has been primarily limited to low-strength materials by today's standards. Consequently, much of the data is inaccurate and incomplete when applied to current high strength materials.

This paper summarizes a portion of the results of an experimental program associated with the study of the overstrain of thick-wall cylinders in the diameter ratio range of 1.4–2.4 and nominal yield strength level of 165,000 psi. Experimental data are presented for the pressure required for, and the displacements associated with, the 100 percent overstrain condition. Using empirical relationships, the solution for the open-end cylinder condition using the von Mises criterion is presented. Simplified relationships are given and compared to the experimental data for both the stresses and displacements in the plastic and elastic portion.

In addition to those subjects covered within this paper, other phases of the study of overstrained thick-wall cylinders are under way and will be reported at a later date. Included are experimental determinations of the residual stress distribution, effects of material removal and temperature on the elastic strength, and progressive stress damage studies.

DESCRIPTION OF TESTS AND APPARATUS

Test Specimens

The specimen geometry consisted of a common initial 1-in. bore diameter with a length of 11 in. This length was determined to be great enough to overcome end effects in the largest diameter ratio investigated.

All specimens were obtained from 4340 steel billets 80 in. long and 4.25 in. in diameter which were gun drilled and cut into two 40 in. lengths. These lengths were heat treated by austenitizing at 1525°F, oil quenching in the longitudinal direction and tempering at 1075°F $\pm$ 25° with a resultant nominal yield strength of 165,000 psi. Each heat treated bar was then finish reamed to 1 in. I.D. and cut to obtain three 11 in. specimens. The remaining 7 in. of material provided tensile and charpy specimens.

Restraining Containers

Preliminary experimentation was conducted using several specimens, ranging in diameter ratio from 1.4 to 2.4, to determine the uniformity of strain along the specimen length. Due to the natural inhomogeneity of material, particularly at this high strength level, large variations in plastic dilation were noted, both along the length and circumferentially. Therefore, to insure uniform deformation throughout, external restraining containers were utilized. These containers were split at the half-length point and recessed to allow the application of strain gages to the specimen surface as shown in Fig. 1.

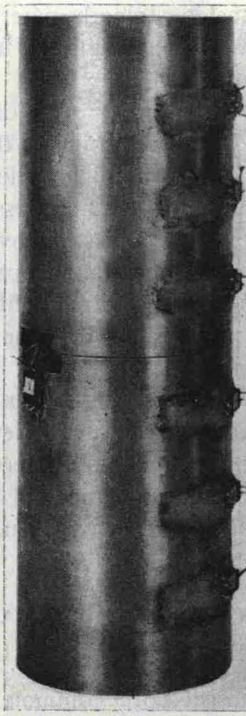

FIG. 1. Specimen and container arrangement.

Pressure Seals

The seal configuration used, as shown in Fig. 2, was of the unsupported area type consisting of an "O" ring and an annealed 1020 steel ring that is forced up an inclined plane by the internal pressure. This configuration was considered as the simplest and most trouble-free over the large range of pressures, permanent bore enlargements, and diameter ratios encountered in this investigation.

Test Apparatus

The pressure source as shown in Fig. 3 was a 200,000 psi 10 in^3/min intensifier type pumping system manufactured by the Harwood Engineering Company. This system has an intensification ratio of 100:1 with a low pressure source of 2000 psi and a charging pressure of 10,000 psi.

Pressures were measured with a Manganin cell and a Wheatstone bridge. This Manganin pressure measurement system was calibrated on a controlled clearance piston gage which utilizes a known weight supported on a free piston of known area. In this device the unknown pressure, which the Manganin cell measures, is introduced into the bottom of the cylinder and