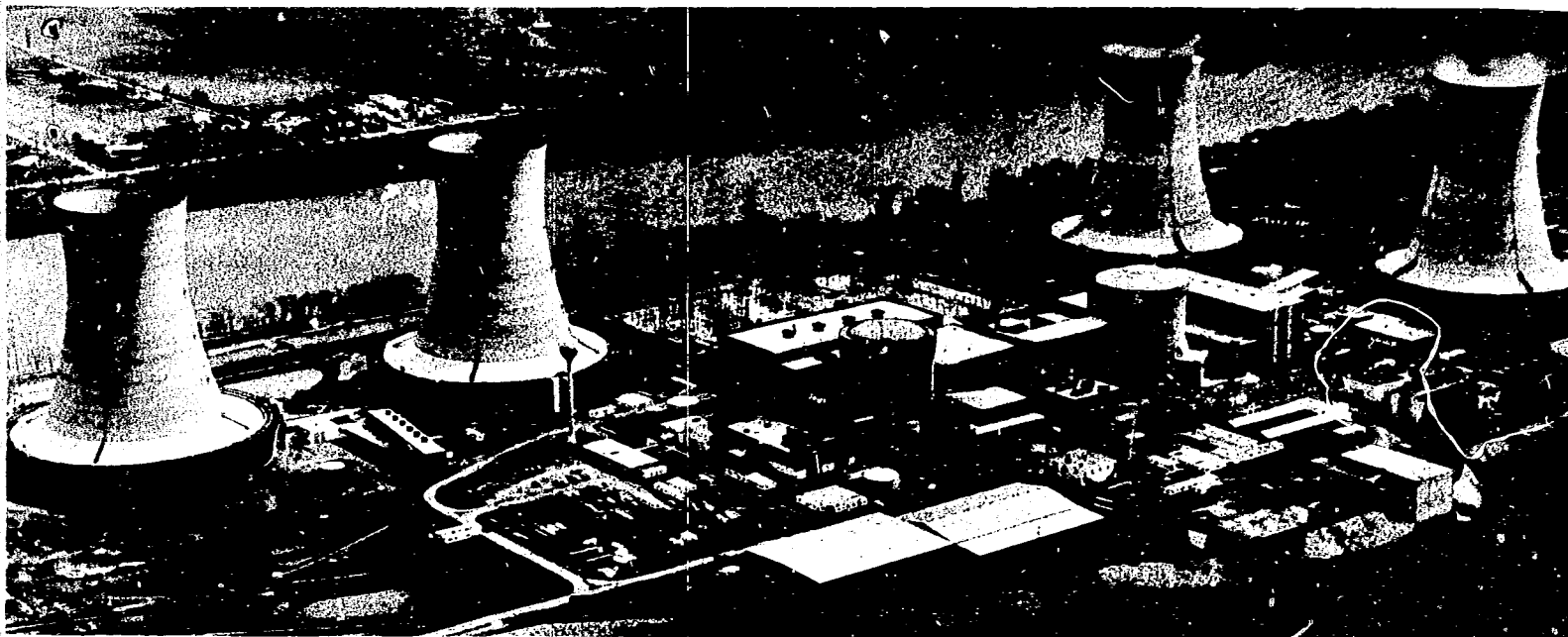


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TMI-2 PRESSURE TRANSMITTER EXAMINATION AND EVALUATION OF CF-1-PT1, CF-2-LT1, AND CF-2-LT2

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U.S. Department of Energy
Three Mile Island Operations Office
Under DOE Contract No. DE-AC07-761D01570

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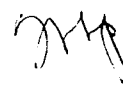
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Published April 1984

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ABSTRACT

Pressure transmitters CF-1-PT1, CF-2-LT1, and CF-2-LT2 were removed from the Three Mile Island Unit 2 (TMI-2) Reactor Building and examined during FY-83. The purpose of the examination was to establish the operational characteristics and determine the failure mode of two of the three transmitters.

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TMI-2 PRESSURE TRANSMITTER
EXAMINATION AND EVALUATION OF CF-1-PT1, CF-2-LT1, AND CF-2-LT2

INTRODUCTION

This report discusses the examination and evaluation of pressure transmitters CF-1-PT1, CF-2-LT1, and CF-2-LT2 that were removed from the Three Mile Island Unit 2 (TMI-2) Reactor Building in June 1983 and evaluated by EG&G Idaho, Inc. at the Idaho National Engineering Laboratory (INEL). All three units were shipped to the INEL where they were examined in their as-received condition. No attempts were made to decontaminate the units.

The Foxboro transmitter, CF-1-PT1, was found to be in operational condition, while the two Bailey transmitters, CF-2-LT1 and CF-2-LT2, failed as a result of water damage to the signal conditioning electronics located inside the transmitter housing.

Additional transmitters will be removed during FY-84 and examined to determine the water intrusion mechanisms and another report will be released discussing the results of their evaluation.

This report is a continuation of work that was initiated shortly after the TMI-2 accident, when selected pressure transmitters were removed from the Reactor Building for laboratory tests and examination. Two transmitters were previously removed and evaluated and the findings are reported in Reference 1. Reference 1 also describes the test program and provides a list of transmitters located in TMI-2 with some pertinent information on each. The following is a summary of the previous examination.

- o CF-2-LT3, a Bailey type BY level transmitter, was found to have significant internal corrosion, rendering the unit inoperable. The failure was believed to be due to leakage of water into the transmitter housing by way of the electrical conduits.
- o CF-1-PT3, a Foxboro type E11GM pressure transmitter, was found to be in excellent operating condition. Contaminants found in the junction box mounted externally on the transmitter housing indicated that water also entered the junction box by way of the conduit. A seal between the transmitter housing and the junction box prevented water from damaging the transmitter's electrical and mechanical components.
- o The radiation environment resulting from the accident did not appear to cause any permanent damage to the Foxboro transmitter, while its effect on the Bailey transmitter could not be determined because of extensive water damage to the transmitter.

EXAMINATION

The purpose of the examination was to evaluate the transmitters in their as-received condition and determine their operational status and, if necessary, isolate their failure modes. The examination included a visual inspection and, where possible, a functional check of each unit.

Reference 1 details information on the operation of each unit as well as the laboratory tests that were performed. The radiation and radioactive contamination levels noted during the examination of these three transmitters were similar to those observed earlier.

Foxboro E11GM

The unit designated CF-1-PT1 was one of two transmitters used to measure the pressure in Core Flood Tank A. The following is a summary of it's characteristics:

Manufacturer	The Foxboro Company
Model	E11GM-HSAD1
Serial Number	2517275
Calibration Range	0 to 800 psig
Output	10 to 50 mA
Power supply voltage	63 to 95 Vdc
Capsule and body	316SS

The transmitter was located at the 324-ft elevation, well above the high water mark in the building. No failure or degradation of the transmitter was reported during or after the accident.

In situ tests were performed in January 1983 by General Public Utilities Nuclear Corporation (GPU Nuclear) under the direction of EG&G Idaho. These test measurements were passive in nature since it was not practical to vary the input pressure to the transmitter. Measurements included monitoring the transmitter's output, performing time domain

reflectometry measurements of input/output cables, and measuring capacitance and resistance. Results of the in situ tests indicated that the transmitter's output signal corresponded with the actual tank pressure; therefore the transmitter was considered functional. However, because of the limited nature of the testing it was not possible to determine if any changes in the operational characteristics of the transmitter had occurred during the accident.

From initial visual examination at the INEL, it appeared that the transmitter was in good condition, except for a heavy coating of corrosion and some rust on the bolts holding the pressure port assembly together (see Figures 1 and 2). The interior of the transmitter, including the sensor/electronic module assembly, was free from corrosion and radioactive contamination. The circular junction box showed no signs of corrosion and was relatively free of radioactive contamination. The minor amount of contamination found in the junction box during the examination was probably a result of the removal process, since there was no corrosion present. It appears that the conduit installation associated with this transmitter did not permit water to enter the junction box, as was the case with the earlier Foxboro unit removed from TMI-2.

An as-received calibration was performed on the transmitter and compared to the last calibration performed prior to the accident. Both sets of data consisting of six data points were subjected to a least squares linear regression in order to identify changes which had occurred between the two calibrations. The correlation coefficient (r) for each set of data was also computed. A correlation coefficient of ± 1 represents perfect correlation between the data points and the best fit straight line.

The best fit straight line for the 1977 calibration data is represented by

$$I = 0.499268 P + 10.064 \text{ mA}$$

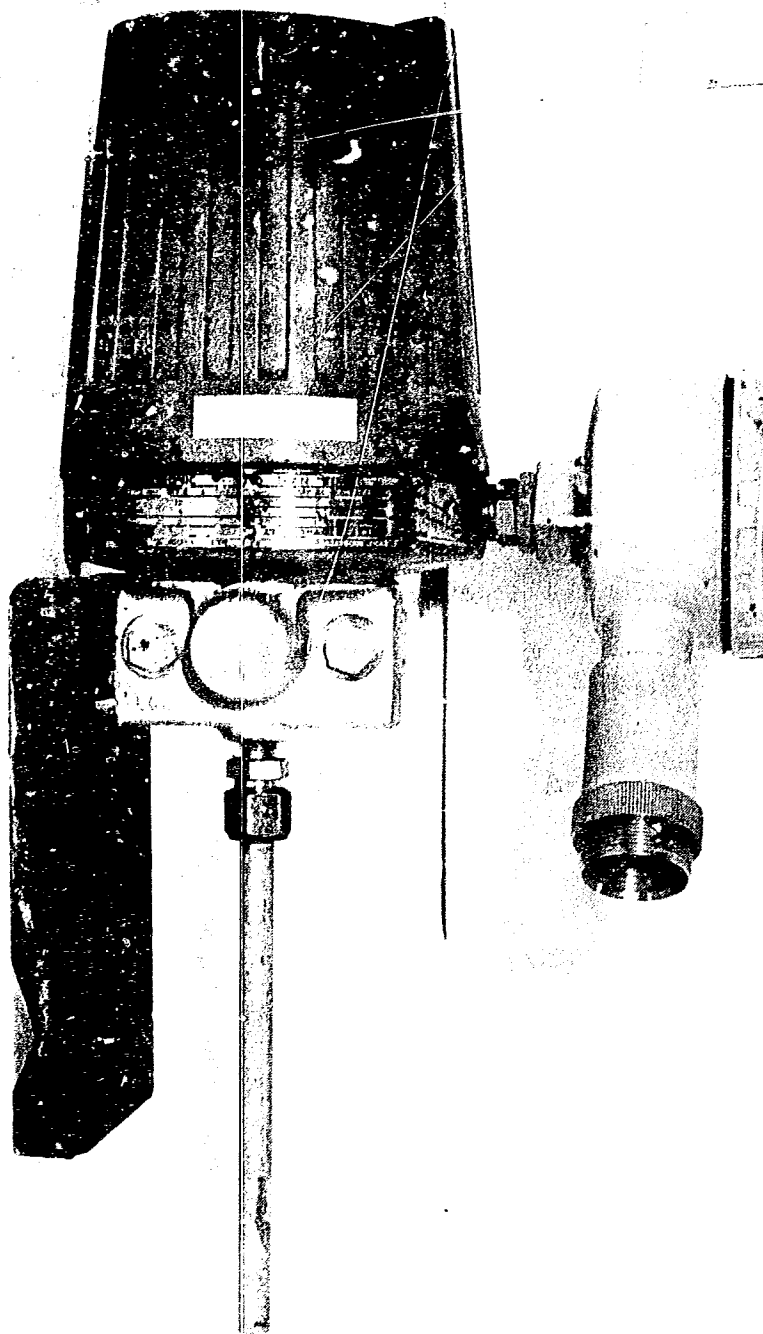


Figure 1. Foxboro Transmitter CF-1-PT1.

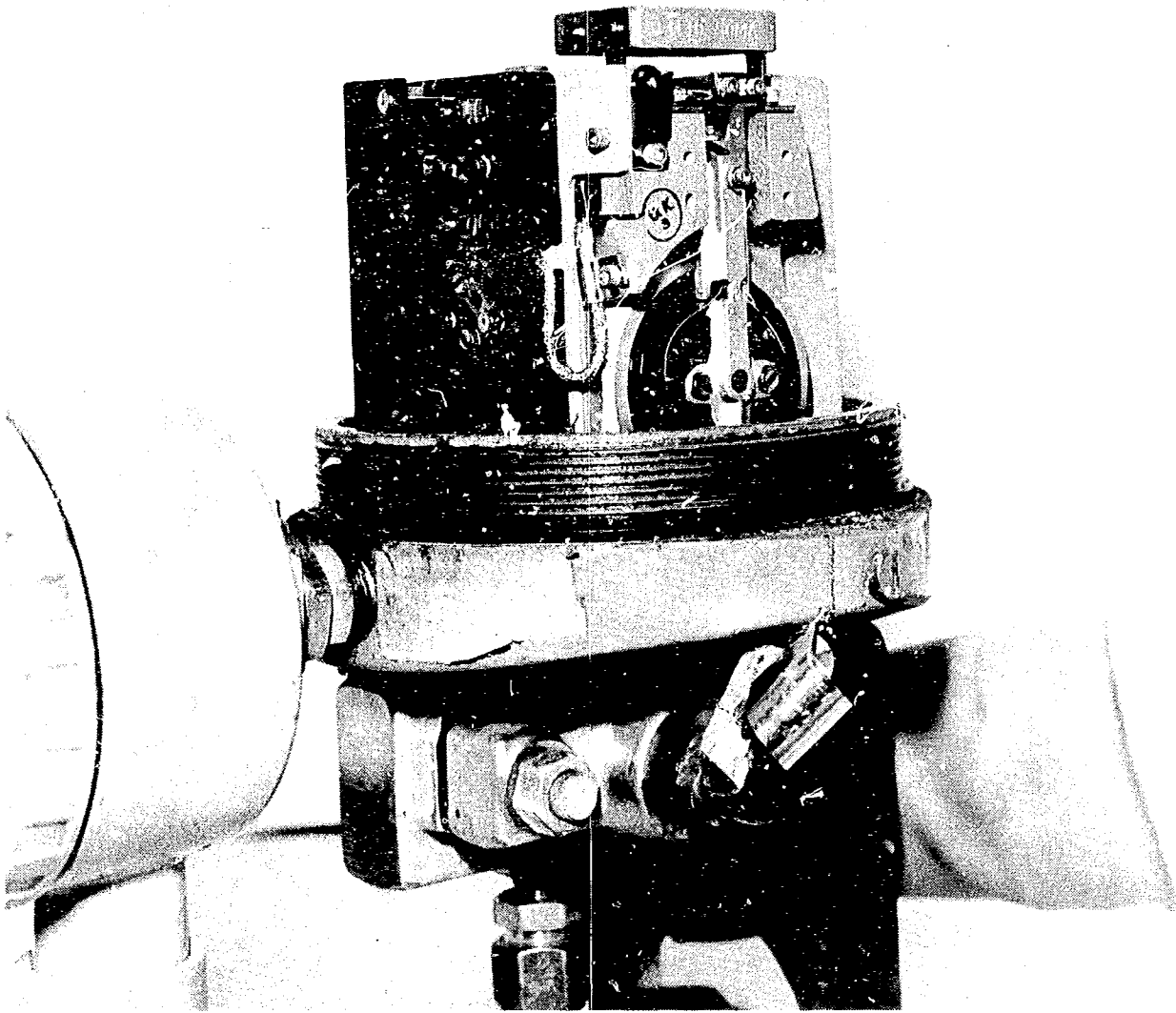


Figure 2. Foxboro Transmitter CF-1-PT1 - internal view.

where "I" denotes the transmitter's output current and "P" equals the applied input pressure. The correlation coefficient was 0.9999985. The 1983 calibration data had a correlation coefficient of 0.99999815 and was represented by

$$I = 0.498054 P + 10.0895 \text{ mA.}$$

The linearity for both sets of calibration data was better than $\pm 0.1\%$. The percentage change in both zero shift and span occurring during the 70 month calibration interval was calculated. The zero shifted 0.0632% of span, whereas a 0.243% decrease occurred in the transmitter's sensitivity to pressure. The transmitter was in excellent operating condition.

Bailey Type BY

CF-1-LT1 and CF-1-LT2 were transmitters used to measure the water level in Core Flood Tank A. Both of these transmitters were also located at the 324-ft elevation. The following is a summary of their characteristics:

Manufacturer	Bailey Meter Company
Model	BY8231X-A
Serial Number (CF-1-LT1)	790923
(CF-1-LT2)	721884
Calibration Range	0 to 14 ft H ₂ O
Output	- 10 to + 10 Vdc
Power	118V 60 Hz

In situ tests were performed on CF-2-LT2 during September 1980 by Technology for Energy Corporation, with the results indicating that the unit had probably failed². All in situ tests consisted of passive measurements. No in situ tests were performed on CF-2-LT1; however, both of the Bailey transmitters were removed from service on December 12, 1980 because they did not respond to a known level change in Core Flood Tank A.

A general visual examination of the Bailey units revealed that the following conditions existed in both units:

- o There was a heavy layer of rust on assembly nuts and conduit fittings.
- o There was severe corrosion and degradation of internal components rendering the units inoperable (see Figures 3 and 4).
- o The units had a high level of internal radioactive contamination, indicating leakage into the units subsequent to the accident.

Considering each of the transmitters on an individual basis the following observations were made:

CF-2-LT1 (Figure 5)

- o Portions of the cover plate seal appeared to be in poor condition (see Figures 6 and 7). This may have permitted additional moisture to enter the housing.
- o The water level in the transmitter appeared to reach a depth of approximately 3-1/3 in. (see Figures 6 and 7).
- o The water inside the transmitter apparently leaked out of the housing through the seal. This is evident from the corrosion and hard water deposits around the lower exterior portion of the transmitter (see Figure 3).

CF-2-LT2 (Figure 8)

- o The cover plate seal appeared to be in good condition and there was minimum corrosion around the seal (see Figure 9).

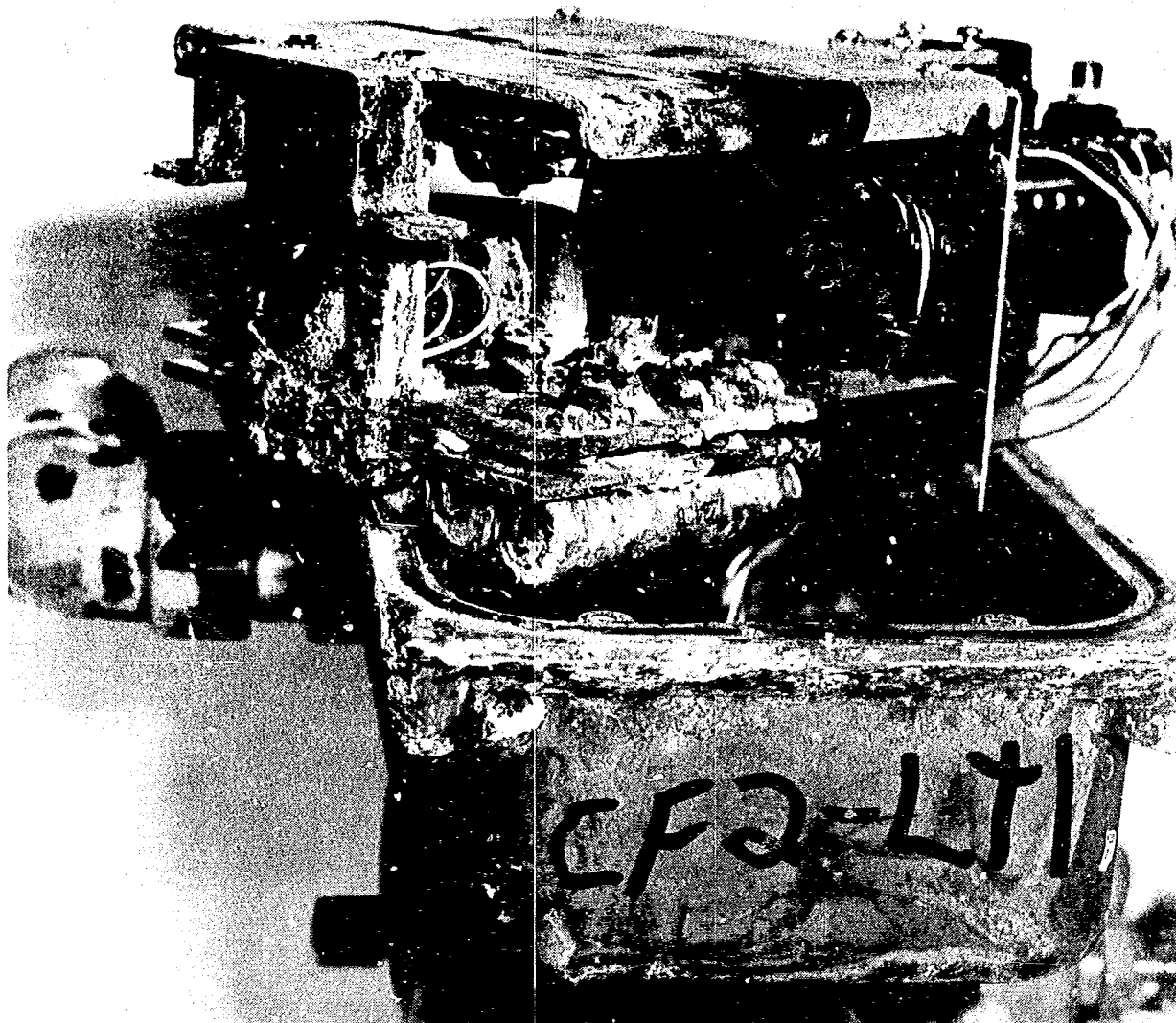


Figure 3. CF-2-LT1 showing condition of the electronic module and base of housing.

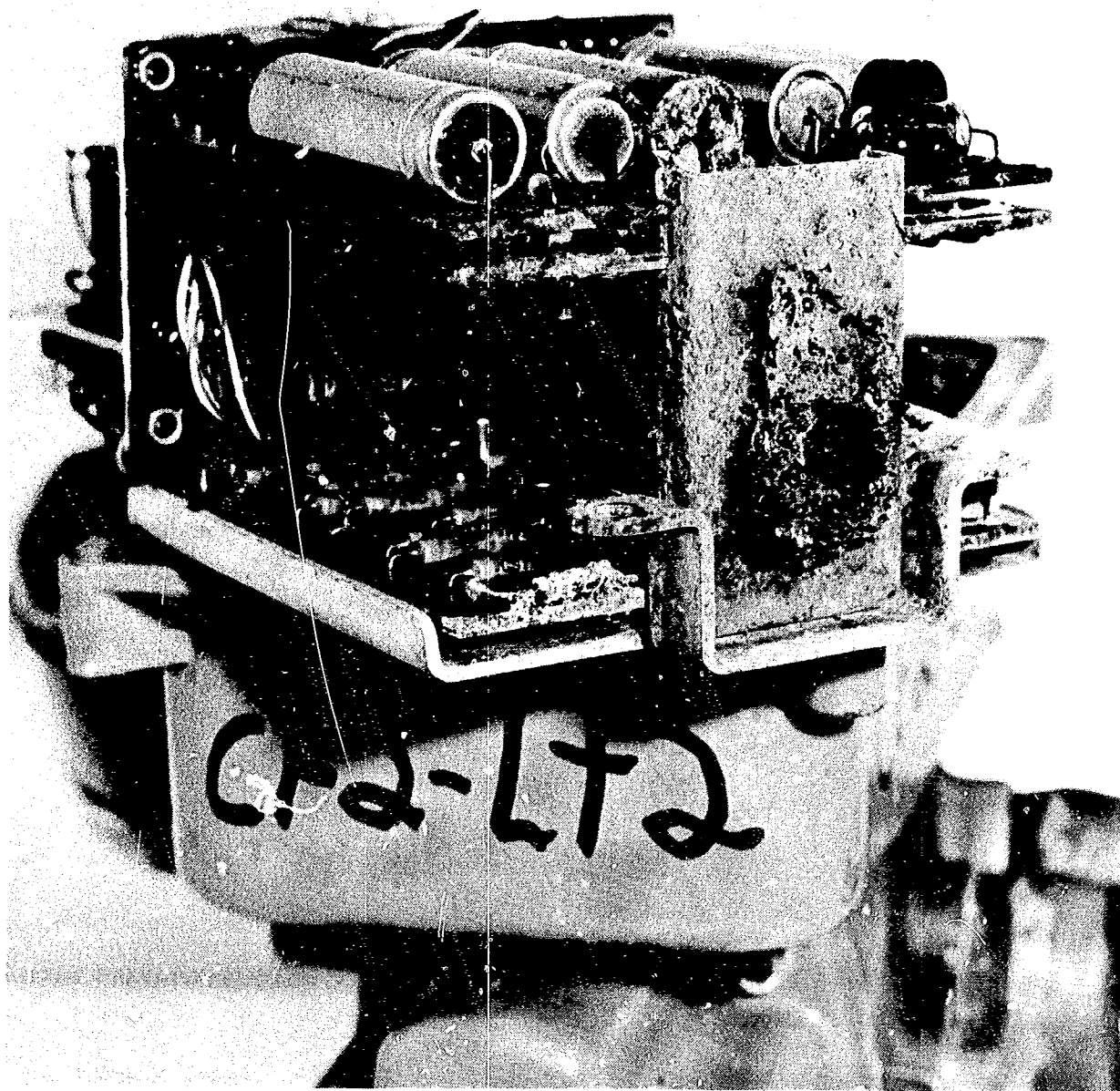


Figure 4. CF-2-LT2 showing the condition of the electronic module.

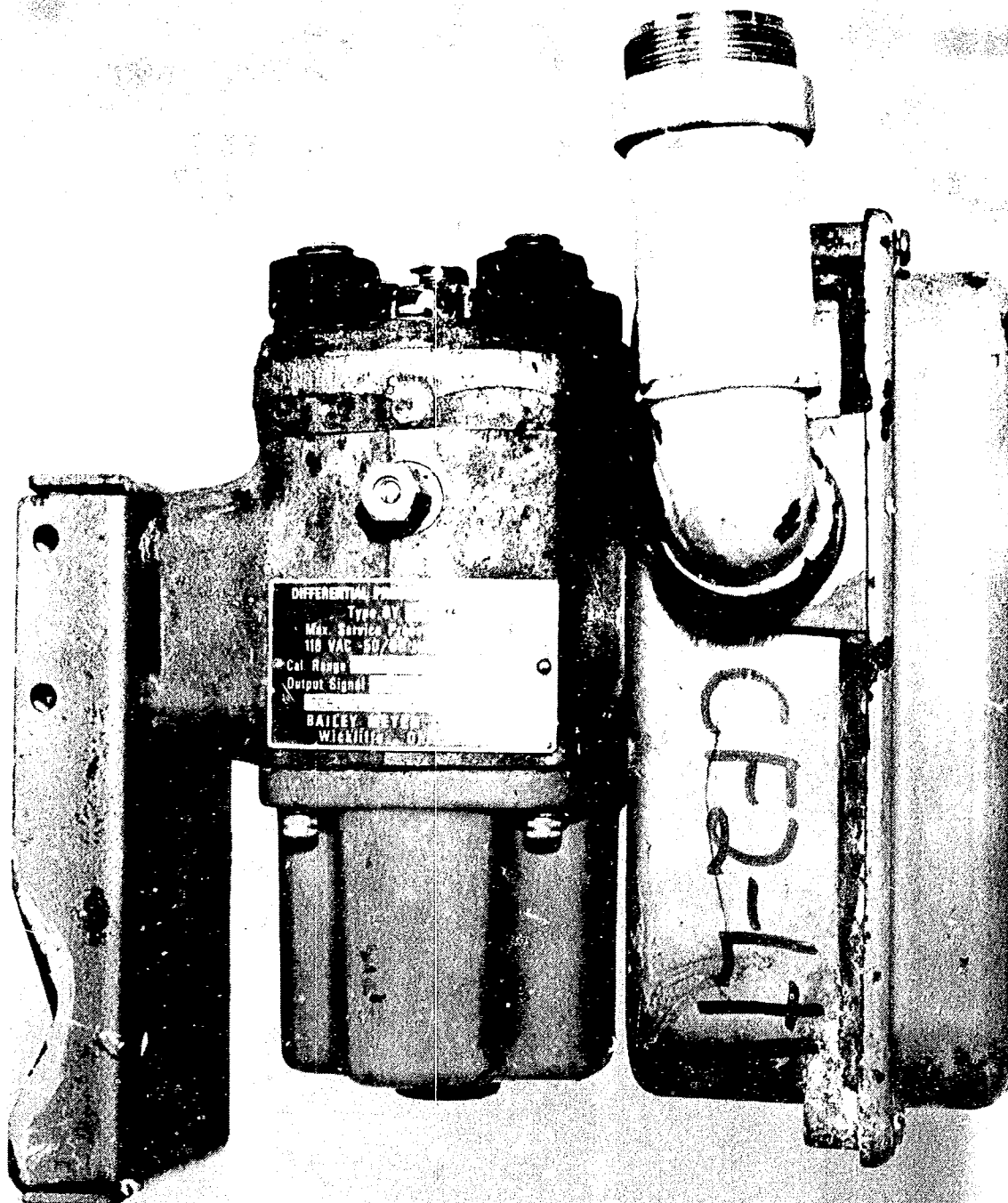


Figure 5. Bailey Transmitter CF-2-LT1.

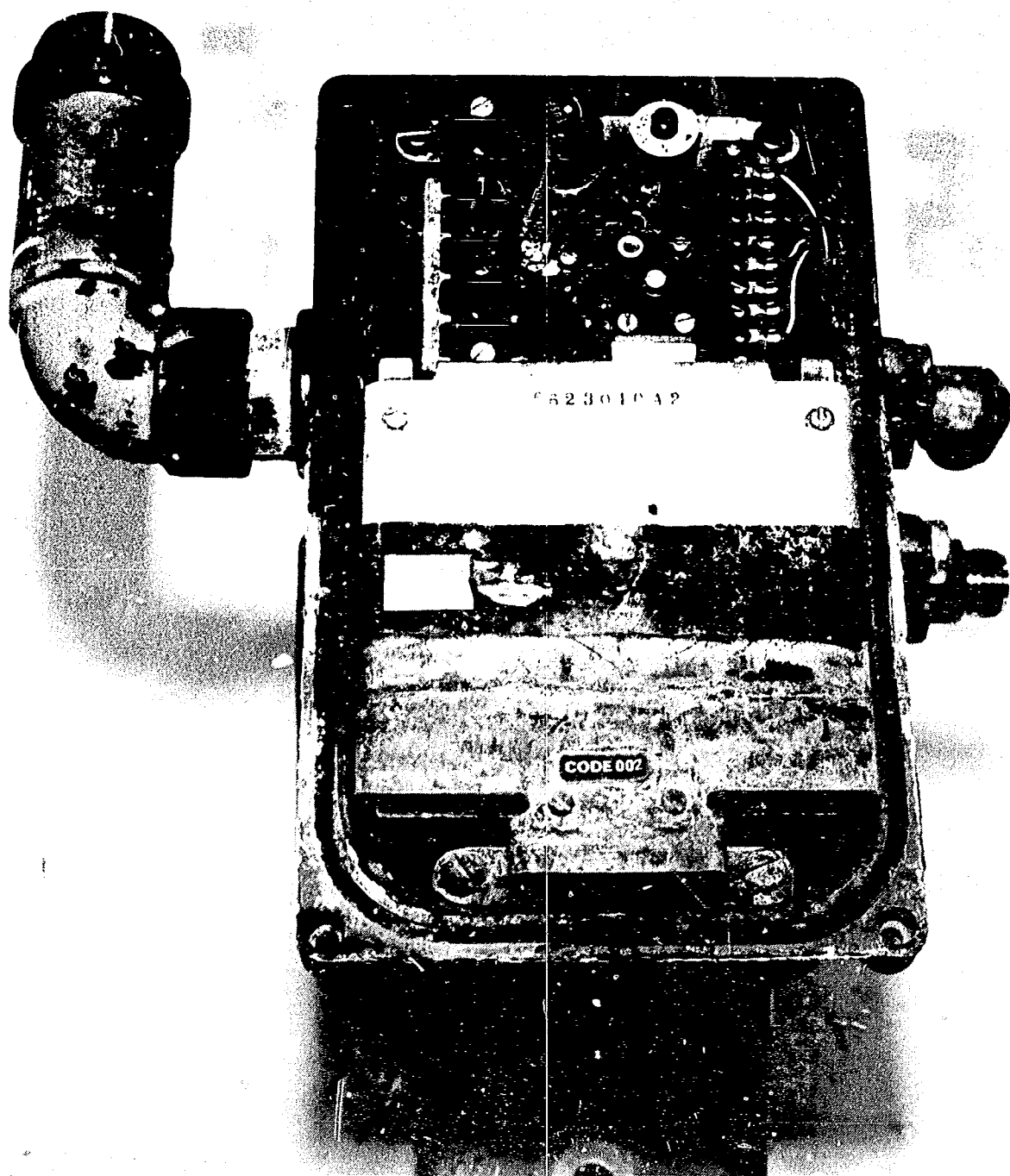


Figure 6. CF-2-LT1 with cover plate removed.

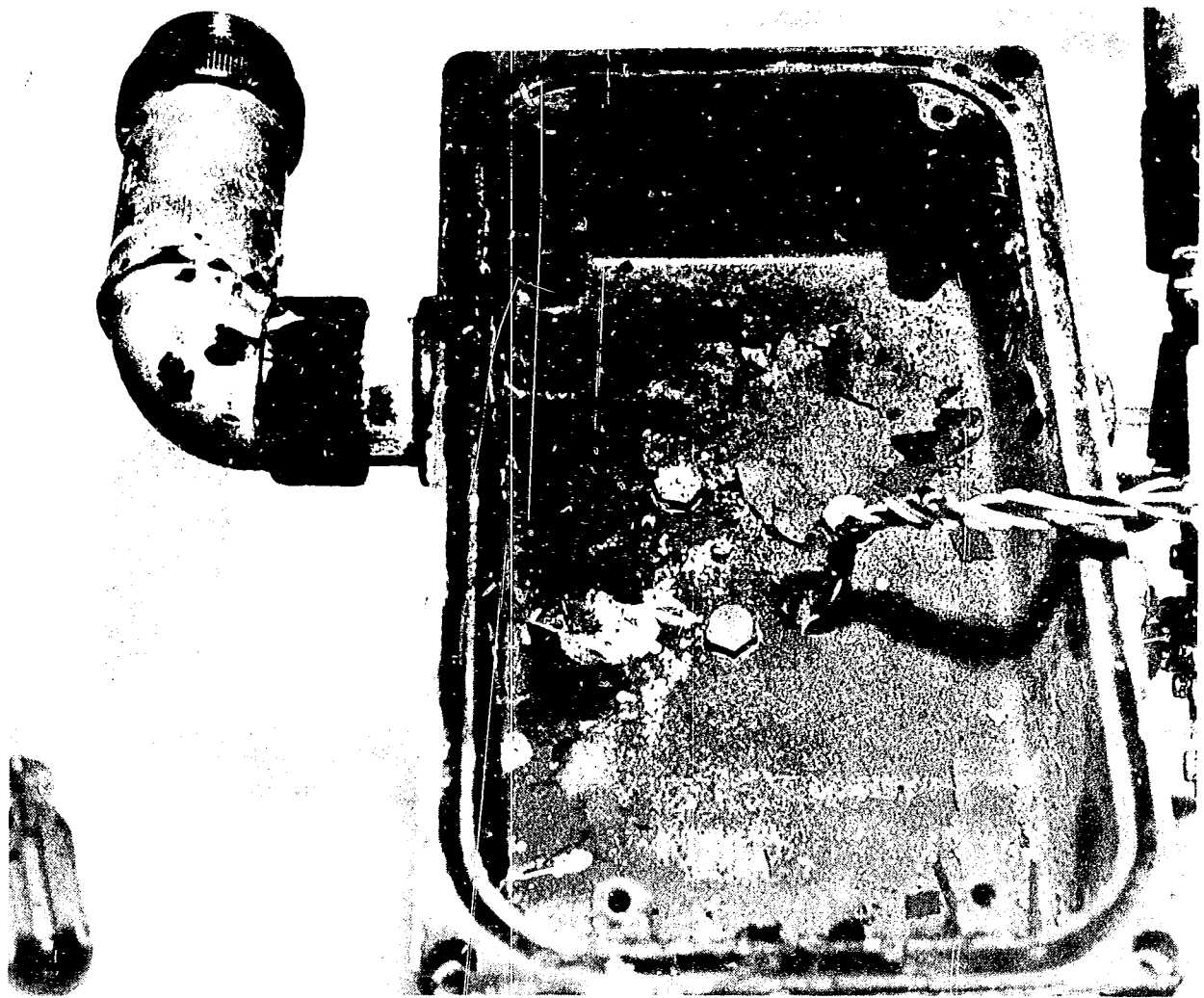


Figure 7. CF-2-LT1 with electronic module removed.

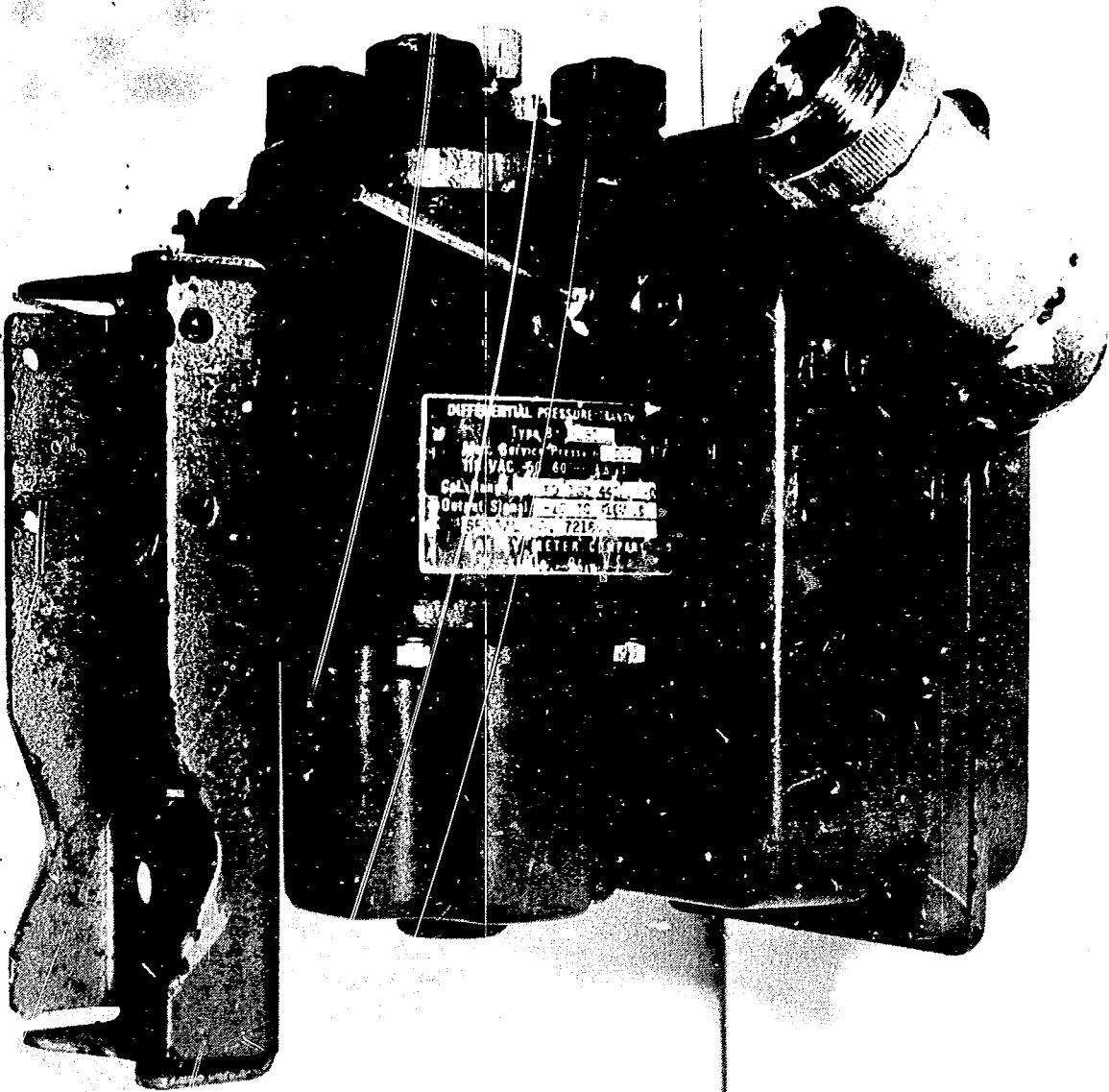


Figure 8. Bailey Transmitter CF-2-LT2.

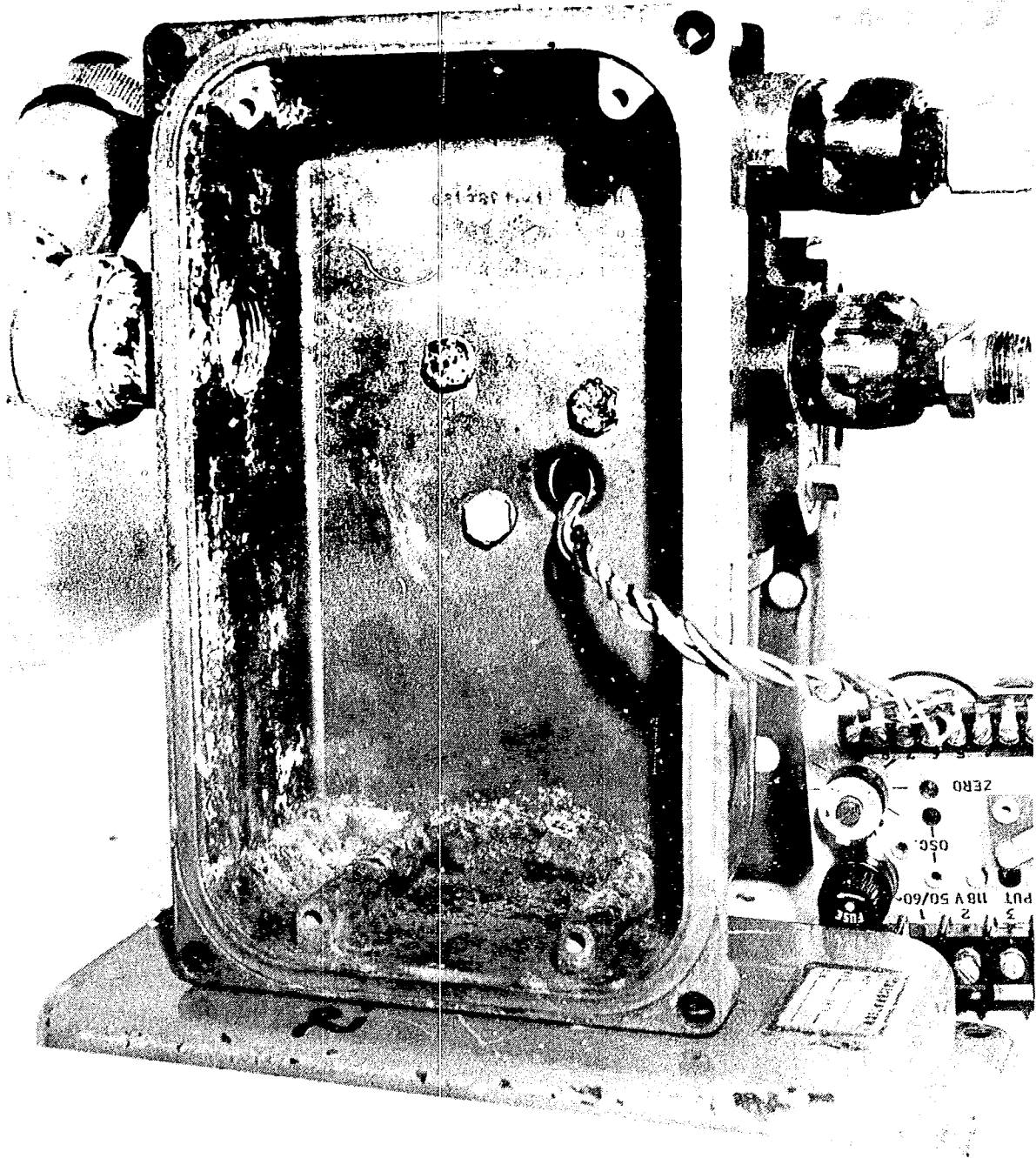


Figure 9. CF-2-LT2 with electronic module removed.

- o The water level in the transmitter appeared to have reached a depth of approximately 2/3 in. (see Figure 10).
- o It appears that the water entered through the conduit and ran down the inside of the transmitter. Internal corrosion was mainly along the side where the conduit entered the housing and the bottom area (see Figure 9).
- o The water that got inside the transmitter did not appear to leak out of the transmitter through the seal area. This is evident from the lack of corrosion on the exterior surface of the housing around the cover plate seal (see Figure 10).

No further functional tests were attempted because of the extensive corrosion.

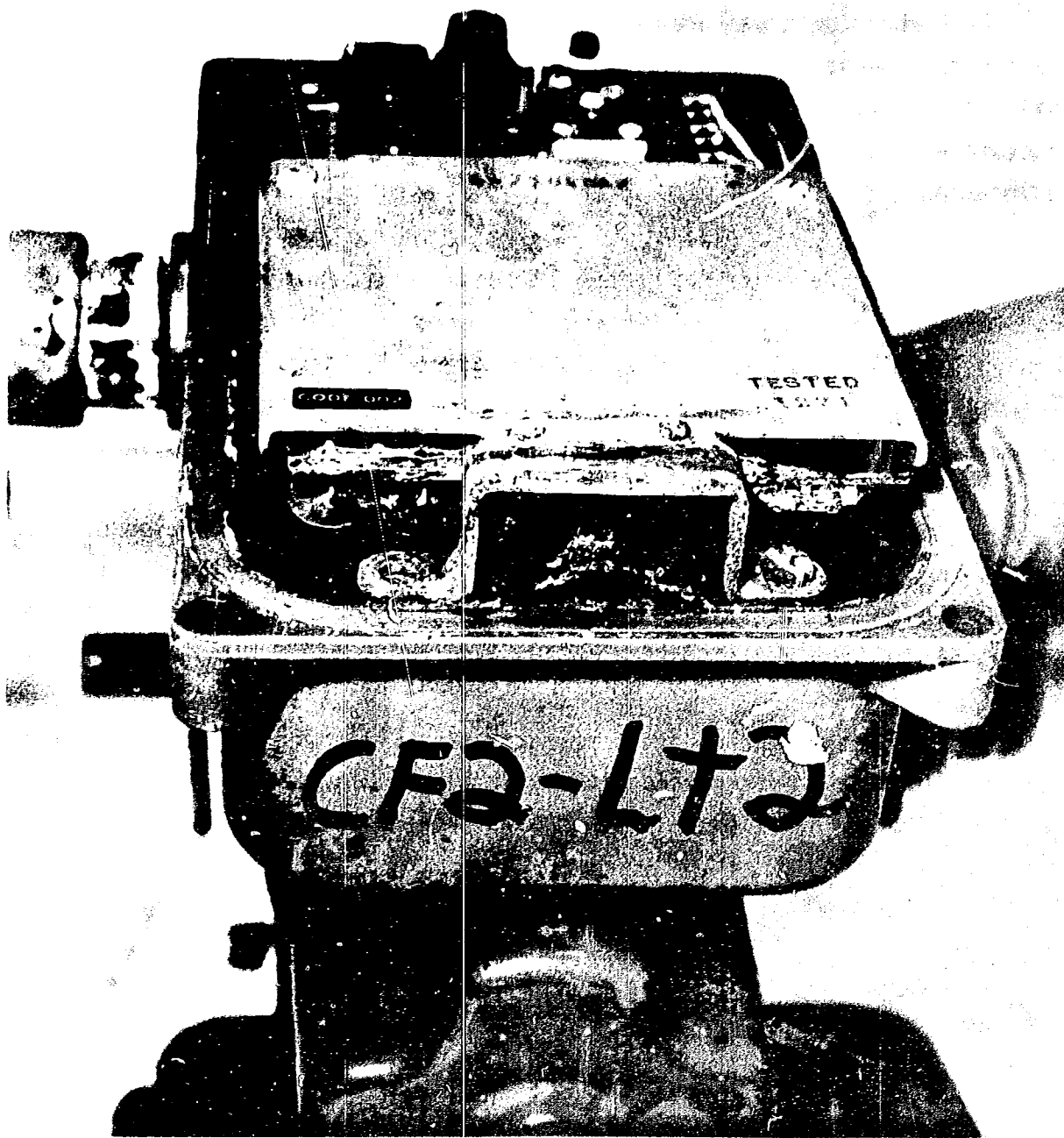


Figure 10. CF-2-LT2 with cover plate removed.

CONCLUSIONS

The results of the evaluation of these transmitters confirm the earlier findings reported in Reference 1.

The Foxboro unit was adequately sealed to prevent moisture damage to the internal mechanisms and the electronic module. The radiation environment appeared to have no effect on the long-term operation of the transmitter. Laboratory evaluation indicated that this unit was still in calibration.

The two Bailey units exhibited extensive internal corrosion resulting from inadequate sealing. The major source of water into the housings was through the electrical conduits leading into the housing. Additional investigations are planned to identify possible water paths. One of the transmitters appeared to have a faulty seal around the cover plate which may have permitted some moisture to enter the transmitter housing. The water in the housing resulted in extensive corrosion and degradation of the electronic module. Both units were inoperable. Considering the condition of the transmitters upon removal, it was not possible to determine what effect, if any, the radiation had on these units.

These results indicate the importance of a well defined installation procedure that ensures adequate sealing of the housing and the following of approved conduit installation practices to prevent moisture leaks in the systems.

REFERENCES

1. R. C. Strahm and M. E. Yancey, TMI-2 Pressure Transmitter Examination Program Year-End Report: Examination and Evaluation of Pressure Transmitters CF-1-PT3 and CF-2-LT3, GEND-INF-029, February, 1983.
2. J. E. Jones, H. T. Smith, M. V. Mathis, Field Measurements and Interpretation of TMI-2 Instrumentation: CF-2-LT2, GEND-INF-017, Vol. V, January 1982.