TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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AN INSTRUMENT FOR ESTIMATING TAUTNESS OF DOPED FABRICS ON AIRCRAFT

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SUMMARY

The linear deflections of doped fabrics under a given load serve as criteria for comparing the tautnesses of various panels. The usual type of tautness meter employs weights for loading and can be used only on approximately horizontal surfaces. This prevents its application for estimating the tautness of many wing and fuselage sections on the airplane itself or during their storage in vertical positions. A spring-loaded tautness meter has therefore been developed which can be used in both horizontal and vertical positions. Results of tests made on the fabric coverings of various airplanes are reported and discussed. It is concluded that the actual deflection of the fabric under the arbitrary 1-pound load, irrespective of the distance between ribs, is a more reliable criterion of the tautness than a deflection constant calculated on the assumption of a linear relation between deflection and spacing.

INTRODUCTION

Various methods for the measurement of the tautness of doped fabrics were reviewed in a previous publication (reference 1). It was concluded that the McGowan tautness meter provided a simple and rapid method for determining the relative tautness produced by different dopes on the same fabric attached to small experimental panels. With this instrument, the linear deflection of the fabric under a given load serves as a criterion for comparing the tautness of various panels. However, the McGowan tautness meter has the disadvantage that it can be used only on approximately horizontal surfaces. This prevents its use for checking the tautness of many wing and fuselage sections on the airplane itself or during their storage in vertical positions to conserve space. Therefore, at the request of the Bureau of Aeronautics, Navy Department, an instrument has been developed at the National Bureau of Standards for measuring the relative tautness of doped fabrics in both horizontal and vertical positions.

This investigation was sponsored by the Bureau of Aeronautics, U. S. Navy Department, and the results are published by permission of the Chief of that Bureau. The authors wish to express their appreciation of the interest and suggestions during the course of this work of Lieut. Comdr. C. F. Cotton and Mr. J. E. Sullivan of the Bureau of Aeronautics, and of Dr. Walter Ramberg of the National Bureau of Standards.

DESCRIPTION OF THE TAUTNESS METER

The tautness meter is shown in figure 1 in position for determining the tautness of doped fabric on a test panel. The method of application of the instrument to a wing section when same is in a vertical position is illustrated in figure 3. The instrument is essentially a Schiefer compressometer (reference 2), modified to adapt it to measuring the deflection of a doped fabric instead of the thickness and compressibility of textile fabrics and similar materials. A diagram of the construction of the instrument is shown in figure 2.

For measuring tautness, the instrument is placed upon the fabric, A, of a panel or wing section with the foot C, midway between the two ribs, B. The foot, C, is of spherical shape with a 0.5-inch radius of curvature. It is fastened to the bottom of the spindle, D, of the lower dial micrometer, E. The rod, F, is fastened to the top of the spindle, D, at G, and to the top of a helical spring, H, at I. The bottom of the spring is fastened to the tube, J, at K. The upper dial micrometer, L, is fastened to the top of the tube at M. The spindle, N, of the upper dial micrometer is attached to the rod, F, at O by a ball-and-socket union. The tube may be moved up or down relative to the frame, P, by turning the knob, Q, of the rack and pinion, R. The frame, P, consists of an aluminum beam having a three-point support which rests on the framework of the panel or on any two adjacent ribs of a wing, as shown in figures 1 and 2. Graduations on the beam indicate the width of the rib spacing so that the instrument may be centered quickly and conveniently. By turning the knob, the foot may be lowered upon the doped fabric. The load which is applied to the specimen by the foot may be ascertained from the upper dial reading, which indicates the elongation of the spring, and a calibration curve of the spring. The amount of deflection of the doped fabric when loaded is indicated on the lower dial, which is graduated to read directly to 1/1000 inch.

To calibrate the spring, the foot is placed above the center of one pan of a balance. A load is placed on the other pan. The foot is lowered until the two pans are in balance and the elongation of the spring is read on the upper dial. Similar readings are taken for the various loads which it is desired to apply to the doped fabric. The instrument which was used for the tests described in this report was calibrated for loads of 3 and 19 ounces, which were found to correspond to readings of 5 and 96 respectively on the upper dial.

TEST PROCEDURE

The instrument is placed in contact with the fabric-covered panel or airplane section as shown in figures 1 and 2. The foot is lowered upon the specimen by means of the rack and pinion until the load on the fabric is 3 ounces, as indicated by the upper dial. A reading of the lower dial is taken at this load. Then the load on the fabric is increased to 19 ounces and a second reading of the lower dial is taken. The difference between these two readings of the lower dial is the deflection in 1/1000 inches of the doped fabric under 1-pound load, as tested.

The initial load of 3 ounces corresponds approximately to the weight of the plunger and accessories on tautness meters for use on horizontal surfaces, such as the McGowan or the Schmidt gage (reference 3). Because of variations in the height of the taped surfaces supporting the frame, it is not practical to construct a tautness meter which will have a definite initial reading of the lower dial when the foot comes in contact with the fabric. The tautness meter described in this report could be adjusted so that an initial reading of the deflection dial at zero load could be obtained, because of the control of the application of the load by a rack and pinion. However, it is difficult to determine closely the position of the foot when it just makes contact with the fabric under zero load, and the ratio of deflection to load is greater, the lower the load. Any error in establishing the zero point would therefore be magnified in the deflection obtained with the 1-pound load. For these reasons and in order to obtain results which are comparable with other types of tautness meter, the initial load of 3 ounces was selected for our measurements.

RESULTS OF TESTS ON FABRIC-COVERED AIRPLANES

The practicability of utilizing the instrument for the estimation of tautness was demonstrated by tests made on the doped fabric of various airplanes. The results of these tests are shown in table I. It will be noted that the average deflections of the fabrics under the 1-pound load varied from 0.052 to 0.124 inch. The fabrics which gave deflections of more than 0.100 inch under the conditions of the test were considered to be in poor condition by a number of men familiar with aircraft maintenance.

DISCUSSION OF ACTUAL DEFLECTION VERSUS DEFLECTION CONSTANT VALUES

It has been suggested that a deflection constant calculated by the formula:

$$\text{Deflection constant} = \frac{\text{observed deflection}}{\text{rib spacing}} + \frac{\text{observed deflection}}{\text{span}} \quad (1)$$

would furnish a satisfactory measure of the tautness of a doped panel. Some values of this deflection constant of wing panel areas of various dimensions are shown in table II. It will be noted that for a given wing, the variation in the observed deflection caused by a 1-pound load is considerably less than the variation of the calculated deflection constant. Thus, for the wing of airplane No. 3, the observed deflections were between 0.055 and 0.061 for rib spacings of 8 to 12 inches and spans of 29 to 48 inches, whereas the calculated deflection constants varied from 0.0064 to 0.0097. All the areas on a particular wing can be considered to have had approximately similar treatment so far as initial fabric tension, amount of dope applied, and conditions of doping are concerned. It is therefore considered that the actual deflection of the fabric under the 1-pound load is a more reliable criterion of the tautness than the deflection constant calculated on the basis of a linear relation between deflection and spacing, for which there appears to be no theoretical basis.

An additional reason for using the actual deflection regardless of rib and span spacing as a measure of the tautness is the fact that it is this factor which governs the suitability of the fabric covering for flight purposes. The tolerance for the tautness of a fabric when the ribs are 14 inches apart is no greater than for ribs spaced 7 inches from each other. It is suggested, however, that in making tautness measurements areas with maximum rib spacing and span be slected for test and a record be kept of the shorter dimension between the supports, whether this be the rib spacing or the span.

EFFECT OF LOCATION OF LOADING ON TAUTNESS VALUE

Some measurements were made to determine the effect of applying the test load at various distances from the trailing edge. The locations on the span were varied from a point corresponding to one half the distance between ribs to a point at the middle of the span. The data in table III indicate that this is not a controlling factor in the deflection of the fabric under the 1-pound load. However, the values reported in table I were obtained with the foot of the tautness meter placed at the center of the panel area and it is believed desirable to adhere to this procedure for routine measurements.

CONCLUSIONS

1. A tautness meter which can be used in both horizontal and vertical positions has been developed for estimating the tautness of doped fabric surfaces on aircraft.

2. The deflection of the fabric under 1-pound load (measured between an initial load of 3 ounces and a final load of 19 ounces) serves as the criterion for comparing the tautness of different surfaces.

3. Measurements made on various airplanes at the Anacostia Naval Air Station are reported.

4. It is suggested that a desirable limit for maximum deflection measured under 1-pound load as described is 0.100 inch.

National Bureau of Standards,
Washington, D. C., December 13, 1937.

REFERENCES

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TABLE I

Tautness of Doped Fabrics on Aircraft

Identification number of airplane	Section of airplane tested	Number of measurements averaged	Average deflection by 1 lb. (in.)	Minimum and maximum deflection observed (in.)	Average rib spacing (in.)	Minimum and maximum rib spacing (in.)
1	Right elevator	5	0.089	0.082 - 0.095	10.9	9 - 12
2	Left elevator	6	.114	.102 - .133	10.4	8 - 12
2	Aileron	3	.124	.118 - .132	12.2	12 - 12.5
3	Left wing	8	.058	.055 - .061	9.9	8 - 12
3	Left elevator	4	.086	.077 - .093	11.5	10 - 12
3	Right wing	1	.070	-	12	12 - 12
4	Left elevator	3	.108	.103 - .111	11.5	11 - 12
5	Left wing	7	.092	.081 - .102	7.1	6 - 8
5	Right aileron	3	.086	.081 - .091	13.8	13.5-14
5	Left aileron	3	.095	.090 - .098	7	7 - 7
6	Right wing	5	.052	.049 - .055	12.8	11 - 14.5
6	Left wing	3	.058	.057 - .059	13.7	12 - 14.5
7	Right wing	8	.071	.066 - .074	10.1	7 - 12
8	Stabilizer	3	.072	.070 - .075	12	11 - 13
9	Right elevator	5	.088	.084 - .094	11.5	10 - 12
9	Left aileron	5	.077	.070 - .081	11.2	10 - 12
9	Right aileron	5	.085	.082 - .087	11.2	10 - 12
10	Wing	1	.064	-	10	-
11	Wing	3	.066	.056 - .076	8.3	5 - 10

TABLE II

Effect of Rib Spacing and Span on Deflection of Doped Fabric

Identification number of airplane	Rib spacing (in.)	Span (in.)	Deflection by 1-pound load (in.)	Deflection per inch of rib spacing (in.)	Deflection per inch of span (in.)	Combined deflection constant computed by equation (1) (in.)
3	8	29	0.055	0.0069	0.0015	0.0084
	8	36	.061	.0076	.0021	.0097
	9	36	.057	.0063	.0016	.0079
	9	48	.061	.0068	.0013	.0081
	10	36	.057	.0057	.0016	.0073
	11	48	.060	.0055	.0013	.0068
	12	36	.058	.0048	.0016	.0064
	12	36	.058	.0048	.0016	.0064
7	7	50	.066	.0094	.0013	.0107
	9	35	.069	.0077	.0020	.0097
	9	50	.069	.0077	.0014	.0091
	10	35	.074	.0074	.0021	.0095
	11	50	.074	.0067	.0015	.0082
	11	50	.070	.0064	.0014	.0078
	12	35	.072	.0060	.0021	.0081
	12	35	.070	.0058	.0020	.0078
2	8	40	.106	.0133	.0027	.0160
	9	22	.108	.0120	.0049	.0169
	10	22	.102	.0102	.0046	.0148
	11.5	30	.109	.0095	.0036	.0131
	12	22	.133	.0111	.0060	.0171
	12	22	.125	.0104	.0057	.0161

TABLE III

Effect of Applying Load at Various Distances from Trailing Edge on the Deflection of the Doped Fabric

Identification number of airplane	Section of airplane tested	Rib spacing (in.)	Span (in.)	Distance from trailing edge (in.)	Deflection by 1-pound load (in.)
3	Left wing	12	36	6 12 18	0.066 .060 .058
3	Right wing	12	36	6 12 18	.071 .074 .070
5	Right wing	7	42	3.5 7 10.5 21	.084 .085 .087 .091
6	Right wing	12	36	6 12 18	.052 .051 .053

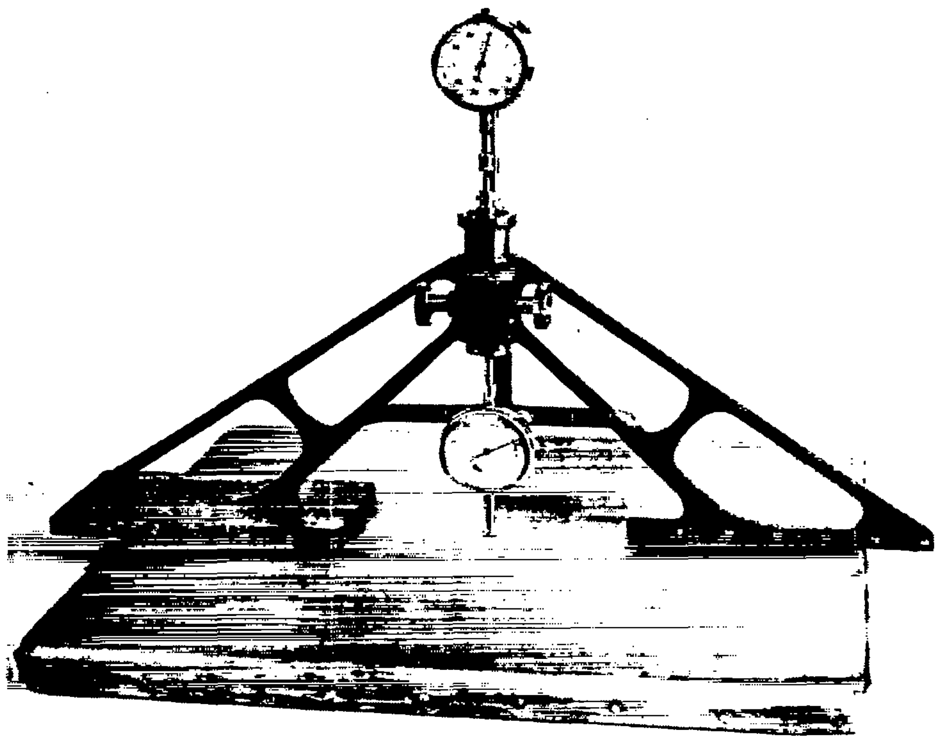

Figure 1.- Spring-loaded tautness meter.

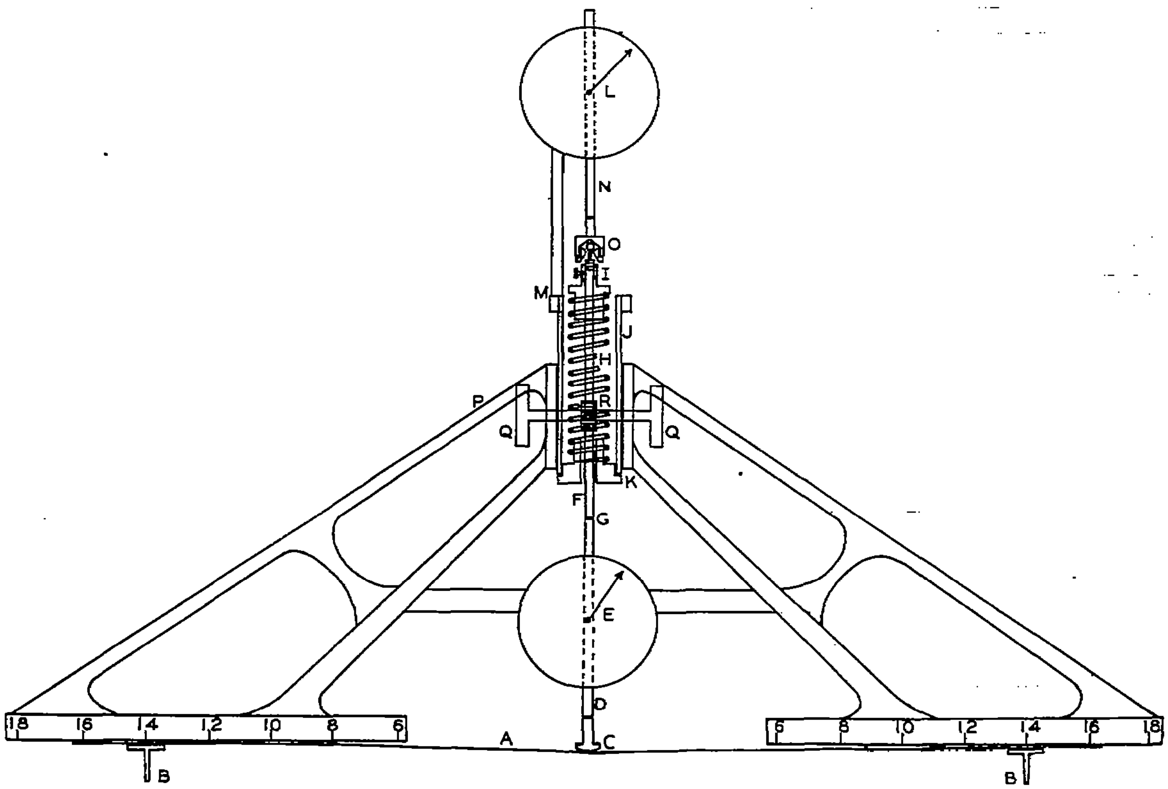

Figure 2.- Schematic diagram of essential details of the tautness meter.

Figure 3.-Application of tautness meter to a wing section.