CHAPTER III

APPARATUS, SPECIMEN AND TECHNIQUE OF TESTING

Tension Tests

Tension tests were carried out by using the Hounsfield Tensometer type W (see Fig. 3). The specimens were type C with cross-section area 20 m/m^2 (0.1984 in. in diameter) as shown in Fig. 7. The specimens were loaded in increments of about 50-100 kg and as the limit of proportionality was approached, the increment was reduced to 20 kg. The loads and elongations were measured after a delay of 2 minutes. The tests were continued to failure.

For the values of Young's Modulus, the elongation recordedon the recorder drum was not sufficiently accurate although the elongation of the system was sub-tracted. Hence, an accurate extensometer was used, contact being detected using a light bulb of small voltage. It can be read within 0.00001 in, the fifth decimal place being estimated. The gauge length was 2 inches and the diameter of the specimen was as before, except the length between heads was 4 inches in order to eliminate end effects.

Torsion Tests

The Tecquipment Torsion Testing Machine (Fig. 4) was used for obtaining the Modulus of Rigidity and the elastic limit in pure shear. The specimens were of circular cross-section with hexagon ends (see Fig. 8). The torques in in-lbs, were measured by a spring balance at arm radius 8 inches.

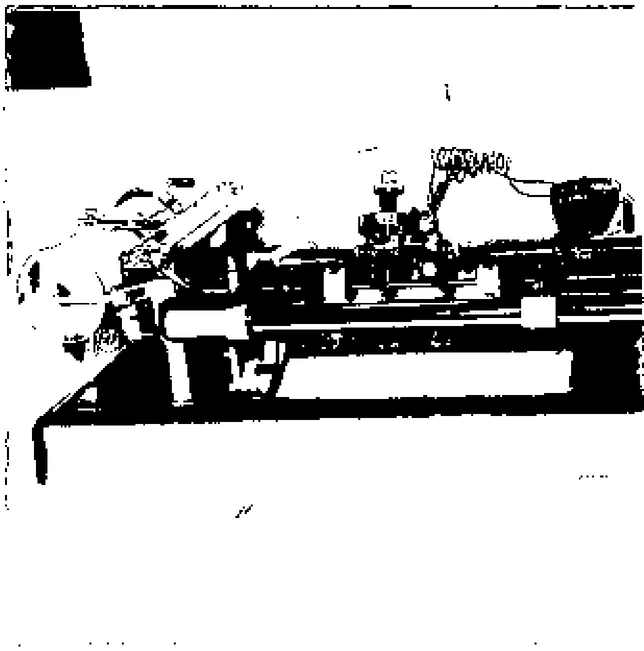

Fig.3 Hounsfield Tensometer.

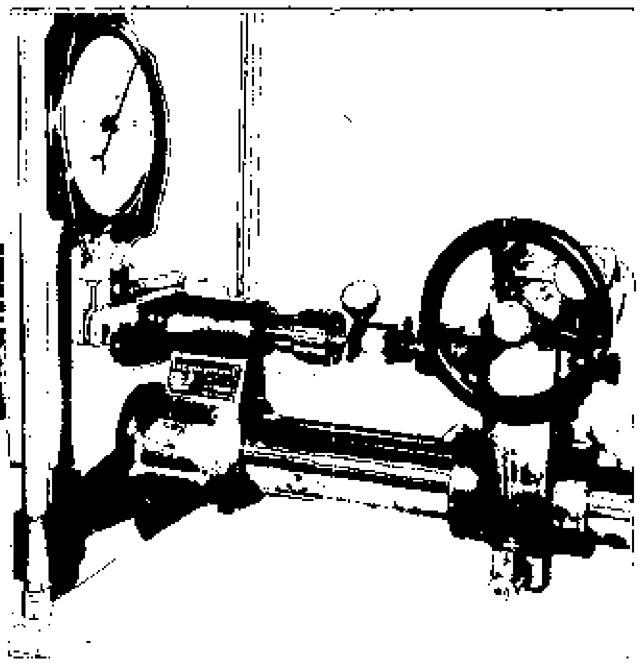

Fig.4 Torsion Testing Machine.

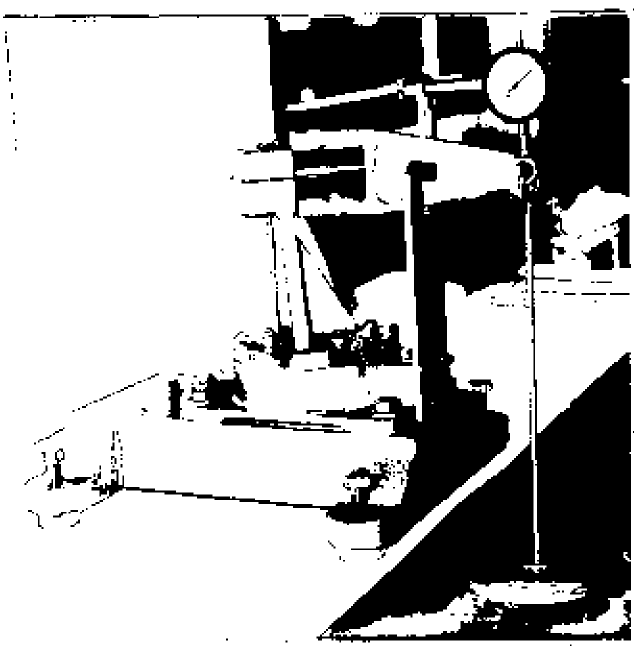

Fig.5 Combined Bending and Torsion Apparatus.

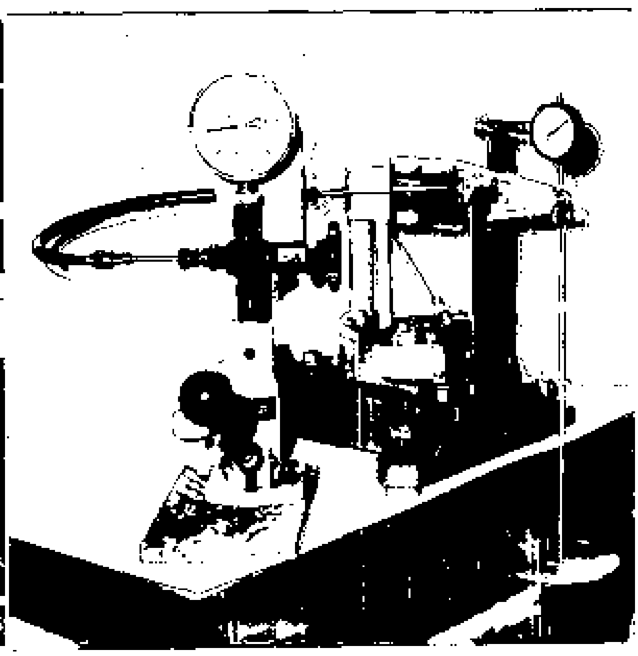

Fig.6 Specimen Subjected to BTI.

The angles of twist were measured by a 2-inch gauge length torsiometer. The angle could be read within 0.0001 radian. The loading time was 3 minutes for each increment.

Combined Bending and Torsion Tests

The combined bending and torsion apparatus of Norwood Instruments as shown in Fig. 5 and 6 was used to carry out the tests. The amount of tension and torsion loading could be carried by rotating the central support from ϕ = 0 degree to ϕ = 90 degree. The angle is divided into 15 degree intervals. Hence 7 specimens were needed for each kind of material. When the support was turned from ϕ = 0 degree to ϕ = 90 degree, M/T was varied from maximum to zero.

From Fig. 8, the equations for calculation are as follows:-

$$T = WR \sin\theta \quad (9)$$

$$M = WR \cos\theta \quad (10)$$

$$\sigma_x = \frac{32 WR \cos\theta}{\pi d^3} \quad (11)$$

$$\tau = \frac{16 WR \sin\theta}{\pi d^3} \quad (12)$$

$$\sigma_1 = \frac{16 WR}{\pi d^3}\left(\cos\phi + 1\right) \quad (13)$$

$$\sigma_2 = \frac{16 WR}{\pi d^3}\left(\cos\phi - 1\right) \quad (14)$$

The specimen of dimensions shown in Fig. 9 was set so that reduced section is on the axis of the pin of the loading arm.

The loading arm of the apparatus is 8 inches long. The equivalent weight of the loading arm is 0.48 pound, and the weight of the hanger is 0.5 pound. This weights were added to

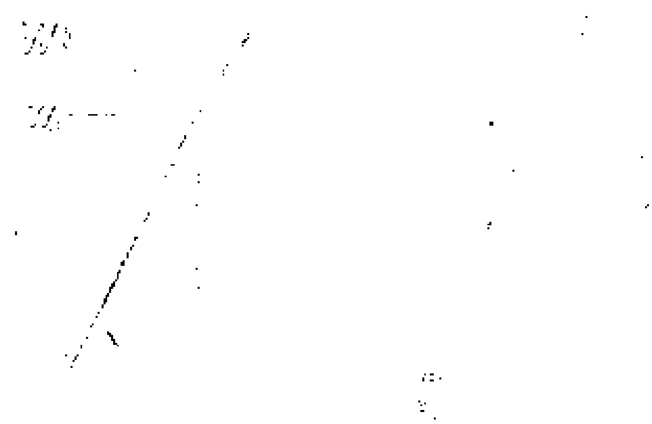

Fig. 12

the load applied to the hanger to give W in equations 9-14. The deflections of the specimens were measured at the distance R = 8 inches. A dial gauge was needed to measure these deflections, one division on the dial being equal to 0.0001 in.

The loading time was 3 minutes with one pound and half pound load increaments available. The loading continued until the load deflection-curve show in Fig. 11 started to depart from the elastic curve. Then the value of W_e was used to calculate the principal stresses from equations 13 and 14. The procedure was repeated for the other angles, using a new specimen for each angle.

Combined Bending, Torsion and Internal Pressure Tests

These specimens had the same length as in the combined bending and torsion tests, except the reduced section was 11/32 in. in diameter, and they had a hole drilled through them of 5/16 in. in diameter (see Fig. 12). In making the specimens, firstly the bar was faced and drilled through with 19/64 in. drill, and it was reamed to 0.3125 in. diameter. A mandrel 5/16 in. diameter was fitted to the hole. Then the outer surface of the bar was cut on the milling machine down to about 11/32 in. diameter. These dimensions were selected because according to ASME codes, cylinders with $r_o/r_i > 1.1$ are considered as thick-walled cylinders, and the Lamé formula must be used.

The pressure was applied from a hand-operated pump, and held constant at 1000 psi throughout the tests. The pressure medium was lubricating oil # 40. The load W was applied after the pressure ceased to drop. If there was a small drop in pressure during the test, a pressure adjusting screw was provided to compensate for it. The maximum pressure of the pump was 7000 psi. Other test procedures were the same as in the combined bending and torsion test.

The equations used are modified slightly as follows :

$$\text{Bending Stress} = \sigma_x = \frac{32 W R d \cos\phi}{\pi (d_o^4 - d_i^4)} \qquad (15)$$

$$\text{Shear Stress} = \tau = \frac{16 W R d \sin\phi}{\pi (d_o^4 - d_i^4)} \qquad (16)$$

$$\text{Circumferential Stress} = \sigma_y = \frac{P d_i}{d_o - d_i} \qquad (17)$$