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DRY ELECTRODES FOR PHYSIOLOGICAL MONITORING

by Charles W. Patten, Frank B. Ramme,
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SUMMARY

A method for very rapid application of electrocardiogram electrodes by spraying a conductive mixture is described. The electrodes are also suitable for electroencephalograms. All required equipment and the application procedure are described in detail. The finished electrode is dry and is less than 0.01-inch thick. Electrical and operational factors are not considered.

INTRODUCTION

This paper outlines a method for rapid instrumenting of subjects in an operational environment. This method of electrode application is well suited to the active subject and results in neither bulk nor significant discomfort. The electrodes described have relatively high impedance, by current clinical standards. The feasibility of using high-impedance electrodes and the methods for acquiring electrocardiogram information through the use of such high-impedance techniques are described in reference 1. The present paper deals only with techniques for preparation and application of electrodes.

The method described is a general one for rapid application of conductive cement. For specific applications, it could be greatly simplified. As outlined, it permits the use of, and experimentation with, a variety of conductive mixtures. Dry electrodes of this particular configuration are new. Since little information is available concerning their use, such experimentation may well prove necessary.

This method was developed at the NASA Flight Research Center, Edwards, Calif., in a cooperative effort between NASA personnel and a field team from Spacelabs, Inc., under contracts NAS4-390 and NAS4-791.

MATERIALS AND EQUIPMENT

This method of electrode application centers on the use of a special spray-gun assembly, electrode lead wires, and a conductive mixture. Detailed drawings of the spray-gun and the lead-wire assemblies are shown in figures 1 and 2, respectively. A photo of a portable bioinstrumentation cart, which includes all the necessary materials and equipment used in this method, is shown in figure 3. Inasmuch as the cart carries an air-supply source, it need only be connected to an ac power source to be capable of full operation, such as when a technical demonstration is to be presented.

The spray gun used in this procedure is a modified DeVilbiss No. 156 atomizer assembly with two valves and a glass 1-ounce supply bottle. A special barrel (figs. 4(a) to 4(c)) with a slit tab on the end holds the wire electrode lead, a spring-loaded release rod disengages the lead wire from the gun, and a vented barrel confines the liquid spray to a circular area of half-dollar size. A T-connector is incorporated to enable use of one air hose instead of two. The two valves permit using liquid spray for electrode application and air for drying. Normally, an air pressure of 20 pounds per square inch is adequate.

A separate 12-volt Ritter heated-air syringe and hose assembly is used for rapid drying of the nonconductive spray covering after the electrode is applied. This assembly is a standard dental-equipment item.

Figure 5 shows the elastic band-clamp assemblies used as clothing restraints. One assembly has two alligator clamps to hold a towel across the subject's waist during deinstrumentation. The electrode-disconnect block is secured on a nonconductive silastic-covered neck chain.

A donning table (surgical instrumentation stand and tray) holds the equipment (fig. 6). The following equipment and materials are recommended; however, personal on-hand items may suffice, and dimensions of some items are optional:

1 table, low, 2 feet by 4 feet by 30 inches
1 stand, surgical instrument, adjustable height
1 tray, surgical instrument (used with stand)
1 container, sponge, stainless steel, 2-quart capacity
1 container, sponge, stainless steel, 1-quart capacity
1 basin, emesis, 6-inch
1 beaker, 400 milliliter, with lid
1 beaker, 50 milliliter
2 cups, medicine, stainless steel, 2 ounces
1 jar, ointment, glass with lid, 2 ounces
1 tray, stainless steel, 2 inches by 6 inches by 1 inch
1 hose assembly, heated air with 12-volt transformer
1 hose assembly, atomizer
1 compressed-air or inert-gas supply (20 lb/sq in., minimum)
1 regulator assembly, pressure control, with gages
4 bottles, atomizer, 1 ounce
1 rack, atomizer bottle, 4-bottle capacity
1 gun, spray, electrode application (modified DeVilbiss atomizer)

1 lamp assembly, adjustable, with spotlight
1 mirror, parabolic
1 toothbrush assembly, electric
2 syringes, plastic, 2 cubic centimeter
1 tube, electrode jelly
2 cans, aerosol, insulation, electrode adhesive, 2 ounces (Hauser LSA-1, Hauser Research & Engineering Co., P. O. Box G, Boulder, Colo.)
A/R sponge, gauze, 4 inches by 4 inches
1 brush, artist's, 1 inch
1 cleaner assembly, ultrasonic
1 bottle, acetone, 1-quart capacity (5-gallon supply)
1 bottle, zephiran chloride aqueous solution (1 - 1000), 1 gallon
1 bottle, tincture of green soap
A/R mat, floor, plastic, acetone resistant
1 scale, health, with height measurement
1 thermometer, ambient air
3 extinguishers, fire, carbon dioxide (CO_2)
2 band-clamp assemblies, neck (10 to 12 inches long)
2 band-clamp assemblies, waist (18 to 20 inches long)
2 band-clamp assemblies, waist, with clips (18 to 20 inches long)
6 neck chains, plastic covered, nonconductive

PREPARATION OF EQUIPMENT

The donning equipment should be prepared daily. Two technicians are recommended, hereafter referred to as Technician 1 and Technician 2. In the NASA project being conducted at the USAF Aerospace Research Pilot School, Edwards, Calif., where this method of instrumentation is in daily use, the instrumentation room is outfitted with two complete donning tables and associated equipment.

The methods of preparing the individual items of equipment are described in detail in the following sections.

Electrodes

Prepare the electrode lead-wire assemblies using a No. 38 gage Teflon coated copper wire (fig. 2). An ample supply of these assemblies should be prepared well in advance of need. Solder a pin connector to one end, and strip the other end of the Teflon covering to expose the bare wire 3/4 inch (±1/8). Silver-plate this end and attach a retaining ball of approximately 1/32 inch, using a suitable epoxy dispensed by a small plastic syringe. Place the prepared electrode lead-wire assemblies onto pressure-sensitive, transparent, double-coated tape on one side of a narrow plastic board. This board gives the technicians two spare leads readily available at the donning table if needed.

Continuity test.— Remove an electrode lead-wire assembly from the board. Attach both ends of the wire to flat jaw clips on a volt-ohm meter and check. The meter should indicate 1.0 (±0.2). Gently tug wire near pin end and observe the meter for any indication of needle fluctuation. Should this occur, do not use the lead-wire assembly. Lay aside any rejected assembly for laboratory check and evaluation. Repeat the continuity check on each electrode lead to be used for the next subject. Check all electrode leads for continuity prior to use.

Insulation Cement

Inspect the insulation-cement aerosol can. Test by shaking, and test-spray on a paper towel to check the nozzle for plugging. Place can, nozzle down, in a 2-ounce medicine cup and pour in about 3/4 inch of acetone to soften the insulation cement on the nozzle and prevent plugging.

CAUTION

When ambient air is below 70° Fahrenheit, warm the insulation-cement aerosol can by holding in the hand or placing in WARM water. Do NOT place in hot water or heat to warm the can. This could cause the can to explode.

Syringes and Toothbrushes

Prepare two plastic (1 cc or 2 cc) hypo-syringes (less needles) with electrode jelly by removing plunger and inserting electrode-jelly tube into the plunger-end of the syringe and inject jelly to the half-full mark. Remove tube and replace plunger. Place prepared syringes in a shallow cup containing a small amount of zephiran chloride to prevent the small opening of the syringe from drying and plugging.

Using a syringe, prepare four to six toothbrushes (two for each subject) by applying electrode jelly to the base of the brush fibers, on both sides, and within the fibers from the top. Place prepared toothbrushes in an empty cup and cover with a water-moistened 4-inch by 4-inch gauze sponge to prevent drying.

Gauze Sponges and Neck Chains

Lay out two stacks of 4-inch by 4-inch gauze sponges on the surgical instrumentation tray and have a supply of neck-chain assemblies available.

Spray-Gun Assembly

Flush spray gun by test spraying with acetone in the 1-ounce container. Check the conductive-cement mixture by pouring from the 1-ounce container into the supply container and shaking thoroughly to suspend silver particles. Refill the 1-ounce container with the mixture to the raised-rib line. Remove the 1-ounce container of acetone from the spray gun and install the 1-ounce container of conductive-cement mixture on the spray gun. Place the prepared spray-gun assembly on the receptacle located on the surgical instrumentation tray. Spray test is not normally required.

NOTE

Preparation of conductive-cement mixture for attaching on spray gun should be performed about 15 minutes before instrumentation. When delay occurs, remove the 1-ounce container of conductive-cement mixture from spray gun and shake container to keep silver particles suspended (every 15 minutes). Refer to "Conductive-Cement Mixture" (page 6) for instructions on mixing ingredients.

Heated-Air Hose

Test heated-air hose by depressing the valve button to check for air pressure and heat. Return hose assembly to the receptacle located on the surgical instrumentation tray.

Adjustable Lamp Assembly

Standing in front of the donning table, a technician positions the lamp so the spotlight is centered on the chest area and not directed into the eyes of the test subject.

Towel and Band-Clamp Assemblies

Check to determine that a clean bath towel is supplied, for use during deinstrumentation, and that the neck band-clamp assembly and two waist band-clamp assemblies (one with clips) are attached to the side of the surgical instrumentation tray.

Acetone Supply

Check the supply of acetone for daily use and cleanup. Fill three 1-ounce atomizer containers to the raised-rib line and store in atomizer bottle rack.

Conductive-Cement Mixture

Prepare a supply of conductive-cement mixture in an 8-ounce bottle using the following ingredients:

(a) 43 grams (1 tube) Duco household cement (Dupont S/N 6241)

(b) 43 grams silver powder (Handy & Harmon Silflake No. 135, or equivalent)

(c) 125 milliliters (4 oz) acetone

Combine these ingredients in an 8-ounce bottle, cap the bottle, and thoroughly mix the solution by shaking until inspection shows absence of lumps.

NOTE

Keep bottle capped at all times to prevent evaporation of acetone, which causes thickening and concentration of the mixture.

INSTRUMENTATION OF SUBJECT

Previous experience is not required to perform the following procedure properly. With a minimum of practice, two technicians can develop this technique which will enable them to regularly instrument a test subject in less than 3 minutes. Although the procedure is used primarily for pilots, it is also used in the laboratory for instrumenting test subjects and is easily adaptable for clinic and hospital work.

Preparation of Test Subject

Have the test subject stand directly in front of the donning table, with the flight suit unzipped to below the waistline. Technician 1 works to the right of the test subject, and Technician 2 on the left.

(a) Place insulated neck chain around the test subject's neck and beneath the undershirt.

(b) Have the test subject lift undershirt, pulling it up evenly to expose chest; place short neck band-clamp assembly around neck, securing undershirt high against the neck. Check that neck chain hangs free underneath, and secure to one side of flight suit.

(c) Place waist band-clamp assembly around waist and secure with clamps to anchor flight suit, exposing chest.

(d) Technician 1 begins skin cleanup using prepared (electrode jelly) electric toothbrush (fig. 7). Three areas are cleaned: one just below the

clavicle on the manubrium; one on the lower end of the body of the sternum; and one over the cardiac apex.

NOTE

Electrodes should be positioned 4 inches or more apart for best results.

(e) As Technician 1 cleans an area, Technician 2 follows with clean, dry, 4-inch by 4-inch sponges to clean off electrode jelly.

Electrode Application

Technician 2 takes an electrode lead-wire assembly from the plastic board and attaches the ball end of the wire to the slit tab on the barrel of the spray-gun assembly. Working together, the two technicians apply electrodes to the prepared skin areas as follows:

(a) Technician 1, with a small amount of electrode jelly on the forefinger, makes a light wiping motion to place a very thin film (1/2-inch diameter) on the prepared skin.

(b) Technician 2 places the nozzle of the spray gun (with lead wire in the slit tab) against the skin (fig. 8), centered over the jelly coat, and sprays a coating of conductive-cement mixture to form a half-dollar-size electrode and to capture the lead wire in the cement. (See figure 9 for cross-sectional view.)

NOTE

Inasmuch as this spray technique does not require shaving, quick inspection should be made of especially hairy areas before air drying is completed to insure that the wire is properly captured in the cement. If not, momentarily press the wire or give a second very short spray of cement mixture; the correct action will be determined through experience.

With the nozzle still in place, begin air drying; with free hand, push the spring-loaded release rod forward (figs. 10 and 11) to release the ball end of the lead wire from the slit tab.

NOTE

For best results, it is important that a thin coat of conductive mixture be sprayed and dried before the wire is pressed onto the skin. Direct contact between skin and wire is undesirable.

(c) While continuing air drying, move spray gun away from skin about 1/2 inch until drying is completed (fig. 12). (Spray gun must be withdrawn from skin within 2 seconds after starting air drying to prevent gun from adhering to sprayed area on skin.)

(d) Repeat steps (a) through (c) for the remaining electrodes.

(e) During air drying of final electrode, Technician 1 prepares insulation-cement spray by shaking spray aerosol container.

(f) Technician 2, upon completion of final air-drying operation, lays aside spray gun and takes heated-air gun, directing heated air in a circular motion to the first electrode in a continuous jet of heated air. The heated-air jet is continuous before, during, and after application of the insulation cement.

(g) Technician 1, using insulation cement, directs insulation-cement spray to cover and overlap the perimeter of the electrode about 1/4 inch as the heated-air jet is applied (fig. 13).

(h) Repeat step (g) to insulate the remaining electrodes.

Electrode Lead Connections

Upon completing the insulating, plug the pin-connector end of the electrode-lead-wire assemblies into the electrode-connection block, color-coded as follows:

WHITE: Pin connector from manubrium
RED: Pin connector from lower sternum
BLACK: Pin connector from apex region

(a) When the three electrodes have been properly connected and checked (refer to color code), reverse the electrode-connection block so that the lead wires and the curved portion of the pin connectors face outward, away from the skin of the test subject (fig. 14). This reduces the possibility of perspiration dripping into the connection and lessens the chance of pins being pulled loose by rubbing against the chest.

(b) Place the insulated neck chain across the electrode-connection block and over the lead wires. Secure the block on the chain by inserting the chain into slots on both sides of the block, sliding up the slots enough to prevent the chain from slipping out.

(c) After final inspection, both technicians working together remove the neck and waist band-clamp assemblies, using care not to disturb the electrodes, lead wires, and block, and pull the undershirt down.

DEINSTRUMENTATION

Subject stands in front of the donning table and technicians are positioned as during the instrumentation operation. The following inspection and deinstrumentation of the subject should normally be accomplished in about 2 minutes.

Preparation of Test Subject

Before beginning deinstrumentation, check to determine that an emesis basin containing two 4-inch by 4-inch acetone-soaked gauze sponges and an ample supply of clean, dry gauze sponges are available on the surgical instrumentation tray for use by both technicians. Prepare test subject as follows:

(a) Technician 2 attaches bath towel to alligator clip on the left end of the waist band-clamp assembly and installs clamp on left side of unzipped flight suit, then passes band around back of test subject to Technician 1 for clamp attachment to right side of flight suit.

(b) Using care not to disturb electrodes and lead wires, lift undershirt, and both technicians install the short neck band-clamp assembly around neck of test subject, securing undershirt with restraints, then quickly inspect the position and condition of all three electrodes, the lead wires, and the pin connections to the electrode connection block.

NOTE

During inspection, note if any wire is broken or pulled loose, any pin disconnected, or other evidence of damage. Enter these observations on instrumentation form, which will provide valuable reference sources when necessary during later analysis of recordings.

(c) Technician 2 passes bath towel across front mid-section of test subject, and Technician 1 receives towel, pulling it tightly and securing with alligator clip on right waist band-clamp assembly.

CAUTION

Be sure towel is tight across mid-section of test subject. Towel is installed to catch, absorb, and prevent any spillage or drainage of acetone to lower abdomen of test subject during deinstrumentation operation, which could cause discomfort. (Refer to "Safety Precautions: Spillage," page 12.)

Electrode Removal

Before removing the electrodes, the pin connectors are disconnected from the electrode-connection block, the block disengaged from the neck chain, and the neck chain secured under the folds of the undershirt for the following procedure:

(a) Technician 1 places emesis basin, containing 4-inch by 4-inch gauze sponges and acetone, with outer curved side to test subject (fig. 15) just below uppermost instrumented electrode and firmly against the skin. Using the saturated gauze sponges, Technician 1 generously applies acetone to cemented

area by patting, thoroughly soaking, and wiping away dissolved cement. Technician 2, using three or more dry 4-inch by 4-inch gauze sponges, assists by wiping and absorbing any acetone spillage below the basin.

NOTE

During electrode removal, the lead wires are ignored as they fall away and are discarded after use.

(b) When the first electrode has been dissolved and wiped, Technician 1 moves basin to lower electrode and repeats step (a). Technician 2 performs a further cleanup with dry gauze sponges on the first electrode, and wipes to absorb any spillage of acetone during soaking and dissolving of the lower electrode.

(c) Technician 1, after dissolving and wiping the lower electrode, reverses the emesis basin, placing inside curve against the natural curve of the rib cage (fig. 16) of test subject just below the instrumented electrode in the heart region and repeats step (a).

(d) When the last electrode has been removed, both technicians perform a final cleanup on all three areas.

(e) If cleaned skin areas appear to be inflamed or test subject expresses discomfort, Technician 1 applies skin lotion over the area, using a clean 4-inch by 4-inch gauze sponge for application. Normally, application of skin lotion will not be required.

Ultrasonic Cleaning

Remove and cap the 1-ounce container of conductive-cement mixture from the spray-gun assembly and install a 1-ounce container of acetone on the spray gun. Spray about three-fourths of the acetone into a suitable waste receptacle to clean spray gun and nozzle. While spraying, momentarily invert spray gun, to clean inner part of gun assembly.

CAUTION

Do NOT invert spray gun except during continuous spraying of clear acetone for cleaning. Otherwise, plugging or accidental admittance of acetone or cement mixture could occur in the valve assembly and ultimately in the hose. This could damage the equipment.

After spray cleaning, immerse the spray gun and nozzle assembly, with acetone container attached, into the acetone cleaning agent on top of the ultrasonic cleaning unit (fig. 17). Be sure that the valve assembly and trigger are not immersed. Clean ultrasonically, normally about 10 minutes. When the assembly is thoroughly cleaned, remove from ultrasonic cleaner, momentarily

depress each valve to complete cleaning, and install on the receptacle located on the surgical instrumentation tray.

NOTE

When the next instrumentation is scheduled soon after the first (within 15 to 30 minutes), the technician may choose acetone for spray cleaning and wait until the schedule permits ultrasonic cleaning. However, ultrasonic cleaning is a recommended daily procedure.

Toothbrush Cleaning

Clean used brushes in a hot, diluted tincture of green-soap solution by scrubbing one brush against another. Soak clean brushes in zephiran chloride for about 10 minutes. Remove and store in a clean container, or prepare when necessary as instructed in the section on "Syringes and Toothbrushes," page 4.

Electrode Instrumentation Records

Upon completion of the deinstrumentation procedure, equipment cleanup, and preparation, Technician 2 enters information on a record sheet (fig. 18). A record sheet should be completed for each test subject instrumented and the sheet placed in a log book.

EMERGENCY OPERATIONS

Fouled Spray Gun

During electrode instrumentation of a test subject, when the spray gun malfunctions by becoming plugged, fouled, or by loss of air pressure, do NOT attempt to repair the spray-gun assembly. Place the assembly on the receptacle located on the surgical instrumentation tray. Using the artist's paint brush, dipped into the backup supply of conductive-cement mixture, apply the mixture on the lead wire and skin. When no air pressure is available for the spray gun or heated air, use a piece of cardboard or folded paper to fan the cement mixture until dry. Repeat fanning to dry the insulation-cement application. This measure is not recommended unless at least two electrodes are completed.

Heated-Air Hose

During instrumentation of a subject, when the heated-air hose assembly malfunctions because of loss of air pressure, do NOT attempt to repair the assembly. Place the hose assembly on the receptacle located on the surgical instrumentation tray and air-dry the electrode spray by fanning, as described

in the previous paragraph, or, when possible, use the air valve on the spray-gun assembly.

Safety Precaution: Spillage

During deinstrumentation when a supply of acetone is used in the emesis basin, wipe away any spillage. When an accident occurs causing acetone to spill from the basin onto the lower abdomen of the test subject, DO NOT HESITATE. Open the flight suit and immediately pull clothing away from the acetone-wetted skin area and permit air to evaporate the acetone.

CAUTION

Removal of clothing soaked in acetone is imperative. Evaporation of acetone on the skin is rapid in an open area. However, acetone-soaked clothing held against the skin cannot evaporate quickly and can cause extremely rapid skin irritation, resulting in burning or blistering. Quick action can prevent this. When the situation requires, have test subject remove all clothing and use towels for rapid drying by airing the wetted area. Afterward apply skin lotion and request that the subject be examined by medical personnel.

Flight Research Center,
National Aeronautical and Space Administration,
Edwards, Calif., January 14, 1966.

REFERENCE

1. Roman, James A.; and Lamb, Lawrence E.: Electrocardiography in Flight. Aerospace Medicine, vol. 33, May 1962, pp. 527-544.

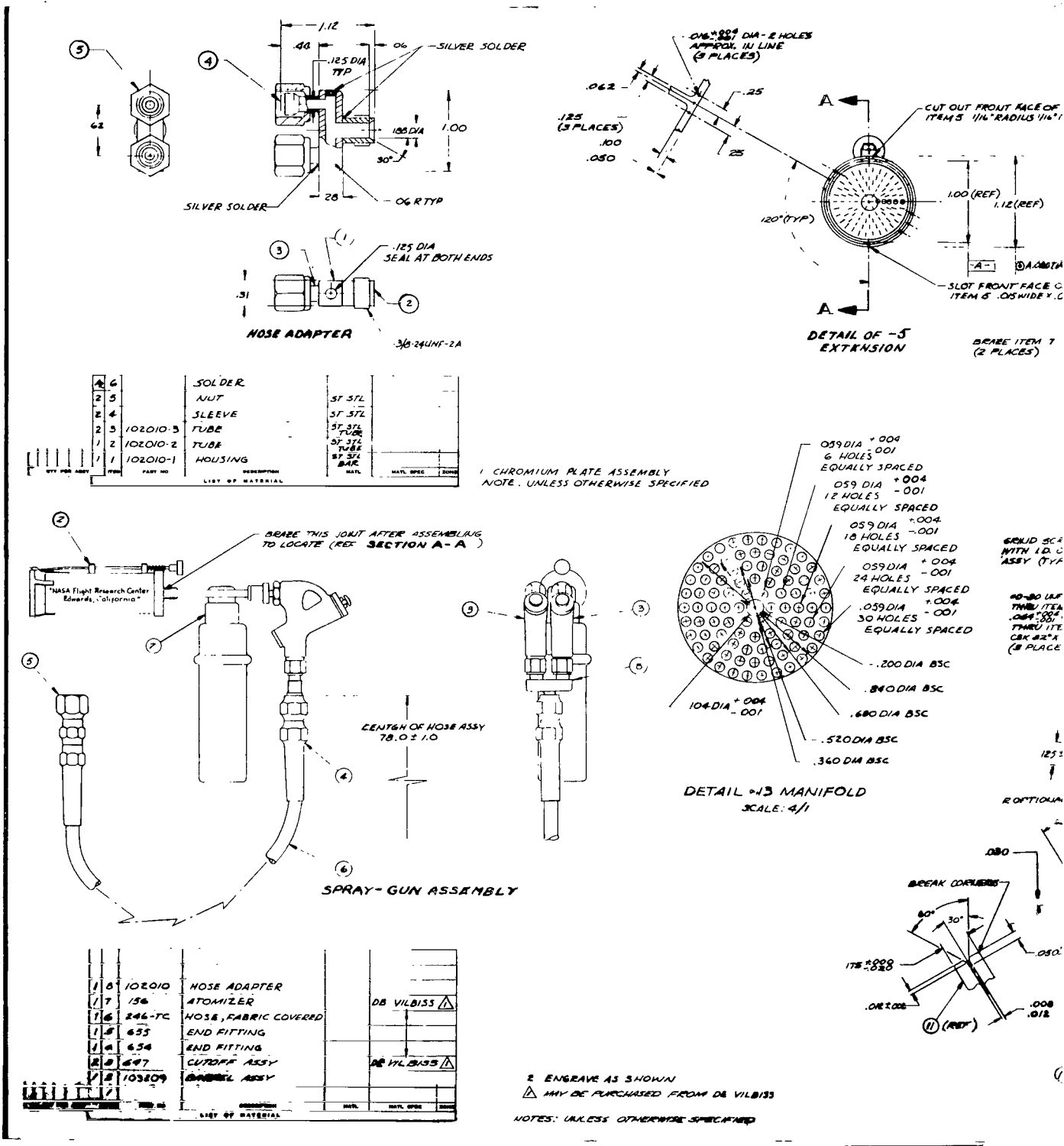
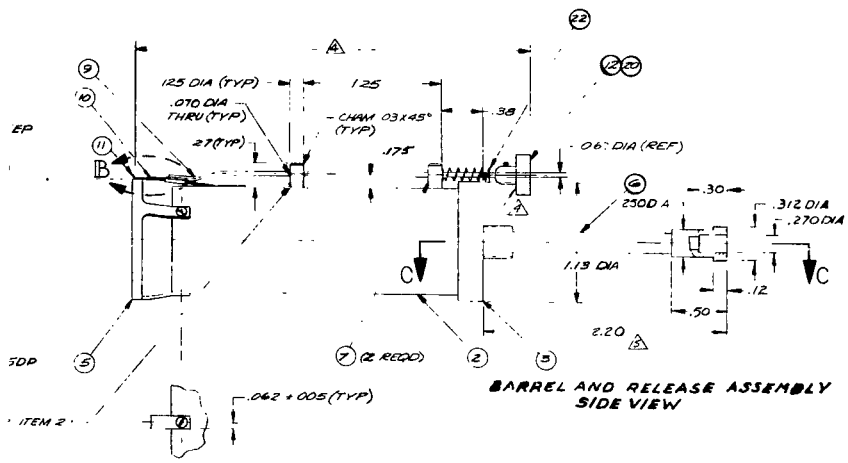
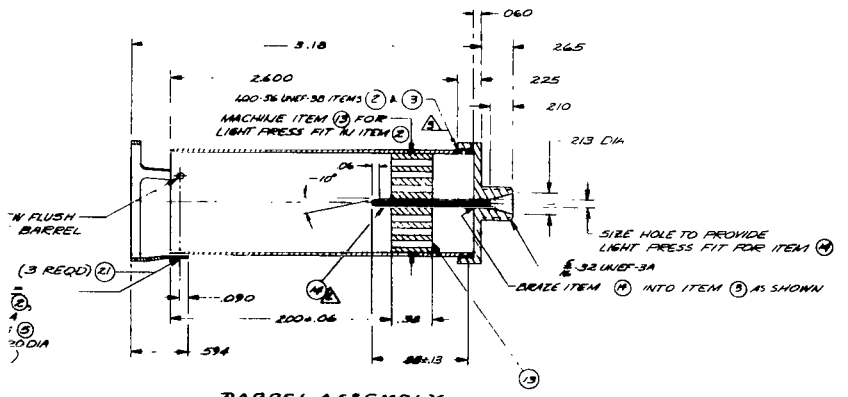


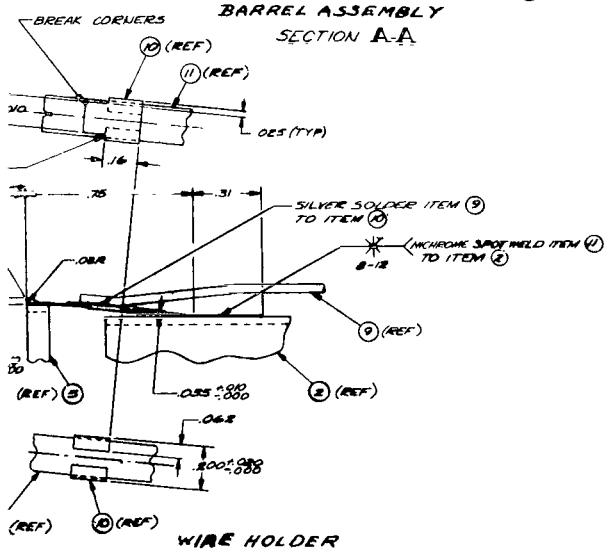
Figure 1.— Drawing of spray gun (modified DeVilbiss).



BARREL AND RELEASE ASSEMBLY
SIDE VIEW

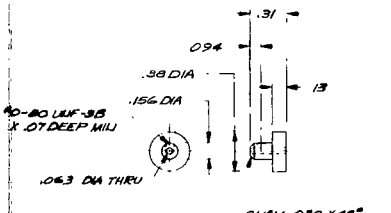


BARREL ASSEMBLY
SECTION A-A

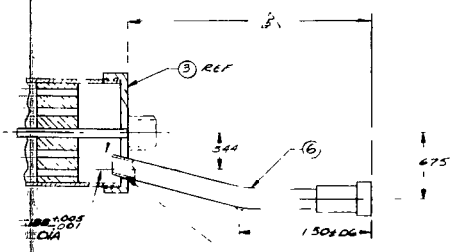


WIRE HOLDER

DETAIL B
(SCALE: 4/1)



DETAIL OF -12 KNOB



SECTION C-C

DRYING-AIR TUBE

ITEM	QTY PER ASSY	PART NO	DESCRIPTION	MATL	MATL SPEC	SHEET
20						
19						
18						
17						
16						
15						
14	1	-14	NEEDLE	ST STL TUBE, 3/32 I.D.		
13	1	-13	MANIFOLD	BRASS		5/16
12	1	-12	KNOB	ST STL		5/16
11	1	-11	SPRING	.008 SPRING STL		5/8
10	1	-10	SPRING	.008 SPRING STL		5/8
9	1	-9	STEM	ST STL WIRE, .062 DIA		5/8
8	1	-8	COLLAR	ST STL BAR		5/8
7	2	-7	GUIDE	ST STL BAR		5/8
6	1	-6	TUBE	SMLS ST STL TUBE, 3/16 O.D. x .035 WALL		5/16
5	1	5	EXTENSION	SMLS ST STL TUBE, .115 O.D. x .035 WALL		5/8
4	1	-4				
3	1	-3	END CAP	ST STL BAR		5/16
2	1	-2	BARREL	SMLS ST STL TUBE, .400 O.D. x .035 WALL		5/8
1	1		BARREL ASSY			

LIST OF MATERIAL

6 CHROMIUM PLATE ASSEMBLY

5 DIMS NOTED TO BE EQUAL WITHIN .015

4 WHEN INDICATED FACE OF ITEM (4) BUTTS AGAINST ITEM (5), ITEM (10) SHOULD BE FLUSH WITH ITEM (5) AT FRONT EDGE

3 FINISH PART (2) B PRESS INTO PART (3) PRIOR TO THREADING ITEM (3)

2 NECK ITEM (4) (3/32 TUBING) DOWN TO APPROX 1/16 EXISTING I.D. AS SHOWN USING MANDREL

1 REMOVE ALL BURRS & SHARP EDGES

NOTES: UNLESS OTHERWISE SPECIFIED

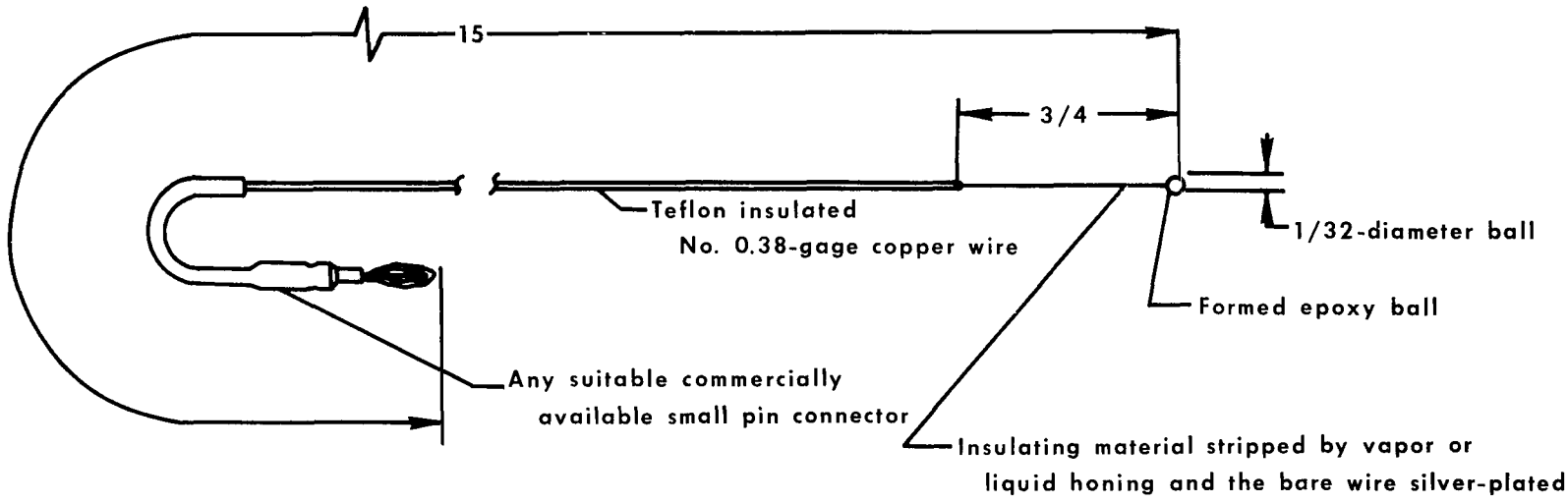


Figure 2.– Electrode lead-wire assembly. Dimensions in inches.

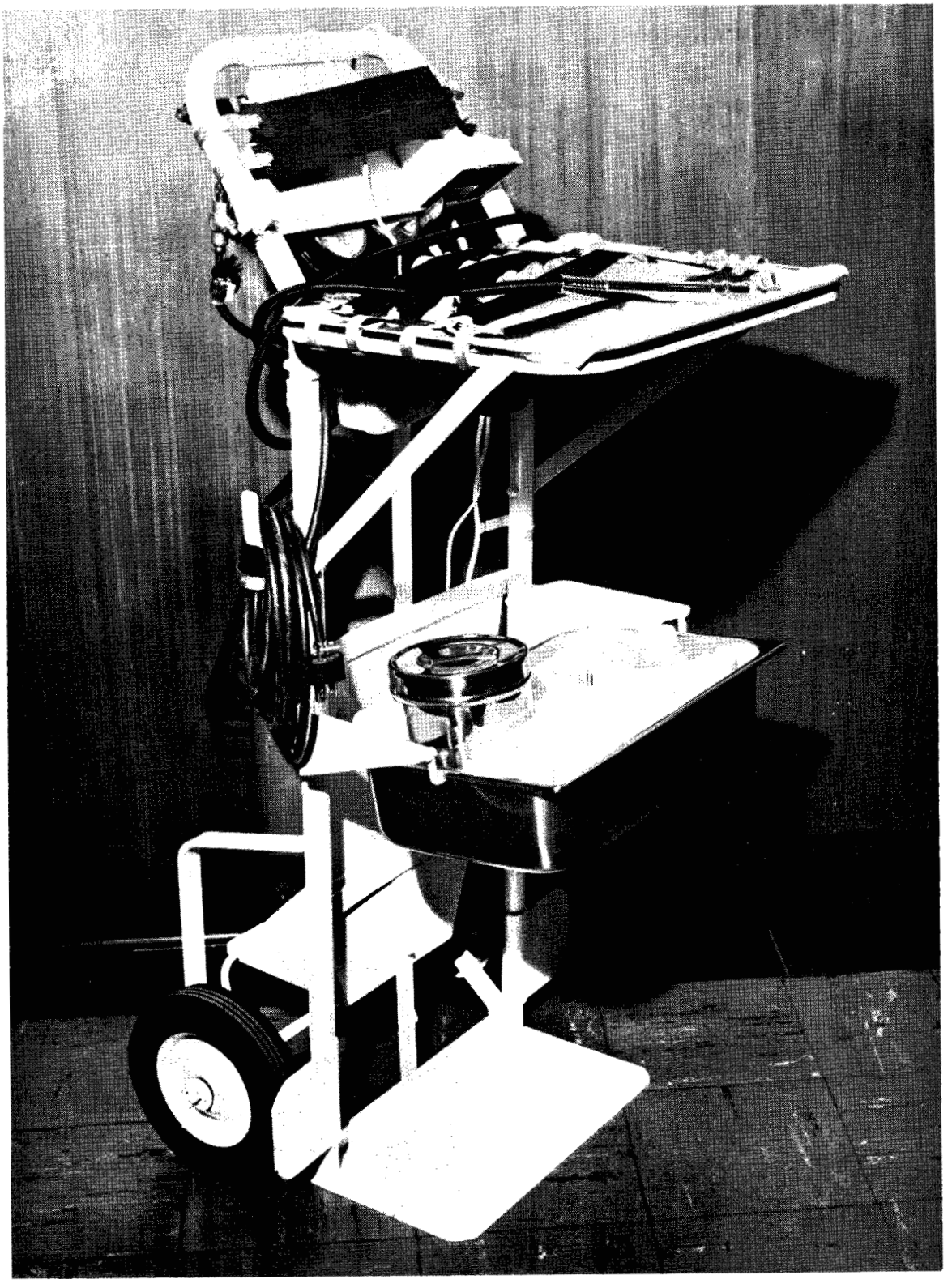
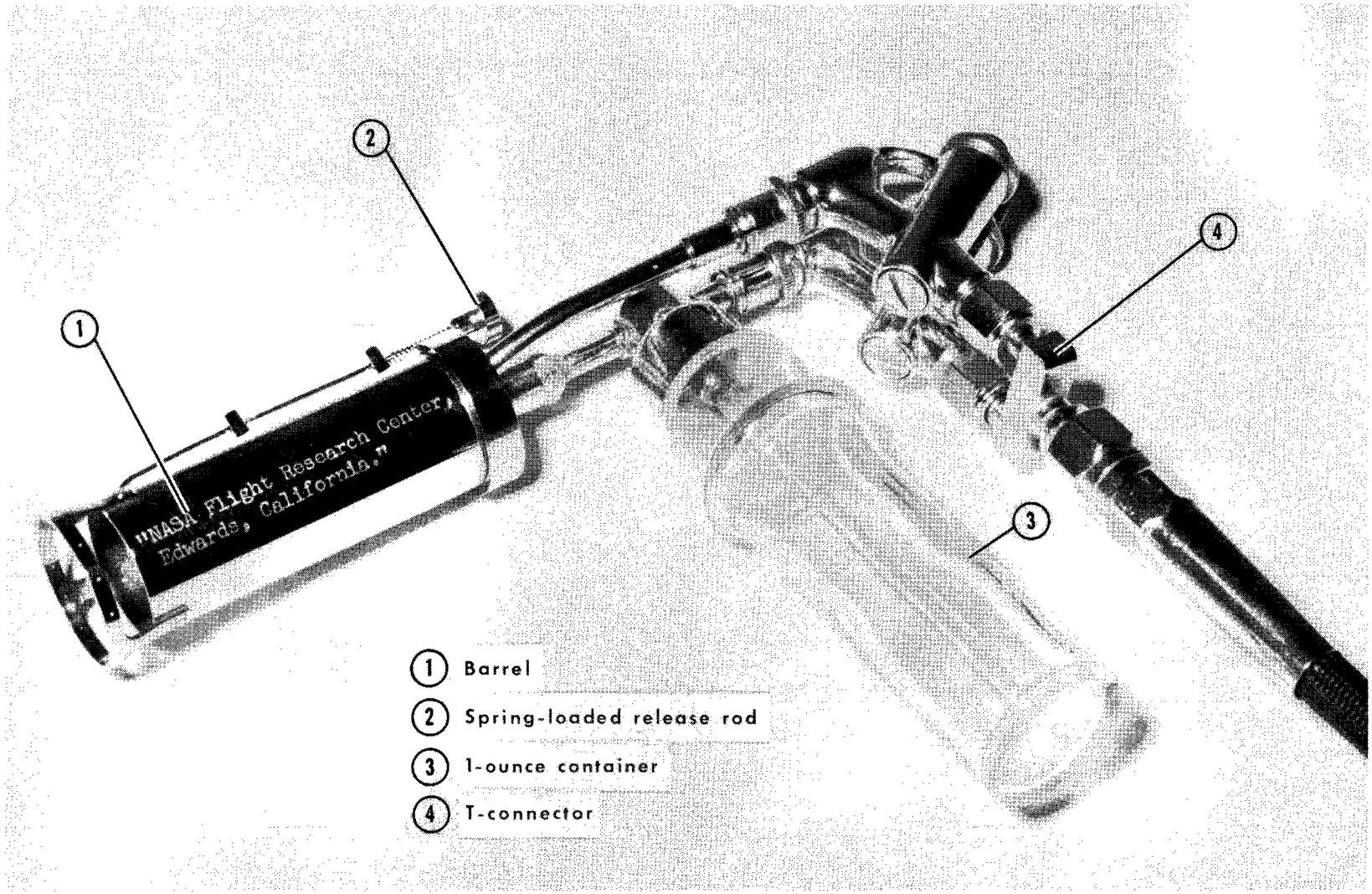


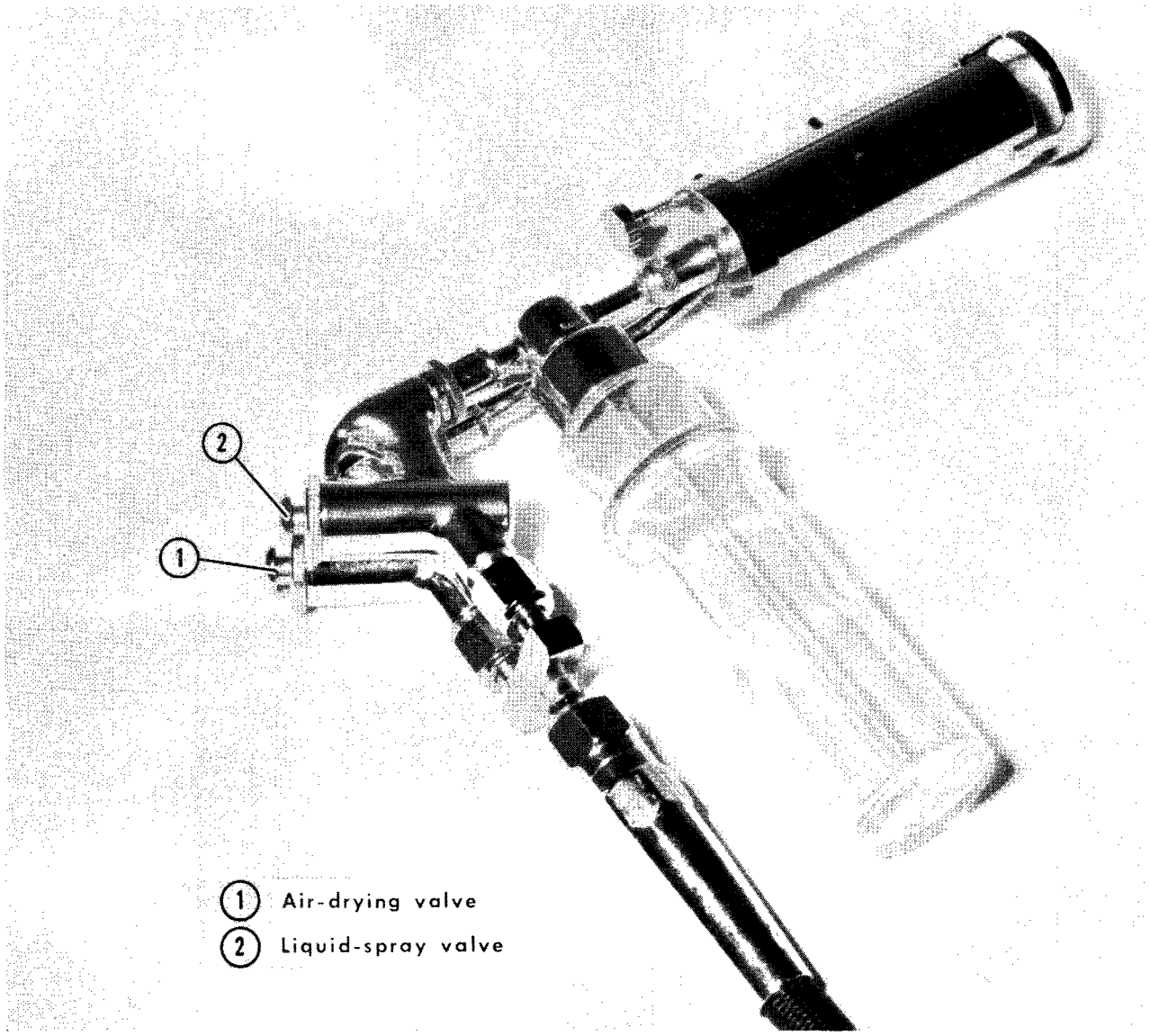
Figure 3.– Portable bioinstrumentation cart. E-13270



E-13862

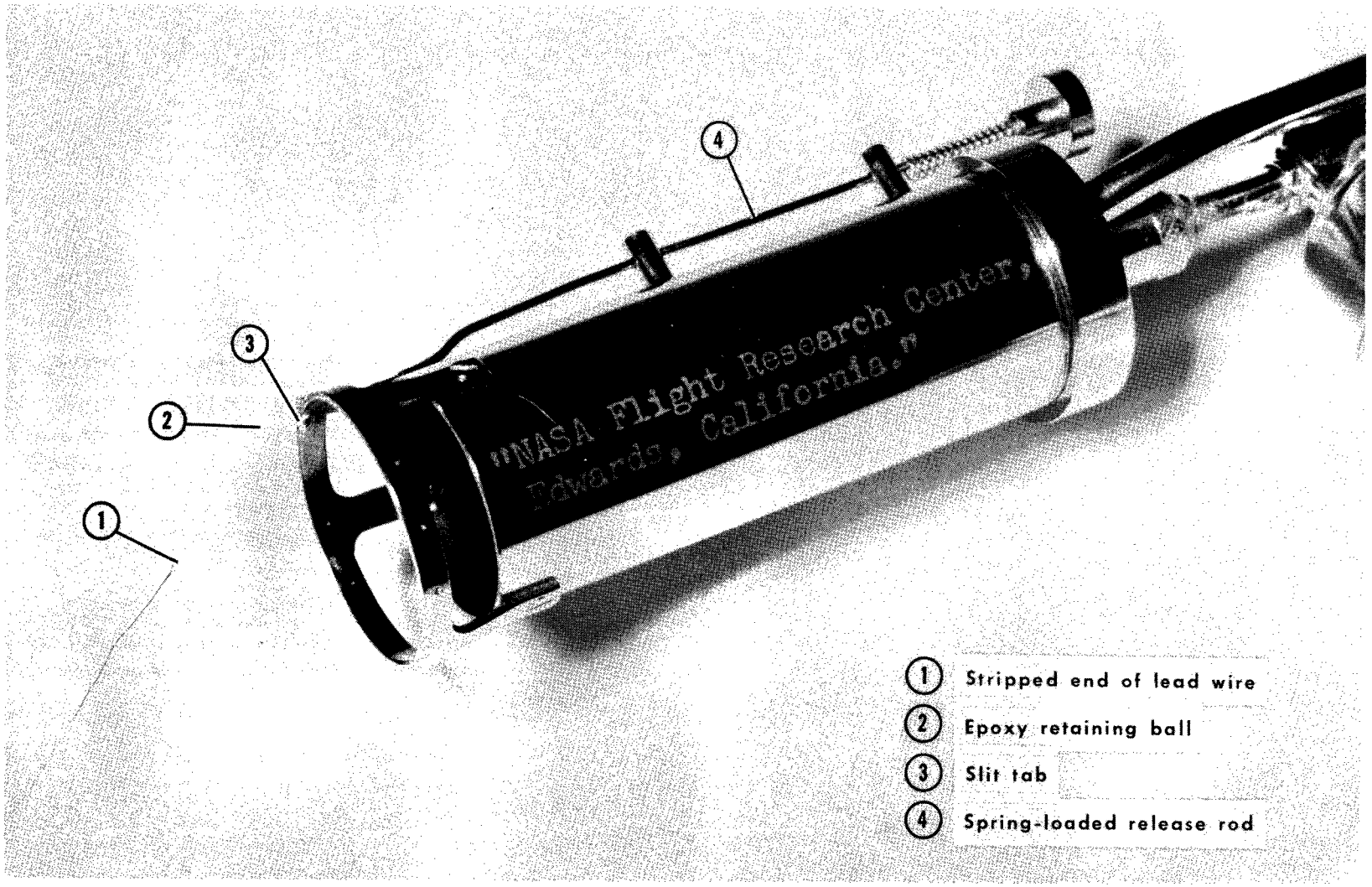
(a) Front view.

Figure 4.– Spray-gun assembly.



(b) Rear view. E-13861

Figure 4.– Continued.



(c) Closeup showing lead wire about to be attached to slit tab. E-13863

Figure 4.– Concluded.

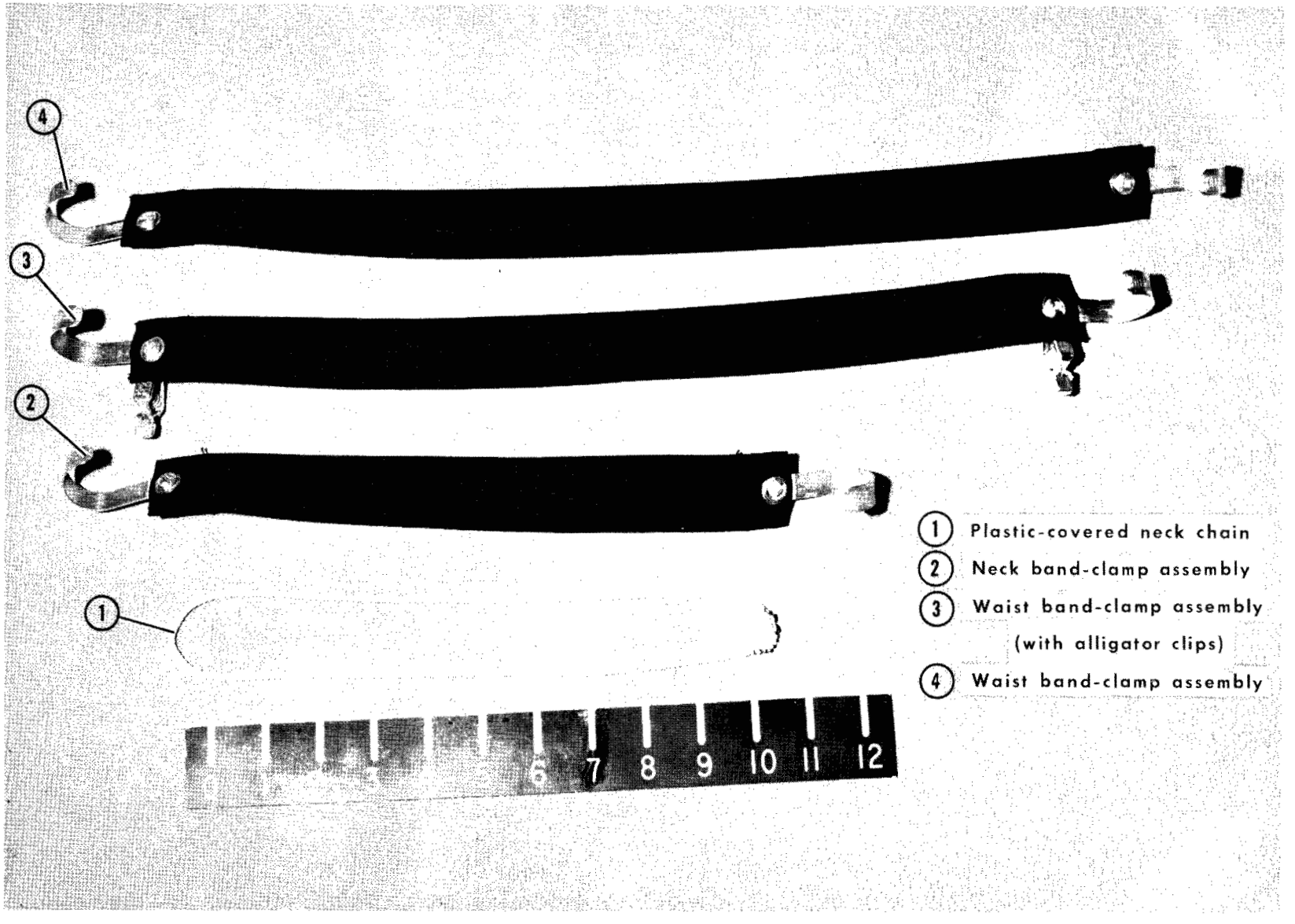
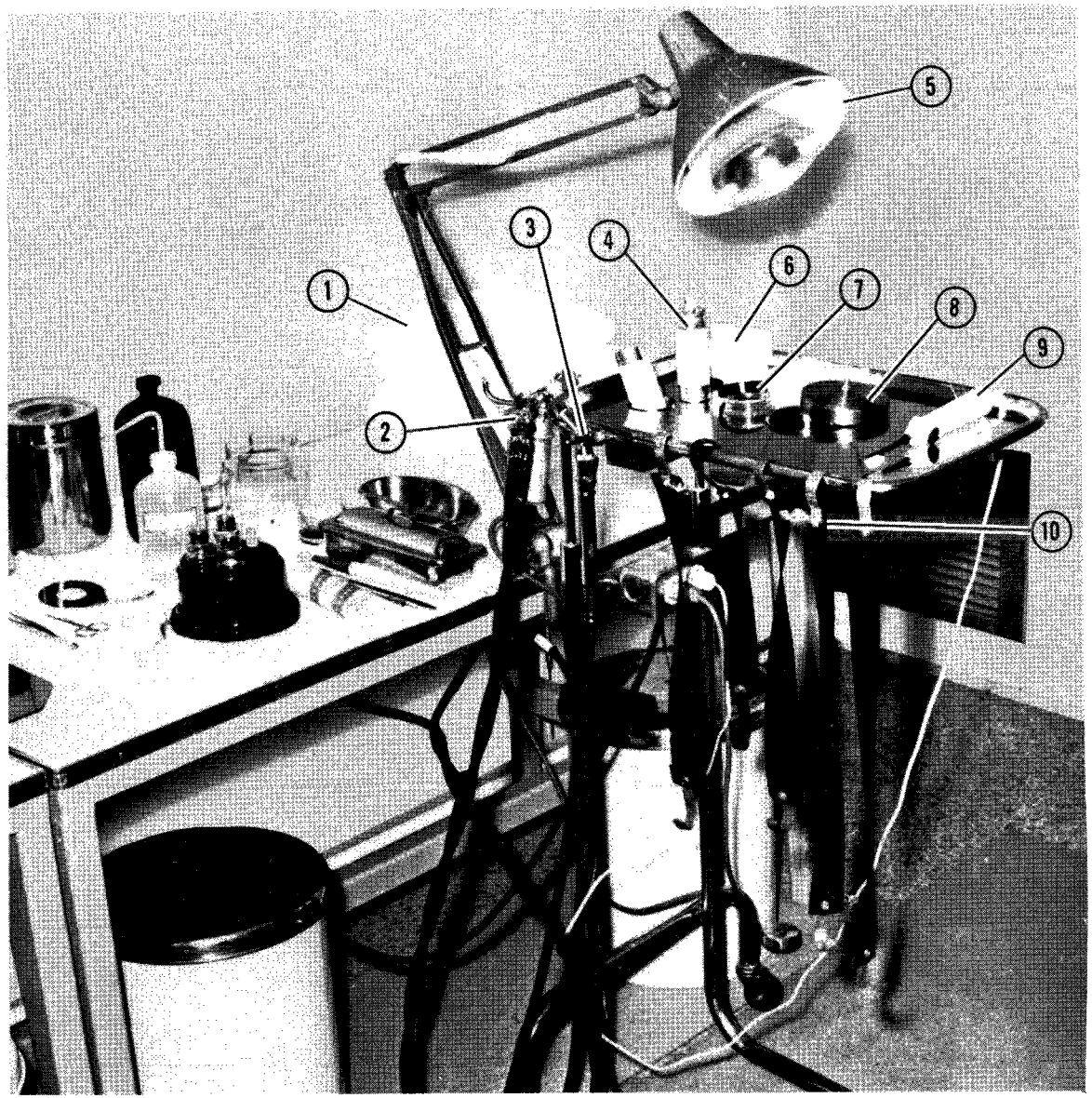


Figure 5.– Clothing restraints and neck chain. E-13309



1. Bath towels
2. Spray-gun assembly
3. Heated-air gun assembly
4. Insulation aerosol can
5. Adjustable lamp assembly
6. 4-inch by 4-inch gauze sponges
7. Electrode jelly
8. Acetone supply
9. Electric-toothbrush assembly
10. Band-clamp assemblies

E-14234

Figure 6.- Instrumentation donning table.

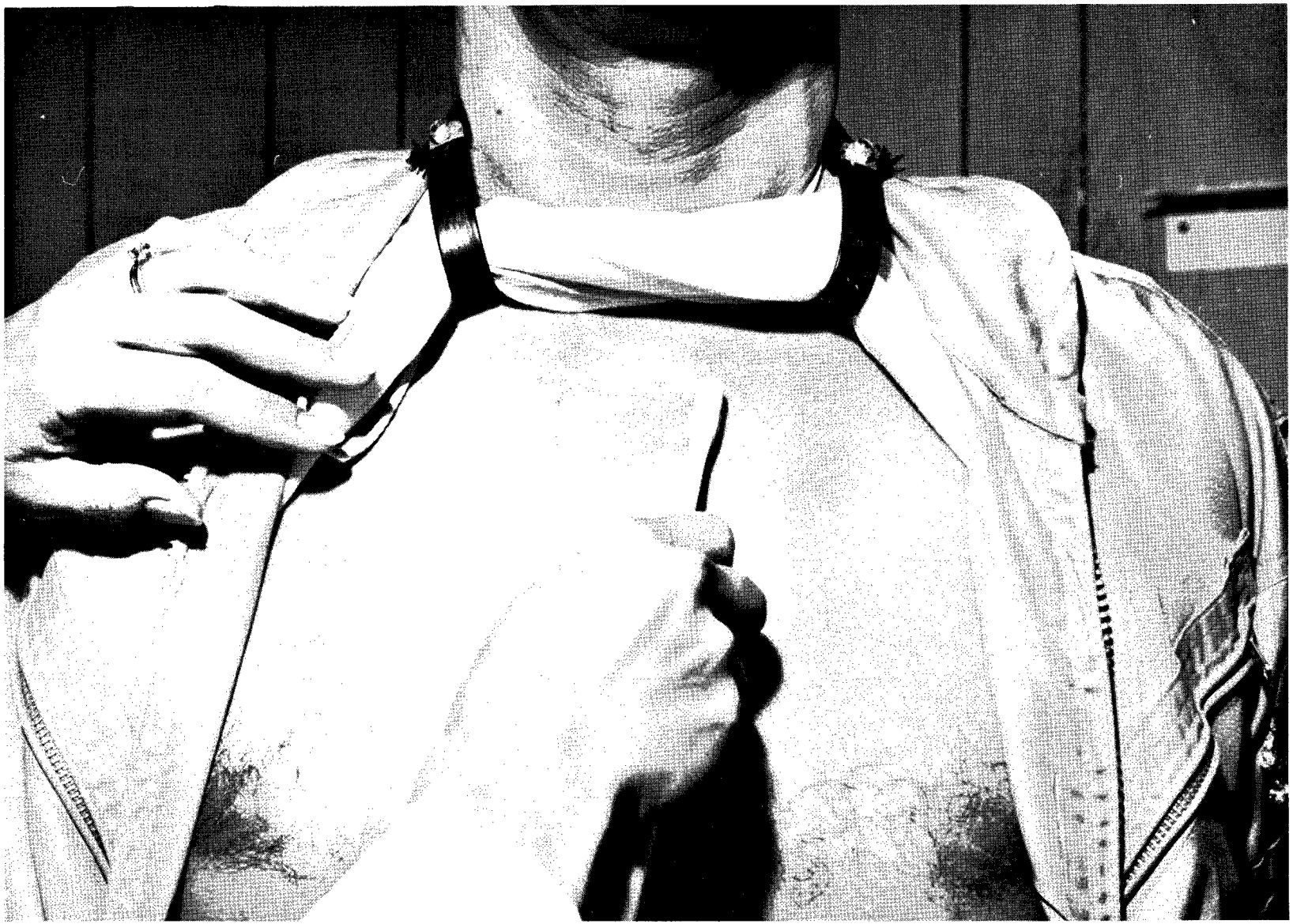


Figure 7.— Skin preparation using electric toothbrush and electrode jelly. E-13297

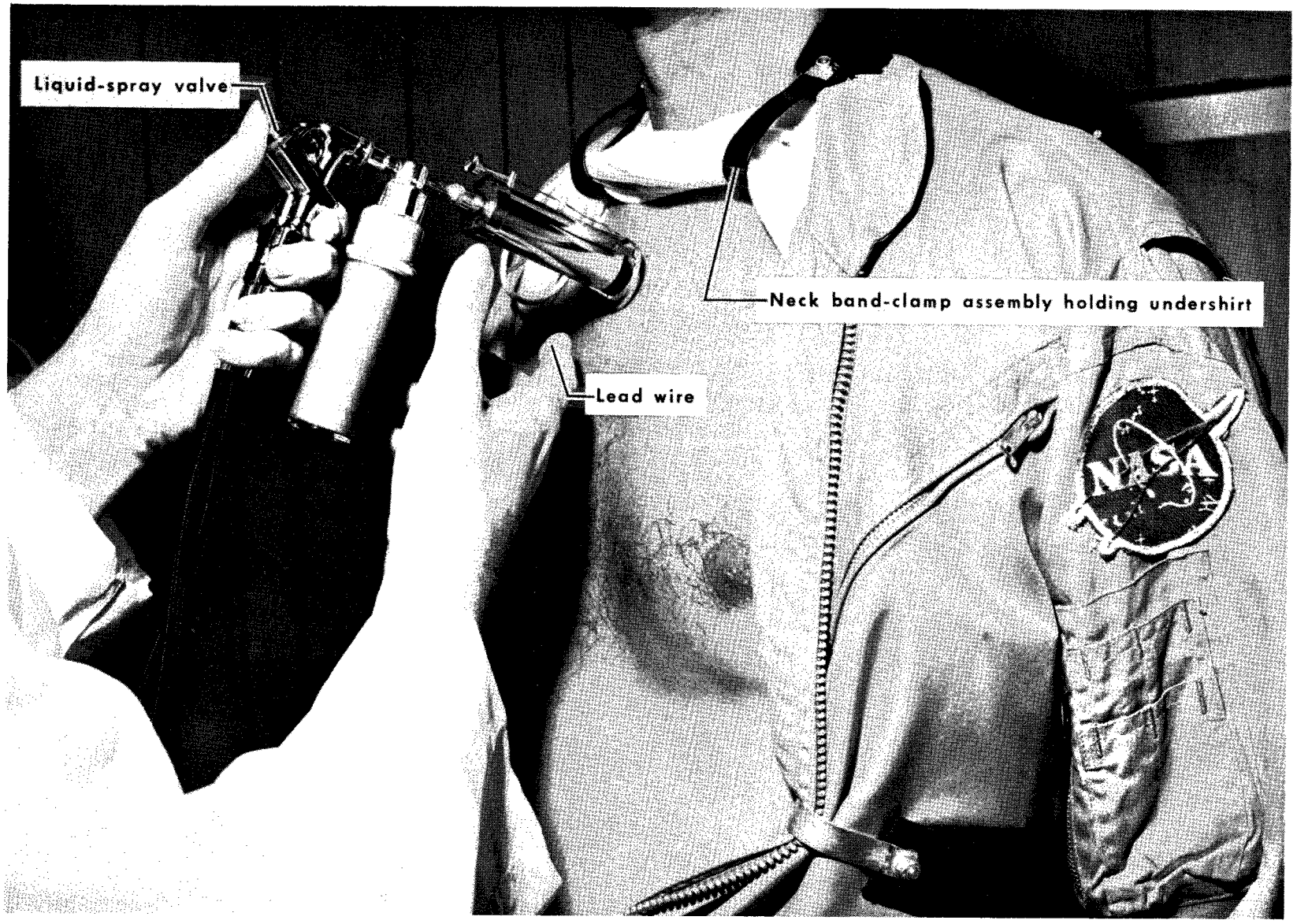


Figure 8.– Spray gun in position for spraying-on electrode. E-13303

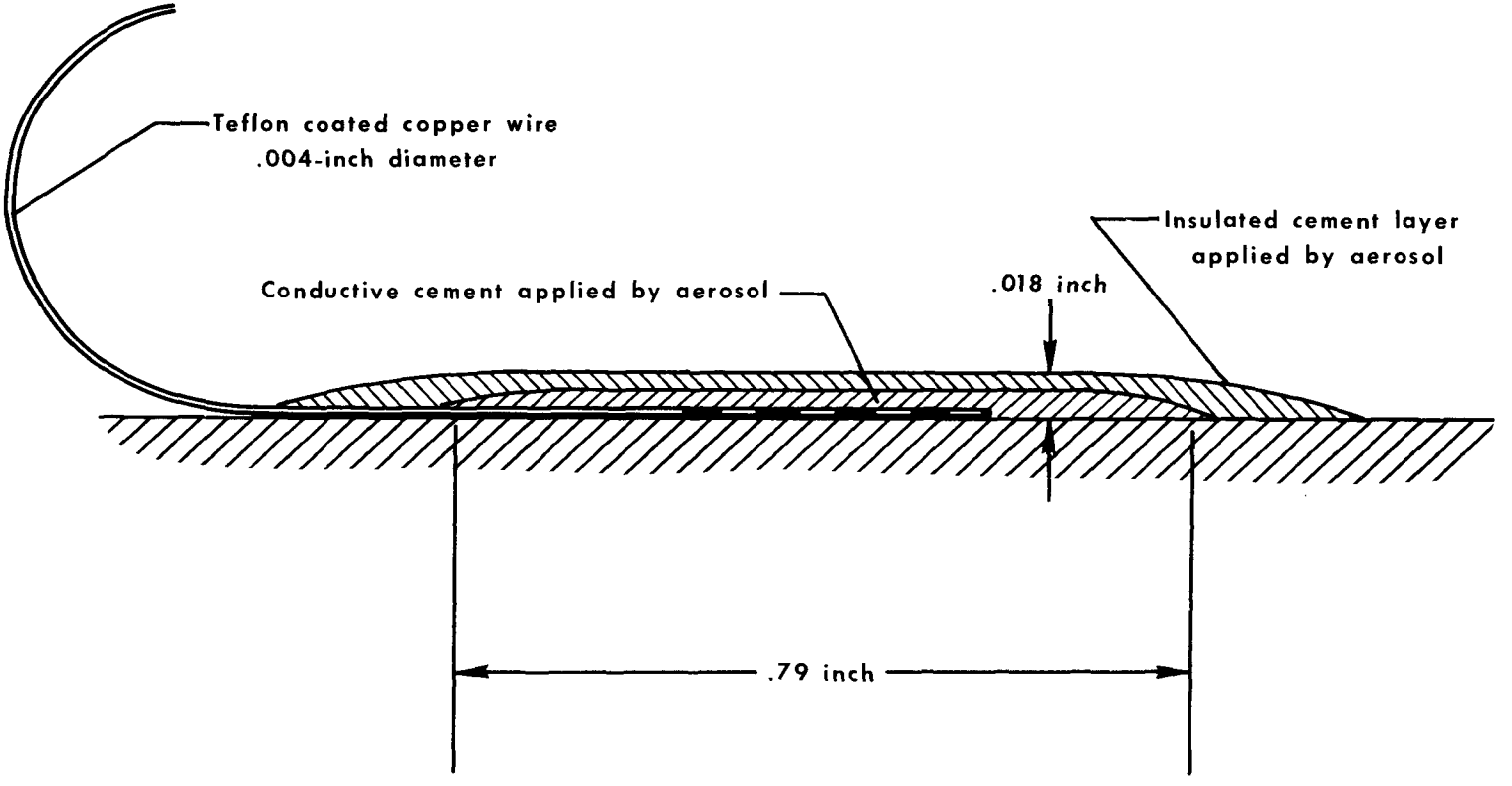


Figure 9.- Typical standard spray-on electrode (showing relative size and dimensions).

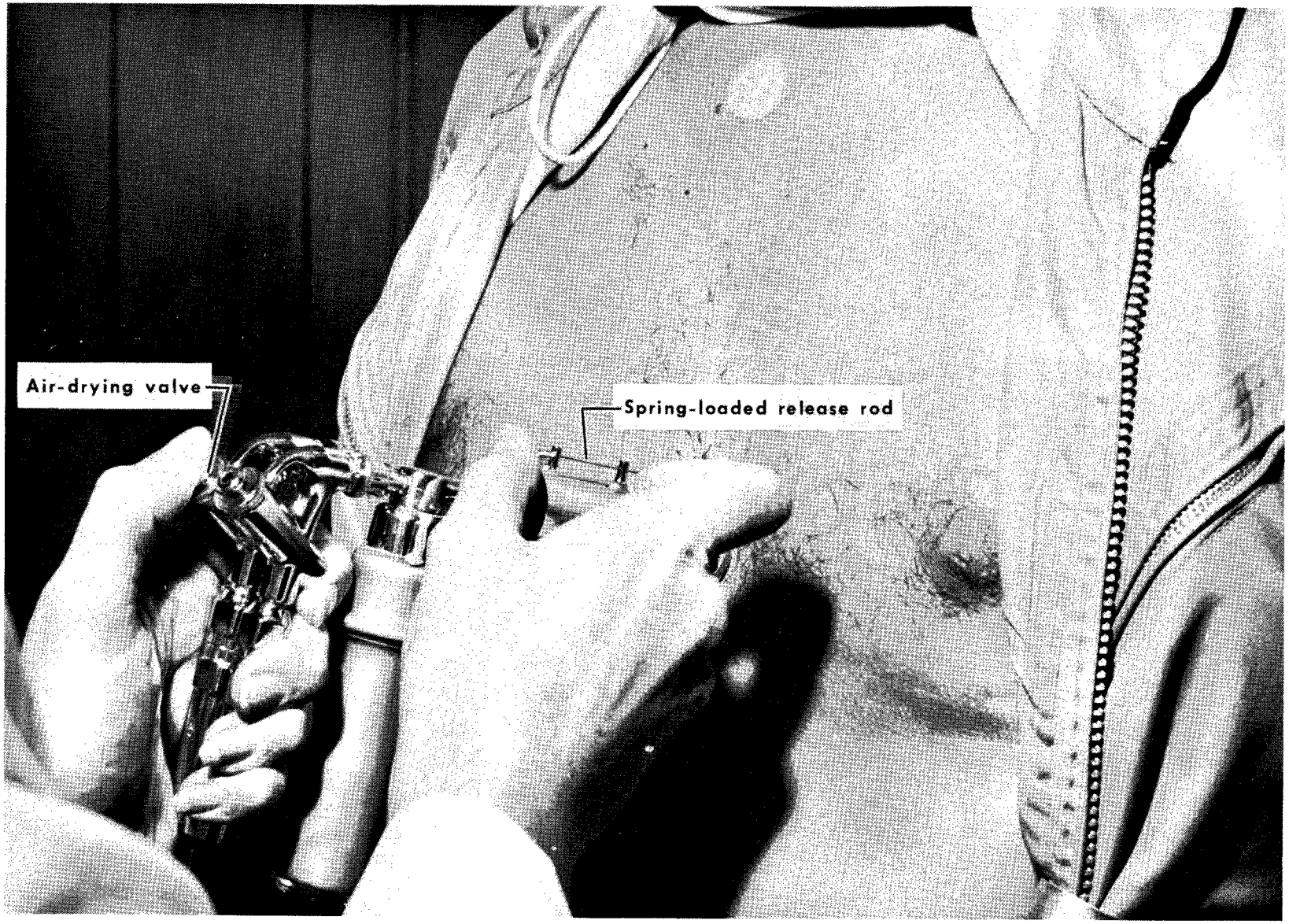


Figure 10.— Pushing spring-loaded release rod to release lead wire. E-13305

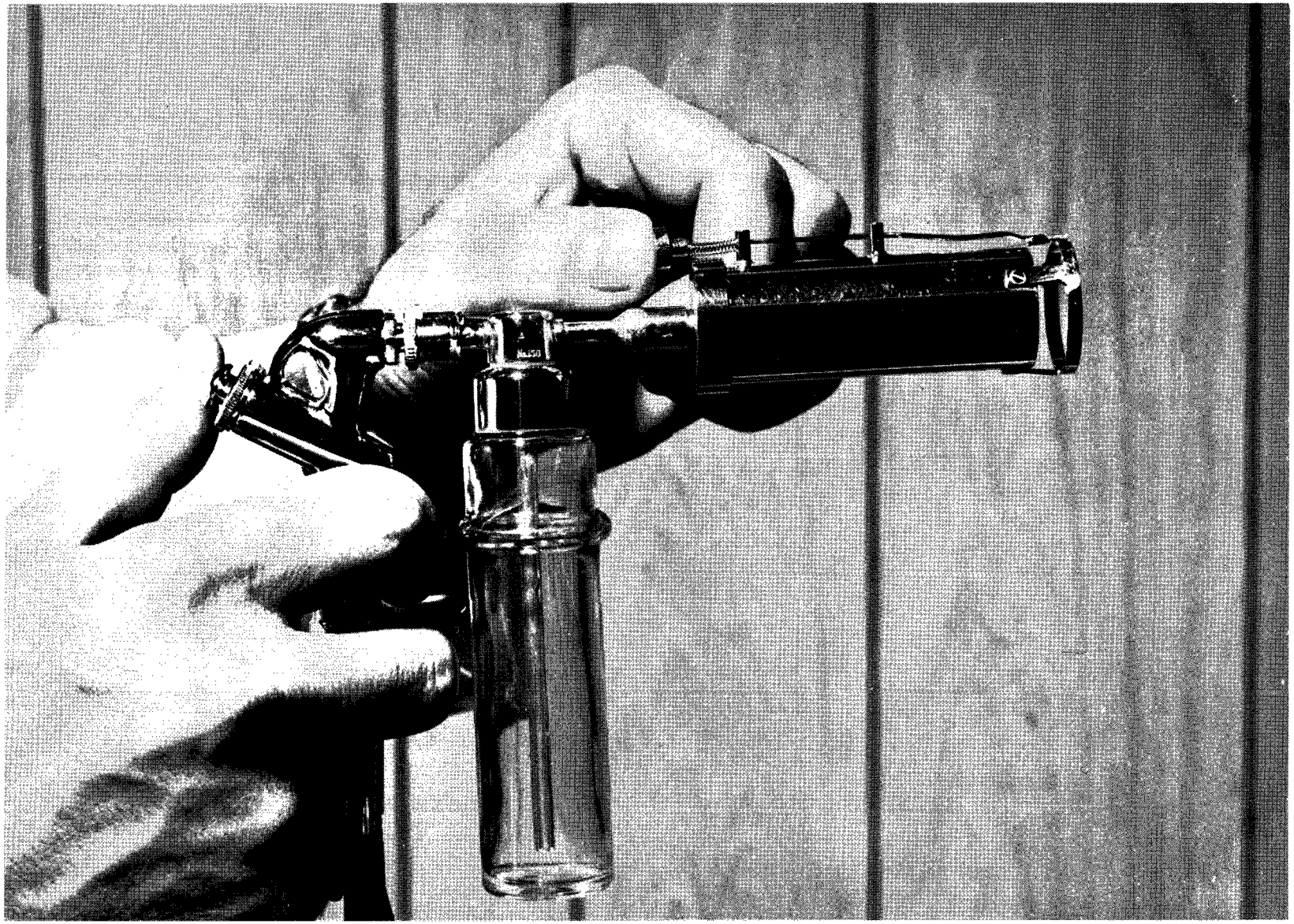


Figure 11.— Closeup of spray-gun assembly showing spring-loaded release rod being pushed. E-13302

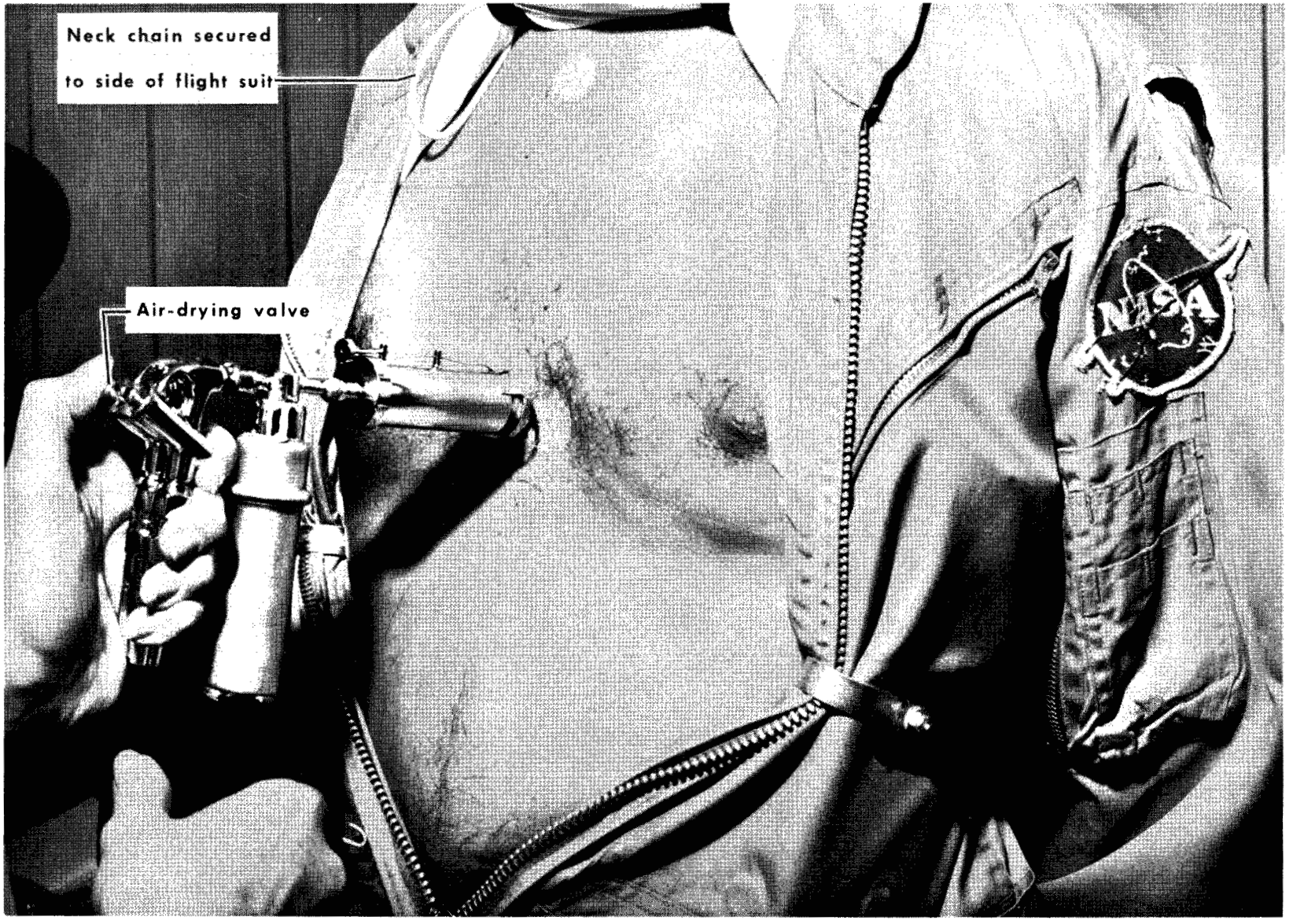


Figure 12.– Spray gun moved back 1/2 inch while air-drying electrode. E-13300

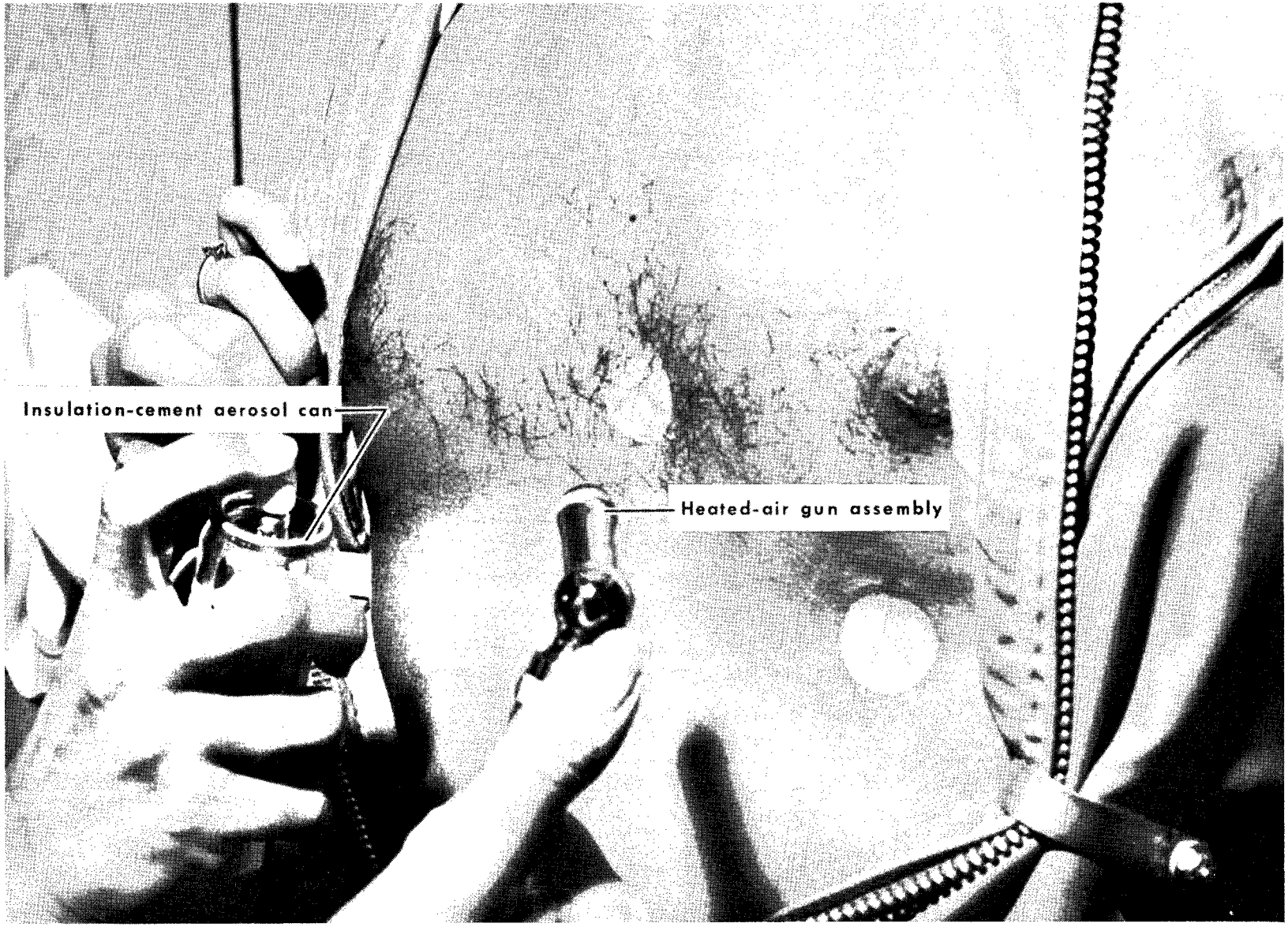


Figure 13.– Application of insulation-cement spray and heated-air drying. E-13298

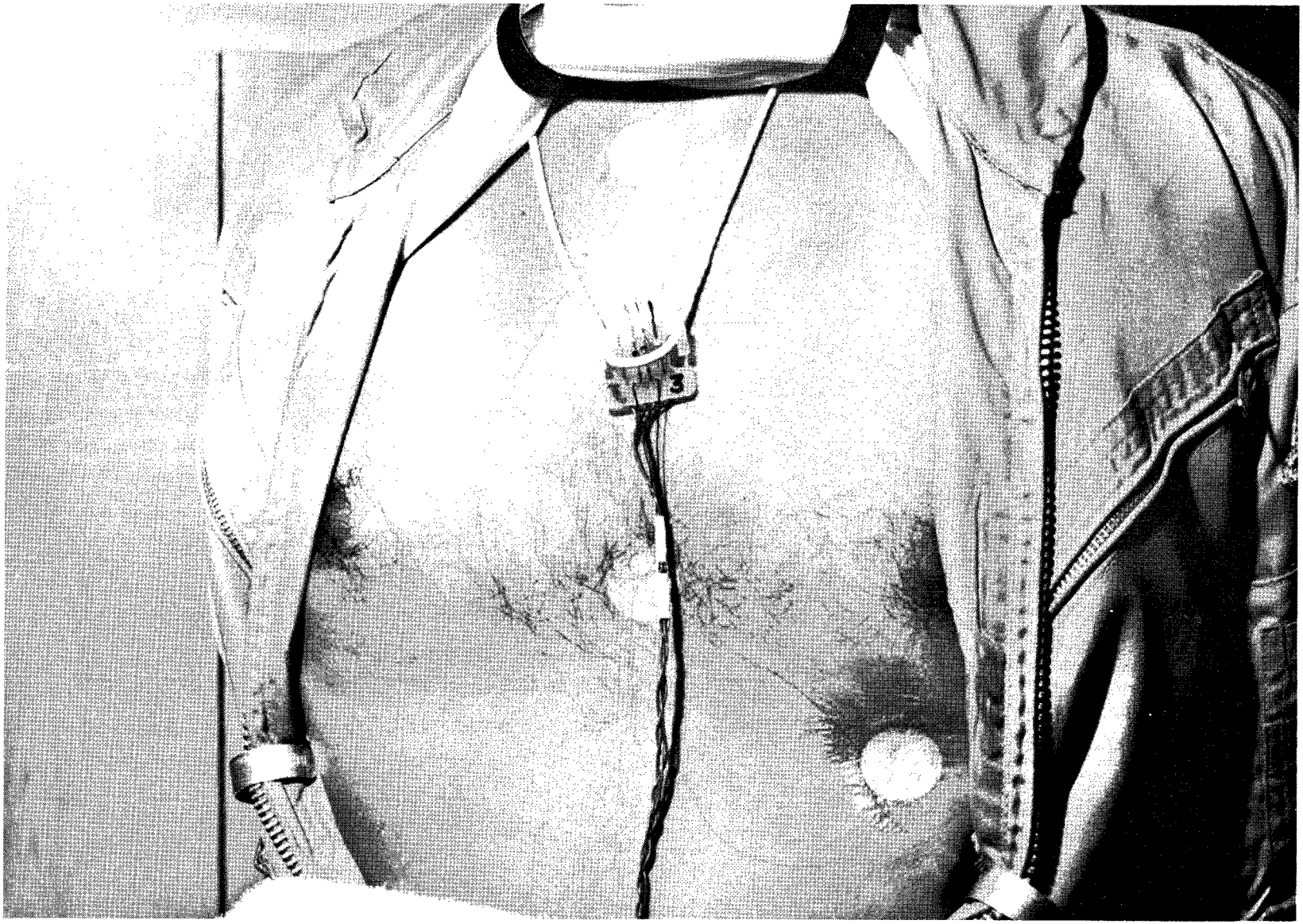


Figure 14.– Instrumented test subject showing lead wires connected to electrode-connection block secured on neck chain.

E-13304

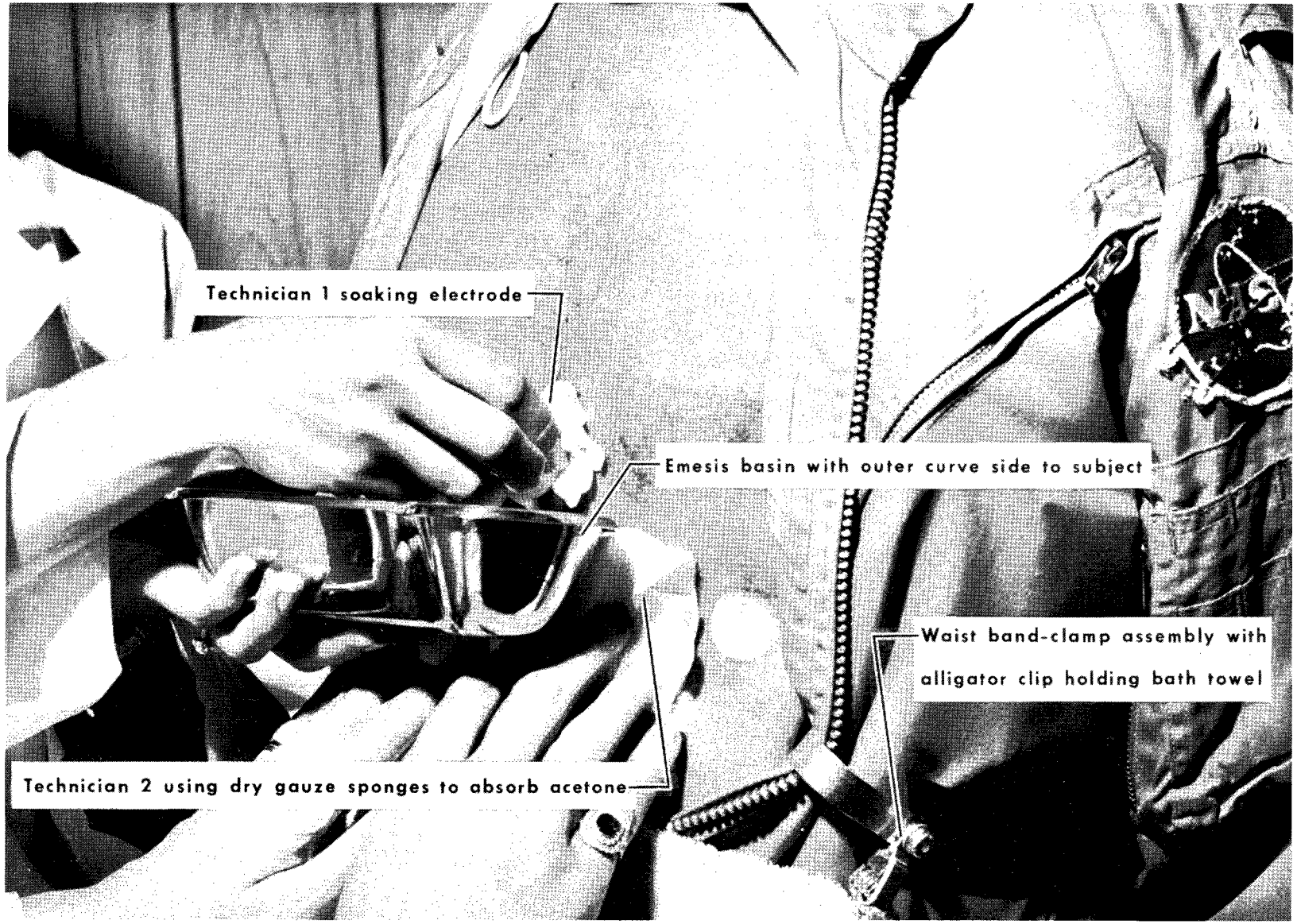


Figure 15.– Electrode removal using acetone and 4-inch by 4-inch gauze sponges. E-13301

Figure 16.– Emesis basin with inside curve placed against the natural curve of rib cage.

E-13299

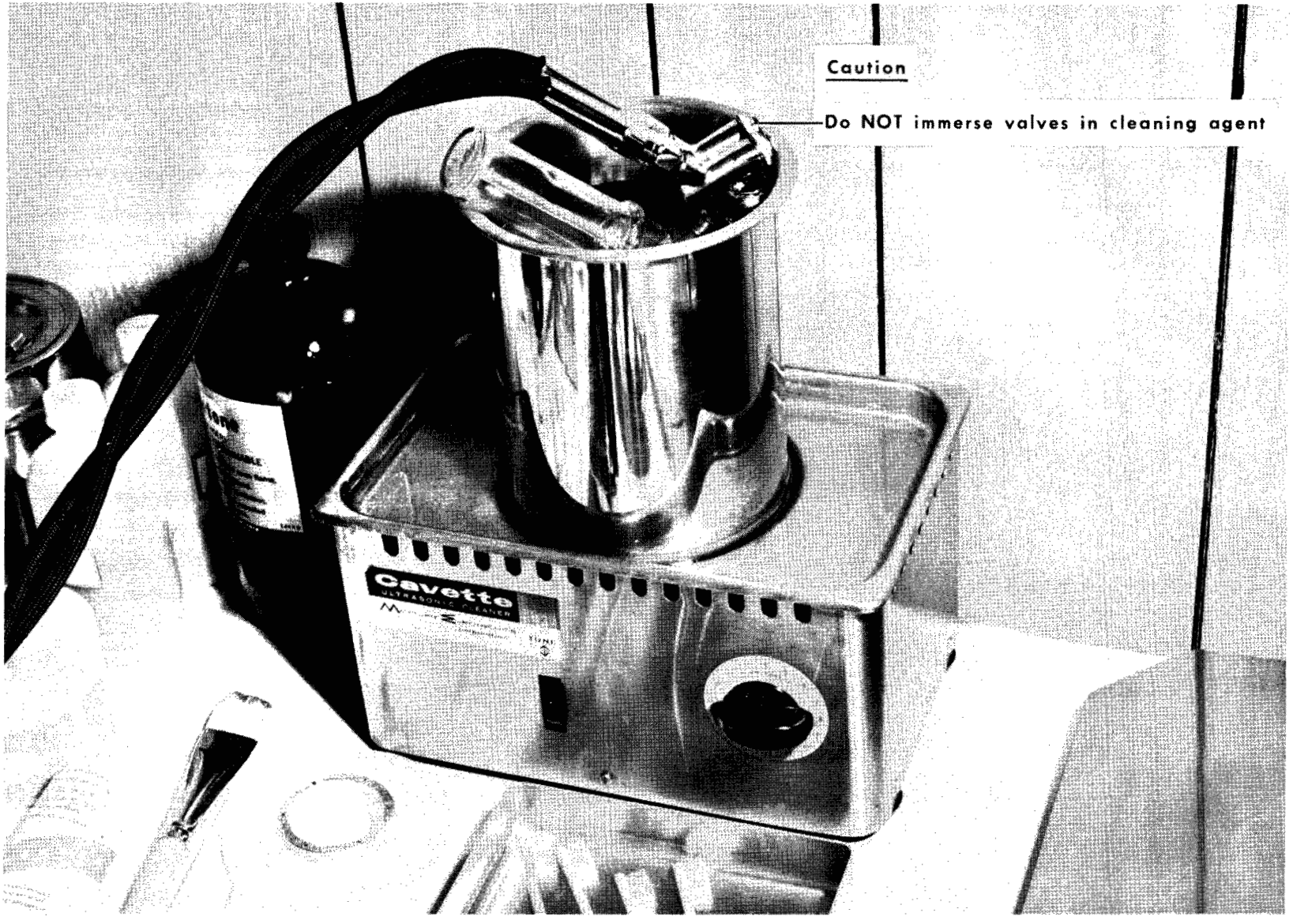


Figure 17.– Ultrasonic cleaner assembly showing spray-gun cleaning. E-13306

AEROSPACE TEST PILOT SCHOOL

Date _____ Subject _____

Aircraft type & no. _____ Flight time _____ Type of mission _____

Time of arrival _____ Electrode technicians _____ Harness technicians _____

3 4 ECG PN/T Accel. ZPN

Number of electrodes Parameters

Subject's Remarks:

Observations:

Instrumentation Time _____ De-instrumentation Time _____

Skin Condition:

Conclusions:

Figure 18.- Typical record sheet.

NASA-Langley, 1966

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—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

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