Yale University
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DEVELOPMENT OF NON-DESTRUCTIVE TESTS FOR LAMINATED GUNSTOCK BLANKS

Progress Report No. 4
December 1, 1953 to January 31, 1954

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Development of Non-destructive Tests for Laminated Gunstock Blanks. Progress Report No. 4 for the period December 1, 1953 to January 31, 1954

Introduction

This is the fourth of a series of progress reports on work undertaken at the Yale School of Forestry to develop a practical method of testing laminated gunstock blanks with respect to integrity of the glue bond. The study is sponsored by the Springfield Ordnance District of the Department of the Army under Contract No. SAR/DA-19-059-ORD-1329.

The study anticipates the application of appropriate non-destructive test methods followed by recognized destructive testing of gunstock blanks fabricated under production conditions in a commercial laminating plant. Work began on June 1, 1953, with a review of literature pertaining to the subject. The first progress report of this series included a description of exploratory testing with x-ray absorption and high-frequency sound transmission techniques, in addition to the literature review mentioned above. The second progress report presented sound transmission data collected on several laminated blanks assembled in a manner to simulate gunstock Types B and C, Class 1.[/1] In addition, x-ray photographs of the same blanks were included in the second progress report. The third report contained an analysis of the ultrasonic energy transmission data that had been presented in the second report.

This fourth report includes a complete working plan for the destructive

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/1 Final Report, Laminated Gunstock Blanks. Gamble Bros., Inc. Louisville, Kentucky. Research No. G.G. 3728, Order No. S.A. 7220-50, March 14, 1952.

testing portion of this study. Preliminary data collected from an experimental delamination test are also presented. In addition, the results of non-destructive audio-frequency vibration testing are presented on the first fifty gunstock blanks to be processed. It is anticipated that results of the destructive testing of these blanks will be presented in the next progress report when more complete information will have been accumulated and a comparison between destructive tests and non-destructive test of the audio-frequency vibration variety can be made. Further methods of non-destructive testing are being sought and will be incorporated in future tests of gunstock blanks if preliminary trials appear promising.

No additional information relative to applicable non-destructive test methods has been uncovered since the previous progress report; therefore the literature review section has been omitted from this report. However, it is intended to continue this review throughout all succeeding reports when suitable material is found. This is done to provide a complete bibliography at the termination of the project.

Experimental Testing

Testing by Ultrasonics

No new additional data have been collected in this phase of the project. As mentioned in Progress Report No. 3 of this series two new transducers of larger dimensions and higher frequency responses have been obtained and assembled into sending and receiving units. These transducers will be evaluated on the basis of the results obtained in detecting defective areas in laminates as compared to the results obtained on the same laminates with the original pair of transducers.

Due to the small face area and the relatively low resonant frequency of the original pair of transducers it is believed that considerable scattering of ultrasonic energy occurred. Transducers with a larger face area and a higher frequency response will result in less beaming of the ultrasonic energy and thus possibly allow a more critical detection of the magnitude of glue line voids. In addition, with higher frequencies it should be possible to detect defects of less depth provided that the wood is not of such a nature as to completely attenuate the ultrasonic waves. Thus, it may be possible that defective areas in laminates where a glue line is present, but no bonding has occurred, may be detected. The new transducers are resonant at 68 kilocycles, but they may also be driven efficiently at harmonics of 220 and 450 kilocycles, thus giving a wide range of testing frequencies. More thorough data of this nature will be presented in future reports.

Testing by Audio-frequency Methods

Six laminated black walnut beams have been assembled with a room-temperature setting, phenol-resorcinol adhesive. Four of the beams consisted of two end-matched pairs. This was done to provide similar physical and mechanical properties within each matched pair. One laminate of each pair was assembled with a considerable portion of the total glue line area containing either waxed areas or areas devoid of adhesive. The remaining laminate of each pair was assembled free of any defective areas. Each beam consisted of two laminations of the dimensions 3/4 x 2 1/2 x 30 in.

The remaining two laminates consisted of three laminations each of the dimensions 3/4 x 6 x 30 in. As described above one beam was assembled free of defective areas while the second contained defective areas taking the form of waxed spots and glue line voids.

All six beams were vibrated at their resonant frequency and the decay of vibration from resonance was observed and photographed on the screen of a cathode-ray oscilloscope. A free-free method/2 of support was used for vibrational purposes, support being obtained by loops of fine linen thread at the nodal points. The use of thread for support has been found most suitable since the amount of external vibration transmitted to the beam is reduced to a minimum. A 5-in., moving-coil loud speaker was used as an exciter. This was placed approximately 1/8 in. below the beam at mid-span. Vibration of the beam was converted to an electric signal by means of a phonograph cartridge pick-up (a Rochelle-salt crystal) and displayed on the screen of the oscilloscope. The cartridge was placed in contact with the vertical face of the beam near one end.

The test proper consisted of sweeping an audio-signal generator through a frequency range, amplifying the signal by means of an audio amplifier, and applying this signal to the loud speaker. By means of air coupling the vibration of the cone of the speaker was transmitted to the beam. When the audio-signal generator was tuned to the resonant frequency of the beam, maximum amplitude of vibration occurred and was observed on the oscilloscope screen. A schematic diagram of the test apparatus is shown in Fig. 1.

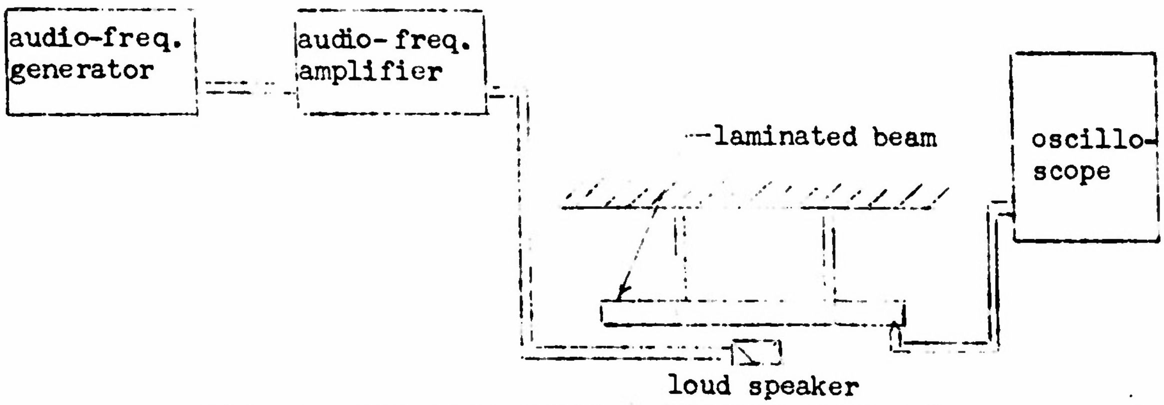

Fig. 1. Schematic diagram of test apparatus for vibrational testing in the audio-frequency range.

/2 Support is obtained in such a manner that the ends are free to vibrate.

After the beams had been set into vibration the frequency at resonance was recorded and a photograph was obtained of the decay envelope of vibration after the exciter had been switched off. The switching of the oscillator and photographing of the decay envelope were controlled manually. Using the internal sweep frequency of the oscilloscope, this method appears to be quite satisfactory.

The resonant frequency is related to Young's modulus by the fundamental relationship:

$$f_r \propto \sqrt{\frac{E}{d}}$$

where f_r = fundamental resonant frequency

E = Young's modulus of elasticity

d = density/2

From the photograph of the decay of vibration, the log decrement, a measure of internal friction, may be computed from the formula:

$$\delta = \frac{1}{n} \ln \frac{A_1}{A_n}$$

where A_1 and A_n are the amplitudes of two vibrations n cycles apart./4

The following results were obtained on the three pairs of laminated beams. Numbers 1 and 2 are an end-matched pair consisting of two laminations each, as are 3 and 4. Numbers 5 and 6 are a pair consisting of three laminations each. Blank nos. 1, 3, and 5 were assembled free of defects

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/2 Progress Report No. 1 Development of Non-destructive Tests for Laminated Gunstock Blanks. June 1 to July 31, 1953.

/4 Progress Report No. 3 Development of Non-destructive Tests for Laminated Gunstock Blanks. October 1 to November 30, 1953.

while blank nos. 2, 4, and 6 contained defective areas as described previously.

Blank No.	f_r	δ
1	237	.0370
2	234	.0460
3	225	.0420
4	232	.0460
5	573	.0285
6	550	.0335

These preliminary results support data presented by Galginaitis and others/5 indicating that there may be a relation between internal friction of laminates and the quality of an adhesive bond. The relationship between Young's modulus and bond quality, however, is not as consistent. Obviously it will be necessary to obtain considerably more data before any definite conclusions may be drawn.

On the basis of these results and the results of Galginaitis and associates mentioned above, twenty-five gunstocks of Type B and twenty-five of Type C, Class 1 of a shipment of 250 gunstock blanks received at the Yale Forestry School have been vibrated, the frequency at resonance recorded, and the log decrement of vibrational decay computed from photographs of the decay envelope. The gunstocks were supported in a free-free manner with loops of fine linen thread. Only vibrations normal to the plane of the principal glue lines have been employed in this initial analysis. In the

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/5 Galginaitis, S. V., E. L. Bell, A. M. Fine, and G. Auer. *The Non-Destructive Testing of Wood Laminates*. Final Report. Office of Naval Research, University of Louisville, Institute of Industrial Research.

future it is planned to vibrate the gunstocks normal to the edge joints as well as to the principal glue lines.

Since both gunstock types were of a varying cross-sectional area, it was necessary to locate the nodal points for a free-free method of support. This was carried out by use of Lissajous figures on the oscilloscope screen and by location of the point of zero amplitude of vibration. Both methods located the nodal points accurately. The results of vibrational testing of the first fifty gunstocks are presented in Table 1. Due to the varying cross-sectional area of the gunstocks, Young's modulus has not been computed. Instead resonant frequency is presented.

Table 1. Vibrational data collected on fifty gunstock blanks.

Gunstock Type B			Gunstock Type C, Class 1		
Blank No.	f_r	δ	Blank No.	f_r	δ
1	430	.0225	26	497	.0275
2	427	.0225	27	518	.0210
3	423	.0275	28	518	.0245
4	425	.0240	29	528	.0290
5	448	.0230	30	487	.0230
6	399	.0235	31	494	.0290
7	402	.0245	32	505	.0295
8	423	.0215	33	499	.0295
9	421	.0245	34	485	.0265
10	360	.0235	35	500	.0220
11	418	.0220	36	500	.0230
12	433	.0220	37	460	.0215
13	425	.0245	38	519	.0240
14	437	.0210	39	452	.0285
15	420	.0245	40	515	.0190
16	440	.0205	41	533	.0235
17	382	.0265	42	498	.0200
18	420	.0235	43	501	.0285
19	428	.0190	44	512	.0240
20	430	.0225	45	473	.0290
21	438	.0235	46	533	.0220
22	421	.0245	47	490	.0190
23	424	.0255	48	510	.0205
24	402	.0220	49	529	.0245
25	428	.0230	50	495	.0240

It is apparent from the results obtained from vibrational testing that quite a wide variation exists in resonant frequency and the log decrement of the group of fifty gunstock blanks tested. The resonant frequencies of the gunstocks of Type C, Class 1 are obviously higher than those of Type B. This would be expected due to the greater depth of cross section of Type C. The range of log decrement (δ) for the two types is essentially the same. Destructive data are not yet available to compare with these non-destructive test results.

Testing by Destructive Methods

One blank consisting of three 3/4 x 6 x 36-in. laminations has been assembled with Cascophen LT-68 (a phenol-resorcinol). The blank was subjected to an elevated temperature cure at 180° F for a period of 10 hours. It was stored for a period of 10 days and then divided into eleven 3-in. delamination sections, allowing 3 in. for end trim of the blank. The delamination sections were subjected to a standard vacuum-pressure cycle while immersed in water. The sections were then subjected to a drying period at 80° F and 25 percent relative humidity.[6]

Maximum delamination occurred after 4 days of drying. It is planned to use this schedule in the destructive testing of the laminated gunstock blanks.

A recent shipment of 250 gunstock blanks (125 of Type B and 125 of Type C, Class 1) has been received from Gamble Brothers Inc., Louisville, Kentucky. A working plan for the destructive testing of the gunstock blanks has been formulated and is presented in the Appendix of this report. It is now apparent that the original goal of testing 400 gunstock blanks

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[6] This delamination cycle is described more completely in the "Working Plan for the Destructive Testing of Type B and C, Class I Gunstock Blanks" presented in the Appendix of this report.

cannot be attained and present plans are to complete non-destructive and destructive tests as outlined on 200 of these 250 blanks within the contract period. Twenty-five gunstocks of Type B have been sawn into delamination and shear sections and the shear testing completed. Delamination testing of the sections from these blanks will be undertaken at a later date.

When the entire destructive testing of several groups of blanks has been completed (delamination and shear), the results of destructive and appropriate non-destructive tests employed will be presented.

Plans for Future Work

Future plans call for the assembly of several end-matched pairs of laminated blanks. One blank of each pair will contain defective areas while its mate will be free of defects. These blanks will be assembled specifically for vibrational testing, but will also be subjected to other non-destructive tests being explored. Destructive testing of experimental blank nos. 1 through 6 will be completed in the near future and an attempt made to correlate these results with the non-destructive test results obtained.

Additional improvement of electronic equipment is necessary for accurate measurement of the vibrational characteristics of the blanks. These improvements are to be made before the next group of blanks is processed.

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APPENDIX

Working Plan for the Destructive Testing of Type B and Type C, Class 1 Gunstock Blanks

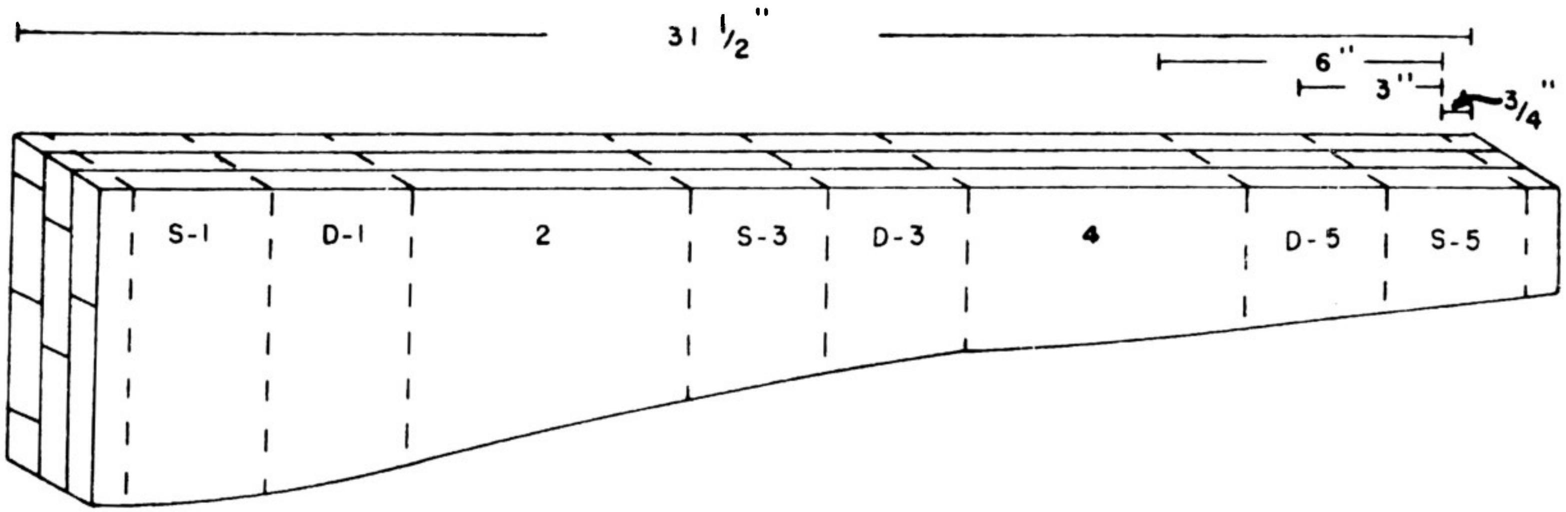
Two hundred gunstock blanks will be available for destructive testing, 100 of Type B and 100 of Type C, Class 1. Twenty-five of each type will be prepared for testing, and the shear tests on these 50 gunstock blanks will be completed. Following this the remaining 75 Type B and 75 Type C, Class 1 blanks will be cut into the specified sections as shown in Figures 1 and 2 in order that all delamination specimens can be tested at one time. When the delamination testing is completed the shear sections of the remaining 150 gunstock blanks will be prepared and tested.

Preparation of Gunstock Blanks for Testing

Initially each gunstock blank will be numbered consecutively from 1 to 150 with black keel. Type B blanks will be numbered 1-25, 51-75, 101-125, and 151-175; Type C, Class 1 blanks will be numbered 26-50, 76-100, 126-150, and 176-200.

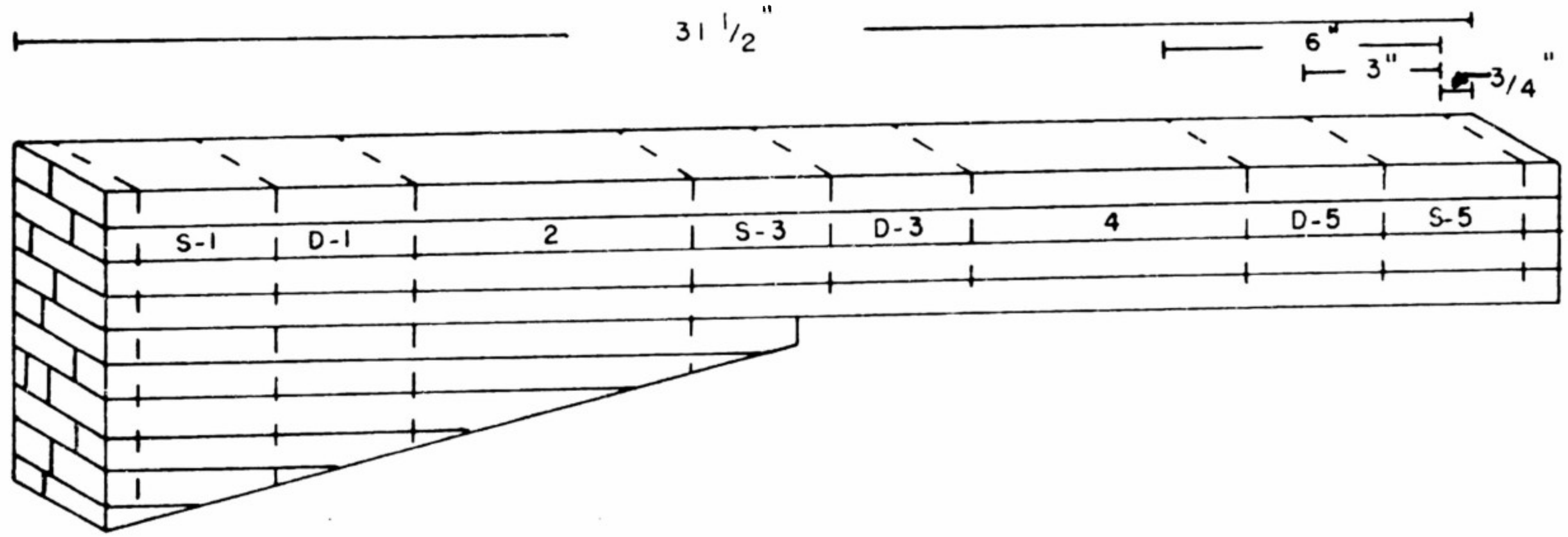
Beginning at the butt end of each gunstock blank (Figures 1 and 2), a 3/4-in. section in length along the grain will be trimmed. Then five 6-in. sections will be cut and the initial blank number plus the section number (1 to 5) will be marked in black keel on each section. Sections 1, 3, and 5 will then be cut into two 3-in. sections. In blocks 1 and 5 the 3-in. sections adjacent to the ends of the blank will be used for shear tests. The 3-in. section adjoining each of the shear sections will be used for delamination tests. Each 3-in. section will be numbered as above plus the letter -D- to designate a delamination specimen and the letter -S- to designate a shear section. Sections 2 and 4 will be held in reserve for

FIGURE 1.



CUTTING DIAGRAM OF
TYPE B GUNSTOCK BLANKS

FIGURE 2.



CUTTING DIAGRAM OF
TYPE C-1 GUNSTOCK BLANKS

possible future testing and will be stored in an unheated room. Sections 1, 3, and 5 will also be stored in an unheated room prior to testing.

In machining the standard shear test specimens,[1] care will be taken to make the loading surfaces smooth and parallel to each other and perpendicular to the face. Care will also be exercised to ensure that the longitudinal saw cut extends to, but not beyond, the bearing surface. A sharp tungsten-carbide tipped saw will be used for all cutting.

The shear sections from Type B gunstock blanks (Figure 1) will be cut as follows: Section 1 will be cut into three equal parts perpendicular to the principal glue lines to form three shear blocks, section 3 will be cut into two equal parts to form two shear blocks, and section 5, being only 2¼ in. wide at the barrel end, will form one shear block. This will make a total of six shear blocks or twelve shear tests per gunstock blank. A ¼-in. step will be cut in each lamination to form a series of three steps. The steps will start at the face[2] lamination at the butt end of the section. Each lamination of each shear block will be numbered in black keel with the gunstock blank numbwr, the section number, the designating letter (D or S), the designating letter showing the position of the block in the section (T, M, or B),[3] and a sub-number to designate the lamination (1, 2, or 3). The face lamination will always be the number 1 lamination (Example: $1\text{-}1_1\text{-S-T}$ is blank 1, section 1, shear section, top, and lamination 1). Glue line 1 will be the glue line between laminations 1 and 2, and glue line 2 will be the glue line between laminations 2 and 3.

/1 ASTM Designation: D905-49. Standard Method of Test for Strength Properties of Adhesives in Shear by Compression Loading.

/2 The face implies that lamination which is on the right side when the gunstock blank is held against the shoulder.

/3 Top, middle, and bottom, respectively.

The shear sections cut from the Type C, Class 1 gunstock blanks (Figure 2) will be cut as follows: Section 1 will be divided into two sections (1 and 1') by band-sawing the center lamination on its center line. Each section will then be cut with a ¼-in. step in each lamination to form a series of five steps. Sections 3 and 5 will be cut with a ¼-in. step in each lamination to form a series of four steps. This will make a total of 3 shear blocks or fourteen shear tests per gunstock blank. The steps will start at the top lamination./4 Each lamination will be numbered as in the Type B blanks except that the letter designating the position of the block in the section will be omitted and the top lamination will be numbered 1. (Example: 1-1_1-S is blank 1, section 1, shear section, and lamination 1.)

The width and height of the shear block at the glue line will be measured to the nearest 0.01 in. to determine the shear area.

Delamination specimens will be marked on the end surfaces with the letters F or B designating the front or the back. The front will be the end surface closer to the barrel end of the gunstock blank. Each glue line will be numbered starting from the face lamination on the Type B blanks and from the top lamination on the Type C, Class 1 blanks.

Block Shear Test

Load at failure in shear in pounds per square inch and the percentage of wood failure will be recorded for each test. A platen speed of 0.015 in. per minute will be used. Upon completion of the shear testing of the principal glue lines, the edge joints in each lamination of each shear block will be tested by a chisel method to determine percentage of wood failure.

/4 The top implies that lamination which is on top when the gunstock blank is held against the shoulder.

Delamination Test

The 3-in. delamination specimens will be subjected to a soak-dry delamination test patterned after Military Specification MIL-A-397.

Vacuum-pressure Cycle. The specimens will be placed in an autoclave, weighted down, submerged in water, and subjected to two consecutive cycles of vacuum and pressure, each consisting of a vacuum of 20 in. of mercury maintained for 2 hours followed by pressure of 75 p.s.i. for 2 hours.

Drying Period. The specimens will then be dried in a humidity cabinet for a period of 4 days in circulating air at 80 to 85° F. and 25 to 30 percent relative humidity. Air velocity will be maintained at the rate of 200 ± 50 feet per minute. During the drying, the specimens will be placed at least 2 in. apart with the front and back (end) surfaces parallel to the direction of air movement.

Duration of Test. Three cycles of soaking and drying for a total period of 13 days.

Measurement of Delamination. Measurement of delamination will be made on all adhesive lines of both cross-sectional surfaces at the end of each cycle of the drying period. Prior to subjecting the specimens to the cycling, the cross-sectional surfaces will be sanded in order that delamination may be determined more accurately. Delamination will be read to the nearest 0.1 in. and the percentage of delamination will be calculated by dividing the total length of delamination measured along all glue lines on both end surfaces by the total length of the glue lines.

Moisture Content and Specific Gravity Determination

Immediately following the shear testing of section 1 of the Type B blanks, each lamination of the top and bottom block will be sanded to remove slivers and weighed. The blocks will then be oven dried and reweighed at constant weight and their moisture contents determined. Immediately after oven-dry weights have been taken the specimens will be dipped in paraffin, and their volumes taken by the immersion method. Specific gravity will then be determined on an oven-dry weight, oven-dry volume basis. The same procedure will be followed for section 1 of the Type C, Class 1 blanks with the exception that all laminations will be used.

Results

Results of these destructive tests will be employed as follows:

1. To provide a basis for evaluating the quality of glue lines in individual gunstock blanks for possible correlation with the results of non-destructive tests of the same blanks.
2. To furnish data relative to the variation in quality of glue bonds in commercially laminated stock.
3. To provide data for statistical analyses to determine the feasibility of using a sample taken from one end of a gunstock blank to represent the entire blank.

Preliminary Delamination Data to Establish Length of Drying Cycle for Black Walnut

The following is a group of raw data obtained over a period of six days on the experimental blank assembled for the purpose of determining a drying schedule for the delamination test. Delamination is recorded to the nearest 0.1 in. and the percentage of delamination based on the entire glue line length of the front and back of each section (24.4 in.) is recorded at the bottom of each sheet column of readings. Delamination readings were taken every 24 hours for a period of six days.

Sec. No.		Glue Line No.	Visible delamination at various periods in drying cycle											
			1 day		2 days		3 days		4 days		5 days		6 days	
			Front	Back	Front	Back	Front	Back	Front	Back	Front	Back	Front	Back
1	Delamination, in.	1	0.0	0.1	0.0	0.2	0.0	0.2	0.0	0.3	0.0	0.2	0.0	0.2
	" "	2	0.0	0.0	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.1	0.0
	" "	Total	0.1		0.5		0.5		0.6		0.3		0.3	
	Delamination, %	Total	0.4		2.1		2.1		2.5		1.2		1.2	
2	Delamination, in.	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	" "	2	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
	" "	Total	0.0		0.1		0.1		0.1		0.1		0.1	
	Delamination, %	Total	0.0		0.4		0.4		0.4		0.4		0.4	
3	Delamination, in.	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	" "	2	0.0	0.0	0.1	0.0	0.1	0.0	0.2	0.0	0.1	0.0	0.1	0.0
	" "	Total	0.0		0.1		0.1		0.2		0.1		0.1	
	Delamination, %	Total	0.0		0.4		0.4		0.8		0.4		0.4	
4	Delamination, in.	1	0.1	0.0	0.2	0.1	0.2	0.1	0.2	0.1	0.0	0.0	0.0	0.0
	" "	2	0.1	0.0	0.4	0.0	0.4	0.0	0.4	0.0	0.0	0.0	0.0	0.0
	" "	Total	0.2		0.7		0.7		0.7		0.0		0.0	
	Delamination, %	Total	0.8		2.9		2.9		2.9		0.0		0.0	
5	Delamination, in.	1	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
	" "	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	" "	Total	0.1		0.1		0.1		0.1		0.0		0.0	
	Delamination, %	Total	0.4		0.4		0.4		0.4		0.0		0.0	
6	Delamination, in.	1	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.1	0.0	0.1
	" "	2	0.2	0.0	0.4	0.2	0.4	0.2	0.4	0.3	0.1	0.1	0.0	0.1
	" "	Total	0.2		0.8		0.8		1.0		0.3		0.2	
	Delamination, %	Total	0.8		3.3		3.3		4.1		1.2		0.8	
7	Delamination, in.	1	0.1	0.0	0.5	0.2	0.5	0.2	0.6	0.2	0.6	0.1	0.5	0.1
	" "	2	0.0	0.0	0.1	0.0	0.1	0.1	0.2	0.1	0.1	0.0	0.1	0.0
	" "	Total	0.1		0.8		0.9		1.1		0.8		0.7	
	Delamination, %	Total	0.4		3.3		3.7		4.5		3.3		2.9	

Sec. No.		Glue Line No.	Visible delamination at various periods in drying cycle											
			1 day		2 days		3 days		4 days		5 days		6 days	
			Front	Back	Front	Back	Front	Back	Front	Back	Front	Back	Front	Back
8	Delamination, in.	1	0.0	0.0	0.0	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1
	" "	2	0.1	0.0	0.2	0.1	0.2	0.0	0.2	0.1	0.0	0.0	0.0	0.0
	" "	Total	0.1		0.5		0.5		0.6		0.2		0.2	
	Delamination, %	Total	0.4		2.1		2.1		2.5		0.8		0.8	
9	Delamination, in.	1	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.4	0.0	0.3	0.0	0.3
	" "	2	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
	" "	Total	0.0		0.2		0.3		0.5		0.4		0.4	
	Delamination, %	Total	0.0		0.8		1.2		2.1		1.6		1.6	
10	Delamination, in.	1	0.1	0.0	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1
	" "	2	0.0	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1
	" "	Total	0.2		0.6		0.6		0.6		0.4		0.4	
	Delamination, %	Total	0.8		2.5		2.5		2.5		1.6		1.6	
11	Delamination, in.	1	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.1	0.0	0.1
	" "	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	" "	Total	0.0		0.2		0.2		0.2		0.1		0.1	
	Delamination, %	Total	0.0		0.8		0.8		0.8		0.4		0.4	

It is obvious from the data presented above that maximum delamination occurred on the fourth day of drying. As mentioned previously, this schedule will be used in the destructive testing of the gunstock blanks.

Distribution List

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District Chief Springfield Ordnance District Springfield 1, Massachusetts Attention: Contracting Officer	(1)
Central Air Documents Office U. B. Building Dayton 2, Ohio	(2)