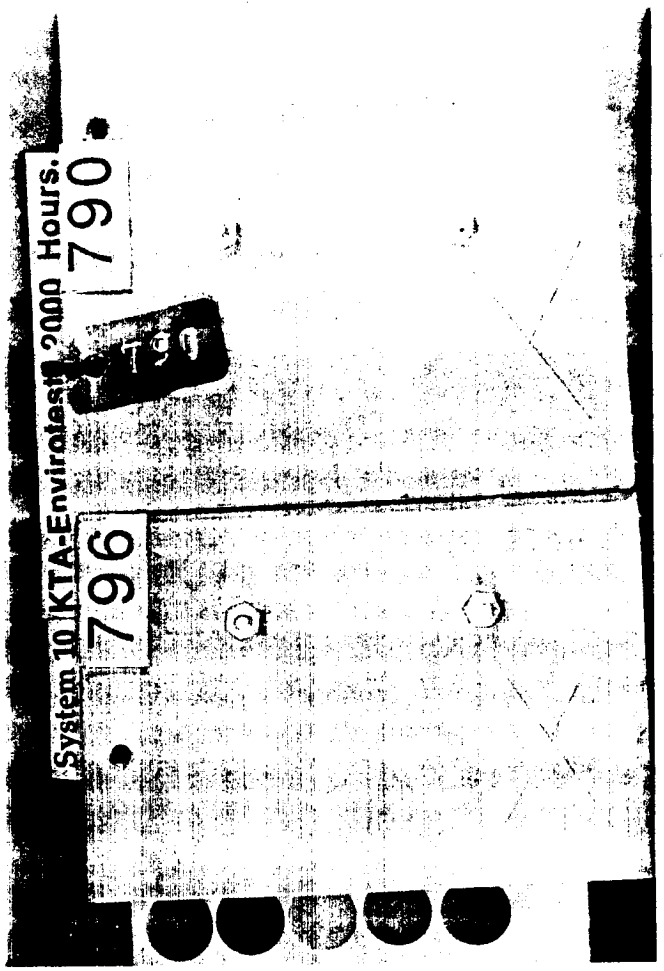
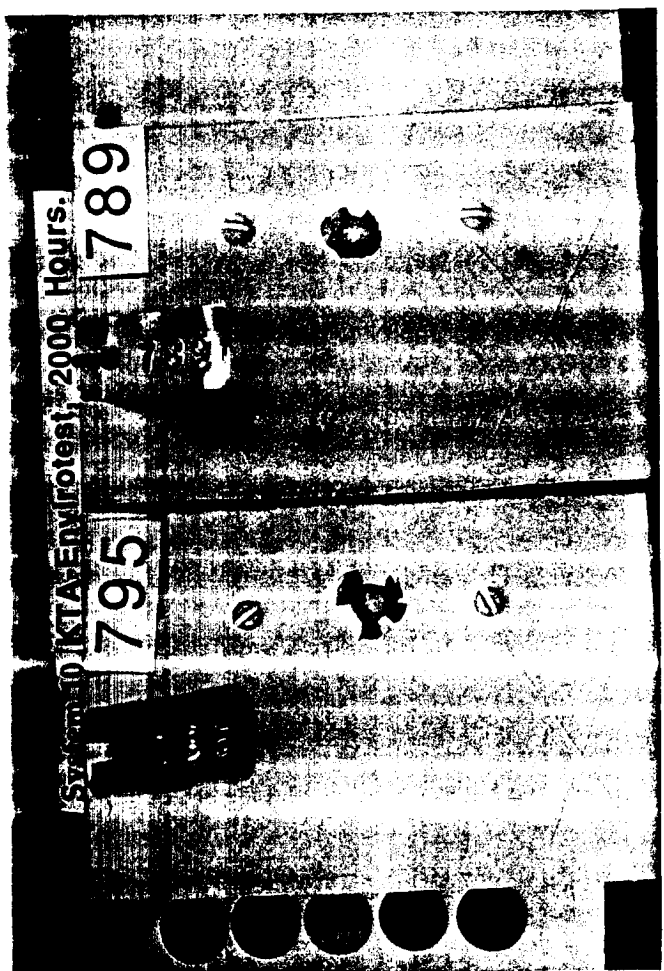
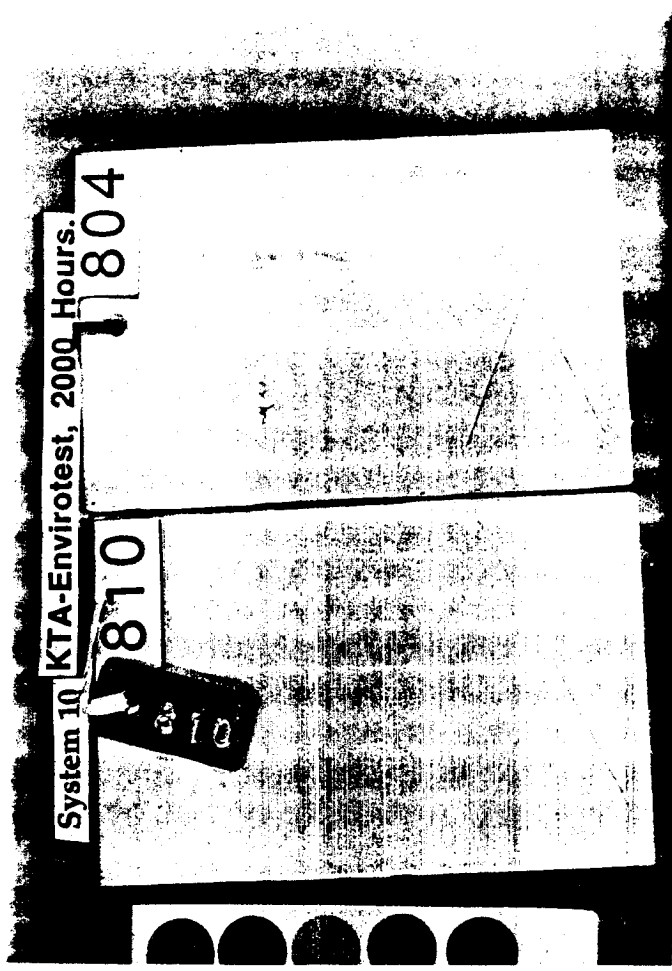
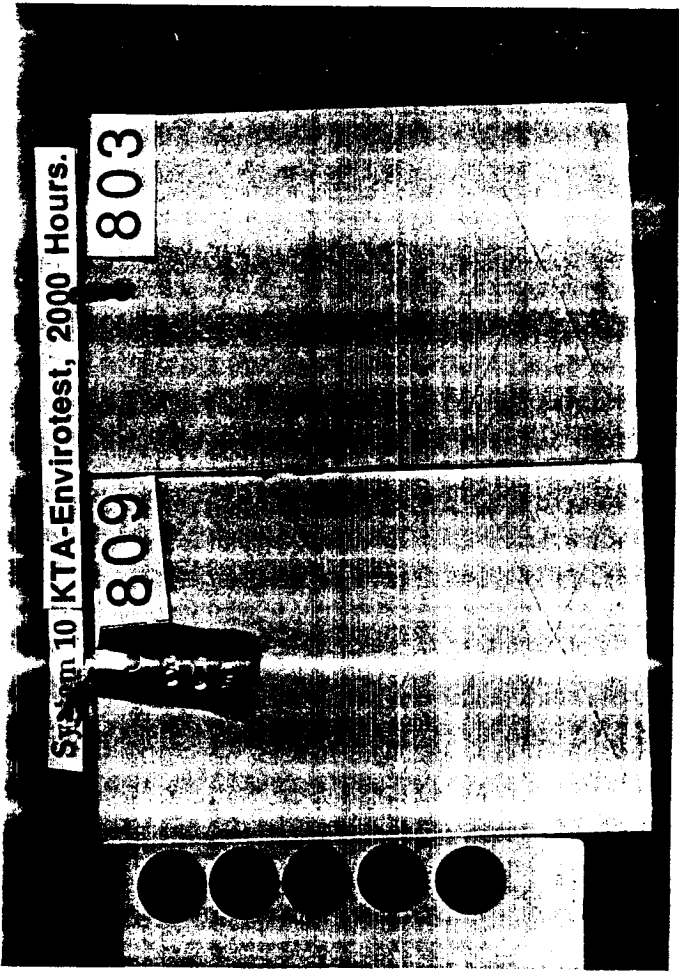
727



System 9 KTA-Envirotest, 2000 Hours. 722

728





System 10 KTA-Envirotest, 2000 Hours.

753

747

System 10 KTA-Envirotest, 2000 Hours.

755

748

System 10 KTA-Envirotest, 2000 Hours.

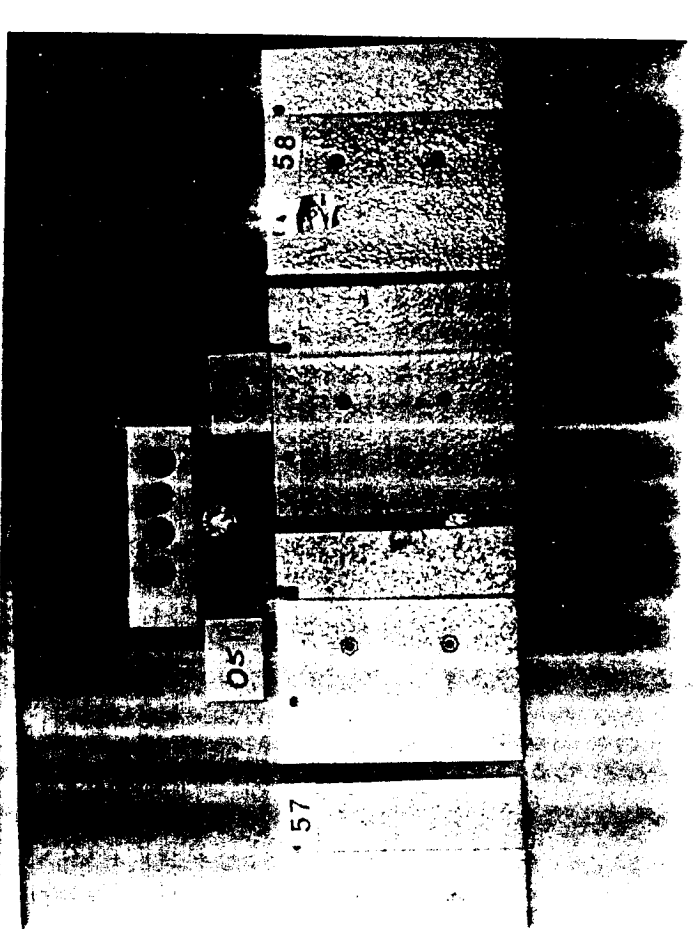
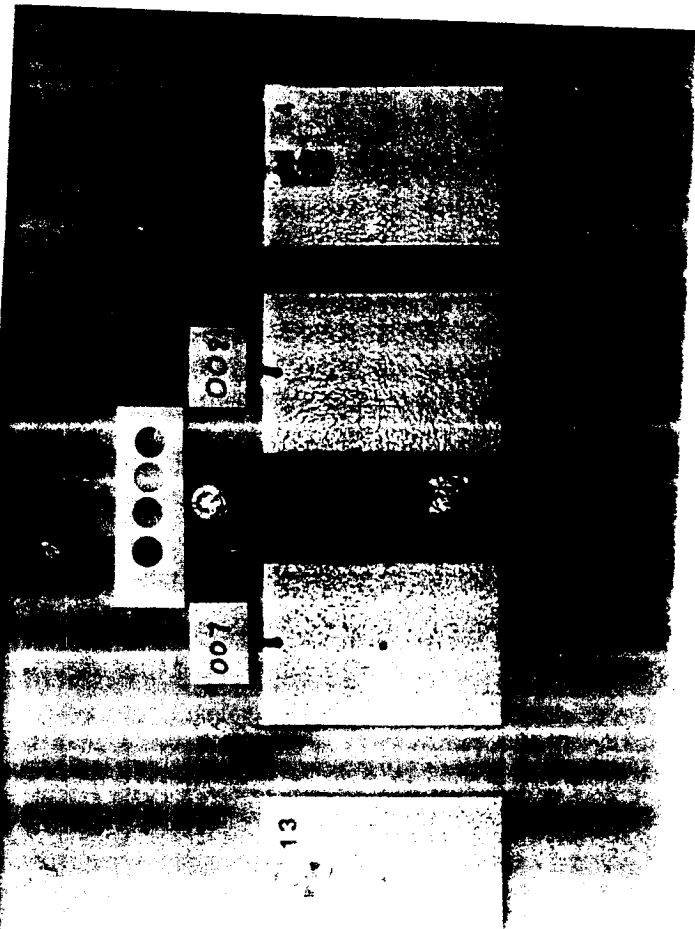
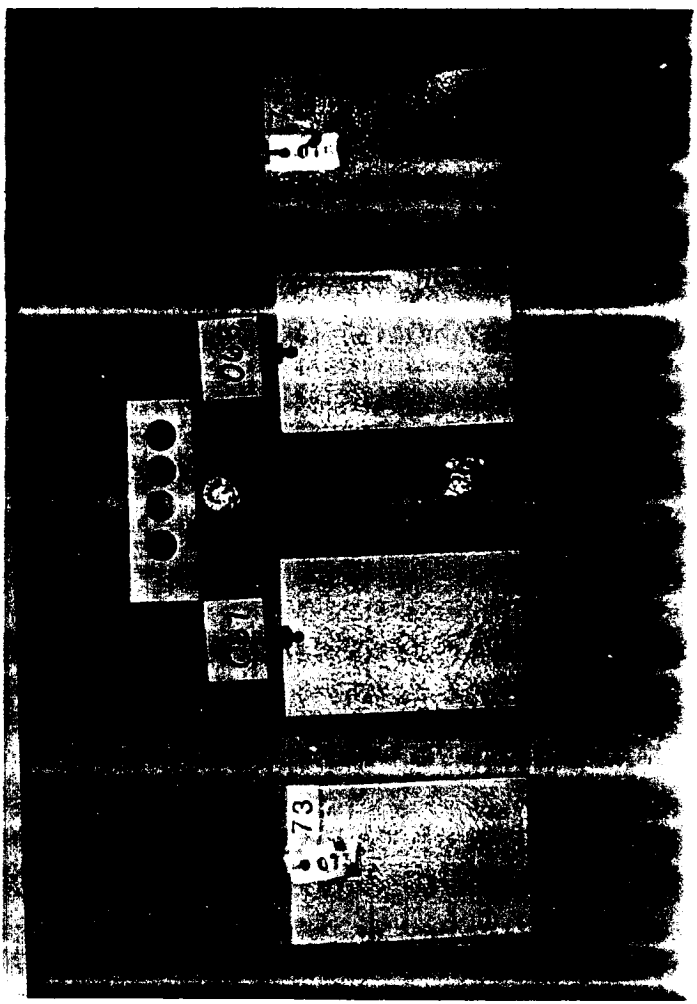
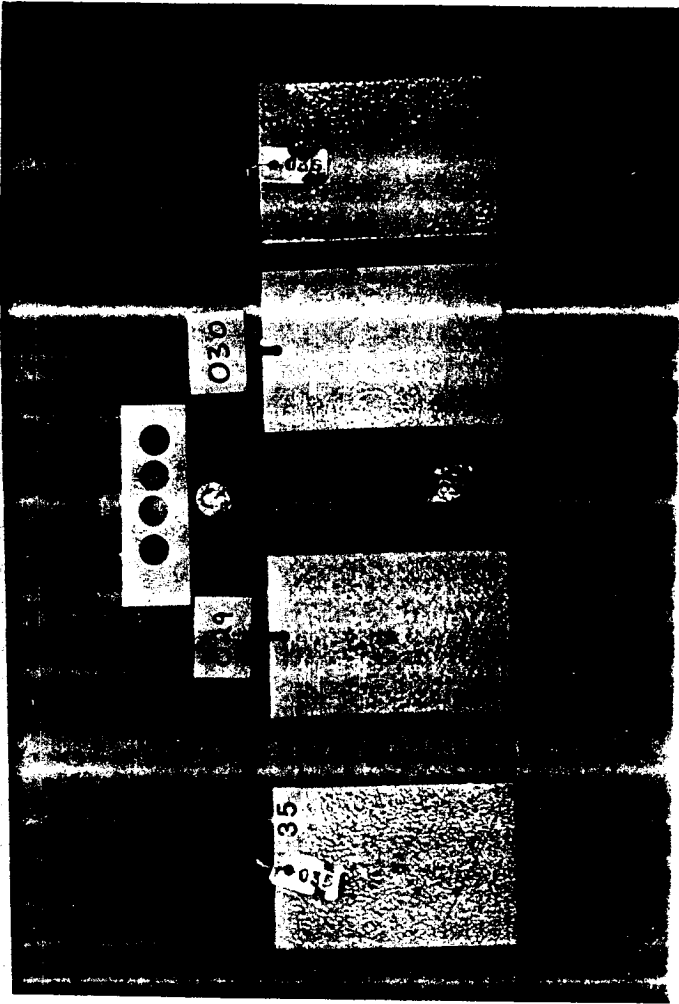
774

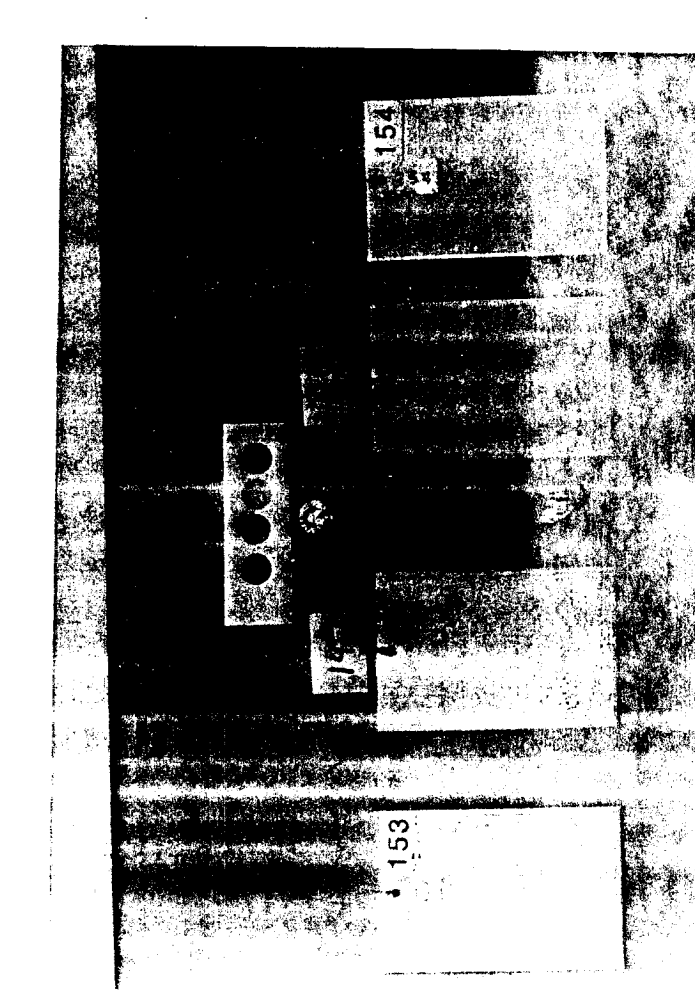
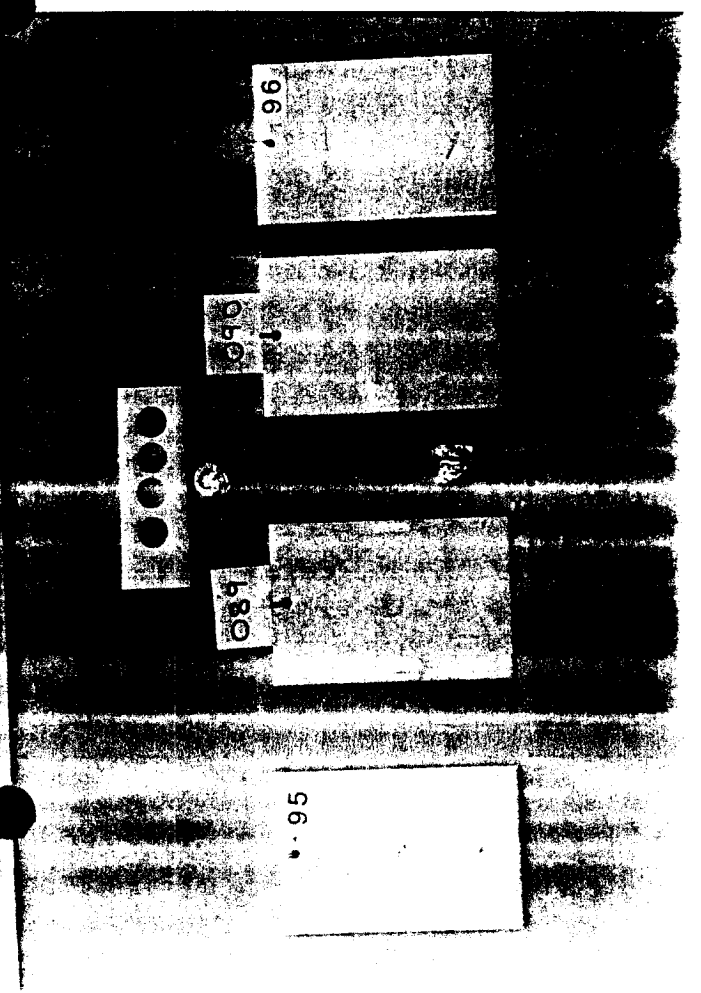
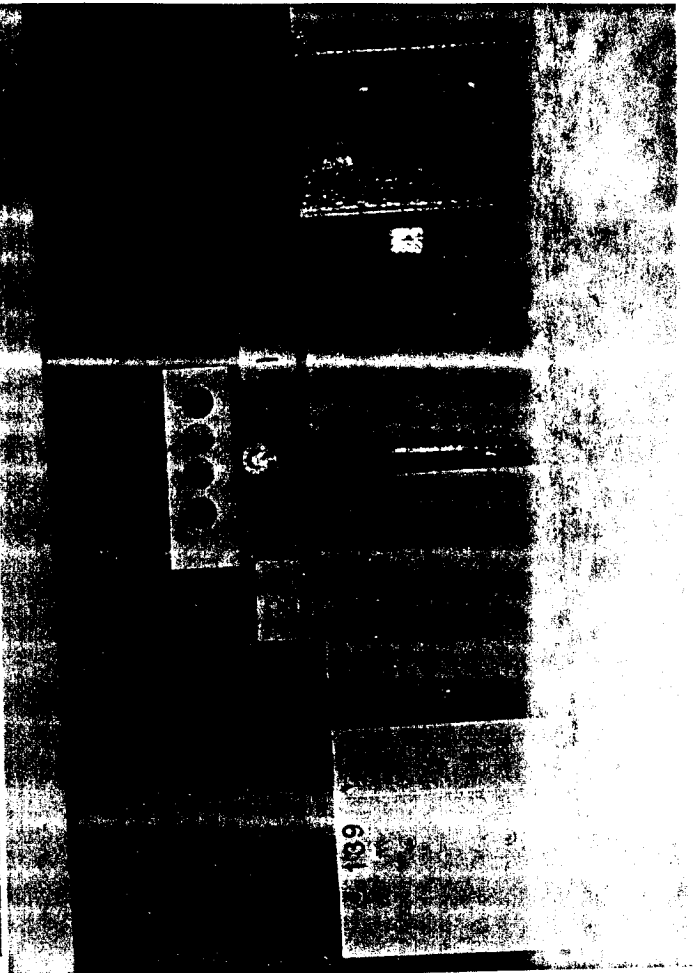
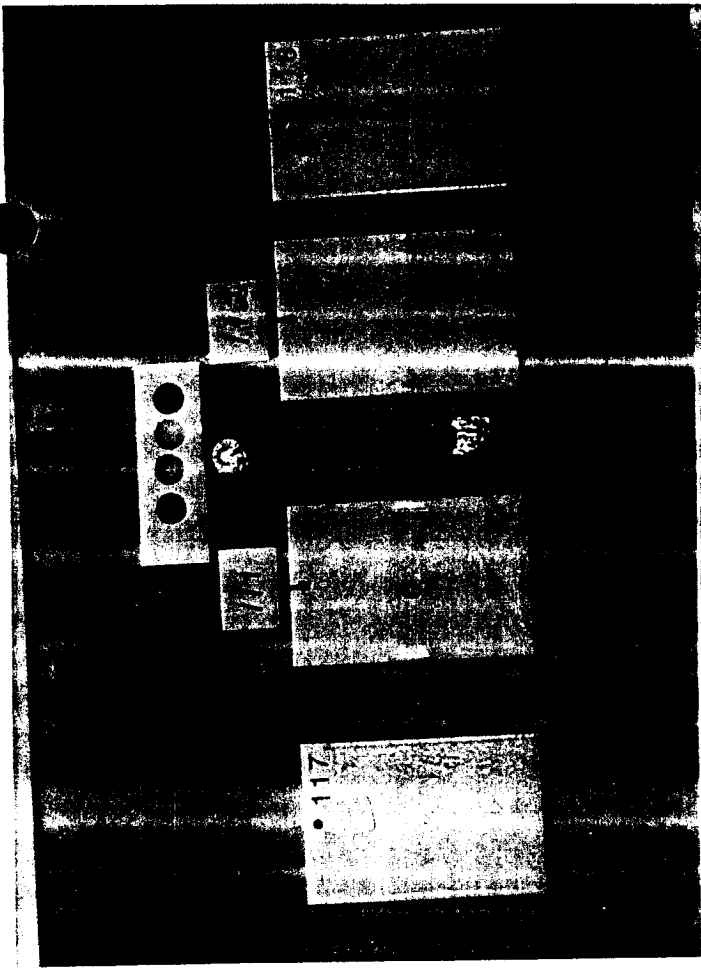
769

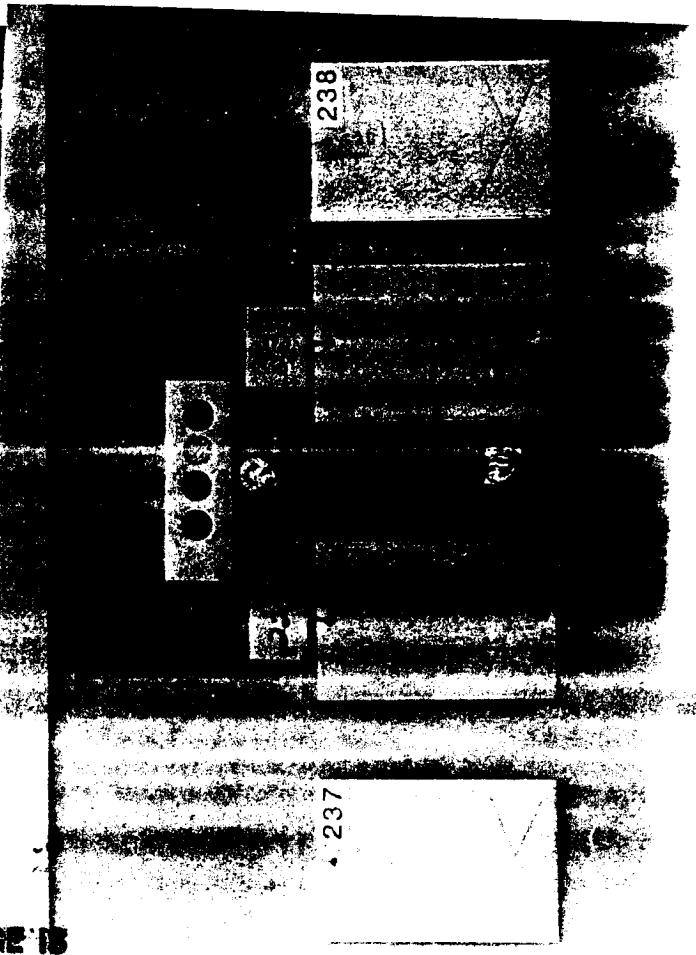
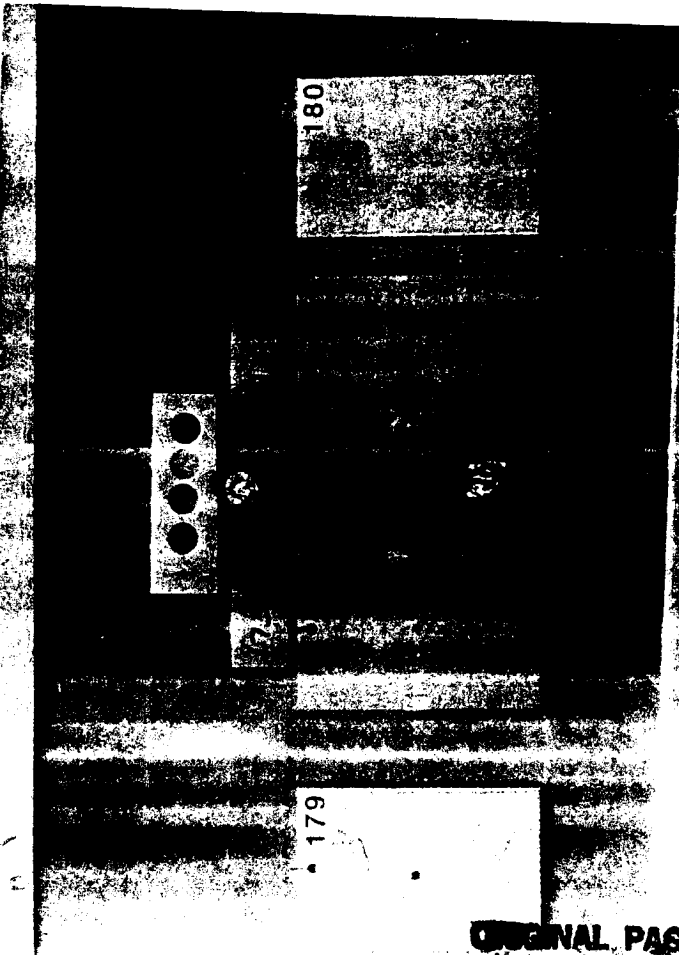
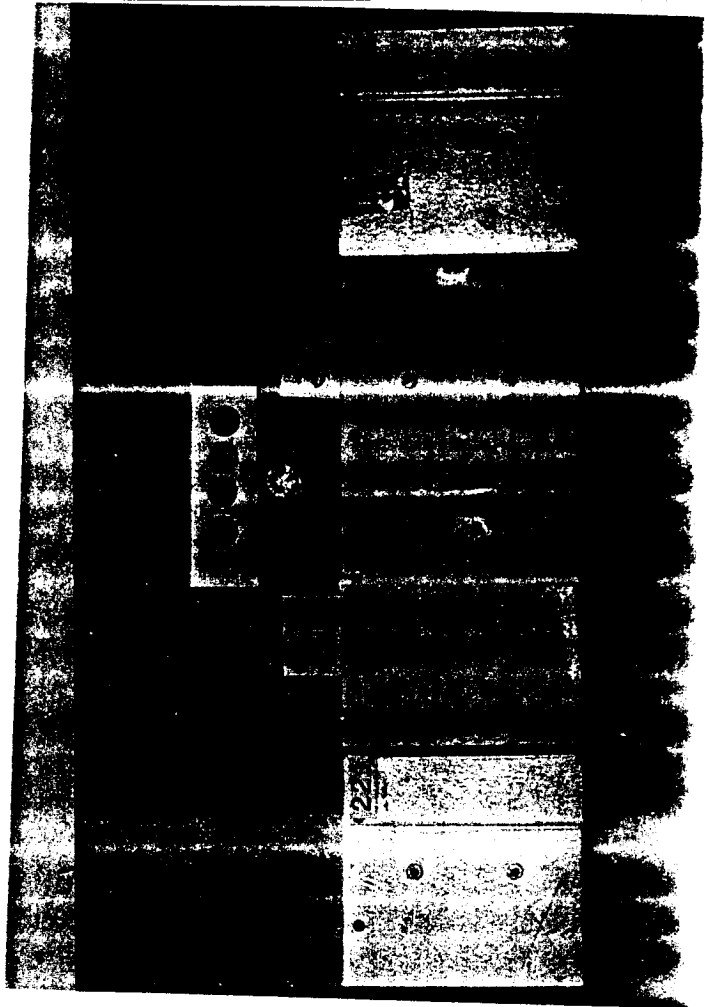
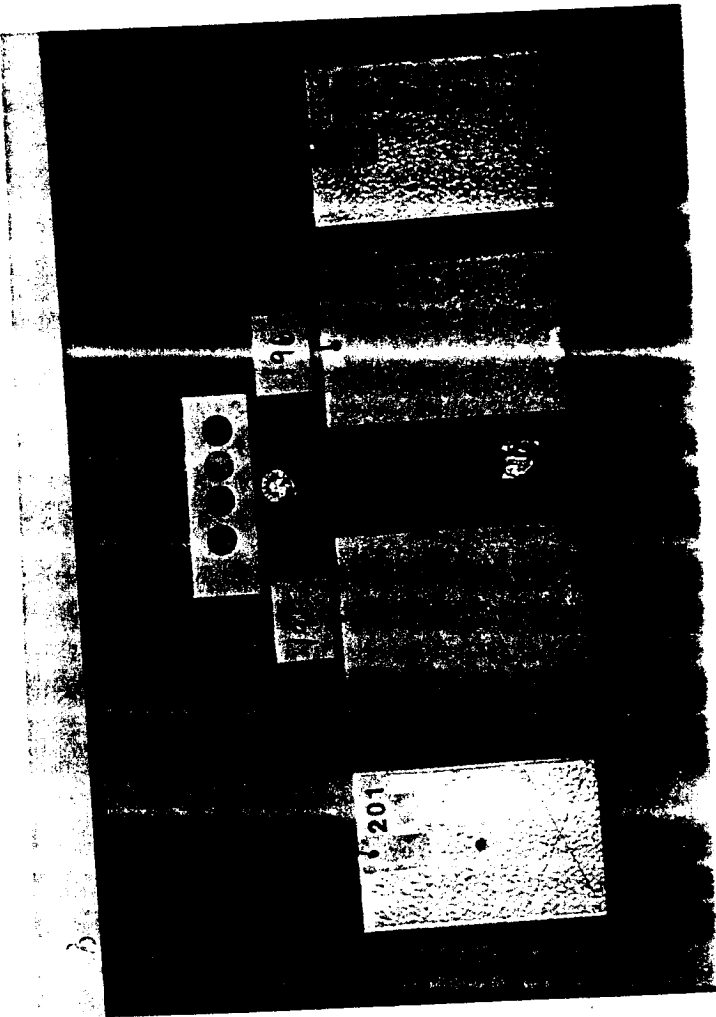
System 10 KTA-Envirotest, 2000 Hours.

776

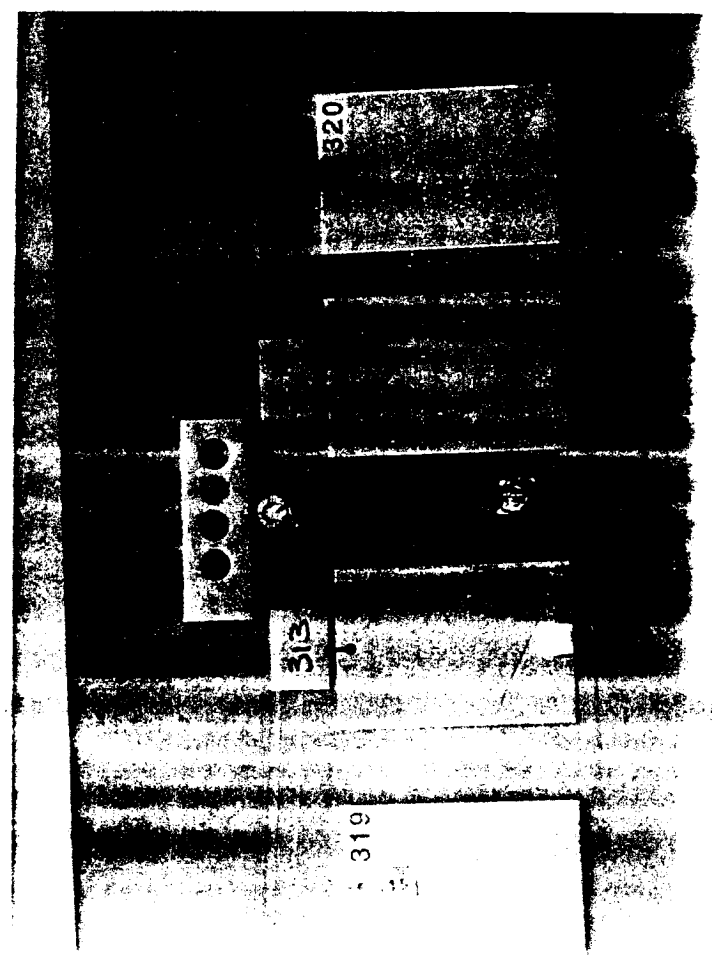
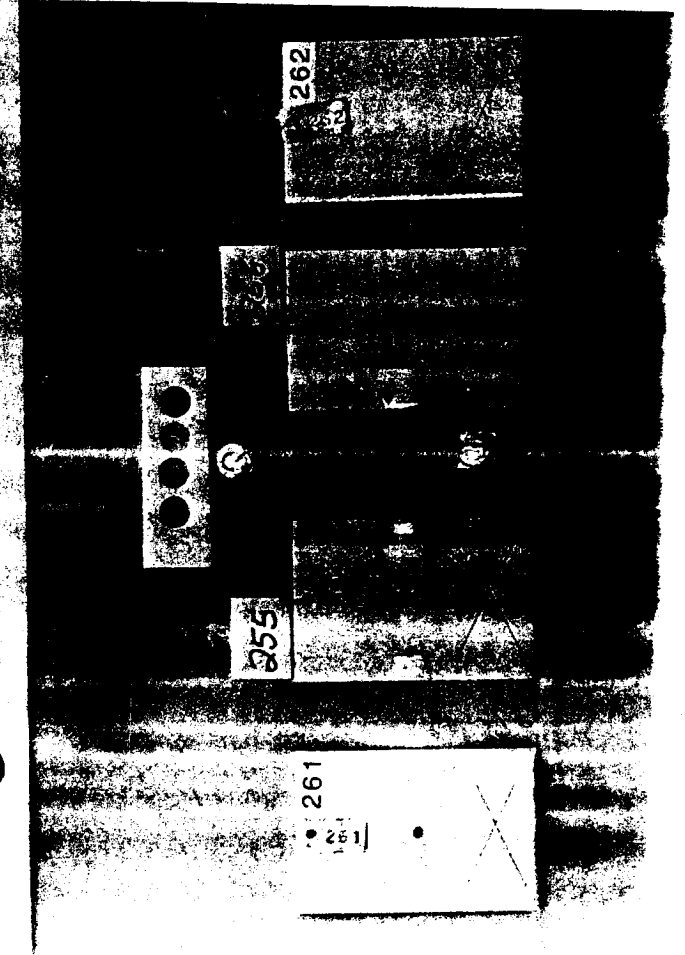
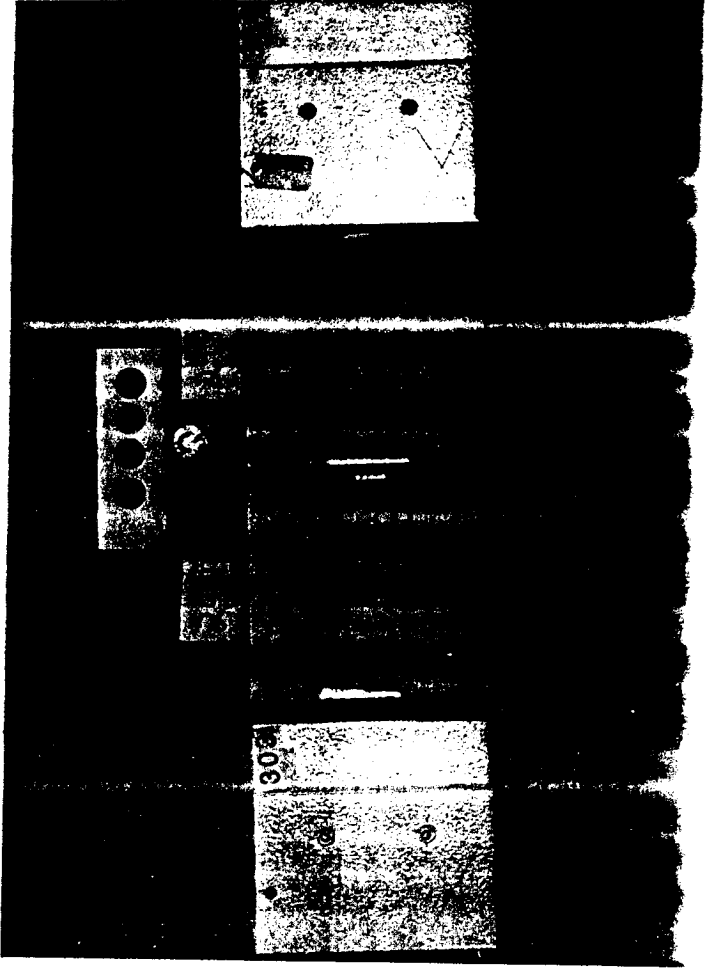
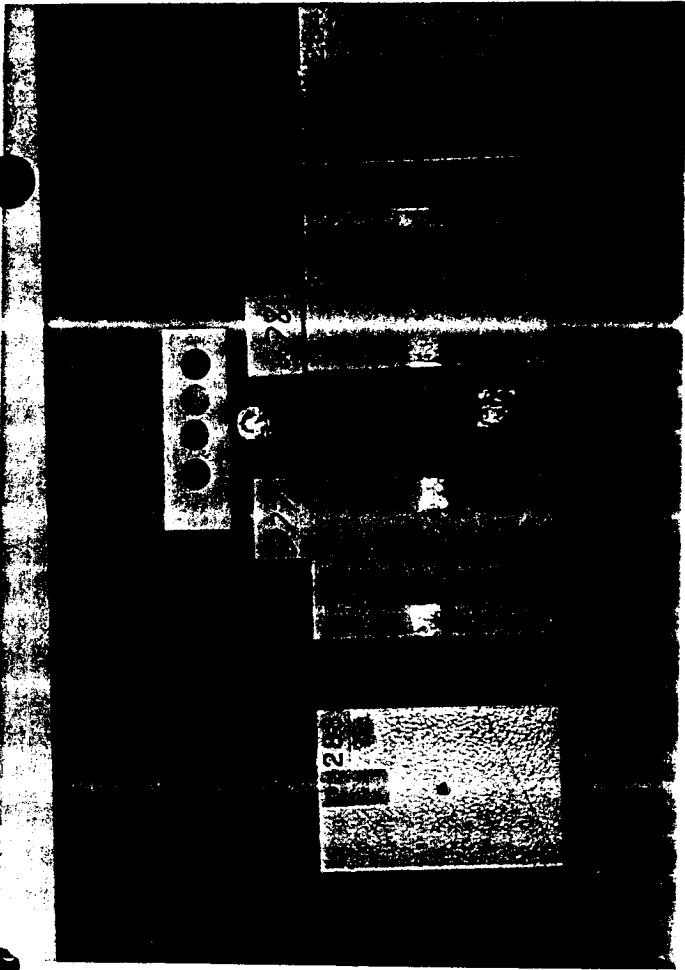
768

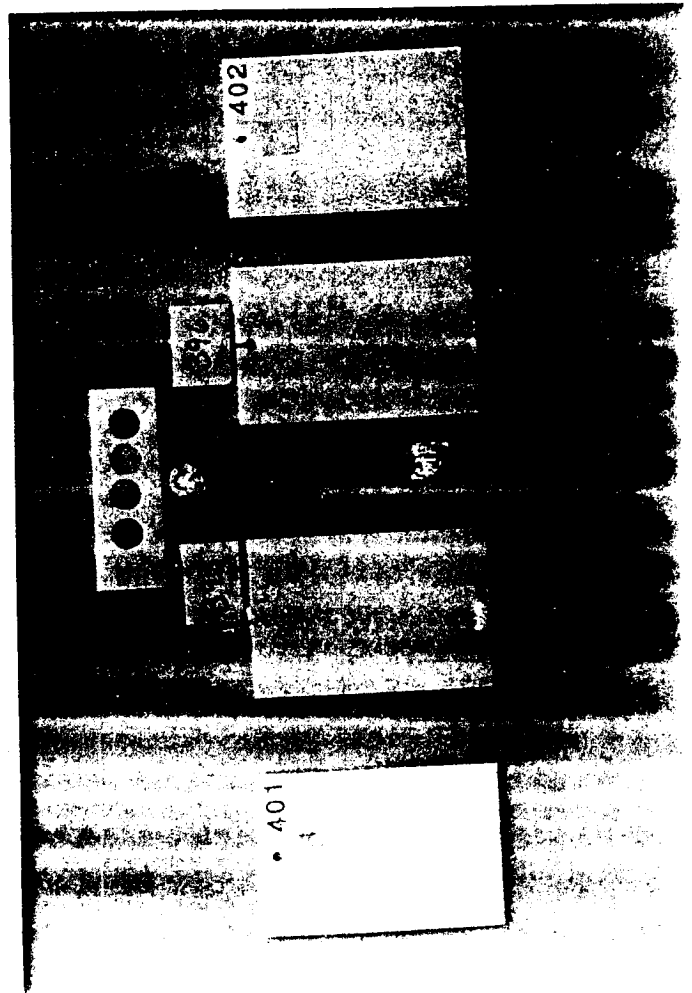
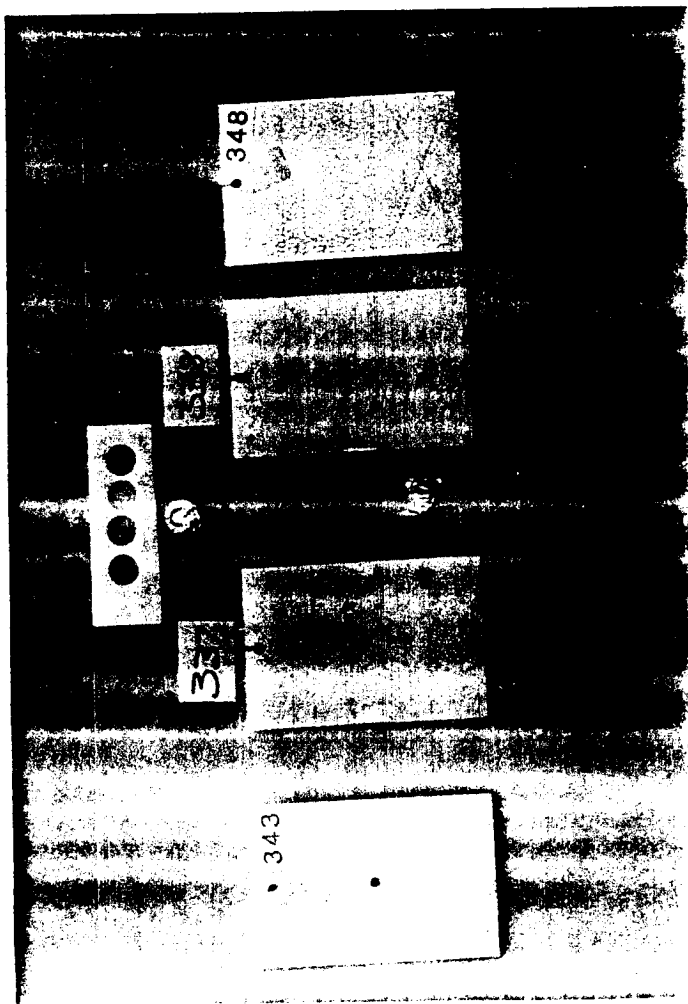
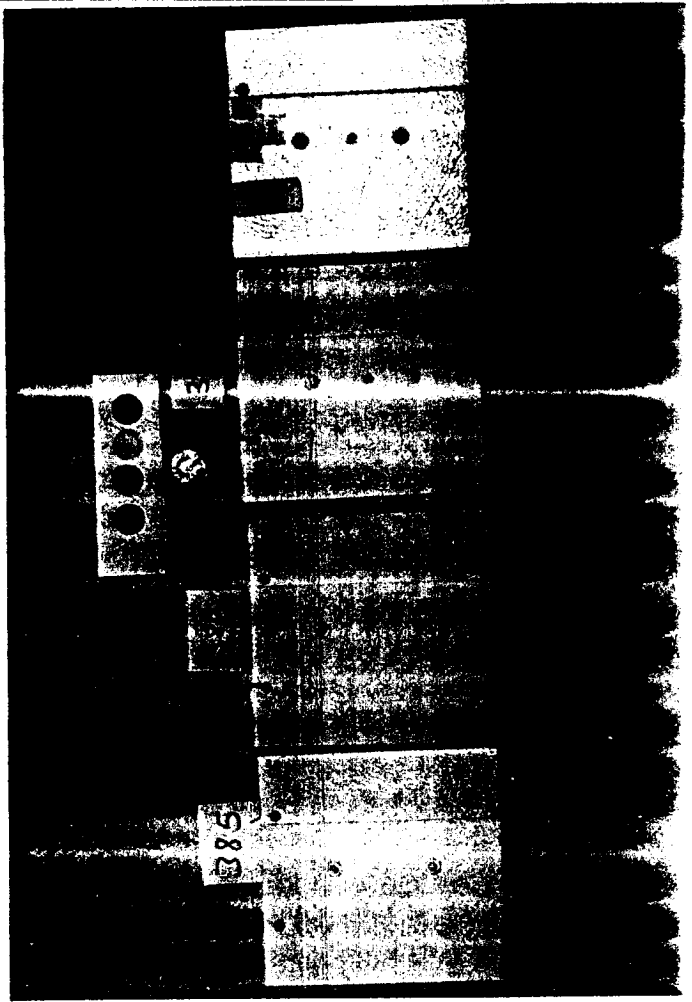
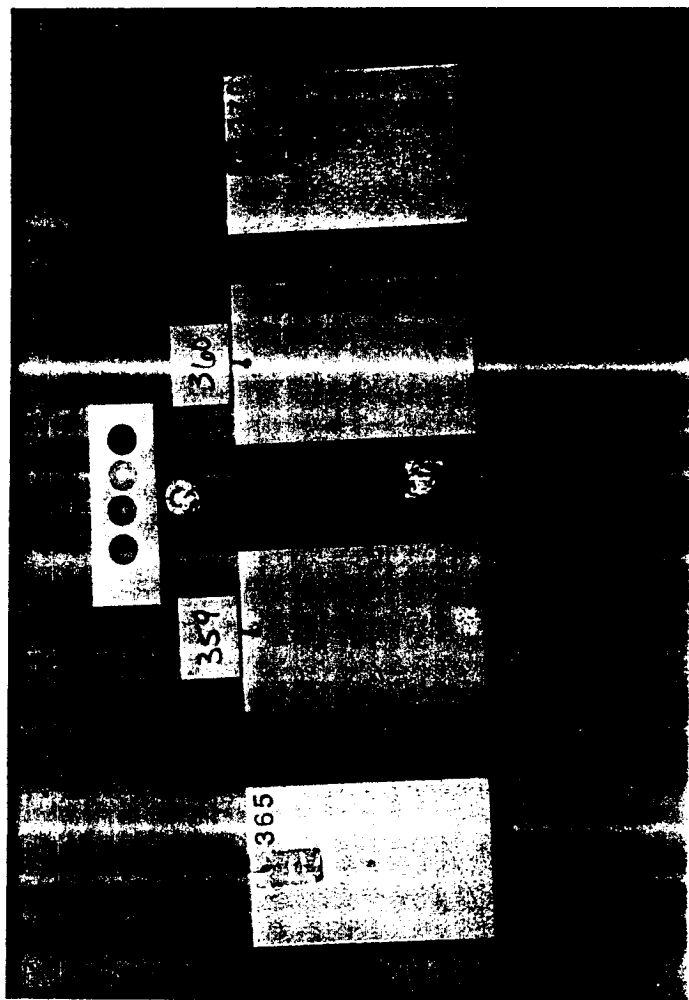


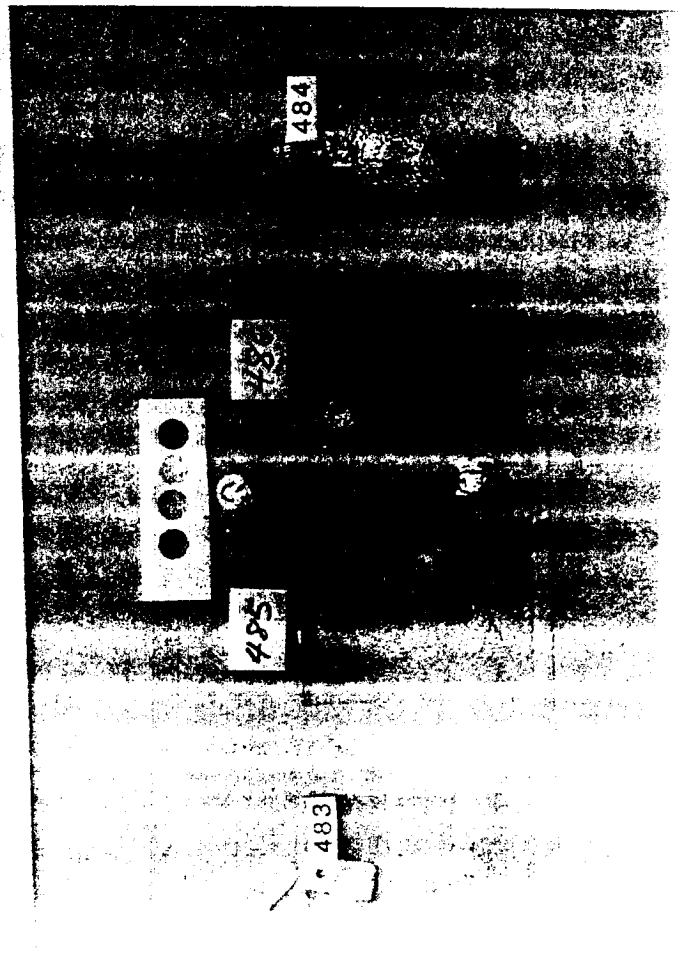
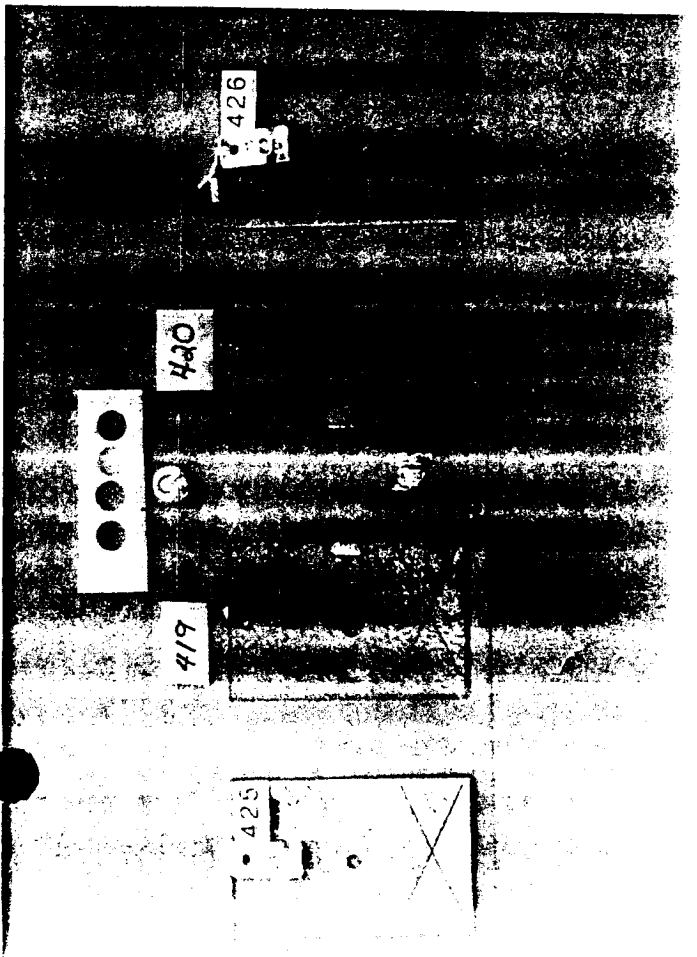
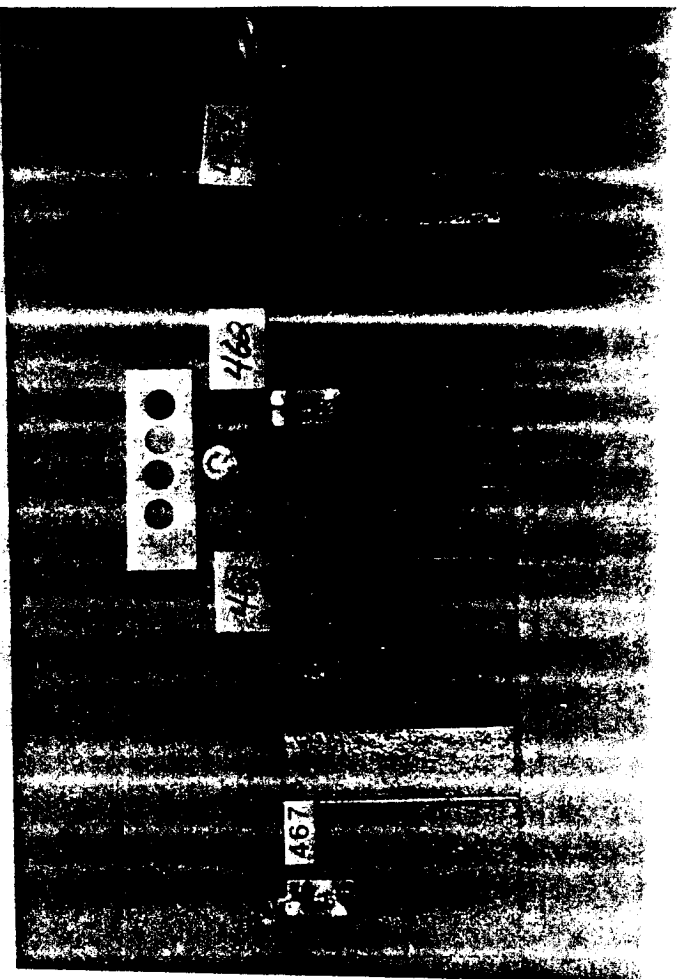
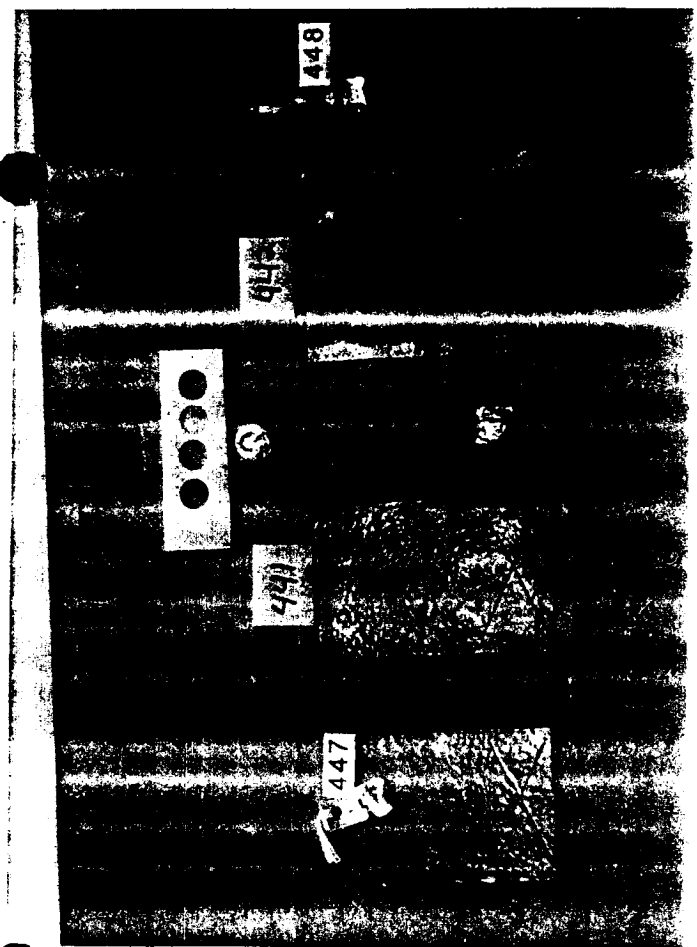


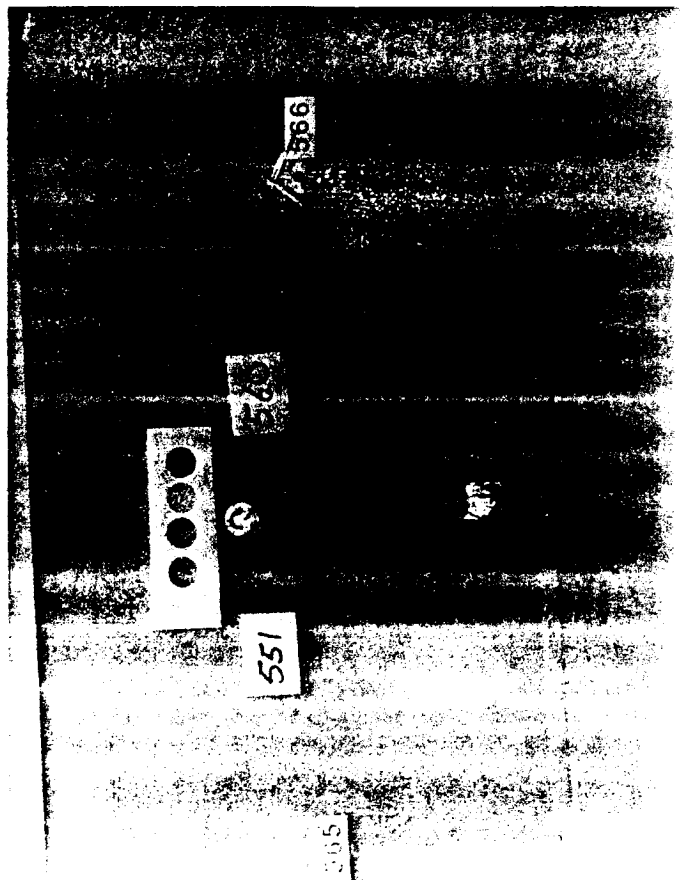
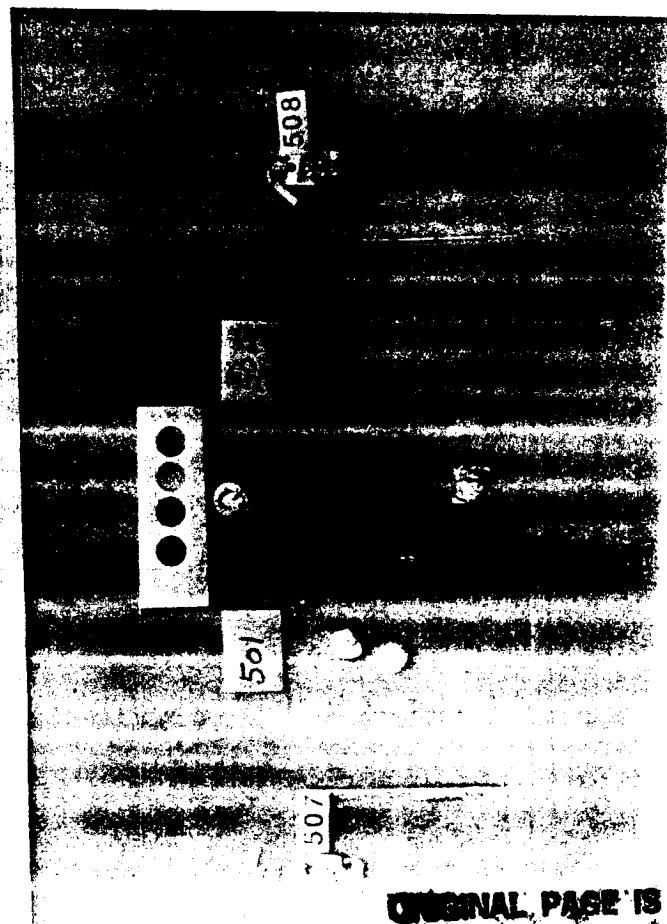
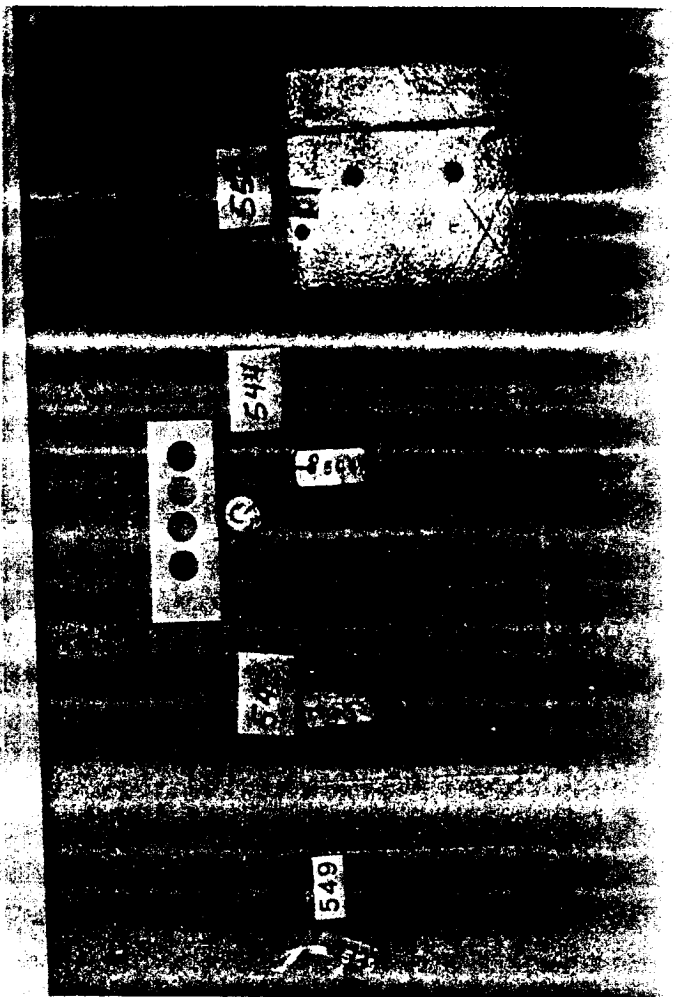
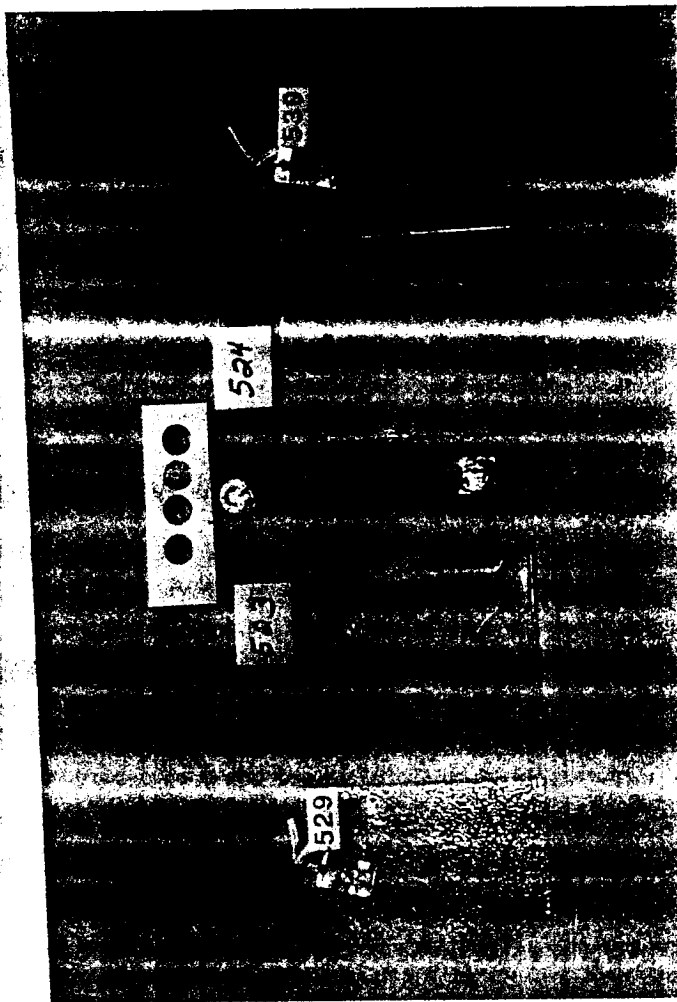


ORIGINAL PAGE IS
OF POOR QUALITY

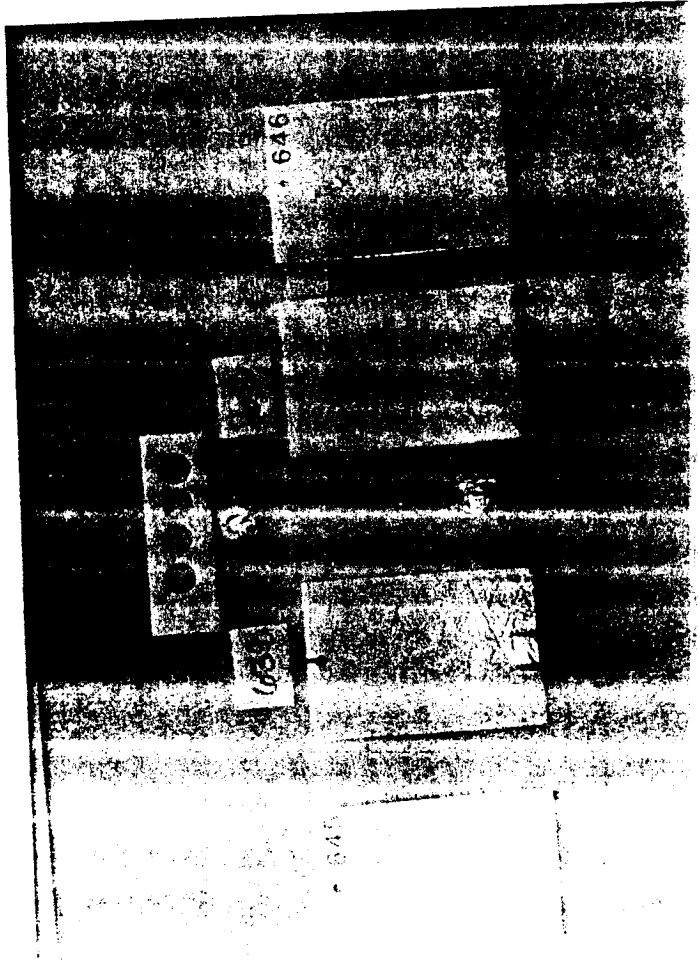
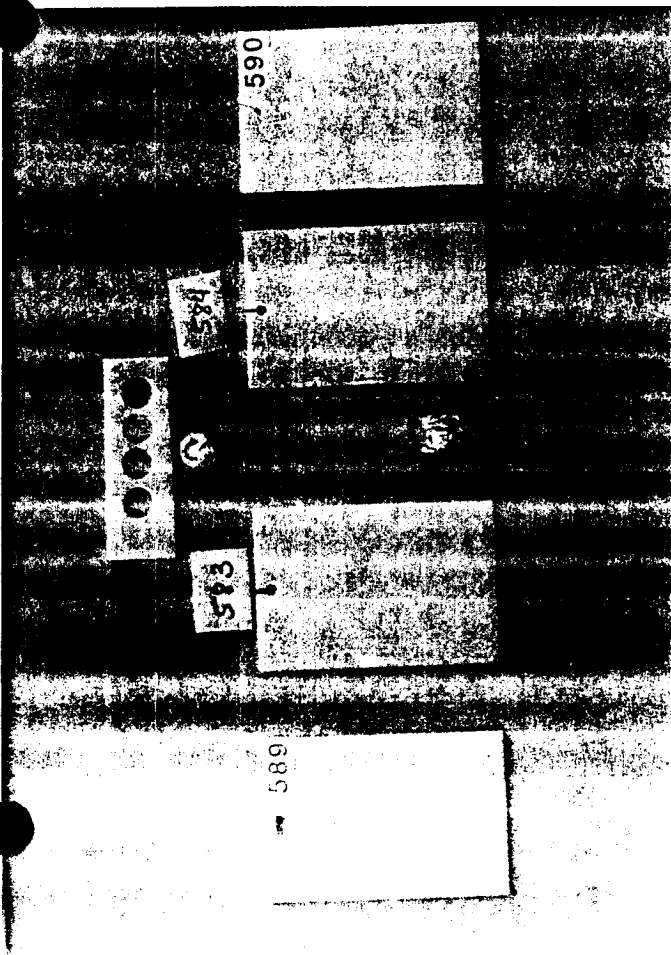
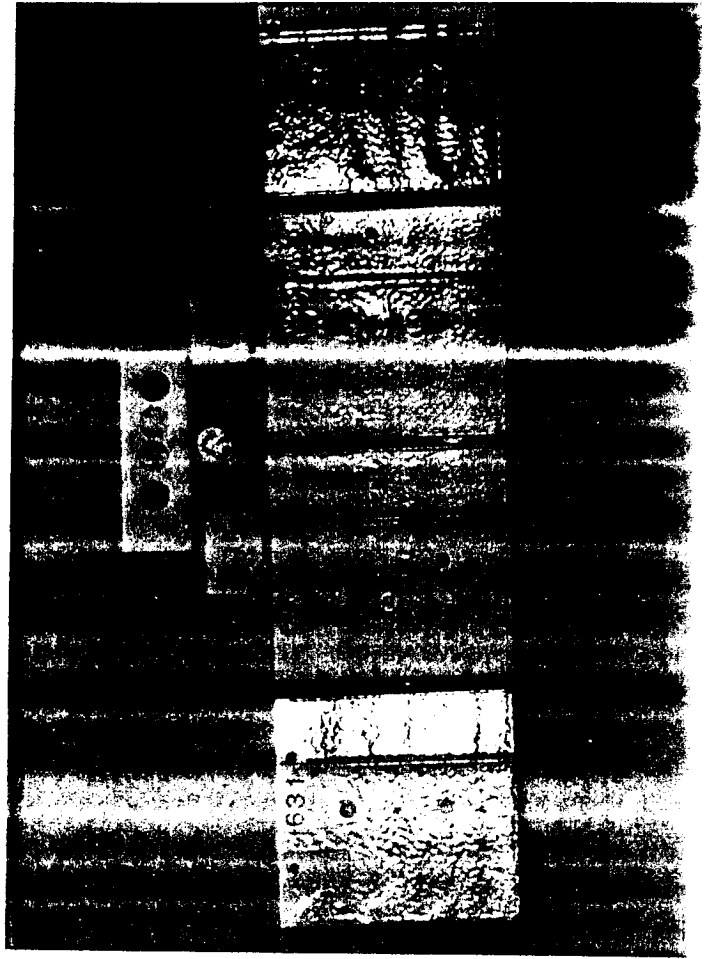
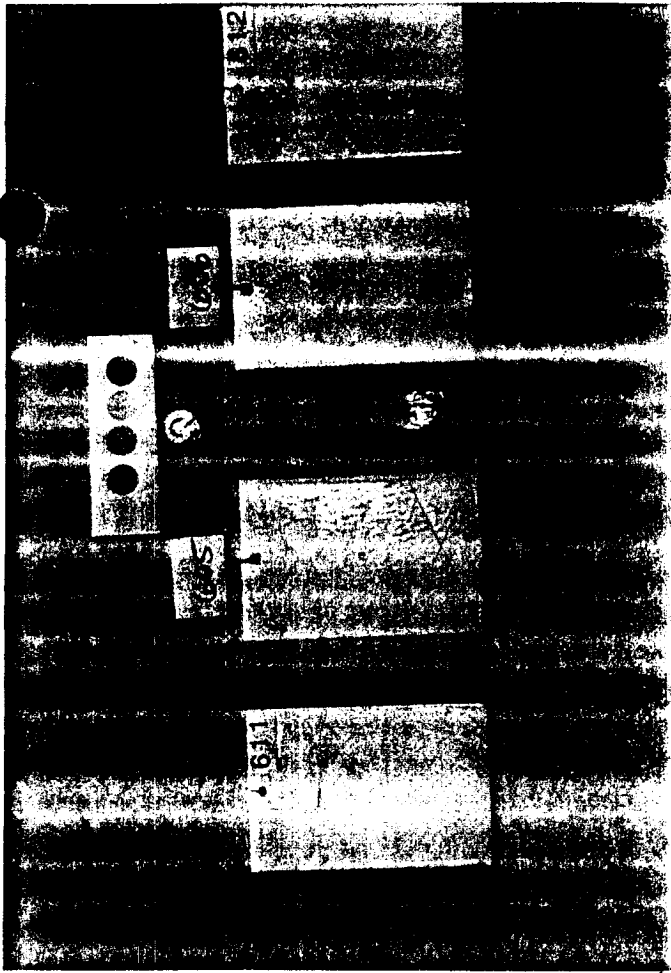


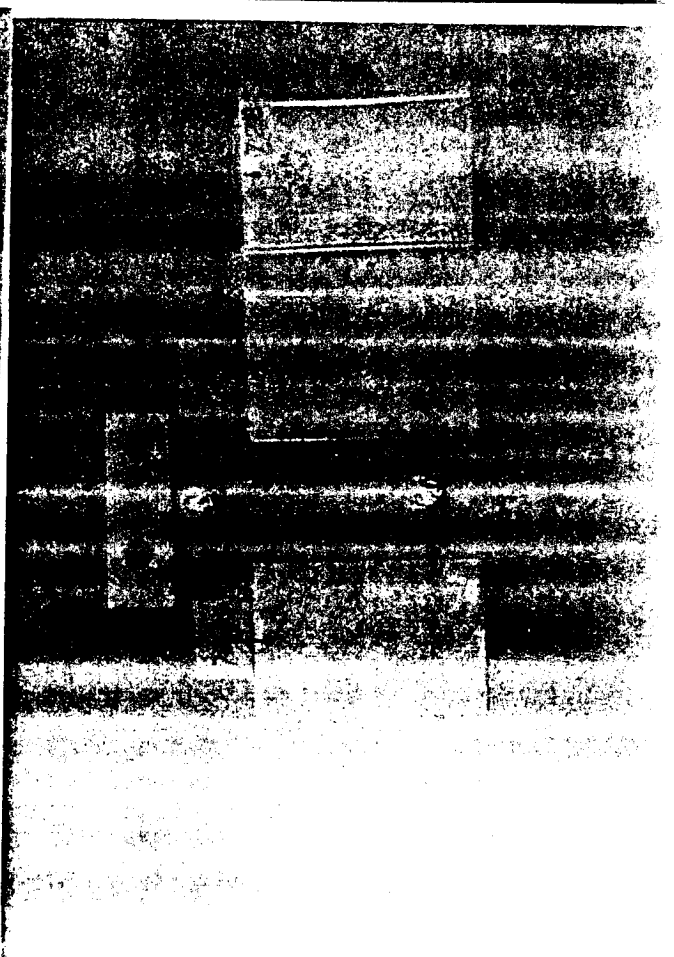
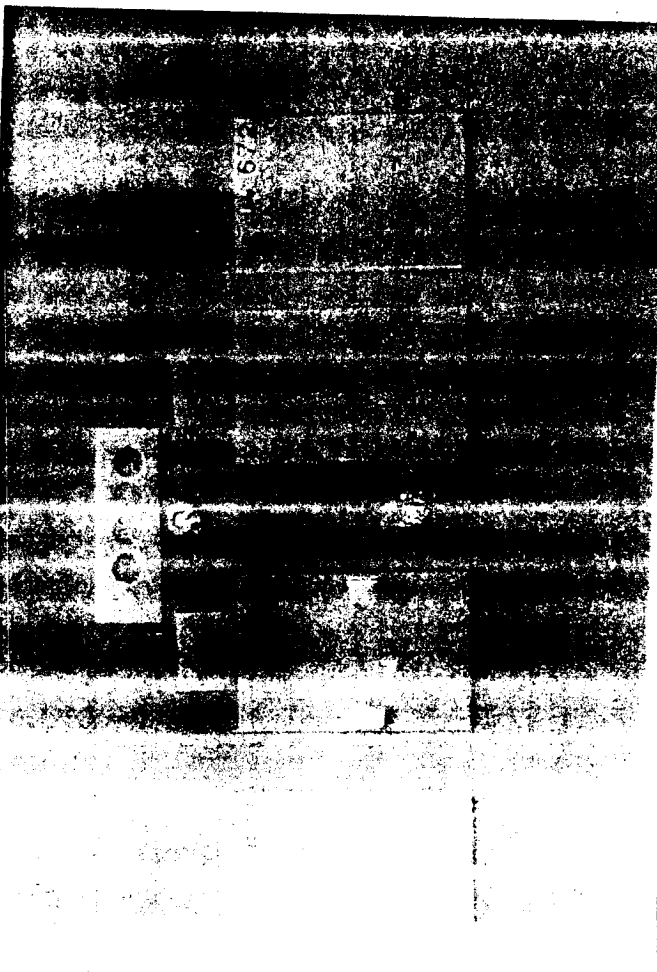
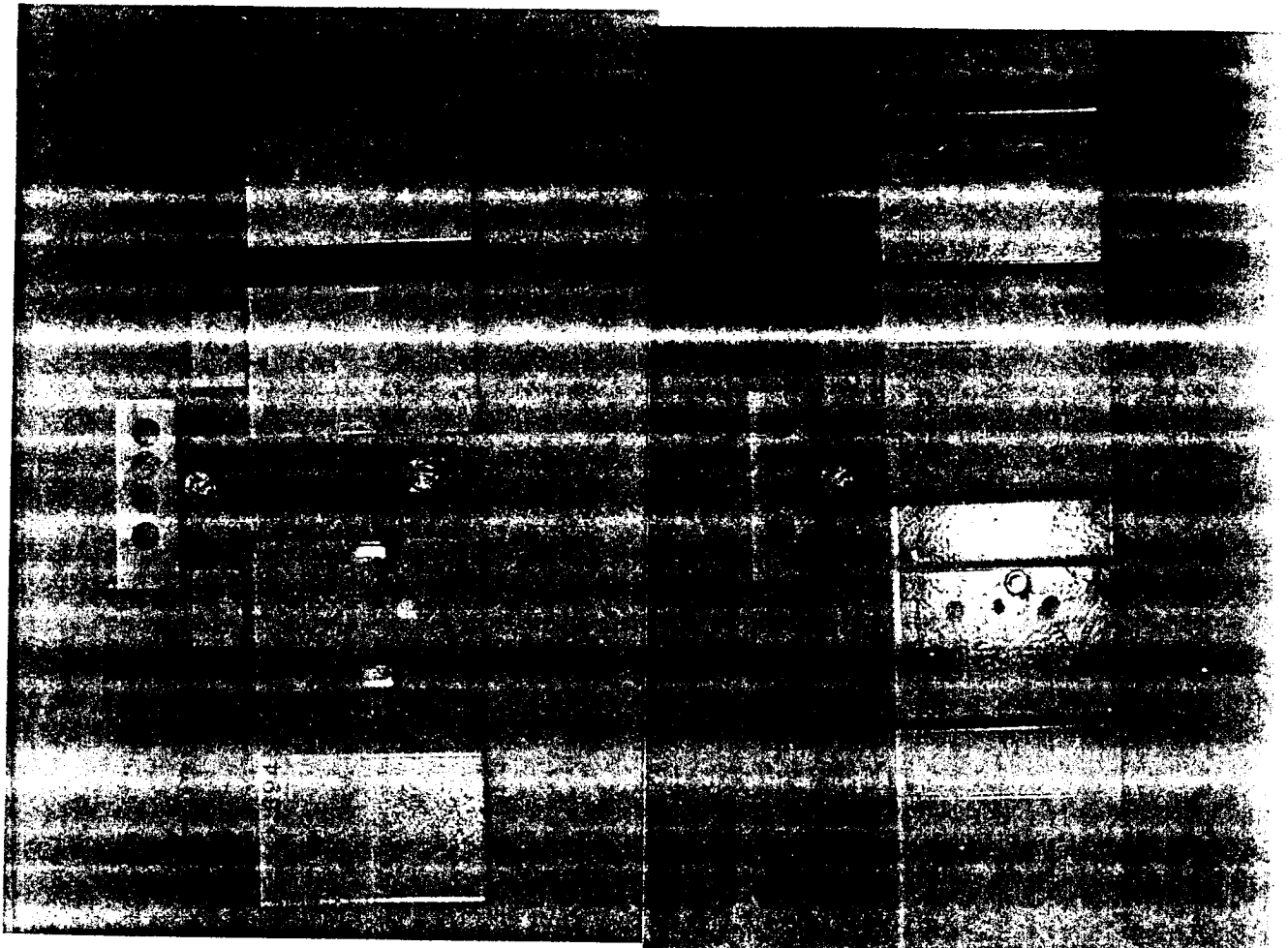


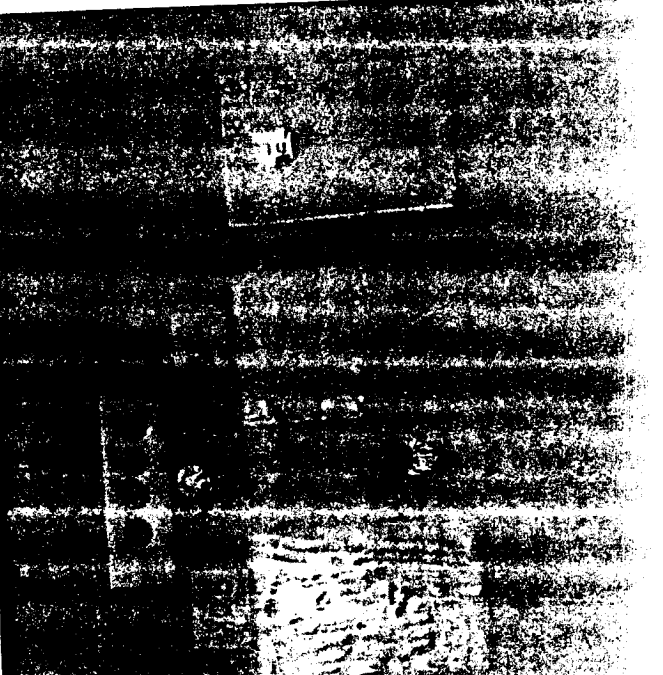
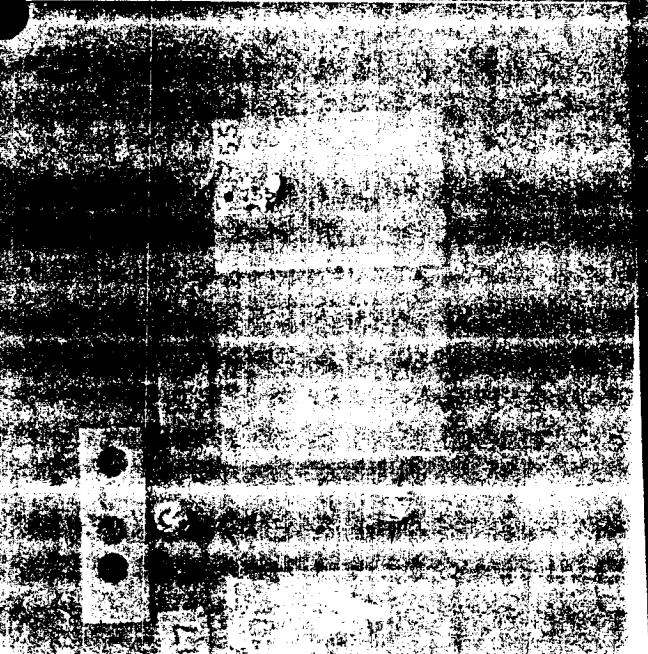
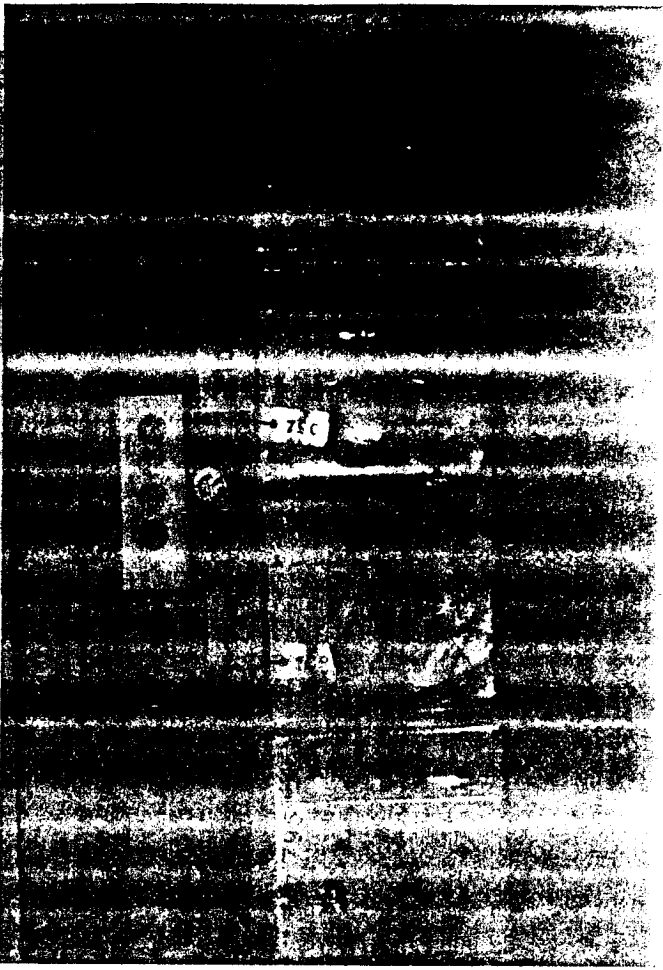
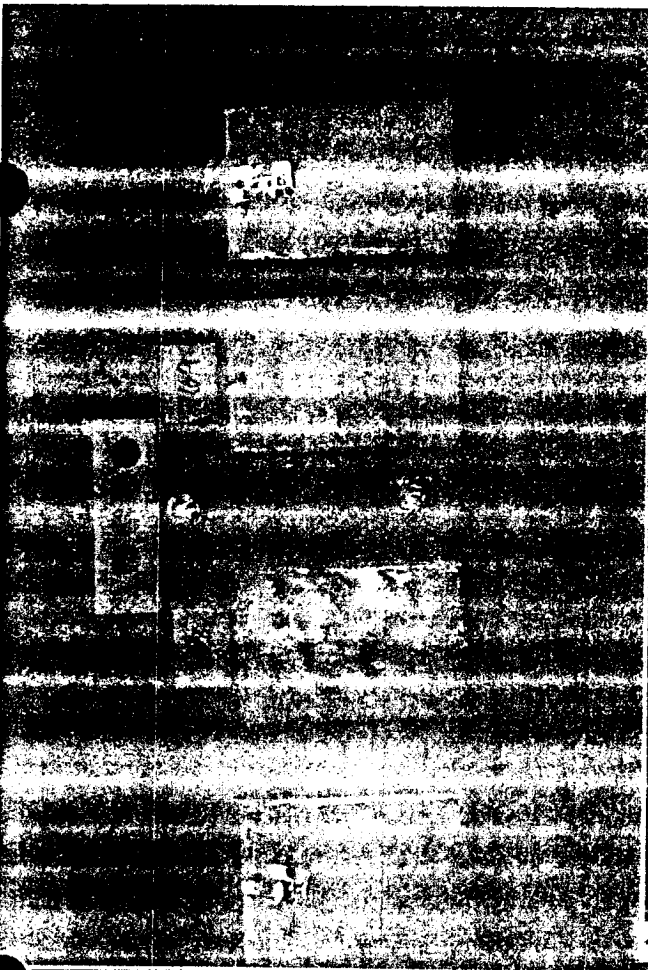




ORIGINAL PAGE IS
OF POOR QUALITY

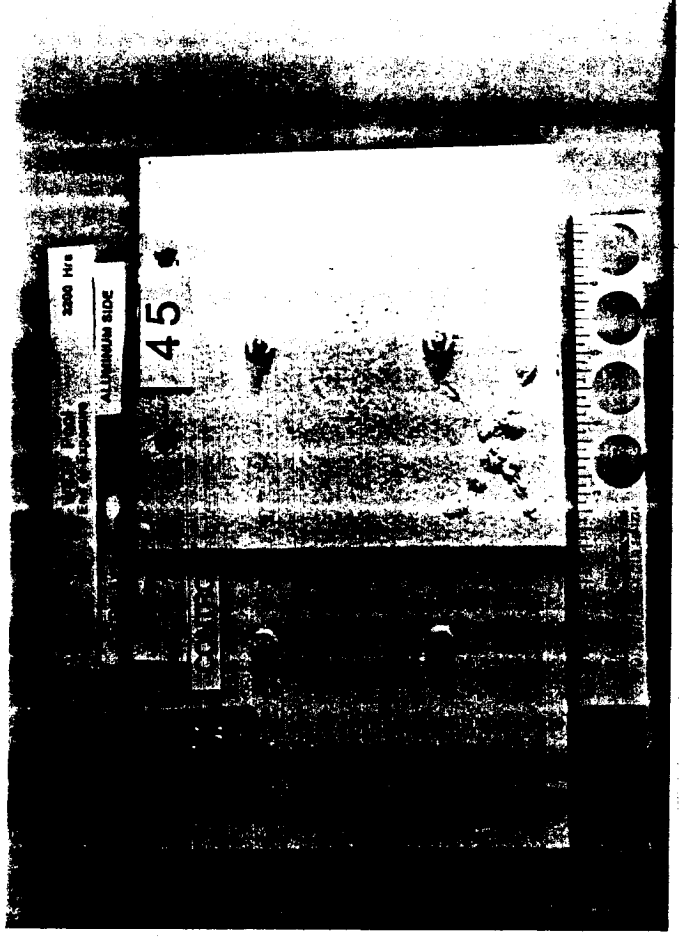
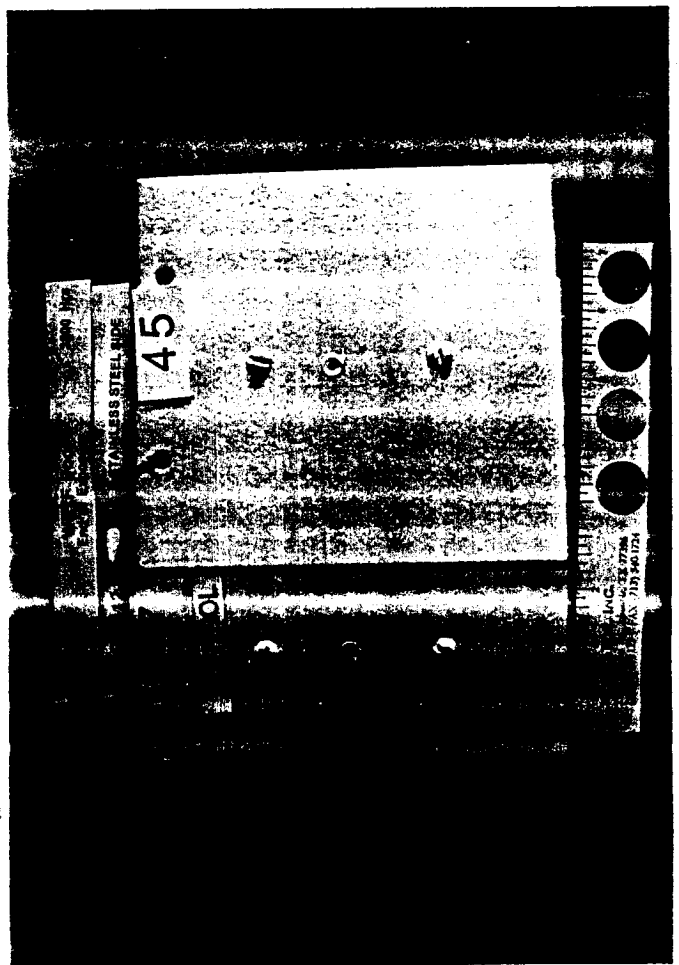
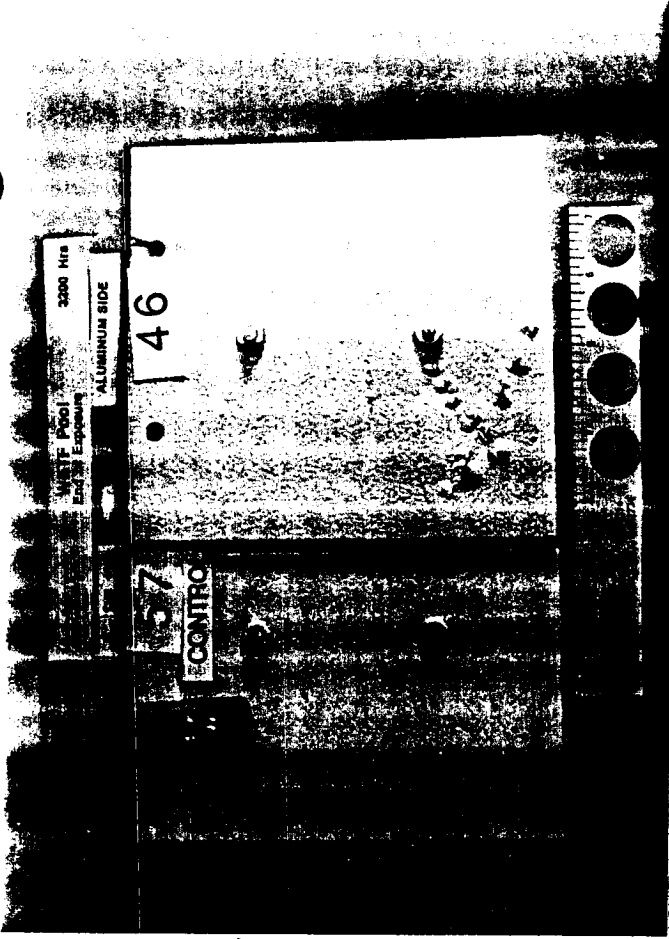
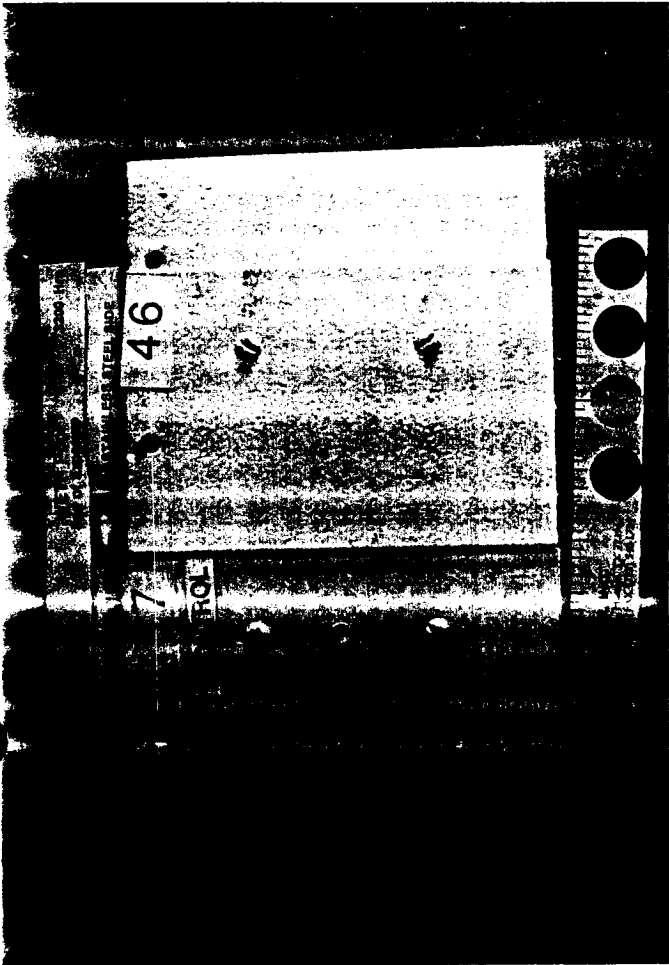






ORIGINAL PAGE IS
OF POOR QUALITY

02



DATE

ИЗДАНИЕ

ИЗДАНИЕ

ИЗДАНИЕ
ИЗДАНИЕ

ИЗДАНИЕ
ИЗДАНИЕ

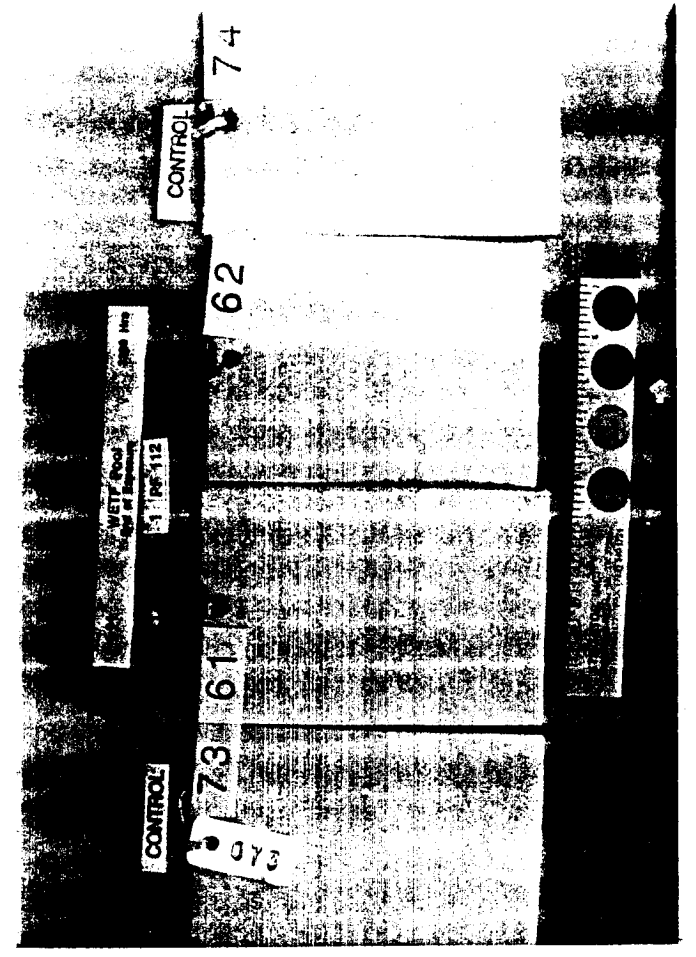
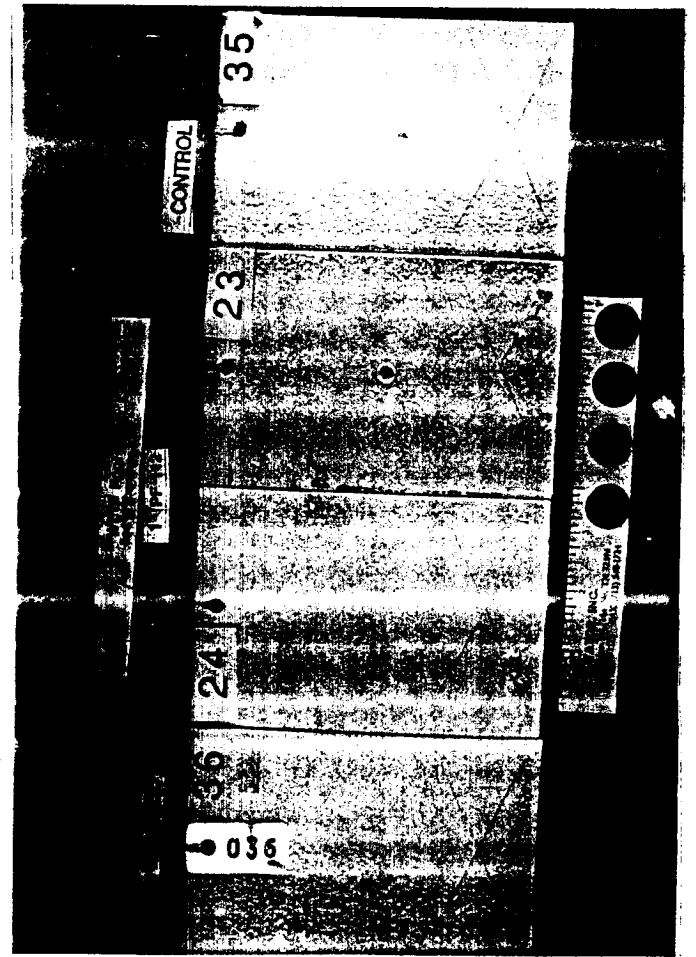
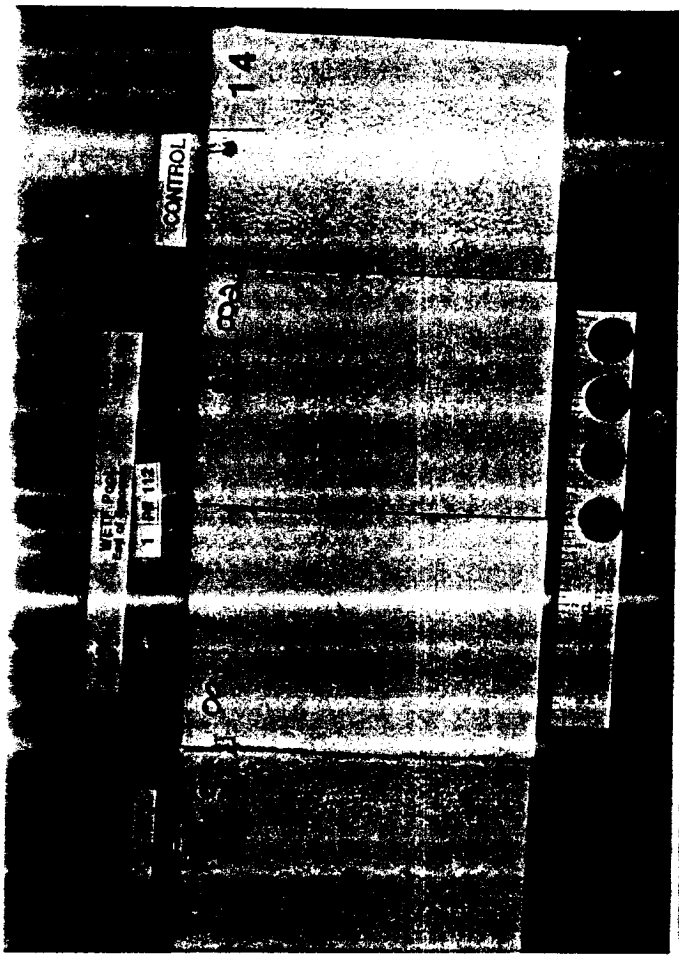
ИЗДАНИЕ

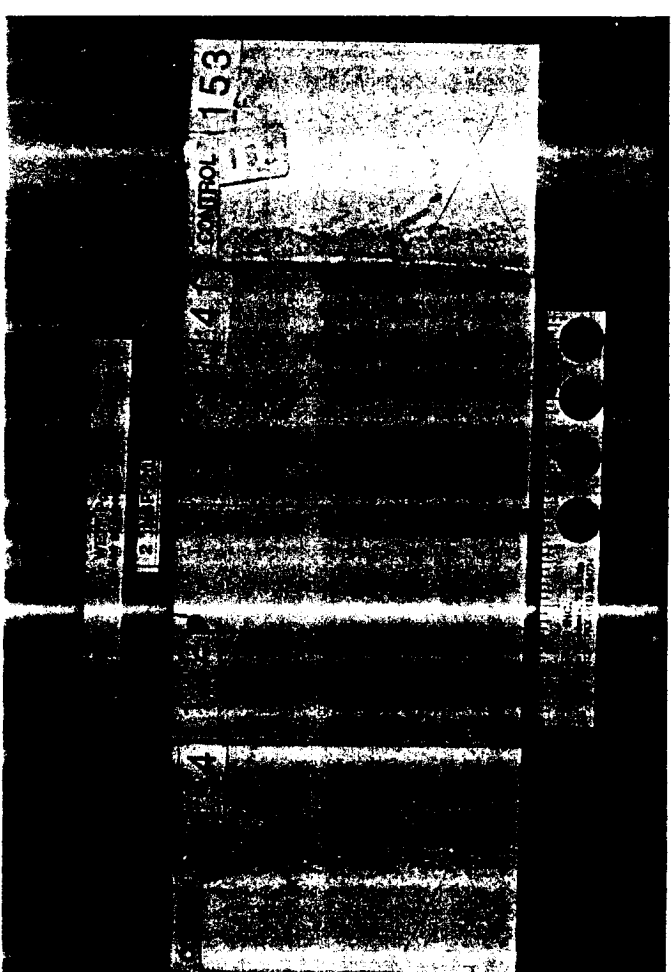
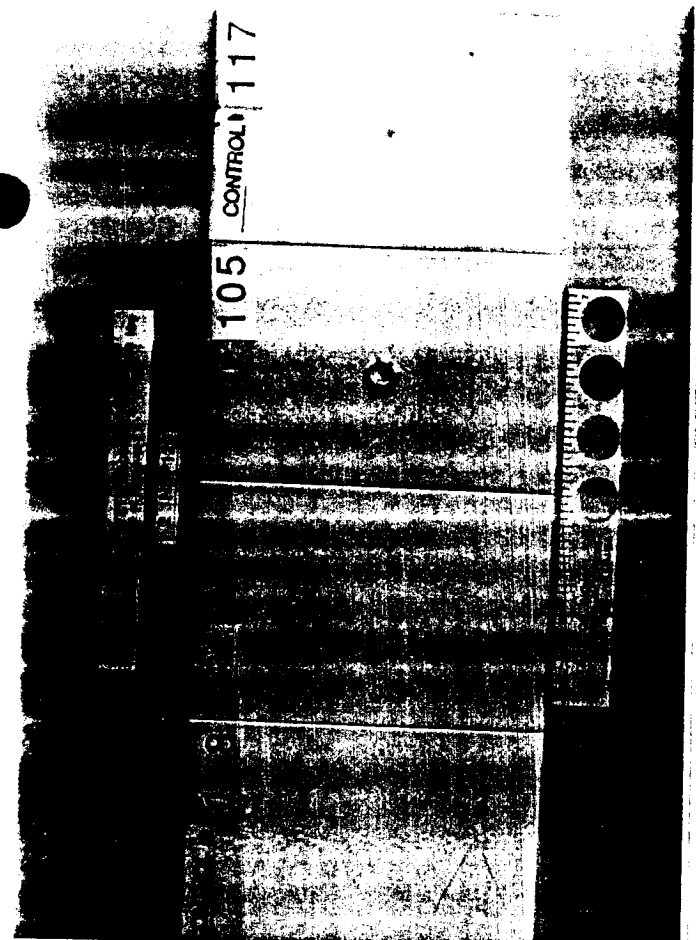
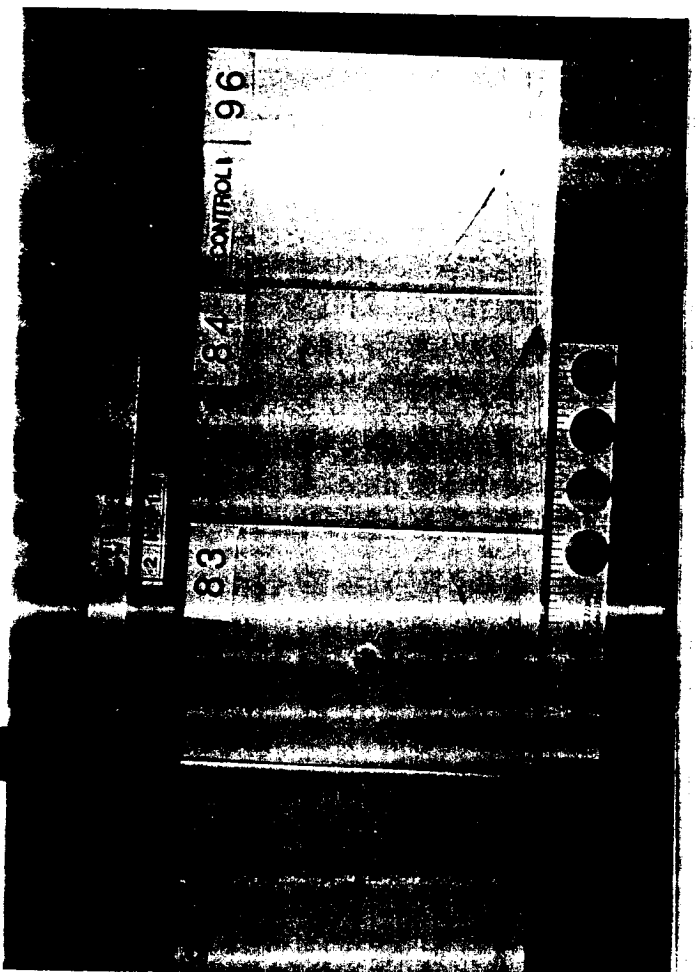
ASSIGNMENT:

DATE:

STYLE NO. 35-8P

FILE NO.:





DVALE

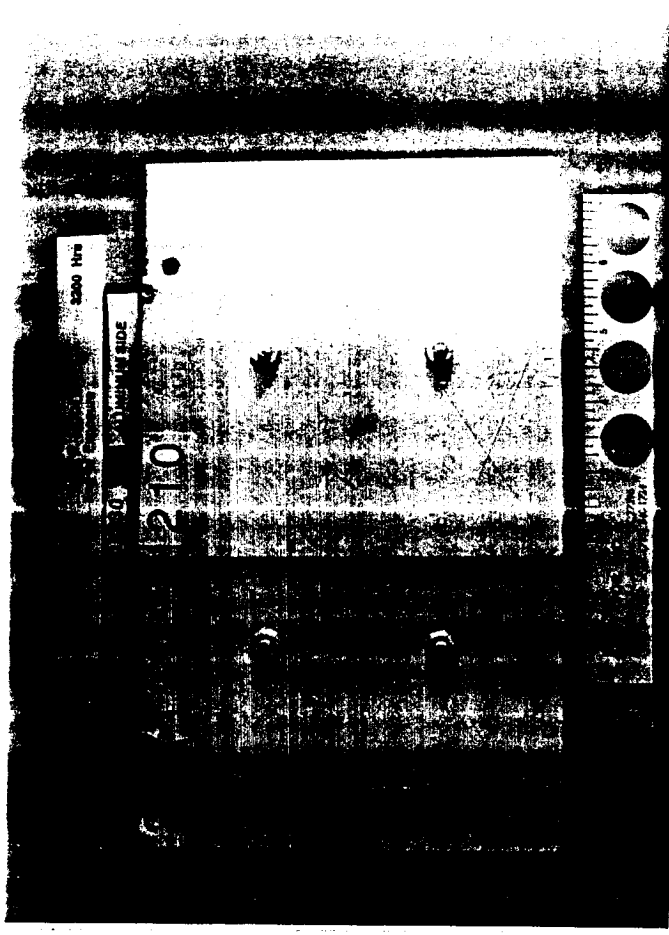
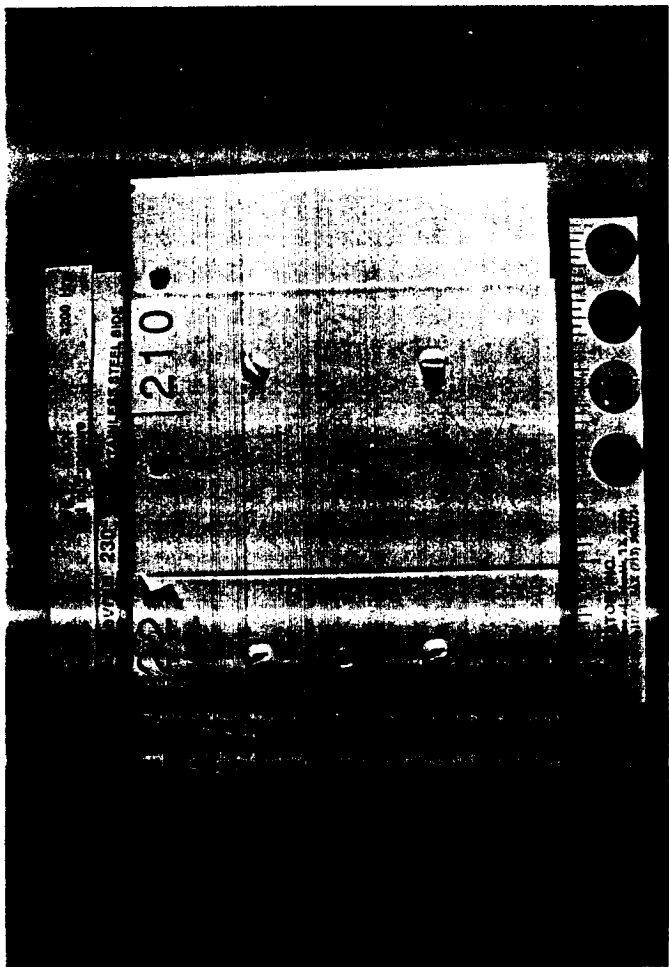
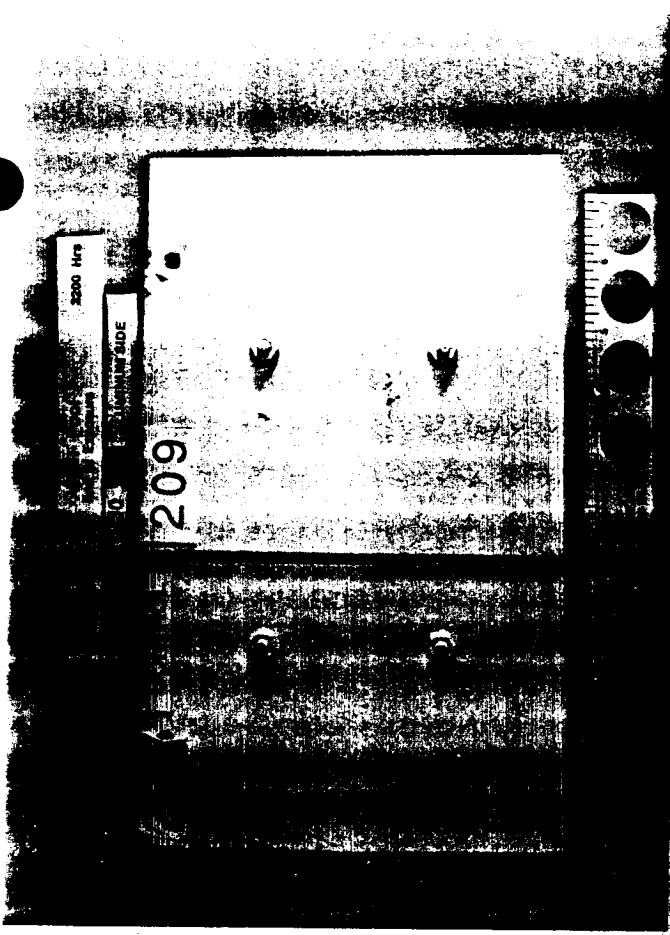
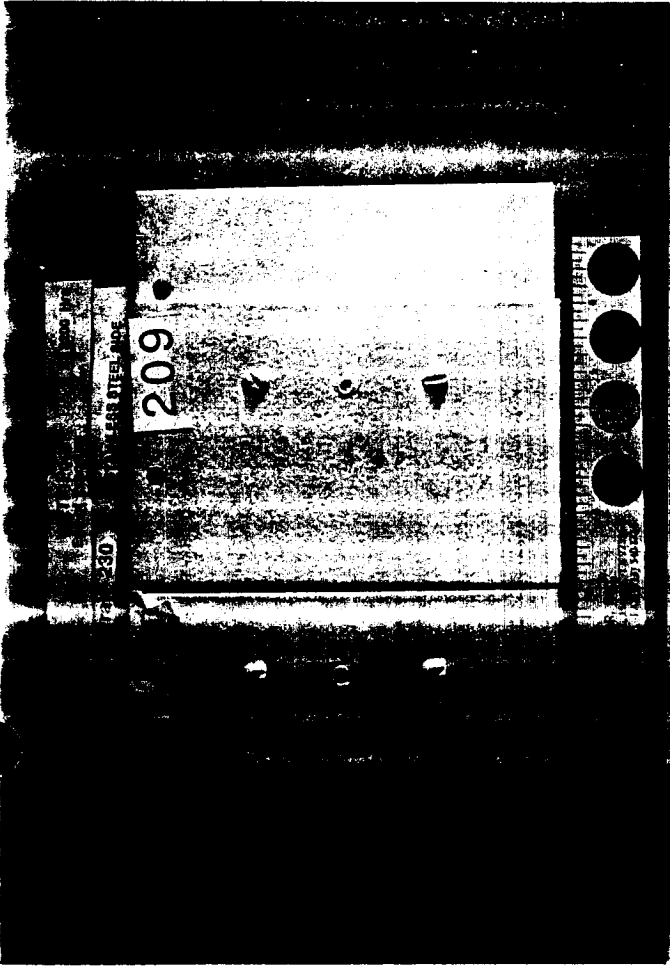
VZGICHIVENI!

УКЧАВ, ДБЛ СЕГАЛЕЗ
ДОНИМ ПЛК

Б'О ВОХ 801838 · ОКЛУИДО ЕГ 33890 · (401) 888-3100

НИТЕ ИО'

ЗЛАТЕ ИО' 32'86



01741

2221010101

ВНИМАНИЕ!
Копия документа

09-2-88 (ТОН) - 08800 - 03800 - (801) 88-2100

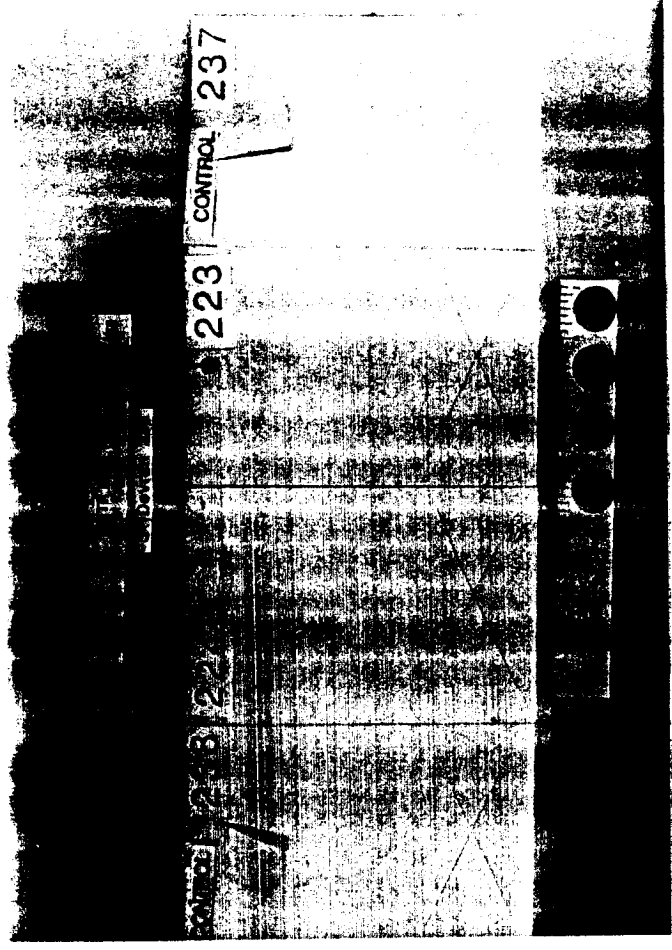
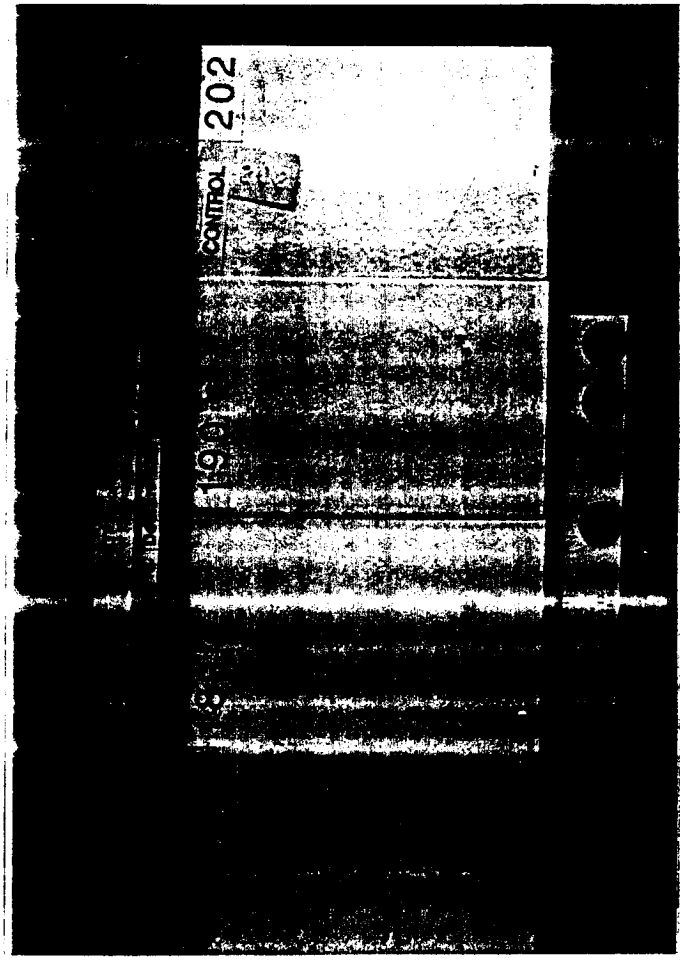
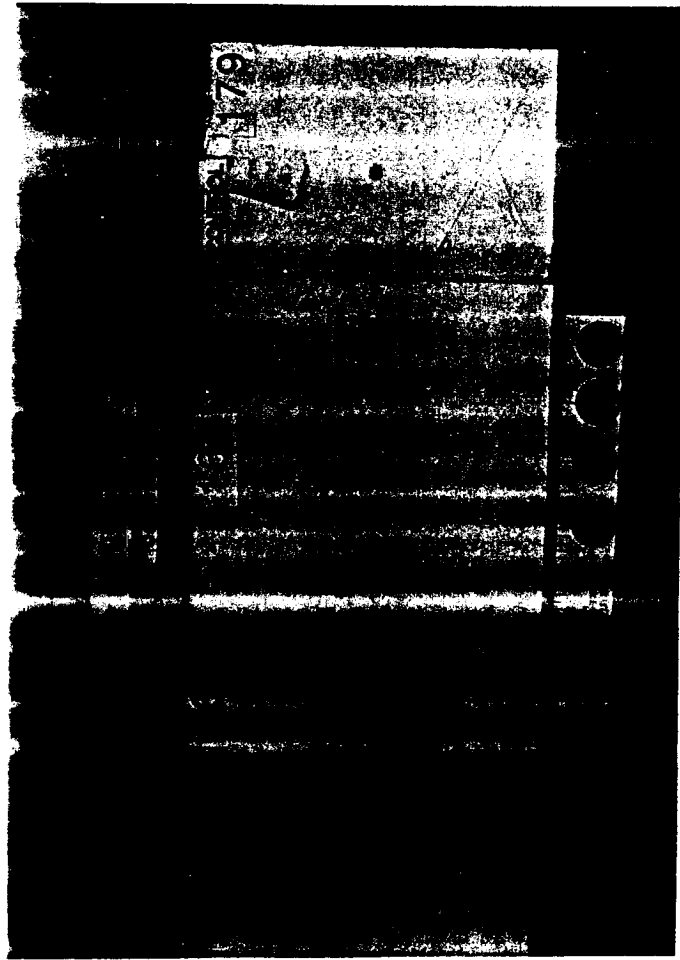
ИТЕ ИО'

21111 ИО' 32-86

ASSIGNMENT:

DATE:

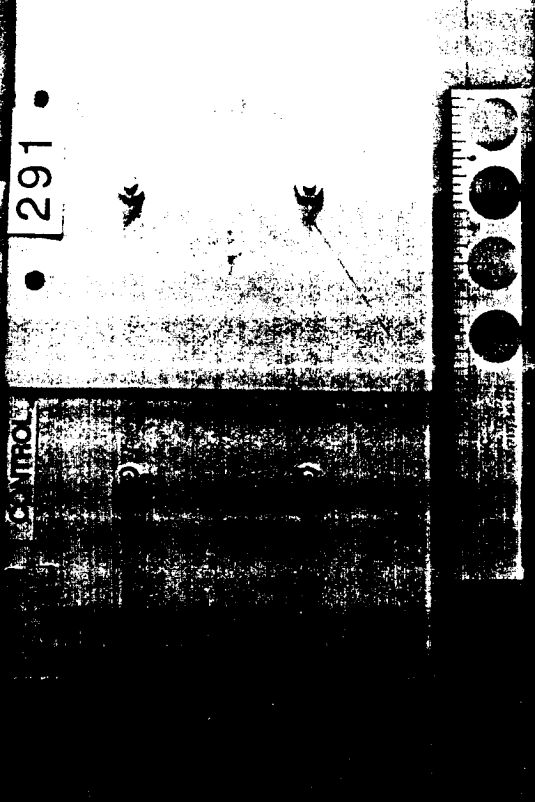
FILE NO.:



FILE NO. 1

WET F POOL
End of Exposure
3200 Hrs
ALUMINUM SIDE

291



WET F POOL
End of Exposure
3200 Hrs
ALUMINUM SIDE

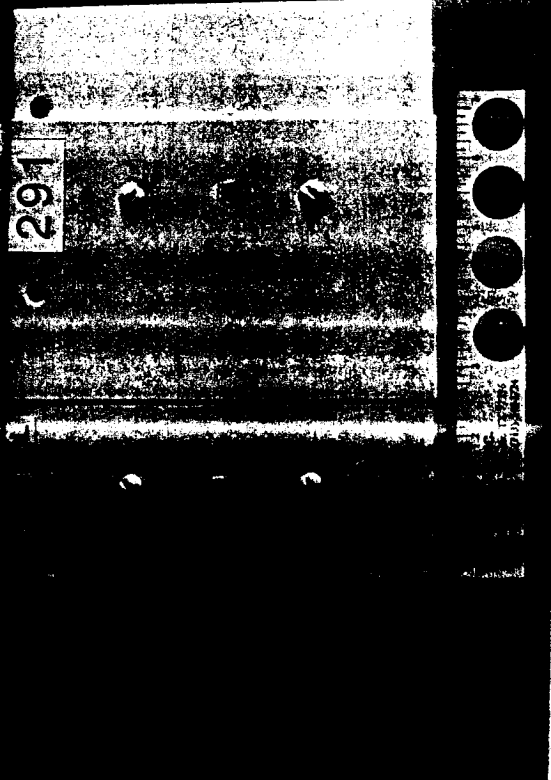
292



ASSIGNMENT:

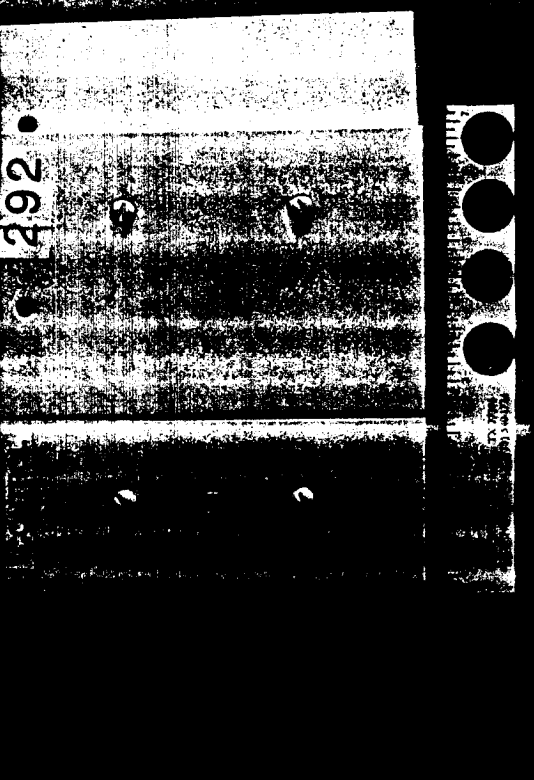
WET F POOL
End of Exposure
3200 Hrs
ALUMINUM SIDE

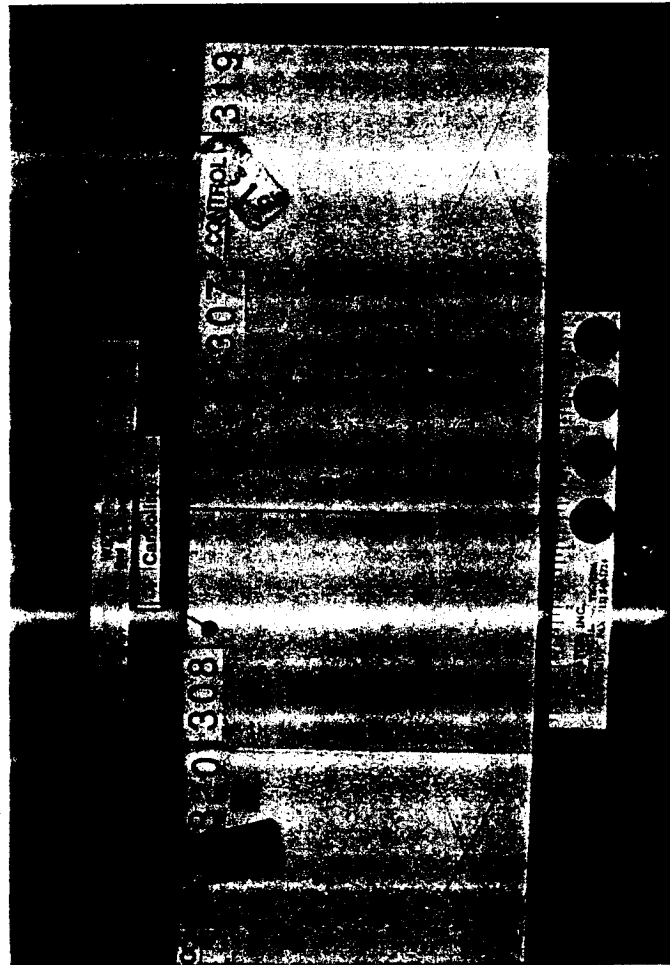
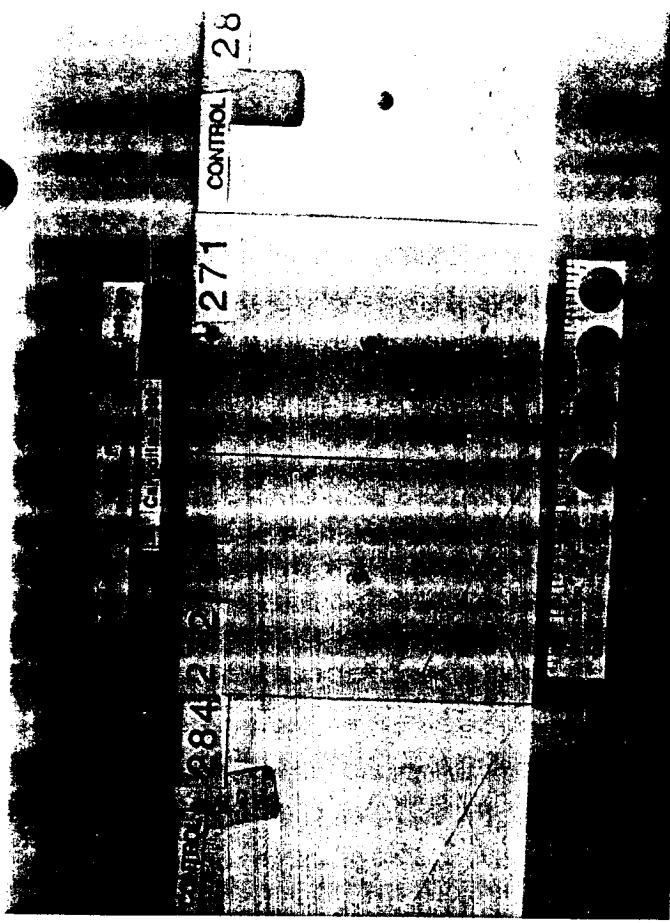
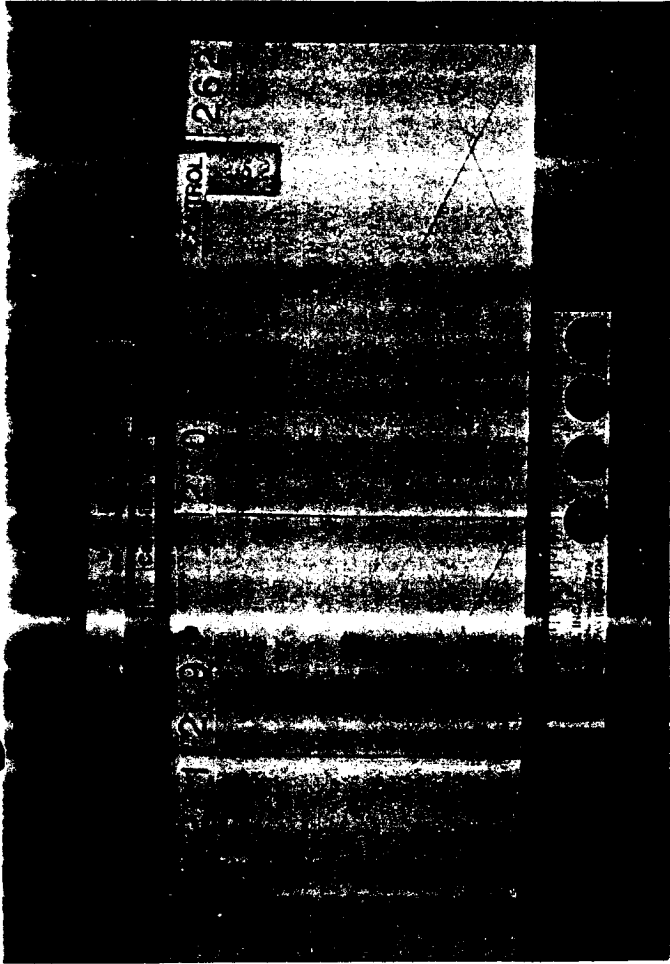
291



WET F POOL
End of Exposure
3200 Hrs
ALUMINUM SIDE

292





DVITE!

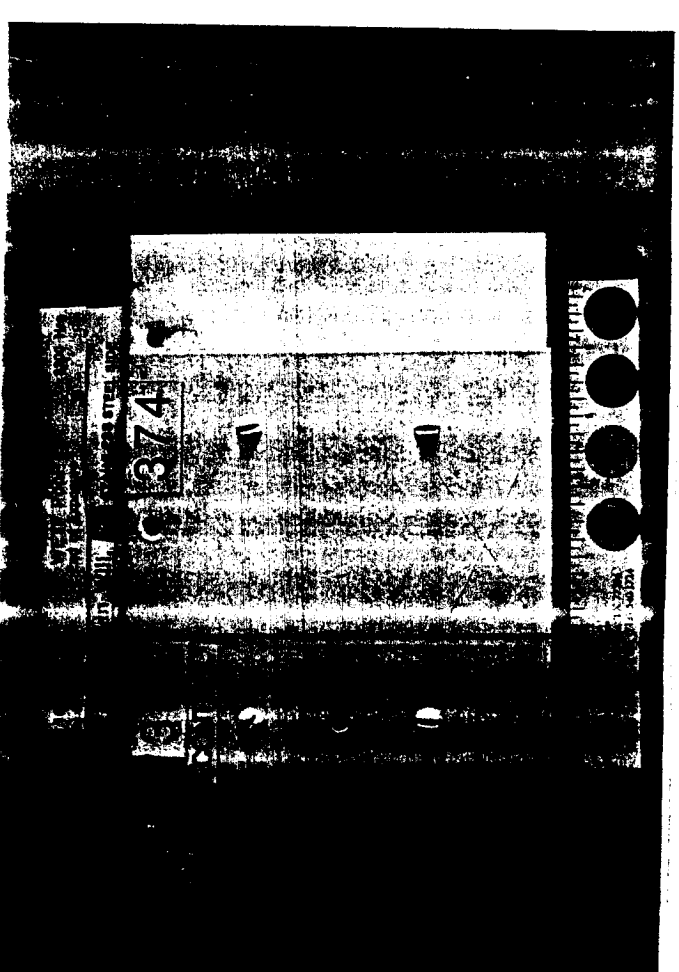
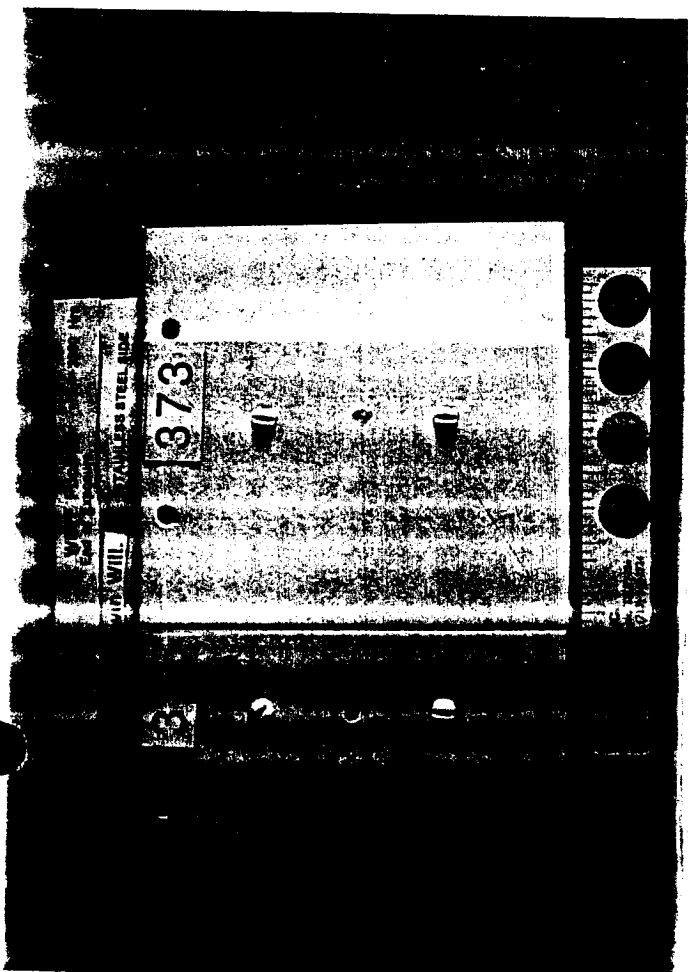
УЗГІСІМІВЕНІ!

УКРАЇНА ІНТЕРБАНК
Interbank

БОНУС ВОХ РОЗРАХУН • ОБСЛУГОВУВАННЯ • (401) 884-3100

МІГЕ МО!

ЗЛАГЕ МО! 32-86



1740 VIII.

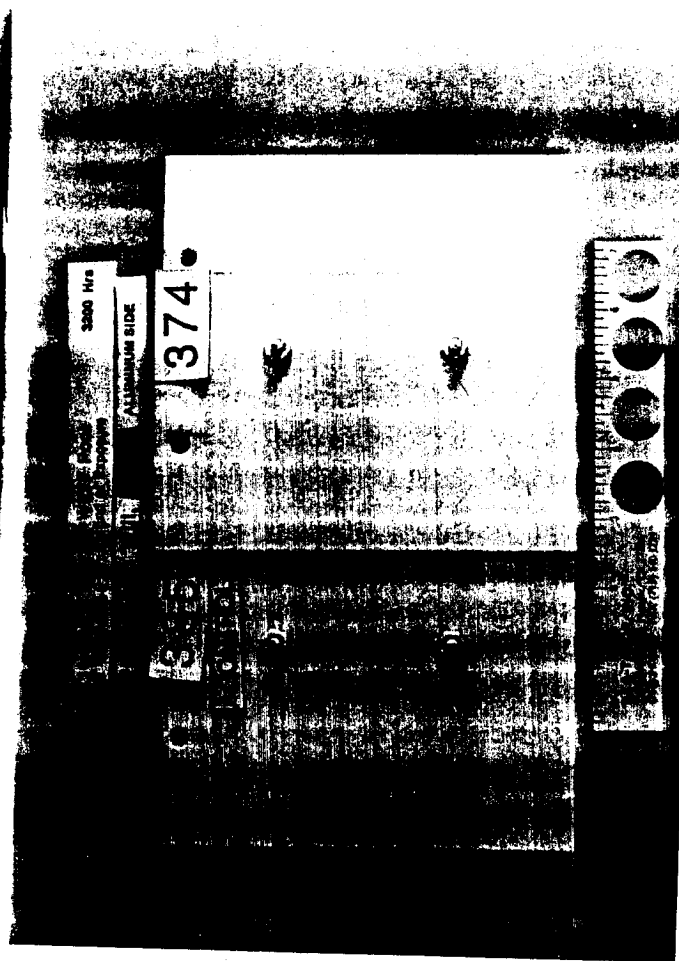
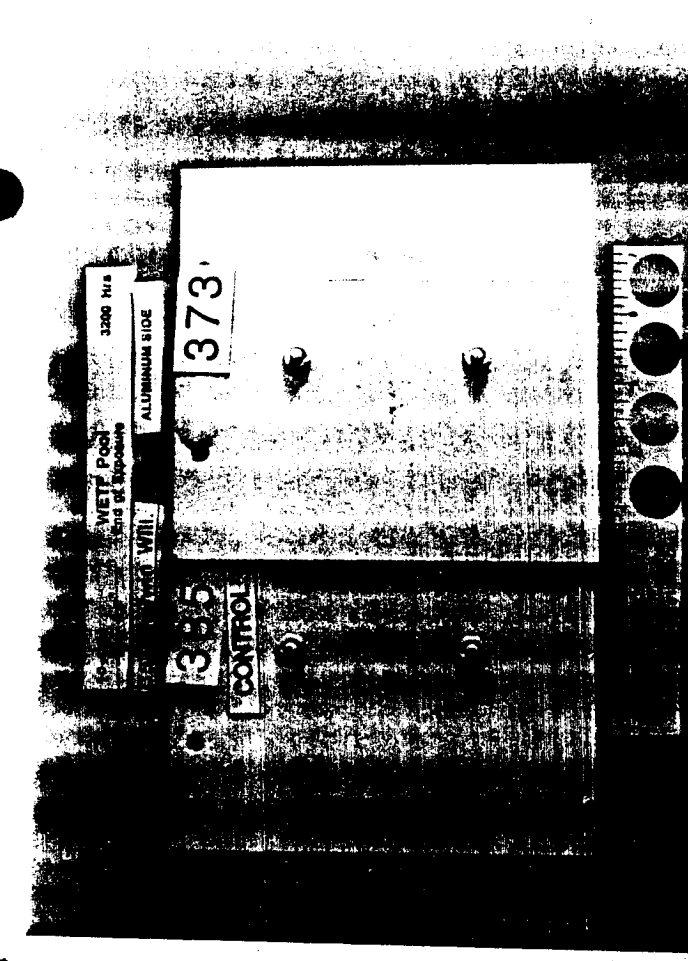
3200 K14

VIET POOL

Side of Exposure

ALUMINUM SIDE

373



1740 VIII.

3200 K14

VIET POOL

Side of Exposure

ALUMINUM SIDE

373

1740 VIII.

3200 K14

VIET POOL

Side of Exposure

ALUMINUM SIDE

373

1740 VIII.

3200 K14

VIET POOL

Side of Exposure

ALUMINUM SIDE

373

1740 VIII.

3200 K14

VIET POOL

Side of Exposure

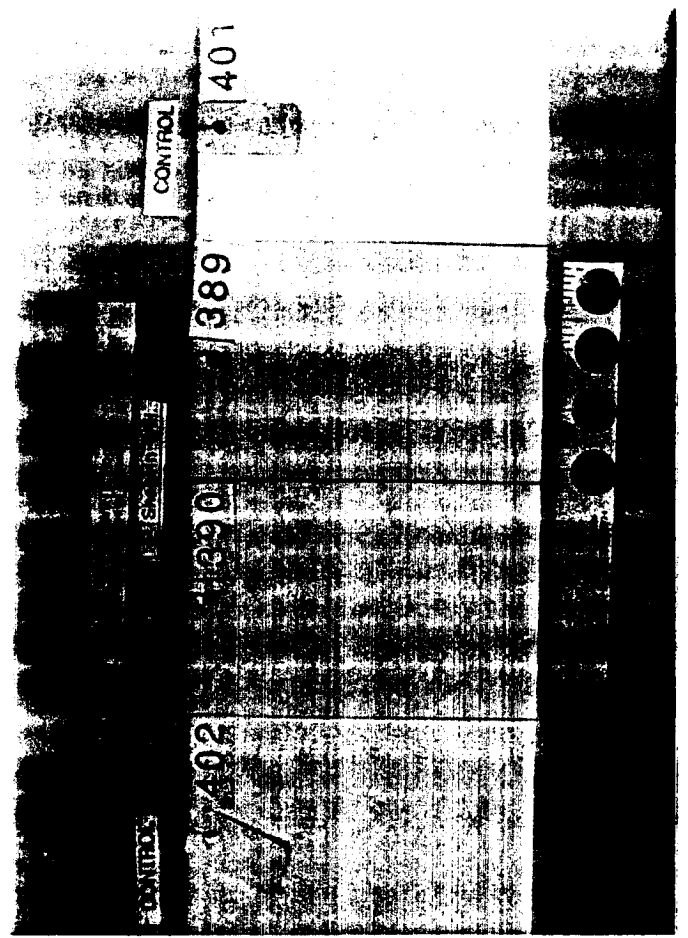
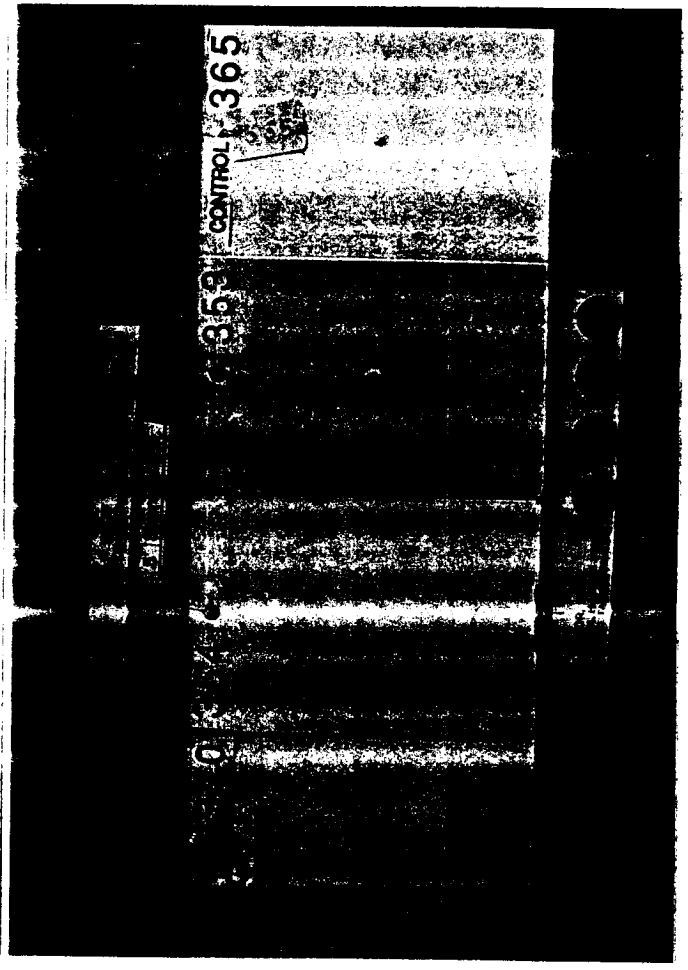
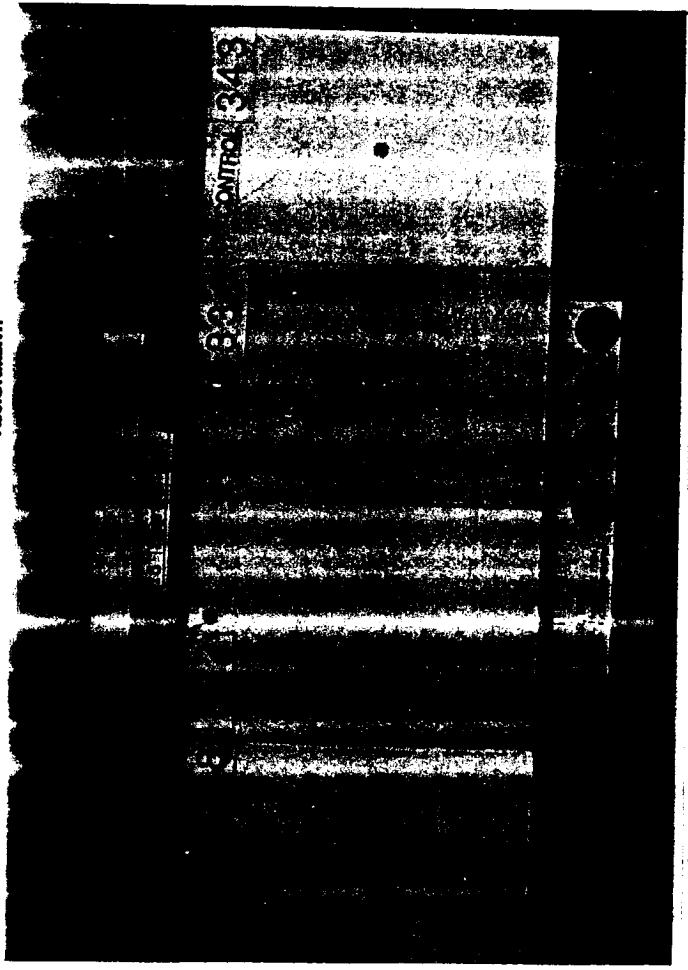
ALUMINUM SIDE

373

DATE:

ASSIGNMENT:

FILE NO.:



DATE:

ASSIGNMENT:

FILE NO.:

10-4-94

WETF Pool
End of Exposure

3200 Hrs

UT Plast

STAINLESS STEEL SIDE

467
CONTROL

455

10-4-94

WETF Pool
End of Exposure

3200 Hrs

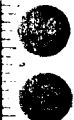
UT Plast

ALUMINUM SIDE

467
CONTROL

455

KTA-TATOR, INC.



ORIGINAL PAGE IS
POOR QUALITY

10-4-94

WETF Pool
End of Exposure

3200 Hrs

UT Plast

STAINLESS STEEL SIDE

467
CONTROL

456

10-4-94

WETF Pool
End of Exposure

3200 Hrs

UT Plast

ALUMINUM SIDE

467
CONTROL

456

KTA-TATOR, INC.



KTA-TATOR, INC.



10-4-94

WETFF Pool
End of Exposure

3200 Hrs

CONTROL

425 413

414

426

CONTROL

10-4-94

WETFF Pool
End of Exposure

4200 Hrs

CONTROL

447

435

436

6 UT Plast, Extra

CONTROL

STATATON, INC

10-4-94

WETFF Pool
End of Exposure

3200 Hrs

CONTROL

483 471

472

484

CONTROL

6 UT Plast, Extra

STATATON, INC

DATE:

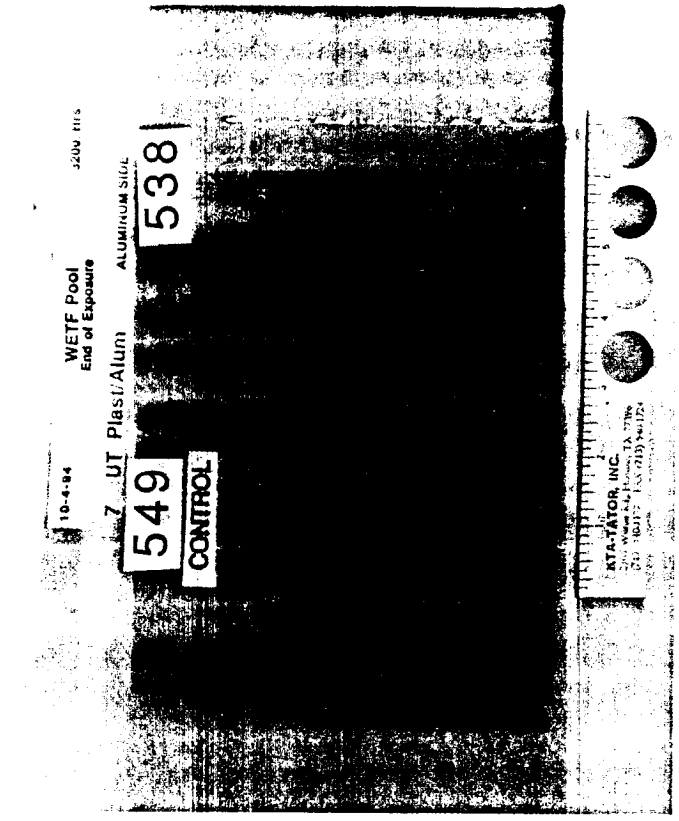
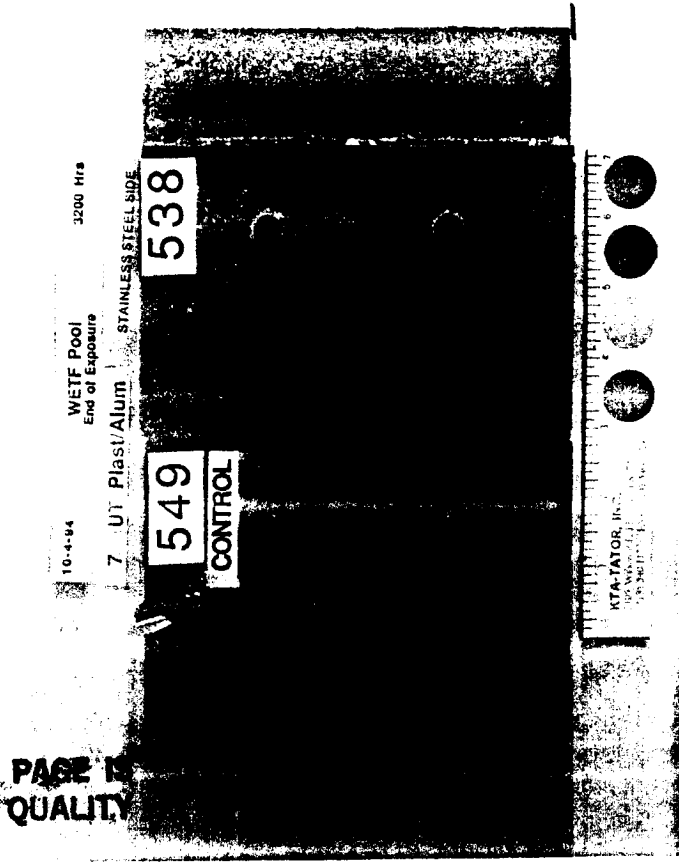
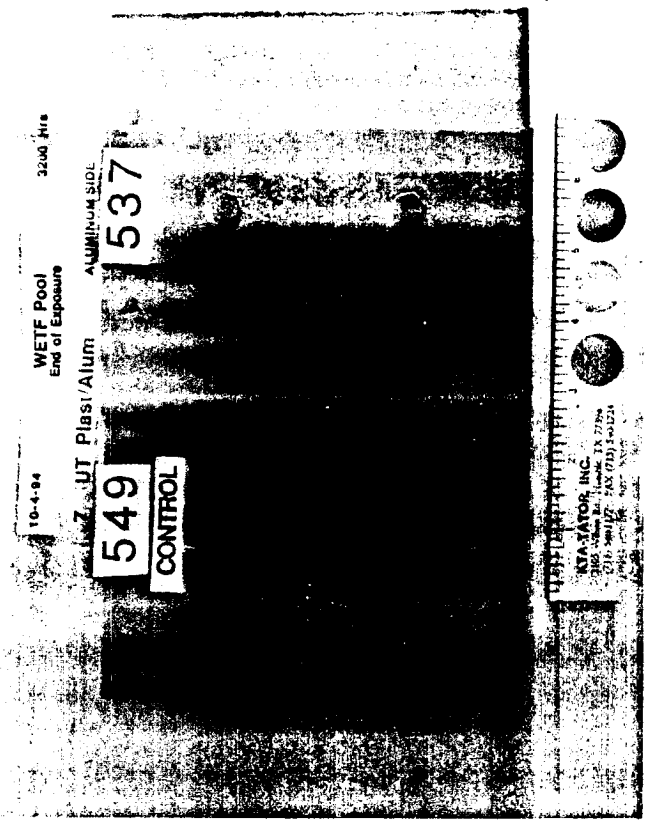
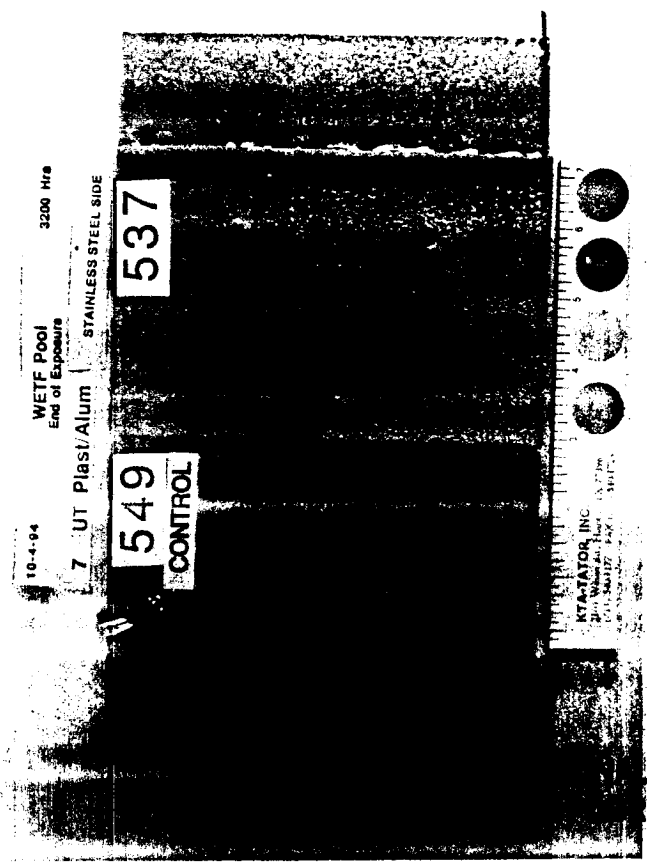
УЗГІСІНЕНЦІ

ВІСІЛАНТ ПЕРСОНАЖ
Dynamat Batts

Б'О ВОХ РОЛІВУВ • ОБГЛУНДО' ЇР 33860 • (901) 888-3100

DATE NO:

ЗЛАГЕ НО: 32-86



PAGE 15
QUALITY

DATE:

ARRANGEMENT:

REF NO:

ATA-TATOR, INC.
200 West 4th Street
Houston, TX 77002
(713) 544-1724

601 BOX 901838 • ORLANDO, FL 32880 • (407) 898-2100

PLATE NO. 32-86

DATE: _____

FILE NO: _____

10-4-84

WETF Pool
End of Exposure

3200 Hrs

7 UT Plast/Alum

CONTROL

508

496

495

507

507

STATATOR, INC.

10-4-84

WETF Pool
End of Exposure

3200 Hrs

7 UT Plast/Alum

CONTROL

529

517

518

530

CONTROL

STATATOR, INC.

10-4-84

WETF Pool
End of Exposure

3200 Hrs

7 UT Plast/Alum

CONTROL

566

554

553

565

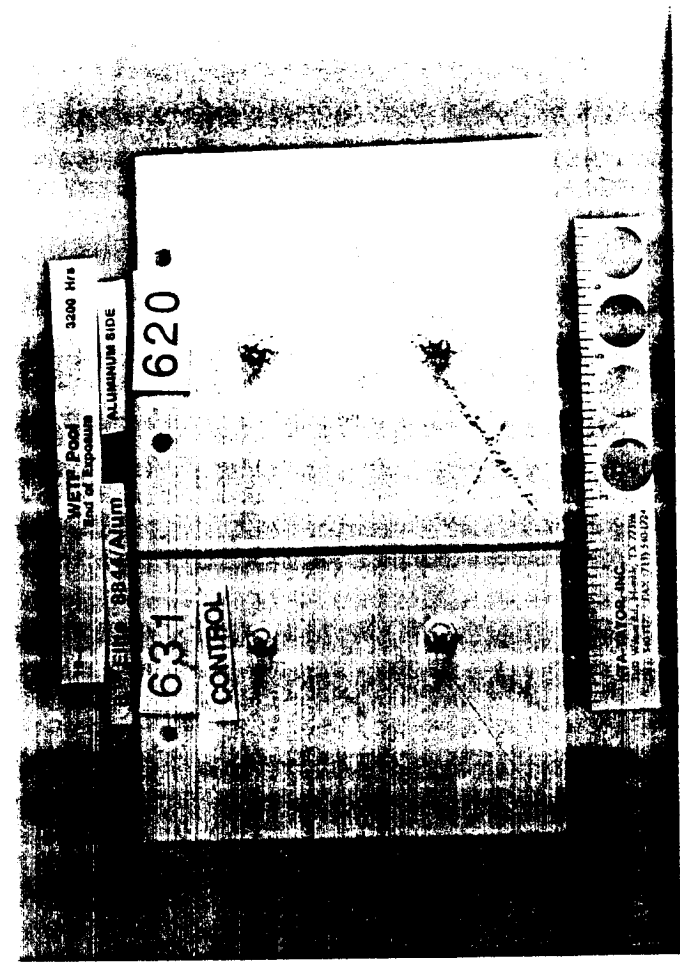
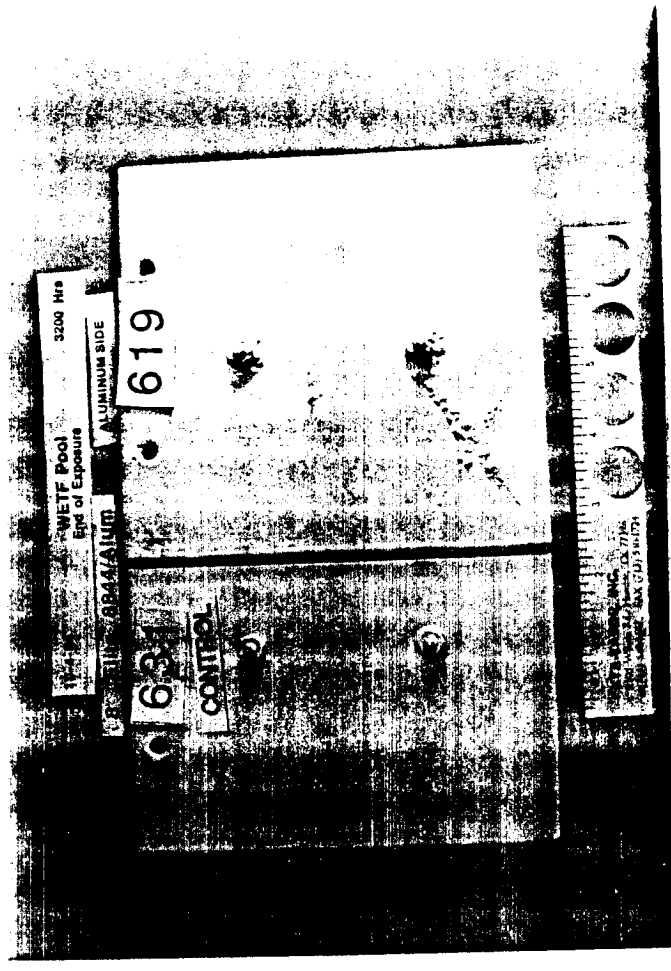
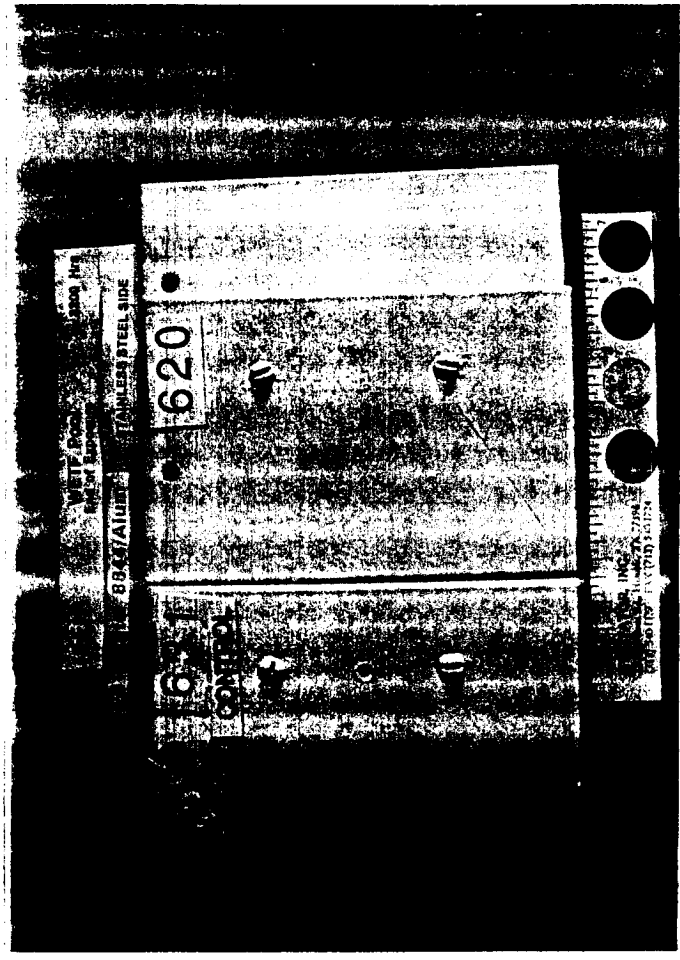
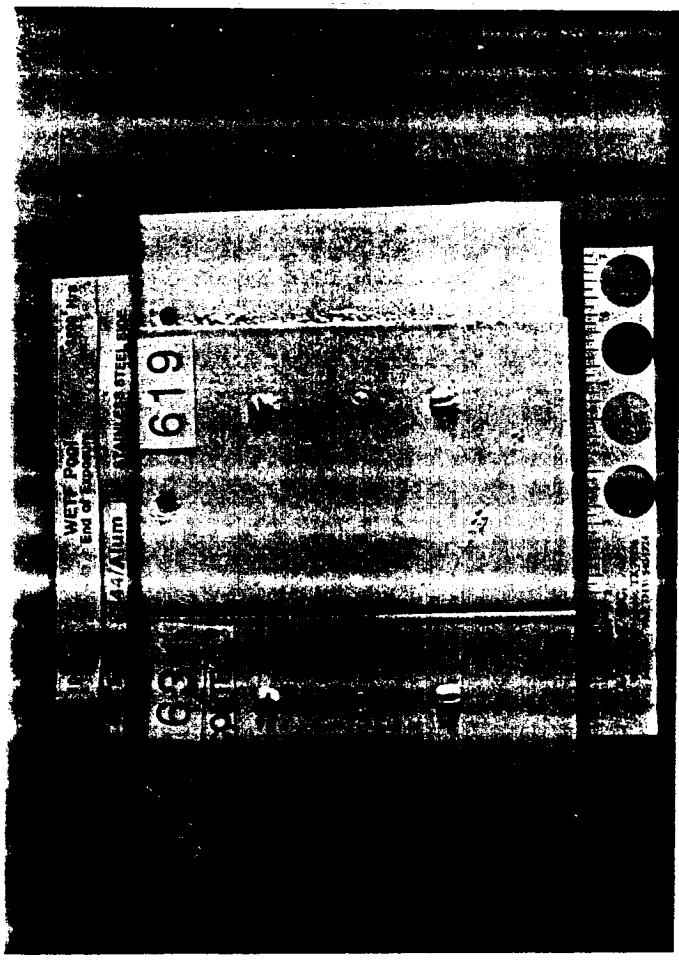
STATATOR, INC.

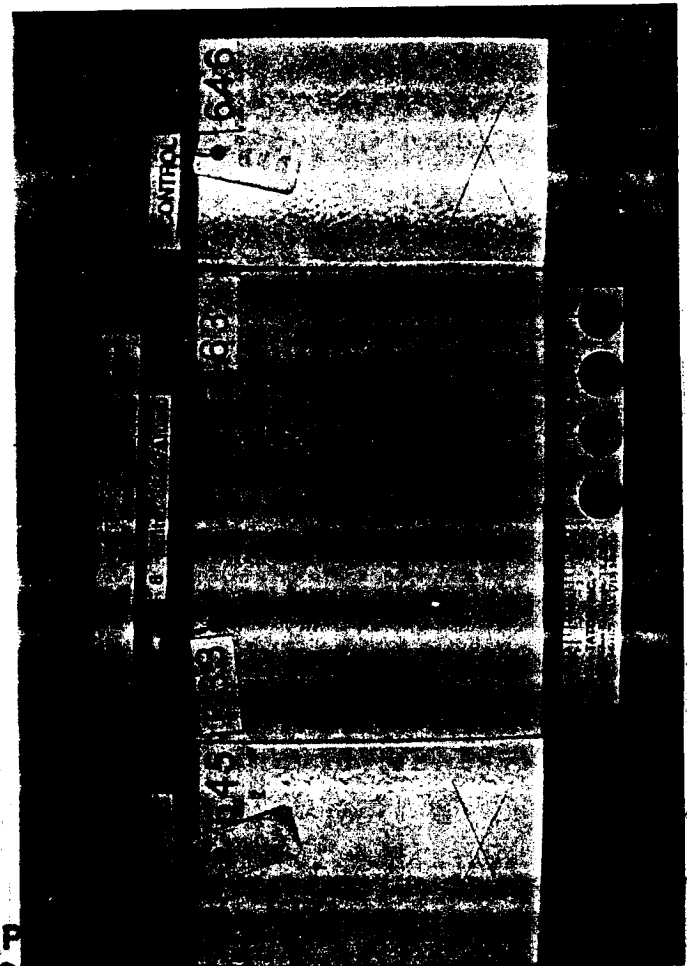
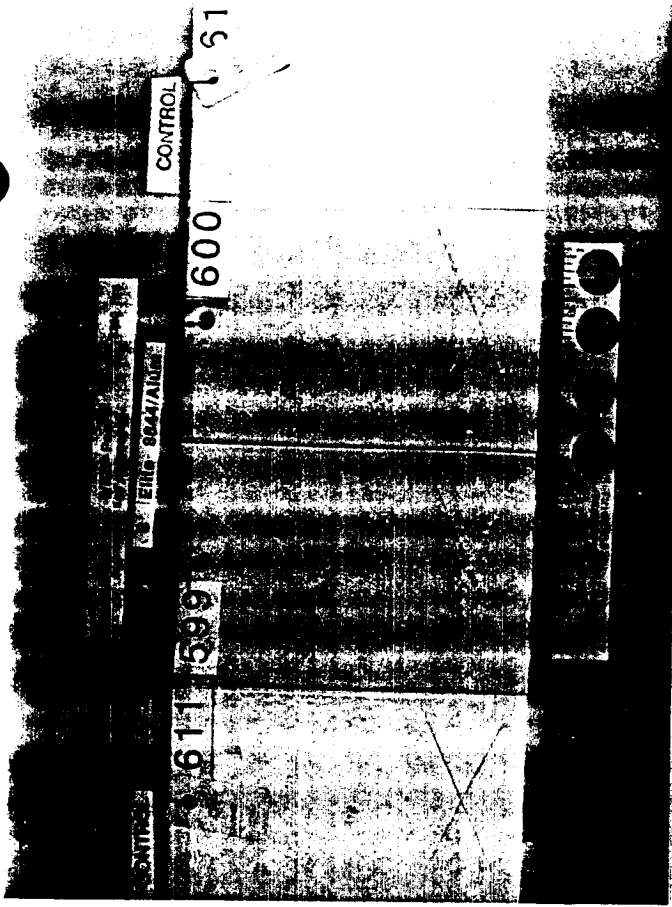
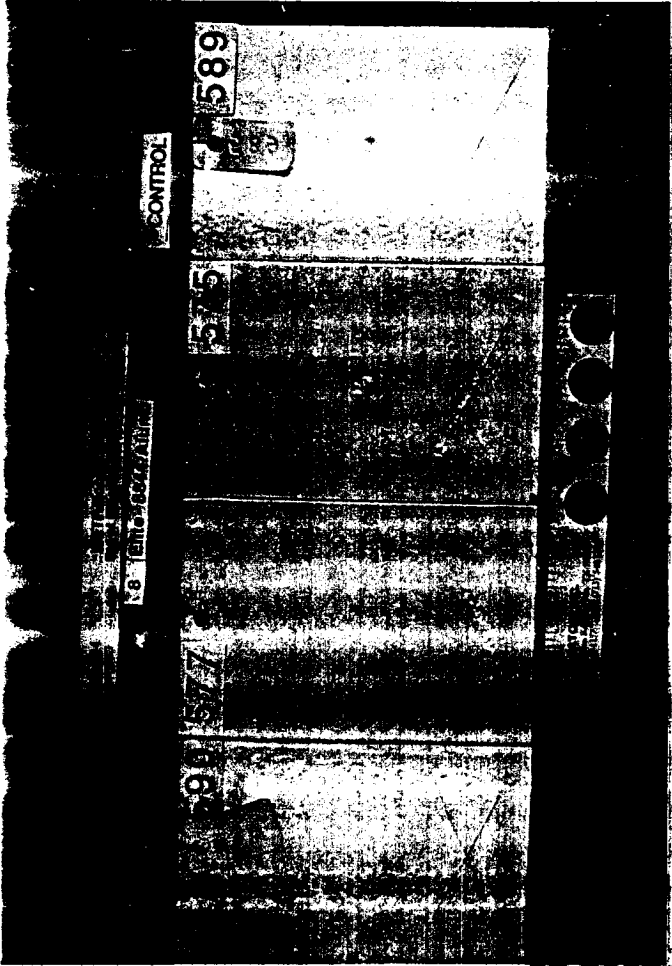
DATE:

ASSIGNMENT:

STYLE NO. 35-8P

FILE NO.:

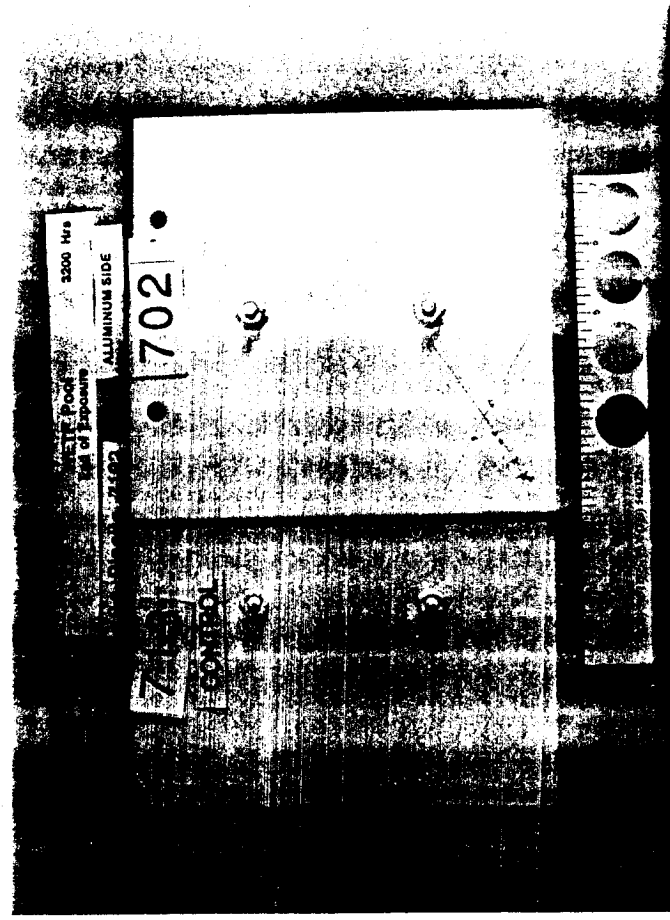
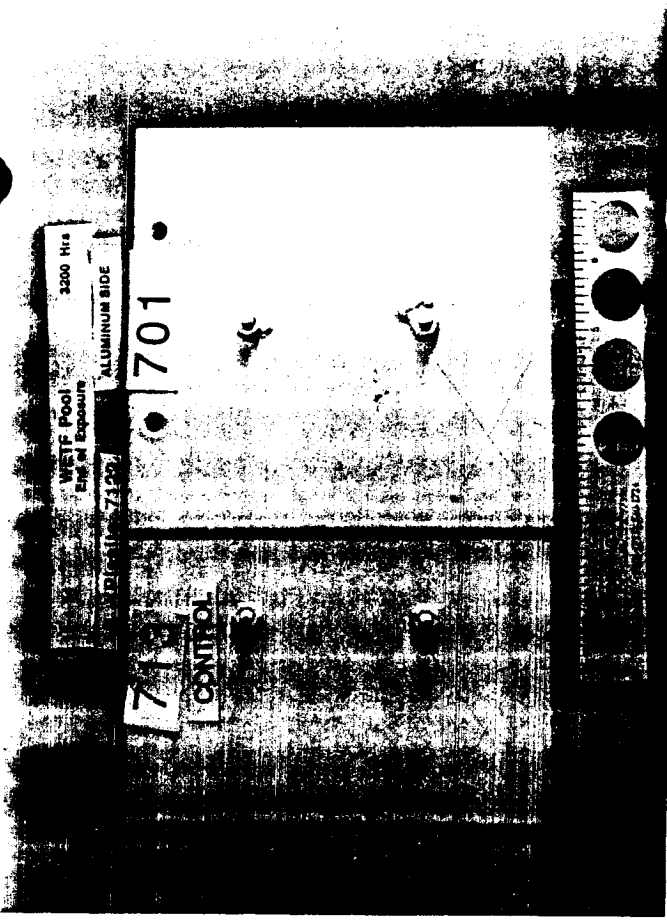
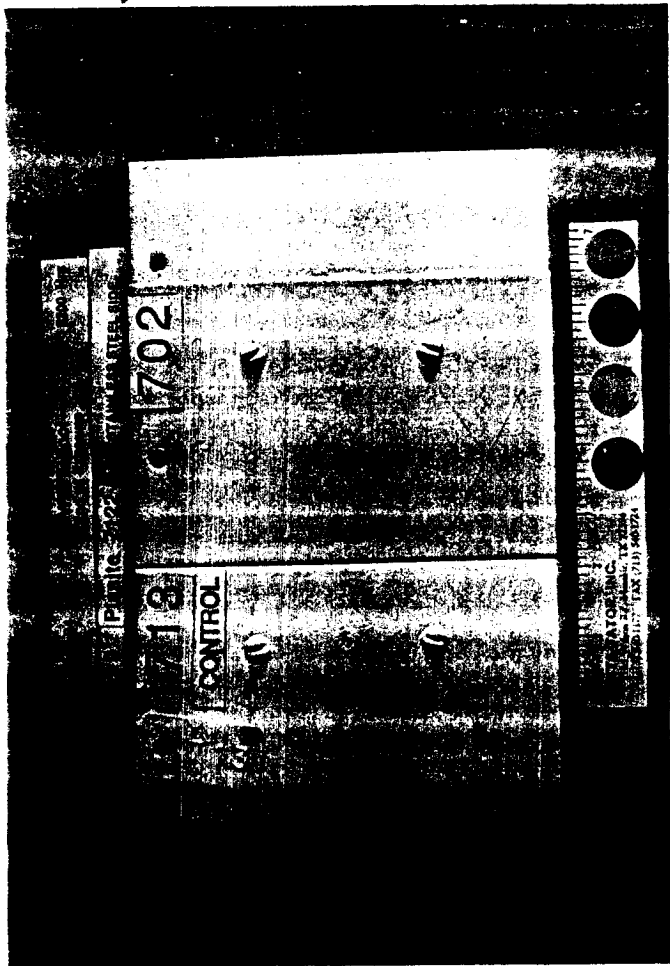
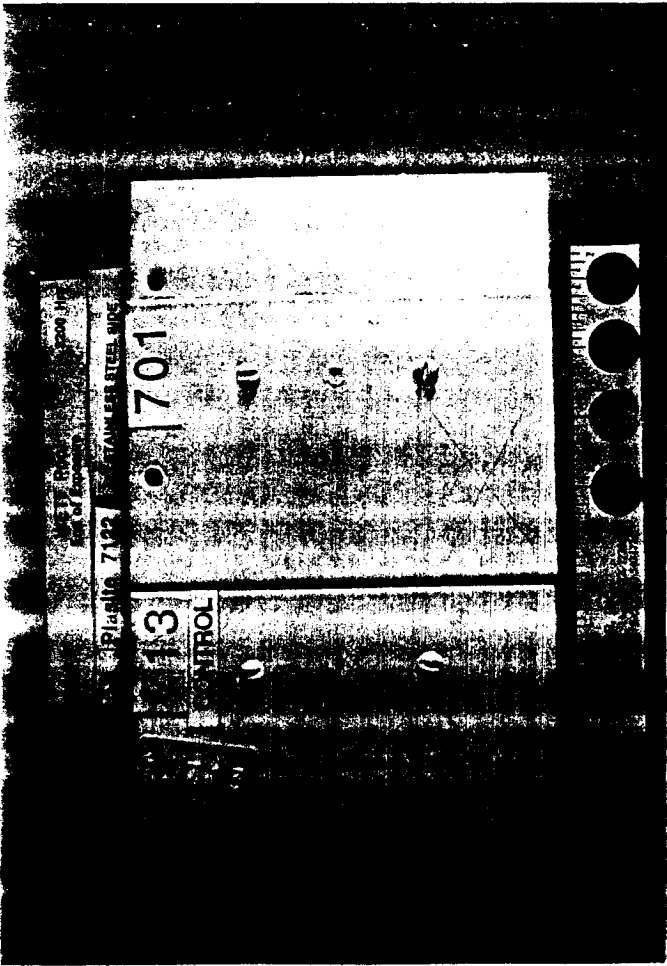




OF POOR QUALITY

DATE: 17.08.1952
VIBCHIVAT' IZ BEZELIENIY
BY THE FBI
VZACHIVENIY
60' BOX 5001938 • OBYEKTOY IZ OBYEKTOY KOD. 04
0078-488 (TOP) • OBYEKTY IZ OBYEKTOY KOD. 04

BYE NO:
BYE NO: 32-56



7120

7120

7120

7120

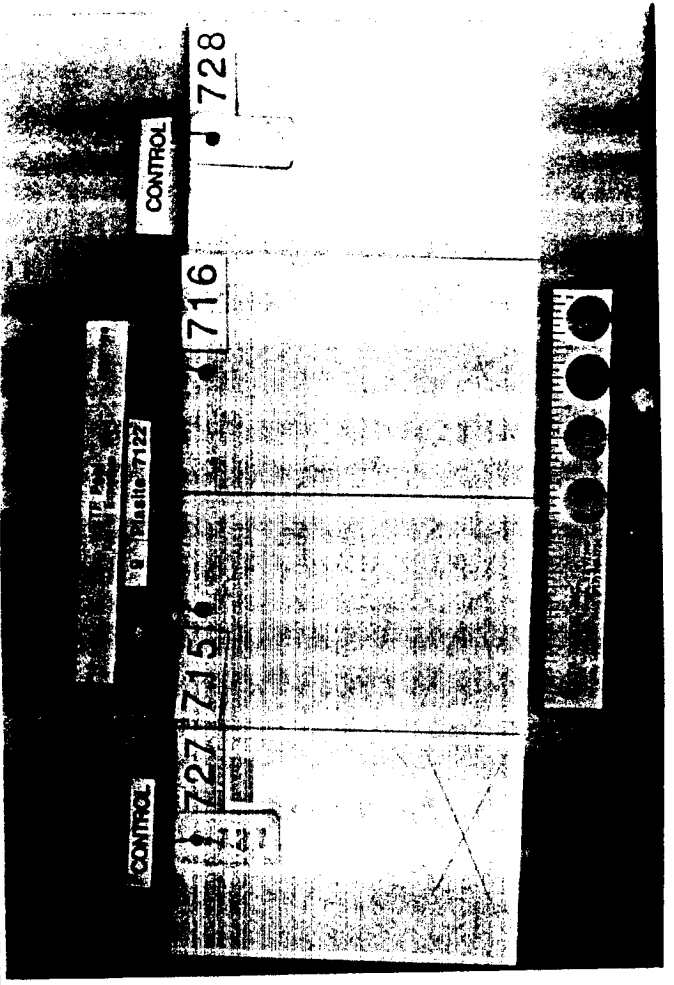
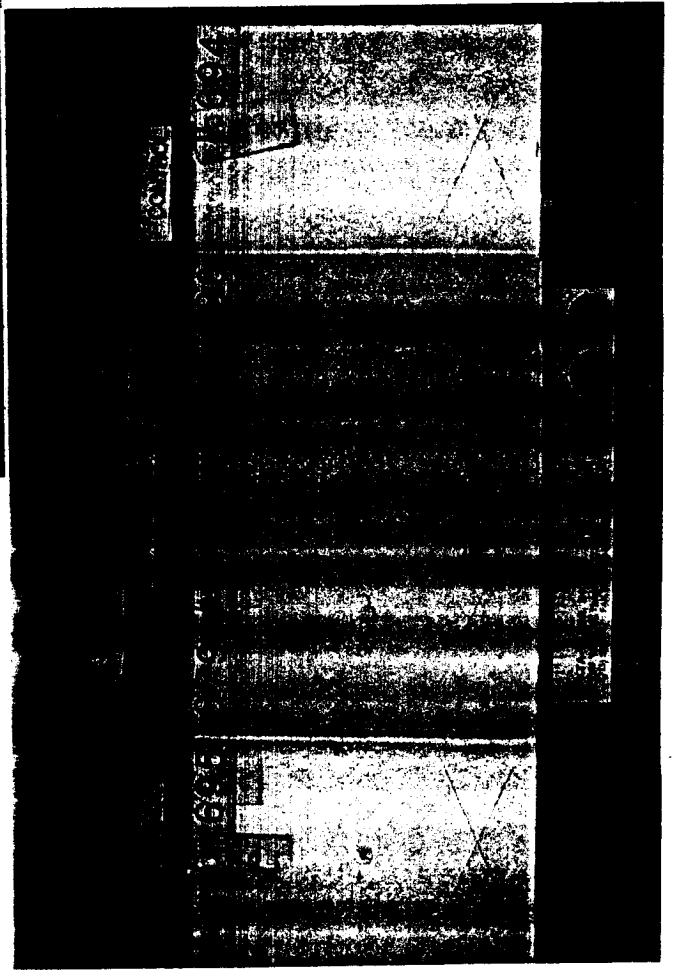
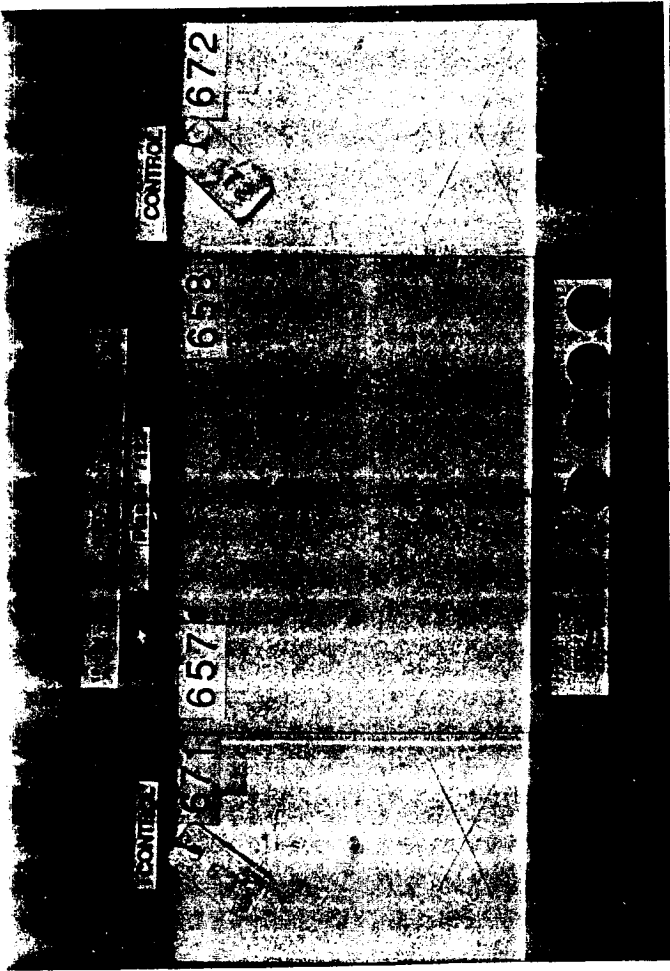
7120

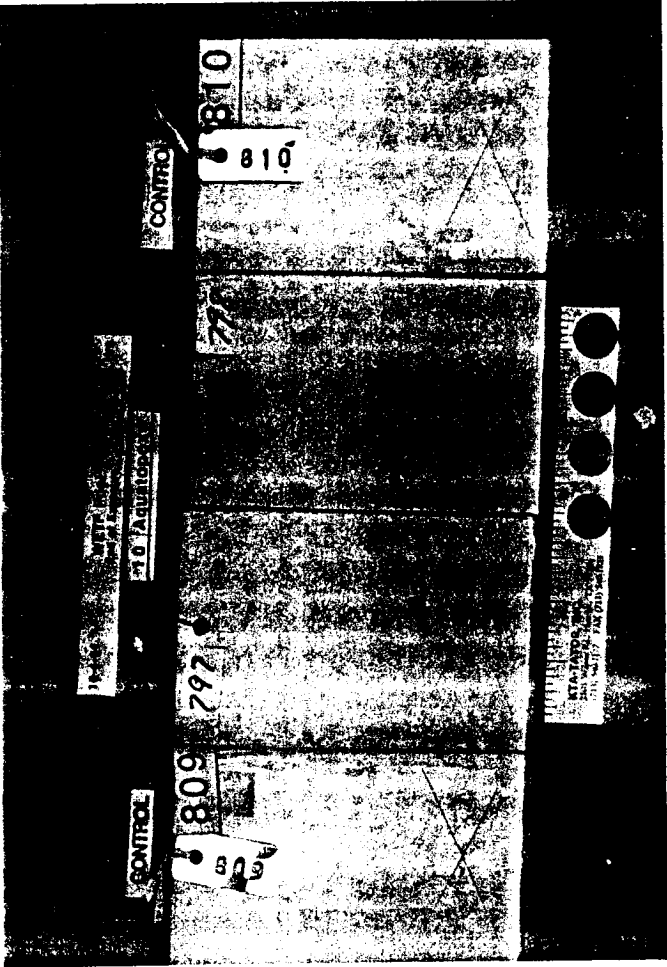
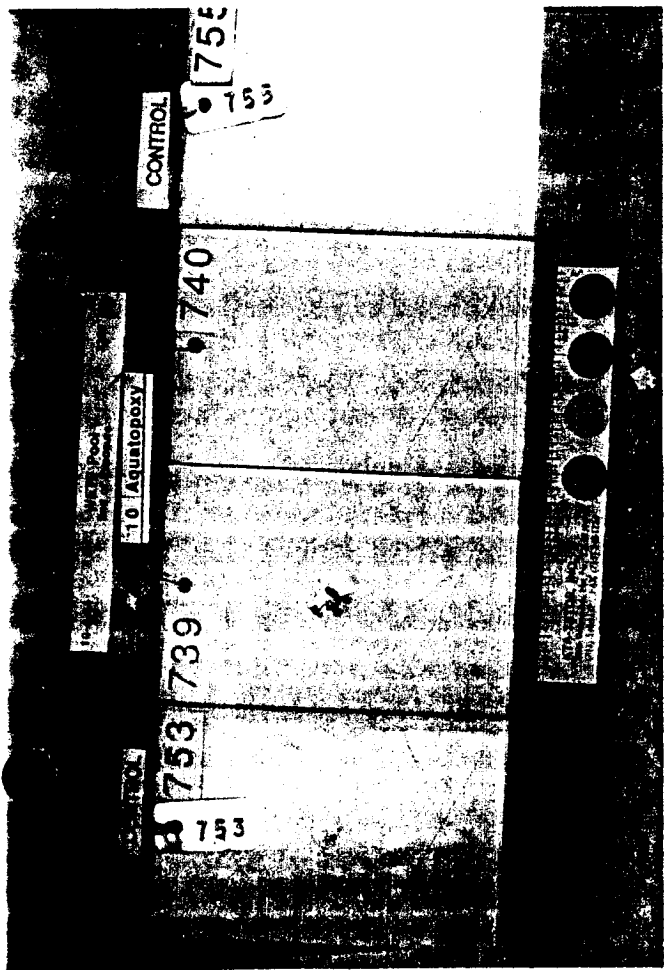
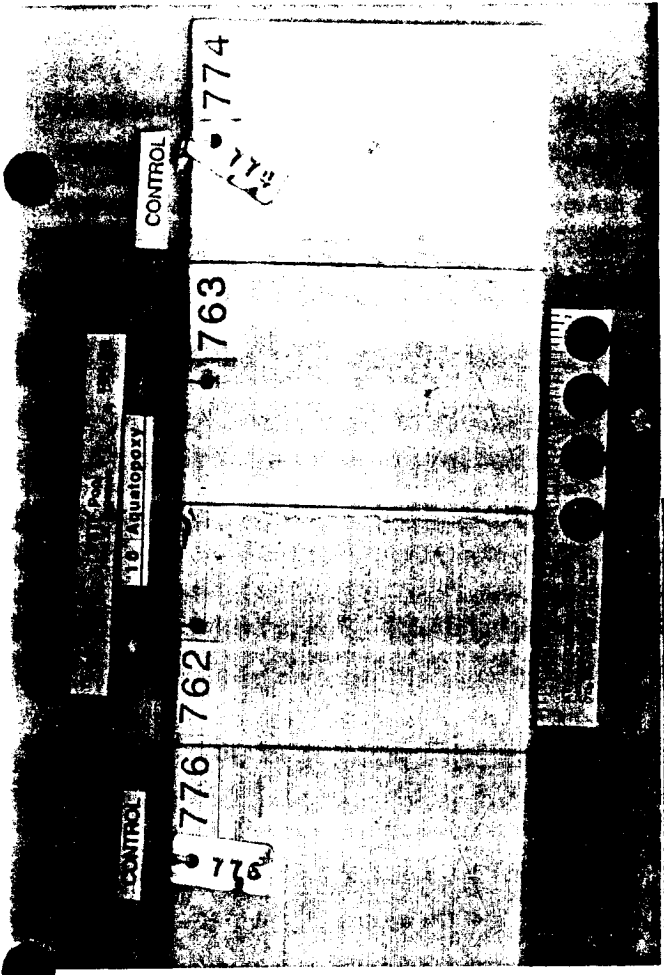
7120

7120

7120

7120





APPENDIX C
Photographic Presentation of Panels

WETF Pool- Repair Panels

One System per Page:

3200 hrs

| |
|-----------------|
| Stainless Steel |
| CPVC |

| |
|----------|
| Aluminum |
| Empty |

or

| |
|-----------------|
| Stainless Steel |
| Aluminum |

| |
|-------|
| Empty |
| CPVC |

2000 hrs

Right Hand Page:

As labeled: Before Repair

Left Hand Page:

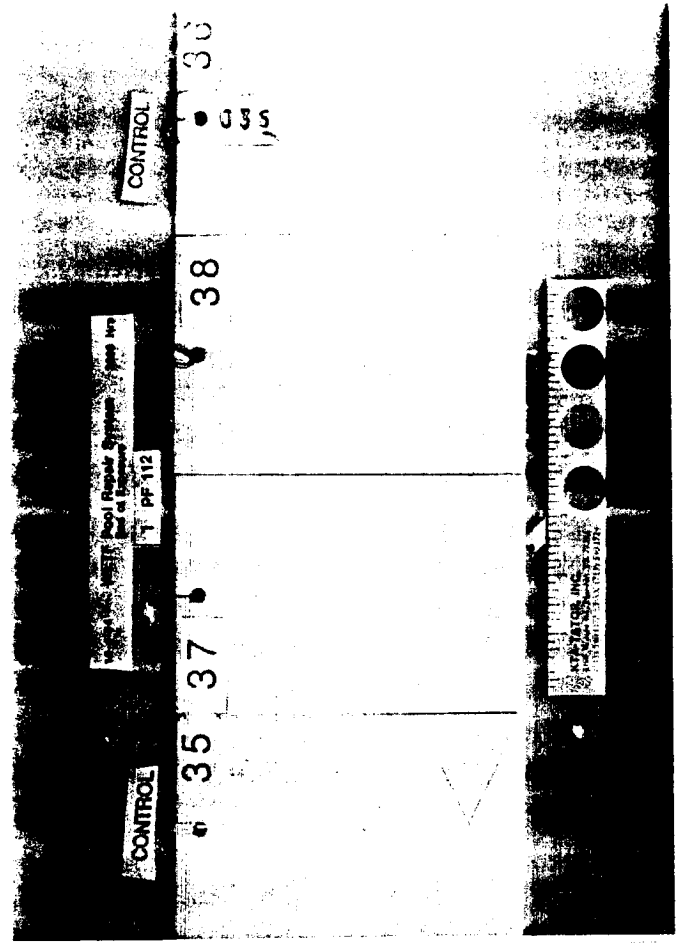
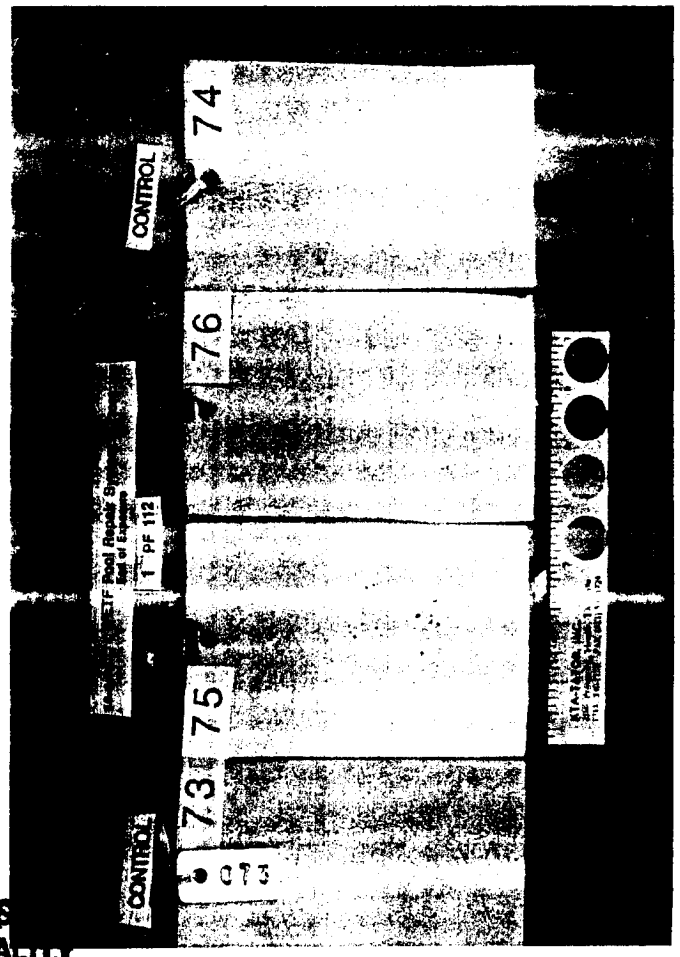
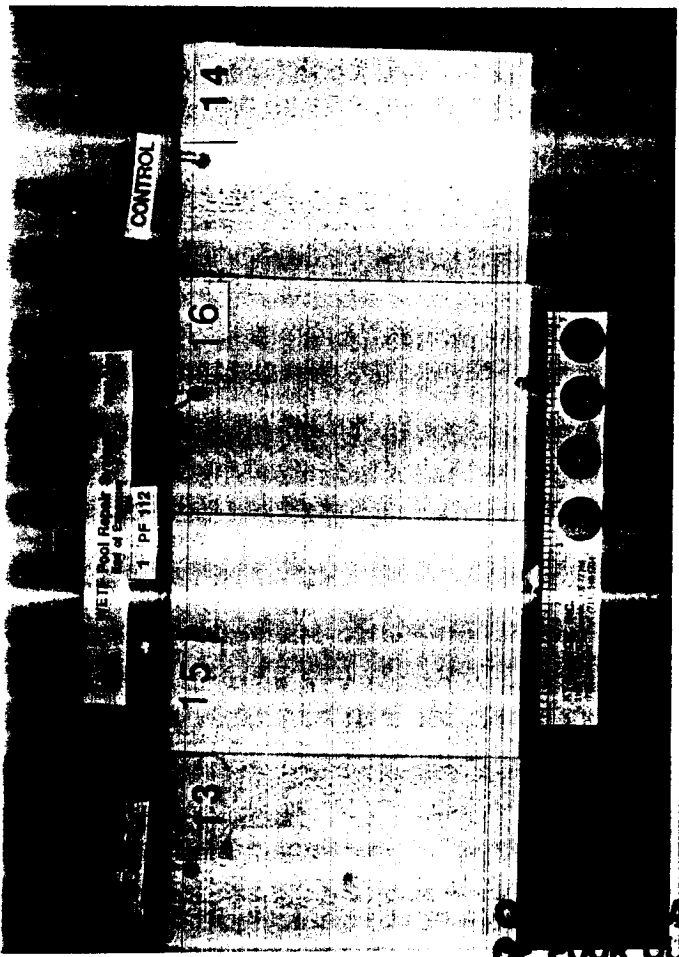
After Repair, Examples of Wire Brushed Surfaces

DATE:

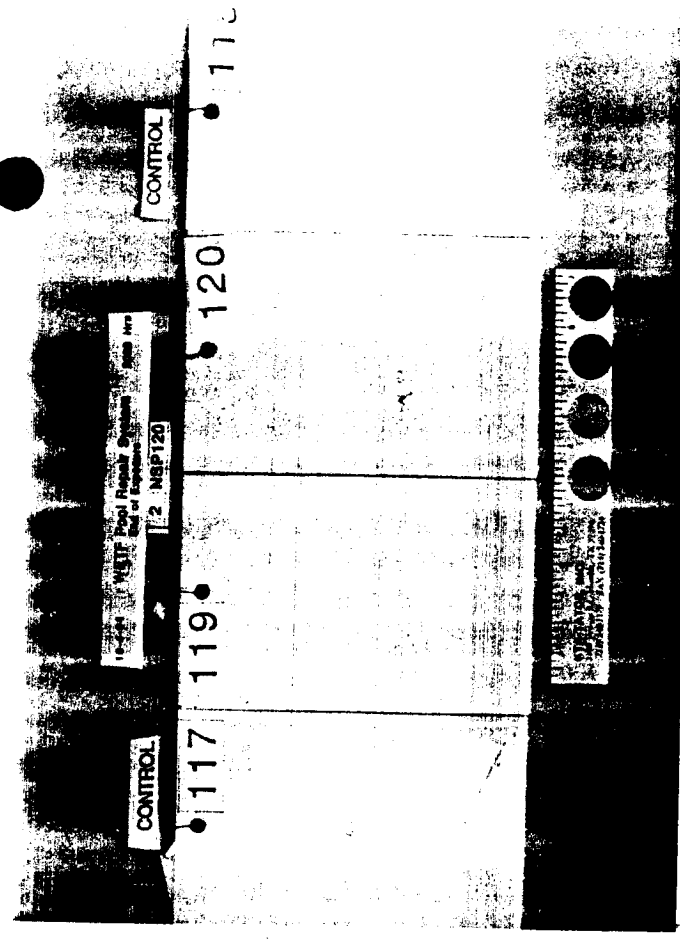
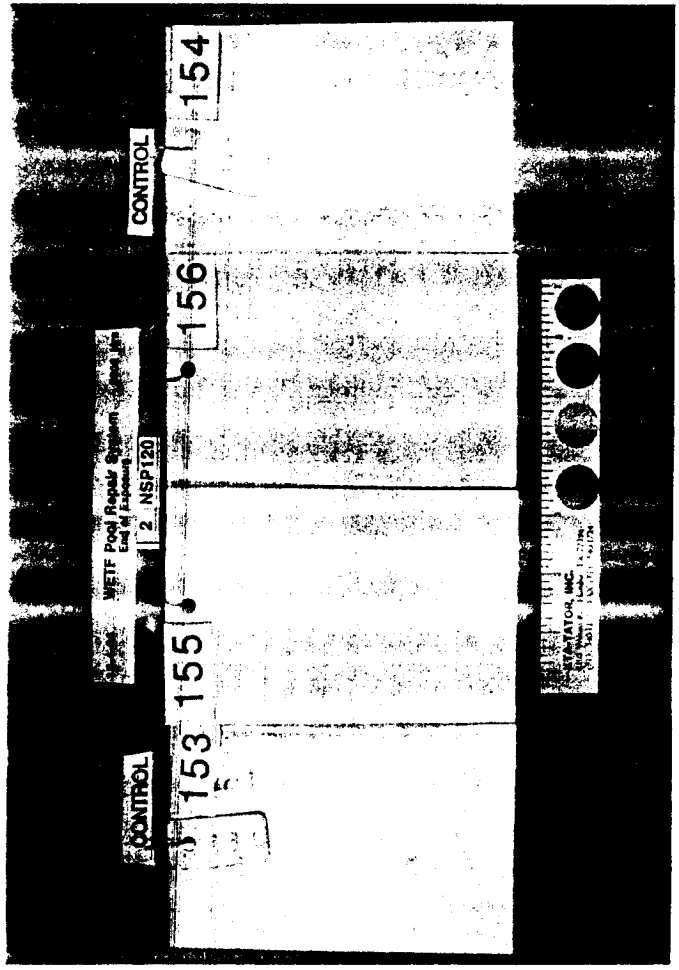
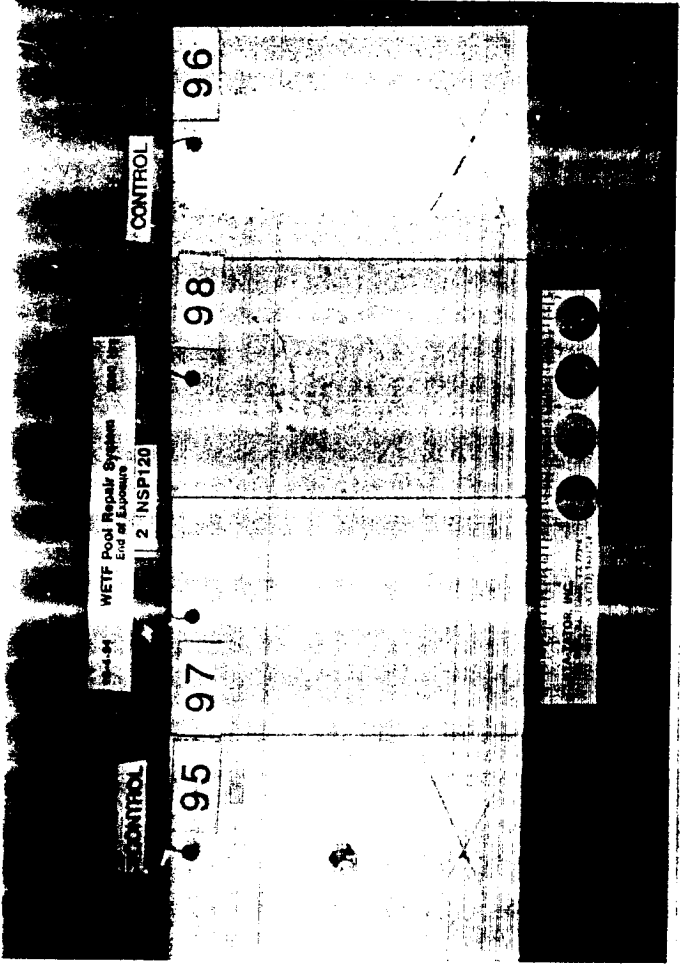
ASSIGNMENT:

STYLE NO. 35-8P

FILE NO:



OF POOR QUALITY



DIVISION 1222

DATE

YACHT CLUB
BOAT CLUB

PO BOX 901438 - ORLANDO FL 32890 - (407) 889-3100

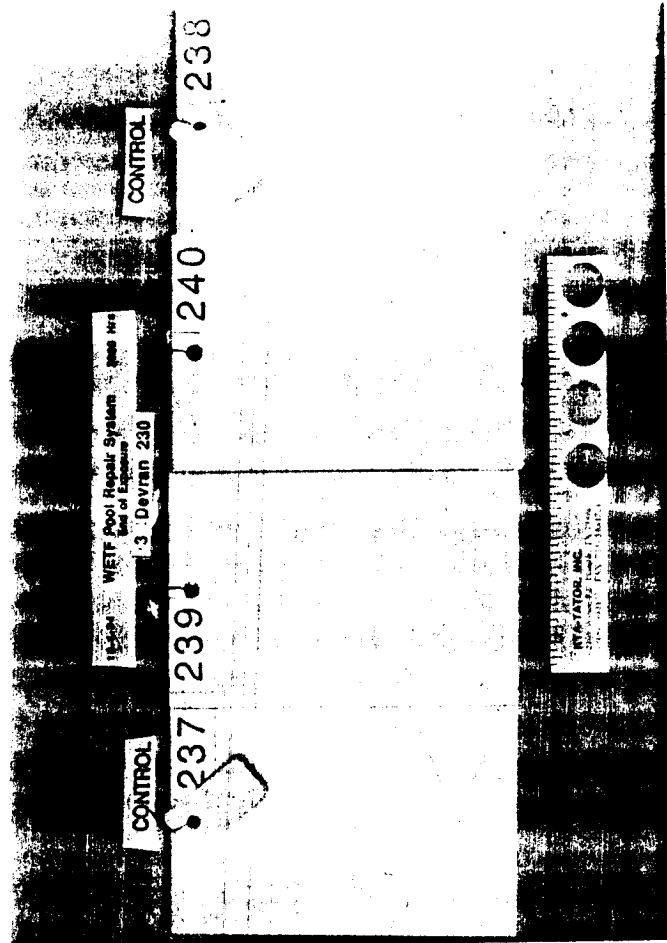
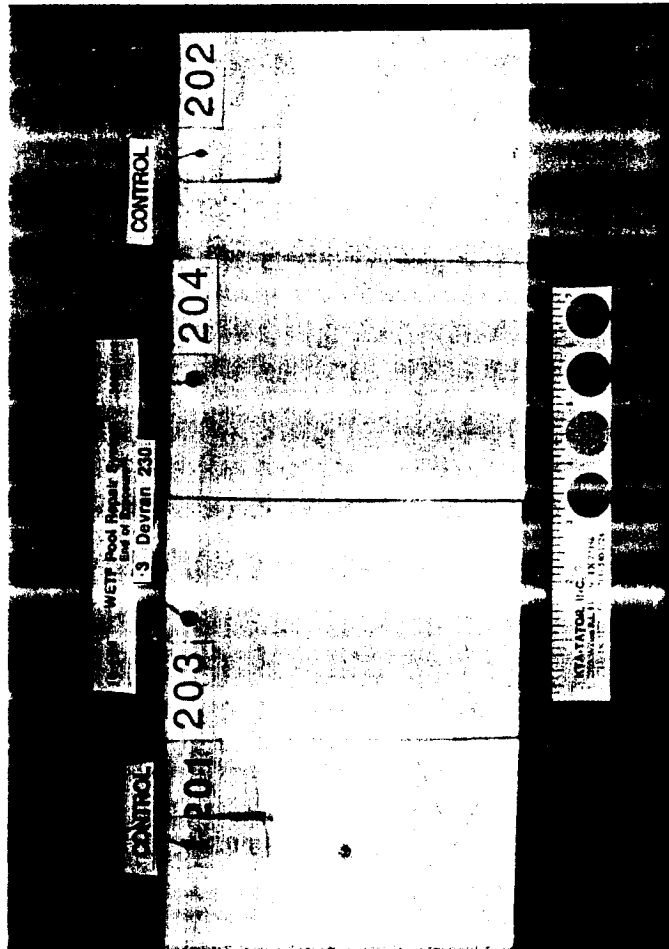
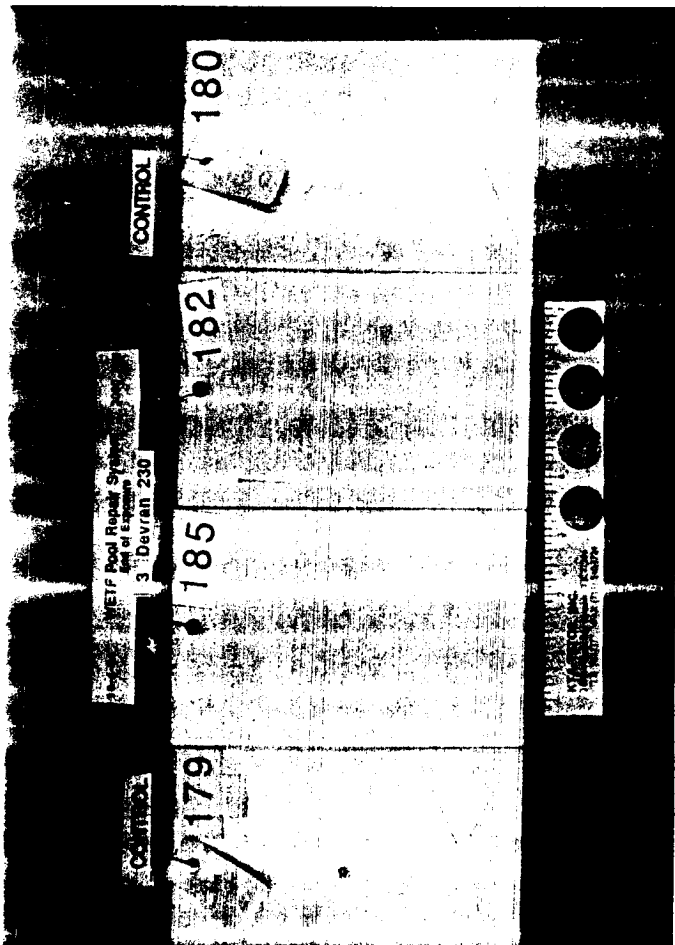
DATE

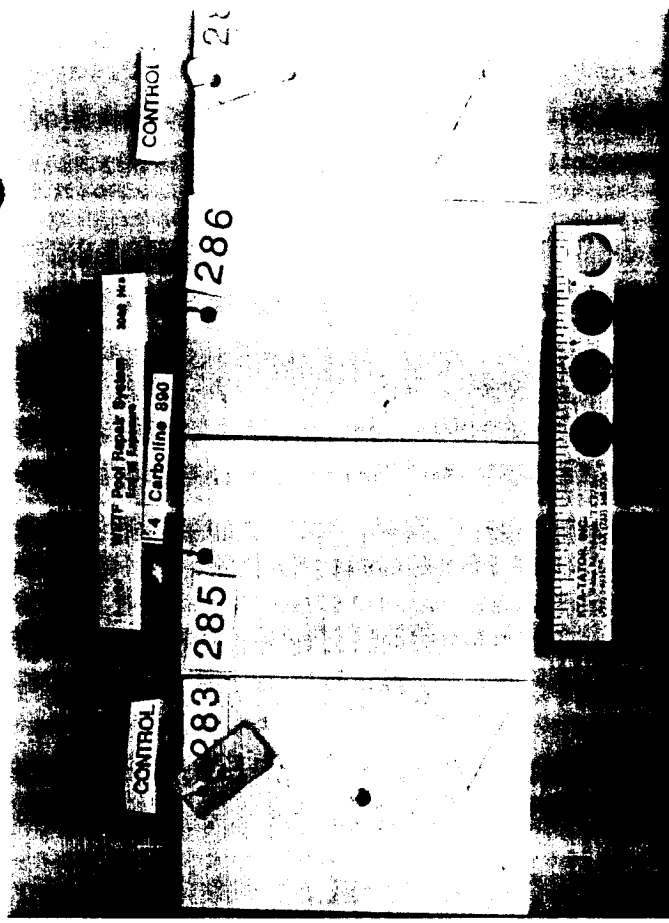
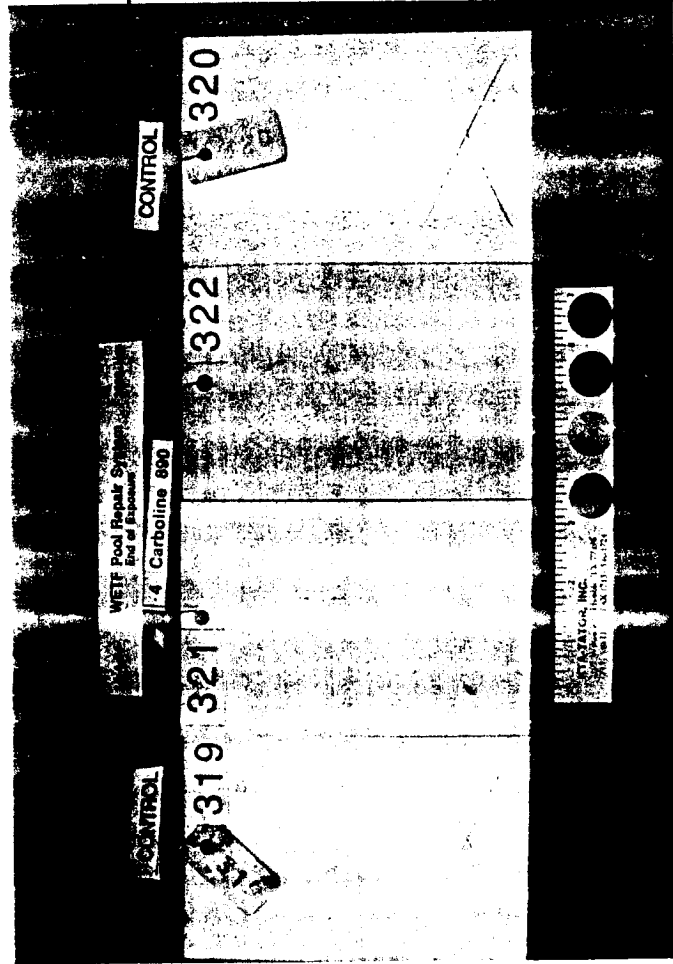
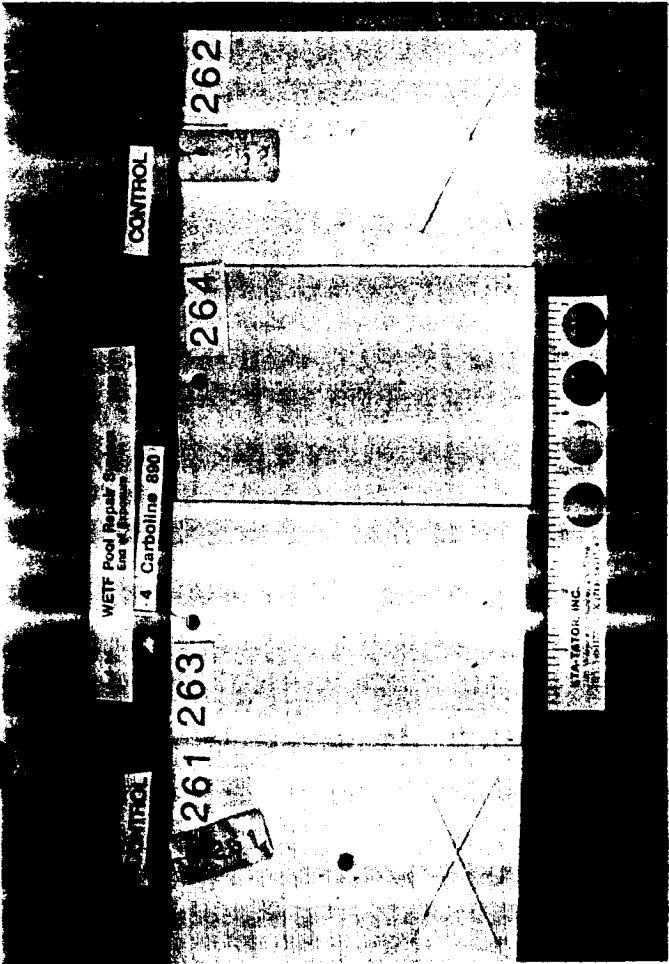
NO. 32-88

DATE:

ASSIGNMENT:

FILE NO.:





DATE

IDENTIFICATION

FILE NO.

AMT
D. W. J. S.

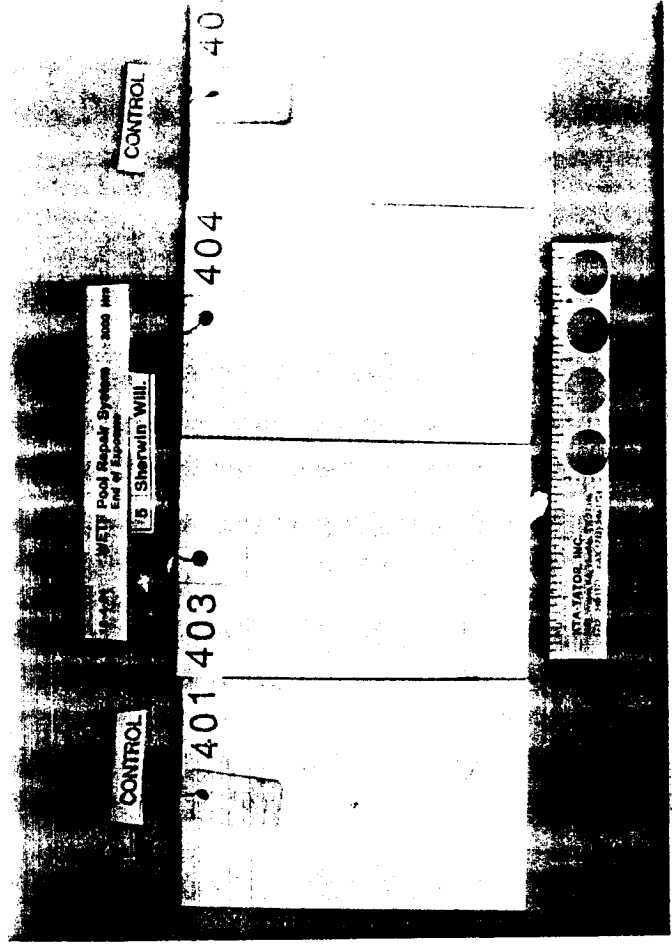
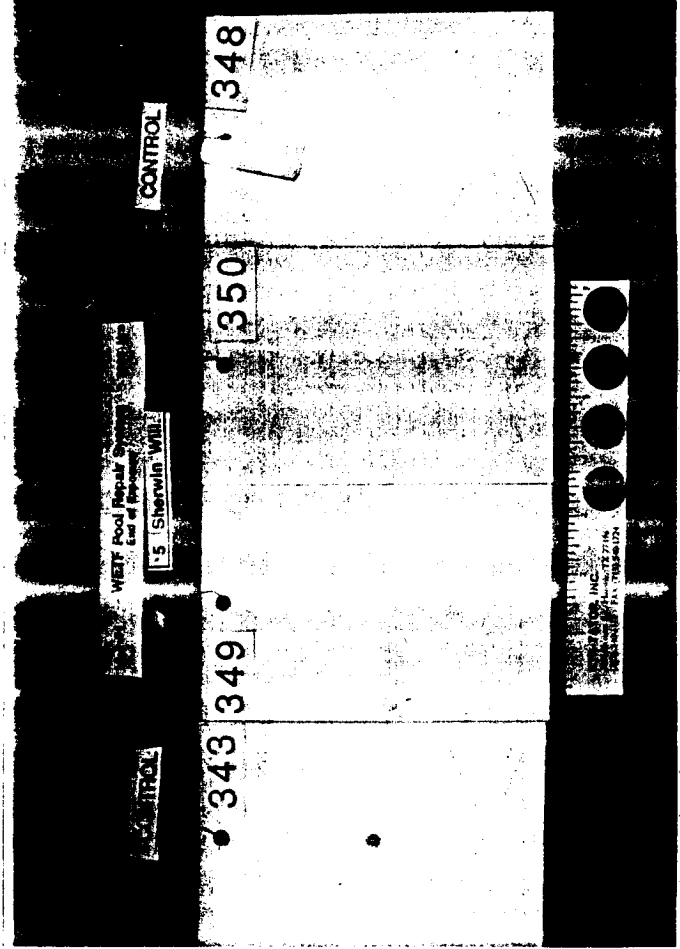
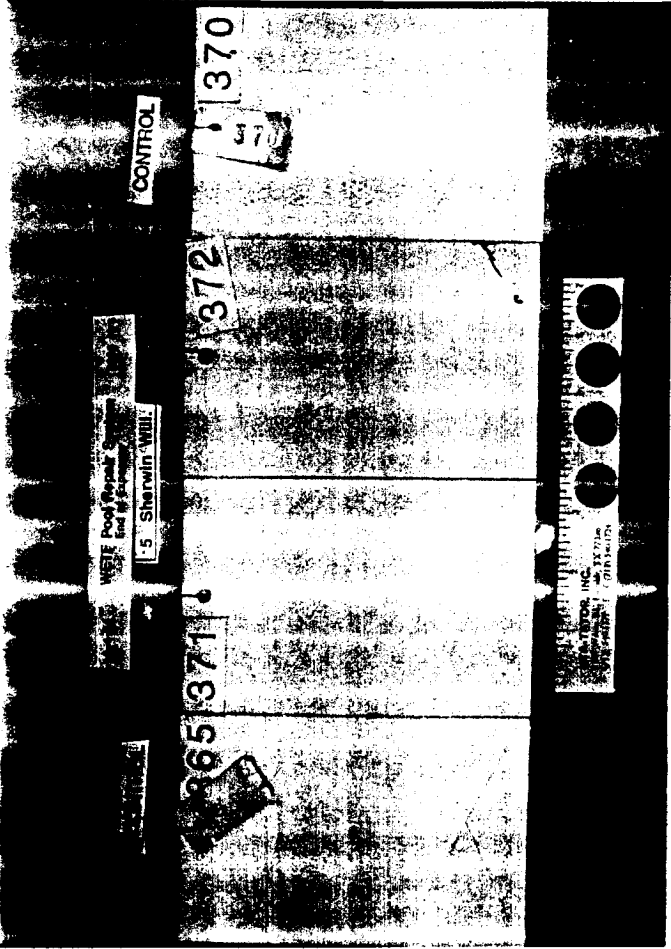
507 S. 8th St. (TOD) • 08552 • BEATON • 507 BOX 50338 • (401) 888-1100

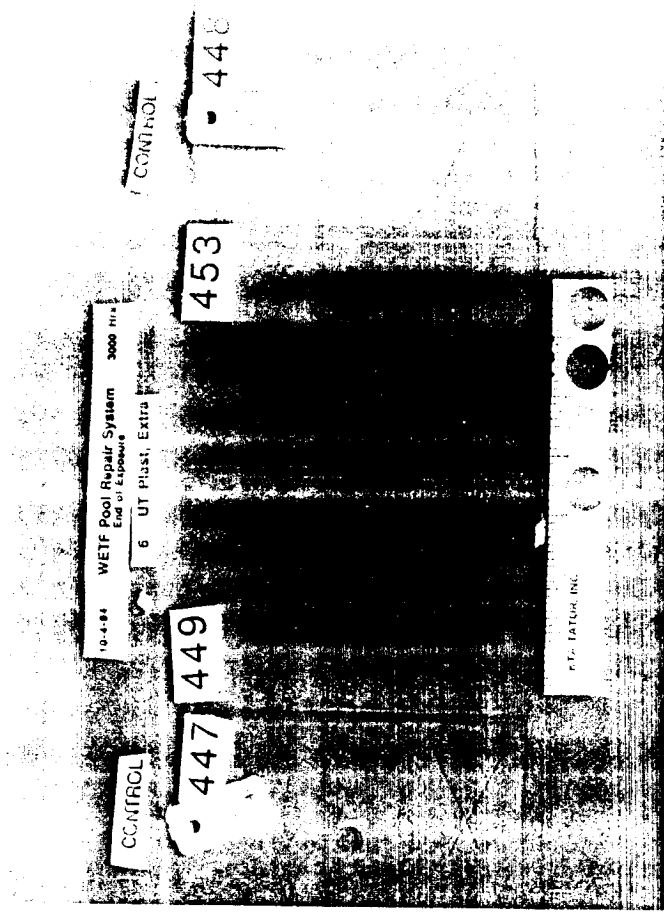
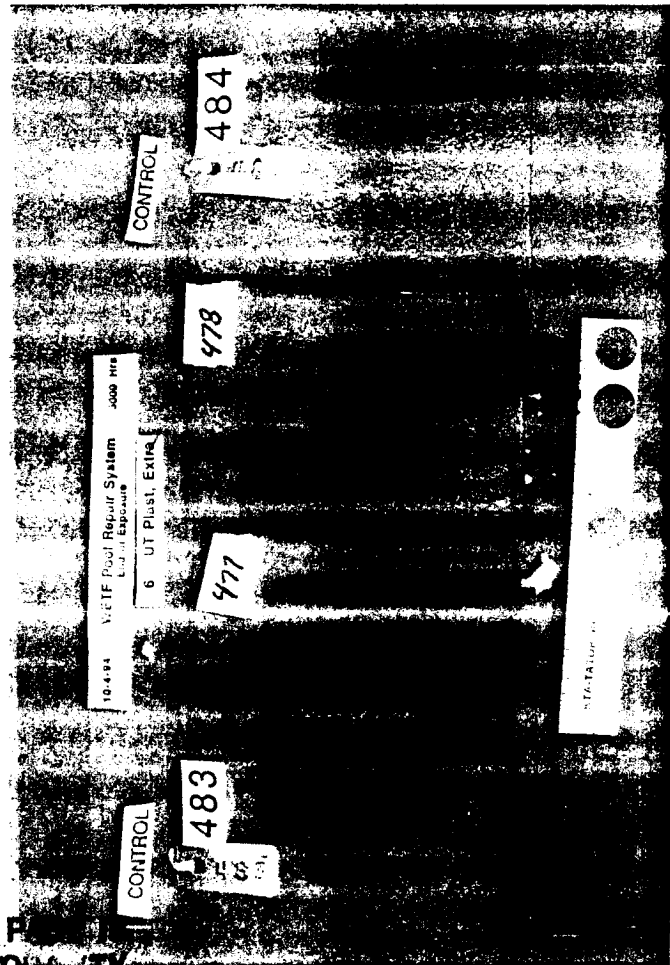
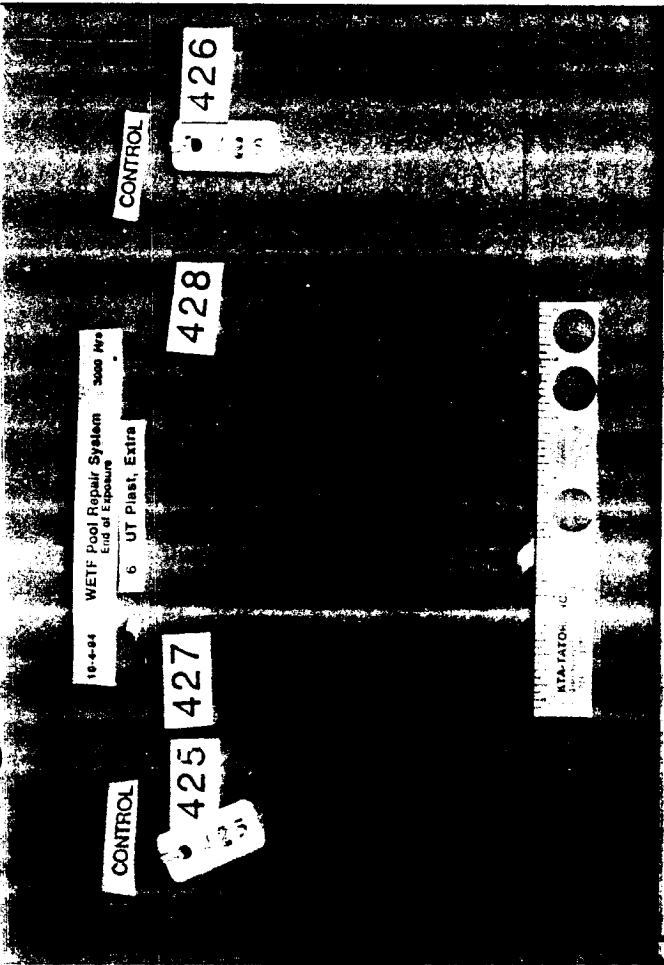
PLATE NO. 32-BU

DATE: _____ ASSIGNMENT: _____

STYLE NO. 35-df

FILE NO:





DVALE

Y22ICINWENTL

WIFE NO

ARCHIVE OF DOCUMENTS
DVALE

PO BOX 801428 • OREGON • (503) 888-3100

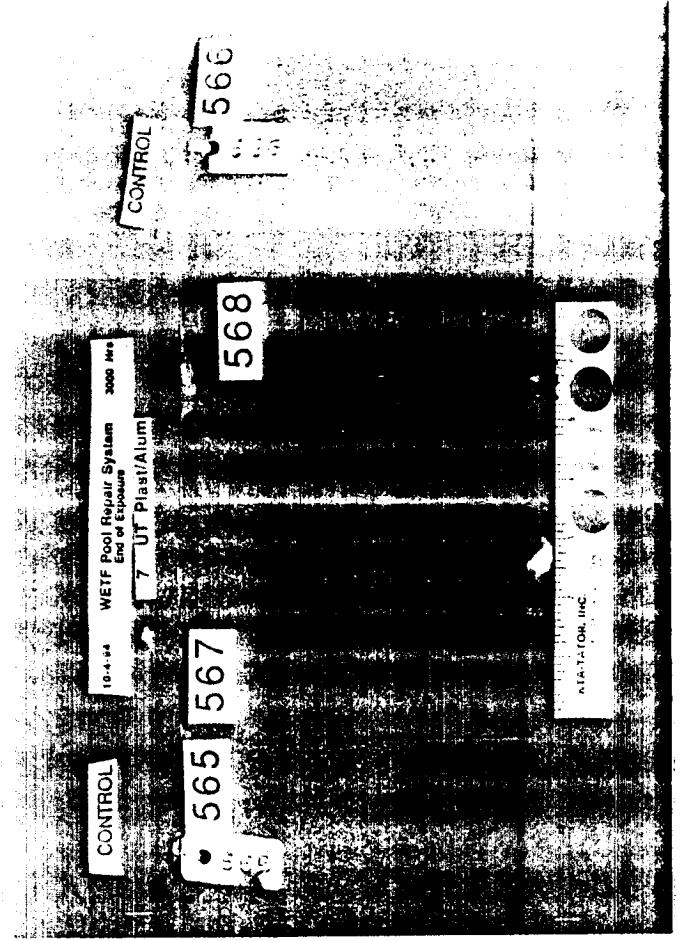
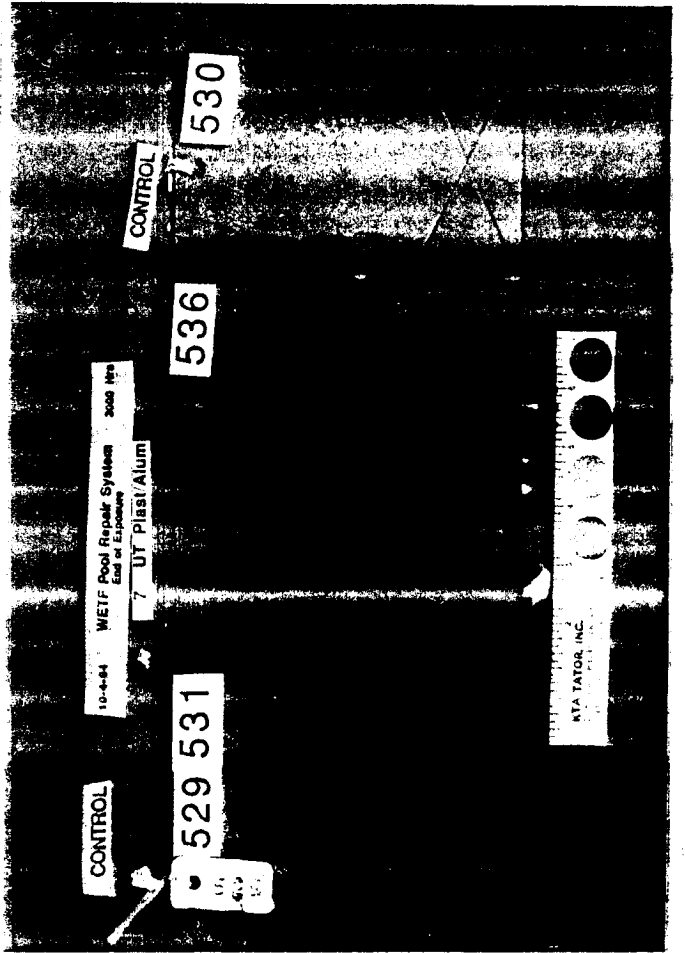
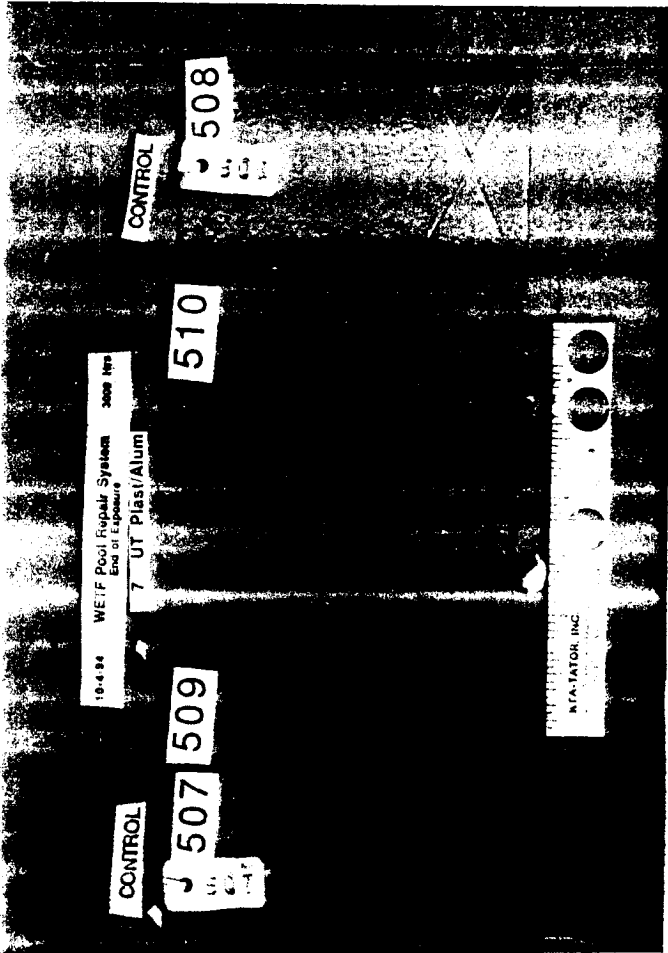
PLATE NO 32-86

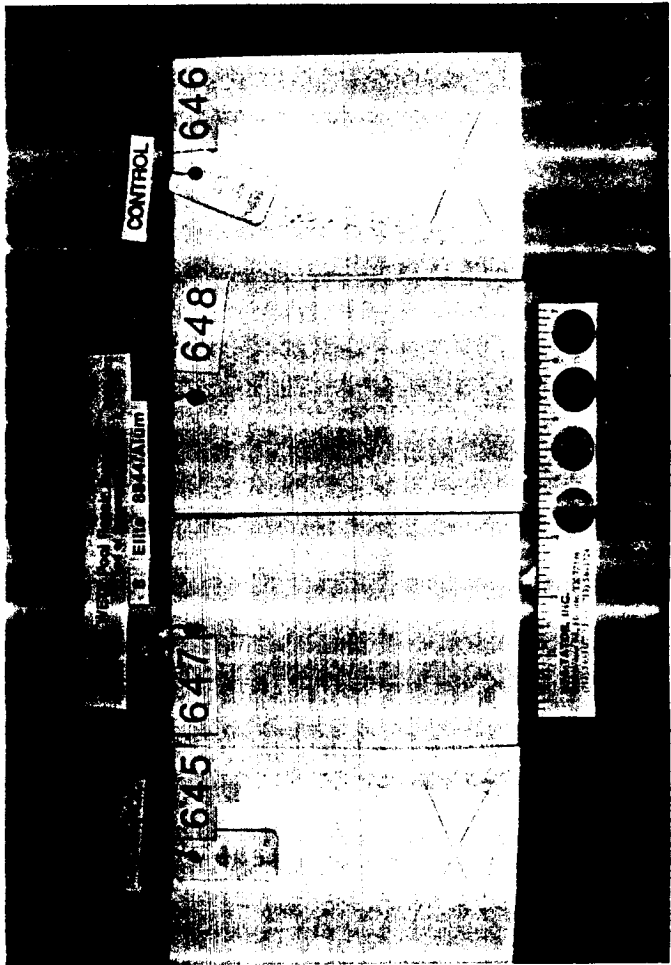
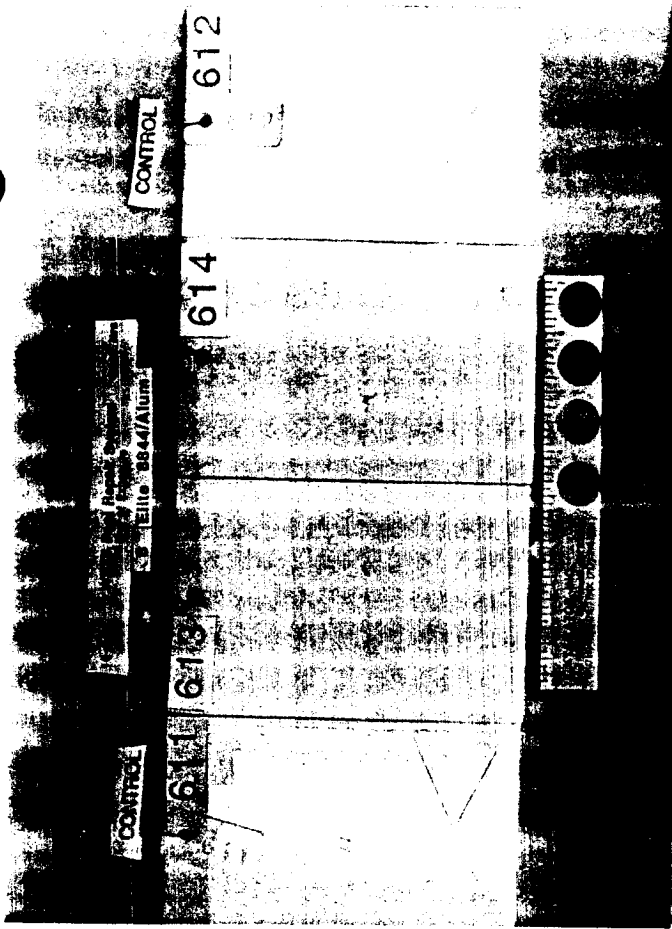
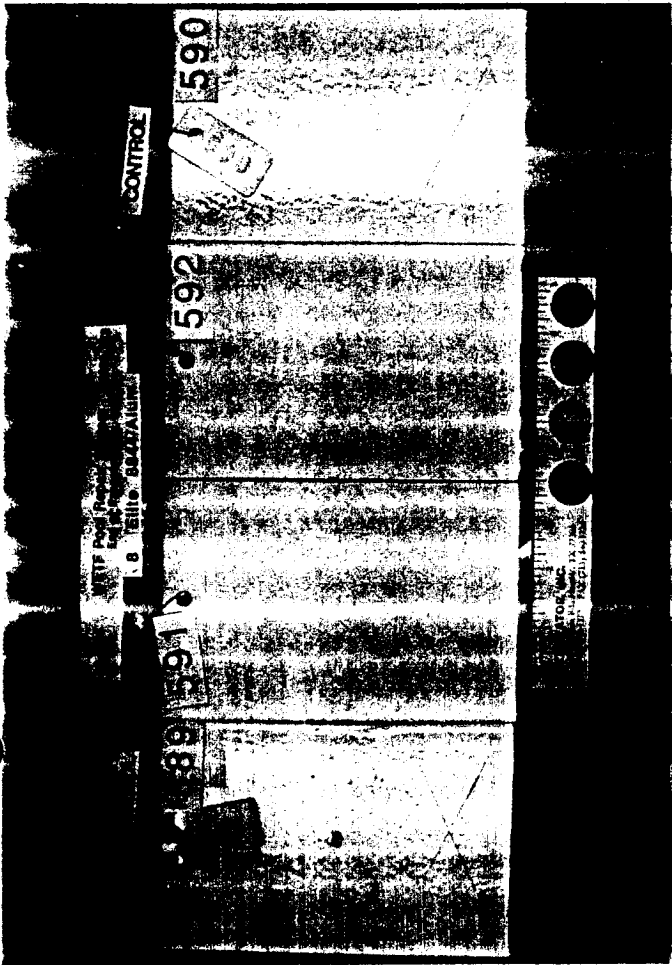
OF POOR QUALITY

DATE:

ASSIGNMENT:

FILE NO:





УЗГОННЕВАУ

ТАДА

БИТЕ НО'

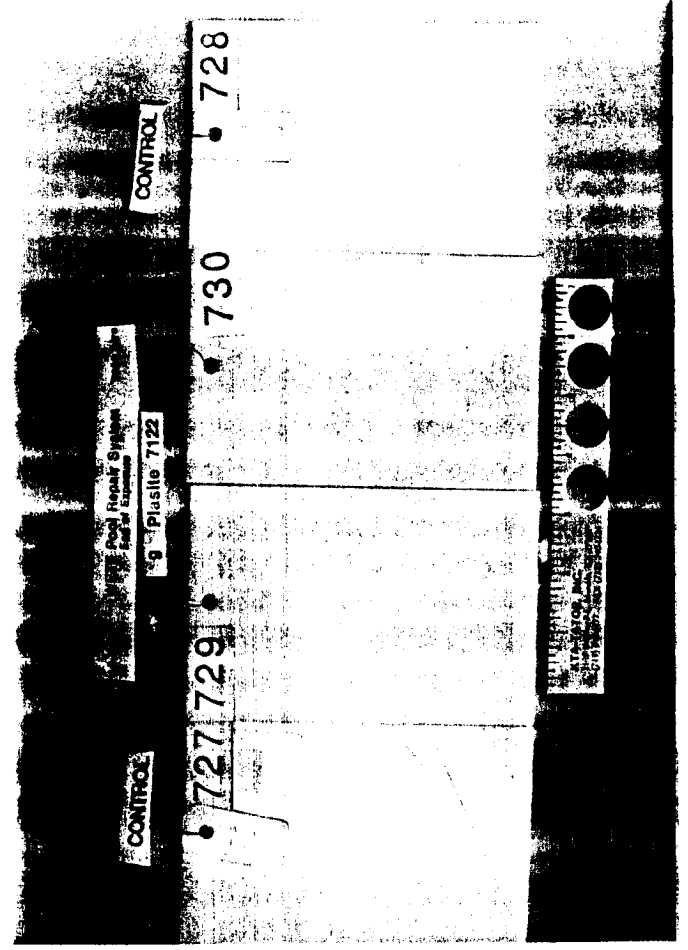
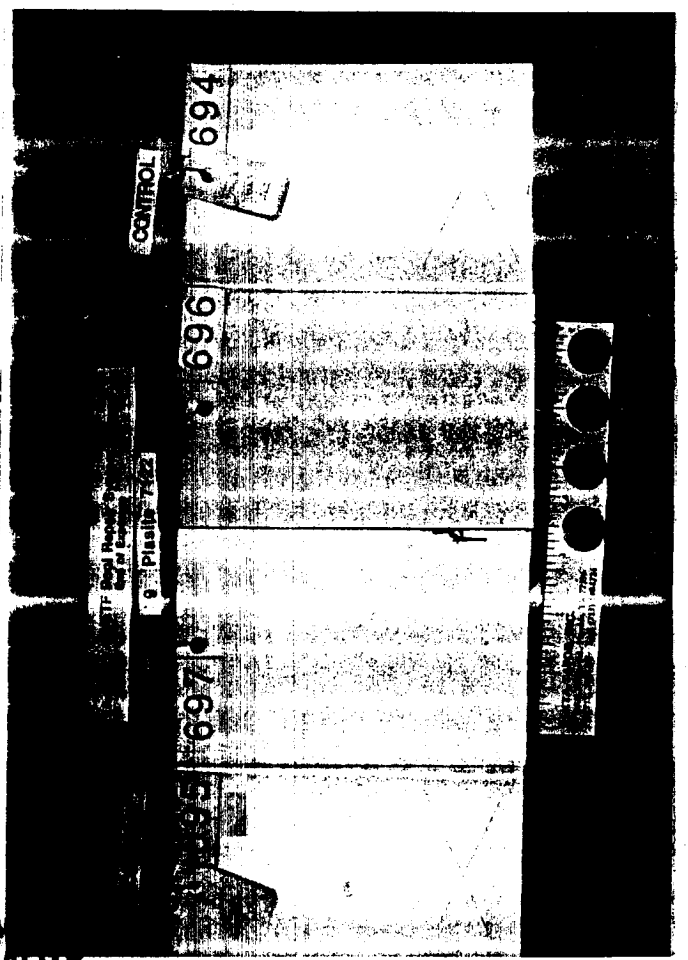
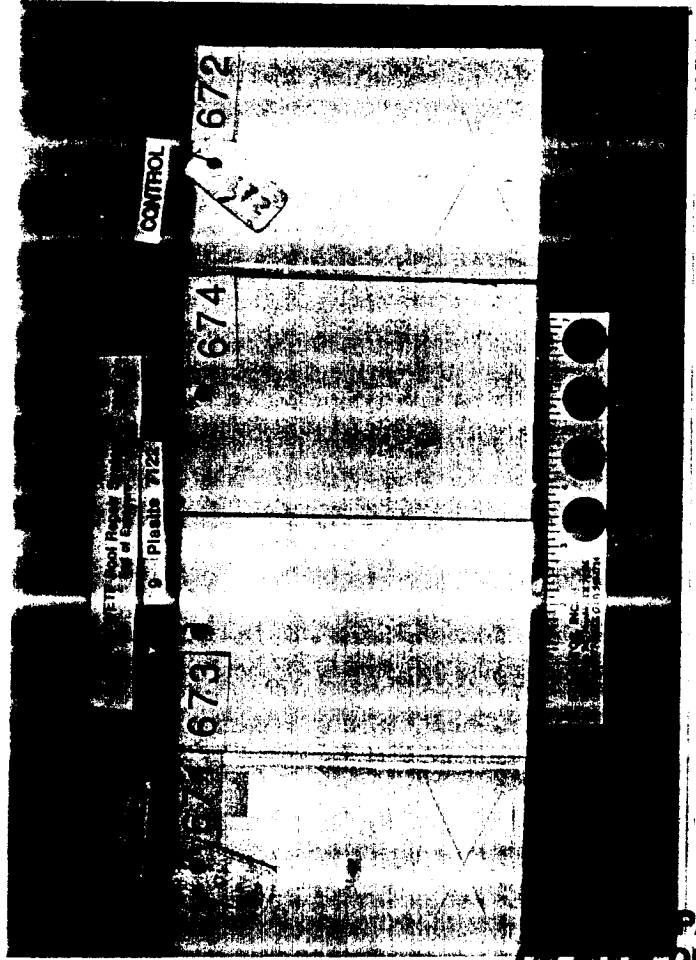
ВУКЧУ ВТ ЛОК СЕВА СЕЗ
Brumfijs

Б'О' БОХ 801438 • ОБГЛУДО' ЕГ 3880 • (401) 888-1100

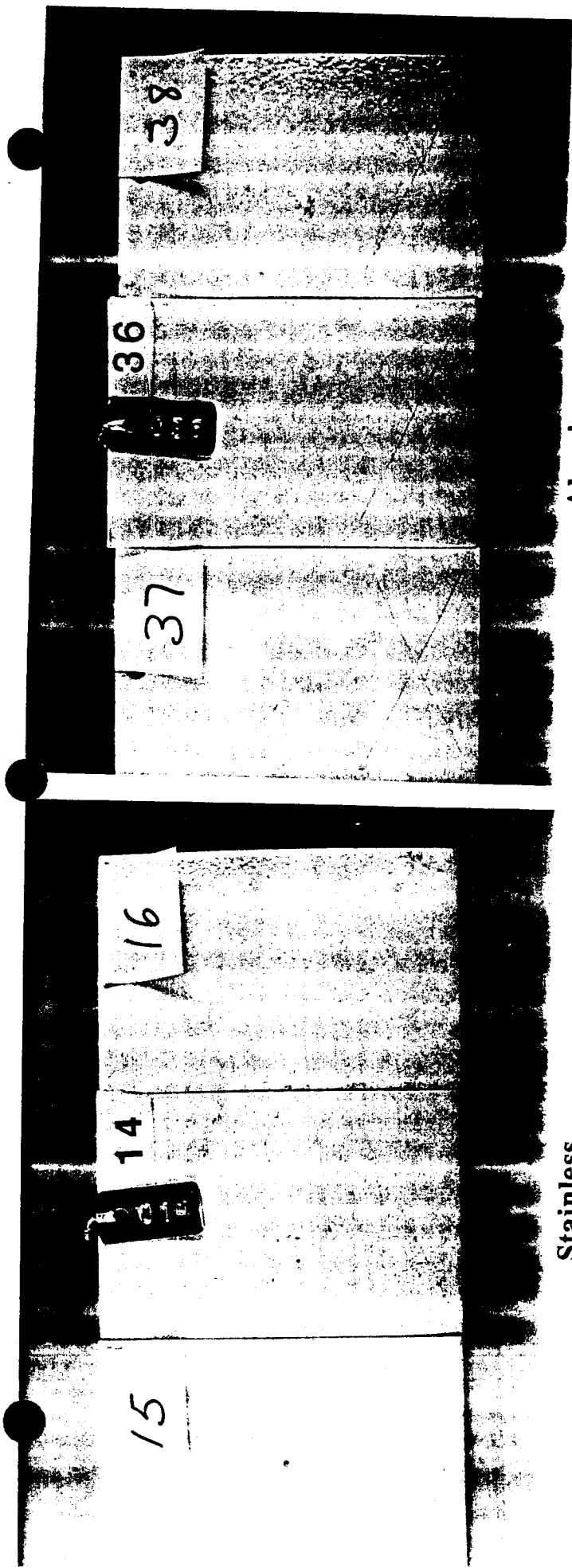
ЗЛАГЕ НО' 32-86

DATE: _____

ASSIGNMENT: _____

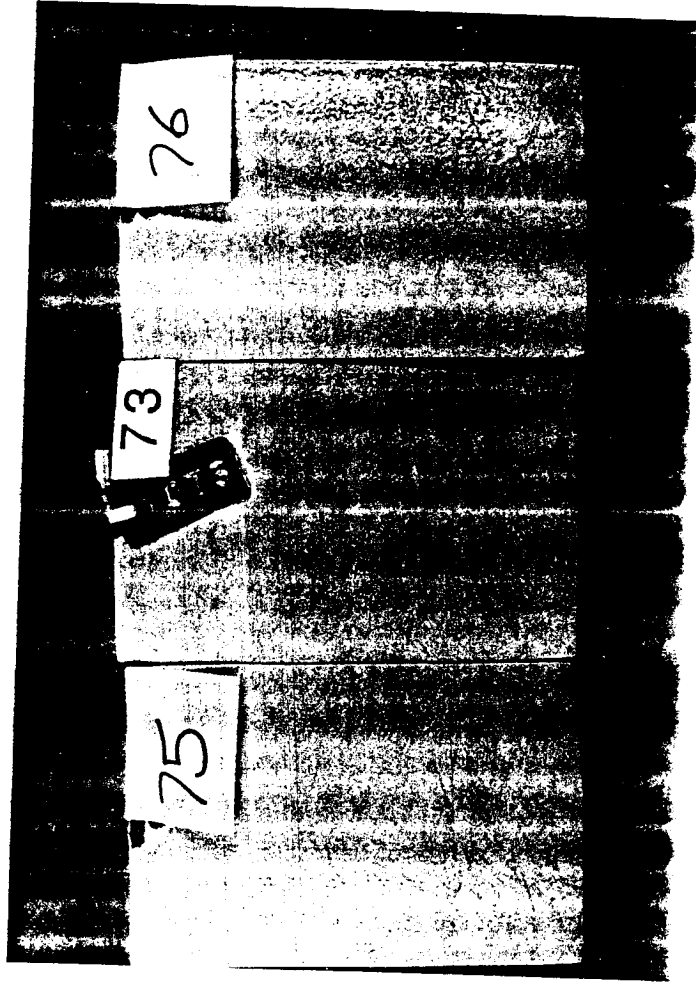


PA
OF POOR QUALITY

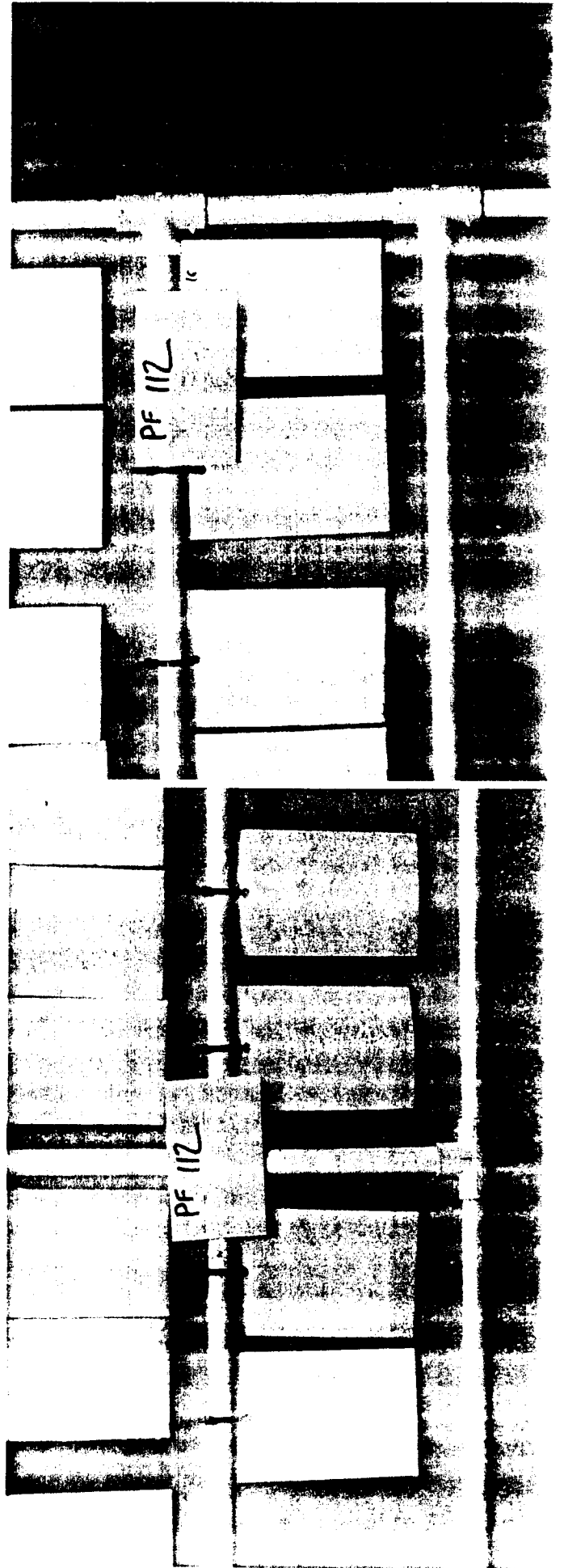
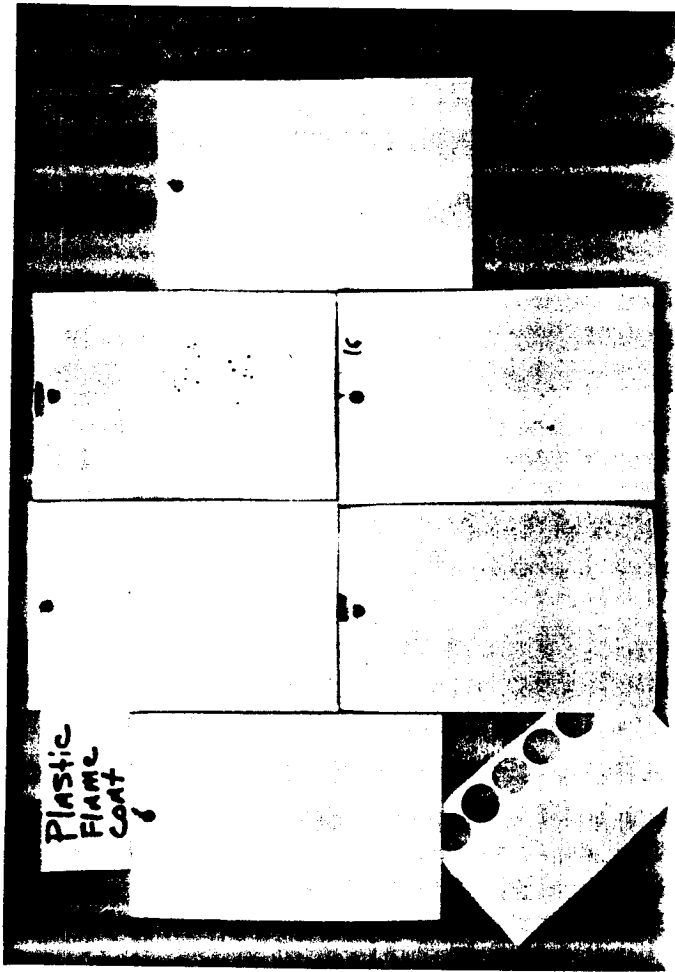


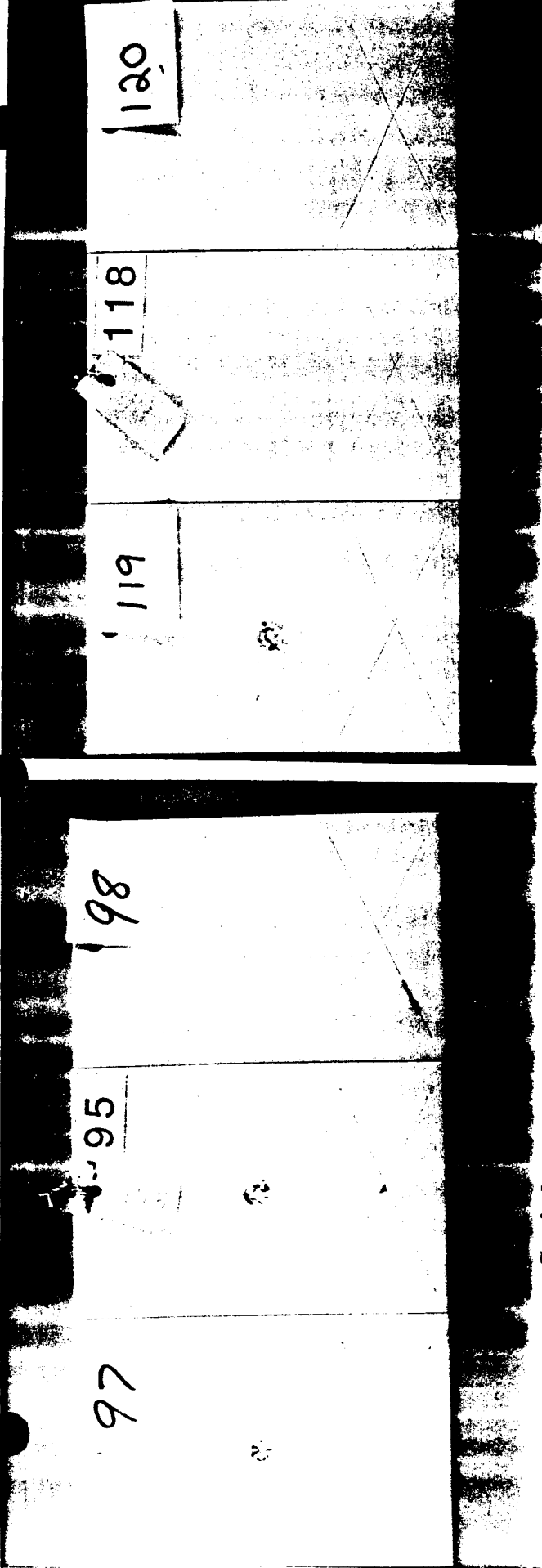
Stainless

Aluminum



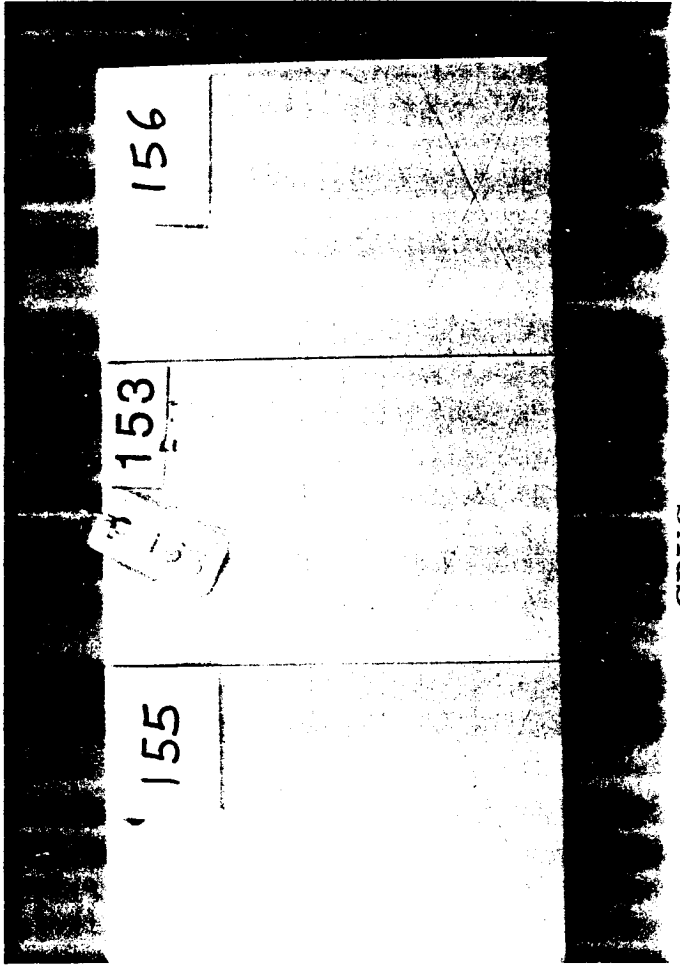
CPVC



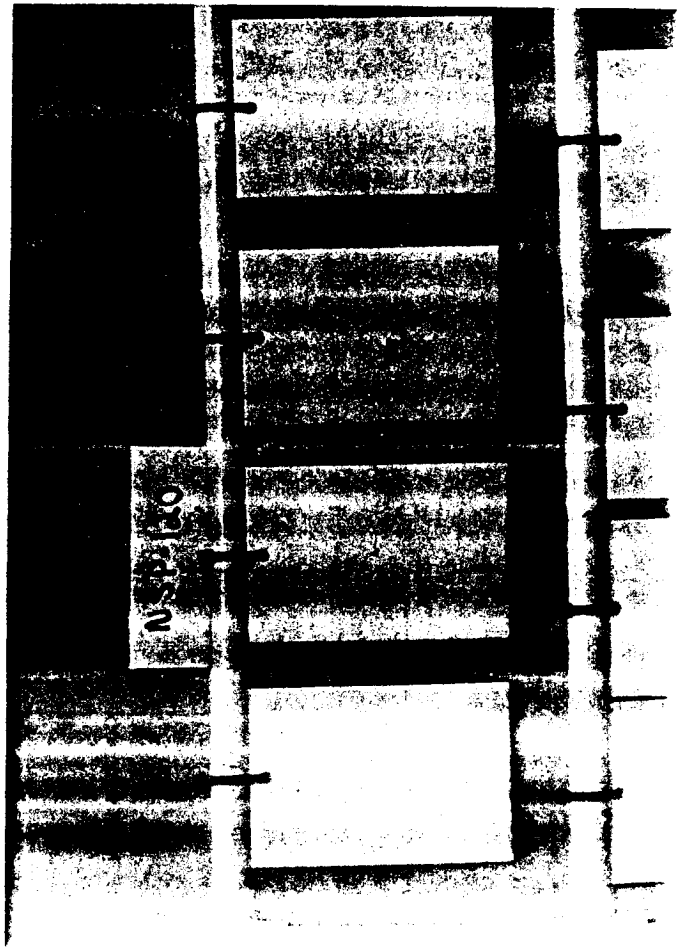
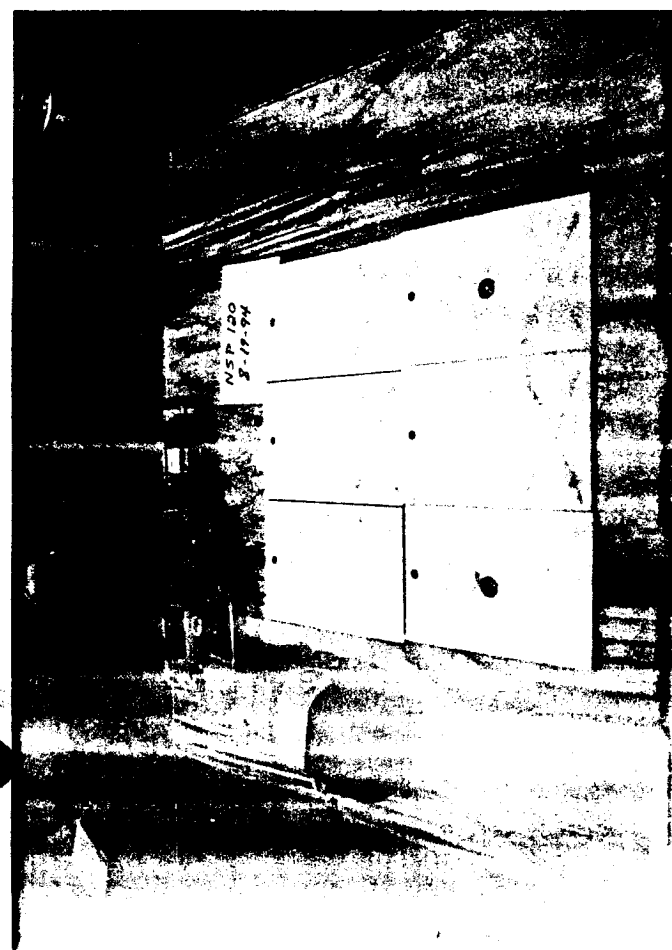
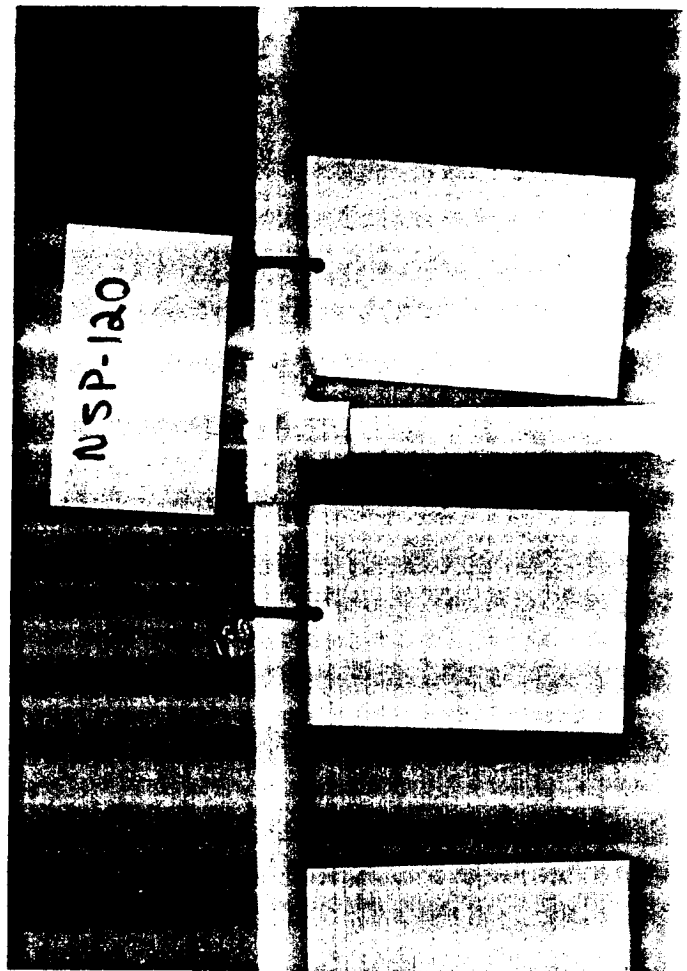
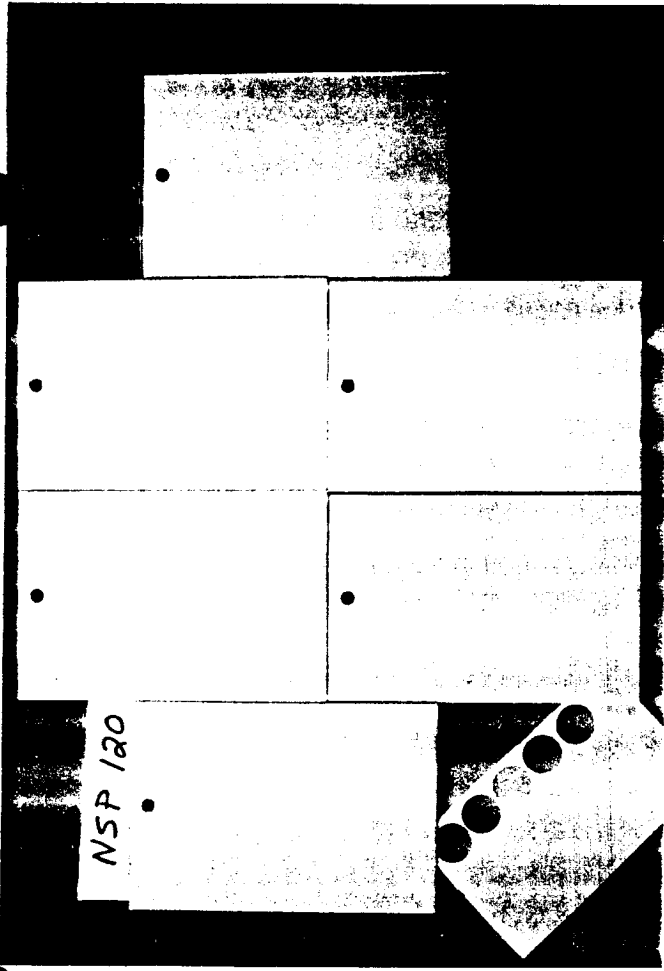


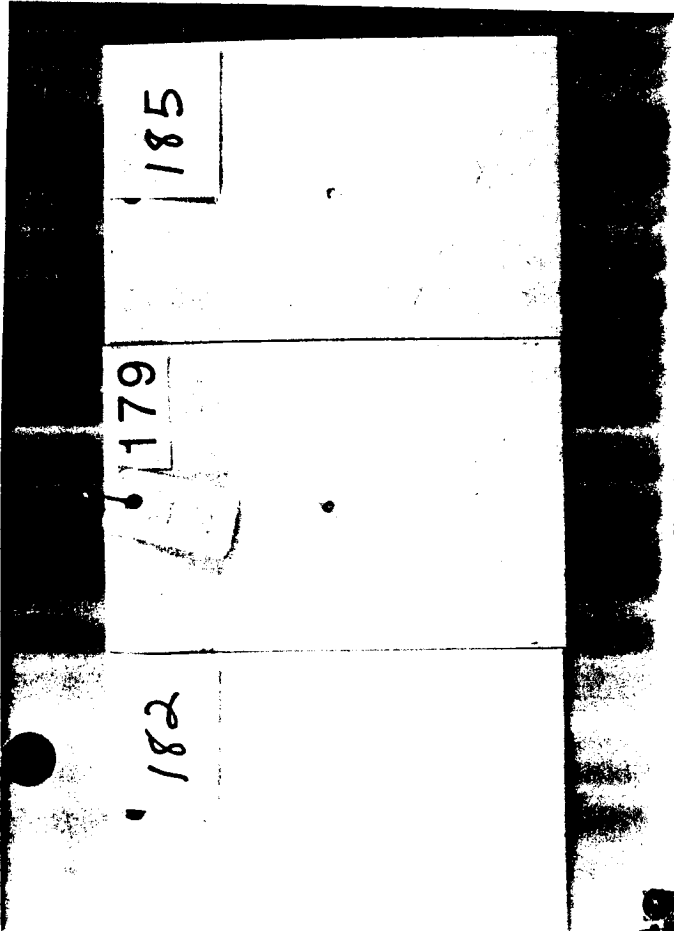
Aluminum

Stainless

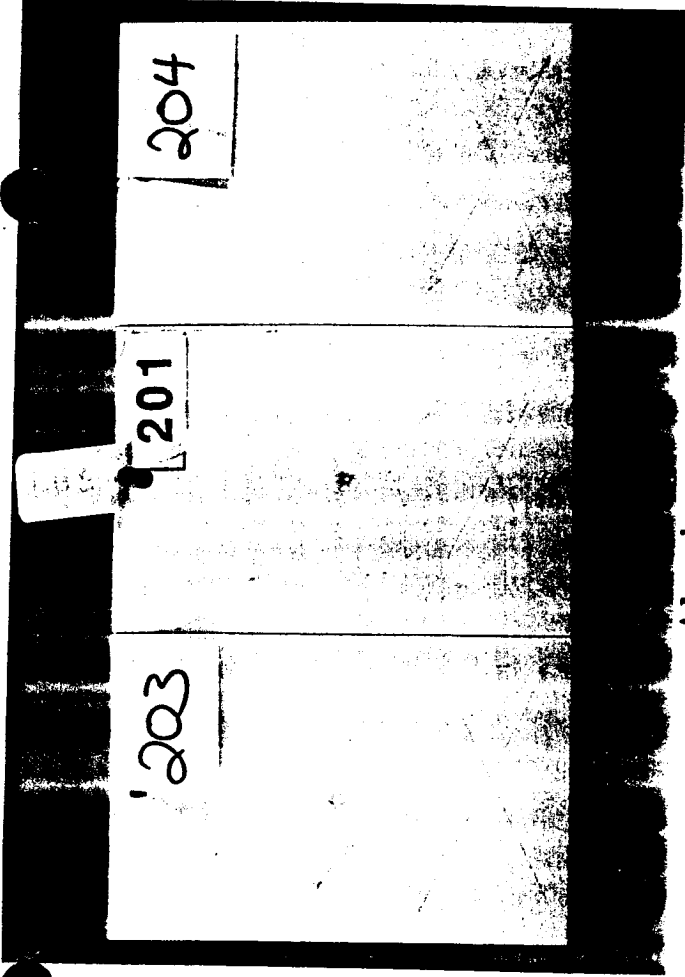


CPVC

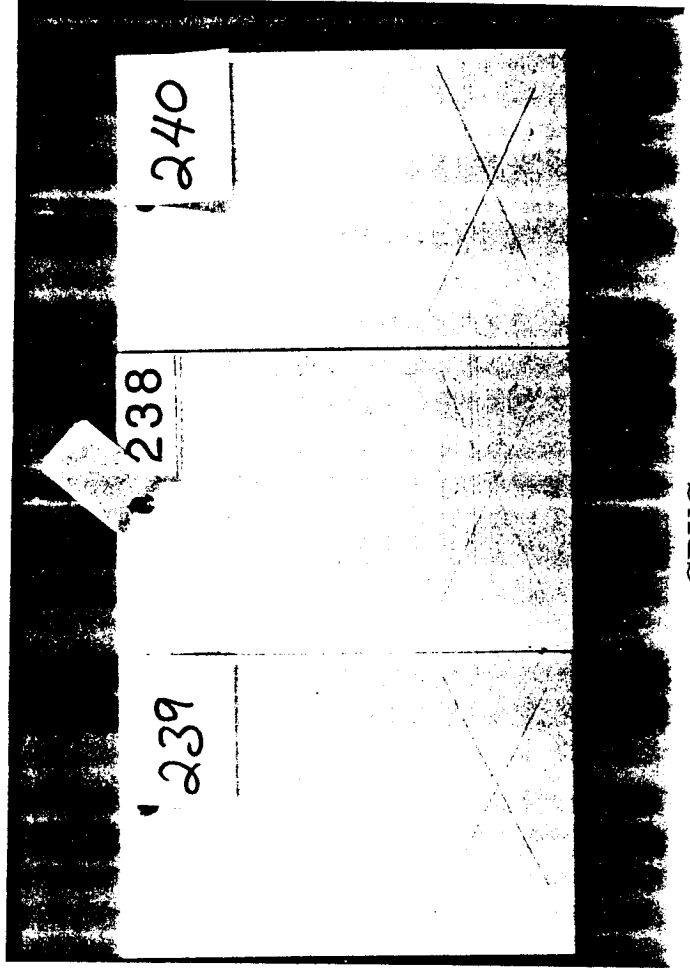




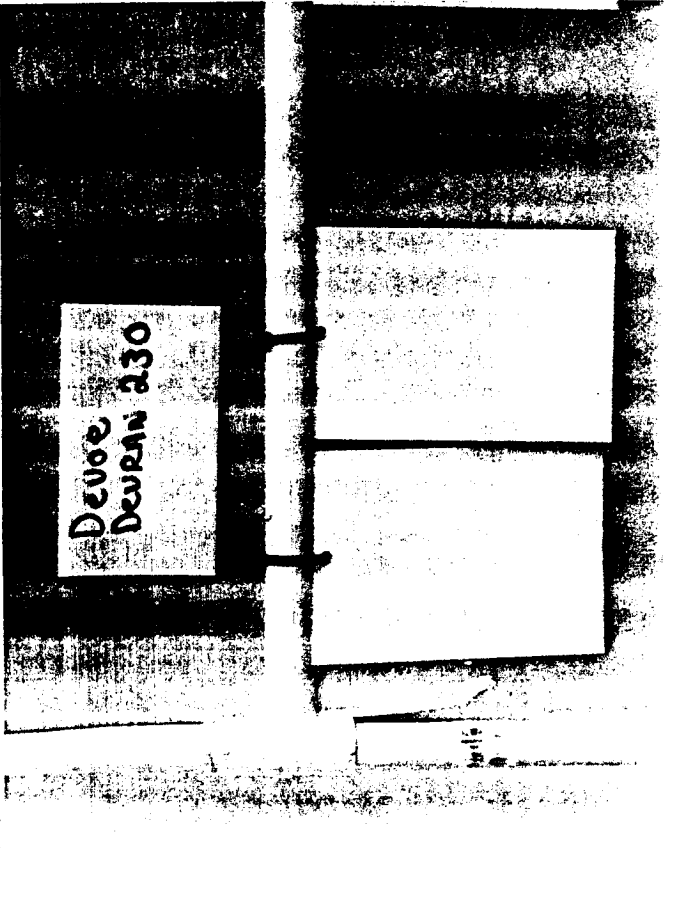
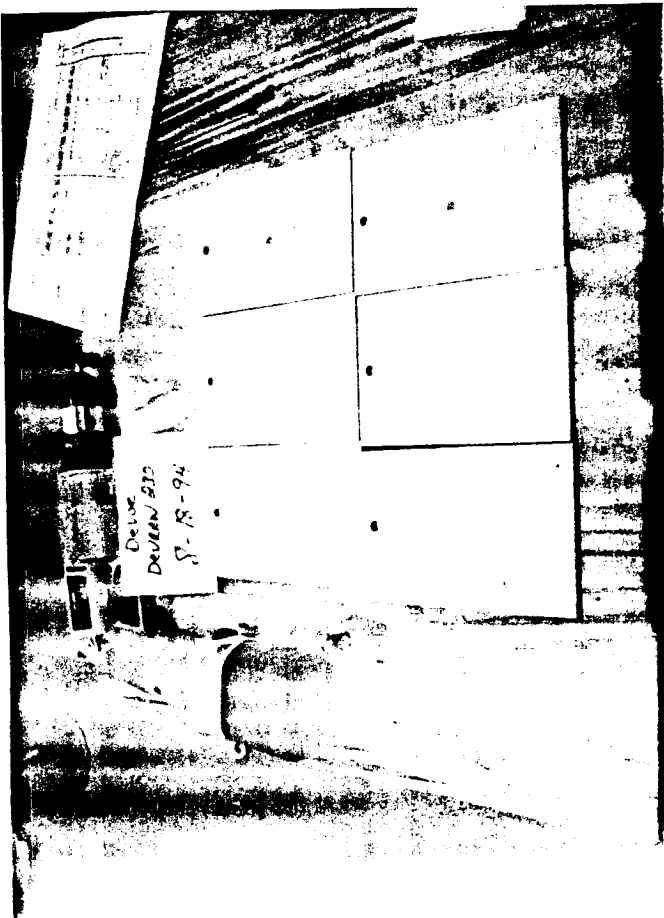
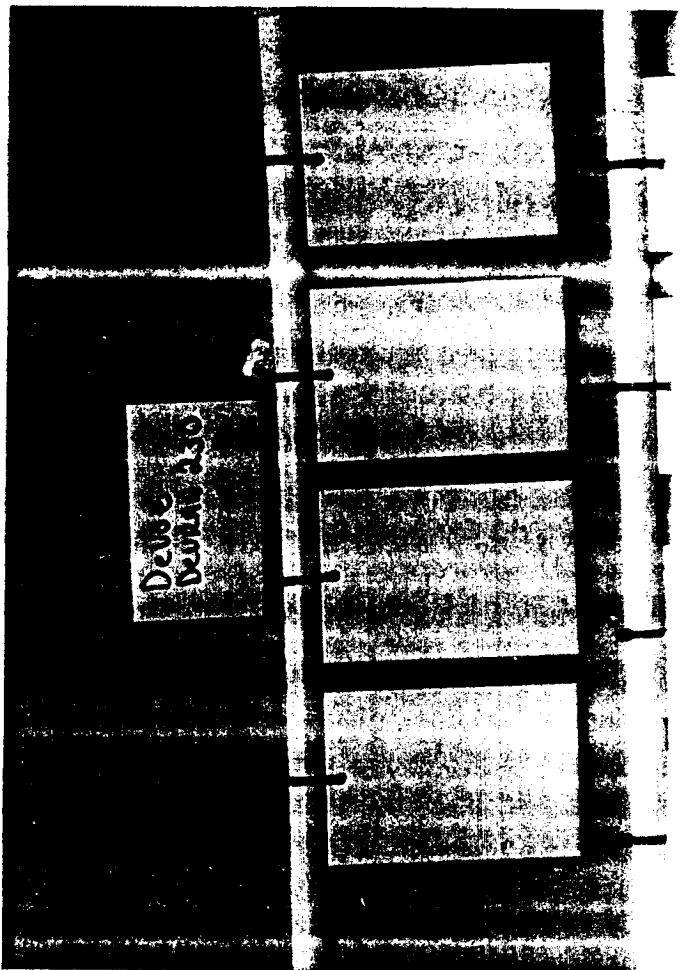
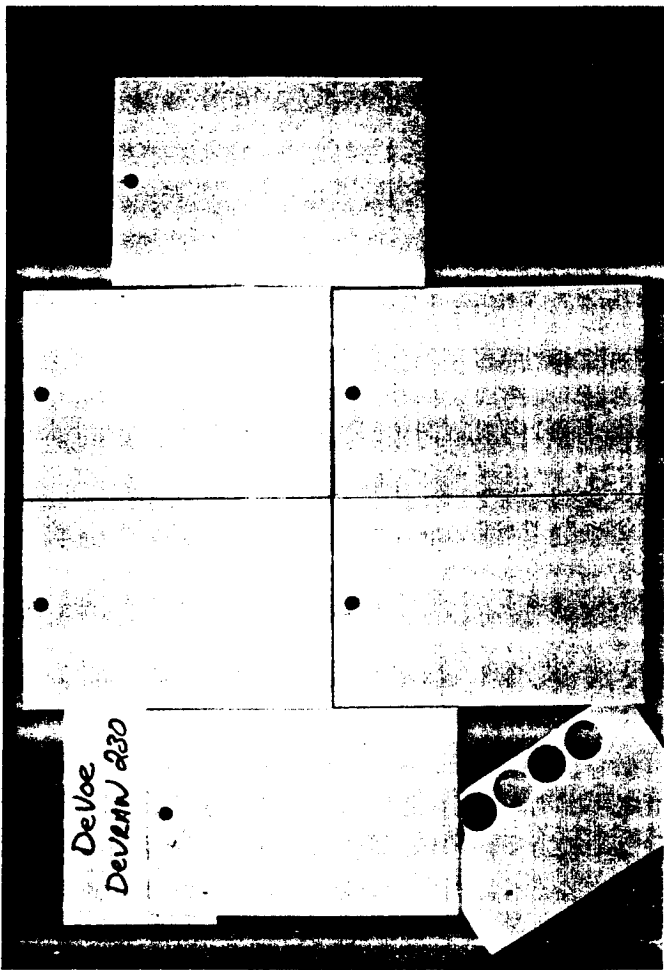
Stainless

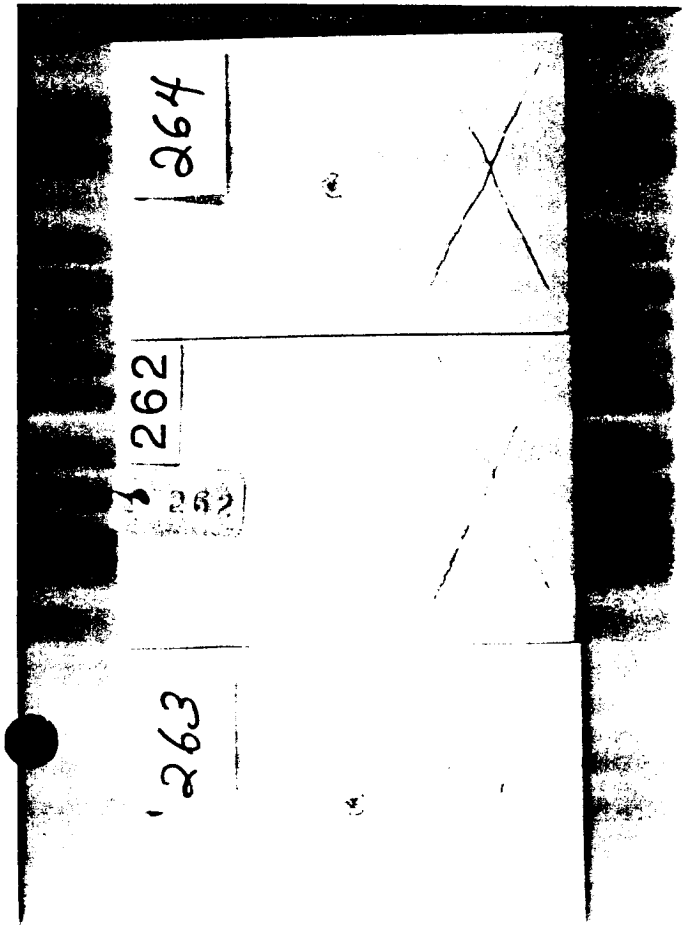


Aluminum

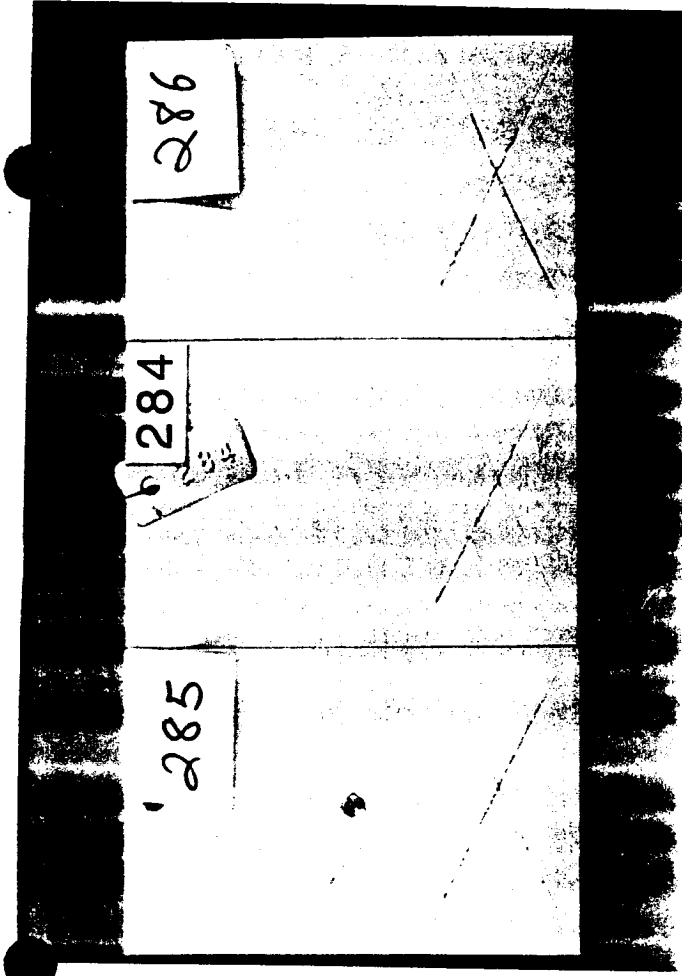


CPVC

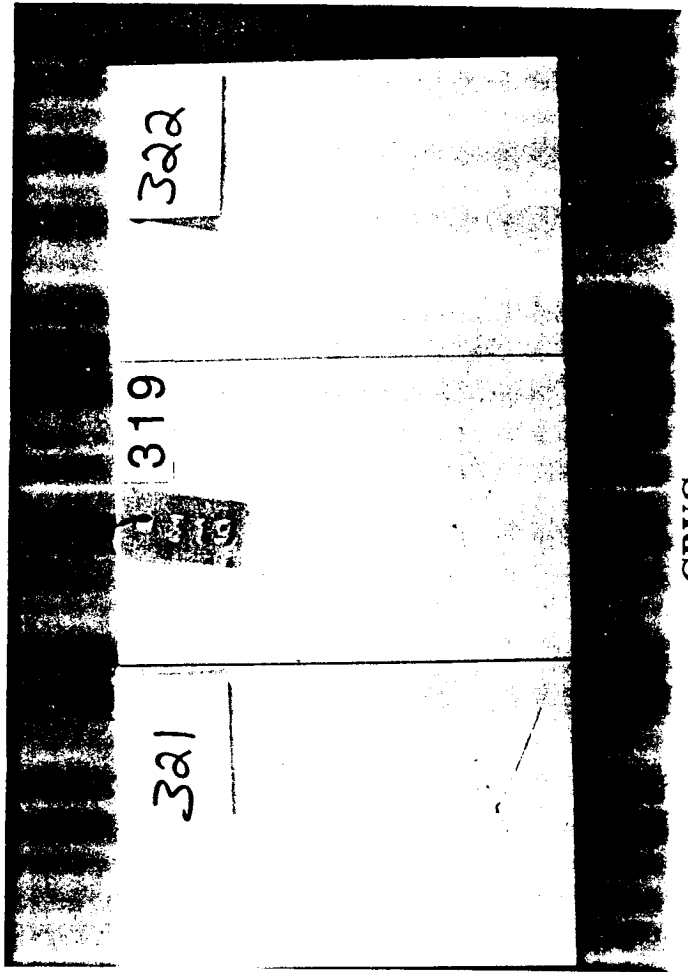




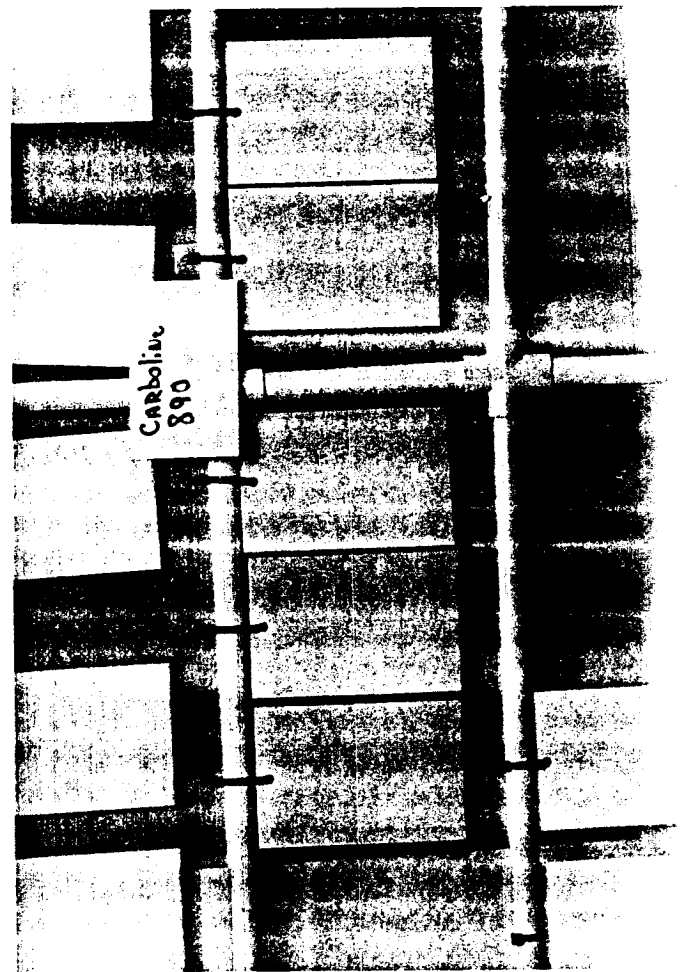
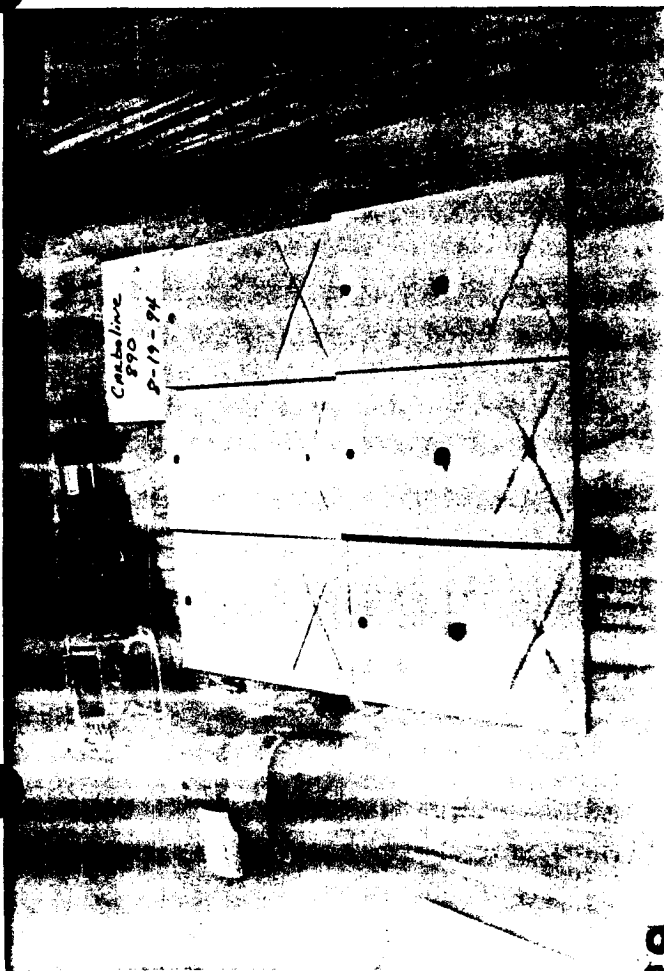
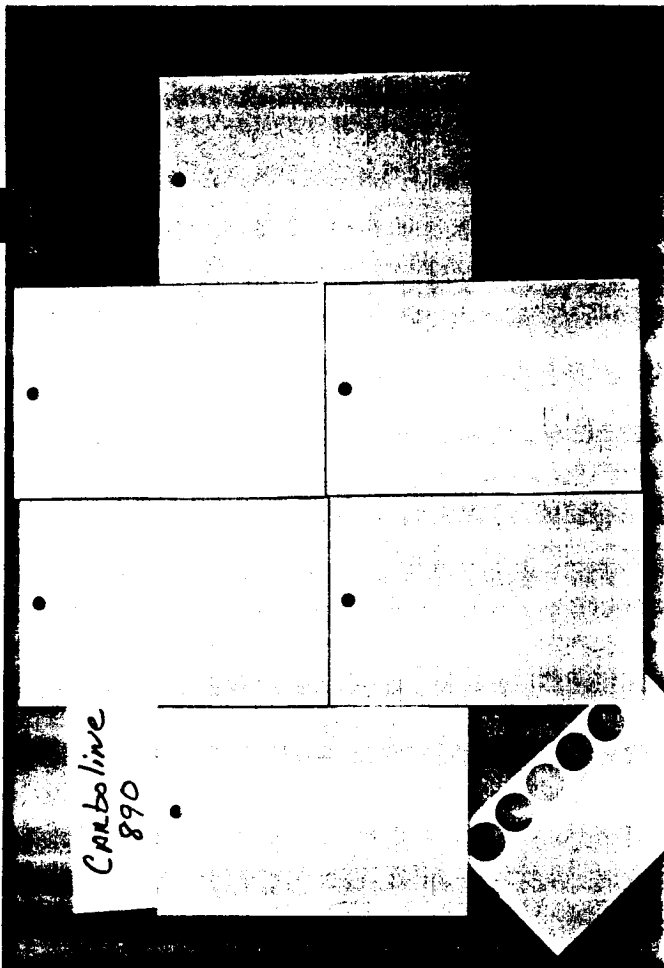
Stainless



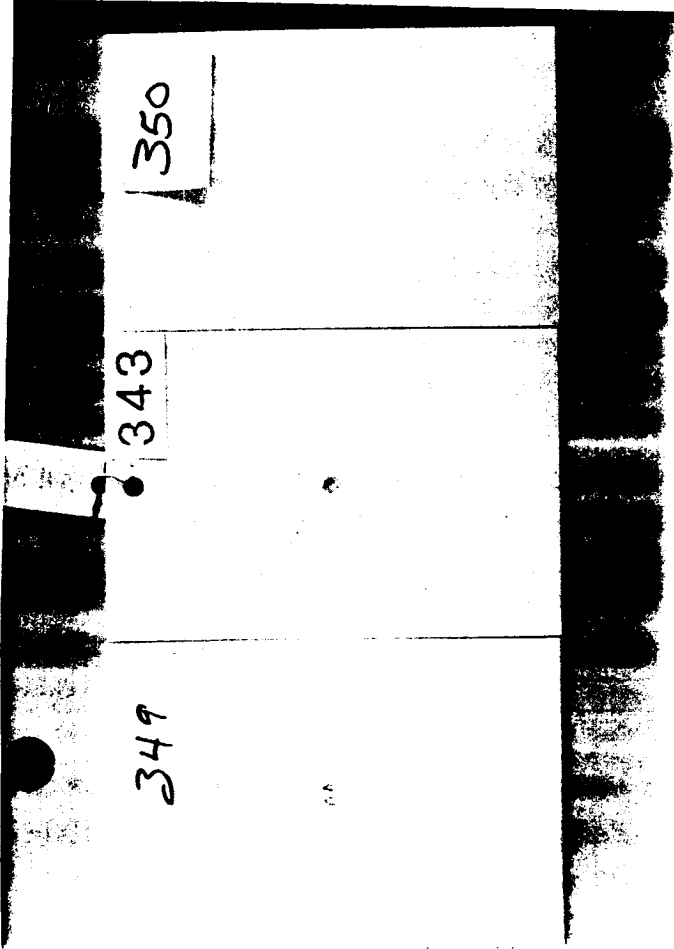
Aluminum



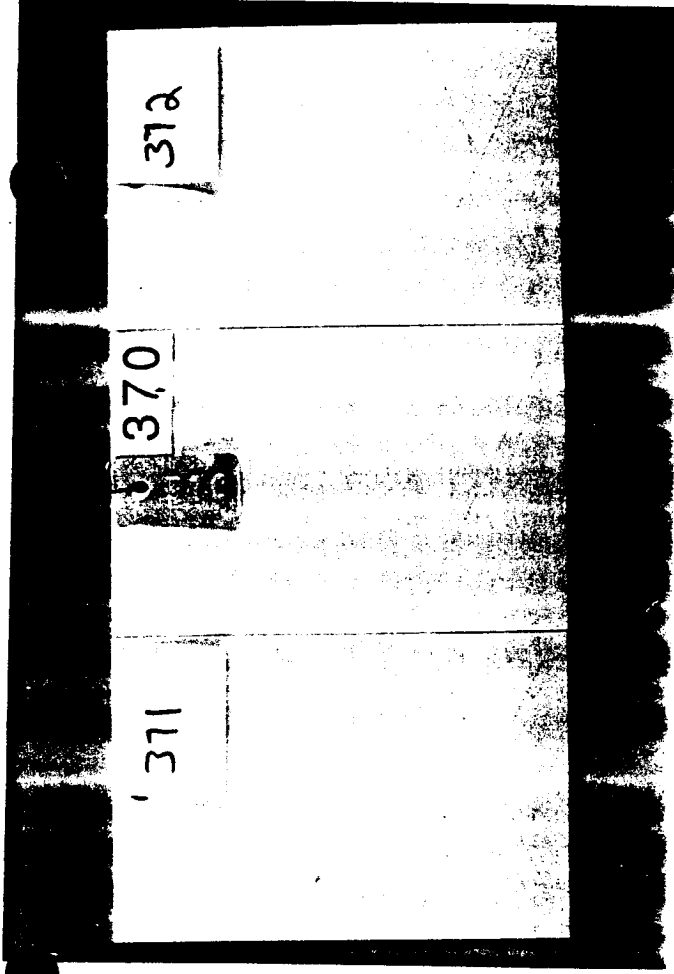
CPVC



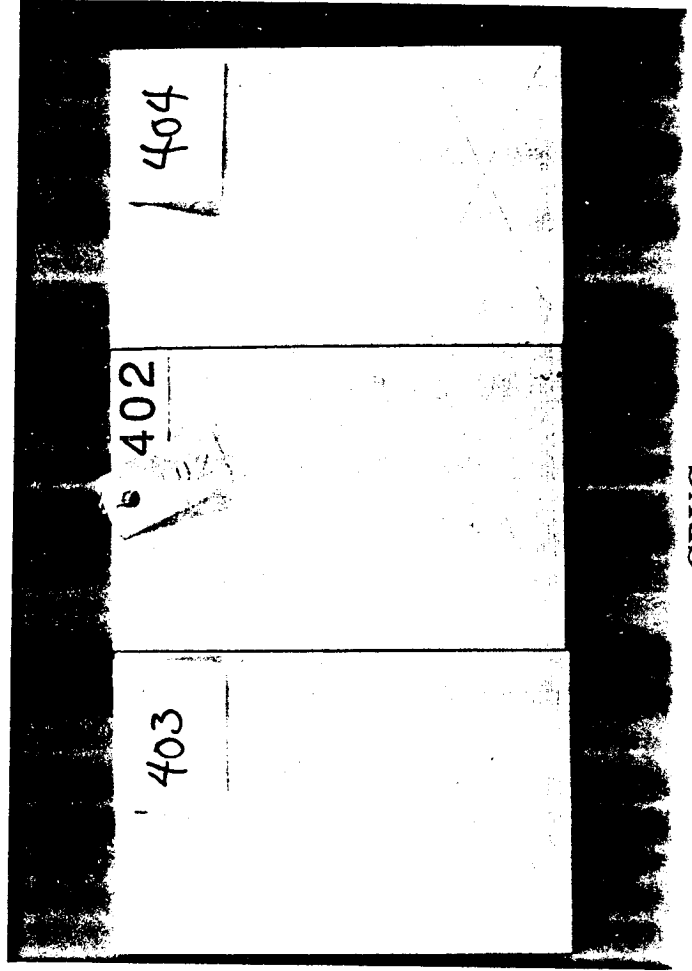
ORIGINAL PAGE IS
OF POOR QUALITY



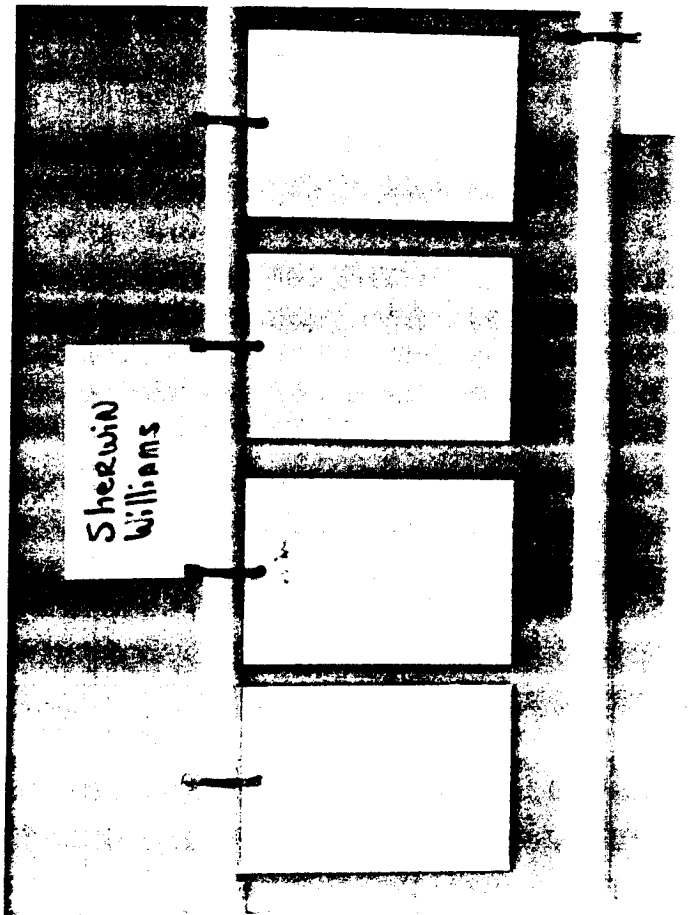
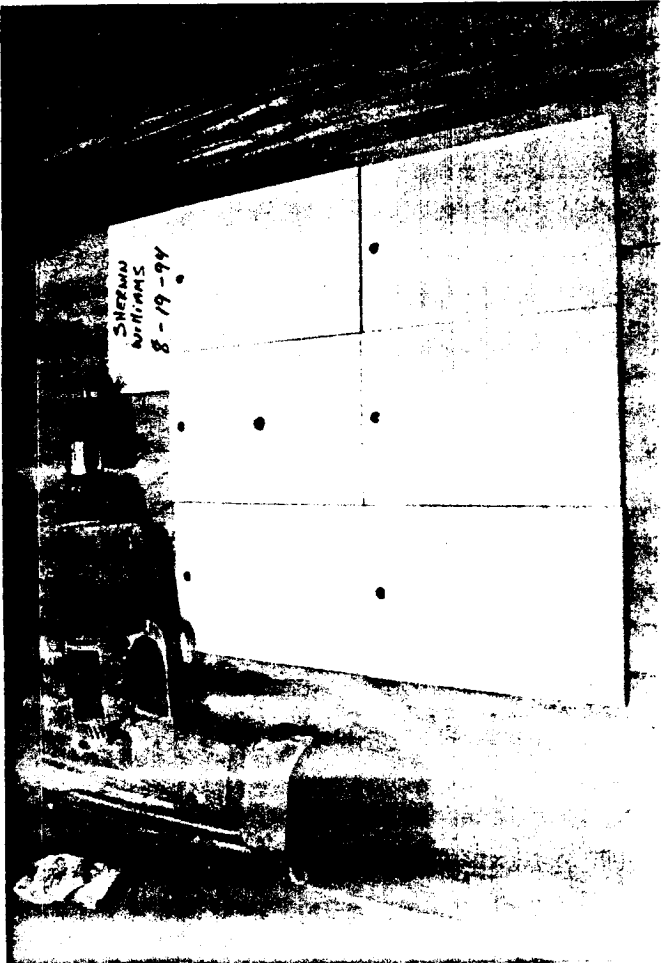
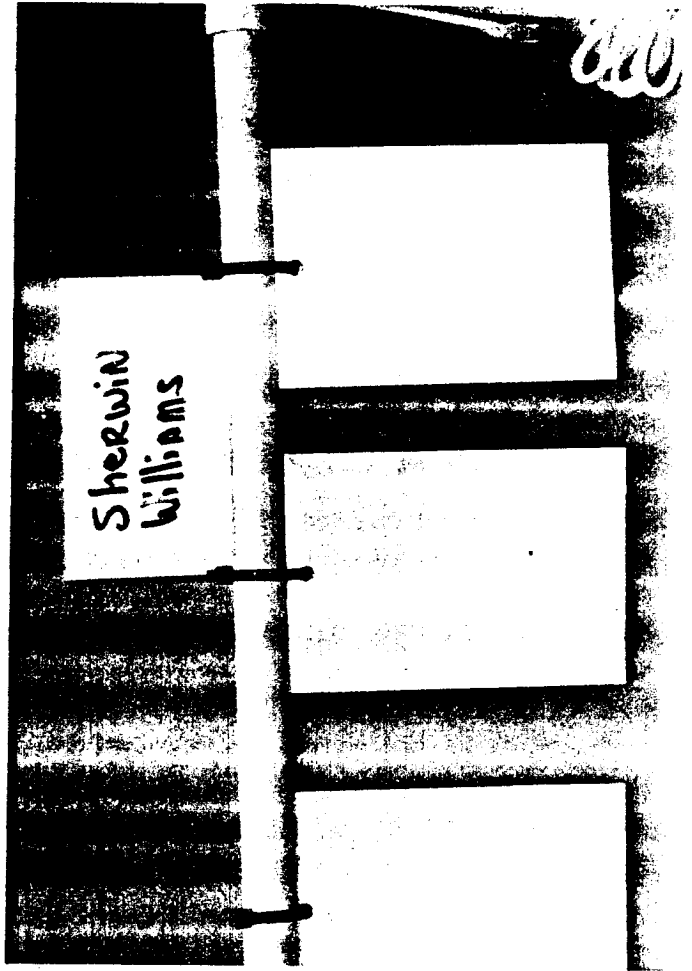
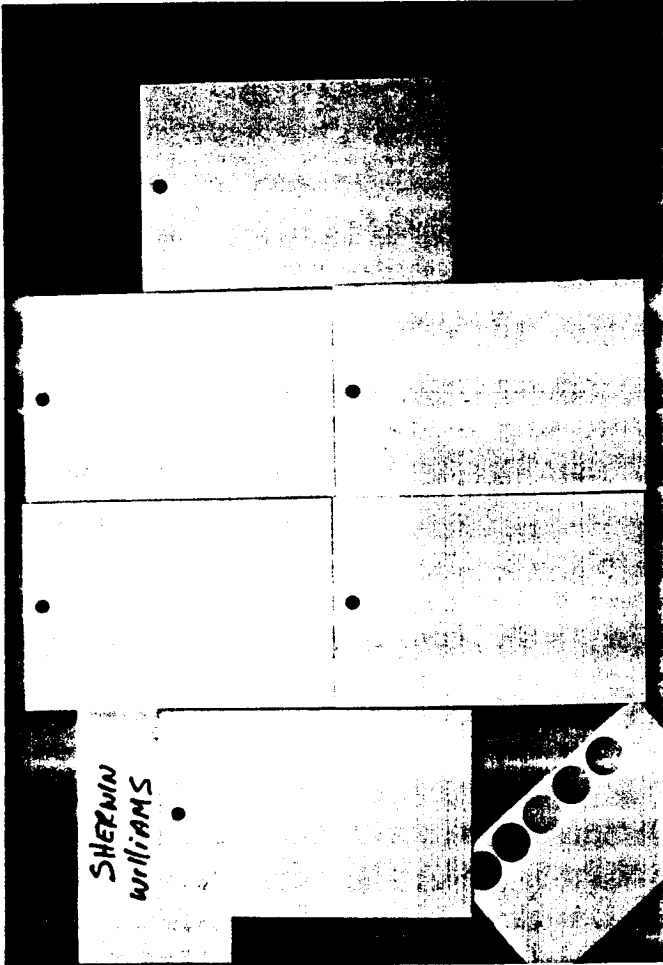
Stainless



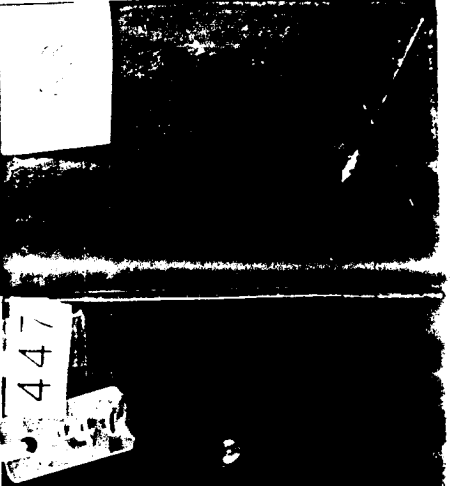
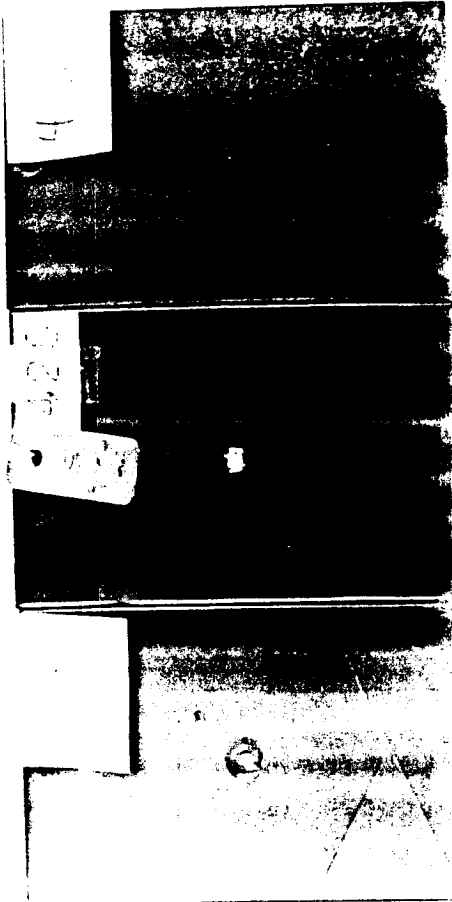
Aluminum



CPVC



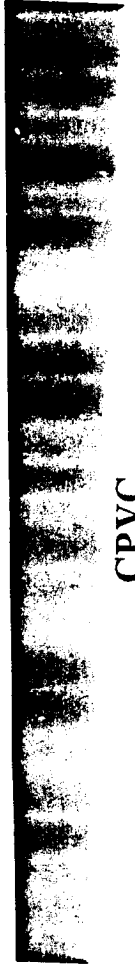
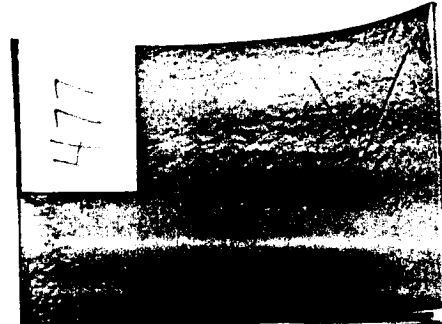
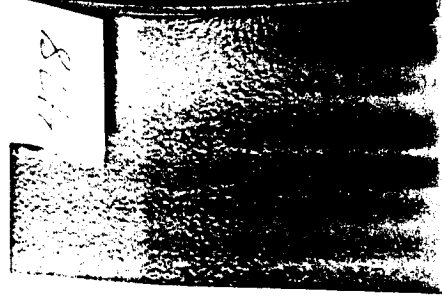
ORIGINAL PAGE IS
OF POOR QUALITY



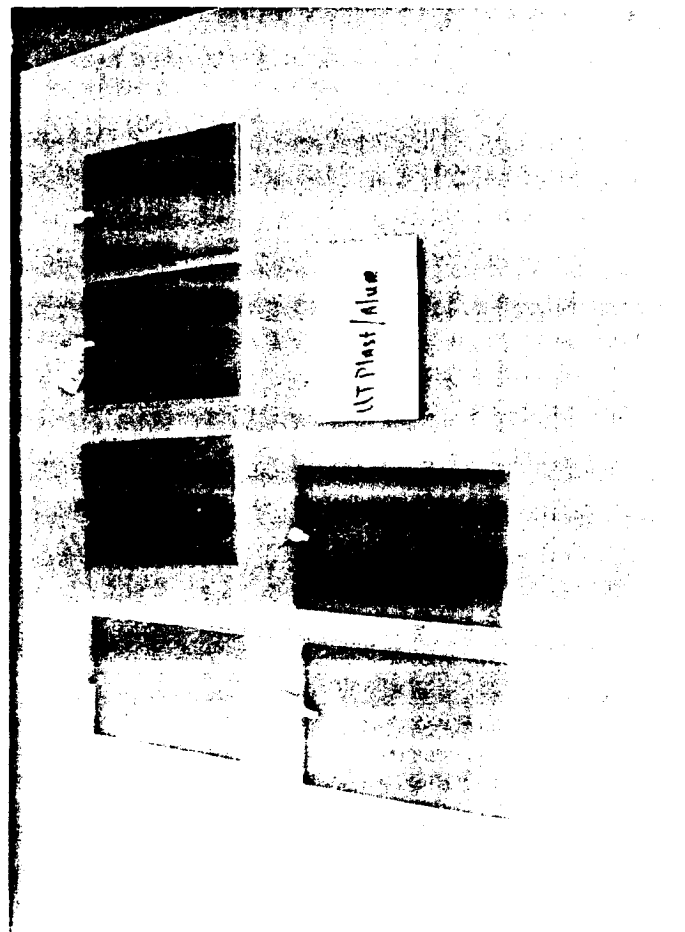
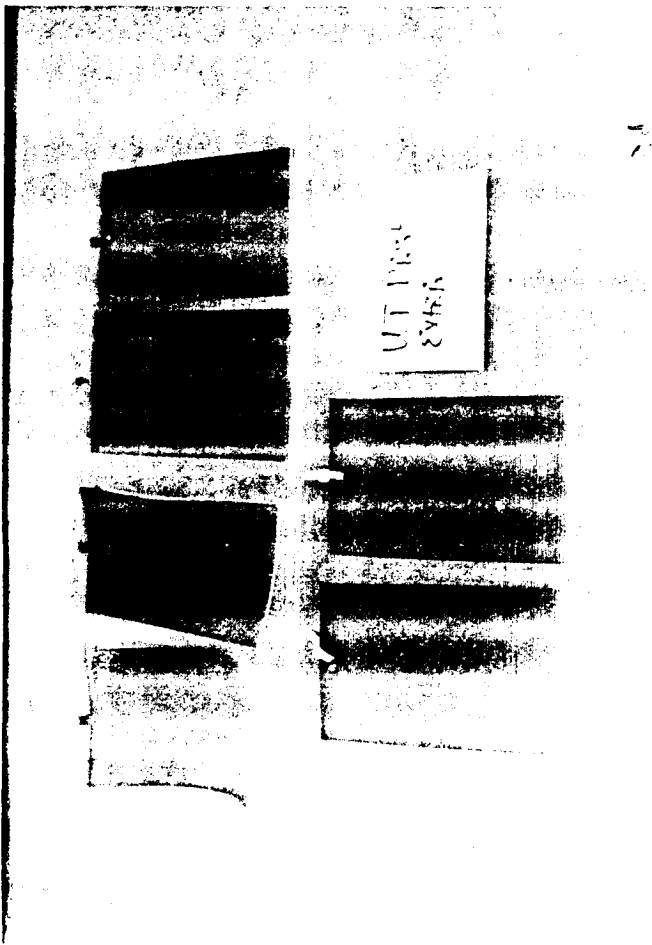
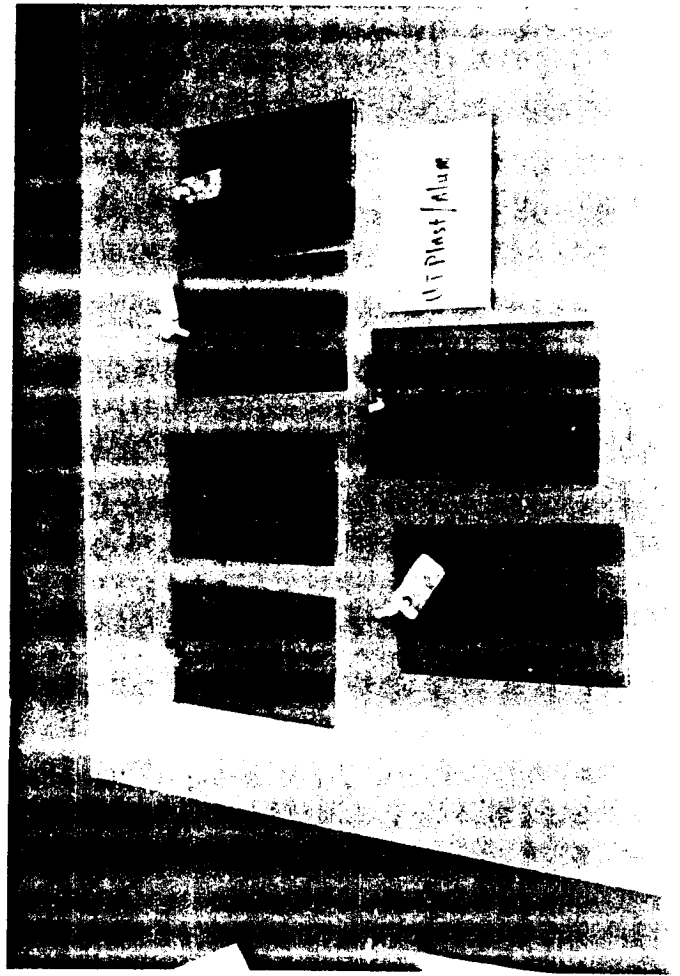
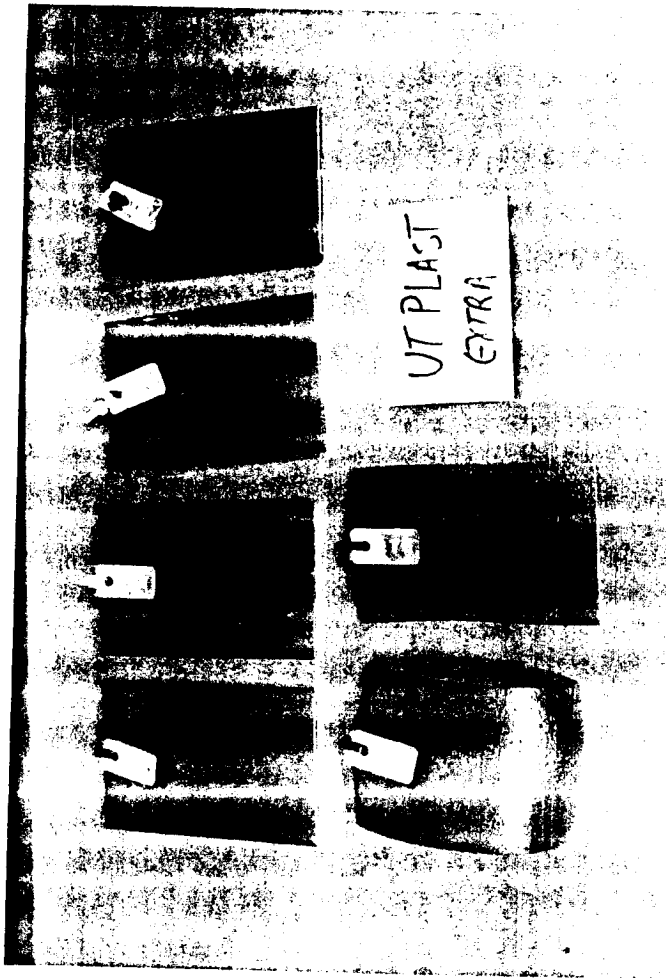
Stainless

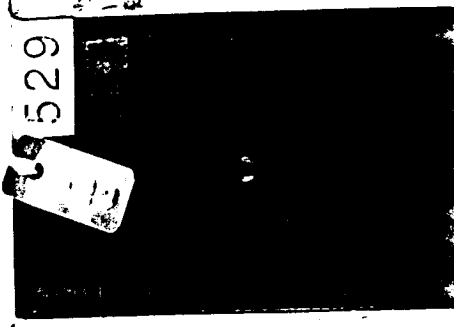


Aluminum



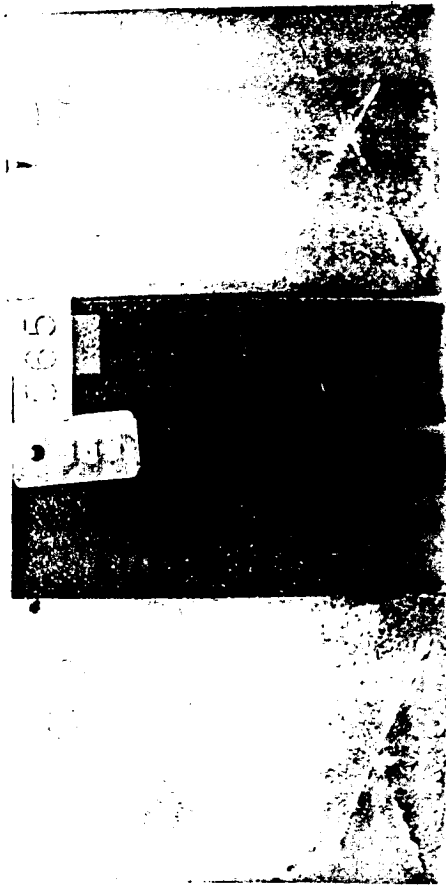
CPVC





Stainless

Aluminum



CPVC

ORIGINAL PAGE IS OF POOR QUALITY

536

531

508

531

565

529

591

590

592

613

612

614

Stainless

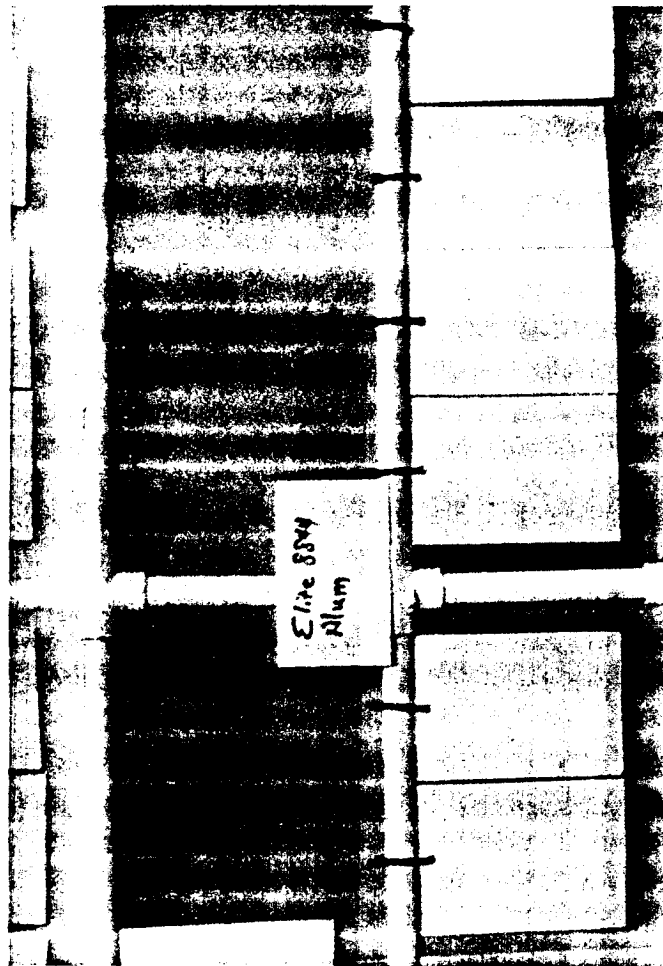
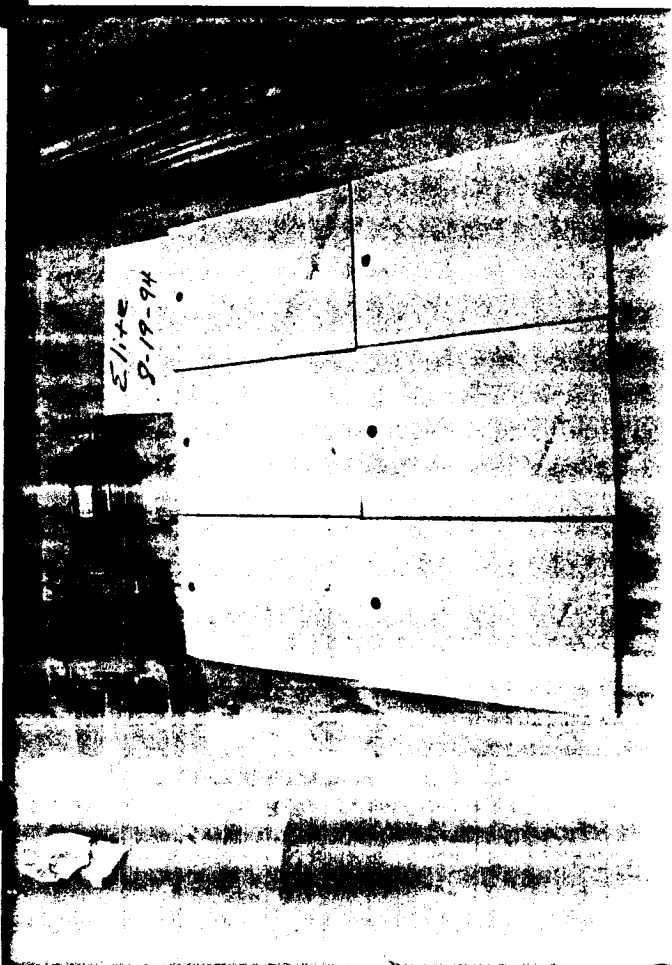
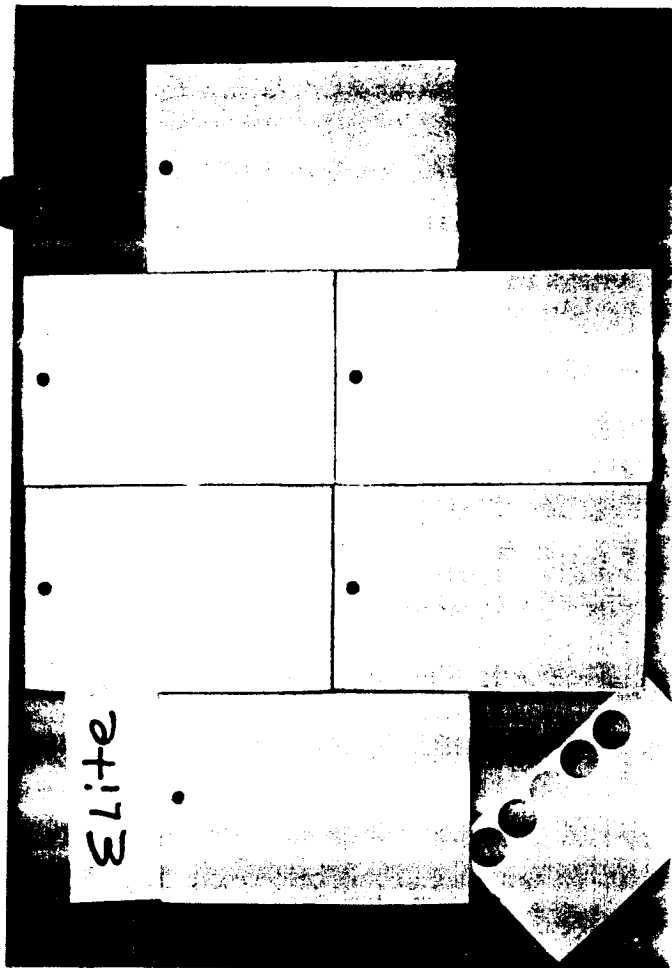
Aluminum

647

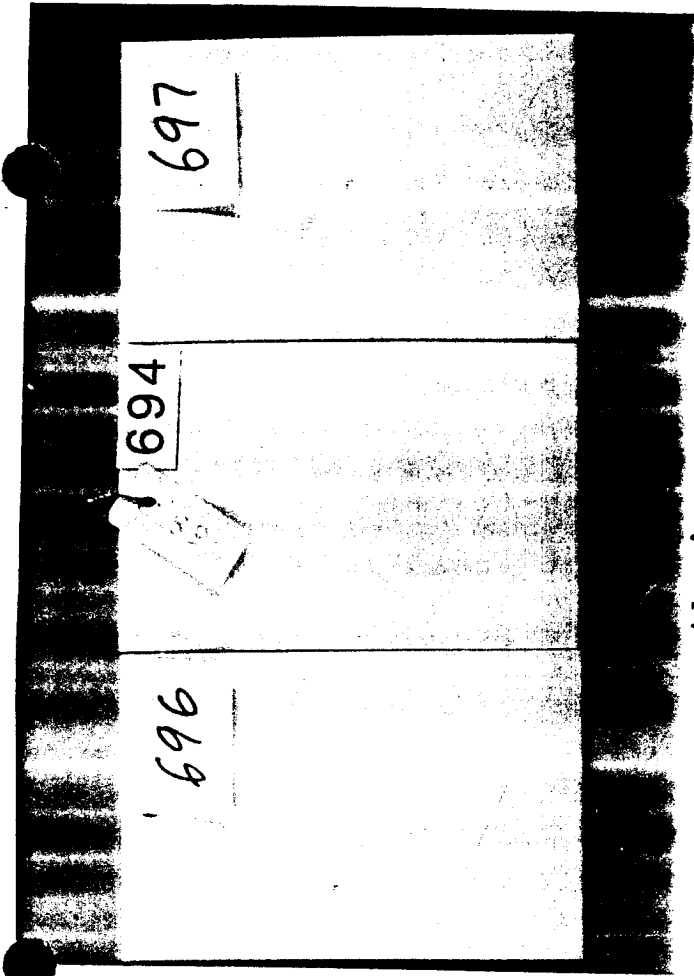
645

648

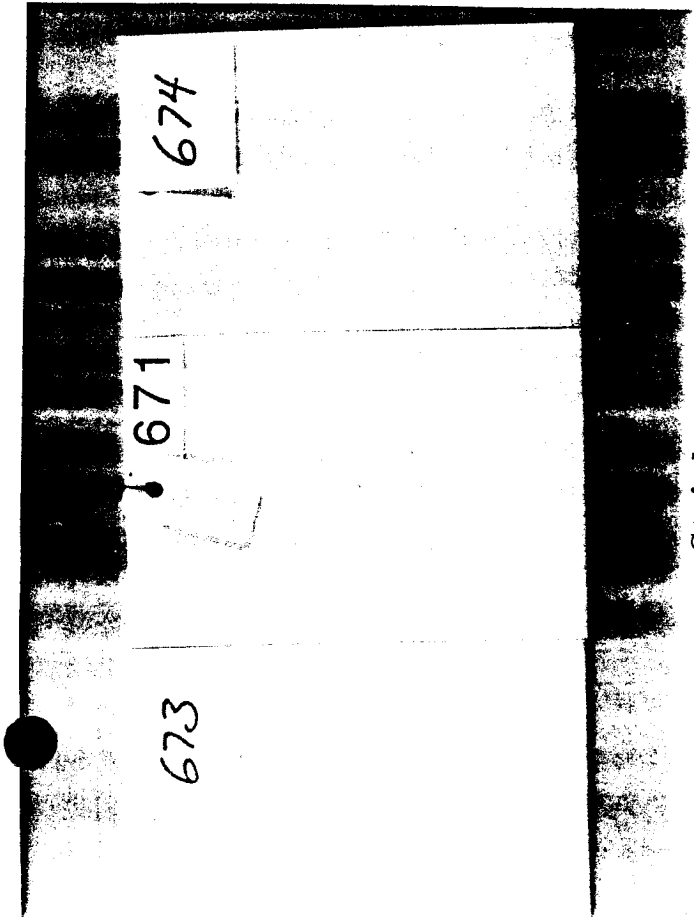
CPVC



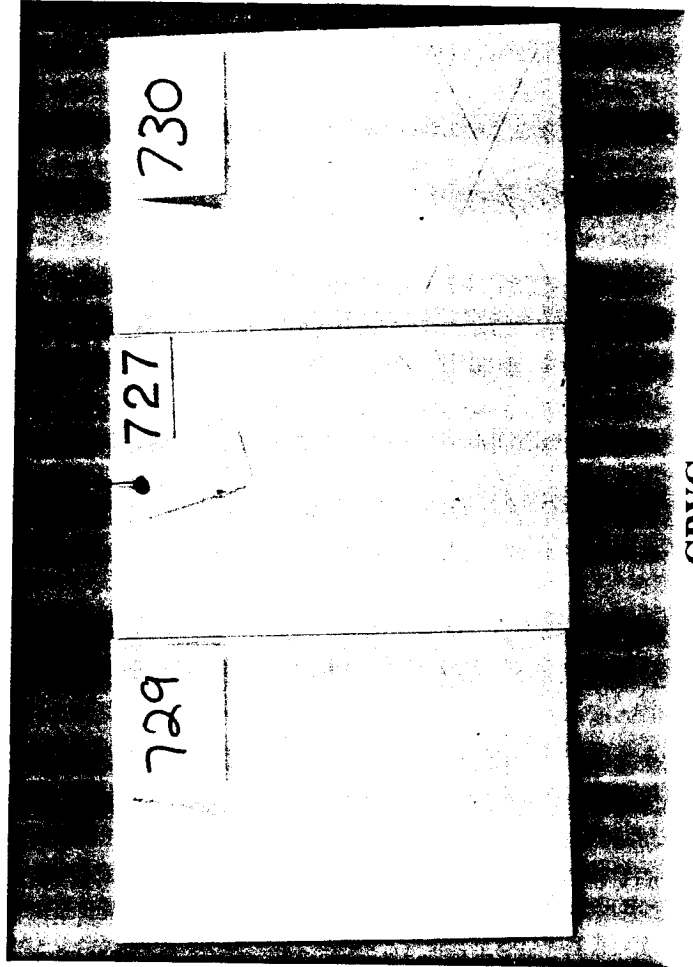
ORIGINAL PAGE IS
OF POOR QUALITY



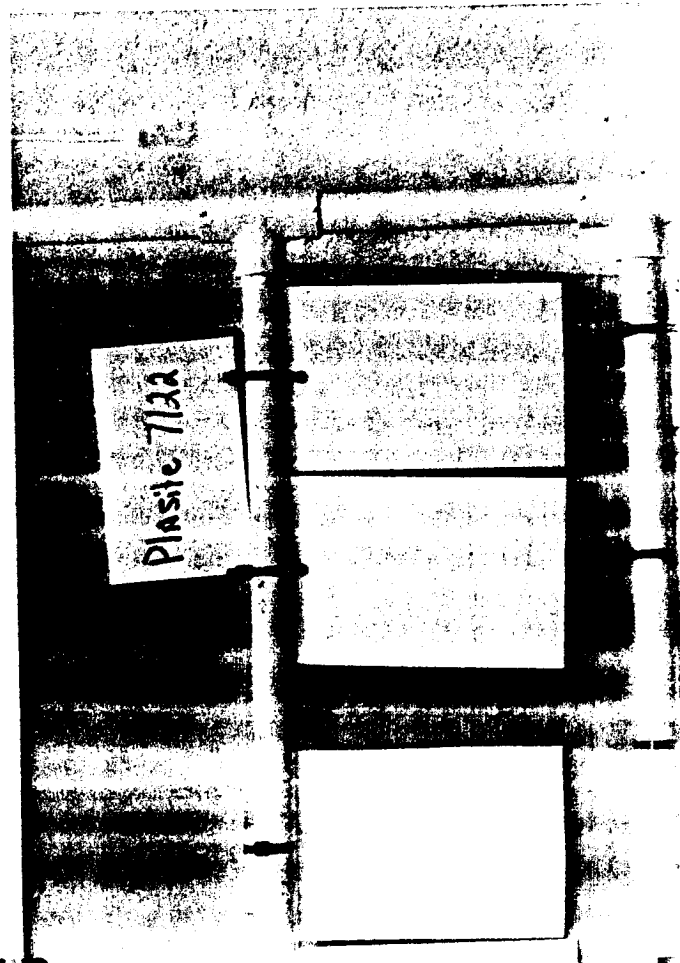
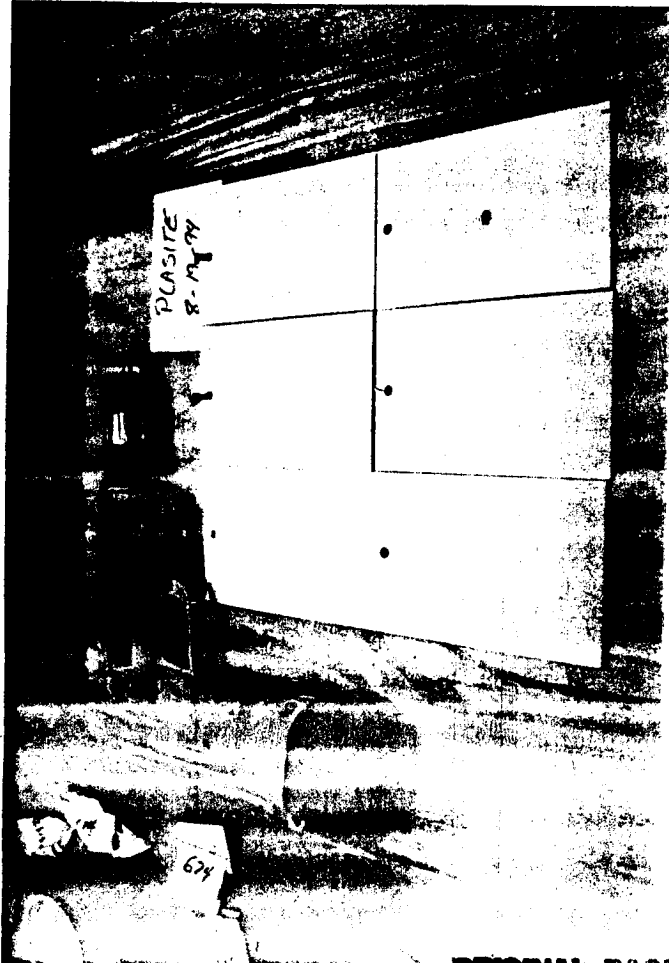
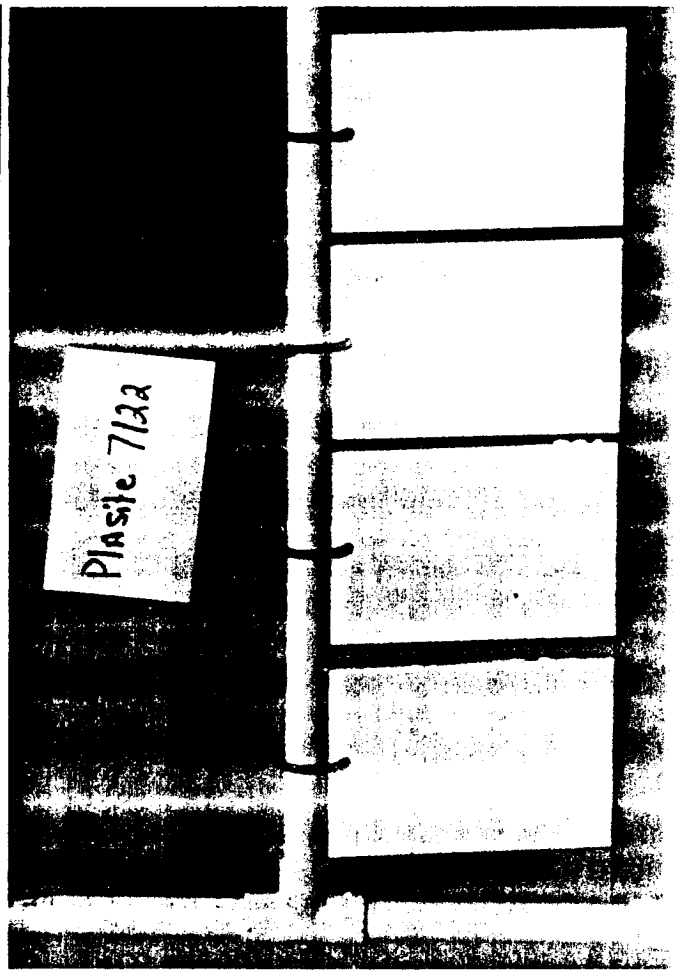
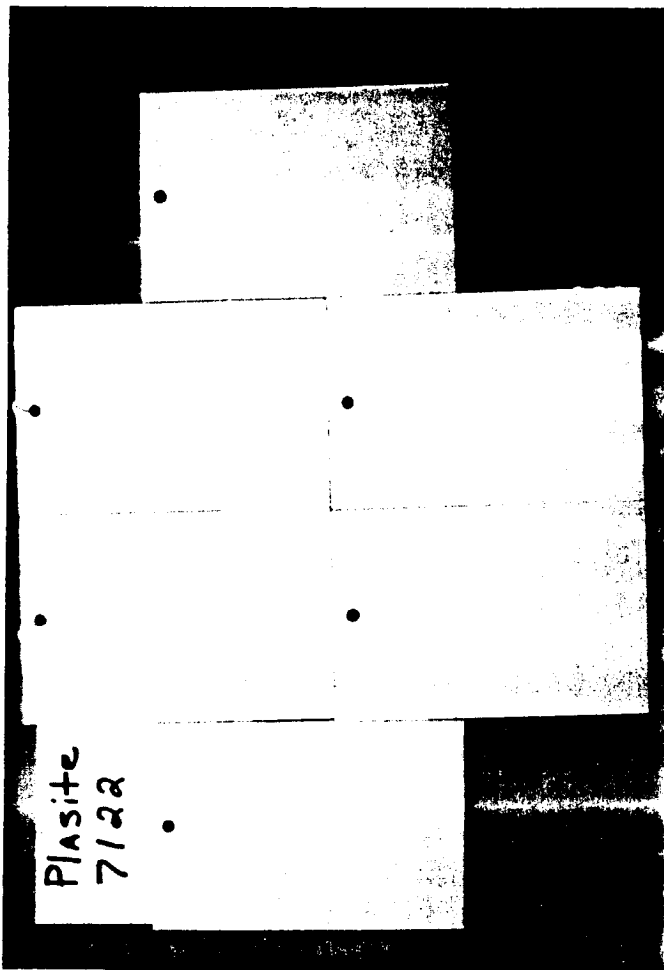
Aluminum



Stainless



CPVC



'756

755

759

Stainless

777

774

779

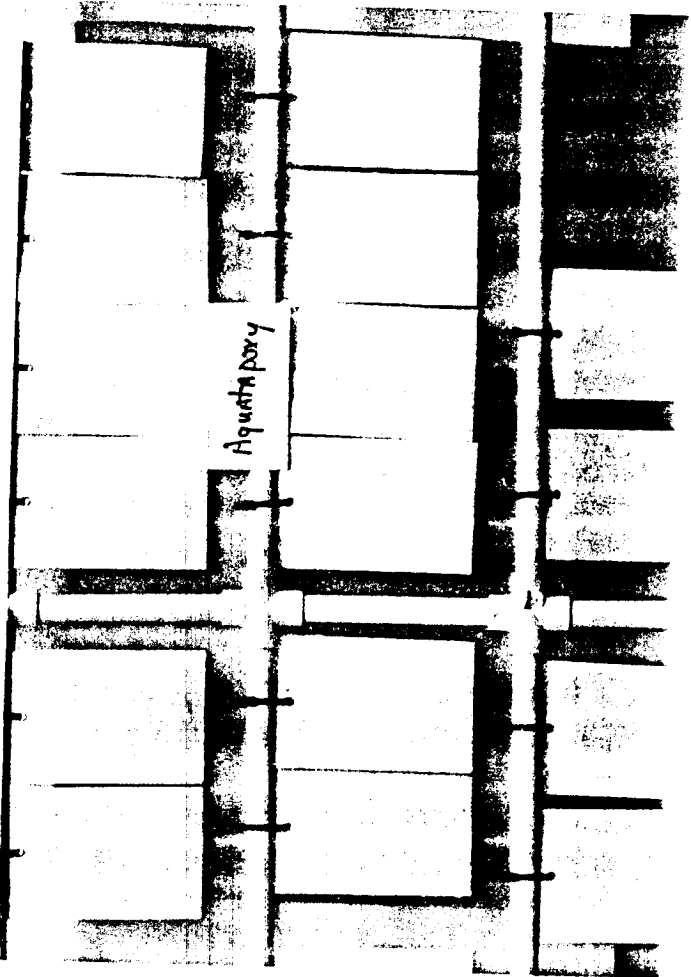
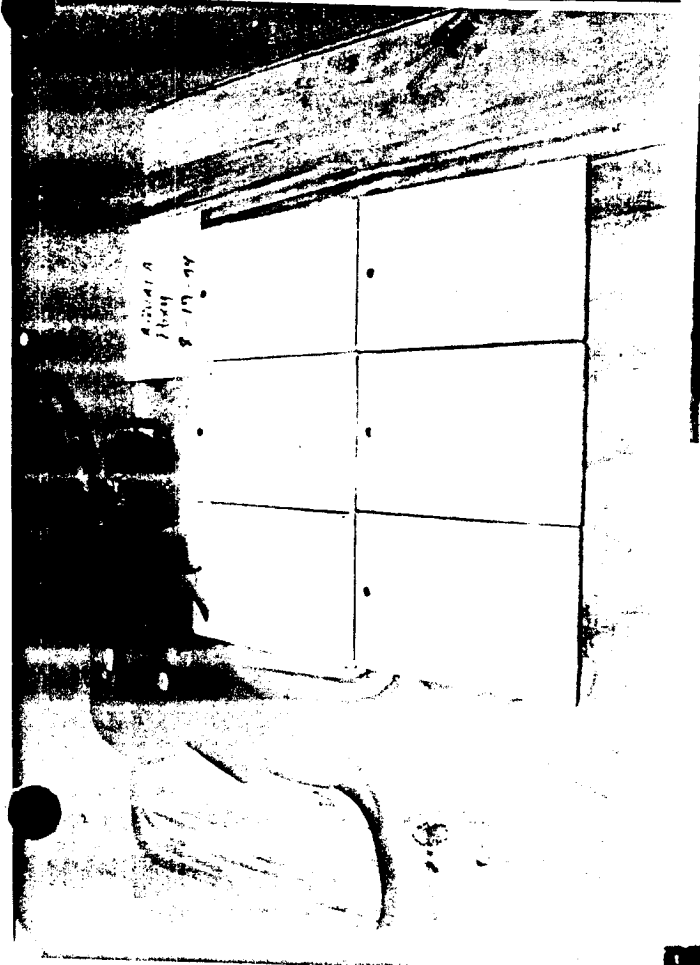
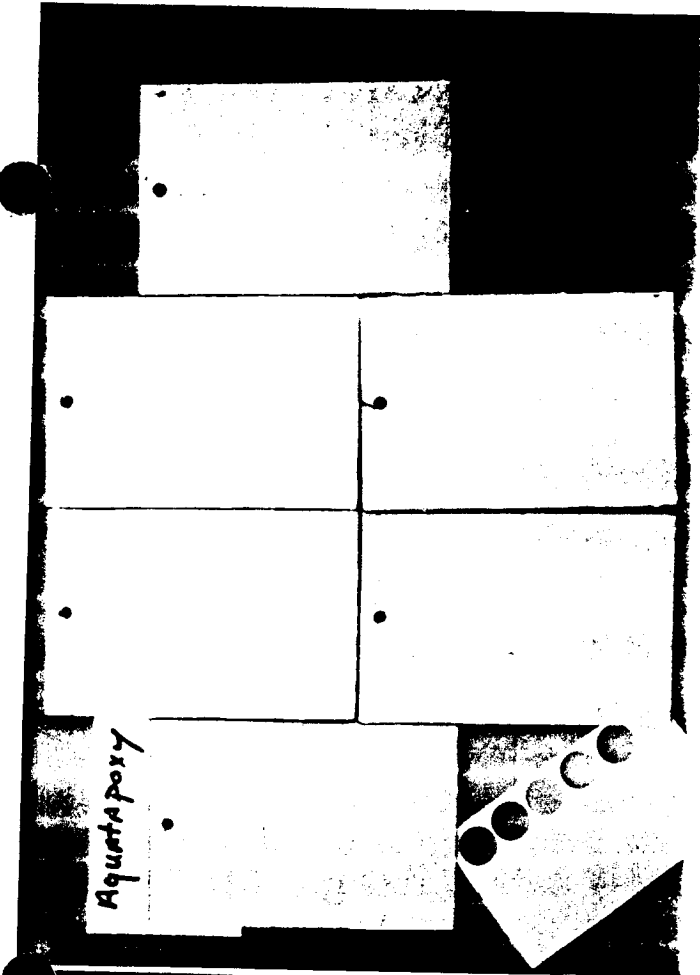
Aluminum

'811

810

812

CPVC



APPENDIX C
Photographic Presentation of Panels

WETF Pool- Cathode Panels

Two Systems per Page:

| |
|-----------------|
| Stainless Steel |
| Stainless Steel |

| |
|----------|
| Aluminum |
| Aluminum |

FILE NO:

CONTROL

36

42

41

35

WETZ Pool Zinc Anodes
Type of Anode
NSP-112



5
4
3

CONTROL

117

123

124

118

WETZ Pool Zinc Anodes
Type of Anode
NSP-120



CONTROL

CONTROL

14

20

19

WETZ Pool Zinc Anodes
Type of Anode



ASSIGNMENT:

DATE:

CONTROL

96

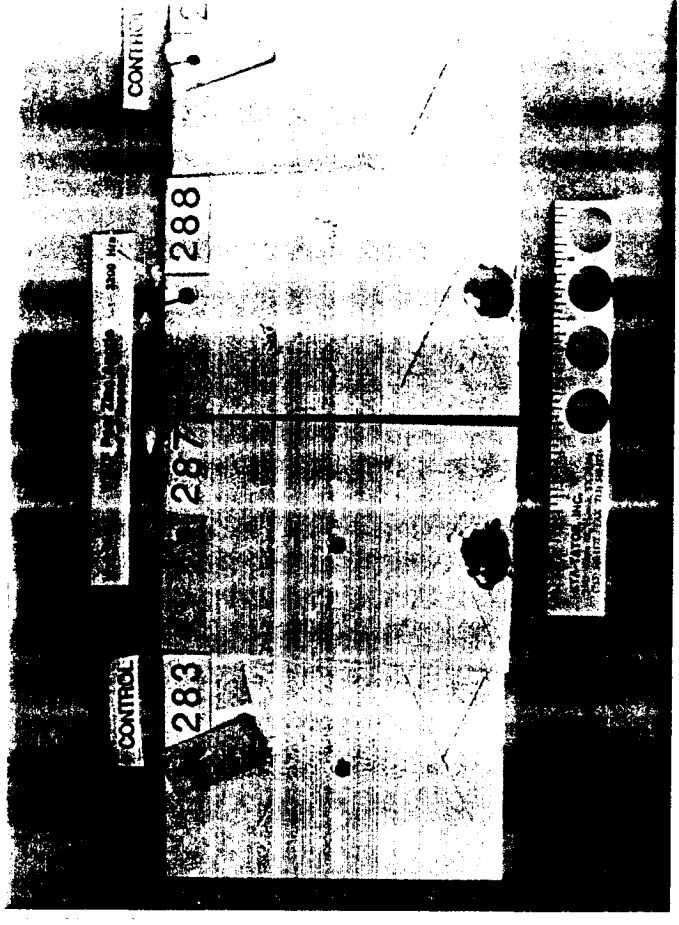
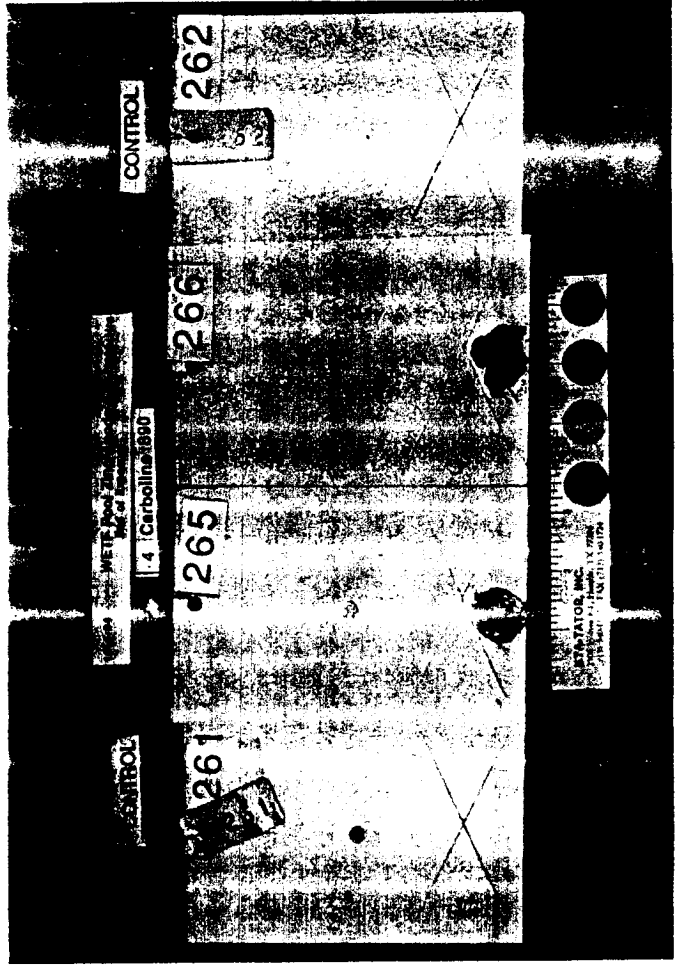
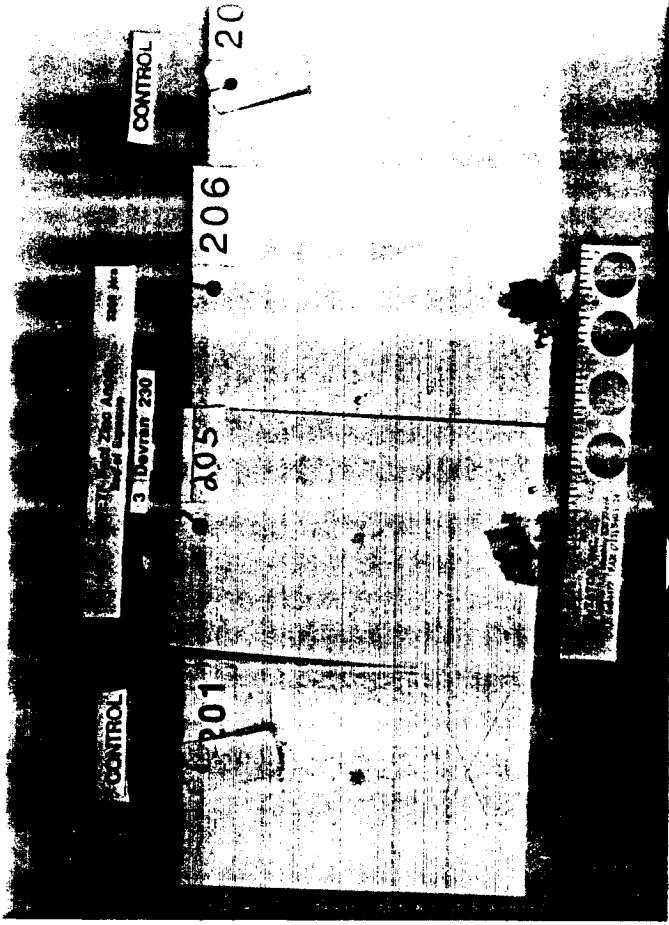
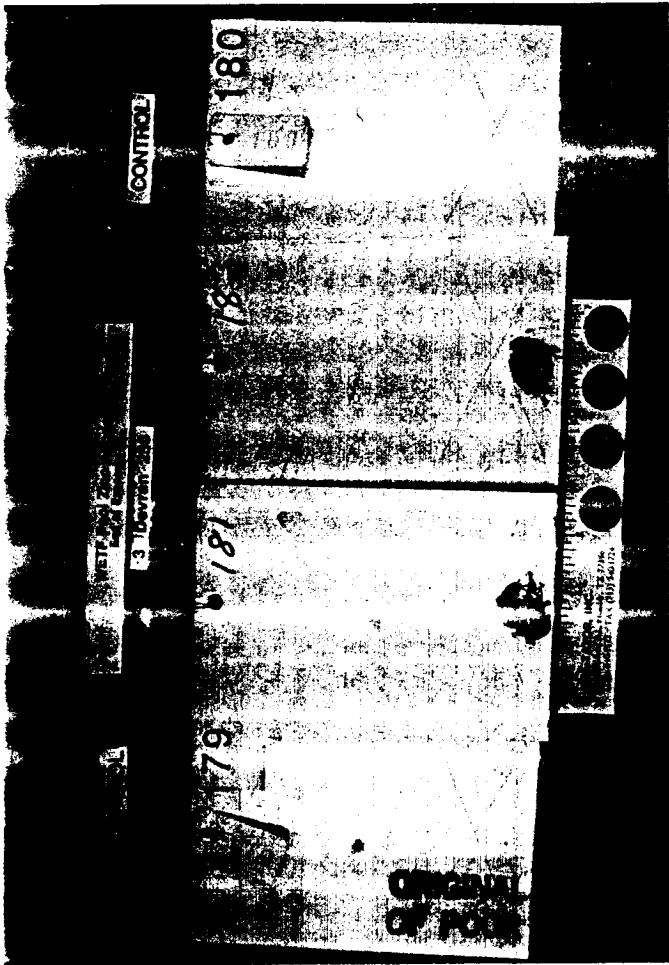
102

101

105

WETZ Pool Zinc Anodes
Type of Anode
NSP-120





DATE

ITEMNO1222A

WFE MOI

VIDEO SERVICES
FOR FILM

NO. BOX 601938 - OBTAINING 11 33890 - (401) 888-2100

SLATE NO 32-86

10-4-84

WETF Pool Zinc Anode
End of Exposure
7 UT Plast/Alum

CONTROL

507

511

512

508

CONTROL

508



10-4-84

WETF Pool Zinc Anode
End of Exposure
7 UT Plast/Alum

CONTROL

530

533

532

535



10-4-84

WETF Pool Zinc Anode
End of Exposure
8 Elite 8844/Alum

CONTROL

590

594

593

589



10-4-84

WETF Pool Zinc Anode
End of Exposure
8 Elite 8844/Alum

CONTROL

612

616

615

61



10-4-84

WETF Pool Zinc Anode
End of Exposure
8 Elite 8844/Alum

CONTROL

612

616

615

61



STAD

ITMAM122A

RIE MO:

RYAN-TATOR, INC.
15770 W. 15th Ave.
Golden, CO 80230
303-279-1074

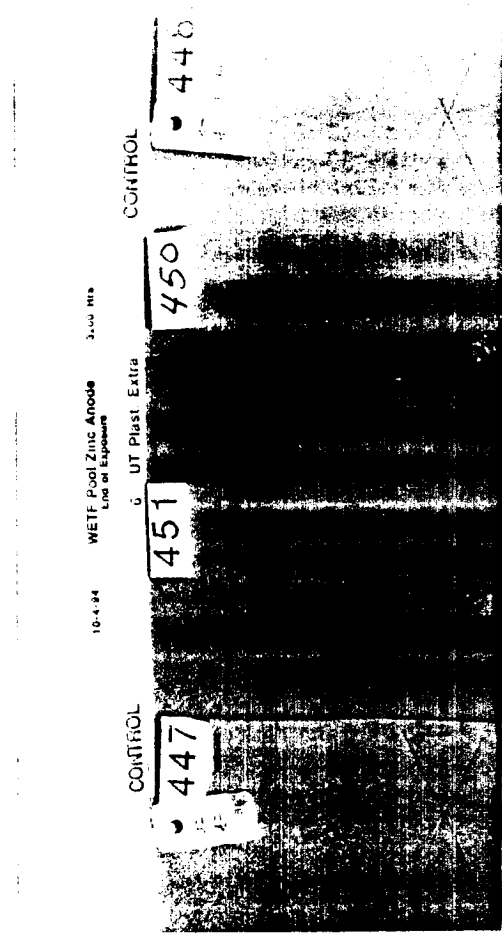
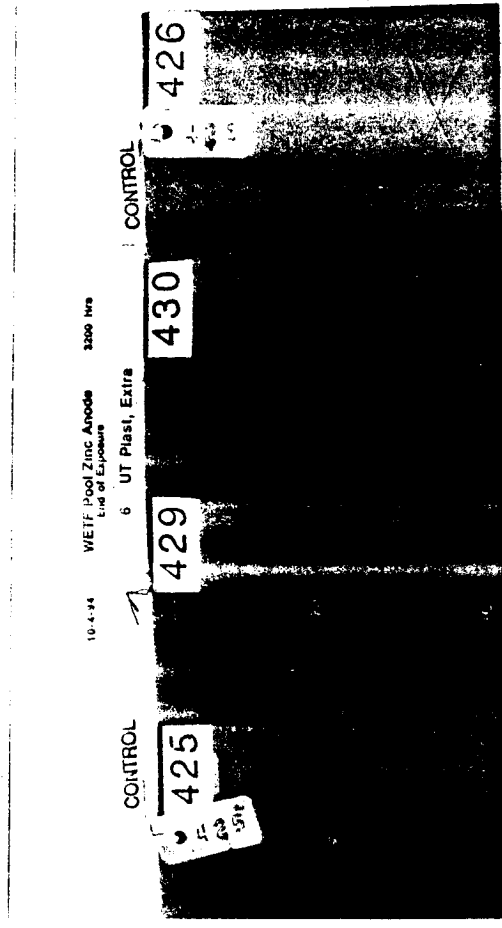
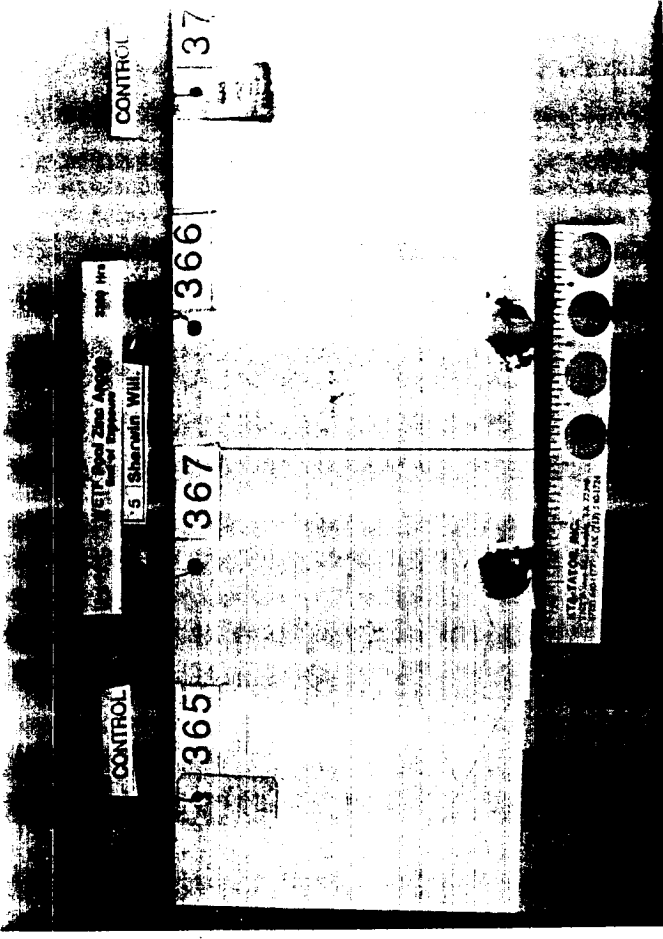
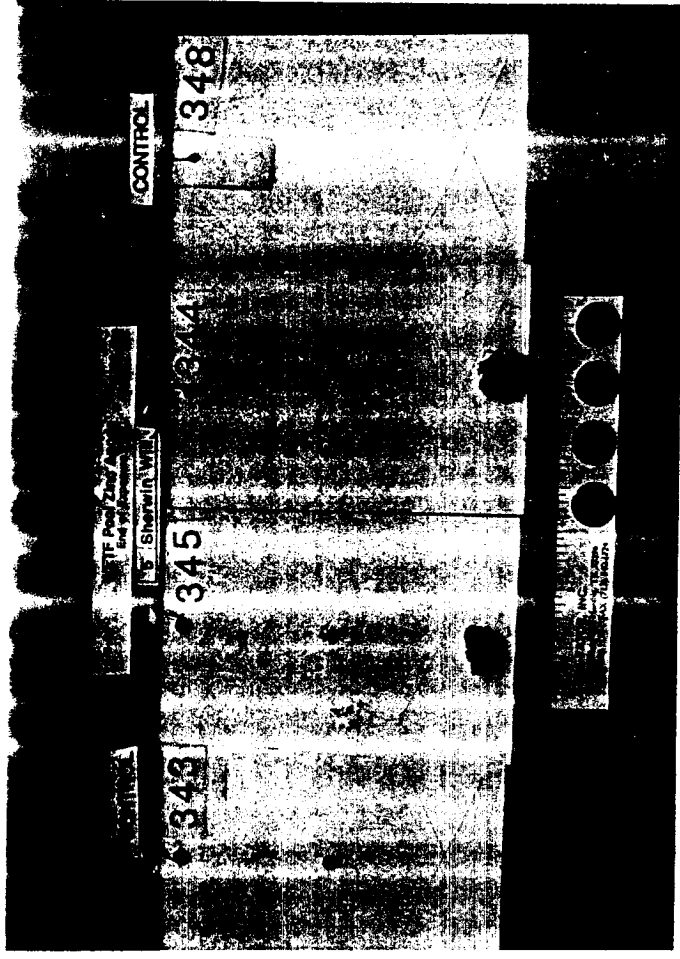
NO. BOX 80198 • OGDEN, UT 84301 • 888-888-1001

PLATE NO. 32-8b

OF POOR QUALITY

DATE: _____ ASSIGNMENT: _____

FILE NO: _____

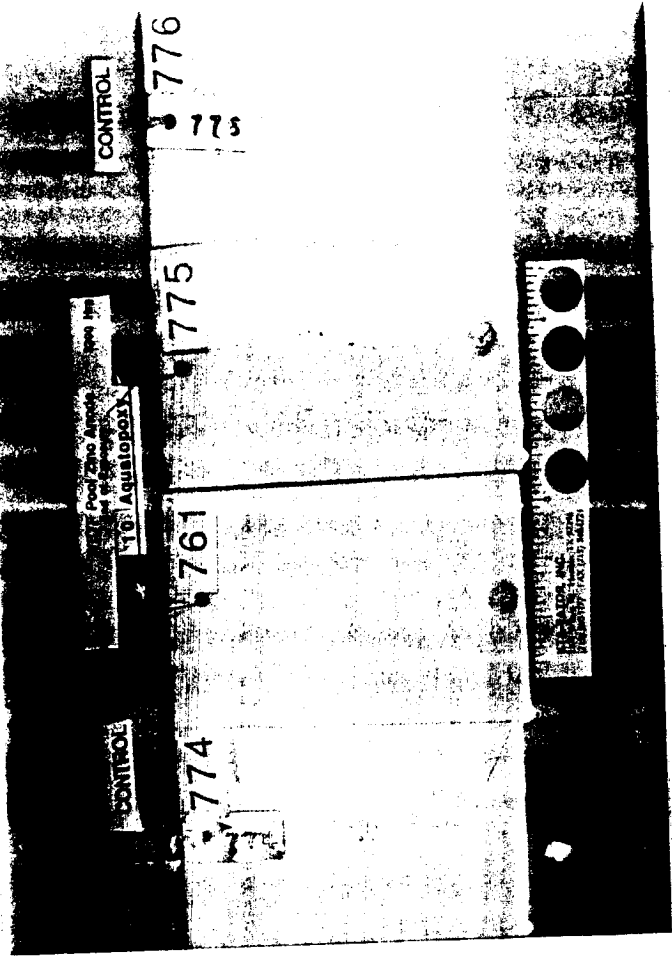
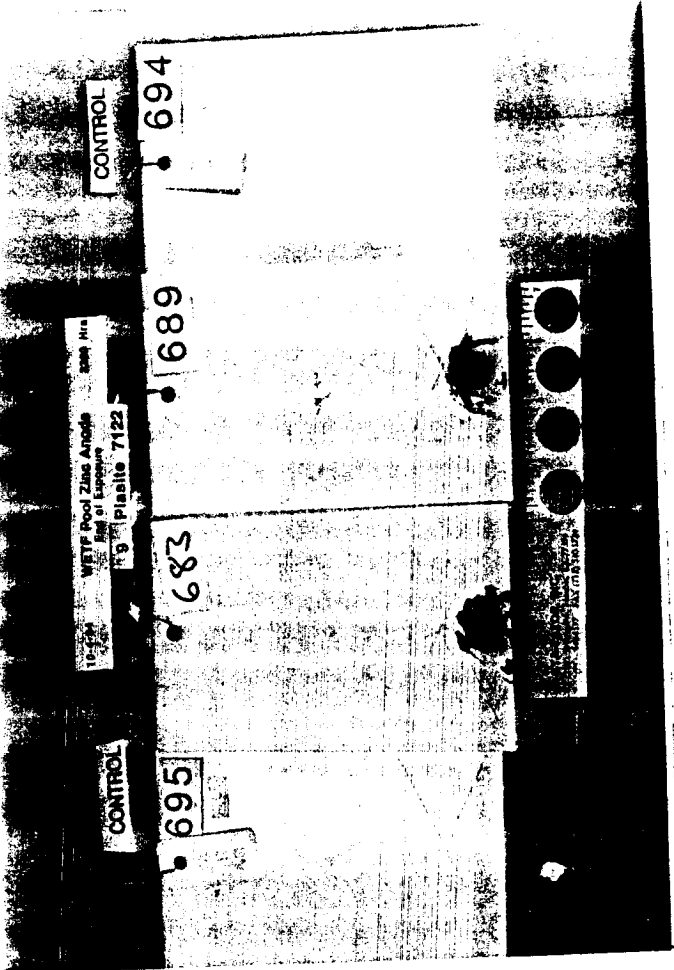
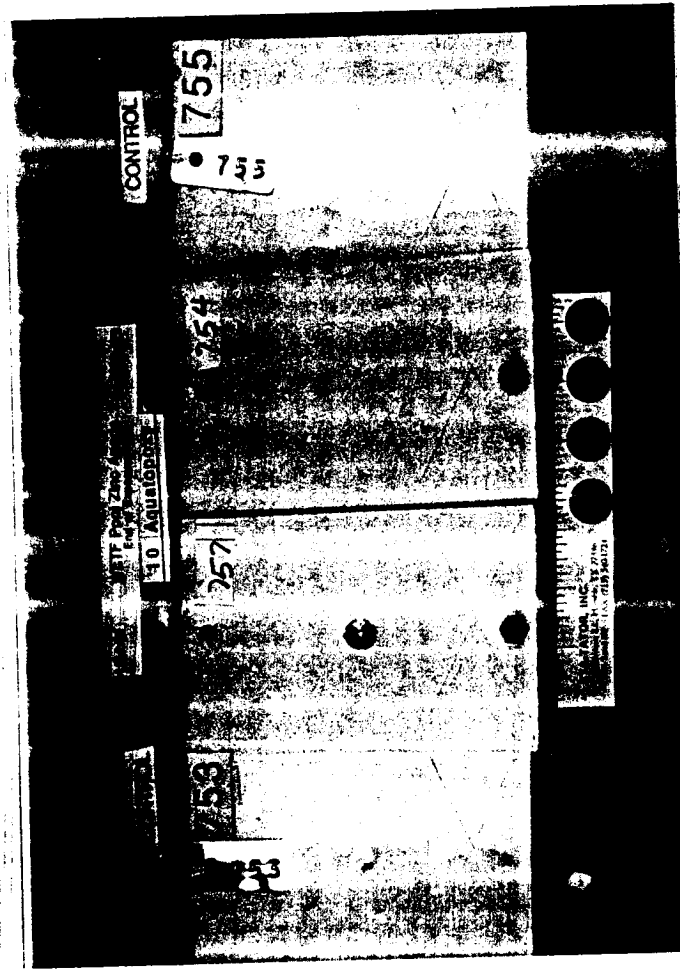
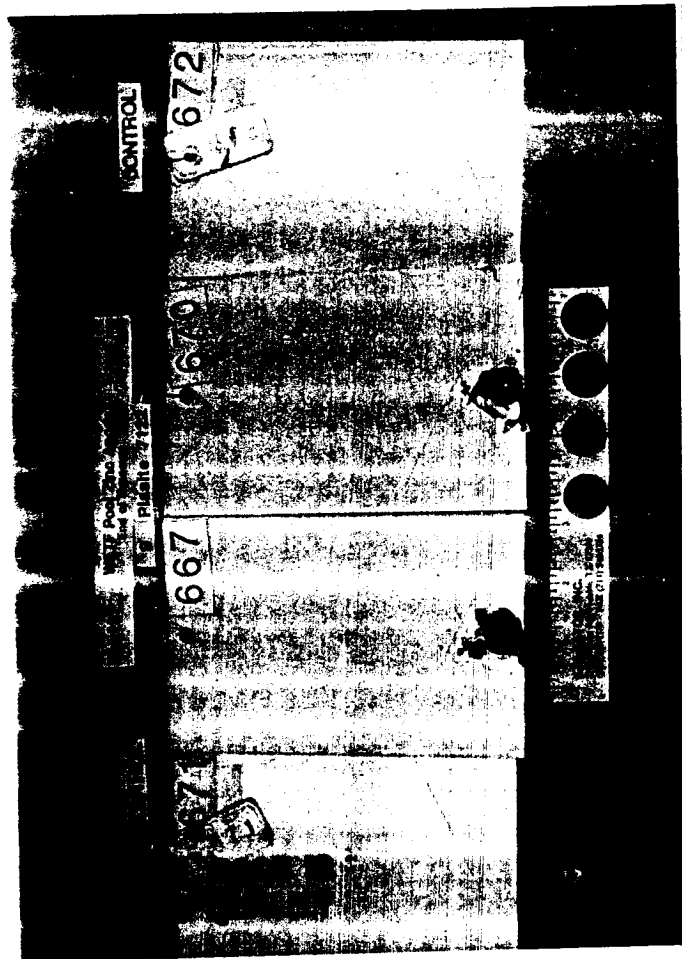


FILE NO:

Print File
ARCHIVAL PRESERVERS

ASSIGNMENT:

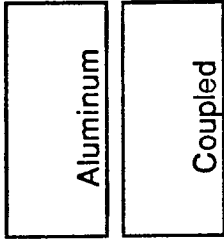
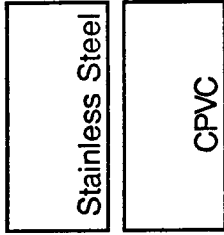
DATE:



APPENDIX C
Photographic Presentation of Panels

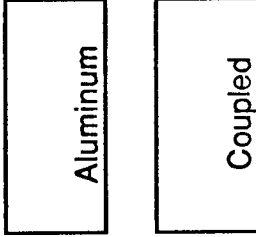
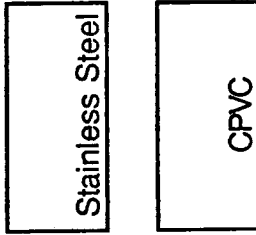
Laydown Area Panels

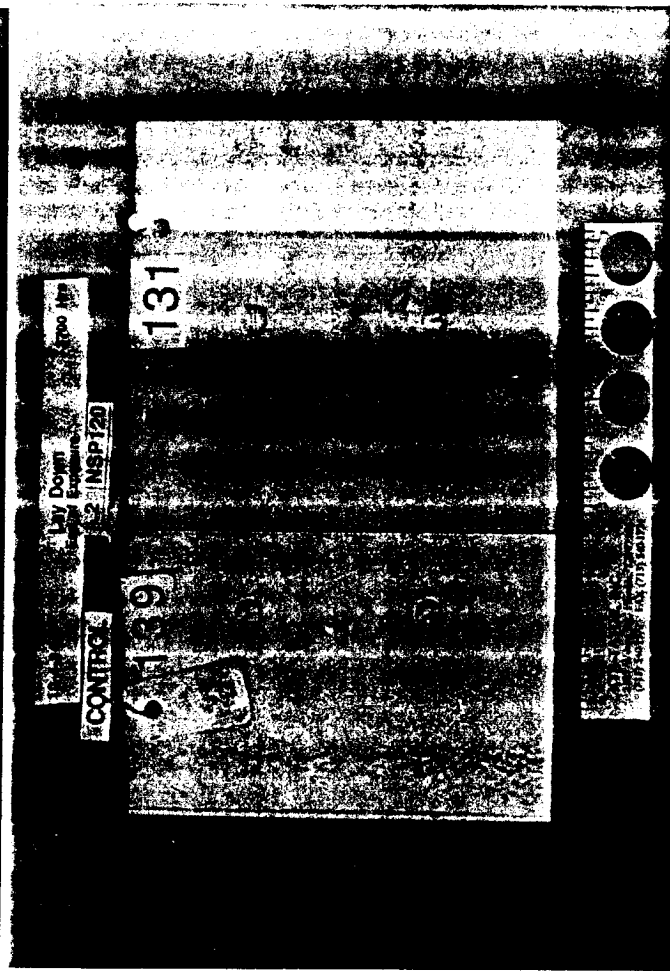
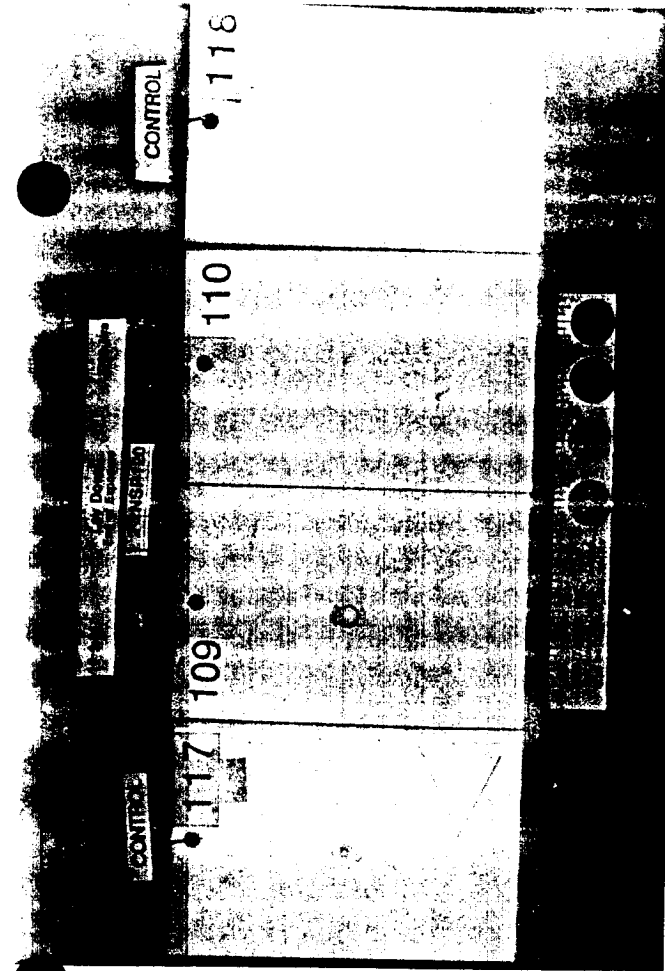
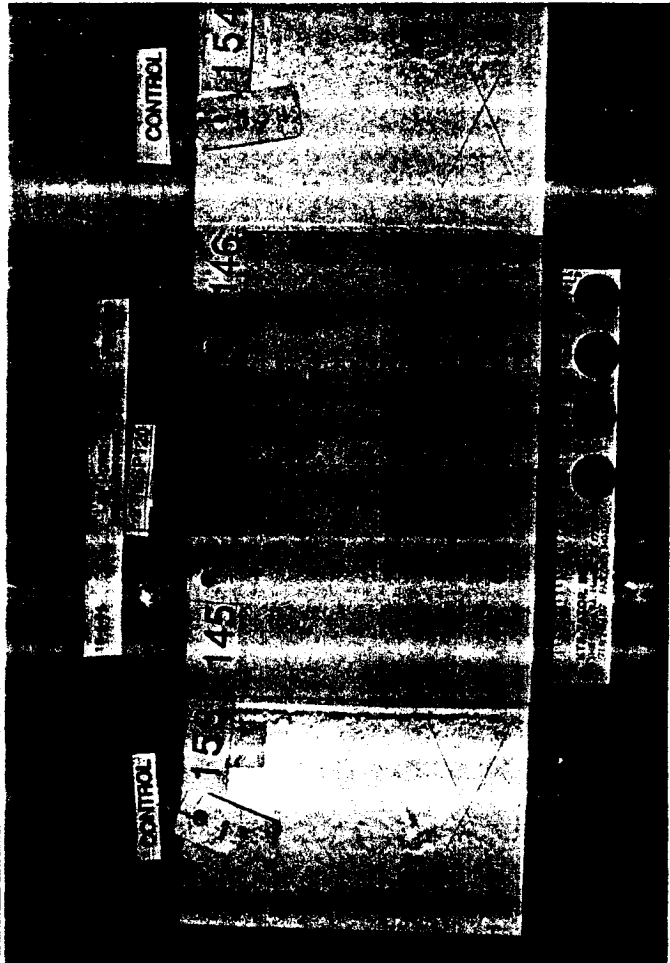
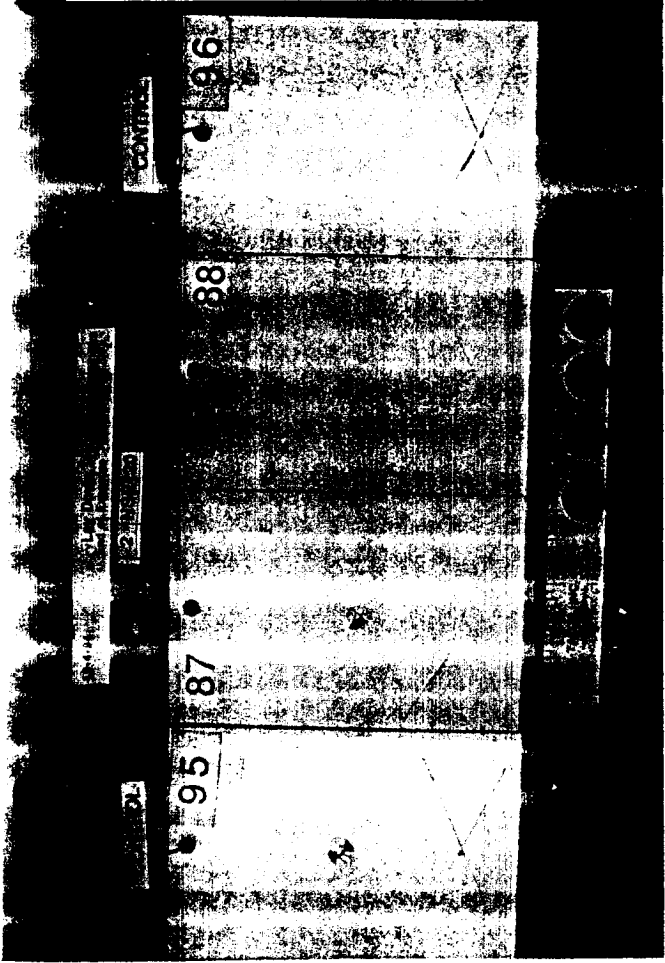
One System per Page:

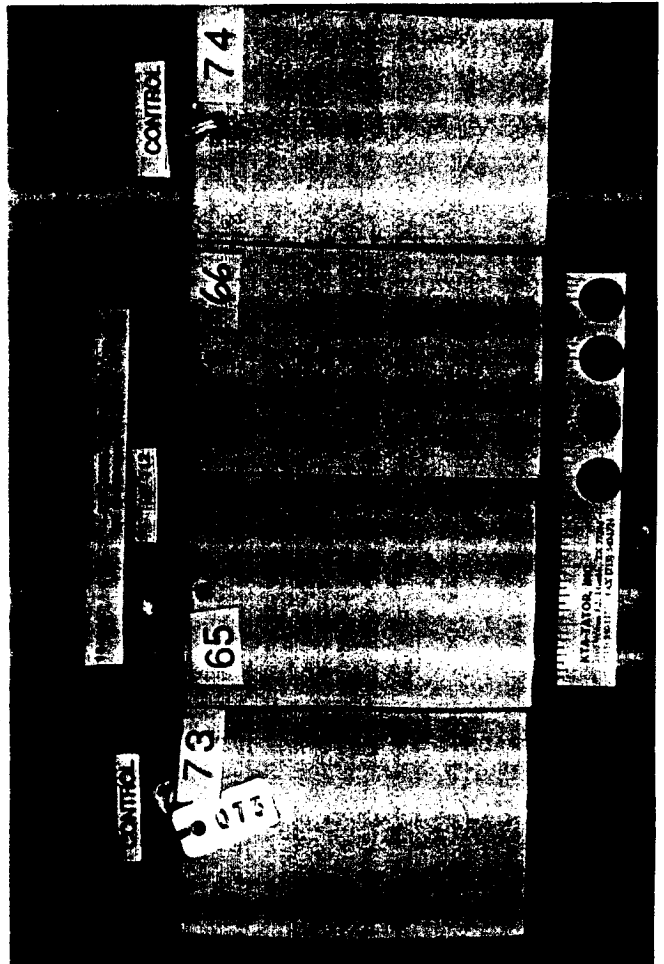
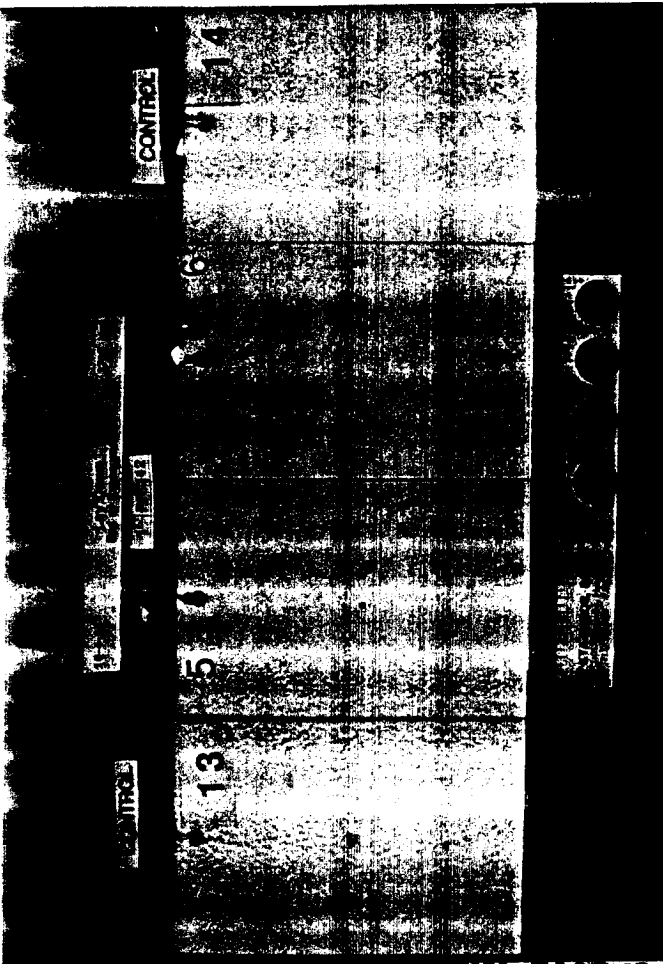
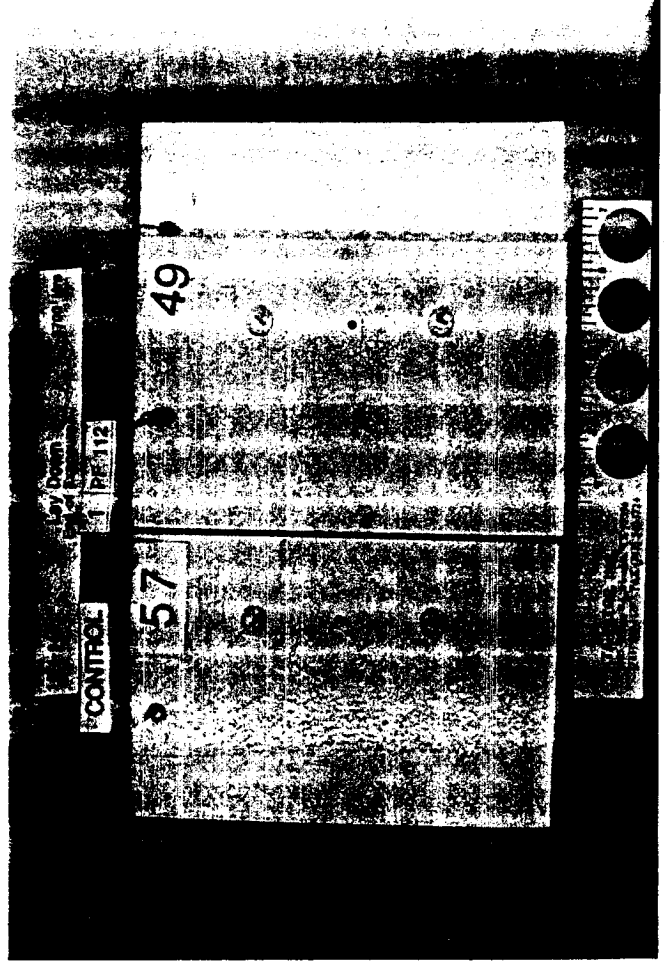
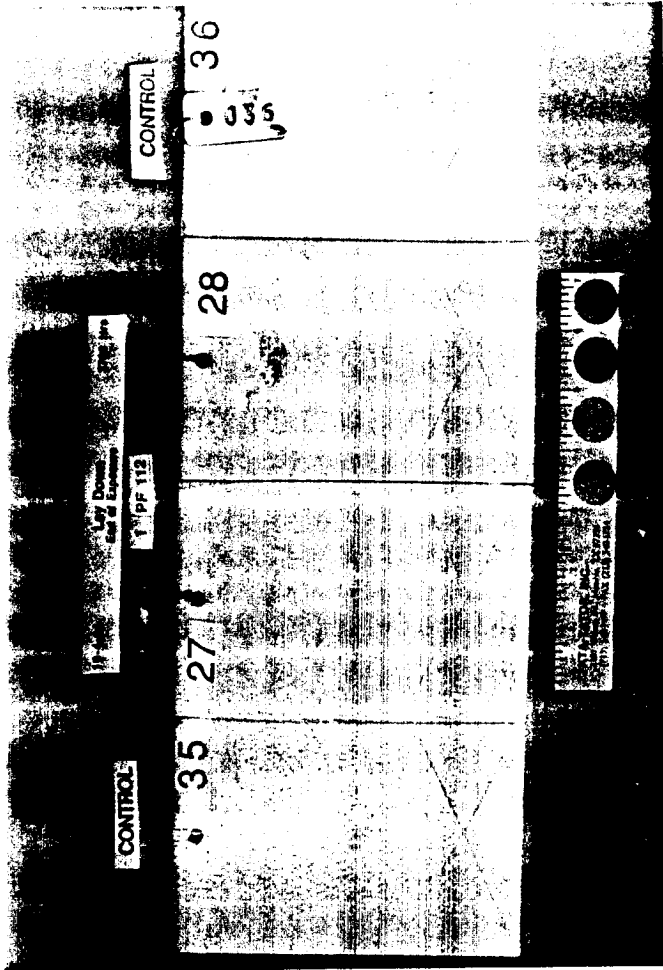


One System per page

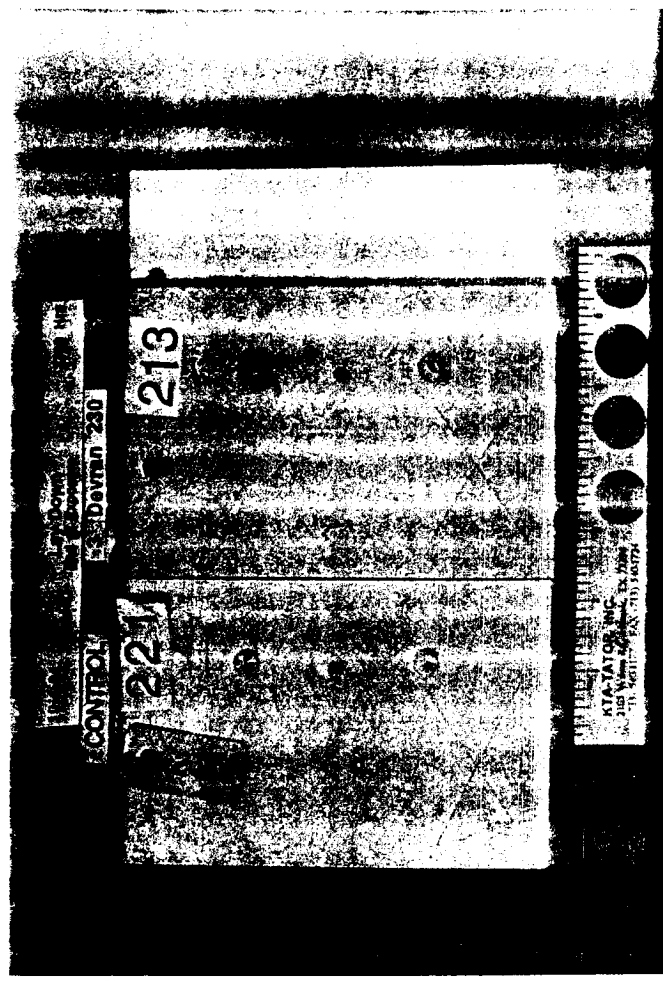
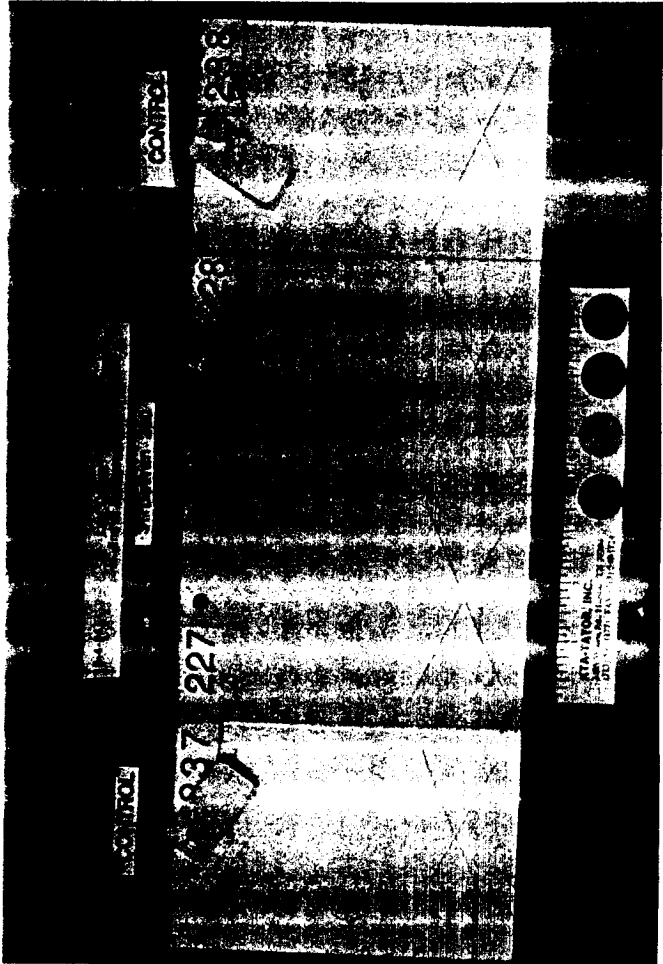
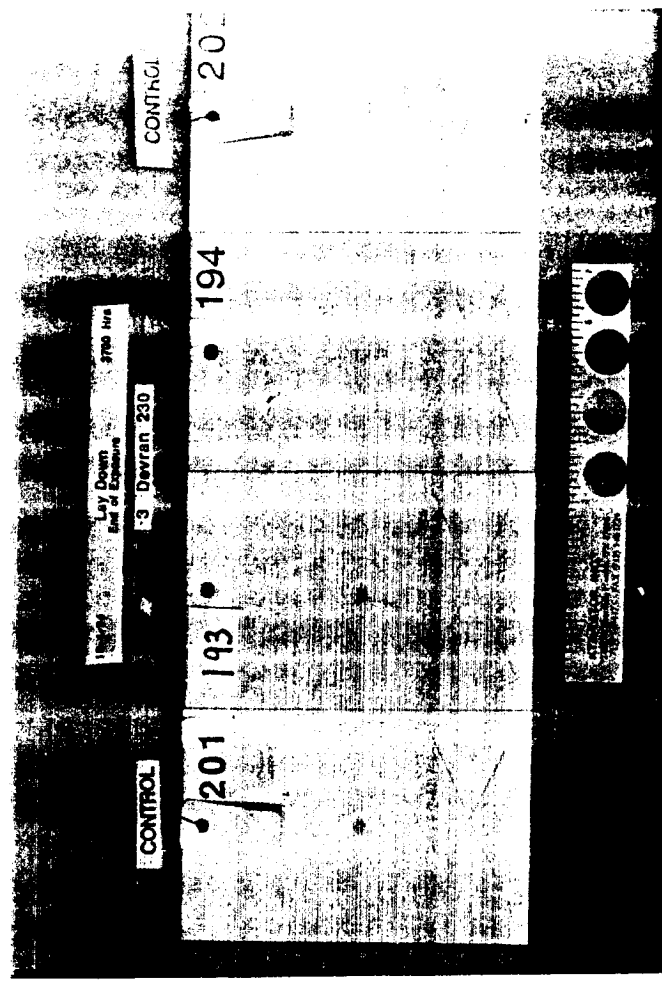
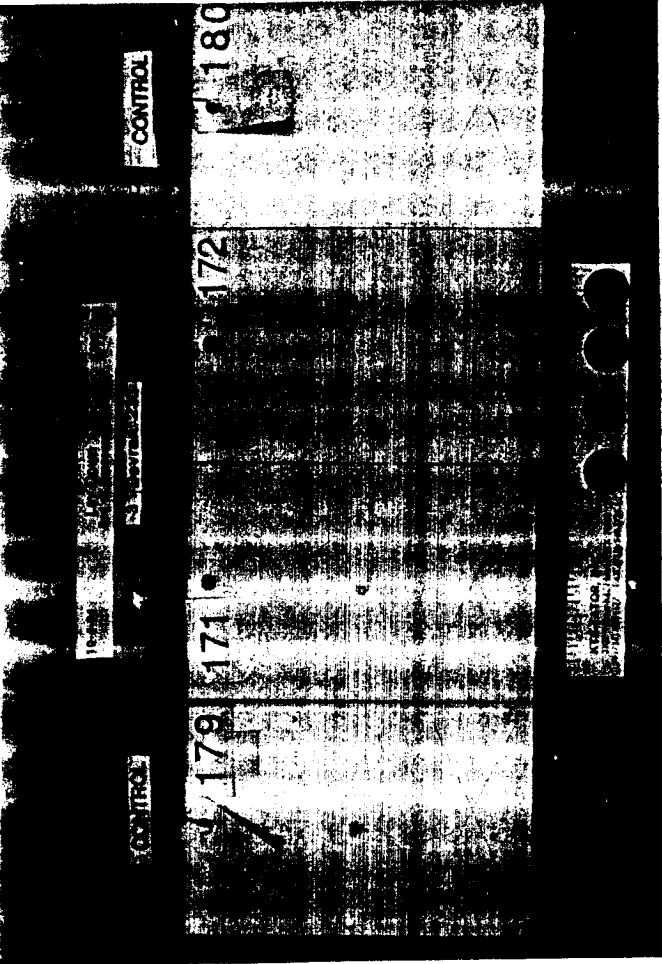
2000 hrs

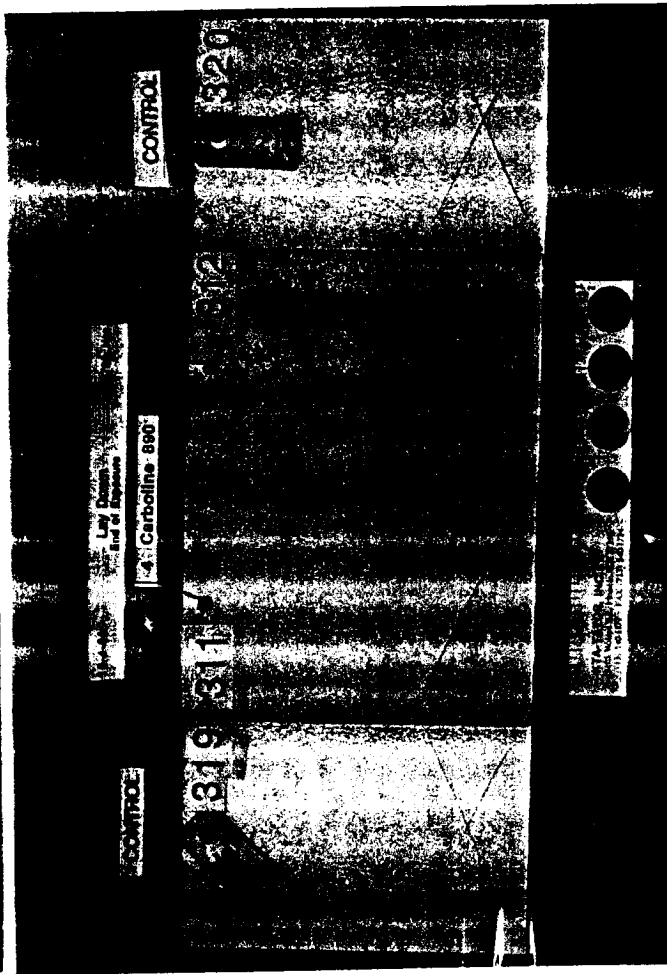
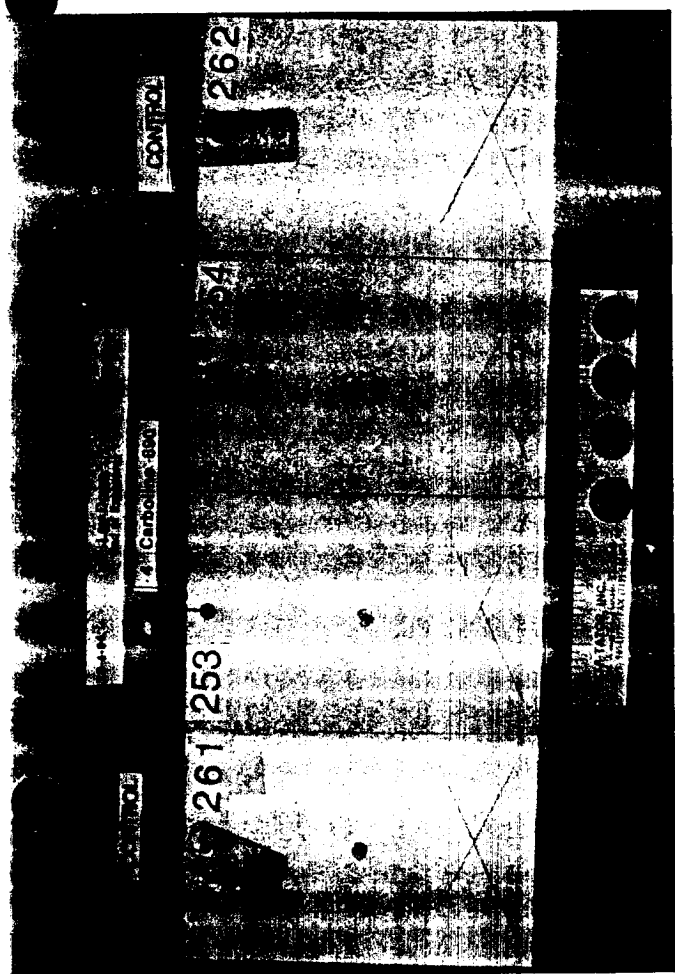
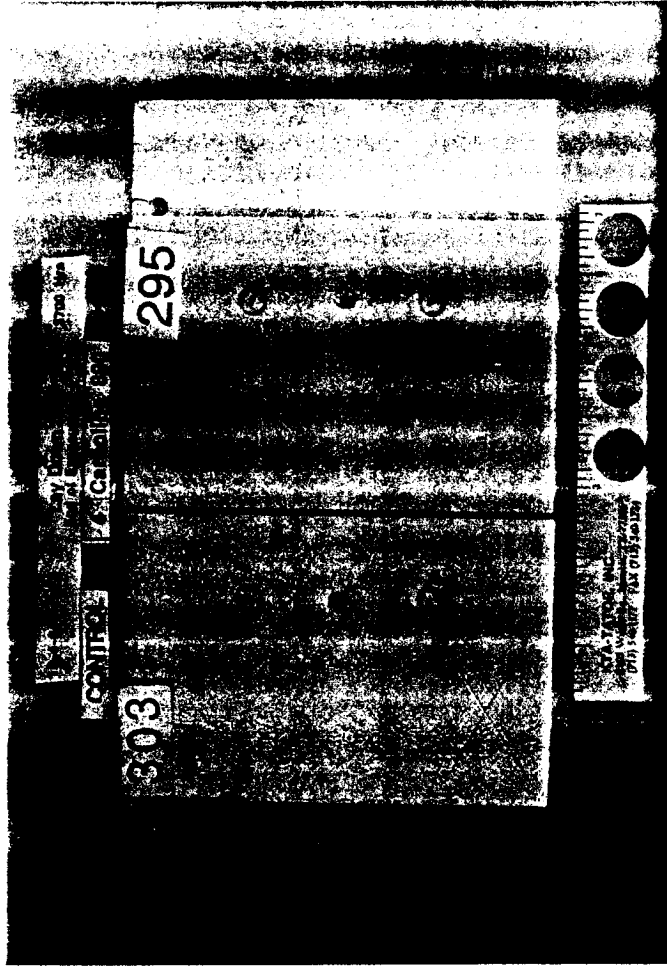
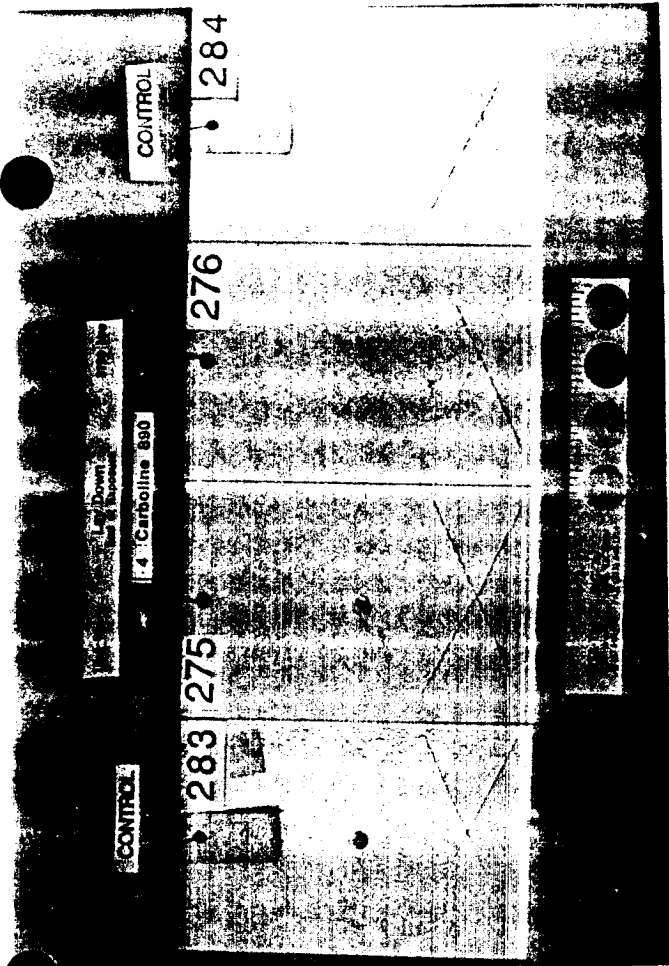


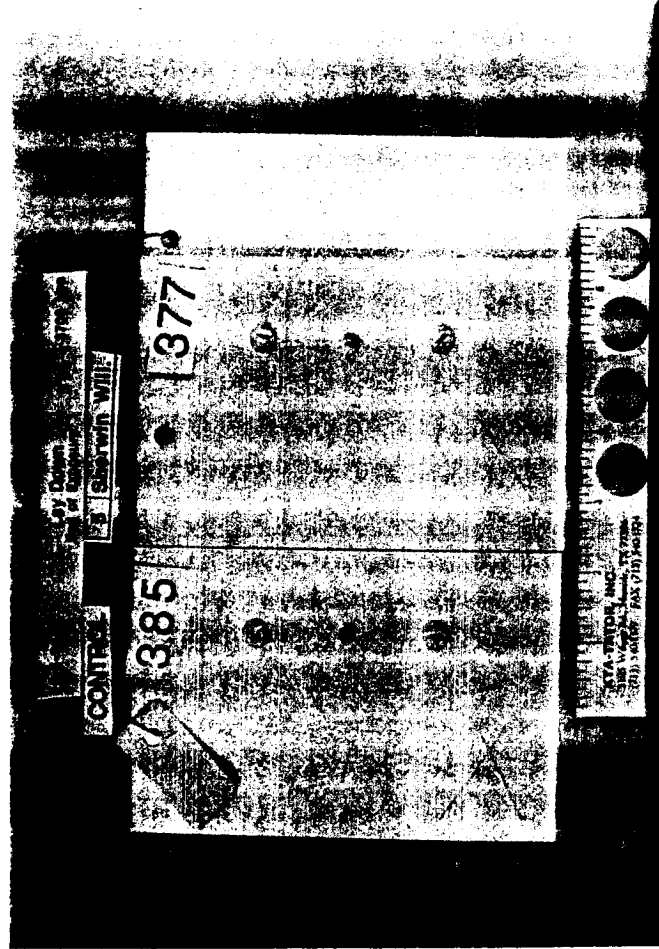
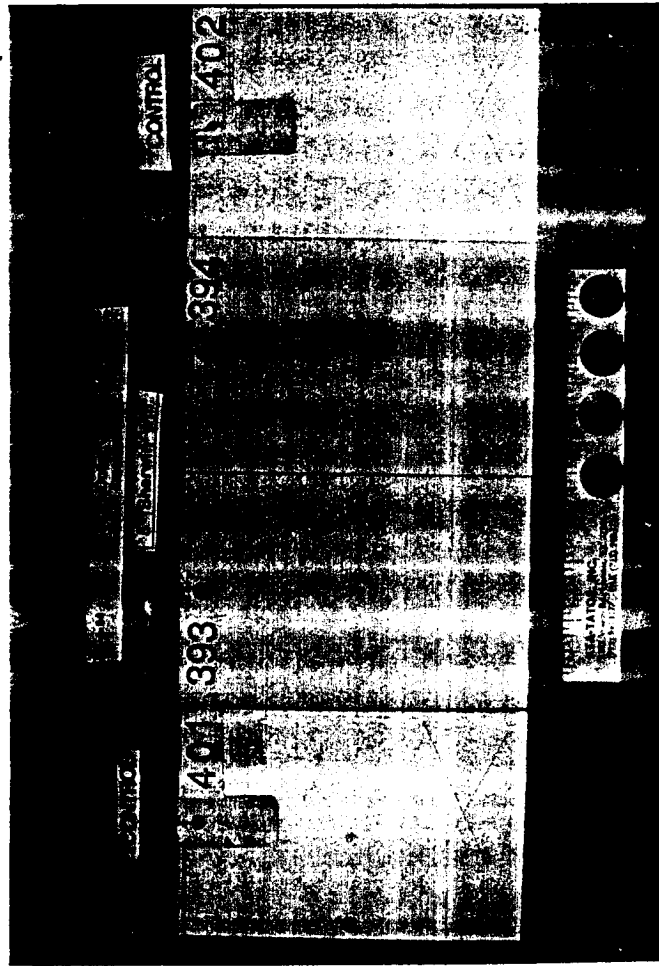
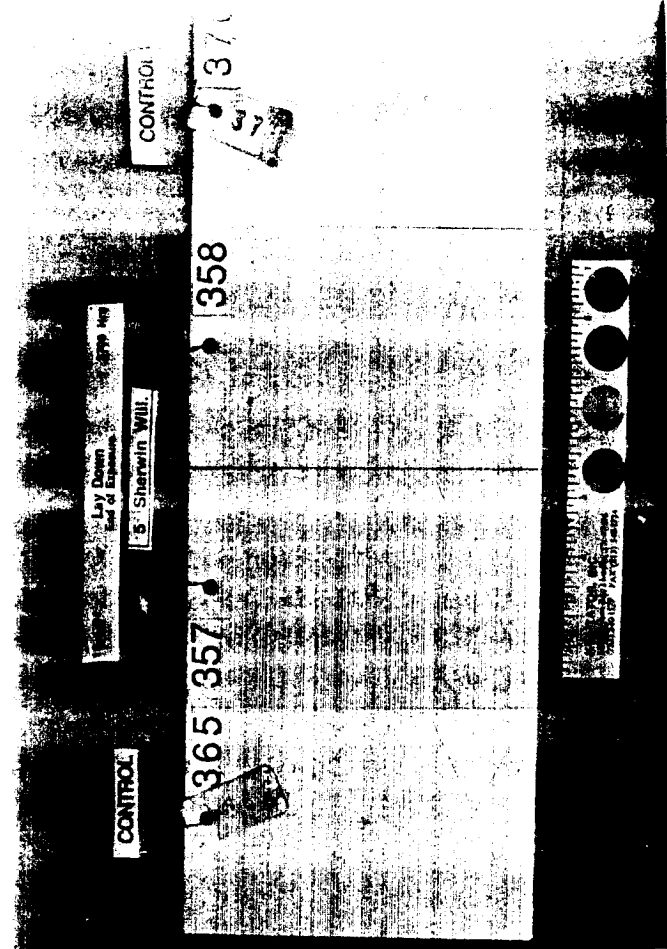
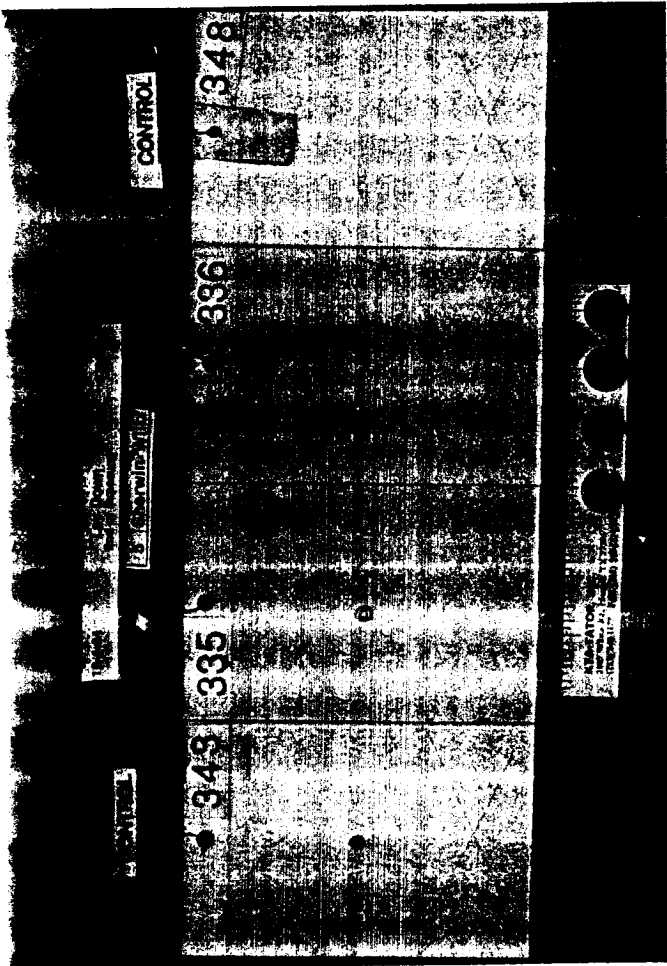


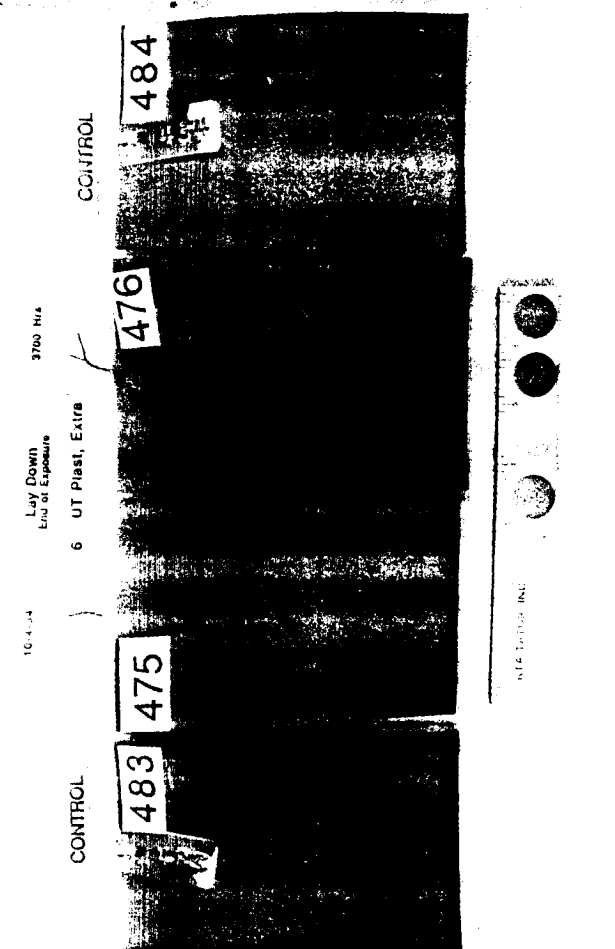
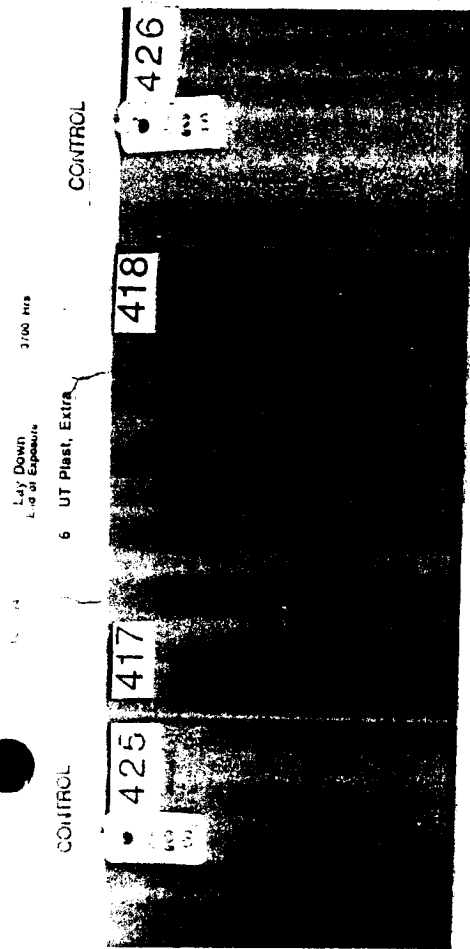
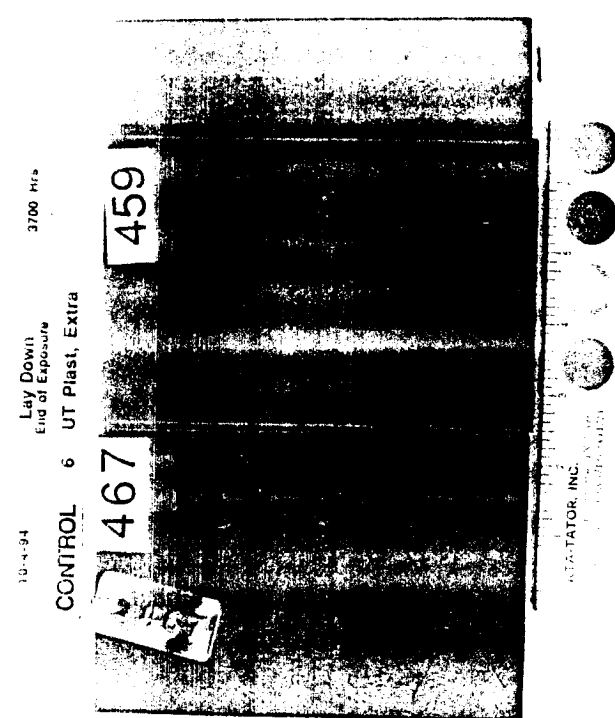
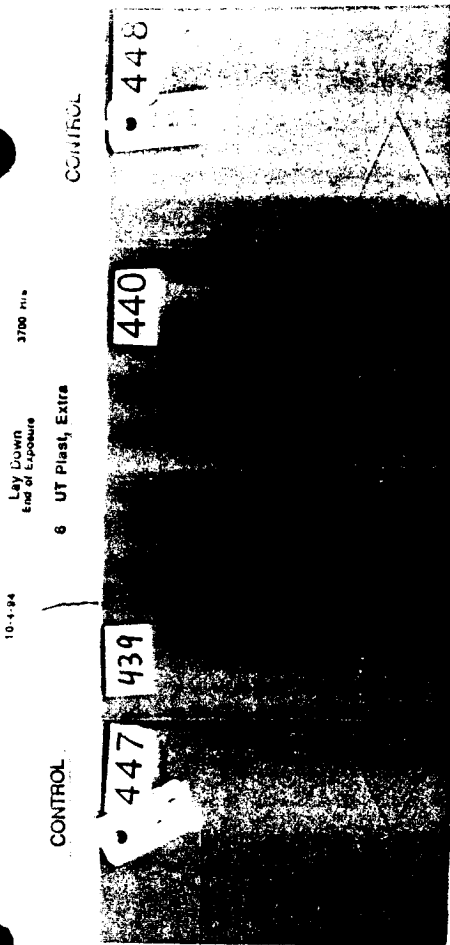


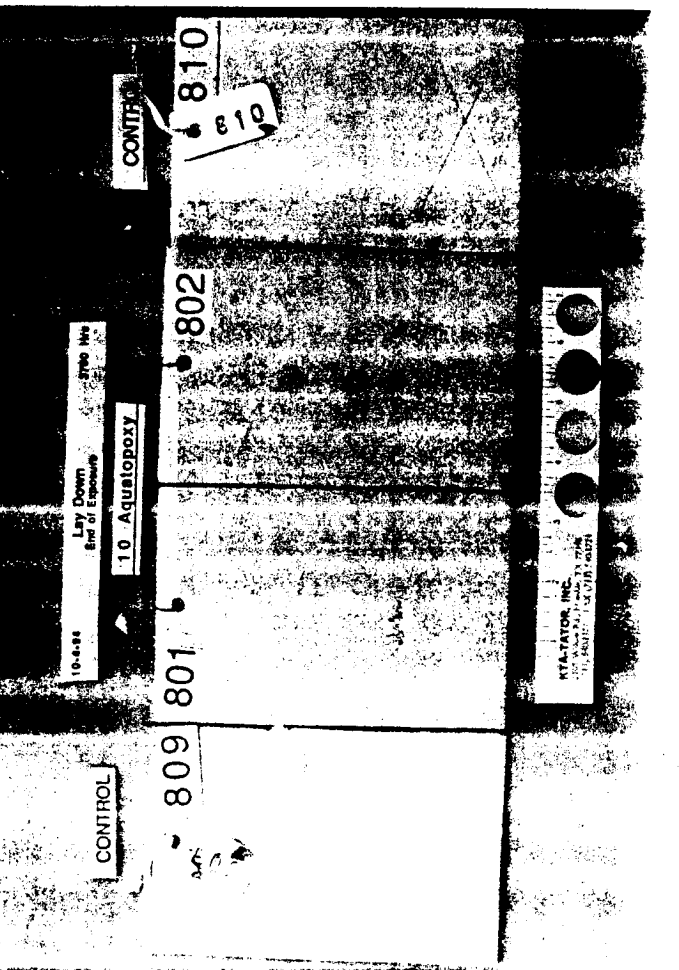
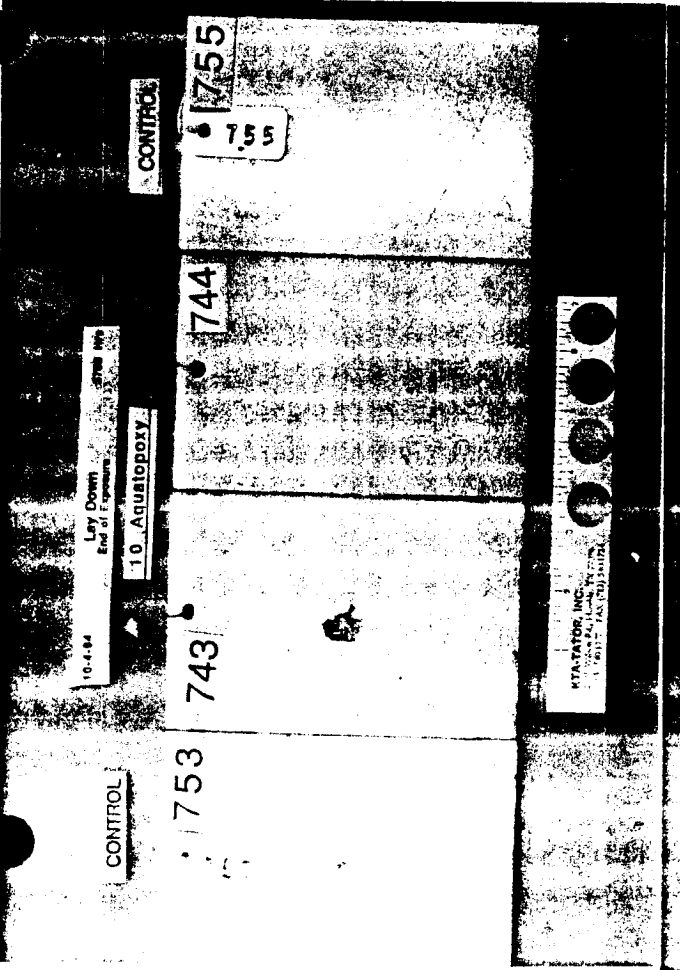
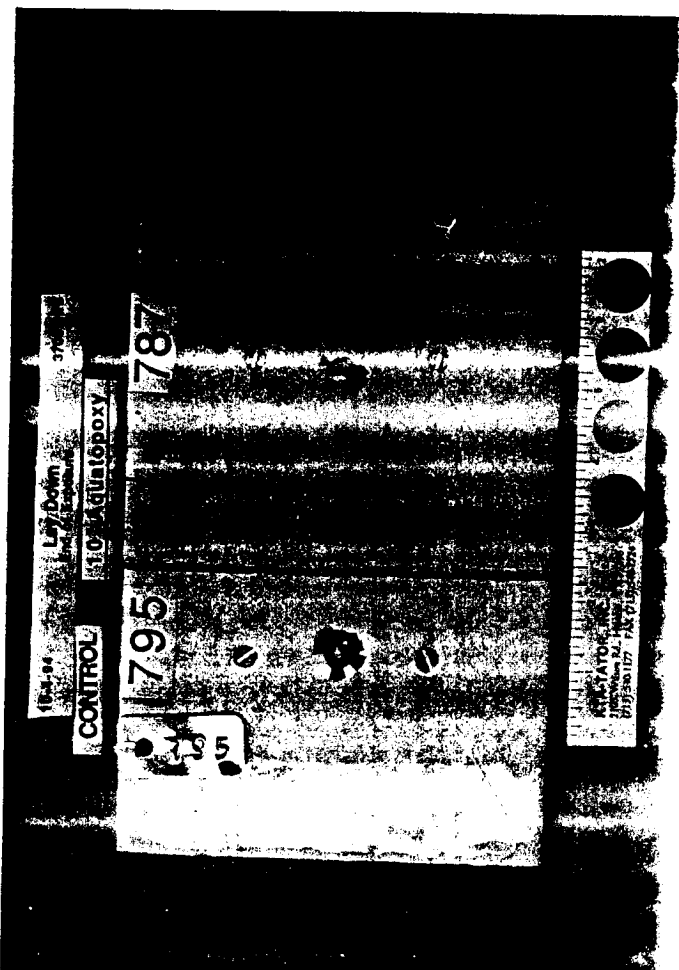
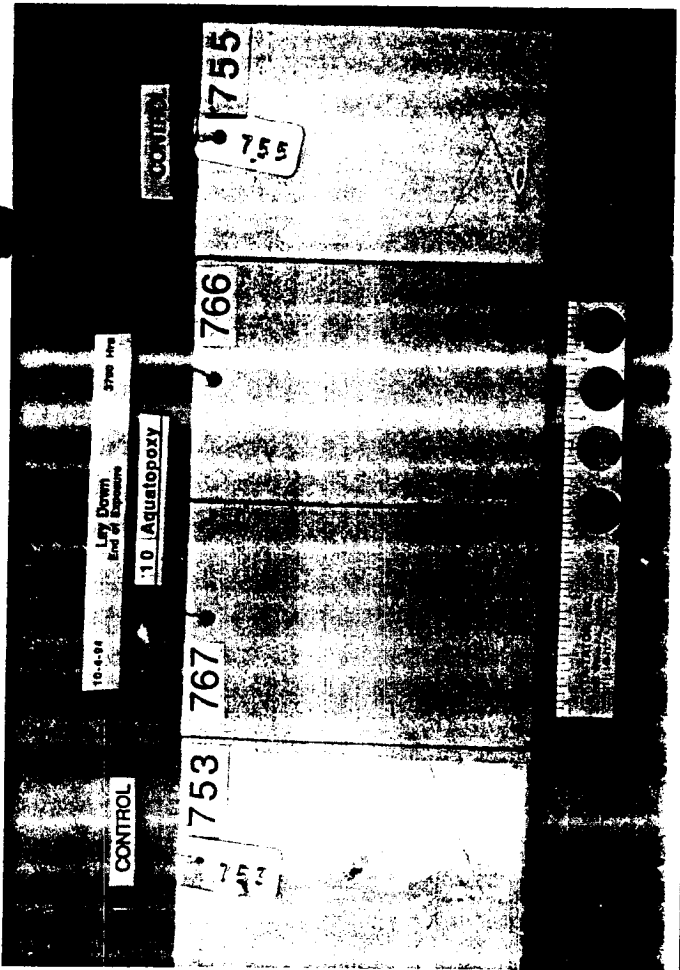
ORIGINAL PAGE IS
OF POOR QUALITY



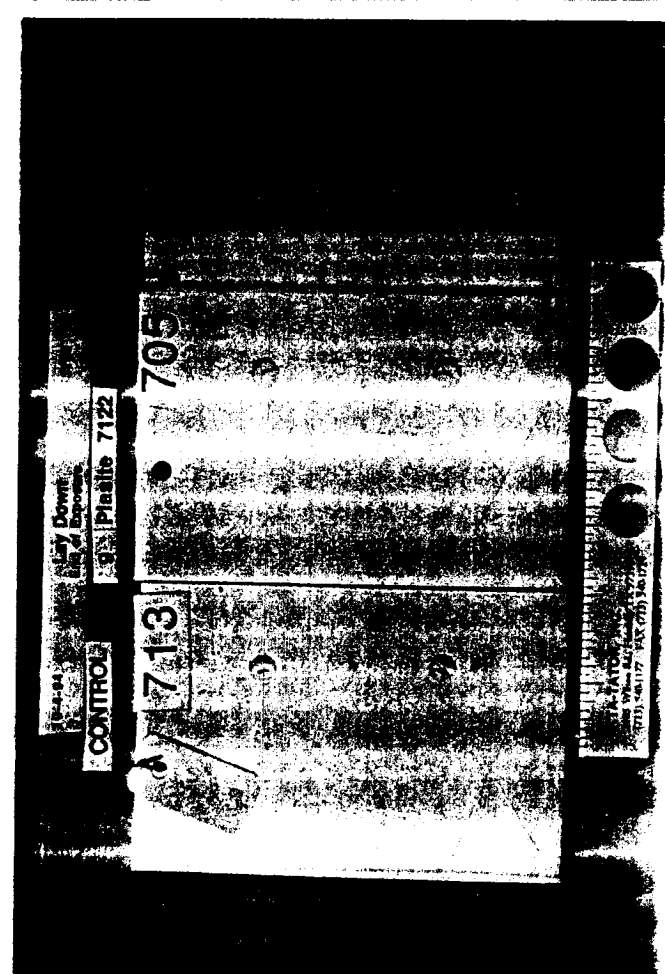
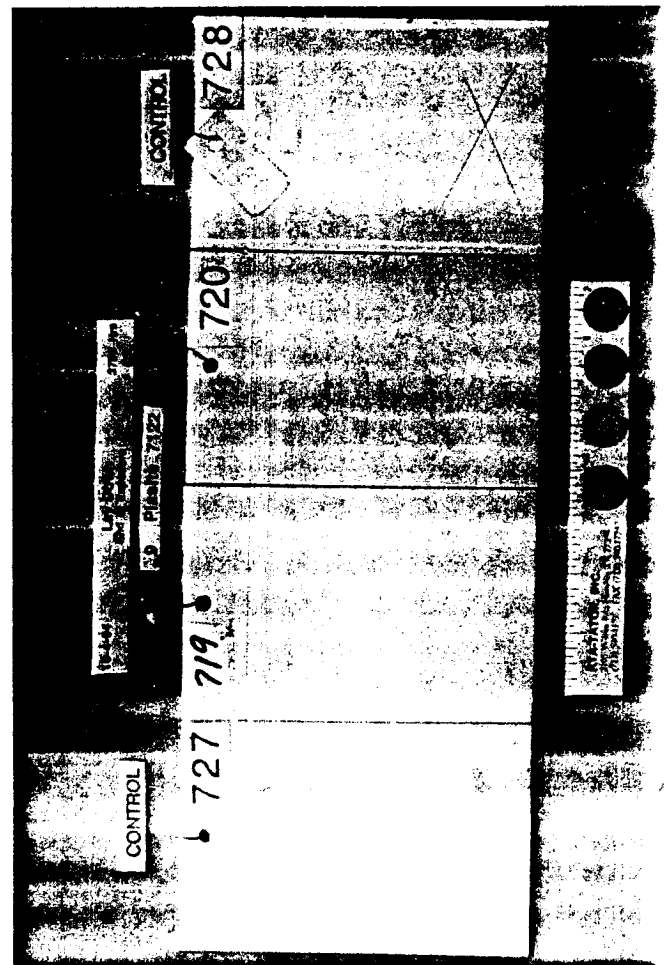
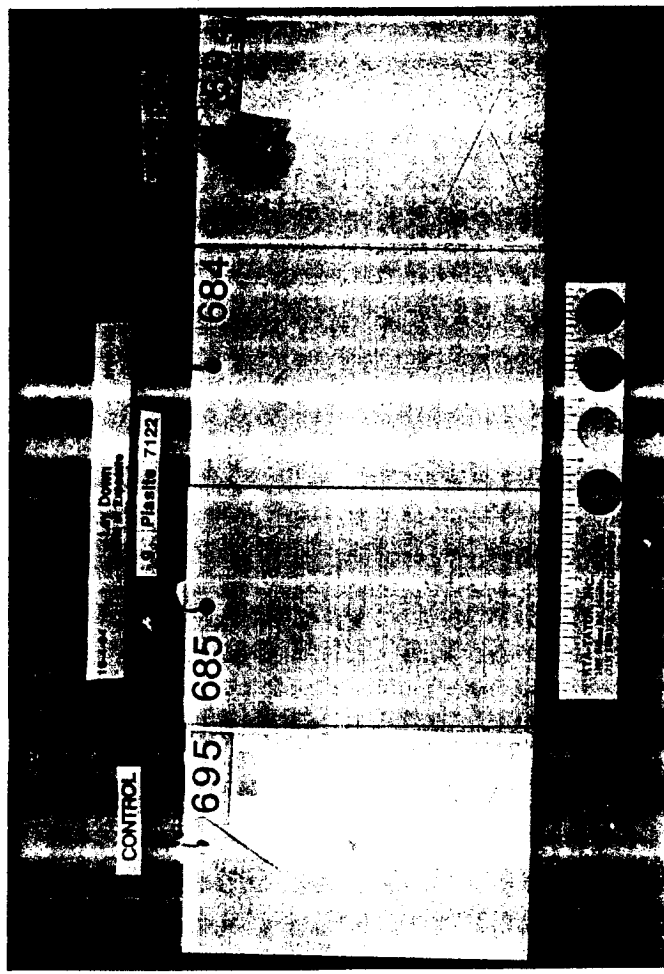
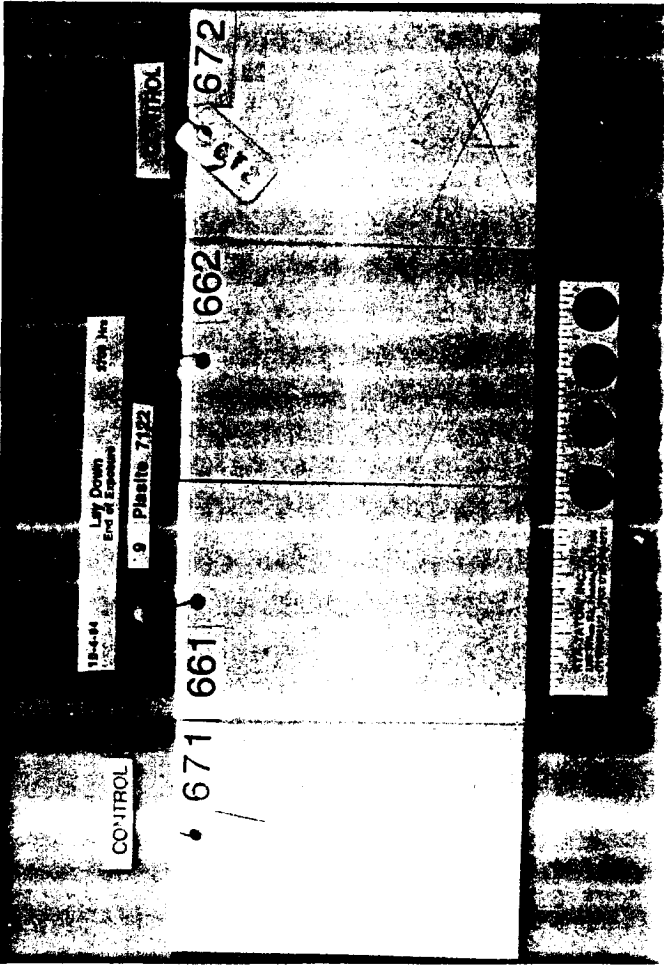


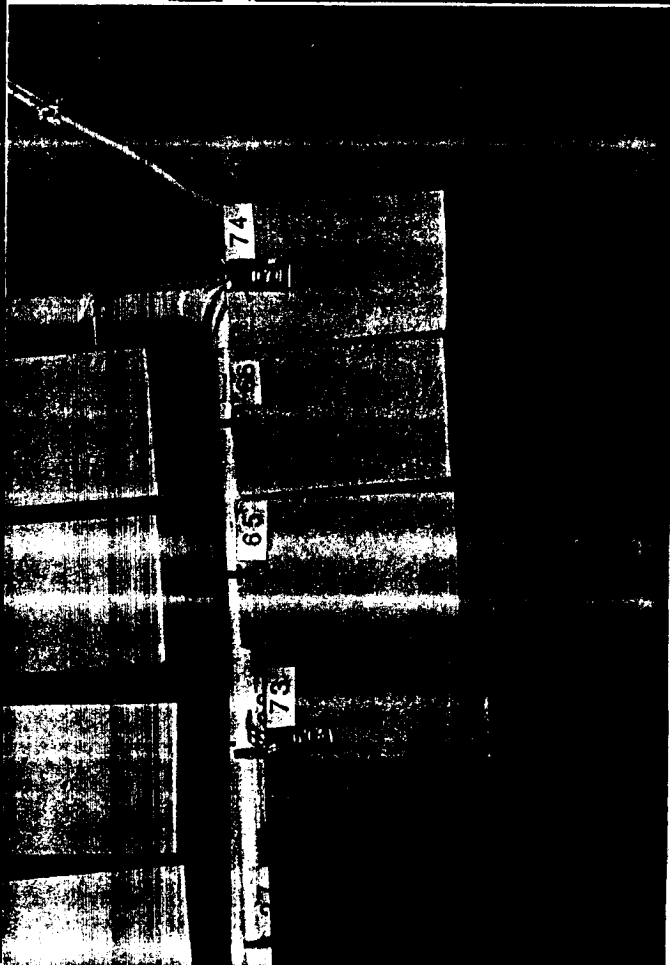
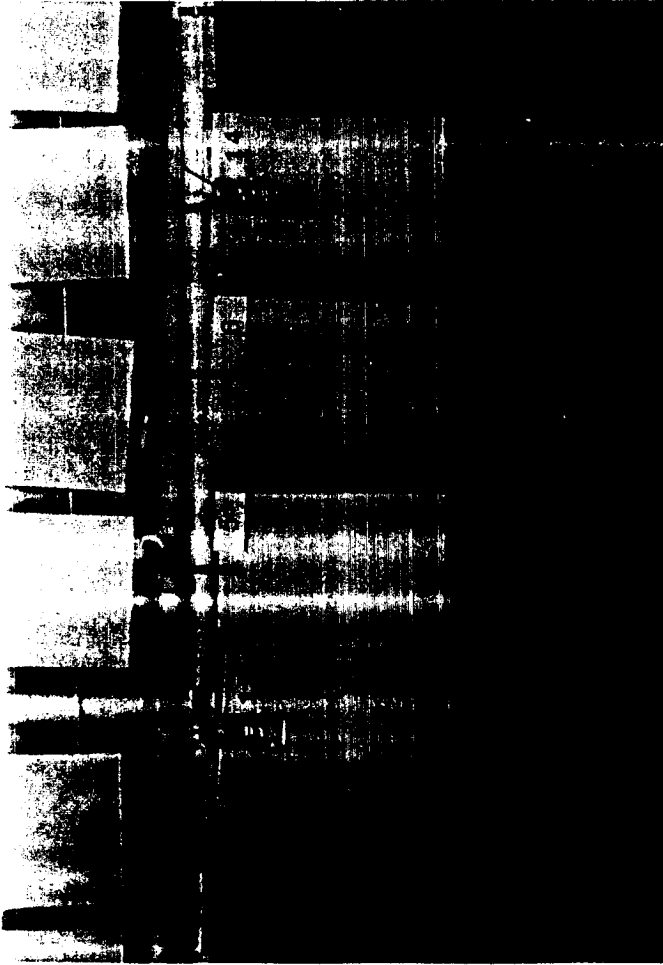
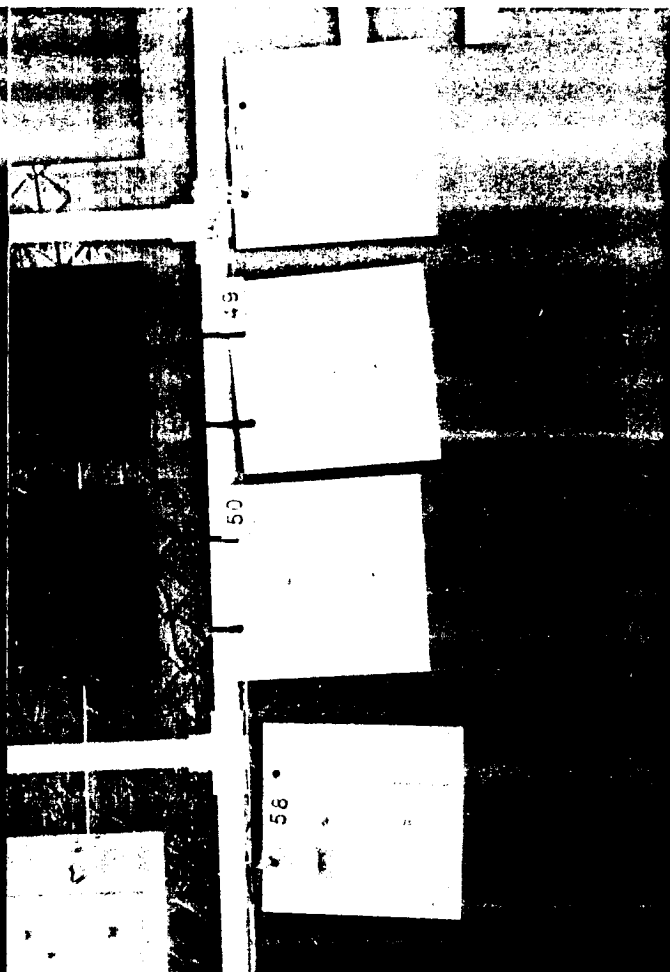
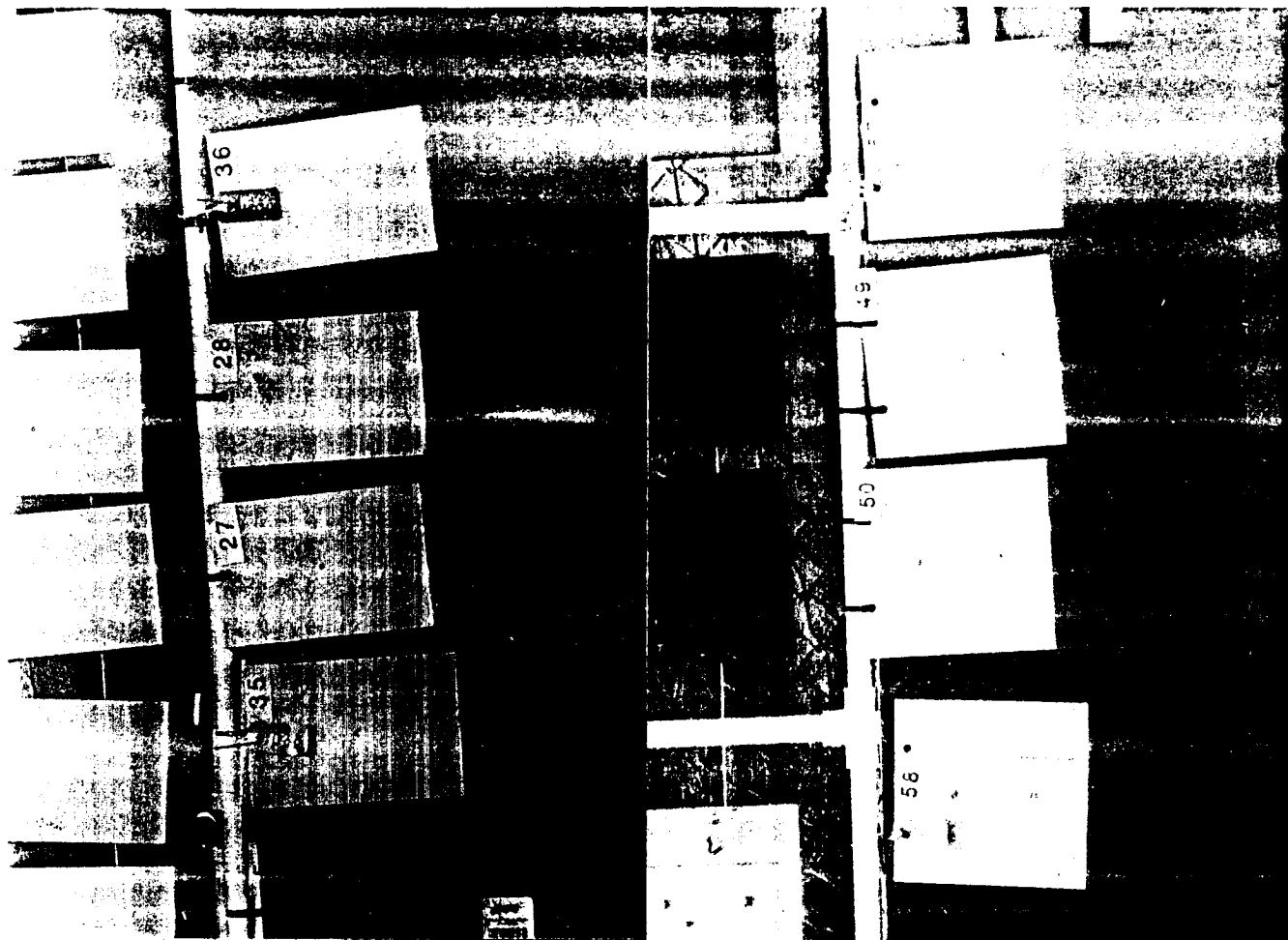


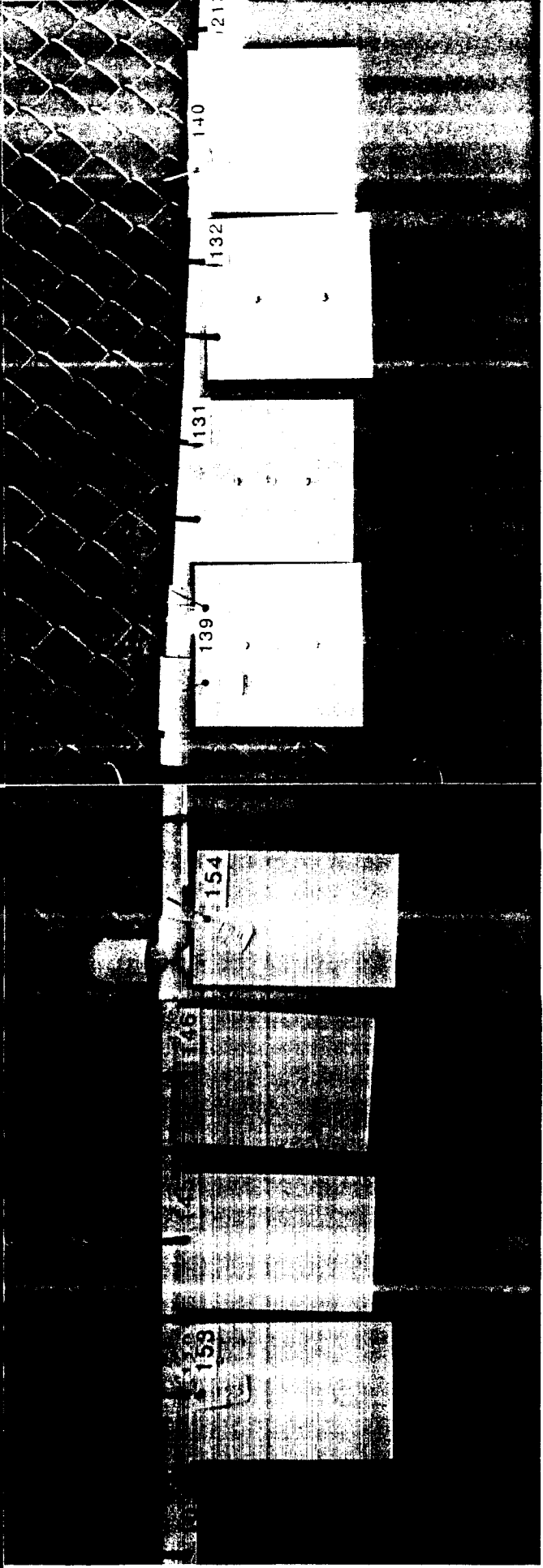
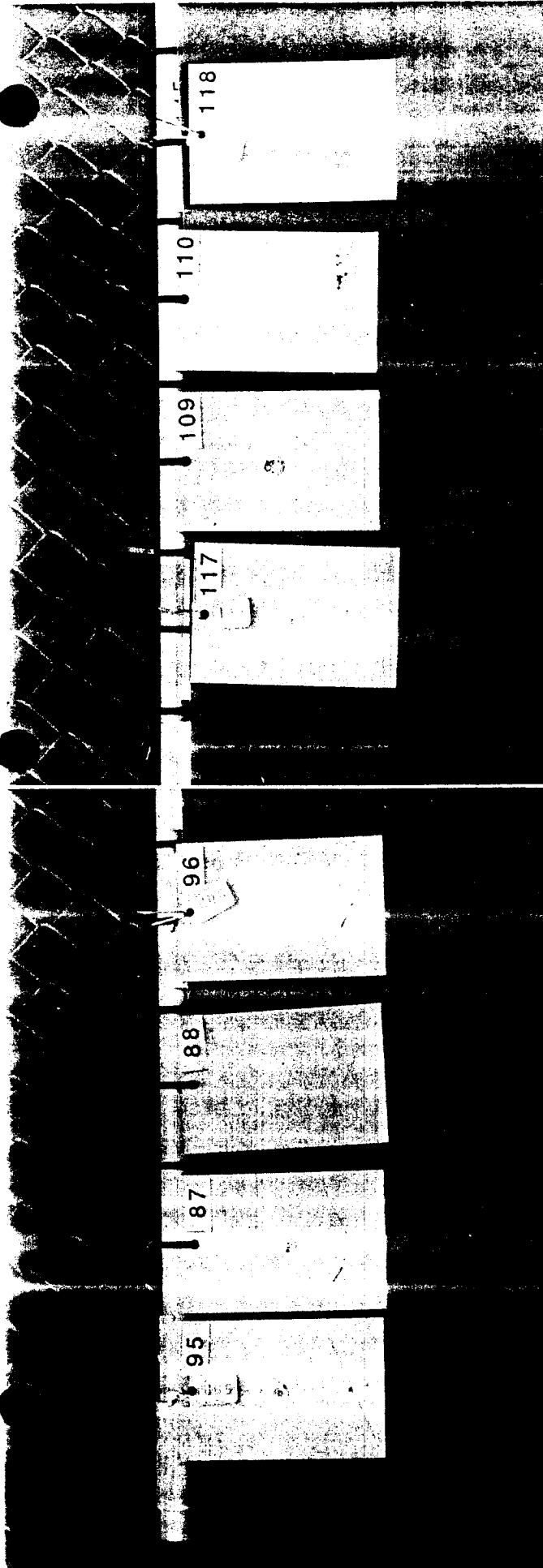


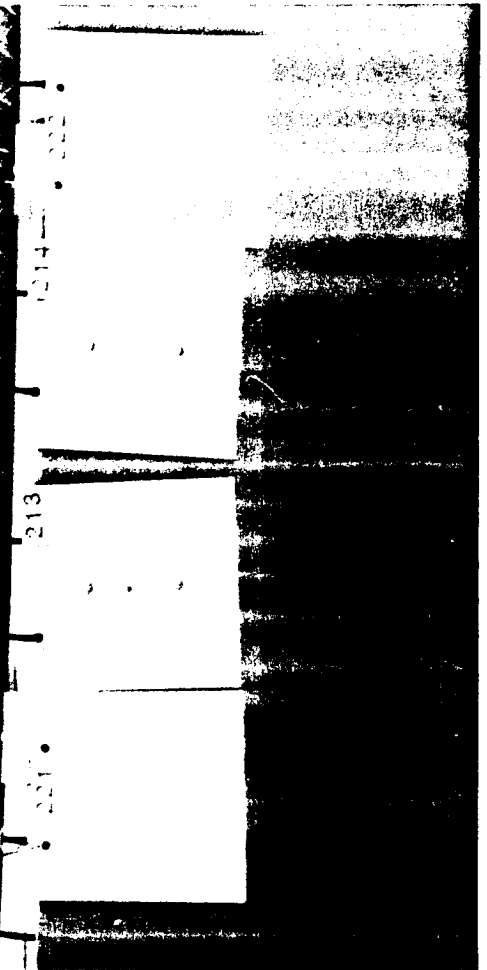
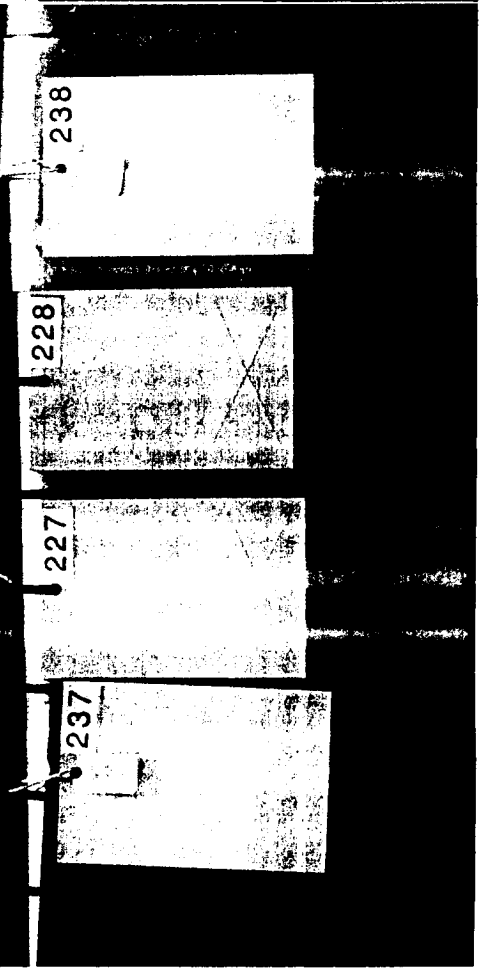
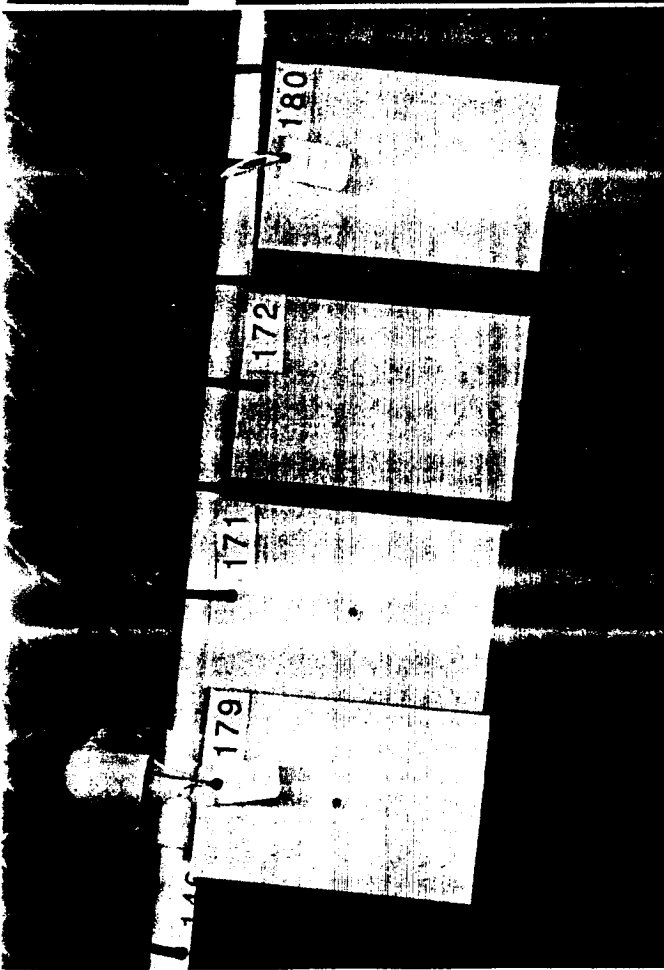


ORIGINAL PAGE IS
OF POOR QUALITY









284

276

275

283

253

262

254

25

261

304

296

295

303

14

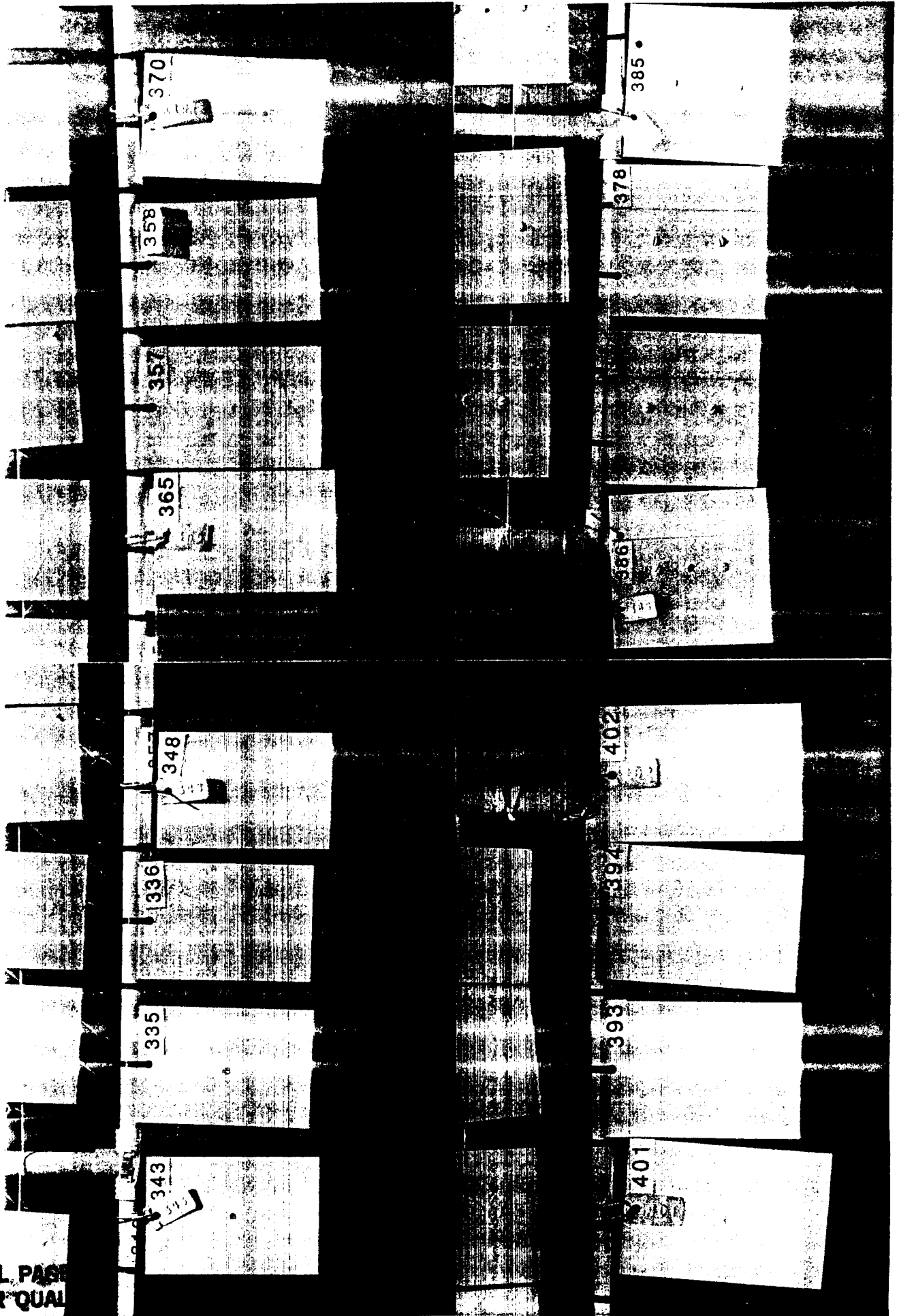
320

312

31

319

ORIGINAL PAGE
OF POOR QUALITY



343

335

336

348

365

357

358

370

393

394

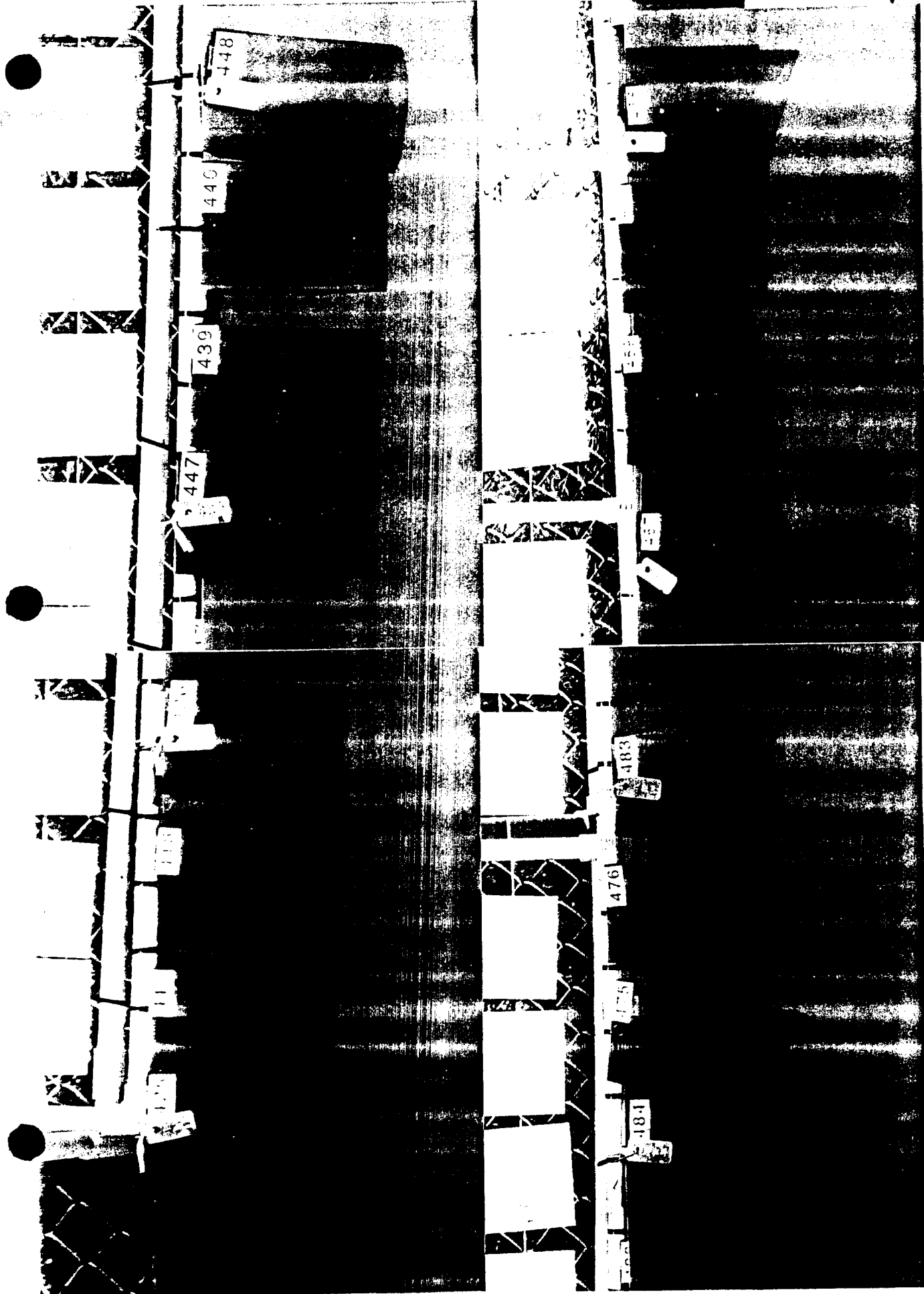
402

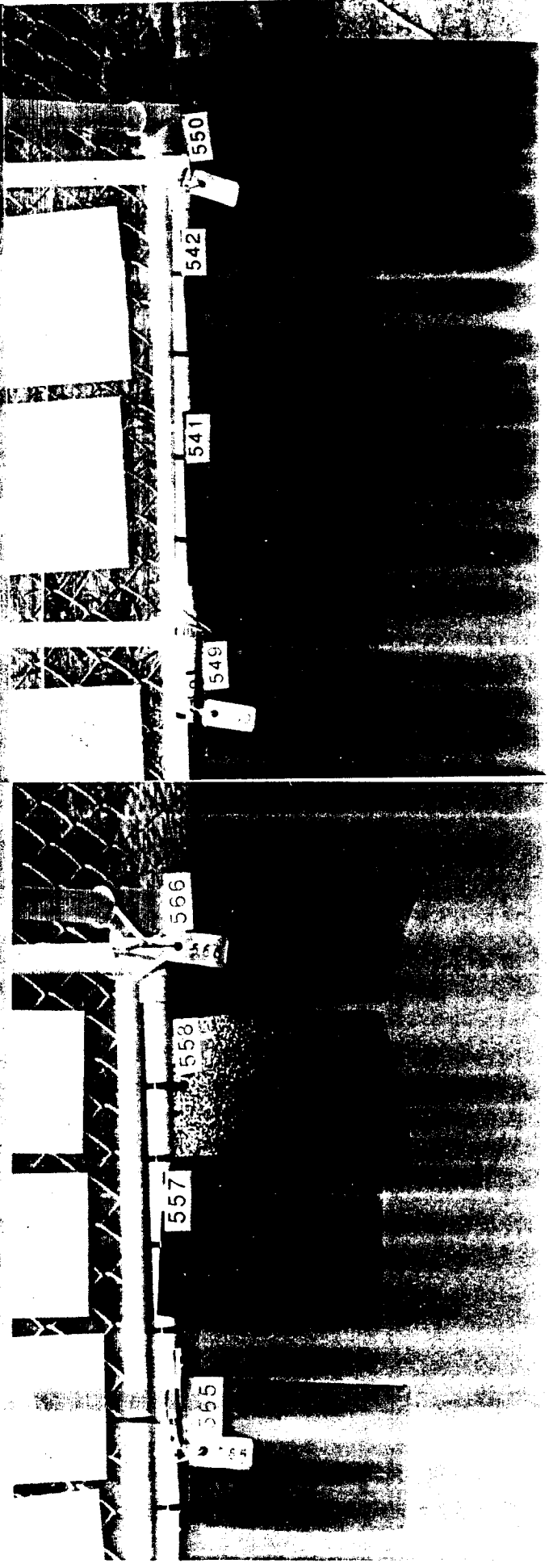
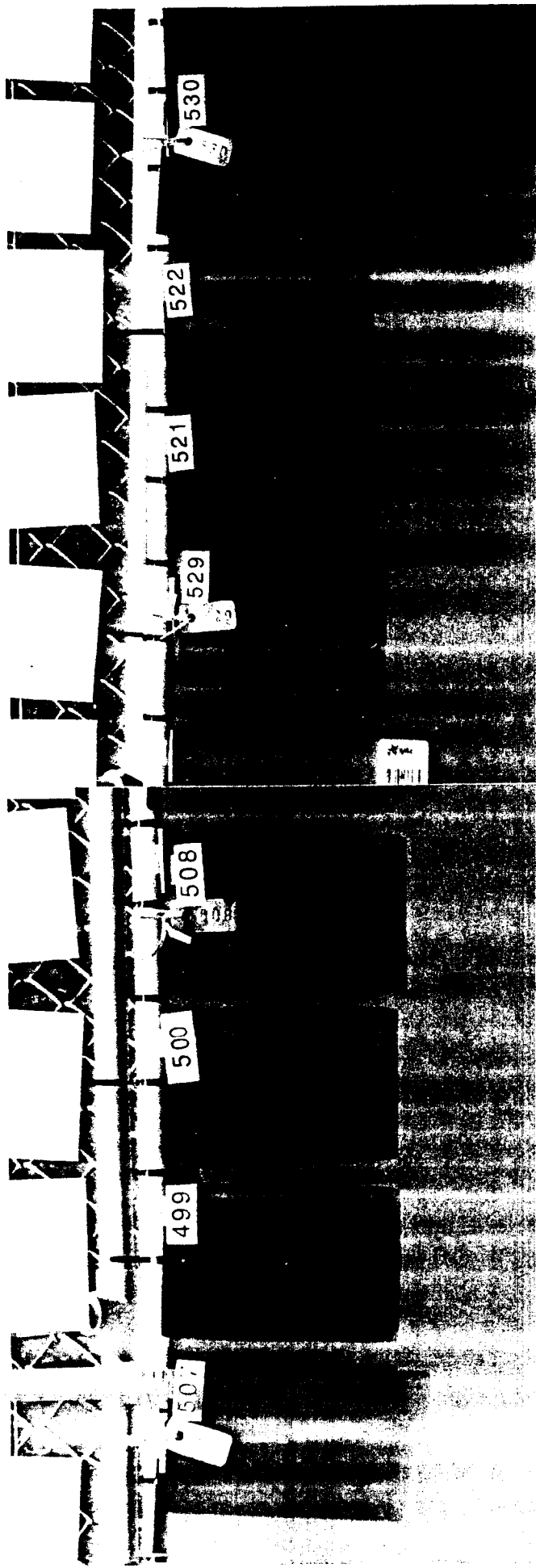
401

360

378

385





589

581

582

590

581

611

603

604

612

645

637

638

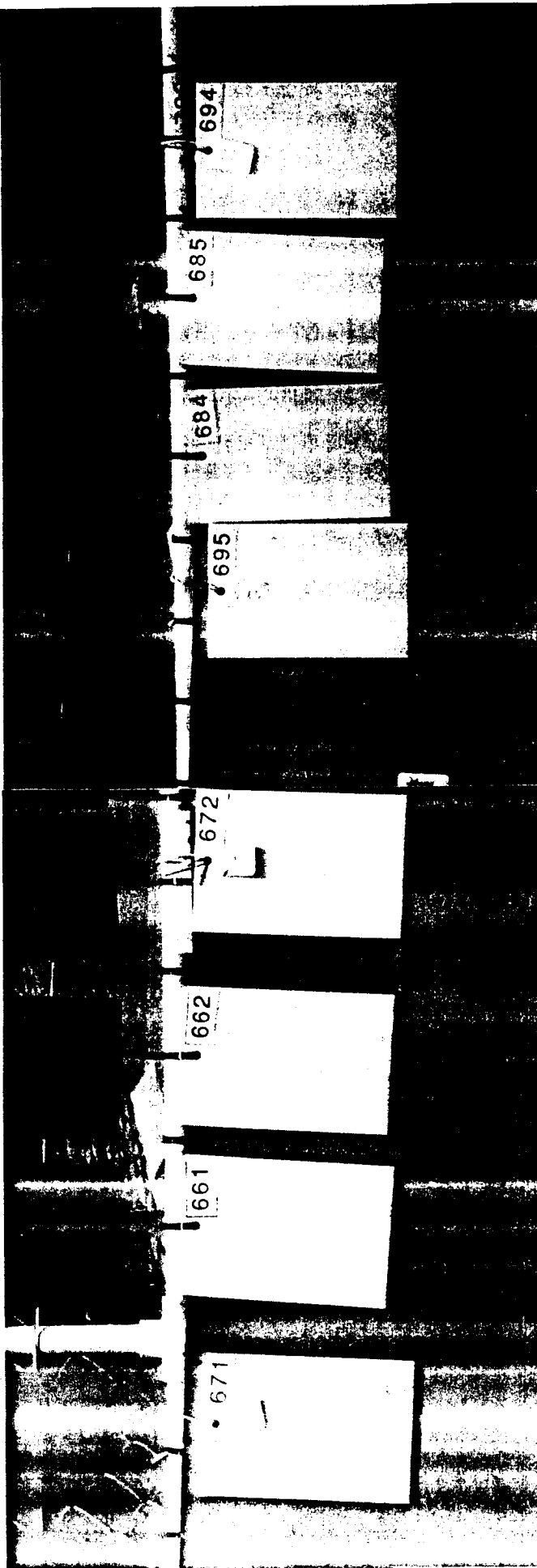
646

631

623

624

632



753

743

744

755

748

774

762

766

776

780

795

787

788

796

APPENDIX C
Photographic Presentation of Panels

Rotunda Panels

One System per Page:

Stainless Steel

Aluminum

CPVC

Coupled

One System per page

2000 hrs

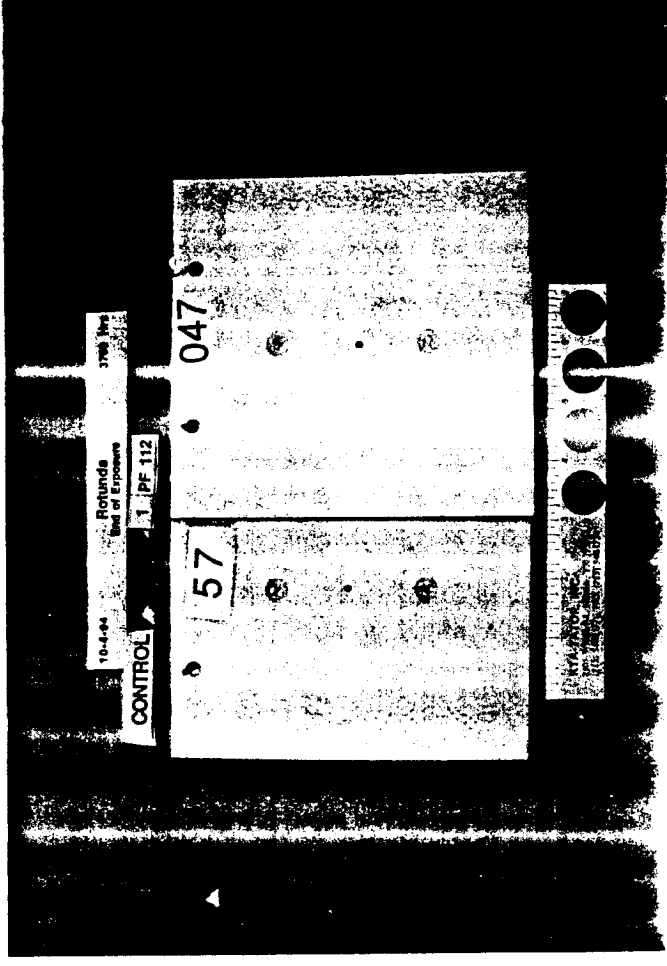
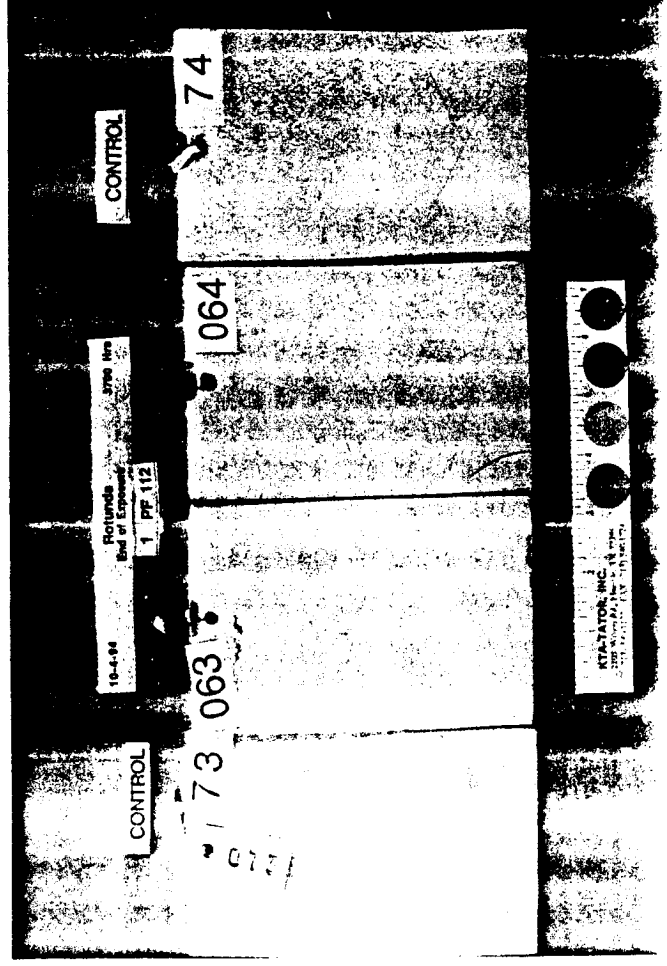
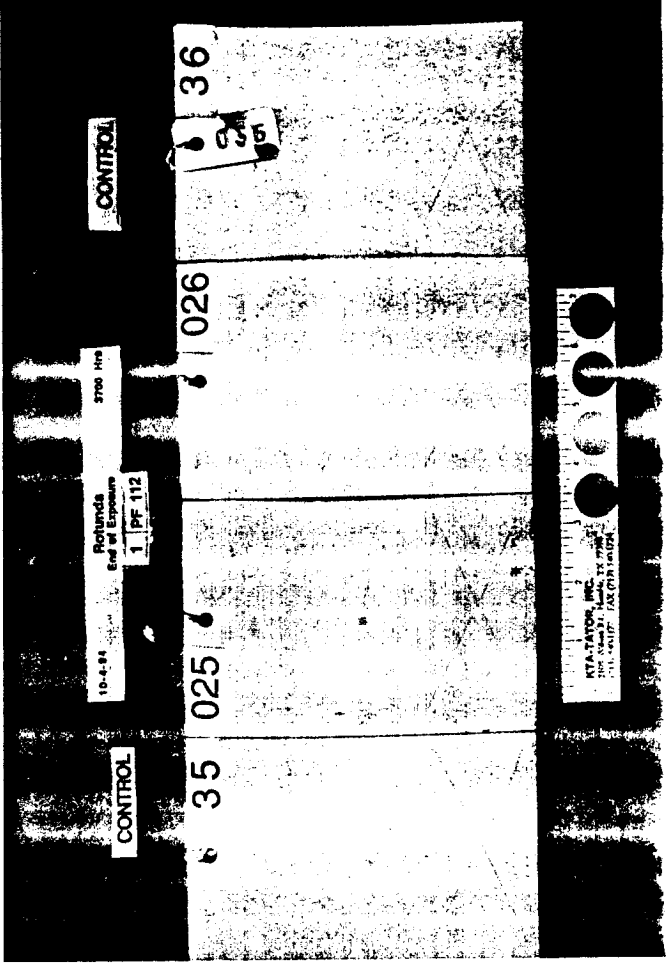
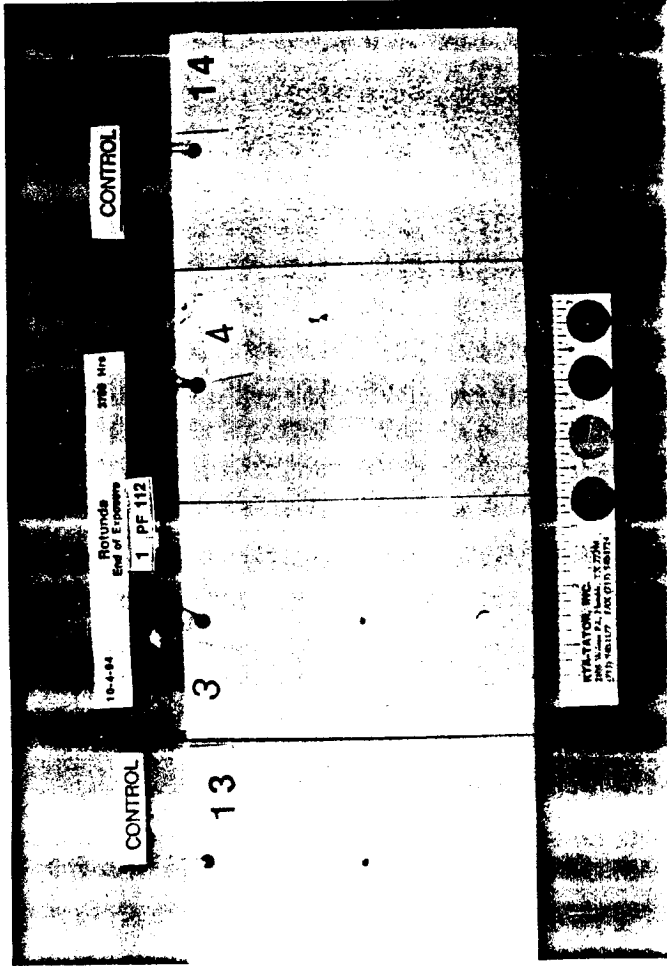
Stainless Steel

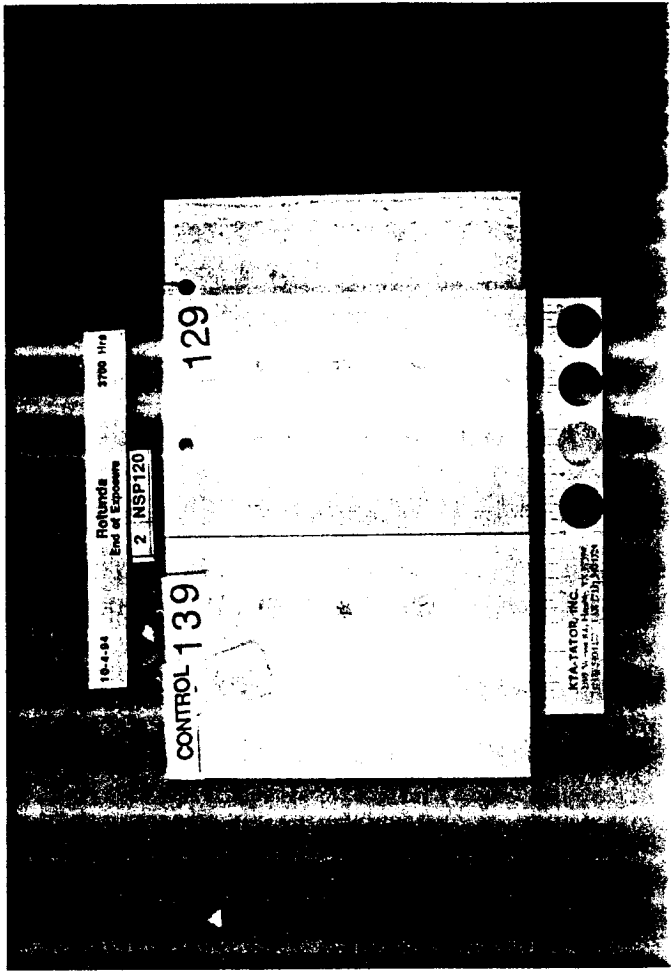
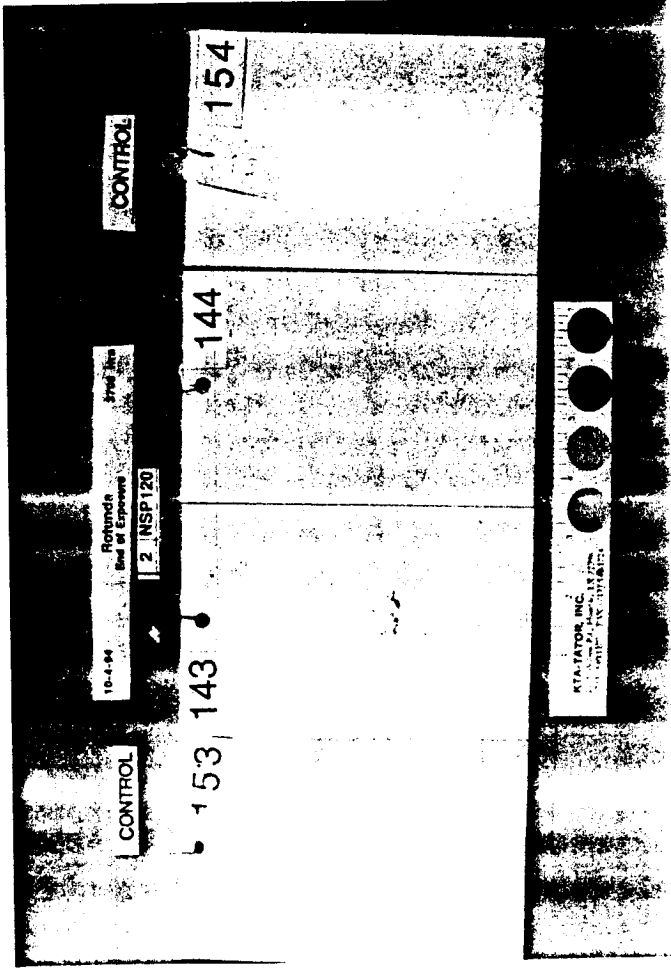
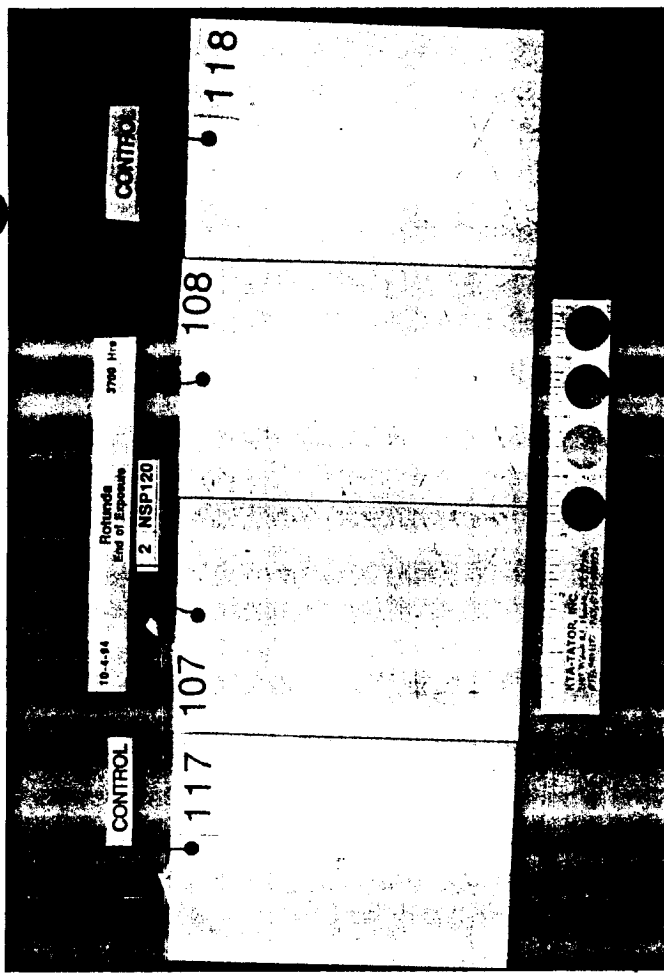
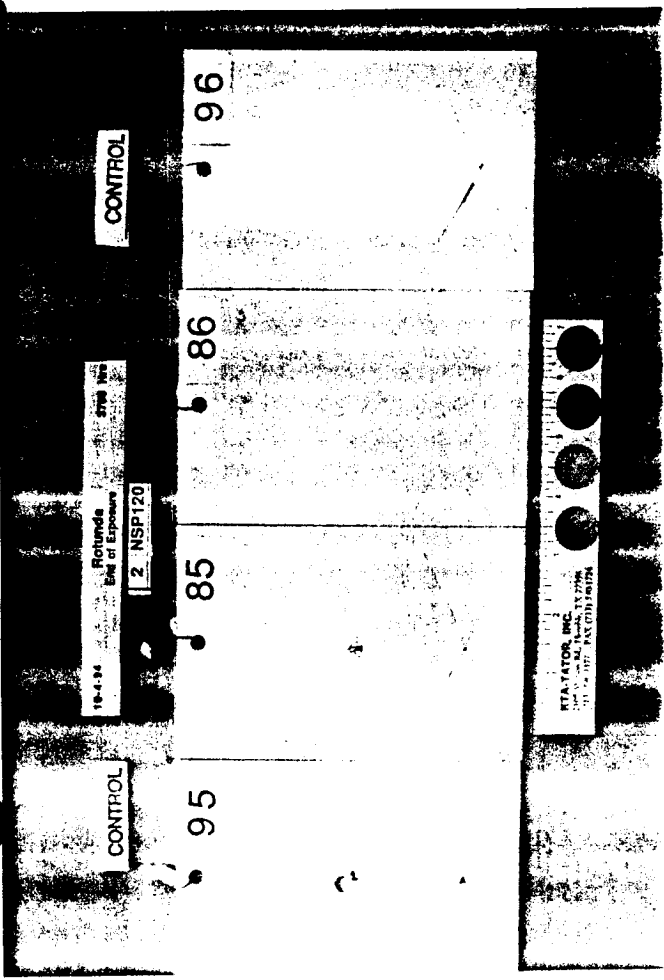
Aluminum

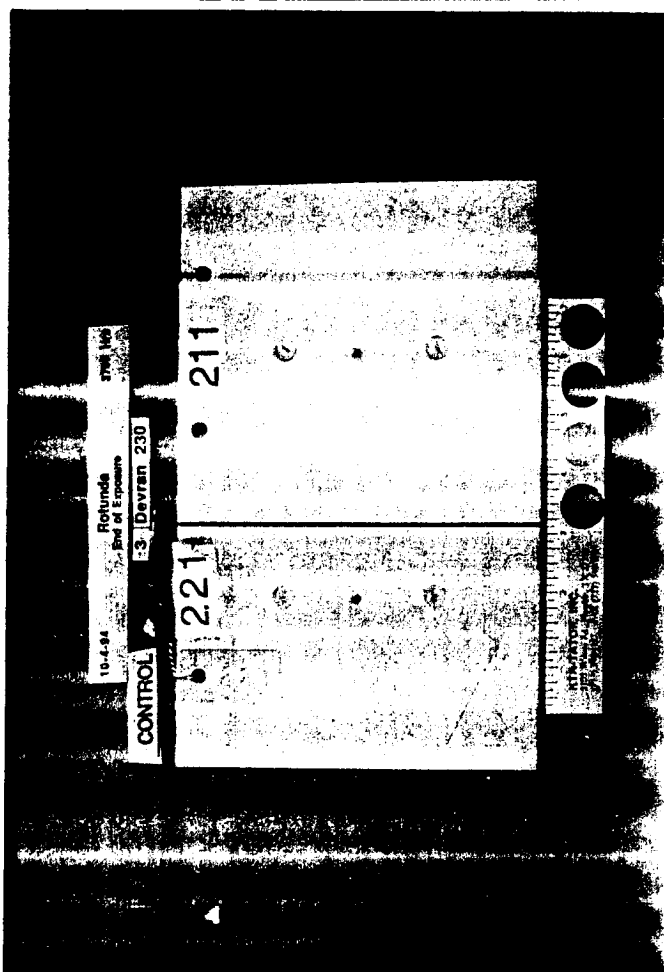
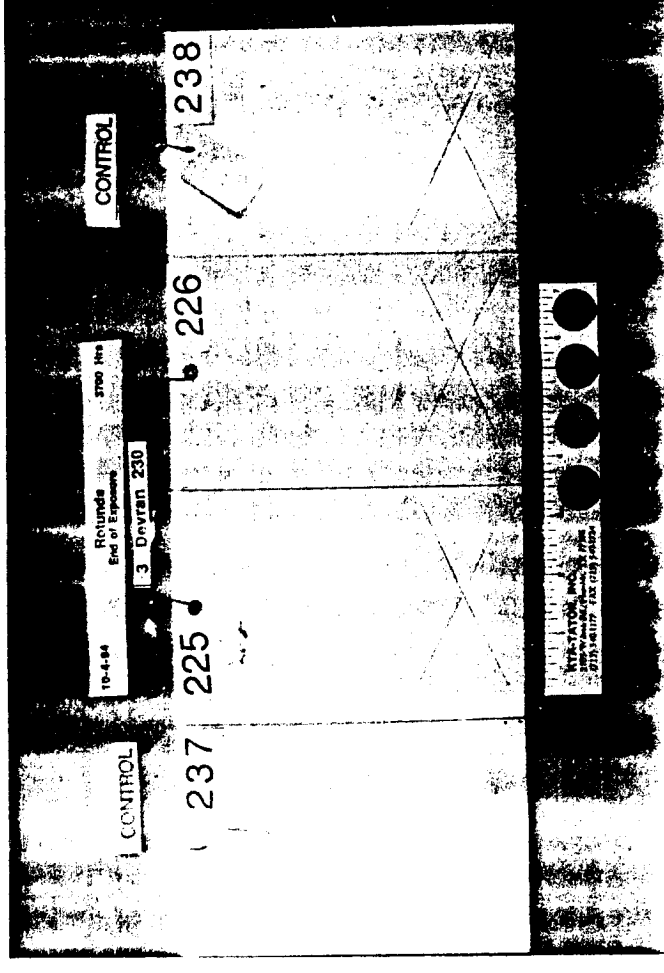
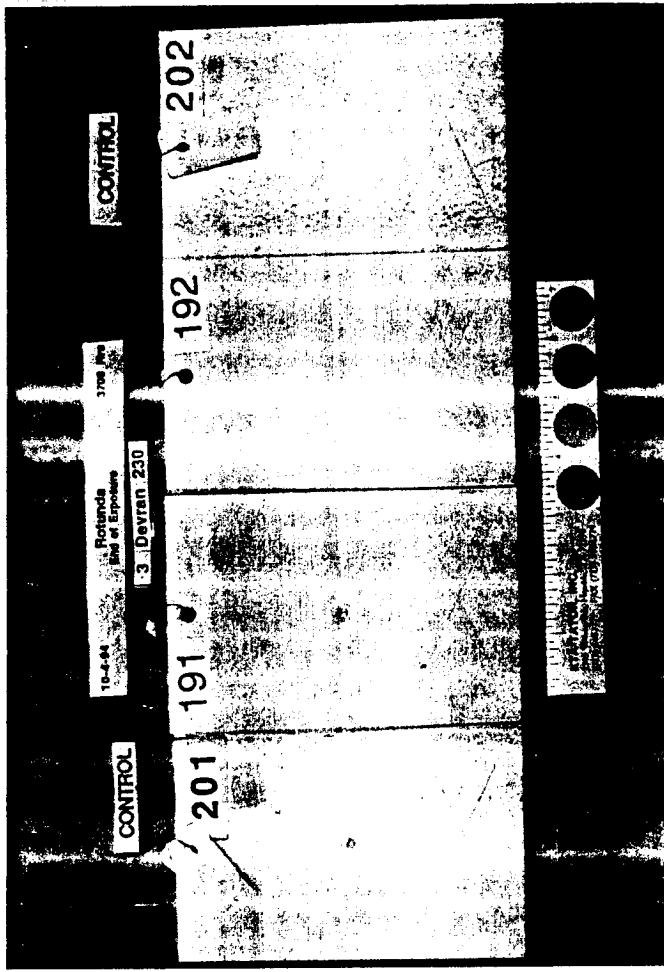
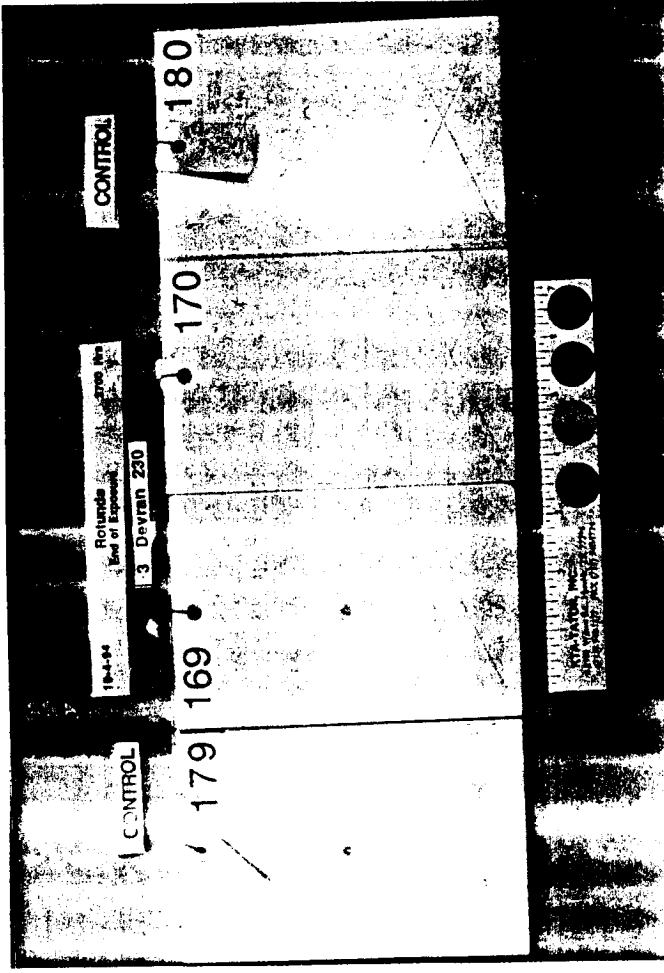
CPVC

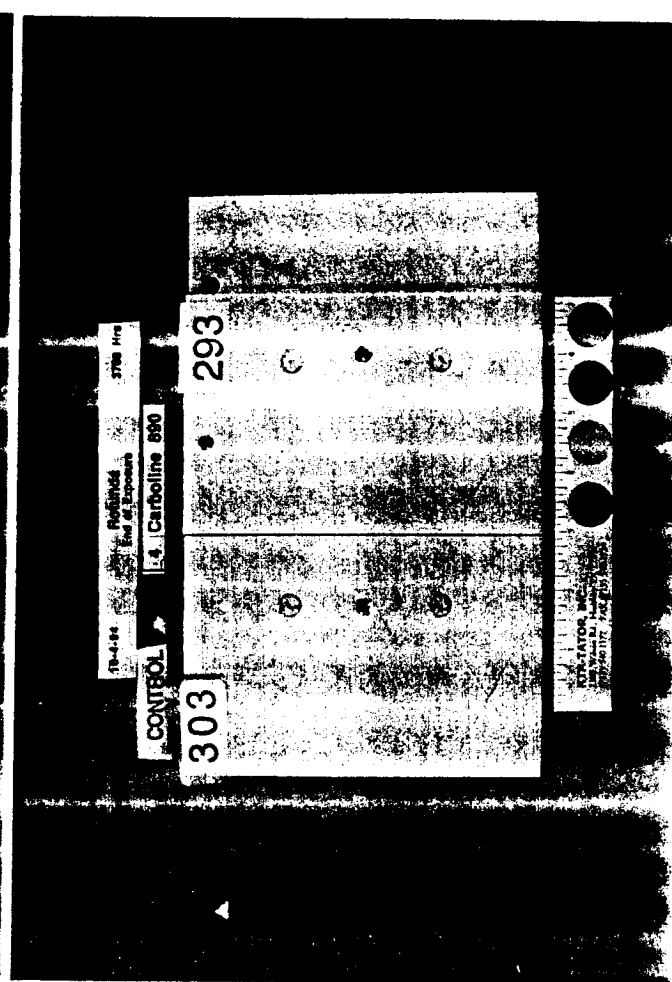
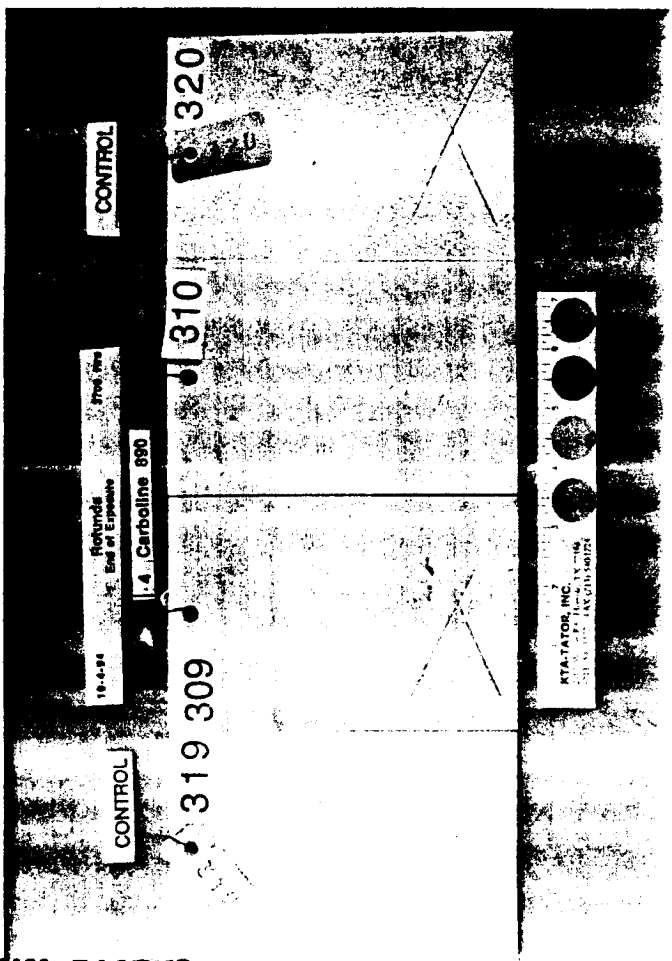
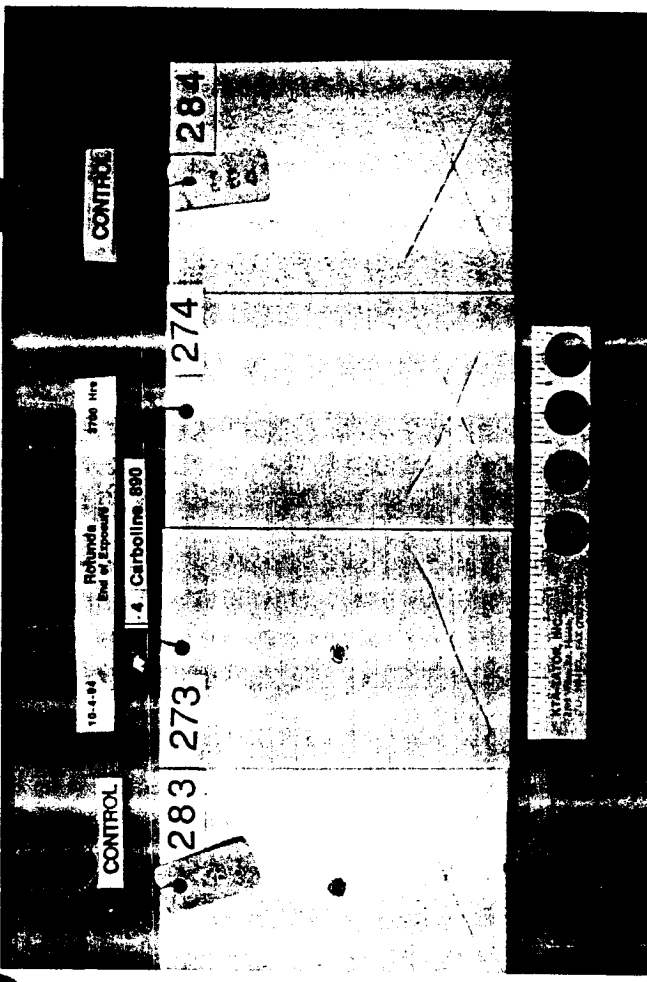
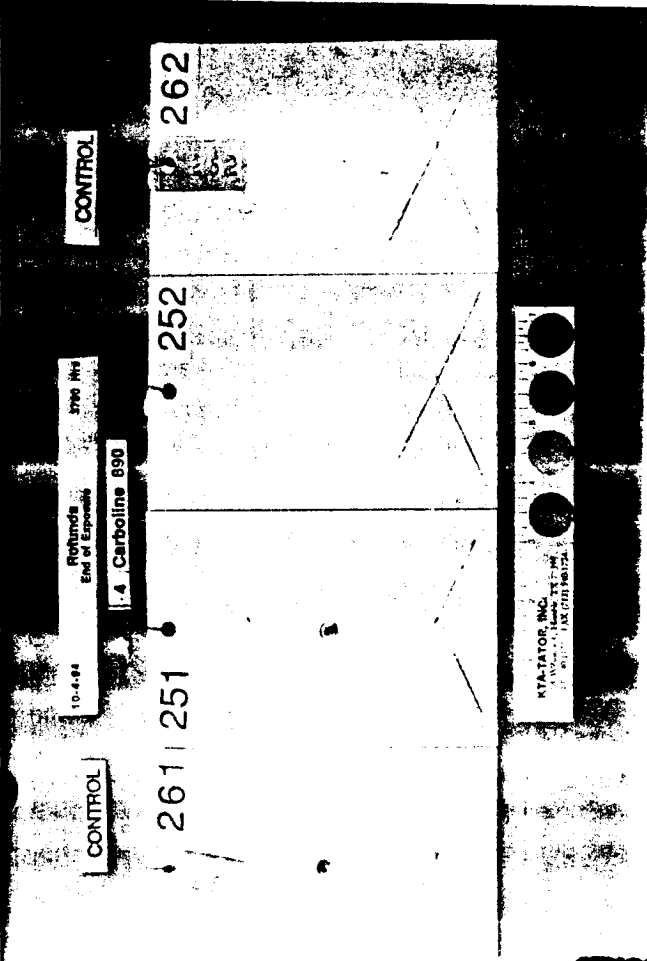
Coupled

ORIGINAL PAGE IS
OF POOR QUALITY

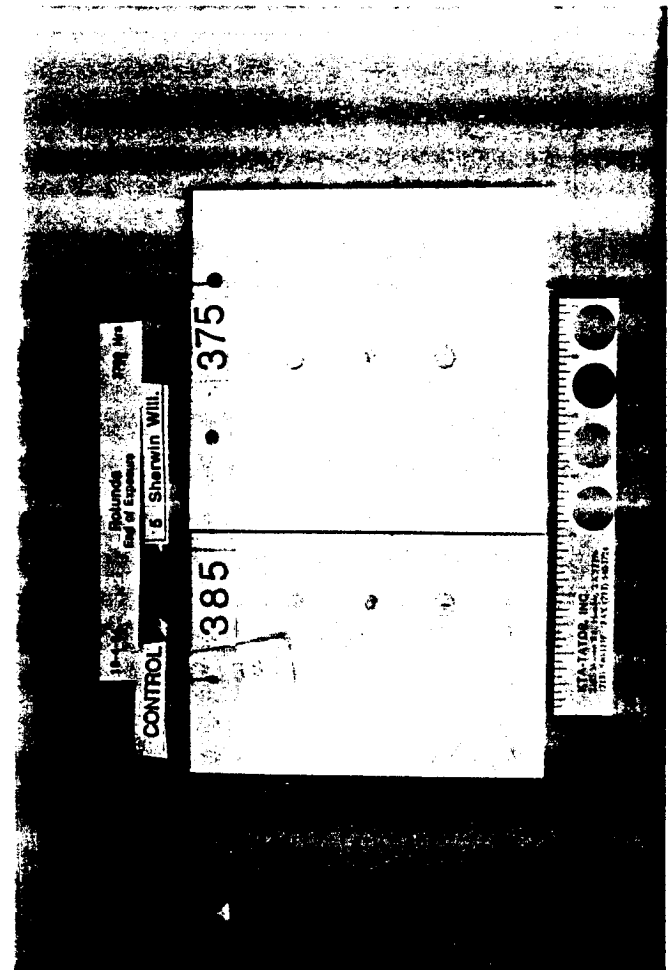
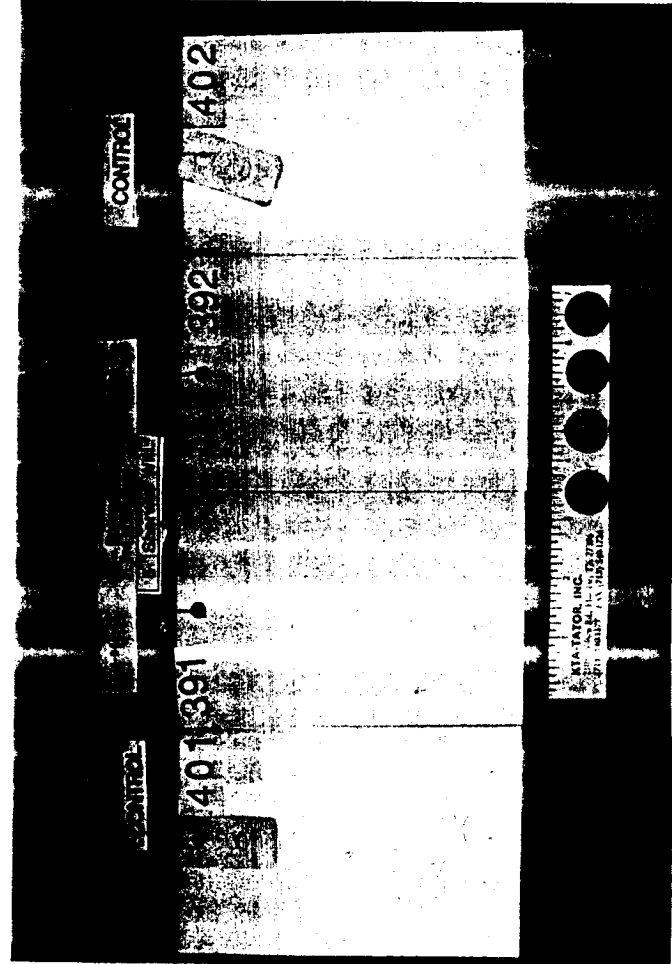
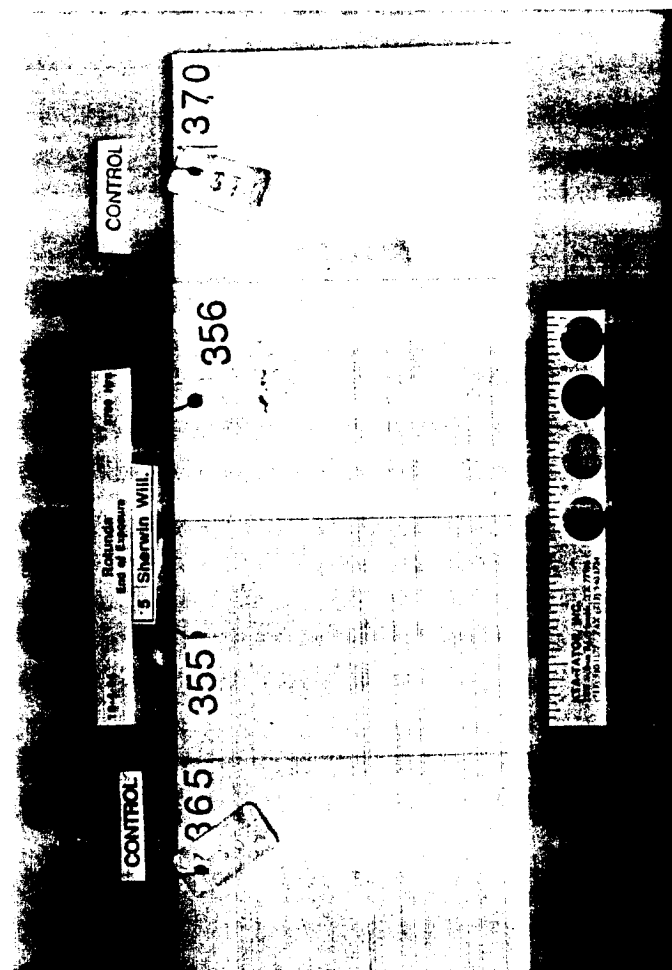
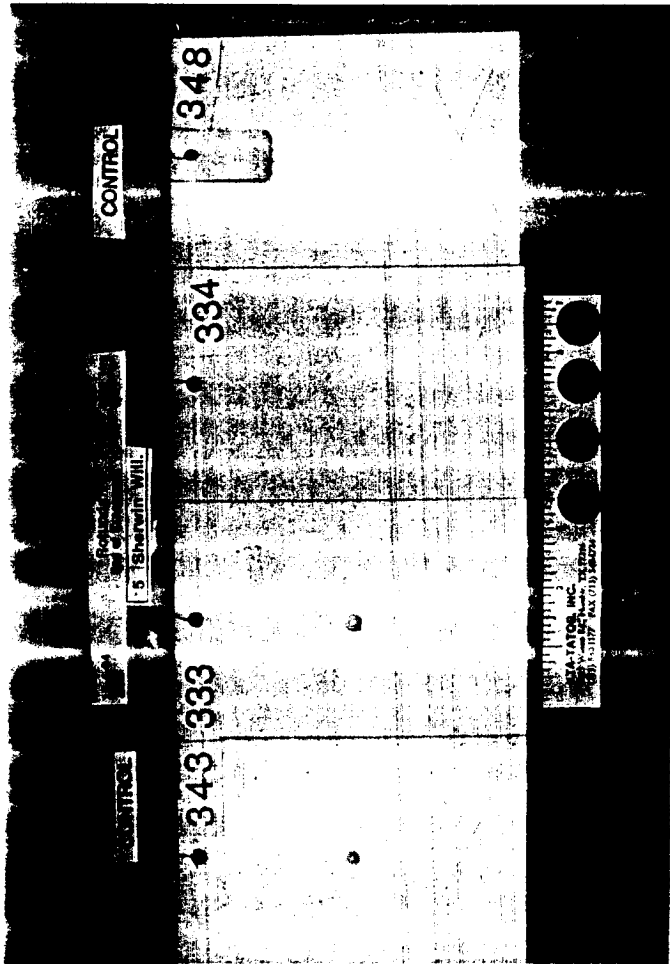








ORIGINAL PAGE IS OF POOR QUALITY



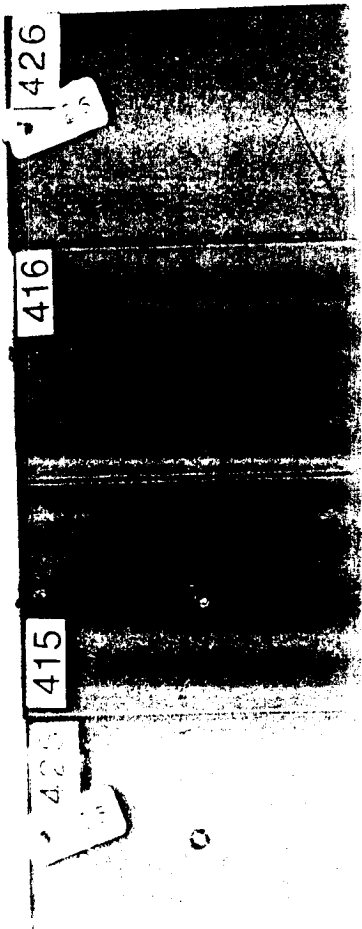
10-4-84

1700 Hrs

Rotunda
End of Exposure

6 UT Plast. Extra

CONTROL



CONTROL

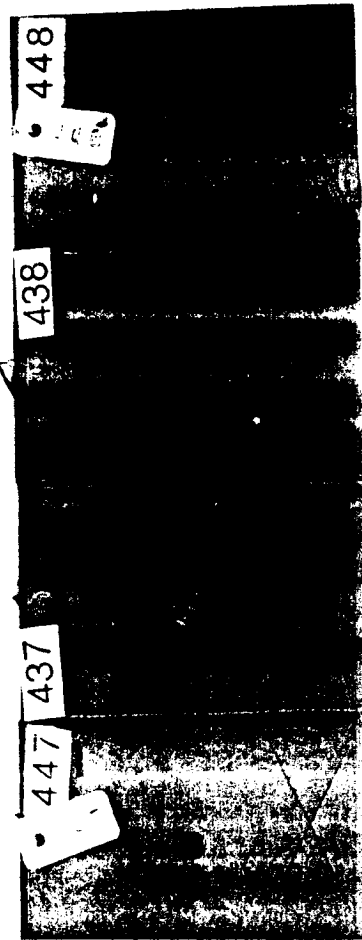
10-4-84

1700 Hrs

Rotunda
End of Exposure

6 UT Plast. Extra

CONTROL



CONTROL

KTA-TATOR, INC.



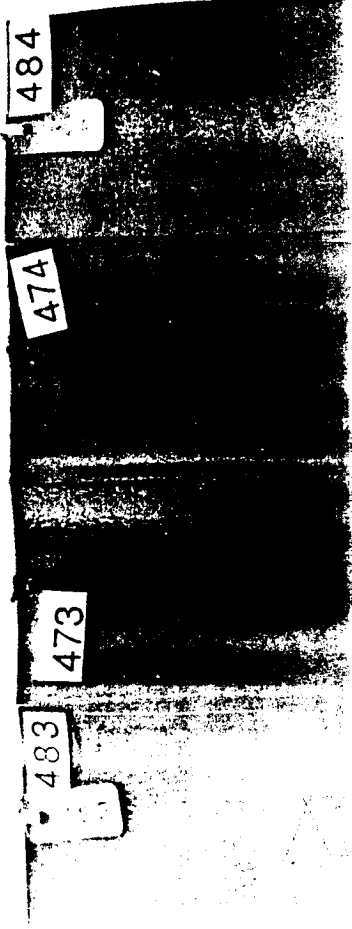
10-4-84

1700 Hrs

Rotunda
End of Exposure

6 UT Plast. Extra

CONTROL



CONTROL

KTA-TATOR, INC.



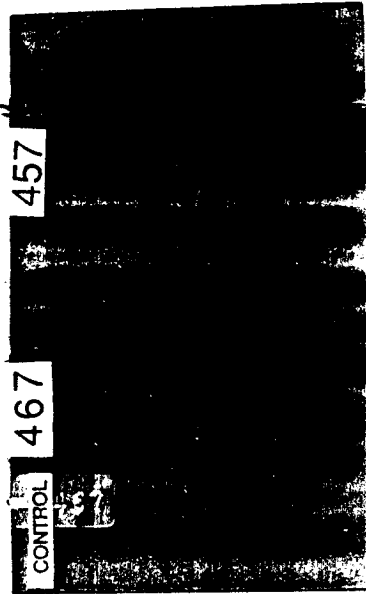
10-4-84

1700 Hrs

Rotunda
End of Exposure

6 UT Plast. Extra

CONTROL



CONTROL

KTA-TATOR, INC.



ORIGINAL PAGE IS
OF POOR QUALITY

FILE NO:

CONTROL

10-4-84 Rotunda End of Exposure 3700 Ina

9 Plasilite 7122

695 681 682 694

STATOR INC
1115 W. 17th St.
Miami, FL 33134

CONTROL

10-4-84 Rotunda End of Exposure 3700 Ina

9 Plasilite 7122

713 703

STATOR INC
1115 W. 17th St.
Miami, FL 33134

Print File
ARCHIVAL PRESERVERS

ASSIGNMENT:

DATE:

CONTROL

10-4-84 Rotunda End of Exposure 3700 Ina

9 Plasilite 7122

671 659 660 672

STATOR INC
1115 W. 17th St.
Miami, FL 33134

CONTROL

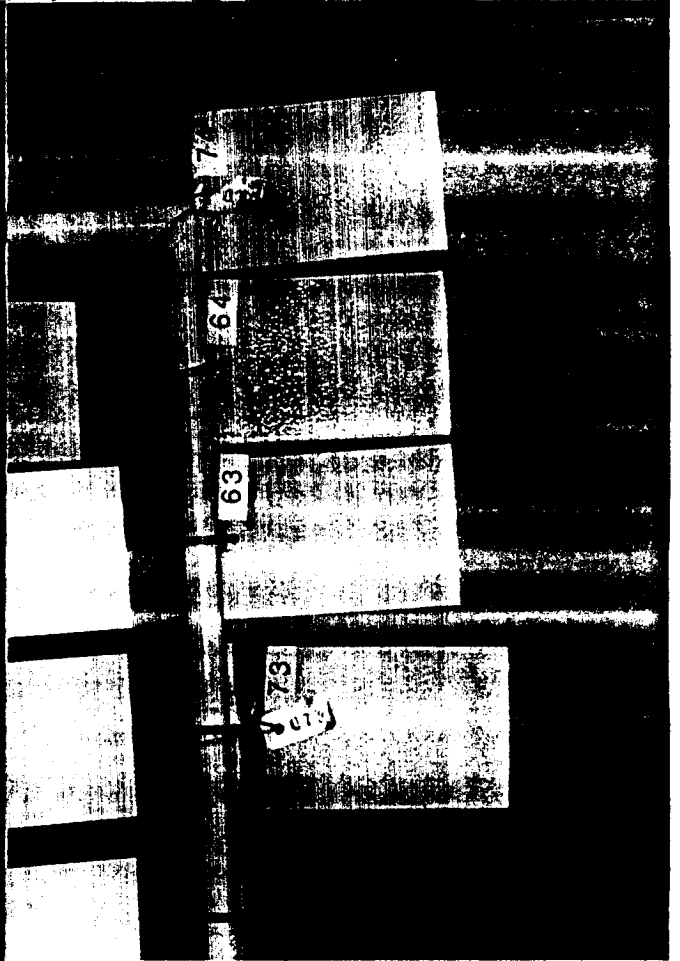
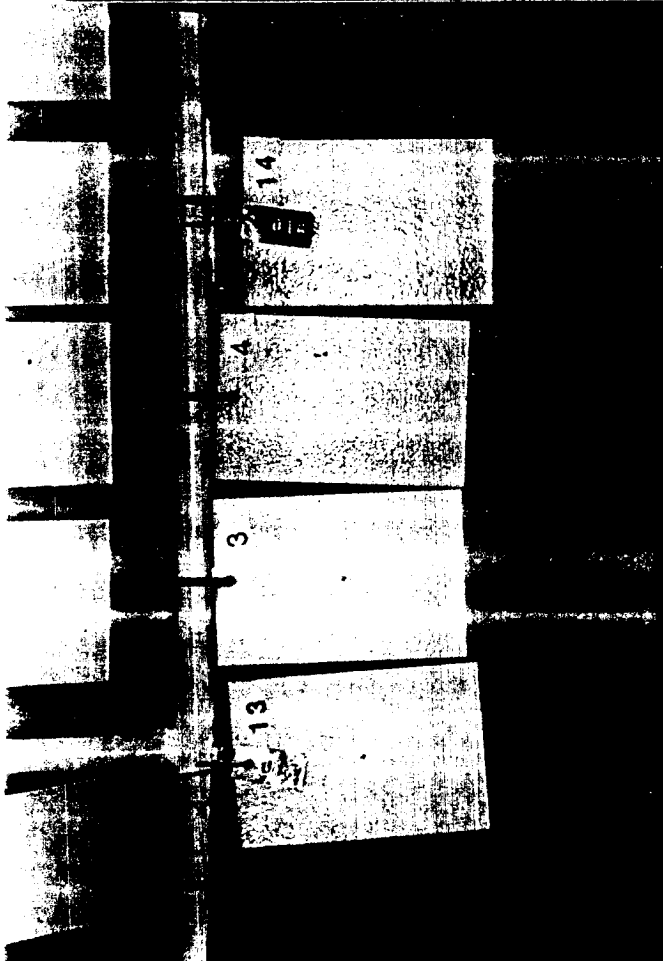
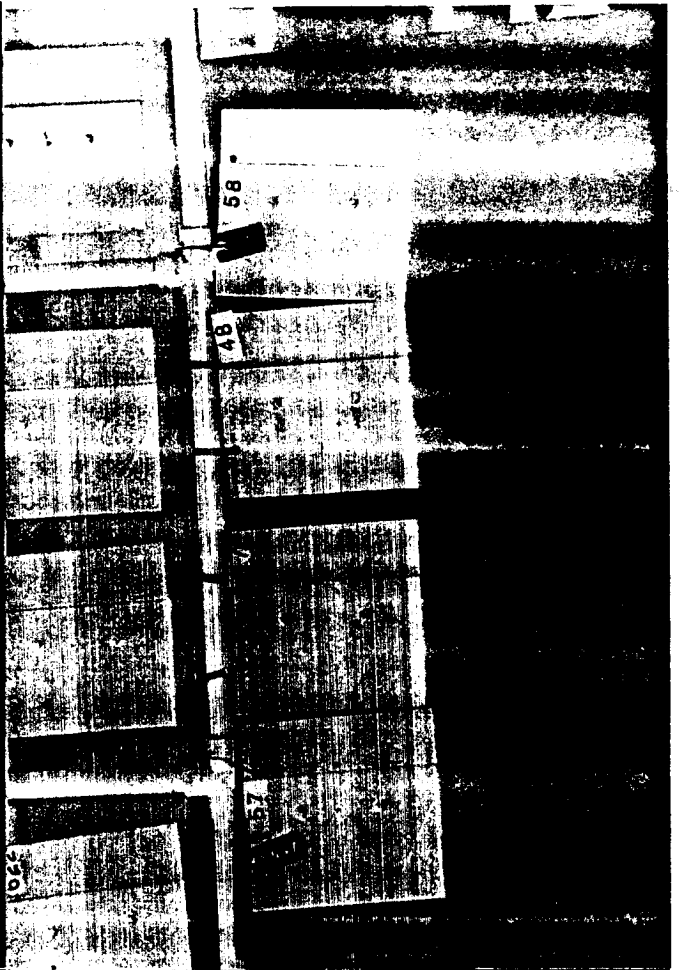
10-4-84 Rotunda End of Exposure 3700 Ina

9 Plasilite 7122

727 717 718 728

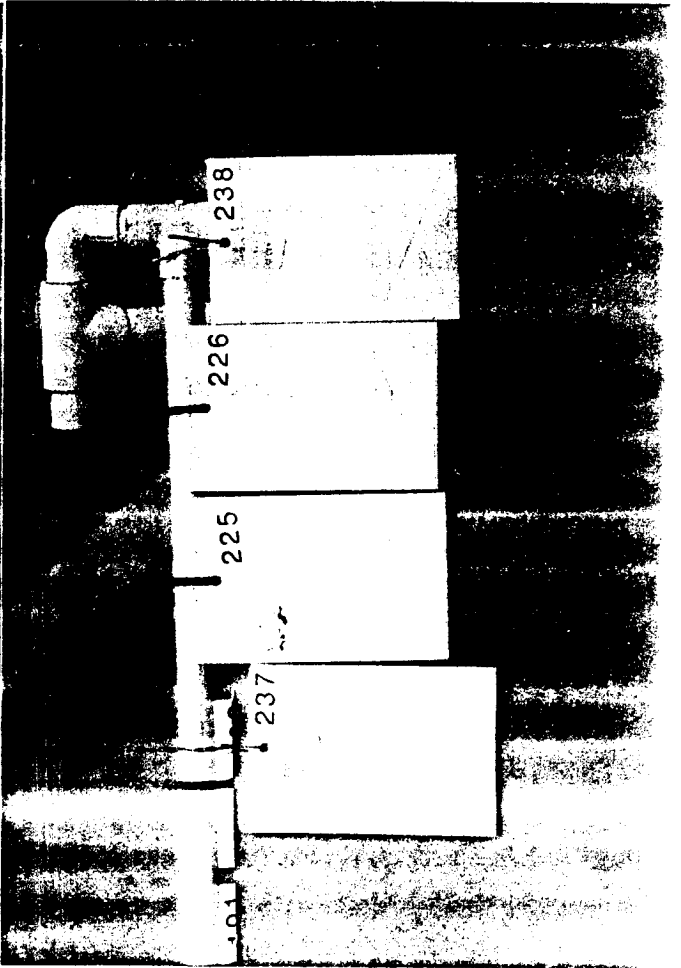
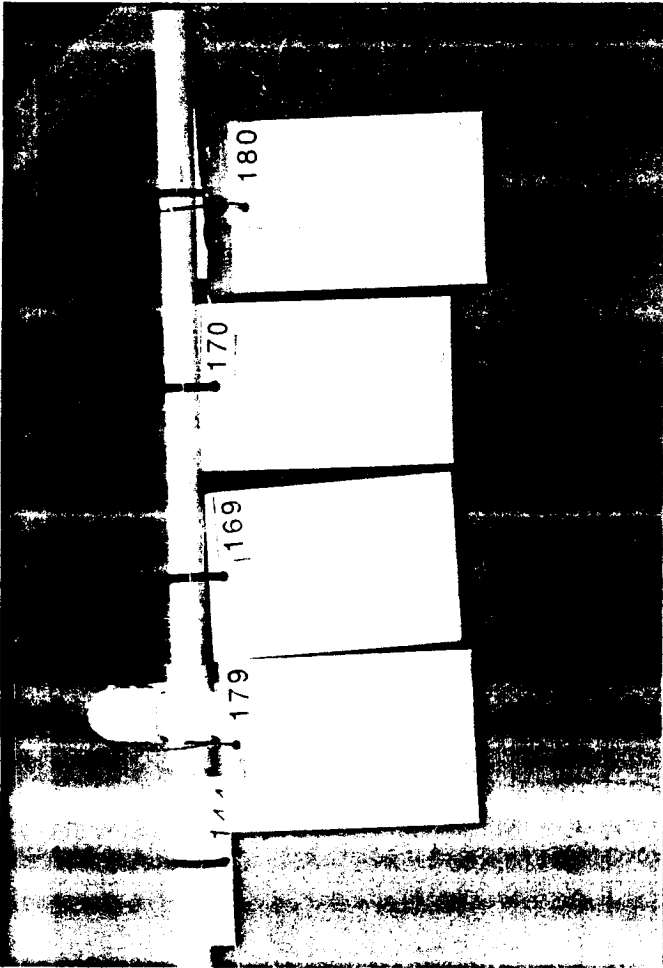
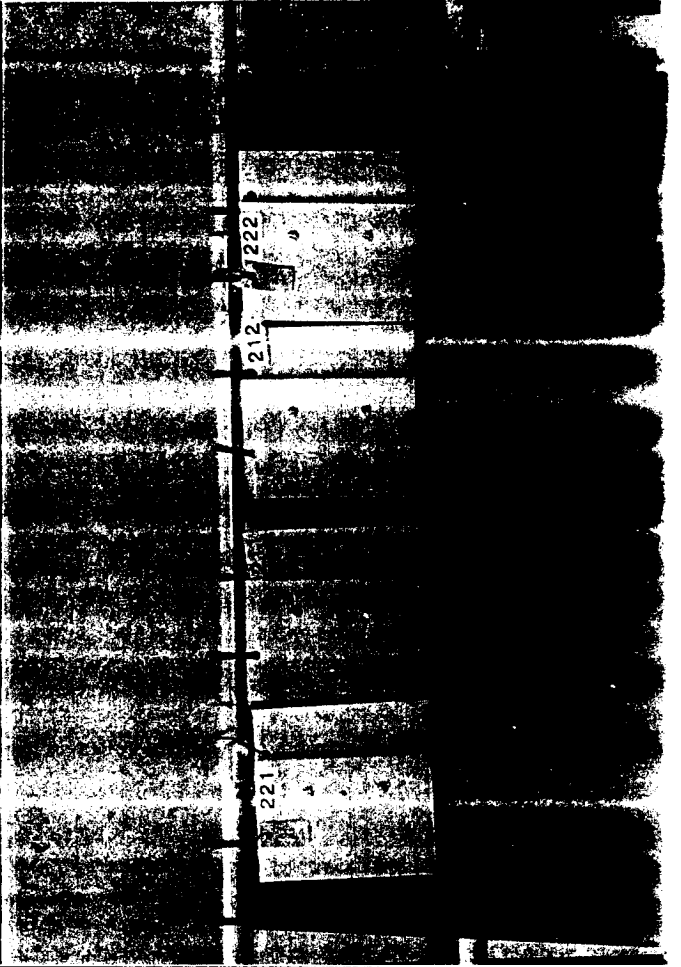
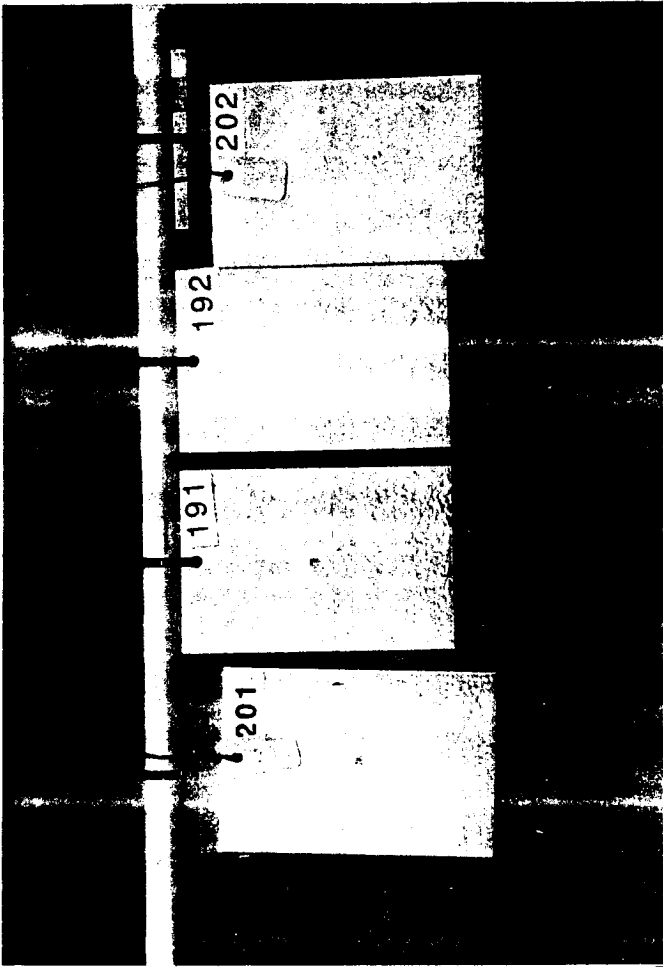
STATOR INC
1115 W. 17th St.
Miami, FL 33134

ORIGINAL PAGE IS
OF POOR QUALITY





ORIGINAL FILM IS
OF POOR QUALITY



ORIGINAL PAGE IS
OF POOR QUALITY

284

274

273

283

304

294

293

303

262

252

251

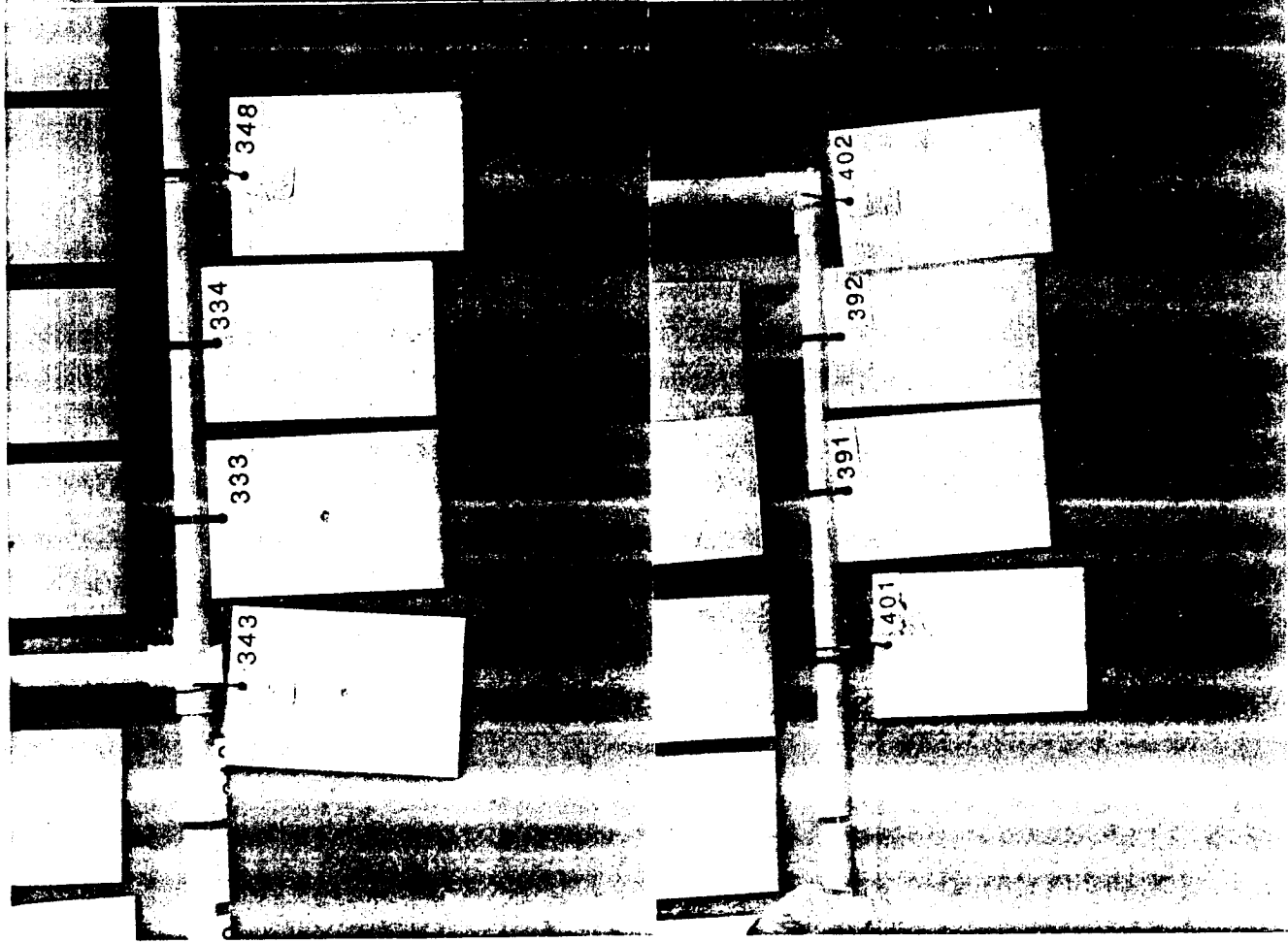
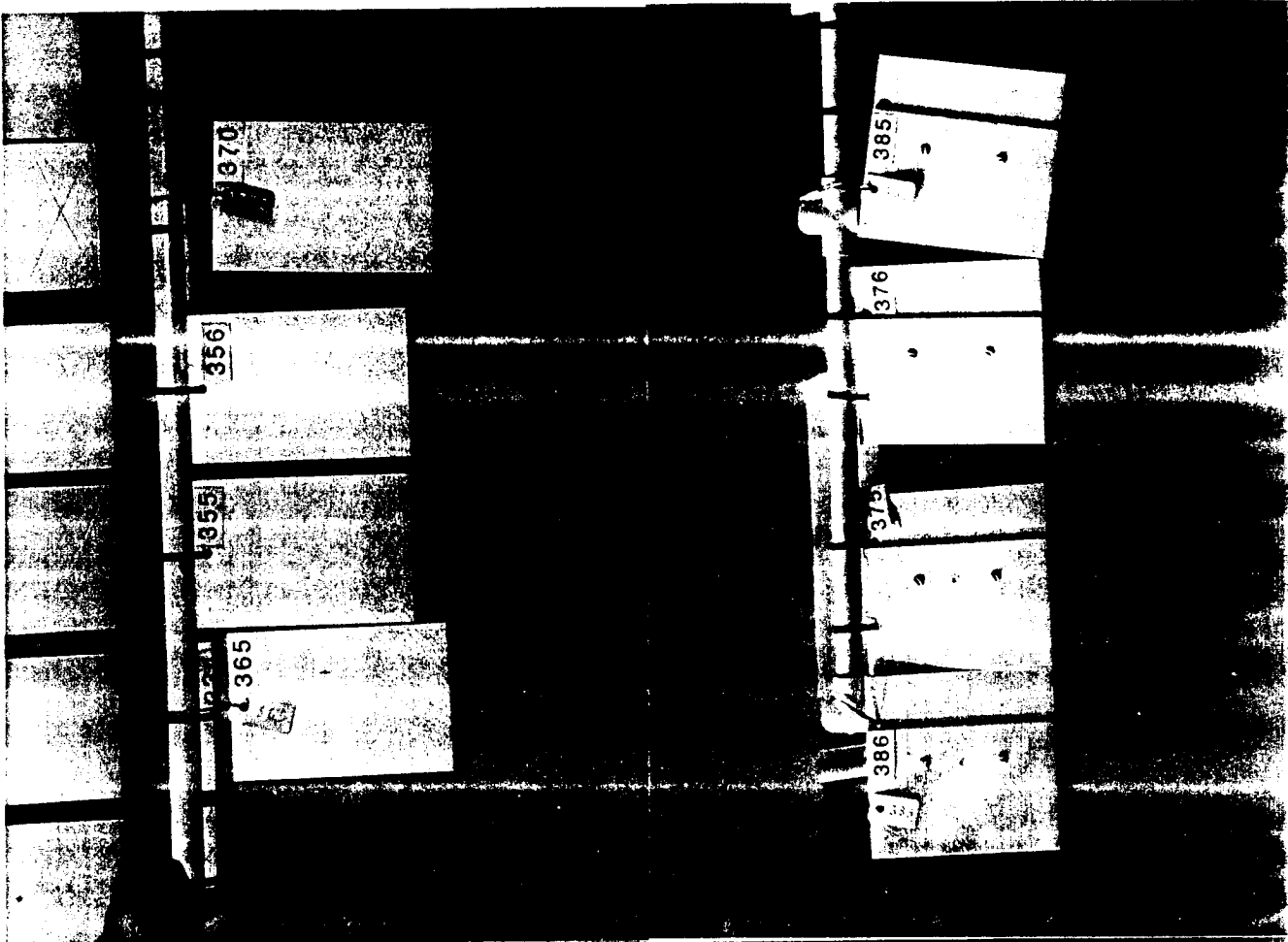
261

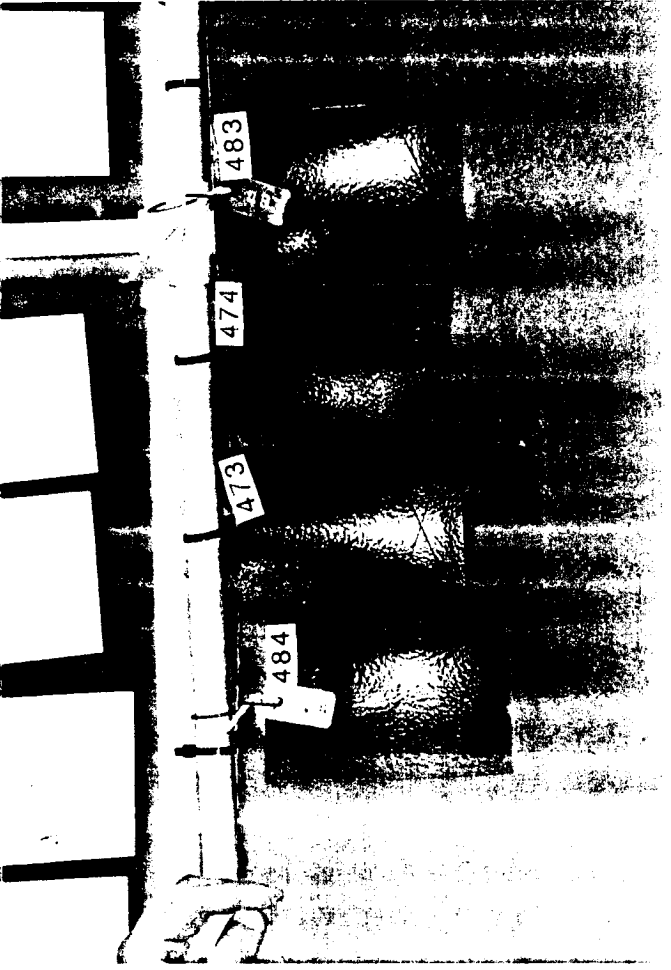
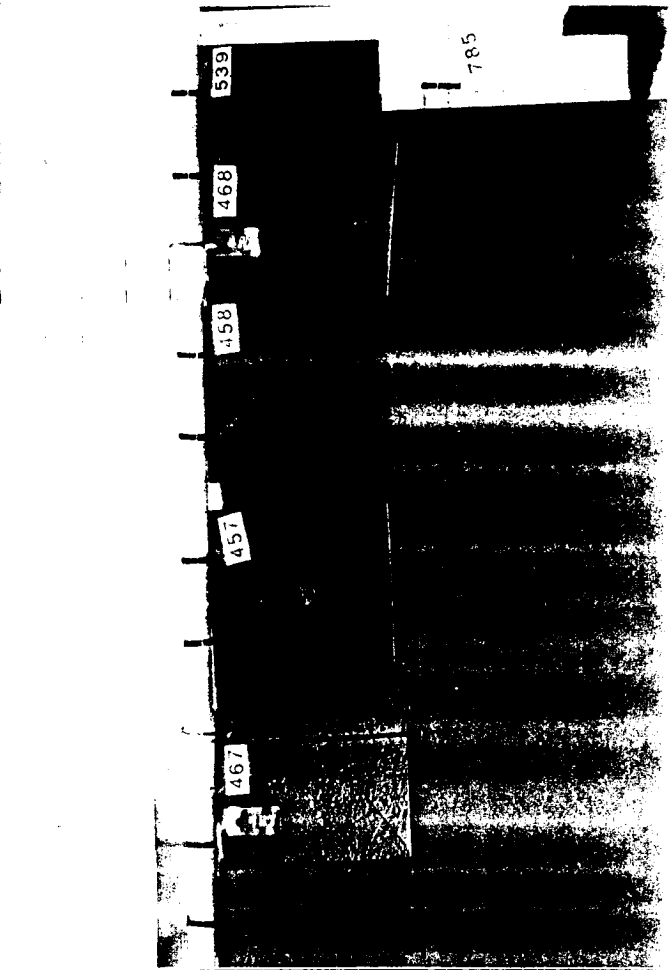
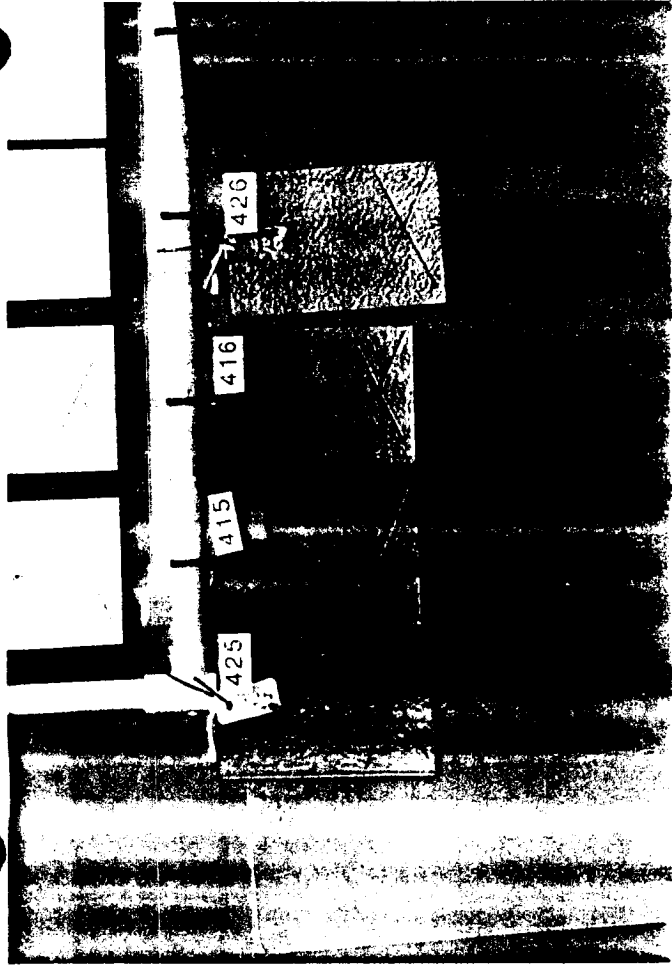
320

310

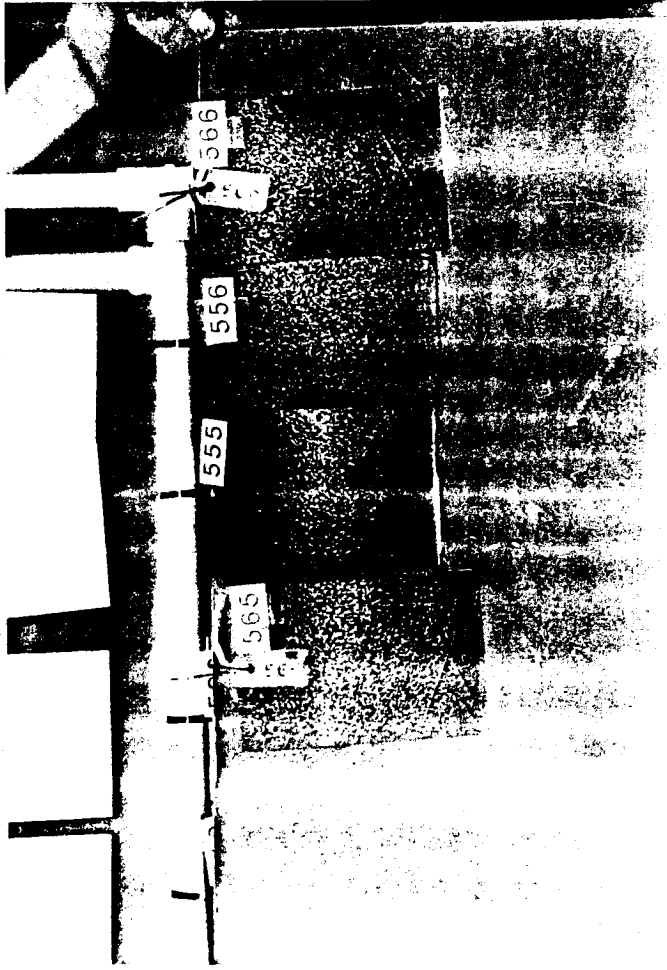
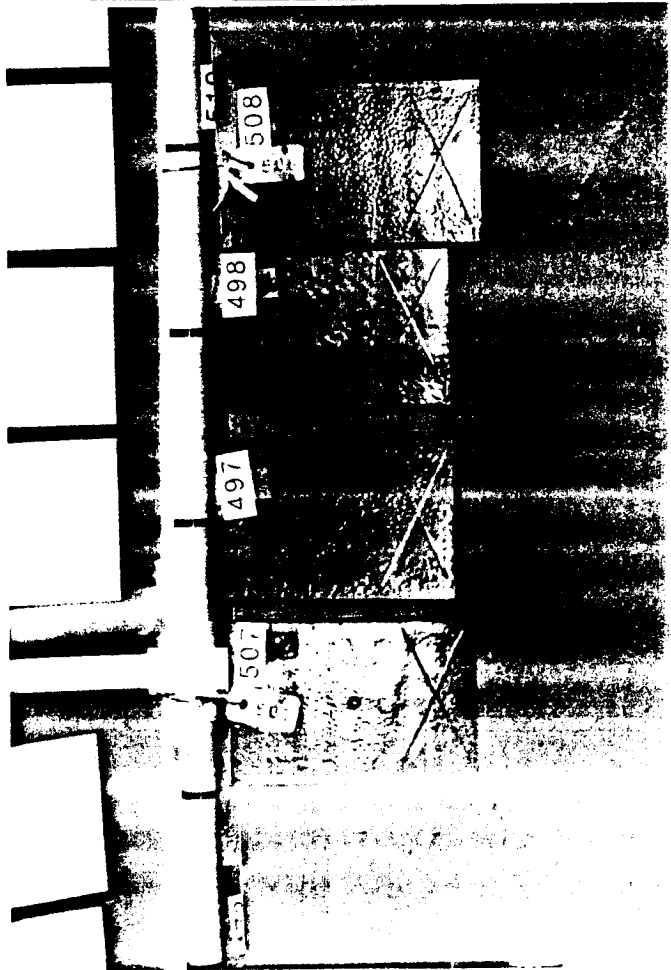
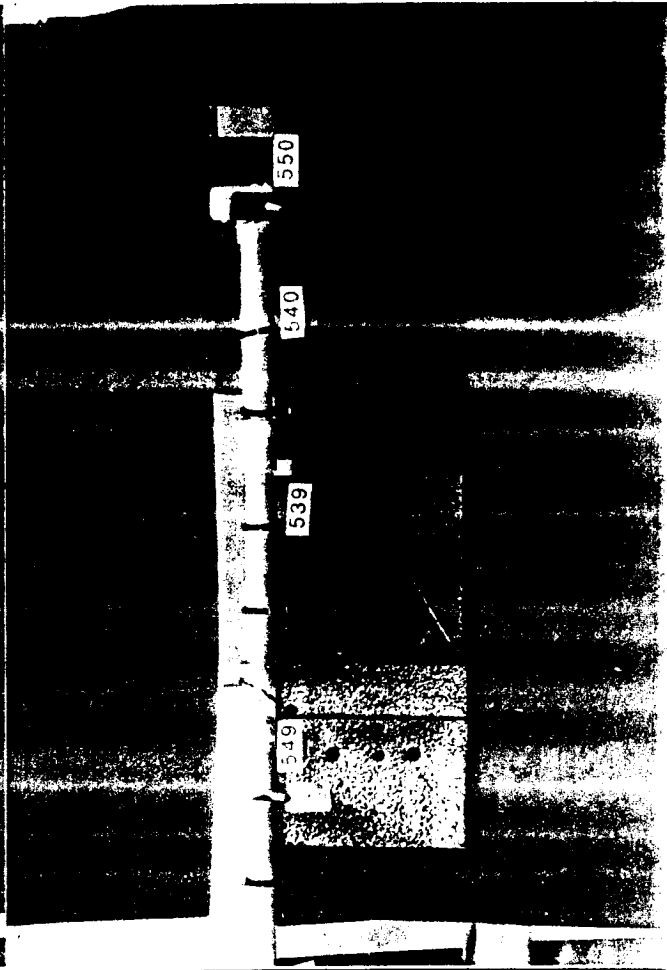
309

319





785



612

602

601

611

590

579

588

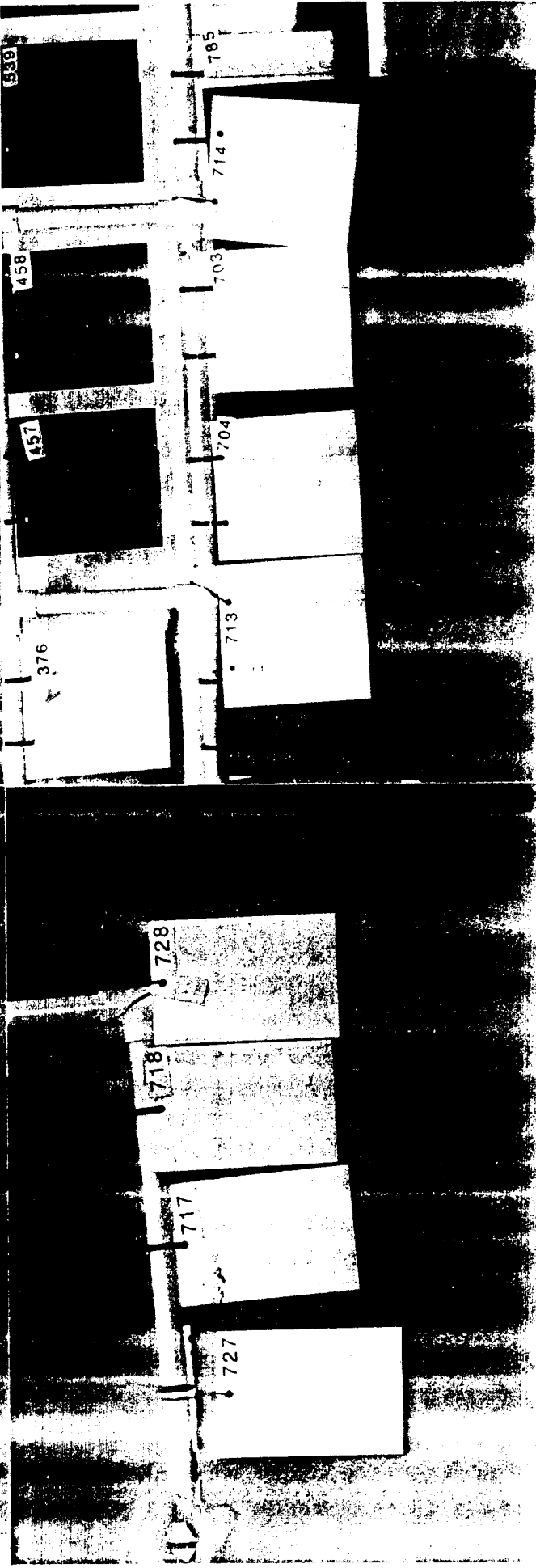
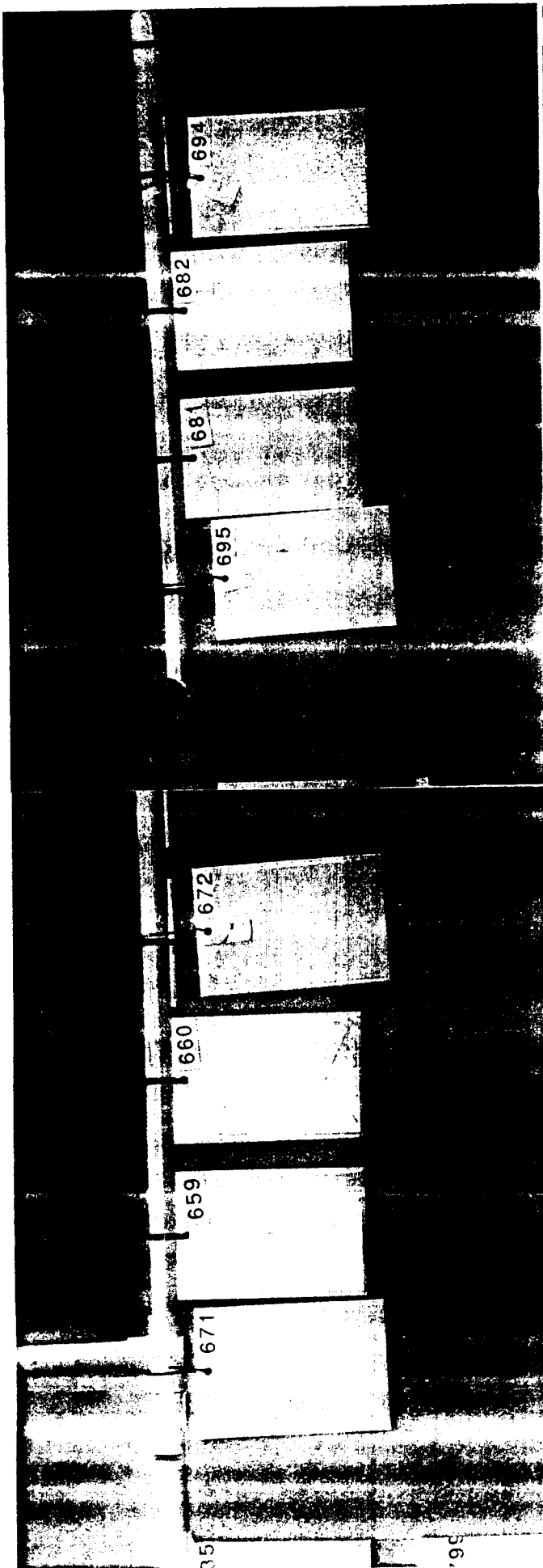
632

622

621

631

646



ORIGINAL PAGE IS
OF POOR QUALITY

C-3.

776

764

765

774

786

785

795

755

742

741

753

810

800

809

APPENDIX C
Photographic Presentation of Panels

Pre Exposure, System Examples

Two Systems per Page:

As Labeled

Note: Systems are in order, however, start with System #2., System #1 was submitted later. See System #1 controls in other photos.

Last Page:

In Place Rotunda and Laydown Racks

Rotunda

Stainless Steel, Aluminum and CPVC

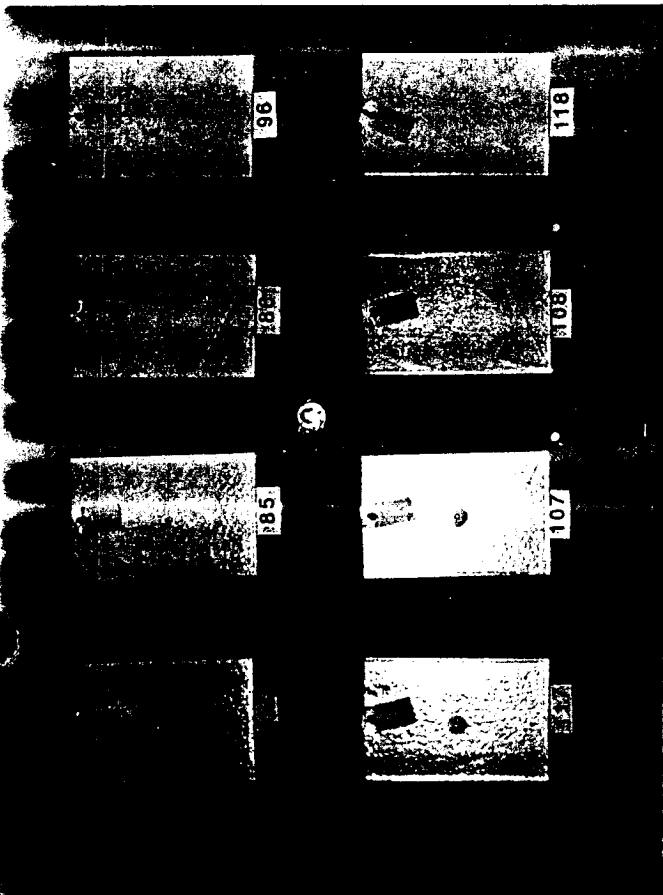
Coupled Panels

Laydown

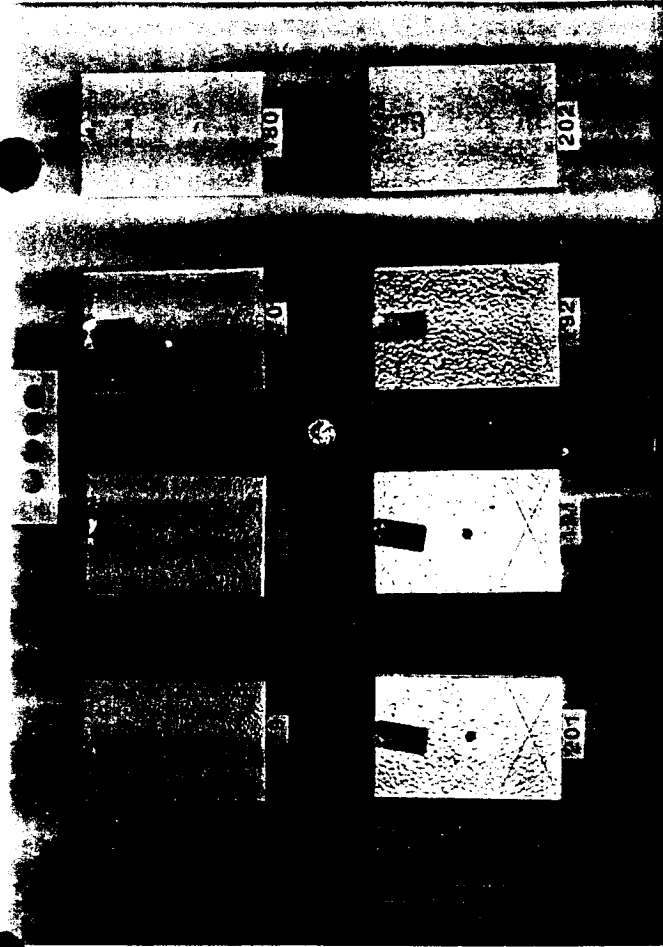
Stainless Steel, Aluminum and CPVC

Coupled Panels

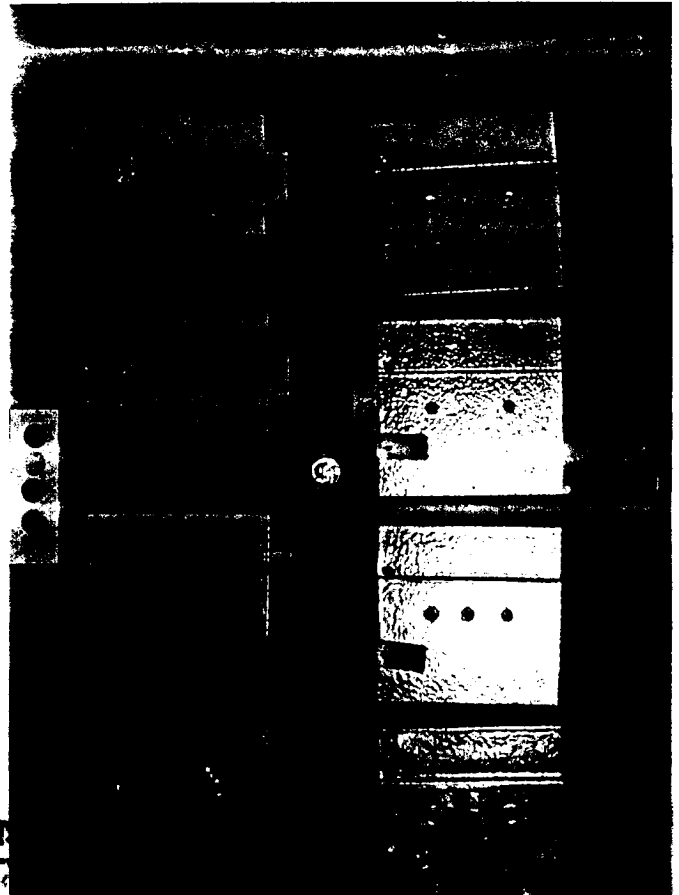
System Panels are grouped together



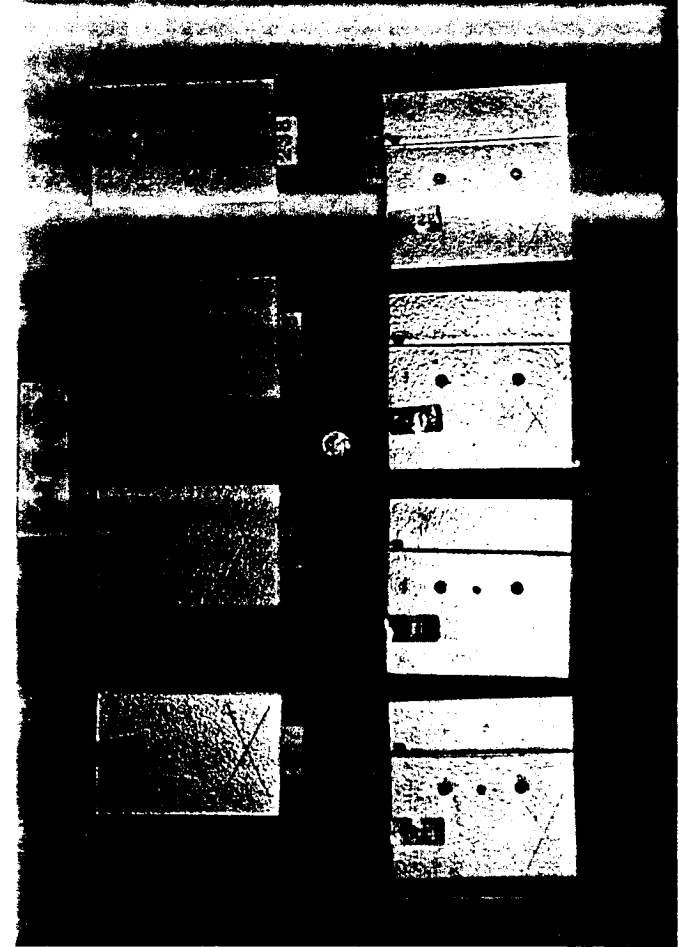
Stainless



Aluminum

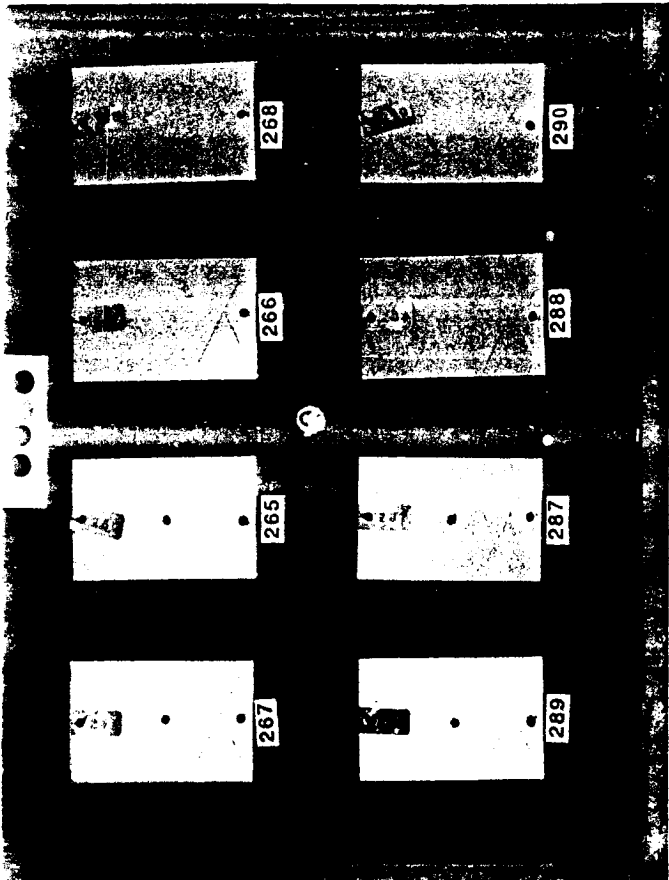


CPVC

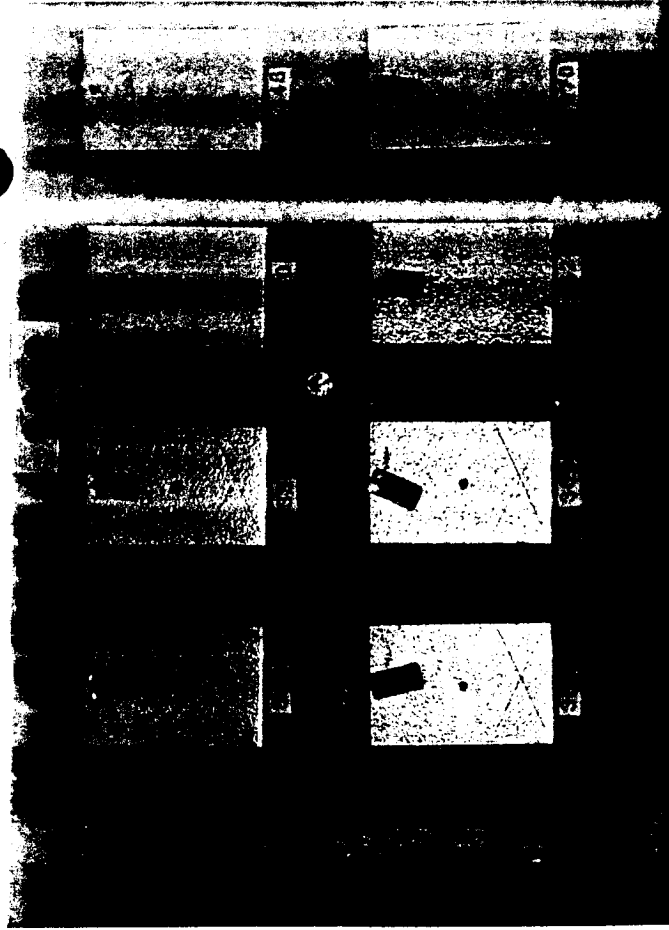


Coupled

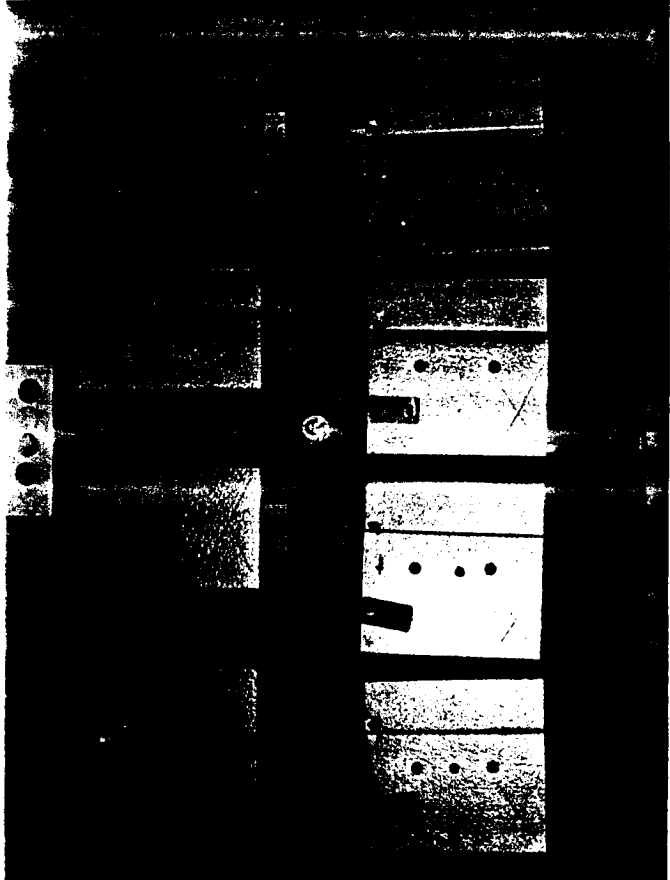
Pre-exposure Test Panels, System Examples



Stainless



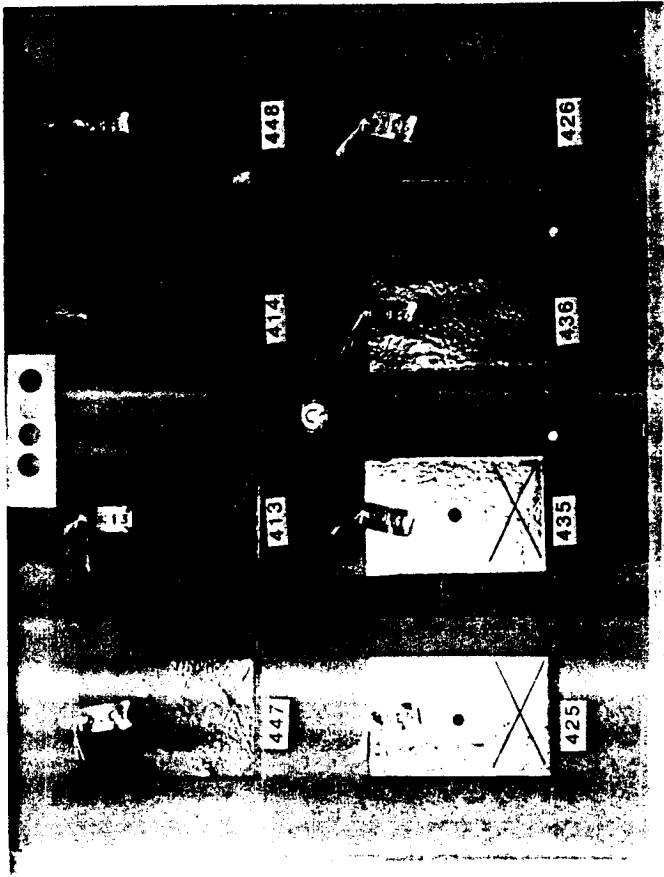
Aluminum



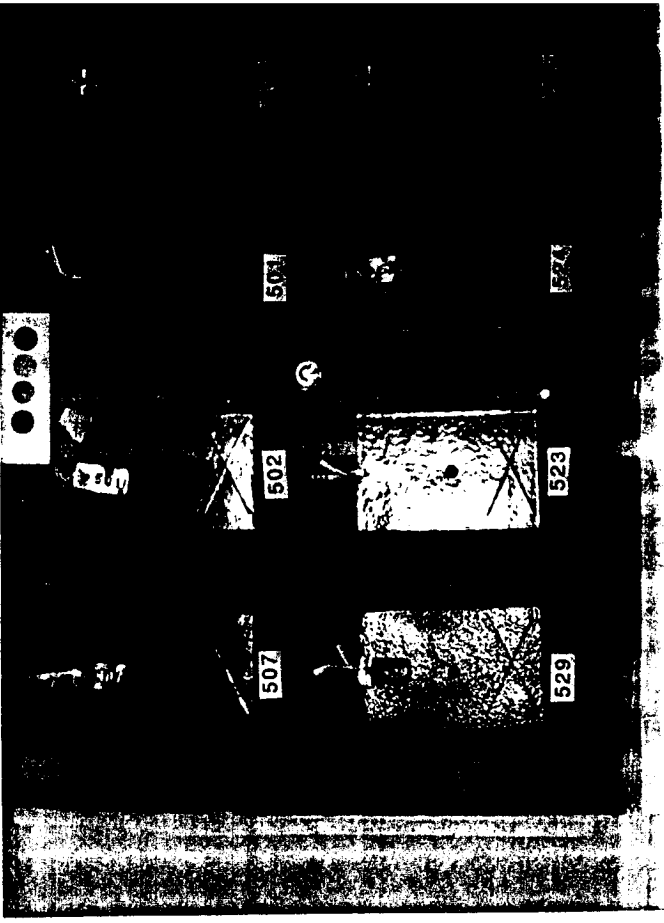
CPVC



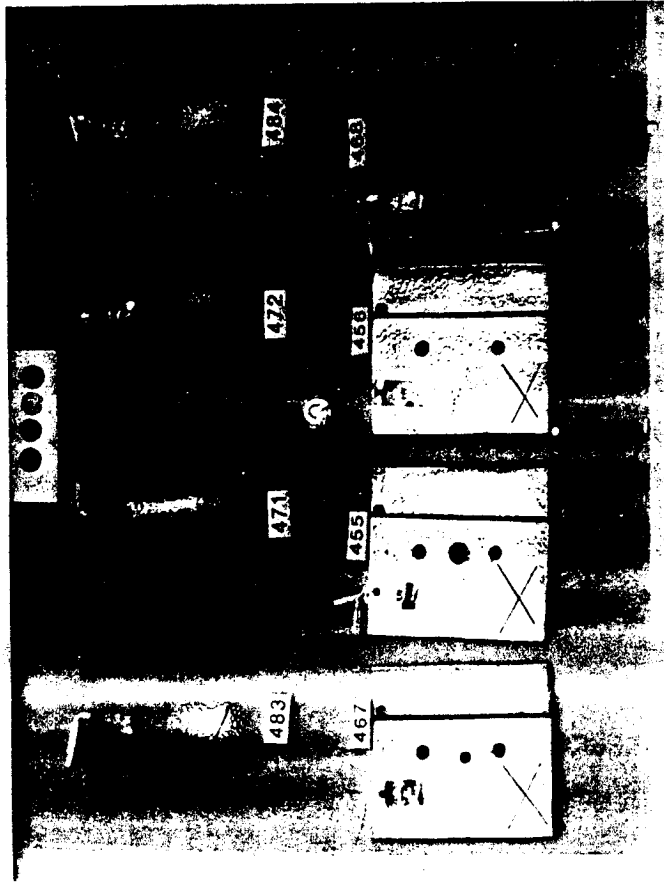
Coupled



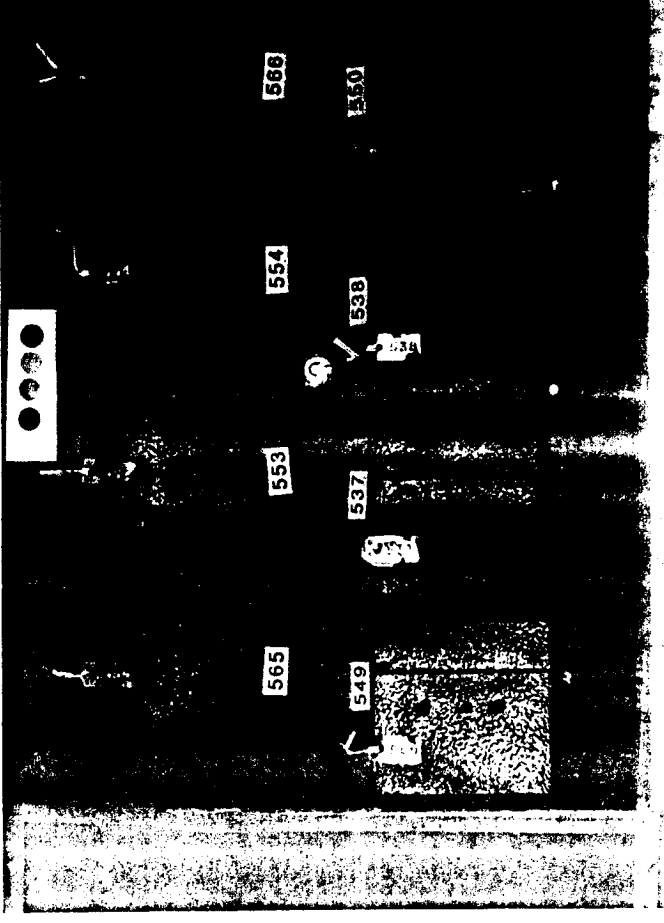
Stainless



Aluminum

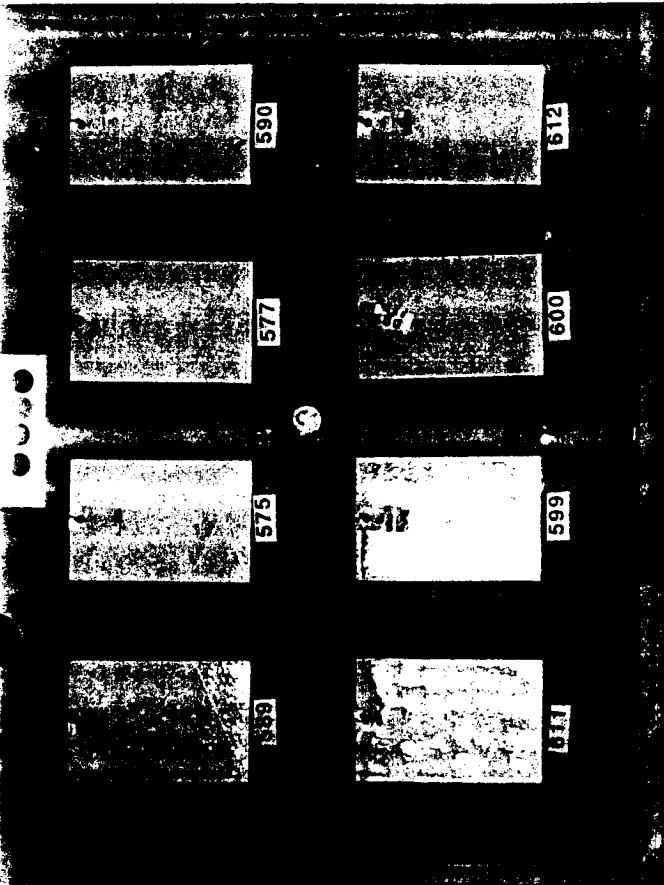


CPVC

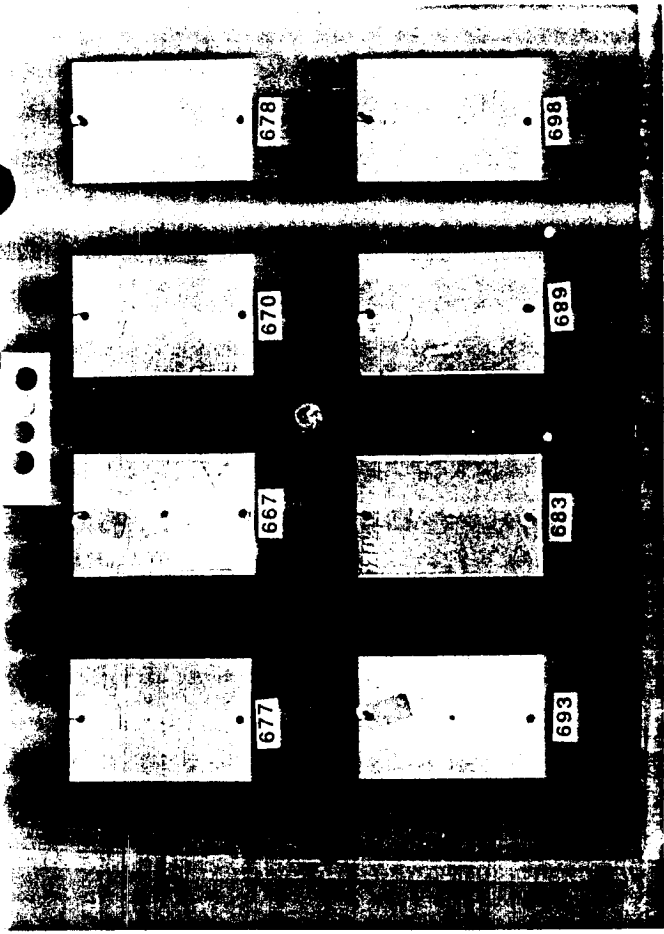


Coupled

Stainless



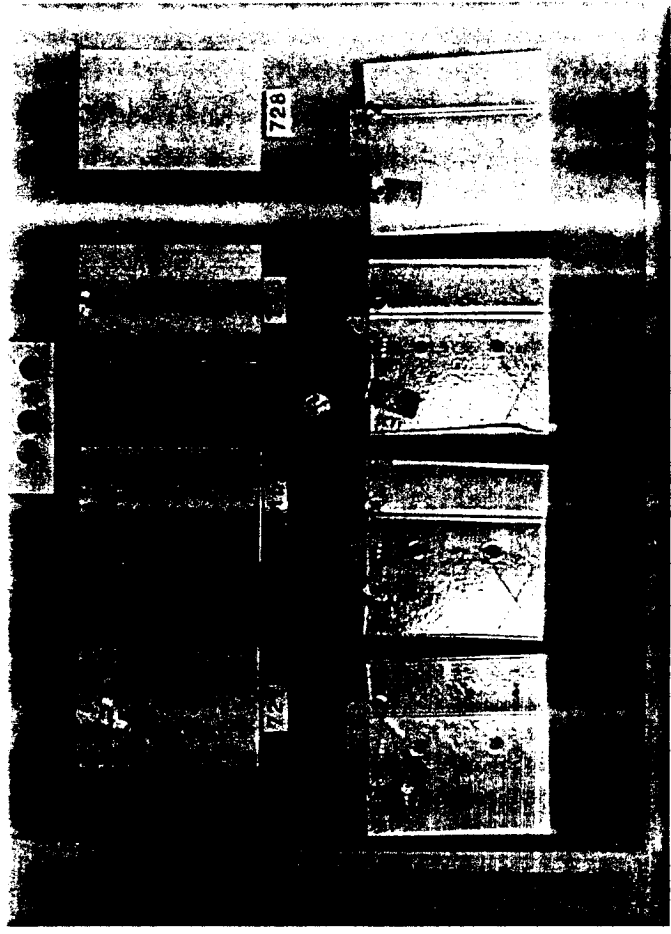
Aluminum



CPVC

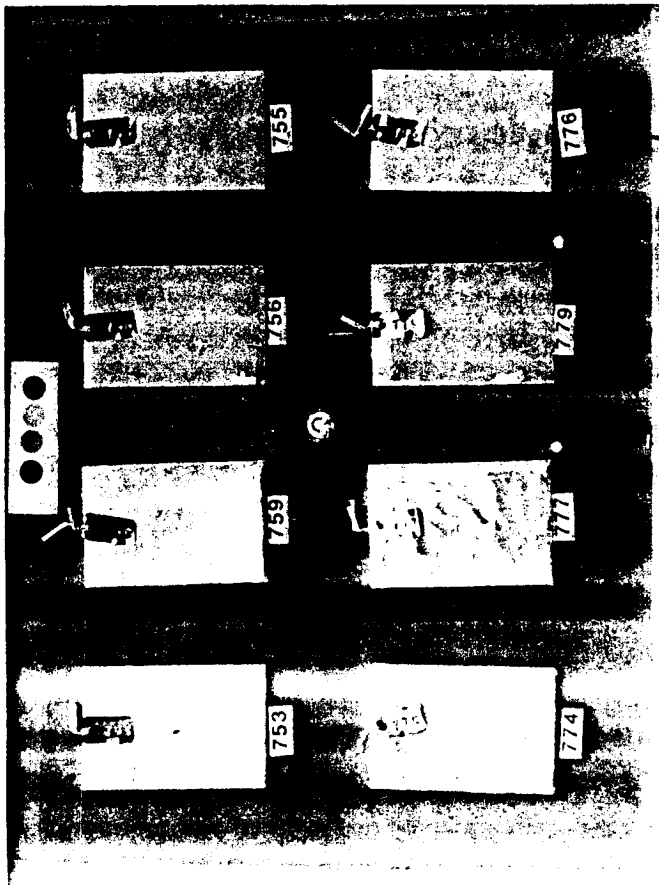


Coupled

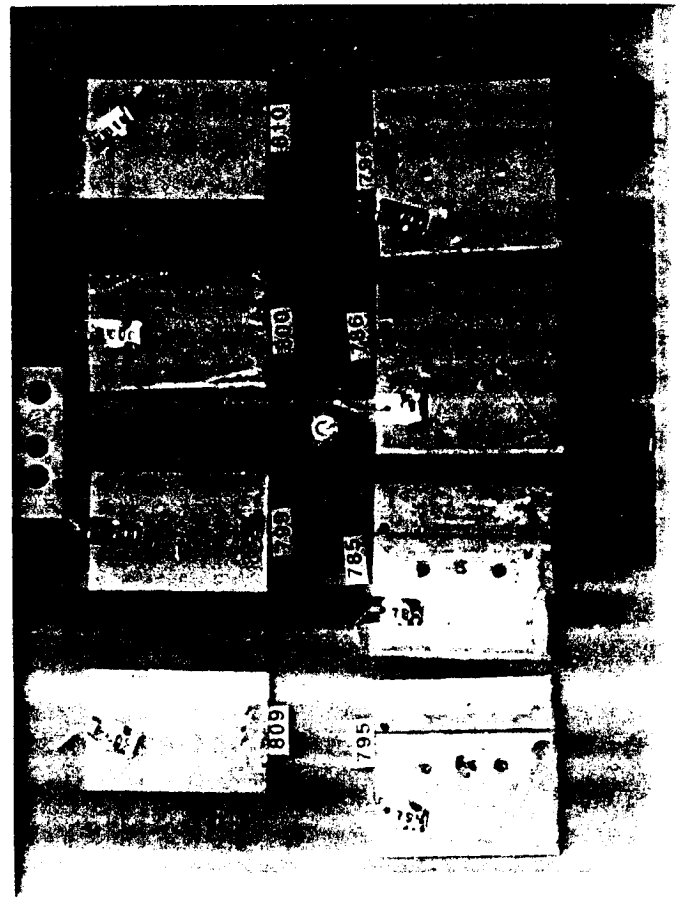


Pre-exposure Test Panels, System Examples

Stainless

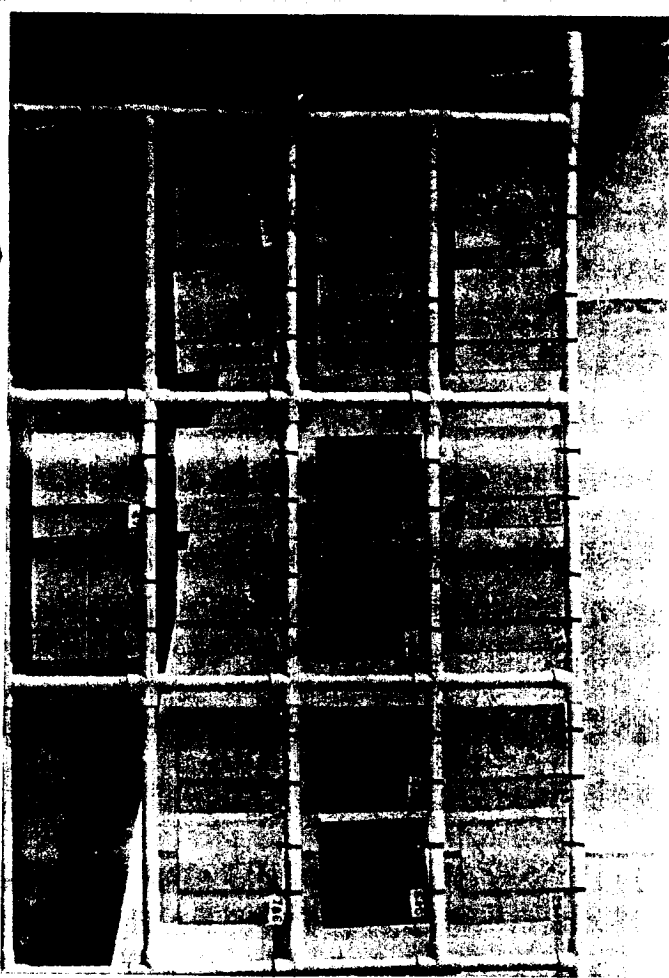


Aluminum



CPVC

Coupled



APPENDIX D

Methods and Procedures

ASTM

| | |
|-------------|--|
| ASTM D 610 | Standard Test Method for Evaluation Degree of Rusting on Painted Steel Surfaces |
| ASTM D 714 | Standard Test Method for Evaluation Degree of Blistering of Paints |
| ASTM D 1654 | Standard Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments |
| ASTM D 2794 | Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact) |
| ASTM D 3359 | Standard Test Methods for Measuring Adhesion by Tape Test |
| ASTM D 4060 | Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser |
| ASTM D 4214 | Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films |

Steel Structures Painting Council

| | |
|------------|--|
| SSPC-SP 1 | Surface Preparation Specification No. 1, Solvent Cleaning |
| SSPC-SP 2 | Surface Preparation Specification No. 2, Hand Tool Cleaning |
| SSPC-SP 10 | Surface Preparation Specification No. 10, Near-White Blast Cleaning |
| SSPC-SP 5 | Surface Preparation Specification No. 5, White Metal Blast Cleaning |
| SSPC-AB 1 | Abrasive Specification No. 1, Mineral and Slag Abrasives |
| SSPC-PA 2 | Paint Application Specifications, Measurement of Dry Paint Thickness with Magnetic Gages |



Standard Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces¹

This standard is issued under the fixed designation D 610; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This method has been approved for use by agencies of the Department of Defense to replace Method 6451 of Federal Test Method Standard No. 141A. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

^{ε1} NOTE—Editorial changes were made throughout, including the title, in October 1989.

1. Scope

1.1 This test method covers the evaluation of the degree of rusting on painted steel surfaces using visual standards. These visual standards² were developed in cooperation with the Steel Structures Painting Council (SSPC) to further standardization of methods.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Document

- 2.1 *Adjunct:*
D 610 Degree of rust (four photos)²

3. Significance and Use

3.1 The amount of rusting beneath or through a paint film is a significant factor in determining whether a coating system should be repaired or replaced. This test method provides a standardized means for quantifying the amount of rust present.

4. Interferences

4.1 The colored photographic reference standards and the associated rust-grade scale cover only rusting not accompanied by blistering and evidenced by visible rust.

4.1.1 Rust blistering beneath paint may be graded using the same scale by assuming the rust was completely visible and noting that the rusting was rust blistering.

4.2 The use of the photographic reference standards² requires the following cautions:

4.2.1 Some finishes are stained by rust. This staining must not be confused with the actual rusting involved.

4.2.2 Accumulated dirt or other material may make accurate determination of the degree of rusting difficult.

4.2.3 Certain types of deposited dirt that contain iron or iron compounds may cause surface discoloration that should not be mistaken for corrosion.

4.2.4 It must be realized that failure may vary over a given area and discretion must therefore be used when selecting a single grade that is to be representative of a large area or structure.

4.2.5 In evaluating surfaces, consideration shall be given to the color of the finish coating, since failures will be more apparent on a finish that shows color contrast with rust, such as used in these reference standards, than on a similar color, such as an iron oxide finish.

5. Procedure

5.1 Visually compare the surface with the photographic reference standards to determine the percentage of the area rusted. As a guide use Fig. 1 and the scale and verbal descriptions shown in Table 1.

NOTE 1—The linear, numerical rust grade scale is an exponential function of the area of rust so that slight amounts of first rusting have the greatest effect on lowering the rust grade; the rust grade versus area of rust is a straight line plot on a semilogarithmic plot from rust grade 10 to rust grade 4. The slope of the curve was changed at 10 % of the area rusted to 100 % rusted to permit inclusion of complete rusting on the 0 to 10 rust scale.

NOTE 2—The pictorial representations illustrated in Fig. 1³ show examples of area percentages that may be helpful in rust grading.

5.2 The photographic reference standards are not required for use of the rust-grade scale since the scale is based upon the percent of the area rusted and any method of assessing area rusted may be used to determine the rust grade.

5.3 This test method may be projected to include blistering beneath the paint by including the blistered area as if it were rust.

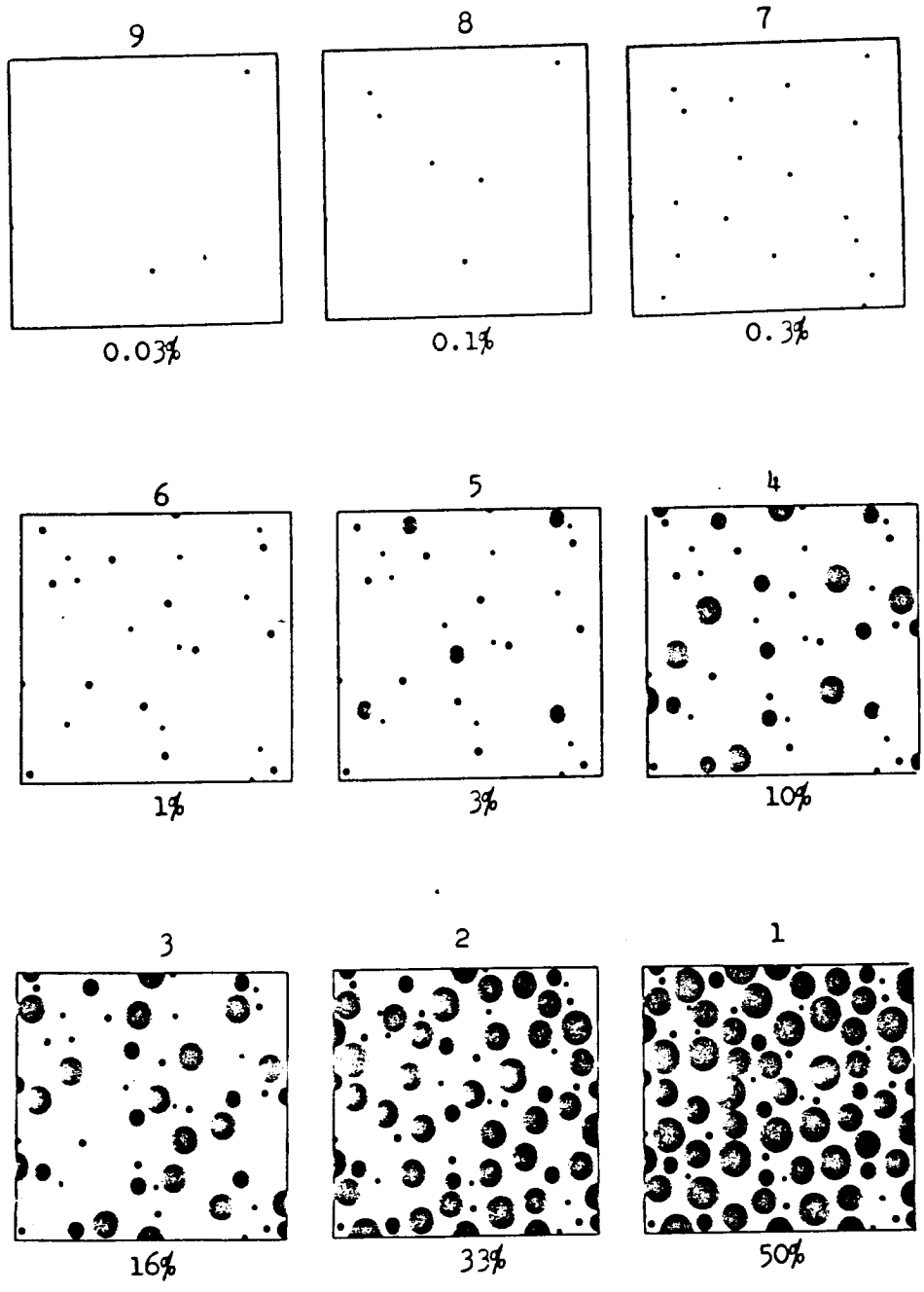
¹ This test method is under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings and Materials and is the direct responsibility of Subcommittee D01.46 on Industrial Protective Painting.

This test method has been jointly approved by ASTM and the Steel Structures Painting Council.

Current edition approved Oct. 25, 1985. Published December 1985. Originally published as D 610 - 41. Last previous edition D 610 - 68 (1981).

² The colored photographic reference standards are available at a nominal cost from ASTM Headquarters (request Adjunct No. 12-40-100-00), and from the Steel Structures Painting Council, 4409 5th Ave., Pittsburgh, PA 15213.

³ Original source is *Steel Structures Painting Manual*, Vol 2, Steel Structures Painting Council, Pittsburgh, PA.



▲ Corres
■ Corres
○ Corres
□ Corres
⊞ Rust gra
⊞ Corres

FIG. 1 Examples of Area Percentages

TABLE 1 Scale and Description of Rust Grades

| Rust Grades ^A | Description | ASTM-SSPC Colored Photographic Standard |
|--------------------------|--|---|
| 10 | no rusting or less than 0.01 % of surface rusted | unnecessary |
| 9 | minute rusting, less than 0.03 % of surface rusted | No. 9 |
| 8 ^B | few isolated rust spots, less than 0.1 % of surface rusted | No. 8 |
| 7 | less than 0.3 % of surface rusted | none |
| 6 ^C | extensive rust spots but less than 1 % of surface rusted | No. 6 |
| 5 | rusting to the extent of 3 % of surface rusted | none |
| 4 ^D | rusting to the extent of 10 % of surface rusted | No. 4 |
| 3 ^E | approximately one sixth of the surface rusted | none |
| 2 | approximately one third of the surface rusted | none |
| 1 | approximately one half of the surface rusted | none |
| 0 ^F | approximately 100 % of surface rusted | unnecessary |

^A Correspond to Swedish Pictorial Standards for Rusting (1955) (black and white).
^B Corresponds to SSPC Initial Surface Conditions E and British Iron and Steel Research Assn (BISRA) 0.1 %.
^C Corresponds to SSPC Initial Surface Conditions F and BISRA 1.0 %.
^D Corresponds to SSPC Initial Surface Condition G.
^E Rust grades below 4 are of no practical importance in grading performances of paints.
^F Corresponds to SSPC Initial Surface Condition H.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.



Standard Test Method for Evaluating Degree of Blistering of Paints¹

This standard is issued under the fixed designation D 714; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This test method has been approved for use by agencies of the Department of Defense to replace Method 6461 of Federal Test Method Standard No. 141 A and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 This test method employs photographic reference standards to evaluate the degree of blistering that may develop when paint systems are subjected to conditions which will cause blistering. While primarily intended for use on metal and other nonporous surfaces, this test method may be used to evaluate blisters on porous surfaces, such as wood, if the size of blisters falls within the scope of these reference standards. When the reference standards are used as a specification of performance, the permissible degree of blistering of the paint system shall be agreed upon by the purchaser and the seller.

2. Significance and Use

2.1 A phenomenon peculiar to painted surfaces is the formation of blisters relative to some system weakness. This test method provides a standard procedure of describing the size and density of the blisters so that comparisons of severity can be made.

3. Reference Standards

3.1 The photographic reference standards are glossy paints.² Figures 1 to 4 are reproductions of these standards and are included to illustrate two characteristics of blistering: size and frequency.

3.2 *Size*—Reference standards have been selected for four steps as to size on a numerical scale from 10 to 0, in which

No. 10 represents no blistering. Blistering standard No. 8 represents the smallest size blister easily seen by the unaided eye. Blistering standards Nos. 6, 4, and 2 represent progressively larger sizes.

3.3 *Frequency*—Reference standards have been selected for four steps in frequency at each step in size, designated as follows:

Dense, *D*,
Medium dense, *MD*,
Medium, *M*, and
Few, *F*.

NOTE 1—A quantitative physical description of blistering would include the following characteristics determined by actual count:

- Size distribution in terms of mensuration units,
- Frequency of occurrence per unit area,
- Pattern of distribution over the surface, and
- Shape of blister

For the usual tests, an actual count is more elaborate than is necessary.

4. Procedure

4.1 Subject the paint film to the test conditions agreed upon by the purchaser and the seller. Then evaluate the paint film for the degree of blistering by comparison with the photographic reference standards in Figs. 1 to 4.

5. Reporting

5.1 Report blistering as a number (Note 2) designating the size of the blisters and a qualitative term or symbol indicating the frequency.

5.2 Intermediate steps in size or frequency of blisters may be judged by interpolation.

5.3 When the distribution of blisters over the area has a nonuniform pattern, use an additional phrase to describe the distribution, such as "small clusters," or "large patches."

NOTE 2—The number refers to the largest size blister that is numerous enough to be representative of the specimen. For example, photographic standard No. 4, "Dense," has blisters ranging in size from about No. 7 to No. 4, inclusive.

¹This test method is under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings and Materials and is the direct responsibility of Subcommittee D1.27 on Accelerated Testing.

Current edition approved May 29, 1987. Published July 1987. Originally published as D 714 - 43 T. Last previous edition D 714 - 56 (1981).

²Glossy prints of the photographic reference standards showing types of blistering are available at a nominal charge from ASTM Headquarters, 1916 Race Street, Philadelphia, PA 19103. Request Adjunct No. 12-407140-00.

ORIGINAL PAGE IS OF POOR QUALITY

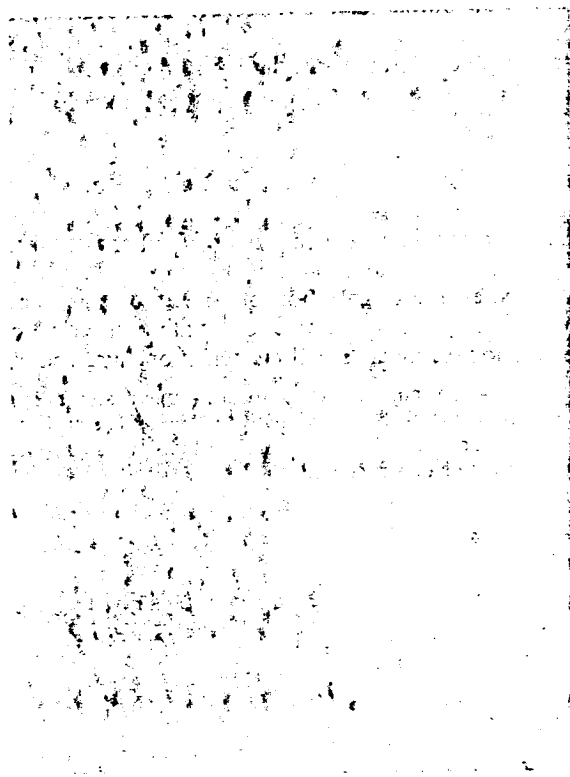
PRECEDING PAGE BLANK NOT FILMED



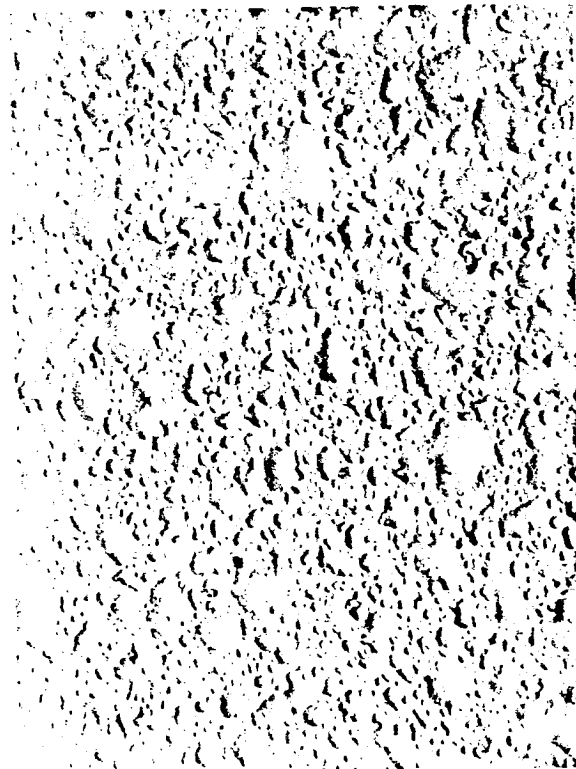
Few

Medium

FIG. 1 Blister Size No. 2



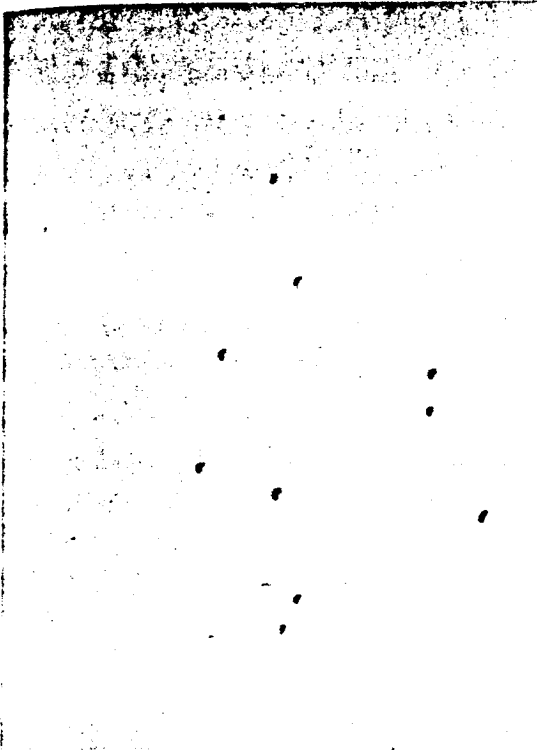
Medium Dense



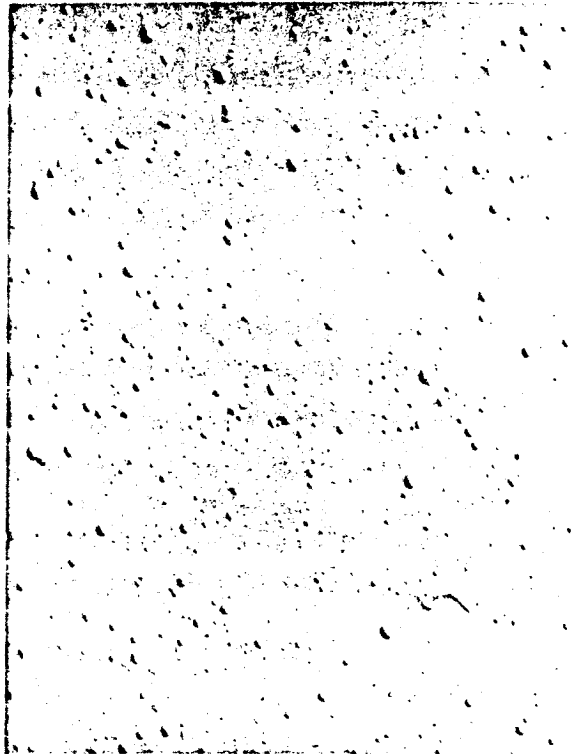
Dense

FIG. 1 Continued

ORIGINAL PAGE IS
OF POOR QUALITY

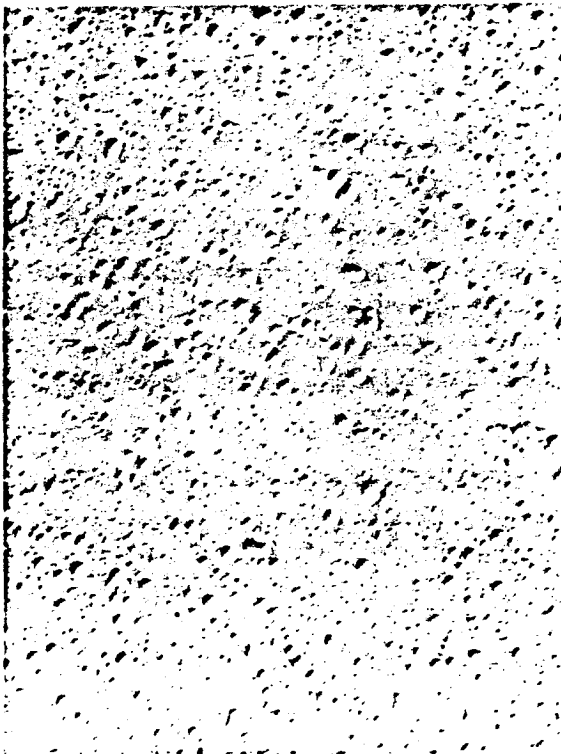


Few

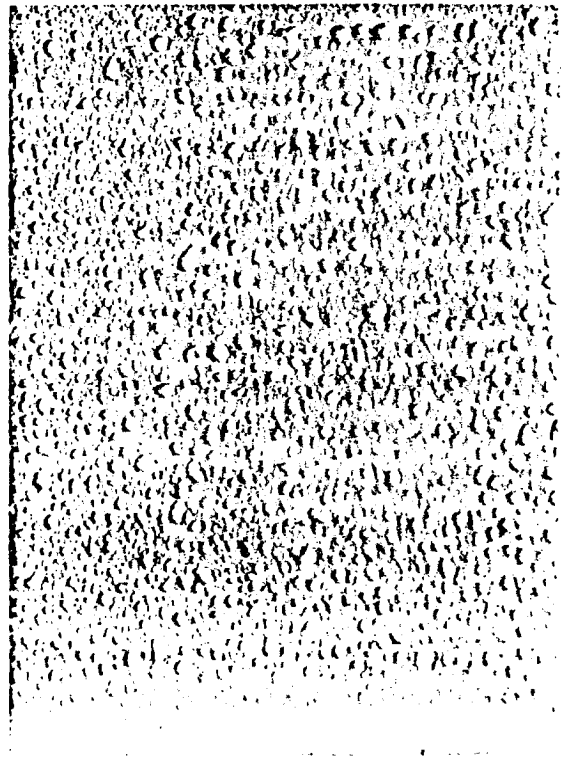


Medium

FIG. 2 Blister Size No. 4

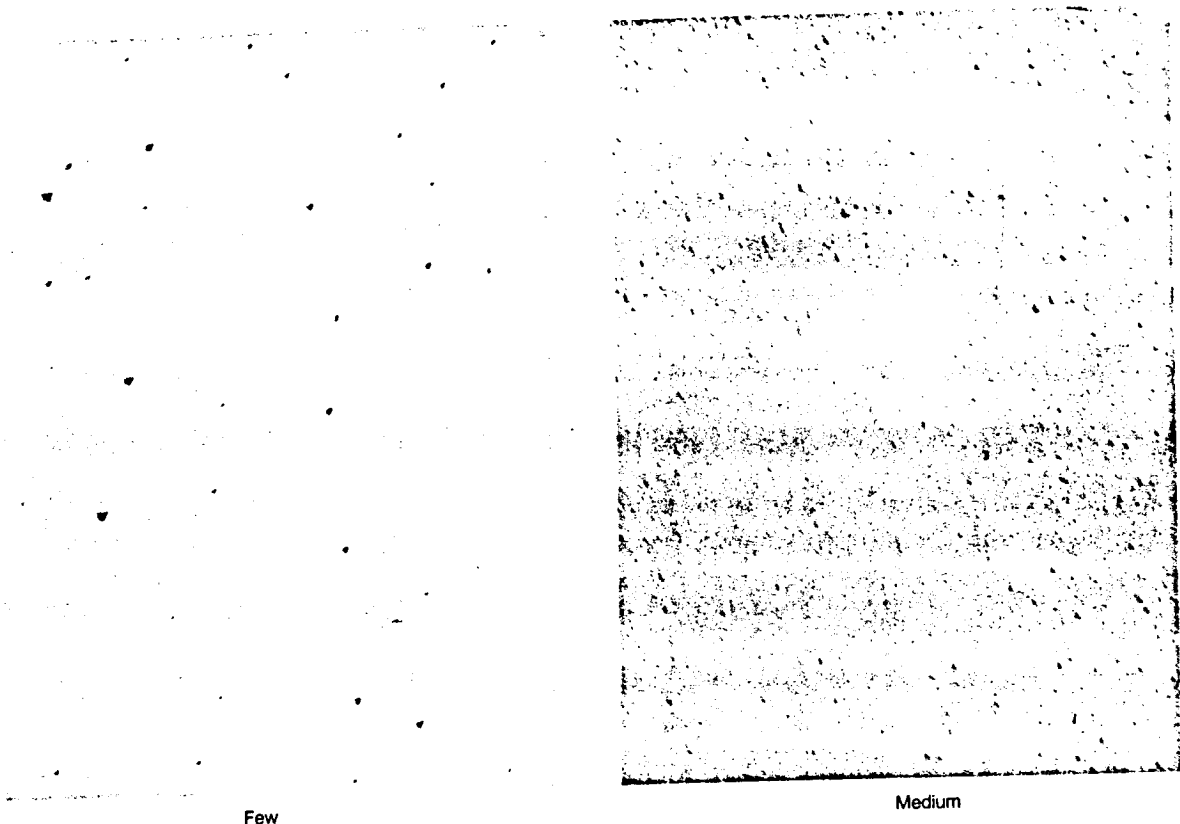


Medium Dense



Dense

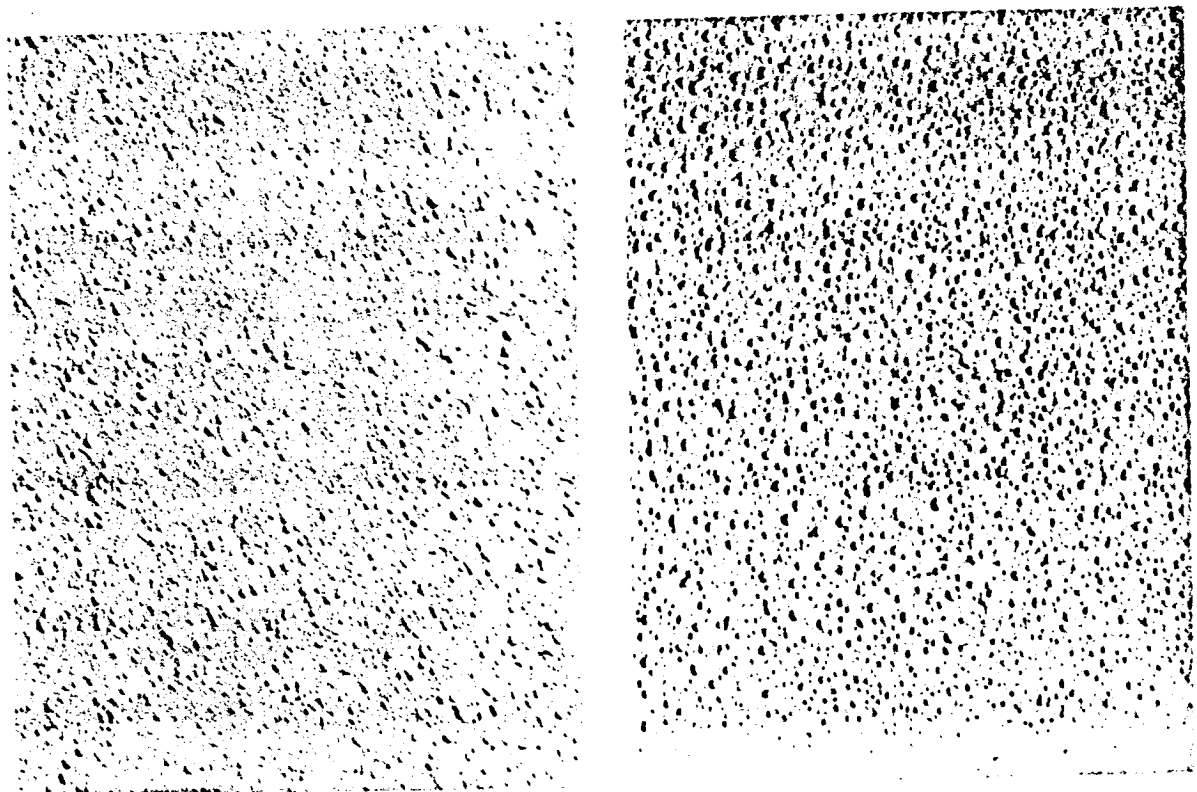
FIG. 2 Continued



Few

Medium

FIG. 3 Blister Size No. 6

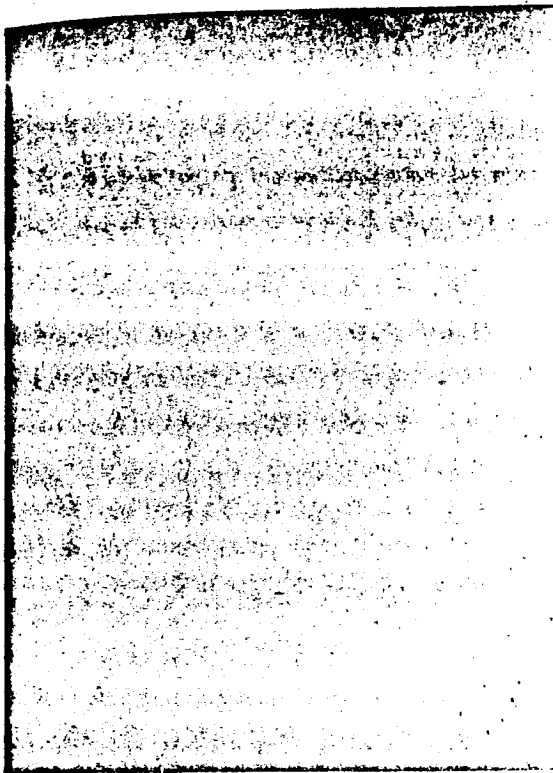


Medium Dense

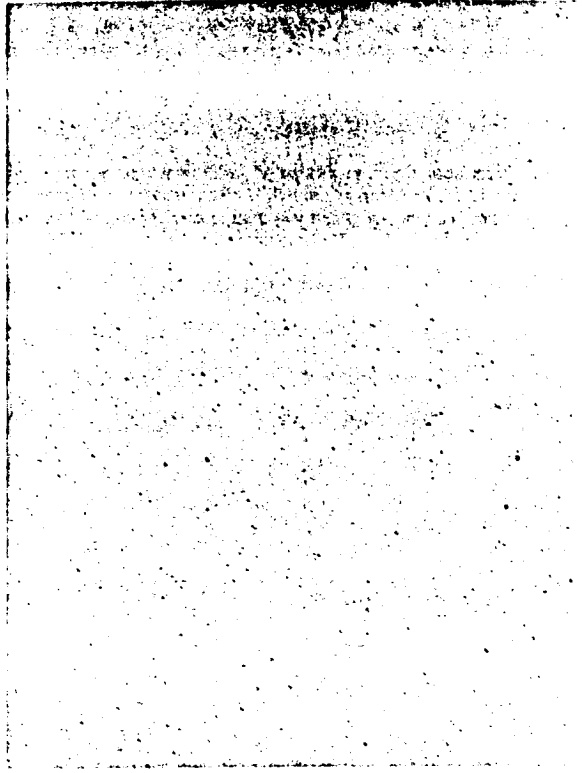
Dense

FIG. 3 Continued

**ORIGINAL PAGE IS
OF POOR QUALITY**

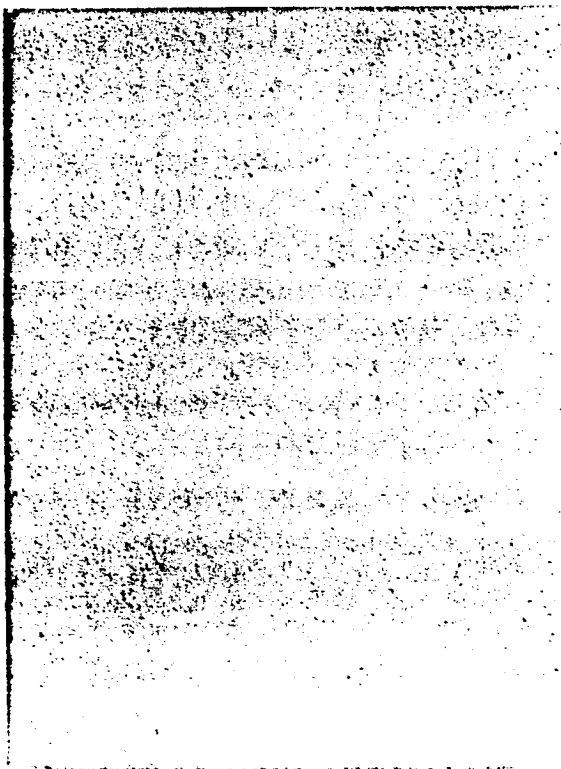


Few

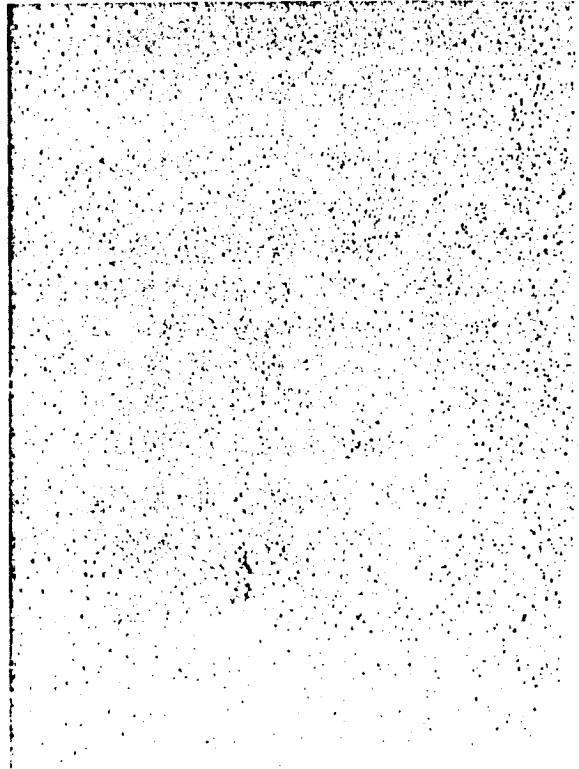


Medium

FIG. 4 Blister size No. 8



Medium, Dense



Dense

FIG. 4 Continued

**ORIGINAL PAGE IS
OF POOR QUALITY**



Standard Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments¹

This standard is issued under the fixed designation D 1654; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

^{ε1} NOTE—Editorial changes were made throughout in July 1984.

1. Scope

1.1 This method covers the treatment of previously painted or coated specimens for accelerated and atmospheric exposure tests and their subsequent evaluation in respect to corrosion, blistering associated with corrosion, loss of adhesion at a scribe mark, or other film failure.

1.2 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards:

- B 117 Method of Salt Spray (Fog) Testing²
- B 287 Method of Acetic Acid-Salt Spray (Fog) Testing³
- D 610 Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces⁴
- D 714 Test Method for Evaluating Degree of Blistering of Paints⁴
- D 1014 Test Method for Conducting Exterior Exposure Tests of Paints on Steel⁴
- D 2803 Test Method for Filiform Corrosion Resistance of Organic Coatings on Metal⁴

3. Significance and Use

3.1 This method provides a means of evaluating and comparing basic corrosion performance of the substrate, pretreatment, or coating system, or combination thereof, after exposure to corrosive environments.

4. Apparatus

4.1 **Scribing Tool**—A straight-shank tungsten carbide tip, lethe cutting tool (Brazed tool, Style E, with 1/64-in. nose radius) is recommended; however, other styles may be used

provided they are ground to a single point having an included angle of $60 \pm 15^\circ$. Any other type of scribing instrument such as a scalpel, razor blade, knife, or sharp pointed tool is unacceptable unless agreed upon between the producer and the user.

4.2 **Straightedge**—Any straightedge of sufficient length and rigidity to guide the scribing tool in a straight line.

4.3 **Air Compressor**—A source of compressed air capable of producing 80 psi (550 kPa) open line pressure.

4.4 **Air Gun**—An air dusting gun and nozzle combination⁵ to meet the following specification:

| Air Consumption, ft ³ /min (m ³ /min) | Pressure, psi (kPa) | Nozzle Diameter, in. (mm) |
|--|------------------------|------------------------------|
| 8.4 (0.24) | 80 (550) | 0.12 (3.0) |

4.4.1 A guard consisting of barriers, baffles, or screens is required to protect the operator and other individuals near the area where the air is being used. The guard must be placed between the air nozzle and the operator. A device such as a sand-blasting cabinet has been found to be acceptable.

NOTE 1—The use of an air gun without a guard is in violation of the U. S. Occupational Safety and Health Administration regulation.

4.5 **Scraping Tool**—A rigid metal spatula, dull knife, or similar instrument.

4.6 **Scale**—Any rule with 1-mm divisions.

4.7 **Grid**, plastic or wire with 1/2-in. (13-mm) squares necessary to permit measurements of the required accuracy.

5. Preliminary Treatment of Test Specimens

5.1 Scribed Specimens:

5.1.1 Where specified or agreed upon, prepare each specimen for testing by scribing it in such a manner that the scribe can be exposed lengthwise when positioned in the test cabinet. This position will allow solution droplets to run lengthwise along the scribe.

5.1.2 Scribe the specimen by holding the tool at approximately a 45° angle to the surface. Position the tool so that only the carbide tip is in contact with the surface. Pull the scribing tool to obtain a uniform V-cut through the coating that is being tested. The scribe should be of sufficient length to cover the significant test area but should not contact the

¹ This method is under the jurisdiction of ASTM Committee D-1 on Paint and Coatings and Materials and is the direct responsibility of Subcommittee D-1.02 on Accelerated Tests For Protective Coatings.

² Formerly approved Nov. 26 and Dec. 3, 1979. Published January 1980.

³ Originally published as D 1654 - 59. Last previous edition D 1654 - 74.

⁴ Annual Book of ASTM Standards, Vols 03.02 and 06.01.

⁵ Discontinued; see 1988 Annual Book of ASTM Standards, Vol 06.01.

⁶ Annual Book of ASTM Standards, Vol 06.01.

⁵ Spray gun and nozzles, Model No. 22-L and 0010 have been found satisfactory and may be obtained from Spray Systems Co. Equivalents may be used.

ORIGINAL PAGE IS OF POOR QUALITY

PRECEDING PAGE BLANK NOT FILMED

edge of the specimen. The scribe must penetrate all coatings on the metal, leaving a uniformly bright line free of burrs. Quality of the scribe may be observed with the aid of lower magnification. Note, mark, and describe defects, staining, and flaws that may affect results.

5.1.3 Scribe lines other than those of a single, straight nature may be used if agreed upon between the producer and the user.

5.1.4 Expose scribed specimens in accordance with 6.1 and rate in accordance with Section 7.

5.2 *Unscribed Specimens*—Specimens coated with paint undercoats, oils, or waxes may be evaluated without a scribe. Expose such specimens in accordance with Section 6 and rate for corrosion of the general surface in accordance with Section 8.

6. Exposure of Test Specimens

6.1 Expose test specimens in accordance with Methods B 117, B 287, D 1014, D 2803, or any other applicable test method, as agreed upon between the producer and the user. The length of test and evaluation intervals should be agreed upon prior to exposure of specimens.

7. Procedure A—Evaluation of Scribed Specimens

7.1 *Method 1 (Air Blow-Off)*—Rinse each specimen after completion of the exposure period, using a gentle stream of water at a temperature up to 110°F (45°C). Holding the nozzle at approximately a 45° angle, blow along the entire scribe line, disturbing the surface adjacent to the scribe mechanically by the air nozzle to ensure an opening for the air blast. Complete the air blasting within 15 min of specimen removal from the exposure cabinet. If the air blasting cannot be completed within the prescribed time, immerse the specimens in water at room temperature or store in a plastic bag to avoid any drying effect.

7.2 *Method 2 (Scraping)*—Rinse the specimen after completion of the exposure period, using a gentle stream of water at a temperature up to 110°F (45°C). Scrape the specimen vigorously with an instrument described in 4.5 while under the gentle stream of the rinse water. Hold the scraper with its face perpendicular to the specimen surface and parallel to the scribe, moving it back and forth across the scribe to remove the coating that has been undercut and has suffered loss of adhesion only, not to remove the coating that still has adhesion. Complete the scraping within 15 min of specimen removal from the exposure cabinet. If scraping cannot be completed within the prescribed time, immerse the speci-

TABLE 1 Rating of Failure at Scribe (Procedure A)

| Representative Mean Creepage From Scribe | | |
|--|----------------------|---------------|
| Millimetres | Inches (Approximate) | Rating Number |
| Over 0 | 0 | 10 |
| Over 0 to 0.5 | 0 to 1/64 | 9 |
| Over 0.5 to 1.0 | 1/64 to 1/32 | 8 |
| Over 1.0 to 2.0 | 1/32 to 1/16 | 7 |
| Over 2.0 to 3.0 | 1/16 to 1/8 | 6 |
| Over 3.0 to 5.0 | 1/8 to 3/16 | 5 |
| Over 5.0 to 7.0 | 3/16 to 1/4 | 4 |
| Over 7 to 10.0 | 1/4 to 3/8 | 3 |
| Over 10 to 13.0 | 3/8 to 1/2 | 2 |
| Over 13.0 to 16.0 | 1/2 to 5/8 | 1 |
| Over 16.0 to more | 5/8 to more | 0 |

TABLE 2 Rating of Unscribed Areas (Procedure B)

| Area Failed, % | Rating Number |
|----------------|---------------|
| No failure | 10 |
| 0 to 1 | 9 |
| 2 to 3 | 8 |
| 4 to 6 | 7 |
| 7 to 10 | 6 |
| 11 to 20 | 5 |
| 21 to 30 | 4 |
| 31 to 40 | 3 |
| 41 to 55 | 2 |
| 56 to 75 | 1 |
| Over 75 | 0 |

mens in water at room temperature or store in a plastic bag to avoid any drying effect.

NOTE 2—Some specimens exposed to natural weathering do not require rinsing, air blasting, or scraping to evaluate corrosion. Alternative methods may be used if agreed upon between the producer and the user.

7.3 *Rating*—Rate the corrosion or loss of paint extending from a scribe mark as prescribed in Table 1. Record the representative mean, maximum, and minimum creepage from the scribe, and note whether or not the maximum is an isolated spot. Also, rate in accordance with Table 2 the prevalence of corrosion on areas removed from the scribe.

8. Procedure B—Evaluation of Unscribed Areas

8.1 Rinse the specimen after completion of the exposure period (Section 6), using a gentle stream of water at a temperature up to 100°F (40°C). Dry the surface of the specimen with paper towels or compressed air. Drying should be done in such a manner that the corrosion on the specimen surface is not disturbed.

8.2 Evaluate unscribed specimens for corrosion spots, blisters, and any other types of failure that may occur. Depending upon the contour of the specimen, the use of a grid, as described in 4.7, is recommended as an aid in evaluating this type failure (Fig. 1). The percent of surface failure, excluding rust staining or run down, can be estimated by counting the number of squares that have points of failure and relating this number to the total number of squares covering the test area. Discount corrosion within 1/2 in. (12.7 mm) of edges.

8.3 *Rating*—Convert percent failure to the rating number in accordance with Table 2. In some instances, the rating number may be used as a factor with the corresponding exposure time intervals to produce a performance index number.

NOTE 3—Formation of under-film corrosion may be evaluated and reported in accordance with Table 2 if the film is first carefully stripped with a neutral stripper. Exercise care to avoid alteration of the corrosion pattern or pretreatment.

NOTE 4—Where the character of the failure permits, the photographic blister standards given in Test Method D 714 may be used to describe the results of the exposure test, in respect to size of blisters of corroded areas, while Method D 610 may serve to describe the frequency and distribution, if desired.

9. Report

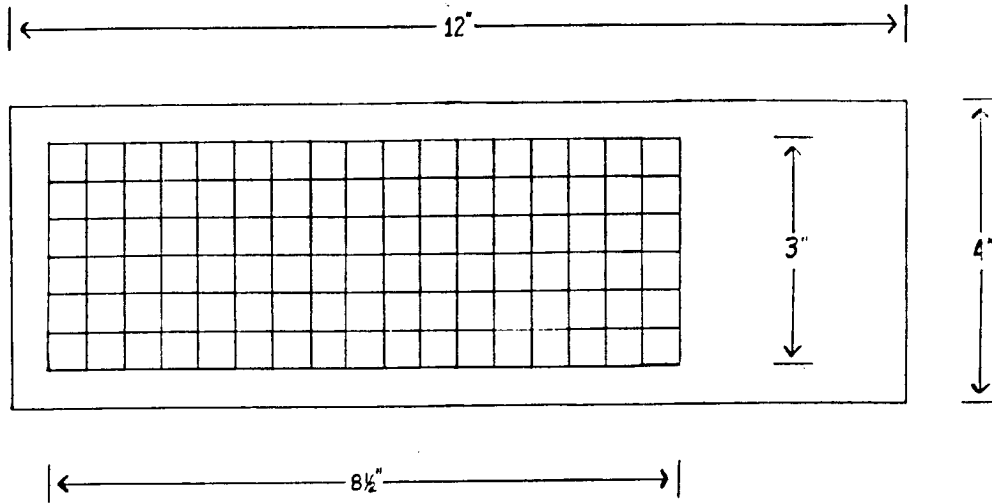
9.1 Report the ratings of the test specimens, the procedures, and, for scribed panels, the method followed. Also

NOTE—1 in. = 25.4 mm

report the e subjected.

10. Precision

10.1 Since measurement



NOTE—1 in. = 25.4 mm.

FIG. 1 Typical Grid with 1/2-in. (13-mm) Squares

Support the exposure test to which the specimens were subjected.

applicable to each specific method of exposure to corrosive atmospheres applies. The preferred methods of measurement, using ruled plastic sheets, are at least equal in precision to the various methods of exposing test specimens to corrosive environments.

10. Precision and Use

10.1 Since this is a method of evaluation based on measurements after various tests, the statement of precision

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

**ORIGINAL PAGE IS
OF POOR QUALITY**



Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)¹

This standard is issued under the fixed designation D 2794; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a procedure for rapidly deforming by impact a coating film and its substrate and for evaluating the effect of such deformation.

1.2 This test method should be restricted to testing in only one laboratory when numerical values are used because of the poor reproducibility of the method. Interlaboratory agreement is improved when ranking is used in place of numerical values.

1.3 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

D 609 Practice for Preparation of Steel Panels for Testing Paint, Varnish, Lacquer, and Related Products²

D 823 Test Methods for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels²

D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base²

3. Terminology

3.1 Description of Term Specific to This Standard:

3.1.1 *impact resistance, of a coating*—the number of inch-pounds (kilogram-metres) required to produce cracking in the deformed coating.

4. Summary of Test Method

4.1 The organic coatings under test are applied to suitable thin metal panels. After the coatings have cured, a standard weight is dropped a distance so as to strike an indenter that deforms the coating and the substrate. The indentation can be either an intrusion or an extrusion. By gradually increasing the distance the weight drops, the point at which failure usually occurs can be determined. Films generally fail by cracking, which is made more visible by the use of a magnifier, by the application of a copper sulfate (CuSO₄)

solution on steel, or by the use of a pin hole detector.

5. Significance and Use

5.1 Coatings attached to substrates can exhibit cracking when subjected to rapid deformation, produced by impacts of objects during manufacturing and service. This test method has been very useful in evaluating attached coatings for their ability to resist cracking caused by impacts.

6. Apparatus

6.1 *Tester*, consisting of a vertical tube to guide a cylindrical weight that is dropped on a punch resting on the test panel.³

6.1.1 *Guide Tube*, 24 to 48 in. (0.6 to 1.2 m) long mounted vertically in a base plate. A slot is cut lengthwise on one side of the tube to act as a guide for a cylindrical weight that fits inside the tube. Graduations are marked in inch-pounds along the slot. The base is constructed so that a thin flat panel can be inserted at 2 in. (50 mm) below the tube.

6.1.2 *Weight*, metal cylinder, made to fit inside the guide tube. A pin is fitted into one side of the weight to act as a guide by riding in the slot of the tube and to serve as a handle by which the weight can be raised and released and serve as the indicator of inch-pounds (kilogram-metres).

6.2 *Indenter*—A steel punch with a hemispherical head having a diameter of either 0.500 in. (12.7 mm) or 0.625 in. (15.9 mm). The head rests on the test panel and the punch is held vertically by a guide ring.

6.3 *Panel Support*—A steel fixture with a 0.64-in. (16.3-mm) diameter cylindrical hole centered under the indenter for supporting the test panel.

6.4 *Magnifier*.

6.5 *Pin Hole Detector*.⁴

7. Reagents

7.1 An acidified copper sulfate (CuSO₄) solution prepared by dissolving 10 g of CuSO₄·5H₂O in 90 g of 1.0 N hydrochloric acid (HCl).

8. Test Specimens

8.1 Apply uniform coatings of the material to be tested to

³ Suitable instruments are the Gardner-SPI Modified Impact Tester, available from BYK-Gardner, Inc., Gardner Laboratory, 2435 Linden Lane, Silver Spring, MD 20910, or the Universal Impact Tester Model No. 172, available from Paul N. Gardner Co., Inc., 316 N.E. First St., PO Box 10688, Pompano Beach, FL 33061-6688. Equivalent apparatus may be used.

⁴ Suitable instruments are the Elcometer Pinhole Detector Model 104 and Zorelco Model 169 Pin Hole Detector, available from Zorelco Corp., PO Box 25500, Cleveland OH 44125, and the K-D Bird Dog Holiday Detector.

¹ This test method is under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings and Materials and is the direct responsibility of Subcommittee D-1.23 on Physical Properties of Applied Paint Films.

Current edition approved July 27, 1990. Published November 1990. Originally issued as D 2794 - 69. Last previous edition D 2794 - 84¹.

² Annual Book of ASTM Standards, Vol 06.01.

ORIGINAL PAGE IS OF POOR QUALITY

PRECEDING PAGE BLANK NOT FILMED

24-gage
conversi
Practice
imum of

NOTE 1—
Methods P
Other gae
producer

8.2 Cu
and temp
user.

NOTE 2—
accordance

9. Condi

9.1 Ur
and the
at 73.5 ±
Conduct
on remove

10. Proce

10.1 Ins
or agreed
coated side
sure the p
indenter
Lightly p
tube so th
weight up
failure will
indenter.

10.2 Re
observe the
are evident
creasing
observed,
slightly ab
first trial. T
one height

10.3 Exa

10.3.1 Us

10.3.2 Hc
acidified co

34-gage (0.025 in. or 0.63 mm) steel panels treated with a conversion coating in accordance with Procedure A of Practice D 609, unless otherwise specified. Prepare a minimum of four coated panels for the material.

NOTE 1—The coatings should be applied in accordance with Test Methods D 823, or as agreed upon between the producer and the user. Other gage steel panels may be used if agreed upon between the producer and the user.

8.2 Cure the coated panels under conditions of humidity and temperature agreed upon between the producer and the user.

NOTE 2—The thickness of the dry coatings should be measured in accordance with Test Methods D 1186.

9. Conditioning

9.1 Unless otherwise agreed upon between the producer and the user, condition the coated test panels for at least 24 h at 73.5 ± 3.5°F (23 ± 2°C) and 50 ± 5 % relative humidity. Conduct the test in the same environment or immediately on removal therefrom.

10. Procedure

10.1 Install the punch having the head diameter specified or agreed upon. Place the test panel in the apparatus with the coated side either up or down as specified or agreed upon. Be sure the panel is flat against the base support and that the indenter is in contact with the top surface of the panel. Lightly place the weight on the indenter and adjust the guide tube so that the lifting pin is at the zero mark. Raise the weight up the tube to a height where it is expected that no failure will occur. Release the weight so that it drops on the indenter.

10.2 Remove the test panel from the apparatus and observe the impact area for cracks in the coating. If no cracks are evident, repeat the procedure at a greater height, increasing 1 in. (25 mm) at a time. Once visible cracks are observed, repeat the test five times at each of three heights; slightly above, slightly below, and at that determined in the first trial. Test in a random fashion so that all impacts from one height are not made in succession or on one panel.

10.3 Examine the impacted areas for cracking by one of the following methods:

10.3.1 Use a magnifier to examine the area for cracks.

10.3.2 Hold a white flannel-type cloth saturated with the acidified copper sulfate (CuSO₄) solution (7.1) over the

impacted areas for at least 15 min. Remove the cloth and examine both the test areas and cloth for evidence of copper deposition or iron-rust staining respectively.

NOTE 3—The copper sulfate solution will not perform properly on zinc-phosphate-treated metal unless the conversion coating cracks.

10.3.3 To detect breaks in the film with a pin hole detector, first connect the ground lead from the instrument to the bare substrate and connect the instrument to an electrical power source. Moisten the probe sponge with tap water and slowly draw the probe over the impact area. The presence of cracks will be indicated by an audible alarm.

10.4 For each inch-pound (kilogram-metre) level, tabulate the number of times the coating passed or failed. The value where the results change from mainly passing to mainly failing is the impact failure end point.

11. Report

11.1 Report the following for each coating tested:

11.1.1 The inch-pounds (kilogram-metres) at the impact failure end point,

11.1.2 Whether intrusion or extrusion was used,

11.1.3 Diameter of the punch used,

11.1.4 Thickness of coating,

11.1.5 Substrate thickness and type of metal,

11.1.6 Method of panel preparation, and

11.1.7 Atmospheric conditions under which the coated panels were conditioned and tested.

NOTE 4—Because of the poor reproducibility of this method, the reporting of inch-pounds (kilogram-metres) in comparing coatings for impact resistance should be restricted to one laboratory. For interlaboratory comparisons, rankings of coatings for impact resistance should be reported.

12. Precision

12.1 On the basis of an interlaboratory test in which operators in six laboratories tested three paints having a broad range of impact resistance on two metal substrates, the between-laboratories coefficients of variation were found to be as follows:

| | Coefficient of Variation | |
|--|--------------------------|--------------|
| | Intrusion, % | Extrusion, % |
| Brittle coating (less than 6 in.-lb) | 25 | 100 |
| Average coating (between 6 and 140 in.-lb) | 80 | 100 |
| Flexible coating (more than 140 in.-lb) (0.625 in.-diameter punch) | 10 | 25 |

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

ORIGINAL PAGE IS
OF POOR QUALITY

ORIGINAL PAGE IS
OF POOR QUALITY



Standard Test Methods for Measuring Adhesion by Tape Test¹

This standard is issued under the fixed designation D 3359; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

These methods have been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 These test methods cover procedures for assessing the adhesion of coating films to metallic substrates by applying and removing pressure-sensitive tape over cuts made in the film.

1.2 Test Method A is primarily intended for use at job sites while Test Method B is more suitable for use in the laboratory. Also, Test Method B is not considered suitable for films thicker than 5 mils (125- μ m).

NOTE 1—Subject to agreement between the purchaser and the seller, Test Method B can be used for thicker films if wider spaced cuts are employed.

1.3 These test methods are used to establish whether the adhesion of a coating to a substrate is at a generally adequate level. They do not distinguish between higher levels of adhesion for which more sophisticated methods of measurement are required.

NOTE 2—It should be recognized that differences in adherability of the coating surface can affect the results obtained with coatings having the same inherent adhesion.

1.4 In multicoat systems adhesion failure may occur between coats so that the adhesion of the coating system to the substrate is not determined.

1.5 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

D 609 Methods for Preparation of Steel Panels for Testing Paint, Varnish, Lacquer, and Related Products²

D 823 Test Methods for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels²

D 1730 Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting³

D 2092 Practices for Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting²

D 2370 Test Method for Tensile Properties of Organic Coatings²

D 3330 Test Method for Peel Adhesion of Pressure-Sensitive Tape of 180° Angle⁴

D 4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser²

3. Summary of Test Methods

3.1 *Test Method A*—An X-cut is made in the film to the substrate, pressure-sensitive tape is applied over the cut and then removed, and adhesion is assessed qualitatively on the 0 to 5 scale.

3.2 *Test Method B*—A lattice pattern with either six or eleven cuts in each direction is made in the film to the substrate, pressure-sensitive tape is applied over the lattice and then removed, and adhesion is evaluated by comparison with descriptions and illustrations.

4. Significance and Use

4.1 If a coating is to fulfill its function of protecting or decorating a substrate, it must adhere to it for the expected service life. Because surface preparation (or lack of it) has a drastic effect on adhesion of coatings, a test method for evaluating adhesion to different surface treatments or of different coatings to the same treatment is of considerable use in the industry.

4.2 The limitations of all adhesion methods and the specific limitation of this test method to lower levels of adhesion (see 1.3) should be recognized before using it. The intra- and inter-laboratory precision of this test method is similar to other widely-accepted tests for coated substrates (for example, Test Method D 2370 and Test Method D 4060), but this is partly the result of it being insensitive to all but large differences in adhesion. The limited scale of 0 to 5 was selected deliberately to avoid a false impression of being sensitive.

TEST METHOD A—X-CUT TAPE TEST

5. Apparatus and Materials

5.1 *Cutting Tool*—Sharp razor blade, scalpel, knife or other cutting devices. It is of particular importance that the

¹ These test methods are under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings and Materials and are the direct responsibility of Subcommittee D01.23 on Physical Properties of Applied Paints and Films.

Current edition approved Oct. 26, 1990. Published December 1990. Originally published as D 3359 - 74. Last previous edition D 3359 - 87.

² *Annual Book of ASTM Standards*, Vol. 06.01.

³ *Annual Book of ASTM Standards*, Vols. 02.05 and 06.01.

⁴ *Annual Book of ASTM Standards*, Vol. 15.09.

⁵ Permacel 99 manufactured by Permacel, New Brunswick, NJ 08903, and available from various Permacel tape distributors, is reported to be suitable for this purpose. The manufacturer of this tape and the manufacturer of the tape used in the interlaboratory study⁵ have advised this subcommittee that the properties of these tapes were changed. Users of it should, therefore, check whether current material gives comparable results to previous supplied material.

cutting edges be in good condition.

5.2 *Cutting Guide*—Steel or other hard metal straightedge ensure straight cuts.

5.3 *Tape*—One-inch (25-mm) wide semitransparent pressure-sensitive tape with an adhesion strength agreed upon by the supplier and the user is needed. Because of the variability in adhesion strength from batch-to-batch and with time, it is essential that tape from the same batch be used when tests are to be run in different laboratories. If this is not possible the test method should be used only for ranking a series of test coatings.

5.4 *Rubber Eraser*, on the end of a pencil.

5.5 *Illumination*—A light source is helpful in determining whether the cuts have been made through the film to the substrate.

6. Test Specimens

6.1 When this test method is used in the field, the specimen is the coated structure or article on which the adhesion is to be evaluated.

6.2 For laboratory use apply the materials to be tested to panels of the composition and surface conditions on which it is desired to determine the adhesion.

NOTE 3—Applicable test panel description and surface preparation methods are given in Methods D 609 and Practices D 1730 and D 2092.

NOTE 4—Coatings should be applied in accordance with Test Methods D 823, or as agreed upon between the purchaser and the seller.

NOTE 5—If desired or specified, the coated test panels may be subjected to a preliminary exposure such as water immersion, salt spray, or high humidity before conducting the tape test. The conditions and time of exposure will be governed by ultimate coating use or shall be agreed upon between the purchaser and seller.

Procedure

7.1 Select an area free of blemishes and minor surface imperfections. For tests in the field, ensure that the surface is clean and dry. Extremes in temperature or relative humidity may affect the adhesion of the tape or the coating.

7.2 Make two cuts in the film each about 1.5 in. (40 mm) long that intersect near their middle with a smaller angle of between 30 and 45°. When making the incisions, use the straightedge and cut through the coating to the substrate in one steady motion.

7.3 Inspect the incisions for reflection of light from the metal substrate to establish that the coating film has been penetrated. If the substrate has not been reached make another X in a different location. Do not attempt to deepen a previous cut as this may affect adhesion along the incision.

7.4 Remove two complete laps of the pressure-sensitive tape from the roll and discard. Remove an additional length at a steady (that is, not jerked) rate and cut a piece about 3 in. (75 mm) long.

7.5 Place the center of the tape at the intersection of the cuts with the tape running in the same direction as the smaller angles. Smooth the tape into place by finger in the area of the incisions and then rub firmly with the eraser on the end of a pencil. The color under the transparent tape is a useful indication of when good contact has been made.

7.6 Within 90 ± 30 s of application, remove the tape by peeling the free end and pulling it off rapidly (not jerked) back upon itself at as close to an angle of 180° as possible.

7.7 Inspect the X-cut area for removal of coating from the

substrate or previous coating and rate the adhesion in accordance with the following scale:

- 5A No peeling or removal,
- 4A Trace peeling or removal along incisions or at their intersection,
- 3A Jagged removal along incisions up to 1/16 in. (1.6 mm) on either side,
- 2A Jagged removal along most of incisions up to 1/8 in. (3.2 mm) on either side,
- 1A Removal from most of the area of the X under the tape, and
- 0A Removal beyond the area of the X.

7.8 Repeat the test in two other locations on each test panel. For large structures make sufficient tests to ensure that the adhesion evaluation is representative of the whole surface.

7.9 After making several cuts examine the cutting edge and, if necessary, remove any flat spots or wire-edge by abrading lightly on a fine oil stone before using again. Discard cutting tools that develop nicks or other defects that tear the film.

8. Report

8.1 Report the number of tests, their mean and range, and for coating systems, where the failure occurred that is, between first coat and substrate, between first and second coat, etc.

8.2 For field tests report the structure or article tested, the location and the environmental conditions at the time of testing.

8.3 For test panels report the substrate employed, the type of coating, the method of cure, and the environmental conditions at the time of testing.

8.4 If the adhesion strength of the tape has been determined in accordance with Test Method D 3330, report the results with the adhesion rating(s).

9. Precision and Bias⁶

9.1 In an interlaboratory study of this test method in which operators in six laboratories made one adhesion measurement on three panels each of three coatings covering a wide range of adhesion, the within-laboratories standard deviation was found to be 0.33 and the between-laboratories 0.44. Based on these standard deviations, the following criteria should be used for judging the acceptability of results at the 95 % confidence level:

9.1.1 *Repeatability*—Provided adhesion is uniform over a large surface, results obtained by the same operator should be considered suspect if they differ by more than 1 rating unit for two measurements.

9.1.2 *Reproducibility*—Two results, each the mean of triplicates, obtained by different operators should be considered suspect if they differ by more than 1.5 rating units.

9.2 Bias cannot be established for these test methods.

TEST METHOD B—CROSS-CUT TAPE TEST

10. Apparatus and Materials

10.1 *Cutting Tool*—Sharp razor blade, scalpel, knife or other cutting device having a cutting edge or edges angled

⁶ Supporting data are available from ASTM Headquarters. Request RR D01-1008.

between
several
cutting
10.2
posed to
straight
10.3
measur
10.4
10.5
10.6
10.7
used w
area.
11. Test
11.1
12. Proc
12.1 V
specimen
test (see
blemish
12.2 F
illuminat
12.2.1
including
make ele
12.2.2
2.0 mils (
apart and
Test Meth
12.2.3
through t
just suffic
edge reach
with the
12.3 A
with a sof
ribbons of
12.4 E
any flat s
stone. Ma
centered o
12.5 Br
reflection
been reach
12.6 Re
Remove a
rate and c
12.7 Pl
area of the
good conta
on the end
indiction o
12.8 Wit
seizing the
as close to
12.9 In
substrate o
magnifier.

between 15 and 30° that will make either a single cut or several cuts at once. It is of particular importance that the cutting edge be in good condition.

10.2 *Cutting Guide*—If cuts are made manually (as opposed to a mechanical apparatus) a steel or other hard metal straightedge or template to ensure straight cuts.

10.3 *Rule*—Tempered steel rule graduated in 0.5 mm for measuring individual cuts.

10.4 *Tape*, as described in 5.3.

10.5 *Rubber Eraser*, on the end of a pencil.

10.6 *Illumination*, as described in 5.5.

10.7 *Magnifying Glass*—An illuminated magnifier to be used while making individual cuts and examining the test area.

11. Test Specimens

11.1 Test specimens shall be as described in Section 6.

12. Procedure

12.1 Where required or when agreed upon, subject the specimens to a preliminary test before conducting the tape test (see Note 3). After drying or testing, select an area free of blemishes and minor surface imperfections.

12.2 Place the panel on a firm base and under the illuminated magnifier make parallel cuts as follows:

12.2.1 For coatings having a dry film thickness up to and including 2.0 mils (50 μm) space the cuts 1 mm apart and make eleven cuts unless otherwise agreed upon.

12.2.2 For coatings having a dry film thickness between 2.0 mils (50 μm) and 5 mils (125 μm), space the cuts 2 mm apart and make six cuts. For films thicker than 5 mils use Test Method A.

12.2.3 Make all cuts about 3/4 in. (20 mm) long. Cut through the film to the substrate in one steady motion using just sufficient pressure on the cutting tool to have the cutting edge reach the substrate. When making successive single cuts with the aid of a guide, place the guide on the uncut area.

12.3 After making the required cuts brush the film lightly with a soft brush or tissue to remove any detached flakes or ribbons of coatings.

12.4 Examine the cutting edge and, if necessary, remove any flat spots or wire-edge by abrading lightly on a fine oil stone. Make the additional number of cuts at 90° to and centered on the original cuts.

12.5 Brush the area as before and inspect the incisions for reflection of light from the substrate. If the metal has not been reached make another grid in a different location.

12.6 Remove two complete laps of tape and discard. Remove an additional length at a steady (that is, not jerked) rate and cut a piece about 3 in. (75 mm) long.

12.7 Place the center of the tape over the grid and in the area of the grid smooth into place by a finger. To ensure good contact with the film rub the tape firmly with the eraser on the end of a pencil. The color under the tape is a useful indication of when good contact has been made.

12.8 Within 90 ± 30 s of application, remove the tape by seizing the free end and rapidly (not jerked) pulling it off at as close to an angle of 180° as possible.

12.9 Inspect the grid area for removal of coating from the substrate or from a previous coating using the illuminated magnifier. Rate the adhesion in accordance with the following scale illustrated in Fig. 1:

5B The edges of the cuts are completely smooth; none of the squares of the lattice is detached.

4B Small flakes of the coating are detached at intersections; less than 5% of the area is affected.

3B Small flakes of the coating are detached along edges and at intersections of cuts. The area affected is 5 to 15% of the lattice.

2B The coating has flaked along the edges and on parts of the squares. The area affected is 15 to 35% of the lattice.

1B The coating has flaked along the edges of cuts in large ribbons and whole squares have detached. The area affected is 35 to 65% of the lattice.

0B Flaking and detachment worse than Grade 1.

12.10 Repeat the test in two other locations on each test panel.

13. Report

13.1 Report the number of tests, their mean and range, and for coating systems, where the failure occurred, that is, between first coat and substrate, between first and second coat, etc.

13.2 Report the substrate employed, the type of coating and the method of cure.

13.3 If the adhesion strength of the tape has been determined in accordance with Test Method D 3330, report the

Classification of Adhesion Test Results

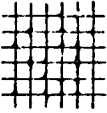



| Classification | Surface of cross-cut area from which flaking has occurred. (Example for six parallel cuts) |
|----------------|--|
| 5B | None |
| 4B |  |
| 3B |  |
| 2B |  |
| 1B |  |
| 0B | Greater than 65% |

FIG. 1 Classification of Adhesion Test Results

results with the adhesion rating(s).

Precision and Bias⁶

14.1 On the basis of two interlaboratory tests of this test method in one of which operators in six laboratories made one adhesion measurement on three panels each of three coatings covering a wide range of adhesion and in the other operators in six laboratories made three measurements on two panels each of four different coatings applied over two other coatings, the pooled standard deviations for within- and between-laboratories were found to be 0.37 and 0.7.

Based on these standard deviations, the following criteria should be used for judging the acceptability of results at the 95 % confidence level:

14.1.1 *Repeatability*—Provided adhesion is uniform over a large surface, results obtained by the same operator should be considered suspect if they differ by more than one rating unit for two measurements.

14.1.2 *Reproducibility*—Two results, each the mean of duplicates or triplicates, obtained by different operators should be considered suspect if they differ by more than two rating units.

14.2 Bias cannot be established for these test methods.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

**ORIGINAL PAGE IS
OF POOR QUALITY**

1. Scope

1.1 This condition...
mended F...
and relate...
unfiltered

NOTE 1—
by Practice...
the enclosed...
in Practice...
radiation ne...

1.2 Thi...
ations, ar...
address a...
the respon...
appropria...
applicabil...

2. Referen

- 2.1 AS...
- D 523 T...
- D 609 M...
- Paint...
- D 610 T...
- Paint...
- D 659 T...
- Exteri...
- D 660 T...
- Exteri...
- D 661 T...
- Exteri...
- D 662 T...
- Exteri...
- D 714 T...
- Paint...
- D 772 T...
- (Scali...
- D 822 P...
- Coatin...
- Carbo...

¹ This prac...
Related Coati...
D01.27 on Ac...
Current ed...
published as...
² Annual L...



Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser¹

This standard is issued under the fixed designation D 4060; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the resistance of organic coatings to abrasion produced by the Taber Abraser on coatings applied to a plane, rigid surface, such as a metal panel.

1.2 Because of the poor reproducibility of this test method, it should be restricted to testing in only one laboratory when numerical abrasion resistance values are to be used. Interlaboratory agreement is improved significantly when rankings of coatings are used in place of numerical values.

1.3 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- D 823 Test Methods for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels²
- D 968 Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive²
- D 1005 Test Methods for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers²
- D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base²
- D 1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base²
- D 2240 Test Method for Rubber Property—Durometer Hardness³

3. Terminology

3.1 Descriptions of Terms Specific to This Standard:

3.1.1 Abrasion resistance can be expressed as one or more of the following terms:

3.1.1.1 *wear index*—1000 times the loss in weight in milligrams per cycle.

3.1.1.2 *weight loss*—the loss in weight in milligrams,

determined at a specified number of cycles.

3.1.3 *wear cycles per mil*—the number of cycles of abrasion required to wear a film through to the substrate per mil of film thickness.

4. Summary of Test Method

4.1 The organic coating is applied at uniform thickness to a plane, rigid panel and, after curing, the surface is abraded by rotating the panel under weighted abrasive wheels.

4.2 Abrasion resistance is calculated as loss in weight at a specified number of abrasion cycles, as loss in weight per cycle, or as number of cycles required to remove a unit amount of coating thickness.

5. Significance and Use

5.1 Coating on substrates can be damaged by abrasion during manufacturing and service. This test method has been useful in evaluating the abrasion resistance of attached coatings. Ratings produced by this test method have correlated well with ratings produced by the falling abrasive values in Test Method D 968.

6. Apparatus

6.1 *Taber Abraser*.⁴

6.2 *Abrasive Wheels*—Resilient calibrase wheels No. CS-10 or CS-17, as required, shall be used. Because of the slow hardening of the rubber bonding material in this type of wheel, the wheels should not be used after the date marked on them, or one year after their purchase if the wheels are not dated.

NOTE 1—The hardness of the wheels can be checked by Test Method D 2240. An acceptable hardness for both types of wheels is 81 ± 5 units on Shore Durometer A-2 Scale.

NOTE 2—The CS-17 wheels produce a harsher abrasion than the CS-10 wheels.

6.3 *Resurfacing Medium*, an S-11 abrasive disk, used for resurfacing the abrasion wheels.

6.4 *Vacuum Pick-Up Assembly*, consisting of a vacuum unit, a variable transformer suction regulator, a nozzle with bracket attachment, and a connecting hose with adaptor.

7. Test Specimens

7.1 Apply a uniform coating of the material to be tested to a plane, rigid panel. Specimens shall be a disk 4 in. (100 mm) in diameter or a plate 4-in. (100-mm) square with rounded corners and with a 1/4-in. (6.3-mm) hole centrally located on

¹ This test method is under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings and Materials and is the direct responsibility of Subcommittee D01.23 on Physical Properties of Applied Paint Films.

Current edition approved May 25, 1990. Published July 1990. Originally published as D 4060 - 81. Last previous edition D 4060 - 84.

² *Annual Book of ASTM Standards*, Vol 06.01.

³ *Annual Book of ASTM Standards*, Vol 09.01.

⁴ Available from Teledyne Taber, North Tonawanda, NY 14120.

each panel. material.
 NOTE 3—T
 Methods D 823
 NOTE 4—T
 accordance w
 3. Standard
 8.1 Mou
 Change hold
 Abrasive sur
 8.2 Mou
 on the turn
 the wheels
 vacuum pic
 distance of
 8.3 Set th
 to approxim
 increased to
 appears nece
 8.4 Start t
 the abrader.
 against the r
 NOTE 5—T
 testing each sp
 9. Condition
 9.1 Cure
 and temper
 seller.
 9.2 Under
 seller, cond
 and 50 ± 5
 environmen
 10. Procedu
 10.1 Weig
 record this
 to be repa
 10.2 Mea
 several locat
 10.3 Mou
 abrading he
 nozzle in p
 action regu
 10.4 Start
 the abrader.
 specified nu
 coating is c
 through, stop
 the test speci
 Weig
 Weig
 Weig
 Cycle

each panel. Prepare a minimum of two coated panels for the material.

NOTE 3—The coatings should be applied in accordance with Test Methods D 823, or as agreed upon between the purchaser and the seller.

NOTE 4—The thickness of the dry coatings should be measured in accordance with Test Methods D 1005, D 1186, or D 1400.

8. Standardization

8.1 Mount the selected abrasive wheels on their respective change holders, taking care not to handle them by their abrasive surfaces. Adjust the load on the wheels to 1000 g.

8.2 Mount the resurfacing medium (S-11 abrasive disk) on the turntable. Lower the abrading heads carefully until the wheels rest squarely on the abrasive disk. Place the vacuum pick-up nozzle in position and adjust it to a distance of 1/32 in. (1 mm) above the abrasive disk.

8.3 Set the counter to "zero" and set the suction regulator to approximately 50 points on the dial. The setting may be increased to 90 if more effective removal of the abrasings appears necessary.

8.4 Start the vacuum pick-up and then the turntable of the abrader. Resurface the wheels by running them 50 cycles against the resurfacing medium.

NOTE 5—The wheels should be resurfaced in this manner before testing each specimen and after every 500 cycles.

9. Conditioning

9.1 Cure the coated panel under conditions of humidity and temperature as agreed upon between purchaser and seller.

9.2 Unless otherwise agreed upon between purchaser and seller, condition the coated panel for at least 24 h at 23 ± 2°C and 50 ± 5 % relative humidity. Conduct the test in the same environment or immediately on removal therefrom.

10. Procedure

10.1 Weigh the test specimen to the nearest 0.1 mg and record this weight, if either the wear index or the weight loss is to be reported.

10.2 Measure the coating thickness of the test specimen in several locations along the path to be abraded.

10.3 Mount the test specimen on the turntable. Place the abrading heads on the test film and the vacuum pick-up nozzle in position as outlined in 8.2. Set the counter and suction regulator as outlined in 8.3.

10.4 Start the vacuum pick-up and then the turntable of the abrader. Subject the test specimen to abrasion for the specified number of cycles or until wear through of the coating is observed. In determining the point of wear through, stop the instrument at intervals for examination of the test specimen.

10.5 Remove any loose abrasings remaining on the test specimen by light brushing. Reweigh the test specimen.

10.6 Repeat 10.1 to 10.5 on at least one additional test specimen of the material under test.

11. Calculation

11.1 Wear Index—Compute the wear index, *I*, of a test specimen as follows:

$$I = \frac{(A - B) 1000}{C}$$

where:

A = weight of test specimen before abrasion, mg.

B = weight of test specimen after abrasion, mg, and

C = number of cycles of abrasion recorded.

NOTE 6—In calculating wear index it may be advisable to discard the last 200 cycles because the results may be affected by abrasion of the exposed substrate.

11.2 Weight Loss—Compute weight loss, *L*, of the test specimen as follows:

$$L = A - B$$

where:

A = weight of test specimen before abrasion, mg, and

B = weight of test specimen after abrasion, mg.

11.3 Wear Cycles Per Mil—Compute the wear cycles per mil, *W'*, of the test specimen as follows:

$$W' = D/T$$

where:

D = number of cycles of abrasion required to wear coating through to substrate and

T = thickness of coating, mils (0.001 in.) (to one decimal place).

NOTE 7—In calculating the wear cycles, it is advisable to discard the first and last readings because the first may be affected by an uneven surface and the last by abrasion of parts of the substrate.

12. Report

12.1 Report the following information for each test material:

12.1.1 Temperature and humidity during conditioning and at the time of testing.

12.1.2 Thickness of coating when wear cycles are specified,

12.1.3 Kind of calibre abrasive wheels used,

12.1.4 Load applied to the abrasive wheels,

12.1.5 Number of wear cycles recorded for each test specimen,

TABLE 1 Precision of Taber Abrasion Values

| | Within Laboratory | | Between Laboratories | |
|----------------------------|-----------------------------|---------------------------------|-----------------------------|---------------------------------|
| | Coefficient of Variation, % | Maximum Allowable Difference, % | Coefficient of Variation, % | Maximum Allowable Difference, % |
| Weight loss at 500 cycles | 12 | 4E | 36 | 105 |
| Weight loss at 1000 cycles | 10 | 4E | 30 | 90 |
| Wear index at 500 cycles | 13 | 52 | 30 | 100 |
| Wear index at 1000 cycles | 10 | 4E | 30 | 92 |
| Cycles per mil | 13 | 44 | 31 | 92 |

12.1.6 Wear index, weight loss, or wear cycles per mil for each test specimen, and

12.1.7 Mean and range of the abrasion resistance values of replicate coated panels.

13. Precision⁵

13.1 On the basis of an interlaboratory test of this test method in which operators in five laboratories tested four coatings having a broad range of abrasion resistance, the within-laboratory coefficients of variation and between-laboratories coefficients of variation were found to be those in Table 1. Based upon these coefficients, the following

criteria should be used for judging the acceptability of results at the 95 % confidence level:

13.1.1 *Repeatability*—Two results by the same operator should be considered suspect if they differ by more than the maximum allowable difference values shown in Table 1.

13.1.2 *Reproducibility*—Two results obtained by operators in different laboratories should be considered suspect if they differ by more than the maximum allowable difference values shown in Table 1.

NOTE 8—When this test method is used to rank a series of coatings by magnitude of abrasion resistance, the precision is significantly better than shown in Table 1. In the interlaboratory study for evaluating precision, all laboratories ranked the coatings in the same order of abrasion resistance.

14. Keywords

14.1 wear index

⁵ Supporting data are available from ASTM Headquarters. Request RR: D01-1037.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

1. Scop
1.1 T
ment of
materi
and tra
1.2 S
mined
Likewis
angles t
1.3 T
based o
changes
angle ra
1.4 T
facility
does no
of hous
1.5 T
ations.
address
the res
appropri
applica

2. Refe
2.1
E 28
M
E 30
Us
E 80
E 80
of
2.2
No.

3. Tern
3.1
3.1.1
in an in
directio
a wide

¹ This
and Rel
mittee D
Curre
² Ann
³ AN
Illumina
Somerset

ORIGINAL PAGE IS
OF POOR QUALITY



Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films¹

This standard is issued under the fixed designation D 4214; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

Scope

1.1 These test methods cover the evaluation of the degree of chalking on white or lightly tinted exterior paint films. It describes the procedures recommended for transferring the chalk to a fabric or fingertip, which is then compared to photographic reference standards, or in the case of adhesive tapes, compared to a reflectance table or photographic reference standards, to determine the degree of chalking.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

D 659 Method of Evaluating Degree of Chalking of Exterior Paints²

D 662 Test Method for Evaluating Degree of Erosion of Exterior Paints²

D 1150 Single and Multi-Panel Forms for Recording Results of Exposure Tests of Paints^{2,3}

E 97 Test Method for Directional Reflectance Factor, 45-Deg 0-Deg, of Opaque Specimens by Broad-Band Filter Reflectometry²

2.2 Other Document:

Pictorial Standards of Coating Defects⁴

3. Terminology

3.1 Definition:

3.1.1 *chalking*—the formation on a pigmented coating of a friable powder evolved from the film itself at or just beneath the surface.

4. Significance and Use

4.1 The procedures provide a broader range of techniques and photographic references to evaluate chalking of exterior

paints than that in Method D 659 and are thus an extension of that method.

5. Type of Chalking

5.1 Only one type of chalking is recognized, as defined in Section 3.

6. Use of Photographic Reference Standards

6.1 The photographic reference standards that are part of this test method are representative of the degrees of chalking on a paint film. The photographs shown in Figs. 1 and 2 are for illustration purposes only and should not be used for evaluation.

6.2 The use of photographic reference standards illustrated in Figs. 1, 2, 3, and 4 requires the following precautions:

6.2.1 The degree of chalking will vary over any given area. Therefore, an average portion of the coating should be evaluated. On large surfaces, it is recommended that the rating be made at several locations and the mean and range reported.

6.2.2 It is difficult to make readings on a windy day and making readings at such time should be avoided. It should also be noted that rain, snow, or moisture in any form will remove chalk so that readings should be made after a period of clear weather and when the surface is dry.

6.2.3 Chalking and erosion (Note 1) are closely related, and erosion is a result of chalking failure. However, the rate of chalking as measured by these test methods, and the rate of erosion may not be comparable because some pigment combinations tend to retain chalk on the surface while other pigment combinations exert a self-cleaning action by natural means.

NOTE 1—For the evaluation of erosion, see Test Method D 662.

6.3 Records may be kept on forms such as shown in Fig. 3, according to Standard D 1150, or other inspection forms. The reporting of the results shall include the information given in Section 10.

6.4 When this test method is referenced in specifications for performance, the permissible degree of chalking is established between the producer and the user.

7. Recommended Procedures—Wood Substrates

7.1 Test Method A—Method D 659:

7.1.1 *Material*—Fabric, as agreed upon between the producer, user, or other interested parties, to rub against the surface being tested. Black wool felt, velvet, and velveteen have proven particularly effective.

7.1.2 *Procedure*—Wrap the fabric around the index fingertip, then apply it with medium pressure to the coating under observation. Rotate the finger through an angle of

¹ These test methods are under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings and Materials and are the direct responsibility of Subcommittee D01.27 on Accelerated Testing.

Current edition approved March 31, 1989. Published June 1989. Originally published as D 4214 - 82. Last previous edition D 4214 - 82 (1987)¹.

² *Annual Book of ASTM Standards*, Vol 06.01.

³ These record sheets may be obtained from ASTM, 1916 Race St., Philadelphia, PA 19103 (request Adjunct Nos. 12-411500-11 and 12-411500-21) and from the Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422.

⁴ Copies of the pictorial photographic reference standards applicable to Test Method D 659 are contained in the publication *Pictorial Standards of Coatings Defects* and may be obtained from the Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422.

ORIGINAL PAGE IS OF POOR QUALITY

PRECEDING PAGE BLANK, NOT FILMED

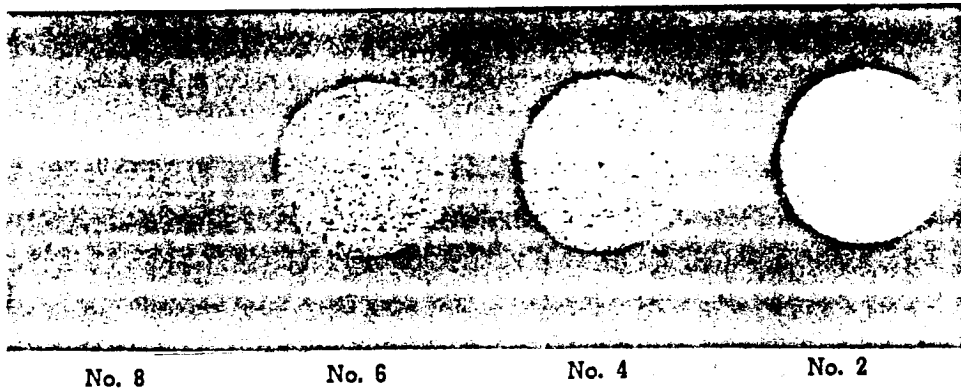


FIG. 1 Photographic Reference Standard No. 1—Test Method D 659

180° holding the fabric so it also rotates. Remove the fabric and compare the spot of chalk on it with Photographic Reference Standard No. 1.

7.2 Test Method B—Stroke Method:

7.2.1 Material—Fabric as in 7.1.1.

7.2.2 Procedure—Wrap the fabric around the index fingertip, then make a 3-in. (75-mm) stroke with medium pressure on the coating under observation. Remove the fabric and compare the spot of chalk on it with Photographic Reference Standard No. 1.

7.3 Test Method C—Wet Finger Method:

7.3.1 Procedure—Moisten a fingertip and with medium pressure make one continuous rub 2 to 2½ in. (50 to 65 mm) in length on the surface under test. Compare the rub-off on the finger with Photographic Reference Standard No. 1. This test method can be used quite effectively by experienced operators and is recommended mainly for in-the-field evaluation when use of one of the other methods is impractical.

8. Recommended Procedures—Metallic Substrate—Industrial, Automotive, and Coil Coatings

8.1 Test Method C—Wet Finger Method—See 7.3.

8.2 Test Method D—Transparent Tape Method:⁵

8.2.1 Materials:

8.2.1.1 Cellulose Adhesive Tape,⁶ ½ in. (13 mm) wide, pressure-sensitive.

8.2.1.2 Eraser, ¼ in. (20 mm), wrapped with cellophane tape.

8.2.1.3 Masking Tape, ½ in. (13 mm) wide.

8.2.1.4 Plastic Sheet Protector, clear.

8.2.1.5 Photographic Reference Standard No. 2, TNO.⁷

8.2.1.6 Reflectance Standard, polished black glass.

⁵ Permission to include this method is provided as a courtesy of NL Chemicals, Wyckoff Mills Rd., Hightstown, NJ 08520.

⁶ Permaceal 404 manufactured by Permaceal, Inc., Route 1, New Brunswick, NJ 08903 and Scotch Brand tape No. 600 manufactured by The 3M Company, Packaging Systems, 3M Center, Bldg. 230F267, St. Paul, MN 55144, have been found suitable for the purpose.

⁷ The TNO Method and photographic reference standard are provided as a courtesy of Verifinstituut TNO Paint Research Institute TNO, Schoemakerstraat 111a, Nederland. The original source of the photographic reference standard is shown in Fig. 2 is the Paint Research Institute, TNO. The ASTM numerical designation of chalking shown on the photographic reference standard is opposite to the original TNO scale.

8.2.1.7 Reflectance Standard, white tile.

NOTE 2—The black reference standard is necessary as the background for this measurement, since the reflectance of black paper is too high. Reflectometers (tristimulus colorimeters), with 0 to 45 degree geometry, use the Y value.

8.2.2 Optional Materials:

8.2.2.1 China Marker, black.

8.2.2.2 Razor Blade.

8.2.3 Preparation:

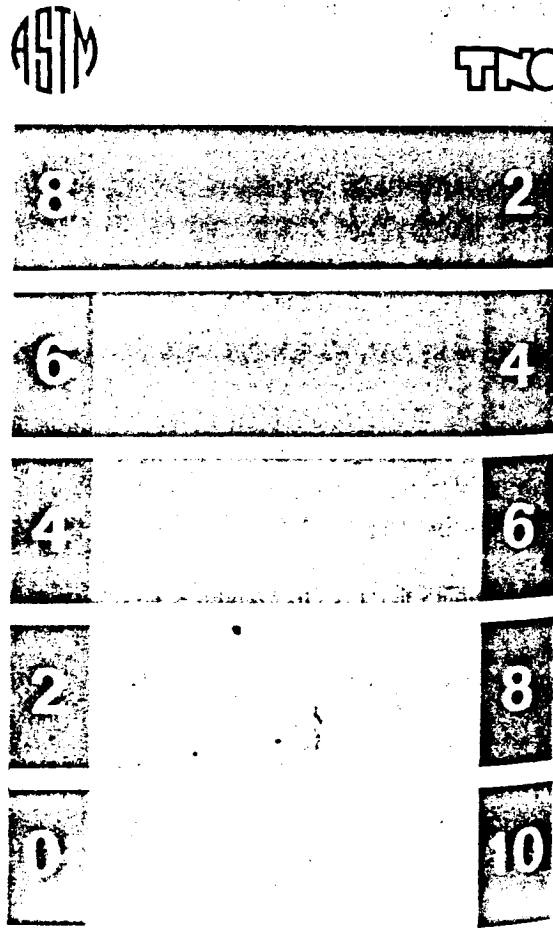


FIG. 2 Photographic Reference Standard No. 2—Verifinstituut TNO

Client No
Order #
Radiation

Sheet
Type & Sheet
1st S

1
2
3
4
5
6
7
8
9
10

Type & Sheet
Sheet

Note—Label size
specimens of the s

8.2.3.1 Sepa
pieces of mask
sheet cover le
pieces (see Fig
8.2.3.2 Rem
(cellulose,
face it across
using a ¼-in. (1
label this tap
black china m

Note 3—The
"blank" ta

ORIGINAL PAGE IS
OF POOR QUALITY

SHEET
TAPE CHALK RATING WORKSHEET
Reflectance Method **BLANK**

Client Name _____
Order # _____
Radiation to date _____

| Sheet | Measurements | AVG/% | Corrected Value | Rating |
|--------------|--------------|---------|-----------------|--------|
| Sheet | | | | |
| Tape & Sheet | | | | 4 |
| | 1st Set | 2nd Set | | |
| 1 | | | | 5 |
| 2 | | | | 6 |
| 3 | | | | 7 |
| 4 | | | | 8 |
| 5 | | | | 9 |
| 6 | | | | 10 |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| Tape & Sheet | | | | BLANK |
| Sheet | | | | SHEET |

Date _____
Inspected by _____

NOTE—Label sample numbers, apply initial blank tape, and proceed with tape specimens of the samples.

FIG. 3 Example of Worksheet

8.2.3.1 Separately mount and apply two 11-in. (279-mm) pieces of masking tape along the right side of the clear plastic sheet cover leaving 1 1/4 in. (32 mm) of space between the pieces (see Fig. 3).
8.2.3.2 Remove a 2 in. (50 mm) long piece of 1/2 in. (13 mm) cellulose, pressure-sensitive adhesive tape from the roll, place it across the masking strips, and adhere it to the sheet using a 3/4-in. (20-mm) eraser, wrapped with cellophane tape. Label this tape "blank" on the clear plastic sheet cover. A black china marker has been found useful for this purpose.

NOTE 3—The average reflectance measurements of the initial and ending "blank" tapes less the correction value for the clear plastic sheet

TAPE CHALK RATING WORKSHEET **SHEET**
Reflectance Method **BLANK**

Client Name ABC Company
Order # 164433
Radiation to date 4/4 MS/m² of UV

| Sheet | Measurements | AVG/% | Corrected Value | Rating | |
|--------------|--------------|---------|-----------------|--------|-----|
| Sheet | 0.94 | 0.004 | — | — | |
| Tape & Sheet | 2.78 | 0.0229 | 0.0194 | 1.0 | |
| | 1st Set | 2nd Set | | | |
| 1 | 24.20 | 24.14 | 0.2380 | 0.2325 | 2.0 |
| 2 | 16.46 | 17.65 | 0.1644 | 0.1619 | 4.5 |
| 3 | 14.91 | 16.19 | 0.1418 | 0.1573 | 4.5 |
| 4 | 14.65 | 15.74 | 0.1484 | 0.1439 | 5.0 |
| 5 | 22.14 | 20.64 | 0.2103 | 0.2058 | 3.5 |
| 6 | 21.23 | 20.00 | 0.2046 | 0.2001 | 3.5 |
| 7 | 25.11 | 22.98 | 0.2468 | 0.2323 | 2.0 |
| 8 | 9.54 | 9.70 | 0.0962 | 0.1016 | 7.5 |
| 9 | 26.77 | 27.23 | 0.2619 | 0.2574 | 0.5 |
| 10 | 5.86 | 5.17 | 0.0520 | 0.0472 | 9.0 |
| Tape & Sheet | 2.40 | 0.0229 | 0.0194 | BLANK | |
| Sheet | 0.46 | 0.004 | | BLANK | |

Date 6-20-87
Inspected by John R. Doe

NOTE—The cut-out section is for illustration purposes only. The labeling (china marker) may be removed by rubbing the sheet with a clean tissue or cloth.
FIG. 4 Completed Worksheet

divided by 100 are used to verify a rating of 10 using Table 1.⁸

8.2.4 Procedure:

8.2.4.1 Apply a 2 in. (50 mm) long piece of 1/2 in. (13 mm) wide tape to the surface being rated. Rub ten times with moderate pressure using the covered eraser, to remove all bubbles and prevent scratching. Remove the tape from the surface and adhere it to the sheet by rubbing with the eraser. Label specimens using a black china marker. Place successive tapes vertically adjacent to previous tapes, separated by 1/8 in. (3 mm). Follow the instructions given in 8.2.3.2, and place the final "blank" tape across the masking tape strips and label "blank" on the clear sheet. When completed, use a razor blade to cut along the inside edges of the masking tape, cutting through the adhesive tapes. The removal of the masking tape will leave only the tapes to be measured and evaluated with the sample number of each tape listed on the sheet (see worksheet example in Fig. 4). Before proceeding, check to ensure all sample numbers have been recorded on the sheet.

8.2.4.2 Insert the 1/2-in. (13-mm) aperture and calibrate the reflectometer according to the manufacturer's instructions, setting the reflectometer for zero reflectance using the

⁸ Kronos-Titan Table for Chalk Rating from Reflectance Reading using the Transparent Tape Method is provided as a courtesy of Kronos-Titan GmbH, Leverkusen, West Germany. The original source of Table 1 is Kronos-Titan GmbH.

ry as the back-
ack paper is too
0 to 45 degree

77
2
4
2
0

nstituut

ORIGINAL PAGE IS OF POOR QUALITY

TABLE 1 Chalk Rating from Reflectance Reading^a

| Reflectance Range | Chalk Rating |
|-------------------|--------------|
| 0-0.038 | 10 |
| 0.0381-0.044 | 9.5 |
| 0.0441-0.054 | 9.0 |
| 0.0541-0.062 | 8.5 |
| 0.0621-0.072 | 8.0 |
| 0.0721-0.082 | 7.5 |
| 0.0821-0.095 | 7.0 |
| 0.0951-0.105 | 6.5 |
| 0.1051-0.120 | 6.0 |
| 0.1201-0.131 | 5.5 |
| 0.1311-0.150 | 5.0 |
| 0.1501-0.165 | 4.5 |
| 0.1651-0.190 | 4.0 |
| 0.1901-0.210 | 3.5 |
| 0.2101-0.235 | 3.0 |
| 0.2351-0.260 | 2.5 |
| 0.2601-0.286 | 2.0 |
| 0.2861-0.310 | 1.5 |
| 0.3101-0.340 | 1.0 |
| 0.3401-0.366 | 0.5 |
| >0.366 | 0 |

^a This table is based upon a correlation between tape reflectance measurements and visual evaluations of the same tape compared to the photographic standards prepared by Kronos-Titan.⁸

black reflectance standard and standardizing with the white reflectance standard and record the values. Refer to Test Method E 97 should there be any question on the correct procedure to follow in the calibration of the instrument.

8.2.5 Reflectometer Measurements:

8.2.5.1 Leave the transparent tapes mounted on the clear plastic sheet. Remove the black paper that may have been inserted behind the sheet and fold back the unused portion of the sheet. Measure the reflectance of the clear plastic sheet against the black reflectance standard of the instrument (Note 5) as a backing or background and record its value. Move the sheet until the first tape is exposed to the light source with the adhesive side toward the light and the black reflectance standard behind the area being measured, and record the value.

8.2.5.2 Continue this procedure until ten tapes have been measured, then check reflectance values for the white and black standards. If no changes have occurred, proceed with measurements. If values have changed, restandardize and record values before proceeding to the remaining tapes. Following the final tape measurement, record reflectance values of the clear plastic sheet cover and the white and black reflectance standards.

8.2.5.3 Subtract the mean reflectance value of the sheet from each reading, enter on worksheet form (Fig. 4), or other form used, and determine from Table 1⁸ the chalk rating value of each tape to the nearest 0.5 unit. Record the rating on the worksheet or other form. The worksheet form (Fig. 4), inserted into the plastic sheet protector with a black background gives a clear permanent record of these measurements and evaluations.

8.2.6 These tape chalks may also be compared to Photographic Reference Standard No. 2 as an alternative procedure.

8.3 Test Method E-TNO Method:

8.3.1 Materials:

8.3.1.1 *Photographic Reference Standard No. 2* for the determination of chalking, consisting of a photograph of five strips of tape mounted on a black background, numbered 0, 2, 4, 6, and 8, and varying in this order from white to almost black. The numerical rating of chalking shown on the photographic reference standard is opposite of the original TNO Scale.

8.3.1.2 *Polyethylene Tape*,⁹ transparent, 1-in. (25-mm) wide.

8.3.1.3 *Black Velvet*, dull black with a short pile and without a tendency to crush, size approximately 8 by 12 in. (200 by 300 mm), mounted on a flat substrate. Place adjacent to the standard for the ratings.

8.3.2 *Procedure*—Apply a piece of tape, approximately 4-in. (100-mm) long, to the coating by uniform gentle pressure of the finger, remove the tape, and lay it with the adhesive side on the piece of velvet. Under diffused light compare the tape on the black velvet with Photographic Reference Standard No. 2, and determine which of the five grades most closely matches the whiteness of the adhering pigment. If the degree of chalking is obviously between two adjacent grades, select the intermediate odd number as the chalk rating.

8.3.3 Chalk ratings may also be determined by following the procedures of 8.2.3 and comparing to the values shown in Table 1. The use of the worksheet form shown in Figs. 3 and 4 may be used as a permanent record.

9. Recommendations

9.1 The procedures recommended for various substrates and coatings are based upon the results obtained in interlaboratory testing. The selection of the method to be used is subject to agreement between producer and user.

10. Report

10.1 A record of the test method used, the rating, panel number, and other pertinent information must be clearly shown on the inspection report for each evaluation. The report form may be in accordance with Standard D 1150 or other form agreed upon between the producer and the user.

10.2 The pertinent information should include: date of inspection, date of exposure start, purchase order number of testing organization, duration, remarks about unusual weather, etc., the name of the person making the inspection, and other information agreed upon between the producer and the seller.

⁹ Sellotape 1401, Transparent Polythene Electrical, manufactured by Sellotape Products Ltd., Edgware, Middlesex, England has been found suitable for this purpose.

ORIGINAL PAGE IS
OF POOR QUALITY

Steel Structures Painting Council

SURFACE PREPARATION SPECIFICATION NO. 1

Solvent Cleaning

1. Scope

1.1 This specification covers the requirements for the solvent cleaning of steel surfaces.

2. Definition

2.1 Solvent cleaning is a method for removing all visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants from steel surfaces.

2.2 It is intended that solvent cleaning be used prior to the application of paint and in conjunction with surface preparation methods specified for the removal of rust, mill scale, or paint.

3. Surface Preparation Before and After Solvent Cleaning

3.1 Prior to solvent cleaning, remove foreign matter (other than grease and oil) by one or a combination of the following: brush with stiff fiber or wire brushes, abrade, scrape, or clean with solutions of appropriate cleaners, provided such cleaners are followed by a fresh water rinse.

3.2 After solvent cleaning, remove dirt, dust, and other contaminants from the surface prior to paint application. Acceptable methods include brushing, blow off with clean, dry air, or vacuum cleaning.

4. Methods of Solvent Cleaning

4.1 Remove heavy oil or grease first by scraper. Then remove the remaining oil or grease by any of the following methods:

4.1.1 Wipe or scrub the surface with rags or brushes wetted with solvent. Use clean solvent and clean rags or brushes for the final wiping.

4.1.2 Spray the surface with solvent. Use clean solvent for the final spraying.

4.1.3 Vapor degrease using stabilized chlorinated hydrocarbon solvents.

4.1.4 Immerse completely in a tank or tanks of solvent. For the last immersion, use solvent which does not contain detrimental amounts of contaminant.

4.1.5 Emulsion or alkaline cleaners may be used in place of the methods described. After treatment, wash the surface with fresh water or steam to remove detrimental residues.

4.1.6 Steam clean, using detergents or cleaners and follow by steam or fresh water wash to remove detrimental residues.

5. Inspection

5.1 All work and materials supplied under this specification shall be subject to timely inspection by the purchaser or his authorized representative. The contractor shall correct such work or replace such material as is found defective under this specification. In case of dispute the arbitration or settlement procedure established in the procurement documents, if any, shall be followed. If no arbitration or settlement procedure is established, the procedure specified by the American Arbitration Association shall be used.

5.2 The procurement documents covering work or purchase should establish the responsibility for testing and for any required affidavit certifying full compliance with the specification.

6. Safety

6.1 All safety requirements stated in this specification and its component parts apply in addition to any applicable federal, state, and local rules and requirements. They also shall be in accord with instructions and requirements of insurance underwriters.

7. Notes*

7.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the SSPC cannot assume responsibility or incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

7.2 A Commentary Section is available (Chapter 2 of Volume 2 of the Steel Structures Painting Manual) and contains additional information and data relative to this specification. The Surface Preparation Commentary, SSPC-SP COM, is not part of this specification. The table below lists the subjects discussed relevant to solvent cleaning and appropriate Commentary Section.

| Subject | SSPC-SP COM Section |
|------------------------------|---------------------|
| Solvents and Cleaners | 11.1 through 11.1.3 |
| Steam Cleaning | 11.1.4 |
| Threshold Limit Values | 11.1.5 |
| Film Thickness | 10 |

*Notes are not requirements of this specification.

**ORIGINAL PAGE IS
OF POOR QUALITY**

Steel Structures Painting Council

SURFACE PREPARATION SPECIFICATION NO. 2

Hand Tool Cleaning

1. Scope

1.1 This specification covers the requirements for the hand tool cleaning of steel surfaces.

2. Definitions

2.1 Hand tool cleaning is a method of preparing steel surfaces by the use of non-power hand tools.

2.2 Hand tool cleaning removes all loose mill scale, loose rust, loose paint, and other loose detrimental foreign matter. It is not intended that adherent mill scale, rust, and paint be removed by this process. Mill scale, rust, and paint are considered adherent if they cannot be removed by lifting with a dull putty knife.

2.3 ISO 8501-1:1988 or other visual standards of surface preparation agreed upon by the contracting parties may be used to further define the surface.

3. Reference Standards

3.1 The standards referenced in this specification are listed in Section 3.4 and form a part of the specification.

3.2 The latest issue, revision, or amendment of the reference standards in effect on the date of invitation to bid shall govern unless otherwise specified.

3.3 If there is a conflict between the requirements of any of the cited reference standards and the specification, the requirements of the specification shall prevail.

3.4 STEEL STRUCTURES PAINTING COUNCIL (SSPC) SPECIFICATIONS:

SSPC-SP 1 Solvent Cleaning

3.5 International Organization for Standardization (ISO):

8501-1:1988 Preparation of steel substrates before application of paints and related products: visual assessment of surface cleanliness, Part I

4. Surface Preparation Before and After Hand Tool Cleaning

4.1 Before hand tool cleaning, remove visible oil, grease, soluble welding residues, and salts by the methods outlined in SSPC-SP 1.

4.2 After hand tool cleaning and prior to painting, reclean the surface if it does not conform to this specification.

4.3 After hand tool cleaning and prior to painting, remove dirt, dust, or similar contaminants from the surface. Acceptable methods include brushing, blow off with

5. Methods of Hand Tool Cleaning

5.1 Use impact hand tools to remove stratified rust (rust scale).

5.2 Use impact hand tools to remove all weld slag.

5.3 Use hand wire brushing, hand abrading, hand scraping, or other similar non-impact methods to remove all loose mill scale, all loose or non-adherent rust, and all loose paint.

5.4 Regardless of the method used for cleaning, if specified in the procurement documents, feather edges of remaining old paint so that the repainted surface can have a reasonably smooth appearance.

5.5 If approved by the owner, use power tools or blast cleaning as a substitute cleaning method for this specification.

6. Inspection

6.1 All work and materials supplied under this specification shall be subject to timely inspection by the purchaser or his authorized representative. The contractor shall correct such work or replace such material as is found defective under this specification. In case of dispute the arbitration or settlement procedure established in the procurement documents, if any, shall be followed. If no arbitration or settlement procedure is established, the procedure specified by the American Arbitration Association shall be used.

6.2 The procurement documents covering work or purchase should establish the responsibility for testing and for any required affidavit certifying full compliance with the specification.

7. Safety

7.1 All safety requirements stated in this specification and its component parts apply in addition to any applicable federal, state, and local rules and requirements. They also shall be in accord with instructions and requirements of insurance underwriters.

8. Notes*

8.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the SSPC cannot assume responsibility or incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

**ORIGINAL PAGE IS
OF POOR QUALITY**

8.2 A Commentary Section is available (Chapter 2 of Volume 2 of the Steel Structures Painting Manual) and contains additional information and data relevant to this specification. The Surface Preparation Commentary, SSPC-SP COM, is not part of this specification. The table below lists the subjects discussed relevant to hand tool cleaning and appropriate Commentary Section.

| | SSPC-SP COM Section |
|----------------------------|---------------------|
| Degree of Cleaning | 11 |
| Film Thickness | 10 |
| Maintenance Painting | 3.2 |
| Rust Back | 8 |
| Visual Standards | 7 |
| Weld Spatter | 4.1 |

*Notes are not requirements of this specification.

Steel Structures Painting Council

SURFACE PREPARATION SPECIFICATION NO. 10

Near-White Blast Cleaning

1. Scope

1.1 This specification covers the requirements for Near-White Blast Cleaning of steel surfaces by the use of abrasives.

2. Definition

2.1 A Near-White Blast Cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except for staining as noted in Section 2.2.

2.2 Staining shall be limited to no more than 5 percent of each square inch of surface area and may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied paint.

2.3 **ACCEPTABLE VARIATIONS IN APPEARANCE THAT DO NOT AFFECT SURFACE CLEANLINESS** as defined in Sections 2.1 and 2.2 include variations caused by type of steel, original surface condition, thickness of the steel, weld metal, mill or fabrication marks, heat treating, heat affected zones, blasting abrasives, and differences in the blast pattern.

2.4 When painting is specified, the surface shall be roughened to a degree suitable for the specified paint system.

2.5 Immediately prior to paint application, the surface shall comply with the degree of cleaning as specified herein.

2.6 SSPC-Vis 1-89 or other visual standards of surface preparation may be specified to supplement the written definition.

*NOTE: Additional information on visual standards is available in Section A.4 of the Appendix.

3. Blast Cleaning Abrasives

3.1 The selection of abrasive size and type shall be based on the type, grade, and surface condition of the steel to be cleaned, type of blast cleaning system employed, the finished surface to be produced (cleanliness and roughness), and whether the abrasive will be recycled.

3.2 The cleanliness and size of recycled abrasives shall be maintained to insure compliance with this specification.

3.3 The blast cleaning abrasive shall be dry and free of oil, grease, and other harmful materials at the time of use.

3.4 Any limitations or restrictions on the use of specific abrasives, quantity of contaminants, or degree of embedment shall be included in the procurement documents (project specification) covering the work, since abrasive embedment and abrasives containing contaminants may not be acceptable for some service requirements.

*NOTE: Additional information on abrasive selection is available in Section A.2 of the Appendix.

4. Reference Standards

4.1 If there is a conflict between the cited reference standards and this specification, this specification shall prevail unless otherwise indicated in the procurement documents (project specification).

4.2 The standards referenced in this specification are:

| | |
|---------------|--|
| SSPC-SP 1 | Solvent Cleaning |
| SSPC-Vis 1-89 | Visual Standard for Abrasive Blast Cleaned Steel |

5. Procedure Before Blast Cleaning

5.1 Before blast cleaning, visible deposits of oil or grease shall be removed by any of the methods specified in SSPC-SP 1 or other agreed upon methods.

5.2 Before blast cleaning, surface imperfections such as sharp fins, sharp edges, weld spatter, or burning slag should be removed from the surface to the extent required by the procurement documents (project specification).

*NOTE: Additional information on surface imperfections is available in Section A.5 of the Appendix.

6. Blast Cleaning Methods and Operation

6.1 Clean, dry, compressed air shall be used for nozzle blasting. Moisture separators, oil separators, traps

*Notes are not requirements of this specification.

or other equipment may be necessary to achieve this requirement.

6.2 Any of the following methods of surface preparation may be used to achieve a Near-White Blast Cleaned surface:

6.2.1 Dry abrasive blasting using compressed air, blast nozzles, and abrasive.

6.2.2 Dry abrasive blasting using a closed cycle, recirculating abrasive system with compressed air, blast nozzle, and abrasive, with or without vacuum for dust and abrasive recovery.

6.2.3 Dry abrasive blasting, using a closed cycle, recirculating abrasive system with centrifugal wheels and abrasive.

6.3 Other methods of surface preparation (such as wet abrasive blasting) may be used to achieve a Near-White Blast Cleaned surface by mutual agreement between the party responsible for performing the work and the party responsible for establishing the requirements or his representative.

*NOTE: If wet abrasive blasting is used, information on the use of inhibitors to prevent the formation of rust immediately after wet blast cleaning is contained in Section A.9 of the Appendix

7. Procedures Following Blast Cleaning and Immediately Prior to Painting

7.1 Visible deposits of oil, grease, or other contaminants shall be removed by any of the methods specified in SSPC-SP 1 or other methods agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work.

7.2 Dust and loose residues shall be removed from prepared surfaces by brushing, blowing off with clean, dry air, vacuum cleaning or other methods agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air.

7.3 After blast cleaning, surface imperfections which remain (i.e., sharp fins, sharp edges, weld spatter, burning slag, scabs, slivers, etc.) shall be removed to the extent required in the procurement documents (project specification). Any damage to the surface profile resulting from the removal of surface imperfections shall be corrected to meet the requirements of Section 2.4.

*NOTE: Additional information on surface imperfections is contained in Section A.5 of the Appendix.

7.4 Any visible rust that forms on the surface of the steel after blast cleaning shall be removed by reblasting the rusted areas to meet the requirements of this

specification before painting.

*NOTE: Information on rust-back (rerusting) and surface condensation is contained in Sections A.7 and A.8 of the Appendix.

8. Inspection

8.1 Work and materials supplied under this specification are subject to inspection by the party responsible for establishing the requirements or his representative. Materials and work areas shall be accessible to the inspector. The procedures and times of inspection shall be as agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work.

8.2 Conditions not complying with this specification shall be corrected. In case of dispute the arbitration or settlement procedure established in the procurement documents (project specification) shall be followed. If no arbitration or settlement procedure is established, then the procedure established by the American Arbitration Association shall be used.

8.3 The procurement documents (project specification) should establish the responsibility for inspection and for any required affidavit certifying compliance with the specification.

9. Safety and Environmental Requirements

9.1 Blast cleaning is a hazardous operation. Therefore, all work shall be conducted in such a manner to comply with all applicable insurance underwriter, local, state, and federal safety and environmental rules and requirements.

*NOTE: SSPC-PA Guide 3, "A Guide to Safety in Paint Application," addresses safety concerns for coating work.

10. Comments

10.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the Steel Structures Painting Council cannot assume responsibility nor incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

10.2 Additional information and data relative to this specification are contained in the following brief Appendix. More detailed information and data are presented in a separate document, SSPC-SP COM, "Surface Preparation Commentary." The recommendations contained in the Notes, Appendix, and SSPC-SP COM are believed to represent good practice, but are not to be considered as requirements of the specification. The table below lists the subjects discussed relevant to Near-White Blast Cleaning

and appropriate section of SSPC-SP COM.

| Subject | Commentary Section |
|-----------------------------------|--------------------|
| Abrasive Selection | 5 |
| Degree of Cleaning | 11.10 |
| Film Thickness | 10 |
| Wet Abrasive Blast Cleaning | 9 |
| Maintenance Painting | 3.2 |
| Rust Back (Rerusting) | 8 |
| Surface Profile | 6 |
| Visual Standards | 7 |
| Weld Spatter | 4.1 |

A. Appendix

A.1 FUNCTION—Near-White Blast Cleaning (SSPC-SP 10) provides a greater degree of cleaning than Commercial Blast Cleaning (SSPC-SP 6) but less than White Metal Blast Cleaning (SSPC-SP 5). It should be used where a high degree of blast cleaning is required. The primary functions of blast cleaning before painting are: (a) to remove material from the surface that can cause early failure of the coating system, and (b) to obtain a suitable surface roughness.

A.2 ABRASIVE SELECTION—Types of metallic and non-metallic abrasives are discussed in the Surface Preparation Commentary (SSPC-SP COM). It is important to recognize that blasting abrasives may become embedded in or leave residues on the surface of the steel during preparation. While normally such embedment or residues are not detrimental, care should be taken (particularly if the prepared steel is to be used in an immersion environment) to assure that the abrasive is free from detrimental amounts of water soluble, solvent soluble, acid soluble, or other such soluble materials. Requirements for selecting and evaluating mineral and slag abrasives are given in SSPC-AB 1, "Mineral and Slag Abrasives."

A.3 SURFACE PROFILE—Surface profile is the roughness of the surface which results from abrasive blast cleaning. The profile depth (or height) is dependent upon the size, type, and hardness of the abrasive, particle velocity and angle of impact, hardness of the surface, amount of recycling, and the proper maintenance of working mixtures of grit and/or shot.

The allowable minimum/maximum height of profile is usually dependent upon the thickness of the paint to be applied. Large particle sized abrasives (particularly metallic) can produce a profile which may be too deep to be adequately covered by a single thin film coat. Accordingly, it is recommended that the use of larger abrasives be avoided in these cases. However, larger abrasives may be needed for thick film coatings or to facilitate removal of heavy mill scale or rust. If control of profile (minimum/maximum) is deemed to be significant to coatings performance, it should be addressed in the procurement documents (project specification).

Typical maximum profile heights achieved with com-

mercial abrasive media are shown in Table 8 of the Surface Preparation Commentary (SSPC-SP COM). Methods (i.e., comparators, replica tape, depth micrometers) are available to aid in estimating the profile of surfaces blast cleaned with sand, steel grit, and steel shot.

A.4 VISUAL STANDARDS—Note that the use of visual standards in conjunction with this specification is required only when they are specified in the procurement documents (project specification) covering the work. It is recommended, however, that the use of visual standards be made mandatory in the procurement documents (project specification).

SSPC-Vis 1-89, "Visual Standard for Abrasive Blast Cleaned Steel," provides color photographs for the various grades of surface preparation as a function of the initial condition of the steel. The following table lists the photographs for this specification that are applicable to the rust grades listed below.

| Rust Grade | 100% Adherent Mill Scale | 100% Mill Scale and Rust | 100% Rust | 100% Rust With Pits |
|------------|--------------------------|--------------------------|-----------|---------------------|
| Pictorial | | | | |
| Standards | A SP 10 | B SP 10 | C SP 10 | D SP 10 |

Many other visual standards are available and are described in Section 7 of the Commentary (SSPC-SP COM).

A.5 SURFACE IMPERFECTIONS—Surface imperfections can cause premature failure when the service is severe. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features which are difficult to properly cover and protect include crevices, weld porosity, laminations, etc. The high cost of the methods to remedy the surface imperfections requires weighing the benefits of edge rounding, weld spatter removal, etc., versus a potential coating failure.

Poorly adhering contaminants, such as weld slag residues, loose weld spatter, and some minor surface laminations, may be removed during the blast cleaning operation. Other surface defects (steel laminations, weld porosities, or deep corrosion pits) may not be evident until the surface preparation has been completed. Therefore, proper planning for such surface repair work is essential since the timing of the repairs may occur before, during, or after the blast cleaning operation. Section 4 of the Commentary (SSPC-SP COM) contains additional information on surface imperfections.

A.6 CHEMICAL CONTAMINATION—Steel contaminated with soluble salts (i.e., chlorides and sulfates) develops rust-back rapidly at intermediate and high humidities. These soluble salts can be present on the steel surface prior to blast cleaning as a result of atmospheric contamination. In addition, contaminants can be de-

**ORIGINAL PAGE IS
 OF POOR QUALITY**

posited on the steel surface during blast cleaning whenever the abrasive is contaminated. Therefore, rust-back can be minimized by removing these salts from the steel surface, preferably before blast cleaning and eliminating sources of recontamination during and after blast cleaning. Identification of the contaminants along with their concentrations may be obtained from laboratory and field tests. A number of tests for soluble salts are now under study by the SSPC, ASTM, Maritime Administration, and ISO.

A.7 RUST-BACK—Rust-back (rerusting) occurs when freshly cleaned steel is exposed to conditions of high humidity, moisture, contamination, or a corrosive atmosphere. The time interval between blast cleaning and rust-back will vary greatly from one environment to another. Under mild ambient conditions it is best to blast clean and coat a surface the same day. Severe conditions may require coating more quickly while for exposure under controlled conditions the coating time may be extended. Under no circumstances should the steel be permitted to rust-back before painting regardless of the time elapsed (see Appendix A.6).

A.8 DEW POINT—Moisture condenses on any surface that is colder than the dew point of the surrounding air. It is, therefore, recommended that the temperature of steel surface be at least 5 degrees F (3 degrees C) above the dew point during dry blast cleaning operations. It is advisable to visually inspect for moisture and periodically check the surface temperature and dew point during blast cleaning operations. It is important that the application of paint over a damp surface be avoided.

A.9 WET ABRASIVE BLAST CLEANING—Steel that is wet abrasive blast cleaned may rust rapidly. Clean water should be used for rinsing (studies have shown that water of at least 15,000 ohm-cm resistivity is preferred). It may be necessary that inhibitors be added to the water or applied to the surface immediately after blast cleaning to temporarily prevent rust formation. The coating should then be applied before any rusting is visible. One inhibitive treatment for blast cleaned surfaces is water containing 0.32% sodium nitrite and 1.28% by weight secondary ammonium phosphate (dibasic).

CAUTION: Some inhibitive treatments may interfere with the performance of certain coating systems.

A.10 FILM THICKNESS—It is essential that ample coating be applied after blast cleaning to adequately cover the peaks of the surface profile. The dry paint film thickness above the peaks of the profile should equal the thickness known to be needed for the desired protection. If the dry film thickness over the peaks is inadequate, premature rust-through or failure will occur. To assure that coating thicknesses are properly measured, refer to SSPC-PA 2, "Measurement of Dry Paint Thickness with Magnetic Gages."

A.11 MAINTENANCE AND REPAIR PAINTING—When this specification is used in maintenance painting, specific instructions should be given on the extent of surface to be blast cleaned or spot blast cleaned to this degree of cleanliness. SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems," provides a description of accepted practices for retaining old sound paint, removing unsound paint, feathering, and spot cleaning.

Steel Structures Painting Council

SURFACE PREPARATION SPECIFICATION NO. 5

White Metal Blast Cleaning

1. Scope

1.1 This specification covers the requirements for White Metal Blast Cleaning of steel surfaces by the use of abrasives.

2. Definition

2.1 A White Metal Blast Cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter.

2.2 **ACCEPTABLE VARIATIONS IN APPEARANCE THAT DO NOT AFFECT SURFACE CLEANLINESS** as defined in Section 2.1 include variations caused by type of steel, original surface condition, thickness of the steel, weld metal, mill or fabrication marks, heat treating, heat affected zones, blasting abrasive, and differences in the blast pattern.

2.3 When painting is specified, the surface shall be roughened to a degree suitable for the specified paint system.

2.4 Immediately prior to paint application the surface shall comply with the degree of cleaning as specified herein.

2.5 SSPC-Vis 1-89 or other visual standards of surface preparation may be specified to supplement the written definition.

*NOTE: Additional information on visual standards is available in section A.4 of the Appendix.

3. Blast Cleaning Abrasives

3.1 The selection of abrasive size and type shall be based on the type, grade, and surface condition of the steel to be cleaned, type of blast cleaning system employed, the finished surface to be produced (cleanliness and roughness), and whether the abrasive will be recycled.

3.2 The cleanliness and size of recycled abrasives shall be maintained to insure compliance with this specification.

3.3 The blast cleaning abrasive shall be dry and free of oil, grease, and other harmful materials at the time of use.

3.4 Any limitations or restrictions on the use of

*Notes are not requirements of this specification.

specific abrasives, quantity of contaminants, or degree of embedment shall be included in the procurement documents (project specification) covering the work, since abrasive embedment and abrasives containing contaminants may not be acceptable for some service requirements.

*NOTE: Additional information on abrasive selection is available in Section A.2 of the Appendix.

4. Reference Standards

4.1 If there is a conflict between the cited reference standards and this specification, this specification shall prevail unless otherwise indicated in the procurement documents (project specification).

4.2 The standards referenced in this specification are:

- SSPC-SP 1 Solvent Cleaning
- SSPC-Vis 1-89 Visual Standard for Abrasive Blast Cleaned Steel

5. Procedure Before Blast Cleaning

5.1 Before blast cleaning, visible deposits of oil or grease shall be removed by any of the methods specified in SSPC-SP 1 or other agreed upon methods.

5.2 Before blast cleaning, surface imperfections such as sharp fins, sharp edges, weld spatter, or burning slag should be removed from the surface to the extent required by the procurement documents (project specification).

*NOTE: Additional information on surface imperfections is available in Section A.5 of the Appendix.

6. Blast Cleaning Methods and Operation

6.1 Clean, dry, compressed air shall be used for nozzle blasting. Moisture separators, oil separators, traps or other equipment may be necessary to achieve this requirement.

6.2 Any of the following methods of surface preparation may be used to achieve a White Metal Blast Cleaned surface:

6.2.1 Dry abrasive blasting using compressed air, blast nozzles, and abrasive.

6.2.2 Dry abrasive blasting using a closed cycle, recirculating abrasive system with compressed air, blast nozzle, and abrasive, with or without vacuum for dust and

abrasive recovery.

6.2.3 Dry abrasive blasting, using a closed cycle, recirculating abrasive system with centrifugal wheels and abrasive.

6.3 Other methods of surface preparation (such as wet abrasive blasting) may be used to achieve a White Metal Blast Cleaned surface by mutual agreement between the party responsible for performing the work and the party responsible for establishing the requirements or his representative.

*NOTE: If wet abrasive blasting is used, information on the use of inhibitors to prevent the formation of rust immediately after wet blast cleaning is contained in Section A.9 of the Appendix.

7. Procedures Following Blast Cleaning and Immediately Prior to Painting

7.1 Visible deposits of oil, grease, or other contaminants shall be removed by any of the methods specified in SSPC-SP 1 or other methods agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work.

7.2 Dust and loose residues shall be removed from prepared surfaces by brushing, blowing off with clean, dry air, vacuum cleaning or other methods agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air.

7.3 After blast cleaning, surface imperfections which remain (i.e., sharp fins, sharp edges, weld spatter, burning slag, scabs, slivers, etc.) shall be removed to the extent required in the procurement documents (project specification). Any damage to the surface profile resulting from the removal of surface imperfections shall be corrected to meet the requirements of section 2.3.

*NOTE: Additional information on surface imperfections is contained in Section A.5 of the Appendix.

7.4 Any visible rust that forms on the surface of the steel after blast cleaning shall be removed by reblasting the rusted areas to meet the requirements of this specification before painting.

*NOTE: Information on rust-back (rerusting) and surface condensation is contained in Sections A.7 and A.8 of the Appendix.

8. Inspection

8.1 Work and materials supplied under this specification are subject to inspection by the party responsible for establishing the requirements or his representative. Materials and work areas shall be accessible to the inspector. The procedures and times of inspection shall be

as agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work.

8.2 Conditions not complying with this specification shall be corrected. In case of dispute the arbitration or settlement procedure established in the procurement documents (project specification) shall be followed. If no arbitration or settlement procedure is established, then the procedure established by the American Arbitration Association shall be used.

8.3 The procurement documents (project specification) should establish the responsibility for inspection and for any required affidavit certifying compliance with the specification.

9. Safety and Environmental Requirements

9.1 Blast cleaning is a hazardous operation. Therefore, all work shall be conducted in such a manner to comply with all applicable insurance underwriter, local, state, and federal safety and environmental rules and requirements. Refer to A12 Appendix.

10. Comments

10.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the Steel Structures Painting Council cannot assume responsibility nor incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

10.2 Additional information and data relative to this specification are contained in the following brief Appendix. More detailed information and data are presented in a separate document, SSPC-SP COM, "Surface Preparation Commentary." The recommendations contained in the Notes, Appendix, and SSPC-SP COM are believed to represent good practice, but are not to be considered as requirements of the specification. The table below lists the subjects discussed relevant to White Metal Blast Cleaning and appropriate section of SSPC-SP COM.

| Subject | Commentary Section |
|---------------------------------------|--------------------|
| Abrasive Selection | 5 |
| Degree of Cleaning | 11.5 |
| Film Thickness | 10 |
| Wet Abrasive Blast Cleaning | 9 |
| Maintenance Painting | 3.2 |
| Rust Back (Rerusting) | 8 |
| Surface Profile | 6 |
| Visual Standards | 7 |
| Weld Spatter | 4.1 |

ORIGINAL PAGE IS OF POOR QUALITY

PRECEDING PAGE BLANK, NOT FILMED

A. Appendix

A.1 FUNCTION—White Metal Blast Cleaning (SSPC-SP 5) provides a greater degree of cleaning than Near-White Blast Cleaning (SSPC-SP 10). It should be used where the highest degree of blast cleaning is required. The primary functions of blast cleaning before painting are: (a) to remove material from the surface that can cause early failure of the coating system, and (b) to obtain a suitable surface roughness.

A.2 ABRASIVE SELECTION—Types of metallic and non-metallic abrasives are discussed in the Surface Preparation Commentary (SSPC-SP COM). It is important to recognize that blasting abrasives may become embedded in or leave residues on the surface of the steel during preparation. While normally such embedment or residues are not detrimental, care should be taken (particularly if the prepared steel is to be used in an immersion environment) to assure that the abrasive is free from detrimental amounts of water soluble, solvent soluble, acid soluble, or other such soluble materials. Requirements for selecting and evaluating mineral and slag abrasives are given in SSPC-AB 1, "Mineral and Slag Abrasives."

A.3 SURFACE PROFILE—Surface Profile is the roughness of the surface which results from abrasive blast cleaning. The profile depth (or height) is dependent upon the size, type, and hardness of the abrasive, particle velocity and angle of impact, hardness of the surface, amount of recycling, and the proper maintenance of working mixtures of grit and/or shot.

The allowable minimum/maximum height of profile is usually dependent upon the thickness of the paint to be applied. Large particle sized abrasives (particularly metallic) can produce a profile which may be too deep to be adequately covered by a single thin film coat. Accordingly, it is recommended that the use of larger abrasives be avoided in these cases. However, larger abrasives may be needed for thick film coatings or to facilitate removal of heavy mill scale or rust. If control of profile (minimum/maximum) is deemed to be significant to coatings performance, it should be addressed in the procurement documents (project specification).

Typical maximum profile heights achieved with commercial abrasive media are shown in Table 8 of the Surface Preparation Commentary (SSPC-SP COM). Methods (i.e., comparators, replica tape, depth micrometers) are available to aid in estimating the profile of surfaces blast cleaned with sand, steel grit, and steel shot.

A.4 VISUAL STANDARDS—Note that the use of visual standards in conjunction with this specification is required only when they are specified in the procurement documents (project specification) covering the work. It is recommended, however, that the use of visual standards be made mandatory in the procurement documents (project specification)

SSPC-Vis 1-89, "Visual Standard for Abrasive Blast Cleaned Steel," provides color photographs for the various grades of surface preparation as a function of the initial condition of the steel. The following table lists the photographs for this specification that are applicable to the rust grades given.

| | 100% Adherent Mill Scale | 100% Mill Scale and Rust | 100% Rust | 100% Rust with Pits |
|---------------------|--------------------------|--------------------------|-----------|---------------------|
| Rust Grade | Mill Scale | and Rust | Rust | Rust |
| Pictorial Standards | A SP 5 | B SP 5 | C SP 5 | D SP 5 |

Many other visual standards are available and are described in Section 7 of the Commentary (SSPC-SP COM).

A.5 SURFACE IMPERFECTIONS—Surface imperfections can cause premature failure when the service is severe. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features which are difficult to properly cover and protect include crevices, weld porosity, laminations, etc. The high cost of the methods to remedy the surface imperfections requires weighing the benefits of edge rounding, weld spatter removal, etc., versus a potential coating failure.

Poorly adhering contaminants, such as weld slag residues, loose weld spatter, and some minor surface laminations, may be removed during the blast cleaning operation. Other surface defects (steel laminations, weld porosities, or deep corrosion pits) may not be evident until the surface preparation has been completed. Therefore, proper planning for such surface repair work is essential since the timing of the repairs may occur before, during, or after the blast cleaning operation. Section 4 of the Commentary (SSPC-SP COM) contains additional information on surface imperfections.

A.6 CHEMICAL CONTAMINATION—Steel contaminated with soluble salts (i.e., chlorides and sulfates) develops rust-back rapidly at intermediate and high humidities. These soluble salts can be present on the steel surface prior to blast cleaning as a result of atmospheric contamination. In addition, contaminants can be deposited on the steel surface during blast cleaning whenever the abrasive is contaminated. Therefore, rust-back can be minimized by removing these salts from the steel surface, preferably before blast cleaning, and eliminating sources of recontamination during and after blast cleaning. Identification of the contaminants along with their concentrations may be obtained from laboratory and field tests. A number of tests for soluble salts are now under study by the SSPC, ASTM, Maritime Administration, and ISO.

A.7 RUST-BACK—Rust-back (rerusting) occurs when freshly cleaned steel is exposed to conditions of high

humidity, moisture, contamination, or a corrosive atmosphere. The time interval between blast cleaning and rust-back will vary greatly from one environment to another. Under mild ambient conditions it is best to blast clean and coat a surface the same day. Severe conditions may require coating more quickly while for exposure under controlled conditions the coating time may be extended. Under no circumstances should the steel be permitted to rust-back before painting regardless of the time elapsed (see Appendix A.6).

A.8 DEW POINT—Moisture condenses on any surface that is colder than the dew point of the surrounding air. It is, therefore, recommended that the temperature of steel surface be at least 5 degrees F (3 degrees C) above the dew point during dry blast cleaning operations. It is advisable to visually inspect for moisture and periodically check the surface temperature and dew point during blast cleaning operations. It is advisable to visually inspect for moisture and periodically check the surface temperature and dew point during blast cleaning operations. It is important that the application of paint over a damp surface be avoided.

A.9 WET ABRASIVE BLAST CLEANING—Steel that is wet abrasive blast cleaned may rust rapidly. Clean water should be used for rinsing (studies have shown that water of at least 15,000 ohm-cm resistivity is preferred). It may be necessary that inhibitors be added to the water or applied

to the surface immediately after blast cleaning to temporarily prevent rust formation. The coating should then be applied before any rusting is visible. One inhibitive treatment for blast cleaned surfaces is water containing 0.32% sodium nitrite and 1.28% by weight secondary ammonium phosphate (dibasic).

CAUTION: Some inhibitive treatments may interfere with the performance of certain coating systems.

A.10 FILM THICKNESS—It is essential that ample coating be applied after blast cleaning to adequately cover the peaks of the surface profile. The dry paint film thickness above the peaks of the profile should equal the thickness known to be needed for the desired protection. If the dry film thickness over the peaks is inadequate, premature rust-through or failure will occur. To assure that coating thicknesses are properly measured, refer to SSPC-PA 2, "Measurement of Dry Paint Thickness with Magnetic Gages."

A.11 MAINTENANCE AND REPAIR PAINTING—When this specification is used in maintenance painting, specific instructions should be given on the extent of surface to be blast cleaned or spot blast cleaned to this degree of cleanliness. SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems," provides a description of accepted practices for retaining old sound paint, removing unsound paint, feathering, and spot cleaning.

A.12 SAFETY—SSPC PA Guide 3, "A Guide to Safety in Paint Application," addresses safety concerns for coating work.

Steel Structures Painting Council

ABRASIVE SPECIFICATION NO. 1

Mineral and Slag Abrasives

1. Scope

1.1 This specification defines the requirements for selecting and evaluating mineral and slag abrasives used for blast cleaning steel and other surfaces for painting and other purposes.

1.2 The abrasives covered by this specification are primarily intended for one-time use without recycling; reclaimed materials must again be tested against and meet the requirements of this specification. (See Note 7.1.)

2. Description

2.1 The abrasives are categorized into two types, three classes and five grades as described below. Normally the user shall specify the types, classes and grades required. If no abrasive type is specified, then either Type I or Type II is considered acceptable. If no abrasive class is specified, then any class will be considered acceptable. If no abrasive profile grade is specified, the abrasive shall satisfy the requirements of any of the five grades listed.

2.2 The following abrasive types are included.

Type I - Natural Mineral Abrasives

These are naturally occurring minerals, including, but not limited to quartz sands, flint, garnet, staurolite, and olivine.

Type II - Slag Abrasives

These are slag by-products of coal-fired power production or of metal (such as copper or nickel) smelting.

2.3 The following abrasive classes are included.

Class A - Crystalline silica less than or equal to 1.0%

Class B - Crystalline silica less than or equal to 5.0%

Class C - Unrestricted Crystalline silica

The definition and requirements for Classes A, B and C are given in Section 4.2.

2.4 The abrasive grades and associated profile ranges are listed below.

Grade 1 - Abrasives which produce surface profiles of 0.5 to 1.5 mils (13 to 38 microns) when tested in accordance with Section 4.3.

Grade 2 - Abrasives which produce surface profiles of 1.0

to 2.5 mils (25 to 63 microns) when tested in accordance with Section 4.3.

Grade 3 - Abrasives which produce surface profiles of 2.0 to 3.5 mils (50 to 89 microns) when tested in accordance with Section 4.3.

Grade 4 - Abrasives which produce surface profiles of 3.0 to 5.0 mils (75 to 127 microns) when tested in accordance with Section 4.3.

Grade 5 - Abrasives which produce surface profiles of 4.0 to 6.0 mils (100 to 152 microns) when tested in accordance with Section 4.3.

Other profile ranges may be designated by the purchaser.

3. Reference Standards

3.1 The reference standards listed in Sections 3.4 and 3.5 form a part of this specification.

3.2 The latest issue, revision, or amendment of the referenced standards in effect on the date of invitation to bid shall govern unless otherwise stated.

3.3 If there is a conflict between the requirements of any of the cited reference standards and this specification, the requirements of this specification shall prevail.

3.4 STEEL STRUCTURES PAINTING COUNCIL (SSPC) SPECIFICATIONS:

Vis 1 Visual Standard for Abrasive Blast Cleaned Steel.

SP 10 Near-White Blast Cleaning.

3.5 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS:

C-128 Test Method for Specific Gravity and Absorption of Fine Aggregates

C-136 Test Method for Sieve Analysis of Fine and Coarse Aggregates

C-566 Test Method for Total Moisture Content of Aggregate by Drying

C-702 Method for Reducing Field Samples of Aggregate to Testing Size

D-75 Method for Sampling Aggregates

D-1125 Test Methods for Electrical Conductivity and Resistivity of Water

D-4417 Test Method for Field Measurement of Surface

Profile of Blast Cleaned Steel

D-4940 Test Method for Conductimetric Analysis of Water Soluble Ionic Contaminants of Blasting Abrasives.

E-1132 Practice for Health Requirements Relating to Occupational Exposure to Quartz Dust

4. Requirements

4.1 GENERAL PHYSICAL AND CHEMICAL PROPERTIES

The abrasive shall meet all the requirements of paragraphs 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5, and 4.1.6. These are summarized in Table 1.

4.1.1 Specific Gravity

The specific gravity shall be a minimum of 2.5 as determined by ASTM C-128.

4.1.2 Hardness

The hardness shall be a minimum of 6 on the Mohs scale when tested as follows: Examine the material under low-power microscope (10X) and if grains of different colors or character are present, select a few grains of each. Place in succession the grains thus differentiated between two glass microscope slides. While applying pressure, slowly move one slide over the other with a reciprocating motion for 10 seconds. Examine the glass surface, and if scratched, the material shall be considered as having a minimum hardness of 6 on the Mohs scale. If more than 25% of the grains by count fail to scratch the glass surface, the abrasive does not meet this specification.

4.1.3 Weight Change on Ignition

The maximum permissible loss on ignition is 1.0%, and the maximum permissible gain is 5.0% when tested as follows: A representative portion of the sample shall be ground in an agate mortar and thoroughly dried at 220-230 °F (105-110 °C) for one hour. Transfer approximately 1 gram of the dried sample to a tared crucible with cover and weigh to the nearest milligram. Cautiously heat the crucible with contents, at first

partially covered, and then at approximately 750 ± 50 °C (1382 ± 90 °F) covered. Hold at 750 °C (1382 °F) for 30 minutes, then cool in a dessicator and reweigh. The percent of weight change shall be computed as follows:

$$\% \text{ weight change} = \frac{(\text{final wt.} - \text{orig. wt.}) \times 100}{\text{orig. wt.}}$$

4.1.4 Water Soluble Contaminants

The conductivity of the abrasive shall not exceed 1000 microsiemen when tested in accordance with ASTM D-4940. (See Note 7.3.)

4.1.5 Moisture Content

The maximum moisture content shall be 0.5% by weight, when tested in accordance with ASTM C-566.

4.1.6 Oil Content

The sample, in water, when tested in 4.1.4, shall show no presence of oil, either on the surface of the water or as an emulsion in the water, when examined visually after standing for 30 minutes.

4.2 Crystalline Silica Content

All abrasives must be classed based on crystalline silica content (see Note 7.4). Abrasives designated as Class A or B must meet the requirements of paragraphs 4.2.1 or 4.2.2 respectively.

4.2.1 Class A - Less Than 1% Crystalline Silica

Abrasives shall contain no more than 1.0% by weight of crystalline silica when determined in accordance with procedures described in 4.2.4.

4.2.2 Class B - Less than 5% Crystalline Silica

Abrasives shall contain no more than 5.0% by weight of crystalline silica when determined in accordance with procedures described in 4.2.4.

4.2.3 Class C - Unrestricted Crystalline Silica

**Table 1
REQUIREMENTS FOR CHEMICAL AND PHYSICAL PROPERTIES OF ABRASIVES**

| <u>Section</u> | <u>Properties</u> | <u>Test Procedure</u> | <u>Requirements</u> | |
|----------------|---------------------------|----------------------------------|---------------------|-------------------|
| | | | <u>Min.</u> | <u>Max.</u> |
| 4.1.1 | specific gravity | ASTM C-128 | 2.5 | — |
| 4.1.2 | hardness | Mohs scale | 6 | — |
| 4.1.3 | weight change on ignition | Heat to 750°C | -1.0% (loss) | +5.0% (gain) |
| 4.1.4 | water soluble contaminant | ASTM D-4940 | — | 1000 microsiemens |
| 4.1.5 | moisture content | ASTM C-566 | — | 0.5% |
| 4.1.6 | oil content | observe surface of water extract | — | none |

No restrictions on crystalline silica content.

4.2.4 Crystalline Silica. The crystalline silica content shall be determined by the use of infrared spectroscopy or by other analytical procedures, such as wet chemical or X-ray diffraction analyses.

4.3 SURFACE PROFILE

The average surface profile, when determined in accordance with the description below, shall be within the ranges specified in Section 2.4. A representative sample of the material shall be obtained in accordance with ASTM D-75 and used to abrasive blast a 2-foot by 2-foot by 1/4 inch (61 cm x 61 cm x 64 mm) mild steel plate of SSPC-Vis 1 Rust Grade A to a cleanliness of SSPC-SP 10 (Near-White Metal). The blasting shall be done using a 3/8 (9.6 mm) inch #6 venturi nozzle with a nozzle pressure of 95 ± 5 psig (670 ± 35 Kilopascals) at a distance of 24 ± 6 inches (61 ± 15 cm) from the surface at an angle of 75 to 105 degrees. The resultant surface profile shall be measured at a minimum of 5 locations in accordance with Method C of ASTM D-4417 (see Note 7.5). The average measured profile shall be within the ranges given in Section 2.4. Other methods of determining profile may be used if mutually agreeable between the contracting parties.

4.4 PARTICLE SIZE DISTRIBUTION

4.4.1 The abrasive supplier shall designate range(s) for maximum and minimum retention of each sieve size to meet the profile range(s) specified in Section 2.4 and determined in Section 4.3. The particle size distribution shall be measured in accordance with ASTM C-136 using the following U.S. standard sieves: 6, 8, 12, 16, 20, 30, 40, 50, 70, 100, 140, and 200. Upon request, the supplier shall substantiate that the specified size range will meet the required profile range. (See Note 7.6.)

4.4.2 The designated sieve size distribution and ranges will become the acceptance standard for the specific abrasive submitted (see Section 5.4).

4.5 HEALTH AND SAFETY REQUIREMENTS

4.5.1 The abrasive material as supplied shall comply with all applicable Federal, State, and Local regulations (see Note 7.7).

4.5.2 The manufacturer shall provide the purchaser with sufficiently detailed chemical analyses to allow the user to provide the protective engineering and administrative controls for blast cleaning identified in Federal, State, and Local codes.

4.5.3 Material Safety Data Sheets shall be furnished for all abrasive materials supplied.

4.6 OTHER REQUIREMENTS

4.6.1 In addition to the requirements of Sections 4.1 through 4.5, the specifier may also stipulate performance tests to establish abrasive consumption rate, cleaning rate, and abrasive breakdown. As there are currently no standards for these tests, they are not a part of this specification. However, upon

mutual agreement between supplier and purchaser, a performance test procedure can be established. Appendix A outlines a suggested procedure.

5. Qualification Testing and Conformance Testing

5.1 RESPONSIBILITIES FOR TESTING

The procurement documents should establish the specific responsibilities for qualification testing and conformance testing. Unless otherwise specified, the supplier is responsible for performing and documenting the tests and inspections called for in this specification.

5.2 CLASSIFICATION OF TESTING

The tests given in Section 4 are classified as qualification tests or conformance tests, as defined below:

5.2.1 Qualification tests are those tests which are run to initially qualify a material for this specification. Qualification tests are also required whenever a significant change has occurred in the source, method of processing, method of shipping or handling of the abrasives. The qualification tests include all the tests in Sections 4.1 through 4.6.

5.2.2 Conformance tests are those tests which are performed to verify that the material being submitted has the same properties as the material which initially qualified. Conformance tests shall be conducted on each lot as required by the purchaser. The frequency and lot size for quality conformance testing shall be mutually agreed upon between the supplier and the purchaser. The required conformance tests are particle size distribution (Section 4.4), water soluble contaminants (Section 4.1.4), moisture content (Section 4.1.5) and oil content (Section 4.1.6).

5.3 METHODS OF SAMPLING

5.3.1 Sampling for Qualification Tests

5.3.1.1 Bagged Abrasive. Three or more sacks of abrasive shall be randomly selected from each inspection lot. The sacks shall be mixed and separated and a 50 kilogram (kg) (110 Lb) composite sample prepared in accordance with ASTM C-702.

5.3.1.2 Bulk Abrasive. A 50 kg (110 lb) composite sample shall be obtained from the blended finished product in accordance with ASTM D-75. (See Note 7.8.)

5.3.2 Sampling for Conformance Tests

5.3.2.1 Bagged Abrasive. One sack of abrasive shall be randomly selected from each inspection lot and a 2 kg (4 Lb) composite sample prepared in accordance with ASTM C-702.

5.3.2.2 Bulk Abrasive. A 2 kg (4 lb) composite sample shall be obtained from the blended finished product in accordance with ASTM D-75.

5.3.3 Other methods of sampling may be used if mutually agreeable between the contracting parties.

5.4 DOCUMENTATION OF INSPECTION AND TESTING

The supplier shall furnish all documentation required to verify that he has completed the requirements of the qualification tests and conformance tests specified. At a minimum, the documentation shall include the following:

5.4.1 List of tests performed. This list shall include the title of the test, the appropriate standards used, any deviation from standard practice, and the numerical results of the testing.

5.4.2 Testing facilities. The documentation of facilities shall include the name and location of the laboratory, the responsible laboratory official, and laboratory certification or other evidence of qualification.

5.4.3 Date of testing. This shall include the date of original qualification (if applicable) and dates of completion and official approval of testing results.

5.4.4 Affidavit. The procurement documents should establish the responsibility for any required affidavit certifying compliance with this specification.

5.5 FREQUENCY OF TESTING AND INSPECTION

All materials supplied under this specification shall be subject to timely inspection by the purchaser or his authorized representative. The frequency and lot size of inspection shall be established by mutual agreement between the supplier and the purchaser.

5.6 APPROVAL

The purchaser shall have the right to reject any material supplied which is found to be defective under this specification. In case of dispute, the arbitration or settlement procedure, if any, established in the procurement documents shall be followed. If no arbitration procedure is established, the procedures specified by the American Arbitration Association shall be used.

6. Disclaimer

6.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the SSPC cannot assume responsibility nor incur any obligation resulting from the use of any materials or methods specified therein, or of the specification itself.

7. Notes*

7.1 Reclaimed abrasive may not meet the requirements of this specification because of particle degradation and retained contaminants. To confirm compliance, reclaimed abrasive shall

be retested.

7.2 Materials furnished under this specification which produce the required surface profile under standard test conditions may produce a different surface profile depending upon job condition, type of surface, blasting pressure, etc.

7.3 The limitation for abrasive conductivity is based on pressure immersion testing and accelerated outdoor exposure tests performed by SSPC and the National Shipbuilding Research Program.

7.4 Users of abrasives containing quartz (crystalline silica) should comply with the requirements of ASTM E-1132.

7.5 Methods A and B of ASTM D-4417 or National Association of Corrosion Engineers RP-02-87, "Field Measurement of Surface Profile of Abrasive Blast Cleaned Steel Using Replica Tape" may also be specified by agreement between purchaser and supplier.

7.6 SSPC will maintain a list of abrasives and sieve sizes for which data on profile and other specified tests have been submitted. The data will not be verified by SSPC, but will be furnished upon request to those wishing to use this specification. It is anticipated that at a future date, specific size designations for individual abrasives will be incorporated into this or another SSPC specification.

7.7 Disposal of abrasives should be in compliance with all applicable Federal, State, and local regulations. It is noted that the spent abrasive may contain hazardous paint and other foreign matter.

7.8 The importance of properly obtaining a sample cannot be over-emphasized. All subsequent analyses performed on the selected sample are likely to be affected by particle size, so it is imperative that every reasonable effort be made to select the sample in a way that will assure proper representation. Therefore, it is important to select the proper sampling location, and to use proper techniques to select the sample.

The following guidelines should be kept in mind when deciding on a sampling method:

7.8.1 If possible, sample the material to be tested when it is in motion, in such places as a conveyor output point or a chute discharge.

7.8.2 The whole of the material stream should be taken for many short periods of time in preference to part of the material stream being taken for the whole of the time.

*Notes are not requirements of this specification.

Steel Structures Painting Council

PAINT APPLICATION SPECIFICATION NO. 2

Measurement of Dry Paint Thickness with Magnetic Gages

1. Scope

1.1 GENERAL: This method describes the procedures to measure the thickness of a dry film of a nonmagnetic coating applied on a magnetic substrate using commercially available magnetic gages. These procedures are intended to supplement manufacturers' instructions for the manual operation of the gages. The types of gages covered are nondestructive to the film being measured.

1.2 GAGE TYPES: Magnetic gages of two types may be used:

Type 1 — Pull-off Gages (such as Mikrotest, Inspector, and Tinsley Thickness Gages, and the Elcometer Pull-Off Gage); and

Type 2 — Fixed Probe Gages (such as Elcometer Thickness Gage, Minitector, General Electric Type B Thickness Gage, Verimeter, Permascope, and Dermitron).

2. Calibration and Measurement Procedures

2.1 GENERAL:

2.1.1 ACCESS TO BARE SUBSTRATE: To determine the effect of the substrate condition on the gage readings, access is required to some unpainted areas. Small representative areas may be masked-off during the painting. If the paint has already been applied to the entire surface, small areas of paint may be removed and later patched. An alternative procedure that may be specified is to provide separate unpainted reference panels of similar steel and surface condition. These would be used as the bare substrate in the procedures of Section 2.2 and 2.3.

2.1.2 Repeated gage readings, even at points close together, may differ considerably due to small surface irregularities. Therefore, three (3) gage readings shall be made for each spot measurement of either the substrate or the paint. Move the probe a distance of one to three inches for each new gage reading. Discard any unusually high or low gage reading that cannot be repeated consistently. Take the average (mean) of the three gage readings as the spot measurement.

2.2 CALIBRATION MEASUREMENTS — TYPE 1 PULL-OFF GAGES:

2.2.1 For Type 1 gages, the preferred calibration standards are small, chromeplated steel panels that are available from the National Bureau of Standards in coating

thicknesses from 0.5 to 80 mils (12.5 to 2030 microns) or more. The plated panels are flat smooth steel 1.125 x 1.125 inches (2.85 x 2.85 cm) in size. They exceed the critical mass of steel needed to satisfy the magnetic field of the Type 1 (pull-off) magnets. Shims of plastic or of non-magnetic metals which are acceptable for calibration of Type 2 (fixed probe) gages should *not* be used for calibration of the Type 1 gages.

2.2.2 Using the Type 1 (pull-off) gage, measure the thickness of a series of calibration standards covering the expected range of paint thickness. Record the calibration correction either + or - required at each standard thickness. To guard against gage drift during use, recheck the gage at least once during each work shift with one or more of the standards. In case of dispute the buyer and seller should agree on the details and frequency of calibrations.

2.2.3 When the gage adjustment has drifted so far that large corrections are needed, it is advisable to re-adjust closer to the standard values and recalibrate. When the gage can no longer be adjusted into reasonable agreement with the reference standards, have it rebuilt or replaced.

2.2.4 Measure (A), the bare substrate, at a number of spots to obtain a representative average value. Note the gage is *not* to be calibrated on the bare substrate.

2.2.5 Measure (B), the dry paint film, at the number of spots specified in Section 3.

2.2.6 Subtract the readings (A) and (B) to obtain the thickness of the paint film.

NOTE: When an uncalibrated gage is used, it is necessary to correct the A and B readings using the corrections as determined from Section 2.2.2.

2.3 CALIBRATION AND MEASUREMENT — TYPE 2, FIXED PROBED GAGES

2.3.1 For Type 2 (fixed probe) gages, shims of plastic or of non-magnetic metals laid on the appropriately cleaned steel base, at least 3 x 3 x 0.125 inches (7.6 x 7.6 x 0.32 cm), are suitable working standards. During calibration hold the gage firmly enough to press the shim tightly against the steel surface. Avoid excessive pressure that might indent the plastic or, on a blast cleaned surface, might impress the steel peaks into the under surface of the plastic. A very smooth plate of mild steel free of mill scale and rust is suitable for the zero thickness standard.

Because of the stronger magnetic field of the Type 2 (fixed probe) gages, the small, National Bureau of Standards calibration standards, acceptable for Type 1 (pull-off) gages, shall *not* be used with Type 2 gages.

2.3.2 It is **IMPORTANT** to confirm the gage setting by measuring the shim at several other areas of the bare substrate. Readjust the gage as needed to obtain an average setting representative of the substrate.

2.3.3 Spot measurement of paint: With the gage adjusted as above, measure the dry paint film as specified in Section 3. The gage readings indicate the paint film thickness.

2.3.4 Recheck the gage setting at frequent intervals during a long series of measurements.

3. Number of Measurements for Conformance to a Thickness Specification

3.1 NUMBER OF MEASUREMENTS AND MINIMUM THICKNESS: Make five (5) separate spot measurements (average of three readings, see Section 2.2) spaced evenly over each 100 square feet (9.3 square meters) of area to be measured. The *average* of five spot measurements for each such 100 square foot area shall not be less than the specified thickness. No single spot measurement in any 100 square foot area shall be less than 80% of the specified thickness. Any one of three readings which are averaged to produce each spot measurement may under-run by a greater amount. The five spot measurements shall be made for each 100 square feet of area as follows:

3.1.1 For structures not exceeding 300 square feet in area, each 100 square foot area shall be measured.

3.1.2 For structures not exceeding 1,000 square feet in area, three 100 square foot areas shall be randomly selected and measured.

3.1.3 For structures exceeding 1,000 square feet in area, the first 1,000 square feet shall be measured as stated in Section 3.1.2 and for each additional 1,000 square feet of area or increment thereof, one 100 square foot area shall be randomly selected and measured.

3.1.4 If the dry film thickness for any 100 square foot area (Sections 3.1.2 and 3.1.3) is not in compliance with the requirements of Section 3.1, then each 100 square foot area shall be measured.

3.2 Other size areas or number of spot measurements may be specified in the procurement documents as appropriate for the size and shape of the structure to be measured.

3.3 THICKNESS LIMITS: Some paints are especially sensitive to high or low film thickness. In all cases, limitations on maximum or minimum film thickness specified in the manufacturer's instructions shall be followed.

4. Accuracy

4.1 GAGE ACCURACY: All of the above magnetic gages, if properly adjusted and in good condition, are inherently accurate to within $\pm 15\%$ (most gages within $\pm 10\%$). It should be noted that this is only the accuracy built into the gages themselves.

4.2 ITEMS WHICH AFFECT GAGE ACCURACY: Much larger, external errors may be caused by variations in method of use of gages or by unevenness of the surface of the substrate or of the coatings. Also, any other films present on the steel (rust or mill scale or even a blast cleaned profile zone) will add to the apparent thickness of the applied paint film. Thus, for accurate use of the magnetic gages, some knowledge is required of the nature of the surface being painted and of its effect on the gage readings. For this purpose the gage operator must have access to at least small areas of the unpainted substrate as in Section 2.1.1. As a minimum, he must know whether he is measuring only paint, or paint plus mill scale, or paint plus steel surface roughness.

5. Notes*

5.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the SSPC cannot assume responsibility nor incur any obligation resulting from the use of any material, paint, or method specified therein.

5.2 PRINCIPLES OF THE MAGNETIC GAGE: Each of these gages can sense and indicate only the distance between the magnetic surface of the steel and the small rounded tip of the magnet that rests on the top surface of the paint. This measured distance, from the top surface of the paint, must be corrected for the thickness of any extraneous films or other interfering conditions on the surface of the steel. Such correction is made, as described in Sections 2.2 and 2.3. It might be noted that many disagreements in thickness reports arise from different conceptions of this correction, or of just what is measured by the gages under various conditions and methods of use.

5.2.1 Type 1 (pull-off) gages use a type of spring balance to pull a small permanent magnet from the surface of the painted steel. The magnetic force holding to the surface varies inversely as a non-linear function of the distance between magnet and steel, i.e., the thickness of the dry paint film (plus any other films present).

Normally, Type 1 gages are not adjusted or reset for each new series of measurements. In fact, adjustment is not advisable unless the gage is to be very carefully calibrated with National Bureau of Standards calibration standards as indicated in Section 2.2.1. In normal use the gage may not require adjustment for months.

Shims of sheet plastic or of non-magnetic metals which are permissible for calibrating Type 2, fixed probe gages, should not be used for calibration of Type 1 gages. Such shims are usually fairly rigid and curved, and do not

lie perfectly flat even on a smooth steel test surface. Near the pull-off point of the calibration measurements with any Type 1 gage, the shim frequently springs back from the steel surface, raising the magnet too soon and causing erroneous calibration readings.

5.2.2 Type 2 (fixed probe) gages depend on changes in magnetic flux within the probe or the instrument. The magnitudes of these changes also are an inverse (non-linear) function of the distance between the probe and the steel surface under the paint. The probes of these gages remain in contact with the paint during the measurement. Type 2 gages differ also in that they are usually adjusted to a selected film thickness value before each new series of measurements.

Type 2 gages should be checked periodically for sensitivity. Using a smooth steel base at least 0.125 inches thick (0.32 cm) and free of mill scale, set the gage with a shim in the thickness range most used. Measure several other shims, thicker and thinner than the setting. The gage should respond fully to the difference in thickness of the shims.

5.3 REPEATABILITY: These magnetic gages are necessarily sensitive to very small irregularities of the paint surface or of the steel surface directly below the small rounded tip of the magnet. The gage readings are also influenced by the steadiness of the operator's hand. Thus, repeated gage readings on a rough surface, even at points very close together, frequently differ considerably. However, repeated gage readings within 0.2 mils (5 microns) have been reported for average readings taken in a limited area and on a variety of surfaces.

5.4 ZERO SETTING: It is sometimes suggested that the magnetic gages be adjusted or set at the scale zero (0), with the gage applied to a very smooth uncoated steel panel. However, the zero point on most of the gage scales appears to be least accurately positioned. Therefore, the scale should be set to indicate most accurately in the range of thicknesses that are to be measured. It would be still worse to "zero" the gage on a rough bare steel surface. This would misplace the nonlinear scale considerably.

5.5 ROUGHNESS OF THE STEEL SURFACE: If the steel surface is smooth and even, its surface plane is the effective magnetic surface, and the distance indicated by the gage is truly the paint thickness. However, if the steel is roughened, as by blast cleaning, the "apparent" or effective magnetic surface that the gage senses is an imaginary plane located between the peaks and valleys of the surface profile. For this reason, paint thickness would appear to the gage to be greater than it actually is above the peaks. The procedures of Section 2.2 and 2.3 provide a correction for this magnetic effect of the surface profile. Actually, the distance from the plane of the peaks to the effective magnetic plane is much less than the peak-to-valley distance. A typical sand blast profile, 2.8 mils (71 microns) maximum height, increased Mikrotest readings

on a 4 mil (102 microns) paint coat by only 0.5 mils (13 microns).

5.6 DIRTY, TACKY, OR SOFT FILMS: The surface of the paint and the probe of the gage must be free from dust, grease, and other foreign matter in order to obtain close contact of the probe with the paint and also to avoid adhesion of the magnet. The accuracy of the measurement will be affected if the coating is tacky or excessively soft. Tacky paint films also cause unwanted adhesion of the magnet. Unusually soft films may be dented by the pressure of the probe. Soft or tacky films can sometimes be measured satisfactorily by putting a shim on the film, measuring total thickness of paint plus shim, and subtracting shim thickness.

5.7 ALLOY STEEL SUBSTRATES: Appreciable differences in certain magnetic properties of the substrates will affect the magnetic gage readings. However, such differences among most mild low-carbon steels are insignificant. Also, at least two of the high-strength, low-alloy steels have no appreciably different effect on the gages. For higher alloy steels, the gage response should be checked. In any event, the gage should be recalibrated on the same steel over which the coating has been applied.

5.8 PROXIMITY TO EDGES: The magnetic gages are sensitive to geometrical discontinuities of the steel, as at holes, corners, or edges. The sensitivity to edge effects and discontinuities varies from gage to gage. Measurements closer than one inch (2.5 cm) from the discontinuity may not be valid unless the gage is calibrated specifically for that location. It may be used as a "go, no-go" gage at such locations by setting or calibrating it for one thickness under precisely similar conditions.

5.9 PROXIMITY TO OTHER MASS OF STEEL: Some of the Type 2 gages in particular are sensitive to the presence of another mass of steel close to the body of the gage. This effect may extend as much as three inches (7.6 cm) from an inside angle.

5.10 CURVATURE OF STEEL SURFACE: Magnetic gage readings may be affected by the surface curvature in proportion to the degree of departure from flatness. If the curvature is appreciable, valid measurements may still be obtained by calibrating or setting the gage on a similarly curved surface.

5.11 TILT OF PROBE: All of the magnets or probes must be held perpendicular to the painted surface to produce valid measurements.

5.12 OTHER MAGNETIC FIELDS: Strong magnetic fields, as from welding equipment or nearby power lines, will interfere with operation of the gages. Also, residual magnetism in the steel substrate may affect gage readings. With two-pole gages in such cases, it is recommended that the readings before and after reversing the pole positions be averaged. Other gages may require demagnetization of the steel.

5.13 EXTREMES OF TEMPERATURE: Most of the magnetic gages have operated satisfactorily at 40° F and 120° F (4° C and 49° C). However, if such temperature extremes are met in the field, the gage might well be checked with at least one reference standard after both the standard and the gage are brought to the same ambient temperature.

5.14 VIBRATION: The accuracy of the Type 1 (pull-off) gages is affected by traffic, machinery, concussions, etc. When these gages are set up for calibration or measurement of paint films, there should be no apparent vibration.

*Notes are not requirements of this specification.

APPENDIX E

Application Equipment Costs

| | | |
|--------------|---|-------------|
| Airless | 30:1 bulldog pump | \$3,200.00 |
| | Repair Kit | \$87.75 |
| | Hoses 3/8" dia = 50' | \$108.00 |
| | Whip 1/4" dia = 25' | \$58.00 |
| | Graco Gun | \$245.00 |
| | Gun Repair Kit | \$72.50 |
| Conventional | 5 gal agitated double reg & double gage pot | \$1,090.00 |
| | Air line 50' | \$57.00 |
| | Fluid line 50' | \$98.00 |
| | Spray Gun | \$250.00 |
| | Gun Repair Kit | \$24.75 |
| UPT | Flame Spray Equip | |
| | Gravity Feed 6#hr 2" pattern | \$9,000.00 |
| | Fluidized bed 20-25#hr 6" pattern | \$11,500.00 |
| | Support regulators & gages | \$2,500.00 |
| | Gas hoses set 50' | \$300.00 |

Note: Using acetylene and O₂ gases to spray/heat

| | | |
|-----------|---|------------|
| Flamecoat | Application Equipment | |
| | 60 ft ² /hr - Fluidized Bed, small, powder pistol 1" gun | \$1,600.00 |
| | 100 ft ² /hr - Gravity feed (1ger), 2" and 4" guns | \$5,400.00 |
| | <u>Package</u> - Air Filter, 25' hose, regulator | |

Note: Propane Only. Winds can cause heat problems in open areas.

| | | |
|------------------|---|--------------------|
| Cert Applicators | Aqua Epoxy - Plural Comp. Application Equipment | |
| | Aqua 2000 unit, Air assist, 25' hose | \$20,000.00 |
| | Total | \$55,591.00 |

**ORIGINAL PAGE IS
OF POOR QUALITY**

APPENDIX F

Solicitation of Candidate Coating Systems

KTA-Tator, Incorporated solicited candidate coatings for the WETF Materials Coating Evaluation Systems by two primary means. First, major coating manufacture's were contacted by telephone to describe the project and environmental conditions. A follow-up letter, copy attached, was issued to the point of contact suggested by the manufacturer.

The second method of coating solicitation was publication of the desire for project candidate coatings in the Journal of Protective Coatings and Linings (JPCL). This was published in December 1993 under Research News in Vol. 10 No 12 of the JPCL. A copy is attached.

A third means to obtain coating manufacturer recommended systems was through direct contact with manufacturer representatives at the Steel Structures Painting Council National Conference held in New Orleans, Louisiana November 13-18, 1993.

Follow-up communication with manufactures indicating interest was by telephone and written correspondence. Recommended systems were compiled and the candidates submitted to NASA-JSC on a periodic basis. Approximately thirty (30) candidate coating systems were identified which included twenty four (24) discrete systems and various system alternatives. A list of the candidate coating systems is attached. From the candidate coating systems, ten (10) "recommended" systems were identified based upon communications between NASA-JSC, Ms. June Huhn and KTA-Tator, Incorporated, Mr. Richard Burgess. EDO 1000, a thermally applied plastic had been selected for inclusion in the study, however, the manufactures, EDO Corporation, was withdrawing from the coating market and a second UT plastic product was substituted. A copy of the recommended systems list and KTA- Tator's correspondence identifying the system is attached.

October 14, 1993

«Name»
«Company Name»
«Address»
«City» «State», «Zip»

**SUBJECT: Candidate Coating Systems for Weightless Environment
Training Facility Test Panel Program, Johnson Space Center**

Dear Mr. «Last Name»:

KTA-Tator, Inc., under contract to The National Aeronautics and Space Administration, Lyndon B. Johnson Space Center (NASA/JSC), is undertaking a coating materials evaluation program to identify and test candidate coating systems for use on crew training mock-ups in the Weightless Environment Training Facility (WETF) pool.

The purpose of this correspondence is to provide «Company Name» the opportunity to identify and submit information on coating systems you manufacture which are expected to provide corrosion protection and extended service life in specific exposure environments. A brief description of anticipated service environments and material substrates is provided below.

SERVICE ENVIRONMENTS

Pool Immersion: Pool immersion of the mockups and support equipment occurs in the WETF pool which is maintained at a water temperature between 31 and 34 degrees Celsius and a chlorine content of 1 to 2 parts per million. The pool is indoors; therefore, there is no direct sunlight exposure. Lighting is supplied by overhead mercury vapor lamps. Dissimilar metals (for example, 6061-T6 aluminum and 300 series stainless steel) are present on a normal basis. Some mockups are cathodically protected by the addition of zinc anodes. During service and handling, all mockups are subjected to direct impacts and abrasion from SCUBA tanks and other mockup hardware.

Rotunda Storage: The WETF rotunda houses the training pool and storage for the various, frequently used, mockups and support stands. The general condition is such that the relative humidity is between 20 and 40 percent. The lighting is supplied by overhead mercury lamps with some indirect sunlight. The temperature ranges between 10 and 35 degrees Celsius. Due to the enclosed nature of the pool within the rotunda, chlorine vapors are frequently detectable. Mockups are drip dried after pool immersion which can introduce mineral buildup on the mockup/coating surfaces.

Outdoor Storage: When not in use, mockups are stored outdoors in the lay down area adjacent to Building 220. This concrete lot is exposed to normal outdoor elements, such as wind, moisture, direct sunlight, and temperature variations. The relative humidity varies between 10 and 100 percent, and the temperature typically falls in the range of -7 to 40 degrees Celsius.

MATERIAL SUBSTRATES

Mockup structures and hardware at the WETF are typically fabricated from 6061-T6 aluminum and 300 series stainless steel. Smaller items commonly use CPVC (Chlorinated Polyvinyl Chloride), fiberglass, lexan, and thermoformed acrylic polyvinyl chloride alloy plastic sheet (e.g. KYDEX[®]) materials. The test plan shall evaluate various coating systems on the aluminum, stainless steel (304) and gray CPVC substrates. Panel sizes will be specified by KTA-Tator, Inc. and are expected to be nominal 3/16"-1/4", 4"x6". Test panels of aluminum fastened to stainless steel (dissimilar metal contact) and with zinc anode cathodic protection will be employed as well.

A minimum of twenty (20) coating systems will be considered for inclusion in a listing of candidate systems. Ten (10) coating systems will ultimately be subject to evaluation based upon agreement between KTA-Tator, Inc. and NASA/JSC. Standard coating systems as well as newer technology coating systems are to be considered for evaluation. Gloss white is the preferred color although specialized products of other light color may be considered.

The primary consideration of the testing program is coating performance in the service environments discussed above, however, other factors of importance include: ease of surface preparation and application; physical properties (tabor abrasion, impact, flexibility); compliance to State of Texas VOC regulations, coating touch up repairs, availability, and cost.

Based upon the above information, KTA requests that «Company Name» submit for review and consideration specific coating systems which, in your judgment, are candidates for the project to be undertaken. This may include more than one candidate coating system.

In responding please provide the most recent technical data sheets for each product, Material Data Safety Sheets(MSDS) and other relevant technical considerations. Data from other testing programs or studies would be of value to us as well.

KTA would like to thank you for your assistance and should you have any questions or comments, please contact Richard Burgess at the KTA-Tator, Inc. Houston Regional office.

Very truly yours,

KTA-TATOR, INC.

Richard A. Burgess

RAB/lm

cc: K. Tator

JN: H-6341

ORIGINAL PAGE IS
OF POOR QUALITY

Coating System Sought for NASA Test Program

Coatings manufacturers are invited to submit information on coating systems for possible use in a coatings evaluation program sponsored by the National Aeronautics and Space Administration (NASA) and the Johnson Space Center (JSC). The purpose of the program is to identify and test candidate coating systems for use on crew training mock-ups in the Weightless Environmental Training Facility (WETF) pool.

Systems are needed for the following service environments.

- Pool immersion: Pool immersion of the mock-ups and support equipment occurs in the WETF pool, which is maintained at a water temperature between 31 and 34 C (88 and 93 F) and a chlorine content of 1 to 2 parts per million. The pool is indoors; therefore, there is no direct sunlight exposure. Lighting is supplied by overhead mercury vapor lamps. Dissimilar metals (for example, 6061-T6 aluminum and 300 series stainless steel) are present. Some mock-ups are cathodically protected by the addition of zinc anodes. During service and handling, all mock-ups are subjected to direct impacts and abrasion from SCUBA tanks and other mock-up hardware.

- Rotunda storage: The WETF rotunda houses the training pool and storage for the frequently used mock-ups and support stands. The relative humidity is between 20 and 40 percent. Lighting is supplied by mercury lamps with some indirect sunlight. The temperature ranges between 10 and 35 C (50 and 95 F). Because the pool is enclosed, chlorine vapors are frequently detectable. Mock-ups are drip-dried after pool immersion, which can introduce mineral build-up on the mock-up/coating surfaces.

- Outdoor storage: When not in use, mock-ups are stored outdoors in the concrete lay down area adjacent to Building 220. The lot is exposed to normal outdoor elements, such as wind, moisture, direct sunlight, and

temperature variations. The relative humidity varies between 10 and 100 percent, and the temperature falls in the range of -7 to 40 C (19 to 104 F).

Mock-up structures and hardware at the WETF are typically fabricated from 6061-T6 aluminum and 300 series stainless steel. Smaller items commonly use chlorinated polyvinyl chloride (CPVC), fiberglass, lexan, and thermofomed acrylic polyvinyl chloride alloy plastic sheet materials. The test plan shall evaluate various coating systems on the aluminum, stainless steel (304), and gray CPVC substrates. Panel sizes will be specified by the testing firm and are expected to be nominal $\frac{3}{8}$ in. (4.8 mm), $\frac{1}{2}$ in. (6.4 mm), 4 in. (102 mm), and 6 in. (152 mm). Test panels of aluminum fastened to stainless steel (dissimilar metal contact) and with zinc anode cathodic protection will be used as well.

At least 20 coating systems will be considered for inclusion in a listing of candidate systems. Ten coating systems will ultimately be subject to evaluation based upon agreement between the testing firm and NASA/JCS. Standard as well as newer technology coating systems are to be considered. Gloss white is the preferred color, although specialized products of other light colors may be considered.

The primary consideration of the testing program is coating performance in the service environments discussed above; however, other factors of importance include ease of surface preparation and application; physical properties (abrasion, impact, flexibility); compliance with State of Texas volatile organic compound regulations; coating touch-up repairs; availability; and cost.

Respondents should provide the most recent technical data sheets for each product submitted, material safety data sheets, and other relevant technical considerations. Data from other testing programs are also welcome.

For further information, contact Richard Burgess, KTA-Tator, Inc., 2105 Wilson Rd., Humble, TX, 77396; 713/540-1177. □

Table I-1
Candidate Coating Systems

| System Options | Candidate Coatings Manufacturer Product | Manufacturer's Product Data and Recommendations | | | | | | | | | | Material gal. @dft 1000 ft2 | VOC lb/gal solids |
|----------------|--|---|-------------------|-------------|----------------|-------------------|---------------------|-------------------------------|--------------------|---------------------------|-----------------------|-----------------------------|--------------------|
| | | Surface Prep | Profile mils | Coats # | DFT, ea. (mid) | Vol. Solids % | VOC lb/gal | Application Equipment* | Ambient Limits | | Coverage ft2/mil-Gal. | | |
| | | | | | | | | | FH | Temp (F) | | | |
| 1 | Madison Chemical Tufsheen II polyurethane-aliphatic | SP-10 | 2.5+ | 1 | 10 | 100% | 0 | P | 85% | NA | 1605 | 6.2 | 0.0 |
| 2 | Madison Chemical Corrocote "S" polyurethane-aromatic Acrylathane topcoat (opt) acrylic polyurethane | SP-10 | 3 - texture | 1 | 7 3 | 72% 80% | 2.35 1.58 | B,R,C,A B,R,C,A | 85% 85% | NA 32+ | 1150 850 | 8.5 4.4 | 3.3 2.0 |
| 3 | Flamecoat PF111 Ethylene methacrylic acid | SP-6 | 2-3 | 1 | 10 | 100% | 0 | Flamecoat | 100% | N/A | per lb. 100 | lbs. 100.0 | 0.0 |
| 4 | Flamecoat PF112 (metal salt additive) Ethylene methacrylic acid | SP-6 | 2-3 | 1 | 10 | 100% | 0 | Flamecoat | 100% | N/A | per lb. 100 | lbs. 100.0 | 0.0 |
| 5 | Carboline 1037 Wash Primer polyvinyl butyral Carbomastic 15M500-red polyamine alum. epoxy Glamer Glaze 200-White polyamide epoxy | SP-2 (SP-10) SP-1 | rough 1-3 - | 1 1 2 | 0.5 5 3 | 10% 90% 60% | 6.2 0.74 2.8 | B,R,C,A B,R,C,A B,R,C,A | 85% 95% | 60-90 50-100 50+ | 160 1444 960 | 31.3 3.8 10.4 | 62.0 0.8 4.7 |
| 6 | Carboline 1037 Wash Primer polyvinyl butyral Carbomastic 15M500-red polyamine alum. epoxy Carboline 890 amine epoxy | SP-2 (SP-10) SP-1 | rough 1-3 - | 1 1 1 | 0.5 5 5 | 10% 90% 75% | 6.2 0.74 1.78 | B,R,C,A B,R,C,A B,R,C,A | 85% 95% 80% | 60-90 50-100 50-110 | 160 1444 1203 | 31.3 3.8 5.5 | 62.0 0.8 2.4 |
| 7 | Sherwin-Williams Hi-Solids Catalyzed Epoxy polyamide epoxy Kem Cure Hi-Solids Epoxy phenolic epoxy MC-Miomastic moisture cure urethane | SP-5 SP-5 SP-2,3,7 | 1.5-2 - | 2 2 1 | 6 6 3 | 61% 64% 62% | 2.76 2.69 2.6 | B,R,C,A B,C,A B,R,C,A | 85% 50+ 100% | 55-95 50+ 45+ | 978 1026 990 | 20.1 18.3 4.9 | 4.5 4.2 4.2 |
| 8 | NSP Specialty Products NSP 120 phenolic epoxy Mavor-Kelly (dist.) | SP-7 | 1 | 2 | 10 | 100% | 0 | B,R,C,A | 100% | 45+ | 1605 | 12.5 | 0.0 |

Table F-1
Candidate Coating Systems

| System Options | Candidate Coatings Manufacturer Product | Surface | | | | | Manufacturers Recommendations | | | | | Material gal. @dft 1000 ft2 | VOC lb/gal solids |
|----------------|--|--------------------------|--------------|---------|----------------|---------------|-------------------------------|------------------------|------------|-----------------|-----------------------|-----------------------------|-------------------|
| | | Prep | Profile mils | Coats # | Coats DFT, ea. | Vol. Solids % | VOC lb/gal | Application Equipment* | Ambient RH | Limits Temp (F) | Coverage ft2/mil-gal. | | |
| 9 | The 3E group Polaprime 3 Polaroof NW ethylene-styrene (solvent) | No data provided SP-1 | - | 1 | 15 | 55% (wt.) | B,R,C,A | | | 1320 | 20.7 | 0.0 | |
| 10 | The 3E group Polaroof Firegard PVC-ethylene acetate (aq.) | SP-1 | | | | 60% (wt.) | B,R,A | >35 | | | | | |
| 11 | The 3E group Polagard PVC-ethylene acetate (aq.) | SP-1 | - | 2 | 12 | 67% (wt.) | B,R,C,A | >35 | | 1440 | 24.9 | 0.0 | |
| 12 | Devco Coatings Bar-Rust 235 amine epoxy Dexthane 379 (optional) urethane enamel | SP-3 | - | 2 | 7 | 68% | B,R,C,A | | | 1091 | 18.9 | 3.5 | |
| | | SP-1 | - | 1 | 3 | 63% | B,R,C,A | | | 1011 | 4.7 | 4.1 | |
| 13 | Devco Coatings Devgard 238 amine epoxy | SP-10 | 2 | 2 | 9 | 77% | A | | | 1235 | 18.9 | 2.2 | |
| 14 | Devco Coatings Pre-Prime 167 amine epoxy Devran 230 polyamide epoxy Dexthane 379 urethane enamel | SP-1 | - | 1 | 2 | 100% | B,R,C | | | 1604 | 0.9 | 1.7 | |
| | | SP-1 | - | 1 | 5 | 71% | B,R,C,A | | | 1139 | 6.2 | 3.0 | |
| | | SP-1 | - | 1 | 3 | 63% | B,R,C,A | | | 1011 | 4.7 | 4.1 | |
| 15 | Elite Coatings Elite 8844 amine-epoxy | SP-5 | 2 | 2 | 4 | 70% | B,R,C,A | | 50+ | 1091 | 10.5 | 3.3 | |
| 16 | American Chemical Aquatapoxy A6 amine epoxy | SP-5 | 2 | 2 | 8 | 100% | BR,P | 100% | | 1600 | 10.0 | 0.0 | |
| 17 | Wisconsin Prot. Ctgs Plasite 7122 epoxy phenolic (employed by NASA) | SP-5 | 3 | 2 | 6 | 56% | B,C,A | | 50 | 898 | 23.9 | 6.1 | |
| 18 | Wisconsin Prot. Ctgs Plasite 7122L (low VOC) epoxy phenolic | SP-5 | 3 | 2 | 6 | 64% | B,A | | 50 | 1026 | 18.3 | 4.2 | |
| 19 | Wisconsin Prot. Ctgs Plasite 7133 polyamide-epoxy note: Aluminum substrates require chemical surface treatment after blast cleaning & prior to application of PLASITE products. | SP-5 | 2 | 2 | 5 | 50% | C,A | | 50 | 802 | 24.9 | 6.4 | |

Table F-1
Candidate Coating Systems

| System Options* | Candidate Coatings Manufacturer Product | Manufacturer's Product Data and Recommendations | | | | | | | | | | Material gal. @dft 1000 ft2 | VOC lb/gal solids |
|-----------------|--|---|--------------|---------|----------------|---------------|------------|------------------------|------------|-----------------|-----------------------|-----------------------------|-------------------|
| | | Surface Prep | Profile mils | Coats # | DFT, ea. (mil) | Vol. Solids % | VOC lb/gal | Application Equipment* | Ambient RH | Limits Temp (F) | Coverage ft2/mil-Gal. | | |
| 20 | Wisconsin Prot. Ctgs Plasite 9133 (low VOC) polyamide-epoxy note: Aluminum substrates require chemical surface treatment after blast cleaning & prior to application of PLASITE products. | SP-5 | 2 | 2 | 5 | 86% | 1.5 | C.A | | 50 | 1373 | 8.5 | 1.8 |
| 21 | UTPlast ethylene/vinyl alcohol | SP-5 | 3 | 2 | 8 | 100% | 0 | Spray-Jet | - | - | per lb. 150 | lbs. 106.7 | 0.0 |
| 22 | Xymax Coatings Inc. Mono Prime 7300 aromatic polyurethane Mono Gard 7900 coal tar polyurethane | SP-6 | 2 | 1 | 3.5 | 61% | 2.8 | B,R,C,A | >40 | 23 | 983 | 5.8 | 4.6 |
| 23 | Metalized Thermal Systems alternatives: Aluminum (Al) Zinc (Zn) Al-Zn alloy | | | 2 | 4 | 62% | 2.8 | B,C,A | | 32 | 992 | 13.0 | 4.5 |
| 24 | EDO Corporation thermoplastics EDO 1000 polyamids, EDO 2000 elastomer EDO 4000 polyethylene EDO 5000, fluoropolymer | SP-10 | 3 | 1 | 15 | 100% | 0 | thermal spray | 100% | N/A | per lb. 175 | lbs. 85.7 | 0.0 |
| | | SP-10 | 3 | 1 | 10 | 100% | 0 | thermal spray | 100% | N/A | 192 | 52.1 | 0.0 |
| | | SP-10 | 3 | 1 | 15 | 100% | 0 | thermal spray | 100% | N/A | 214 | 70.1 | 0.0 |
| | | SP-10 | 3 | 1 | 15 | 100% | 0 | thermal spray | 100% | N/A | 107 | 140.2 | 0.0 |

Comments: Data absent from column headings was not provided with the Manufacturer's information.

*Equipment: B=brush, R=roller, C=conventional spray, A=airless, P=plural or Special (by Name)

** Preheated Substrate Temperature



KTA-TATOR, INC.

2105 Wilson Road, Humble, TX 77396
1-800-826-5381 • FAX (713) 540-1724

PROTECTIVE COATINGS (PAINT) CONSULTANTS: Testing • Instruments • Inspection • Analytical Laboratory

March 3, 1994

Ms. June Huhn
NASA-Lyndon B. Johnson Space Center
Neutral Buoyancy Simulation Section
Mail Code SP 54
Houston, TX 77058

**SUBJECT: Weightless Environment Training Facility Materials Coating
Evaluation: Progress Report No. 20, Contract NAS 9-18973**

Dear Ms. Huhn:

This correspondence is provided to you as progress report number twenty (20) addressing KTA-Tator, Inc. project activities conducted during the period February 24, 1994 to March 3, 1993.

Candidate Coating Systems

Candidate coating systems represent four (4) major categories of coating materials. These include the epoxies (phenolic, amine, amide), urethanes (aliphatic, aromatic), thermoplastics (ethylene, polyethylene, polyamide, fluoropolymer) and metalized (aluminum, aluminum-zinc). Epoxy coatings were the most frequently identified coating for the exposure environments identified (immersion, humid, atmospheric). The manufacturer recommended systems included both single product applications (polyurethane-aliphatic, thermoplastics, phenolic epoxy, amine epoxy, polyamide epoxy) of one or two coats and multi product application (aromatic-polyurethane/acrylic polyurethane; polyamine epoxy/polyamide epoxy; amine epoxy/polyamide epoxy/urethane; amine epoxy/urethane) of two or three coats per material.

Key considerations in selection of the test materials for performance characteristics are three fold: immersion service; ultraviolet light resistance; impact resistance. Epoxy systems based on amines provide excellent resistance to alkalis, acids, water and salt solutions, however, ultraviolet resistance, flexibility, hardness and moisture sensitivity during application are limitations. Polyamide epoxies are somewhat superior to amine epoxies for water resistance and exhibit excellent adhesion, impact and abrasion resistance. Extended cure time and limitations on low temperature curing are disadvantages. Although ultraviolet light induces chalking this is less significant than for the amine epoxies. Chalking of polyamide epoxies is reduced relative to amine cure epoxies and, based on film thickness, may be of little significance. Surface gloss will be lost over time. Phenolic epoxies provide excellent chemical resistance and cure to a hard tight film. Curing of these materials has historically involved heat application and/or baking. Ambient curing phenolic epoxies can be heated to reduce curing time. Polyurethanes are noted for chemical resistance, gloss, color and ultraviolet resistance. Properties vary widely depending on the polyol and isocyanate components employed in the formulation. Aromatic polyurethanes may darken due to ultraviolet exposure. Moisture resistance is comparable to that of polyamide epoxy and abrasion

**ORIGINAL PAGE IS
OF POOR QUALITY**

resistance is usually excellent. However, sensitivity to the isocyanates may result in exposed workers and under humid conditions gassing (carbon dioxide) and flatness in finish can result.

Polyurethanes have not historically been employed for immersion service since cost and application requirements relative to epoxy systems favored the latter. Common polyurethane formulations are not generally immersion service designed.

Thermoplastics applied by thermal spray can provide a durable continuous film with excellent flexibility and abrasion resistance. Application requires heating of the substrate to temperatures sufficient to melt and fuse the material, this limits use on temperatures sensitive materials and materials which may release gases, oils or chemicals beneath the film. Since surface temperature is elevated during application, ambient temperatures and humidity are not limitations. Cure time is minimal (minutes) and repair reported to be effected by reapplication over existing films (which melt together). Specialized application equipment is required but is portable for small scale operations or can be established as fluidized beds for parts or shop coating.

Metalized systems involve application of metal to the substrate, e.g. aluminum over steel. Durability is excellent since the applied metal alloy can be specifically identified for the service environment. Low corrosive alloys can be applied as a thin film over inexpensive metal which may be subject to rapid corrosion in environments. The applied material, deposited as fluid droplets can be porous if application is poor. This limitation can be overcome by application of an organic coating system.

Recommendations

1. Plasite 7122, manufactured by Wisconsin Protective Coatings, is a phenolic epoxy which will be included in the test program. The system provides a point of reference for other materials since the coating has been used by NASA. Future use may be impacted by VOC regulations. Replacement of this product by an alternative phenolic must be considered.
2. NSP 120, manufactured by NSP Specialty Products, is a phenolic epoxy which is indicated to be 100% solids. VOC levels are reported by the manufacturers to be 0 lbs/gallon. This product may serve as a potential replacement for Plasite 7122 and provides a second phenolic epoxy for evaluation. The recommended surface preparation (SP-7) suggest the product is more surface tolerant than the Plasite materials.
3. BAR-Rust 235, manufactured by Devoe Coatings is an amine-epoxy coating. Based upon surface preparation requirements (SP-3). The material is surface tolerant which suggests repairs to the coating system may be more easily accomplished than with less surface tolerant coatings.
4. Bar-Rust 235/Devthane 379, manufactured by Devoe Coatings represents an amine-epoxy/urethane system. The amine epoxy alone (system 3 above) is subject to chalking with extended exposures to ultraviolet light. Use of Devthane 379 was recommended as an option for overcoating to provide ultraviolet light resistance. In combination, systems 3 and 4 may permit assessment of the efficacy of aliphatic urethane top coating.
5. Pre-Prime 167/Devran 230/Devthane 319, manufactured by Devoe Coatings represents an amine epoxy/polyamide epoxy/urethane enamel system. Use of an amine-epoxy polyamide epoxy system is recommended. The system can exclude use of the urethane topcoat or include its use. The improved ultraviolet stability of the polyamide over the amine is expected to be demonstrated during exposure in QUV and NASA-lay down area exposures.
6. 1037 Wash Primer/Carbomastic 15M/Carboline 890, manufactured by Carboline represents a system with amine/epoxy applied over a polyamide. Use of the wash primer reduces degree of surface preparation suggesting surface tolerance and ease of repair. Wash primers have relatively high VOC content. This may be a significant drawback. The polyamide epoxy is an aluminum mastic.

**ORIGINAL PAGE IS
OF POOR QUALITY**

7. PF 112, manufactured by Plastic Flamecoat, is a thermoplastic ethylene methacrylic acid product. The use of thermal spray thermoplastics is an opportunity to assess performance of these type systems. Little comparative data between thermoplastics and conventional organic coatings is available in literature. Impact resistance, flexibility and water resistance are key features of thermoplastics. The PF 112 product contains a metal salt absent from PF 111. This alters abrasion resistance and stability.

8. UT Plast, manufactured by UTP Welding Technology, is an ethylene vinyl thermoplastic. The general characteristics are similar to those of PF 112 (above) but based upon vinyl alcohol rather than methacrylic acid. Alternatively an EDO product, EDO 1000, 2000, 4000 or 5000 may be employed. Use of a minimum of two (2) thermoplastics in the test program is recommended. As discussed above, little comparative data is available for these alternative systems.

9. Aluminum Metalizing over coated with Bar Rust/Devthane 379 (System 4 above). The evaluation of use of metalized coating, sealed with an epoxy system, for comparison to unmetalized substrates will assist in evaluation of the influence of thermally applied metal coatings. The metalized coatings offer excellent impact and abrasion resistance.

10. Aluminum Metalizing overcoated with a thermoplastic system. Either the PF 112 (Plastic Flamecoat) or UT Plast (UTP Welding Technology) thermoplastic over metalized coating merits evaluation. The hard characteristic of the metalized film in conjunction with the flexibility and impact resistance of thermoplastic appears unique. No discussion of this system combination has been encountered in the literature.

Should you have any questions or comments, please do not hesitate to contact me at the KTA Houston office.

Very truly yours,

KTA-TATOR, INC.



Richard A. Burgess

RAB/lm

cc: G. Evans

JN: H-6341



KTA-TATOR, INC.

2105 Wilson Road, Humble, TX 77396
1-800-826-5381 • FAX (713) 540-1724

PROTECTIVE COATINGS (PAINT) CONSULTANTS: Testing • Instruments • Inspection • Analytical Laboratory

March 16, 1994

Ms. June Huhn
NASA-Lyndon B. Johnson Space Center
Neutral Buoyancy Simulation Section
Mail Code SP 54
Houston, TX 77058

**SUBJECT: Weightless Environment Training Facility Materials Coating
Evaluation: Progress Report No. 22, Contract NAS 9-18973**

Dear Ms. Huhn:

This correspondence is provided to you as progress report number twenty two (22) addressing KTA-Tator, Inc. project activities conducted during the period March 10, 1994 to March 16, 1993.

KTA-Tator, Inc. has contacted the suppliers/distributors for the ten (10) coating systems to be employed in the test panel program. A summary of materials status is provided below.

Wisconsin Protective Coatings - Plasite 7122: Chandelle Company, Houston, TX, - Distributor
Contact 3/11/94 awaiting response

NSP Specialty Products - NSP 120: Mavor Kelly Company, Houston, TX, - Distributor
Response 3/11/94: Material to be delivered week of 3/14/94.

Devoe Coatings Company - Devran 230: Devoe coatings, Houston, TX
Response 3/11/94 and 3/14/94: Material available for pick-up week of 3/14/94.

Carboline Company - Carbomastic 15/Carboline 890: Carboline Company, Houston, TX.
Response 3/16/94: Material to be shipped week of 3/16/94.

Plastic Flamecoat - Flamecoat PF 112: Plastic Flamecoat, Big Spring, TX.
Response 3/15/94: Tentative Application Date 3/23/94 at supplier facility.

EDO Corporation - EDO 1000: EDO Corporation Salt lake City, UT
Response 3/9/94: Will apply (to be scheduled) at supplier Facility

UTP Welding Technology: - UTPlast: UT Welding Technology, Houston, TX.
Response 3/9/94: Will apply subsequent to aluminum metallizing (to be scheduled)

American Chemical Company - Aquatapoxy A6: American Chemical Co., St. Louis, Mo.
Response 3/11/94: Will discuss arrangements and advise shipment

**ORIGINAL PAGE IS
OF POOR QUALITY**

**ORIGINAL PAGE IS
OF POOR QUALITY**

Sherwin-Williams Company - High Solids Epoxy: Sherwin-Williams, Cleveland, OH.
Response: Material to be supplied from Sherwin-Williams, Humble, TX.

Elite Coatings - Elite 8844: Elite Coatings Company, Gordon, GA.
Response 3/15 & 3/16/94: Will ship materials from facility week of 3/16/94.

Each manufacturer/distributor of the selected coating systems was contacted on March 11, 1994 or March 14, 1994 (or earlier) via facsimile and/or telephone.

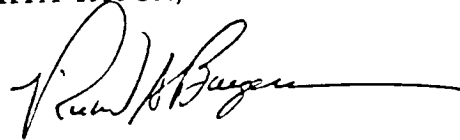
Test panel identification will employ a serial number stamped onto a 302 stainless steel tag. The original panel identification, stamped into each panel may be hidden when surface preparation and coating application is completed, therefore, the tags will be cross referenced to original panel identification and remain with the panels throughout the test project.

Aluminum metallizing and application of all flame spray plastic materials will be performed by others under the direction of KTA-Tator, Inc. Other coating materials are to be applied by KTA-Tator, Inc. personnel.

Should you have any questions or comments do not hesitate to contact this office.

Very truly yours,

KTA-TATOR, INC.



Richard A. Burgess

RAB/lm

cc: G. Evans

JN: H-6341

October 19, 1993

Mr. L. J. Guillory
Mavor-Kelly Co.
10422 West Gulf Bank
Houston, TX 77040-3128

Subject: Candidate Coating System for Weightless Environment
Training Facility Test Panel Program, Johnson Space
Center

Dear Mr. Guillory:

With reference to a letter dated October 14, 1993 from KTA-Tator, Inc. regarding corrosion protection and extended service life for the coating system described above, NSP 120 Multipurpose High Build Coating, with proper preparation and application, will meet service environments and other specifications as outlined in the letter from KTA-Tator, Inc.

I am enclosing MSDS, Technical Data, Chemical and Mechanical Bulletins, Application Guidelines, and representative color cards on NSP 120 Coating.

Please note that if substrate is exposed to direct sunlight, some discoloring may occur; however there will be no effect in the chemical or mechanical properties of the coating.

Thank you for the opportunity to be involved in this project and feel free to contact me at 800-248-8907 should you have any questions.

Sincerely,


Larry Harrison
President

enclosures

NSP Specialty
Products

P.O. Box 4690 Pinehurst, North Carolina 28374-4690 919-944-1255

**ORIGINAL PAGE IS
OF POOR QUALITY**

February 4, 1994

Mr. L. J. Guillory
Mavor-Kelly Co.
10422 West Gulf Bank
Houston, TX 77040-3128

Subject: Candidate Coating System for Weightless Environment
Training Facility Test Panel Program, Johnson Space
Center

Dear Mr. Guillory:

With reference to our telephone conversation regarding coating material evaluation for the above, I would like to submit the following specifications for NSP 120 Coating.

Recommended Surface Preparation for Aluminum and Stainless Steel:

Thoroughly clean and degrease surface using pressure washer, scraping or detergent scrubbing. Abrasive brushoff blast in accordance with SSPC-SP7. If material is too light or thin to blast clean, use medium to coarse grit sandpaper or power disc sander to etch an anchor profile into the surface. After etching, remove dust by water rinse, vacuum, brush or blowing with dry, oil-free compressed air. Do not wipe etched surface.

Recommended Surface Preparation for CPVC Substrate:

Mechanically abrade surface to remove "gloss". Profile to approximately 1 mil. After etching, remove dust by water rinse, vacuum, brush blowing with dry, oil free compressed air. Do not wipe etched surface.

Recommended Coating Systems:

Immersion: (2) coats @ 10 mils DFT each
Rotunda Storage: (1) coat @ 10 mils DFT
Outdoor Storage: (2) coats @ 10 mils DFT each

Thank you for the opportunity to participate in this project and please feel free to contact me for assistance.

Sincerely,


Larry Harrison
President

**NSP Specialty
Products**

P.O. Box 4690 Pinehurst, North Carolina 28374-4690 910-644-1255

**ORIGINAL PAGE IS
OF POOR QUALITY**

October 25, 1993

Mr. Richard A. Burgess
KTA-Tator, Inc.
2105 Wilson Road
Humble, TX 77396

Ref: Coating Recommendations for WETF, Johnson Space Center

Dear Mr. Burgess:

I have received your request from October 14th on the above referenced project. Carboline is pleased to provide the following recommendations.

POOL IMMERSION

Two coats of Carboline 890 epoxy @ 4-6 mils / coat

ROTUNDA STORAGE

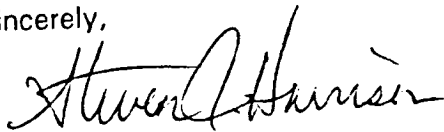
One coat of Carbo Zinc 12 VOC @ .3 mils
One coat of Carboline 893 @ 3-5 mils
One coat of Carbothane 134 HS @ 2 mils

OUTDOOR STORAGE

Two coats of Carboline 3359 @ 2-3 mils / coat

Enclosed you'll find Product Data Sheets and Material Safety Data Sheets on these products. Should you have any questions please feel free to call me directly.

Sincerely,



Steven J. Harrison

Enclosures

cc: Paul Litzsinger
Ray Bartula

December 3, 1993

Mr. Richard A. Burgess
KTA-Tator, Inc.
2105 Wilson Road
Humble, TX 77396

RE: Coating Recommendations for WETF, Johnson Space Center

Dear Mr. Burgess:

As we have discussed, Steve Harrison's recommendations were made with the understanding that you were painting a pool instead of the mock-up placed in the pool. We recommend the following for the areas you requested in your letter of October 14, 1993.

SYSTEM #1 Primer coat Carbomastic 15 M500 Red - 1 coat @ 5 mils.

Top coat Glamor Glaze 200 White - 2 coats @ 3 mils per coat.

SYSTEM #2 Primer coat Carbomastic 15 M500 Red - 1 coat @ 5 mils.

Top coat Carboline 890 epoxy S800 White - 1 coat @ 4-6 mils.

Note: All white epoxies become slightly yellow prior to chalking white in approximately 6 months.

Carboline's Glamor Glaze is used for swimming pool paint and will work very well for you.

I hope this information is useful. I have enclosed the MSDS and Product Data Sheets you requested. We have the above products readily available in stock.

Sincerely,



Bill Smith

BS:dd

kta.doc

cc: RAE, D.Meyer, PSL, S.Harrison

Elite Coatings Company

October 26, 1993

Mr. Richard A. Burgess
KTA-TATOR, Inc.
2105 Wilson Road
Humble, TX 77396

RE: Candidate Coating Systems for Weightless Environment
Training Facility Test Panel Program, Johnson Space
Center

Dear Mr. Burgess,

Elite Coatings Company would like to submit our 8844
Cycloaliphatic Amine Epoxy as a candidate for testing and use in
both service environments you have shown in your letter dated 10-
14-93.

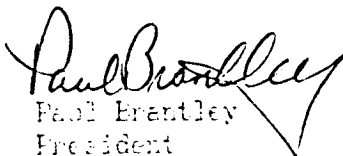
This product is presently being used in the Pulp & Paper Industry
as a finish coat for structural steel surfaces in the bleach
plant areas and the wet end of paper machines. It is also being
used as a two coat system in the interior of kaolin slurry cars.
We have approximately 5 years of service in these areas without
failure. It has passed the standard ASTM D 1308 test.

Enclosed is a technical data sheet & MSDS sheet for your review.
Wet samples of this product can be supplied as needed for
testing.

We appreciate this opportunity to have our product considered
and look forward to the completion of your test.

Please feel free to call me at 1-800-633-5318 for any additional
information.

Sincerely,


Paul Brantley
President

PE; tss

Enclosure

ORIGINAL PAGE IS
OF POOR QUALITY



The Sherwin-Williams Company
101 Prospect Avenue, N.W.
Cleveland, Ohio 44115-1075

November 1, 1993

KTA-Tator, Inc.
2105 Wilson Road
Humble, Texas 77396

Attn: Richard Burgess
re: NASA Study-Test Panel Program

Dear Richard:

Enclosed, please find Product Data Pages and MSDS Sheets for three products
Sherwin-Williams would like evaluated for inclusion into the Weightless Environment
Facility Test Panel Program.

Hi-Solids Catalyzed Epoxy
Kem Cure High Solids Epoxy
MC-Miomastic (Wasser coatings private label)

If you need any additional information, please call me. Thank you for allowing us the
opportunity to submit coatings for this test program.

Sincerely,
The Sherwin-Williams Company

Todd R. Hart
Industrial Maintenance Coatings
216-566-2897

cc: DFinch

ORIGINAL PAGE IS
OF POOR QUALITY

10110 International Center
500 Ely Mitchell Road
St. Louis, MO 63110
TEL: 314-228-1000
FAX: 314-228-1000

January 7, 1994
FSD#153-SO/94L-004

Richard Burgess
KTA-Tator, Inc.
2105 Wilson, Rd.
Humble, TX 77396

Dear Richard,

I appreciated speaking with you this afternoon about the NASA Coating System Test Program. Per your request, I have enclosed our brochure, product data sheets and samples of EDO 1000, 2000, 4000, and 5000. If you have any further questions, please give me a call. We look forward to working with KTA-Tator and NASA on this test program.

Sincerely,



Steve Olsen
Sales Manager

Stephen

Returned Call

Coverage as provided is wrong
should be sq.ft / lb.

Surface Prep SP-10, or SP-5
profile 3 mils

CHANDELLE COMPANY

1050 NORTH POST OAK ROAD
#210
HOUSTON, TEXAS 77055

TELEPHONE: (713) 634-0000
FACSIMILE: (713) 634-1000
TEXAS WATTAGE: (100) 800-0000

February 1, 1994

Mr. Richard Burgess
KTA-Tator, Inc.
2105 Wilson Road
Humble, Texas 77396

Re: Candidate coating systems for weightless environment
training facility test panel program, Johnson Space Center

Dear Mr. Burgess:

Plasite, which is the trademark for Wisconsin Protective Coating's Corporation has been supplying for over ten years, two product lines for the above subject. One being Plasite 7133 for most of the large modules of solid colors. The trim colors of red, yellow, and some blue and black were always #7122. Exhaustive tests were conducted prior to these being established as standards.

For this new testing program we will include several new candidates due to current V.O.C. regulations as well as the old standards.

- 7122 - Standard cross linked epoxy-phenolic
- 7122 L - Low V.O.C. cross linked epoxy phenolic
- 7133 - The original product NASA uses which is a combination of epoxy and polyamide type resins.
- 9133 - A high solids epoxy cured with a polyamine curing agent. Low V.O.C. and is NSF approved. This product is the low V.O.C. high solids version of their originally approved product 7133.

Briner Paint Company, Corpus Christi, Texas which is owned by Wisconsin Protective Coatings Corporation has a product which should perform in the subject environment as well. Briner #754 is a high solids amine cured epoxy finish. The product does come in all the colors used by NASA.



**ORIGINAL PAGE IS
OF POOR QUALITY**

Page 2

Product data sheets are enclosed for your evaluation. Please advise if I can assist you further.

Sincerely,

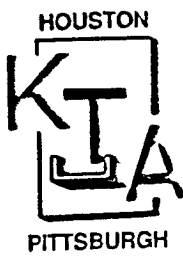
CHANDELLE COMPANY

Harry Myers

Harry Myers

HM:mf

cc: Joe Wolf - WPCC



KTA-TATOR, INC.

2105 Wilson Road, Humble, TX 77396
1-800-826-5381 • FAX (713) 540-1724

PROTECTIVE COATINGS (PAINT) CONSULTANTS: Testing • Instruments • Inspection • Analytical Laboratory
March 11, 1994

L.J. Guillory
Mavor Kelly
10422 West Gulf Bank
Houston, TX 77040-3128

**SUBJECT: Candidate Coating Systems for Weightless Environment
Training Facility Test Panel Program, Johnson Space Center**

Dear Mr. Guillory:

As you are aware, KTA-Tator, Inc., under contract to The National Aeronautics and Space Administration, Lyndon B. Johnson Space Center (NASA/JSC), is undertaking a coating materials evaluation program to test coating systems for use on crew training mock-ups in the Weightless Environment Training Facility (WETF) pool. In excess of twenty (20) coating systems were considered for inclusion in the test program. Ten (10) coating systems have been selected for evaluation.

The purpose of this correspondence is to advise you that the following coating distributed by Mavor Kelly has been selected for inclusion in the study.

NSP Specialty Products: NSP 120 (phenolic epoxy)
Coats: 2
Dry Film Thickness, mils, per coat: 10
Application: Conventional Spray
Estimated Quantity, Mixed Coating: 0.5 gal. min.

Sufficient resin and converter, will be required to provide the minimum estimated quantity of mixed coating. A minimum of two (2) 1 gallon kits is requested, one to be retained for touch-up/repair. Please include with your shipment the recommended product thinner.

The estimated quantity of mixed coating is based upon coating 120 test panels, approximately 40 square feet. Gloss white is the preferred topcoat color. Please advise on delivery time, quantity to be shipped and any associated costs to KTA-Tator, Inc. for procurement of materials. Response by facsimile (713-540-1724) would be appreciated. Current product data sheets and MSDS should be forwarded by mail.

Metal test panels will be prepared to an SSPC SP-10 "Near White Abrasive Blast Cleaning" (NACE 2) with aluminum oxide. Profile is anticipated to be approximately 2 mils. CPVC test panels will be abrasive blast cleaned with a softer media (possibly glass beads) to texture the surface. All panels will be solvent cleaned (SSPC SP-1 "Solvent Cleaning") prior to coating application. In general, for the ten (10) systems being included in the study, the above manner of

surface preparation is consistent with product data sheets provided for review during the coating selection process. Should the proposed surface preparation be judged inappropriate to your coatings, please advise KTA-Tator, Inc. immediately. A brief description of anticipated service environments and material substrates is provided below.

SERVICE ENVIRONMENTS

Pool Immersion: Pool immersion in the WETF pool at a water temperature between 31 and 34 degrees Celsius and a chlorine content of 1 to 2 parts per million. The pool is indoors; therefore, there is no direct sunlight exposure.

Rotunda Storage: The WETF rotunda houses the training pool and storage for various, frequently used, equipment. The general condition is such that the relative humidity is between 20 and 40 percent. Temperature ranges between 10 and 35 degrees Celsius.

Outdoor Storage: When not in use equipment may be stored outdoors at a lay down area. This concrete lot is exposed to normal atmospheric conditions for the Houston, Texas region (such as wind, moisture, direct sunlight, and temperature).

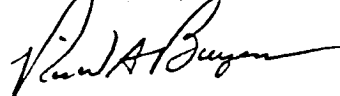
MATERIAL SUBSTRATES

Test panels to be employed include 6061-T6 aluminum, 304 series stainless steel and CPVC (Chlorinated Polyvinyl Chloride). Panel sizes are nominal 3/16"-1/4", 4"x6".

KTA would like to thank you for your assistance and should you have any questions or comments, please contact Richard Burgess at the KTA-Tator, Inc. Houston Regional office.

Very truly yours,

KTA-TATOR, INC.



Richard A. Burgess

RAB/lm

JN: H-6341



KTA-TATOR, INC.

2105 Wilson Road, Humble, TX 77396
1-800-826-5381 • FAX (713) 540-1724

PROTECTIVE COATINGS (PAINT) CONSULTANTS: Testing • Instruments • Inspection • Analytical Laboratory
March 14, 1994

Mr. Andy House
Devoe Coatings Company
4000 DuPont Circle
Louisville, KY 40207

*Dennis Harris
4555 Howerkirk Suite 606
675-5115
FAX 675-5703*

**SUBJECT: Candidate Coating Systems for Weightless Environment
Training Facility Test Panel Program, Johnson Space Center**

Dear Mr. House:

Per our previous correspondence, KTA-Tator, Inc., under contract to The National Aeronautics and Space Administration, Lyndon B. Johnson Space Center (NASA/JSC), is undertaking a coating materials evaluation program to test coating systems for use on crew training mock-ups in the Weightless Environment Training Facility (WETF) pool.

The purpose of this correspondence is to advise you of a change in the coating manufactured by Devoe Coatings Company to be included in the study.


| | |
|--------|--|
| Devoe: | Devran 230 |
| | Coats: 2 |
| | Dry Film Thickness, mils, per coat: 5 |
| | Application: Conventional Spray |
| | Estimated Quantity, Mixed Coating: 1.0 gal. min. |

Note that this change is from Bar Rust 235 to Devran 230. The rationale is to employ a polyamide system rather than an amine cure epoxy.

KTA would like to thank you for your assistance and should you have any questions or comments, please contact Richard Burgess at the KTA-Tator, Inc. Houston Regional office.

Very truly yours,

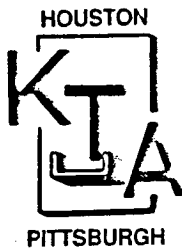
KTA-TATOR, INC.


Richard A. Burgess

RAB/lm

JN: H-6341

**ORIGINAL PAGE IS
OF POOR QUALITY**



KTA-TATOR, INC.

2105 Wilson Road, Humble, TX 77396
1-800-826-5381 • FAX (713) 540-1724

PROTECTIVE COATINGS (PAINT) CONSULTANTS: Testing • Instruments • Inspection • Analytical Laboratory
March 31, 1994

Mr. Rocco J. Corvelli
UTP Welding Materials, Inc.
PO Box 721679
Houston, TX 77272-1678

**SUBJECT: Candidate Coating Systems for Weightless Environment
Training Facility Test Panel Program, Johnson Space Center**

Dear Mr. Corvelli:

As you are aware, KTA-Tator, Inc., under contract to The National Aeronautics and Space Administration, Lyndon B. Johnson Space Center (NASA/JSC), is undertaking a coating materials evaluation program to test coating systems for use on crew training mock-ups in the Weightless Environment Training Facility (WETF) pool. In excess of twenty (20) coating systems were considered for inclusion in the test program. Ten (10) coating systems have been selected for evaluation.

The purpose of this correspondence is to advise you that the following coatings manufactured by UTP has been selected for inclusion in the study.

System No. 6: UT Plast Super (Polyamide 11)
 Surface Preparation/Profile: *Advise*
 Coating Application: *Advise*
 Film Thickness (mils): *Advise*

System No. 7 Aluminum Metallizing to be overcoated with:
 UT Plast (Ethylene/vinyl/alcohol copolymer)
 Surface Preparation/Profile: *Advise*
 Coating Application: Film thickness (mils): *Advise*

Application of the above systems is to be performed per manufacturer's recommendations for the service environments and substrates included in the study (described below). All manufacturers have been asked to provide product data sheets and material safety data sheets (MSDS) for products to be employed.

Mr. Donnie Murrell, Vesca Plastic Fabricators, has agreed to provide surface preparation, aluminizing and application services to KTA-Tator for this project. Vesca Plastics has been identified as an approved applicator of UTP Welding Technology products. It is our understanding the UTP will provide Vesca Plastics with materials to be applied. Gloss white is the preferred color.

**ORIGINAL PAGE IS
OF POOR QUALITY**

Metal test panels should be prepared to manufacturers recommended cleanliness and profile with aluminum oxide. Profile is anticipated to be approximately 2 mils. CPVC test panels should be abrasive cleaned to texture the surface. All panels have been solvent cleaned (SSPC SP-1 "Solvent Cleaning") but should be reexamined and if necessary, recleaned prior to coating application.

Please advise our office, and Mr. Murrell, of your recommendations for surface preparation and coating application. A brief description of anticipated service environments and material substrates is provided below.

SERVICE ENVIRONMENTS

Pool Immersion: Pool immersion in the WETF pool at a water temperature between 31 and 34 degrees Celsius and a chlorine content of 1 to 2 parts per million. The pool is indoors; therefore, there is no direct sunlight exposure.

Rotunda Storage: The WETF rotunda houses the training pool and storage for various, frequently used, equipment. The general condition is such that the relative humidity is between 20 and 40 percent. Temperature ranges between 10 and 35 degrees Celsius.

Outdoor Storage: When not in use equipment may be stored outdoors at a lay down area. This concrete lot is exposed to normal atmospheric conditions for the Houston, Texas region (such as wind, moisture, direct sunlight, and temperature).

MATERIAL SUBSTRATES

Test panels to be employed include 6061-T6 aluminum, 304 series stainless steel and CPVC (Chlorinated Polyvinyl Chloride). Panel sizes are nominal 3/16"-1/4", 4"x6".

The coated panels are to be tested in each environment, therefore separate coating systems for each environment is not under evaluation. Two (2) tables are provided which detail panel distribution for the coating systems.

KTA would like to thank you for your assistance and should you have any questions or comments, please contact Richard Burgess at the KTA-Tator, Inc. Houston Regional office.

Very truly yours,

KTA-TATOR, INC.



Richard A. Burgess

RAB/lm

JN: H-6341



KTA-TATOR, INC.

2105 Wilson Road, Humble, TX 77396
1-800-826-5381 • FAX (713) 540-1724

PROTECTIVE COATINGS (PAINT) CONSULTANTS: Testing • Instruments • Inspection • Analytical Laboratory
April 4, 1994

Mr. Donnie Murrell
Vesca Plastics
102 South Avenue A
Freeport, TX 77541

SUBJECT: Candidate Coating Systems for Weightless Environment Training Facility Test Panel Program, Johnson Space Center

Dear Mr. Murrell

Please accept this as authorization for Vesca Plastics to provide surface preparation and coating application services for KTA-Tator, Inc.

KTA-Tator, Inc. Purchase Order #94PO169 is provided for the work to be performed at a fee of \$1000.00

Briefly, three (3) sets of test panels are being provided by KTA-Tator, Inc. and each set includes

| | |
|---------------------------------------|--------------|
| Twenty-two (22) stainless steel (304) | 4"x6" panels |
| Twenty-two (22) aluminum (6061-T6) | 4"x6" panels |
| Fourteen (14) coupled (SS+AL) | 5"x6" panels |
| Eighteen (18) CPVC (plastic) | 4"x6" panels |
| Two (2) carbon steel (SSPC-SP10) | 4"x6" panels |
| Two (2) carbon steel (Impact) | 4"x6" panels |
| Two (2) carbon steel (Tabor) | 4"x4" panels |

for a total of eighty-two (82) panels per set.

Each of the sets represent a separate coating system for evaluation as part of the NASA test program. These are described below.

System No. 6: UT Plast Super (Polyamide 11)
Surface Preparation/Profile: *Advise*
Coating Application: *Advise*
Film Thickness (mils): *Advise*

System No. 7: Aluminum Metallizing to be overcoated with:
UT Plast (Ethylene/vinyl/alcohol copolymer)
Surface Preparation/Profile: *Advise*
Coating Application: Film thickness (mils): *Advise*

Application of the above systems is to be performed per UTP Welding Technology recommendations for the service environments and substrates included in the study (described below).

**ORIGINAL PAGE IS
OF POOR QUALITY**

System No. 8

Aluminum Metalizing, to be overcoated by KTA-Tator, Inc. The overcoat is an epoxy system which will be placed over the aluminum metalizing.

Preparation of test panels for aluminum metalizing should employ standard industry practice. The protocol should be documented for project purposes. It is recognized that the CPVC panels may present an unsuitable substrate due to the temperatures required for application. We request that an attempt be made to apply the coating systems. If unsuccessful, the effort to coat the CPVC can be stopped, however, please document the difficulties encountered.

Mr. Rocco Corvelli, UTP Welding Technology, has agreed to provide surface preparation and application recommendations to KTA-Tator for this project. Vesca Plastics has been identified as an approved applicator of UTP Welding Technology products. It is our understanding the UTP will provide Vesca Plastics with materials to be applied. Gloss white is the preferred color.

Please advise our office, and Mr. Corvelli, of your recommendations for surface preparation and application of the aluminum. A brief description of anticipated service environments and material substrates is provided below.

SERVICE ENVIRONMENTS

Pool Immersion: Pool immersion in the WETF pool at a water temperature between 31 and 34 degrees Celsius and a chlorine content of 1 to 2 parts per million. The pool is indoors; therefore, there is no direct sunlight exposure.

Rotunda Storage: The WETF rotunda houses the training pool and storage for various, frequently used, equipment. The general condition is such that the relative humidity is between 20 and 40 percent. Temperature ranges between 10 and 35 degrees Celsius.

Outdoor Storage: When not in use equipment may be stored outdoors at a lay down area. This concrete lot is exposed to normal atmospheric conditions for the Houston, Texas region (such as wind, moisture, direct sunlight, and temperature).

MATERIAL SUBSTRATES

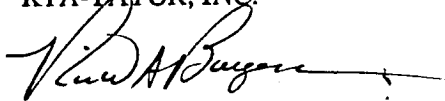
Test panels to be employed include 6061-T6 aluminum, 304 series stainless steel and CPVC (Chlorinated Polyvinyl Chloride). Panel sizes are nominal 3/16"-1/4", 4"x6".

The coated panels are to be tested in each environment, therefore separate coating systems for each environment is not under evaluation.

KTA would like to thank you for your assistance and should you have any questions or comments, please contact Richard Burgess at the KTA-Tator, Inc. Houston Regional office.

Very truly yours,

KTA-TATOR, INC.


Richard A. Burgess

RAB/lm

JN: H-6341