1.6 LOW FLUID LEVEL IN PULSE ROD SHOCK ABSORBER, H. C. Aderhold (Cornell University)

The Cornell University Modified Mark II Pulsing TRIGA has 4 control rods; Safety, Shim, Regulating, and Transient (Pulse) rods. Several years ago it was first observed that during pulse mode operation, the regulating rod had dropped when the pulse rod was withdrawn. At that time the origin of the problem was thought to be associated with one or all of the following.

1) Low magnet current
2) Electrical transients affecting magnet current
3) Poor coupling between the control rod armature and magnet

The suspected problem areas were investigated and corrections made where warranted. These efforts seemed to correct the problem, however, after a month or more and after a good deal of pulse mode operation, the problem would recur. Eventually, it became worse and on several occasions, both, the shim and regulating rods would drop simultaneously when the pulse rod was withdrawn, resulting in a reduced pulse.

At this time an all out effort was made to correct the problem, eventually finding that the regulating rod extension would separate from its support magnet at the time the pulse rod drive piston would strike the shock absorber anvil. Fig. 1 shows a schematic view of the pulse rod drive assembly. This ruled out the possibility of an electrical transient problem and indicated one of mechanical origin which was eventually traced to the pulse rod drive shock absorber shown in Fig. 2.

Fortunately we were able to borrow an identical shock absorber (one which had seen very little service) from Columbia University. Immediately upon installing the borrowed unit our problem appeared to disappear. However, because of the infrequent nature of the problem we chose to compare the performance of each unit by the following methods.

1) Manual operation
2) Accelerometer test
3) Direct measure of pulse rod travel

In the manual test both units were compared by merely operating them by hand on a table top. The borrowed unit appeared to absorb more energy. The output of an accelerometer clamped to the pulse rod drive support also indicated that the borrowed unit absorbed more energy. The third performance test was made by attaching a slide wire mechanism to the pulse rod extension and recording the movement of the pulse rod by feeding the output of the slide wire to a Honeywell Visicorder. Fig. 3 gives a schematic diagram of the system with the results of the comparison test shown in Fig. 4.

Results of the investigation pointed to the possibility of low hydrolic fluid in our shock absorber. Through the cooperation of Gulf General Atomic we obtained a shop drawing which gave us the information needed to inspect for fluid level. This involved drilling a small hole through the outer wall of the shock absorber at the point of prescribed fluid level. As expected no fluid was present at that point. By using a syringe, 43.5 cc of heavy duty brake fluid was added in order to bring the level to the proper point. The inspection hole was then welded shut and a comparison of pulse rod travel was again made which is shown in Fig. 5. Our shock absorber was then put into continous service and since that time after several dozen pulses, not a single recurrence of the problem has been observed.

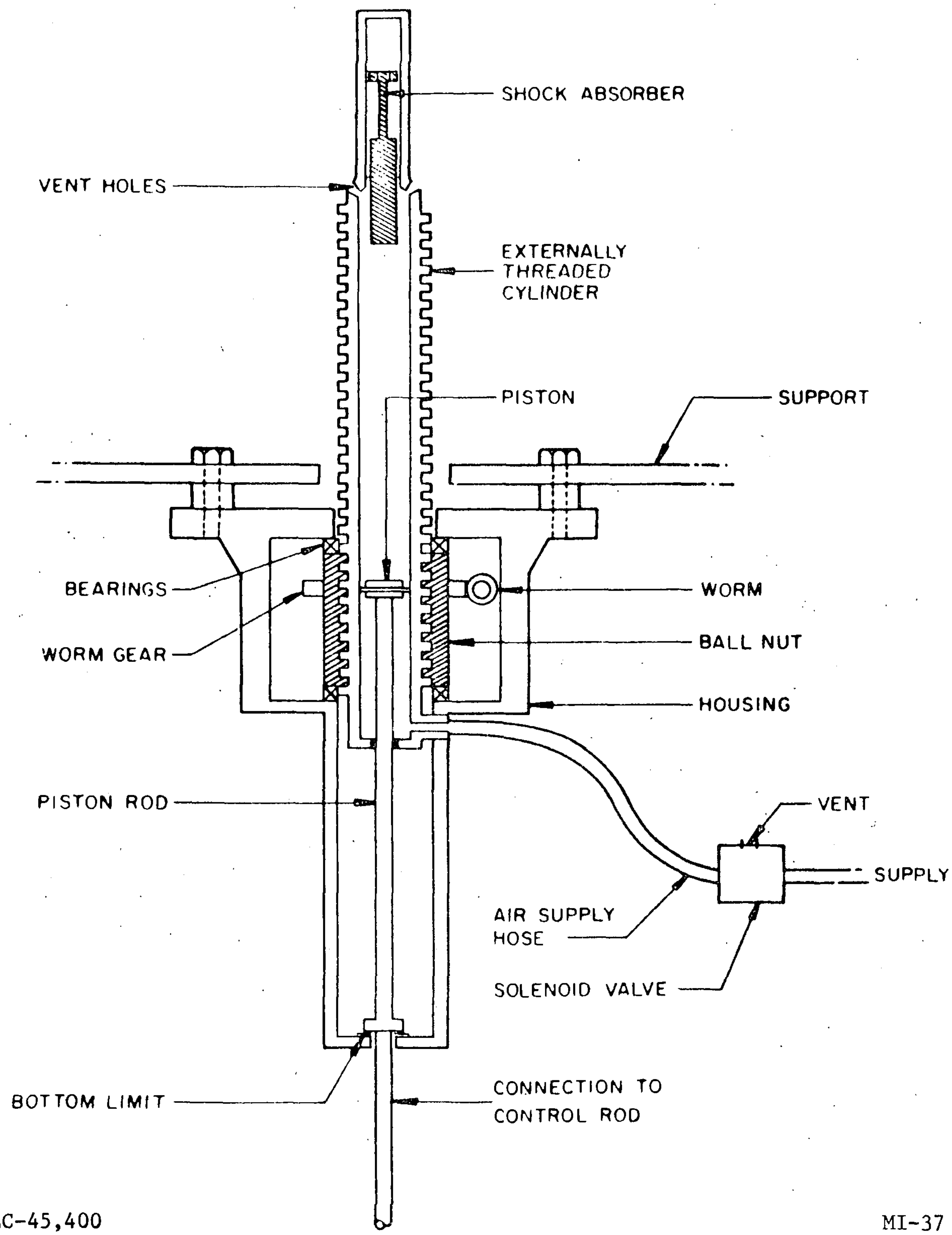
Our investigation demonstrated that filling the shock absorber to the proper level corrected the problem, it did not tell us whether low fluid level was a result of leakage or whether it was due to insufficient filling initially. However, in case that leakage does in fact occur, the following non-destructive methods for periodically observing fluid level were investigated.

1) Ultrasonic sound
2) Use of x rays
3) Use of neutrons

Ultrasonic sound and x rays were tried but were unsuccessful. The use of neutrons was considered last because the only source of sufficient magnitude was our TRIGA itself which we thought would have to be operated at high power levels with the pulse rod inserted (the air supply to the pulse rod drive cylinder must be disconnected for safety) in order to obtain a collimated beam of sufficient density. However, the following experiments show that for our purposes a very low neutron flux, therefore, low reactor power is sufficient.

First, a mock-up was made from stainless-steel tubing having the same wall thickness and approximately the same O.D. as the outer cylinder of the shock absorber and then partially filled with hydraulic fluid. Two very course measurements of the fluid level in the mock-up were made; 1) by neutron activation of Dysprosium foils and 2) by neutron exposure of ^{7}Li-F and ^{6}Li-F TLD's. The thermal neutron beam having an intensity of 4×10^{4}n/cm^{2}sec was from a 1.5 inch diameter access port penetrating the 4 foot thick concrete shield door of our thermal column. Dysprosium foil activation gave about a 10 to 1 difference in the neutrons penetrating the cylinder in the area of the fluid as compared to those neutrons penetrating the area below the fluid. The results of the TLD measurements are given in Fig. 6. These preliminary measurements though very course, demonstrated the effectiveness of using thermal neutrons for detecting the level of hydraulic fluid in the pulse rod drive shock absorber.

Searching for still a simpler and more accurate method for detecting the fluid level, neutron radiography was considered. After a series of experiments it was found that the fluorescence from a ^{10}B-ZnS converter screen was sufficient to expose Polaroid Type 57 4x5 film. In order to obtain a larger crossectional collimated neutron beam, the inner 5 inch square shield plug was removed from the thermal column door and a 4 inch long Cd-Pb collimator was installed at the reactor core end of the opening shown in Fig. 7. This gave a thermal neutron beam of approximately 6×10^{3}n/cm^{2}/sec. The resulting neutron radiograph of Cornell's pulse rod drive shock absorber is shown in Fig. 8. The arrow indicates the prescribed fluid level.



LC-45,400 MI-37

Fig. 1. Schematic of transient-rod drive assembly

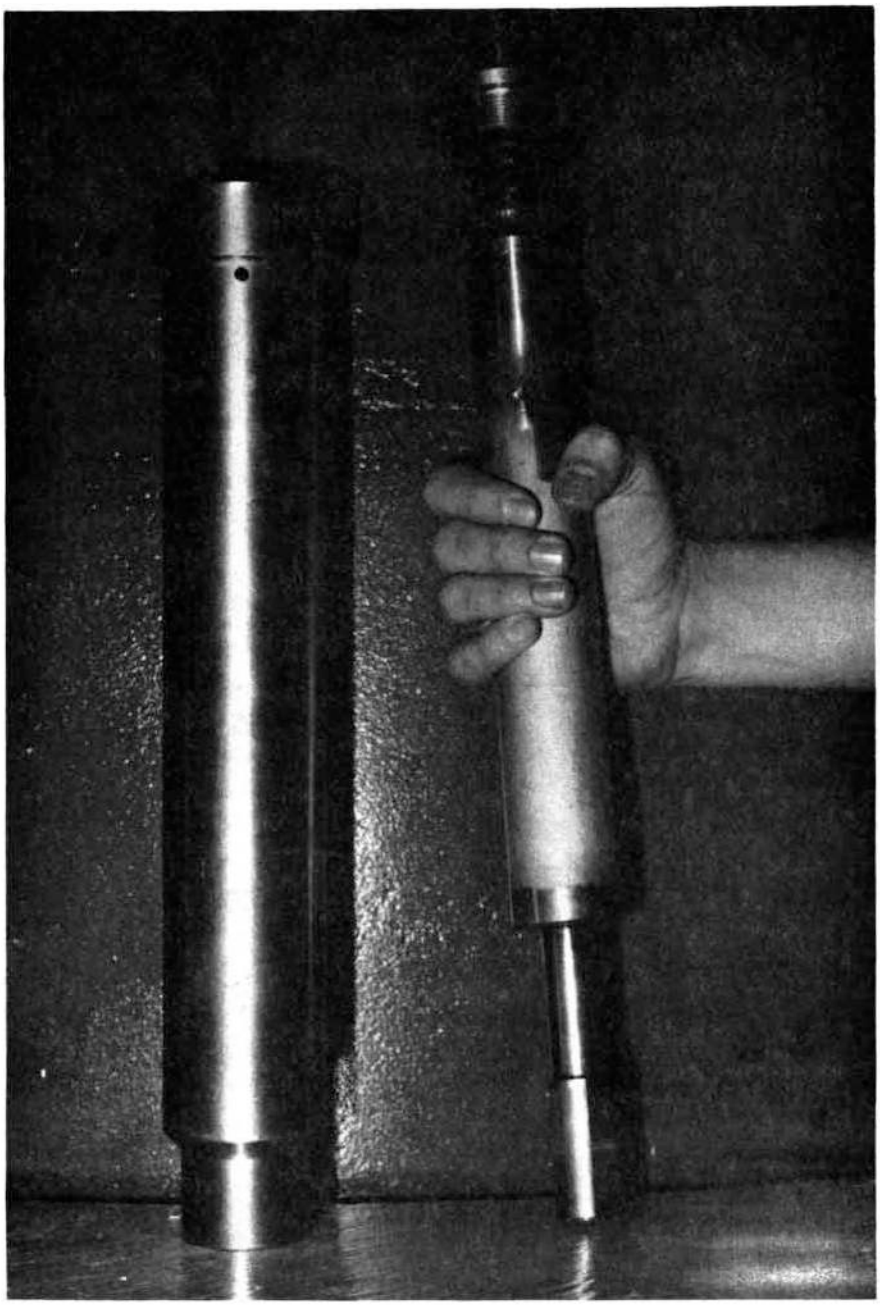


Fig. 2. Pulse rod drive shock absorber

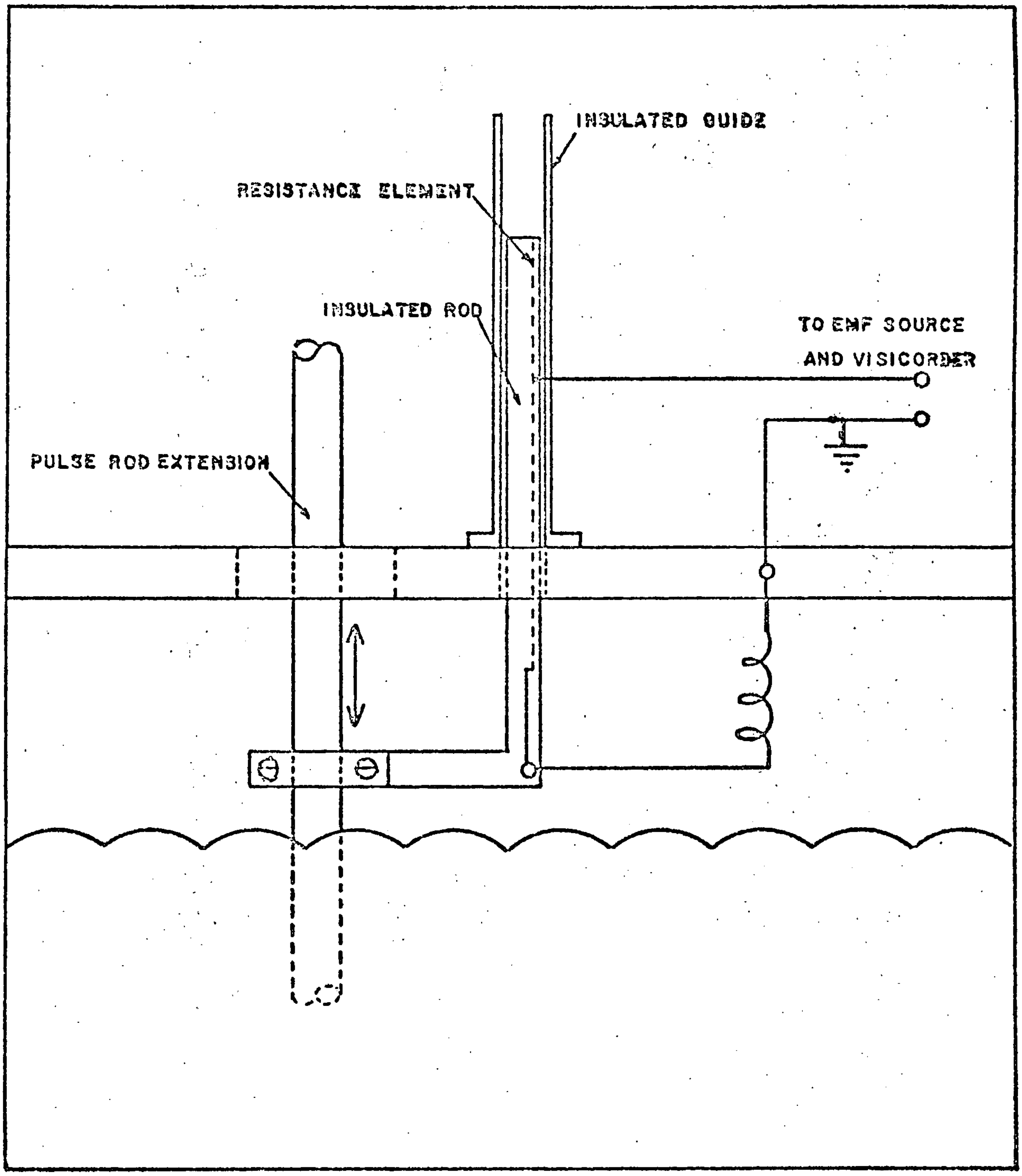


Fig. 3. Pulse rod position measuring devise

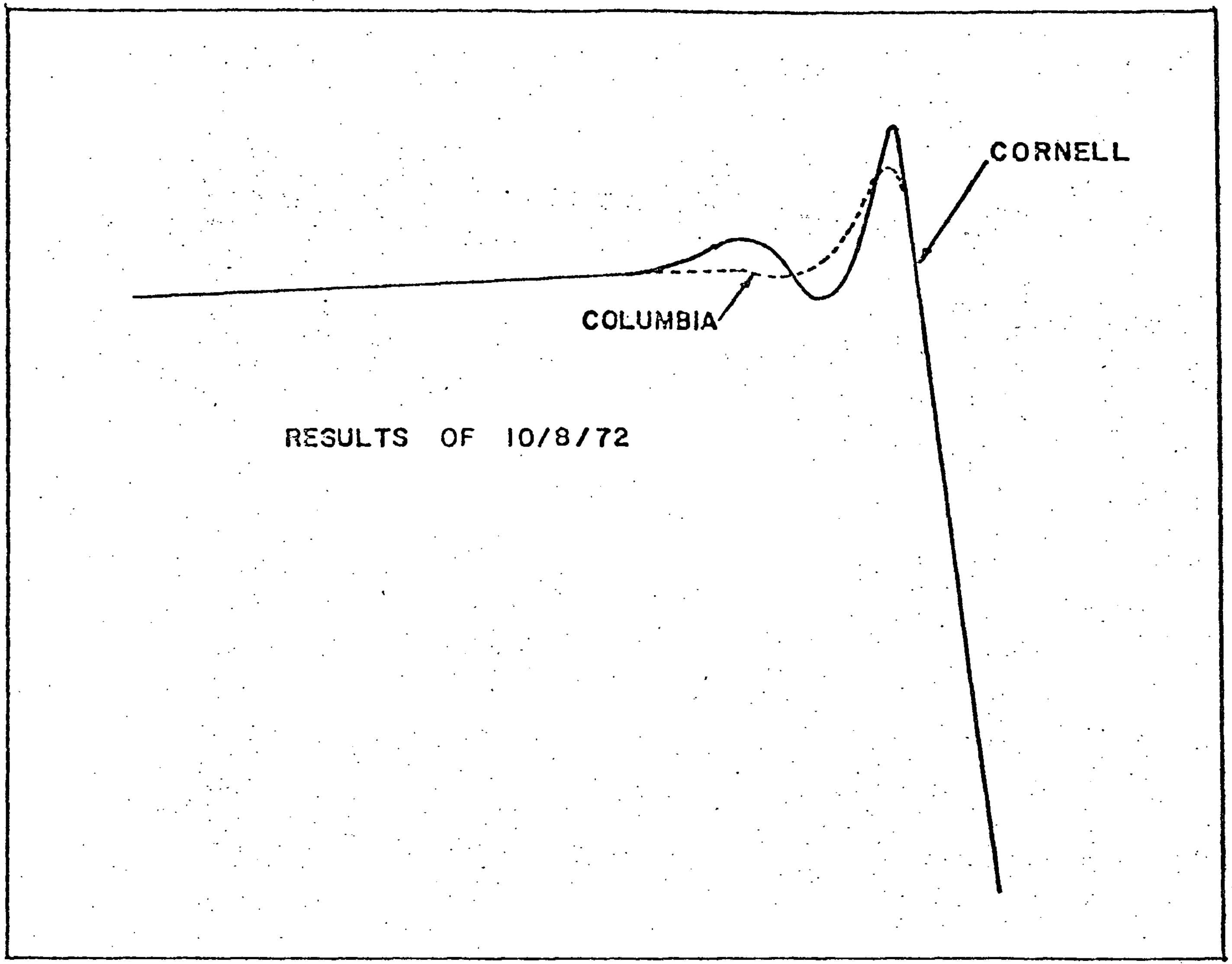


Fig. 4. Visicorder trace of shock absorber response

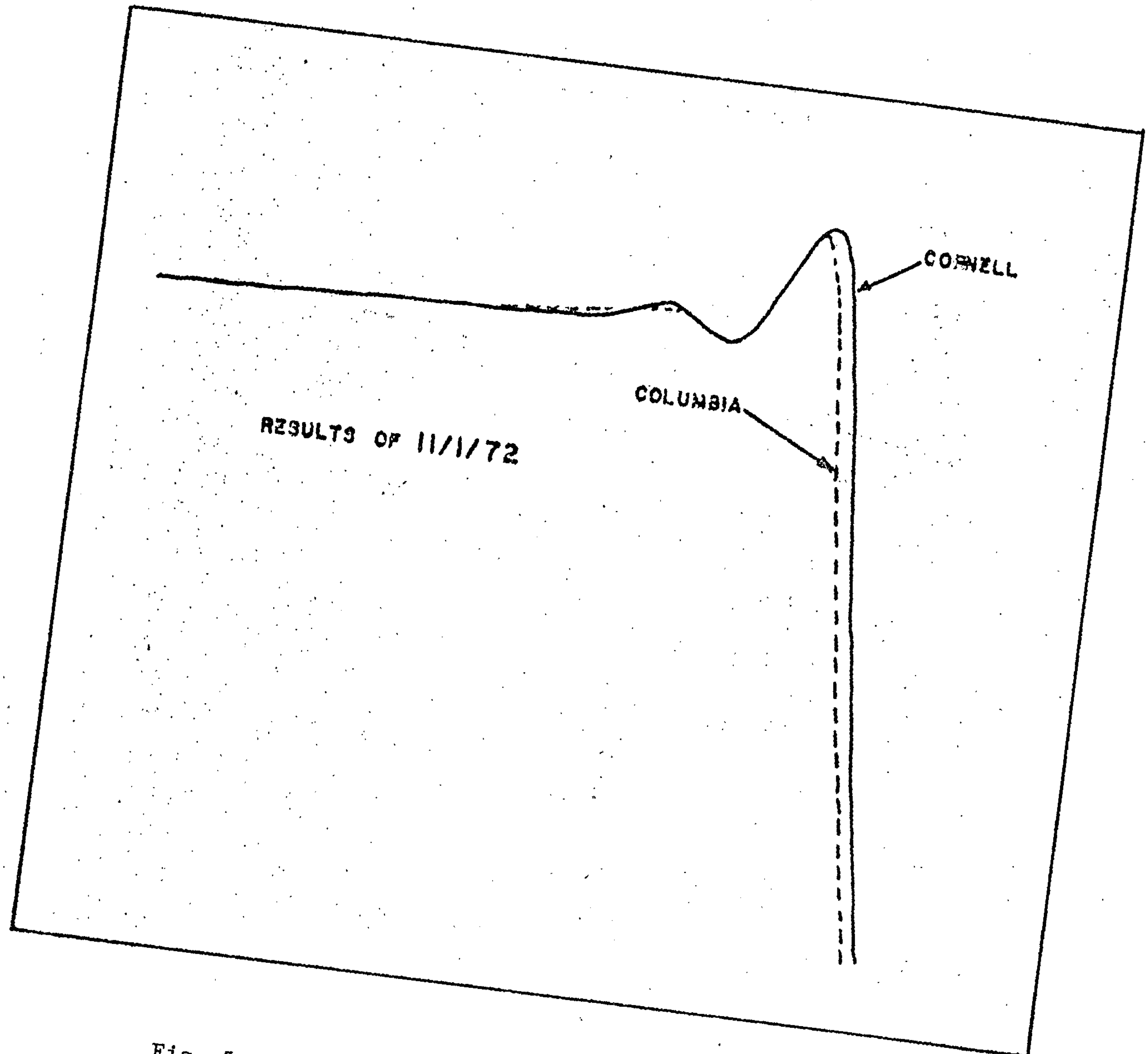


Fig. 5. Visicorder trace of shock absorber response

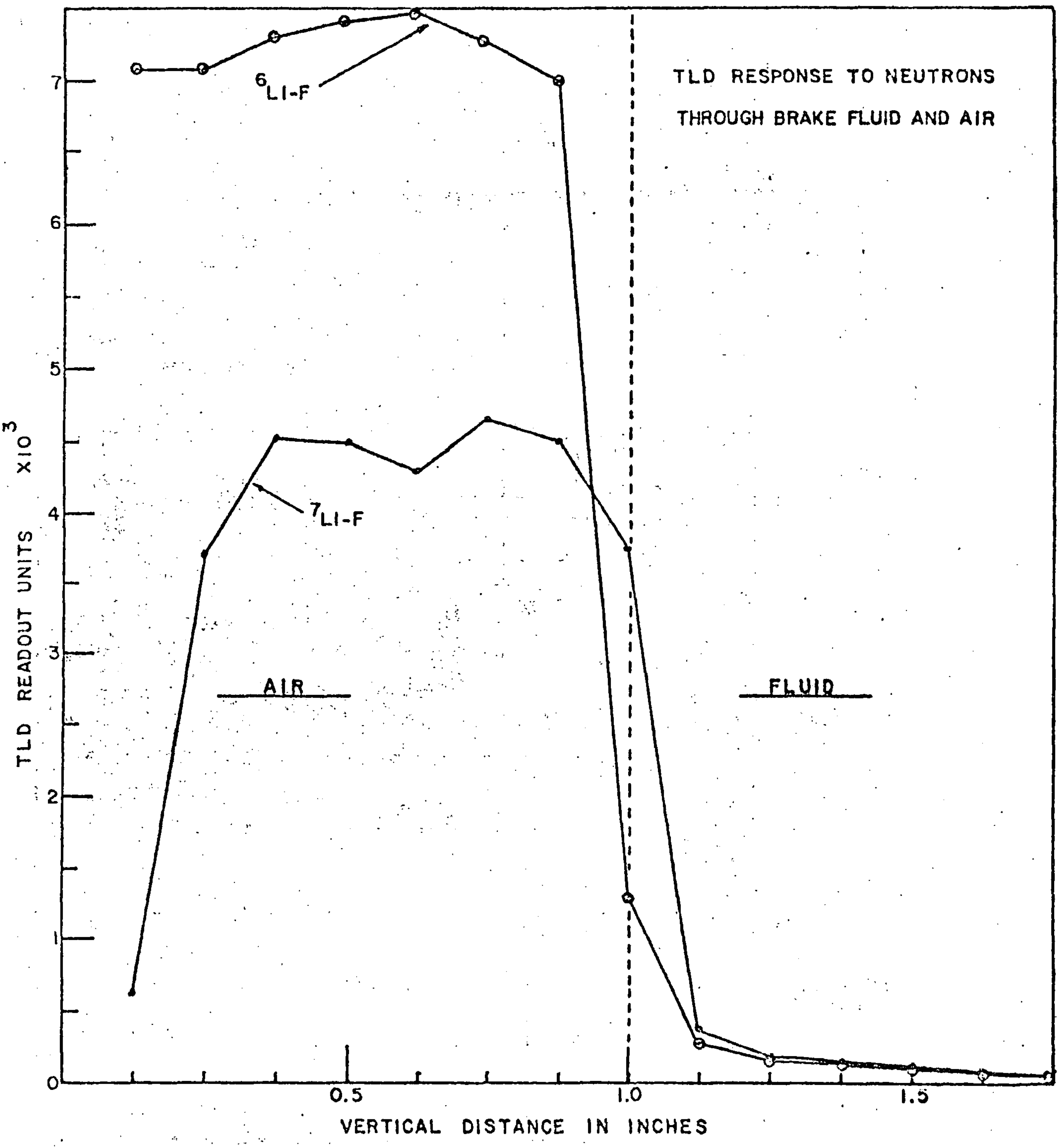

TLD RESPONSE TO NEUTRONS
THROUGH BRAKE FLUID AND AIR
6LI-F
7LI-F
AIR
FLUID
TLD READOUT UNITS X10^3
VERTICAL DISTANCE IN INCHES
0
1
2
3
4
5
6
7
0.5
1.0
1.5

Fig. 6

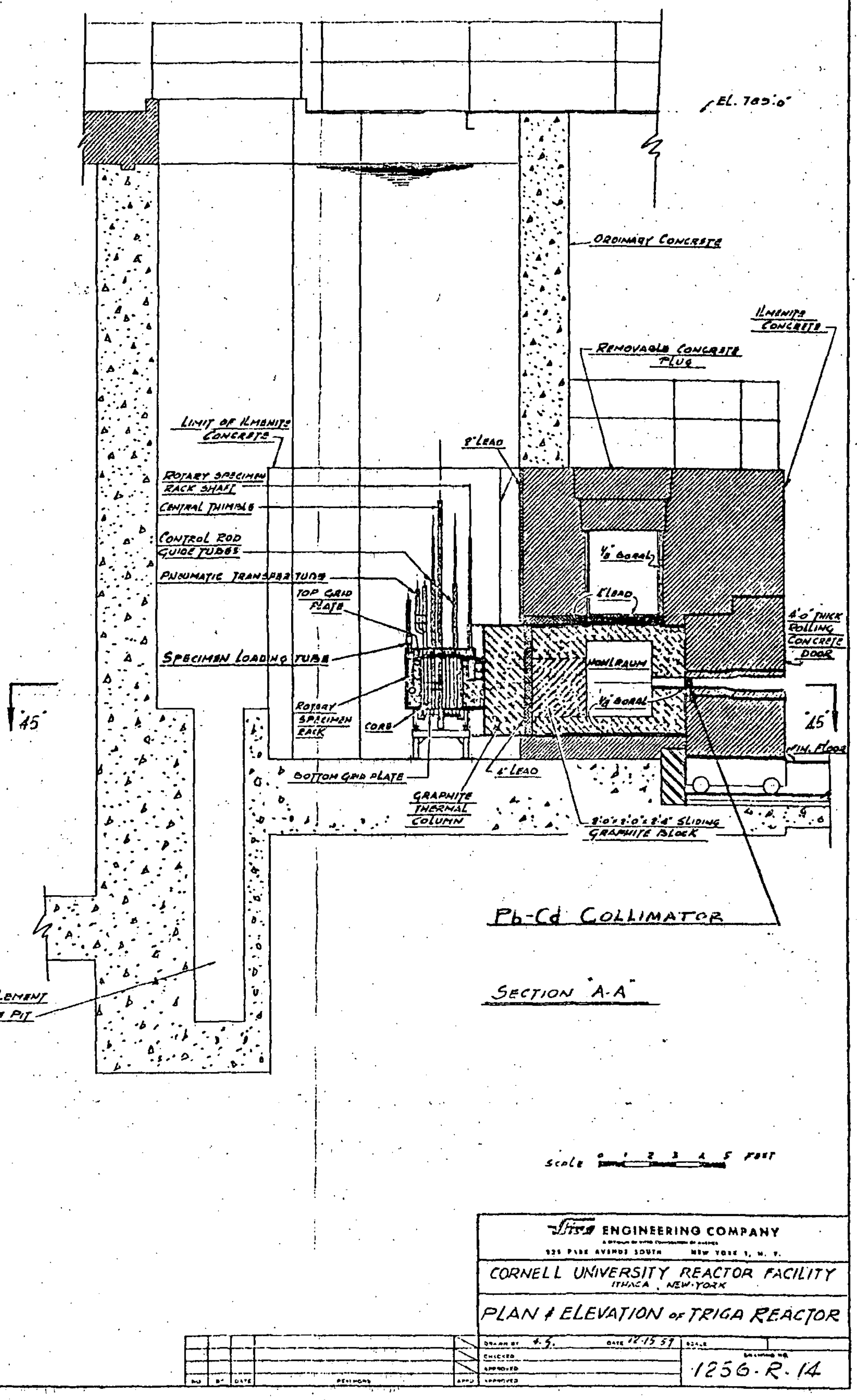

EL. 785'-0"
ORDINARY CONCRETE
ILMENITE CONCRETE
REMOVABLE CONCRETE PLUG
LIMIT OF ILMENITE CONCRETE
8" LEAD
ROTARY SPECIMEN RACK SHAFT
CENTRAL THIMBLE
CONTROL ROD GUIDE TUBES
PNEUMATIC TRANSFER TUBE
TOP GRID PLATE
SPECIMEN LOADING TUBE
ROTARY SPECIMEN RACK
CORE
BOTTOM GRID PLATE
GRAPHITE THERMAL COLUMN
4" LEAD
HOHLRAUM
1/4" BORAL
4'-0" THICK ROLLING CONCRETE DOOR
FIN. FLOOR
45°
Pb-Cd COLLIMATOR
SECTION "A-A"
FUEL ELEMENT STORAGE PIT
SCALE 0 1 2 3 4 5 FEET
ENGINEERING COMPANY
CORNELL UNIVERSITY REACTOR FACILITY
ITHACA, NEW YORK
PLAN & ELEVATION OF TRIGA REACTOR
1256-R-14

Fig. 7

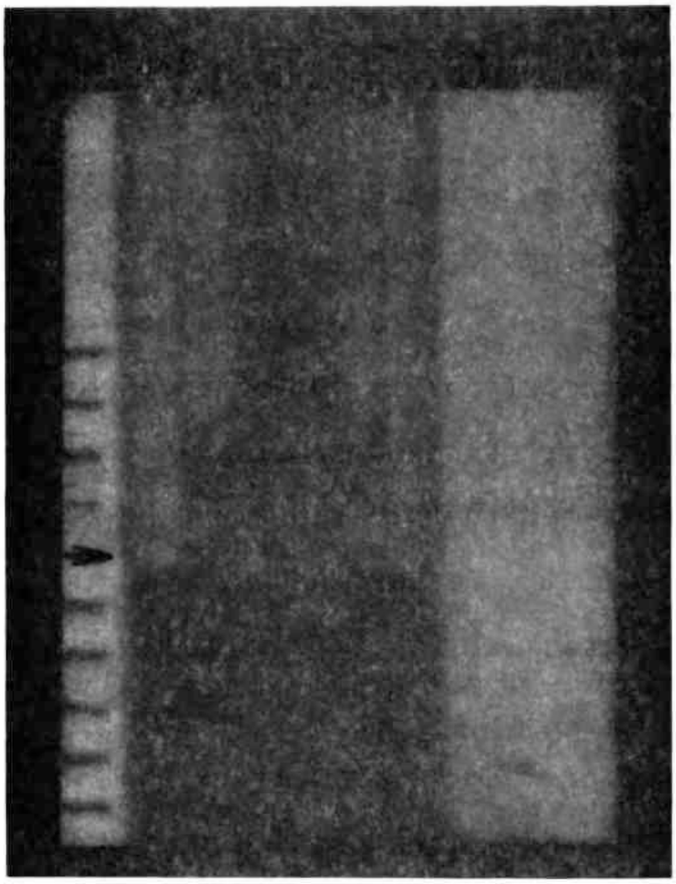


Fig. 8. Neutron radiograph of pulse rod shock absorber. Arrow indicates prescribed fluid level.