CHAPTER 4

AIRCRAFT PAINTING AND FINISHING

GENERAL

Metal- or wood-covered aircraft frequently are painted to protect their surfaces from deterioration and to provide a desirable finish. Many types of finishes are used on aircraft structures. Wood structures may be varnished, whereas aluminum and steel frequently are protected and preserved by applying paint. The term "paint" is used in a general sense and includes primers, enamels, lacquers, and epoxies.

Aircraft finishes can be separated into three general classes: (1) Protective, (2) appearance, and (3) decorative. Internal and unexposed parts are finished to protect them from deterioration. All exposed parts and surfaces are finished to provide protection and to present a pleasing appearance. Decorative finishing includes trim striping, the painting of emblems, the application of decals, and identification numbers and letters.

FINISHING MATERIALS

A wide variety of materials are used in aircraft finishing. Some of the more common materials and their uses are described in the following paragraphs.

Acetone

Acetone is a fast-evaporating dope solvent that is suitable for removing grease from fabric prior to doping, for cleaning spray paint guns, and as an ingredient in paint and varnish removers. It should not be used as a thinner in dope since its rapid drying action causes the doped area to cool and collect moisture. The absorbed moisture prevents uniform drying and results in blushing.

Alcohol

Butyl alcohol is a slow-drying solvent that can be mixed with dope to retard drying of the dope film on humid days, thus preventing blushing. Generally, 5 to 10% of butyl alcohol is sufficient for this purpose.

Butyl alcohol and ethyl alcohol are used together as a mixture to dilute wash coat primer as necessary for spray application. The percentage of butyl alcohol used will depend on the temperature and humidity. Tne butyl alcohol retards the evaporation rate. In some cases a 25% butyl/75% ethyl alcohol mixture may be satisfactory; in others, a 50/50 mixture may be required.

Denatured alcohol is used for thinning shellac to spray gun consistency, and as a constituent of paint and varnish remover.

Isopropyl alcohol is used as a diluent in the formulation of oxygen system cleaning solutions. It is also used in preparing nonionic detergent mixtures.

Benzene

Benzene is used for cleaning equipment in which enamel, paint, or varnish has been used. It is also used as a constituent of paint and varnish remover.

Thinner

Dopes, enamels, paints, etc., are thinned for use in spray guns, for more efficient brushing consistency, and for reducing the thickness of coats. The correct thinner must be used with a specific finishing material.

Several materials required for thinning specific paints and lacquers are also available for solvent cleaning, but they must be used with care. Most of these materials have very low flash points and, in addition, will damage existing paint finishes. Some of the more common paint thinners are briefly discussed in the following paragraphs.

Acrylic Nitrocellulose Lacquer Thinner

Acrylic nitrocellulose lacquer thinner may be effectively used to wipe small areas prior to paint touchup. It will soften the edges of the base paint film, which in turn will assure improved adhesion of the touchup coating. However, the thinner contains toluene and ketones and should never be used indiscriminately for cleaning painted surfaces.

Cellulose Nitrate Dope and Lacquer Thinner

This thinner is both explosive and toxic as well as damaging to most paint finishes. It may be used

for hand removal of lacquer or primer overspray. It is the approved thinner for nitrocellulose lacquers and is a mixture of ketones, alcohols, and hydrocarbons.

Volatile Mineral Spirits

This material is very similar to dry-cleaning solvent but evaporates somewhat faster and leaves less residue after evaporation. It can be effectively used in wiping stripped metal surfaces just before the re-application of paint finishes. It is also used as a carrier for solvent-emulsion compounds in general cleaning.

Toluene

Toluene (toluol) may be used as a paint remover in softening fluorescent finish clear topcoat sealing materials. It is also an acceptable thinner for zinc chromate primer.

Turpentine

Turpentine is used as a thinner and quick-drier for varnishes, enamels, and other oil-base paints. Turpentine is a solvent for these types of materials and can be used to remove paint spots and to clean paint brushes.

Dope

Aircraft dope is essentially a colloidal solution of cellulose acetate or nitrate, combined with sufficient plasticizers to produce a smooth, flexible, homogeneous film. The dope imparts to the fabric cover additional qualities of increased tensile strength, airtightness, weather-proofing, and tautness of the fabric cover. Dope must possess maximum durability, flexibility, blush resistance, and adhesion, while adding the least additional weight. Each coating of dope applied over undercoats must penetrate and soften them, and build up a smooth, united surface without lessening the degree of fabric tautness.

The six essential constituents of dope are:

(1) Film-base compounds, which are either cellulose acetate or cellulose nitrate.

(2) Plasticizers, such as camphor oil and castor oil, used to produce a durable, flexible film.

(3) Solvents, used to dissolve the cellulose-base materials.

(4) Diluents, used for thinning the mixture. Toxic diluents, such as benzol, are never used.

(5) Slow dryers, such as butyl alcohol, used to prevent too rapid drying, which tends to over-cool the surface, thus causing condensation of moisture and resultant blushing.

(6) Colors or pigments, which are finely ground particles of inorganic material added to clear dope to give a desired color.

The three types of dope used for aircraft finishes are: (1) Clear, (2) semi-pigmented, and (3) pigmented. Their characteristics and uses are:

(1) There are two clear nitrate dopes. One is used to produce a gloss finish over semi-pigmented finishes, and as a vehicle for bronze/aluminum doped finishes. The other is a specially prepared, quick-drying material to be used only for patching.

(2) Semi-pigmented nitrate dope contains a limited quantity of pigment. It is used for finishing fabric-covered surfaces.

(3) Pigmented nitrate dope contains a greater quantity of pigment than does semi-pigmented dope, and is normally used for code marking and finishing insignia. One or two coats applied over semi-pigmented dope will produce the desired color effect.

Dope should not be applied over paint or enamel because it tends to remove such material.

Nitrocellulose Lacquer

Nitrocellulose lacquers are available in both glossy and flat finishes. They are also available in either clear or pigmented form. These materials can be applied over either old type zinc chromate or the newer modified zinc chromate primer. The lacquer finish is applied in two coats; a mist coat first, with a full, wet cross coat applied within 20 to 30 min. afterward. The lacquer finishes should be thinned as necessary, using cellulose nitrate dope and lacquer thinner. Clear lacquer may be substituted for spar varnish over doped fabric and is also used with bronze/aluminum powder to produce aluminized lacquer. Clear lacquer should never be applied over paint, enamel, or varnish because it tends to remove such material.

Acrylic Nitrocellulose Lacquer

This is the most common topcoat in use today, available either in flat or glossy finish. Both types of material are required in refinishing conventional aircraft. Anti-glare areas generally require the use of flat finishes. The remaining surfaces usually are finished with glossy materials to reduce

heat absorption. The base materials should be thinned as necessary for spray application with acrylic nitrocellulose thinner.

Paint Drier

Paint drier is added to paint when improved drying properties are desired. Excessive drier in paint will result in a brittle film, causing cracking and peeling.

Linseed Oil

Linseed oil is used to reduce semi-paste colors, such as dull black stenciling paint and insignia colors, to brushing consistency. It is also used as a protective coating on the interior of metal tubing.

Zinc Chromate Primer

Zinc chromate primer is applied to metallic surfaces, before the application of enamel or lacquer, as a corrosion-resistant covering and as a base for protective topcoats. Older type zinc chromate primer is distinguishable by its bright yellow color compared to the green cast of the modified primers currently used. The old type primer will adhere well to bare metal. It is still specified as an acceptable coating for internal surfaces, and it forms a part of the old type nitrocellulose system finishes. It can be applied by brush or spray and should be thinned for spraying as necessary with toluene. When this material is to be applied by brush, it should be thinned to brushing consistency with xylene to give better wet-edge retention. It dries adequately for overcoating within an hour. Zinc chromate primer is satisfactory for use under oil-base enamels or nitrocellulose lacquers. It is also an excellent dope proof paint.

Standard Wash Primer

Some paint finishes in general use include a standard wash primer undercoat, also termed a metal pre-treatment coating compound. It is a two-part material consisting of resin and alcoholic phosphoric acid, which is added just prior to application. The two components should be mixed very slowly and carefully and allowed to stand at least 30 min. before use. The primer should be used within a total time of 4 hrs. Any necessary thinning is done with a 25/75 to 50/50 mixture of butyl alcohol and ethyl alcohol, respectively. The percentage of butyl alcohol used will be determined by the evaporation rate. The percentage of butyl alcohol should be kept to the minimum possible under local temperature and humidity conditions. It is particularly important that the ratio of acid to resin in the wash primer be maintained. Any decrease in acid will result in poor coat formation. An excess of acid will cause serious brittleness.

Acrylic Cellulose Nitrate Modified Primer

The lacquer primer currently applied over the wash coat base is a modified alkyd-type zinc chromate developed for its adherence to the wash primer. It does not adhere well to bare metal, but works effectively as a sandwich between the wash coat primer and the acrylic nitrocellulose topcoating. It can be thinned as necessary for spray application with cellulose nitrate thinner. In areas where the relative humidity is high, it may be more desirable to use acrylic nitrocellulose thinner. It should be topcoated within 30 to 45 min. after its application for best results.

Under no condition should it dry more than an hour and a half before finish coats of acrylic lacquer are applied. If primer coats are exposed to atmospheric conditions for longer than this maximum drying period, a re-application of both the wash primer and modified primer is necessary, followed immediately by the application of the acrylic lacquer topcoat. Otherwise, complete stripping of the coatings and refinishing is required.

In general, freshly applied coatings can be removed with either acrylic lacquer thinner or methyl ethyl ketone. However, once the coat is dry, paint stripper is required for complete removal of the coating.

The finish coatings are usually applied in two coats over the modified zinc chromate primer; the first a light mist coat, and the second a wet cross-coat with 20 to 30 min. drying time allowed between the two coatings. On amphibians or seaplanes, where maximum protection is required, the finish is increased to two coats of primer and three coats of lacquer. Once the paint finish has set, paint stripper is necessary for its removal.

Enamel

Enamels are special types of varnish having either an oil base or nitrocellulose base as the solvent. Enamel finishes are generally glossy, although flat enamel finishes are available. Enameled surfaces are hard, resist scratching and the action of oils or water, and certain grades resist high temperatures. Enamel can be applied by spraying or brushing and is suitable for either interior or exterior application.

Varnish

Spar varnish is used for finishing interior or exterior wood surfaces. It produces a transparent, durable coating for use where high gloss and hardness are not the principal requirements.

Asphalt varnish is a black coating used for the protection of surfaces around lead acid batteries, and where acid or water are present.

Oil Stain

Oil stain is used to stain wood for decorative purposes. It is available in light and dark shades, simulating mahogany, oak, walnut, or other wood.

Color

Various coloring materials are used for special applications, such as insignia and signs. These colors are obtainable as pastes (powder ground in oil) to be mixed with the proper solvent.

Paint

Paint is a mechanical mixture of a vehicle and a pigment. The vehicle is a liquid that cements the pigment together and strengthens it after drying. The pigment gives solidity, color, and hardness to the paint. Among the commonly used pigments are: iron oxide, zinc chromate, titanium oxide, iron blue lead chromate, carbon black, and chrome green.

The vehicles used for paint can be divided into two general classes: (1) Solidifying oils, and (2) volatile oils. The solidifying oils dry and become tough leathery solids upon exposure to the air. China wood oil, tung oil, or linseed oil are the most common solidifying oils used in aircraft paint. Volatile oils, or spirits are those which evaporate when exposed. These oils are used to dilute paint to the proper consistency and to dissolve varnish resins. The most common volatile vehicles are: Alcohol, turpentine, benzine, toluene, ethyl acetate, and butyl acetate. Paints, varnishes, and enamels are usually composed of a pigment and a mixture of both solidifying and volatile oils. Lacquer, which is noted for its rapid drying, is composed of pigments, resins, and volatile oils.

Paint Remover

General-purpose paint and enamel remover is a good, nonflammable, water-rinsable paint remover. It is used for stripping lacquer and enamel coatings from metal surfaces, and it consists of active solvents, amines, ammonia, thinners, emulsifiers, a stable chlorinated solvent, and a cresol mixture that can be applied by fluid spray or brush. The cresol additive swells the resins in the paint coatings, while the chlorinated constituents penetrate through and lift the softened resins by evaporation. This material is water-rinsable after application and can be applied several times on stubborn coatings. It should never be permitted to contact acrylic windows, plastic surfaces, or rubber products. This material should be stored indoors or in an area well protected against weather conditions. Goggle-type eyeglasses and protective clothing should be worn when using it. Paint stripping procedures, discussed later in this chapter, are the same for touchup as for a complete repainting.

Epoxy Coating Remover

Strong acid solutions or alkaline tank stripping agents are the most effective materials for removal of certain well-cured epoxies at the present time, but these stripping agents may not be used on aluminimum surfaces. General-purpose paint and enamel remover can remove most epoxy finishes. Several applications or extended dwell times may be necessary for effective results.

Fluorescent Paint Remover

Fluorescent paint remover, water-rinsable type, is a paint stripper designed to remove fluorescent paint finishes from exterior surfaces of aircraft. This material is used for stripping the high-visibility coatings without affecting the permanent acrylic or cellulose nitrate coatings underneath. A permanent base coating of cellulose nitrate lacquer may be softened by this material if allowed to remain too long.

Work with paint remover should be done out of doors in shaded areas whenever practicable, or with adequate ventilation when used indoors. Rubber, plastic, and acrylic surfaces require adequate masking. Goggle type glasses, rubber gloves, aprons, and boots should be worn during any extensive application of this stripper. Hand stripping of small areas requires no special precautions.

Masking Material

Masks are used to exclude areas to which dope or lacquer, etc., is not to be applied. Masks are made of thin metal, fiberboard, paper, or masking tape. Metal and fiberboard masks are usually held in place by weights, and paper masks by masking tape.

Liquid spray shield is a solution applied to protect areas, thus serving as a liquid mask. The liquid shield and the finish deposited upon it are easily washed off with water when the design is dry.

Storage of Finishing Material

Dope, paint, enamel, and other finishing material should be stored in a dry place away from direct sunlight and heat. Each container is assigned a code and color number identifying the material contained therein.

Stored paint, enamel, and other finishing material that has separated from the vehicle must be mixed to regain usefulness. If the pigment is caked, pour most of the liquid into another container and mix the caked pigment until it is free of lumps. A broad paddle or an agitator may be used for this purpose. When the pigment is smooth and free from lumps, the liquid is added slowly and the stirring is continued to ensure complete mixing.

PAINT TOUCHUP

A good intact paint finish is one of the most effective barriers available for placement between metal surfaces and corrosive media. Touching up the existing paint finish and keeping it in good condition will eliminate most general corrosion problems.

When touching up paint, confine paint coverage to the smallest area possible. Acrylic primer or lacquer may be used, but adhesion is usually poor. Epoxy coatings, as well as the older type of zinc chromate primer, may be used for touchup on bare metal.

When a paint surface has deteriorated badly, it is best to strip and repaint the entire panel rather than attempt to touchup the area. Touchup materials should be the same as the original finish. Surfaces to be painted should be thoroughly cleaned and free from grease, oil, or moisture. Where conditions are not suitable for painting, preservatives may be used as temporary coatings until good painting conditions are restored. Paint finishes should not be too thick since thickness promotes cracking in service.

Much of the effectiveness of a paint finish and its adherence depends on the careful preparation of the surface prior to touchup and repair. It is imperative that surfaces be clean and that all soils, lubricants, or preservatives be removed.

Cleaning procedures for paint touchup are much the same as the procedures for cleaning before inspection. Many types of cleaning compounds are available. Chapter 6, "Hardware, Materials, and Processes," in the Airframe and Powerplant Mechanics General Handbook, AC 65-9A, describes many of these compounds.

IDENTIFICATION OF PAINT FINISHES

Existing finishes on current aircraft may be any one of several types, combinations of two or more types, or combinations of general finishes with special proprietary coatings.

Any of the finishes may be present at any given time, and repairs may have been made using materials from several different types. Some detailed information for the identification of each finish is necessary to assure adequate repair procedures. A simple test is valuable in confirming the nature of the coatings present. The following tests will aid in paint finish identification.

Apply a coating of engine oil (Military Specification MIL-L-7808, or equal) to a small area of the surface to be checked. Old nitrocellulose finishes will soften within a period of a few minutes. Acrylic and epoxy finishes will show no effects.

If not identified, next wipe down a small area of the surface in question with a rag wet with MEK (methyl ethyl ketone). MEK will pick up the pigment from an acrylic finish, but will have no effect on an epoxy coating. Wipe the surface; do not rub. Heavy rubbing will pick up even epoxy pigment from coatings that are not thoroughly cured. Do not use MEK on nitrocellulose finishes. No test of fluorescent finishes should be necessary other than visual examination.

PAINT REMOVAL

One of the most important jobs is the stripping of old paint finishes preparatory to applying a new surface cover coat. An original finish may have to be removed in any of the following cases:

(1) If a panel or other area on the aircraft has badly deteriorated paint surfaces.

(2) If repair materials are not compatible with the existing finish, thereby precluding touchup repair.

(3) If corrosion is evident or suspected under an apparently good paint coating.

The area to be stripped must be cleaned of grease, oil, dirt, or preservatives to assure maximum efficiency of the stripping compound. The selection of the type of cleaning materials to be used will depend on the nature of the matter to be removed. Dry-cleaning solvent may be used for removing oil, grease, and soft preservative compounds. For heavy-duty removal of thick or dried preservatives, other compounds of the solvent-emulsion type are available.

In general, paint stripping materials are toxic and must be used with care. The use of a general-purpose, water-rinsable stripper is recommended for most field applications. Wherever practicable, paint removal from any large area should be done out of doors and preferably in shaded areas. If indoor removal is necessary, adequate ventilation must be assured. Synthetic rubber surfaces, including aircraft tires, fabric, and acrylics, must be thoroughly protected against possible contact with paint remover. Care must be taken when using paint remover around gas- or water-tight seam sealants, since this material will soften and destroy the integrity of the sealants.

Mask any opening that would permit stripper to get into aircraft interiors or critical cavities. Paint stripper is toxic and contains ingredients harmful to both skin and eyes. Rubber gloves, aprons of acid repellent material, and goggle type eyeglasses should be worn if any extensive paint removal is to be done. A general stripping procedure is discussed in the following paragraphs.

No prepared paint remover should be used on aircraft fabric or be allowed to come in contact with any fiberglass reinforced parts such as radomes, radio antenna, or any component such as fiberglass reinforced wheel pants or wing tips. The active agents will attack and soften the binder in these parts.

CAUTION: Any time you use a paint stripper, always wear protective goggles and rubber gloves. If any stripper is splashed on your skin, wash it off immediately with water; and if any comes in contact with your eyes, flood them repeatedly with water and CALL A PHYSICIAN.

Brush the entire area to be stripped with a cover of stripper to a depth of 1/32 in. to 1/16 in. Any paint brush makes a satisfactory applicator, except that the bristles will be loosened by the effect of paint remover on the binder. The brush should not be used for other purposes after being exposed to paint remover.

After applying the stripping compound, it may be covered with an inexpensive polyethane drop cloth. Covering prevents rapid evaporation of the solvents and facilitates penetration of the paint film.

Allow the stripper to remain on the surface for a sufficient length of time to wrinkle and lift the paint. This may vary from 10 min. to several hours, depending on the temperature, humidity, and the condition of the paint coat being removed. Scrub the paint-remover-wet surface with a bristle brush saturated with paint remover to further loosen any finish that may still be adhering to the metal.

Re-apply the stripper as necessary in areas that remain tight or where the material has dried, and repeat the above process. Nonmetallic scrapers may be used to assist in removing persistent paint finishes.

Remove the loosened paint and residual stripper by washing and scrubbing the surface with water. If water spray is available, use a low-to-medium pressure stream of water directly on the scrubbing broom. If steam cleaning equipment is available and the area is sufficiently large, this equipment, together with a solution of steam cleaning compound, may be used for cleaning. On small areas, any method may be used that will assure complete rinsing of the cleaned area.

RESTORATION OF PAINT FINISHES

The primary objective of any paint finish is the protection of exposed surfaces against deterioration. Other reasons for particular paint schemes are:

(1) The reduction of glare by nonspecular coatings.
(2) The use of white or light-colored, high-gloss finishes to reduce heat absorption.
(3) High visibility requirements.
(4) Identification markings.

All of these are of secondary importance to the protection offered by a paint finish in good condition. A faded or stained, but well-bonded paint finish is better than a fresh touchup treatment improperly applied over dirt, corrosion products, or other contaminants.

NITROCELLULOSE LACQUER FINISHES

Nitrocellulose finishes ordinarily consist of a wash primer coat and a coat of zinc chromate primer. A nitrocellulose lacquer topcoat is applied over the prime coats.

Replacement of Existing Finish

When an existing nitrocellulose finish is extensively deteriorated, the entire aircraft may have to be stripped of paint and a complete new paint finish applied. When such damage is confined to one or more panels, the stripping and application of the new finish may be limited to such areas by masking to the nearest seam line.

The complete nitrocellulose lacquer finish is begun with the application of standard wash primer

undercoat. The wash primer should be applied in a thin coat, with the texture of the metal still visible through the coating. If absorption of water results and the coat shows evidence of blushing, successive coatings will not adhere. The area should be re-sprayed with butyl alcohol to re-deposit the wash primer. If blushing is still evident, it should be stripped and re-sprayed. After 20 min. drying time, adherence of the film should be checked with a thumbnail test. A moderate thumbnail scratch should not remove the prime coat.

The wash primer must be applied over a pre-cleaned surface that has been wiped with a volatile solvent such as MEK, naphtha, or paint and lacquer thinners just before paint application. Evaporation of the solvent should be complete before the prime coat is added. Better results will be obtained if the solvent wipe-down is followed by a detergent wash.

Lacquer primer is a modified alkyd-type zinc chromate developed for its adherence to the wash primer. Lacquer primer does not adhere well to bare metal, but works effectively as a sandwich between the wash coat primer and the nitrocellulose topcoating, and can be thinned as necessary for spray application with cellulose nitrate thinner. In areas where the relative humidity is high, it may be more desirable to use acrylic nitrocellulose thinner. For best results, lacquer primer should be topcoated within 30 to 45 min. after its application.

The old type primer will adhere well to bare metal and is still specified as an acceptable coating for internal surfaces as well as a part of the nitrocellulose finishes. Apply by brush or spray; thin for spraying with toluene. When this material is to be applied by brush, thin to brushing consistency with xylene to give better wet-edge retention. Overcoating may be applied within an hour.

Nitrocellulose lacquers are available in both glossy and nonspecular finishes. The lacquer finish is applied in two coats: a mist coat first, with a full wet crosscoat applied within 20 to 30 min. The lacquer should be thinned as necessary, using cellulose nitrate dope and lacquer thinner.

Cellulose nitrate dope and lacquer thinner (Federal Specification TT–T–266) is both explosive and toxic, as well as damaging to most paint finishes. Dope and lacquer thinner may be used for hand removal of lacquer or primer overspray, is an approved thinner for nitrocellulose lacquers, and is a mixture of ketones, alcohols, and hydrocarbons.

The surface areas of damaged paint must be clean prior to touchup repair, and all soils, lubricants and preservatives must be removed. Cleaning procedures for paint touchup are much the same as those for paint removal.

If the old finish is not to be completely stripped, the existing surface must be prepared to receive the new cover coat after cleaning. If good adhesion is to be obtained, all loose paint should be brushed off, giving particular attention to overpaint usually found in wheel wells and wing butt areas. Curled or flaky edges must be removed and feathered to provide about 1/2 in. of overlap. A fine abrasive approved for aircraft use should be used and extreme care taken to ensure that existing surface treatments are not damaged.

After sanding, sanded areas and bare metal should be wiped with either mineral spirits, alcohol, aliphatic naphtha, or dry-cleaning solvent. Following complete evaporation of these solvents, a detergent wash using a nonionic detergent/isopropyl alcohol mixture should be applied just prior to painting. This will improve paint adhesion.

ACRYLIC NITROCELLULOSE LACQUER FINISH

Acrylic nitrocellulose lacquer is one of the most common topcoats in use today, available either as nonspecular material or glossy finish. Both types of material are required in refinishing conventional aircraft. Surfaces visible from above and other anti-glare areas generally require the use of nonspecular finishes. The remaining surfaces are usually finished with glossy materials to reduce heat absorption. The base materials should be thinned as necessary for spray application with acrylic nitrocellulose thinner.

Replacement of Existing Acrylic Nitrocellulose Lacquer Finish

This finish includes a wash primer coat, modified zinc chromate primer coat, and an acrylic nitrocellulose lacquer topcoat. This finish may be applied only in the sequence specified in the manufacturer's instructions and will not adhere to either the old nitrocellulose coatings or the new epoxy finishes. Even when finishes are applied over old acrylic coatings during touchup, a softening of the old film with a compatible thinner is required.

When a finish is being rebuilt from bare metal, the steps through the application of the modified primer are the same as for nitrocellulose finishes, except that old type zinc chromate primer may not be used. As with the nitrocellulose finish, the acrylic nitrocellulose topcoat should be applied within 30 to 45 min. The finish coatings are usually

applied in two coats over the modified primer: the first a mist coat, and the second a wet, full-hiding crosscoat, with 20 to 30 min. drying time allowed between the two coatings. Once the paint finish has set, paint stripper is necessary for its removal.

Acrylic nitrocellulose lacquer thinner is used in thinning acrylic nitrocellulose lacquers to spray consistency.

When rebuilding acrylic finishes, use two separate thinners: (1) Cellulose nitrate dope and lacquer thinner to thin the modified primer, and (2) acrylic nitrocellulose lacquer thinner to reduce the topcoat material. Make sure that the thinner materials are used properly and that the two are not mixed.

Touchup of Acrylic Nitrocellulose Finishes

After removal of damaged paint, the first step before application of touchup acrylic nitrocellulose lacquer is preparing the old coat to receive the new. Acrylic nitrocellulose lacquer thinner may be effectively used to wipe small areas prior to painting. This will soften the edges of the base paint film around damaged areas, which in turn will assure improved adhesion of the touchup coating. However, the thinner contains toluene and ketones and should never be used indiscriminately for cleaning painted surfaces.

When softening old, good-condition acrylic nitrocellulose finishes with thinner, care should be taken to avoid penetration and separation of the old primer coats. The new acrylic lacquer coat should be applied directly over the softened surface without the use of primers between the old and new coats.

EPOXY FINISHES

Another type of paint becoming increasingly common is a Military Specification epoxy finish or proprietary epoxy primer and topcoats. These finishes ordinarily consist of a conventional wash primer coat and two coats of epoxy material. However, in some cases it may consist of a three-coat finish that includes wash primer plus epoxy-polyamide primer with an epoxy-polyamide topcoat.

The high gloss inherent with this system is primarily due to the slow flowing resins used. The thinners flash off quickly but the resins continue to flow for three to five days. It is this long flow-out time and the even cure throughout the film that gives the pigment and the film time to form a truly flat surface, one that reflects light and has the glossy "wet" look which makes them so popular.

Polyurethane finish is used on agricultural aircraft and seaplanes because of its abrasion resistance and resistance to chemical attack. Phosphateesten (Skydrol) hydraulic fluid, which quite actively attacks and softens other finishes, has only minimal effect on polyurethanes. Even acetone will not dull the finish. Paint strippers must be held to the surface for a good while to give the active ingredients time to break through the film and attack the primer.

The epoxy material presently in use is a two-package system that consists of a resin and a converter which must be mixed in definite proportions just before application. Since the proportions will vary between colors used and also with sources of procurement, it is important that instructions on the specific container be observed carefully. The converter should always be added to the resin, ***never resin to the converter.*** Also, do not mix materials from two different manufacturers. The mixture should be allowed to stand at least 15 min. before initial use.

In this time the curing action is started. The primary purpose of this waiting period is to aid in the application and actually has little to do with the results of the finish itself. After this induction period, the material is stirred and mixed with reducer to the proper viscosity for spraying. When you have the proper viscosity, spray on a very light tack coat, lighter than with a conventional enamel. Allow it to set for about 15 minutes so the thinner can flash off, or evaporate, and spray on a full wet cross coat. The main problem with the application of polyurethane lies in getting it on too thick. A film thickness of about 1.5 mils (one and a half thousandths of an inch) is about maximum for all areas except for those subject to excessive erosion, such as leading edges. Too thick a film which might build up in the faying strips can crack because of loss of flexibility. A good practical way to tell when you have enough material is to spray until you feel that one more pass will be just right, then quit right there, before you make that "one more pass." The high solids content of polyurethane, its slow drying, and low surface tension allows the finish to crawl for an hour or so after it has been put on. If you can still see the metal when you think you have almost enough, don't worry; it will flow out and cover it. Almost no polyurethane job will look good until the next day, because it is still flowing. It will actually flow for about 3 to 5 days. It will be hard in this time, and the airplane may be flown in good weather, but the paint below the surface is still moving.

Masking tape may be applied after 5 hours under the most ideal conditions, but it is far better if you

can wait 24 hours after application of the finish; it should be removed as soon after the trim is sprayed as possible. If it is left on the surface for a day or so, it will be almost impossible to remove.

Both the polyurethane enamel and the epoxy primer which bonds the film to the surface are catalytic materials. They should be mixed and used within 6 hours. If they are not applied within this time, they will not have the full gloss because of the reduced flow time. If it is impossible to spray all of the polyurethane within the 6 hour time period, careful addition of reducer can add a couple of hours to the useful life of the material.

The catalysts used for these primers and finishes are highly reactive to moisture, and the cans should be recapped immediately after using. If a can of the catalyst is allowed to remain open for a period of time, and is then resealed, the moisture in the can will activate it, and swell it up so much there is danger of the can bursting. High humidity and/or heat accelerates the cure.

All catalyzed material must be removed from the pressure pot, the hose, and the gun, immediately upon completion of the spraying operation, and the equipment thoroughly washed. If any of this material is allowed to remain overnight, it will solidify and ruin the equipment.

Precautions must be taken to assure respiratory and eye protection when mixing the two-part resin and activator. Gloves and aprons should also be used to prevent skin contact. Smoking or eating in the mixing area should be specifically prohibited, and mixing should be accomplished in a well-ventilated area. The uncured resins and catalysts contained in these mixtures can cause skin sensitivity similar to a poison ivy reaction.

Touchup of Epoxy Finishes

Epoxy coatings may be applied directly over bare metal in small areas. Minor damage such as scratches and abrasions should be repaired by applying the epoxy topcoat directly to the damaged area, whether or not the damage extends through to the bare metal. The area should be thoroughly cleaned and the edges of the old coating roughened to assure adherence. This material builds up very rapidly. Coats that are too heavy are easily produced and are particularly subject to poor adhesion and cracking.

Larger areas of damage should be repaired by stripping to the nearest seam line and building a complete epoxy finish.

FLUORESCENT FINISHES

Fluorescent paint finishes are available in two types of equal fade- and weather-resistant qualities: (1) A removable finish which is designed for ease of removal and (2) a permanent finish which ordinarily may not be removed without stripping the entire paint finish down to bare metal. These fluorescent paints are applied over full-hiding, clean, white undercoats for maximum reflectance.

Replacement of Existing Finish

For optimum weather resistance and film properties, the dry film thickness must be at least 3 mils for the fluorescent body coat and 1 mil for the clear topcoat. A clear topcoat of from 1 to 1-1/2 mils is necessary to screen out ultraviolet rays from the sun and prevent early or spotty fading of the fluorescent finish. The use of clear lacquers, other than those provided with the fluorescent paint, may also promote fading.

When the permanent finish is white and a fluorescent finish is needed, the permanent white finish may serve as the undercoat. If the permanent finish is any other color, a white lacquer should be used under the fluorescent paint.

When applying fluorescent paint to epoxy finishes, first coat the epoxy surface with white nitrocellulose lacquer, since the fluorescent finish does not adhere too well to the epoxy films. These high-visibility finishes are effective for periods of 6 to 8 months.

Touchup of Fluorescent Finishes

Touchup of fluorescent finishes is difficult to control and should seldom be attempted. Any touchup will be noticeable because of the variations in shading.

Minor damage in fluorescent coatings is repaired by masking, stripping with toluene down to the white undercoat, and repainting with fluorescent paint. This should include one or more touchup coatings of fluorescent paint finish and then overcoated with a clear topcoat sealant.

ENAMEL FINISHES

Enamels frequently are used for the topcoats in finishing aircraft. Practically all aircraft enamels are made by mixing a pigment with spar varnish or glycerol phthalate varnish.

Most enamel finishes used on aircraft components are baked finishes that cannot be duplicated under field conditions. Some are proprietary (patented) materials that are not available in standard stock.

However, for touchup purposes on any enameled surface, standard air-drying, glossy enamel or quick-drying enamel may be used.

High-gloss enamel is thinned with mineral spirits, can be applied by brushing, and should ordinarily be used over a zinc chromate primer coat base. Quick-drying enamel is best thinned with aromatic naphtha. In situations where a primer is not available, either of these enamels may be applied directly to bare metal.

If no enamel is available for touchup purposes, epoxy topcoat material may be substitued. The use of acrylic nitrocellulose lacquer for enamel repairs usually is not satisfactory.

PAINT SYSTEM COMPATIBILITY

The use of several different types of paint, coupled with several proprietary coatings, makes repair of damaged and deteriorated areas particularly difficult, since paint finishes are not necessarily compatible with each other. The following general rules for constituent compatibility are included for information and are not necessarily listed in the order of importance:

(1) Old type zinc chromate primer may be used directly for touchup of bare metal surfaces and for use on interior finishes. It may be overcoated with wash primers if it is in good condition. Acrylic lacquer finishes will not adhere to this material.

(2) Modified zinc chromate primer will not adhere satisfactorily to bare metal. It must never be used over a dried film of acrylic nitrocellulose lacquer.

(3) Nitrocellulose coatings will adhere to acrylic finishes, but the reverse is not true. Acrylic nitrocellulose lacquers may not be used over old nitrocellulose finishes.

(4) Acrylic nitrocellulose lacquers will adhere poorly to both nitrocellulose and epoxy finishes and to bare metal generally. For best results the lacquers must be applied over fresh, successive coatings of wash primer and modified zinc chromate. They will also adhere to freshly applied epoxy coatings (dried less than 6 hrs.).

(5) Epoxy topcoats will adhere to all the paint systems that are in good condition and may be used for general touchup, including touchup of defects in baked enamel coatings.

(6) Old wash primer coats may be overcoated directly with epoxy finishes. A new second coat of wash primer must be applied if an acrylic finish is to be applied.

(7) Old acrylic finishes may be refinished with new acrylic if the old coating is thoroughly softened using acrylic nitrocellulose thinner before paint touchup.

(8) Damage to epoxy finishes can best be repaired by using more epoxy, since neither of the lacquer finishes will stick to the epoxy surface. In some instances, air-drying enamels may be used for touchup of epoxy coatings if edges of damaged areas are first roughened with abrasive paper.

METHODS OF APPLYING FINISHES

There are several methods of applying aircraft finishes. Among the most common are dipping, brushing, and spraying.

Dipping

The application of finishes by dipping is generally confined to factories or large repair stations. The process consists of dipping the part to be finished in a tank filled with the finishing material. Prime coats are frequently applied in this manner.

Brushing

Brushing has long been a satisfactory method of applying finishes to all types of surfaces. Brushing is generally used for small repair work and on surfaces where it is not practicable to spray paint.

The material to be applied should be thinned to the proper consistency for brushing. A material that is too thick has a tendency to pull or rope under the brush. If the materials are too thin, they are likely to run or will not cover the surface adequately.

Spray Painting

All spray systems have several basic similarities. There must be an adequate source of compressed

air, a reservoir or feed tank to hold a supply of the finishing material, and a device for controlling the combination of air and finishing material ejected in an atomized cloud or spray against the surface to be coated.

There are two main types of spray equipment. A spray gun with integral paint container is satisfactory when painting small areas. When large areas are painted, pressure-feed equipment is usually preferred, since a large supply of finishing material can be provided under constant pressure to a pressure-feed type of spray gun.

The air-pressure supply must be entirely free from water or oil to obtain good spray painting. Oil and water traps as well as suitable filters must be incorporated in the air pressure supply line. These filters and traps must be serviced on a regular basis.

The spray gun can be adjusted to give a circular or fan type of spray pattern. Figure 4–1 shows the spray pattern at various dial settings. When covering large surfaces, set the gun just below maximum width of the fan spray. The circular spray is suitable for "spotting-in" small areas.

The gun should be held 6 to 10 in. away from the surface and the contour of the work carefully followed. It is important that the gun be kept at right angles to the surface. Each stroke of the spray gun should be straight and the trigger released just before completing the stroke, as shown in figure 4–2. The speed of movement should be regulated to deposit an even, wet, but not too heavy, coat.

Each stroke of the gun should be overlapped to keep a wet film, thus absorbing the dry edges of the previous stroke.

The spray should be applied as an even, wet coat that will flow out smoothly and be free from "spray dust." Inadequate coverage results from spraying too lightly and "runs" and "sags" from spraying too heavily.

To aid in obtaining good results, make sure the air pressure to the spray gun is between 40 and 80 p.s.i., depending on the material being used. With air pressures below 40 p.s.i. spraying is slow and tedious. Also, with viscous materials, full atomization is not obtained. Above 80 p.s.i. "dust" and blowback become troublesome.

When using pressure-feed equipment, adjust the air pressure in the container according to the viscosity of the paint and the length of the fluid hose used. The pressure must be such that the material reaches the spray gun head in a gentle and continuous flow. Generally, a pressure between 5 and 15 p.s.i. should be used. Higher pressures lead to runs and sags caused by the delivery of too much paint.

PREPARATION OF PAINT

Before paint is used, it must be stirred thoroughly so that any pigment which may have settled to the bottom of the container is brought into suspension and distributed evenly throughout the paint. If a film, called "skinning," has formed over the paint, the skin must be completely removed before stirring. Mechanical stirring is preferable to hand stirring. A mechanical agitator or tumbler may be used. However, as tumbling does not always remove pigment caked at the bottom of the container, a test with a stirrer should be made to ensure that the pigment is completely held in suspension. For hand stirring, a flat-bladed, nonferrous stirrer should be used.

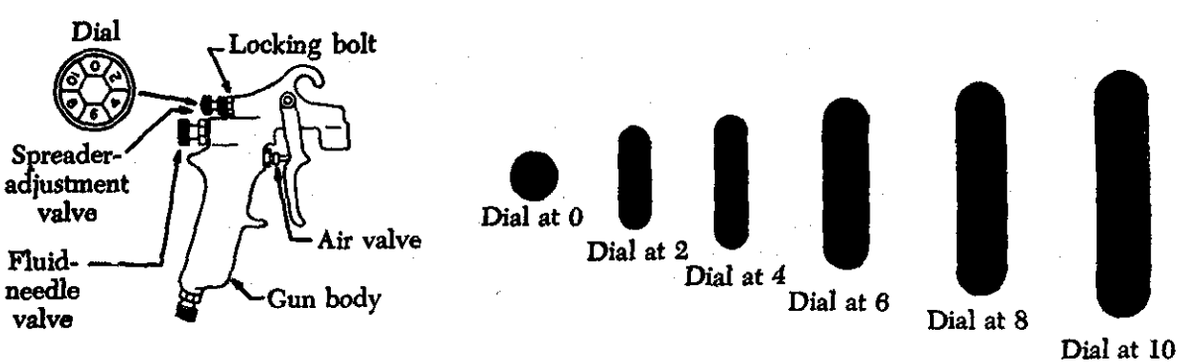

FIGURE 4–1. Spray patterns at various dial settings.

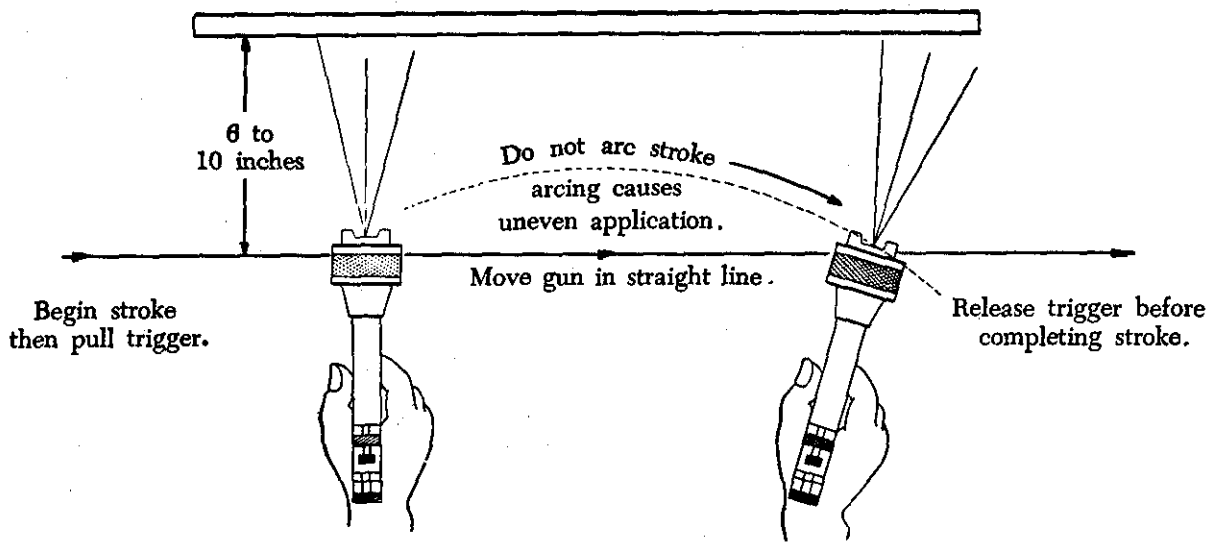

FIGURE 4–2. Spray gun stroke.

The degree of thinning depends on the type of spray equipment, air pressure, atmospheric conditions and the type of paint being used. No hard and fast rule for thinning ratios can be applied. Because of the importance of accurate thinning, some manufacturers recommend the use of viscosity control. This is usually accomplished by using a viscosity (flow) cup. When the right proportion of thinner is mixed into the material, a cupful of material will flow out completely in a designated number of seconds. The finishing manufacturer can specify the number of seconds required for a given material. Material thinned using this method will be of the correct viscosity for best application.

In many cases manufacturers recommend that all materials should be strained before use. A 60- to 90-mesh strainer is suitable for this purpose. Strainers are available in metal gauze, paper, or nylon mesh.

COMMON PAINT TROUBLES

Poor Adhesion

Paint properly applied to correctly pretreated surfaces should adhere satisfactorily, and when it is thoroughly dry, it should not be possible to remove it easily, even by firm scratching with the fingernail. Poor adhesion may result from one of the following:

(1) Inadequate cleaning and pretreatment.
(2) Inadequate stirring of paint or primer.
(3) Coating at incorrect time intervals.
(4) Application under adverse conditions.
(5) Bad application.

Spray Dust

Spray dust is caused by the atomized particles becoming dry before reaching the surface being painted and thus failing to flow into a continuous film. The usual causes are incorrect air pressure or the distance the gun is held from the work.

Sags and Runs

Sags and runs result from too much paint being applied causing the film of wet paint to move by gravity and presenting a sagging appearance. Incorrect viscosity, air pressure, and gun handling are frequent causes. However, inadequate surface preparation may also be responsible.

Spray Mottle

Sometimes known as "orange peel" or "pebble," spray mottle is usually caused by incorrect paint viscosity, air pressure, spray gun setting, or the distance the gun is held from the work.

Blushing

Blushing is one of the most common troubles experienced and appears as a "clouding" or

"blooming" of the paint film. It is more common with the cellulose than synthetic materials. It may be caused by moisture in the air supply line, adverse humidity, drafts, or sudden changes in temperature.

PAINTING TRIM AND IDENTIFICATION NUMBERS

When an aircraft is being painted, the predominate color usually is applied first over the entire surface. The trim colors are applied over the base color after it dries. When the top of the fuselage is to be painted white with a dark color adjoining it, the light color is applied and feathered into the area to be painted with the dark color. When the light color has dried, masking tape and paper are placed along the line of separation and the dark color is then sprayed on.

Allow the paint to dry for several hours before removing the masking tape. Remove the tape by pulling slowly parallel to the surface. This will reduce the possibility of peeling off the finish with the tape.

All aircraft are required to display nationality and registration marks. These marks may be painted on or affixed using self-adhering plastic figures. The marks must be formed of solid lines using a color that contrasts with the background. No ornamentation may be used with the markings, and they must be affixed with a material or paint that produces a degree of permanence. Aircraft scheduled for immediate delivery to a foreign purchaser may display marks that can be easily removed. Aircraft manufactured in the United States for delivery outside the U. S. may display identification marks required by the State of registry of the aircraft. The aircraft may be operated only for test and demonstration flights for a limited period of time or for delivery to the purchaser.

Aircraft registered in the United States must display the Roman capital letter "N" followed by the registration number of the aircraft. The location and size of the identification marks vary according to the type of aircraft. The location and size are prescribed in the Federal Aviation Regulations.

DECALCOMANIAS (DECALS)

Markings are placed on aircraft surfaces to provide servicing instructions, fuel and oil specifications, tank capacities, and to identify lifting and leveling points, walkways, battery locations, or any areas that should be identified. These markings can be applied by stenciling or by using decalcomanias.

Decalcomanias are used instead of painted instructions because they are usually cheaper and easier to apply. Decals used on aircraft are usually of three types: (1) Paper, (2) metal, or (3) vinyl film. These decals are suitable for exterior and interior surface application.

To assure proper adhesion of decals, clean all surfaces thoroughly with aliphatic naphtha to remove grease, oil, wax, or foreign matter. Porous surfaces should be sealed and rough surfaces sanded, followed by cleaning to remove any residue.

The instructions for applying decals are usually printed on the reverse side of each decal and should be followed. A general application procedure for each type of decal is presented in the following paragraphs to provide familiarization with the techniques involved.

Paper Decals

Immerse paper decals in clean water for 1 to 3 min. Allowing decals to soak longer than 3 min. will cause the backing to separate from the decal while immersed. If decals are allowed to soak less than 1 min., the backing will not separate from the decal.

Place one edge of the decal on the prepared receiving surface and press lightly, and then slide the paper backing from beneath the decal. Perform minor alignment with the fingers. Remove water by gently blotting the decal and adjacent area with a soft, absorbent cloth. Remove air or water bubbles trapped under the decal by wiping carefully toward the nearest edge of the decal with a cloth. Allow the decal to dry.

After the decal has dried, coat it with clear varnish to protect it from deterioration and peeling.

Metal Decals with Cellophane Backing

Apply metal decals with cellophane backing adhesive as follows:

(1) Immerse the decal in clean, warm water for 1 to 3 min.

(2) Remove it from the water and dry carefully with a clean cloth.

(3) Remove the cellophane backing but do not touch adhesive.

(4) Position one edge of the decal on the prepared receiving surface. On large foil decals, place the center on the receiving

surface and work outward from the center to the edges.

(5) Remove all air pockets by rolling firmly with a rubber roller, and press all edges tightly against the receiving surface to assure good adhesion.

Metal Decals with Paper Backing

Metal decals with a paper backing are applied similarly to those having a cellophane backing. However, it is not necessary to immerse the decal in water to remove the backing. It may be peeled from the decal without moistening. After removing the backing, apply a very light coat of cyclohexanone, or equivalent, to the adhesive. The decal should be positioned and smoothed out following the procedures given for cellophane-backed decals.

Metal Decals with No Adhesive

Apply decals with no adhesive in the following manner:

(1) Apply one coat of cement, Military Specification MIL–A–5092, to the decal and prepared receiving surface.

(2) Allow cement to dry until both surfaces are tacky.

(3) Apply the decal and smooth it down to remove air pockets.

(4) Remove excess adhesive with a cloth dampened with aliphatic naphtha.

Vinyl Film Decals

To apply vinyl film decals, separate the paper backing from the plastic film. Remove any paper backing adhering to the adhesive by rubbing the area gently with a clean cloth saturated with water; remove small pieces of remaining paper with masking tape.

Place the vinyl film, adhesive side up, on a clean porous surface, such as wood or blotter paper.

Apply cyclohexanone, or equivalent, in firm, even strokes to the adhesive side of decal.

Position the decal in the proper location, while adhesive is still tacky, with only one edge contacting the prepared surface.

Work a roller across the decal with overlapping strokes until all air bubbles are removed.

Removal of Decals

Paper decals can be removed by rubbing the decal with a cloth dampened with lacquer thinner. If the decals are applied over painted or doped surfaces, use lacquer thinner sparingly to prevent removing the paint or dope.

Remove the metal decals by moistening the edge of the foil with aliphatic naphtha and peeling the decal from the adhering surface.

Vinyl film decals are removed by placing a cloth saturated with cyclohexanone or MEK on the decal and scraping with a Micarta scraper. Remove the remaining adhesive by wiping with a cloth dampened with dry-cleaning solvent.