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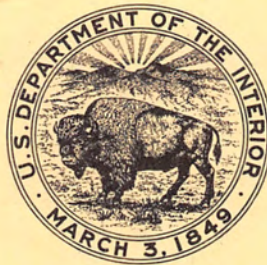
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**DESIGN, ASSEMBLY AND USE OF A  
PORTABLE VANE SHEAR TESTER**

**Hydraulic Laboratory Report No. Hyd-434**

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**DIVISION OF ENGINEERING LABORATORIES**



COMMISSIONER'S OFFICE  
DENVER, COLORADO

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**June 21, 1957**

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Commissioner's Office--Denver  
Division of Engineering Laboratories  
Hydraulic Laboratory Branch  
Hydraulic Investigations Section  
Denver, Colorado  
June 21, 1957

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DESIGN, ASSEMBLY AND USE OF A PORTABLE VANE SHEAR  
TESTER LOWER-COST CANAL LINING PROGRAM

SUMMARY

A study under the Lower-cost Canal Lining Program to determine the relationship between erosion of earth materials in earth lined and unlined canals, and the hydraulic tractive forces causing erosion, is underway by the Hydraulic and Earth Laboratories. Various soils properties are being correlated with hydraulic conditions occurring in canals to improve our methods of design. One soil property that is determined is the in-place resistance to shear near the soil surface. To determine the maximum shear stress an earth material near the surface can withstand when in place in a canal and in a saturated condition, a portable vane shear tester was designed and constructed. Using this instrument, a simple and inexpensive test in the field can be made by one man,

INTRODUCTION

To aid in the erosion-tractive force studies under the Lower-cost Canal Lining Program, it was desired to determine the in-place shear strengths of saturated soils near the surface in canal bottoms and banks. A vane shear testing apparatus\* presently in use in the Earth Laboratory was developed principally for foundation investigations. The instrument is equipped for testing at various depths under a wide variety of conditions. Accurate shear measurements are made by controlling the rate of testing and providing a complete stress versus rotation record. The primary concern in the erosion and tractive force study is to obtain the shear resistance of the earth canal lining when

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\*Description and procedure available in Earth Laboratory.  
Gibbs, H. J., "An Apparatus and Method of Vane Shear Testing of Soil," Symposium In-place Shear Testing of Foundations by the Vane Method, American Society for Testing Materials, Publication STP-193.

water is flowing in the canal. To accomplish this it is necessary for one man to be able to obtain numerous, quickly made shear measurements. It would be unhandy to use the Earth Laboratory instrument in its present form to obtain these measurements because of its regulating equipment. For this reason a smaller, simplified vane shear tester, patterned after the Earth Laboratory instrument, was designed and constructed. By eliminating most of the regulating equipment, precise measuring devices and other features necessary for foundation investigations and testing at varying depths, the vane shear tester was made portable, comparatively light and easily operated by one man.

The design, assembly and operation of the small portable vane shear tester is described in this report.

### DESIGN, ASSEMBLY AND USE OF THE VANE SHEAR TESTER

As shown by Figures 1 and 2, the instrument consists of a 2-foot-long torque handle, a 5-inch-diameter torque ring machined from a high yield-point steel, a dial strain gage, several 4-foot-long sections of 1-inch-diameter extension rods, a soil surface plate, and 3 sets of vanes. The sizes of the 3 vanes are: 2 inches in diameter by 4 inches high; 3 inches in diameter by 4 inches high; and 4 inches in diameter by 8 inches high. While vanes are usually designed with a diameter equal to one-half their length, the 3-inch by 4-inch vane was designed to furnish a vane with a shear stress range between those of the other two vanes, and to concentrate testing near the soil surface. The torque ring has a 3/8-inch-wide segment removed so that when a torque is applied the ring can deflect. The amount of deflection is measured by the dial strain gage mounted on the ring.

The instrument is assembled in the following sequence, see Figures 1 and 2:

- (1) A vane of the desired size is selected and attached to the bottom of a section of the 1-inch extension rod.
- (2) The soil surface plate is fastened in the recess just above the vane.
- (3) The necessary number of additional extension rods are attached.
- (4) The torque ring and dial gage assembly are attached to the top of the rods.
- (5) The torque handle is attached.

In use, the instrument is placed perpendicular to the surface of the soil to be tested and the vane is gently pushed into the material. If necessary, the soil surface plate may be used as a foot support to help push the vane into the soil surface. A zero reading of the dial gage is recorded, and a torque is slowly and steadily applied to the torque ring by twisting the 2-foot-long torque handle mounted on top of the ring. The operator should make the rate of rotation slow since the recommended rate of rotation for the Earth Laboratory instrument is 0.1 degree per second. Although speed control is considered important, it was necessarily eliminated in the smaller instrument to adapt it for this study. The torque is transferred through the split ring into the extension rod fastened to the bottom of the ring. The torque in the rod causes the vanes fastened to the lower end of the rod to turn. The turning of the vanes is resisted in shear by a cylindrical area of earth equal to the periphery of the vanes plus the circular area covered by the bottom of the vanes.

The torque is applied until the dial gage reading reaches a maximum and backs off. The maximum reading is recorded and the difference between the zero reading and the maximum is a measure of the applied torque. The split ring was calibrated to determine the relationship between applied torque and dial gage deflection reading. This relationship is shown by the graph on Figure 3. The torque applied to the instrument at the time of maximum shear stress is determined from the maximum dial gage reading and the curve on Figure 3. The shear stress is then determined from Figure 4 using the proper curve for the vane size used.

Figure 5 shows the torque ring, the 4-inch by 8-inch vane, and a test hole that resulted from a shear test performed on a saturated loess material. Note the smooth sides of the hole and the corresponding circular soil core clinging to the vanes.

#### ANALYSIS OF LOADS ON VANE

The vanes are pushed into the soil until the surface plate is flush with the soil surface. Shearing resistance is developed on the cylindrical surface described by the vertical edges of the vanes and on the circular area described by the bottom edges. It is assumed that the shearing stress is uniform over the surface of the cylinder and the bottom circular area. Friction is insignificant and is neglected. A short computation of the total resisting moment follows:

The total resisting moment developed by the cylindrical surface  $T'_c$  is:

$$T'_c = 2\pi r^2 HSs$$

where

$r$  = radius of the cylindrical surface described by the vanes

$H$  = height of the vanes

$Ss$  = the unit shearing stress over the entire surface

The total resisting moment developed by the circular bottom area  $T''_c$  is:

$$T''_c = \frac{2}{3}\pi r^3 Ss$$

The total resisting moment  $T_c = T'_c + T''_c$  or  
 $T_c = 2\pi r^2 Ss(H + \frac{r}{3})$

### CALIBRATION

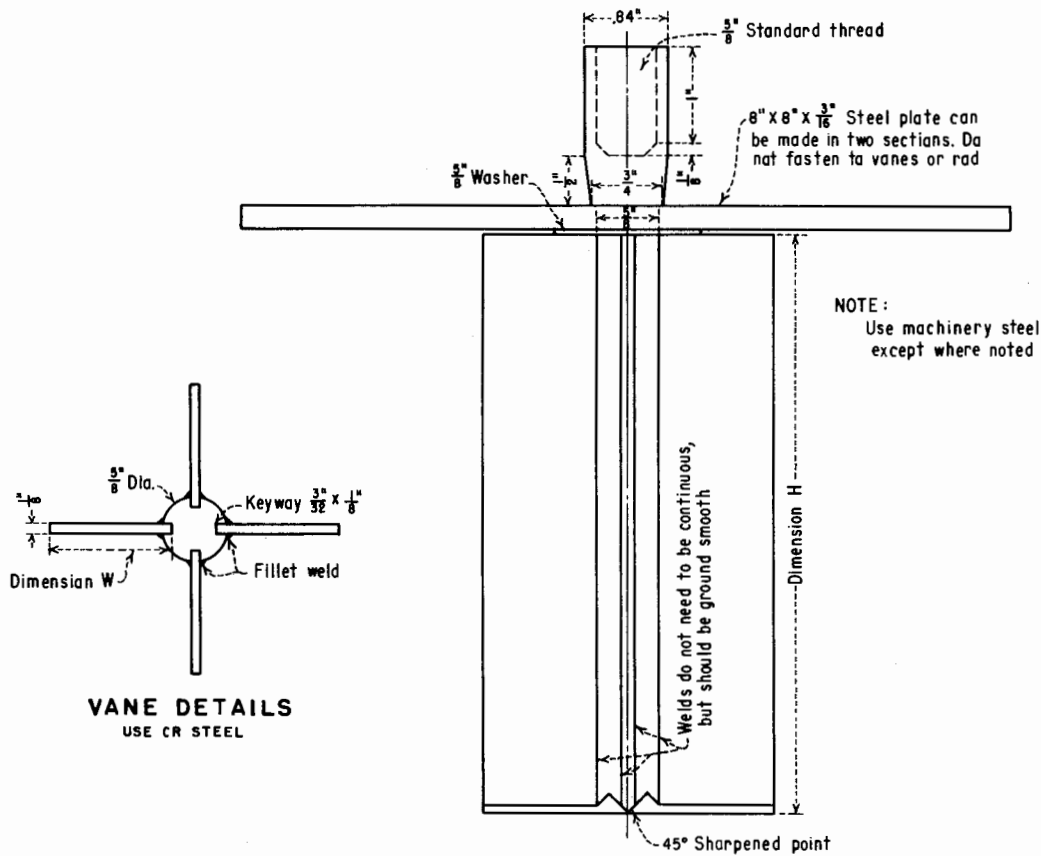
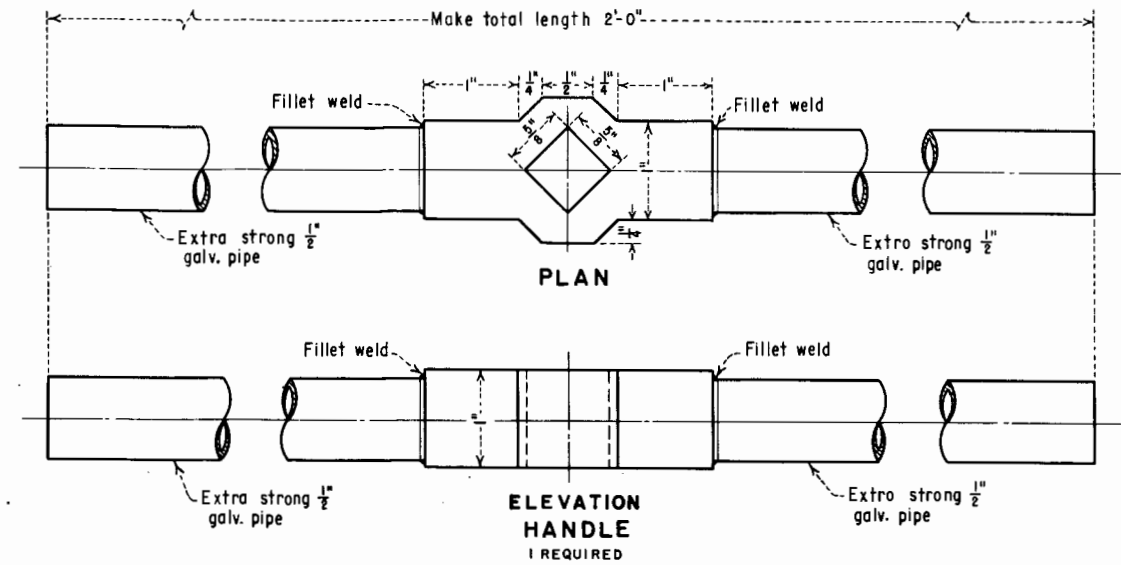
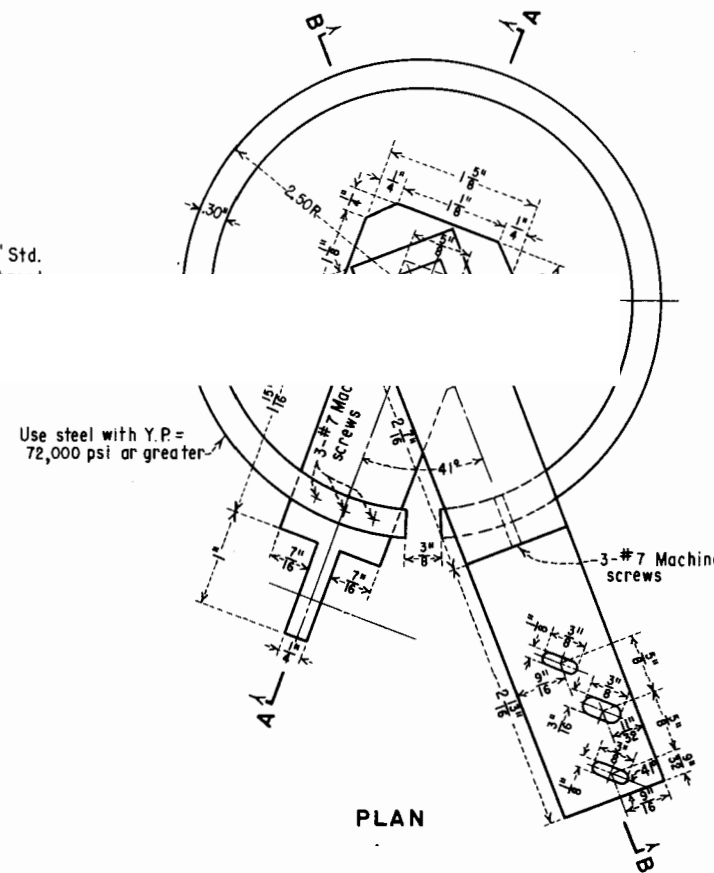
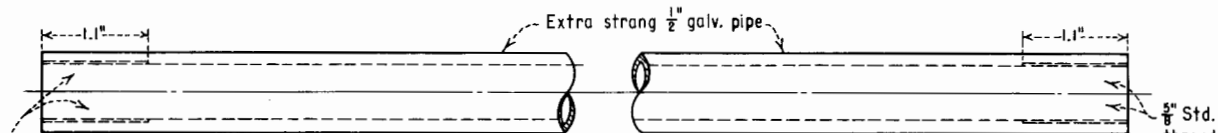
The instrument was calibrated by applying a known torque to the vanes and recording the dial gage reading. The plotted average of 12 runs is shown in Figure 3. Calibration results indicated a maximum of 10 percent deviation from the highest to the lowest dial gage reading at a given known torque.

To establish the stress at which the soil fails in shear, the torque required to turn the vanes is first obtained from Figure 3. The torque is then used with Figure 4, which relates the torque to the shear stress for each of the three vanes.

### CONCLUSIONS

The relationship between shear resistance of soils in earth canals and their resistance to erosion due to hydraulic tractive forces is one correlation being used in a study under the Lower-cost Canal Lining Program to improve methods of design of earth canals. Using a portable vane shear tester, Figure 2, designed for this purpose, a simple and inexpensive field test can be made to determine the shear resistance of soils, in place, and in a saturated condition. The test can be performed by one man and does not require the extraction of earth samples from the canal.

The vane shear tester described in this report was designed for the special purpose of testing for the erosion and tractive force study in earth canals. It is not considered adaptable to foundation testing where greater control and more complete information are desired, or to subsurface investigations at varying depths.

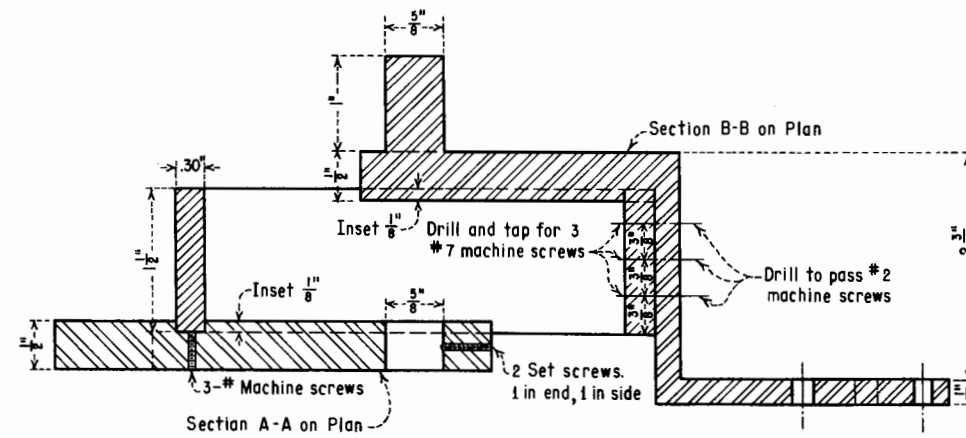


NOTE:  
Use machinery steel  
except where noted

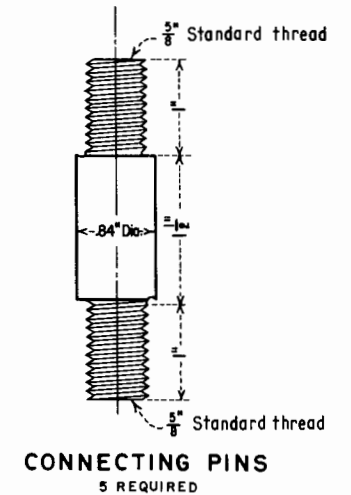
VANE DETAILS  
USE CR STEEL

DIMENSIONS	
H	W
4"	$1\frac{25}{32}$ "
4"	$1\frac{1}{32}$ "
6"	$1\frac{25}{32}$ "
8"	0

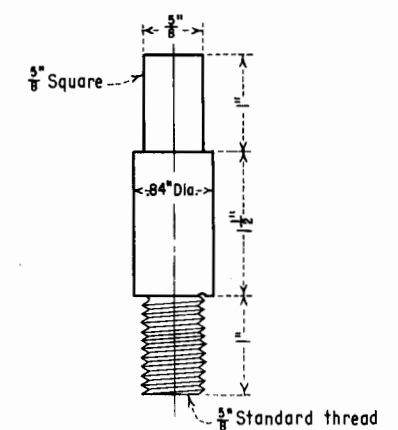
VANES  
4 REQ'D. (SEE DIMENSIONS AT LEFT)  
3-WITH VANES  
1-CENTER RDD ONLY



SECTIONS  
TORQUE RING  
WITH BRACKETS



CONNECTING PINS  
5 REQUIRED

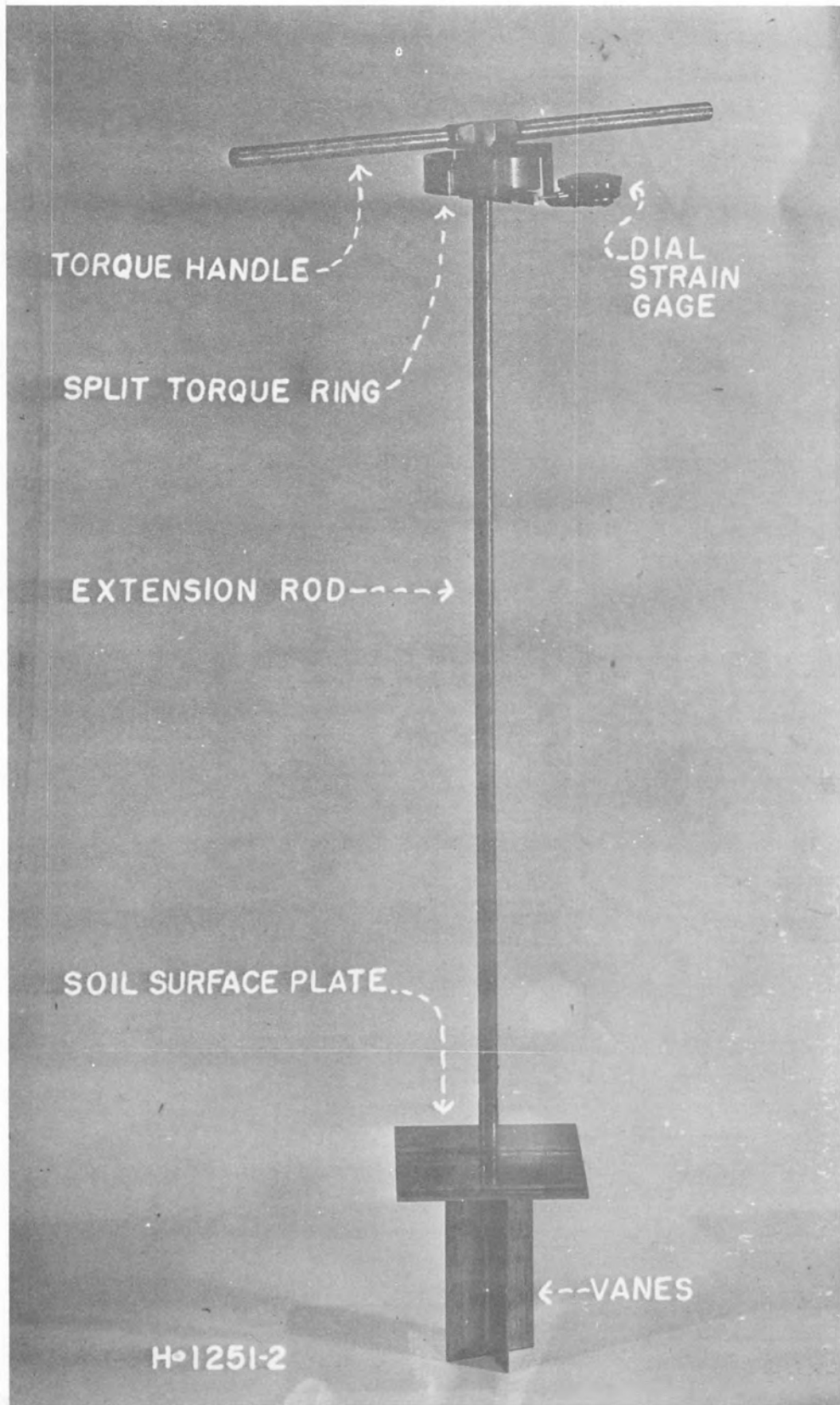


END PIN  
2 REQUIRED

HYDRAULIC LABORATORY  
VANE SHEAR TESTER  
FOR NEAR-SURFACE EROSION  
AND TRACTIVE FORCE INVESTIGATION



Figure



HYDRAULIC LABORATORY  
VANE SHEAR TESTER

FIGURE 3

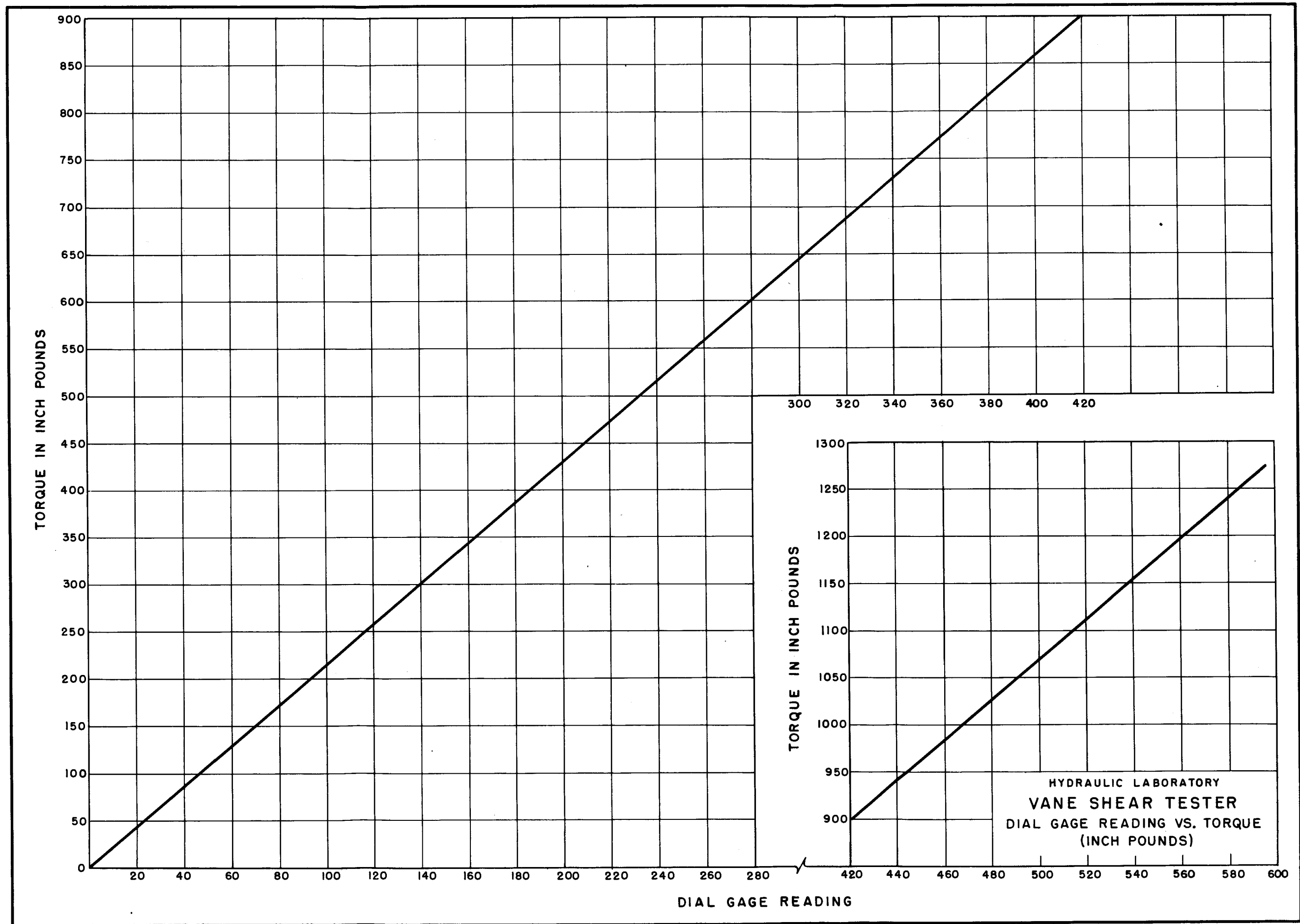
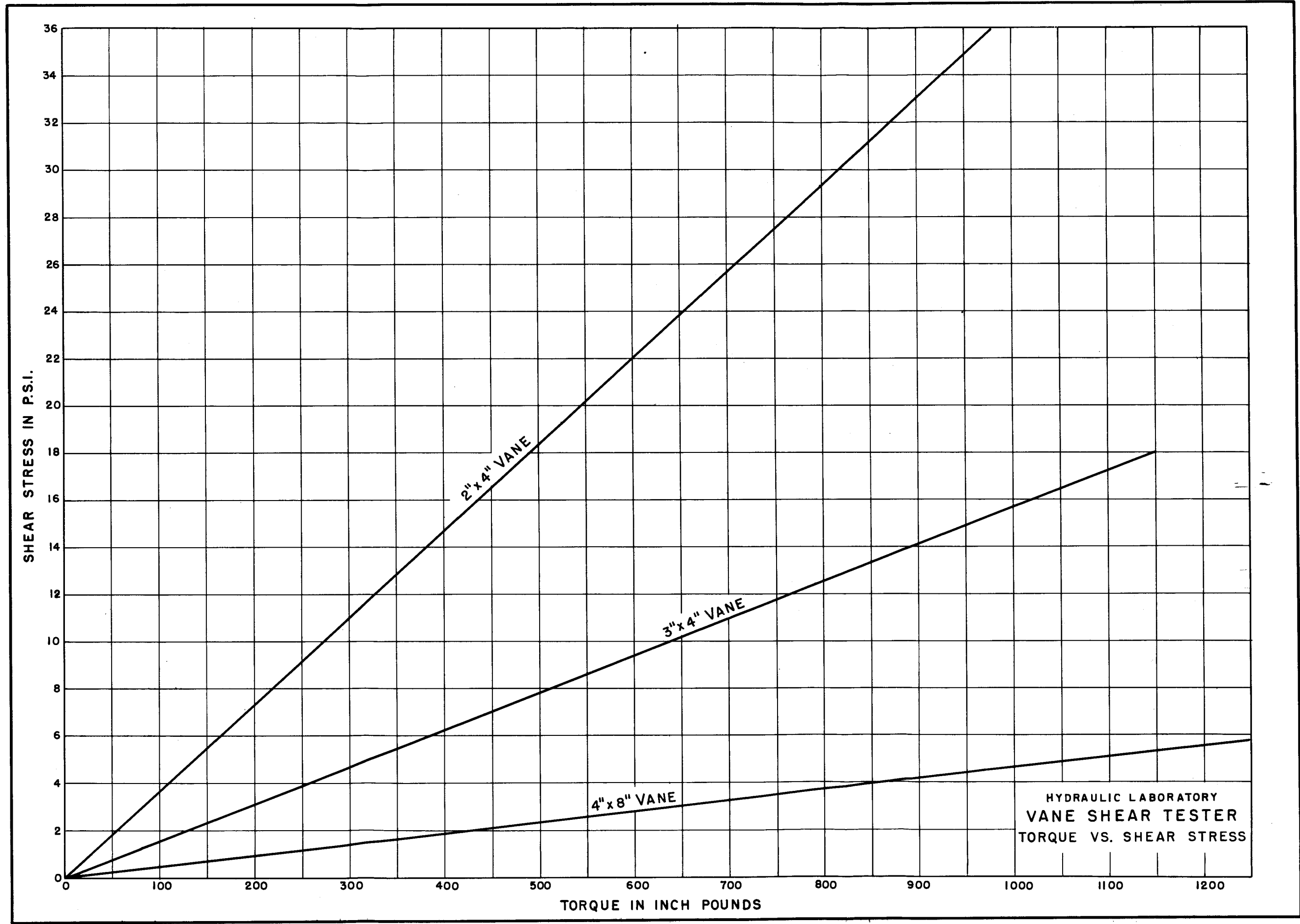


FIGURE 4



**Figure 5**



**HYDRAULIC LABORATORY**

**4- BY 8-INCH VANE. SPLIT TORQUE RING AND HOLE  
RESULTING FROM SHEAR TEST.**

