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A minimum of 125 feet of cable will be used between the transducer and the electronics. Also an adjustment to eliminate effects in the drag disk system has been incorporated.

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EG&G Idaho, Inc.

(LTR) Report No. 141-109

Date: June 6, 1980

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USNRC - P394

# INTERNAL TECHNICAL REPORT

Title: MODULAR DRAG DISC TURBINE QUALIFICATION TESTS

Organization:

Author: V. E. Flitton

Checked By: R. E. Ford

Approved By: D. J. Hanson

EG&G Idaho, Inc.

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**LOFT TECHNICAL REPORT**

| Title | LTR No. |
|---|---|
| Modular Drag Disc Turbine Qualification Tests | LTR 141-109 |

| Author | Released By LOFT CDCS |
|---|---|
| V. E. Flitton V. E. Flitton 4/15/80 | Date June 6, 1980 |
| Performing Organization | Project System Engineer |
| LOFT Review and Approval | R. E. Ford 4/15/80 |
| LTSD Mgr — LMD Mgr 5/23/80 | |

## ABSTRACT

Qualification Tests were perfomred on three modular drag-disc turbines (MDTT) at ARA III under the direction of C. E. Winsel. The tests were performed on MDTTs that had been rejected by the Quality Division (Quality Division Reports were issued) due to the sensitivity range and accepted as is by the Project Engineer. These tests consisted of full flow calibration and vibration tests. The results of these tests indicate the MDTT will survive 7.5g peak loading below 1400 Hz and should not be subjected to g loading for extended periods of time between 1400 and 1450 Hz.

The repeatability of the MDTT system during full flow at ambient conditions is dependent upon the electronics, system cabling and initial setup of the electronics. However, the results show the drag disc and the turbine are repeatable to within one percent of reading.

The testing indicated a minimum of 125 feet of cable is required between the MDTT and the drag disc electronics. Also, a dc-offset - adjustment potentiometer had to be installed in drag disc electronics to adjust out a dc offset that was caused when the drag disc was nulled.

## DISPOSITION OF RECOMMENDATIONS

A minimum of 125 feet of cable will be used between the transducer and the electronics. Also an adjustment to eliminate effects in the drag disk system has been incorporated.

## RECOMMENDATIONS

The three MDTTs (SN 027802, 027803, and 027805) are acceptable for LOFT service. The drag disc and the turbine have a ±1% repeatability. The MDTTs will survive a 7.5g peak loading over the range of 128 Hz and 1400 Hz; destructive damage may result to the units if they are used outside this range. A minimum of 125 feet of cable should be used between the MDTT and the drag disc electronics. An adjustment to eliminate offsets due to drag disc electronics should be incorporated.

## SUMMARY

Qualification Tests were performed at ARA III to determine if the MDTT could survive the vibration loading found at LOFT and to determine the repeatability of the MDTT data under full flow conditions.

Without sufficient cable (125 feet minimum) between the MDTT and drag-disc electronics, the cable balance control adjustment could not be nulled.

By calibrating the turbine readout amplifier at 50 Hz and 500 Hz with 175 feet of cable between the MDTT and electronics, subsequent tests revealed that the repeatability of the MDTT was better than one percent for both the turbine and drag disc. No attempt was made to evaluate the MDTT at elevated temperatures.

The vibration tests were conducted to evaluate the MDTT at a level that would exceed known levels in the LOFT environment. The maximum level of vibration was set at 7.5g peak. The frequency spectrum from 10 Hz to 2150 Hz was used. The MDTT was subjected to vibrations in the vertical (fluid flow) direction and in the horizontal (normal testing) mode.

Two points of resonance were noted in the vertical mode, one at approximately 128 Hz and the other between 1400 Hz and 1450 Hz. The 128 Hz resonant frequency is the spring and mass constant for the units tested and was not evident in the horizontal mode of vibration. The resonant frequency between 1400 Hz and 1450 Hz was evident in both the horizontal and vertical vibration modes.

## 1.0 TEST SEQUENCE

The qualification tests conducted at ARA III consisted of vibration and full flow tests. The tests were conducted on three MDTTs: SN 027802, 027803, and 027805. These MDTTs had failed Acceptance Test TP-220 due to a sensitivity range lower than that required for an A-1 range MDTT.

The qualification tests were conducted to see if the MDTT would survive a level of vibration loading at least equal to that in the LOFT system (refer to LTR-141-62), and how well it would repeat the full flow test parameters of TP-220 after vibration.

## 2.0 VIBRATION TEST

The vibration tests consisted of placing the MDTT on a fixture (in free air) in one of two modes of operation (see Figures 1, 2, and 3). The frequency spectrum of 10 Hz to 2100 Hz was swept at one g peak to determine the resonance frequencies.

The MDTT was then subjected to peak g levels of 2.5, 5 and 7.5 at those frequencies of interest. The MDTT was also subjected to the specific natural frequencies suggested in LTR-141-62 for the rake assemblies; i.e., 313 Hz (lift), 626 Hz (drag), and 1130 Hz (twist).

The horizontal mode displayed resonances at 670 to 680 Hz, 1420 to 1450 Hz, and 1750 to 1760 Hz. With 1g peak acceleration applied, the shroud displayed a 12g peak at 1420 Hz while the drag-disc module and turbine module had a 6.6g peak at 1450 Hz. No resonance was found at the frequencies suggested in LTR-141-62.

The vertical mode displayed resonances at 128 Hz, 1400 to 1450 Hz, 1900 Hz, and 2150 Hz. With 1g peak acceleration applied, the shroud displayed 4.4g at 1450 Hz and 4.4g at 2120 Hz.

The drag-disc module had a 20.5g peak at 128 Hz, 6.4g at 1410 Hz, and 1.56 at 1900 Hz. The 128 Hz resonance is due to the spring assembly natural frequency of 128 Hz. The tests were conducted in free air, not an aqueous solution, and the natural damping effect of an aqueous solution was not obtained. The 1410 Hz resonance was also evident in the horizontal mode.

The turbine module had a 6.6g peak at 128 Hz and 3.7g at 1400 Hz. The vibration at 128 Hz appears to be a sympathetic vibration caused by the drag disc natural frequency. The vibration at 1400 Hz is common to shroud, drag disc, and turbine in both the vertical and horizontal test modes.

No resonant frequencies were observed at the frequencies predicted in LTR-141-62. If modes of vibration exist in the frequency ranges between 1400 Hz and 1450 Hz at the locations where the MDTTs will be installed, failure of the unit may result.

## 3.0 FULL FLOW TEST

The full flow tests indicated that the drag-disc sensitivity had changed by as much as 30 percent from that taken during the acceptance tests, and the turbine sensitivity had changed by as much as 5 percent. These errors were due to insufficient signal cable (causing an improper cable balance setting) and use of different drag-disc and turbine electronics between tests.

The following corrections were made to the MDTT system, and the MDTTs were retested per TP-220 in the forward flow direction only to determine repeatability. The retest consisted of three forward runs with the electronics detuned and reset prior to each run.

A. Three-conductor, shielded cable, No. 22 AWG, 175 feet long, was added between the MDTT and electronics except for the thermocouple.

B. The turbine readout amplifier was calibrated for 0.500 ± 0.001 volts at 50 Hz and 5,000 ± 0.001 volts at 500 Hz (refer to Figure 4).

C. The cable balance potentiometer on the drag-disc electronics was correctly wired (to eliminate a wiring error).

D. The drag-disc electronics was calibrated for a voltage change of 4.000 ± 0.001 volts between null and imbalance due to the calibration network when the calibrate button was pressed.

E. Drag-disc electronics SN 005 was used for all testing.

The test results are tabulated as follows and indicate a high level of repeatability can be achieved provided the MDTT system is properly used.

TABLE I

Turbine Volts Vs. Average Velocity (m/s)
Values in (m/s)/volt (sensitivity)

| SN | Average from Acceptance Test | Average from Qualification Test | Repeatability |
|---|---|---|---|
| 027802 | 8.495 | 8.086 | (1) 8.327*<br>(2) 8.312* |
| 027803 | 8.306 | 7.907 | (1) 8.294*<br>(2) 8.161* |
| 027805 | 8.224 | 7.780 | (1) 7.962<br>(2) 8.578<br>(3) 8.632<br><br>(4) 8.188*<br>(5) 8.119*<br>(6) 8.058* |

TABLE II

Differences Between Turbine Units

| SN | Acceptance vs Qualification | Average Repeatability vs Acceptance | Average Repeatability vs Qualification | Average Repeatability vs Runs |
|---|---|---|---|---|
| 027802 | -4.8% | -1.0% | 4.0% | (1) 0.8%*<br>(2) -0.8%* |
| 027803 | -4.8% | -2.1% | 2.9% | (1) 0.1%*<br>(2) -0.1%* |
| 027805 | -5.4% | -2.0% | 1.3% | (1) -5.1%<br>(2) 2.2%<br>(3) 2.9% |
| | | 4.4% | -1.3% | (4) 0.8%*<br>(5) 0.0%*<br>(6) -0.8%* |

* After addition of 175 feet of cable and adjustment of cable-balance potentiometers.

TABLE III

Drag Disc Volts vs Mometum Flux ($Kg/m-s^2$)
Values in ($Kg/m-s^2$)/Volt (sensitivity)

| SN | Average from Acceptance Test | Average from Qualification Test | Repeatability |
|---|---|---|---|
| 027802 | 8.3920 | 9.0583 | (1) 8.8481*<br>(2) 8.8898* |
| 027803 | 8.2618 | 8.5517 | (1) 7.9586*<br>(2) 7.9253* |
| 027805 | 7.7384 | 8.0515 | (1) 10.2418<br>(2) 10.8407<br>(3) 9.7387<br><br>(4) 7.9819*<br>(5) 7.9802*<br>(6) 8.0625* |

TABLE IV

Differences Between Drag Disc Units

| SN | Acceptance vs Qualification | Average Repeatability vs Acceptance | Average Repeatability vs Qualification | Average Repeatability vs Runs |
|---|---|---|---|---|
| 027802 | 2.9% | 7.2% | 9.7% | (1) -0.2%*<br>(2) -0.2%* |
| 027803 | -3.4% | -4.0% | -7.1% | (1) 0.2%*<br>(2) -0.2%* |
| 027805 | 4.0% | 32.8% | 27.6% | (1) -0.3%<br>(2) 5.5%<br>(3) -5.2% |
| | | 3.5% | -0.5% | (4) -0.3%*<br>(5) -0.3%*<br>(6) 0.7%* |

* After addition of 175 feet of cable and adjustment of cable-balance potentiometers.

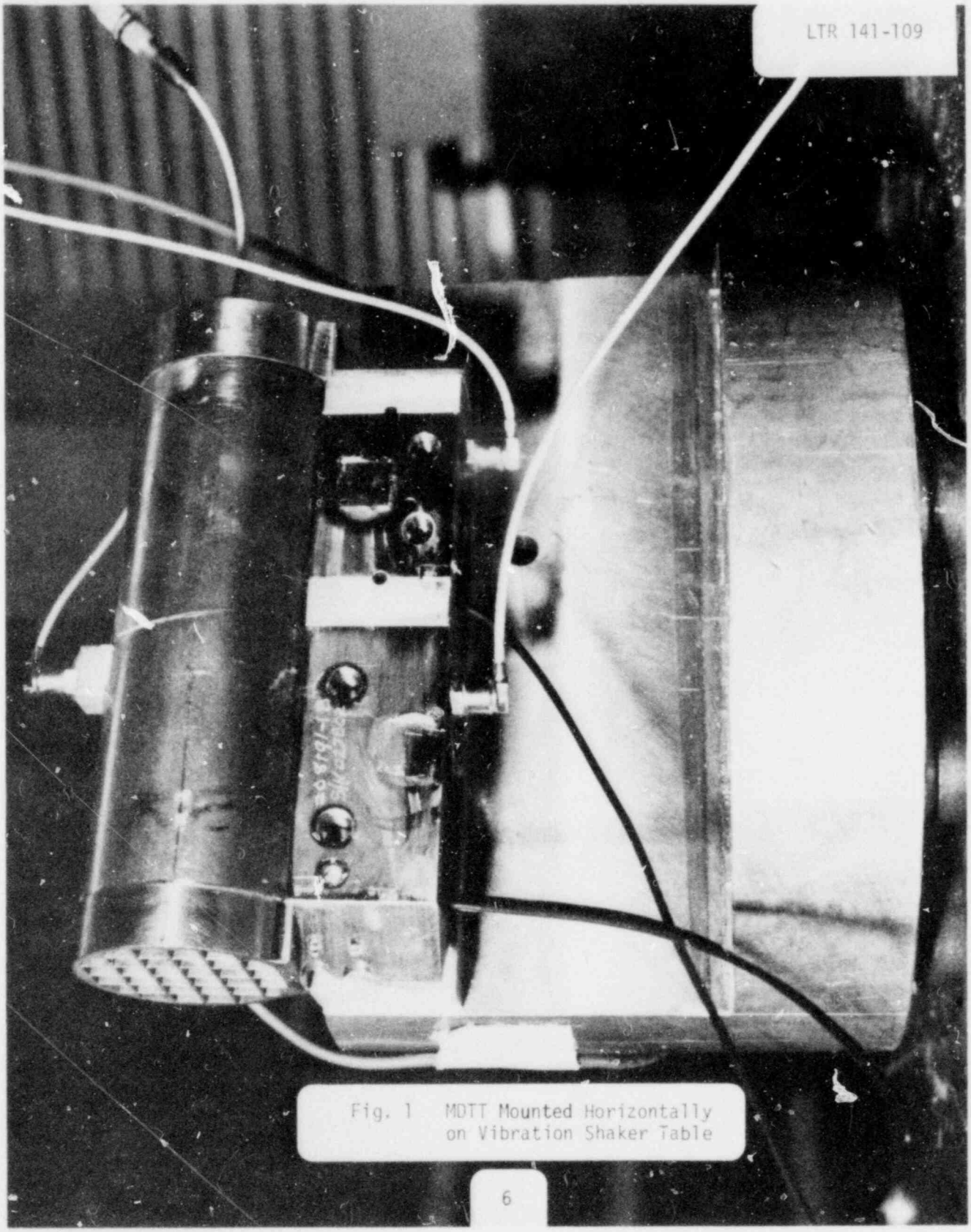

Fig. 1 MDTT Mounted Horizontally on Vibration Shaker Table

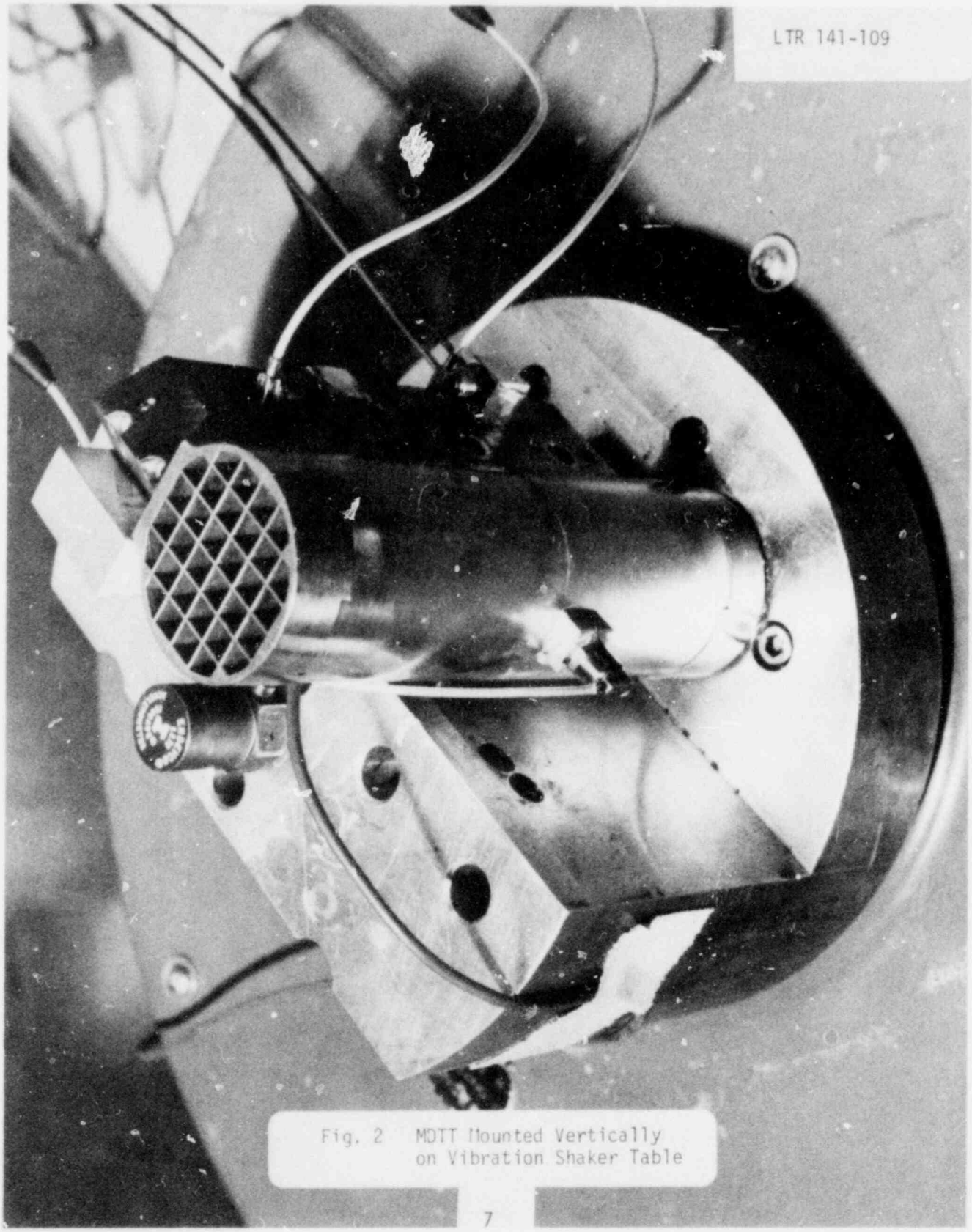

Fig. 2 MDTT Mounted Vertically on Vibration Shaker Table

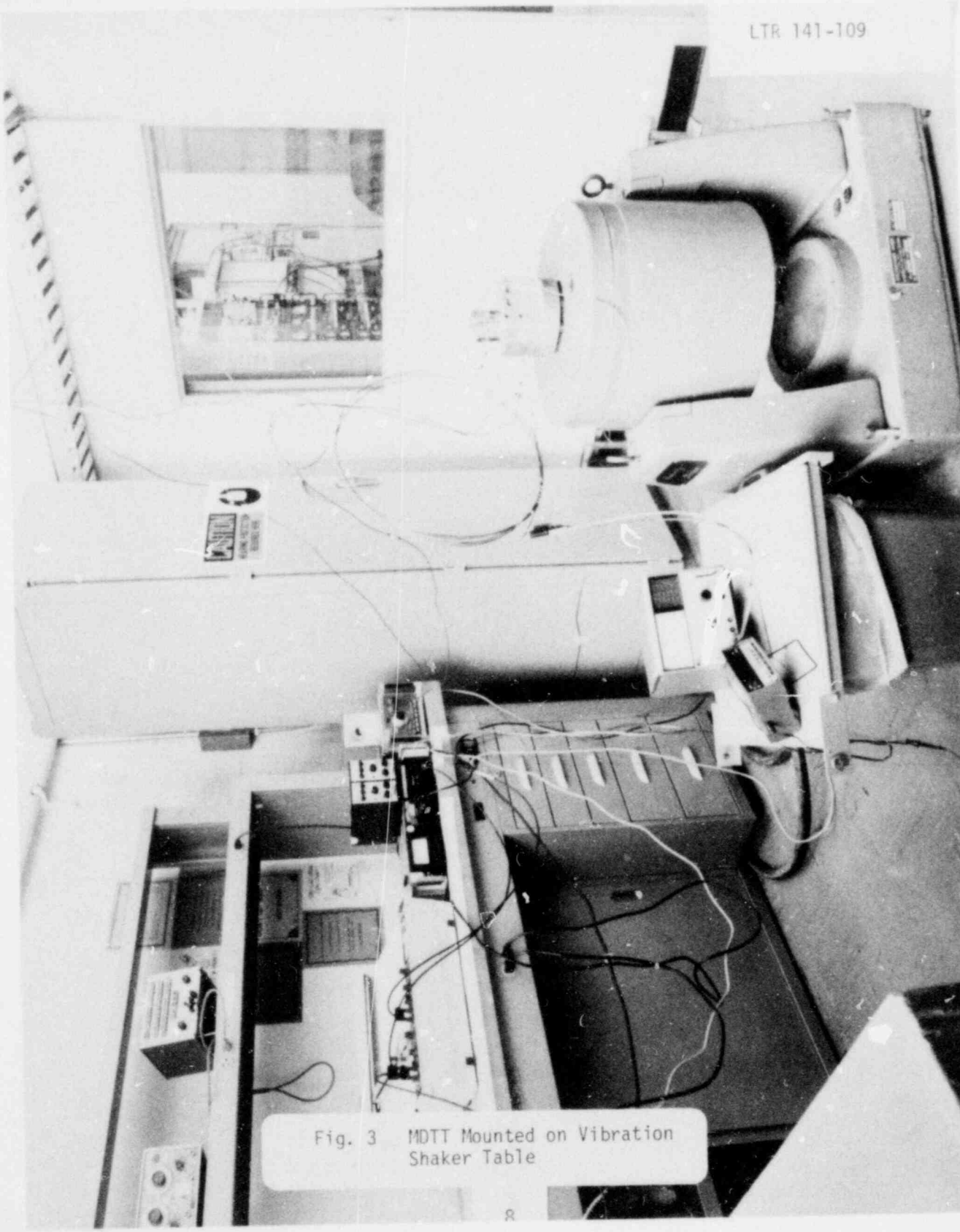

Fig. 3 MDTT Mounted on Vibration Shaker Table

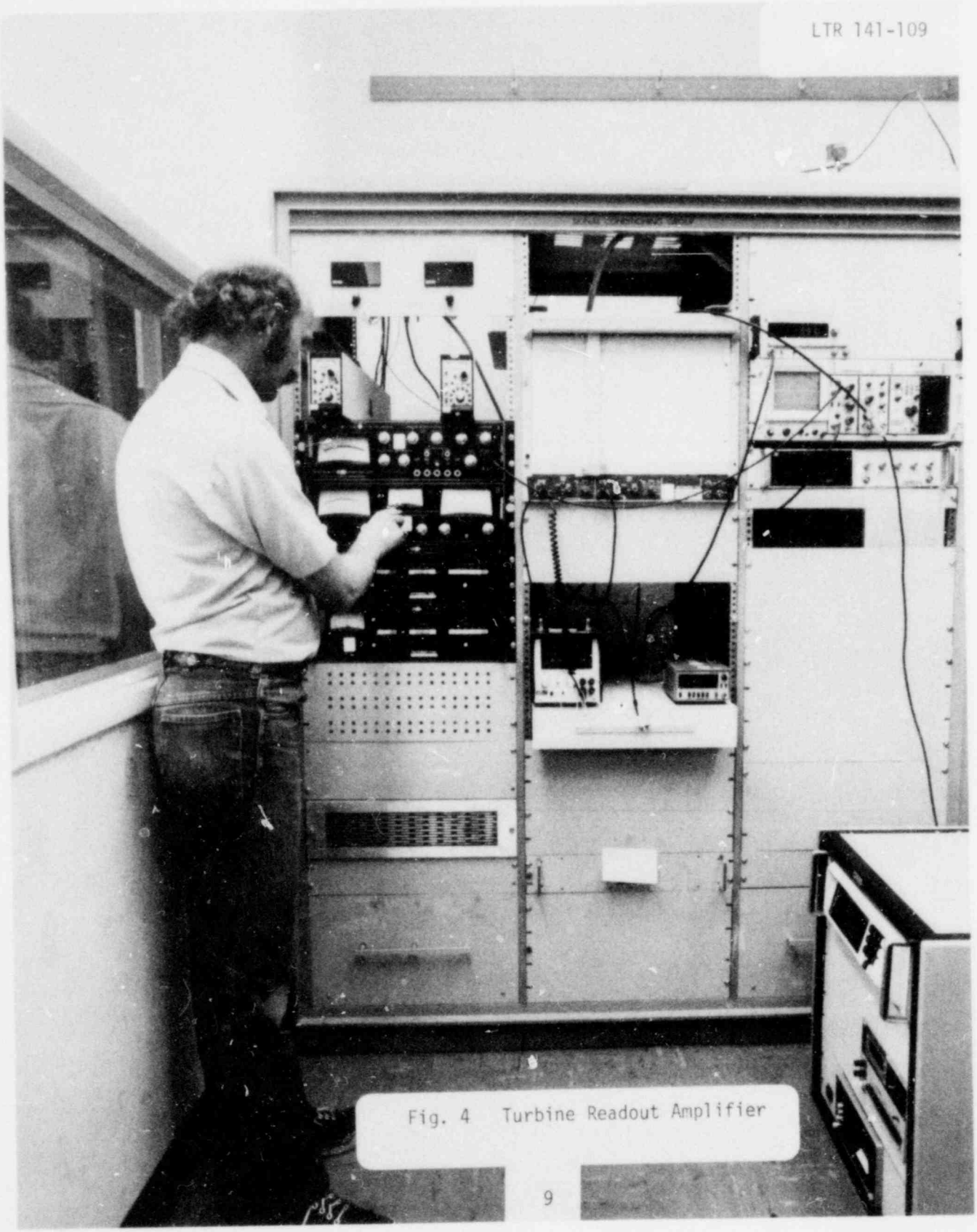

Fig. 4 Turbine Readout Amplifier