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DEPARTMENT OF MINES AND RESOURCES

BUREAU OF MINES

CANADA

Ottawa, May 30, 1946.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2054.

Fatigue Properties of Aluminium Alloy Sheet 17ST (0.063-inch Gauge), As Determined by the Krouse Flat Sheet Fatigue Testing Machine.

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(Copy No. 4.)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

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Mines and Geology Branch

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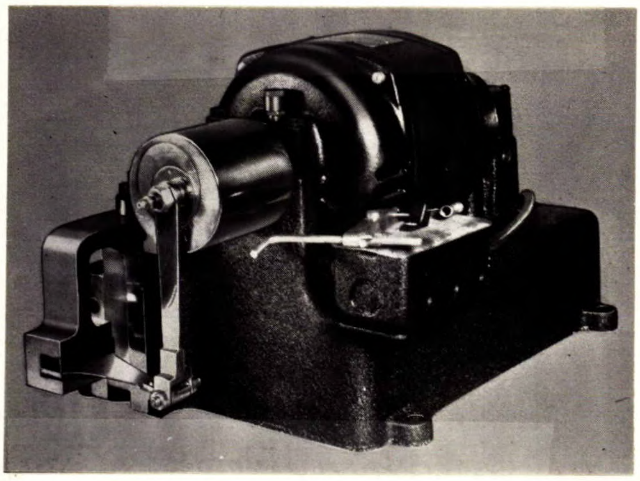
Introduction:

The work of this investigation was carried out on a Krouse sheet fatigue testing machine in order to determine its characteristics and suitability for testing the endurance properties of sheet metal materials.

Apparatus:

Figure 1 is a photograph of the Krouse sheet fatigue testing machine.

Figure 1.



KROUSE SHEET FATIGUE TESTING MACHINE.

This machine, of the fixed deflection type, tests a sheet specimen designed to give uniform stress over a considerable portion of its cantilever length. One end of the specimen is held firmly in a vise while the other is loaded through a flexible joint fastened to a connecting rod, whose stroke can be carried over a wide range by adjusting the variable throw crank. This change of stroke length is accomplished by loosening a locking screw and rotating an inner eccentric crank pin with respect to the outer shell.

By moving the specimen vise along its ways, the range of stress on the specimen may be changed from the completely reversed cycle of stress to any other stress range attainable by bending.

The stress deflection characteristics of the specimen may be obtained by applying dead loads on the specimen at its point of junction with the connecting rod, the

(Apparatus, cont'd) -

connecting pin being easily removable. A pointer on the connecting pin bearing indicates the deflection on a scale affixed to the machine base. The connecting pin is then replaced and the crank is adjusted to give the desired deflection.

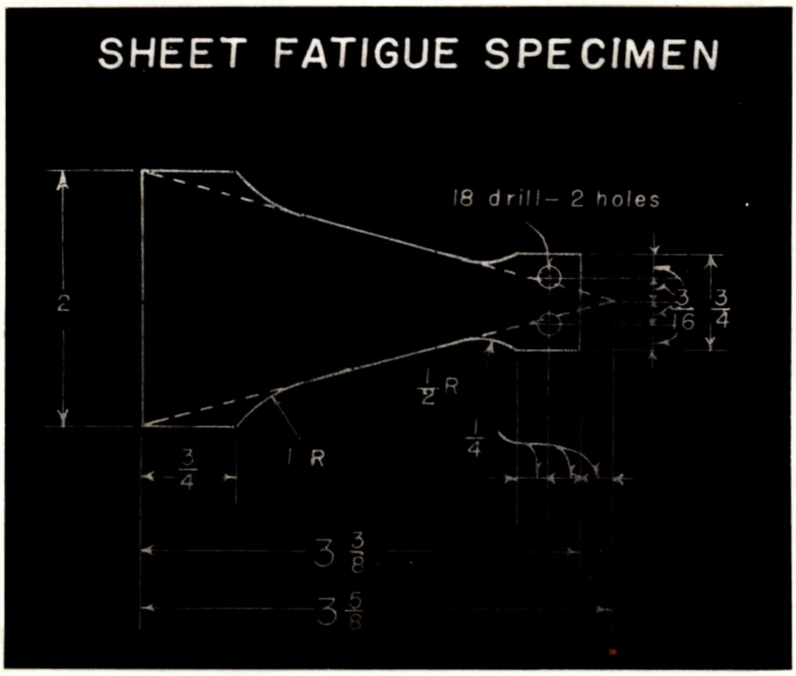
The 1/3 h.p. motor operates at 1750 r.p.m. on a single phase, 110-volt, 60-cycle power source.

A counter located at the rear of the machine records up to 100 million cycles. When the specimen fails, an automatic switch stops the motor.

Specimen:

Figure 2 shows the dimensions of the sheet fatigue specimen used in these tests.

Figure 2.



DIMENSIONS OF SPECIMEN USED.

Calculation of Bending Forces:

The load to be applied at the connecting pin, necessary to produce the desired bending stresses, is calculated by the flexure formula which reads:

$$S = \frac{Mc}{I} = \frac{6PL}{bd^2}$$

$$\text{or} \quad P = \frac{Sbd^2}{6L}$$

where P = load at connecting pin in pounds and should never be more than 40 pounds;
S = bending stress in pounds per square inch;
L = distance, in inches, between connecting pin and test section;
b = width of specimen, in inches, at distance L from point of load application; and
d = thickness of specimen, in inches.

Example:

$$P = \frac{25,000 \times 2 \times 0.063^2}{6 \times 3.625} = 9.1 \text{ pounds.}$$

EXPERIMENTAL WORK

Material:

The material used in this investigation was 0.063-inch gauge 17ST aluminium alloy sheet manufactured by the Aluminum Company of Canada Limited, Kingston, Ontario.

TABLE I. - Chemical Analysis.

		Nominal	Found
		- Per Cent -	
Copper	-	4.0	4.25
Manganese	-	0.5	0.54
Magnesium	-	0.5	0.69

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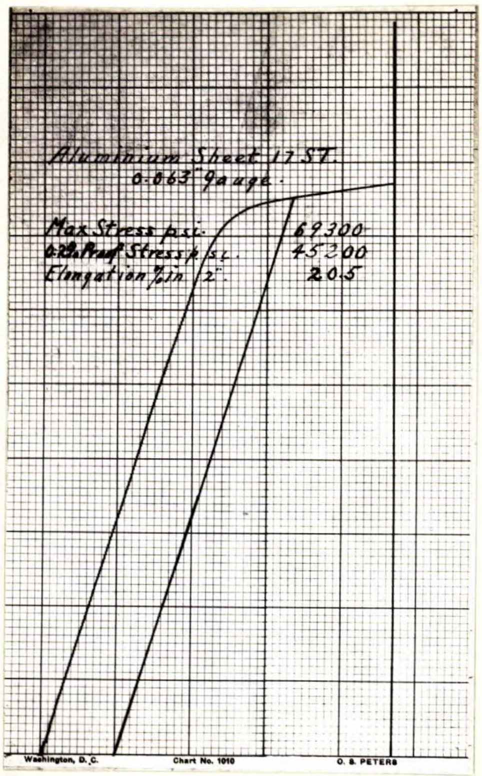
Tensile Properties:

Figure 3.



STRESS-STRAIN DIAGRAM,
17ST ALUMINIUM SHEET.

-

The results of mechanical tests on a longitudinal sample of 17ST sheet, and the nominal values for this material, are given in the following table:

TABLE II. - Mechanical Properties.

	Nominal	Found
Ultimate stress, p.s.i.	62,000	69,300
0.2 per cent proof stress, p.s.i.	40,000	45,200
Elongation, per cent in 2 inches	20.0	20.5
Brinell hardness (500-kg. load)	100	128*

* Vickers Hardness Number (10-kg. load).

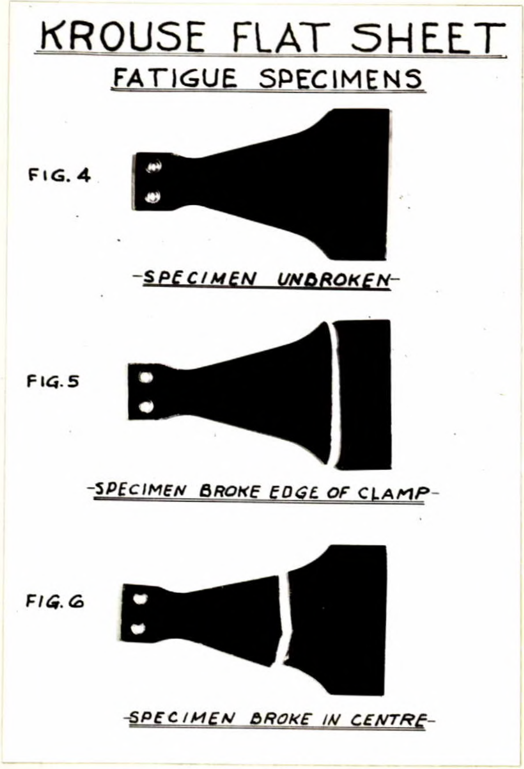
Fatigue Tests:

The sheet specimens in these tests were first mounted in the Krouse flat sheet fatigue testing machine between two metal spacers. However, it was found that a large number of specimens broke in test at the edge of the clamp (see Figure 5).

(Continued on next page)

(Fatigue Tests, cont'd) -

Figures 4, 5 and 6.



In order to reduce the stress concentration at this point a paper shim was placed between the specimen and the metal spacers in the clamp. By this procedure, breakages at the edge of the clamp were prevented, and the specimens broke as shown in Figure 6. The results of the fatigue tests on 17ST aluminium alloy sheet, 16 gauge (0.063-inch thick), are given in the following table:

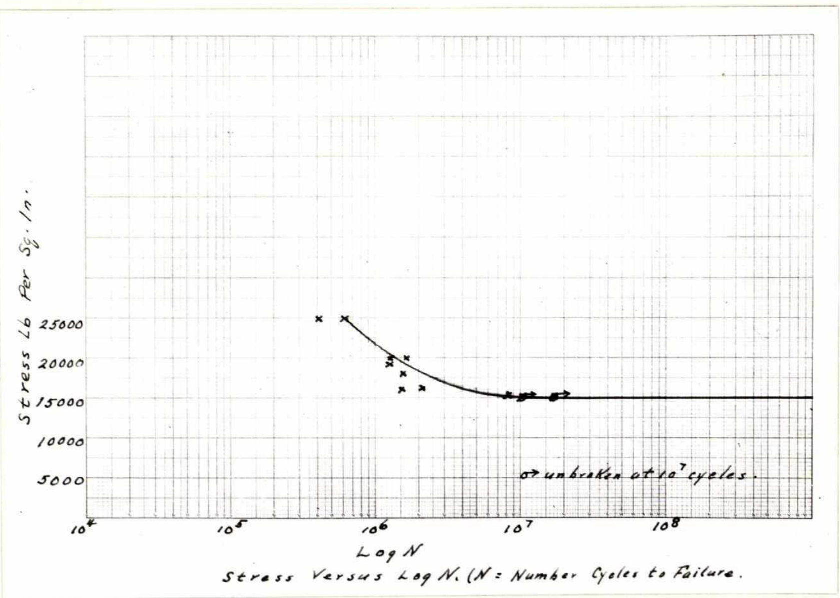
TABLE III. - Fatigue Properties.

Stress, p.s.i.	Total Cycles to Failure	Remarks
25,000	421,000	Broken in centre.
"	679,000	" " "
20,000	1,601,000	" " "
"	2,263,000	" " "
18,000	1,173,000	" " "
"	1,500,000	" " "
16,000	2,246,000	" " "
15,500	8,712,000	" " "
15,000	15,319,000	No break.
"	14,700,000	" "

(Fatigue Tests, cont'd) -

An S-N curve plotted from the test data tabulated in Table III is shown in Figure 7.

Figure 7.



RELATION OF FIBRE STRESS TO REVERSALS
OF STRESS, ALUMINIUM ALLOY SHEET 17ST.

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DISCUSSION OF RESULTS:

The material tested had a chemical composition similar to that of 17ST aluminium alloy sheet. The tensile strength, proof stress, elongation and hardness values were slightly higher than the published nominal values for this alloy in 16 gauge sheet.

Irregular fatigue test values were encountered at first in this investigation, due to breakages at the edge of the grips. This was overcome by the use of paper shims between the metal spacers in the grips.

The majority of fatigue tests are designed to determine the endurance limit of a material. The number of (discussion of Results, cont'd) -

repetitions of stress that will serve to establish an endurance limit varies with different materials. For ferrous materials, H. F. Moore has shown that stresses which do not cause failure at 10,000,000 cycles will not cause failure up to 100,000,000 (and sometimes to 1,000,000,000) cycles.* Therefore the endurance limit of ferrous materials can be determined with a minimum of 10,000,000 cycles.

This does not hold for non-ferrous metals. Various investigators have found that no endurance limit could be found for certain aluminium alloys up to 500,000,000 cycles. In the present study, in order to save time, 10,000,000 cycles was arbitrarily set as the limit of the individual tests. The results obtained would indicate that the fatigue strength of 17ST aluminium alloy sheet, 16 gauge (0.063-inch thick), is approximately 15,500 p.s.i. at 10^7 cycles. This value compares very favourably with published fatigue test data for this material.

From the results of this investigation it is concluded that the Krouse sheet fatigue testing machine will give satisfactory fatigue test results on non-ferrous materials.

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* "Present Day Knowledge of Fatigue," Committee Reports, A.S.T.M., (1930), 30, Part I, p. 261.