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ROYAL CANADIAN AIR FORCE

PLASTIC AND GLASS FABRIC REPAIR

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PLASTIC AND GLASS FABRIC REPAIR

PLASTICS

General

1 There are three types of transparent plastic commonly used in military aircraft; acrylic plastics (also known as acrylate or methacrylate base plastics), laminated acrylic plastic, and cellulose acetate base plastics.

Acrylic Plastics

2 Acrylic plastics only are used for replacement of transparent plastic on all RCAF aircraft. They are manufactured under the trade names of Lucite (Item 65), Plexiglass (Item 66) and Perspex (Item 67).

Laminated Acrylic Plastics

3 Laminated acrylic plastics are made from acrylic plastic bonded by a vinyl resin interlayer but are not characterized by specific trade names.

Cellulose Acetate Base Plastics

4 Cellulose acetate base plastics are manufactured under the trade names of:

Fibestos (Item 68), Lumarith (Item 69),

Plastacele (Item 70) and Nixonite (Item 71).

5 Cellulose acetate base plastic is not to be used as a substitute for acrylic plastic. Take precautions to correctly identify the original and replacement or repair materials. Acrylic plastics contract about five times as much as light alloy and ten times as much as steel and their thermal conductivity is about 1/1000 that of metal.

Identification of Plastics

6 Since the methods of working the two common plastic materials (acrylic plastic and cellulose acetate base plastic) differ, it is important that the material to be worked is properly identified. Use a known piece of equal size and thickness for comparison in attempting to establish the identity of an unknown material. There are several means of identification, some of which are as follows:

(a) View the light transmitted through the edge of the panel. The cellulose-acetate base plastics appear relatively dark and generally are tinted pink, green or blue. The acrylic plastics are quite transparent and colourless. This test is useful only on clear colourless panels.

(b) Rap the cellulose acetate material with the knuckles. A dull sound is emitted in comparison with the ringing note given off by the acrylic plastic. This method is reliable only when direct comparison of two materials is possible.

(c) Both acrylic and cellulose acetate base plastics have characteristic odours when burned. Cellulose acetate base plastic burns with a smoky flame which will not propagate downward, and can be identified by a smell of vinegar which is detected in the smoke immediately after the flame is extinguished. Acrylic plastic ignites more easily and burns with a clear, smokeless flame which will propagate downward. The acrylic plastics are more rigid than cellulose acetate base material, and will bend less readily.

Storage and Care of Plastic Panels

7 Keep plastic sheets away from heating coils, radiators, hot water and steam pipes. Store in a cool, dry location away from solvent fumes such as may exist near paint spray and paint storage areas. Keep masked sheets out of the direct rays of the sun, as this may accelerate deterioration of the masking paper adhesive, causing it to cling to the plastic and making removal difficult. Store the sheets on solid shelves. Do not store small sheets between large sheets, thus leaving unsupported sections. If the sheets are stored

vertically, they must be well supported. If plastic sheets become bowed, remove masking paper, heat to forming temperature, place on a flat surface protected by a layer of soft flannel and allow to cool. Storage of acrylic sheets presents no special fire hazard since the materials are slow burning. Leave masking paper in place as long as possible.

8 Stack washed sheets with wads of cotton wool separating the surfaces. Support curved or formed sections so that there is no tendency for them to lose their shape. Avoid vertical supports except in specially designed racks. Simple frames or supports are necessary to relieve strain or unusual pressure on curved parts. Always cover parts with cloth or soft paper to protect from dust. Protect formed parts from temperatures higher than 120°F which might tend to cause loss of shape.

Masking

9 Transparent plastic sheets are supplied with a coating of masking paper. Leave this paper in place as long as possible and do all work on the sheets with the paper in position. If masking paper hardens to the surface of plastic sheets, making removal difficult, moisten the paper with lukewarm water, this should soften the adhesive which is water soluable enabling the paper to be easily removed. Any stubborn masking paper residue, oil or grease stains may be removed using aliphatic naptha solvent (Item 72). Wash sheets so treated with soap (Item 3) and water before attempting forming operations.

CAUTION

Use only liquids specified. The use of other materials may soften or craze the plastic.

10 For formed parts, use protective coatings which are applied by spraying. Since many compounds are inadequate or definitely harmful, use only approved material (Item 1). To remove masking from the plastic, peel off or lift the corner of the film and blow a jet of compressed air under it. Sometimes a paper tab embedded in the film to assist in its removal is advisable, otherwise it is impossible to lift the corner and peel the masking off.

Use of Coating Compound

11 Instructions governing the use of coating compound are as follows:

(a) The application of coating compound (Item 1) is mandatory during fabrication and manufacture on all canopies and windows used for vision in flight, and on all parts and materials prior to storage and prior to shipment, except as stated in Sub-paragraph (c) following.

(b) The application of coating compound is recommended on all parts not used for vision in flight such as junction box covers, and emergency door handle shields, during fabrication and installation.

(c) Coating compound is not required on parts and materials protected with kraft paper or other suitable covering upon receipt from the supply depot. Such protective covering is to remain in place as long as possible.

12 During fabrication, transparent plastic parts should be left bare only when necessary for forming, buffing and polishing. Carry out all other operations such as routing, drilling, sawing etc., with either the original protective covering or coating compound.

Preparation of Plastic Parts and Materials

13 Clean the surfaces of plastics which are to be covered with coating compound. (Refer to Paragraph 23, following.)

Preparation of Coating Compound

14 Clean off the top of compound containers or drums before opening. Where coating compound is received in small (5 gallon) containers, stir the compound thoroughly in the container until a smooth uniform consistency is obtained. If, after stirring, the compound is too thick, add from one pint to a maximum of one quart of tepid water per 10 gallons of compound, and continue stirring until the water is dispersed throughout the compound. Do not use any other solvents at any time for thinning. After stirring, and thinning if required, filter the compound into the spray gun cup through a fine cheese cloth.

Application of Coating Compound

15 The spray gun recommended for use in applying the coating is a Type MBC-510, fitted with external mix spray head, one quart capacity suction feed cup, type E nozzle and needle, and No. 30 air cap, manufactured by

the DeVilbiss Manufacturing Co. Ltd., Windsor, Ontario. To apply the compound, proceed as follows:

(a) Spray coating compound (Item 1) onto all surfaces of plastic parts. The applied coating should not be less than .006 inch in thickness. Air pressure through the gun should not be less than 60 psi; 70 psi is recommended. (Refer to EO 50-20A-2.)

(b) Room temperature during spraying operations should be between 65° and 90° F.

(c) After spraying, allow the coating to dry at room temperature for 12 hours.

(d) Any tackiness remaining on the film after drying may be removed by sprinkling with a light coating of talc (Item 7). Where parts are to be stored face to face or shipped in wrappings, use talc to prevent possible sticking of parts to each other or to the wrappings.

(e) Where the coating compound is torn during subsequent handling, remove the damaged portion, (refer to Paragraph 18, following). Spray a second coating onto the damaged area overlapping at least 1 inch onto the surrounding undamaged coating. (Refer to EO 50-20A-2.)

Do not store coating compound in freezing temperatures or excessive heat. Storage temperature should be within the range of 60° to 80° F.

Maintenance of Spray Guns and Accessories

16 Maintain spray guns and accessories as follows:

(a) Clean spray guns and accessories thoroughly, with water only, after each day's operations. Do not use any other solvents for cleaning. Clean spray gun air caps more frequently or uneven coatings will result.

(b) Air lines supplying the spray guns must include filters to exclude oil and foreign matter. Keep filters clean.

(c) Where it is desired to use the spray gun specified with a pressure tank feed, use a type FX or FF nozzle and needle and a No. 765 air cap.

Installation of Coated Parts

17 When installing coated parts, remove the coating only from contact areas where the parts fit into frames, channels, etc., (refer to Paragraph 18, following). In critical areas where extra protection is desired, spray a second coating onto that portion of the contact areas remaining bare after installation and overlap at least 1 inch onto the surrounding parts or structure and onto the original coating. Retain coating in position on parts installed in aircraft until immediately prior to the first flight.

Removal of Coating Compound

18 Remove coating from parts by lifting at one edge with a finger nail and peeling off. If the coating has been applied correctly and the minimum thickness of .006 inch maintained, a steady pull will remove it easily and in one piece. Do not attempt to remove the coating at any time with tools, solvents or air hoses. Where a central portion of the coating is to be removed, break the film with a fingernail and peel the coating off as required. Take care not to scratch the underlying plastic surface.

General Precautions

19 Optical quality is of paramount importance. Avoid scratching or otherwise damaging the plastic surface while servicing the aircraft. Take the following general precautions in all maintenance and repair operations:

(a) Do not rub the surface with a dry cloth, as frequently the cloth does not clean perfectly and scratching and/or marring of windscreens results. Refer to Paragraph 23, following.

(b) Handle transparent plastic material with clean gloves at all times.

(c) Do not use harmful liquids, such as gasoline, paint, dope solvents, alcohol, thinners or dopes as cleaning agents.

(d) Fabrication, repair and maintenance instructions must be followed closely.

(e) Avoid operations which tend to scratch or distort the plastic surface.

(f) Clean optical plastic surfaces as per paragraph 23.

Crazing

20 Liquids which cause crazing can be generally classified as those which either swell or dissolve the material. In some cases vapours from open containers of solvents have been found to cause crazing. The material as it is cast gives a random crazing pattern, whilst heat-treated material exhibits craze lines lying in the direction perpendicular to the direction of the applied tensile stress. The only type of crazing which is considered acceptable is the very fine variety which has no visible depth when viewed with the naked eye. Refer to Paragraphs 26 and 27, following. Slight crazing occurs in such a large proportion of components at the present time that some have to be accepted until means of preventing it is found. If crazing is of the directional variety and has visible depth, it should definitely be rejected.

Scribing and Edge Sanding

21 This method of cutting is generally employed on flat sections or two dimensional curved pieces. The sheet is first cut to approximate shape on a band saw, using a scribed line as a guide and cutting approximately 1/16 inch oversize. The choice of abrasive and successive grades of abrasive depends on the amount of material to be removed, and the finish desired, and must of necessity be left to judgement. For the best results, abrasive wheels, discs, drums and belts should operate at about 3000 surface feet per minute. Wet sanding is preferred to dry sanding, as water dissipates frictional heat, eliminates loading of the abrasive, settles dust, increases the speed of cutting and extends the life of the wheel. For surface sanding procedure used in finishing acrylic plastics, refer to Paragraphs 109 to 117 following.

Scribe Cutting

22 Where extreme accuracy is not required, thin acrylic plastic sheeting may be cut in a straight line in the same manner as glass, by scribing a line on the surface and breaking the sheet along the line. This method should not be used on thickness over about 0.080 inch. Acrylic plastics cannot be cut with shears or scissors.

Cleaning Exterior Plastic Surfaces

23 Flush with plenty of clean water. Use the bare hand gently to feel and dislodge any dirt, salt or mud. Wash with detergents (Item 3 or 4) and clean water. A soft cloth, sponge or chamois may be used in washing, but only as a means of carrying sudsy water to the plastic. Go over the surface only with the bare hand, so that any dirt can be quickly detected and removed before it scratches the plastic surface.

24 Dry with a clean, damp chamois. A soft, clean, cloth or soft tissue may be used if care is taken not to continue rubbing the acrylic plastic after it is dry. Remove oil and grease by rubbing lightly with a cloth wet with kerosene (Item 2) or hexane (Item 5).

CAUTION

Use only specified liquids. The use of other liquids may soften or craze the plastic.

25 Do not rub the acrylic plastic with a dry cloth, since this will cause scratches and build up an electrostatic charge which attracts dust particles to the surface. If the surface does become charged, patting or gently blotting with a clean, damp chamois will remove this charge as well as the dust.

26 If, after removing dirt and grease, no great amount of scratching is visible, polish the plastic with wax (Item 8). The wax will fill in minor scratches and help prevent further scratching. Apply the wax in a thin even coat and bring to a high polish by light rubbing with a soft, dry cloth.

27 If, after removing dirt and grease, the plastic surface is found marred by scratches, apply an approved polish (Item 8) by hand. If buffing equipment is available, buff out the scratches as described in Paragraph 112, following.

Do not attempt either hand polishing or buffing until the surface is clean. Dirt, grit and sand present during these operations may cause more serious damage than the original scratches. Since even skilful sanding, buffing and polishing introduce slight optical distortions, do not perform these operations on navigator astrodromes, gun turret sighting panels and similar critical optical parts.

Wash and wax these parts. If they are damaged by a number of deep scratches, replace them.

Cleaning Interior Surfaces

28 Dust the plastic surface lightly with a soft, damp cloth or sponge. Keep the cloth or sponge free from grit by rinsing frequently in clean water. Apply wax as described in Paragraph 26, preceding. Do not wipe the surface with a dry cloth.

Hot Climate Precautions

29 To prevent distortion of plastic enclosures in hot climates, open doors and windows of aircraft slightly to permit free circulation of air through the cabin when the aircraft is parked out under the direct rays of the sun. This will assist in preventing a high temperature condition on the inside that might soften the plastic sheets.

30 In general, sunlight has very little effect on acrylic plastic. Covers need not be used as a protective measure unless there is a danger of sand storms which will cause abrasion of the plastic sheets, or unless covers are required for camouflage purposes. Covers should not be drawn tightly over the enclosure since the pressure may distort the panel. If possible, allow room for the circulation of air between the cover and plastic.

31 There are a number of methods of installing plastic panels in aircraft. When installing a replacement panel, follow the same mounting method used by the manufacturer of the aircraft.

NOTE

Where difficulty is encountered in rivet installation, bolts may be used in installing replacements when the original design permits.

32 When subjected to large stresses (over 1000 psi), acrylic plastics are apt to craze, lowering the transparency and strength of the panel. It is important that these plastics be mounted and installed so that such stresses are avoided.

Installation

33 Never force any acrylic plastic panel out of shape to make it fit a frame. Acrylic panels are reasonably flexible, but if they are forced into a frame, high or unequal stresses will be set up in certain areas of the panel. If a replacement part does not fit easily into the mounting, obtain a replacement or heat and reform the panel.

CAUTION

Do not heat and reform limited areas of the panel, since local heating methods are apt to be only superficial and not thorough enough to reduce stress conceptrations.

34 In clamping or bolting acrylic panels into their mountings, do not place the plastic under excessive compressive stress. It is easy to develop more than 1000 psi on the plastic by drawing up bolts tightly. Tighten each nut to a firm fit then back it off one full turn.

35 Use spacers, collars, shoulders or stop nuts in bolt installations to prevent tightening the bolt excessively. Wherever such devices are used by the aircraft manufacturer they should be retained in the replacement installation.

36 Mount acrylic plastic panels between rubber, cork or other gaskets to make the installation waterproof, to reduce vibration and to help to distribute compressive stresses on the plastic.

37 Since acrylic plastics expand and contract approximately three times as much as the metal channels in which they are mounted, suitable allowance for dimensional changes with temperatures must be made, as follows:

(a) Clearances of 1/8 inch minimum should be allowed all around the edges of the panel.

(b) If the installation involves bolts or rivets, make holes through the plastic oversize by 1/8 inch and centre so that plastic will not bind at these parts. In large self-supporting parts, such as nose sections, gun turrets, etc., elongate old holes radially.

(c) Mount panel to a sufficient depth in the channel to avoid danger of falling out when it contracts at extremely low temperatures or

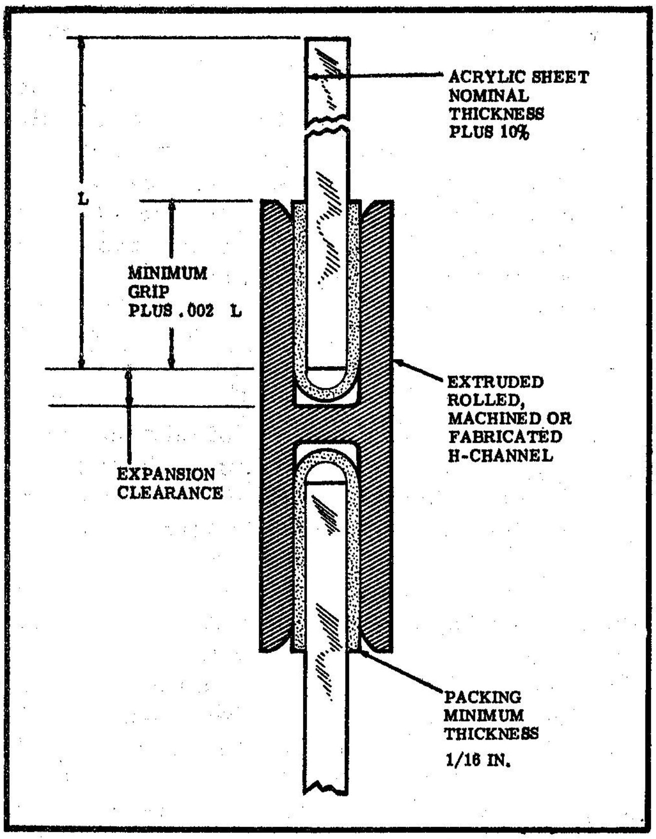

Figure 1 Simple Channel Installation

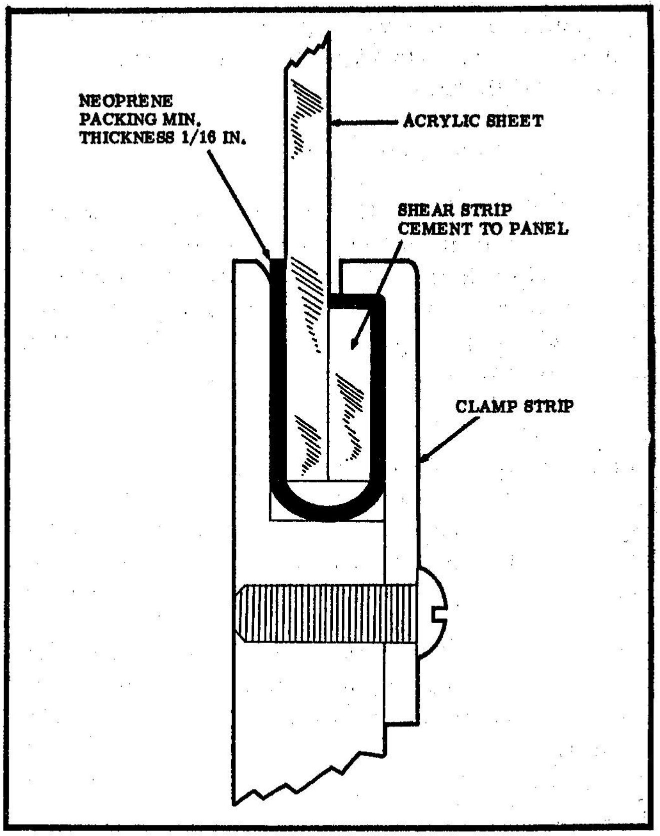

Figure 3 Clamp Installation with Reinforcing Rib

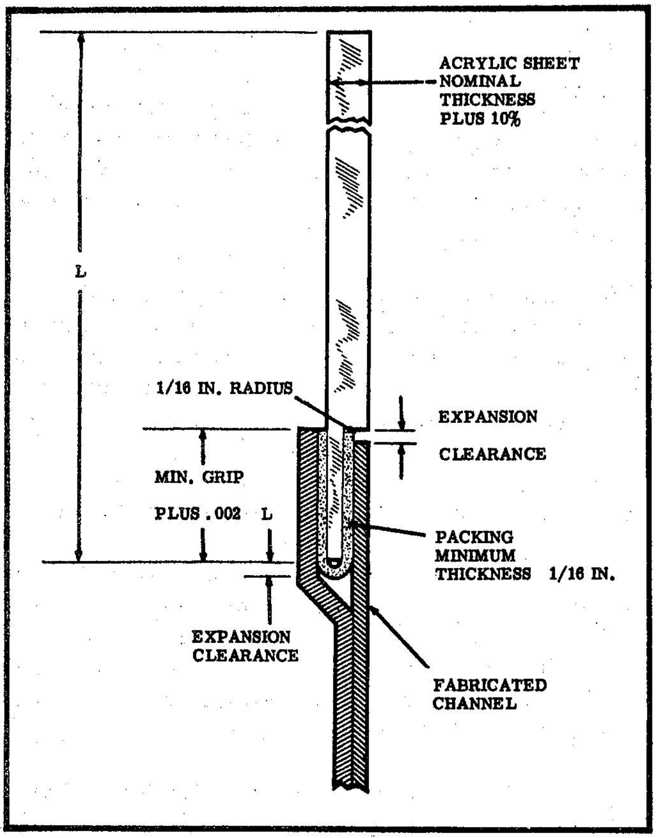

Figure 2 Channel Installation with Routed Edge

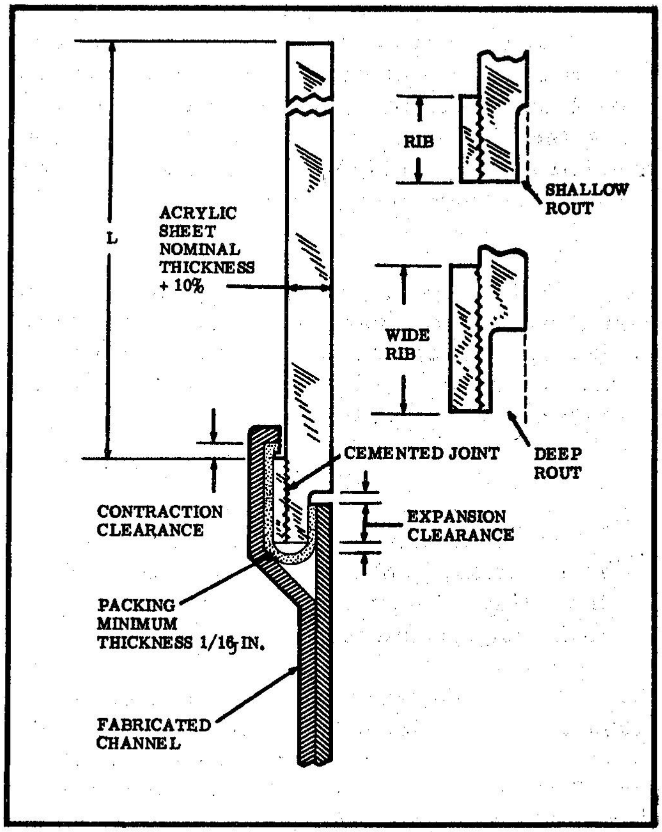

Figure 4 Flush Mounted Clamp Installation with Reinforcing Rib

when it is flexed. When the original design permits, panels up to twelve inches on either side should be mounted to a minimum depth of 3/4 of an inch; larger panels to a minimum depth of 1-1/8 inches.

Channel and Clamp Mountings

38 Wherever possible, avoid bolting or rivetting through holes drilled in the channel for the plastic. Clamp installations are definitely superior in distributing stresses. In this type of mounting, the principal precautions are:

(a) Make channel oversize to permit free linear expansion and contraction of the plastic relative to the frame.

(b) When installing acrylic plastics, ensure that clamping action is uniform.

(c) Make channels deep enough to hold the plastic securely despite flexing and thermal contraction. A safe rule is that plastic panels up to twelve inches on either side should extend into the channel a minimum of 3/4 inch; larger panels to a minimum of 1-1/8 inches.

(d) In calculating these allowances, note that linear sawing tolerances for acrylic plastics are usually ± .060 inch. Tolerances of ± .030 inch have been maintained when necessary on panels under twelve inches in length.

(e) Approved channel and clamp mountings are shown in Figures 1 to 5.

Bolt and Rivet Mountings

39 When special considerations make channel and clamp mountings impractical, holes may be drilled in the plastic for bolt or rivet installations. Because of difficulties experienced with rivet installations, bolt mounting is preferable. Give special consideration to the following factors:

(a) Use as many bolts or rivets as practical. Distribute the total stress as equally as possible among these bolts or rivets.

(b) Make holes drilled in plastic sufficiently larger than the diameter of the bolt to permit expansion and contraction of the plastic relative to the frame.

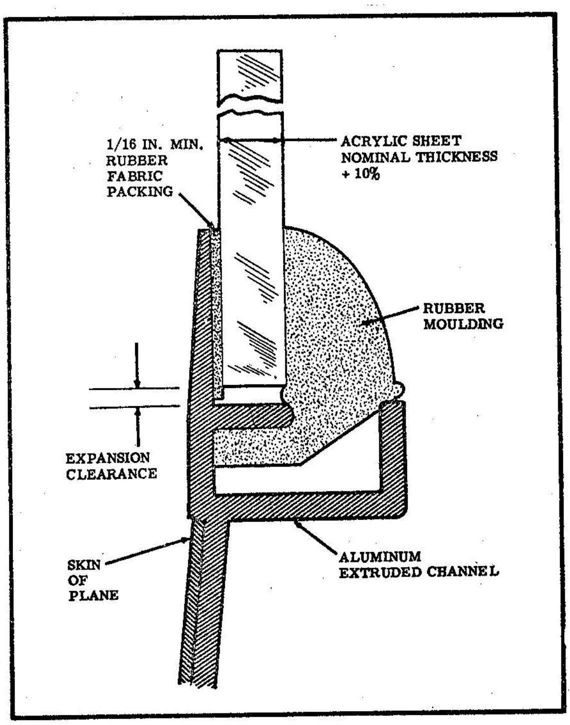

Figure 5 Hunter Sash Mounting

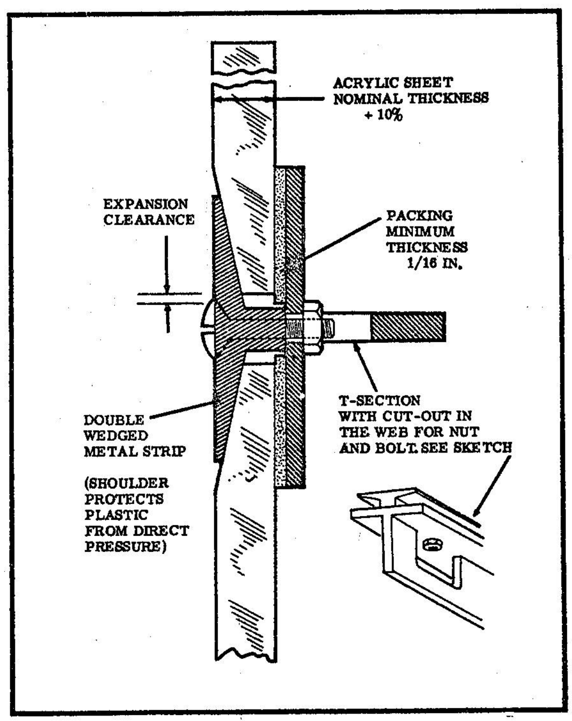

Figure 6 Wedge Section Installation

(c) Make holes in the plastic concentric with the holes in the frame so that greater relative expansion of the plastic will not cause binding at one edge of the hole.

(d) Use oversize tube spacers, shoulder bolts or rivets, cap nuts or some other device to protect the plastic from direct pressure.

40 Possible bolt and rivet installations are shown in Figures 6 and 7.

Cellulose Acetate Base Materials

41 The coefficient of expansion of cellulose acetate base plastic is greater than that of metals commonly employed for mounting structures and exceeds the coefficient of expansion of acrylic plastics. Cellulose acetate base plastics are affected by moisture and will change dimensionally as they absorb water. Allowance must be made in mounting acetate plastic if wide variations of temperature and humidity are to be encountered. In general, an allowance of about 1/8 inch per foot of panel length must be made for expansion and 3/16 inch per foot for contraction.

CEMENTING

General

42 The recommended cement (Item 26) for acrylic plastics consists of solvents or mixtures of solvents which soften the plastic, permitting the two surfaces to be joined to intermingle. When the solvent penetrates and evaporates, a hard clear joint is obtained.

Fitting

43 For a satisfactory joint, the two pieces to be cemented together should fit accurately. In butt joints, both edges must be made true and square before starting a cementing operation. It is also preferable to cement flat surfaces rather than curved and it is advisable to rout or sand curved sections to present flat surfaces before cementing. Where two curved surfaces must be cemented, the curves of both should be of the same radius.

Finish

44 The two surfaces should have a smooth finish. It is not necessary that they be polished

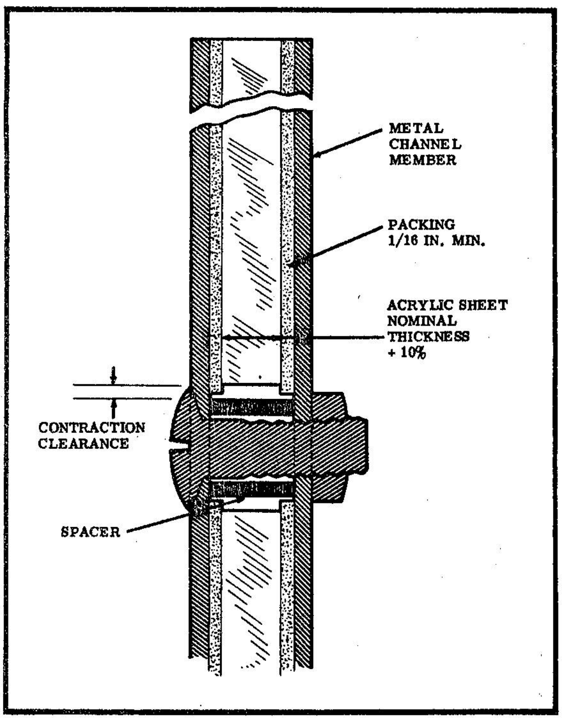

Figure 7 Bolt and Spacer Installation

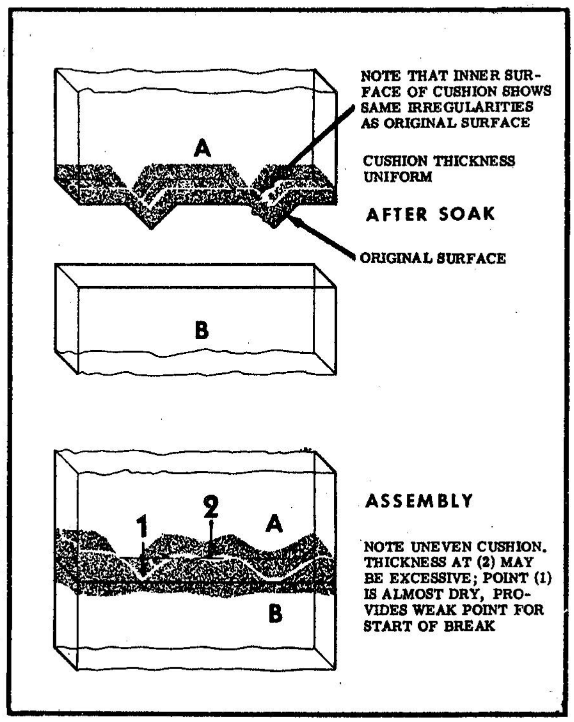

Figure 8 Cementing of Rough Surfaces

but they should at least be sanded smooth. The reason for this is that the solvent penetrates at an even rate on every point on the exterior surface and translates the texture of the original surface to the inner limit of the cushion. If the exterior surface is irregular, the cushion will be uneven in thickness when pressed against a smooth surface. (See Figure 8).

Masking

45 To confine the softening action of the cement to the area of the joint, it is necessary to mask the surrounding plastic. Use a pressure sensitive adhesive tape (Item 12) impervious to the action of the cement.

Soaking

46 The function of the cushion formed by the cement is to permit intermingling of the two surfaces to be bonded. The liquid on the cushion surface is the bonding agent. The size of the cushion need be no greater than is necessary to obtain intimate conta t. Although no arbitrary soaking time can be set, an average of about fifteen minutes in normal cement will form a cushion deep enough to take care of normal permissible irregularities of fit, (see Figure 9). It should be remembered that the deeper the cushion, the longer the drying time and the more of the solvent will be trapped in the joint. On the other hand, too thin a cushion may not give good contact of the surfaces and the joint may have dry spots and vapour bubbles in it. The cushion, therefore, should be somewhat deeper than the maximum allowable irregularities of fit.

47 Sometimes it is more convenient to use the syrup method, which consists of dissolving clean acrylic shavings, (about 3% by volume), in the solvent to make a viscous cement which can be handled like glue. The cement acts only as a carrier for the solvent. (See Figure 10).

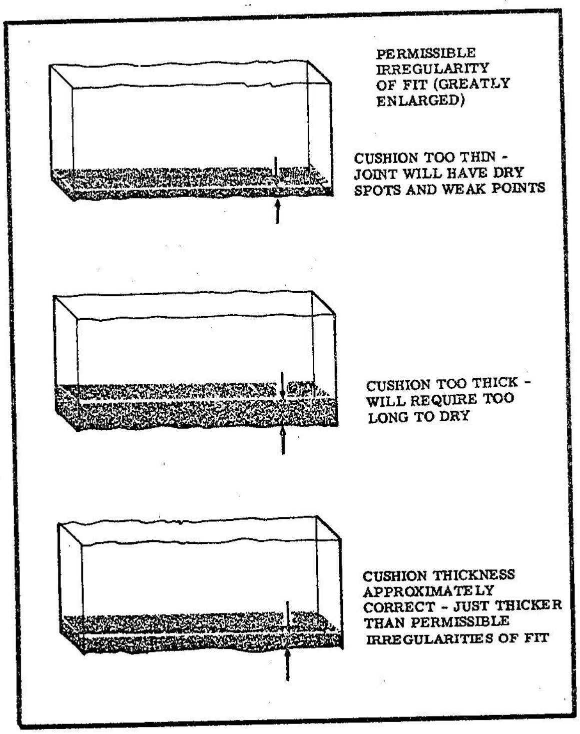

Figure 9 Cushion Thickness

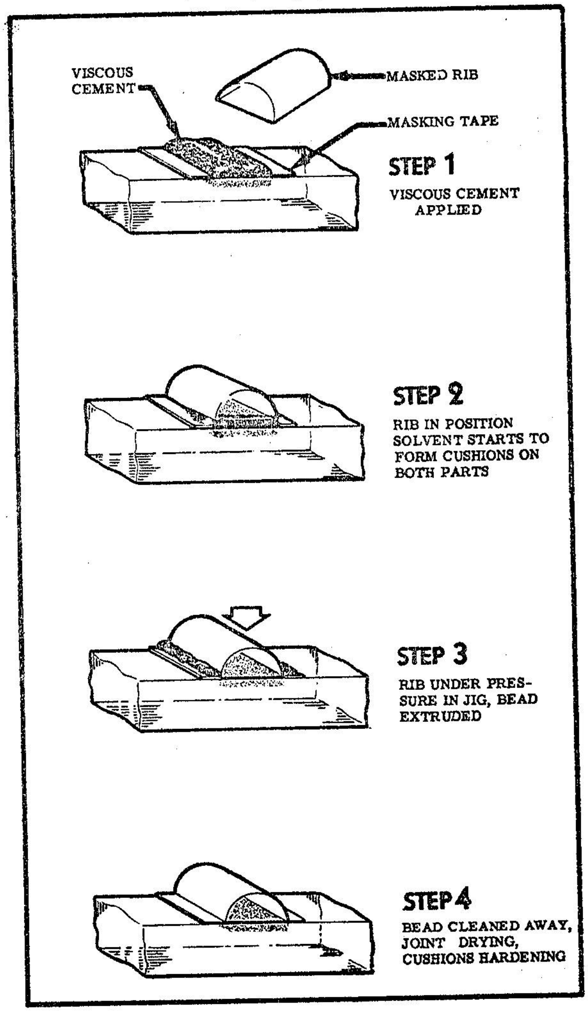

Figure 10 Cementing Using Syrup Cement

Assembly

48 The interval between removal from solvent container and the assembly of the joint is perhaps the most critical of the whole cementing operation. Since these liquid cements evaporate quickly, it is necessary that the joint be assembled as quickly as possible. The container should be near the cementing operation and the job or jigs should be so arranged that the operator can assemble the two parts accurately with a minimum of delay. If the interval between soaking and assembly is too long and the cushion surface dries or crusts over, it should be wet again with solvent, using a small pan of solvent and a brush placed near the cementing jig. It is important to allow a slight interval between the time the two pieces are placed in contact and the time pressure is applied. During this interval, the liquid surface of the cushion will be absorbed by the opposite dry surface. If pressure is applied immediately, this liquid is at least partially squeezed out of the joint, (see Figure 11). Ordinarily fifteen to thirty seconds is a sufficient interval.

Jigs

49 The success of a cementing job depends on the design of the jigs holding the two sections in place until the joint is hard. The jig should keep the two pieces firmly together but should not force either of them out of shape. Under the latter condition, the action of the cement on the stressed part is almost certain to cause objectionable crazing.

50 The pressure should be great enough to squeeze all air bubbles from the joint and assure thorough intermingling of the cushions. It should be applied evenly all along the joint to avoid stress concentration at any point, and be maintained to compensate for the shrinkage that takes place in the joint during setting or hardening. If the two pieces are attached so rigidly that they cannot move together while drying, the cushion, as it shrinks, will draw the cushion material back into the joint. The joint will then be marked with a curve or dimple, or by air bubbles. The three vital conditions are best met by using spring clips (spring clothes pins or battery clamps) either alone or in conjunction with wood or metal jigs, (see Figure 12). In order to avoid localized stress concentration which would cause crazing, avoid excessive pressure.

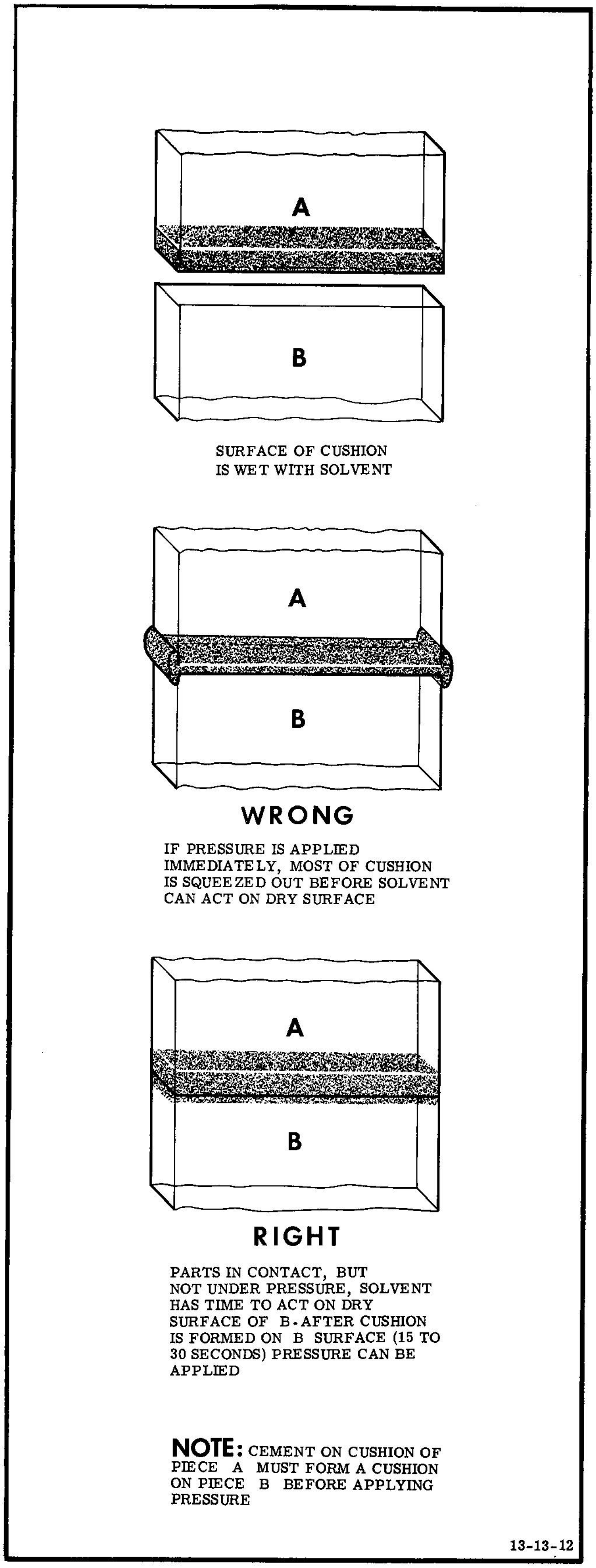

Figure 11 Cementing Methods

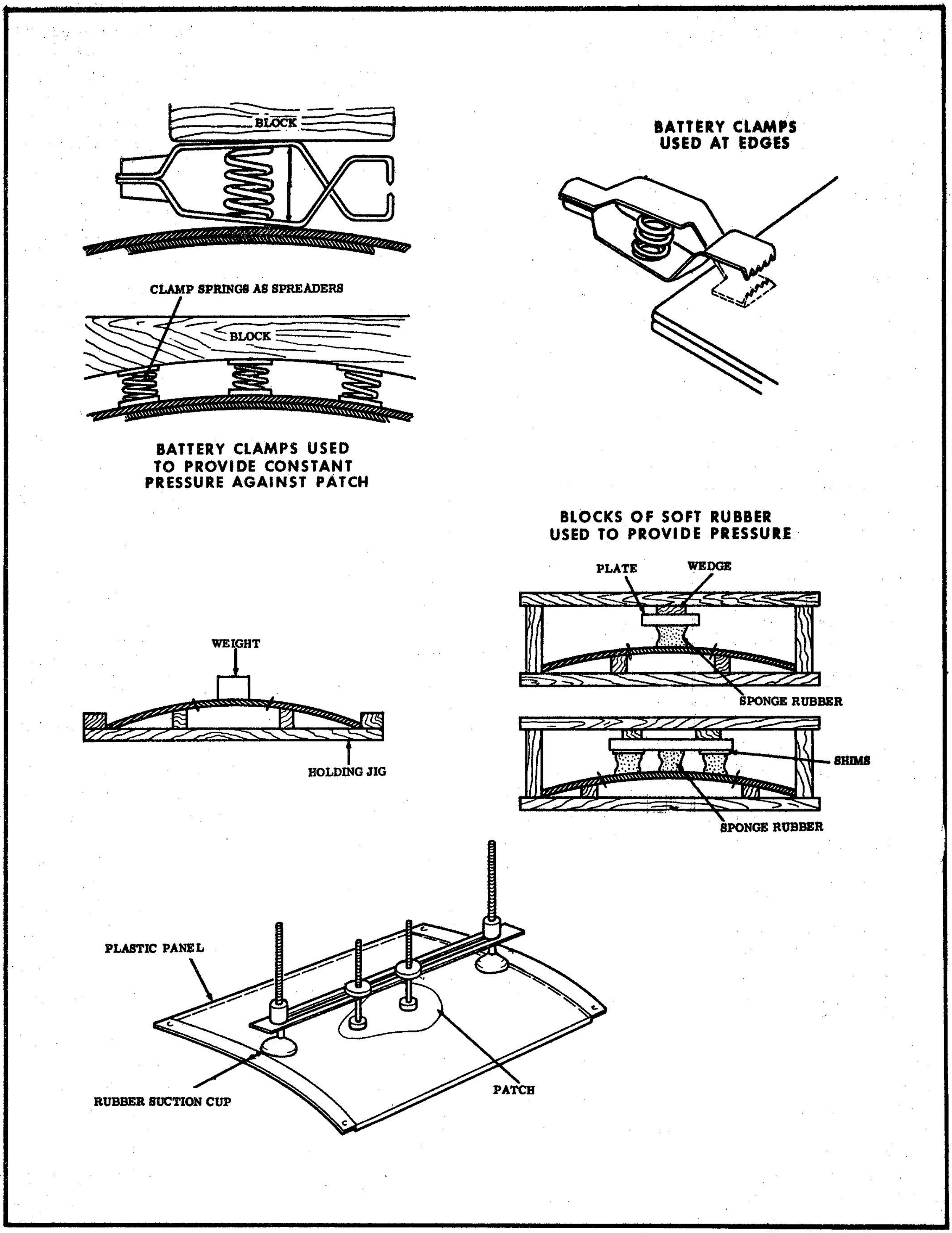

Figure 12 Typical Assembly Jigs

51 When placing the assembly in the jig and at intervals thereafter, it is advisable to examine the joint carefully. If slipping is noted before the joint has set, the pressure can be readjusted or the joint taken apart for reassembly. After the assembly has been locked in the jig, any excess cement and cushion which has extruded from the joint should be removed.

52 The assembly should be allowed to stand in the jig for at least four hours and an additional four hours should elapse before the assembly is subjected to handling or given heat treatment.

Curing and Heat Treatment

53 A solvent joint does not dry and will never become entirely free of solvent. If left at room temperature, the solvent in the cushion will penetrate to a certain depth and no further. In other words, an equilibrium of solvent and plastic is established that remains practically stable at any fixed temperature. If the temperature is raised, the cushion will slowly enlarge until a new equilibrium is reached. On cooling, the cushion will be larger and correspondingly harder if it contains less solvent per unit of volume. Heating a solvent joint long enough to expand its cushion to a new equilibrium will, therefore, produce a much stronger joint.

54 Heat treating of cemented joints must be undertaken with caution. Heat first activates the solvent which softens the cushion and the cushion then slowly expands as the solvent penetrates the material. If the plastic at that point is thin, or if the original cushion is too large, this expansion may cause serious weakening of the section. In heat treating, it is important that the temperature used should not approach the softening point of acrylic plastic nor too far exceed the boiling point of the cement. Suitable treatment would consist of 48 hours at 122° F. If this temperature causes undue dimensional changes in intricate assemblies, it may be desirable to heat treat at 113° F for 96 to 168 hours. Within these limitations, the strength of a solvent joint depends on the highest temperature to which it has been subjected. For example, if an untreated joint is heated by direct sunlight, the cushion is softened and the joint may be dangerously weakened. If, however, the joint has been heat treated, its strength will not fall below a safe limit when slightly reheated.

55 Heat treatment offers an additional advantage if the cement contains monomer. The same process (polymerization) by which this liquid becomes solid in the casting of acrylic plastic sheets takes place when the joint is heated. In other words, the monomer hardens into acrylic plastic, increasing the strength of the joint.

56 It is important that the joint be thoroughly hard before machining, sanding or polishing to remove the bead. The softened material in the joint continues to shrink until it has fully set. If the joint is trimmed or sanded too soon, a visible recessive scar will be left along the joint.

Cementing Procedure

57 Strict adherence to the following should result in strong and durable joints.

(a) Both pieces to be joined should fit accurately without forcing.

(b) The surfaces to be cemented should be polished or be sand or machine smoothed.

(c) The area around the joint should be masked against the etching action of the cement, using a tape impervious to the cement.

(d) Use only an approved cement (Item 26).

(e) Dip one of the two pieces of plastic in cement for approximately fifteen minutes until the surface has softened into a cushion.

(f) Assemble the two pieces quickly, so that the cement on the surface of the cushion will soften the dry surface of the other piece.

(g) Allow the two pieces to come in contact for a short interval (fifteen to thirty seconds) before applying pressure to allow the second cushion to form.

(h) Clamp the two pieces together, by means of spring clips, clothes pins or a jig incorporating springs, under just enough pressure to assure intermingling of the two cushions. This pressure need not be great and should be distributed evenly along the joints.

(j) Clean the joint promptly by scraping excess cement and extruded cushion onto the masking tape and removing the tape.

(k) Allow the assembly to stand in the jig for at least four hours.

(m) After an additional four hours, the assembly should be heat treated for 48 hours at 122° F.

(n) Remove excess cement. Clean and polish the joint.

58 For cementing cellulose acetate base plastic, a solution of base material filings and acetone (Item 6) may be prepared, the preparation depending upon climatic conditions. Thick adhesive is most suitable for hot climates. The use of acetone sometimes causes cloudy, unsightly joints of inferior strength. Acetone is highly inflammable.

TOOLS AND MACHINING METHODS

General

59 The fabrication of acrylic plastic parts may be generally compared to that of other materials, such as wood or soft metal. Light to medium woodworking equipment is satisfactory, but heavy duty machines, which are less apt to vibrate, are better. General rules for machining apply. Acrylic plastics are poor conductors of heat and being thermoplastic, tend to soften in excessive heat generated during machining. Water is the recommended coolant. Other coolants may contain chemicals harmful to the plastic.

Drilling

60 Standard drill presses are satisfactory. They can be of the single head, multiple head or radial type. Portable hand drills may also be used where convenient. Regular machine twist drills can be used successfully if ordinary care is observed. Standard drills, ground for hard metals, have a tendency to pull into the material and cause grabbing in much the same manner as with copper and aluminum. This may be overcome by using a modified drill, (see Figure 13).

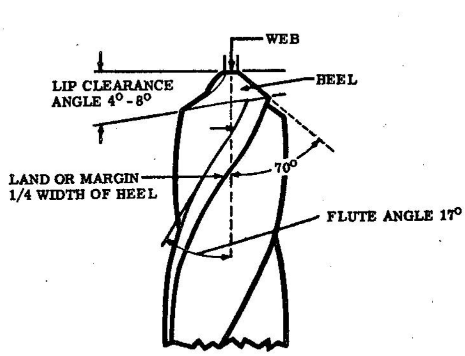

Figure 13 Plastic Drill Dimensions

NOTE

A thin web gives deep flutes and facilitates removal of chips. If the web is too thin, the drill will wobble and some compromise must be made between wobbling and convenient chip removal.

61 For drilling thin sheets, two other types of drills are satisfactory. One is a flat base drill such as has been used for many years to drill cellulose plastic. The other is a modified long lead twist drill with a sharp lip angle. Hollow end mills, mounted in a vertical drill press, can be used for drilling large diameter holes in thin stock. They produce clean, accurate holes and exhibit no tendency to chip on the break-through. Fly-cutters (or trepanning tools) are useful for cutting holes of more than one inch in diameter. Hole saws may be used for the same purpose. None of the tools should be run at high speed. Too fast a feed causes chipping and strain cracks. Proper feed is achieved when smooth, continuous, spiral chips or ribbons result. To avoid overheating, the rate of speed should be decreased as the depth of cut increases.

Drill Lubricants

62 Drill lubricants aid in chip removal, carry away heat and improve the surface finish of the hole. The best lubricant for drilling acrylic is a thin, mild, soap solution (Item 3). In drilling deep holes, the plastic should be immersed in the lubricant or provisions made to direct a steady stream of lubricant at the drill. In the latter case, the drill must be withdrawn every half inch to allow the chips to be cleared and the hole to be filled with lubricant.

Threading and Tapping

63 Taps and dies similar to those used in the metal working industry are used. If threading or tapping is necessary, observe the following precautions:

(a) Allow for the difference in thermal expansion between the different materials.

(b) Use special thread inserts when thread wear is expected. (Refer to EO 05-1-3/6).

(c) Use standard taps and dies for cutting threads at 25% slower speed than for brass or cellulose plastic. High speed will cause excessive friction and gumming of the chips.

(d) Back the taps out frequently. Use the mild soap solution lubricant (Item 3) freely, especially when machine threading or tapping.

Sawing

64 Three general types of saw are used for cutting acrylic plastic: Circular saws, usually employed for cutting squares and rectangles; band saws, used for cutting irregular flat shapes and veneer saws, particularly suitable for trimming formed parts to shape while they are held in position on a jig.

65 Where extreme accuracy is not required, cutting lines may be pencilled directly onto the masking paper. For close tolerances, however, it is advisable to scribe layout lines directly on the surface of the plastic. If the masking paper is removed before scribing, it should be replaced again to within about one-quarter of an inch of the scribed markings before the piece is cut. A razor blade can be used to scribe and trim back the masking paper.

66 Jig saws for cutting curves with small radii and band saws for larger curves and straight cuts in thick material should have accurate blade guides in good adjustment. Circular saws are preferred for straight cutting of pieces which are not too large to be fed to the saw. Circular saws should be equipped with stiffener washers at the shaft to minimize blade vibration.

67 Because of the length of band saw blades, they dissipate heat more rapidly than do circular saws. Accordingly, they operate at lower temperatures and are better suited to cutting thick plastic sheets. Fine cutting may be done with hollow ground circular saws. Blades with from five to eight teeth per inch and no set give good results when running at a peripheral speed of about 10,000 feet per minute (4800 rpm for an eight inch diameter blade). As a general rule, the thicker the material being cut, the larger the diameter and the fewer number of teeth per inch needed.

68 The feed should not be forced, but will vary with the thickness of the stock being cut, the type of blade used, the speed and sharpness of the blade and the power available. Moderate smoking and smearing at the edge is an indication of too rapid speed. To obtain smooth edges at the exit end of the cut, slow the feed as the blade leaves the cut. The chipping of edges with circular saws can be minimized by adjusting the blade to the minimum height with relation to the table and thickness of stock. Keep saw blades sharp to obtain highest cutting efficiency. It is advisable to clean all types of blades periodically by soaking them in acetone (Item 6), toluene (Item 13), methylene dichloride (Item 14), ethylene dichloride (Item 15), trichlorethylene (Item 16) or some other suitable solvent to remove gummy deposit.

NOTE

Ensure that acrylic plastics do not come in contact with, or are not exposed to, the vapours of the above solvents.

Routing

69 Routers are used for a variety of operations, including machining flat sections to accurate contour, rabbetting edges to facilitate flush mounting, and machining rib sections to predetermined cross sections. For certain rabbetting operations, a jointer may be used. For rabbet or stepped routs, (see Figure 14), back off the teeth of the cutter on the underside to prevent drag and avoid burning. Radius the corners of routing cutters 1/16 inch to produce a fillet at the bottom of the rout. This prevents stress concentration and adds to the strength of the piece. Where an edge of the plastic bears on a router spindle collar as a guide during routing, oil the collar

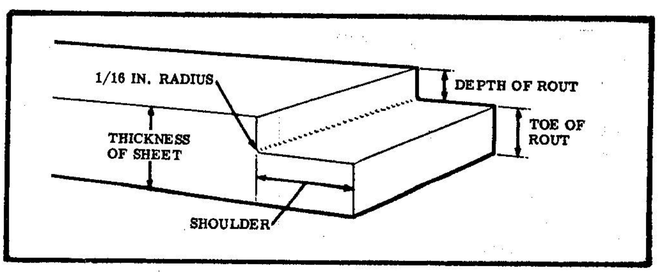

Figure 14 Step Rout or Rabbet

to reduce friction and excess heating. Special cross sections can be routed by using cutters ground to the desired shape. Rib shapes, for example, can be made by routing strips in much the same way that wood moulding is produced.

Routing to Shape

70 For high speed portable routers, standard two bladed wood cutters give satisfactory results. On vertical spindle shapers, multiple blade cutters may be used. Keep cutters sharp. Grind cutters with a back clearance of about 10°. Rake angle should be 20° to 30° for best results (see Figure 15).

71 Use high routing speeds to get smoother cuts, particularly on small diameter cutters under 1-1/2 inches. High speeds permit each cutter blade to take a very light cut as it passes the material and so reduces the tendency to chip. Acrylic sheets must be fed slowly and continuously to avoid any tendency to crack or overheat. Air blast or suction will remove chips and cool the cutter simultaneously. Hold work firmly by hand or in suitable fixtures which may be designed to serve as guides for the work.

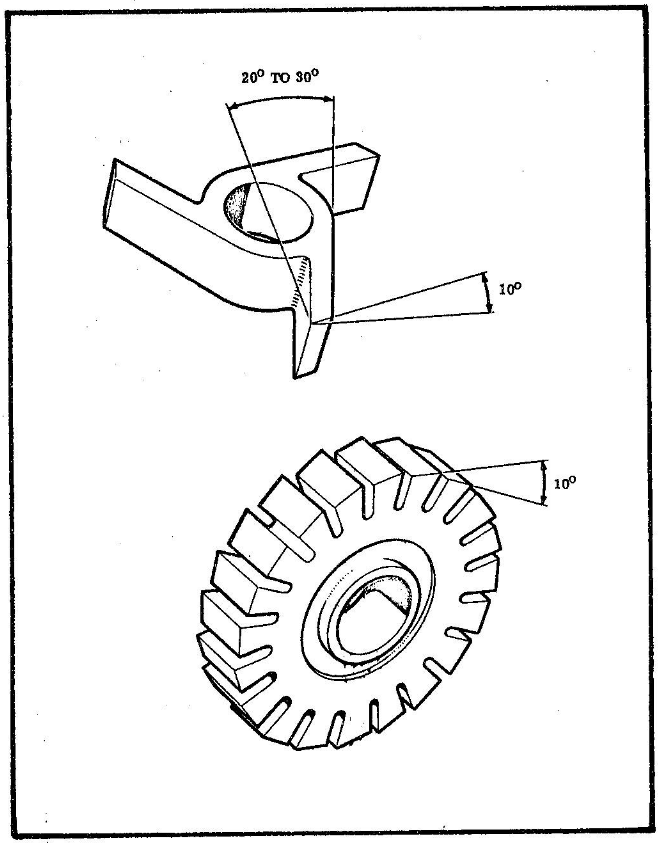

Figure 15 Typical Routing Cutters

72 Work in a clean room, and brush the forms free of dust and dirt before use. The acrylic plastic blanks should be slightly larger than the required finished size to provide an edge which can be handled freely without danger of scarring the surface of the material of the finished part. The pressures required to form acrylic plastics are extremely low and often the weight of the material itself is sufficient. The application of high, or even moderately high pressures, is neither necessary nor desirable, since it tends to increase the extent of mark-offs. After the material has been formed, allow it to cool slowly. Cooling can be accelerated by means of a fan or other device. Cool slowly and uniformly over the entire surface to reduce internal strain.

73 For complicated shapes, reinforced plaster forms are easy to make and are perfectly satisfactory. Forms should be free from waviness and other variations in contour which might cause optical distortions on the formed part. Smooth the surface and cover with a soft cloth, such as billiard felt, outing flannel, flannelette, imitation chamois or flocked or suede rubber sheeting. Where cloth is used, an application of petrolatum (Item 11) may be advisable. In an emergency, it is often possible to make forms from plaster using the broken panel itself as a mould. The broken panel is taped securely together and its inside surface well greased with petrolatum (Item 11) or soap (Item 3). Sand is packed around the outside surface to provide adequate support, while the plaster is poured and allowed to set.

74 The form should be provided with some means of holding the edges of the plastic sheet against the form. In some cases, flat rubber bands, fastened to the form block so that they can be snapped over the edges of the formed piece, will exert the necessary pressure.

Two Dimensional (Drape) Forming

75 Remove all masking paper from the plastic before heating. If the sheets become dusty or dirty after unmasking, rinse well with distilled water. If ordinary tap water is used, dry the sheet thoroughly by blotting with soft tissue paper. Any solvent in ordinary tap water will dig into the plastic surface if this precaution is not taken. After heating, and wearing soft cotton gloves, remove the hot plastic sheet from the oven and lay it carefully

over the form. Hold the edges of the sheet against the form, either by hand or by means of hold-down rings or yokes, until the sheet has thoroughly cooled.

Three Dimensional Forming

76 Parts with compound curves are formed from acrylic sheets by several different methods.

Stretch Forming (Manual and Mechanical)

77 Many compound shapes can be made by stretching the heated plastic sheet across the form. Heat the sheet slightly hotter than for drape forms. Fasten a number of wooden carpenter's clamps or anchor clamps to the edges, six to ten inches apart. Holding the sheet by these clamps, draw it down around the form. For some shapes, one edge of the sheet may be clamped to the form, and the sheet stretched over the form from the other edges. Since several men may be required for the stretching, depending on the size and thickness of the piece and the extent of the stretch, the form must be well built and firmly mounted. Stretch the sheet as uniformly as possible. Clamp a metal ring in position around the edges. This requires the use of a slightly oversized sheet, which not only simplifies handling but also compenstes for the slight tendency of the plastic to curl away from the form and flare at the edges.

Male and Female Forming

78 For compound shapes of irregular contour, stretch the hot sheet across the top of one form (usually the female), and hold in position with clamps while lowering the other form into place. Do not use high speeds and high pressures, since both tend to increase the extent of bolt marks or mark-off on the plastic sheet. The objection to this type of forming is that both surfaces of the plastic come in contact with the mould surfaces and the mark-off is doubled.

Trimming

79 Use a bandsaw to follow the correct outline which has been previously scribed on the surface. Where exact dimensional requirements are to be met on a large number of pieces, use a jig to hold the part in a rigid position. Trim, using a veneer saw or a hand router equipped with an end mill cutter.

80 Since they are thermoplastics, acrylic plastics become soft and pliable when heated over 220° F. They can then be bent to almost any shape and will retain the shape when cooled, except for a small contraction caused by the lowering of temperature. If the formed part shows excessive mark-offs or other imperfections, except scratches, on the surface, it can be placed back in the forming oven. It will resume its flat shape and original surface, except for scratches, and then can be formed again. It is usually easier and better to reform several times than to sand and polish mark-off and other mould imperfections.

Ovens

81 Ovens are used for softening acrylic plastic sheets prior to forming. A circulating air oven is preferable, heated by steam, electricity or gas. The oven should be capable of operating over a range of 220° to 350° F. Provide automatic control so that any desired temperature, within a few degrees, can be maintained throughout the oven. For uniform heating, hang the sheets of plastic vertically. Remove protective masking compound prior to heating. Wear white cotton gloves for handling the unmasked sheeting. In an emergency, any available oven, such as a kitchen baking oven, may be used. An alternative method employs a bath of mineral oil (Item 17) heated by immersion heaters or steam coils. This method is somewhat hazardous because of possible crazing and the danger in handling sheets covered with hot oil. It is also difficult to clean the plastic after such treatment. As a last resort, a heatgun or blowtorch may be used. Such equipment should be avoided whenever possible since it is almost certain to cause severe distortion. In general, any method other than oven heat is undesirable and should be used only when the latter is not available.

82 Thick heavy pieces are best supported by drilling a series of holes, spaced about six to twelve inches apart, along the edge of the sheet, and threading a heavy cord through the holes and around a supporting pole. For small pieces which are inconvenient to hang, and for pieces cut to finished dimensions which have no scrap edge to which the clips or channels can be clamped, shelves or drawers must be provided. Shelves, covered with soft felt or flannel, should be of open work construction to allow maximum circulation of air around the sheet to assure uniform heating. The oven should be so

designed that sheets which are hung vertically are heated by opposing streams of air which impinge directly upon opposite sides of the sheets. The air distribution should be uniform over the entire surface. Use filtered air and clean the oven frequently to prevent accumulation of dirt which may deposit on the sheet.

Heat Welding

83 It is possible to bond acrylic plastic sheets together by the use of heat and pressure. The process is quick and simple and produces joints that are transparent and fairly strong. The heating action may, however, set up internal stress that could reduce the strength of the plastic in the area of the joint. This method is not recommended where the joined panel will be subject to high stresses.

Heating Medium

84 A convenient heating medium consists of an electrical resistant strip of stainless steel, with a rheostat to control its temperature. It should be held in a frame designed to keep it hot when in use. The voltage and amperage necessary to obtain the required temperature will vary, depending on the size of the strip. With a 30 x 2 x .069 inch blade for example, a heavy duty transformer with a secondary output of 456 amperes and 3 volts is used.

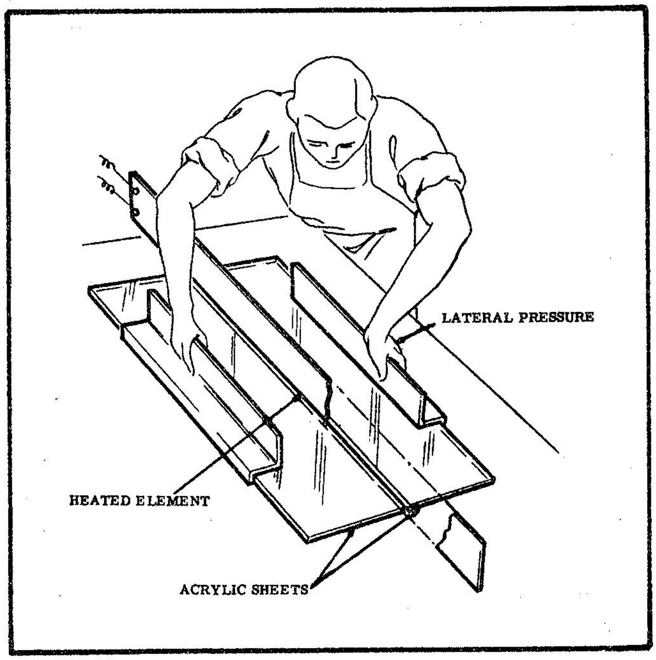

Figure 16 Pressure Application for Heat Welding

Butt Welding

85 Joints made at the blade temperature 662° F have a strength very nearly that of the material itself. If the blade is cooler than 572° F, the acrylic plastic does not decompose enough to form a liquid surface. If hotter than 752° F, the monomer vapourizes so rapidly that there is insufficient liquid left on the surface to form a bond. The temperature of the blade should be checked frequently with a pyrometer.

86 Hold the two acrylic plastic sheets to be joined rigidly in line by a jig set as close to the edges as possible. The heated material at the joint will become soft and will not remain accurately aligned under pressure unless properly supported by the jig. When the sheets are aligned, bring the hot blade between the two plastic edges and close the joint until, through this pressure and the softening of the material against the blade, a perfect contact between the two edges and the blade is established all along the blade. The pressure is then released so that the liquified surface is not extruded as it liquifies. At this point, edges of the material should be boiling and soaking slightly. In general, a joint should be heated only long enough to establish perfect contact and this bubbling condition (approximately thirty seconds). If it is heated any longer, the adjacent material is too deeply softened and will be deformed too easily under subsequent pressure.

87 Withdraw the heating blade and bring the edges immediately together under a spring or deadweight pressure of about two hundred and fifty pounds per square inch of joined area. Maintain pressure until the entire joint is cooled below forming temperature, (see Figure 16). The material immediately adjacent to the joint is soft and forms under this pressure, pushing outward as a rounded ridge, or as beads. If pressure is not maintained until the joint is cool, the distorted material will tend to return to its original shape, tearing or tending to tear apart. Experiments have shown that if pressure is released before the joint is cool, this shrinking of the material decreases the tensile strength of the joint by 10% to 15%. If a distorted joint is planed smooth, a groove is formed by the shrinking of the remaining material.

88 These disadvantages are overcome by confining the joint above and below the weld,

Two rigid non-heat-conducting surfaces, placed on either side of the joint and pressed against it after lateral pressure is applied, reduce distortion. This confining of the joint not only makes it possible to polish the joint immediately, but reduces loss of strength if the joint is heated for forming.

89 It is important to allow the joint to cool as slowly as practicable. The plastic expands when heated and if cooled too rapidly, the surface becomes rigid, forming a shell over the still hot interior. This uneven cooling sets up severe internal strains in the material. Thus, chilling not only tends to make the joint brittle but creates a tendency to crease. If cooled slowly, as in a confined joint, it is possible to obtain a joint with a minimum of stress.

90 Heat welded joints will contain dirt unless blade and plastic are kept clean. When proper precautions are taken, the resultant joint is very nearly invisible and has the advantage of immediate full strength without the delays, complicated jigs and hazards of the conventional solvent joints. Many variations of the welding technique are possible, depending on the type of joint and its strength requirements. Many different heating elements may be used and various jigs may be devised to apply the continuous low pressures required.

ACRYLIC PLASTIC REPAIR PROCEDURES

General

91 In general, repairs to acrylic plastic panels are at best only make-shift methods and usually result in serious impairment of clear vision characteristics. They should be considered for temporary use only and damaged sections replaced as soon as possible.

Patching

92 Repairs to damaged panels of acrylic plastic may be grouped into three categories: Patches secured by screws or rivets; inlay patches secured at the edges by an adhesive; and overlap or lap joints secured by an adhesive, (see Figure 17). Do not use cemented lap joints in any position where clarity of vision is essential, since the use of an adhesive on the surface of acrylic plastic tends to produce a minute greasing effect which cannot be removed. For emergency repair of cracks and holes, drill small holes at the end of each crack to relieve stress concentration and prevent further lengthening of the cracks. In the case of long cracks, drill a series of small holes along both sides and lace with soft wire (Item 18), (see Figure 18).

93 Acrylic plastic can be remoulded for making patches by the use of heat and light pressure. The temperature should be closely controlled. The correct temperature for remoulding material up to 1/8 inch thick is 212° F. Boiling water is used to apply the heat. The correct temperature for remoulding material over 1/8 inch thick is 230° F, immersed in oil or glycerine. Moulded repair patches should not be used in positions where clear vision is necessary, as instances have been recorded of transparent material becoming partially opaque after remoulding.

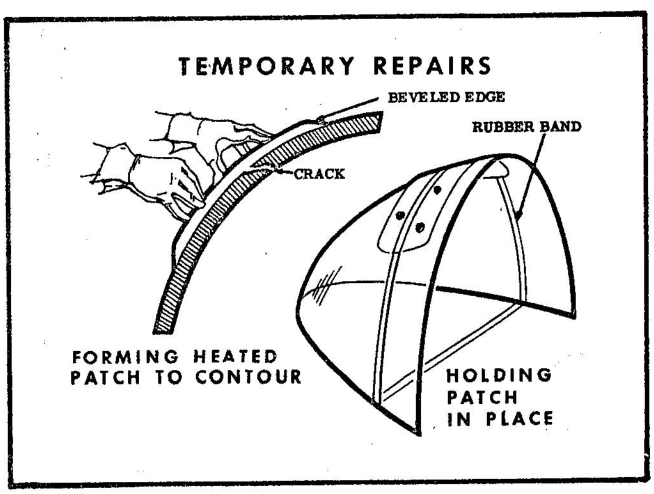

Figure 17 Overlay Patch to Reinforce Crack

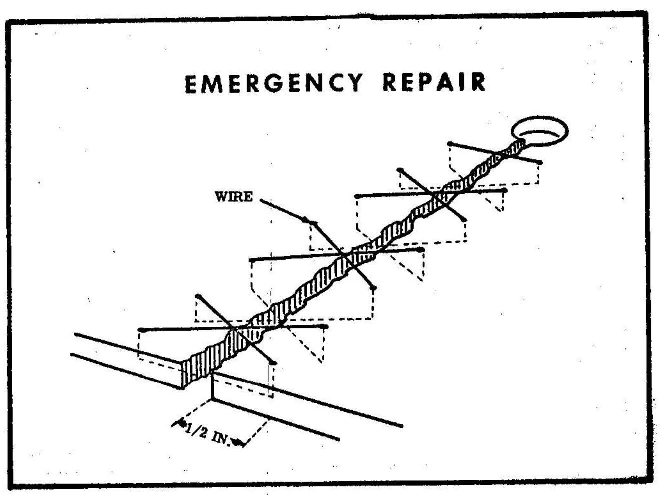

Figure 18 Lacing of Crack for Emergency Repair

Patches Secured by Screws or Rivets

94 Transparent patches secured to acrylic plastic panels by mechanical means may be of the same material or of a cellulose acetate base plastic. For panels up to 5/32 inch in thickness, a patch of 3/64 inch material may be used. For panels of greater thickness, the patch should be of 5/64 inch material. Always apply patches to the inside surface of the panel to minimize air resistance and erosion of the joint.

95 Drill holes for screws or rivets at intervals of one inch to two inches and not less than 1/4 inch from the edge of the patch. Use tubular or semi-tubular rivets and drill 1/64 inch oversize. Patches may be secured by bolts or screws. When bolts are used, drill fine clearance holes in both patch and panel. Screws require clearance holes in the patch and a tapping hole in the panel. Pass screw through the hole in the patch and screw tightly into panel, then cut off projection and file flush. Weatherproof by filling cracks and spaces with one of the approved cements.

Inlay Patches Secured by Cement

96 Trim small holes, up to two inches in diameter, to make them circular. Bevel the full thickness of the panel at an angle of 30°. Form bevel so that the patch is inserted from the side of the panel which receives air pressure during flight. The tendency will then be for the patch to be forced more securely against the panel. Another method of securing an inlay patch is to bevel the sides of the hole in the panel for half the thickness of the panel from each side. Two inlay patches are then fitted, each half the thickness of the panel, one from each side. Cement the patches together during fitting so that they become, in effect, a single plug, able to resist pressure from both sides. The material from which an inlay patch is to be made must always be the same as that of the panel and of the same thickness, except where a plug is made from two laminations, each half the thickness of the panel.

97 Before cementing a patch in a panel, remove all trace of oil or grease by cleaning with methylated spirits. Rub the surfaces to be joined with emery cloth (Item 20) using plenty of water. There is no need to polish these surfaces. Repairs by inlay patches requiring insertions larger than two inches in diameter should be effected by cutting a hole in the panel to a rectangular or square shape with rounded corners and shaping a piece of the same material as the panel to suit the hole.

Overlay Patches Secured by Cement

98 Use the following procedure to secure overlay patches by cement:

(a) Trim the damaged area.

(b) Cut a piece of plastic large enough to cover the area and bevel the edges. Form the patch, if necessary, by heating and pressing it over the area to be covered.

(c) Treat inner surface of patch with cement and apply to surface.

(d) Use regular cementing procedure, refer to Paragraph 57, preceding. Apply pressure using weights or clamps.

(e) When dry, the joint should be cleaned of all surplus cement by using emery cloth (Item 20) with plenty of water. Finally polish as previously detailed.

Butt Joints with Overlay

99 Mill edges of panels to be joined to ensure that mating surfaces are parallel. Bring panels together until a gap of only 1/16 inch remains between their edges. This gap can be maintained by laying the panels on a sheet of black paper coated with paste. Cut an overlap strip of similar composition and thickness to the panels and 3/4 to 1-1/2 inches in width and lay in position on the panels to be joined. Cover the surfaces of the panel on either side of the strip with masking tape (Item 12) to protect them from the cement. Remove the strips and pour an excessive amount of cement on the margins of the panels on which the strip is to be placed and in the 1/16 inch groove. Take care to prevent the formation of bubbles. Make joint by placing one end of the strip in position and gently lowering the remainder until contact is made along the entire length of the strip. Apply a light pressure with the fingers to remove air bubbles and excess cement, the latter being scraped away from the edges of the strip. After approximately one hour, the backing paper and masking tape may be removed and the joint baked for twenty-four hours at from 104° to 140° F.

Butt Joints without Overlay

100 Mill edges of panels to be joined in order to leave a groove 1/16 inch wide on each side of the assembly when the two panels are brought together. Cover the surfaces of the panel with masking tape as described in Paragraph 99, preceding. Backing paper, if used, will have to be removed and replaced by masking strips after the initial drying of the joints, in order to run the cement into the 1/16 inch groove on the underside of the panels. In other respects, the procedure is similar to that outlined in Paragraph 99, preceding. Butt joints without overlay should only be used where an increase in thickness is not permitted.

Repairs of Holes and Cracks

101 Acrylic plastic, up to 122° to 140° F, behaves as a glass-like, hard solid, and once a fracture has started in it, little extra energy is needed to propagate the fracture through the bulk. Its resistance to crack propagation is low and, in the failure of a structure, the critical stage in the process of the failure is the initial development of a surface crack in the structure. Prevent cracks from spreading by drilling or burning a hole at each end of the crack with a 1/16 inch diameter drill. Cover the crack by cementing a strip of acrylic plastic over it. This may be accomplished by either of two methods, as follows:

(a) Cut a strip of the transparent material 1/2 inch wide and long enough to cover the crack plus 1/4 inch overlap at each end of the crack. With the covering strip in position, use a No. 27 drill and drill a hole through one end of the crack and through the strip. Repeat at the other end of the crack. If the length of the crack is more than three inches, drill one or more intermediate holes of the same diameter through both the crack and the strip. Apply cement to the whole of one surface of the strip and to the area it covers surrounding the crack and clamp strip to panel by means of two or three small bolts and washers through the holes. When cement has set, remove bolts and washers, tap the holes and plug with shredded pieces of acrylic plastic which have been dipped in cement. Clean and polish the surface.

(b) Cut a strip of the transparent material two inches wide and long enough to cover the crack plus about one inch overlap at each end. Bolt or rivet strip to the panel as described in Paragraphs 94 to 97, preceding. Drill the holes

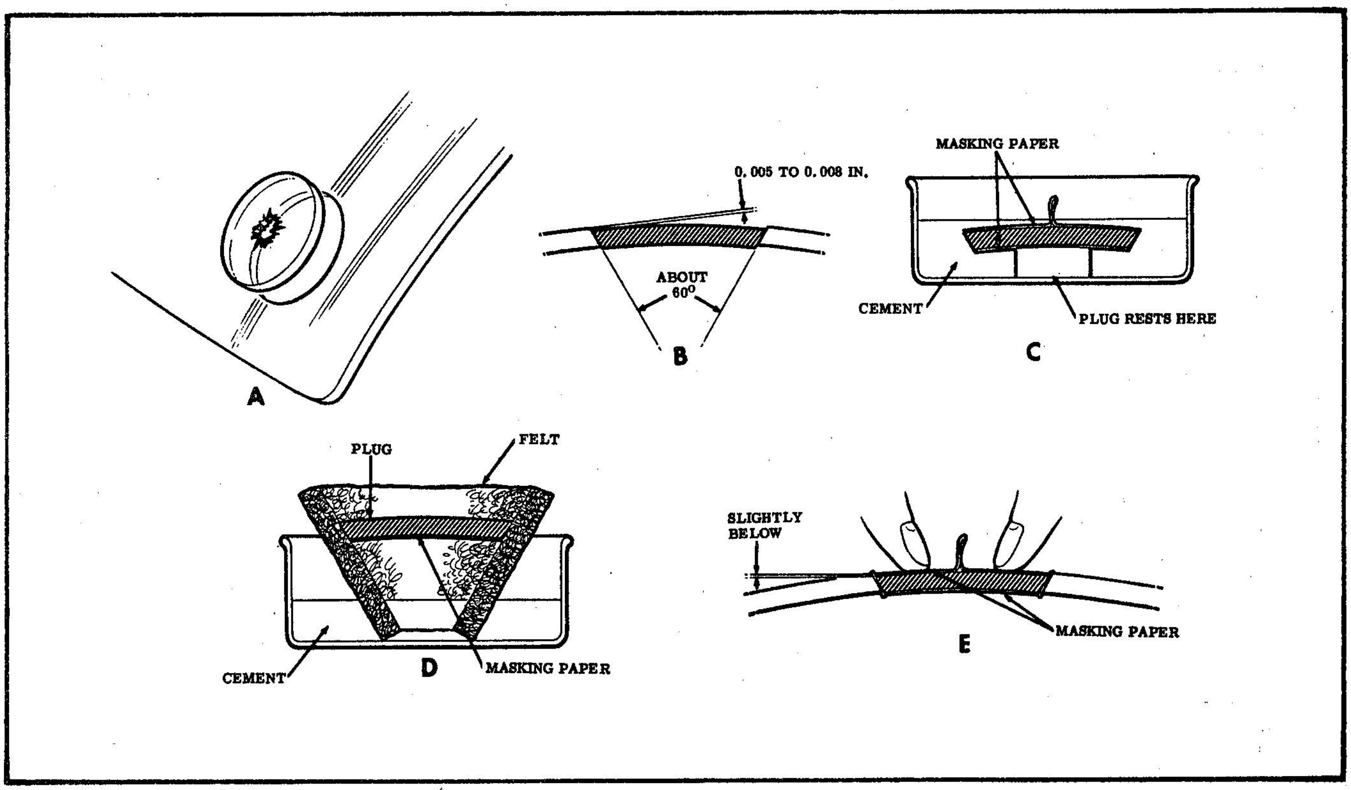

Figure 19 Plug Patch Installation

for the screws or rivets clear of the crack in the panel.

102 Where holes have radiating cracks, repair the holes with a circular inlay patch. At the extremity of each crack, drill and tap hole and plug with shredded acrylic plastic which has been dipped in the cement. Paint the crack with a solution of the cement and when set, clean and polish the surface. Owing to its brittle nature, acrylic plastic should only be drilled when the hole is to be plugged or filled with a cemented patch. Otherwise holes should be formed with a hot wire or needle.

Cemented Fabric Patch

103 Badly fractured areas may be reinforced in an emergency by cementing a layer of strong fabric over the damaged section. Rubber cement (Item 21), clear lacquer (Item 22) or acetate soap (Item 23) may be used as an adhesive. The use of acetate soap carries with it a risk of crazing.

Plug Patch

104 Another effective patch for temporary repairs is the plug patch shown in Figure 19. The damaged area should be removed by cutting a circular hole in the panel and bevelling the edges, as shown. A plug is cut and bevelled to fit. If the panel is curved, the material from which the plug is to be cut should be formed to the existing curvature and cemented.

CELLULOSE ACETATE PLASTIC REPAIRS

General

105 Do not attempt to remould distorted panels, since the application of heat necessary for the purpose causes severe shrinkage and the panel may become partially opaque after the repair has been effected. Replace distorted panels by new ones at the earliest opportunity. In general, the repair procedures used on cellulose acetate base plastic are similar to those for acrylic plastic. The chief difference between acrylics and acetate base plastics lies in the nature of the cements used. Because of the different chemical composition of the two materials, different solvents are required. In general these cements are two types, the solvent-type and dope-type.

Solvent-type Cement

106 The solvent-type cement (Item 26) is used where transparency must be maintained in the joint. It is relatively quick drying and hence is well adapted for use in making emergency repairs. The drying time will vary with the size of the joint and atmospheric conditions. Normally, from six to ten hours are allowed for thorough drying.

Dope-type Cement

107 The dope-type cement is preferred for use where the surfaces to be joined do not conform exactly. This cement softens the surfaces of a joint and creates a layer between the pieces being cemented. It does not yield a transparent joint and is slower drying than the solvent type. From twelve to twenty-four hours must be allowed for the joint to reach full strength.

FINISHING

General

108 Sanding or buffing carried out to remove a surface blemish may result in an ultimate finish poorer than that of untouched sheeting. For this reason, it is important that acrylic plastic be handled carefully during fabrication and servicing so that unnecessary finishing operations can be avoided.

CAUTION

> Under no circumstances should astrodomes, sighting panels or other critical optical parts be sanded or polished. Such sections should always be replaced when scratched.

Sanding

109 Never use sanding when ordinary buffing can be used to remove the blemish, nor should sanding be used unless some type of mechanical buffing equipment is available, since hand polishing is not sufficiently effective to restore polish to a sanded surface.

Hand Sanding

110 Where sanding is indicated, the finest sandpaper (Item 27) that will remove the scratch or other defect (no coarser than No.

320) must be used first. Wrap around a felt or felt covered wooden block and rub the defective area. Rub lightly, using water or a 2% soap solution as a lubricant. The use of soap will speed and improve the sanding operation. Use waterproof abrasive paper. Use light pressure and circular strokes. Sand an area having a diameter of about two to three times the length of the defect, (see Figure 20), to minimize optical distortion and excessive thinning. Follow the initial sanding by similar treatments using successively fine grades of sandpaper grits in the following sequence: 360A, 400A and 500A or 600A. Wash between each sanding.

Machine Sanding

111 The same general procedures apply to sanding with power-driven sanding machines as apply to hand sanding and the same succession of sandpaper grits is used. The generous use of water as a lubricant is especially necessary to dissipate frictional heat. Extremely light pressure is to be used.

CAUTION

Power sanders should only be used where the severity of the defect is such as to require excessive hand sanding. Only flat surfaces or surfaces with a radius of curvature greater than thirty-six inches should be so treated. Machine sanding tends to flatten curved surfaces of small radii, thereby producing excessive optical distortions and thinning out. After deep scratches have been removed, rinse thoroughly with clean water, rubbing with the hands to loosen any abrasive or foreign matter and wipe with a clean, damp, flannel cloth. The remaining scratches in the sanded area should be approximately 0.003 inch, when properly sanded.

Buffing

112 Machine buffing or hand buffing may be used to remove scratches remaining after the sanding operation or scratches that do not require sanding.

Machine Buffing

113 For machine buffing, use the following procedure:

(a) Buff the plastic with a wheel coated with tallow (Item 29) and Tripoli buffing compound (Item 28). When buffing wheels have been used before, remove any hardened tallow by running them against a metal edge. The abrasive coated wheel should operate at approximately 2000 fpm.

(b) Wash the plastic thoroughly with soap (Item 3) and water to remove all traces of abrasive. Dry and then buff with a soft cotton wheel to which only tallow has been applied. This wheel should operate at 3200 to 3600 fpm.

(c) Apply one coat of Anstac M plastic cleaner (Item 4) to the buffed area with a clean cloth and then wipe dry.

(d) A high gloss may be obtained by applying wax (Item 31) and polishing using a soft, clean, cotton cloth.

Hand Buffing

114 For hand buffing, use the following procedure:

(a) Remove scratches with a small amount of polish (Item 32) added to a damp flannel cloth which is wrapped around a wood or rubber block. Polish the entire area in a circular motion, as with the sandpaper.

(b) After the scratches have been removed, rinse thoroughly with clean water, rubbing with the hands to loosen any abrasive or foreign matter and wipe with a clean, damp flannel cloth.

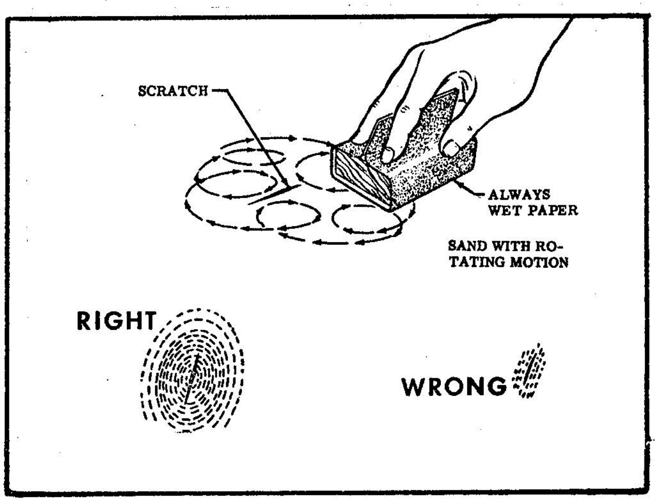

Figure 20 Sanding Methods

(c) As a final buffing agent, use fine abrasive (Item 33) and repeat procedure outlined in Sub-paragraph (a), preceding.

(d) Apply one coat of plastic cleaner (Item 4) to the buffed area with a clean cloth and then wipe dry.

(e) A high gloss may be obtained by applying wax (Item 31) and polishing the plastic using a soft, clean, cotton cloth.

NOTE

When sanding or buffing plastics, care should be taken to avoid overheating the material. While buffing, the plastic should be constantly moved so as not to buff the same area constantly. In critical areas of acrylic plastic parts, maximum allowable depth of scratches permissible for rework is .015 inch; in non-critical areas, .025 inch.

Ashing

115 Ashing is an alternative to sanding using a thick abrasive paste on a cloth wheel. Speed and pressure are critical. To prevent overheating. hold both within limits. Overheating will result in poor finish and, in extreme cases, formation of drag-marks on the surface. As a further precaution against over-heating, the plastic or the wheel should be kept in constant motion with relation to the other. For ashing, a wheel speed of approximately 900 surface feet per minute is recommended.

Hand Polishing

116 When buffing equipment is not available, a good cleaner or polish can be applied by hand to remove light scratches and other minor imperfections. Use a soft damp cloth, such as a soft fibre cloth, imitation chamois, glove lining, outing flannel or flannelette. Wash area to be polished to remove dirt and grit and rub vigorously with the polish. Do not rub too long in one place, but rub with a free circular motion over a fairly wide area. Several applications of cleaner may be necessary.

Waxing

117 To finish to a high polish and to protect the surface, use a good paste or water emulsion wax. This final application is done by hand. Most polishing waxes will effectively fill tiny hair scratches and make them less apparent. The wax also imparts a protective coating to the plastic. Wax should be applied with a soft cloth in the same manner as polish.

FORMING POLYTHENE PLASTIC TUBING

General

118 The following paragraphs give the procedures to be followed when forming polythene plastic tubing.

Bending

119 To bend a polythene plastic tube, proceed as follows:

(a) Fill the tubing with sand and plug both ends with wooden or rubber stoppers. Where a long tube is to be bent near one end only, the whole length of tubing should be filled with sand.

(b) Heat the tubing and the selected bend block in a hot water tank and bend the tubing by hand around the bend block, preferably while still in the tank.

(c) Remove from hot water, and with tube still bent around the block, immerse in a tank of cold water.

(d) Remove the sand from the tubing and blow out with compressed air. Ensure sand is completely removed.

Recommended Bend Radii

120 The following are the recommended minimum bend radii for polythene tubing with 1/16 inch walls:

(a) 1-inch OD, 8-inch radius.

(b) 3/4-inch OD, 6-inch radius.

(c) 1/2-inch OD, 4-inch radius.

Assembly of Beaded Connections

121 When assembling polythene tubing over beaded metal tubing, use either Aeroseal Type QS-200 or Wittek Type WWD clamps. Wrap tubing with two turns of black friction tape in those areas that are in contact with clamps.

Cleaning

122 Wash the tubing with soap (Item 3) and water. Use cold water on tubing that has been formed, flared, bent or assembled with hose clamps. Hot water may be used in other cases. Rinse with cold water or wipe with clean moist cloths after washing. The use of any solvent, such as thinners, trichlorethylene, gasoline, carbon tetrachloride etc., is prohibited.

Testing

123 Use compressed air for testing with the assembly immersed in water.

NOTE

In bending operations, make allowance for spring-back of the bend during cooling and subsequent pressure testing. If a final bend radius of 8 inches is required, the actual bending should be done on a radius of approximately 1 to 2 inches less. The dimensions shown in Paragraph 120, preceding, are the final radii.

NOTE

Reheating of the tubing above 120° F will tend to return the tubing to its original shape, and care must be taken to localize the heating, where more than one forming operation is required on a particular length of tubing.

NOTE

Wittek Type FBSS clamps are not suitable for use with polythene tubing.

FORMING THERMOPLASTIC TUBING

General

124 The procedure in the following paragraphs applies to all types of tubing fabricated from thermoplastics such as ethyl cellulose or cellulose acetate and cellulose acetate butyrate.

Softening

125 In order to permanently form thermoplastics without distortion, heat the material and place in jig for forming and cooling.

Heating

126 Heating may be performed as follows:

(a) Place in oven at 350° F. Length of heating process depends on wall thickness and tube diameter. Test, using scrap material, to determine time needed for heating.

(b) As an alternate method for small pieces, use boiling water.

CAUTION

Tube must not be heated to a temperature where it will collapse; only to a point where it will form with a minimum of distortion.

Bending

127 Immediately after heating, place the tube in a suitable jig and form. Allow the tube to cool sufficiently hard to handle without distortion. Force cool, passing air through the inside and over the outside of the tube. The forming jig must be of such design that a minimum distortion of the tube is achieved. Standard hand tube benders may be used. If distortion occurs during bending, insert a hard rubber tube in the plastic tube before heating, which will keep the tube from collapsing and aid in the bending.

GLASS FABRIC LAMINATE REPAIRS

General

128 The materials and procedures used in the repair of glass fabric laminate are described in the following paragraphs. The types of damage discussed are holes or cavities, ruptures, cracks, delamination, sections to be spliced, resin-starved areas, resin-excess areas, blisters and pulled inserts. In describing the repairs, reference is made to the methods of preparing, pressing and curing glass fabric laminate. These methods are described in separate paragraphs following the repair procedures. Use cellophane or approved parting agents, (refer to Paragraph 129, following), when pressurizing in contact with impregnated resin. Pressurizing and curing (application of heat) must be applied immediately after application of impregnated resin. The pressure required will be between 25 and 50 psi.

Parting Agents

129 The following approved types of parting agents may be used when necessary:

(a) Grease (Item 34).

(b) Grease (Item 35).

(c) Silicone (Item 36).

(d) Silicone Resin (Item 37).

Small Holes

130 Remove all foreign matter from the hole or cavity, fill with impregnated fibres, and cure, (refer to Paragraphs 142 and 147, following). After curing, refinish surface as necessary.

Large Holes

131 Sand area around edge of hole with coarse sandpaper. Coat with resin and place a piece of impregnated glass fabric cloth (Item 38), over the hole so that it overlaps the edge approximately 1/2 inch. Push the cloth into the hole to form a slight cavity and fill cavity with a quantity of impregnated glass fabric mat (Item 39), equal to the thickness of the laminate being repaired. Cover the patch with cellophane (Item 40) and cure, applying pressure during curing if strength and finish requirements are rigid, (refer to Paragraph 146, following). Refinish surface as necessary.

Minor Ruptures

132 In the case of a minor rupture, work a coating of resin (Item 41) into the ruptured area and cure, subsequently refinishing the surface.

Major Ruptures

133 In the case of a major rupture, sand area around rupture on reverse side. Laminate a prescribed number of resin-impregnated cloth layers over area, (refer to Paragraph 142, following). Tape cellophane (Item 40) over cloth and cure. Pressure must be applied during curing if requirements are rigid, and surface must be refinished after curing.

Cracks along Trailing Edge

134 To repair a crack along the trailing edge, sand the area for one inch on both sides of the crack. Insert a 1/2 inch strip of impregnated glass fabric mat (Item 39) in crack so that the edge of the mat is flush with the trailing edge of the part, (refer to Paragraph 142, following). The mat should extend the entire length of the crack. Cover the crack with one-ply glass fabric cloth (Item 38) so that the cloth overlaps the crack at least 1/2 inch. Cover patch with cellophane (Item 40), apply pressure if necessary, and cure.

Delamination

135 To repair delamination, work the resin in between the layers using a hypodermic needle. After working resin between the layers, apply pressure to force them together, and cure.

Sections to be Spliced

136 When a section is to be spliced, separate the layers in the laminate for a distance of approximately one inch from both edges. Work the resin between the layers and dovetail the edges together. Apply pressure, cure the rework, and refinish as necessary.

Resin-starved Areas

137 To repair a resin-starved area, coat the dry area with a 50-50 solution of resin and Zoluol (Item 42). Remove all excess resin and cure the rework.

Resin-excess Areas

138 When a resin-excess area is found, sand or chip off the excess resin to the bare glass fabric. Apply a coat of resin to seal the fibres and cure.

Blisters

139 To repair a blister, split with a knife and force resin inside using a hypodermic needle. Apply pressure and cure the rework.

Pulled Inserts in Moulded Glass Fabric

140 When repairing pulled inserts in moulded glass fabric, file the retaining grooves as deep as possible in the inserts in order to afford a good mechanical lock. Screw the insert on a bolt to keep resin out of the threads and clean the outside of the insert with Zoluol (Item 42). Clean out the hole in the glass fabric section with Zoluol and scrape grooves approximately 1/32 inch deep in the inside surfaces. Fill the hole with resin and then force in the insert. Remove all excess resin and cure the section for 10 minutes at 300° F.

Preparation of Resin

141 Weigh the desired amount of resin and to it add 2%, by weight, of benzoyl peroxide catalyst (Item 10). Stir the mixture until catalyst is dissolved. To prepare a 50-50 coating solution, add one part resin (Item 41) to one part Zoluol (Item 42) and stir until a uniform solution is obtained.

Preparation of Impregnated Fibres

142 Stir together 1 part milled glass fabric (Item 43) and approximately 3 parts, by weight, of prepared resin (Item 41) until a smooth, creamy mixture is obtained.

Preparation of Impregnated Mat and Cloth

143 Apply a thin coat of resin to the glass mat or cloth and scrape off the surplus. To thin the resin prior to the addition of catalyst, up to 5% by volume of Styrene N-99 (Item 44) may be added to the resin. Then add 2%, by weight, of catalyst and heat to approximately 100° F to facilitate catalysis.

General Pressurizing Methods

144 In most cases, sufficient pressure may be obtained by the use of small spring clamps or C-clamps. In other cases, the part may be replaced in the mould and pressure applied as in fabrication of the part. If an electric iron is used in curing, pressure may be applied through it to the laminate. Where these methods fail to produce satisfactory pressure, insert a vacuum valve in a sheet of polyvinyl alcohol (Item 45) and place it over the area to be pressed. Seal the edges of the polyvinyl alcohol sheet with sealing compound (Item 46). If it is not airtight, seal the reverse side of the area with a sheet of cellophane that is sealed around the edges with sealing compound. After the resin has jelled, the vacuum may be stopped.

General Curing Methods

145 Catalyzed resin requires a heat of approximately 300° F for two to ten minutes, varying with the thickness of the laminate, to ensure polymerization (curing). This temperature may be obtained by the use of a hot air gun, electric iron, electric pad, or an oven. Curing times and temperatures must be obtained by experiment, using scrap materials, prior to commencing the repair. The following alternate minimum time and temperatures may be used as a guide:

Temperature (Minimum)	Time in Minutes (Minimum)
190° F	90
200° F	45
225° F	20
240° F	10

146 The resin may also be cured by exposure to ultraviolet light or to sunlight. The time exposure necessary to effect a cure varies according to the thickness of the laminate, the temperature and the degree of the ultraviolet light or sunlight, but usually one hour is sufficient. When using heating equipment on installed parts, avoid damage to adjacent parts.

PHENOLIC PLASTICS

General

147 The following information may be used for the manufacture of materials required for the moulding of phenolic plastics.

Dyes

148 When it is required that the plastic be dyed red or black, use dye (Item 47 or 48).

Parting Agents

149 Parting agents must be applied to the mould prior to casting. Use zinc chromate primer, (Item 49), (refer to EO 05-1-3/23) paint (Item 50) or wax (Item 51).

Flexible Mould Materials

150 For flexible moulds, use Plastiflex (Item 52) or Superlastic P-1500 (Item 53).

Vinyl Resin Cement

151 Use vinyl resin cement (Item 54) or vinylseal (Item 55) with one coat of zinc chromate primer (Item 49) when casting in metal inserts in the mould.

Casting Resin and Catalyst

152 The casting resin (Item 56) is supplied as a liquid viscous resin which can be easily

poured at room temperature . The catalyst must be mixed as directed on the container.

Preparation of Non-flexible Moulds

153 Moulds are made similar to sand casting moulds, using plaster of paris, wood, steel, cement, etc. and using the same type of gates, risers, etc. Apply one coat of zinc chromate primer (Item 49) and three coats of paint (Item 50). Wax lightly before use.

Preparation of Flexible Moulds

154 Flexible moulds are cast over a master which is surrounded by a tin can or similar form. When using Plastiflex (Item 52), heat it to 320° to 340° F. Stir frequently.

CAUTION

Do not exceed 340° F.

155 Heat master form using infra-red lamp and pour liquid Plastiflex (Item 52) over master mould, keeping the liquid hot until evolution of bubbles from liquid ceases. Allow to cool and apply a light coating of wax or oil to the mould. Castor oil (Item 58) or mineral oil (Item 17) may be used. When using Superlastic P-1500, (Item 53) the master mould need not be heated. Stir material well just prior to use, pour over cold master mould and allow to stand for approximately one hour to eliminate bubbles. Then cure mould at 170° F until set up.

NOTE

Use Plastiflex moulds where extreme flexibility is desired and Superlastic P-1500 for slightly flexible moulds. Material for split moulds may be reinforced with plaster of paris. When pouring moulds, ensure that mould is properly tilted or agitated so that all small cavities or irregularities in the casting will be properly filled with mould material.

Phenolic Resin Castings

156 Use only resins based on phenol, melamine or resorcinol for the casting material. Heat the desired quantity of casting resin material to 110° F in oven or water bath.

NOTE

Never heat resin directly over hot plate.

157 Add red or black dye if required. Dye must be added to manufacturers directions. Allow to stand for three hours to disperse bubbles if dye was added. Then reheat to 110° to 125°F. Add catalyst according to manufacturers directions. Allow to stand at room temperature for two to eight hours.

Casting the Part

158 Treat mould with parting agent and preheat to approximately 160° F. Heat resin to pouring viscosity, 120° to 160° F. Pour resin carefully in order to trap as little air as possible. Vibrate or tilt mould as required to allow trapped air to escape while pouring and during next few minutes after pouring. Cure at 160° to 190° F as soon after pouring as possible. When part is sufficiently hard, remove from oven and cure at room temperature for one hour per inch of thickness.

Process Precautions

159 Metal inserts must have burr removed. Apply one coat of zinc chromate primer (Item 49) and approximately .010 inches of vinylseal cement (Item 55).

NOTE

When handling catalyst, observe safety precautions. (Refer to EO 00-80-4/22.

160 Spilled liquid resin may be cleaned up by using denatured ethyl alcohol (Item 59). Recoat moulds with parting agent after each casting. Filter Plastiflex (Item 52) which becomes lumpy through a wire screen. When pouring Plastiflex over plaster of paris master mould, place pattern over the hole of a vacuum plate and apply vacuum continuously during the pouring and until Plastiflex has set up.

Postforming Phenolic Laminate

161 In the postforming process, a predetermined flat pattern blank is heated to plasticity by conventional means, and then, before cooling, is formed to the desired shape by the application of pressure in forming dies. The material is stretched and reformed by externally applied forces as in metal forming. Because of the low magnitude of forces needed to form the material, relatively inexpensive tooling of simple construction can be used. The recommended minimum and absolute minimum bend radii for 90° straight-line bends

are given in Figure 21. The absolute minimum radius can be held only for simple, straight bends. Bends, flanged holes and dimpled cutouts, such as are used for sheet metal, may also be produced in postforming phenolic laminates not exceeding 3/32 inch thickness. Deep drawing to a maximum of 15% is possible, depending upon the particular design. A deeper draw rips the fabric base.

EROSION - RESISTANT COATING OF LAMINATED GLASS FABRIC PARTS

General

162 All glass fabric laminated components, (except as noted in Paragraph 167, following), which are exposed to the airstream are to be maintained and repaired in accordance with the following instructions. The parts affected may be those of turbine or reciprocating engine type and include the following:

(a) Radome assemblies.

(b) Tip antennae housing assemblies of vertical stabilizers.

(c) Miscellaneous housings, covers and fillets.

163 Field repairs are to be made on coated parts when evidence of pitting, blistering, peeling or other visible damage is found on the coating during inspection. Visual inspection of coated parts should be made at least once every 100 flying hours if the speed of the aircraft is less than 350 knots, once every 50 flying hours if the speed of the aircraft is over 350 knots, and at all times when abnormal weather conditions have been encountered.

164 Some rain erosion occurs to a limited extent on glass fabric laminates installed on slow-speed aircraft as well as to those on high-speed aircraft. After a few minutes of flight through rain at the higher speeds, such extensive damage has resulted that in many cases external laminated plastic leading edge surfaces are eroded beyond hope of repair.

165 Rain erosion damage may be readily recognized, since it normally starts along the leading edges of the part and gives the part a characteristic pitted or delaminated appearance. These pits deepen and widen as erosion progresses. The process of erosion is slow in getting under way until after the first penetration takes place. As soon as the first ply of reinforcing cloth is penetrated, lateral spreading of the damage takes place between and under the layers, due to the hydraulic pressures exerted by rain drops.

166 Erosion is more prevalent along those edges having sharper curvature and where the rain strikes at 90° to the surface. Protection must be provided on at least the leading edges, and on all areas which present an angle impact in flight through rain of 15° or more. Head-on impact of a flat surface is considered as 90° angle of impact.

Extent of Repairable Damage of Laminates

167 Field repairs may be accomplished on laminated glass fabric plastic parts on which damage has not progressed to a point severe enough to impair their structural integrity. The repair of eroded surfaces will be governed by the following conditions:

(a) Repair may be accomplished over an unlimited area wherein only surface resin erosion has occurred, with no penetration through a reinforcing fabric layer.

Material Thickness	Recommended Min. Radius	Absolute Min. Radius
.03	.06	.03
.05	.09	.06
.06	.12	.09
.09	.25	.19
.12	.38	.31
.19	.75	.56
.25	1.50	1.00
.38	3.00	2.25

Figure 21 Bend Radii for Postforming Phenolic Laminate

(b) Eroded areas wherein the damage is not deeper than through the first layer of reinforcing fabric may be repaired, provided that the combined areas of damage do not exceed one square inch within an area enclosed in a six inch diameter circle.

(c) Pits extending through two or more layers of reinforcing fabric may be repaired, provided individual pits are not greater than 1/4 inch maximum diameter and the combined area of such pits does not exceed one square inch within an area enclosed in a six inch diameter circle.

(d) Long narrow eroded areas may be repaired if the maximum width of damage is not greater than 1/4 inch, and provided the depth of damage is not deeper than through the first layer of reinforcing fabric and the length of the eroded area is not greater than 25% of the overall dimension of the laminated plastic part, measured parallel to the length of the damaged area.

(e) If damage is found to be more extensive than outlined or is considered to be dangerous to flight, the part in question is to be replaced.

Coating of Radio Compass Loop Housings

168 The application of neoprene to radio compass loop housings reduces the efficiency of the radio compass under certain flying conditions. Therefore, no radio compass loop housing is to be coated with neoprene even though they are fabricated from glass fabric laminate. Any neoprene on radio compass loop housings should be removed as follows:

(a) Soften the neoprene by applying cloths saturated with toluol (Item 13) to the coated surface.

(b) Rub the coating, using a fibre bristle brush. Several applications of toluol may be necessary.

(c) To hasten removal of the neoprene, lay the saturated cloths on the coated surface for intervals of several minutes prior to scrubbing of the softened coating.

CAUTION

Precautions and careful supervision must be observed to avoid contact of the toluol with the glass fabric laminate underneath the coating since delamination of the part may occur. Steam or paint remover will also deteriorate the glass fabric laminate and must not be used.

(d) Following complete removal of the neoprene, radio compass loop housings (except LP-21-L and LP-21-LM) are to be coated with conductive paint (Item 60).

Repair Procedure of Laminates before Coating

169 Trim out loose or delaminated pieces and sand to a smooth surface, using abrasive paper (Item 27). In sanding the laminated glass, precautionary measures should be taken to keep the glass fibres from the skin. Protective cream (Item 30) is recommended for this purpose. Proceed as follows:

(a) Clean the sanded surface with solvent such as toluol (Item 13) to remove oil or grease.

(b) Apply adhesive filler (Item 25) to the depressions of the eroded area, using a spatula or knife to spread smoothly. Allow to dry for one hour. If sink marks show in the filled-in areas, this operation should be repeated.

(c) Sand the filled surfaces smooth and to the original contour of the surface laminate using abrasive paper (Item 27). Wipe free of dust.

Application of Neoprene Coating

170 The area to be covered will vary with the shape and proposed location of the part being coated. For maximum rain erosion protection, the material should be applied over the leading edge and extended to a point where the undisturbed air stream makes an angle less than 15° to the surface being covered. Apply the neoprene coating as follows:

(a) Process parts to be coated with air-drying neoprene coating (Item 57) in a sheltered area free from dust and protected from weather.

(b) Sand the surface to be coated with abrasive paper (Item 27) to remove paint or glossy finish of the laminate.

(c) Remove sanding dust by wiping with a clean, lint-free cloth and wipe surface lightly with a solvent such as toluol (Item 13).

(d) Some parts may have a hard brown phenolic paint covering the glass laminate, which is very difficult to remove. Do not remove but cover with neoprene coating.

Priming Surface with Adhesive Precoat

171 After cleaning the surface, apply a primer coat of adhesive precoat (Item 24). The thickness for the primer should be 0.001 to 0.002 inch. For brush application, two coats of the unthinned primer are applied by brushing with a well-wetted brush, from the wet to the dry surface, to prevent pinholing and blistering due to trapped air bubbles. For more ease in brushing, the primer may be thinned by using methyl ethyl ketone (Item 9). The thinned primer requires additional coats in order to build up to the specified thickness. For spray application, use one part of primer to a maximum of three parts, by volume, of methyl ethyl ketone. Allow a five minute drying period between coatings.

Preparation of Neoprene Topcoat

172 Neoprene topcoat (Item 57) is packaged unaccelerated to provide good shelf-life. The neoprene is ready to use only after the accelerator has been added. Shelf-life of the unaccelerated components, when stored at room temperature, is eight months. The accelerator is supplied with the topcoating material and the containers are marked with the mixing directions. Thin the topcoat to the desired consistency with toluol (Item 13) for either brush or spray application before adding the accelerator. Add the accelerator and mix thoroughly. The prepared topcoat mixture should be lightly stirred again prior to each successive coat. Only the amount of material to be used within the following eight hours should be accelerated at one time. Material that has been mixed and allowed to stand beyond this period of time, or is hardened, must be discarded. Do not attempt to thin any coating material which has jelled beyond brushable use. Keep containers tightly covered when not in use.

Brush Application of Topcoat

173 Allow sufficient time for the final primer coat to dry (30 to 60 minutes) before brushing on the first neoprene topcoat. Use short, even strokes, brushing from wet to dry surface, to prevent pinholing and blistering due to trapped air bubbles. Do not disturb the surface after a smooth coating has been applied. Brushing over an area that has partially dried will result in drag. This can be minimized by keeping the brush well wetted with the coating material and by thinning with a small amount of toluol (Item 13). Any trapped air can be released by spraying the surface gently with a mist of thinner mixture consisting of one part by volume of methyl ethyl ketone (Item 9) and one part by volume of toluol (Item 13). Allow sufficient time between layers of neoprene top coating for the shiny wet appearance to disappear. Under normal drying conditions, 20 to 30 minutes drying time between coats should be satisfactory. Keep accelerated material container tightly closed when not in use.

Spray Application of Topcoat

174 Allow sufficient time for the final primer coat to dry (30 to 40 minutes) before spraying on the first neoprene topcoat. Use long even passes, spraying from wet to dry surface. Two or three fast passes per coat are preferable to one slow pass since they give a slightly greater coat thickness with less danger of running or sagging. Pinholes are caused by water or oil entering the spray gun, or by improper atomization. Any trapped air can be released by spraying the surface gently with a mist of thinner mixture consisting of one part, by volume, toluol (Item 13) and one part, by volume, methyl ethyl ketone (Item 9). Allow only enough time between coats for the shiny wet appearance to disappear. Under normal drying conditions, 10 to 15 minutes drying time between coats should be satisfactory. Keep accelerated material container tightly closed when not in use.

Thickness of Coating

175 The number of layers of primer and topcoat vary with the viscosity of the material However, the number of coats is not as important as obtaining the correct thickness. Use the number of coats required to obtain a total thickness of 0.007 to 0.009 inch, exclusive of primer. The complete coat (topcoat plus primer) should be 0.008 to 0.011 inch and should air-dry tack-free to the touch in not more than a total time of six hours, including time between coats. Check coating thickness at edge of the part or on a separate piece of sheet

metal which has been given an identical coating to that on the part.

CAUTION

Since the materials used in the foregoing procedure are inflammable and toxic in sufficient concentration, the standard precautions used with such materials, such as fire prevention and adequate ventilation, must be exercised.

Edge Finishing

176 The parts of the metal mounting rim are not to be coated. Where a coating is to extend to a mounting rim, the coating should be terminated under the rim, see Figure 22. If that part of the laminate fitting under the mounting rim is offset to make a smooth outer surface, the laminate at the edge of the rim should be rounded off to a radius of curvature of at least 1/8 inch. Sharper outside radius of plastic parts should be avoided, since erosion resistance falls off rapidly with a decrease in radius of curvature. Where a coating is to be terminated elsewhere than at a mounting rim, the edge of the coating should be feathered to a smooth tapered junction following the curve, by use of abrasive paper (Item 27).

Curing Cycle and Colour of Finished Coating

177 The finished part should cure for at least 72 hours at room temperature. In an emergency, the coated article may be put into service as soon as the neoprene coating is past the tacky stage, or forced drying may be employed. In this case, two or three hours at 150° F will cure the material sufficiently to permit installation. Air-drying neoprene materials are light sensitive and may be expected to darken to nearly black with age. No significance is to be attached to the fact that some batches or areas will darken before others. Subsequent application of paint over the neoprene coating is not to be made.

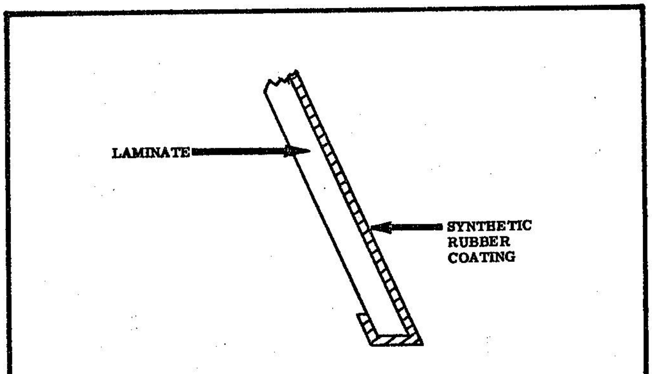

Figure 22 Rubber Coating Methods

Repair of Neoprene Coating

178 When the cured coating is blistered or a localized failure of the coating occurs in service, repair may be made as follows:

(a) Trim loose coating, sand open area of laminate to a smooth surface using abrasive paper (Item 27), and wipe free of dust.

(b) Apply primer (Item 24) and catalyzed neoprene topcoat (Item 57). Cure as described in Paragraph 177, preceding.

NOTE

Avoid applying coating beyond edge of area being repaired since adhesion to existing coating is only fair. Avoid build-up beyond that specified in Paragraph 175, preceding, particularly on radomes, since the electrical properties may be affected. Should complete replacement of the neoprene coat be necessary, the old coat can be removed by following instructions in Paragraph 168, preceding.

Use of Other Neoprene Compounds

179 Do not use neoprene coatings other than that specified (Item 57) without prior approval of engineering authority. Use of coating and catalyst is described in the manufacturer's instructions provided with each container.

APPROVED MATERIALS

General

180 For table showing item numbers, materials, specifications and manufacturers, see Figure 23.

Approved Materials

181 Materials listed in Figure 24 are approved materials but are not specifically mentioned in the text. The supplier's instructions with regards to temperature, mixing, shelf life and application must be complied with.

Item No	Material	RCAF Ref	Specification	Manufacturer
1	Compound, Coating	33G/52	MIL-C-6799A	
2	Kerosene	34A/217	3-GP-3	
3	Soap, Detergent powder	33CM/16	2-GP-103	
4	Cleaner, Anti-static, Anstac M, Soap and liquid	33C/675		Chemical Development Corp., Montreal.
5	Hexane			Technical Grade
6	Acetone	33C/417	15-GP-50	
7	Talc	33C/11	MAT-2-1	
8	Polish, Liquid	33C/652	MIL-W-18723	
9	Methyl Ethyl Ketone	33C/520	15-GP-52	
10	Benzoyl Peroxide (50-50 solution with Tricresyl phosphate)			Lucidol Corp., Buffalo, N.Y.
11	Petrolatum	34A/165	3-GP-665	
12	Tape, Adhesive, Pressure sensitive	33G/5 or 6	43-GP-3A Grade B Type 2	
13	Toluene (Toluol)	33A/467	TT-T-548A	
14	Methylene Dichloride			Technical Grade
15	Ethylene Dichloride	33C/282	C28-23A	
16	Trichlorethylene	33C/163	MIL-T-7003	
17	Oil, General purpose	34A/124	3-GP-335a	
18	Wire, Soft		AN995	
19	Glycerine	14B/43		
20	Cloth, Emery, Durex	29/1833-1840		
21	Adhesive Resin Alkyd	33G/11	G-1276	
22	Lacquer, Clear		MIL-L-7178	

Figure 23 (Sheet 1 of 4) Table of Material Specifications

Item No.	Material	RCAF Ref.	Specification	Manufacturer
23	Soap, Acetate			Technical Grade
24	Adhesive, Precoat	33G/23		
25	Adhesive, Filler	33G/112		
26	Adhesive, Cement, Acrylic resin	33G/10	MIL-C-8576	
27	Paper, Abrasive, Waterproof	29/1869 etc.	Fed. PP 101-1 (US)	
28	Compound, Buffing, Tripoli, Grade 17 (cake), Acrylic plastic	29/1843		Can. Hanson and Van Winkle, Toronto.
29	Tallow, Buffing (rouge)	29/1879		McAlear Manufacturing Co., Chicago.
30	Cream, Hand	33C/759	BD5	Stanley Chemicals Ltd "Kerodex" brand
31	C.I.L. No. 7			Canadian Industries Ltd., Montreal.
32	Plastic Polish	7930-21-805-0969	MIL-C-18767	
33	Abrasive, Fine, Type A5175			Linde Air Products Co., New York City, N.Y. U.S.A.
34	Parting Agent, Grease type, Soyab No. 300 Lecithin, Bleached and Refined			Glidden Paint Co., Toronto.
35	Parting Agent, Grease type, Aquarex L			E.I. Du Pont de Nemours Inc., Wilmington, Del. U.S.A.
36	Parting Agent, Silicone type, DC-7			Dow-Corning Corp., Midland, Mich. U.S.A.
37	Parting Agent, Silicone Resin type, Pan-Glaze			Dow-Corning Corp., Midland, Mich. U.S.A.

Figure 23 (Sheet 2 of 4) (Issue 1) Table of Material Specifications

Item No.	Material	RCAF Ref.	Specification	Manufacturer
38	Cloth, Fiberglas, Impregnated	32E/		Owens-Corning Fiberglas Corp., Toledo, Ohio. U.S.A.
39	Mat, Fiberglas, T-34 .050 inch thickness			Owens-Corning Fiberglas Corp., Toledo, Ohio. U.S.A.
40	Cellophane			Commercial Grade
41	Resin, Styrene Polyester, Selectron No. 5041		MIL-R-7575	Pittsburgh Plate Glass Co., Pittsburg, Pa. U.S.A.
42	Zoluol S-9400X			W.P. Fuller & Co., Los Angeles. U.S.A.
43	Fibres, Milled, Fiberglas, 1/8 in. length			Owens-Corning Fiberglas Corp., Toledo, Ohio. U.S.A.
44	Styrene N-99			Dow Chemical Co., West Toronto.
45	Polyvinyl alcohol, Sheet .003 inch			Resistoflex Corp., Belleville 9, N.J. U.S.A.
46	Compound, Sealing, RL-3700			W.P. Fuller & Co., Los Angeles, U.S.A.
47	Dye, Reichold No. 9403, Black			Reichold Chemicals Co., White Plains, N.Y. U.S.A.
48	Dye, Reichold No. 9406, Red			Reichold Chemicals Co., White Plains, N.Y. U.S.A.
49	Primer, Zinc Chromate, Toluene thinner	33A/462	MIL-P-6889A	
50	Paint, Tygon, TP-21			U.S. Stoneware Corp., Akron 9, Ohio, U.S.A.
51	Wax, Emulsion			S.C. Johnson & Son Inc., Brantford, Ontario
52	Plastiflex			Cal Resin Corp., Los Angeles. U.S.A.

Figure 23 (Sheet 3 of 4) Table of Material Specifications

Item No.	Material	RCAF Ref.	Specification	Manufacturer
53	Superlastic P-1500			P.R.Sales Co.
54	Cement, Vinyl Resin			Bakelite Co., Belleville, Ontario.
55	Vinylseal			Bakelite Co., Belleville, Ontario.
56	Resin and Catalyst, Casting, Phenolic plastics			Bakelite Co., Belleville, Ontario.
57	Coating, Adhesive, Neoprene	33G/110	1801C	
58	Oil, Castor		AN-JJ-O-316	
59	Alcohol, Ethyl, Denatured	34A/213	MIL-A-6091A	
60	Paint, Conductive, 3053	33A/381		Canadian General Electric, Toronto, Ontario.
61	Paper, Abrasive	29/1872		
62, 63, 64 Deleted				
65	Lucite			E. I. Du Pont de Nemours Co. Inc., Wilmington, Del.
66	Plexiglass			Rohm & Haas Co.
67	Perspex			Imperial Chemicals Ltd., England.
68	Fibestos			Monsanto Chemical Co.
69	Lumarith			Celanese Celluloid Corp.
70	Plastacele			E. I. Du Pont de Nemours Co. Inc., Wilmington, Del.
71	Nixonite			St. Nixon Nitration Works, Nixon, N. J. U.S.A.
72	Aliphatic Naptha Solvent	33C/653	TT-N-95	

Figure 23 (Sheet 4 of 4) Table of Material Specifications

BUFFING COMPOUNDS	MANUFACTURER
Compound No.771	Matchless Metal Polish Company, Glen Ridge, N.J., U.S.A.
Learock No. 832	Lea Manufacturing Company, Waterbury, Conn., U.S.A.
Compound 4M-30 (Grey) Compound 6M-157 (White)	Hanson-Van Winkle-Munning Co., Matawan, N.J., U.S.A.
Triple A Buffing Compound	McAleer Manufacturing Company, Rochester, Mich., U.S.A.
Plascor No.705 (White) Plascor No.1403 (White)	United Laboratories, Linden, N.J., U.S.A.
Newcomb No.7	Newcomb Products Company, Cleveland, Ohio, U.S.A.
ASHING COMPOUNDS	**MANUFACTURER**
Pumice, Grade FF or FFF	James H. Rhodes, Chicago, Illinois, U.S.A.
Du Pont Rubbing Compound No.45 (rough) Du Pont Rubbing Compound No.12 (fine)	E.I. Du Pont de Nemours Co.Inc., Wilmington,Del.,U.S.A.
Learock No. 765	Lea Manufacturing Company, Waterbury, Conn., U.S.A.
POLISHES	**MANUFACTURER**
O'Cedar of Canada M37 Plastic	O'Cedar of Canada Limited, Toronto 3, Ontario.
Parko Gloss Polish and Cleaner No. 4B-L	Park Chemical Company, Detroit, Mich., U.S.A.
PL-464-A2	Minnesota Mining & Manufacturing Company, Detroit, Mich., U.S.A.
Ken-Glo	Ken-nite Company, Detroit, Mich., U.S.A.
Lincoln M-3828 Liquid Cleaner	Lincoln Motor Car Division, Ford Motor Company, Dearborn, Mich., U.S.A.
Turco L-567 Cleaner	Turco Products Inc., Los Angeles, Cal., U.S.A.

Figure 24 (Sheet 1 of 3) Table of Approved Materials

POLISHES	MANUFACTURER
WILCO Scratch Removing Compound Nos.55 & 35	WILCO Company, Los Angeles, Cal., U.S.A.
Simoniz Liquid Cleaner	Simoniz Company, Chicago, Illinois, U.S.A.
McAleer Plexi-Glo Cleaner and Polish	McAleer Manufacturing Company, Rochester, Mich., U.S.A.
Aerogroom Cleaner	The Autogroom Company, Inc., Woodside, Long Island, N.Y., U.S.A.
Crystal X Cleaner and Glaze	Crosdale & deAngelis Upper Derby, Pa., U.S.A.
Triple Life Cleaner and Glaze	Franklin Research Company, Philadelphia, Pa., U.S.A.
Noxon Cleaner Polish	Noxon Inc., Ozone Park, N.Y., U.S.A.
Puritan's Plasti-Kleen	Puritan Chemical Company, Atlanta, Ga., U.S.A.
CLEANERS	**MANUFACTURER**
Sinec. No.2 Mark 2 Cleaner	O'Cedar Limited, Slough, England.
Sno-Flake No.223 Cleaner	Snow Flake Products Company, Detroit, Mich., U.S.A.
Franklin High Gloss Cleaner	Franklin Research Company, Philadelphia, Pa., U.S.A.
WAXES	**MANUFACTURER**
Johnson's Industrial Wax No. 102-C	S.C.Johson & Son Inc., Racine, Wisc., U.S.A.
Parko Eze-Wax	Park Chemical Company, Detroit, Mich., U.S.A.
Franklin Plexiglas Wax	Franklin Research Company Philadelphia, Pa., U.S.A.
Simoniz Wax	Simoniz Company, Chicago, Illinois, U.S.A.
3M Auto Wax	Minnesota Mining & Mfg.Co., St.Paul, Minn.U.S.A.

Figure 24 (Sheet 2 of 3) Table of Approved Materials

WAXES	MANUFACTURER
Permaseal	Commercial Chemical Company, Charlestown, Boston, Mass., U.S.A.
MASKING TAPES	**MANUFACTURER**
Scotch MFA (Flat Back Paper) or (Crepe Paper)	Minnesota Mining & Mfg. Co., St. Paul, Minn., U.S.A.
Permacel XB-95	Industrial Tape Corporation, New Brunswick, N.J., U.S.A.
GASKET MATERIALS	**MANUFACTURER**
Neoprene M-8831	U. S. Rubber Company, Detroit, Mich., U.S.A.
Neoprene Dome Gaskets	Vulcanized Rubber Company, Morrisville, Pa., U.S.A.
Fairprene No. 5545	E.I. Du Pont de Nemours & Co., Fairfield, Conn., U.S.A.
Grade GR-1 Synthetic No. 624 GN Synthetic A-086	B. F. Goodrich Company, Akron, Ohio, U.S.A.
Anchorite Buna S No. 200	Anchor Packing Company, Philadelphia, Pa., U.S.A.
Paraplex X-100, Stock JK-160 Paraplex X-100, Stock JK-161	Resinous Products & Chemical Co., Philadelphia, Pa., U.S.A.
Freeze-resisting Neoprene	Peerless-Key Imperial Company, Newark, NY., U.S.A.
Synthetic Glass Sealer No. 23212	Presstite Engineering Company, St. Louis, Mo., U.S.A.
MASTIC MATERIALS	**MANUFACTURER**
3-M Mastic Compound EC-612 3-M Elastic Cement EC-373	Minnesota Mining & Mfg. Company, St. Paul, Minn., U.S.A.
Synthetic Glass Sealer No. 23212	Presstite Engineering Company, St. Louis, Mo., U.S.A.
RL-3774 Cockpit Enclosure Compound	W. P. Fuller & Company, Los Angeles, Cal., U.S.A.
Matiseal	Pittsburgh Plate Glass Company, Pittsburgh, Pa., U.S.A.
GREASES	**MANUFACTURER**
Cazar No. 2 Light Grade No. 3886 Die Lubricant	Esso Marketers and Associates New York 4, N.Y., U.S.A.
Gulf Precision Grease No. 1	Gulf Refining Company, Pittsburgh, Pa., U.S.A.

Figure 24 (Sheet 3 of 3) Table of Approved Materials