LOAD AND DEFLECTION INSTRUMENTATION FOR STRUCTURAL TESTING

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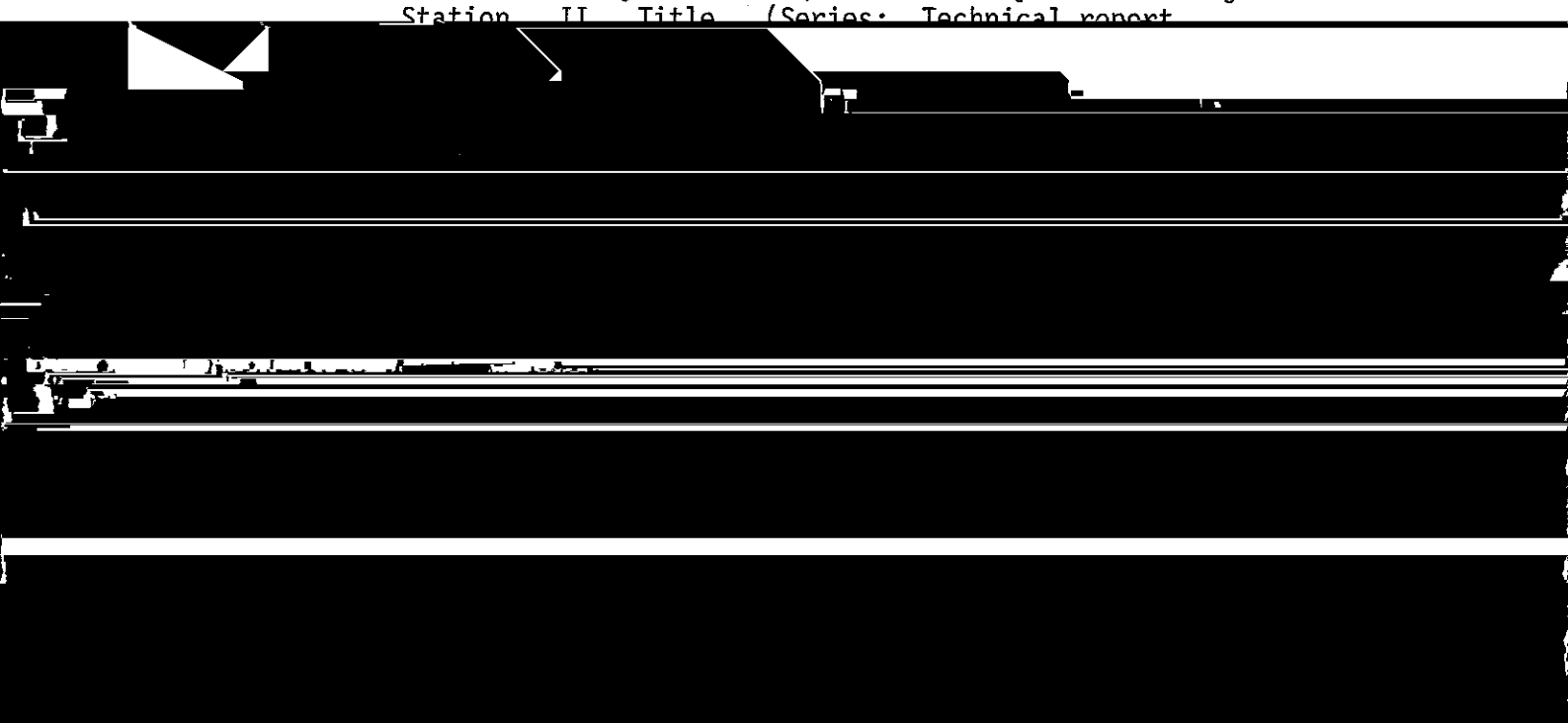

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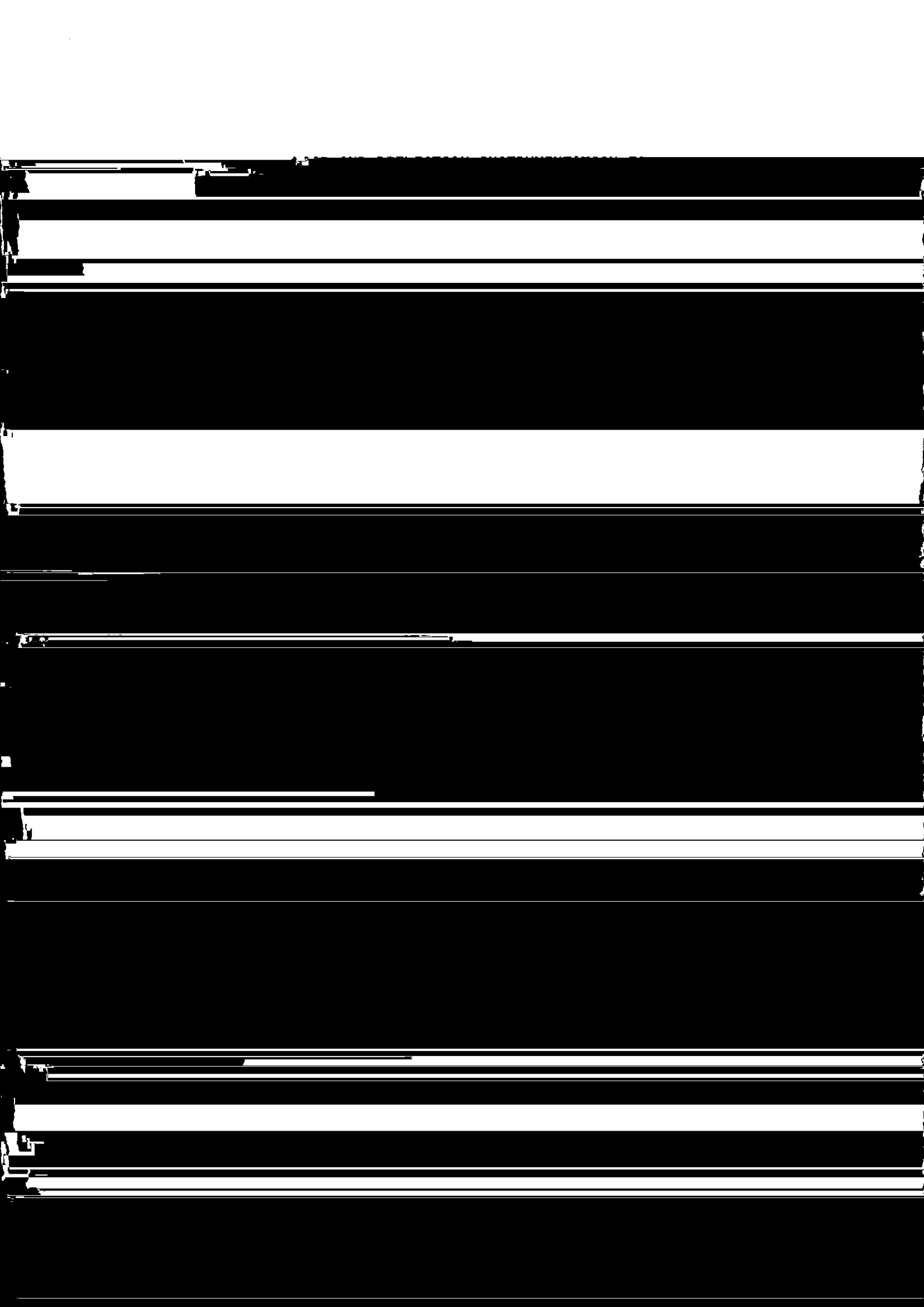


1. INTRODUCTION

Since 1977 the Cyclone Testing Station has been directly involved in the

testing of large number of bui lding components and assemblies ranging from

could be measured within a few seconds, checked and reduced within a fraction of a second and displayed in a way that would enable test personnel to make accurate assessments of the test's progress.

This publication briefly outlines the system developed and the economical displacement transducers built.

2. AIMS AND OBJECTIVES OF THE INSTRUMENTATION SYSTEM

The primary aim was to develop a general purpose instrumentation system that would rapidly and accurately transfer physical measurement to a digital

(often expressed as a percentage of full scale measurement), eg. a scale rule, 300 mm long, graduated in mm, can resolve a distance to the nearest mm. Its resolution would be 1 mm or 1/300 of the full scale reading ie. 1/3%.

(ii) Long Term Drift: The deviation from a "true" reading when measured over a long period (one week). eg. if a 200 mm long bar is measured with a rule continuously for one week and the maximum reading obtained was 201 and the minimum was 199, the long term drift over that period

300 mm long scale rule has a range of 300 mm.

(vii) Accuracy: The overall accuracy of the measurements obtained in tests is affected by all of the above errors with their effects usually additive. The measurement errors are usually compounded by a math-

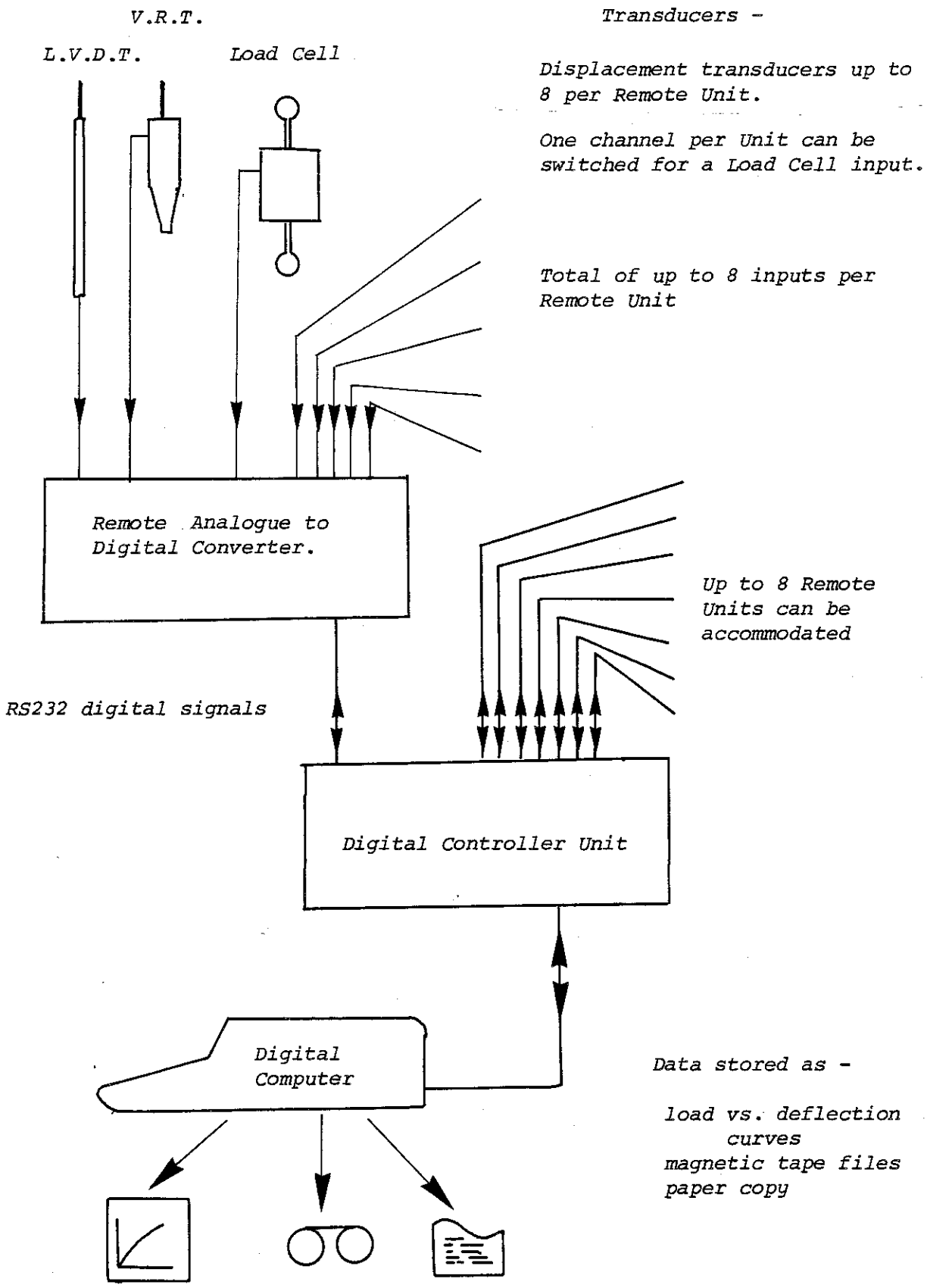


Figure 1. Schematic Sketch of Instrumentation System

the channel of the appropriate transducer. This number is decoded in the Remote Unit, the correct analogue voltage converted to a digital signal and the digital signal returned along the control line. The digital signals are transmitted as a series of zeros and ones along a single wire using an industry standard format designated RS 232, taking just over one thousandth

that this unit can respond to is given below.

(i) Turn Pump Motor on

7. Read Displacement Transducers.

8. Go. to step 2.

A sequence of instructions similar to the one in the above example has been used by the Station to cyclicly apply simulated wind loads to a complete house. With suitable computer controlled safeguards to prevent overloading, the system ran continuously, without fault for over 36 hours.

[redacted]

(iii)	Deviation from linearity	LVDT 0.4% of full scale reading. VRT 1% of full scale reading.
(iv)	Hysteresis	LVDT 0.4% of full scale reading. VRT 1.2% of full scale reading.
(v)	Sampling frequency	9 transducers per second.
(vi)	Data transmission	8 bit digital number RS 232 format with 1 stop bit, no parity bit, 9600 baud.

It can be seen that the System objectives have generally been exceeded by the LVDTs, and compromised only for hysteresis and linearity by the VRTs. The sampling frequency is particularly pleasing as it reduces the reading time for 40 gauges to just over four seconds and does not allow creep to influence readings to a large extent.

4. DEFLECTION MEASUREMENT

As mentioned in the previous section, two different types of displacement transducers were employed in the Instrumentation System.

4.1 Linear Variable Differential Transformer (LVDTs)

These are commercially produced highly accurate devices that do not use any moving electrical contacts. The displacement of an iron core induces voltage in windings in the annular body of the device. The particular units chosen for this system required a dc voltage to power them, and produced a dc voltage proportional to the displacement of the iron core. The stability and linearity of the LVDTs was very good due to precision in manufacture and

used as a check on VRT performance and to calibrate the less expensive but more robust VRTs.

4.2 Variable Resistance Transducers (VRTs)

[redacted]

moving electrical contacts.

A series of tests was conducted to determine durability and long term

4.3 Calibration of Displacement Transducers

Both VRTs and LVDTs return a number from 0 to 255 which is proportional to displacement from the zero position. For most testing, it was the difference between the final and initial positions that is of importance. This could be found by knowing the numbers returned by the transducer at initial and final position, and the calibration constant of the transducer.

For a 50 mm LVDT the calibration constant was typically 0.20 mm per division

5.1 Summary of Specifications of Load Measurement

(i) Resolution 0.4% of full scale reading.

(ii) Long Term Drift (24hrs) ±1% of full scale reading.

Set up order of transducer reading

Input calibration coefficients for all transducers

[redacted]

quick assessment of the test by simply examining a graph and provided very quick documentation of the test. The single program, once written facilitated the data aquisition in this series of tests and will remain available for use in conjunction with other joint tests should they be required.

The setting up of the Instrumentation System involved plugging the Remote Unit in to mains power and the Control Line into the Computer, mounting the two transducers on the test piece and plugging their leads into the Remote Unit. The computer program was then loaded, and the system was ready to work. The total set up time was typically five minutes.

6.2 Case Study of Cyclic Loads on a Full Scale House

In contrast to the previous case study, the Instrumentation System was

also enabled the starting position of each transducer to be checked so that during the course of the test they stayed within their allowable range. All of the data thus assembled was stored on magnetic tape for access during the actual test and subsequent analysis.

The second program then enabled the test to be performed. At the commence

produced elastic behaviour, the results of that portion of the test gave load vs deflection curves that were nearly straight. A traditional least squares analysis was performed for each transducer over that straight line

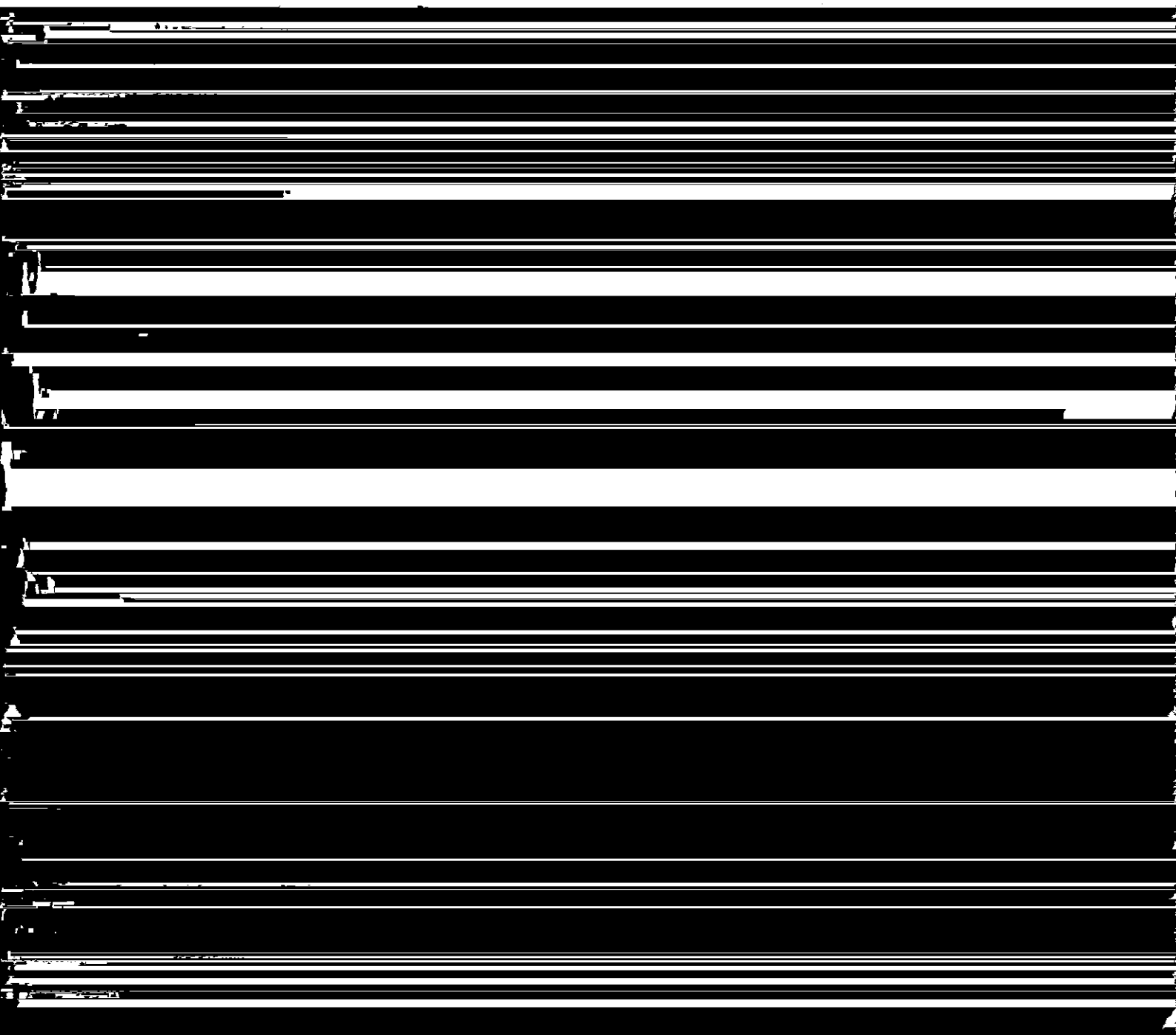
APPENDIX A CALIBRATION OF TRANSDUCERS

All transducers must be calibrated so that the number that is returned to the computer can be translated into a physical measurement. The procedure for

Calibration of LVDTs

These devices were calibrated against precision dial gauges with a resolution of ±0.01 mm. A computer program was written that would accept the dial gauge reading and immediately record the reading on the LVDT. At the completion of the calibration in which a number of readings were taken, a least squares approximation was used to fit a straight line through the points. From this, a correlation coefficient could be calculated and a t-test performed on the calibration coefficient to determine its significance. A sample of the output is shown over.

Calibration of VRTs



CALIBRATION VRT 1 8/6/83

mm	transducer
41.45	1
39.19	13
37.14	32
35.09	46
33.04	64
30.99	81
28.93	94
26.88	109
24.83	125
22.78	139
20.73	155
18.67	171
16.62	190

CALIBRATION LVDT 8L switch UP

Dial gauge	Reading
1500	241
2000	216
2500	191
[illegible]	[illegible]

[redacted]

10.26	241	4500	94
[illegible]	[illegible]	[illegible]	[illegible]