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PRODUCTION OF INSULATED FOOTWEAR USING LIQUID INJECTION MOLDING EQUIPMENT I. METHOD

by
James N. Flood

Uniroyal, Inc.
Naugatuck, Ct

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MOLDING TECHNIQUES	COATINGS	
LIQUID INJECTION MOLDING EQUIPMENT	PROTECTIVE COATINGS	
LIGHTWEIGHT INSULATED FOOTWEAR	BOOTS	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

The objective of this project was to set up and demonstrate a manufacturing line capable of continuous production of 60 pairs per week of lightweight insulated boots from liquid injection molded expanded polyurethane. This report describes in detail all production equipment, production methods, and process conditions used to fabricate the lightweight insulated boot. Cycle times for the various major operations are included based on the optimum operation of the equipment. Mold requirements, equipment layouts, and operations flow chart are listed.

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SUMMARY

This report describes in detail all production equipment, production methods, and process conditions required to fabricate the lightweight insulated boot. Cycle times for the various major operations are included based on the optimum operation of the available equipment. Mold requirements, equipment layouts and operations flow chart are listed.

A manufacturing line has been designed, fabricated, and installed to produce finished lightweight insulated footwear from liquid injection molded expanded polyurethane. The minimum production rate is sixty pair of boots per week, utilizing the equipment one shift per day five days per week. These boots will meet established design criteria and required physical properties. The equipment is capable of producing boots in a size range of 4 through 14 and widths from XN to XW.

The method being used for production of lightweight insulated boots consists of molding a fabric lined, urethane foam upper utilizing four individual mold unit stations and a three-stream foam injection unit. The uppers are trimmed, buffed, and sprayed in specific areas with a release coat. A fabric tube sock is then slipped over the foam upper. The uppers are "banked" until sufficient quantities are produced to warrant switching the equipment to the outsole producing cycle. During this operation, using the same mold stations, the upper is relasted and the outsole is then molded to the upper using a two-stream system in the foam injection unit. After curing, the boot is stripped, trimmed, and buffed.

At this point the boot is ready for application of the outer skin coating. An electrostatic spray unit is used to coat the boots with a tough urethane film. The basic principle is to pump two components to a spinning disc, mixing the components just prior to depositing in a well located in the center of the disc. The disc can be programmed to raise and lower in order to deposit the coating where desired from top to bottom of the boot. The spinning disc "sprays" the coating toward the rotating boot and the urethane particles are electrostatically attracted to the boot. After coating, the boot is cured and then trimmed at the top edge and the snow collar attached.

Approved boots thus finished are final inspected, mated left foot to right foot of the same size and width, and transported to the packing area for pack out and shipment.

PREFACE

An expanded polyurethane pull-on type insulated boot consisting of five component parts has been developed. This insulated boot weighs approximately 830 grams per boot in size 10R as compared to approximately 1300 grams per boot for the standard insulated boot. The current standard insulated boot is fabricated by techniques that are becoming obsolete in the footwear industry. The procedure involves many hand operations and in the case of the insulated boot consists of the hand lay-up of 44 component pieces over a last. The various parts are formed into an integral unit through the use of adhesives and the building tack inherent in the rubber compounds used. The resultant boot is functionally adequate, but suffers from the drawback of excessive weight. The wool fleece now used in the standard insulated boot provides satisfactory insulation in undamaged boots; however, when the outer protective layer is punctured or torn the wool fleece absorbs moisture, resulting in rapid loss of insulating properties. In the expanded polyurethane boot, even if the outer coating is torn, the foam will pick up very little water since it is a closed cell system.

Previous work on this project is covered in Report NATICK/TR-78/004, June 1977, Automated Production of Insulated Footwear. Up to this point there was no production capability to accomplish this new approach to insulated footwear. The current contract was awarded to set up a production line capable of producing 60 pairs of boots per week on a repetitive basis.

This report (1. Method) and an accompanying report (2. Instruction Manual) describes the work performed during the period 15 September 1977 to 15 July 1979 under continuation of the previous program. Under the guidance of Project Officer Joseph E. Assaf, US Army Research and Development Laboratories, the selection, purchase installation, and evaluation of production equipment was performed by Uniroyal Incorporated, Middlebury, Connecticut. This work was conducted under Project 7758035, Automated Production of Insulated Footwear under Contract Number DAAK60-77-0071.

The Project Officer wishes to acknowledge the valued suggestions of Dr. Roy C. Laible of the Polymers and Organic Materials Branch of the Clothing, Equipment and Materials Engineering Laboratory and the guidance of Mr. Douglas S. Swain, Footwear Technologist at NARADCOM, relative to design consideration.

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PRODUCTION OF INSULATED FOOTWEAR USING LIQUID INJECTED MOLDING EQUIPMENT

1. METHOD

BOOT MANUFACTURING TECHNIQUE

Previous work on boot manufacturing technique proved the feasibility of the concept of a lightweight expanded polyurethane pull-on type insulated boot.[1] Since that work was done on pilot plant equipment, the present contract was initiated to scale up the equipment and to select, purchase, install and evaluate production equipment that would be capable of producing 60 pairs of boots of all sizes per 5 day week, while operating a single shift each day.

The boot as it is fabricated consists of an outsole, upper, leg-lining, fabric reinforcing tube sock, outer coating, and a snow collar and duplicates units previously provided by UNIROYAL (Figure 1 and Figure 2). The production process

FIGURE 1 - POLYURETHANE INSULATED BOOT

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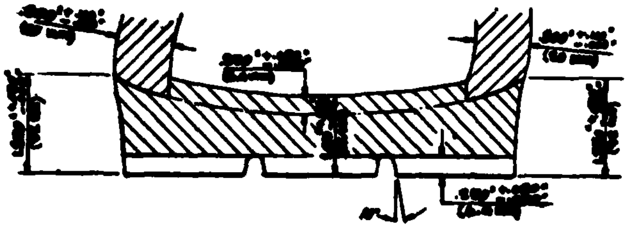
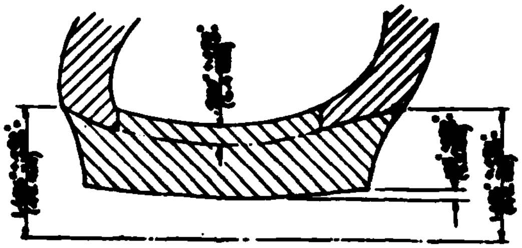
utilizes four UNIROYAL designed unit molding stations; six pair of UNIROYAL designed molds in sizes 8W, 9R, 9W, 10R, 11R and 14XW; one Desma PSA 73 three-stream liquid polyurethane injector; one Ransburg electrostatic coating system, and other ancillary equipment as shown in the layout in Figure 3. This equipment provides a capability of producing sixty pair of finished boots per week, utilizing the equipment one shift per day, five days per week. The prepolymer compounds for the line testing are made at the UNIROYAL-Oxford Corporate Research and Development area and delivered to the production area. All other compounding is done in the production area. Legliners and snow collars are cut in the UNIROYAL Dublin, Georgia Plant Cutting Department and delivered to the production area in Connecticut where all stitching operations are performed. The spray masks used during application of the release coating are thermoformed in the production area.

The sequence of operations required for boot production are as follows: The boot leglining and socklining (Figure 4), are made of 1830/1 black, urethane coated nylon tricot weighing $4.8 {}^{+0.5}_{-0.3}$ ounces per square yard ($163 {}^{+17}_{-10}$ grams

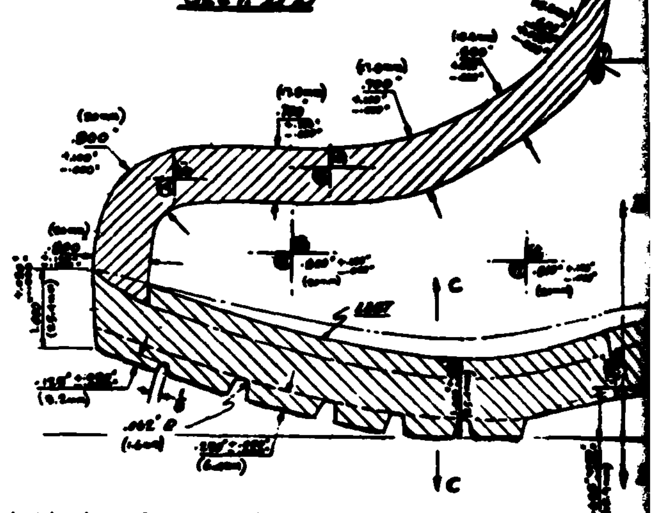
[*1] John C. Gaynor, Automated Production of Insulated Footwear, NATICK/TR-78/004, June 1977 (AD A061049).



SECT. C-C



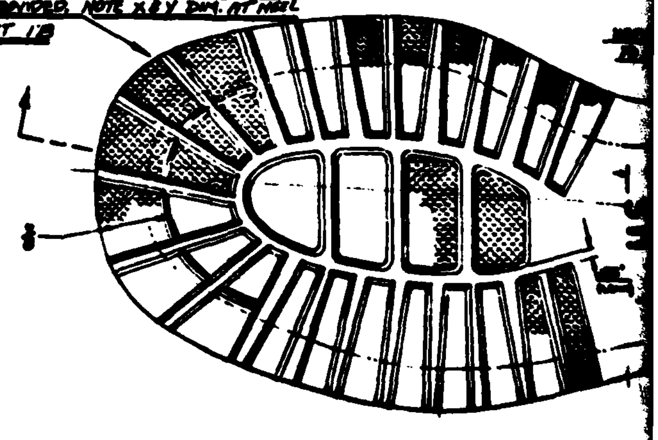
SECT. B-B



	DIMENSION		
SIZE	"X"	"Y"	"W"
4	3.150	2.400	2.957
5	3.250	2.500	3.057
6	3.350	2.600	3.117
7	3.450	2.700	3.197
8	3.550	2.800	3.277
9	3.650	2.900	3.357
10	3.750	3.000	3.437
11	3.850	3.100	3.517
12	3.950	3.200	3.597
13	4.050	3.300	3.677
14	4.150	3.400	3.757

"X"-"Y"-"W" TOLERANCE + .050 - .000

LUG DESIGN SHOWN FOR SIZES 8,9,10 & 11 – DESIGN FOR SIZES 4,5,6,7 AND 12,13,14 WILL BE PROVIDED. NOTE X & Y DIM. AT HEEL SEE SHEET 1/B



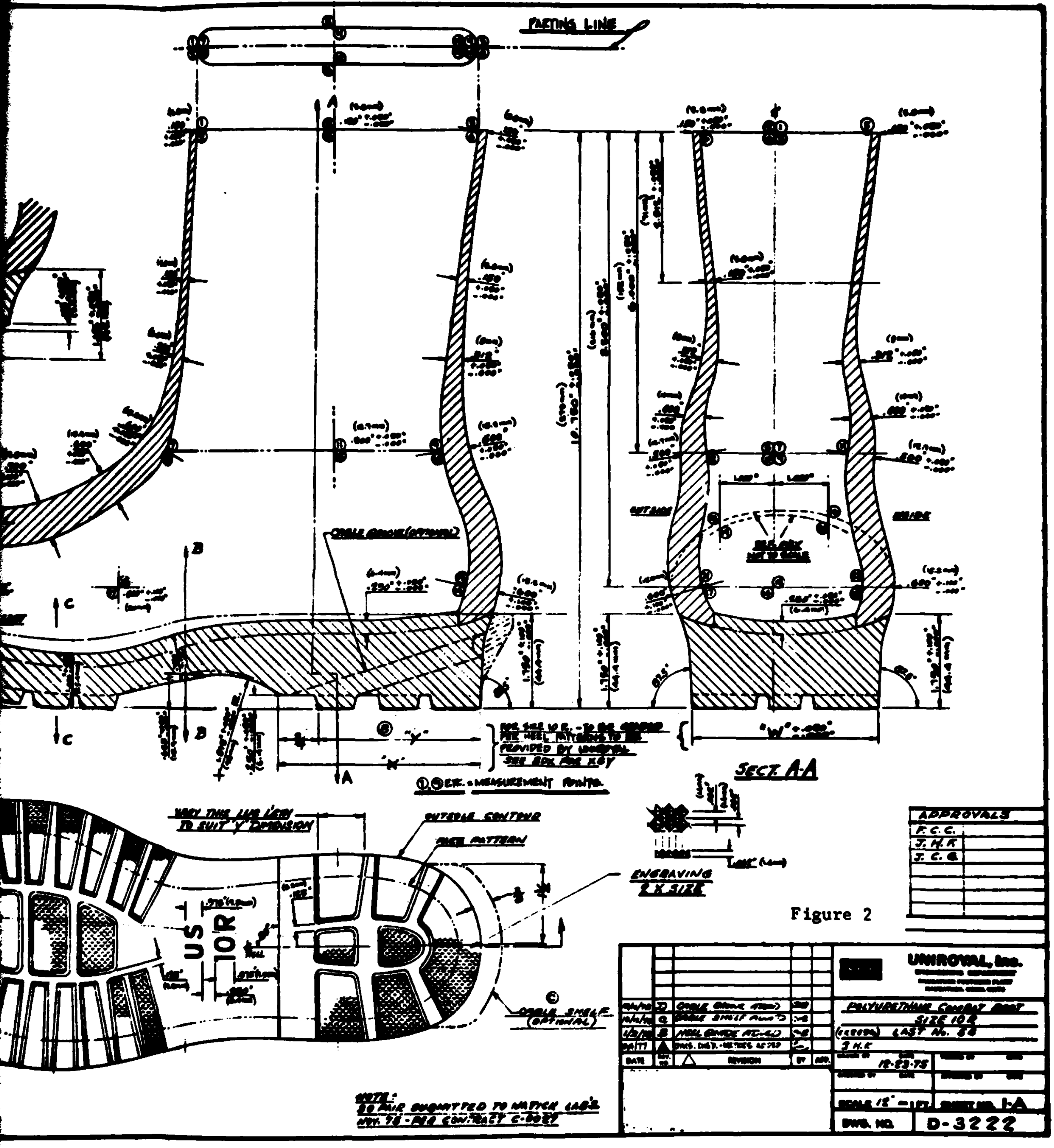
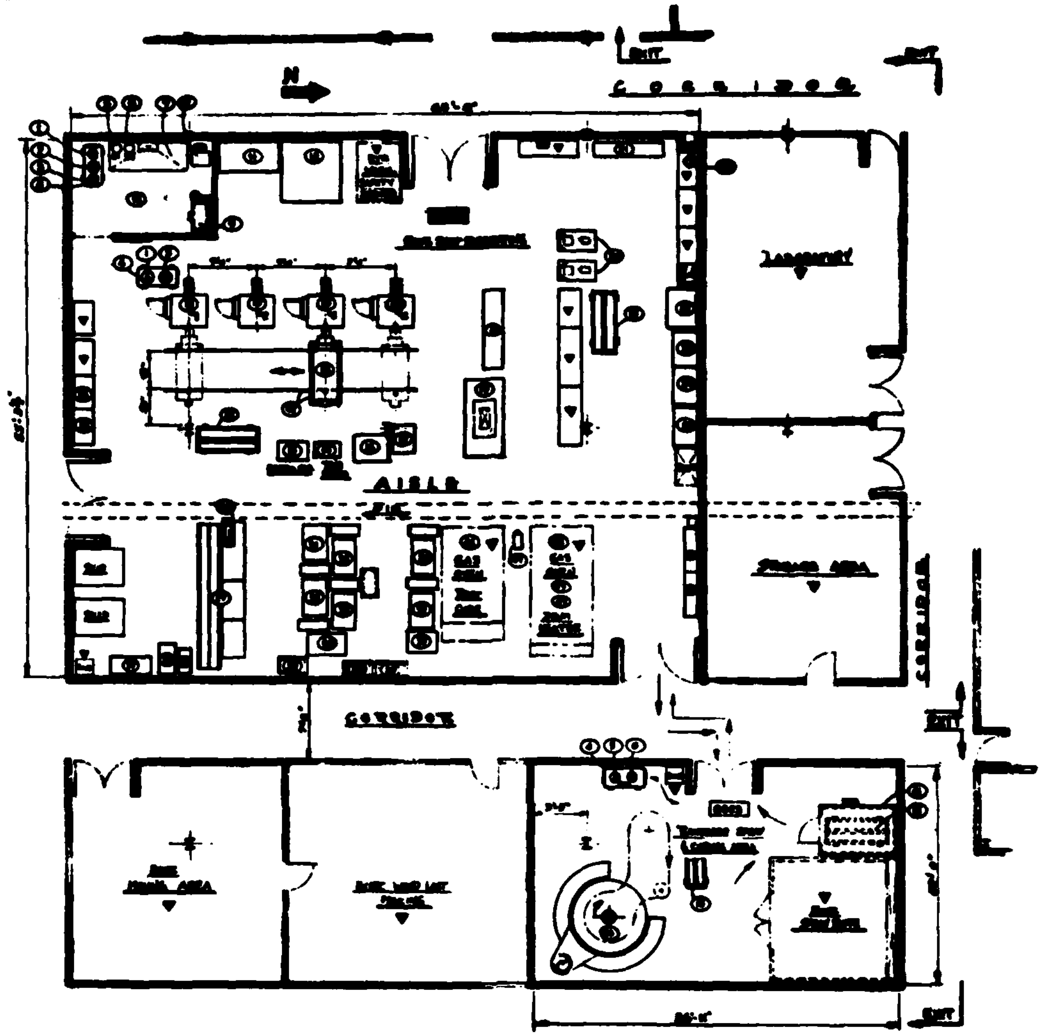

PARTING LINE
SECT. A-A
OUTSIDE
INSIDE
OUTSOLE CONTOUR
FACE PATTERN
ENGRAVING 2 X SIZE
US
10R
CABLE SHELF (OPTIONAL)
APPROVALS
F.C.C.
J.H.K.
J.C.G.
UNIROYAL, Inc.
POLYURETHANE COMBAT BOOT
SIZE 10R
LAST No. 58
D-3222

Figure 2



100
FLOOR PLAN
GOVERNMENT BOOT FABRICATION LAYOUT

ITEM	[illegible]	[illegible]
1	[illegible]	[illegible]
2	[illegible]	[illegible]
3	[illegible]	[illegible]
4	[illegible]	[illegible]
5	[illegible]	[illegible]
6	[illegible]	[illegible]
7	[illegible]	[illegible]
8	[illegible]	[illegible]
9	[illegible]	[illegible]
10	[illegible]	[illegible]
11	[illegible]	[illegible]
12	[illegible]	[illegible]
13	[illegible]	[illegible]
14	[illegible]	[illegible]
15	[illegible]	[illegible]
16	[illegible]	[illegible]
17	[illegible]	[illegible]
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25	—	[illegible]
26	[illegible]	[illegible]
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39	[illegible]	[illegible]
40	[illegible]	[illegible]
41	[illegible]	[illegible]
42	[illegible]	[illegible]
43	[illegible]	[illegible]
44	[illegible]	[illegible]
45	A-1	[illegible]
46	[illegible]	[illegible]
47	[illegible]	[illegible]
48	[illegible]	[illegible]
49	A-2	[illegible]

▼ - [illegible]

[illegible] BOOT FABRICATION [illegible]
LEGEND

UTILITY REQUIREMENTS

ITEM	[illegible]	QUANT.	DESCRIPTION	DRAWING NO. (REF.)	UTILITY REQUIREMENTS
1	A-2	2	MIXING TANK		1/2" ϕ AIR LINE, 220/110 V. 1ϕ, 30 A.
2	A-[illegible]	1	" "		1/2" ϕ AIR LINE, 220/110 V. 1ϕ, 30 A.
3	A-[illegible]	2	" "		1/2" ϕ AIR LINE, [illegible] 1ϕ, 30 A.
4	A-7	3	[illegible]x4' FLAT BED TRUCK		—
5	A-11	2	MIXING TANK		1/2" ϕ AIR LINE
6	A-[illegible]	2	" "		1/2" ϕ AIR LINE
7	A-7	1	3'x8' TABLE W/EXHAUST HOOD		
8	B-2	1	0 TO [illegible] LB. SCALE		
9	A-3	1	MDI MELTING BATH	UNIROYAL D-3307	220/110 V., 30 Amp.
10	A-5	1	MIXING ROOM - 10'x15'		
11	A-4	1	FREEZER		110 V., 1 ϕ
12	A-9	1	6'x6'x8' HIGH WALK IN COOLER	(ALL SHEET METAL)	220 V./110 V. 1ϕ, 30 A.
13	A-[illegible]	4	[illegible] MOLDING FIXTURE - GOV'T. BOOT	UNIROYAL D-3300-[illegible]	1/2" ϕ AIR LINE, 220/110 V. 1ϕ, 60 Amp. [illegible]
14	A-[illegible]	1	DESMA PSA 73 INJECTOR & AUX.		1/2" ϕ AIR LINES(2), [illegible], 480 V., 3ϕ, 60 Amp.
15	A-[illegible]	4	BOOT TRUCK, 60 PR. CAP.	UNIROYAL D-3290-[illegible]	
16	A-[illegible]	1	BUFFER,		110 V., 1ϕ, 20 A.
17	A-[illegible]	1	DUST COLLECTOR		
18	A-18	1	RACK, BOOT MOLD		
19	A-[illegible]	1	HINGED TABLE - BOOT INSPECTION & REPAIR		220/110 V., 1ϕ
20	B-7	2	TRIMMER, BOOT		110 V., 1ϕ
21	B-5	1	CABINET, STORAGE		
22	A-[illegible]	1	THERMO-FORMER - PEDESTAL MOUNT	[illegible]	220/110, 1ϕ
23	A-8	1	STORAGE AREA		220/110 V. 1ϕ, 30 A. OUTLETS
24	—	1	LAST & MARK AREA	UNIROYAL D-3291-[illegible]	" " " " "
25	—	1	SPRAY RELEASE AREA		" " " " "
26	A-6	2	RACK, STITCHING SUPPLIES		
27	A-2	2	TRUCK, WAREHOUSE, CARTON "BOOK" STORAGE		
28	B-2	1	SINGER STITCHER	USMC	110 V., 1ϕ
29	B-2	1	CASE OUT AREA		220/110 V., 1ϕ, 30 Amp. OUTLETS
30	B-12	1	DISPENSER, TAPE - "TAPE SHOOTER JR."	COUNTERBOY, INC.	110 V., 1ϕ
31	B-[illegible]	1	SEWING MACHINE - ZIG ZAG - "107G 253"	SINGER MOD. 107W[illegible]	208 V., 3ϕ
32	A-[illegible]	1	" " - BAR TACK - #269 W 86	SINGER MOD. 269	208 V., 3ϕ
33	A-6	1	STENCIL MACH. MODEL 1050	MARKEM MACH. CO.	110 V., 1ϕ
34	B-9	1	SEWING MACHINE - POST SEAMER # 168 W 101	SINGER MOD. 168	208 V., 3ϕ
35	B-10	1	" " - OZAN - OVEREDGE	OZAN MACH. CO.	220 V., 3ϕ
36	A-12	1	" " - MERROW STITCHER M-3DW-2	MERROW MACH. CO.	220 V., 3ϕ
37	B-1	1	" " - POST SEAMER (SPARE)	SINGER MOD. 168	208 V., 3ϕ
38	B-5	3	TRUCK, CUT PARTS	UNIROYAL - D-3290-[illegible]	
39	B-[illegible]	1	EYELET MACHINE - DUPLEX MODEL B	UNITED SHOE MACHINE CO.	1/2" ϕ AIR LINE, 220 V., 3ϕ
40	A-[illegible]	1	RANSBURG ELECTRO-STATIC SPRAY UNIT & AUX. [illegible]	UNIROYAL D-3301	480 V., 3ϕ, 30 Amp., [illegible], 3ϕ, 4 WIRE, [illegible]
41	B-6	1	OVEN, BOOT DRYING	" D-3302	480 V., 3ϕ, 40 Amp.
42	A-[illegible]	1	CARRIAGE & TRACKING SYSTEM - DESMA PSA 73 S	" D-3303-[illegible]	
43	A-34	1	CONTROLLER, HEAT SEQUENCE	" D-3302	(REF. TO ITEM 41 FOR UTILITIES)
44	B-4	1	OVEN, POST CURE		GAS
45	A-1	1	OVEN, DRUM HEATING		GAS
46	A-[illegible]	1	0 TO 5 Kg. SCALE		
47	A-[illegible]	1	DRUM TRUCK		
48	B-14	1	HAND [illegible] TRUCK		
49	A-2	2	DRUM TRAILER		110 V., 1ϕ

▽ - DENOTES EXISTING EQUIPMENT

REF. DWG. #[illegible], [illegible] REVISED [illegible]
([illegible] - ARCHITECTS)

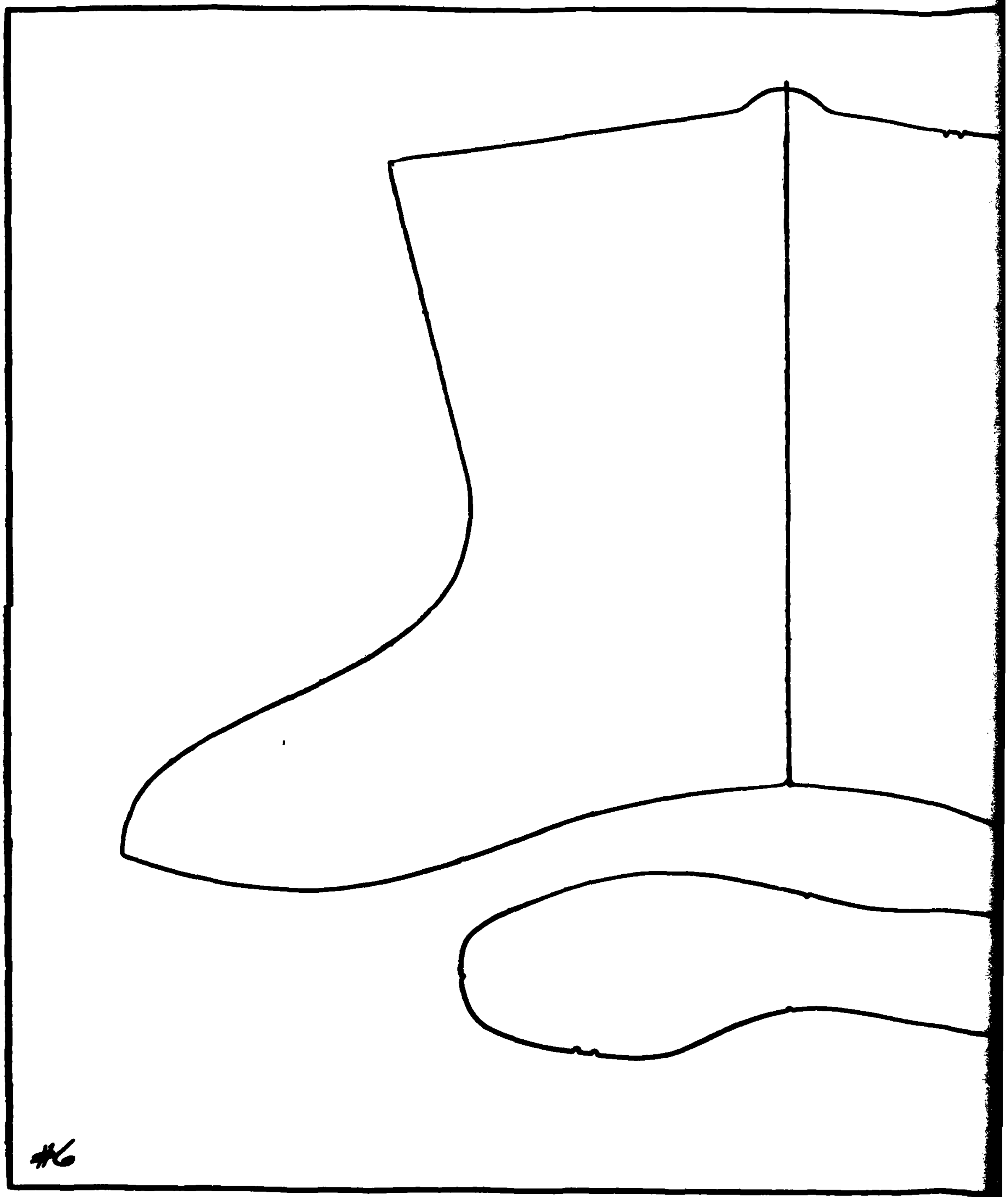
Figure 3

UNIROYAL, Inc.
[illegible]

GOVERNMENT BOOT - FABRICATION [illegible]
LAYOUT - ITEMS & UTILITIES [illegible]
OXFORD RESEARCH CENTER
SECOND FLOOR - [illegible]

DATE	NO.	△	REVISION	BY	APP.

DRAWN BY [illegible] DATE [illegible] TRACED BY DATE
CHECKED BY DATE APPROVED BY DATE
SCALE 1/8" = 1 FT. SHEET NO. 1
DWG. NO. D-3309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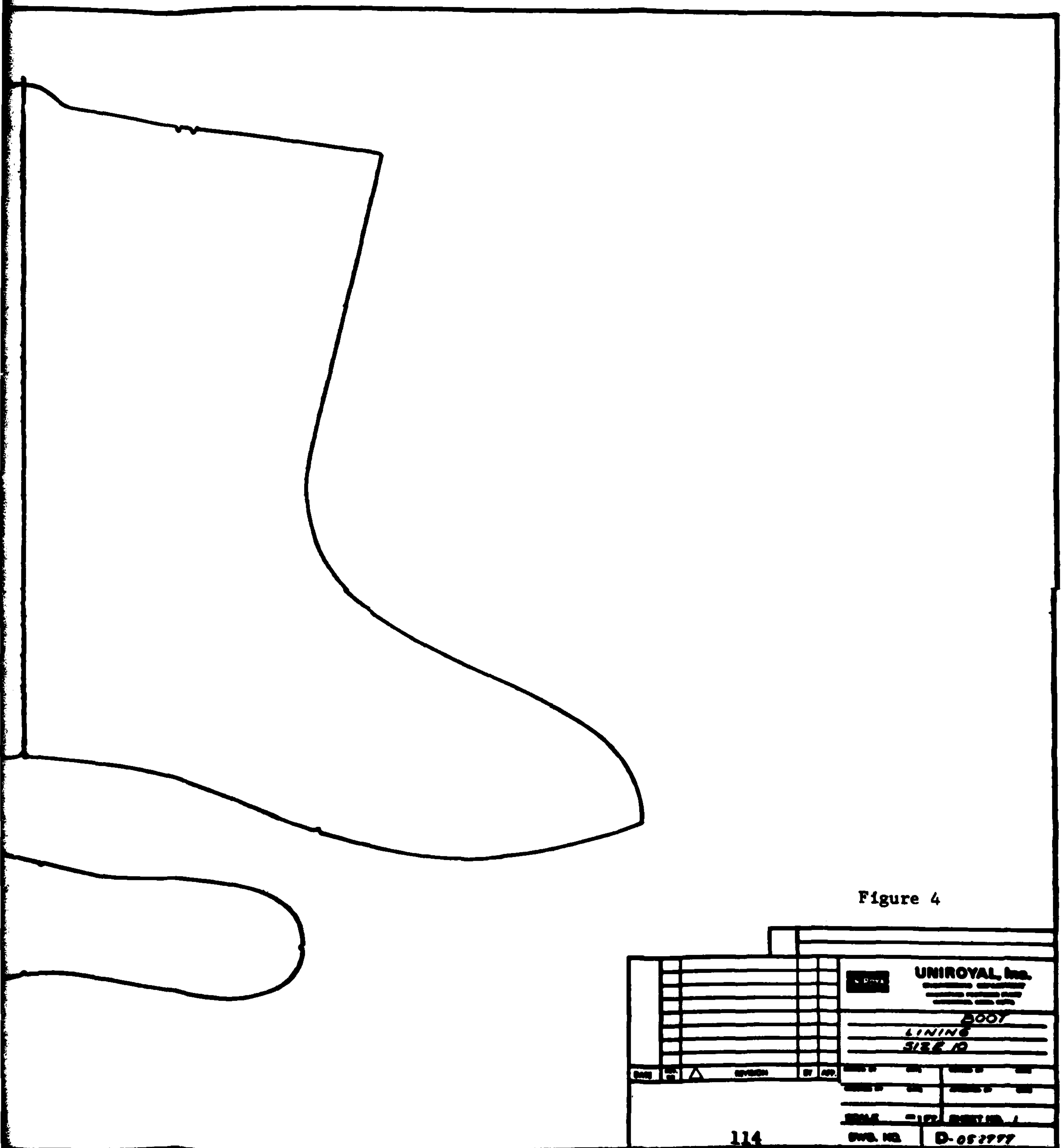
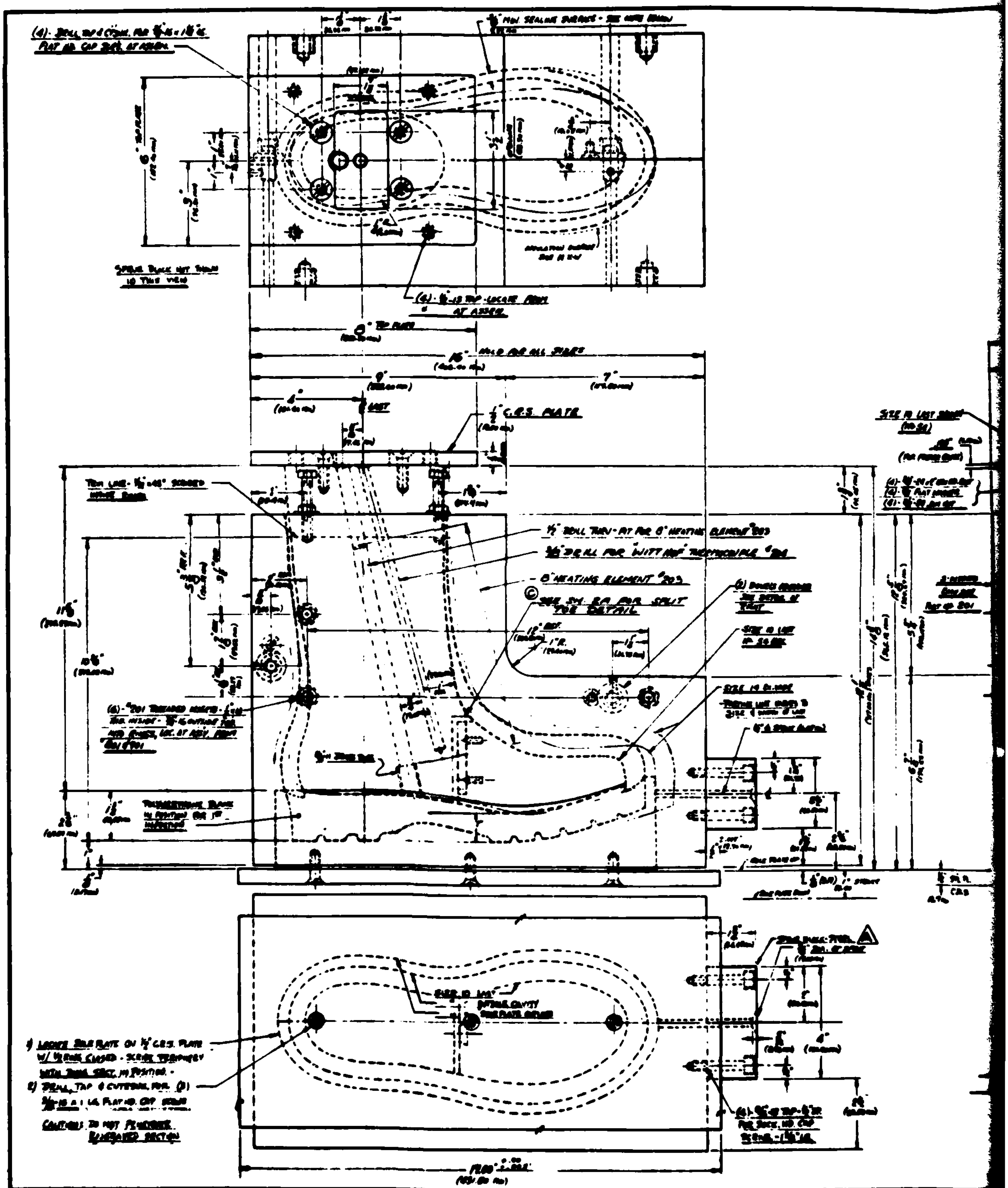
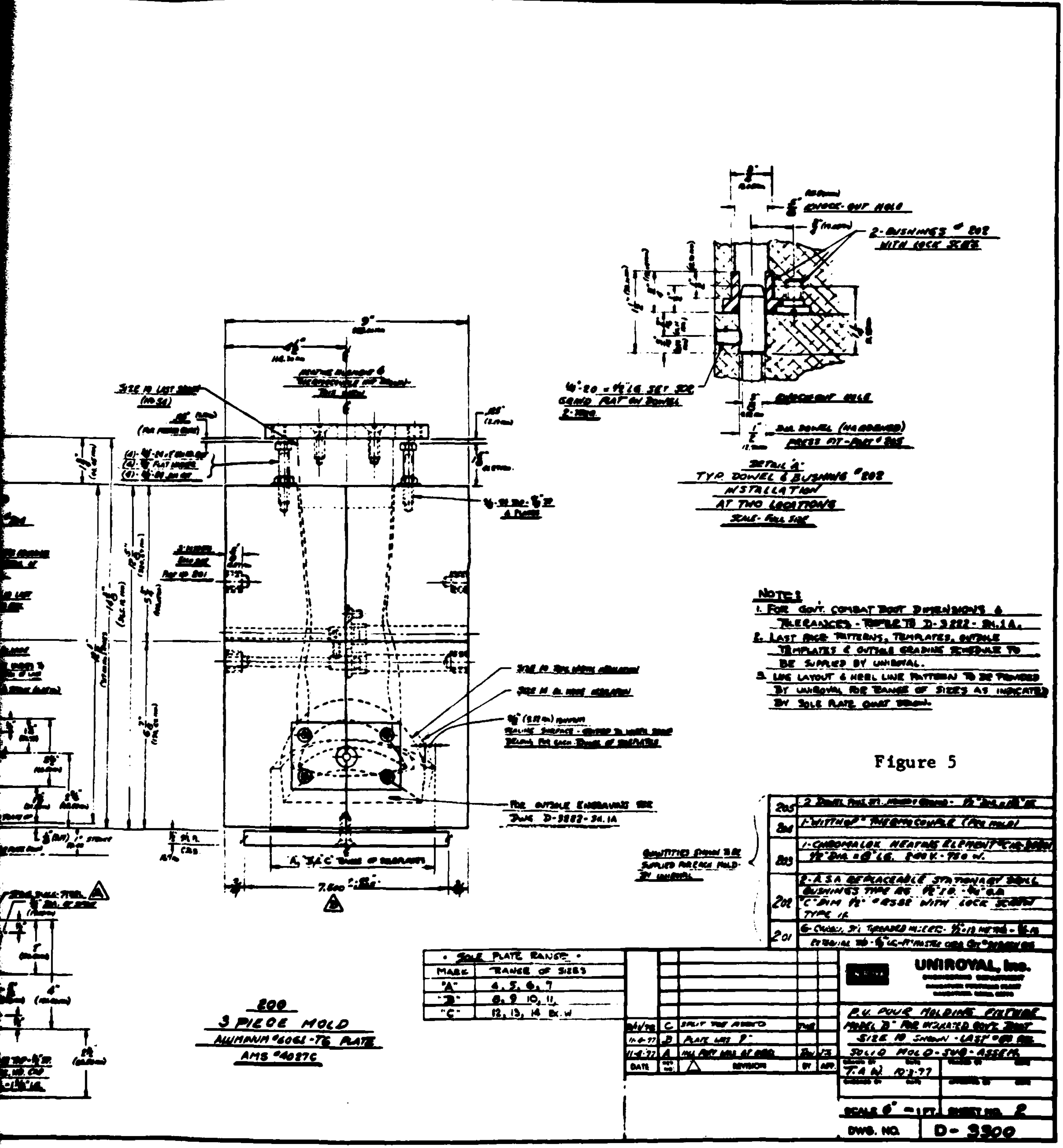


Figure 4


1/2" C.R.S. PLATE
8" HEATING ELEMENT #203
SEE SH. 2A FOR SPLIT TOE DETAIL



NOTES:
1. FOR GOVT. COMBAT BOOT DIMENSIONS & TOLERANCES - REFER TO D-3282-SH.1A.
2. LAST BASE PATTERNS, TEMPLATES, OUTSOLE TEMPLATES & OUTSOLE GRADING SCHEDULE TO BE SUPPLIED BY UNIROYAL.
3. LINE LAYOUT & HEEL LINE PATTERN TO BE PROVIDED BY UNIROYAL FOR RANGE OF SIZES AS INDICATED BY SOLE PLATE CHART SHOWN.
DETAIL "A"
TYP. DOWEL & BUSHING #202
INSTALLATION
AT TWO LOCATIONS
SCALE - FULL SIZE
2-BUSHINGS #202 WITH LOCK SCREWS
KNOCK-OUT HOLE
FOR OUTSOLE ENGRAVING SEE DWG D-3282-SH.1A
7.500
SOLE PLATE RANGE
MARK
RANGE OF SIZES
"A" 4, 5, 6, 7
"B" 8, 9, 10, 11
"C" 12, 13, 14 EX.W
200
3 PIECE MOLD
ALUMINUM #6061-T6 PLATE
AMS #4027C
UNIROYAL, Inc.
SOLID MOLD-SUB-ASSEM.
SCALE 6" = 1 FT.
SHEET NO. 2
DWG. NO.
D-3300

Figure 5

per square meter). These parts are clicker cut from roll stock using dies graded from the size 10R cutting pattern. The leglining is folded and the front seam edge closed with a merrow style A-3-3 stitch, using a loose thread tension at eight stitches per inch. The proper sized socklining is then stitched to the bottom of the leglining with a merrow style A-3-3 stitch, using a loose thread tension at eight stitches per inch. The coated side of the lining is placed to the inside of both parts. Number 69 black nylon thread is used in all stitching operations. The completed lining unit is then hooded over the mold last with the nylon side to the last. The polyurethane coated surface is wiped with vythene to remove any surface contamination, and the stitched seams are taped over with scotch #29 electrical tape 1/2" (1.27 cm) wide. The boot last with its lining assembly is lowered into the mold cavity, and the mold (Figure 5) is closed. The last, as well as the other mold sections, are maintained at a temperature of 200 ^{o}F (93 ^{o}C). Using the foam injection unit (Figure 6), polyurethane foam compound is then injected into the mold cavity defined by the bottom of the last and top of the outsole insert. The soleplate (outsole portion of the mold) is raised, forcing the injected polyurethane into the space defined by the mold walls and the last sides. The foaming action of the polyurethane completes the mold fill. The molded upper

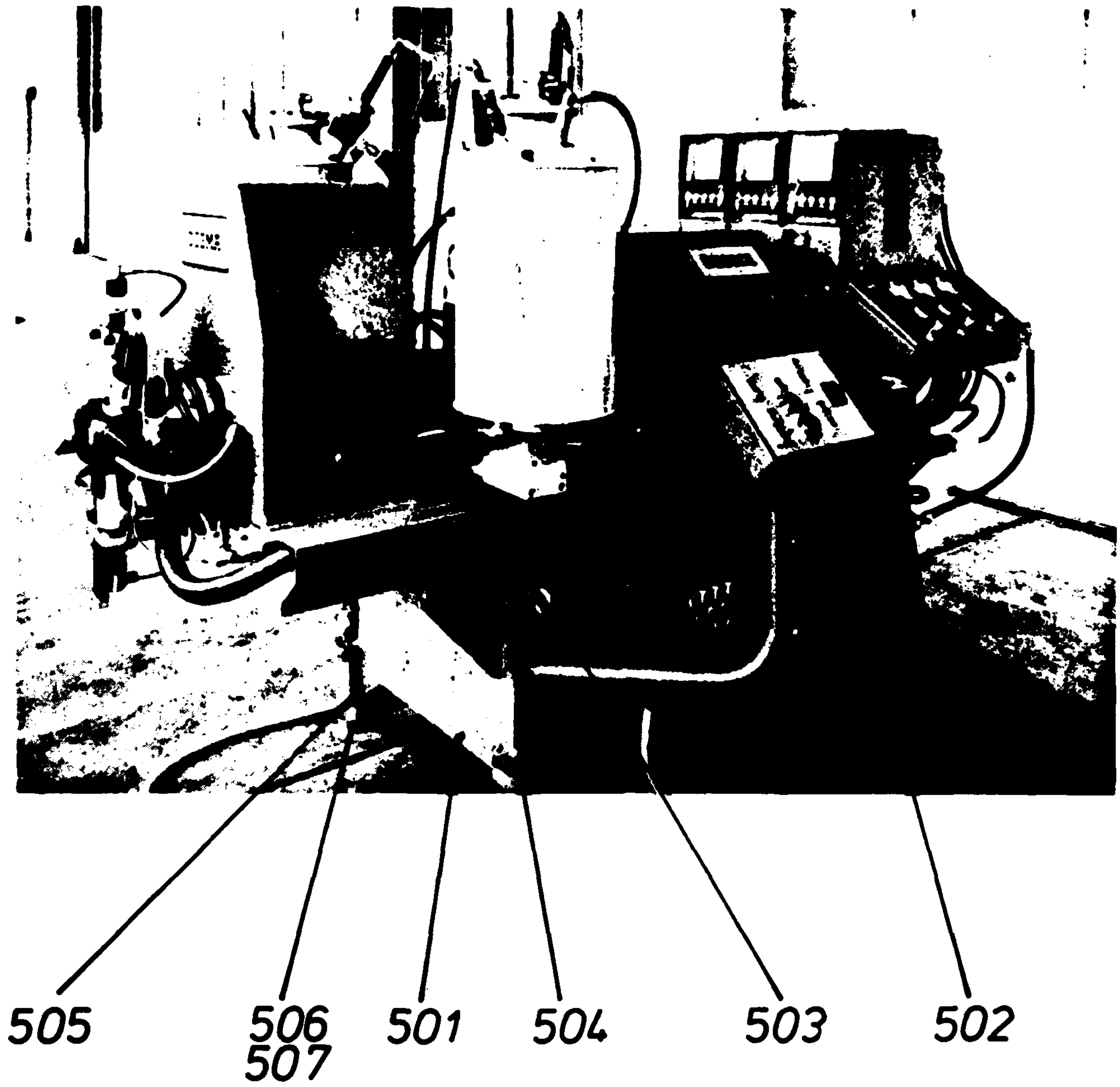


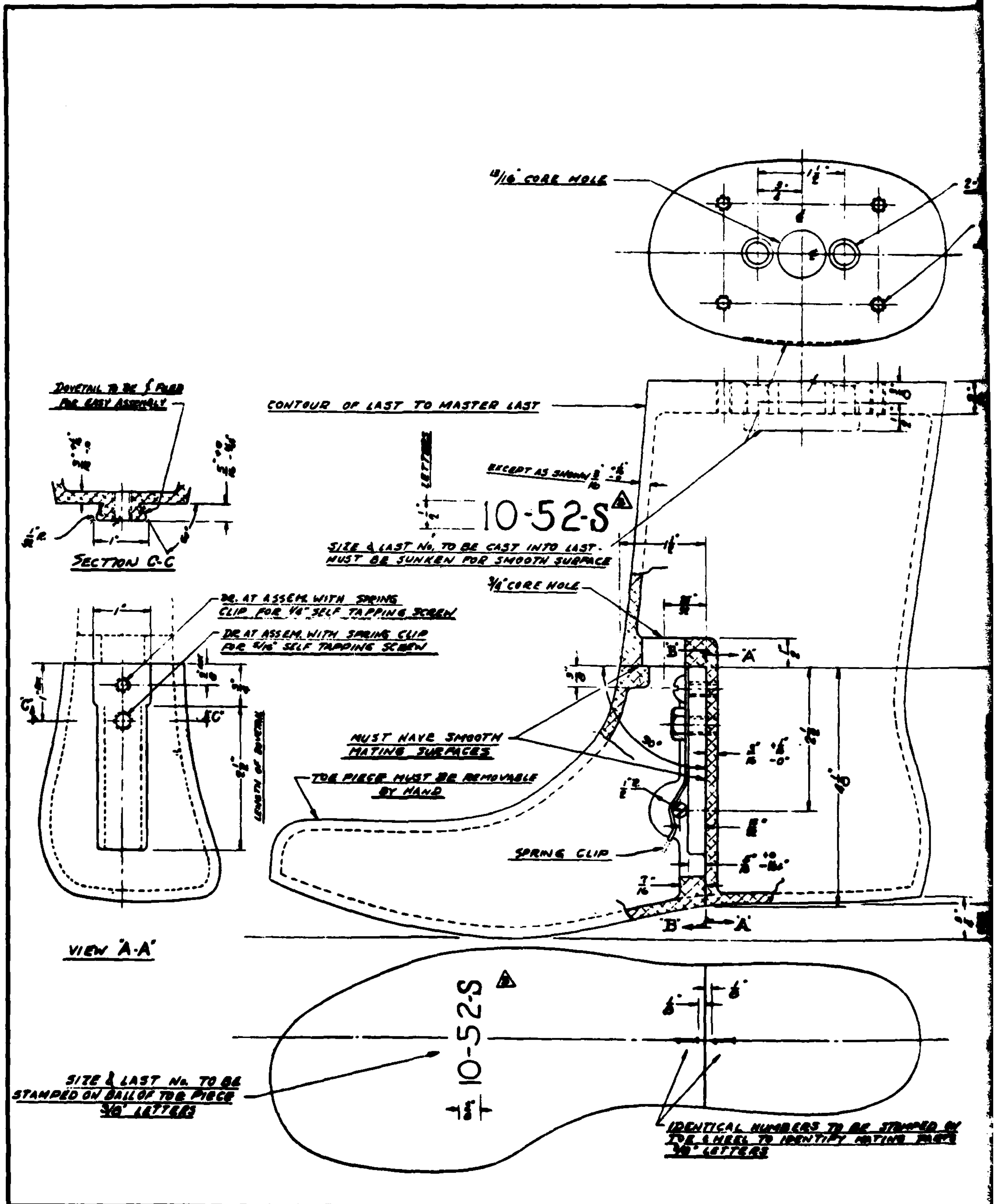
FIGURE 6 - FOAM INJECTION UNIT

is then cured for 15 minutes in the closed mold. At the completion of cure, the mold is opened, the last raised, and the boot upper removed from the last. The flash is then removed from the upper using a rubber roll buffer, and it is inspected, weighed, and repaired if necessary. The repair procedure consists of routing out the bad areas, filling with repair compound and curing the repaired boot for 10 minutes in a hot air oven at a temperature of 140 ^{o}F (60 ^{o}C). After curing, the repaired section is buffed into a smooth contour with the adjoining areas. The upper is now sprayed with a release agent in the area over the vamp, and around the side over the ankle and up the back seam. The vacuum formed spray mask is used to confine the release to the specified areas. The knit fabric tube sock is then pulled over the upper. Approved uppers are then stored on boot trucks in an in-process bank prior to remolding for the application of the outsole.

In the remold operation, the boot upper is relasted on the unit station heated last and the last assembly lowered into the mold, and the mold closed. The polyurethane outsole compound is then injected into the cavity defined by the soleplate, rings, and the boot bottom. The soleplate is raised closing off the injection port, and the foaming action of the polyurethane compound completes the mold fill.

The boot is then cured for 15 minutes at 200 ^{o}F (93 ^{o}C) in the closed mold. The boot's size and width are molded into the shank of the outsole. After the 15-minute cure time, the mold is opened and the boot removed. The mold is brushed clean of any flash and prepared for the next molding. The boot is buffed, weighed, and inspected. After inspection, approved boots are placed in an inventory bank for subsequent processing.

In preparation for electrostatic spray coating, the boot is damp-wiped with methylene cloride over its entire surface--with the exception of the bottom of the outsole--to remove any surface contamination. The boot is hooded over a metal support form (short last)(Figure 7), and a polyurethane spray mask is tacked over the bottom of the outsole of the boot, using short staples or two pieces of double-sided tape. The boot is then attached to the Ransburg electrostatic spray monorail via a swivel hook. The boot is passed through the electrostatic spray system (Figure 8), where the boot is sprayed with a polyurethane coating compound for 12 minutes. During spraying, the metal support form is grounded, and the polyurethane spray is given an electrically positive charge to attract the spray coating to the surface of the boot. The boots are then set aside onto a boot truck 60-pair capacity (Figure 9), and pushed into the drying oven (Figure 10). The oven controls are set to provide a room temperature air-dry for 4 minutes, to allow the solvent to evaporate.


13/16" CORE HOLE
CONTOUR OF LAST TO MASTER LAST
DOVETAIL TO BE ∫ FILED FOR EASY ASSEMBLY
SECTION C-C
EXCEPT AS SHOWN
10-52-S
SIZE & LAST No. TO BE CAST INTO LAST. MUST BE SUNKEN FOR SMOOTH SURFACE
3/4" CORE HOLE
DR. AT ASSEM. WITH SPRING CLIP FOR 1/4" SELF TAPPING SCREW
DR. AT ASSEM. WITH SPRING CLIP FOR 5/16" SELF TAPPING SCREW
LENGTH OF DOVETAIL
MUST HAVE SMOOTH MATING SURFACES
TOE PIECE MUST BE REMOVABLE BY HAND
SPRING CLIP
VIEW "A-A"
SIZE & LAST No. TO BE STAMPED ON BALL OF TOE PIECE 3/16" LETTERS
IDENTICAL NUMBERS TO BE STAMPED ON TOE & HEEL TO IDENTIFY MATING PARTS 3/16" LETTERS

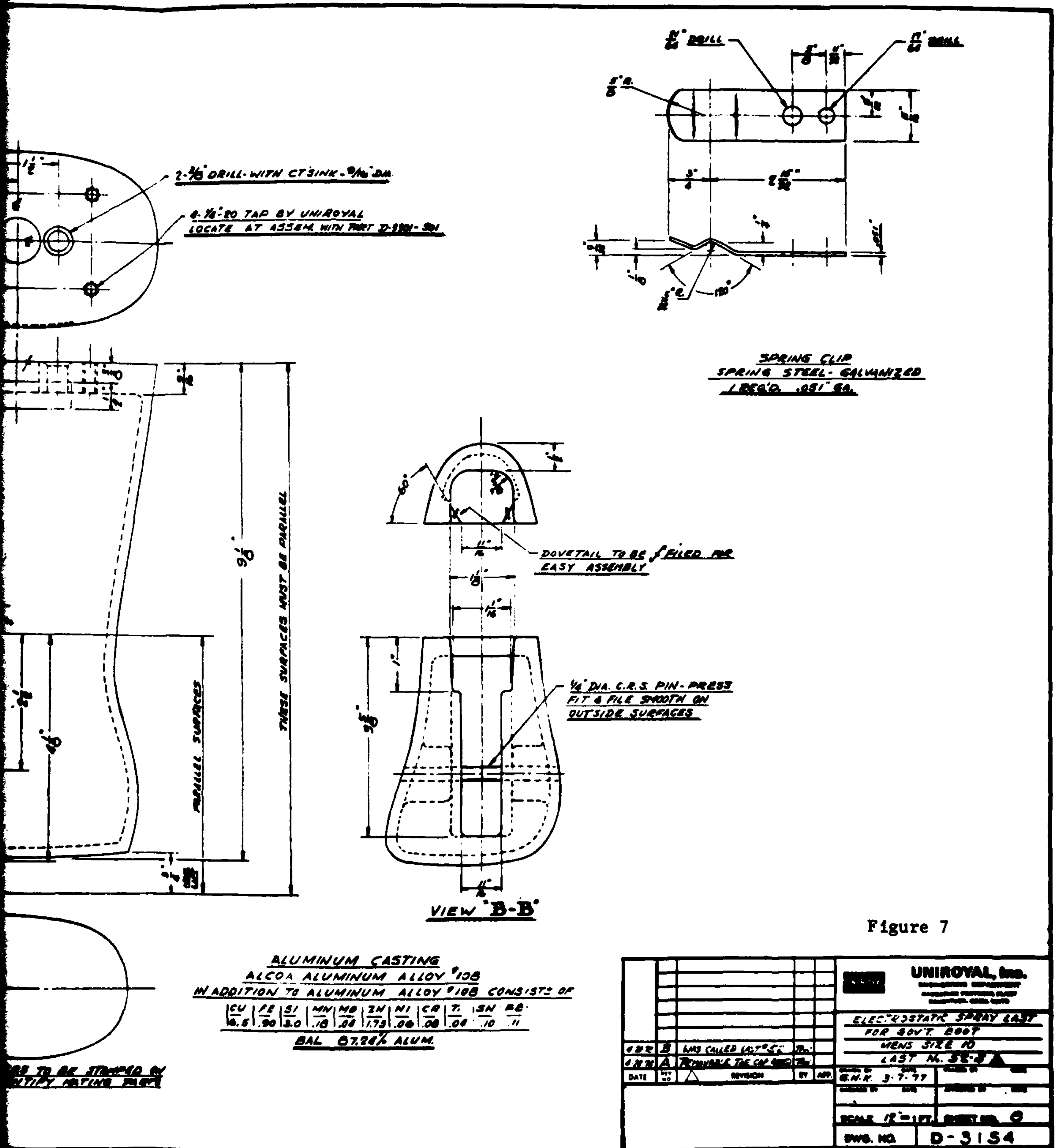
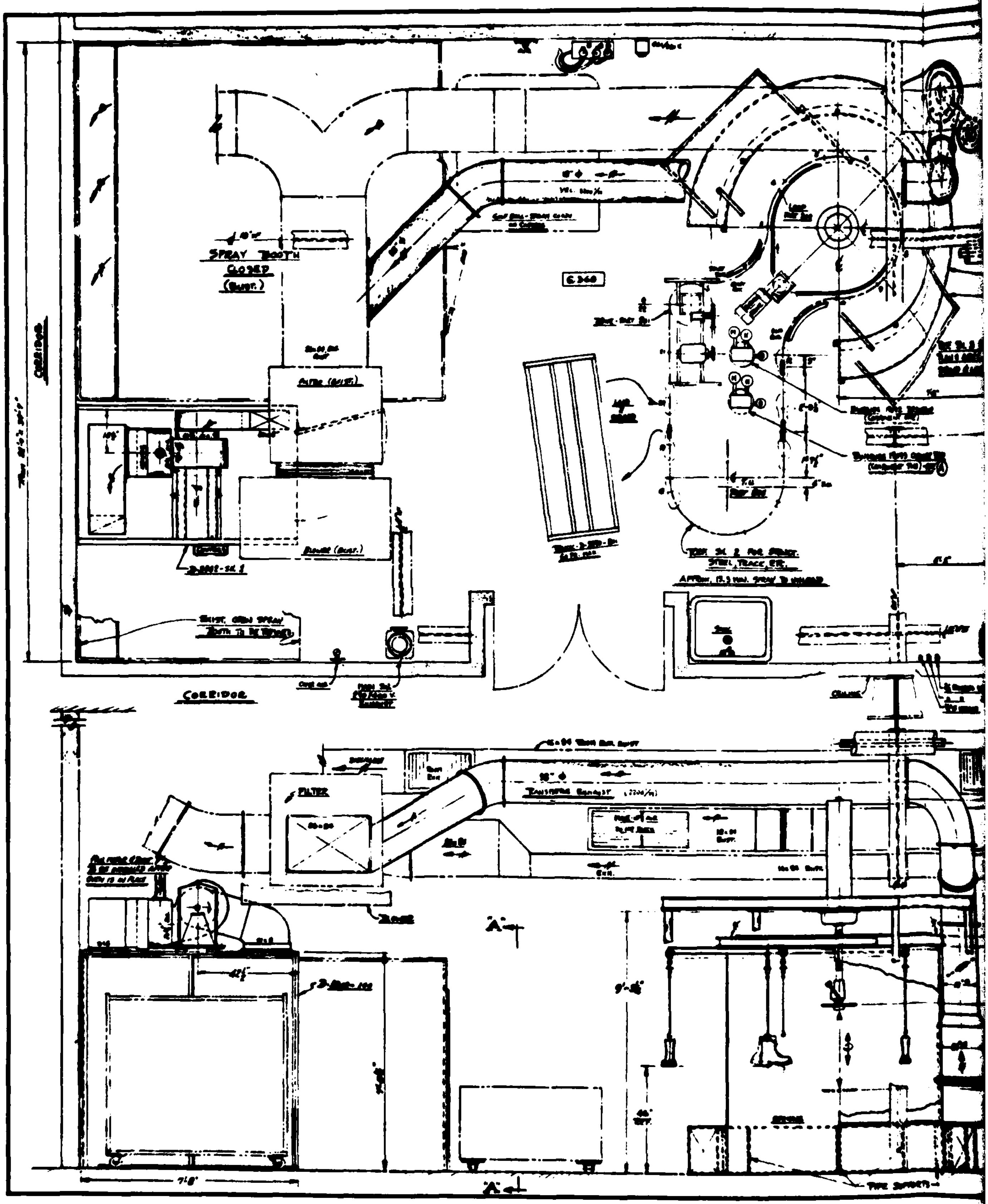

2-3/8" DRILL-WITH CT'SINK-9/16" DIA.
4-1/2"-20 TAP BY UNIROYAL
LOCATE AT ASSEM. WITH PART D-3151-501
SPRING CLIP
SPRING STEEL-GALVANIZED
1 REQ'D. .051" GA.
DOVETAIL TO BE FILED FOR
EASY ASSEMBLY
1/4" DIA. C.R.S. PIN-PRESS
FIT & FILE SMOOTH ON
OUTSIDE SURFACES
VIEW "B-B"
THESE SURFACES MUST BE PARALLEL
PARALLEL SURFACES
ALUMINUM CASTING
ALCOA ALUMINUM ALLOY #108
IN ADDITION TO ALUMINUM ALLOY #108 CONSISTS OF
BAL. 87.26% ALUM.
UNIROYAL, Inc.
ELECTROSTATIC SPRAY LAST
FOR GOV'T. BOOT
MENS SIZE 10
DATE
REVISION
BY
APP.
SCALE
SHEET NO.
DWG. NO.
D-3154

Figure 7



SPRAY BOOTH
CLOSED
(EXIST.)
CORRIDOR
FILTER
BLOWER
CORRIDOR
FILTER
"A"
"A"

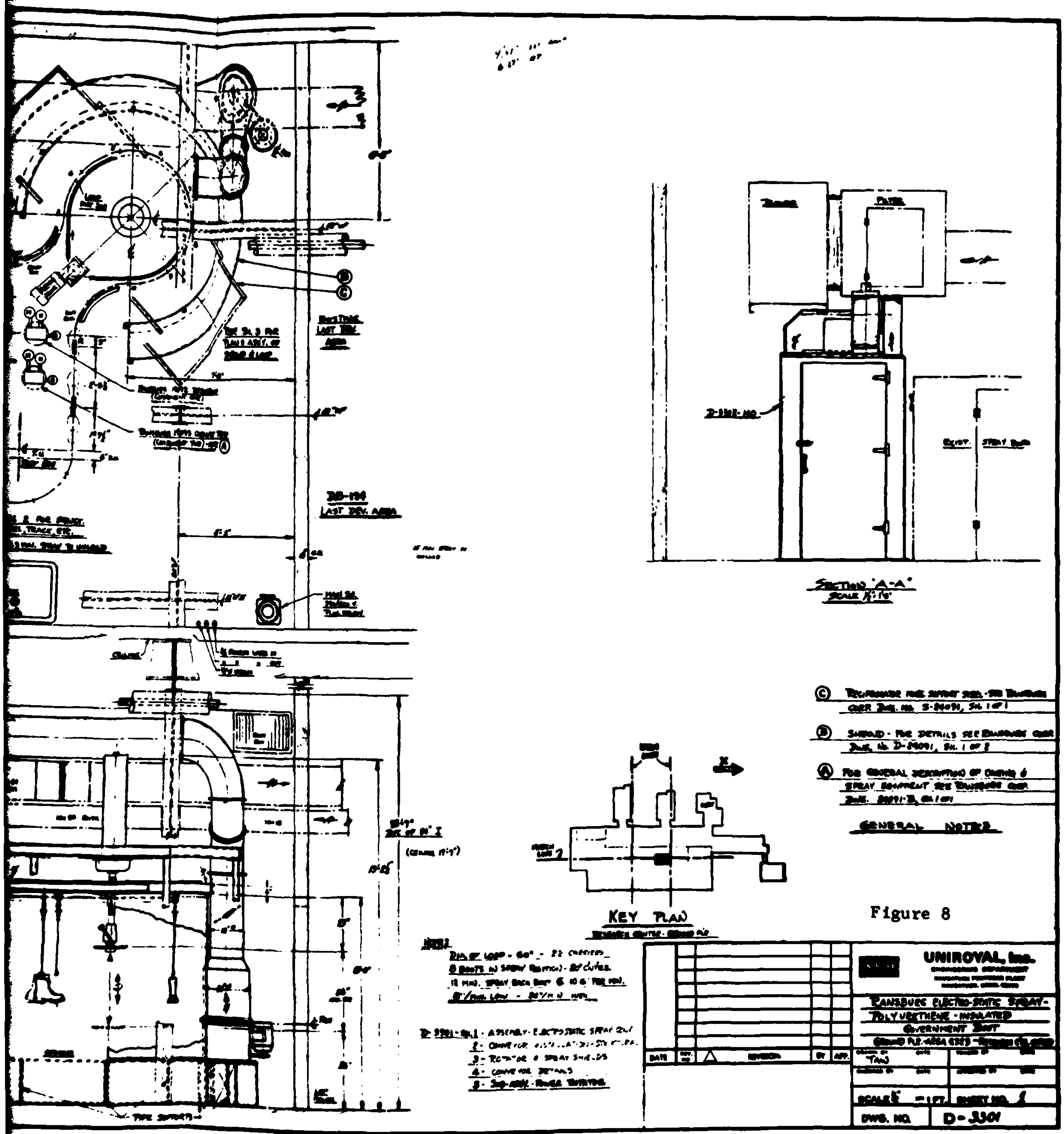
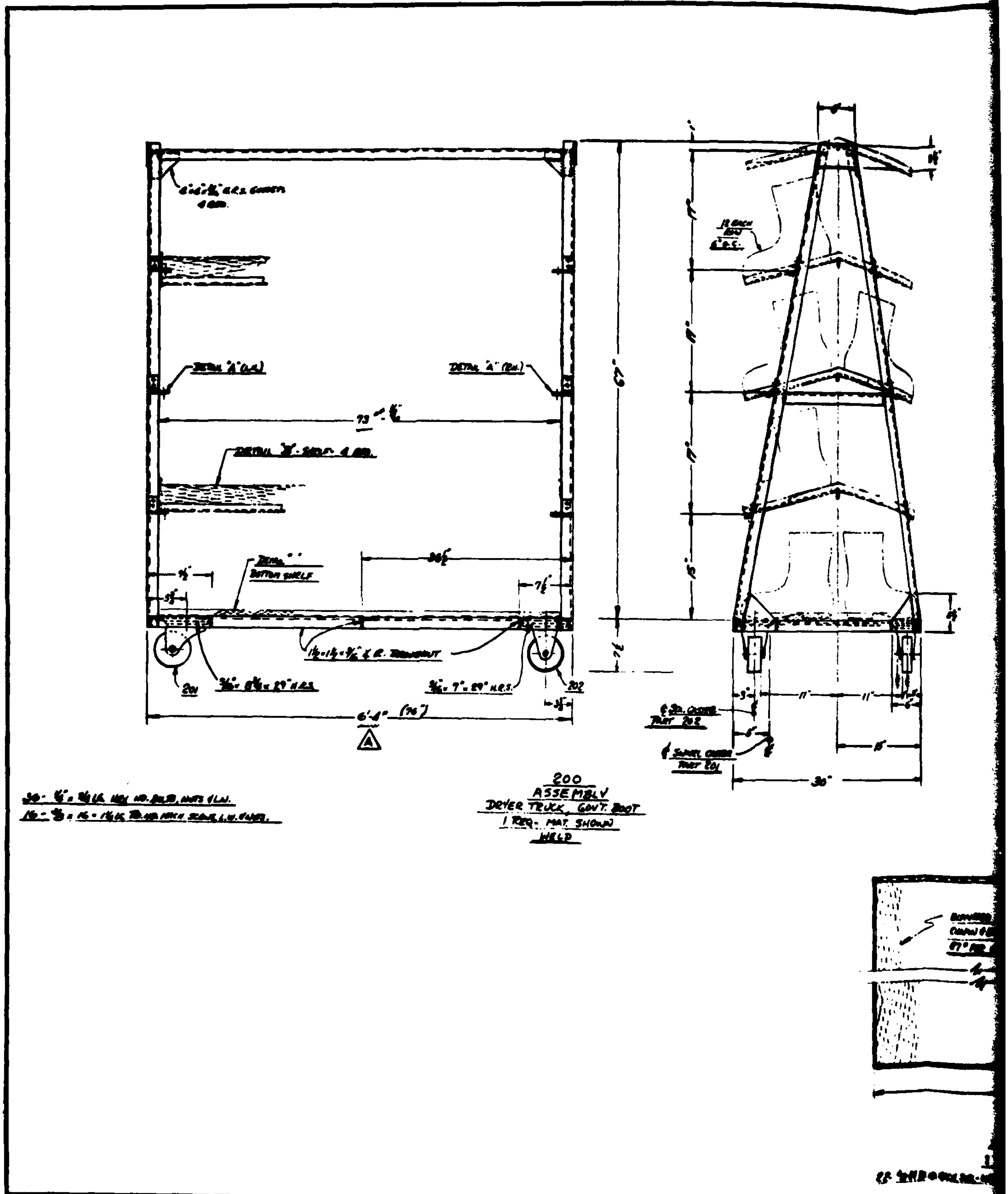
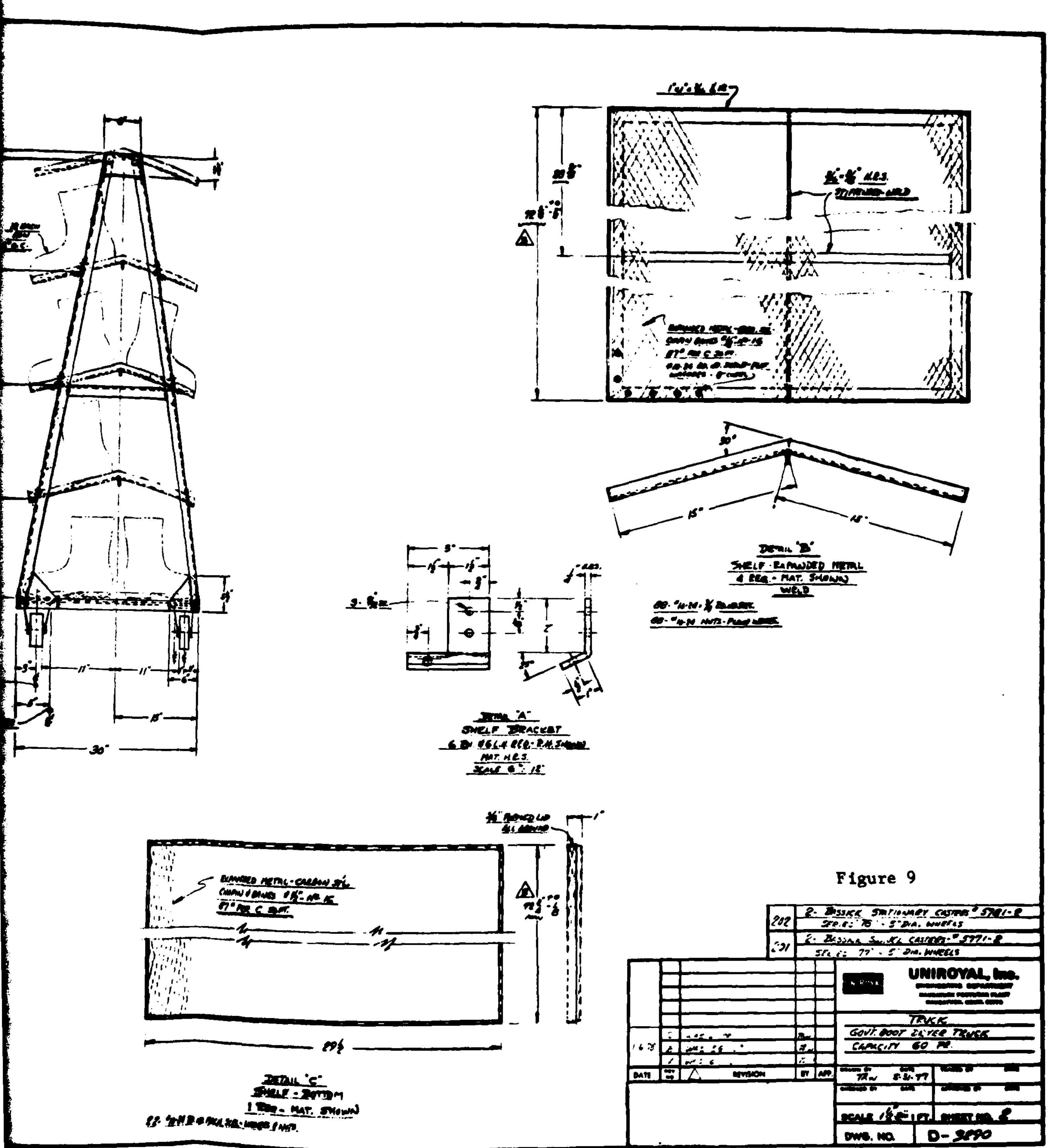

SECTION 'A-A'
KEY PLAN
GENERAL NOTES
UNIROYAL, Inc.
RANSBURG ELECTRO-STATIC SPRAY-
POLYURETHENE-INSULATED
GOVERNMENT BOOT
DWG. NO.
D-3301

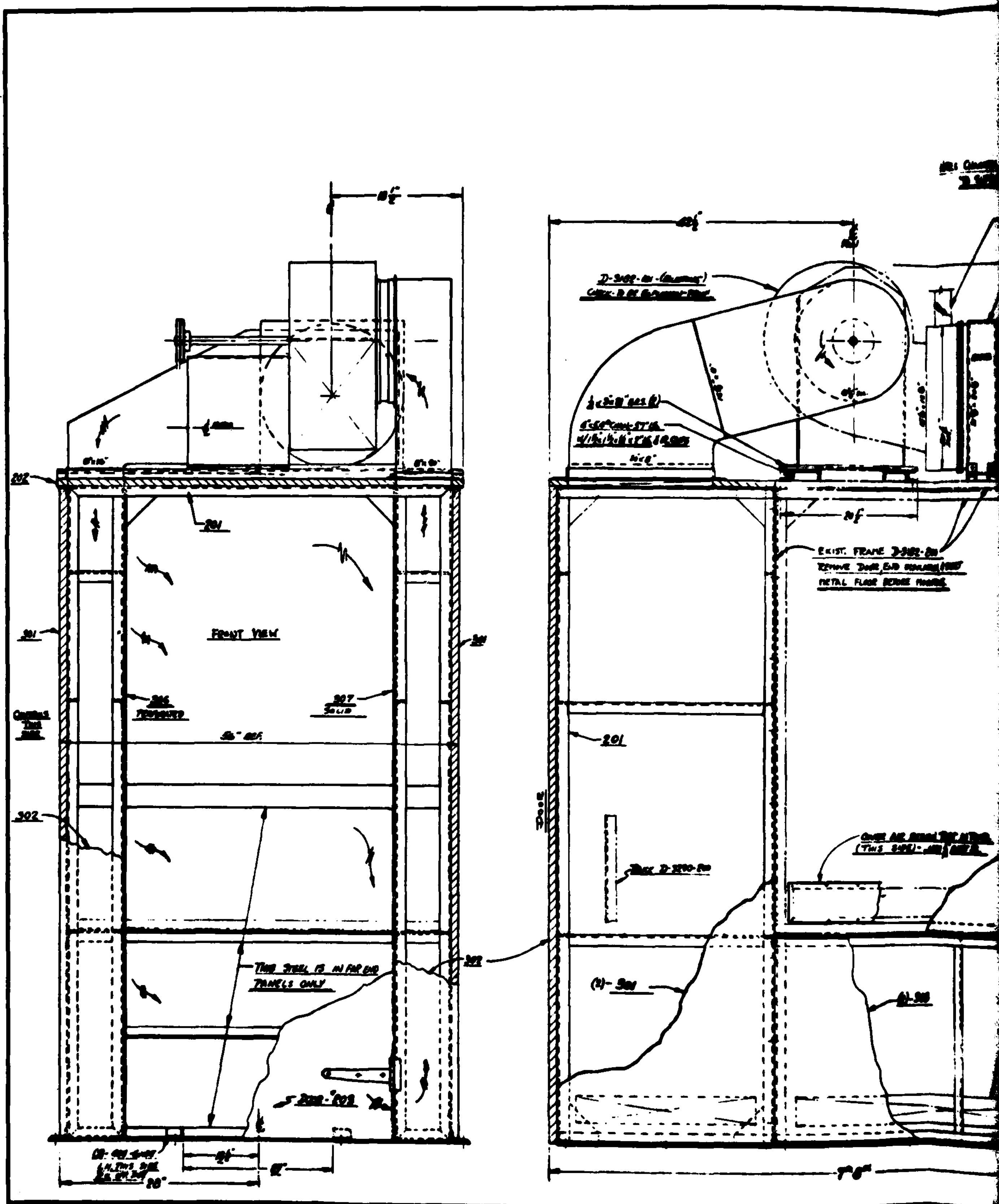
Figure 8

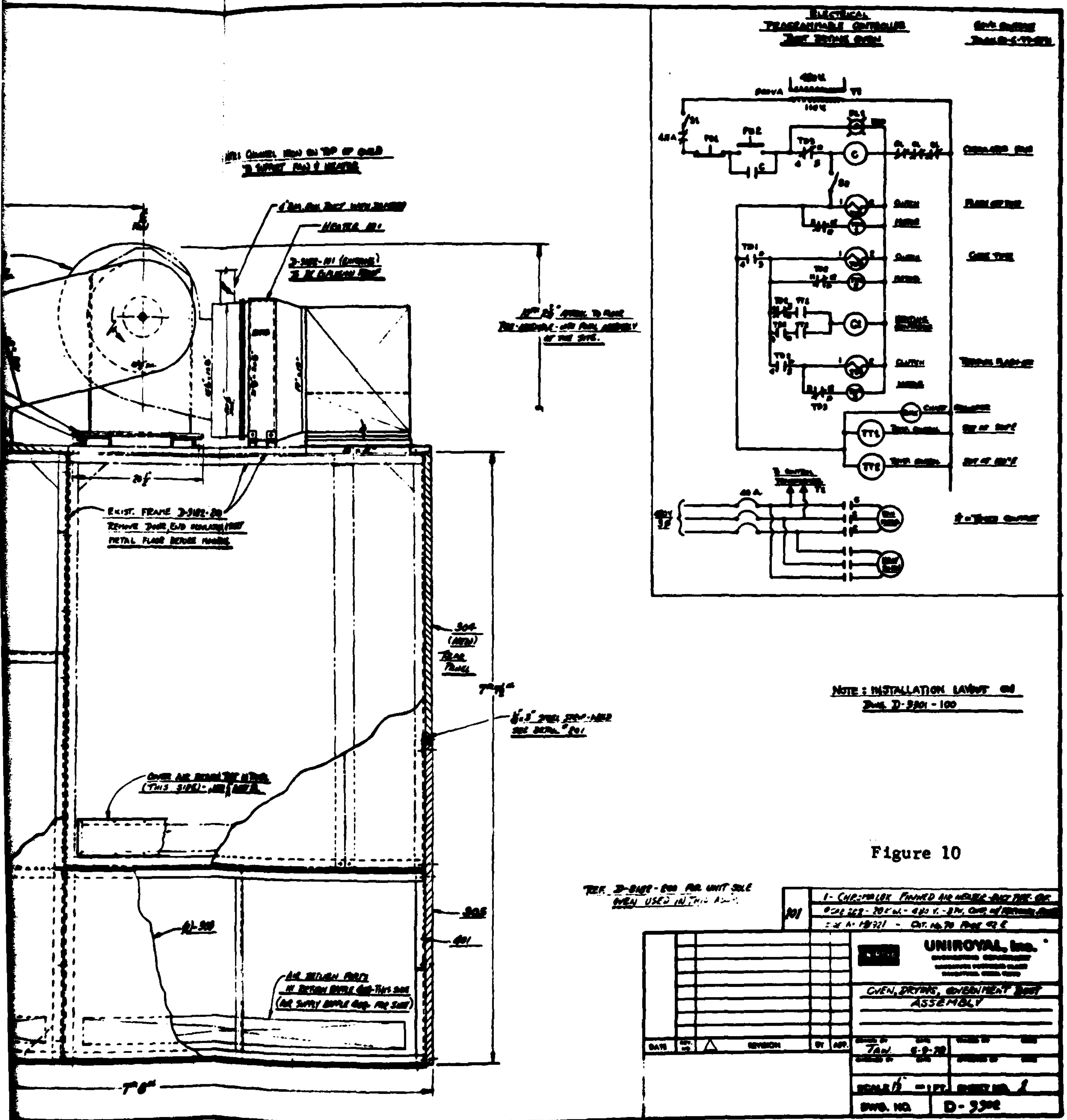

200
ASSEMBLY
DRYER TRUCK, GOVT. BOOT
1 REQ. MAT. SHOWN
WELD
DETAIL "A" (L.H.)
DETAIL "A" (R.H.)
BOTTOM SHELF
6'-4" (76")
30"
201
202



DETAIL 'B'
SHELF - EXPANDED METAL
4 REQ. - MAT. SHOWN
WELD
DETAIL 'A'
SHELF BRACKET
MAT. H.R.S.
DETAIL 'C'
SHELF - BOTTOM
1 REQ. - MAT. SHOWN
UNIROYAL, Inc.
TRUCK
GOVT. BOOT DRYER TRUCK
CAPACITY 60 PR.
DATE
REVISION
BY
APP.
SCALE
SHEET NO. 2
DWG. NO.
D-3890

Figure 9

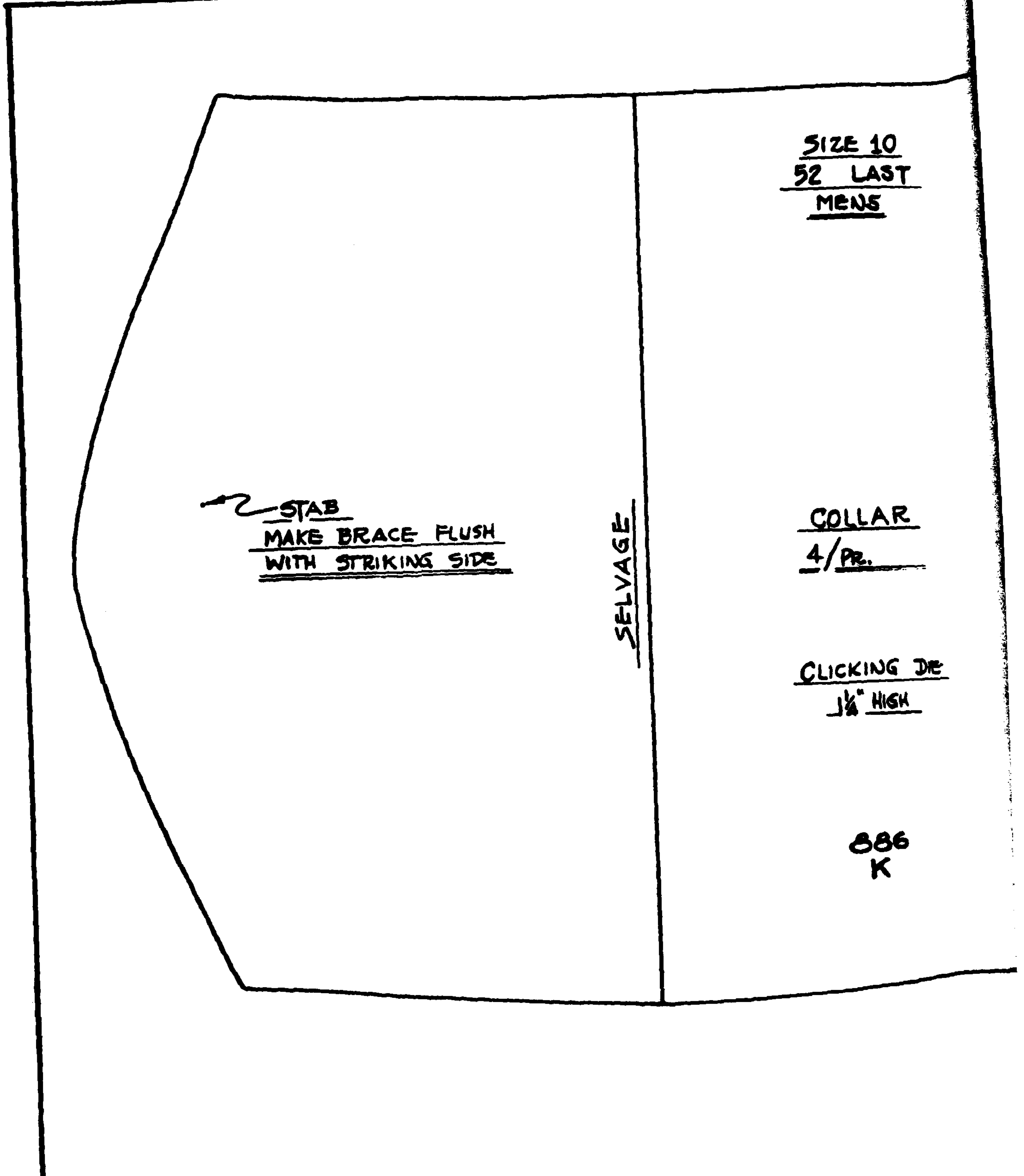

FRONT VIEW
THIS STEEL IS IN FAR END PANELS ONLY
EXIST. FRAME
REMOVE DOOR, END
METAL FLOOR BEFORE
201
202
301
302
307
SOLID



ELECTRICAL
PROGRAMMABLE CONTROLLER
HEATER 101
EXIST. FRAME
NOTE : INSTALLATION LAYOUT ON
DWG. D-3301 - 100
UNIROYAL, Inc.
OVEN, DRYING, ENVIRONMENT TEST
ASSEMBLY
DATE
REVISION
SCALE
DWG. NO.

Figure 10

The boot is then hot-air cured at 250°F (121°C) for 24 minutes. The oven temperature is then lowered to 160°F (71°C) for final solvent evaporation. The boots are left in the oven for 10 hours to assure complete solvent evaporation. After the boots are removed from the final solvent evaporation oven, they are allowed to cool at room temperature for one hour. The metal support form and polyethylene spray mask are removed from the boot, and the boot is returned to the boot dryer truck. The boots are then trimmed to the proper height 10-1/4" (26 cm) minimum. After trimming, the boot is moved to the finishing area where the snow collar (Figure 11) is attached. In the collar operation, the appropriate size collar is clicker cut from roll stock 1830/1 black, urethane coated nylon tricot weighing $4.8\ {}^{+0.5}_{-0.3}$ ounces per square yard ($163\ {}^{+17}_{-10}$ grams per square meter), using dies graded from the size 10R cutting pattern. After cutting, the collar is eyeletted, centered to a die-cut location hole (shown in Figure 11 marked "Stab" (see Figure 11) using a United Shoe Machine Model "C" eyeleteer with washer-type eyelets. There are two eyelets and two washers per collar, and the eyelet must be on the nylon tricot. The bottom of the half side panel of the collar is turn ½" (1.27cm) and single-stitched with #69 nylon thread (Threads, Inc.). With a one-half (side) part of the collar laid flat, nylon side up, and the eyelet to the left, and size notches to the bottom, the contractual markings -- size, width, manufacturer's code, month/year of manufacture, and contract number -- are to be stamped onto the part at a location which is approximately 1" (2.54 cm) below the eyelet and centered within this area. White ink is to be used. With this side panel so stamped and placed, a mated side panel (not stamped) is placed over the first side, nylon to nylon. The curved side edges are then single-needle, lock-stitched together, using a Singer Model "168" post-seamer stitching machine. A stitching margin of 1/8" (0.32 cm) and a setting of eight stitches per inch are to be maintained. With the eyelets centered to the front of the boot top, the inside edge of the collar overlapping the inside top edge of the boot with a 1/4" (0.65 cm) margin, using an Ozan overedge sewing machine set at 6 stitches per inch. A 36" (91.44 cm) black tubular cotton shoe lace with black acetate tip is inserted through the eyelet, looping it around the collar. The top part of the collar is folded down overlapping the top outside edge of the boot by 3/4" (1.9 cm) and zig-zag stitched at 6 stitches per inch with a 1/8" (0.32 cm) minimum and a 1/2" (1.27 cm) maximum stitching overlap using a Singer Model "107W50" sewing machine. At the back seam of the collar, approximately 1" (2.54 cm) down from the folded top edge and lace, the collar is bar-tack stitched together,


STAB
MAKE BRACE FLUSH
WITH STRIKING SIDE
SELVAGE
SIZE 10
52 LAST
MENS
COLLAR
4/PR.
CLICKING DIE
1¼" HIGH
886
K

115

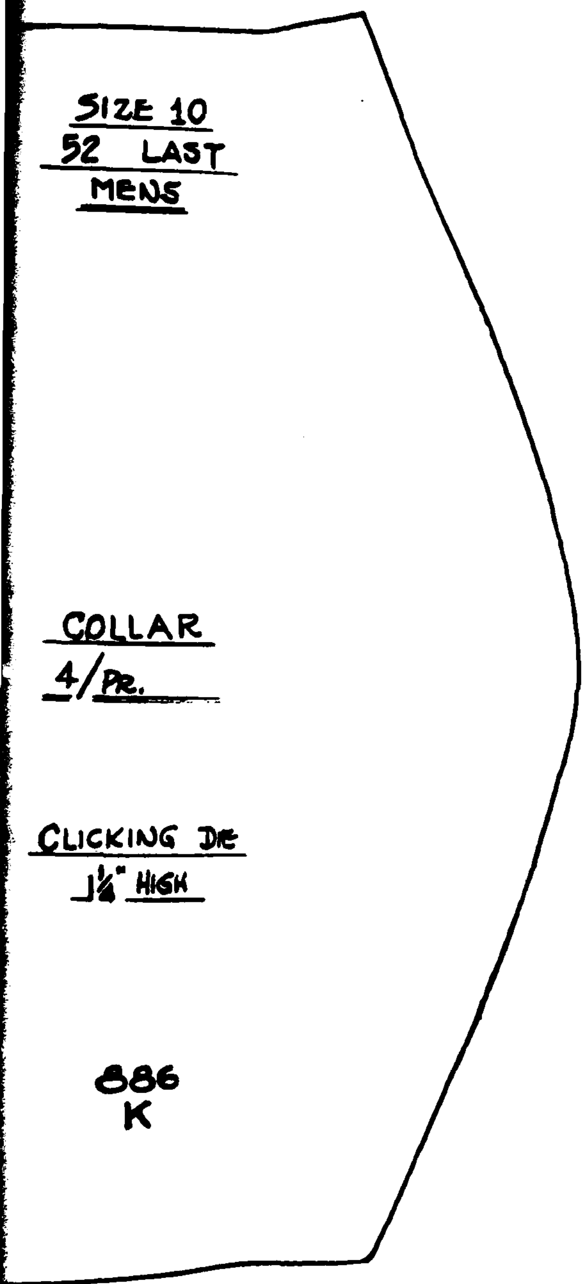


Figure 11

UNIROYAL, Inc.
ENGINEERING DEPARTMENT
NAUGATUCK FOOTWEAR PLANT
NAUGATUCK, CONN. 06770

INSULATED BOOT
"SNOW COLLAR" CUTTING PATTERN

DRAWN BY	DATE	APPROVED BY	DATE
TAW	8-30-77		

SCALE 12" = 1 FT. SHEET NO. 2

DWG. NO. D-052777

DATE	REV. NO.	REVISION	BY	APP.

2

horizontally to the top edge for a distance of approximately 1" (2.54 cm) using a Singer Model 269 bar tacker sewing machine. Each end of the lace is then double-loop tied, to prevent it from pulling back through the eyelet.

Approved boots thus finished are final inspected, mated left foot to right foot of the same size and width, the nylon collar and lace turned down inside the boot and transported to the packing area.

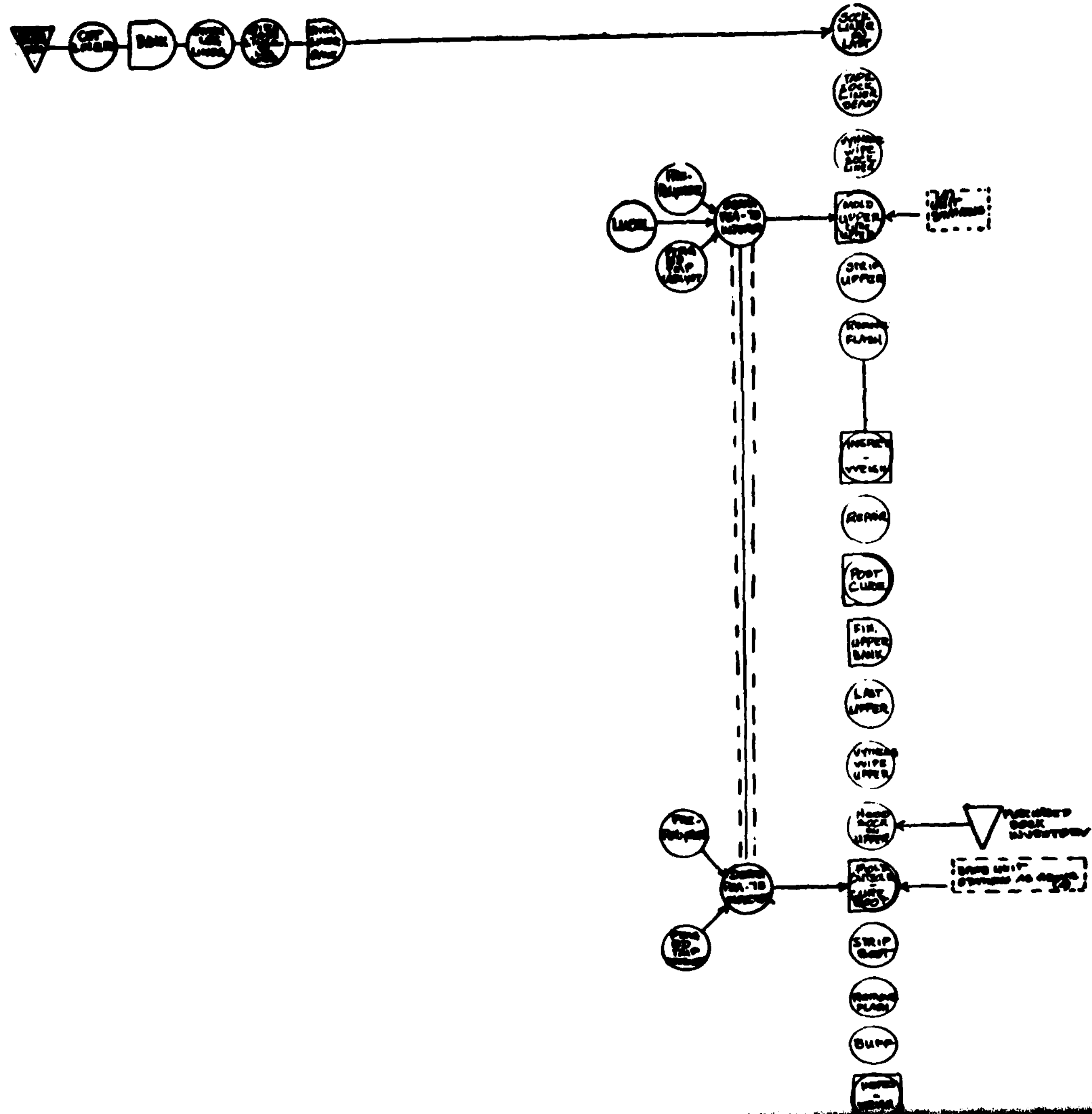
II. PRODUCTION PROCESS DESCRIPTION AND REQUIRED EQUIPMENT

The following process outline and attached operations process flow chart (Figure 12) cover the processing sequence and required equipment necessary to produce lightweight insulated boots. An equipment floor plan was previously shown in Figure 3.

1. Prepare Socklining

All fabric cutting of the urethane coated nylon fabric for the legliner is performed at UNIROYAL's Dublin, Georgia Plant using UNIROYAL equipment and the parts are shipped to the manufacturing area in Middlebury, CT.

SOCK AND LEG LINER PREPARATION



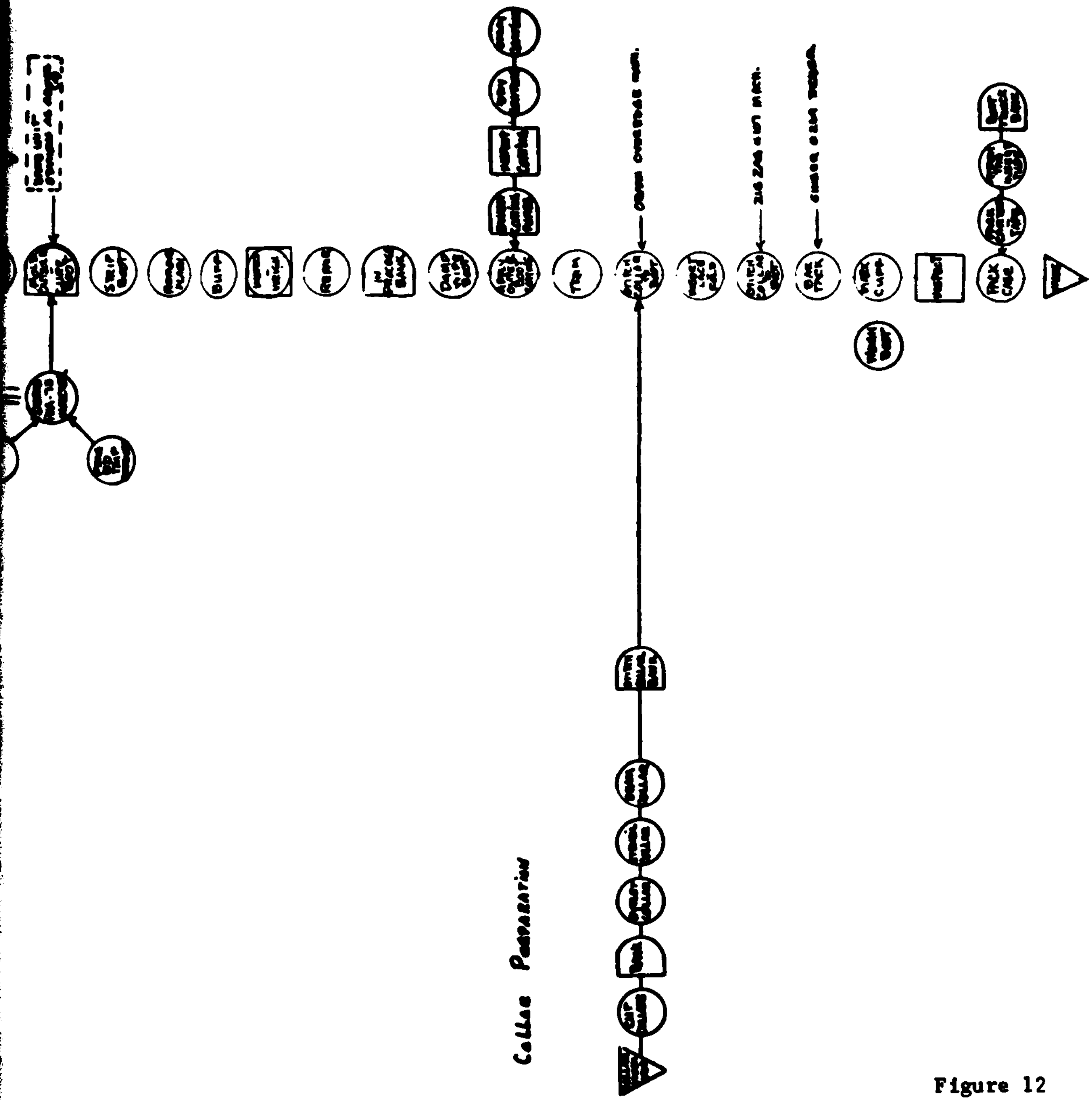


Figure 12

The operations involved are as follows:

(1) Mount roll on let-off.

(2) Ply up fabric on lay-up table.

(3) Cut sock liner (Figure 4) to desired size (Table 1).

(4) Cut leg liner (Figure 4) to desired size (Table 1).

FABRIC CUTTING DIES

TABLE #1

This table lists the fabric cutting dies corresponding to boot size.

Boot Size	Leg Liner Die	Sock Liner Die	Collar Die
8W	CM 1391 8H	CM 1390 8H	CM 1368 8I
9W	CM 1391 9I	CM 1390 9I	CM 1368 9I
9R	CM 1367 9I	CM 1352 9/9	CM 1368 9I
10R	CM 1367 10J	CM 1352 10/10	CM 1368 10J
11R	CM 1367 11K	CM 1352 11/11	CM 1368 11K
14XW	CM 1397 14N	CM 1396 14N	CM 1398 14N

Prepare Socklining (Continued)

(5) Close stitch legliner.

(6) Join sockliner.

(7) Deliver liner to upper molding area storage.

OPERATION	EQUIPMENT
Cut Socklining parts	Brockton Cutting Dies, 1¼" Steel
Clicker cut parts	Hudson Shoe Machinery Clicker, Model A-90
Close stitch legliner	Merrow Sewing Machine, Model A-3-3
Join legliner	Merrow Sewing Machine, Model A-3-3
Store stitched parts	Stitched Parts Storage Trucks, UNIROYAL Property (Figure 13)

2. Produce Upper

The operations involved are as follows:

A. Compound Hardener (Upper Component "B")

(1)Melt down base polymer.

(2) Weigh and add ingredients to mix tank (Figure A-1).

(3) Transfer heated compound to foam machine.

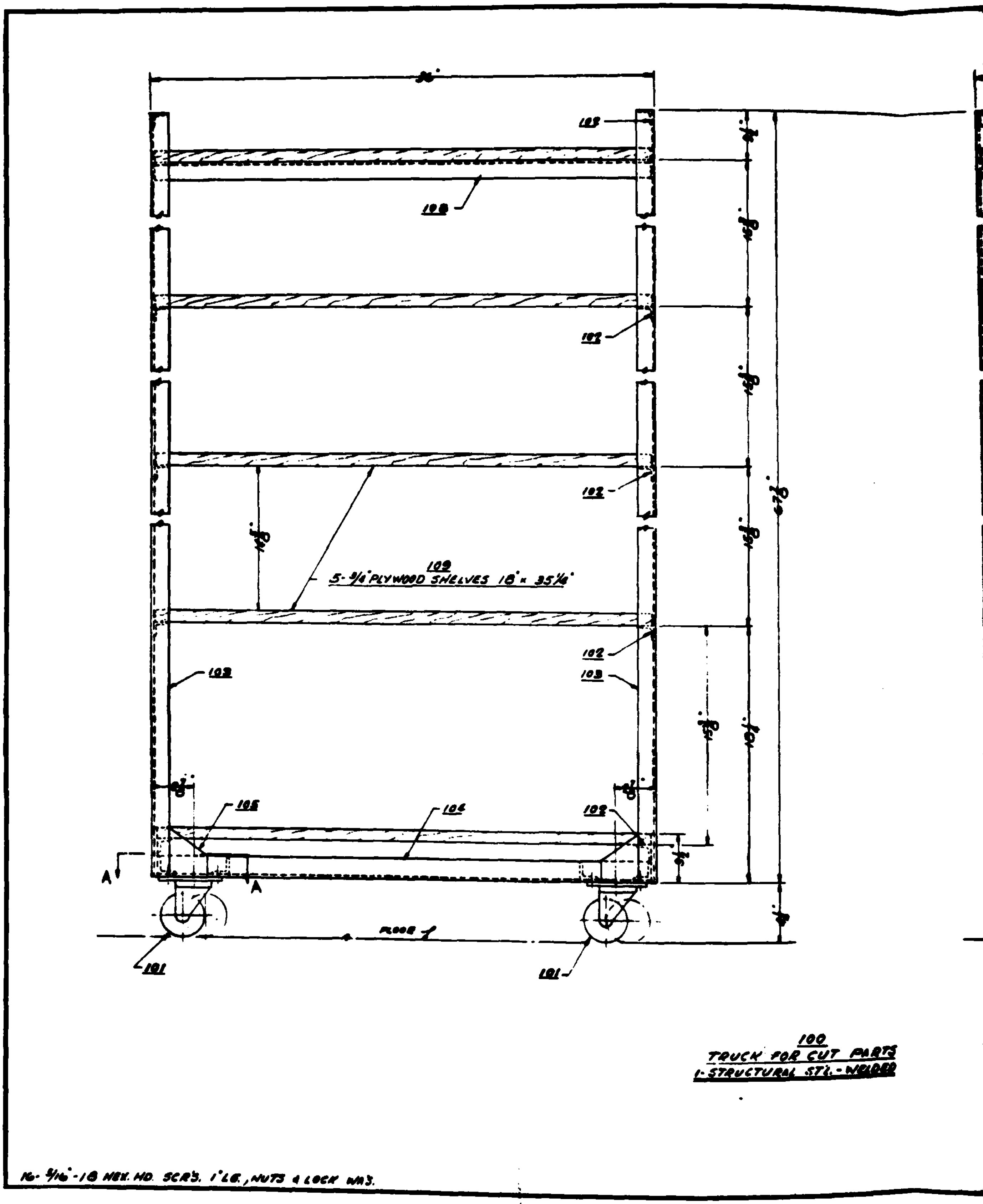
B. Compound Prepolymer (Upper Component "A")

(1) Take prepolymer from cooler.

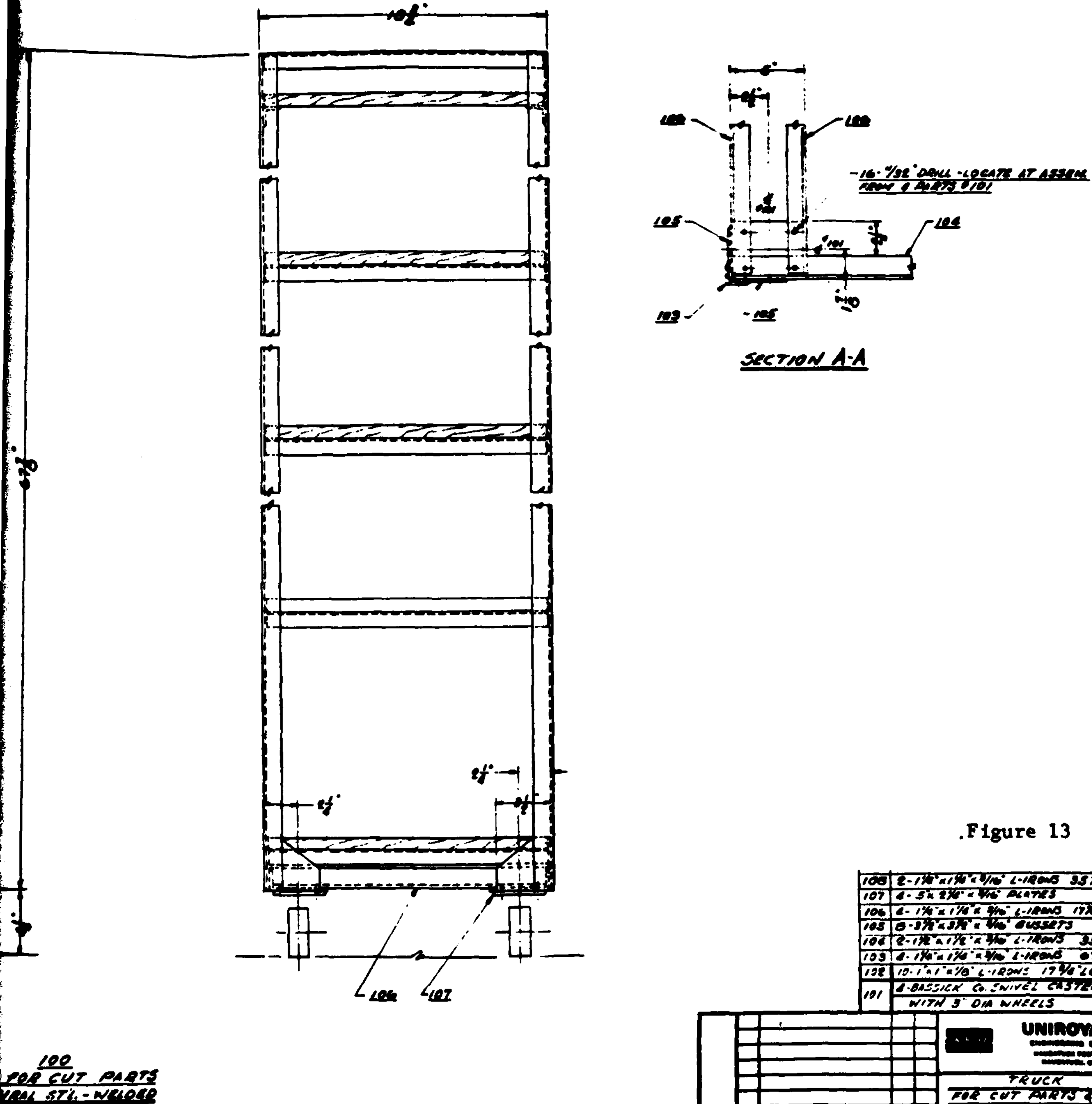
(2) Melt down prepolymer (Figure A-2).

(3) Add prepolymer to mix tank (Figure A-3).

(4) Transfer heated compound to foam machine.



109
5-3/4" PLYWOOD SHELVES 18" x 35½"
108
102
103
105
104
101
FLOOR
A
A
100
TRUCK FOR CUT PARTS
1-STRUCTURAL STL.-WELDED
16-5/16"-18 HEX. HD. SCR'S. 1" LG., NUTS & LOCK WA'S.



.Figure 13

108	2-1⅛"x1⅛"x³⁄₁₆" L-IRONS 35⅞" LG.
107	4-5"x2⅞"x³⁄₁₆" PLATES
106	4-1⅛"x1⅛"x³⁄₁₆" L-IRONS 17⅞" LG.
105	8-3½"x3½"x³⁄₁₆" GUSSETS
104	2-1½"x1½"x³⁄₁₆" L-IRONS 35⅞" LG.
103	4-1⅛"x1⅛"x³⁄₁₆" L-IRONS 67⅞" LG.
102	10-1"x1"x⅛" L-IRONS 17⅛" LG.
101	4-BASSICK Co. SWIVEL CASTERS #[illegible] WITH 3" DIA WHEELS

UNIROYAL, Inc.	
TRUCK FOR CUT PARTS & STITCHING BASKET	
G.H.K. 3-8-77	
SCALE 3" = 1 FT.	SHEET NO. 1
DWG. NO.	D-3290

2

C. Compound Blowing Agent (Upper Component "C")

(1) Take blowing agent from freezer.

(2) Add ingredients to compound mix tank.

(3) Transfer chilled compound to foam machine.

D. Set up Mold Station (Figure A-4)

(1) Mount mold (Figures 5 and A-5; Tables A-1 and A-2) in station.

(2) Heat molds.

(3) Hood sockliner, tape, wipe with vythene.

(4) Close mold.

E. Set up Foam Machine (Figure 6)

(1) Set all control temperatures. (A and B component @ 100°C, C Component @ 10°C).

(2) Check ratios.

(3) Make trial foam cup.

F. Make Upper

(1) Inject foam.

(2) Cure; strip from last.

Truck drum of base resin for the "B" Component to oven area and put on the drum rollator for melting and mixing. Push the rollator into oven and heat until resin is completely melted. Weigh resin and other components into electrically heated mixing tank (Figure A-1). Agitate and heat compound to the supply temperature. Truck the mix tank to the foam machine. Transfer the compound material with nitrogen pressure to the supply tank of foam mixing machine.

Warm the containers of prepolymer ("A" Component) in hot water bath (Figure A-2). Weigh prepolymer into the electrically heated mix tank (Figure A-3). Heat and agitate material to the supply temperature (100 ^{o}C). Truck mix tank to foam machine. Transfer with nitrogen pressure to the supply tank of the foam machine.

Take the blowing agent from the storage freezer. Weigh blowing agent and other ingrediants into the cooled, jacketed mix tank. Agitate and cool until the supply temperature is reached. Transfer with nitrogen pressure to the supply tank of foam machine.

Mount proper size mold rings, outsole plate, and last into the mold unit station (Figure A-4). Turn on heat and bring mold to the desired temperature. Hood sockliner on the last and hook-over pins at top. Tape stitched seams. Close mold.

Activate foam machine and set temperature controls on heat exchangers to control compound temperatures. Check flow rates of all three compounds to determine if proper ratio is set. Set mixing screw to proper set back, and run a foam cup batch to check foam quality.

If all checks are within specifications, inject foam into mold cavity. Allow proper cure time, then open mold, strip part, and put on storage rack.

EQUIPMENT REQUIRED

OPERATION	MODEL USED
Warm Drum Storage	Dispatch Oven, Model RS5HD
Truck Drums	Dosier Equipment Co., Drum Trucks
Rollate Drum	Morse Manufacturing Co., Model 5154 Rollator
Weigh (Grams)	Torsion Balance Co., Model PL-12 Balance
Weigh (Pounds)	Toledo Scale Company, Model 2081
Pressure Feed with Nitrogen	Local Supplier, Nitrogen Cylinders
Melt Down Prepolymer	UNIROYAL Design Tank D-3287
Mix and Heat Compound	Electric Heater Company, Tank 78-2087-1
Mix and Cool Compound	Electric Heater Company, Tank 78-2087-5
Mix and compound room	UNIROYAL Design Room
Mix and inject foam	Desma, GMBH, PSA-73 Foam Machine
Low Temperature Storage	Polar Cooler Mfg., 6' x 6' x 6' Walk-In Cooler
Truck compound Material	Divine Brothers Company, 2' x 4' Truck
Inject into boot mold	UNIROYAL Design Mold Station, D-3301
	Wellman Corporation, UNIROYAL Designed Molds
Exhaust Fumes	Fabricate to suit

3. Release Coat Upper - Hood Tube Sock

The operation involved are as follows:

(A) Trim and buff upper

(1) Scissor Trim

(2) Grind off flash

(B) Form Spray Masks

(1) Cut blank

(2) Load vac form unit

(3) Heat stock and form

(4) Strip and trim

(C) Spray release on Upper

(1) Clamp mask to upper

(2) Spray release coat

(3) Dry upper

Before the foamed upper can be release-coated, it must be trimmed and buffed. Scissors are used to remove excess flash, and final trim is accomplished with a buffer.

In order to control the areas on which the mold release is to be applied, a spray mask is used. It is made of polyethylene and is shaped by vacuum-forming it over a shape duplicating the outer contour of the boot upper. It is then stripped and trimmed leaving a flange than can be clamped to hold the mask to the upper. The release coat is applied with a pressure cup spray gun using just enough material to form a continuous film. The coating is then allowed to dry tack free to the storage truck. The fabric tube sock is then hooded over the foam upper.

OPERATION	MODEL USED
Vac Form Spray Mask	AmPac Company, Model 4005W Vac Former
Spray Release Agent	Dayton Electrical Mfg. Spray Gun 22-366
Buff Boot Flash	Local Mill Supply, Dremmel Tool Set

4. Apply Outsole to Upper

The operations involved are as follows:

A. Drain "A" & "B" Component supply tanks on foam machine.

(1) Flush tanks to remove residual compound.

B. Compound Outsole Hardener

(1) Melt down base polymer.

(2) Weigh and add all ingrediants into mix tank (Figure A-1).

(3) Transfer heated compound to foam machine.

C. Compound Outsole Prepolymer

(1) Take prepolymer from cooler

(2) Melt down prepolymer (Figure A-2)

(3) Add prepolymer to mix tank (Figure A-3)

(4) Transfer heated compound to foam machine.

D. Set Up Mold Station (Figure A-4)

(1) Mount mold in station (Figure 5)

(2) Heat Molds

(3) Relast Upper

(4) Close mold

E. Set up foam machine (Figure 6)

(1) Set all control temperatures.

(2) Check ratios.

(3) Make trial foam cup.

F. Make Outsole

(1) Inject foam.

(2) Cure Strip.

Since both the "A" and "B" components in the outsole are different than the upper components, the supply pots must be thoroughly cleaned before switching compounds. Truck drum of base resin for the "B" component to oven and put on rollator. Push rollator into oven and heat until resin is completely melted. Weigh resin and other components into electrically heated mixing tank (Figure A-1). Agitate and heat compound to supply temperature. Transfer with nitrogen pressure to supply tank of foam mixing machine.

Warm containers of prepolymer ("A" Component) in hot water bath (Figure A-2). Weigh prepolymer into electrically heated mix tank (Figure A-3). Heat and agitate material to supply temperature. Transfer with nitrogen pressure to supply tank of the foam machine.

Mount proper size mold rings, outsole plate and last into mold station (Figure A-4). Turn on heat and bring mold to desired temperature (93°C). Relast foamed upper and close mold. Activate foam machine and set temperature controllers on heat exchangers to control compound temperature. Check flow rates of both "A" and "B" components to determine if proper ratio is set. Set mixing screw to proper set back and run a cup batch to check foam quality.

If all checks are positive, inject foam into mold. Allow proper cure time, then open mold, strip part, and put on storage rack.

EQUIPMENT REQUIRED

OPERATION	MODEL USED
Warm Drum Storage	Dispatch Oven, UNIROYAL Property
Truck Drums	Dosier Equipment Co., 55-Gallon Drum Trucks
Rollate Drum	Morse Manufacturing Co., Model-5154 Rollator
Weigh (Grams)	Torsion Balance Co., Model PL-12
Weigh (Pounds)	Toledo Scale Co., Model 2081
Pressure Feed with Nitrogen	Local Supplier, Nitrogen Cylinders
Melt Down Prepolymer	UNIROYAL Design Tank D-3287
Mix and Heat Compound	Electric Heater Company, Tank 78-2087-1
Mix and Cool Compound	Electric Heater Company, Tank 78-2087-5
Mix in Compound Room	UNIROYAL Design Room
Mix and Inject Foam	Desma, GMBH, PSA-73
Low Temperature Storage	Polar Cooler Mfg., 6' x 6' x 6' Walk-In Cooler
Truck compound Material	Divine Brothers Company, 2' x 4' Truck
Inject into bood mold	UNIROYAL Design Station, D-3301
	Wellman Corporation, UNIROYAL Designed Molds
Exhaust Fumes	Fabricate to Suit

Specifications covering the foam mixing unit, the mold station, and boot molds are included in Appendix A. Detailed prints are included in the Instruction Manual 2.[1]

5. Apply Outerskin

The operations involved are as follows:

A. Compound Prepolymer

(1) Take prepolymer from cooler.

(2) Melt down prepolymer (Figure A-2).

(3) Weigh and add all ingrediants into mix tank (Figure B-1).

(4) Transfer compound to supply tank (Figure B-2).

B. Compound Hardener

(1) Take prepolymer from cooler.

(2) Melt down prepolymer (Figure A-2).

(3) Weigh and add all ingrediants into mix tank (Figure B-1).

(4) Transfer compound to supply tank (Figure B-2).

C. Finish trim and inspect boot.

D. Last boot on metal form

(1) Break last at split section (Figure 7).

(2) Slip toe section into boot.

(3) Slip leg section into boot and join toe.

[1] J. H. Flood, Production of Insulated Footwear using Liquid Injection Molding Equipment. 2. Instruction Manual NATICK/TR-80/020, 1980.

(4) Place spray mask on outsole.

(5) Hang lasted boot on spray conveyor (Figure B-3).

E. <u>Set up electrostatic spray unit (Figure B-3)</u>

(1) Apply pressure to supply pot (Figure B-1).

(2) Start pumps and fill supply lines to disc.

(3) Check flow rate to determine ratio.

(4) Catch cup and measure gel time.

(5) Connect all supply lines.

5. F. <u>Electrostatically Spray Boots (Figure B-3)</u>

(1) Start monorail conveyor and supply pumps.

(2) Spray

(3) Flush disc

(4) Remove sprayed boot from conveyor.

(5) Place on drying truck (Figure 9) and push into oven (Figure 10).

(6) Dry and Cure.

(7) Remove truck from oven.

(8) Truck to finished area.

(9) Remove last and spray mask.

(10) Trim boot to proper height.

Warm the containers of prepolymer for the "A" component in hot water bath (Figure A-2). Weigh and transfer the prepolymer to the mix tank (Figure B-1), and dilute with solvent and agitate until a uniform mix is obtained. Transfer the compound to supply tank at the spray unit (Figure B-2).

Warm the container of prepolymer for the hardener component "B". (Figure A-2). Weigh and transfer the prepolymer to the mix tank (Figure B-1), and dilute with solvent. Add curative and agitate until a uniform mix is obtained. Transfer the compound to the supply tank at the spray unit (Figure B-2).

In preparation for spraying, the molded boot must be finish trimmed, and buffed at the joint line between the upper and outsole.

Lightweight aluminum metal forms constructed in two pieces; a toe section and a heel-leg section (Figure 7) are used to slip inside the foamed boot before spraying. This metal form acts as a negatively charged target for the positively charged spray particles since the boot itself is relatively non-conductive. After the forms are inserted, the boots are hung on the electrostatic spray monorail.

At the spray unit the compounded outer coating solution is fed from the mix container to the supply container by a pressure feed. After filling, a slight positive nitrogen pressure is kept on the supply container to insure the metering pump does not cavitate. The pump supply to the disc is started and the feed lines filled. A weight check is taken on both ingredients to insure that the proper ratio is being supplied to the disc and the gel time is checked. The supply lines are connected to the premixer at the disc.

The electrostatic unit is now activated, and the monorail carries the boots into the spray booth proper. As the boots enter they are rotated as well as moving through the booth. The cycle within the booth is ten minutes. When spraying is completed, the lines are flushed and the unit shut down. The sprayed boots are taken from the monorail and placed in the drying truck. The truck is pushed into the oven for drying and curing.

The truck is then removed from the oven and taken to the finishing area where the boots are stripped off the spray forms and the spray mask is removed. The boot is now ready for trimming to the proper height.

Additional information on the electrostatic spray process is included in Appendix B. Detailed prints of the system and all auxiliary equipment are included in the Instruction Manual. (Reference 2.)

Environmental impact data is contained in Appendix C.

EQUIPMENT REQUIRED

OPERATION	MODEL USED
Mix prepolymer Solution	Electric Heater Company, Tank 78-2087-3
Mix curative solution	Electric Heater Company, Tank 78-2987-3
Last upper on metal form	Wellman Company, UNIROYAL D-3154 last
Transfer prepolymer to supply tank	Electric Heater Company, Tank 78-2087-4
Transfer curative to supply tank	Electric Heater Company, Tank 78-2087-4
Electrostatically Spray Boot	Ransburg Corporation Spray Equipment
Dry Boots	UNIROYAL Design Oven D-3302
	UNIROYAL Design Truck D-3290-2

6. Attach Snow Collar

A. Trim boot to proper height.

B. Procure cut parts (coated fabric) from Dublin Plant following Steps in 1.

C. Eyelet Collar.

D. Stamp Collar with required information.

E. Turn collar halves

F. Lockstitch collar halves together.

G. Attach collar to boot.

The spray-coated boot is now trimmed to the proper height with a mechanical trimmer in preparation for attaching the snow collar.

The snow collars are cut to desired size with appropriate collar dies (Table 1).

Collar halves are processed through an eyelet machine inserting one eyelet in each half. With the half collar fabric side up, the collar is stamped using a rubber hand stamp and white ink with all required size and contract data. Both halves are turned using a flat-bed, single-needle sewing machine. The two halves are now joined together with a single-needle lock stitch using a post seamer. With the eyelets centered in front of the boot top, the snow collar is slipped over the top of the boot. The inside bottom edge of the collar is attached to the inside top edge of the boot using an over edge sewing machine. The lace is inserted through the eyelet and looped on the collar. The top part of the collar is folded down overlapping the top outside of the boot and zig-zag stitched. The back seam of the collar is bar-tack stitched to hold the lace in position. Each end of the lace is double-looped to prevent pulling back through the eyelet.

EQUIPMENT REQUIRED

OPERATION	MODEL USED
Trim top edge of boot	U.S. Shoe Machinery, Model B Trimmer
Eyelet snow collar half	U.S. Shoe Machine, Model B Eyelet Machine
Turn snow collar	Singer Corporation, Model 168WSV7
Join snow collar halves	Singer Corporation, Model 138WSVZ Machine
Overedge stitch collar to boot	Ozan Corporation, Overedge Machine
Zig-Zag stitch-collar to boot	Singer Corporation, Model 107W50 Machine
Bar Tack Collar	Singer Corporation, Model 269 Machine
Load parts in truck	UNIROYAL Design D-3290-1

7. Final Inspect and Pack

A. Check boot against acceptance standards. (Table D-1)

B. Gauge and weigh boot.

C. Fabricate carton for individual pair and stencil.

D. Pack pair with release paper wrap and tube.

E. Staple six-pair carton and stencil.

F. Pack six pair in carton; cement and tape.

G. Truck to warehouse.

Before packing boot, determine compliance with visual acceptance standards (Table D-1). Check gauge and weight. Assemble boot pair carton on case out table. Package pair as per specifications. Staple bottom flaps of six pair and close lid by cementing and then apply three-inch tape. Truck to warehouse with walking pallet truck.

EQUIPMENT REQUIRED

OPERATION	MODEL USED
Weigh Boot	Torsion Balance Company, Model PL-12 Balance
Gauge Boot	Starrett Instrument, Caliper
Staple Carton	McMaster Carr, Model 1954YZ Stapler
Tape Carton	Counterboy, Inc., Model, Tape Shooter Jr.

The listed equipment model numbers and sources are for reference purposes only, and are not to be considered the only sources available.

EQUIPMENT DESCRIPTION AND SPECIFICATIONS

	QUANTITY	DESCRIPTION	SOURCE	UTILITIES
1. FABRIC CUTTING				
(1) Cutting Press	1	Atom Model G-999	Hudson Shoe Machine	
*(2) Cutting Dies	6 sets	1¼" Steel Dies	Brockton Cutting Die	
(3) Cut Parts Trucks	3	UNIROYAL Design D-3290		
2. STITCHING				
(1) Post Seamer	1	Model 138 WSVZ	Singer Corporation	208V, 3ϕ.4A
(2) Eyelet Machine	1	Model "B" with telescopic hopper	U. S. Shoe Machine	½" ϕ Air, 220V, 3ϕ
(3) Overedge Machine	1	Overedge Stitching machine	Ozan Corporation	220V, 3ϕ, 4A
(4) Zig-Zag Machine	1	Model 107 W50	Singer Corporation	220V, 3ϕ, 4A
(5) Bar Tucker	1	Model 269	Singer Corporation	220V, 3ϕ, 4A
(6) Merrow Stitch	1	Style A-3-3	Merrow Sewing Machine	220V, 3ϕ, 4A
*(7) Stitched Parts Truck	3	UNIROYAL D-3290	UNIROYAL, Inc.	
Baskets	20			

	QUANTITY	DESCRIPTION	SOURCE	UTILITIES
3. VAC FORMING				
*(1) Vac Former	1	Model 400 SVA	AmPac Company	480V, 3ϕ, 13A, ½" ϕ Air
(2) Forming Model	6	Fabricate from boot uppers		
4. COMPOUND PREPARATION				
(1) Eight-drum Storage Oven	1	Model RS5HD	Dispatch Oven	Gas, 480V, 3ϕ, 115V, 1ϕ 15.6A
*(2) 55-Gallon Drum Rollator	2	Model 1-5154	Morse Manufacturing Company.	110V, 1ϕ, 7.8A
*(3) Cooler Storage	1	6' x 6' x 6' Walk-In	Polar Cooler Mfg.	110V, 1ϕ, 20A
*(4) MDI Prepolymer Melting Bath	1	UNIROYAL Design D-3287		220V/110V, 1ϕ, 30A
(5) 14 Cu-Ft Freezer	1		Local Supplier	110V, 1ϕ, 20A
*(6) 10' x 15' Enclosed Mixing Area	1			

*Denotes U. S. Government Equipment Purchased on Contract DAAK60-77-C-0071.

	QUANTITY	DESCRIPTION	SOURCE	UTILITIES
*(7) General Exhaust	1	Fabricate to suit area		
*(8) 3' x 8' Compound mixing bench with hood	1	Fabricate or purchase to suit area	Local Supplier	
*(9) Gram Scale (0-2 kg)	1	Model PL-12	Torsion Balance Co.	110V/1ϕ
*(10) 55-Gallon Drum Truck	1	55-Gallon Drum Truck	Dosier Equipment Co.	
(11) Flammable Liquid Storage Cabinet	1	UNIROYAL Design		Exhaust
(12) Solvent dispensing Cans - 1 Gallon	2	1-Gallon Solvent dispensing cans	Local Supplier	
(13) Safety Cans - 5 Gal.		5-Gallon Safety Cans	Local Supplier	
(14) Upper Component mixing tanks				
"A" Component	1	5-Gallon tank 78-2087-2 prepolymer mixing tank electrically heated with turbine type agitator, s.s. lined, 15 PSI pressure rated with safety valve and bottom outlet	Electric Heater Company	½" ϕ Air line, 110V, 1ϕ, 20A
*"B" Component	1	5-Gallon tank 78-2087-1, same as above	Electric Heater Co.	½" ϕ Air line, 110V, 1ϕ, 20A
*(C) Component	1	1-Gallon tank 78-2087-5, blowing agent mixing tank chilled water cooled, with turbine type agitator, 15 PSI pressure rated with safety valve and bottom outlet	Electric Heater Co.	½" ϕ Air Line, 110V, 1ϕ, 20A

	QUANTITY	DESCRIPTION	SOURCE	UTILITIES
(15) Outsole component mixing tanks *"A"		Same as upper component "A" component mix tank	Electric Heater Company	½" ϕ Air Line, 110V, 1ϕ, 2
*"B"		Same as upper component "B" component mix tank		
(16) Outerskin Mixing Tanks *"A"		10-Gallon tank 78-2087-3 curative mix tank, with turbine type agitator s.s. lines, 15 PSI pressure rated with safety valve and bottom outlet	Electric Heater	½" ϕ Air line
*"B" Component		10-Gallon tank 78-2087-3 Same as above		
*(17) Flat Bed Trucks	3	2' x 4' Flat Red Trucks	Divine Brothers, Company	
(18) Barrel Cradles		55-Gallon drum barrel cradle	Local Supplier	
(19) Floor Scale (0-75 lbs.)	1	Model 2081	Toledo Scale	
5. MOLDING AREA				
*(1) Foam machine and auxillary equipment	1	Model PSA 73	Desma GMBH	1/2" ϕ Air line, 480V, 3ϕ, 60A

	QUANTITY	DESCRIPTION	SOURCE	UTILITIES
*(2) Mold Station	4	UNIROYAL Design D-3300 See Figure A-4		½" ϕ Air Line 220/110V, 1ϕ60A
*(3) Boot Molds	6 Pair	UNIROYAL Design D-3300-2 See Figure 5		
*(4) General Exhaust	1	To suit building area and equipment locations		
*(5) Transport and drying truck	4	UNIROYAL Design D-3290-2 60 pr. truck		
(6) Flash buffer with dust collector	1	Baldor Grinder with stand and dust collector	Baldor Electric Company	110V, 1ϕ
(7) Repair Oven	1	Model RSHD4	Dispatch Oven	Gas, 480V, 3ϕ, 115V,1ϕ
*(8) Mold Storage Rack	1	UNIROYAL Design	Local Supplier	
*(9) Boot inspect and repair table with hood	1	Fabricate or purchase to suit area		
(10) Hand buffer	1	Dremmel Tool Set	Local Mill Supply House	110V, 1ϕ
*(11) Slab Molds	2	¼" x 5" x 12" and 3/4" x 5" x 12"	Local Supplier	

	QUANTITY	DESCRIPTION	SOURCE	UTILITIES
6. SPRAY COATING AREA				
*(1) Electrostatic coating unit complete with boot carriers, exhaust and supply tanks	1	Ransburg Design See Figure 8	Ransburg Electrostatic Equipment	480V, 3ϕ, 30A 220V, 3ϕ, 30A
*(2) Spray Forms	30 Pair	UNIROYAL Design D-3154 (See Figure 7)	Wellman Corporation	
(3) Work Table	2	36" x 72" Steel top bench	Fidelity Products	
(4) Dryer Trucks	3	See Item 5-(3)		
*(5) Drying Oven	1	UNIROYAL Design D-3302 See Appendix B		480V, 3ϕ, 30A
7. FINISHING				
(1) Snow collar markings	1	Model 1050	Markem Machine	110V, 1ϕ
(2) Boot Trimmer	1	Model B lining and trimming machine	U.S. Shoe	110V, 1ϕ, 4A
(3) Miscel Tables		As required		
8. PACKING AREA				
(1) Warehouse Trucks	2	UNIROYAL Design		
(2) Tape Dispenser	1			
(3) Case Stapler	1	Silver Stitcher	Acme Steel Company	110V, 1ϕ
(4) Caseout Table	1	UNIROYAL Design		
(5) Walking Pallet Truck	1			

IV. LINE TEST PROCEDURES

The equipment installation for producing lightweight insulated footwear was subjected to a line test procedure in the presence of the project officer to satisfy the requirements of the contract. The following trials were run:

1. Each piece of equipment was operated at a rate adequate to produce 60 pair of boots per week on a one-shift basis, as specified in the contract.
2. Three pair of boots in Sizes 8W and 14XW were molded to show the capability of the mold stations to handle the two extremes of the mold sizes purchased as part of this contract.
3. Two boots were made in successive shots in the same mold under the same process conditions. The boots after curing and cooling were sectioned and gauged at various points. The cross checks showed a 3-5% variation between boot gauges most of which is involved in measuring a cellular compressive material with calipers. The boots were well within the thickness tolerance for the specific areas listed in the contract specification (Table C-3), demonstrating the accuracy of the positive last location within the mold.
4. In making the boots for the various appearance and thickness checks, the capability of the mixing equipment to handle the upper and outsole compounds and make good quality foam was demonstrated.

The following contract requirements were demonstrated by the molding of good quality boots.

a. Ability to handle PTMG and quasi prepolymer compounds since both upper and outsole compounds are based on this type of systems.

b. Ability to meter and mix either a two-component or three-component foam system. The upper compound requires that a three-component system be processed and the outsole required that a two-component system be processed. Both compounds were used to make complete boots.

c. The supply pots, pumps, and feed lines were controlled at the specified temperatures with the "A" and "B" component set at elevated temperatures (100 °C) and the "C" component set at less than room temperature (10 °C).

d. Both sizes 8W and 14XW were shot in consecutive injections by changing the impulse counter on the foam unit which in turn controls the length of the shot time. Any combination of sizes can be run concurrently in the mold stations and all that is required is that the proper impulse count be set before injection.

e. In changing the foam machine over from the upper compound to the outsole compound the supply tanks were changed. The gear drives on the metering pumps were also changed so that the correct ratio of each component was then supplied to the mixer, thus demonstrating the ability to vary the ratio as required by the particular foam system being processed.

f. The boots made on consecutive shots in the same boot mold were weighed and varied by only five to ten grams on a total shot size of approximately 330 grams. If consecutive cup shots from the mixer are made, the variation is even less (1 to 2 grams on a shot of 100 grams) because flash loss and sprue size of the molded part are eliminated as loss factors. This indicates very precise shot size delivery. The accuracy of metering was further demonstrated by taking repetitive cup samples of each of the ingredients as supplied individually to the mixing head and weighing to show reproducability. Shot size varied by less than 1%.

5. The mixing head temperature is controlled by the temperature setting on the associated heat exchanger. The mixing nozzle is supplied with heat initially until the mixing and cleaning action of the screw during foam processing builds up heat. At this time cold water is called for to keep the mixing head at the set temperature demonstrating mixing head temperature control.

6. To demonstrate the temperature control on the mold unit stations the instrument settings were varied up and down and the temperatures of the molds were measured with a pyrometer to show the corresponding change. This is true for each station.

7. Boots were sprayed on the electrostatic spray equipment. Boots were pulled over the metal spray form and hung on the conveyor. Compounded materials were metered to the electrostatically charged spinning disc and the material was "sprayed" onto the boot. Some boots had a release agent applied over their surface prior to spraying so that the spray coating could be stripped and gauged.

Appearance of the sprayed boots was excellent and a thickness check showed the gauge variation is at the extreme toe or heel and the fact these areas are heavier gauge is inherent to the spray process, since these points come closest to the spray disc while being rotated during the spraying cycle.

V. PRODUCTION RATES

The equipment set up currently available will meet the contract requirements of producing 60 pair per week on a one-shift, five-days-a-week production basis.

The factor in producing boots is the molding cycle and the fact that there is only one foam mixing machine available. Since the upper and outsole compounds are different chemically and run at different densities, it is necessary to run uppers for a period of time to build a reasonable bank. After this has been accomplished, the foam machine is switched over to the outsole compound, the uppers are relasted, and the outsoles injected to form the complete foam boot.

The current cycle for curing both the upper and outsole is 15 minutes at 200°F (93°C). With four mold stations, the sequence of operations is as follows:

1. Inject foam in Station 1
2. Wait 7.5 minutes and inject Station 2.
3. Wait 7.5 minutes and inject Station 3, At this point the boot in Station 1 is cured and can be stripped and prepared for another injection.
4. Wait 7.5 minutes and inject Station 4. At this point the boot in Station 2 is cured and can be stipped and prepared for another injection.
5. Repeat cycle and continue to strip part from the stations as the cure cycle is completed.

The net result is that four pair of boot uppers or outsoles per hour can be made repetitively.

Using a factor of seven hours a day, effective production with time out for set up, clean up, and break time, the daily production, one shift, is 28 pairs of uppers or outsole to uppers joining.

4 pair/hour x 7 hours = 28 pair/day one shift
28 pair/day x 5 days =140 pair/week one shift

This means that if uppers were produced for one week and outsoles applied the following week, the net result would be an average for the two weeks of 70 complete pairs per week.

The other major operation is electrostatic spraying of the boot outer coating. This operation can produce 30 boots or 15 pair per hour and is capable of coating one week's production of injected foam boots in one day.

All other preparatory and finishing operations can be done at a rate well in excess of the molding operation.

It is felt that if this operation were moved into an existing plant where some similar operations such as stitching and compounding already are in production, that a two-person crew with a compounder available part-time and a stitcher, full-time, could produce boots at a rate of 60-70 pair per week, and if a second shift could be added, the production rate would more than double.

APPENDIX A

"FOAM MIXING AND MOLDING"

This Appendix includes the specifications covering the foam mixing unit, the mold station and boot molds. The foam unit (PSA73) specifications are covered in the manufacturers' written specifications. Mold stations and boot molds are covered in the blueprints drawn for procurement and fabrication. Detailed prints are included in the Instruction Manual.

Foam mixing is accomplished using a DESMA PSA 73, three-stream metering and mixing unit. The throughput is variable from approximately 50 to 100 grams per second. The foam machine is equipped with two, 30-cc/rev. pumps and one, 6-cc/rev. pump driven by quick-change ratio gears by a single electric motor. The "A" and "B" component flow valves are controlled by a single actuator with the "C" component activated by a separate actuator with the necessary interlocking electronic controls for valve synchronization and lead-lag adjustment. Shot volume is controlled by an impulse counter. The foam machine has three compound tanks and necessary compound supply hoses to the mixing head. Compound tanks, hoses, pump blocks, and mixing head are equipped for heating and cooling, as required, to maintain proper material temperature. All necessary temperature control systems (Heat Exchangers) are part of the unit. The three ingredients are mixed in a high sheer mixer and then injected into the mold cavity for expansion of the foam to the boot configuration.

Foaming of the boot is accomplished in a single mold unit station, (Figure A-4) containing a machined aluminum mold Figure 5 with a cavity of the proper configuration to produce the Arctic Boot. A complete set of detailed prints of the mold station and mold are included in the Instruction Manual.

The mold station is basically a clamping press that will accommodate the four-piece aluminum boot mold consisting of a last, outsole plate, and two outer ring halves. The outer rings are bolted to the heated side platens. The outsole plate is bolted to the bottom heated platen, and the last with internal heaters is fastened to the movable arm. The molds are heated with feed back controls capable of maintaining the molds at the desired temperature. The mold station will accept molds from Size 4 through 14.

The pressure to close and clamp the mold sections is supplied by air-hydraulic cylinders. In the movement sequence, first the last is lowered into the separated outer rings. Once the last is in the down position, the side platens with the outer rings attached are activated and close around the last to form three sides of the mold cavity. All that remains is to raise the outsole plate into position after the foam is injected into the mold. This forms the complete boot cavity.

DESMA INDUSTRIAL MACHINES, INC.
125 Roberts Road • Waltham, Mass. 02154 (617) 899-3000
Telex: 92-3415

CONFIRMATION

UNIROYAL P.O. No. ARW-1150-893-35

March 24, 1978

UNIROYAL, INC.
58 Maple Street
Naugatuck, CT 06770

One (1) Laboratory Unit, consisting of the following:

1) One (1) Injection aggregate PSA 73 - 3 component. Throughput 100 ccm/sec. Mixing head with mixing chamber 30 mm Ø, pumps A and B 30 ccm, pump C 6 ccm. The pumps will be driven by one motor, with adjustable support of gear wheels. The gear wheels will be changed by moving away of the supports. For reaching the different speeds of the mixing screw 18,900 rpm, 17,500 rpm, 18,000 rpm, 18,500 rpm and 19,500 rpm the respective gear discs and toothed belts will be delivered. The height of PSA is adjustable from 762 - 915 mm. The cylinder for the automatic advance is laid out for a stroke of 150 mm. Two manifolds for water and air are mounted on the PSA.

2) One (1) Tempering Unit Junior S for cooling of the bearing, with connections and console.

3) Two (2) tanks with 12 liter volume, special steel, double walled, air operated stirrer, outflow, connection for tempering compressed-air fittings and connections for compressed air-oiler. The tanks are installed at the PSA.

4) One (1) Tank with 2 liter volume specifications as above-mentioned model.

5) One (1) ELA 61 (electric operation and control board) for three components with impluse metering for four (4) stations, for operating the entire machine. Power supply will be increased by 24%. The switches for the tempering units will be integrated into the ELA.

6) Two (2) Tempering Units Junior S, for material tempering range 27°C - 150°C, with electric regulator for tempering components A and B.

7) One (1) Cooling Unit 2 ACD, temperature range from 0°C - 38°C, cooling capacity 3,000 kcal/h on 0°C. For cooling third component and temperature control units under Item 6.

8) Fifty (50) feet of connection pipes and cables between ELA and PSA. In the electric cable there are four (4) more leads included, carrying the steering voltage. The free leads are blind, but can be used later for connection four (4) additional plugs.

DESMA INDUSTRIAL MACHINES, INC.

125 Roberts Road · Waltham, Mass. 02154 (617) 899-3000
Telex: 92-3415

CONFIRMATION (CON'T)

UNIROYAL P.O. No. ARW-1150-893-35

March 24, 1978

UNIROYAL, INC.
Naugatuck, CT 06770

9) Voltage: 460/480 volts, 3 phase, 60 cycle.

10) Two (2) additional material tanks for components A and B, for a quick change of these components.

Sales Price: F.O.B. Boston, Mass. $93,895.00

11) Optional equipment

11.1) One (1) electric control panel mounted on the PSA injection unit equipped with On-switch, emergency stop button, injection start button, injection stop button, and PSA forward and screw cleaning controls.

Sales Price: F.O.B. Boston, Mass. $ 958.00

Total Sales Price: $94,853.00

Delivery: End of June, 1978

Terms: 10% deposit with order
Balance due upon completion of installation or 30 days after delivery, which ever comes first.

The terms and conditions contained herein are supplemental to our general terms and conditions as shown on the reverse side of this confirmation.

THIS CONFIRMATION IS GIVEN SUBJECT TO ALL OF THE TERMS AND CONDITIONS OF THE FACE AND REVERSE SIDES HEREOF, INCLUDING THE PROVISIONS FOR EXCLUSION OF WARRANTIES, ALL OF WHICH ARE ACCEPTED BY BUYER, SUPERSEDE BUYER'S ORDER FORM IF ANY, AND CONSTITUTE THE ENTIRE CONTRACT BETWEEN BUYER AND SELLER. BUYER SHALL BE DEEMED TO HAVE ASSENTED TO ALL OF THE TERMS AND CONDITIONS HEREOF, AND THIS CONFIRMATION SHALL BECOME A CONTRACT FOR THE MACHINERY OR EQUIPMENT SPECIFIED (A) WHEN THIS CONFIRMATION IS SIGNED AND RETURNED BY BUYER TO SELLER AND ACCEPTED IN WRITING BY SELLER, OR (B) WHEN BUYER ACCEPTS DELIVERY OF ALL OR ANY PART OF THE MACHINERY OR EQUIPMENT SPECIFIED AFTER RECEIVING AND RETAINING THIS CONFIRMATION WITHOUT OBJECTION FOR TEN DAYS, OR (C) WHEN BUYER HAS OTHERWISE ASSENTED TO THE TERMS AND CONDITIONS HEREOF. CONTINUED ON REVERSE SIDE.

BUYER'S FIRM NAME Uniroyal, Inc.

BY ______

DATE ______

ACCEPTED BY DESMA INDUSTRIAL MACHINES, INC.

BY Wm R. Creamer
William R. Creamer

DATE March 24, 1978

CL 280 Apr. 1978

UNIROYAL

Division of UNIROYAL, Inc.
Naugatuck Footwear Plant
58 Maple Street
Naugatuck, Connecticut 06770
203-729-0761

February 17, 1978

Desma Industrial Machine Inc.
125 Roberts Road
Waltham, Mass. 02154

Attn: Mr. William Creamer

Dear Sir:

This letter is to confirm our meeting on 2/17/78 to finalize the specifications and requirements for the new PSA-73 Desma injector to be used for producing the Government Insulated Boot.

1. One (1) PSA-73 component mixing and metering unit on an adjustable stand to raise and lower nozzle height 762 mm to 915 mm. There shall be one common drive motor (3 HP) for the A, B and C components with appropriate interchangeable line shaft gearing. There shall be one (1) drive motor (4 HP) for powering the mixing head. The speed of the mixing head should be geared for 18,900 rpm with extra gears supplied for speeds of 17,500, 18,000, 18,500, and 19,500 rpm. Thirty (30) cc pumps and a one hundred (100) cc ratio block is to be supplied with the unit. There shall be a three inch (3") minimum travel on the injection nozzle for injecting into the boot mold stations. This unit will be set up on floor track for traveling between four (4) boot mold stations. It is very important that Desma supply a set of precise detailed dimensional prints on this unit within sixty (60) days after placement of order. Desma should also supply electrical and air load requirements on this injector and associated equipment.

2. One (1) electrical control console (ELA-61) for a three (3) component system. It shall have four (4) separate metering stations, one (1) control system for the A, B and C component drive and one (1) control system for the mixing head drive. There shall be electrical temperature controls for controlling the material line pumps. There shall be 25 percent additional power available in this console for future additions by Uniroyal. The cooling and heating recirculating unit shall be powered from this control console. This console shall meet all electrical safety requirements as per the United States National Electrical Code and please include two (2) sets of English electrical prints along with remote injection controls that will be mounted on the injector.

3. One (1) material tank (C component) of two (2) liter capacity and two (2) material tanks (A and B components) of twelve (12) liter capacity minimum. These tanks shall be mounted on the PSA-73 injector unit. Include two (2) spare twelve (12) liter tanks easily interchangeable with the twelve (12) liter tanks above. All tanks shall have steel double walls, newly improved air mixers, drain cocks, safety valves, thermometers and stainless steel strainers. These tanks shall be equipped for nitrogen pre-pressure and be able to withstand working pressures of five (5) atmospheres. Compound tank covers shall have Viton seals. Nitrogen pressure is to be used along with gravity feed for compound feeding from the tanks and rigid piping is to be used on all compound lines.

4. One (1) chiller and heating recirculator unit (temperature range 0°C to 38°C). This unit will be used for cooling the C component and will also feed three (3) temperature control units (to be supplied) that will be mounted on the injector. This chiller and heating recirculator shall have the capacity of 3000 K Cal/hr. at 0°C and contain 4 KW of heating capacity. The three (3) temperature control units are broken down as follows:

   Unit #1 - Temp Control of A Component (27°C - 150°C)
   Unit #2 - Temp Control of B Component (27°C - 150°C)
   Unit #3 - Temp Control of Screw Bearings & Connections

5. Since the injector will be moving on a tracking system the following conditions will apply:

   A. The three (3) temperature control units will be mounted on the injector.

   B. Air controls, air dryer and air oil supply shall be mounted on the injector (main header to be mounted on the injector for accepting main air line feed). From this header air circuits should be isolated according to requirements. The air oil supply should be isolated from the material tanks and areas where contamination of the compound could exist.

   C. 1. One (1) main electrical harness cable (50 ft.) carrying all control wiring for the injector and remote injection, eight (8) spare #16 gauge wires for future, power feed wiring for motor drives, three (3) spare #14 gauge wires for future, power feed wiring the three (3) temperature controllers and any misc. control or power that is needed for a one (1) harness feeder from console to injector.

      2. One (1) main air line (50 ft.) of sufficient size to connect to main header on the machine.

      3. Two (2) cooling lines (50 ft. each) (feed and return)

5. C. 3. Continued....
1/2" ID each, to be run from the chiller - heater re-circulator unit to the injector.

6. The system shall be designed for 480V - 3 phase - 60 HZ on the electrical system while functioning on a minimum of 70 psi of air pressure. There shall be a minimum of obstruction for any gear changes that are required.

7. Please find attachments A, B and C.

   A. Conditions on successful trial, conducted on 2/9/78.
   B. Sheet containing all problem areas on initial prototype machine.
   C. Operating temperature ranges of the system.

8. Cost should include Desma Technical Services for installation and start-up of this system.

9. This system should be backed by a full guarantee from Desma that it will perform as expected.

Very truly yours,

A. R. Weeks Jr.

A. R. Weeks, Jr.
Divisional Engineering

ARW/gn
Attach: 3

STATE OFFICE BUILDING HARTFORD, CONNECTICUT 06115

February 10, 1977

RECEIVED
FEB 11 1977
ENGINEERING DEPT.

Mr. E.A. Melchiori
Uniroyal, Inc.
Oxford Management & Research Center
Middlebury, Connecticut 06749

SUBJECT: Ruling on Compliance with State Regulations - Uniroyal Contract DAAG-17-76-C-0016 Dept. of Defense - Artic Boots

Dear Mr. Melchiori:

On January 5, 1977 this Department received your request for a ruling on the compliance of the subject production line, as described by the documentation provided. Based on this information, the compliance of this source was evaluated relative to Section 19-508-3 (a)(1), 19-508-18 (e) and 19-508-20 (f), these being respectively permit requirements, particulate emissions from process industries-general, and organic solvents.

The following outlines the compliance determinations by regulation:

Section 19-508-3 (a)(1). The applicable paragraph is 3 (a)(1)(ii). The total quantity of coating material and solvents used is (169 grams/min)(60 min/hr.)(1 lb./454 grams) = 22.3 lbs./hr. This source, as described, is exempt from permit requirements since the total quantity of coating materials and solvents used is less than 30 pounds in any one hour.

Section 19-508-18 (e). The applicable paragraph is 18 (e)(1). This regulations applies to the particulate emissions from the spray booth area of the facility. The particulate emissions at this point are the result of overspray. The total weight of overspray, consisting of solids and solvents, is considered as particulate and in this case is calculated as follows:

(Machine throughput, 169 grams/min)(60 min./hr.) = 10,140 grams/hr. or 10,140 grams/30 boots

(Final Weighed Dry Coat/Boot, 109 grams)(30 boots) = 3,270 grams = 45%

The solvent portion applied to the boot = 55% = 3,997 grams

The total overspray = (10,140 grams) - [(3,270) + (3,997)] = 2,873 grams/hr. or 6.33 #/hr.

Any source with a process weight of from 0 to 50 pounds per hour is allowed an emission rate of 0.36 pounds per hour. To be in compliance with Section 19-508-18 (e), this source would have to demonstrate a 94.3% reduction in particulate emissions which would be quite possible.

Section 19-508-20 (f). The applicable paragraphs are 20 (f)(3), 20 (f)(4) and 20 (i)(1)(iii). In the eventuality that all solvent emissions were to ultimately be ducted to a common stack, this worse case was the one considered. Allowing that the hourly solvent emissions are 55% of 22.3 #/hr. or 12.27 #/hr., there would be no problems unless the DIBK, which is classified R3 photochemically reactive, constituted greater than 20% of the total mixture by volume. DIBK is a photochemically reactive solvent and is limited to 3 lbs. per hour or 15 lbs. per day. THF and PERC are both non-photochemically reactive and are limited to 160 lbs./hr. or 800 lbs./day. As the following table illustrates this proposed facility would be in compliance with Section 19-508-20 (f) and 20 (i)(1)(iii).

	PARAGRAPH	ALLOWABLE	VOL. % OF TOTAL	MAXIMUM PROJECTED
THF	20 (f)(4)	160 #/Hr. (21.6 gal./hr.)	20.14	6.69 #/Hr. (0.90 gal./hr.)
PERC	20 (f)(4)	160 #/Hr. (11.8 gal./Hr.)	27.34	4.95 #/Hr. (0.364 gal./hr.)
DIBK	20 (f)(3) & 20 (i)(1)(iii)	3 #/Hr. (0.44 gal/hr.)	2.88	0.51 #/Hr. (0.08 gal./hr.)

Until an application for a Permit to Construct is submitted, no ruling, as such, can be rendered. However, this source on the basis of the information provided seems perfectly capable of operating in compliance with the DEP Air Quality Regulations. In conclusion, it must be pointed out that when and if this source is constructed in Connecticut, it must be made to comply with all applicable Regulations.

Very truly yours,

Alfred Conklin

Alfred Conklin
Senior Air Pollution Control Engineer

AC/al

UNIROYAL

Uniroyal, Inc. UCI
Oxford Management & Research Center
Middlebury, Connecticut 06749

February 7, 1977

Mr. Sheton Edwards
Principal Engineer
Air Compliance Engineering
Connecticut Department of Environmental Protection
Room 146
State Office Building
Hartford, Connecticut 06115

SUBJECT: Ruling on Compliance with State Regulations - Uniroyal Contract DAAG - 17-76-C-0016, Department of Defense - Arctic Boots

Dear Mr. Edwards:

As per our telephone conversation of January 28, 1977 regarding the above subject, I am sending you the attached information. The gist of the information concerns Uniroyal's method of meeting Sec 19-508-18 (e) (Control of Particulate emissions from process industries). As you will see from the attached information, Uniroyal intends to filter the gas stream leaving the spray booth. In addition, a large amount of particulate over-spray will be contained within the spray booth, due to the nature of the process ie. electrostatic attraction.

In our best judgement, we feel the process will comply with all State Regulations and is environmentally sound.

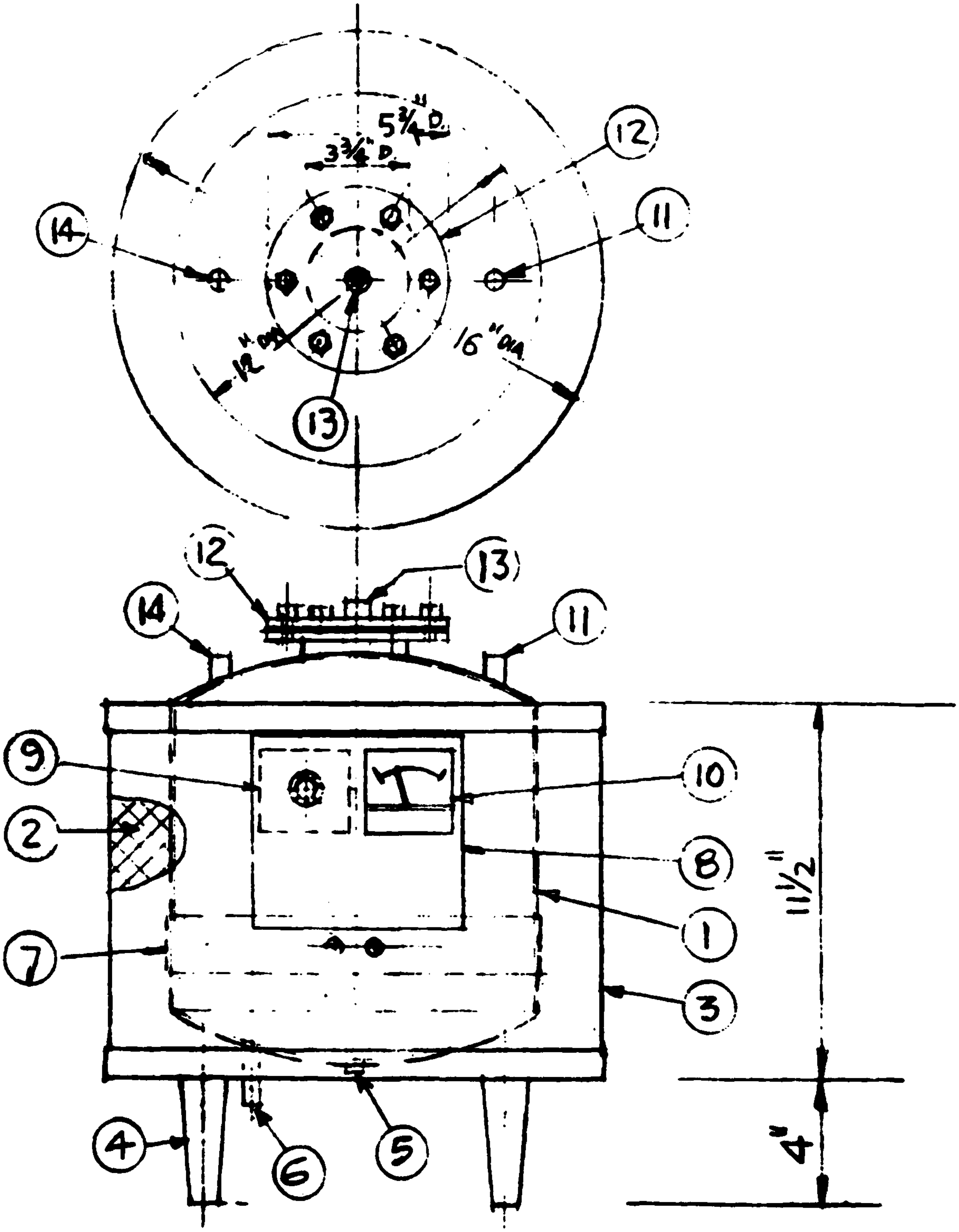
Please let me know if you desire further information. We would appreciate your reply as quickly as possible since we must submit our bid to the Army by the end of this month.

Again, your time and effort is greatly appreciated.

Very truly yours,

Edward Melchiori

klc

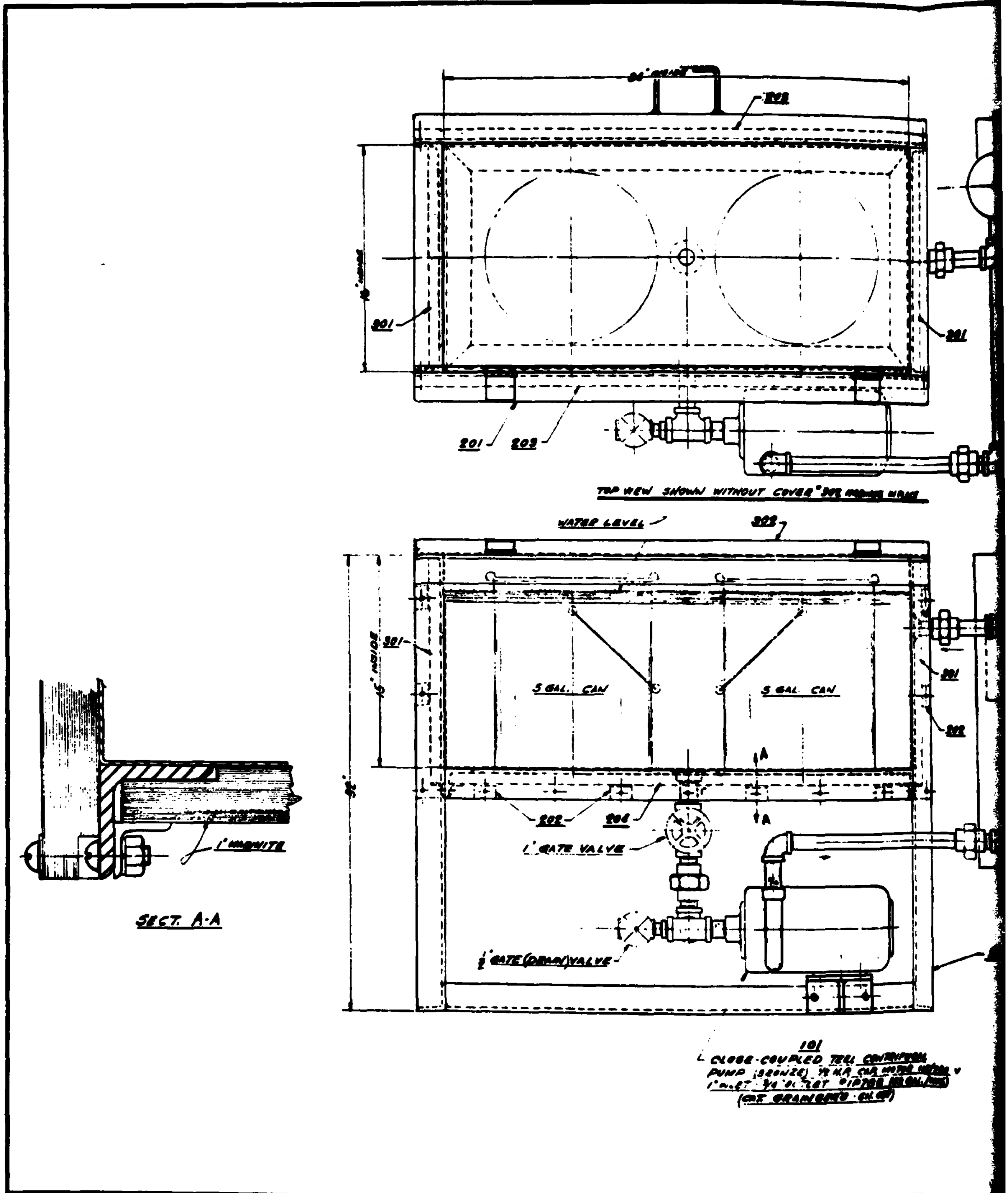


5¾" D.
3¾" D.
12" DIA
16" DIA
14
12
11
13
9
10
2
8
1
7
3
4
6
5
11½"
4"

PC. NO	LIST OF PARTS	SIZE
1	TANK - STAINLESS STEEL TYPE 316	5 GAL. CAP.
2	FIBERGLASS INSULATION 2" THICK	
3	CASING - STEEL	
4	LEG - ADJUSTABLE 4"	
5	THERMISTER PROBE	1/4" IPS
6	OUTLET - NIPPLE	1/2" IPS
7	HEATER ELEMENT	HBT-120
8	ENCLOSURE NEMA 1	
9	CONTROLLER	SERIES 194
10	METER - INDICATING	
11	FILL · COUPLING	1/2" IPS
12	HAND HOLE	
13	COUPLING · AGITATOR	3/4" IPS
14	COUPLING · RELIEF VALVE	1/2" IPS

Figure A-1

ELECTRICALLY HEATED TANK 5 GALLON CAPACITY ALL WETTED SURFACES TYPE 316 SS 500 WATTS 120-1-60 Hz	
THE ELECTRIC HEATER CO. STRATFORD, CONN	
2 REQ'D	DWG. NO. 78-2087-1


TOP VIEW SHOWN WITHOUT COVER
WATER LEVEL
201
202
203
301
5 GAL. CAN
5 GAL. CAN
15" INSIDE
1" MAGNITE
SECT. A-A
1" GATE VALVE
½" GATE (DRAIN) VALVE
101
CLOSE-COUPLED TEEL CENTRIFUGAL
PUMP (BRONZE)
(CAT. GRAINGERS - CH. 69)

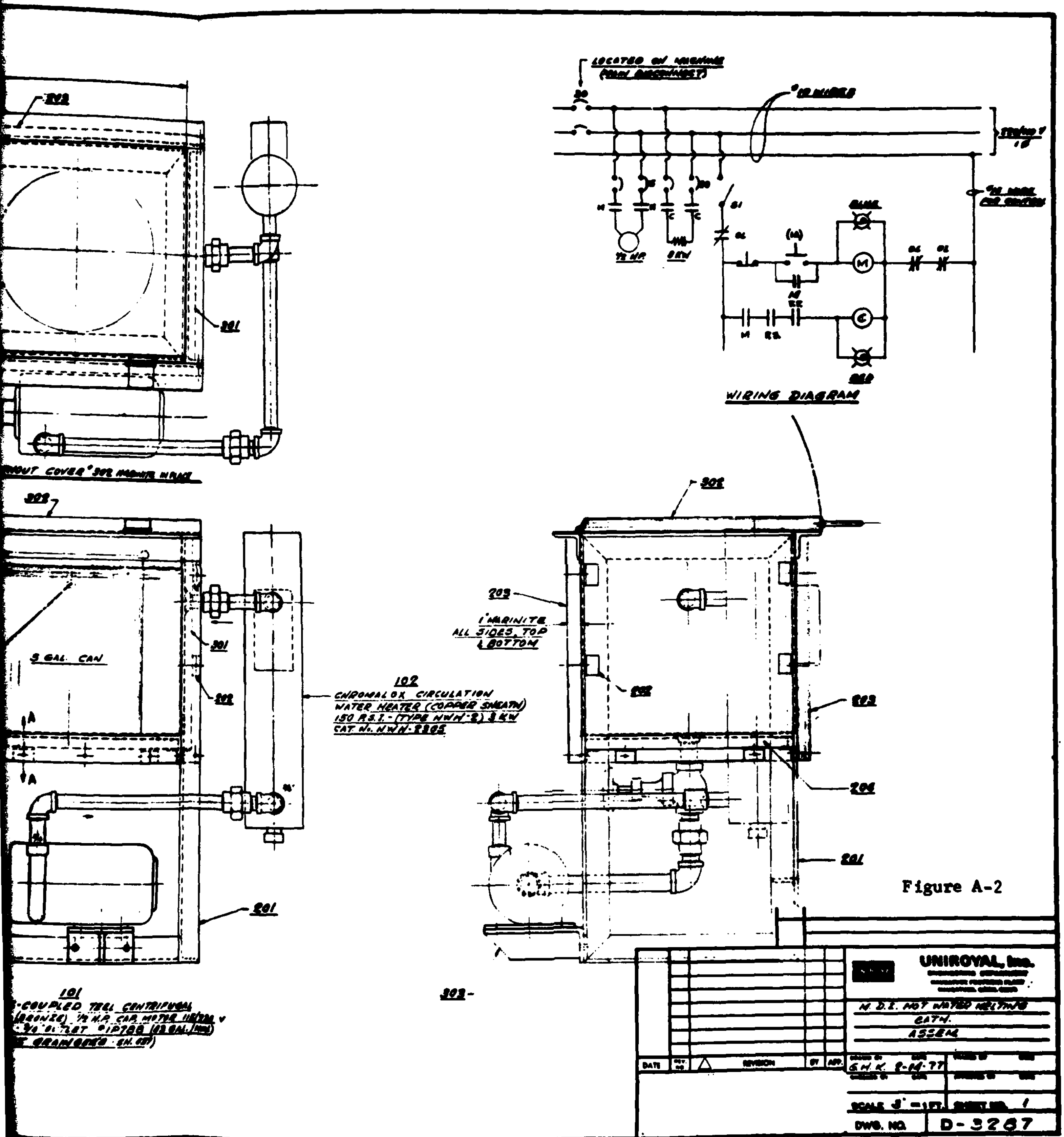
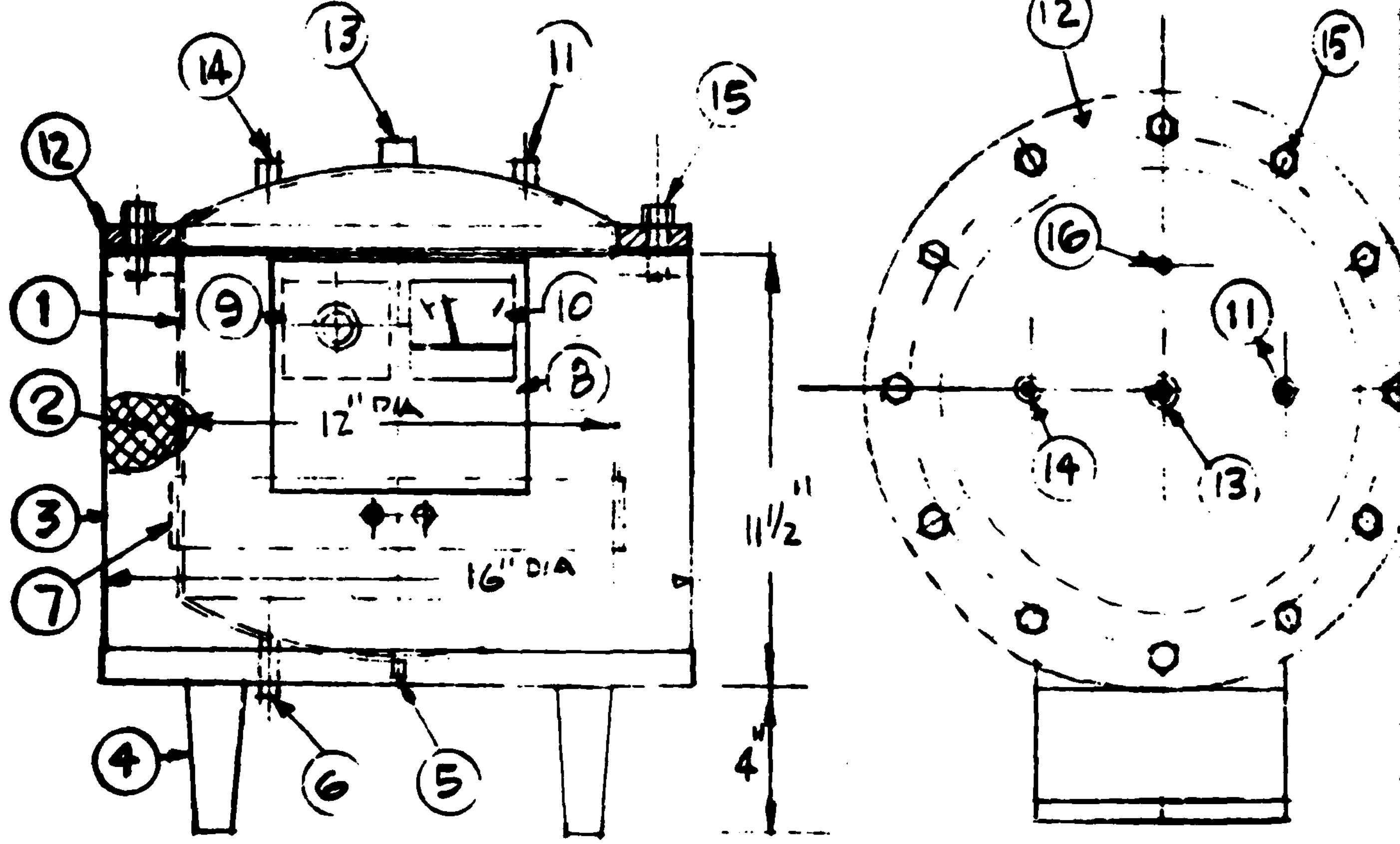
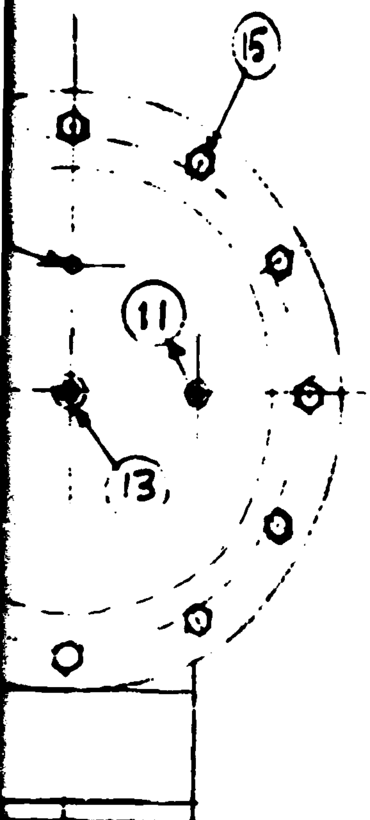

WIRING DIAGRAM
5 GAL. CAN
102
CHROMALOX CIRCULATION WATER HEATER (COPPER SHEATH) 150 P.S.I.-(TYPE NWH-2) 3 KW CAT. No. NWH-2205
1" MARINITE ALL SIDES, TOP & BOTTOM
101
UNIROYAL, Inc.
ASSEM
DATE
REVISION
BY
SCALE 3" = 1 FT.
SHEET NO. 1
DWG. NO.
D-3267

Figure A-2



12
14
13
11
15
1
9
10
8
2
12" DIA
3
7
16" DIA
11 1/2"
4"
4
6
5
16



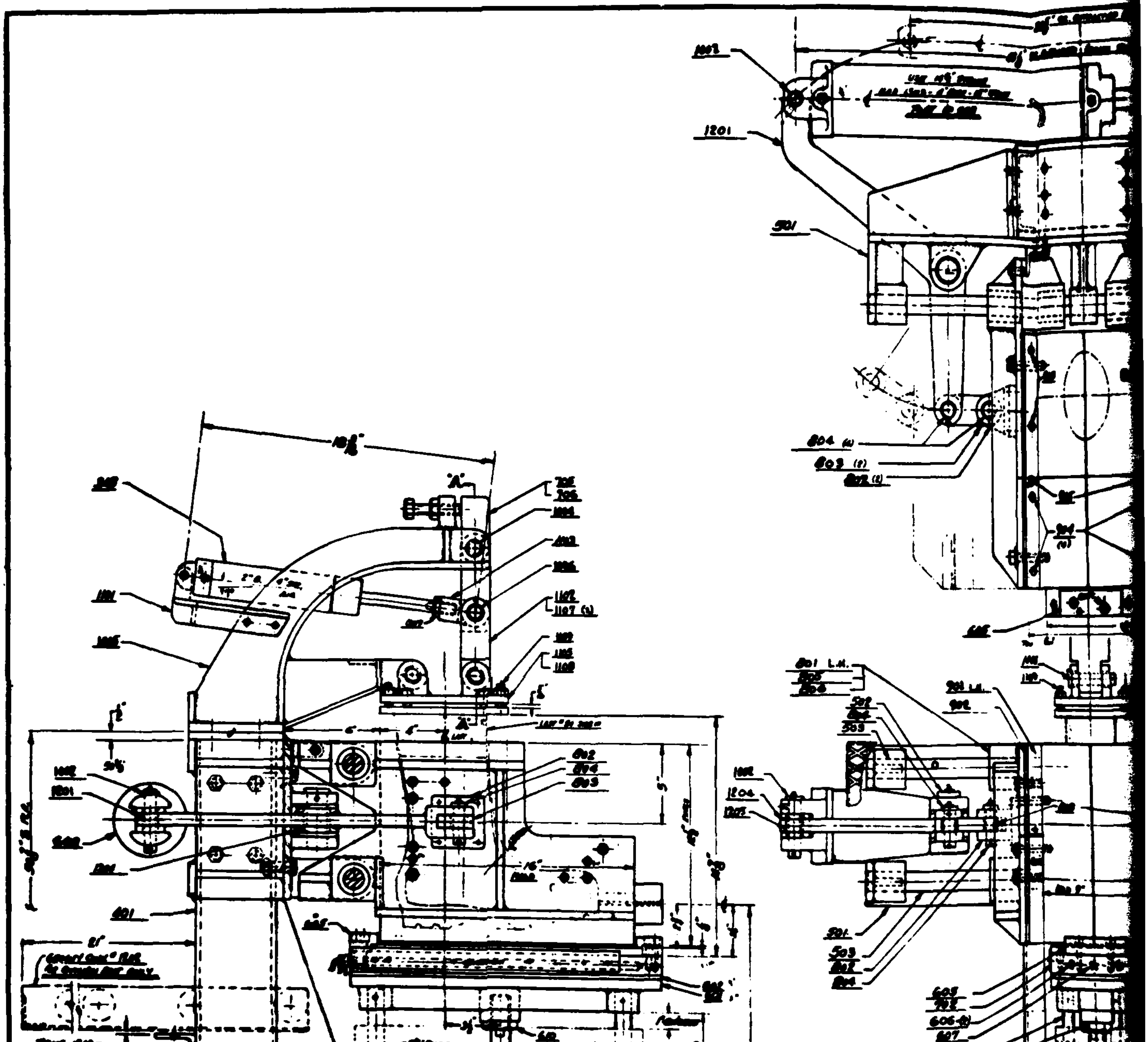
PC. No	LIST OF PARTS	SIZE
1	TANK - STAINLESS STEEL TYPE 316	5 GAL. CAP.
2	FIBERGLASS INSULATION 2" THICK	
3	CASING STEEL	
4	LEG ADJUSTABLE 4"	
5	THERMISTER PROBE	1/4" IPS
6	OUTLET NIPPLE	1/2" IPS
7	HEATER ELEMENT	HBT-120
8	ENCLOSURE NEMA 1	
9	CONTROLLER	SERIES 194
10	METER - INDICATING	
11	FILL - COUPLING	1/2" IPS
12	FLANGE - REMOVABLE	
13	COUPLING - AGITATOR	3/4" IPS
14	COUPLING - RELIEF VALVE	1/2" IPS
15	BOLTS	3/8-16 x 1"
16	COUPLING - N2	3/8" IPS

Figure A-3

ELECTRICALLY HEATED TANK
5 GALLON CAPACITY
REMOVABLE TOP
ALL WETTED SURFACES TYPE 316 SS
500 WATTS 120-1-60 Hz

THE ELECTRIC HEATER Co.
STRATFORD, CONN.

2 REQ'D | DWG NO 78-2087-2


1201
501
401
804
603
606
607
610

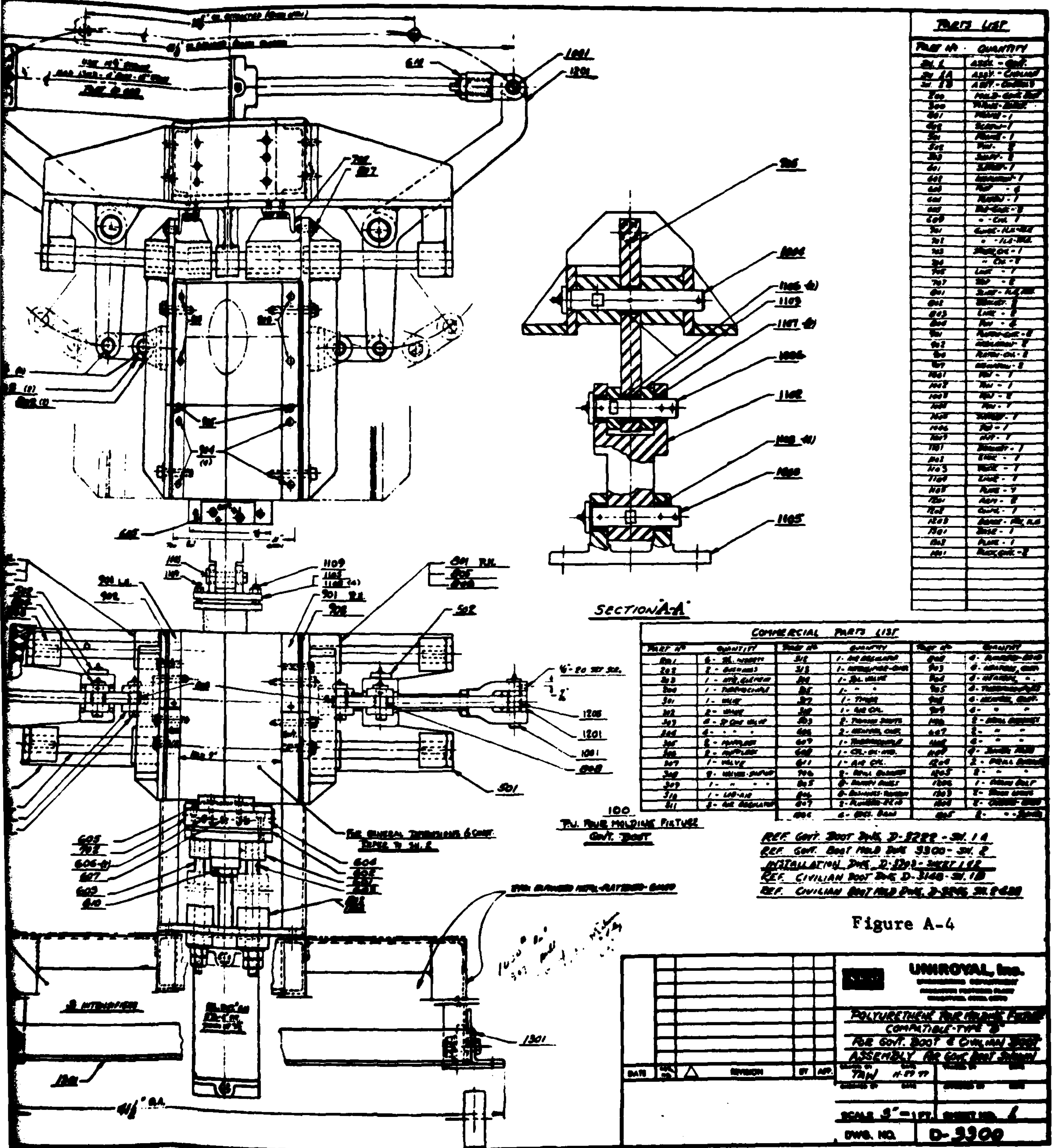
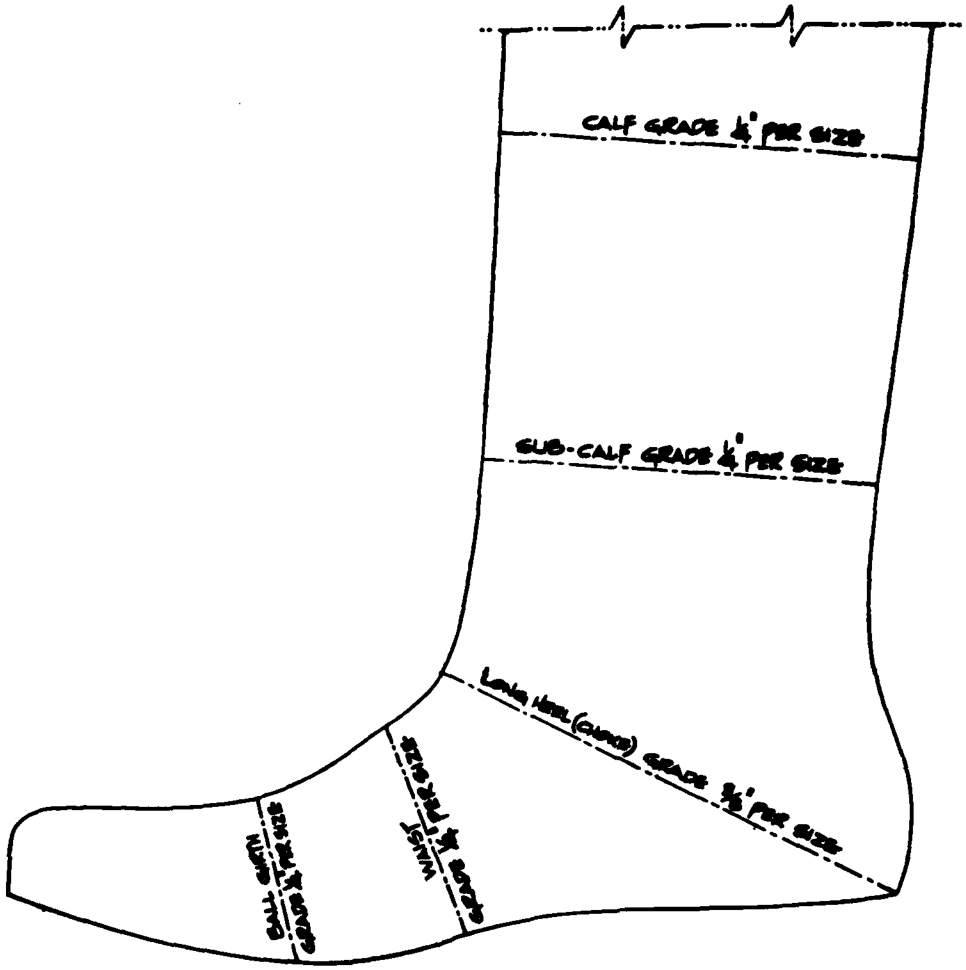
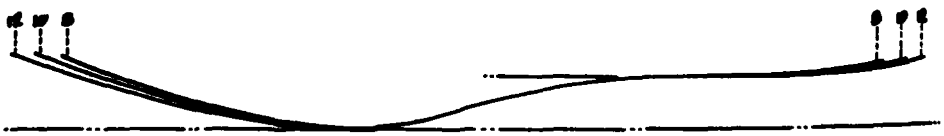

PARTS LIST
SECTION "A-A"
COMMERCIAL PARTS LIST
100
P.U. BOOT MOLDING FIXTURE
GOVT. BOOT
UNIROYAL, Inc.
COMPATIBLE-TYPE "B"
DWG. NO.
D-3300

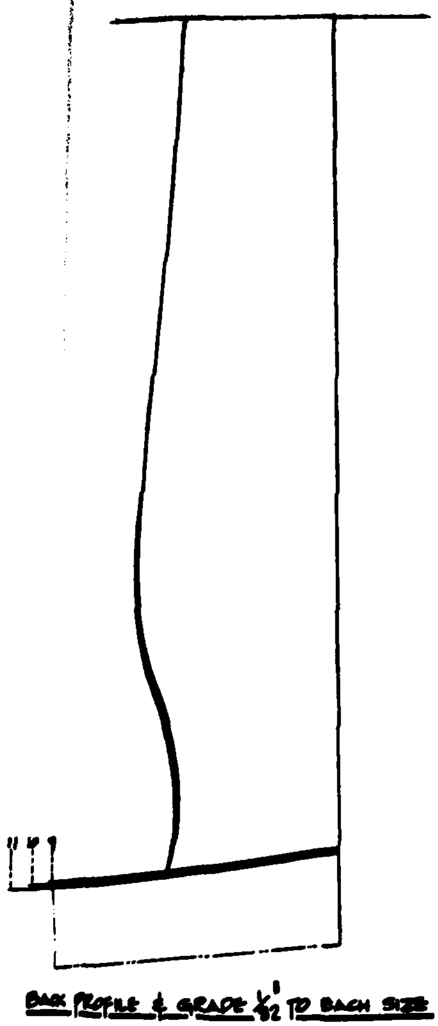
Figure A-4

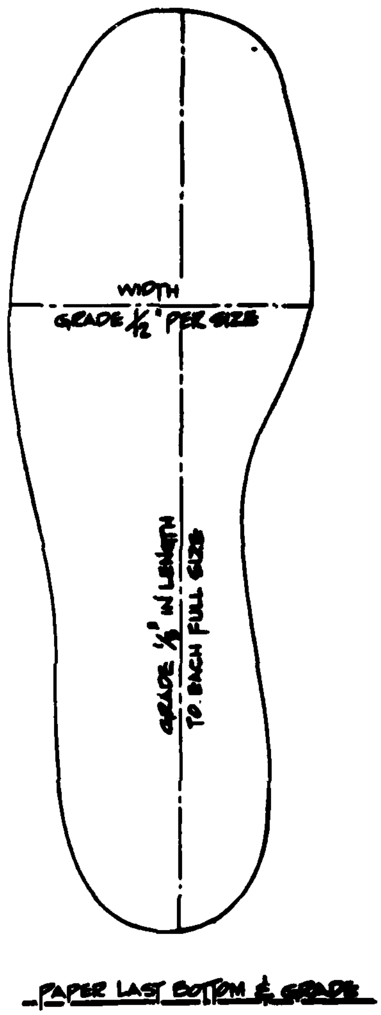


POINTS OF MEASUREMENT



COORDINATED BOTTOM PROFILE


11 10 9
BACK PROFILE & GRADE 1/32" TO EACH SIZE


WIDTH
GRADE 1/12" PER SIZE
GRADE 1/8" IN LENGTH
TO EACH FULL SIZE
PAPER LAST BOTTOM & GRADE

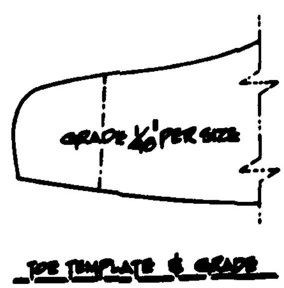
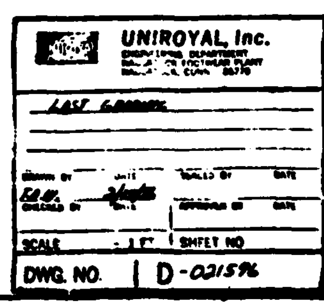

GRADE 1/10" PER SIZE
TOE TEMPLATE & GRADE

Figure A-5


UNIROYAL, Inc.
LAST GRADING
SCALE
SHEET NO
DWG. NO.
D-021596

2

TABLE A-1 LAST DIMENSIONS WITH STANDARD PROPORTIONATE GRADE

(REGULAR WIDTH)

54R EX 2496	GRADE	8 R	9 R	10R	11R	12R	
Waist	1/4"	9-11/16"	9-15/66"	10/3/16"	10-7-16"	10-11/16"	
Ball	1/4"	9-3/4"	10"	10-1/4"	10-1/2"	10-3/4"	
Long Heel	3/8"	14-13/16"	15-3/16"	15-9/16"	15-15/16"	16-5/16"	
Ankle, 5½ Up	1/4"	12"	12-1/4"	12-1/2"	12-3/4"	13"	Grade measurement taken 1/8" grade up & down per size
Calf, 9-5/8" Up	1/4"	13-27/32"	13-31/32"	14-7/32"	14-15/32"	14-23/32"	Grade measurement taken at 1/8" grade up & down per size
Rubber Stick							Stick graduation 1/8" per size
Bunch to Toe		8-1/8	9-1/8	10-1/8	11-1/8	12-1/8	
Toe Thickness 1" back from front edge of toe		1-22/48"	1-23/48"	1-24/48"	1-24/48"	1-25/48"	Grade toe template 1/48" in thickness required
Bottom Profile	Bottom profile coordinated so as to have same heel height all sizes required						Templates
Back Profile	Grade 1/32" in height to each full size. Template required						

TABLE A-1 (CONTINUED)

Last Bottom Paper Length	10-47/48"	11-15/48"	11-31/48"	11-47/48"	12-15/48"	Grade 1/3" in length
Last Bottom Width	3-33/48"	3-37/48"	3-41/48"	3-45/48"	4-1/48"	Grade 1/12" in width

TABLE A-2 LAST DIMENSIONS WITH STANDARD PROPORTIONATE GRADE

(EXTRA WIDE WIDTHS)

54 XW	GRADE	10XW	11 XW	12XW	13XW	14XW
Waist	1/4"	10-11/16"	10-15/16"	11-3/16"	11-7/16"	11-11/16"
Ball	1/4"	10-3/4"	11"	11-1/4"	11-1/2"	11-3/4"
Long Heel	3/8"	16"	16-3/8"	16-3/4"	17-1/8"	17-1/2"
Ankle, 5½ Up	1/4"	13"	13-1/4"	13-1/2"	13-3/4	14
Calf, 9-5/8" Up	1/4"	14-23/32"	14-31/32"	15-7/32"	15-15/32"	15-23/32
Bunch to Toe		10-1/8"	11-1/8"	12-1/8"	13-1/8"	14-1/8"
Toe Thickness	1/48"	1-25/48"	1-26/48"	1-27/48"	1-28/48"	1-29/48"
Bottom Profile		10R	11R	12R	13R	14R
Back Profile	1/32"	10R+1/16"				
Last Bottom Length	1/3"	11-31/48"	11-47/48"	12-15/48"	12-31/48"	12-47/48
Last Bottom Width	1/12"	4-1/48"	4-5/48"	4-9/48"	4-13/48"	4-17/48"
Stick Measurement		± 1/32"				
All Girth Measurements		± 1/16"				
Last Against Bottom Paper		± 1/32" Length ± 1/48" Width				

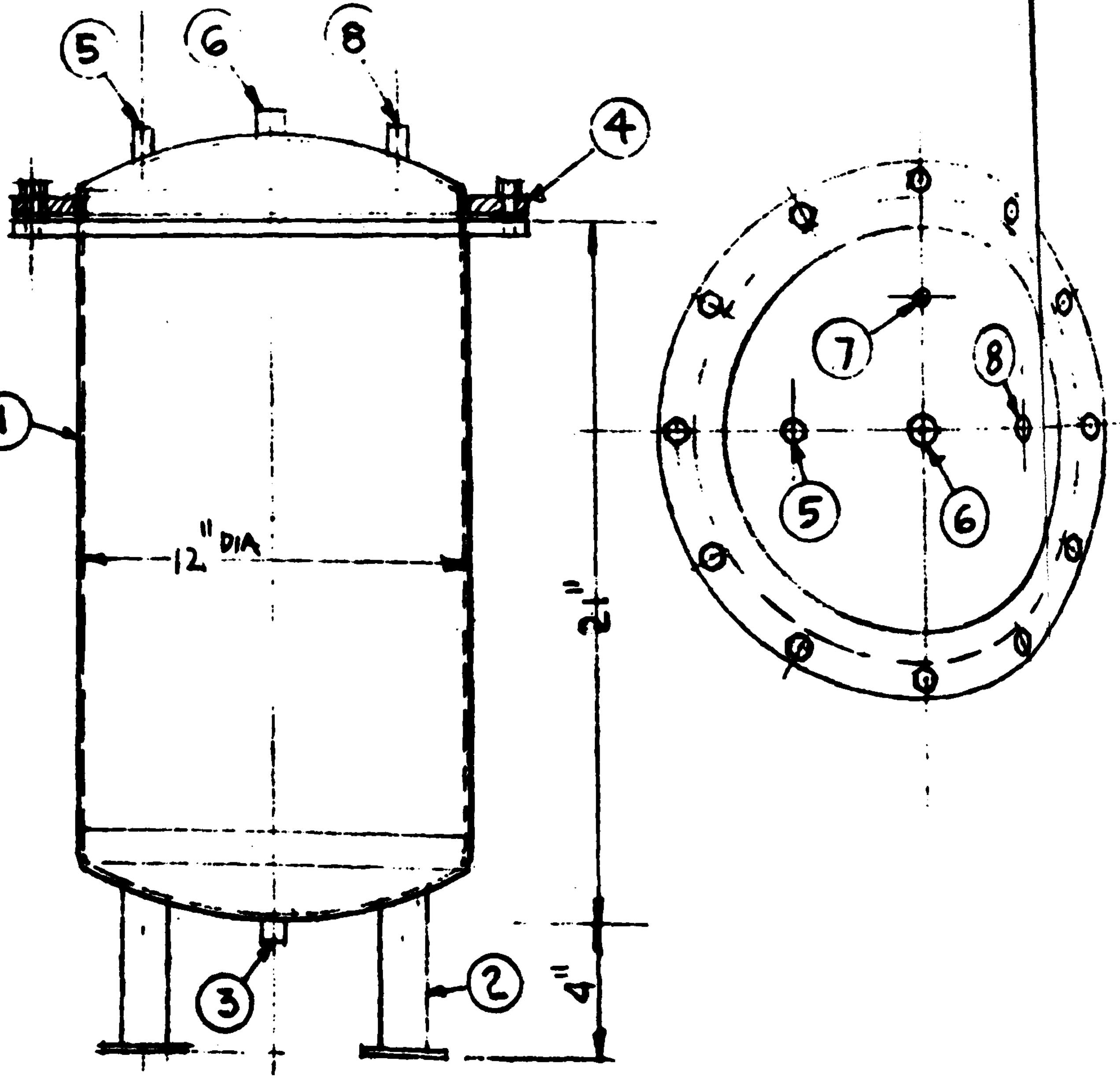
APPENDIX B

SPRAYING - DRYING - CURING

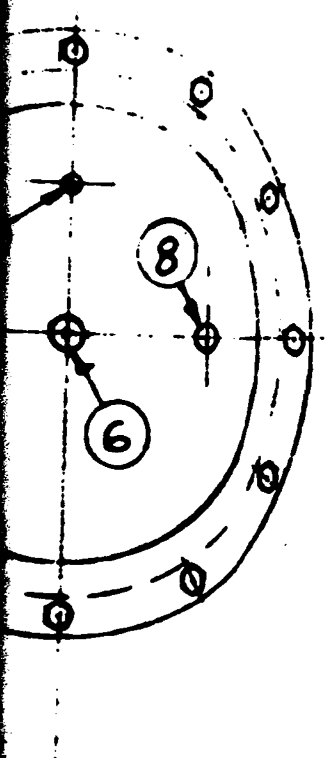
It has been determined that the Ransburg Electrostatic Coating method is the best method of coating the insulated boot. The basic principle is to pump two reactive components to a spinning disc, mixing the components just prior to depositing them in a well located in the center of the disc. The disc can be programmed to raise and lower in order to deposit the coating where desired from top to bottom. The spinning disc breaks up the mixed material as it passes over the surface and throws off a spray of fine particle size toward a rotating boot. The particles are positively charged as they pass over the charged disc and are attracted to the boot surface by use of a metal form inside the boot(Figure B-3) which is grounded to the conveyor and acts as a target for the particles. Disc speed can be varied from 50 to 4000 RPM's. Currently the disc is run at 1350 RPM's.

Figure B-4 is a schematic of a typical two-component electrostatic spray unit including conveyor, mixing disc, and electronic equipment.

Figure 8 shows the basic layout of the conveyor and reciprocator as actually installed with the boots hung on the chain link drive track by means of a swivel suspension. The conveyor can move at a linear speed of 8" to 24" per minute and the boots are suspended on 20" centers. The conveyor will hold 28 boots. Solvent fumes are exhausted from the area through which the conveyor travels. The 5-gallon supply pots and



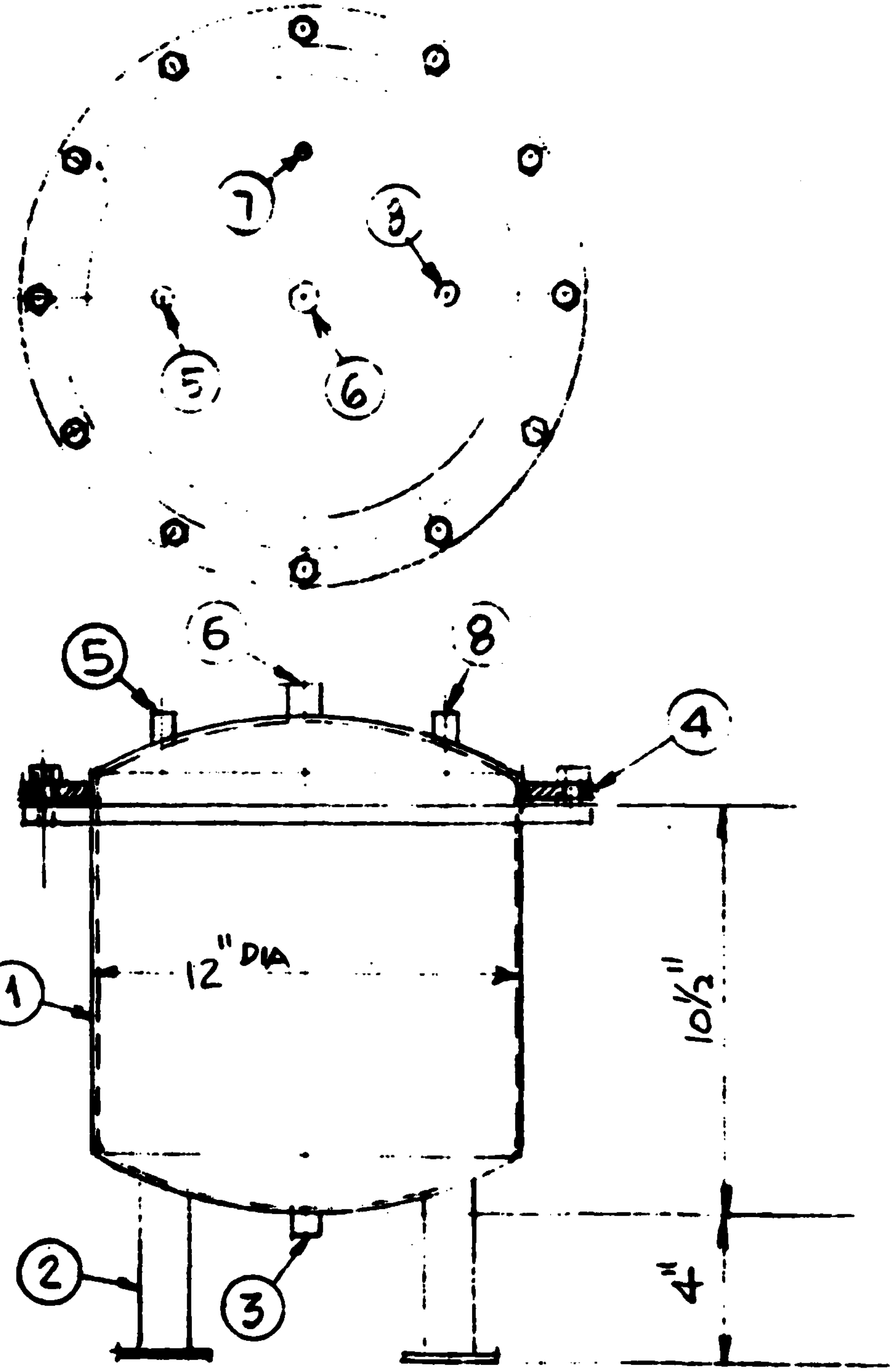
5
6
8
4
1
12" DIA
2
3
24"
4"
7
8
5
6



Pc. No	LIST OF PARTS	SIZE
1	TANK - STAINLESS STEEL TYPE 316	10 GAL CAP.
2	LEG	
3	OUTLET - COUPLING	1/2" IPS
4	FLANGE	
5	COUPLING - RELIEF VALVE	1/2" IPS
6	COUPLING - AGITATOR	3/4" IPS
7	COUPLING N_2	3/8" IPS
8	COUPLING - FILL	1/2" IPS

Figure B-1

STORAGE TANK 10 GALLON CAPACITY ALL WETTED SURFACES TYPE 316 SS	
THE ELECTRIC HEATER CO. STRATFORD, CONN.	
(2) Req	DWG NO 70-2087-8


7
8
5
6
5
6
8
4
12" DIA
1
10½"
2
3
4"

It. No.	LIST OF PARTS	SIZE
1	TANK - STAINLESS STEEL TYPE 316	5 GAL. CAP.
2	LEG	
3	OUTLET - COUPLING	1/2" IPS
4	FLANGE	
5	COUPLING - RELIEF VALVE	1/2" IPS
6	COUPLING - AGITATOR	3/4" IPS
7	COUPLING N_2	3/8" IPS
8	COUPLING - FILL	1/2" IPS

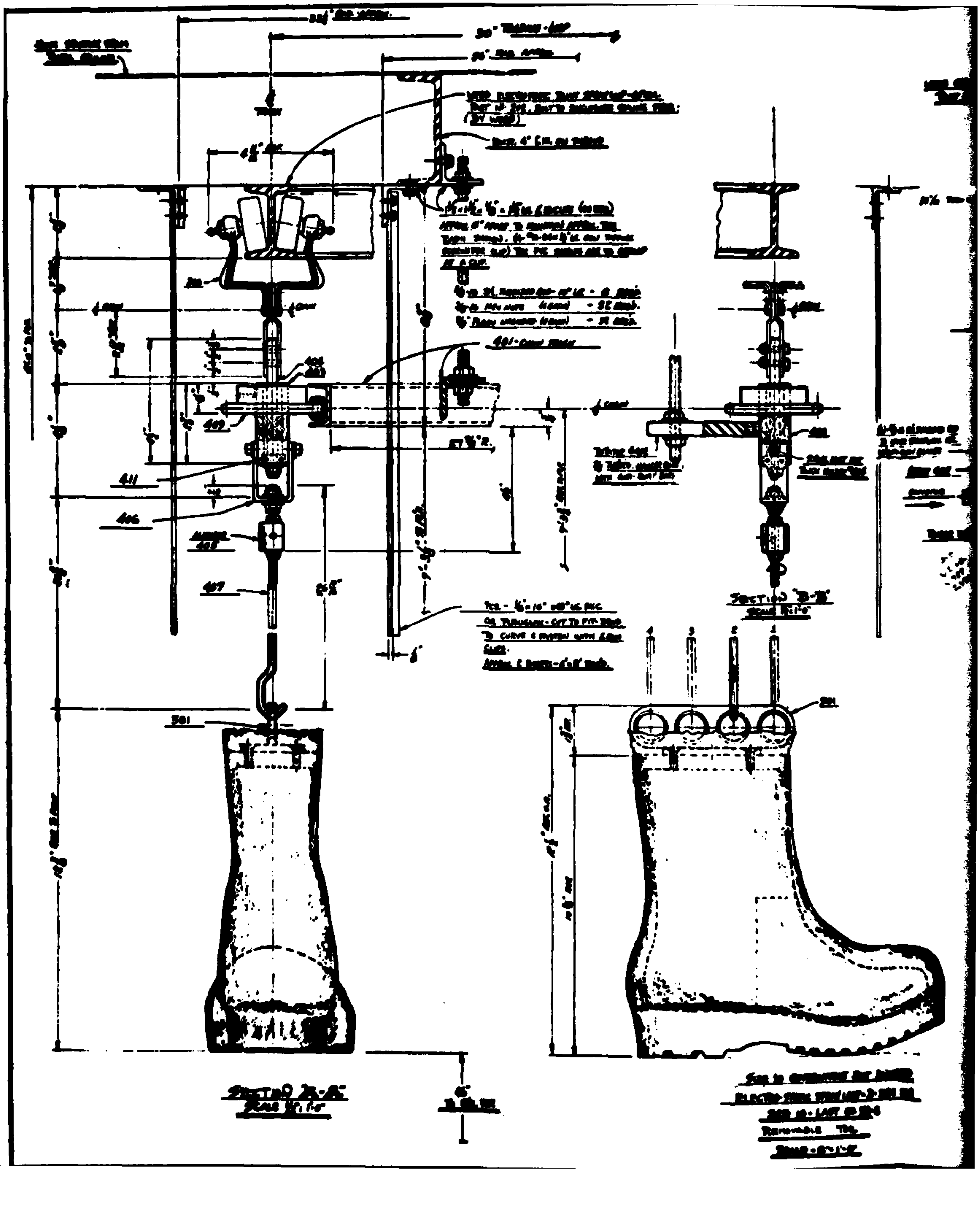
Figure B-2

STORAGE TANK
5 GALLON CAPACITY

ALL WETTED SURFACES TYPE 316 SS

THE ELECTRIC HEATER CO.
STRATFORD, CONN.

2 Req | DWG NO. 78-2087-4



411
406
407
301
409

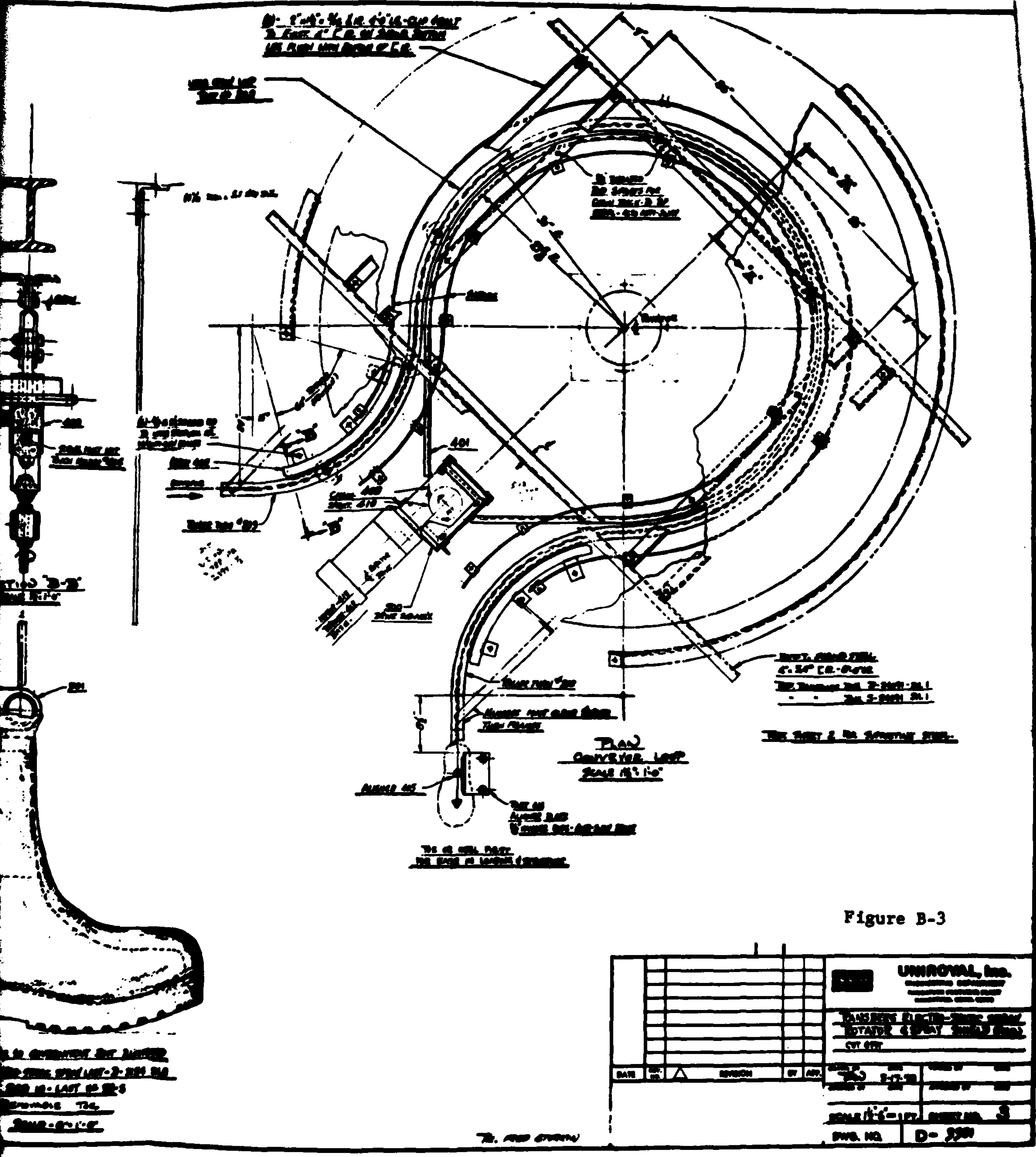


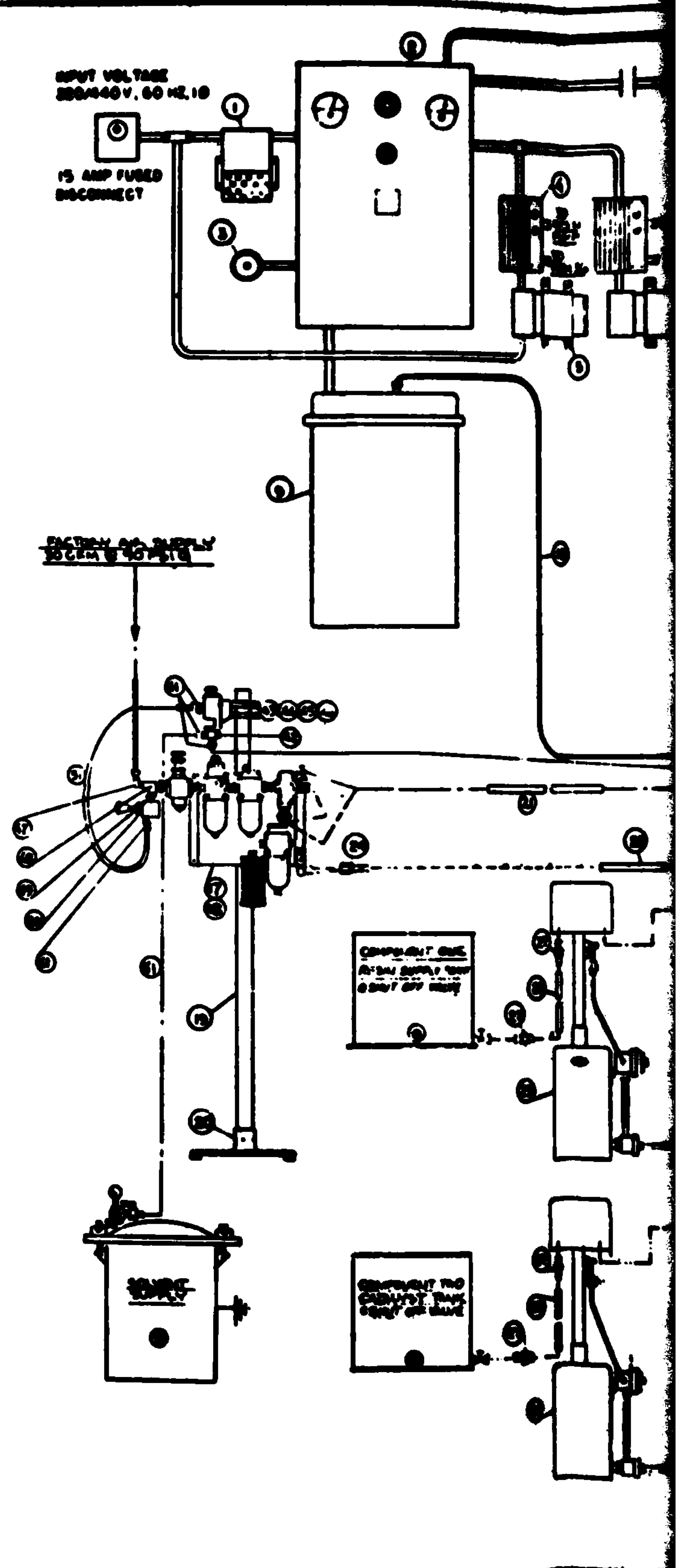
Figure B-3

ITEM NO.	PART NO.	DESCRIPTION	QTY
1	[illegible]-07	CVT TRANSFORMER 220/440V to 115V, 500VA	1
2	17264	CONTROL PANEL	1
3	9487	ALARM BELL	1
4	19143	PUMP SPEED CONTROL	2
5	[illegible]-01	STEP DOWN TRANSFORMER 220/440V to 120V, 500VA	2
6	19102-	MIXER, MTD ASS'Y.	1
7	[illegible]-01	PUSH BUTTON STATION & PILOT LIGHT	3
8	17287	HIGH VOLTAGE BYPASS SWITCH	1
9	10400	POWER SUPPLY	1
10	[illegible]	HIGH VOLTAGE CABLE	[illegible]
11	8115-6	1/4 NPT X 3/8 NPT	1
12	15855	AIR MOTOR	1
13	[illegible]	FRONT COVER	1
14	7785-[illegible]C	MACH SCR - HEX HD.	1
15	16775	DISH SHPD ALUM DEEP WELL	1
16	17424-02	FEED TUBE ASS'Y	1
17	[illegible]	AIR CONTROL PANEL	1
18	17349	MOUNTING BRACKET	2
19	1735-	POLE (-01, 48")(-02, 72")(-03, 108")	1
20	17346	BASE ASSY	1
21	9704-07	TUBING, 1/2 OD × 3/8 ID	[illegible]
22	7683-03	TUBE FITTING, 3/8 NPT × 1/2 TUBE	1
24	9455-05	SWIVEL HOSE FITTING	1
25	8477-10	EXHAUST HOSE	[illegible]
26	17276	BARB FITTING ON [illegible] 25A	1
27	10861-01	SWIVEL FITTING, 1/4 NPS × 1/2 TUBE	8
28	9704-06	TUBING, 1/2 OD × 1/4" I.D.	[illegible]
29	.9092	PUMP - COMPONENT ONE (RESIN)	1
30	19093	PUMP - COMPONENT TWO (CATALYST)	1
31	8186-24F	5/16-24 UNF CAP SCREW	3
32	1613-03	SUPPORT INSULATOR	1
33	17274	CABLE CONNECTOR SINGLE	1
34	17430	CABLE CONNECTOR (DOUBLE) OPTIONAL	
35	1850-00	NIPPLE 1/4 NPS × 1/4 NPT	2
36	19115-00	2 COMPONENT ELECTRICAL CONTROL PANEL	1
37			
38			
39			
40	9216-02	VALVE, FLUID, 1/4 NPT	1
41	7892-09	FITTING 1/4 NPT × 1/4 HOSE	6
42	1625-11	PLUG 1/4 NPT	1
43	9775-01	HANGER	2
44	8747-16C	SCREW 1/4-20 UNC	2
45	7736-06	FLAT WASHER 1/4"	2
46	7735-12	HEX NUT 1/4-20 UNC	2
47	4342-04	STREET "EL" 1/4 NPT	1
48	6782-03	STREET "T" 1/4 NPT	1
49	8115-08	REDUCING NIPPLE 3/8 NPT × 1/4 NPT	1
50	6769-01	VALVE, 3 WAY, MANUAL 1/4 NPT NC AIR PILOTED	1
51	9704-03	AIR TUBING 1/4 OD × .041 WALL	20

ELECTRICAL SCHEMATIC - E-24091, 19156, 19146

Ⓢ ITEMS SUPPLIED BY USER.

ITEMS 1-5 & 9 MUST BE LOCATED 20' MINIMUM FROM SPRAYING AREA.



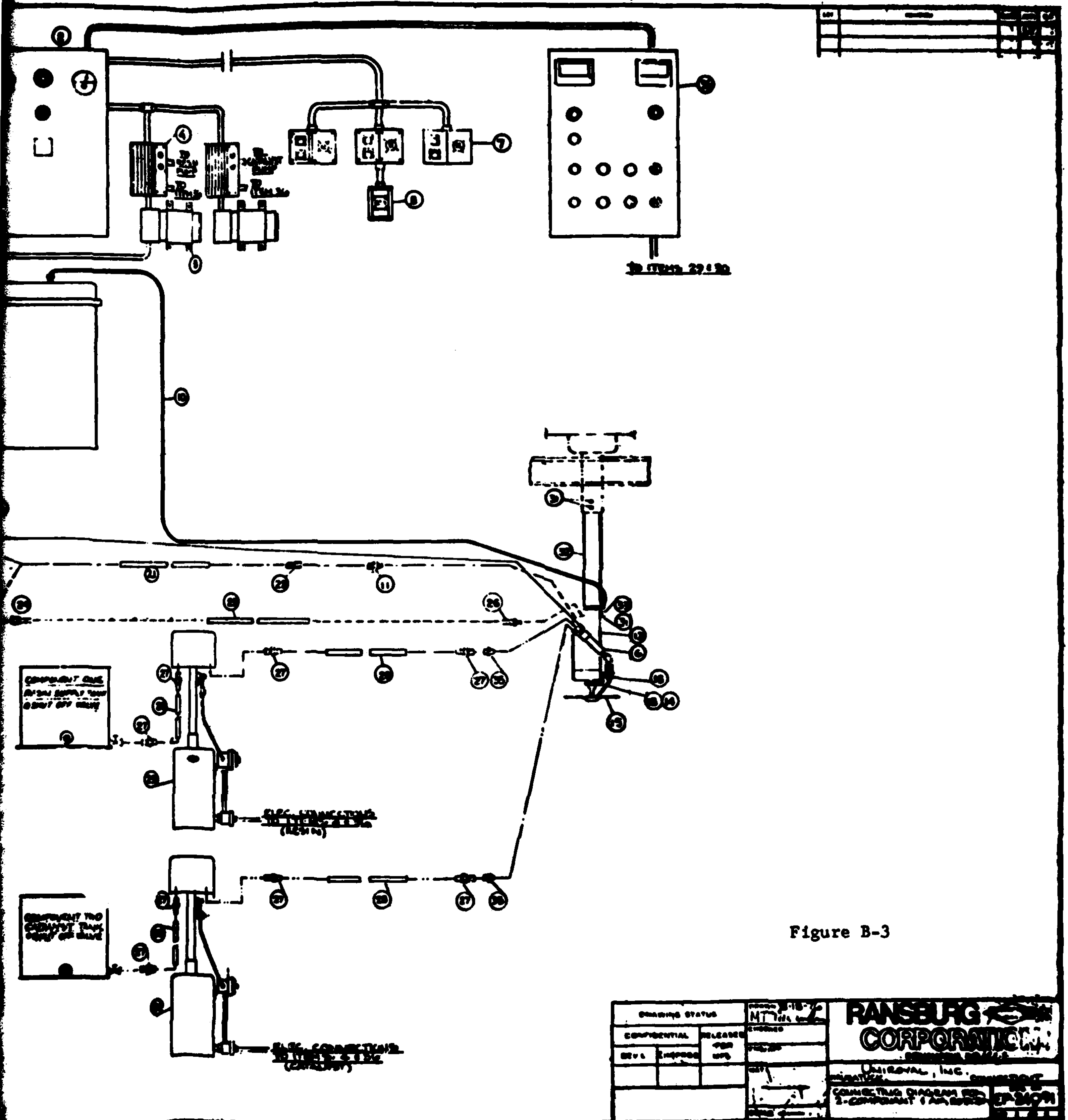

DRAWING STATUS
CONFIDENTIAL
RELEASED FOR MFG
RANSBURG CORPORATION
UNIROYAL, INC.

Figure B-3

metering pumps are located immediately in front of the spray unit and solvent flush is also in the same area. Most of the electronic equipment and the main control panel are located in an adjacent room as shown in the overall layout in Figure 3.

Aluminum spray lasts (Figure 7) are used inside the boots to be sprayed and act to attract the positively charged outer coating particles since the lasts are grounded through the conveyor. The lasts are thinner walled than the normal cast last to reduce the total weight on the conveyor. Last sizes can be two sizes smaller than the boots to be sprayed. This facilitates mounting and removing boots from the lasts. A removable toe section of the last was also added to further ease stripping of the finished boots from the lasts.

After the boots are sprayed and allow to air dry 24 minutes, they are placed on a 60-pair drying and curing truck, Figure 9, and put into an oven for curing removal of residual solvent. The hot air circulating oven, Figure 10, will accommodate one drying truck at a time and has a sequencing control that sets the temperature at 250^{o} (121^{o}C) for 24 minutes and then to 160^{o}F (71^{o}C) for 12 hours. The oven is ventilated to pull out the residual solvent fumes and exhaust them to the outside.

Detailed prints of the electrostatic spray system and all auxiliary equipment are included in the Instruction Manual.

Detailed information on emissions and compliance to state regulations in included in Appendix C of this report.

APPENDIX C

Consumer Products
Oxford R-1-31
(Location)

August 16, 1976

Trip Report: Polyurethane Army Boots--Electrostatic Spray Trials. Ransburg Electro-Coating Corporation, Indianapolis, IN.

Contacts: Mr. William Smith--Ransburg Electro-Coating Corporation.
Uniroyal Personnel: Mr. A. B. Brazdzionis
Mr. R. VanTwisk
Mr. W. C. Delatore

Purpose: Evaluate Ransburg's electrostatic spray equipment and determine if it is suitable for coating the Lightweight Polyurethane Arctic Boot.

Conclusion:

1. The Ransburg Electrostatic Spray System worked very well in coating the Arctic Boots. Varying thicknesses of polyurethane coating were deposited as required. Final appearance of the boots was very good.

2. The polyethylene mask developed by Mr. VanTwisk to prevent material from depositing on the bottom of the outsole, as well as to taper materi[al] along the sides of the outsole, worked sufficiently well.

3. The process goals set by Mr. VanTwisk--spraying times, material outputs, weight of coating, and drying times--were all achieved.

4. Formula No. 4 showed the best properties when using the Ransburg system. The boots coated well and there were no signs of sagging or imperfections on the finished coating. The coating covered all minor blemishes on the boot.

Discussion:

Equipment time was rented at Ransburg so that electrostatic spray trials for coating an insulated Arctic Boot with a polyurethane coating could be run. The polyurethane compound consists of a two component system in which the polyether prepolymer is supplied in a solvent as the "A" component and the curative is supplied in a solvent as the "B" component. The components are metered in a predetermined ratio by positive displacement gear pumps to a Ross static mixer and thereafter, as a one componen[t] to a well in a spinning disc which atomizes the solution and also impart[s] an electrostatic charge. The particles are thrown from the disc by centrifugal force and in turn, attracted to the grounded article which is being coated. More detailed engineering information of the various Ransburg Systems can be obtained from Process Engineering, Consumer Products.

Lab Test No. 4

Three boots sprayed
Formula #3
Machine throughput: 160 grams/minute (measured)
Spray time: 12.0 minutes
Total grams sprayed: 1920 grams (calculated)
Total solids: 45%
Two panels, each representing two boots.
1920 grams sprayed ÷ 7 boots = 274.28 grams/boot x 45% solids =
123.42 grams/boot (theoretical dry weight)
Final coating per boot:
(L) left boot 123 grams, Freon upper. Full last; size 8
(C) center boot 106 grams, Freon upper. Full last; size 7
(R) right boot 143 grams, Freon upper. Full last; size 8
Boot rotation: 6 RPM
Total reciprocator stroke: 8 inches, stopped 5 inches from top of
No hesitation
Pot pressure: 12 psi
Actual ratio: A/B; 100/24.19, by weight
Comments: The change in reciprocator stroke from Lab Test #3 improved the amount of coating deposited on the uppers.

Lab Test No. 5

Three boots sprayed
Formula #4
Machine throughput 169 grams/minute (measured)
Spray time: 12.0 minutes
Total grams sprayed: 2016 grams (calculated)
Total solids: 45%
Two panels, each representing two boots
2016 grams sprayed ÷ 7 boots = 288 grams/boot x 45% solids =
129.6 grams/boot (theoretical dry weight)
Final coating per boot:
(L) left no weight recorded, Lucel upper. Full last; size not record
(C) center 109 grams, Freon upper. Full last; size not recorded.
(R) right no weight recorded, Lucel upper. Full last; size not record
Boot rotation: 6 RPM
Total reciprocator stroke: 9 inches
No hesitation
Pot pressure: 12 psi
Actual compound ratio: A/B; 100/24.30, by weight
Comments: The center boot was the best overall coated boot and would seem to be the most representative of the ability that the Ransburg System could produce under the available conditions.

TEST #5 FORMULA #4 IS THE BASIS USED FOR DESIGN OF PROCESS

UNIROYAL

UNIROYAL, Inc.
Oxford Management & Research Center
Middlebury, Connecticut 06749

January 3, 1977

Mr. Shelton Edwards
Principal Engineer
Air Compliance Engineering
Ct. Dept. of Environmental Protection
Room 146
State Office Building
Hartford, CT 06115

SUBJECT : RULING ON COMPLIANCE WITH STATE REGULATIONS- UNIROYAL CONTRACT DAAG-17-76-C-0016 DEPT OF DEFENSE - ARTIC BOOTS

As per our telephone discussion on 12/20/76, I am forwarding the attached documentation which describes the above captioned project. Again, as a brief review, UNIROYAL is seeking an official ruling from D.E.P. as to the compliance or non-compliance of the proposed process with Connecticut regulations. This is not an application for construction or operation. Should UNIROYAL bid on the Phase III - (Implementation and Production) portion of the contract and elect to build the facility within Connecticut, UNIROYAL will follow standard proceedures and request permits.

The documentation, we believe, fully describes the process and the materials used and emitted. UNIROYAL'S interpretation indicates that the process will comply with State Regulations. However, we would appreciate your formal agreement with that conclusion. If you have any questions or require additional information, please call. We will be happy to meet with you, if required, in order to provide any additional data.

Since we must submit this material to the D.O.D. by February of 1977, we would appreciate your ruling as soon as possible.

E. A. Melchiori

E. A. Melchiori

EAM/kab

cc: J. Gaynor - Naugatuck Footwear, w/attach.
J. T. Colombo - Office, w/attach.
R. C. Niles - Office, w/attach.

CONSUMER PRODUCTS DIVISION

NAUGATUCK, CONNECTICUT FOOTWEAR PLANT

POLYURETHANE ARMY BOOT PROJECT

ENVIRONMENTAL CONTROL

1.00 GENERAL BACKGROUND

Uniroyal Inc.'s Consumer Product Division is currently engaged in a development program for the Natick Army Laboratories, Department of Defense (Contract DAAG-17-76-C-0016). The purpose of the program is to develop technology (Phase I), hardware (Phase II) and finally establish a production facility (Phase III) to produce a specialized artic boot for military personnel.

Uniroyal has been awarded the contract for Phases I & II - Technology Development and Hardware Development.

As part of the criterion for complete hardware development, Uniroyal must assure the D.O.D. that the designed facility, when complete, will comply with all local and state environmental regulations, either by use of judicious process control or through the use of suitable environmental control hardware.

The agreement with the Department of Defense, on Phase II (Hardware Development and Design Engineering) calls for the proposed facility to meet the environmental regulations in the State of Connecticut. It must be made clear, however, that the final site for this production facility

1.00 GENERAL BACKGROUND (Cont'd.)

may not be within Connecticut. This will depend on the location of the firm which becomes the successful bidder on the Phase III component of the program.

2.00 PRESENT STATE OF DEVELOPMENT - PHASES I & II

Uniroyal has now reached a point in fulfillment of Phases I & II, whereby the technology and production method for this article has been developed. Trial production runs have been made, and it is believed that a product which meets the contract specifications can be produced. The following briefly describes the production method and the environmental problems associated with the product.

3.00 PRODUCTION METHOD

Unfinished boots are brought into the finishing area. The boots are mounted on a "last" which serves as the conveying mechanism and grounding mechanism for the electrostatic coating process to follow.

The unfinished boot is conveyed to the electrostatic coating machine. Here a two component system, solvent and polyurethane, is applied to the boot under electrostatically charged conditions.

The two component system is as follows:

COMPONENT A	Weight		% of Total
1) Uniroyal Roylar B-602 (Liquid Polyurethane)	1700	Grams	49.04
2) Perchloroethylene (PERC)	1300	Grams	37.50
3) Tetrahydrofuran (THF)	466.6	Grams	13.46
TOTAL	3466.6	Grams	100%

COMPONENT B			
1) Methyldiethanolamine (MDA) Catylst	400	Grams	15.27
2) THF	1500	Grams	57.25
3) B-602	400	Grams	15.27
4) Diisobutyl Ketone (DIBK)	300	Grams	11.45
5) Carbon Black (CT-BLK) Extremely Fine	20	Grams	0.76
TOTAL	2620	Grams	100%

Component A and Component B are mixed together in the following amounts:

A (100%) + B(24.99% by weight) = Coating

By calculating the component mixtures in proportion to the above ratio, the following results:

$$\frac{B}{A} = \frac{24.99}{100} \times 3466.6 = 866.3 \text{ grams of component B.}$$

A + B = Coating Weight

3466.6 + 866.3 = 4333 Grams

Individual Weights of Each Component

Item		Wt. (Grams)	Volume (Ft.^{3})
1) B-602 Polyurethane (Solid)			
1700 Grams (A) + (866.3 x .1527)(B)	=	1832.3 Grms	0.064
2) THF (Solvent)			
466.6 Grams (A) + (866.3 x .5725)(B)	=	962.6 Grms	0.038
3) PERC (Solvent)			
1300 Grams (A)	=	1300 Grms	0.028
4) DIEK (Solvent)			
(866.3 x 0.1145)(B)	=	99.2 Grms	0.004
5) MDA (Catalyst) (Solid)			
(866.3 x 0.1527)(B)	=	132.3 Grms	0.004
6) Carbon Black (Solid)			
(866.3 x 0.0076)(B)	=	6.6 Grms	0.001
	TOTAL	4333.0 Grms	0.139

This further reduces as follows:

3.00 PRODUCTION METHOD (Cont'd.)

Solvents by Wt. of Total Formulation				Solvents by Volume in Total Formulation	
PERC	- 30 %	=	1300.0 Grm/4333	20.14% =	0.028/0.139
THF	- 22.2 %	=	962.6 Grm/4333	27.34% =	0.038/0.139
DIBK	2.29%	=	99.2 Grm/4333	2.88% =	0.004/0.139
TOTAL	54.49%				

Solvent Percentages by Solvent Only Mixture

	By Weight	By Volume
PERC	55.04%	54.28%
THF	40.76%	40.00%
DIBK	4.20%	5.72%
	100%	100.00

Once the boot has been electrostatically coated, it is left within the production space for approximately 24 minutes. It is then sent to a hot air drying chamber for another 24 minutes. Finally, it is left in a second drying chamber for 12 hours. The purpose of these last three steps is to promote the evaporation of the solvents used in the two component urethane system. Under ambient conditions, long exposure would be required to evaporate this solvent, which is under a urethane cover; therefore, heat exposure is used to accelerate the process.

Schematic SK-1 illustrates the various steps in the process.

4.00 EMISSIONS TO THE ATMOSPHERE

During the feasibility trials, one of the questions to be answered was the emission rates of solvents at various stages in the process. These trials revealed the following:

A Area	B Grams Solvent Evaporated Per Hour	C Design Rate 1.5 Item B	D Design Rate Lb./Hr.
Spray Booth	2400	3600	7.94
Flash-Off	210	300	0.66
Drying Chamber	690	900	1.98
Cool Down	270	350	0.77
Final Drying	510	700	1.54
TOTAL	4080 Grams	5850 Grams	12.89

Based on trials and production rates, an alternate estimate of solvent emissions can be made to cross check the above.

Boot Size - 10R

Production Rate 30 Boots/Hr. or 15 Pair/Hr.

Laydown Rate (Solids) 109 Grams/Boot

$$109\ \frac{\text{Grams}}{\text{Boot}} \times \frac{30\ \text{Boots}}{\text{Hr.}} \times \frac{\text{Lb.}}{453.59\ \text{Grams}} = 7.21\ \frac{\text{Lb.}}{\text{Hr.}}\ \text{Solids}$$

The total weight of the solvent would equal:

$$\frac{7.21}{x} = \frac{45.51}{54.49}$$

$$x = 8.63 = \text{Lb./Hr. Solvent}$$

4.00 EMISSIONS TO THE ATMOSPHERE (Cont'd.)

On that basis, the emissions of solvents would break down as follows:

Item	Estimated Rate	Design Rate
Perchloroethylene	4.75 Lb./Hr.	7.125 Lb./Hr.
Tetrahydrofuran	3.52 Lb./Hr.	5.276 Lb./Hr.
Diisobutyl Ketone	0.36 Lb./Hr.	0.543 Lb./Hr.
TOTAL	8.63 Lb./Hr.	12.944 Lb./Hr.

These figures agree very closely with previous rates based on trial runs.

5.00 EMISSIONS TO ATMOSPHERE AND CONNECTICUT AIR QUALITY REGULATIONS

The solvents used in this process would be emitted as a non-condensed hydrocarbon to the atmosphere. The gas stream will be clear, no visible contaminants will be present.

Connecticut regulations, specifically Connecticut Air Pollution Regulation Sec. 19-508-20, govern the emission of volatile organic compound to the atmosphere. Section (f) of 19-508-20 governs organic solvents.

Of prime importance, in the case of this process, is the determination of the photochemical reactivity of the solvents used in compound mixture. Section (i) of 19-508-20 defines those solvent mixtures which may be regarded as photochemically reactive. The State of Connecticut has also, from time to time, published a list of common solvents. This list classifies various solvents into reactive groups (R_1, R_2, and R_3) and a non-reactive

4.00 EMISSIONS TO THE ATMOSPHERE AND CONNECTICUT AIR QUALITY REGULATIONS (Cont'd.)

group (N). An abbreviated copy of this list is attached in the appendix. As can be seen from this list, the solvents used in this process are designated as follows:

Solvent	% in Compound By Volume	Allowable
1) Perchloroethylene	20.14	No Limit
2) Tetrahydrofuran	27.34	No Limit
3) Diisobutyl Ketone	2.88	20% by Volume

As can be seen, this formulation is clearly unreactive as per Section (i) of 19-508-20.

Section (f) (4) of 19-508-20 defines the allowable rate of emission for non-reactive materials. Section (f) (4) limits the emission of organic materials to not more than 800 lbs. in any one day or 160 lbs. in any one hour.

From Section four (4.00), it was determined that total organic emissions from this process will range between 8 to 13 lbs./hour or 192 to 312 lbs. per day, based on 24 hours/day of production.

Thus, Uniroyal respectfully submits that the process and resultant emissions described herein are in compliance with Air Pollution Control Regulations in the State of Connecticut.

Unabated Rate: 1.4 lbs/Hr.
Control: Reticulated Polyurethane filters at spray booth hood openings. See attached sketch.

Efficiency

It is conservatively estimated that these filters are 90% effective in removing solids. The solids are 0.942% Urethane (see previous submittal for formulation breakdown) and the particulate size will exceed one micron. In addition, two other factors will contribute to the resultant efficiency.

(A) Urethane filters will attract like urethane matter.

(B) A large part of the unabated rate (1.4 lbs/hr) will never reach the filters, but will deposit out on the spray booth walls and contingous apparatus since this equipment is grounded and the solids are charged.

Therefore, at the conservative estimate of 90% abated emission rate is:

$$1.4 \times .1 = 0.14 \text{ lbs/hr},$$

The process weight for this process is:

$$\frac{169 \text{ grms}}{\text{Min}} \times \frac{60 \text{ min}}{\text{Hr}} \times \frac{1\text{b}}{459.3\text{grms}} = 22 \frac{\text{lb}}{\text{hr}}$$

$$\frac{22 \text{ lbs}}{\text{hr}} \times \frac{\text{ton}}{2000 \text{ lb}} = 0.011 \text{ Ton/hr}$$

Based on Sec. 19-508-18 (e) (2) the following emission rate is allowable:

$$E = 3.59 (P)^{0.62}$$

where E is the allowable emission rate in lb/hr and P is the process weight in tons/hr.

$$E = 3.59 (0.011)^{0.62}$$
$$E = 0.22 \text{ lbs/hr}$$

therefore, the estimate abated rate of 0.14 lbs/hr meets the regulation.

ESTIMATED UNABATED PARTICULATE EMISSION FROM ELECTROSTATIC SPRAY BOOTH

See Page 12 of 7/16/76 Evaluation Trials for Ransburg Spray Equipment (attached).

Lab Test #5 Formula #4

Machine Throughput	169 grms/min
Spray Time	12 min
Total Thoughput	2028 grms
Total Boot Throughput	
3 Boots + 2 Panels =	7 boots
Laydown/Boot. Approx.	290 grms/Boot
Grams Solids	130.5 (45%)
Grams Solvent	159.5 (55%)

Final weighed Dry Coat	109 Grams
Solids Over Spray	130.5 - 109 = 21.5 grms/Boot

Machine Rate 15 pair/hour

Unabated Emission $\frac{15 \text{ pair}}{\text{Hr.}} \times \frac{2 \text{ Boots}}{\text{Pair}} \times \frac{21.5 \text{ grms}}{\text{BOOT}} \times \frac{1 \text{ lb}}{459.3 \text{ grm}}$

= 1.4 lbs. Solids/Hr.

PROJECT Aztec Boat [illegible] IAAG 1776-C-4016 - Process Flow Schematic

DATE 12-31-76

BY E.A.M

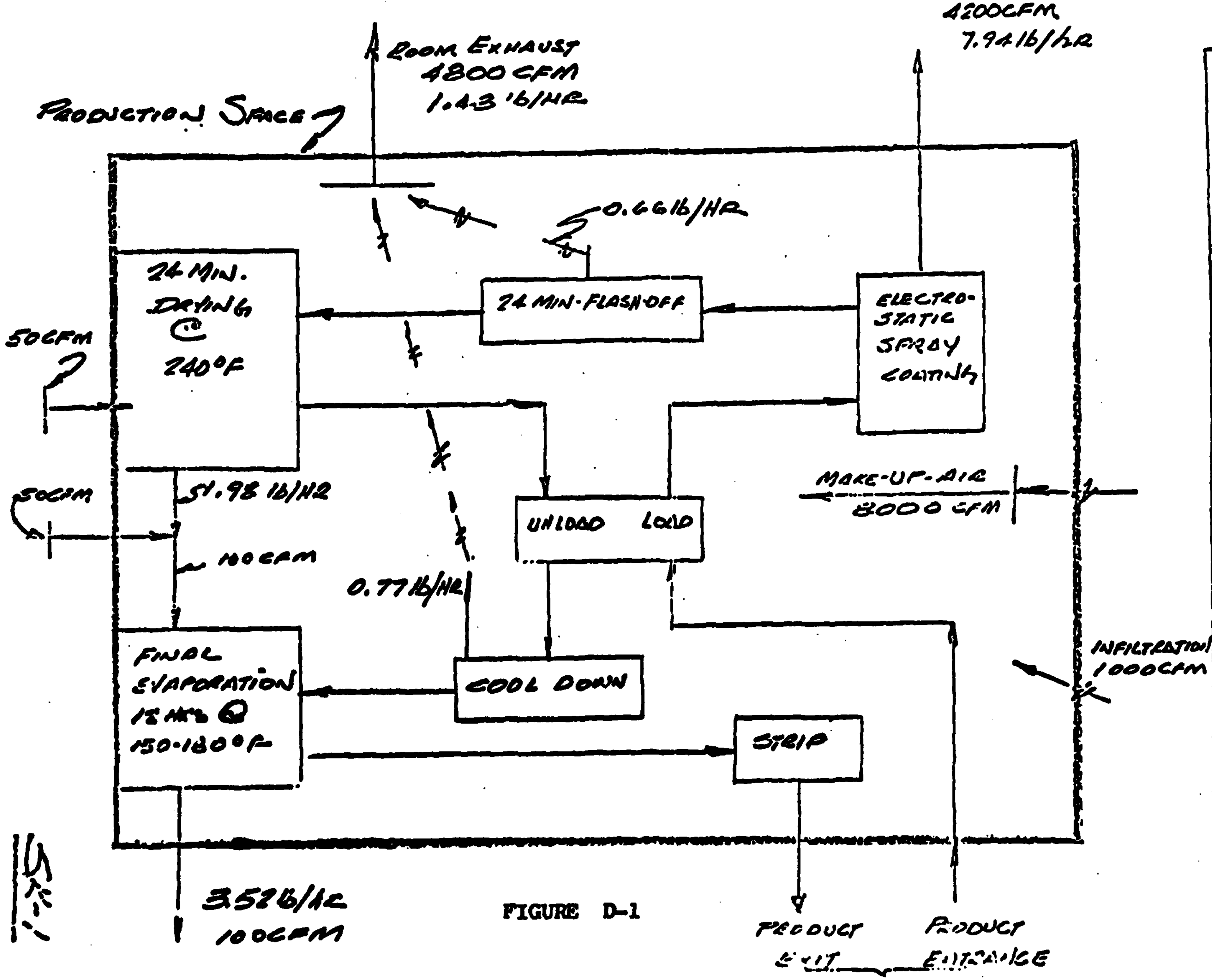


FIGURE D-1

Date: 1/1/75

VOLATILE ORGANIC AND SOLVENT DATA
Connecticut DEP
Conn. Regulation 19-508 Section →

(1) Chemical Name	(2) Empirical Formula	(3) lbs./gal.	(4) Maximum Allowable Emissions Without Controls 2082: 8# Hr.	Gal.	40# Day	(5) 2084: 160# Hr.	Gal.	800# Day	(6) 2081: 3# Hr.	Gal.	15# Day	(7) "Volatile Organic" 1.5 psia [illegible] @ Temp. °F
1,1-Dichloro-1-Nitropropane	$C_3H_5Cl_2NO_2$	10.9				14.6	N	73.0	0.274		1.37	181
Dichloropentane	$C_5H_{10}Cl_2$	9.31				17.2	N	85.9	0.322		1.61	162
Dichloro-di-iso-propyl Ether	$C_6H_{12}Cl_2O$	[illegible]				17.3	N	86.4	0.325		1.62	227
1,2-Dichloro-1,1,2,2-tetrafluoroethane	$C_2Cl_2F_4$	GAS				USE LBS. ONLY						-51
Dicyclohexyl	$C_{12}H_{22}$	7.37				21.7	N	109	0.407		2.04	279
Dicyclohexyl Amine	$C_{12}H_{23}N$	7.59				21.1	N	105	0.395		1.98	315
Diethanolamine	$C_4H_{11}NO_2$	9.15				17.5	N	87.4	0.328		1.64	333
Diethyl Amine	$C_4H_{11}N$	5.92				27.0	N	135	0.507		2.53	39
2-Diethylaminoethanol	$C_6H_{15}NO$	7.37				21.7	N	109	0.407		2.04	214
1,4-Diethyl-benzene	$C_{10}H_{14}$	7.24	1.10	R 2	5.52				0.414		2.07	218
Diethyl Carbitol	$C_8H_{18}O_3$	7.56				21.2	N	106	0.397		1.98	[illegible]
Diethyl Carbonate	$C_5H_{10}O_3$	8.13				19.7	N	98.4	0.369		[illegible]	139
Diethylene Glycol	$C_4H_{10}O_3$	9.34				17.1	N	85.7	0.321		1.60	349
Diethylene Glycol n-Butyl Ether	$C_8H_{18}O_3$	7.96				20.1	N	101	0.377		1.88	298
Diethylene Glycol Dibutyl Ether	$C_{12}H_{26}O_3$	7.38				21.7	N	108	0.407		2.03	307
Diethylene Glycol Methyl Ether	$C_5H_{12}O_3$	8.51				18.8	N	94.0	0.353		1.76	[illegible]
Diethylene Glycol Monoethyl Ether	$C_6H_{14}O_3$	8.52				18.8	N	93.9	0.352		1.76	263
Diethyl Ketone	$C_5H_{10}O$	6.81				23.5	N	117	0.440		2.20	118
Diethyl Oxalate	$C_6H_{10}O_4$	9.00				17.8	N	88.9	0.333		1.67	249
o-Diethyl Phthalate	$C_{12}H_{14}O_4$	9.34	0.85	R 2	4.28				0.321		1.61	402
Di-isobutyl Carbinol	$C_9H_{20}O$	6.78				23.6	N	117	0.442		2.21	239
* Di-isobutyl Ketone	$C_9H_{18}O$	6.76	1.83	R 3	5.92				0.444		2.22	221
Dimethyl Acetamide	C_4H_9ON	7.24				22.1	N	110	0.414		2.07	211
Dimethylaminoethanol	$C_4H_{11}NO$	7.18				22.3	N	111	0.418		2.09	171
Dimethyl Aniline	$C_8H_{11}N$	[illegible]	1.00	R 2	5.04				0.378		1.89	237
Dimethyl Cyclohexanol	$C_8H_{16}O$	7.61				21.0	N	105	0.394		1.97	248

Date: 1/1

VOLATILE ORGANIC AND SOLVENT DATA
Connecticut DEP
Conn. Regulation 19-503 Section →

(1) Chemical Name	(2) Empirical Formula	(3) lbs./gal.	(4) Maximum Allowable Emissions Without Controls: 2022 — 8# Hr.	2022 — Gal.	2022 — 40# Day	(5) 2014 — 160# Hr.	2014 — Gal.	2014 — 800# Day	(6) 2011 — 3# Hr.	2011 — Gal.	2011 — 15# Day	(7) Volatile Organic [illegible] @ Temp. °F
Propylene Glycol Methyl Ether	$C_4H_{10}O_2$	7.66				20.9	N	104	0.392		1.96	147
Propylene Oxide	C_3H_6O	6.92				23.1	N	116	0.434		2.17	-4
Pyridine	C_5H_5N	8.17	0.98	R 1	4.90				0.367		1.84	135
Styrene	C_8H_8	7.57	1.06	R 1	5.28				0.396		1.98	176
Terpineol	$C_{10}H_{18}O$	7.84	1.02	R 1	5.10				0.383		1.91	260
1,1,2,2-Tetrabromoethane	$C_2H_2Br_4$	24.6				06.5	N	32.5	0.122		0.61	324
1,1,2,2-Tetrachloro-1,2-difluoroethane	$C_2Cl_4F_2$	13.7				11.7	N	58.4	0.220		1.09	69
1,1,2,2-Tetrachloroethane	$C_2H_2Cl_4$	13.2				12.1	N	60.6	0.227		1.14	152
Tetrachloroethylene	C_2Cl_4	13.6				11.8	N	58.8	0.220		1.10	1.3
Tetrahydrofuran	C_4H_8O	7.41				21.6	N	108	0.405		2.02	42
Tetrahydrofurfuryl Acetate	$C_7H_{12}O_3$	8.84				18.1	N	90.5	0.339		1.70	22[illegible]
Tetrahydrofuryl Alcohol	$C_5H_{10}O_2$	8.76				18.3	N	91.3	0.342		1.71	220
Tetralin	$C_{10}H_{12}$	8.09	0.98	R 1	4.94				0.371		1.85	353
Toluene	C_7H_8	7.24	1.10	R 3	5.52				0.414		2.07	115
o-Toluidine	C_7H_9N	8.34				19.2	N	95.9	0.360		1.80	251
p-Toluidine	C_7H_9N	8.67				18.5	N	92.[illegible]	0.346		1.73	253
Tolylene-2,4-Di-isocynate	$C_9H_6N_2O_2$	10.1	0.78	R 2	3.93				0.295		1.47	374
Tributyl Phosphate	$C_{12}H_{27}O_4P$	6.29				25.4	N	127	0.477		2.39	451
1,2,3-Trichlorobenzene	$C_6H_3Cl_3$	12.1				13.1	N	65.7	0.246		1.23	271
1,1,2-Trichloroethane	$C_2H_3Cl_3$	12.0				13.3	N	66.6	0.250		1.25	127
Trichloroethylene	C_2HCl_3	12.3	0.64	R 3	3.24				0.243		1.22	84
1,1,2-Trichloro-1,2,2-trifluoroethane	$C_2Cl_3F_3$	13.0				12.3	N	61.2	0.230		1.15	14
o-Tricresyl Phosphate	$C_{21}H_{21}O_4P$	9.84	0.81	R 2	4.07				0.305		1.52	465
Triethanolamine	$C_6H_{15}O_3N$	9.42				17.0	N	84.9	0.318		1.59	570
Triethylamine	$C_6H_{15}N$	6.04				26.5	N	132	0.497		2.48	68
Triethylene Glycol	$C_6H_{14}O_4$	5.82				27.5	N	137	0.515		2.58	397
Triethylene Glycol Dimethyl Ether	$C_8H_{18}O_4$	7.37				21.7	N	109	0.407		2.04	246
	$C_2H_3Cl_3$	12.0				13.3	N	66.6	0.250		1.25	61

NOTE: TETRACHLOROETHYLENE IS A SYNONYM FOR PERCHLOROETHYLENE.

APPENDIX D

TABLE D-1 ACCEPTANCE STANDARDS VISUAL EXAMINATION

1. First Inspection - 100%	Major	Minor
A. Socklining		
(a) Die cut parts not correct or proper dimensions	X	
(b) Die cut parts not correctly stitched		
(1) Over 10 stitches per inch (3.94 stitches per centimeter)	X	
(2) Less than 6 stitches per inch (2.36 stitches per centimeter)	X	
(3) Sharp or rough stitch seam		X
(c) Missing, loose or torn	X	
(d) Wrinkled or creased		
(1) Small (less than 3/4 inch (1.9 cm) long by 1/8" (0.32 cm) wide		X
(2) Large (greater than 3/4 inch (1.9 cm) long by 1/8" (0.32 cm) wide	X	
(e) Depressions or ridges on insole		
(f) Seams not sealed	X	
B. Outsole		
(a) Cleats not formed, incomplete or blisters, poor blow	X	
(b) Untrimmed, unbuffed sole edge buffing dust	X	
(c) Excessive buff, cuts, unrepairable damage	X	
(d) Small voids 1/8" (0.32 cm)		X
(e) Overlap of outsole by upper		X

	Major	Minor
(f) Dirty soles		X
(g) Outsole weight 315 grams max., Size 10R	X	
C. Molded Upper		
(1) Sockllning missing, loose or torm	X	
(2) Sockllning slightly wrinkled or creased		X
(3) Depressions or ridges on insole	X	
(4) Foam strike through		X
(5) Poor blow of upper foam (irregular or none)	X	
(6) Poor adhesion upper to outsole	X	
(7) Surface blisters to 1/2" (1.27 cm) diameter, surface blemishes		X
(8) Flashline groove (void) unbuffed flashline	X	
(9) Not clean (solvent washed)		X
(10) Incomplete repairs, damaged boots, cuts	X	
D. Release Coating Application to Foam at Vamp		
(1) Application in wrong location	X	
(2) Insufficient coating	X	
2. Final Inspection - 100%		
A. Outerskin Coating		
(1) Uncoated or missed area	X	
(2) Damaged or broken skin	X	

	Major	Minor
(3) Pinholes or flecks (not thru skin)		X
(4) Discernible mold lines		X
(5) Blisters, bubbles or depressions within 3" (7.6 cm) from top		X
(6) Contamination		X
(7) Blushing and/or discoloration of skin		X
(8) Slight ridges, sags or drips on outsole (unbuffed)		X
B. Closure		
(1) Torn or cut	X	
(2) Missing laces or non-functional	X	
(3) Height less than 3" (7.62 cm)		X
(4) Folds in collar material under stitching		X
(5) Irregular stitching, loose, broken stitches	X	
(6) Stitching not within specification	X	
(7) Overlap to top edge of boot greater than 3/4 inch (1.9 cm)		X
C. Marking		
(1) Size missing	X	
(2) Cuff stencilling including size not legible		X

	Major	Minor
D. Complete Boot		
(1) Creased or wrinkled	X	
(2) Misshaped (damaged or compressed foam)	X	
(3) Poor alignment upper and outsole	X	
(4) Outside back height less than 10¼ inches (26 centimeters)	X	
(5) Weight (size 10R) more than 830 grams	X	
E. Packing and Shipping		
(1) Incorrect packing	X	
(2) Mixed sizes in box		X
(3) Tissue and cardboard insert missing		X
(4) Box label not legible		X
(5) Incorrect count in box	X	
(6) Incorrect address on shipping box	X	
(7) Shipping container marking not legible		X

TABLE D-2 - PHYSICAL PROPERTY REQUIREMENTS - OUTSOLE - UPPER - COATING

	Physical Property[1]	Test Method	Outsole Requirement	Upper Requirement	Outer Skin Requirement
a.	Color	-	Black	-	Black
b.	Density lb/ft.	ASTM D-2406-65 Par 62 - 67	25 ± 3	14 ± 3	-
c.	Tensile Strength	ASTM D-412-66	Min. 600		Min. 2500
d.	100% Modulus (psi)	-		-	Max. 700
e.	Ultimate Elongation (%)	ASTM D-412-66	Min. 250	-	Min. 450
f.	Compression Deflection @ 25% At room temperature (psi) At 20^{o} F (psi)[2]	ASTM D-1056-67T Par 17-20	Max. 55 Increase not more than 60% from orig.	Max. 15 Increase not more than 50% from orig.	
g.	Compression set at 50% deflection (24 hr. recovery) at room temperature at 158^{o}F	ASTM D-1056-67T Par 21-23	Max.15 Max.70	Max. 15 Max. 85	-
h.	Polyair Flex (no hammer)	-	Min. 15000 cycle	-	-

Physical Property[1]		Test Method	Outsole Requirement	Upper Requirement	Outer Skin Requirement
i.	Gehman Stiffness Test T-10°F	ASTM 1053-65 except par 8&9	-65°F	-65°F	-65°F
j.	Water Absorption % 6 inch head - 48 hr[3]	Fed. Std. 601 method 1241	Max. 8	Max. 50	-
k.	Tear (PPI)	ASTM 624-54 Die C for upper & outsole Die B for outer-skin	Min. 125	Min. 125	Min. 160
l.	Hardness Shore A	ASTM D-2240-64T			
	Original		Min. 45	-	-
	After 70 hrs. @ 212°F	ASTM D-573-67T	Not more than 15 point change from original	-	-
	At - 20°F (after 2 hrs)[4]		Not more than 15 point change from original	-	-
m.	NBS Abrasive Index Original	ASTM D-1630-61	Min. 10	-	-
	After 70 hrs. @ 212°F	ASTM D-573-67T	Min. 10	-	-

1 All foam physical properties run on molded slabs.

2 The test specimen and test apparatus shall be conditioned at -20°F ± 2°F for two hours prior to initiating test.

Physical Property Requirements (continued)

3
The complete skin and socklining shall be removed prior to testing.

4
A specimen at least 0.250 inches thick and at least one inch wide by two inches long shall be tested for hardness as specified in ASTM D2240-64T. The same specimen shall then be conditioned for two hours at $-20^{o}F$ ($\pm$ 3.6 C) and the hardness then determined at that temperature. The difference between the two determinations shall be recorded as the hardness change.

TABLE D-3 - Water Pick-up and Measurement Determination

1. Prior to initiation of testing as specified in Tables I and II, the Contractor shall conduct the following tests on the retained prototype pairs of boots:

   (a) Water pick-up - Entire Boot (with collar removed) immerse for 16 hours at Room Temperature - not more than 5.0% increase in weight.

   (b) Split boot into 2 parts along mold-line and obtain boot dimensions and thicknesses.

   (c) Measurements for size determination:

      1. Upper - After the boot is cut into two parts along the mold lines, refit the sections around the last to insure that the cut edges meet each other and the proper size dimensions have been achieved.

      2. Outsole - Cut out the outsole from the boot and use the last bottom pattern as a measurement device to insure that the proper size dimensions have been achieved.

   (d) Thickness Measurements - A description of the points at which the thickness measurements are to be made are as follows:

      1. Upper Section:

         a. Measurement points 1, 2, 3, 4, 5 and 6 are all located at the top edge of the boot. Points 1 and 2 are located on each side of the front mold parting line. Points 3 and 4 are located on each side of the rear mold parting line. Points 5 and 6 are located on each side midway between the front and rear mold parting line.

         b. Measurement points 7, 8, 9, 10, 11, 12 are exactly in the same position relative to the mold parting lines as those in the paragraph above except that they are all located on a line parallel to the top edge of the boot and 6 inches down from the top edge of the boot.

         c. Measurement points 13 and 14 are located on each side of the rear mold parting line approximately 8½ inches down from the top edge of the boot.

d. Measurement points 15 and 16 are located 5 inches from the bottom of the outsole measured from the front of the toe along each side of the mold parting line.

e. Measurement points 17 and 18 are 2 inches above the bottom of the arch at the point where the sole lugging begins.

f. Measurement points 19 and 20 are located 3 inches from the bottom of the outsole measured from toe on each side of the front mold parting line.

g. Measurement points 21 and 22 are located 2 inches above the bottom of the outsole and 3½ inches back from each side of the front mold parting line.

2. Measurement Point Thicknesses

Point Number	Insulation Thickness Range - Inches
1, 2, 3, 4, 5, 6	.100 - .200
7, 8, 9, 10	.500 - .700
11, 12	.400 - .600
13, 14	.500 - .700
15, 16	.600 - .800
17, 18	.700 - .900
19, 20	.700 - .900
21, 22	.700 - .900

3. Outsole - Cut the outsole into two parts in the length direction along the center line of the outsole. The following measurements are to be made one inch in from each side of the center line:

Location	Insulation Thickness Range - Inches
Heel (includes cleat)	1.750 - 1.850
Ball (includes cleat)	1.000 - 1.100
Arch (does not include cleat)	0.750 - 0.850
Cleat	0.200 - 0.300

2. A pair of standard calipers shall be used to determine the actual thickness.