

## II. EXPERIMENTAL

(a) *Materials*

A Nickel-Chrome-Molybdenum steel,\* often used in this Laboratory for high-pressure cylinders, was chosen as a material of which the tensile strength could be varied by heat-treatment. It was used in three conditions: (i) fully annealed by prolonged heating at 770°C, (ii) tempered at 600°C after hardening, and (iii) tempered at 500°C after hardening. Hardening was effected by quenching in oil from 830°C.

For each series of experiments a set of cylinders, all of  $\frac{1}{4}$  in. inner diameter but with various outer diameters, was used. Other dimensions of the cylinders are shown in Figure 1. In conditions (i) and (ii) of the steel most of the machining was done after heat-treatment, but in condition (iii) the cylinders were machined to correct size from annealed stock, heat-treated in salt baths, and then required only slight lapping of the bore before use. With each series a tensile test bar was made to British Standard No. 18 (with screwed-ends) and underwent exactly the same heat-treatment as the cylinders.

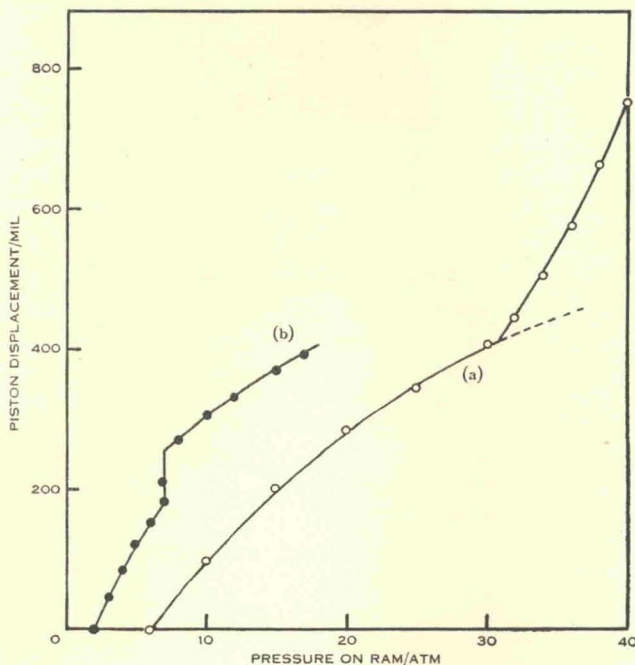


Fig. 2.—Typical piston displacement-pressure curves.  
(a) Yielding of cylinder. (b) Phase transition.

(b) *Procedure*

The test bar was subjected to tension in a Greenwood and Batley 100,000-lb hydraulic testing machine, using a Gerard extensometer with dial gauge calibrated in  $\frac{1}{10}$  mil. Extensions on a 2-in. gauge length were read to  $\frac{1}{100}$  mil by visual inter-

\* S.D.50 steel, manufactured by the Eagle and Globe Co. Makers' analysis: C, 0.30–0.37; Ni, 2.5–2.8; Cr, 0.6–0.8; Mo, 0.4–0.6; Mn, 0.5–0.7 per cent.

pulation on the gauge. The observed extension was plotted against applied load and the stress value at which the plot ceased to be linear was taken as the yield point of

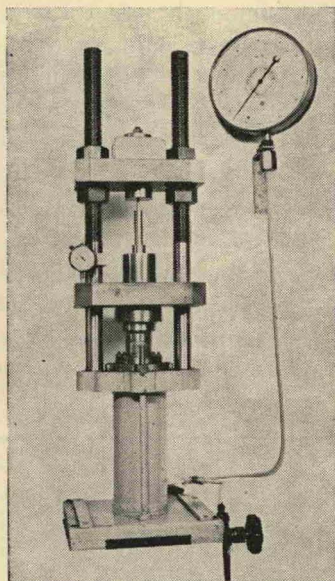


Fig. 3.—The press with test cylinder in position.

the specimen. The load at rupture was observed and the ultimate stress calculated on the basis of the original cross section of the test bar.

TABLE I  
RESULTS OF TENSILE TESTS

Series No.	Heat-Treatment (°C)	Yield Stress (tons/in <sup>2</sup> )	Ultimate Stress (tons/in <sup>2</sup> )	Reduction of Area (%)	Elongation (% on 2 in.)	Hardness (Rockwell c Scale)
1	Fully annealed 770	28.9	55	58	26	26
2	Quench 830 Temper 600	61.2	73.5	62	19.5	31
3	Quench 830 Temper 500	71.4	80.4	56	18.5	38

In testing a cylinder, it was filled with petroleum ether\* and pressure in it developed by the advance of a piston actuated by a 25-ton hydraulic press. The

\* This was used since it is known not to freeze at room temperature under pressures up to 20,000 atm.