BEECHCRAFT

I. INTRODUCTION

a. In 1936 the first serious accident to Beechcraft Airplanes (17 Series) occurred which indicated that the structure was not entirely airworthy. Subsequent accidents caused the facilities of the Civil Aeronautics Administration, National Advisory Committee for Aeronautics, and the Material Division of the Army Air Corps to be combined to solve these problems.

b. Tests on the subject (17 series biplanes) aircraft were made independently, and at different times. These data were then compared, discrepancies discussed, and final conclusions obtained.

II. BEECHCRAFT ACCIDENTS

a. It was considered wise to present a brief resume of the accidents to Beechcraft (17 series) Biplanes to clarify events which preceeded the rather exhaustive flutter investigation.

1. Beechcraft B17R, Serial No. 68, NC 281y. This accident occurred at Dunlo, Pennsylvania on April 19, 1936. Fred Harvey and his wife were fatally injured. This airplane lost pieces of fabric, plywood, wing ribs, fairing, wing leading edge, and all of its wing tips. These parts of the structure were found scattered over approximately a 2 1/2 mile distance behind the wreckage. Icing conditions were reported (unofficially) very bad at the time of the accident. The pilot was probably forced to fly on instruments, and it was considered possible that the airplane had gotten away from him, and he had reached a fairly high speed.

2. Beechcraft B17L, Serial No. 41, NC 15403, at Louen, Mississippi, on June 19, 1938; fatal accident involved the pilot only. The pilot was flying through a severe storm; he was probably on instruments and a novice. This airplane lost the vertical fin, all the ailerons, and all the wing tips from the strut-point outboard. It was apparently in a high speed dive at the time it disintegrated. The wings remained on the ship, though the fabric was torn off.

3. Beechcraft B17R, Serial No. 119, NC 17008, at Farnhaven, Mississippi, November 12, 1939. Evidence shows that the pilot obtained excessive speed. The airplane lost both left wings, and dove into the ground, rotating slowly. Bad flying weather with overcast was reported, and the pilot was probably flying on instruments.

4. Beechcraft D17S, Serial No. 234. This accident occurred in India in 1939. The plane was flying in turbulent air and disintegrated completely; scattering wing parts over a large area.

5. Beechcraft F17D, Serial No. 309, NC 293y, Wichita, Kansas, about August 30, 1939. The second test pilot at Beechcraft Factory was flying this airplane at the time of the accident, and was killed. This airplane was new, and had only about four or five hours flying time. The pilot was performing acrobatics, to some extent, while putting on the usual seven to ten hours service time on the airplane prior to its delivery. The pilot came out of a long dive with considerable speed, and levelled off at about 5000 feet altitude. The plane disintegrated completely, and wing parts were scattered over a large area. The air was reported somewhat gusty at the time.

6. Beechcraft F17D, Serial No. 244, NC 19472, at Blacksburg, South Carolina, during May 1940. This accident resulted in the death of the pilot. The airplane disintegrated completely in air under similar circumstances as those reported in paragraphs 4 and 5 above.

7. Beechcraft F17D, Serial No. 330, NC 2863, Jamestown Airport, Jamestown, New York. The pilot with four passengers, was approaching Jamestown Airport at an indicated airspeed of about 185 m.p.h. in approximately a 45 degree bank. The wheels were retracted, and the throttle was back against the throttle stop. Air conditions were somewhat bumpy, but not unusually severe.

The pilot had just started to open the throttle when the ailerons and wings began to flutter. The ailerons appeared to move throughout their full travel, while the wings vibrated vertically, at the tips with an amplitude of approximately six inches. This wing motion was also combined with a fore and aft motion. From the ground the aileron flutter was noticeable first; followed by wing flutter. This motion continued about two seconds, at which time the airplane became heavy in the nose and left wing. The pilot then pulled the throttle back again and found it necessary to pull the control column well back to make the airplane climb and loose speed. From the time the airplane became nose heavy the flutter lasted nearly one minute; diminishing as the speed was reduced until it finally stopped. In spite of extensive wing structural failure the aircraft was able to continue in flight, and subsequently made a safe landing at Jamestown Airport.

III. TEST DATA

a. Four models of the Beechcraft 17 series of biplanes were tested. They are most conveniently identified as follows:

Beechcraft Model	Placard Never Exceed Speed (MPH)	Design Diving Speed (Vg) (MPH)	Design Level Flight Speed (V_L) (MPH)	Gross Wt. (Pounds)	Power Take-off H.P.	Iden. No.
C17R	225	250	206	3900	420	NC 2
D17S	256	284	211	4200	450	GB 1
E17B	222	247	183	3550	285	NC 91
F17D	222	284	189	3550	330	---

b. These four Beechcraft models are similar in general construction, arrangement, and dimensions; i.e., span, chord, gap, decalage, etc.. However, certain differences exist in control surface arrangements, dynamic balance, spar sizes, rib spacing, and tail bracing that might be expected to influence the vibration characteristics.

c. The possibly dangerous wing cellule natural* frequencies and modes of oscillation for the Beechcraft (17 series) biplanes are presented in Table 2.

Complete data of natural frequencies and modes of oscillation are contained in TABLE 3.

*Complete data on natural frequencies and modes of Beechcraft Model F17D are contained in a letter from N.A.C.A. - Flutter of Beechcraft Biplanes, dated 6-20-40; filed in special accident files (622.0000) CAA, Washington office.

Complete tables of natural frequencies and modes of Beechcraft (C17R, D17S, E17B) Airplanes are contained in a report by the War Department, Air Corps, Material Division, Serial No. EXP.-M-51/C300-4, dated 7-19-40. This report is filed with the CAA (Washington office) in the Technical Files, Flutter Data, file No. 612.0410.

TABLE 2

Dangerous Modes & Frequencies of
Beechcraft (17 series) Biplanes

Part Tested	Mode of Vibration	Frequencies C17R	D17S	E17B	F17D
	Combined Bending & Torsion of Entire Cellule	800	800	820-840	
	Maximum Bending & Torsion of Lower Wing	1360	1220	1200-1300	
Wing	Maximum Bending & Torsion of Upper Wing	1100	1350	1150	
	First Unsymmetrical Torsion of Whole Cellule				800
	First Symmetrical Bending of Whole Cellule				800
	First Symmetrical Torsion of Whole Cellule				1320
Ailerons	Symmetrical Oscillations About Hng. Line	---	850-900	900-1000	
	Aileron Against Controls				1100
Flaps	Torsion of Flap Against Control System	---	1060	1020	
	Local Torsion in Flap				1100

AIR CORPS REPORT	N.A.C.A.
EXP. -M-51/C300-4	Report

MASS BALANCE

The static balance of the ailerons and flaps was checked experimentally for the Models E17B, NC 91 and D17S, GB1. The results are as follows:

	Model E17B		Model D17S	
	R.H. Aileron	R.H. Flap	R.H. Aileron	R.H. Flap
Wt. In Pounds	15.4	11.2	16.5	12.0
Static Unbalance in inch pounds	1.6	18.5	7.4	21.0

IV. ANALYSIS OF TEST DATA

a. Inspection of the test data will disclose that basic frequencies are similar, and that a mutual analysis will predict closely the critical flutter speeds of all four models.

b. Using the statistical method of Kussner as an approximate criterion of the magnitude of the flutter speed in a wing bending vs. torsion mode, the wing critical flutter speeds are as follows:

ASSUMED DANGEROUS FREQ.	CALCULATED FLUTTER SPEED
*800 C.P.M.	123 M.P.H.
1200	185
1300	212

ANALYSIS MADE BY CAA, NACA, AIR CORPS

*The 123 M.P.H. critical speed, based on the lowest frequency of 800 C.P.M., was not considered a "dangerous mode" was in the region of 1200 to 1300 C.P.M., due to large amplitudes.

V. CONCLUSIONS (AIR CORPS)

a. The torsional natural frequencies of the wings of the subject aircraft are low enough to permit flutter in a wing bending vs. torsion mode at speeds below the limit diving speed.

b. The differences in the wing torsional natural frequencies of the various models are not great enough to cause any appreciable difference in the wing bending vs. torsion flutter speeds.

c. Since the natural frequencies of both the ailerons and flaps (850-1100 C.P.M.) are only slightly below the frequencies of the wings in bending and torsion (1100-1300 C.P.M.), and in addition are not dynamically balanced with respect to these wing bending and torsion modes, large responses of the flaps and ailerons may occur which will act to reduce the critical flutter speeds estimated on a basis of wing bending vs. torsion alone.

EFFECTIVE REMEDIAL MEASURES FOR FLUTTER PREVENTION

I. Beechcraft B17 and C17 Models

A. Balance the ailerons

1. Lead should be placed in the aileron as shown in figure 1.

For complete instructions concerning Models B17 and C17 aileron mass balance, notice "Beechcraft Service Bulletin No. 76."

II. Beechcraft D17 Model

A. Increase torsional stiffness of wing tip section (figure 2)

1. For details notice "Beechcraft Service Bulletin No. 75."

B. Balance the ailerons (figure 3).

C. Balance the flaps (figure 4).

III. Beechcraft E17 and F17 Models

Identical with II above. For details see Beechcraft Service Bulletin No. 74.

VI. DETERMINATION OF BEECHCRAFT C_{TR} VALUES OF WING CELLULE (BEECHCRAFT & CAA)

A. PROCEDURE

The method of torsion tests and computations for C_{TR} values of aircraft structure is explained in detail in Civil Aeronautics Manual 04.0000, page .3-8.

1. Torsion tests on Beechcraft Models, (F17D and E17B) in general, consist of:

a. Torsion tests on the biplane cellule to determine the C_{TR} values for the basic wing, and subsequent tests to determine the effects on C_{TR} of adding 38 3/4 inches plywood covering to the tip portion of the wings. Notice figure 5.

DISCUSSION OF AILERON MASS BALANCE

The results of an investigation of actual aileron mass balance, existant in the subject aircraft at the time of the accidents, are shown in figure 6, and tend to indicate the importance of aileron mass-balance for desirable flutter characteristics.

Figure 6 shows quite clearly that aileron flutter difficulties begin to occur with an aileron underbalance of approximately 5#". No serious flutter difficulties appear to have occurred at a value of +4.0#". Therefore, the transition point appears to be about 5#".

LINES OF BREAKAGE

Investigation brought out an interesting point and revealed that, when amplitudes are large, lines of breakage are likely to occur adjacent to nodal lines. The lines of failure of a Beechcraft wing cellule are shown on figure 7.

AILERONS

Average weight of 16.9#. The dangerous unbalanced condition appears to be about 5#".

LEFT ELEVATOR

Average weight = 9.77#

Average unbalanced moment = 38.532#"

RIGHT ELEVATOR

Average weight = 7.74#

Average unbalanced moment = 25.451#"

Total average weight = 17.51#

Total unbalanced moment = 63.983#"

RUDDER

Gross weight of rudder with tab. = 8.46

Unbalanced moment = 43.073#"

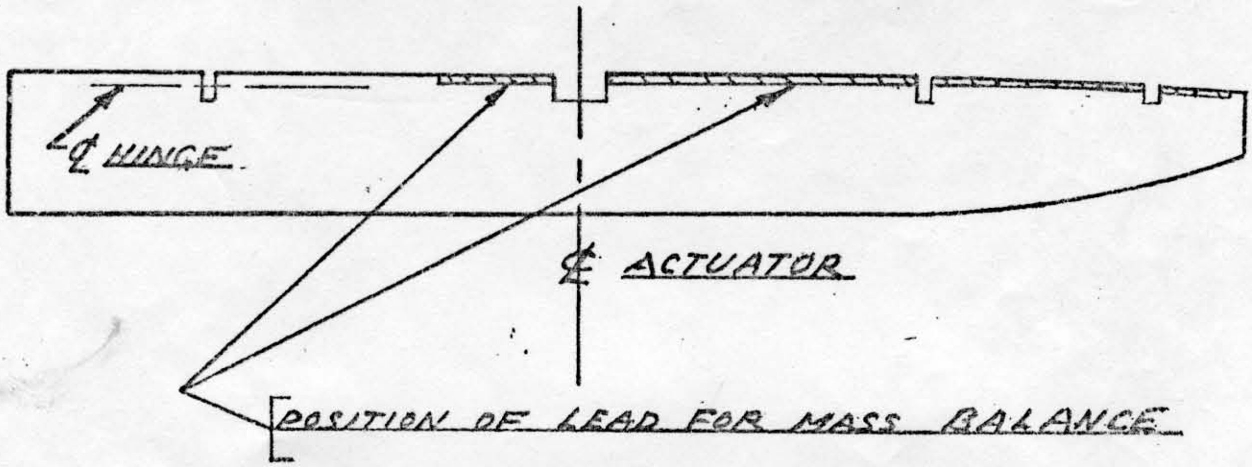
TABLE 3

*Modes & Freq. of Beechcraft (17 series) Airplanes

Part Tested		Frequencies F17D	E17B	D17S	C17R
	First Unsymmetrical Torsion of Whole Cellule	800			
	First Symmetrical Bending of Whole Cellule	800			
	First Symmetrical Torsion of Whole Cellule	1320			
	Local Bending				
	Lower Wing	1300			
	Upper Wing	1100			
Wing	Entire Cellule Moving in Torsion		820-840	800	800
	Max. Response at Lower Wing Tip		1260	1220	
	Max. Torsional Response of Upper & Lower Wings				1380
	Max. Response to Upper Wing		1150	1550	
	Peak of Torsional Response				1100
	Ailerons Oscillating Symmetrically		900-1000	850-900	Not Tested
Ailerons	Torsional Oscillations of Aileron		1650	1850	
	Aileron Against Controls	1100			
	Local Torsion in Aileron	1800			
	Flap in Torsion Against Control System		1080	1060	
Flaps	Local Torsion in Flap	1100			
Eng. Mt.	Engine Mount Rocking	830			
Fuselage	Fuselage Oscillating in Torsion		580	540	
Stab.	Stabilizer Bending Symmetrically		1000-1300	1020	
	Elev. Move Symmetrically About Hng. Line		370	400	
Elev.	Elev. Oscillating Unsymmetrically About Hng.		1000-1200	980	
Fin	Fin Bending		1290	1200	
Rudder	Rudder Oscillating About Hng. Line		200-400	380-450	

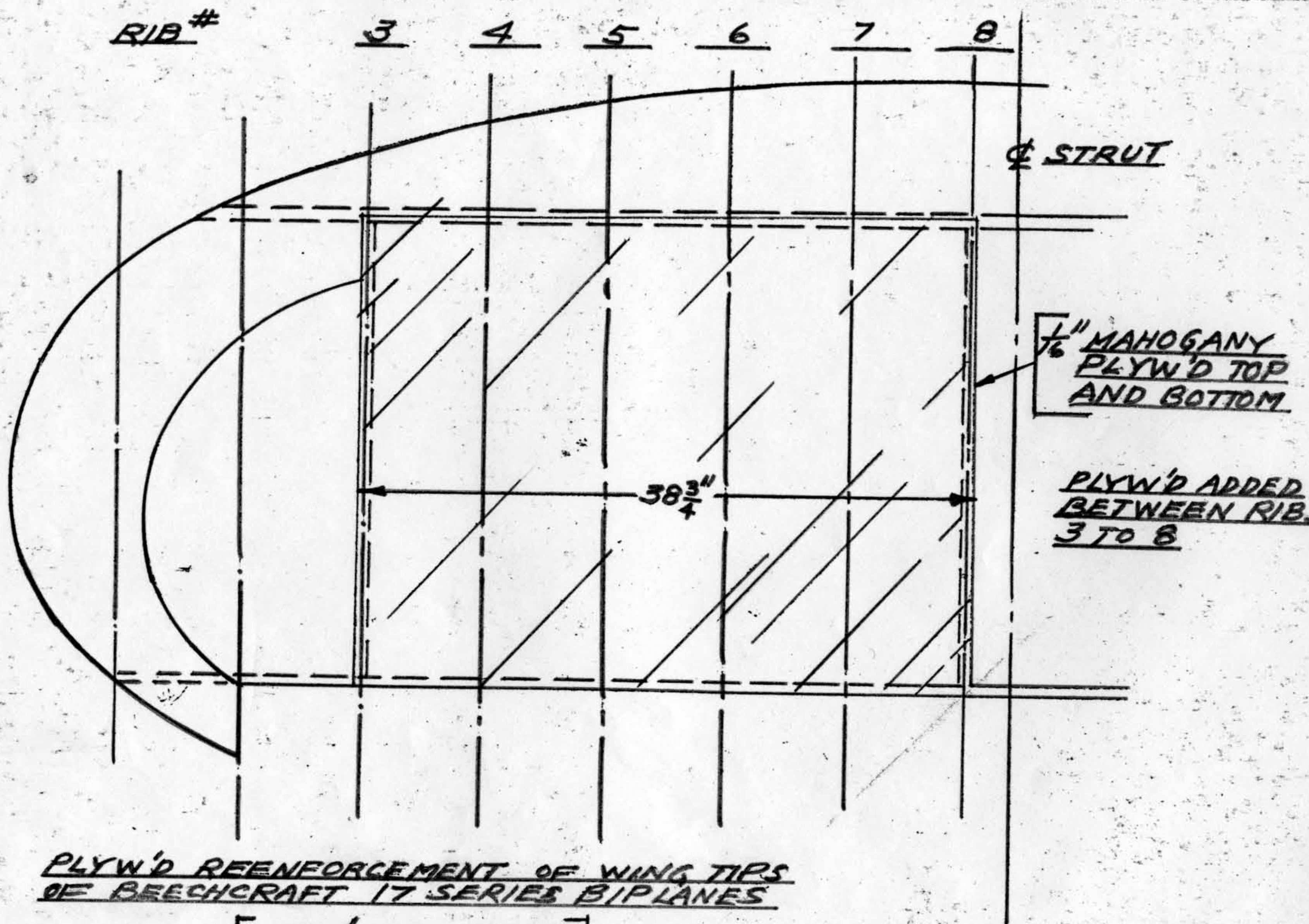
*NOTICE AIR CORPS REPORT SERIAL NO. EXP. M 51/C300-4

MASS BALANCE OF
B17 & C17 AILERONS



THE AMOUNT OF LEAD TO BE ADDED IS DETERMINED BY THE ORIGINAL BALANCING CONDITION OF THE AILERON. SUFFICIENT LEAD MUST BE ADDED TO AT LEAST COMPLETELLY STATICALLY IT. A LITTLE OVER BALANCE IS PERMISSABLE, BUT NO UNDERBALANCE.

FIGURE 1



PLYW'D REENFORCEMENT OF WING TIPS OF BEECHCRAFT 17 SERIES BIPLANES

[D, E & F 17 SERIES AIRPLANES]

FIGURE 2

MASS BALANCE OF
D, E & F 17 AILERONS

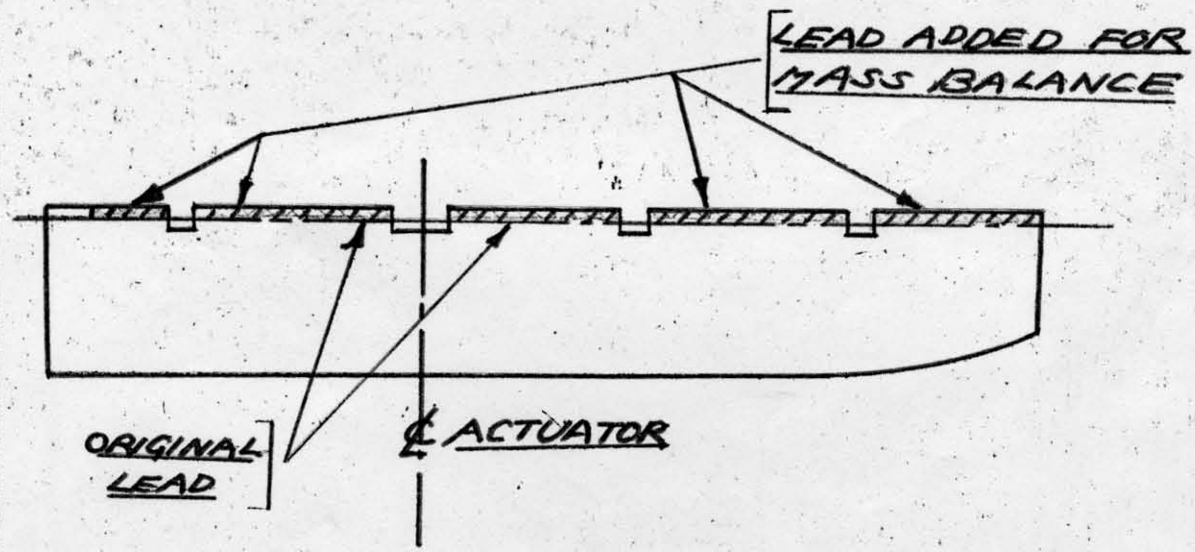


FIGURE 3

BEECHCRAFT

MASS BALANCE OF
D, E & F 17 FLAPS

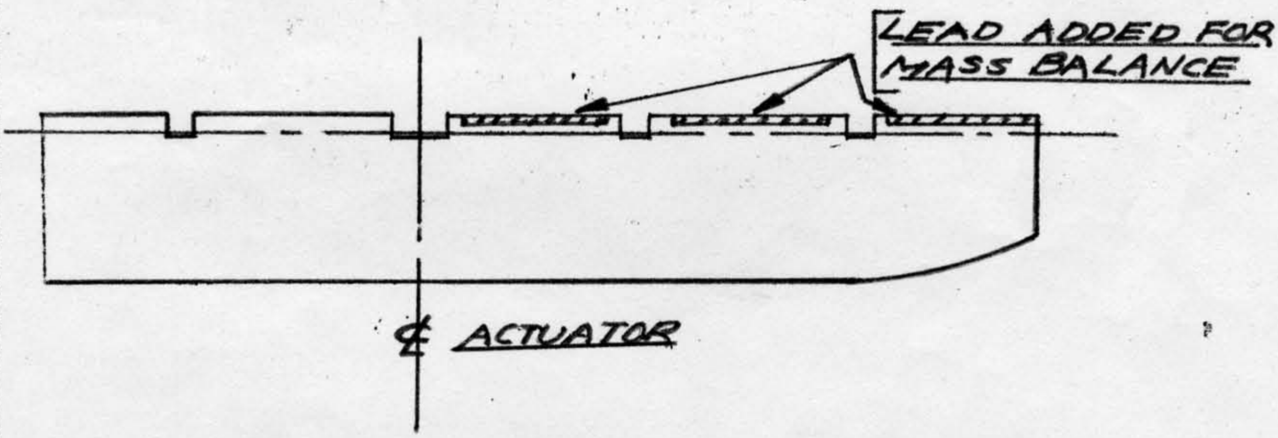
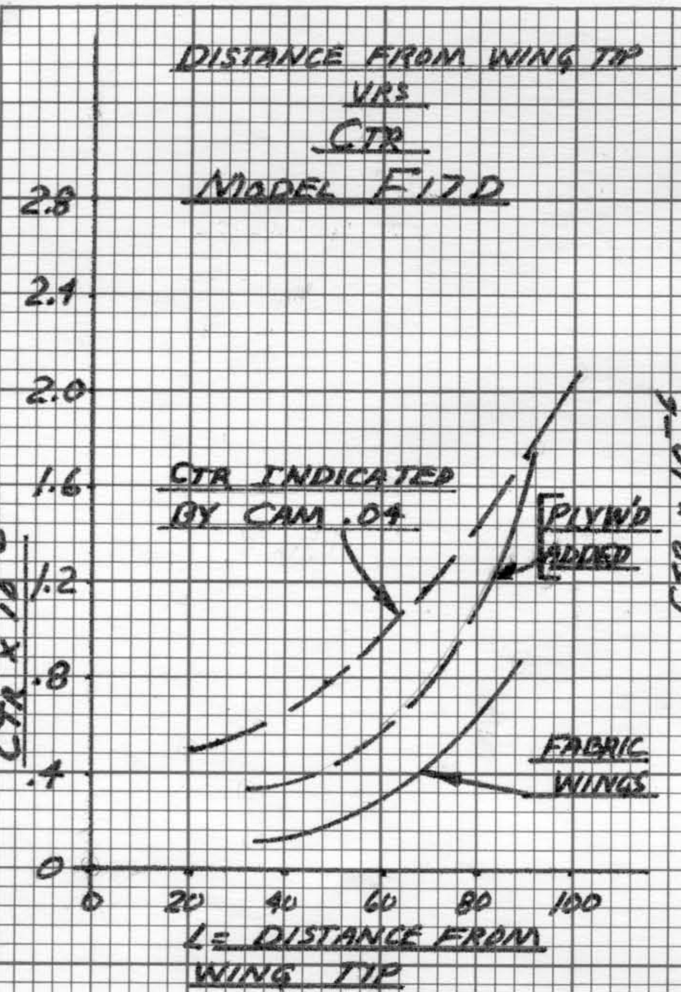
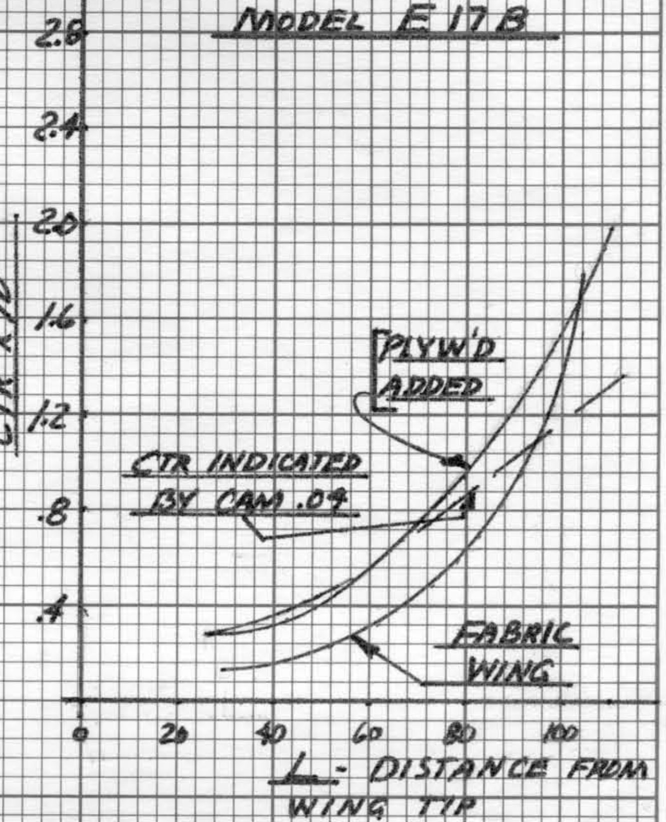
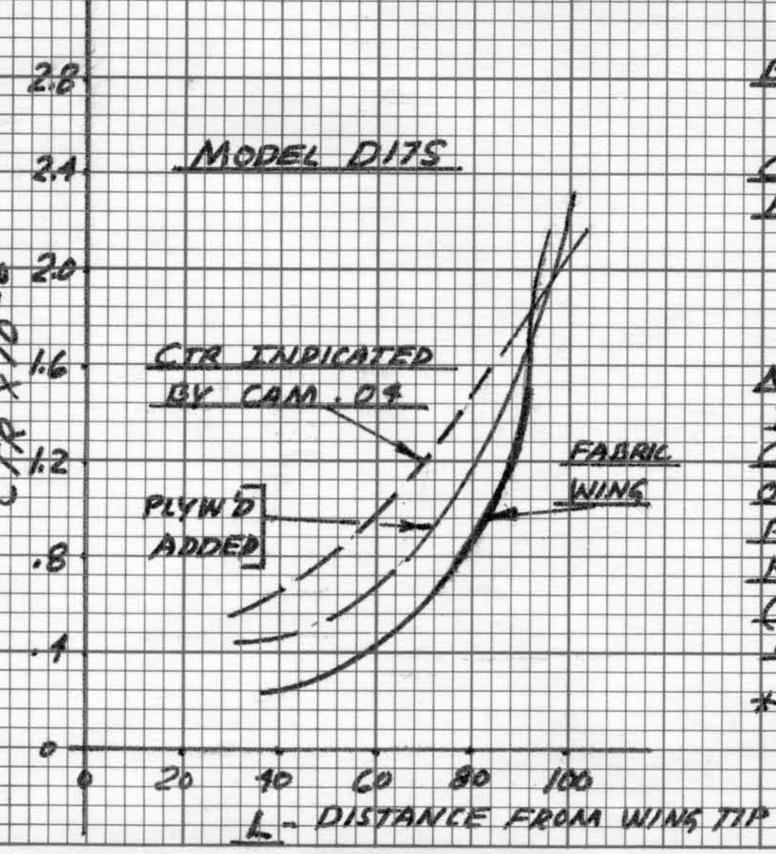


FIGURE 4

BEECHCRAFT







BEECHCRAFT 17 SERIES
BIPLANES

CURVES OF L-DISTANCE
FROM WING TIP

VRS

* CTR

NOTE:
THESE FIGURES PRESENT A COMPARISON OF CTR VALUES OF FABRIC COVERED WING, PLYW'D COVERING, AND THAT REQUIRED IN CAM .04. (NOTE DETAILS OF FABRIC COVERING ON FIG. 2

* COEFFICIENT OF TORSIONAL REGIDITY

FIGURE 5

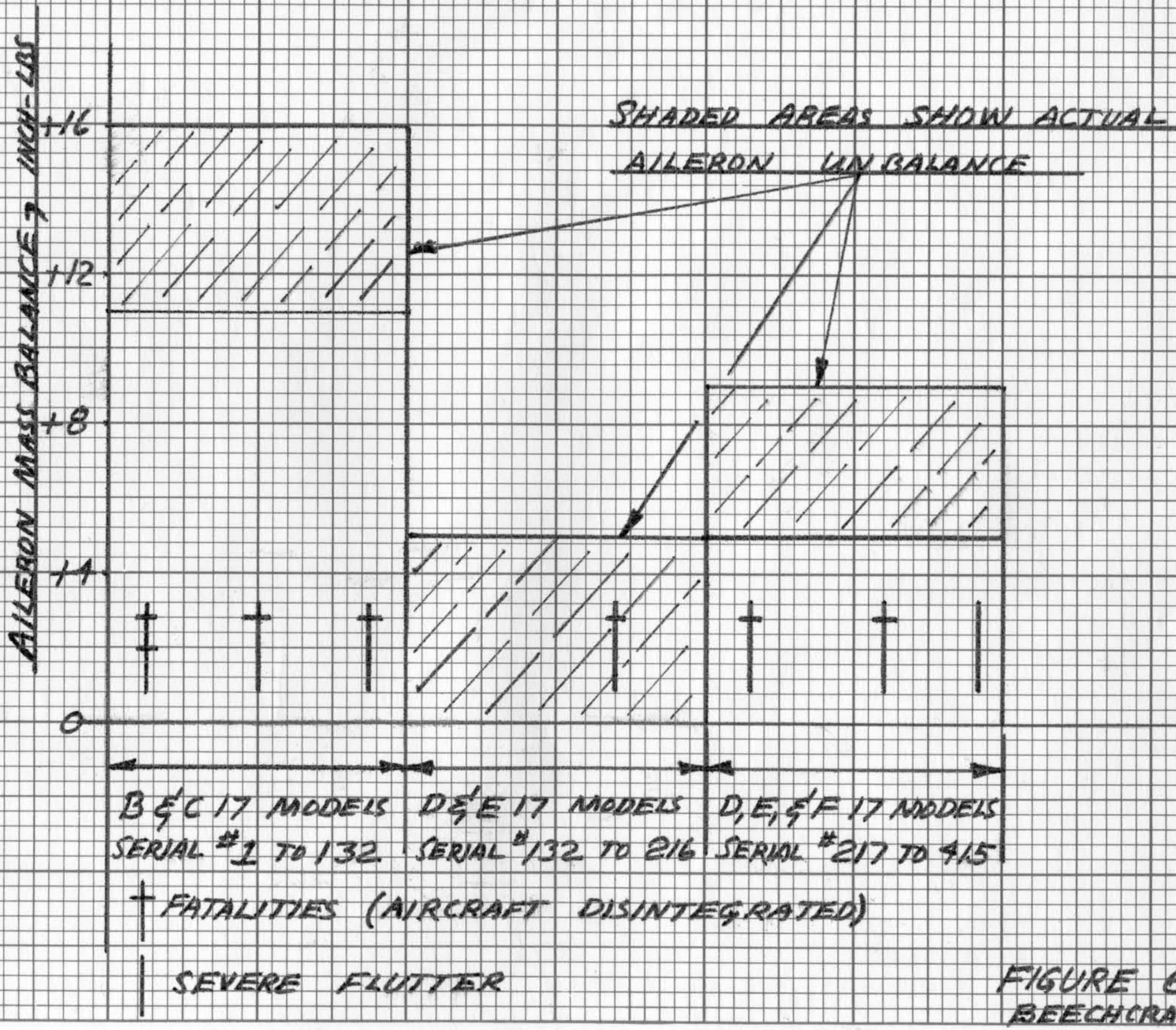


FIGURE 6
BEECHCRAFT

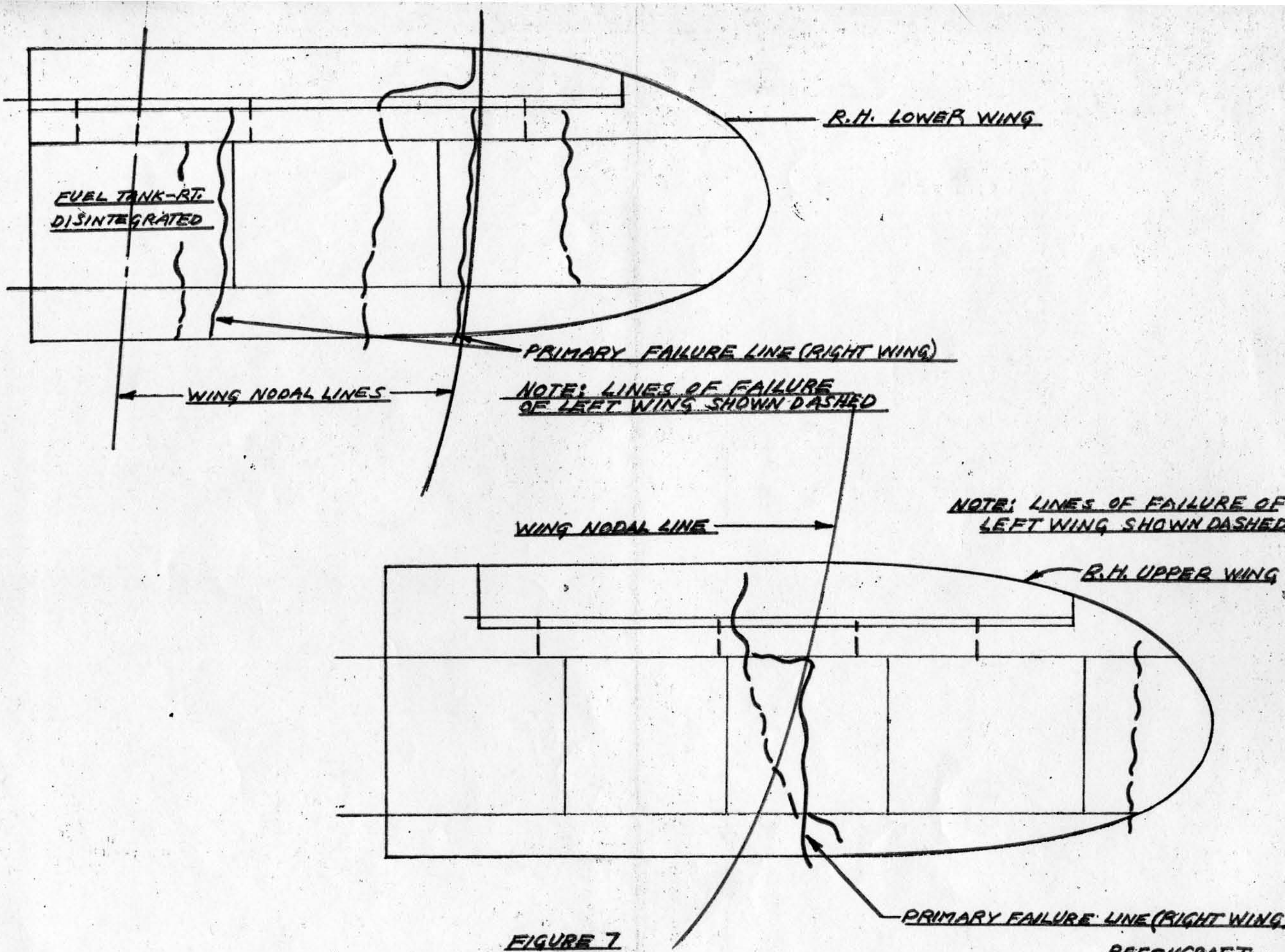


FIGURE 7

BEECHCRAFT