TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

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TESTS ON RIVETED JOINTS IN SHEET DURALUMIN.

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Abstracted and revised by J. G. Lee.

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Introduction.

The following notes were taken from a thesis by H. F. Rettew and C. Thumin, presented in June, 1921, to the Department of Mechanical Engineering, of the Massachusetts Institute of Technology.

The original thesis consisted of twenty-six tension tests on various forms of single-riveted lap-joints. Three thicknesses of duralumin sheet were used: .020" and .040" heat-treated, and .095" annealed. The material was furnished, most of the riveting was done, and advice and assistance were freely given by the Engineering Division of the Army Air Service. In making the tests, the slippage of the joints was noted at three points across each joint. In addition, stress-strain curves were obtained for plain tension specimens, and a chemical analysis was made of the sheet. No analysis was made of the rivets which, incidentally, were annealed duralumin with heads formed before riveting.

Results and Conclusions.

The most surprising results of the work were the unusually high values of crushing and shear found to exist. These values are nearly double what is ordinarily found in shear or compression tests, and

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are apparently due to the friction of the riveted plates and the re-inforcement of the rivet heads. Since this friction and reinforcement is necessarily present in all good riveted joints, the high strength values may properly be used in design.

Following are the values for riveted joints in heat-treated duralumin sheet:

	Commercial values lb/sq.in.	Values from Rettew & Thumin lb/sq.in.	Suggested values for design of joints lb/sq.in.
Tearing (f_t)	55,000	54,000	50,000
Crushing (f_c)	45,000	105,000	100,000
Shear (f_s)	25,000	43,000	40,000

The recommended values for tearing and shear fall below all of the individual test values found by Rettew and Thumin, but certain specimens of crushing, where the variation was much larger, fell as much as 5% below the recommended value of 100,000 lb/sq.in. Nevertheless, 100,000 lb/sq.in. appears to be a reasonably safe average figure.

From the recommended values a chart has been plotted (Fig. 1) based on the following formulas for rivet failure:

Shearing

$$F = \pi d^2 f_s/4 = 31,400\ d^2 \text{ for single shear}$$

$$F = \pi d^2 f_s/2 = 62,800\ d^2 \text{ for double shear}$$

Crushing

$$F = tdf_c = 100,000\ td$$

Tearing

$$F = (p-d)tf_t = 50,000\ t(p-d)$$

Critical Rivet Diameter

$$100,000\ td = 31,400\ d^2 \qquad d = 3.2\ t$$

Double Shear $d = 1.6\ t$

Critical Pitch

$$50,000\ t(p-d) = 100,000\ td, \quad p = 3\ d$$

For double riveting, $50,000\ t(p-d) = 2(100,000\ td)$,

$$p = 5\ d$$

For triple riveting, similarly, $p = 7\ d$

d = driven diameter of rivet

t = thickness of plate

p = pitch of rivets, on centers

It is good practice to have the lap from 2.5 to 3d and the distance between rows in double riveting (staggered) from 1 to 1.5 p.

In reading the chart one usually starts with the plate thickness and follows that line along until it intersects one or other of the shear curves. This gives the critical rivet diameter. The nearest available rivet diameter is chosen (preferably larger) and the strength read off on the scale of ordinates at the left, the ordinate of the plate thickness line being used if the rivet diameter is above the critical figure, while the ordinate of the shear parabola is chosen if the diameter is below the critical. To find the pitch, read down from the chosen diameter, and take the nearest convenient pitch (larger than that given by the graph).

The tensile tests gave the following average results:

	Heat-treated		Annealed
Thickness (inches)	.020	.040	.095
Elongation in 8" (%)	12.67	19.53	12.55
Elongation in 2" (%)	14.83	24.25	17.75
Yield point (lb/sq.in)	27,800	26,100	13,750
Tensile strength (lb/sq.in)	56,530	56,625	31,750
Modulus of elasticity	11,310,000	11,080,000	9,773,000
Reduction of area (%)	15.33	19.97	34.48
Ratio of Y.P. to T.S.	.491	.456	.437

The riveted joints in the .095" annealed sheet showed the following values in lb/sq.in.:

$f_t = 32,700$ $f_s = 42,800$ $f_c = 62,300$

All of the tension failures both in the riveted joints and in the plain specimens occurred as shear along a 45° plane. The crushing failures appeared to be crushing of the plate and not of the rivets, although the plate, being heat-treated, has the higher theoretical strength of the two. The shearing failures were instantaneous, as opposed to the gradual distortion which preceded a failure by crushing or tearing.

The only noteworthy result of the tests for slippage of the joints is that in all cases a redistribution of load takes place at the lower stresses, as is evidenced by the different amounts of slippage at different points along the joint. In general the slippage is small and unimportant.

The chemical analyses of the three thicknesses of sheet are given below:

Thickness	Cu.	Fe.	Si.	Mn.	Mg.
.020"	4.21	.41	.26	.40	.82
.040"	4.04	.38	.23	.38	.87
.095"	4.16	.42	.26	.39	.82

Remainder, aluminum.

Methods of Test.

The plain tensile specimens were tested in the usual manner. Owing to the thinness of the sheet and to the unevenness found in the smoothest of metal jaws it was necessary to use the peculiar form of specimen shown in Fig. 2. The notches cut at the ends were to receive plugs fitted into the testing machine jaws. Several of the more common types of ends were tried but failure generally occurred in the jaws until the above was adopted.

The riveted specimens were made with 5 half-inch bolt holes in the end (Fig. 3) by which they were clamped into a pair of special jaws made without serrations. These jaws, in turn, were fastened into the testing machine. Slippage of the joint was noted by measuring the distance between two scribed lines under a magnifying lens.

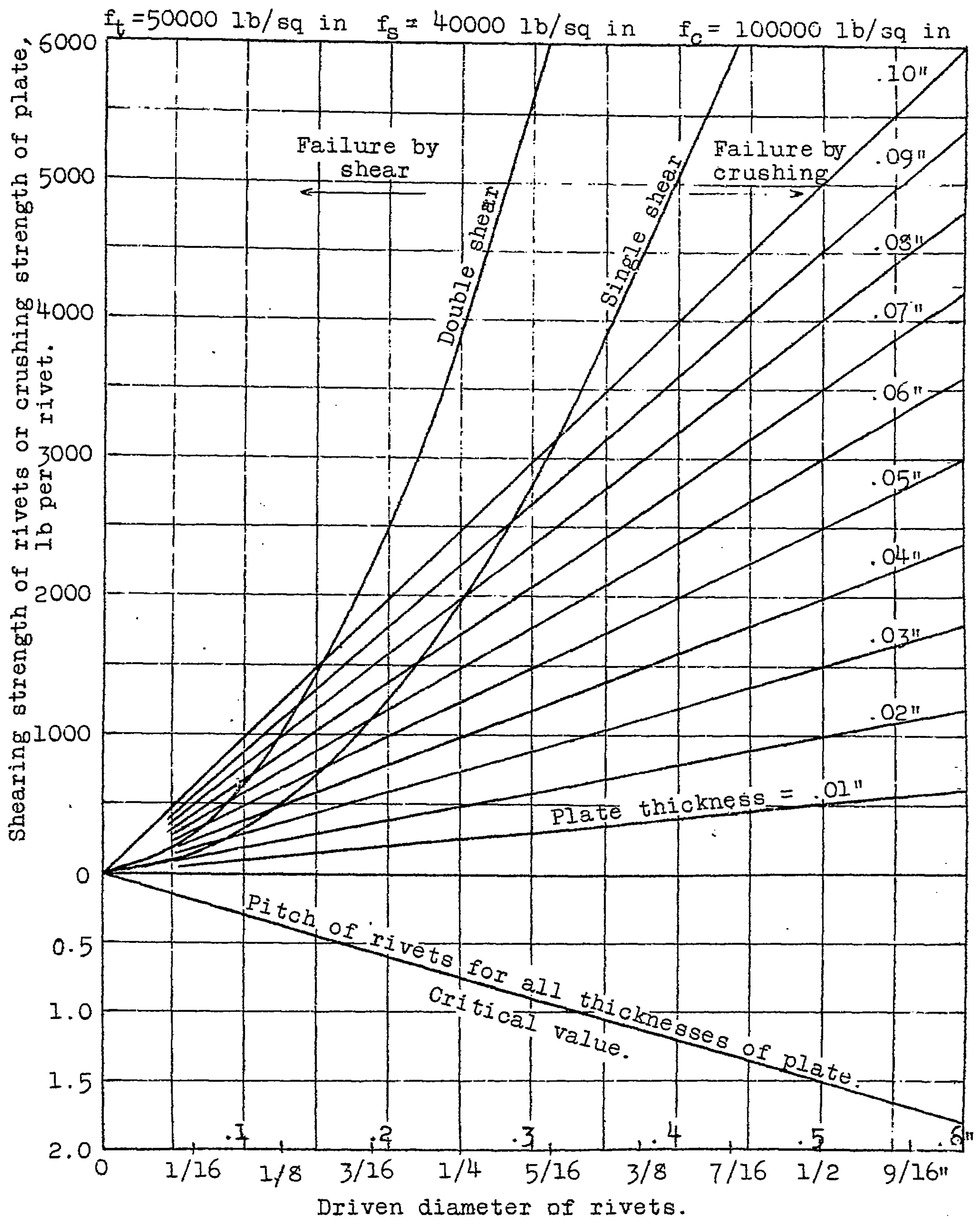
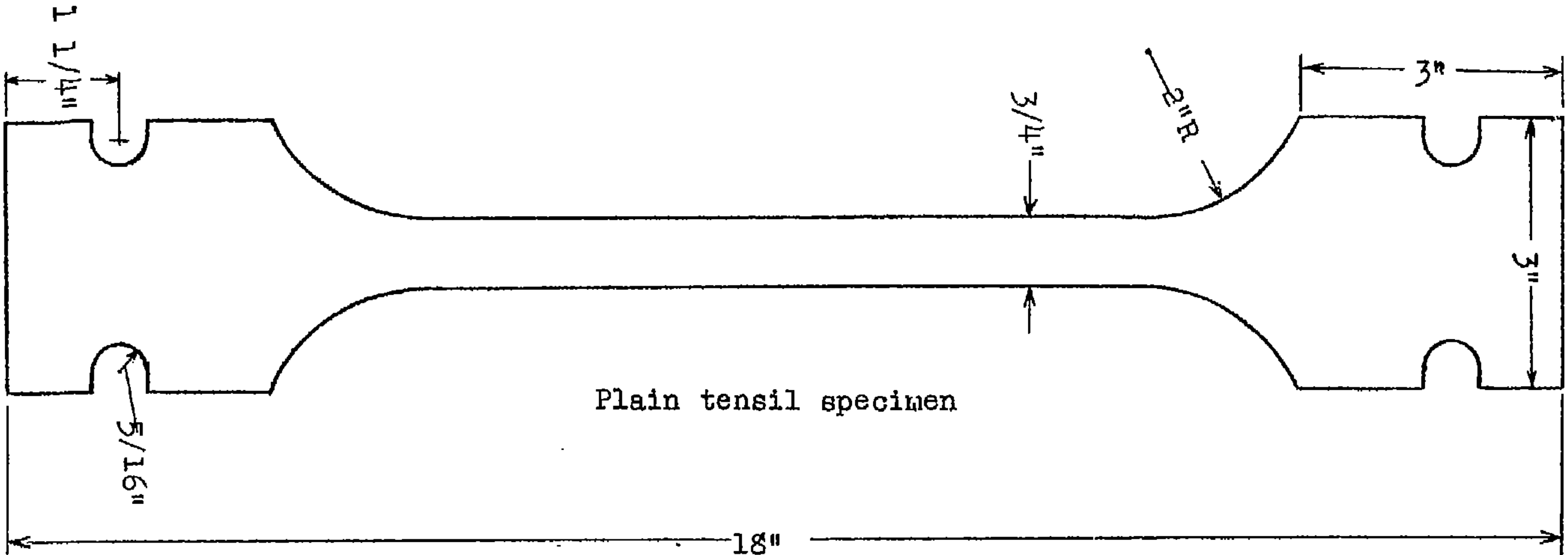


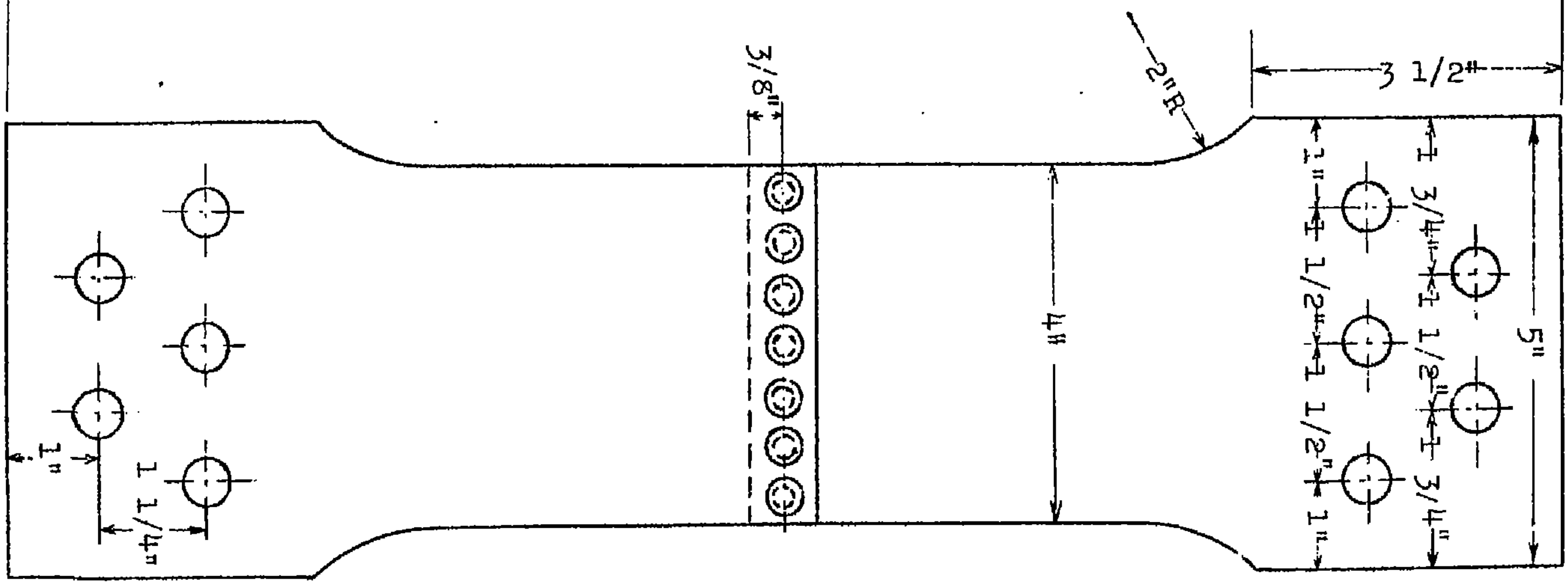
Fig.1 Single-riveted lap joints.

Fig. 2



Plain tensil specimen

Fig. 3



Typical riveted specimen