which can be fixed to the specimen by three screws with pointed ends which are disposed at 120° to one another. A special distance piece has been designed which ensures that the clips are fixed at a known distance apart in the parallel gauge length of the specimen. Mirrors are fixed to each clip and these are made of stainless steel which has been optically polished. Pointers are fixed in the oven which are located close to the degree scale on the clips so that a course strain reading can be taken. With suitable illuminated scales and telescopes it is possible to detect a shear strain of 10^{-5}.

Tension tests were carried out in a 30 tonf Amsler testing machine fitted with a furnace and mirror extensometer supplied by Electronic and Mechanical Engineering Co.Ltd. A saturable reactor type of proportional controller with a platinum resistance thermometer was used for temperature control. The temperature distribution was measured by three Pt/Pt-10%Rh thermocouples. The temperature distribution could be adjusted by trimming the power in each of three furnace windings. To avoid damaging the extensometer it was removed before fracture of the specimen.

In both torsion and tension tests a period of 3 min was allowed after an increment of strain or load had been applied to allow equilibrium to be reached before the readings of load and strain were taken. In some torsion tests the relaxation of stress after an increment of strain had been applied was observed for periods up to 30 min, to get some idea of whether creep was significant.

In the pressure tests on thick-walled cylinders it was assumed that the axial strain was negligible as found by Crossland and Bones (1958) and consequently no axial extensometer was fitted. Again Crossland and Bones found that the diametral expansion of cylinders was perfectly symmetrical except for materials with an appreciable drop of stress at yield, and even then at strains appreciably beyond those at initial yield it was found that there was no significant difference between the strain readings on different diameters. Consequently a single diametral extensometer of the form shown in Figure 3 was used, and the sensitivity was made as large as possible consistent with it having the range to enable it to be used right up to the strains associated with the maximum pressure.

The pressure was generated with the 125000 lbf in^{-2} intensifier described by Crossland and Austin (1965) and measured with a Bourdon tube or an eccentric tube gauge, which was calibrated against a dead weight pressure tester before and after such test. The specimen was mounted in the oven used for torsion tests and the mirrors on the diametral extensometer were viewed through the glass window. Brake fluid was used as the pressure transmitting fluid, though when a cylinder failed the fluid frequently caught fire and sometimes a minor explosion occurred, so that the door of the oven had to be elastically constrained.

During the pressure tests the pressure was maintained for a short time, and then readings of pressure and diametral strain were recorded after a delay of 3 min.

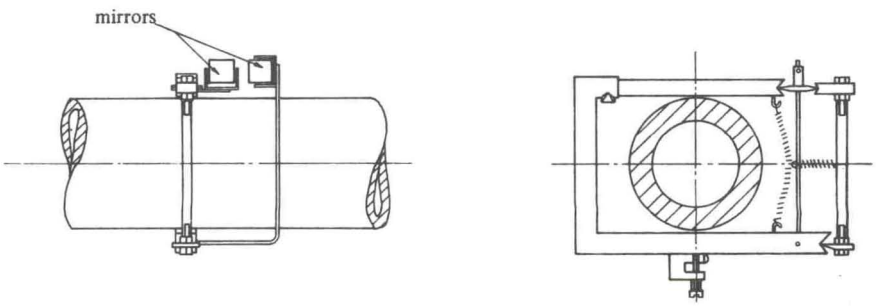

Figure 3. General arrangement of extensometer.

Materials tested

Table 1 gives the analysis of the steels tested. The Hykro and Vibrac V30 were provided in the form of hot-rolled bar which had been hardened and tempered. As the tensile strength of the Hykro proved to be higher than for the Vibrac and as comparability was desired, all the specimens made from the Hykro bar were subjected to 600°C for an hour in a high vacuum furnace which served as a re-tempering and stress relieving heat treatment. The Vibrac specimens were stress relieved in the high vacuum furnace at 600°C which was 50 deg below the original tempering temperature. After machining the EN3 specimens were normalised in the high vacuum furnace at 880°C for an hour and allowed to cool down in the furnace before removal.

Table 1. Analysis of the steels tested.

Steel	C	Si	S	Ph	Mn	Cr	Mo	Ni
Hykro EN40	0·175	0·15	0·002	0·015	0·48	3·18	0·62	0·17
Vibrac V30-EN25	0·29	0·21	0·021	0·022	0·61	0·66	0·56	2·43
Mild steel EN3	0·26	0·13	0·037	0·024	0·65	-	-	-

Very careful consideration was given to the cutting up of the bar material so that tension and torsion specimens and hardness cheek pieces were positioned between each pair of cylinder specimens, to enable any variation of properties along the bars to be established. The torsion and tension specimens were cut in the longitudinal direction, as the diameter of the bar did not allow for reasonable sized transverse specimens, and they were cut from material at the same radius as the cylinder wall material. The form of torsion, tension and cylinder specimens is shown in Figures 4, 5 and 6.

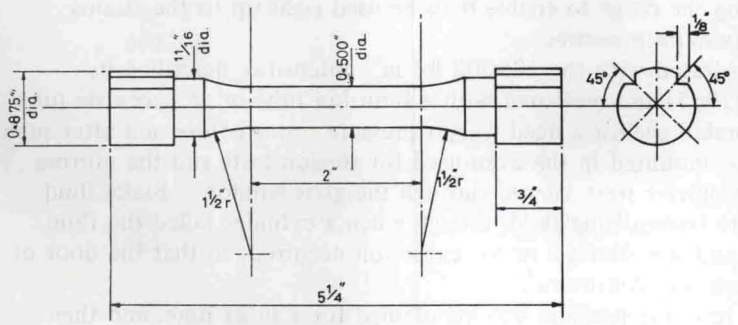

Figure 4. Torsion specimen.

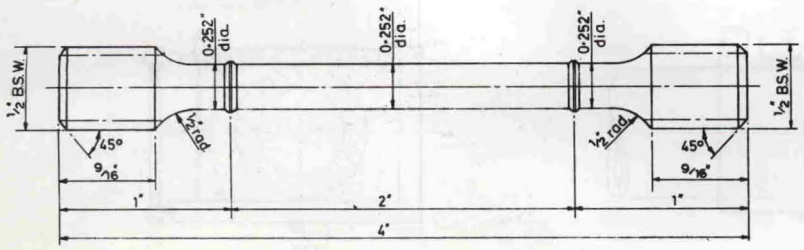

Figure 5. Tension specimen.