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TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 404

THE PROTECTION OF DURALUMIN FROM CORROSION

By Lieut. Comdr. Wm. Nelson, (CC), U.S.N.

From "Aviation," November 8, 1926

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TECHNICAL MEMORANDUM NO. 404.

THE PROTECTION OF DURALUMIN FROM CORROSION.*

By Lieut. Comdr. Wm Nelson, (CC), U.S.N.

The nature of duralumin as now made is such that if left uncoated and unprotected in the uses in which industry employs this light alloy, corrosion will take place and the physical properties will be reduced accordingly. That a stainless and noncorrodible alloy is possible is without the scope of this paper and the use of some form of covering to preserve the material against the ravages of corrosion is presumed to be necessary. It is to this covering that most metals have turned for proper maintenance so it is logical that duralumin should also seek protection therein without a feeling of derision arising.

Coatings are used in most cases for their preserving effects, but other reasons for the application exist and must be given due consideration in any arrangement proposed. The matter, therefore, becomes exceedingly complicated unless the relative importance of each function is specified. With duralumin in aircraft it is assumed that protection of the material is the outstanding feature to be attained, all other objects being secondary thereto.

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Aircraft construction demands the use of relatively thin sections of duralumin. These thin sections of metal in turn fail rapidly and completely unless special protective coatings are used. The stage has not been reached yet where our aircraft will stand the added weight of scantlings proportioned to take care of a reasonable amount of corrosion, so the problem resolves itself into a case of preserving the original dimensions by the application of paints, varnishes, or other coverings high-powered in their ability to inhibit deterioration in any form.

Duralumin Problems are Specialized

Wood construction and steel construction have heretofore prevailed as structures and relatively satisfactory protections have been devised for them. On the other hand, aluminum alloys are new, and the different behavior of platings and paints on duralumin compared to that on steel requires the establishment of precedents not previously existing. Examples of attempts to follow the technique laid down for other metals on the protecting of duralumin have resulted in dismal failures with experience again acting as the expensive teacher. It is an opinion, however, that more efficient means for resisting deterioration in steel and wood will come from the developments of duralumin coatings.

The fundamental principle of protecting duralumin from corrosion can be stated to be the establishment and the maintenance of an inert insulation between the metal and the corroding mediums. In aircraft, the corroding medium with which we are most concerned is moisture, so our problem resolves itself into waterproofing the surface of the metal. This, for aluminum alloys, is far more difficult than most engineers are willing to admit, and so far duralumin aircraft have suffered the consequences.

That duralumin can be protected against corrosion has been amply demonstrated in tests and in practice. That the matter demands detailed care has also been demonstrated in tests and in practice. Examples are available, however, where duralumin has served well without any protective finish, but these examples do not meet the service to which duralumin structures are now put and for that reason are not representative. It is noteworthy in this connection that as long ago as 1896 extensive tests were conducted to exemplify the value of varnishes and paints on aluminum. It is also of interest to note the apparent lapse of attention to the matter between that time and the present. Today, it is recognized that the life of the metal is dependent on an efficient preservative.

If the surface of duralumin could be made impervious to corroding mediums at no expenditure of weight, we would arrive at the ideal solution. Many factors enter into the practicability of that problem, however, and the ideal is not reached. So our efforts are concentrated on obtaining a coating or finish which will be corrosion resistant by presenting a near tight film at a reasonably low expenditure of weight and cost.

In considering and comparing finishes and coatings as a protection for duralumin, it is presumed that any failure of the coating will eventually result in corrosion. This is not exactly true, but, by comparing the establishment and maintenance of an intact film rather than the many factors entering into the combination of coating and corrosion, we reduce the difficulties. Therefore in the following, the coverings are compared on their own merits with questions on corrosion entering to suit.

Preliminary Considerations

Consideration must be given to three things in drawing conclusions on protecting mediums for duralumin, namely:

(1) Preliminary work on metal necessary to prepare the surface for the coating.

(2) Properties of the coatings.

(3) The effect of the coating on the properties of the metal coated.

Those finishes which require no preliminary work in preparing the surface are the most desirable for use, other things being equal. In some cases this preparation amounts only to cleaning with gasoline, benzol, carbon tetrachloride, or some patent liquid to remove oil products which have come on during the manufacture. In other cases it is necessary to disturb the surface mechanically, as by sand blasting, wire brushing, emery paper, etc. If the surface of duralumin is worked very much, as is the case in sand blasting thin sheet, reheat treatment is necessary to restore the physical properties. The other type of preparation consists of etching the metal by some chemical action. Caustic soda solutions or nitric acid solutions can be used very effectively to produce a satin finish on duralumin by immersing it in the solution for periods of time depending on the concentration. It is an essential that washing in clean water must follow the etching dip.

Properties of the Coatings

The methods of protecting against corrosion in duralumin naturally divide themselves into the following groups:

(a) Painting; (b) Electrolytic treatments; (c) Other treatments.

Painting includes the use of various oils and pigments and combinations thereof. Electrolytic treatments include metal platings applied by means of electric currents and the oxidation of the duralumin surface as in the Anodic process. Other treatments take in polishing, buffing, etching and the metal spray application. All of these can be compared together under the classifications into which the properties of coatings are distributed.

The properties of coatings can be classified into the following:

(a) Method of application of the coating;

(b) Weight of coatings;

(c) Cost of coatings;

(d) Resistance to mechanical treatment;

(e) Resistance to weathering;

(f) Resistance to special agents;

(g) Color, appearance, etc.;

(h) Special properties.

Oils, paints, varnishes and enamels can be applied by brushing, spraying, or dipping. The particular process followed usually depends on the costs involved. Electroplating and the Anodic process require special equipment and methods peculiar to aluminum alloys. In general, the application of oils, paints, varnishes, etc., meets the popular demand and it is only to increase the resistance to corrosion and for appearance' sake that the other means are employed at all on duralumin.

Weight Question is Important

The weight of coatings is important since the use of duralumin has been brought to its present state as an aircraft material through its advantage over steel and other metals of being light in weight. To lose any of this advantage by heavy coatings is inadvisable and in the case of airships, impracticable. Since the weight increases in proportion to the thickness of the coating and since additions to the thickness become of decreasing importance as the weight increases, a point of maximum advantage exists with a relatively thin covering.

The cost of finishes involves the cost of applying the finish and the life of the protective means employed. A coating soon comes into disfavor if the cost of material and labor are high, regardless of its life. A cost not exceeding two cents per square foot of surface appears to be reasonable.. Naturally, however, there are circumstances where a much higher figure is commanded for special reasons.

The resistance of the finish to mechanical treatment depends on the adhesive effect of the coating, the hardness, the brittleness, and other factors. The best test in this respect is actual use. It is in many cases in aircraft construction desirable to coat duralumin parts prior to an assembly. In those cases the finish should be capable of resisting shop wear. A coating relatively elastic, tough and tenacious ordinarily meets all the requirements.

Failure of a finish results sooner or later in corrosion of the metal. Its resistance to weathering is a good measure of its effectiveness as a protection. Sunlight, rain, heat, cold, salt spray, etc., are the usual elements the coating must resist and peculiar as it may seem, these elements work very effectively together to destroy the best of laid plans. Paints will blister, crack, alligator and what not; platings will curl and come off; oxides will dissolve off, etc.; and corroding mediums find their way through these impaired finishes very rapidly and manifest themselves by the appearance of aluminum oxides and hydroxides. Consequently, the weathering effect should be practically nil to make ordinary care all that will be necessary for keeping out extensive corrosion. In this connection it might be well to mention that duralumin left in some storages for a year or longer has shown indications of deterioration due to weathering. To protect against such effects it is advisable to coat the stock when received with at least one coat of finishing compound.

Many ingredients exist in the waters where seaplanes and boats are used. Their nature is not always known but if the duralumin covering is inert to their actions the ultimate in this respect is attained. Other special agents to be reckoned with are gasoline, oil, dope, engine exhaust gases and cleaning compounds. It is in some instances desirable to vie with these special agents in limited parts of aircraft only.

The colors available and the appearance of the finished duralumin when coated with these colors has a bearing on the freedom of use. Only a few colors are used in aircraft and they are of secondary importance. A smooth finish capable of easy cleaning is a highly desirable factor though, and is demanded on account of the fact that trimness and neatness can not accompany service without repeated scrubbings.

The special properties are numerous. The insulating effect or its dielectric strength for certain places must be considered.

The antifouling properties of the coating are essential data in considering its use for the hulls of flying boats. And in some other places, due to the relative softness of duralumin, an erosion resisting finish is necessary.

Effect of the Properties on the Metal

The first effect to be considered is the change, if any, produced on the chemical and physical properties of the material finished. For instance, sand blasting reduces the ultimate tensile strength and elongation of thin sheet duralumin materially. Some other chemicals may alter the desired properties so as to make their use detrimental. The usual procedure to determine the effects of coatings on the physical properties is to subject them to tensile and bend tests after the application.

Acids in paints may cause serious corrosion without any assistance from outside elements. Metallic compounds used either as pigments in paints or in plating may produce a couple with the alloy requiring only an electrolyte to cause electrolytic corrosion.

From this it can be seen that the coating should be electropositive to duralumin and should contain no free acids or salts. An inert coating preserves sufficiently if it makes an intact surface.

To determine by laboratory methods what happens when the finished duralumin is placed in service exposures to weather, salt sprays, gasoline, and hot and cold water are employed. It is practically certain that any material which withstands these tests will withstand service in so far as the particular test covers the use. The length of time a coating remains intact under these exposures is a measure of its effectiveness and is the criterion on which its use is recommended. The degree of corrosion in a salt spray in a fixed time gives a value readily comparable with other results obtained with and without coatings.

Oils and Greases

The use of mineral oil and greases as rust preventatives has been recognized in industries using steel. Their use in protecting duralumin can be said to be somewhat analogous. It has been known for some time that oil used for lubricating purposes is in a measure a corrosion preventative for aluminum alloys. This has been brought out particularly in duralumin structures near aircraft engines; but owing to the water which settles with the oil in the bilges, this means of protection is not considered to be sufficiently effective to take the place of more permanent coatings.

Oil and greases have been used as a general protection on duralumin aircraft but they present the following disadvantages: (a) They are relatively heavy; (b) The period of usefulness is extremely limited; (c) They do not present a desirable surface for general service.

For certain purposes, however, a rust preventative compound is considered a good protective coating and will prevent corrosion in duralumin with due attention. Where duralumin is kept in storage for considerable periods of time and where the corroding mediums are not strong, a light coat of compound will tend to keep out corrosion. Mineral oils and light greases are too light to serve this purpose as effectively as the heavy rust preventative compounds. Duralumin pins, bolts, nuts, shackles, etc., in aircraft in use where wear tends to remove paints and where paints are impracticable can be satisfactorily protected with the compound. Structural tubes and enclosed shapes not readily coated with paint can be dipped in hot compound and drained to produce a good inside finish. However, any use to which this grease is put will demand frequent inspections to insure the proper maintenance of the coating.

None of these oils, greases or compounds used should contain any free acid and if practicable no water should be present. Some prepared compounds have a water absorbent ingredient in their make-up to take out moisture. The advantage of this is apparent.

The method of application does not require any special preparation of the surface other than having it dry. The articles to be coated are dipped in hot oil, grease, or compound and cooled in air. A thin coating effectively maintained is as efficient as a thick coat and is more easily removed. If a piece previously coated with grease is to be painted, careful removal of the grease with benzol, alcohol, or carbon tetrachloride is essential. Paints and varnishes will not adhere to an oiled surface.

Paraffins, wax, etc., alone or in compounds can be used in the same manner and as effectively as oil, grease, etc.

Paints and Varnishes

Paints, varnishes, and enamels are the most prolific sources for protective coatings. Extensive experiments have been carried out using them for finishes on duralumin. These tests have not been entirely satisfactory because they have not been standardized and the data derived therefrom are not comparative. Nevertheless, there has been a consistency in these tests in that most paints are extremely inefficient on duralumin aircraft subjected to a salt atmosphere. These failures have been along two lines particularly noteworthy; one is the lack of adhesion of the paint to duralumin, and the other is the lack of continuity in the film produced. In any case though, paints and varnishes are the most important protective coatings readily applied, and accordingly, require more detailed consideration than the others. It is realized that the ultimate has not been attained yet; but experience has given enough data to warrant the greatest care in the selection and the application of this mainstay of all protective finishes.

As duralumin is ordinarily received for use, it is coated with a thin film consisting largely of aluminum oxide. This film if not broken down is very smooth, making adhesion of paints and varnishes thereto difficult. This film can be broken down mechanically or chemically so as to produce any desirable finish from a satin to a relatively rough surface. The degree to which the surface must be prepared depends on the paint or varnish in use.

The methods in use for breaking down the oxide film mechanically include sand blasting, wire brushing, and sand papering. This is called a finishing operation.

Scratch Brush Preparation

The finish known as Scratch Brush is accomplished by a revolving wire brush. It has the appearance of etched glass and is done in four grades, namely, rough, fine, superfine, and extra fine. The suface to be finished is first cleaned of all grease or oil. To produce the rough scratch brush the work is done on a lathe with a steel wire (.005) brush about 10 in. in diameter operated at about 1200 R.P.M. The other finishes use smaller brushes and less speed.

Wire brushing, sandpapering, and sand blasting, are only relatively useful but serve well in meeting the field requirements. They are particularly useful in removing products of corrosion for refinishing. For sand blasting No. 100 sand is used with reduced air pressure and with the object 10 in. from the 1/4 in. nozzle.

Chemical etching can be done by immersing the piece to be etched for two or three minutes in a hot caustic soda solution or longer in a cold caustic solution.

Before finishing duralumin by chemical etching the surface should be cleaned of oil and grease. It is then dipped in a solution made up of 253 parts of sodium hydroxide to each 1000 parts of water by weight. The solution is kept in a wooden vat and is kept boiling by live steam. The duralumin to be etched is then immersed for two or three minutes after which it is washed in cold water followed by a dip in nitric acid (concentrated). The dip in nitric acid is made to neutralize any caustic remaining from the caustic dip. After the acid dip, the duralumin is washed in water again and then dried on a steam table.

Present practice in the aircraft industry does not provide for any treatment of duralumin surfaces on account of the benefit derived from the oxide film as a protective medium in itself. It is believed, however, that etching or roughening of the surface will produce the better results through the better adherence of coatings. But, on the other hand, the cost is increased by etching and it is still a matter of conjecture as to whether or not the added benefit is worth the added cost. It is believed that the better coatings will require no roughening of the surface for good adhesion.

During the fabrication of a duralumin part, oil and grease deposits adhere to the surface of the metal. Unless a clean surface exists, paints and varnishes can not be effectively applied, so it is an absolute essential that a cleaning process precede the application of paint. Any product which will cut the grease and which is 100 per cent volatile, will serve the purpose. Benzol, acetone, alcohol, and carbon tetrachloride are useful cleaning products. To test for a clean surface, water placed thereon will form an even film whereas if oil is still present the water will gather in globules or pools. The importance of a clean surface can not be stressed too much, for it is this point and the application of the coating that determine the relative value of the finish.

Linseed oil and similar oils will not in themselves produce a satisfactory coating for duralumin due to the lack of durability. Oil paints using metallic oxides as pigments have been avoided on account of their weight, the possible injurious effect through electrolytic action, and on account of their nonadhering qualities. Nitrate and acetate dopes are extremely poor in adhering properly to duralumin. Bituminous solutions, varnishes and nitrocellulose lacquers present the most favorable groups for duralumin. They can be used in clear or pigmented forms to suit the demand.

As has been previously stated, any coating used must be neutral or electropositive to duralumin. Bituminous solutions, varnishes and lacquers, used clear, are inert. However, certain uses demand pigmented forms. To meet such requirements the priming coats can be clear and the outer coats pigmented without incurring any adverse action. Pigments which do not permit of a glossy surface are not recommended for aircraft due to cleaning difficulties.

Bituminous solutions on the market are many and varied. They are all of about equal value provided they are not too thin and do not harden to a brittle stage. The merits of each beyond the protective feature depend on the product.

There are two types of varnishes, namely, spar varnish and light gravity varnish. Any varnish which does not check and deteriorate in weather gives protection to duralumin when used as a coating. The light gravity varnishes are perhaps the best for duralumin aircraft in that they remain somewhat flexible at all ordinary temperatures and form a uniform intact film.

The lacquers are outstanding in their adhesive qualities. Thin lacquers without a great many coats are not of sufficient value on duralumin to warrant the expenditure. Sufficient material should exist in the finish to give a relatively heavy body to the coating.

Mechanical Application Methods

The mechanical application of solutions and varnishes is based on dipping, spraying and brushing on the coatings. All three methods should be practicable with a successful paint or varnish. Dipping produces a very uniform coat; spraying, a light weight coat, and brushing, an easy method of application. Varnishes and lacquers should be sprayed to produce the best results. It is a very necessary part of the operation of applying the finish to see that no voids exist and that a uniform smooth coat is the result. Bubbles, no matter how small, must not be permitted.

Several thin coats are better than a few thick coats. When varnish or bituminous solutions are applied with a brush each coat should be well rubbed in so as to afford good protection with less weight. The thinning of varnishes and solutions with oil and turpentine beyond that necessary reduces their properties as protective mediums. Considerable practice and good judgment are necessary to produce the best grade of material for each operation.

Baking is a part of the application process in enamels. This baking is done at temperatures well below the annealing temperature of duralumin, so that no injurious effects to heat-treated material need be expected. Baking produces a harder coating than that produced by air drying.

No less than two coats is considered advisable and the application of four coats of bituminous solution or varnish is the maximum limit for efficient results. The number of coats depends on the finished material and the service to which the duralumin is to be put, but for most purposes two or three coats produce excellent results.

A practice recently developed for duralumin aircraft consists of applying clear varnish or lacquer with a pad rubbed into the surface and left thin, followed by a coat of pigmented varnish or lacquer sprayed or brushed, followed in turn by a second coat of clear or pigmented varnish or lacquer brushed or sprayed. This combination meets weight and weathering requirements satisfactorily.

Weights of Finishes

The weights of some duralumin finishes, each representing one coat dried to touch, are given, as follows:

Bituminous solution	.00514 lb.sq.ft. surface
Spar varnish	.00467 lb.sq.ft. surface
Light gravity varnish	.0023 to .0033 lb.sq.ft. surface

These values are for brushed coats. Spray coating is somewhat less. On material ordinarily used in the aircraft industry these are less than 1 per cent additions to the weight of the product.

Varnishes cost about twice as much as the bituminous solutions per gallon. The cost of application is about the same in each case.

To be effective in resisting mechanical treatment the finish used should never become hard and brittle. A certain amount of elasticity should prevail as long as the coat resists weathering. It should not come clean from the metal when scraped, either as a brittle chip or as a soft film; a poor grade of material, improper cleaning, or improper application produce these results. Constant attention to the maintenance of the coating is necessary. If the finish is accidentally broken or worn off, the places concerned should be recoated. None of the paints or varnishes now in use will resist the mechanical treatment received in forming and manufacturing parts, so that any painting done prior to sub-assembly should not be considered intact.

Durability of Coatings

It must not be assumed that any coating of paint will resist weathering indefinitely. Bituminous compounds, alligator and varnishes check after a time in the sun and rain. The better grades of varnishes and lacquers, on the whole, last relatively long in the weather, but, unless detailed attention is paid to the upkeep, small failures become extensive. Corrosion of the duralumin sometimes manifests itself under the finishes by blistering even before failure of the coating can be seen. In these cases, the corrosion should be scraped off, the area cleaned by brushing, and touching-up resorted to. Unless this is done, increased corrosion will be the result. A life of six months for paints and varnishes subjected to weather such as is found along the seaboard is considered very efficient.

It is estimated that duralumin in aircraft should be inspected every seven to ten days for evidence of corrosion. Whenever corrosion appears on duralumin which has been painted, the corrosion should be scraped off with a knife and the spot rubbed clean of loose paint and corrosion products before any coating material is again applied. The application should be carefully done with enough coats to insure an intact film.

Bituminous solutions are somewhat resistant to acids but are readily dissolved by gasoline and such products. Bituminous solutions are worth very little as finishes where high temperatures are the rule. The varnishes and lacquers meet both difficulties mentioned to a far greater extent than solutions. Where the duralumin structure is subjected to gasoline and oil frequently, extra coats of varnish are advisable.

Coloring

To produce desired color effects on duralumin pigmented varnishes can be used over the clear varnishes. It is possible to apply certain finishing coats on bituminous solutions provided the solution is allowed to dry hard; but there is the danger in this that the bituminous solution will bleed through the finishing coat if the solution is of the best consistency for preservation, whereas it will not bleed through if the bituminous solution is hard and brittle. The hard and brittle solution does not adhere as well as the softer elastic solution.

Inside fuselages, etc.; light colors are desirable to facilitate inspection and for that reason aluminum pigmented bituminous solution is superior to the clear. Varnishes and lacquers, clear or pigmented, with Prussian blue, should be used on interiors where sunlight is not direct.

It is well to mention here special paints, etc., used for special problems. The sodium silicate treatment which is found to be so efficacious in certain places, consists of special cleaning of the alloy in a sodium bichromate solution, an immersion in sodium silicate solution, followed by baking and a fixing operation. This treatment, however, is more suited to castings than to rolled material.

Special enamels such as those that produce a flint-like hardness on drying are particularly useful to withstand erosion. These products should find a bigger field of usefulness as a coating for castings than for wrought alloys.

For faying surfaces of duralumin where water-tightness was desired, it has been the practice to use cotton fabric dipped in bituminous solutions, varnishes, or marine glue (waterproof). Ordinary friction tape has also been used in this respect. For faying surfaces where gasoline tightness is an essential, gums dissolved in benzol, varnishes containing soya bean oil and litharge can be used. In all cases, the faying surfaces should be wet when made up and all interstices absolutely filled with joint material to insure a tight joint and absence of corrosion.

For faying surfaces, duralumin to any other metal or wood, these same compounds can be used, but there, too, it is a matter of maximum importance to have an insulation and to have a well-filled joint. Failure to fill the joint will result in electrolytic action between the dissimilar metals.

Plating

The plating of duralumin can be done in two ways, namely: by electrodeposition of another metal on it, and by spraying a metal on the duralumin. The deposit of another metal on duralumin by electroplating is an exceedingly difficult proposition due to the lack of adhesion obtained. Nickel and zinc can be deposited on duralumin with success by methods for the most part patented. Chrome plating on aluminum alloy castings has been done, but it is not yet available for rolled material. It must not be expected that these platings can be deposited on other than individual parts, for the matter is still quite limited in application.

To make any metal stick to duralumin it is necessary to break down the oxide film. This is done as a rule by sand or steel grit blasting. Metallic aluminum deposited by means of a spray gun on such a prepared surface is extremely effective in maintaining the strength of the plated material in corroding mediums. This process should have wide application.

There has been developed another process somewhat similar to the electroplating operation, which appears to be of value. This is the so-called anodic-oxidation process applicable to aluminum alloys in general. The process consists primarily in building up the aluminum oxide film on the part concerned to the point where its dissolution by corroding mediums is a matter of extended time. The duralumin piece to be oxidized is made the anode in a low percentage chrome solution and varying voltages and currents are applied until the film has been suitably built up. The effect on the weight of the part is to reduce it slightly. The mechanical properties are also slightly reduced indicating a reduction in the effective metal through oxidation. The film produced on duralumin is very uniform and practically continuous, and the resistance to corrosion displayed by anodically treated material is distinct and of outstanding merit. The process has not yet been carried to assemblies but it appears that this is practicable. The main difficulty with the anodic treatment will be in producing a continuity of the oxide film. Parts will have to be treated after the forming operation, for there is a tendency to break the finish in case of any other than minor bends.

Although the anodic oxidation treatment can be used as the sole finish, it is believed that the lack of continuity of the film will require the application of some paint or varnish on the material to insure satisfactory results. The combination, however, should be outstanding as a corrosion resistant protection.

Other Protective Methods

There are two or three other means of finishing duralumin which have their merits in staving off corrosion somewhat. The most interesting one of these is polishing and buffing. Polishing and buffing duralumin to a high degree can be used as a permanent finish where the corroding mediums are not particularly active and where the mill-run material can not be used without a protective coating of some kind.

A dip in nitric acid solutions has a tendency to retard corrosion but the degree of resistance is not sufficient to warrant a high rating.

Oxidation by thermal means is another possibility, which has not yet emerged from the laboratory but which warrants consideration for use on aluminum alloy wires.

The matter of protecting duralumin against corrosion should still be regarded as in its infancy. Much work remains to be done along constructive lines to permit a very general use of the metal. Every measure within reason looking to prolong the life of duralumin in aircraft should be undertaken until the protection of this material is fully understood. It can be expected that the durability will be affected unless precautions are taken from the time of manufacture of the duralumin throughout its career. The protection of duralumin aircraft should be carefully considered in the design, construction and maintenance for maximum degree of success.

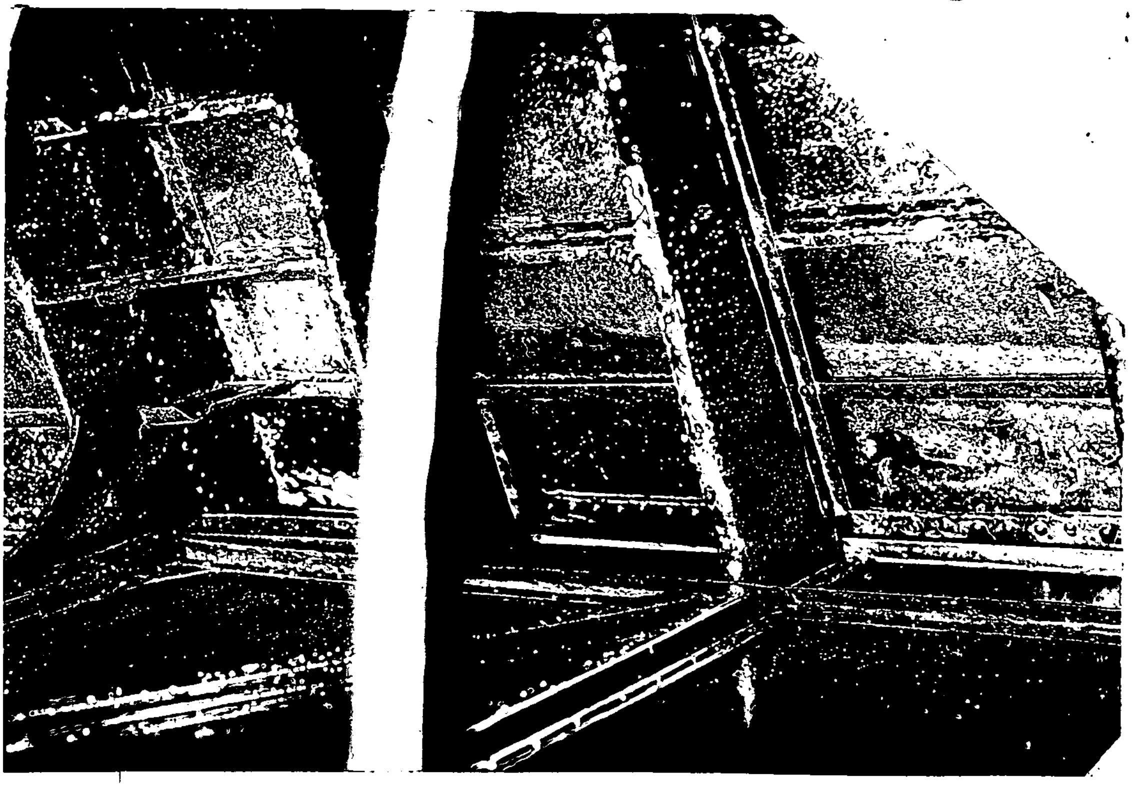
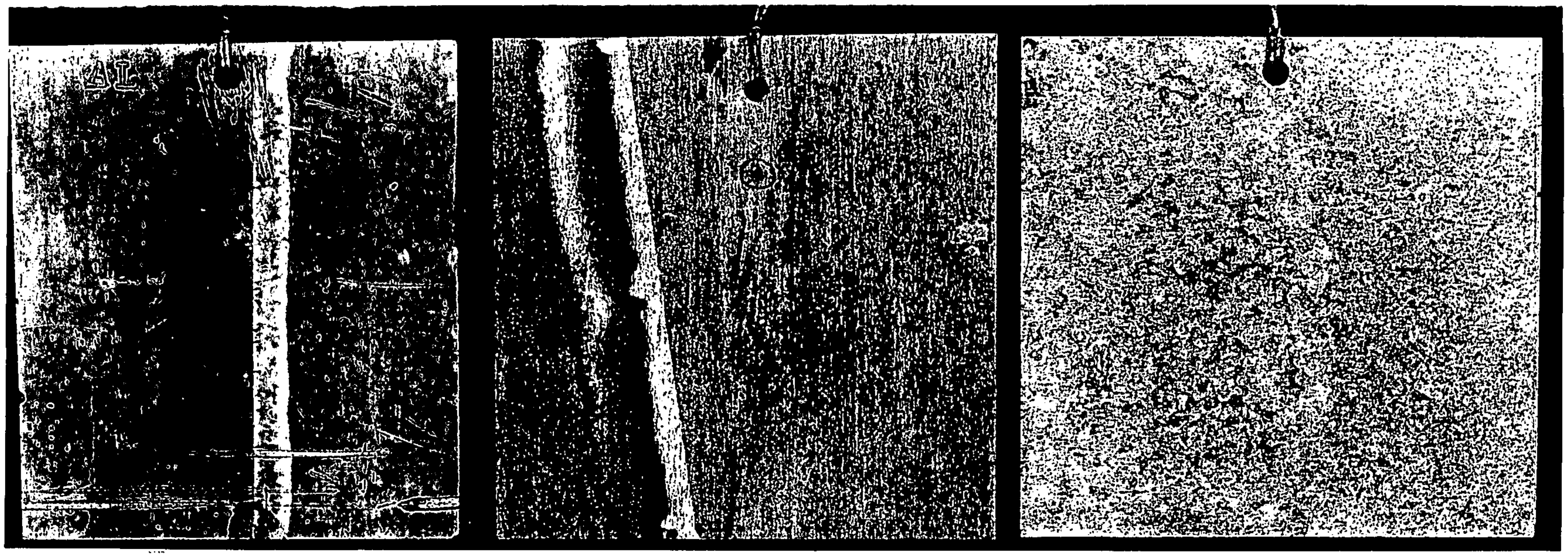


Fig.1 Corrosion inside an airplane float where bitumastic paint was not a sufficient protection.

Fig.2 Note corrosion of rivets due to lack of protection afforded by an anti-corrosive anti-fouling paint.

1892 A.S.



ALUMINUM — DURALUMIN — DURALUMIN

TREATED SURFACE — UN-TREATED SURFACE

After 30 days exposure to salt spray - after removing products of corrosion.

Fig.3 Effect of anodic treatment in protecting duralumin specimen in the salt spray 30 days.

Fig.5 Corrosion intensified by the kind of paint used.

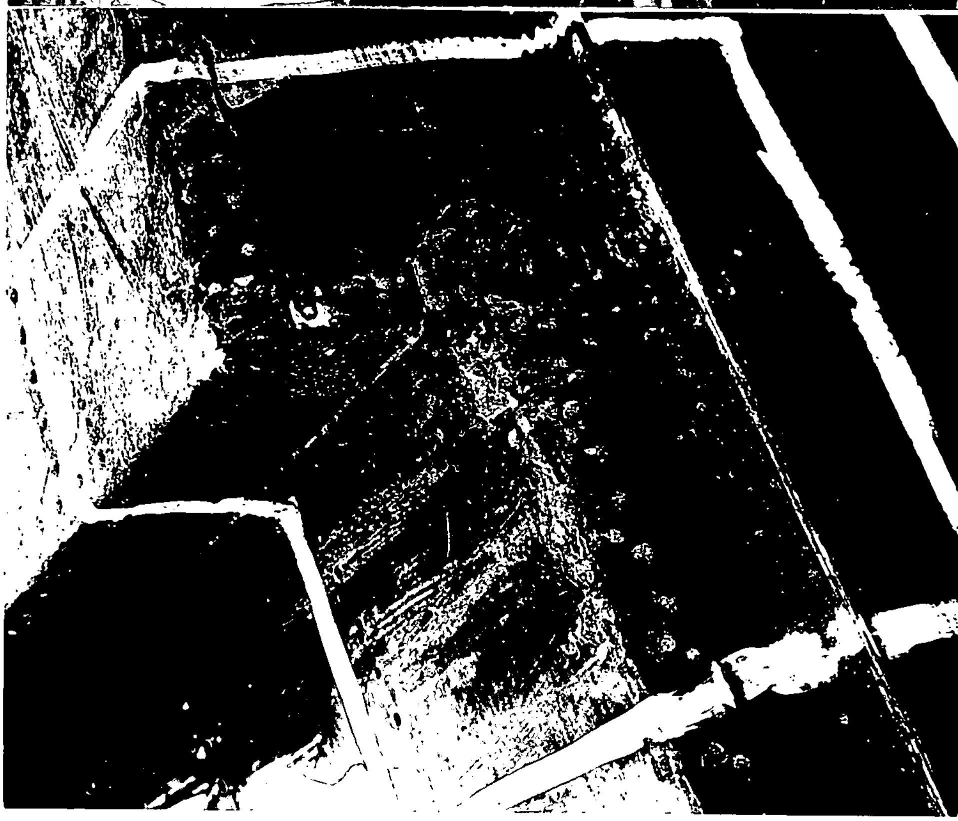


Fig.4

Failure of paint showing corrosion on a duralumin float after a few months service.

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