

# Keeping the Propeller Dry

## The Use of Aluminum Leaf in Making Wood Proof against Moisture

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IN spite of its variability and some properties undesirable in a propeller material, wood seems to be the most satisfactory material for airplane propellers. The successful use of wood, however, depends upon overcoming or at least reducing to a minimum the effects of these undesirable properties, of which perhaps the most important is the tendency to shrink and swell with changes of moisture content.

It is well known that wood is a hygroscopic material; that is, it retains a certain amount of moisture, this amount varying with the relative humidity under which the material is stored. For instance, wood stored out of doors in the northern states will retain from 10 to 12 per cent. moisture and in the drier and more arid sections, such as the states along the Mexican border, will possibly retain only 5 or 6 per cent. on the average.

If a propeller is constructed under certain conditions and shipped to localities which are drier or damper it will absorb more or less moisture according to the atmospheric conditions, unless it is protected by some sort of a coating. As a result of the absorption or loss of moisture, the propeller will lose its balance and the wood will shrink or swell and otherwise distort the blade.

To gain the maximum speed and efficiency from a propeller, it should be entirely free from any tendency to vibrate. Vibrations may be caused by an unbalanced or distorted blade and many propellers are rejected by pilots for these reasons. This condition was forcibly brought out during the Mexican campaign a few years ago, when many propellers were lost because they were used under different conditions from those surrounding their manufacture. It was realized that the same thing might occur in shipping propellers from the United States to Europe where the prevailing moisture conditions are 3 to 5 per cent. higher than in localities in the United States.

To overcome troubles due to moisture changes, it was necessary to use woods comparatively little affected by such changes. It so happens that woods of this class, such as mahogany and walnut, are relatively expensive.

A moisture-proof coating for propellers, therefore, is exceedingly desirable, (1) to produce a propeller unaffected by moisture changes, and (2) to utilize cheaper and more abundant woods such as gum, red oak and other common native hardwoods.

### EXPERIMENTAL MOISTURE-PROOFING WORK.

In the effort to develop a moisture-proof coating, an extensive series of tests was planned, including tests of many different types of coatings, such as spirit, oil, and cellulose varnishes, enamels, linseed oil and wax

treatments, impregnation treatments, and sprayed and electroplated metal. None of these coatings proved to be entirely satisfactory. Defects appeared in all of them, caused by lack of adhesion or inadequate resistance to the transmission of moisture. As a result of the above-mentioned work, however, an exceedingly effective, inexpensive, and easily applied coating was developed. The chief feature of this coating is a layer of aluminum leaf, which is incorporated between coats of varnish.

The diagram presents the comparative results of a number of tests on the effectiveness of various coatings. This diagram also shows clearly the progress that was made in this study to improve the coatings. At our entrance into the European war the first specifications issued called for the finish shown at "B" in

service; that is, the normal or average moisture content for wood in France is about 15 per cent. while the condition under which the test was made would produce a moisture content in wood of from 22 to 25 per cent. The test consisted in applying the coating or treatment to a panel of yellow birch  $\frac{5}{8}$  inch by 4 inches by 8 inches. All surfaces were carefully coated and the specimens were hung in a compartment maintained at a relative humidity of 95 to 100 per cent. The weights of the panels were taken at regular intervals, the gain in weight in grams per square foot being used as a measure of the absorption or the amount of moisture transmitted through the coating.

### METHOD OF APPLYING ALUMINUM LEAF.

Since the purpose of this coating is to moisture-proof wood thoroughly, it should be carefully applied. The leaf used is exceedingly thin and light; there are probably 12,000 to 15,000 leaves per inch, which makes it appear difficult to handle. If the suggestions outlined below are carefully followed, however, the leaf may be easily applied. While this article takes up specifically the process of coating propellers, the same procedure could be followed for coating other products.

Careful sanding to remove all tool marks and other imperfections is required in order to insure a perfectly smooth surface over which to apply the coating.

For open grained woods, a coat of filler consisting of 83 per cent. liquid and 17 per cent. silicx should be used. The liquid should consist of 77 per cent. airplane spar varnish and 23 per cent. turpentine. The silicx must pass a 200-mesh sieve. After the filler is applied to the wood and allowed to flatten, it should be rubbed off across the grain so as to fill the pores thoroughly. It should then dry for at least 24 hours, and afterwards should be sanded lightly.

The shellac varnish should consist of  $4\frac{1}{2}$  pounds of orange shellac gum cut in 1 gallon of clean, neutral, denatured alcohol. This should be applied evenly over the surface of the propeller, allowed to dry 3 or 4 hours, and then sanded lightly.

The size should consist of 75 per cent. airplane spar varnish and 25 per cent. turpentine. It is suggested that a small amount of Prussian blue in Japan be added to the varnish to give it a color, so that spots subsequently left uncovered by the leaf will be readily visible.

The size should be brushed evenly over the surface as sparingly as possible, and allowed to dry until a tack is reached. This will permit the handling of the propeller immediately after the application of the leaf without disturbing the coating. The time will vary

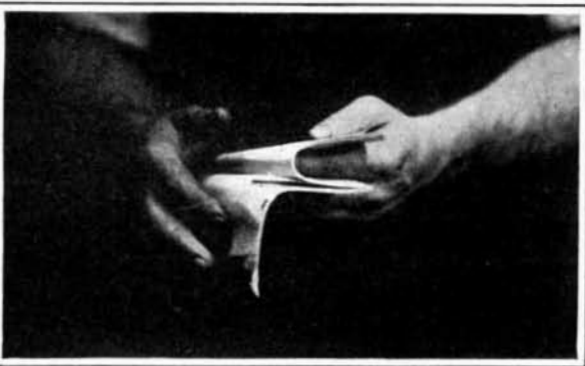
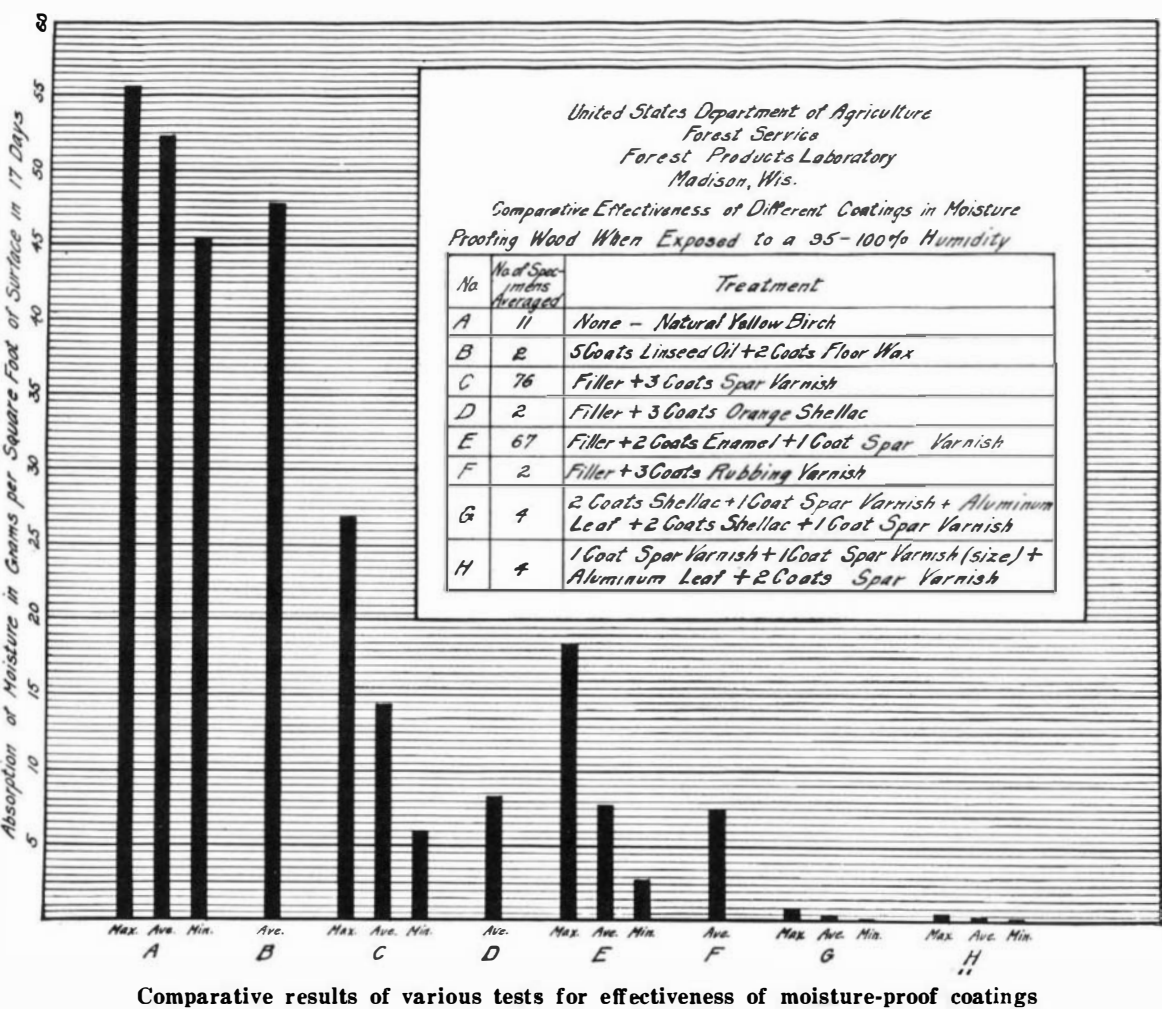


Fig. 1.—Method used in turning pages of aluminum-leaf book



Fig. 2.—Transferring the book from left hand to right



Fig. 3.—Method of holding book when applying leaf

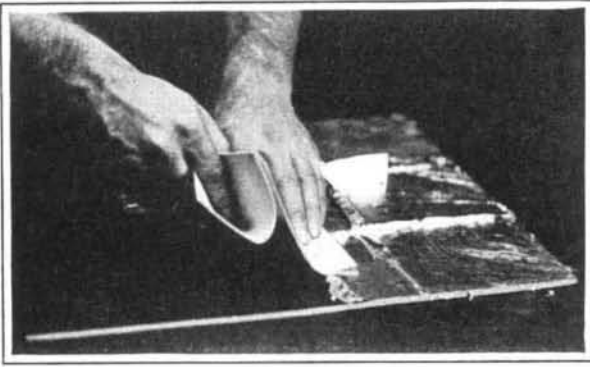


Fig. 4.—First operation in laying leaf

with the varnish and the weather. The varnish should dry for about 1-½ hour on a light dry day or in a heated building in the winter time, but a longer time may be required on a cloudy or damp day. This is an exceedingly important point and should be carefully considered since the coating hardens very slowly after the leaf is applied.

In applying the size, care should be exercised not to produce fatty edges or runs. If they occur, the leaf will be easily rubbed from the surface in handling the blade. For convenience in applying the leaf later, it is best to size one side of the blade at a time.

#### HANDLING ALUMINUM LEAF.

As soon as the size has reached the right tack, the leaf should be applied very rapidly over the surface. After the sized surface has been entirely covered, the leaf should be patted down with the palm of the hand or with a pad of cotton, and the rough edges should then be rubbed away. (See Fig. 6.) Any points not covered with leaf should be coated by applying a small piece of leaf to the spot with the fingers. The coating should be rubbed well with a piece of cotton which has been dipped in aluminum powder. This will insure the leaf sticking securely over the entire surface, and will fill any small holes not already filled.

Aluminum leaf comes in packs containing 500 leaves. The pack is divided up into 10 or 20 books containing 50 or 25 leaves, respectively. The metal leaf is placed between the pages of these books and is in 4-inch, 4½-inch, 5-inch, or 5½-inch squares.

It is best to apply the leaf directly from the book by turning back the first page half way and holding it (Fig. 3) between the first and second fingers of the right hand. The book itself should be held between the thumb and fingers and in such a way that the back of the hand will be toward the work when the leaf is applied, the book being given a slight bend to prevent the corners of the leaf from drooping. The end of the leaf exposed by turning back the first page of the book should be placed against the surface to be coated (Fig. 4) and held securely in place by the left hand. The sheet held between the first and second fingers should be drawn back (Fig. 5) so as to allow the whole leaf to come in contact with the surface. The next sheet should be applied in a like manner, lapping edges with the first, and so on. The best results will be obtained if the gilder works in the same direction with each row of leaf; that is, from left to right. If this is done, it will aid considerably in completing and smoothing off the surface. Fig. 9 shows two propellers completely coated with the leaf.

It is suggested that in turning the pages of the book (Fig. 1) the back be held between the first two fingers of the left hand. The leaves from which the leaf has been removed should be turned back and held between the thumb and first finger of the left hand. The next sheet of paper may then be turned back, exposing one-half of the next leaf. The operation of changing the book from left to right hand is shown in Fig. 2.

#### LARGE HUB HOLE.

The large hub hole should receive the same treatment as the rest of the propeller. In applying the leaf to



Fig. 5.—Second operation in laying leaf

the hub hole, it is convenient to cut the books of leaf up into about 1-inch strips of leaf and paper, drop the strips (Fig. 7) vertically into the opening, and bring them into contact with the size. After the entire surface of the hole has been covered, it should be patted into place (Fig. 8) with a wad of cotton attached to the end of a stick.

#### SMALL HUB HOLES.

These holes should be corked up with ordinary corks, the tops of which should be cut off flush with the surface of the propeller and covered with the regular finish.

#### SHELLAC COLOR VARNISH.

After the application of the leaf, two coats of a shellac color varnish should be applied. This varnish should be made as described under the heading "Shellac Varnish Undercoating," except that enough color should be added to produce the desired shade. Four or five per cent. bismark brown in the shellac varnish will produce a desirable mahogany color. The amount of this material needed to get the best results should be determined by trial. The varnish should dry three or four hours before rubbing or recoating.

Each coat of shellac should be rubbed down lightly between coats without the use of oil.

#### FINISHING VARNISH.

A final flowing coat of airplane spar varnish should be applied and allowed to dry about 48 hours. This coating should not be rubbed or sanded.

#### ESTIMATED TIME REQUIRED TO COAT A PROPELLER.

The time required to apply the leaf to a propeller should not be more than 40 or 50 minutes. This could be reduced after the finisher becomes more experienced. The estimated time for applying the complete finish described would be in the neighborhood of 8 or 10 hours, and the entire total time needed for drying the various coats about 90 hours. The total time required for all operations would probably be in the neighborhood of 100 hours.

#### MODIFICATIONS OF ALUMINUM LEAF SPIRIT VARNISH PROCESS.

It might be desirable in some cases to use oil varnishes or enamels in lieu of the shellac described above. This may be done and satisfactory results obtained. If oil varnishes are substituted, a more durable coating may possibly be obtained, but it requires a much longer time to apply the finish because of the slowness with which oil varnishes dry. Each coat of varnish should dry at least 72 hours before recoating.

#### ACKNOWLEDGMENT.

Acknowledgment is made of valuable suggestions and co-operation extended the Forest Products Laboratory by the Airplane Engineering Department, Bureau of Aircraft Production, United States Army, at McCook Field, Dayton, Ohio, and by Mr. D. A. Kohr of Lowe Bros., Dayton, Ohio, in carrying out this work.



Fig. 6.—Smoothing off the laid leaf

### The Magnetic Field of the Sun

THE deduction from the electromagnetic theory of light made theoretically by H. A. Lorentz and verified experimentally by P. Zeeman, that by passing a beam of light through a magnetic field each spectral component is broken up into several components which are polarized, the number and polarization of the components depending upon the direction in which the light passes relatively to the direction of the lines of magnetic force, was applied several years ago to the investigation of the general magnetic field of the sun at the Mount Wilson Observatory. The results obtained were given in the *Astrophysical Journal*, 27, 1913. Using a polarizing apparatus with the 75-foot spectrograph of the large 150-ft. tower telescope, it was found that four lines in the third order specimen of a Michelson grating gave Zeeman displacements which agreed in sign and closely in magnitude with the theoretical values that would be deduced on the supposition that the sun was a uniformly magnetized sphere, the magnetic poles of the sun being at or near the poles of rotation. The approximate vertical intensity of the sun's general field at the poles was found to be about 50 gauss. Evidence was also obtained that the general magnetic field decreased rapidly in intensity in the upper levels of the solar atmosphere. It was a remarkable piece of work which enabled such conclusions to be put forward with confidence, based upon what at first sight appeared slender evidence, the displacements obtained being very small and not exceeding 0.001 Angstrom unit in amount. Further results since obtained have, however, confirmed the earlier conclusions; they are given in a paper by G. E. Hale, F. H. Seares, A. van Maanen and F. Ellerman in the *Astroph. Journ.* 206, 1918. In this paper, measures of displacements are given for 26 lines in the solar spectrum belonging to iron, chromium, nickel, vanadium, and titanium. Eighteen other lines, which had previously been found susceptible to the influence of the magnetic field in sun-spots, showed no measurable shift. The explanation of this is not clear. Using the laboratory data for the separation of these lines by a magnetic field of known strength, the field-strengths producing the observed separations were calculated and it was found that the field-strength decreased with increasing line-intensity. The strongest lines are those which originate in the upper levels of the solar atmosphere, and therefore this result is interpreted as indicating a field-strength diminishing rapidly with increasing elevation. Using Mitchell's results for the depths at which the chromospheric lines originate, it is concluded that the part of the field accessible to observation lies within the bounding surfaces of a thin shell in the solar atmosphere about 150 km. thick, and that definite values of the calculated field-strength always correspond to definite levels in the solar atmosphere.

The general nature of the sun's magnetic field may now be said to be known with some certainty, but the underlying causes of it remain obscure. The hypothesis that it is due to local whirls is examined, but the evidence on the whole seems to be against it.—*Science Progress*.

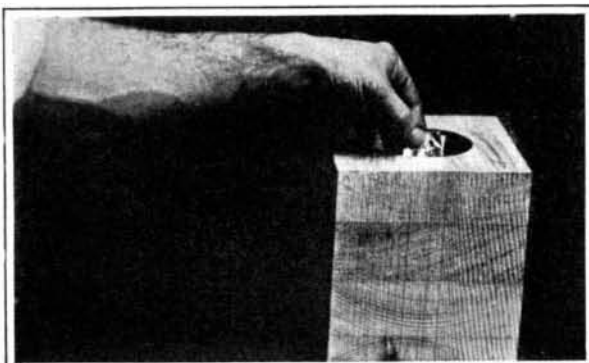


Fig. 7.—Applying leaf to large hub hole

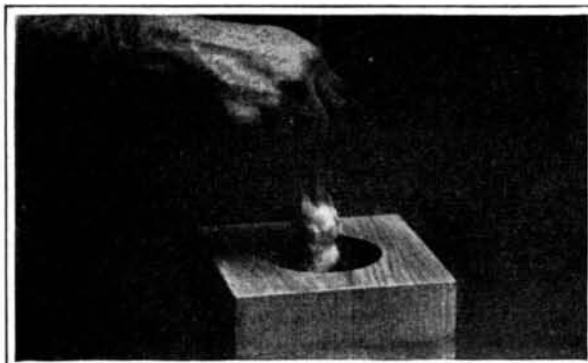


Fig. 8.—Smoothing off leaf in hub hole

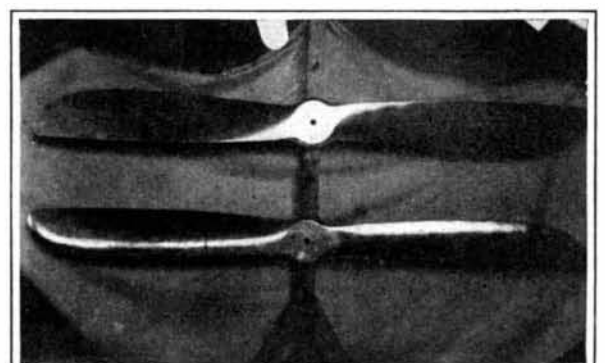


Fig. 9.—Two propellers completely leaf-coated