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LASER-BASED REMOTE MEASUREMENT OF LARGE BIAXIAL DEFLECTIONS.(U)
JUL 78 G WARREN

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A laser-based displacement measurement package is being developed as a tool for continuous, remote monitoring of the dynamic response of slender, very low frequency (VLF) antenna towers. The displacement monitor is designed for use where instrumentation cables are prohibitive due to intense electric fields. The system has been tested on antenna towers 380 meters in height to obtain biaxial displacement with a single sensor. Examples of results are presented with comparisons of results from velocity gages and accelerometers.

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1. Displacement measurement – Biaxial deflection 2. Antenna towers I. ZF61-512-001-071

A laser-based displacement measurement package is being developed as a tool for continuous, remote monitoring of the dynamic response of slender, very low frequency (VLF) antenna towers. The displacement monitor is designed for use where instrumentation cables are prohibitive due to intense electric fields. The system has been tested on antenna towers 380 meters in height to obtain biaxial displacement with a single sensor. Examples of results are presented with comparisons of results from velocity gages and accelerometers.

CONTENTS

INTRODUCTION

An electro-optical method is presented for continuous, remote monitoring of the dynamic behavior of slender tower structures. This study is in support of an ongoing program at the Navy's Civil Engineering Laboratory (CEL) for antenna tower structures. In the past two decades the Navy and Air Force have constructed numerous communication antenna systems composed of slender, guyed antenna towers up to 460 meters in height with top cable arrays. The systems are located throughout the world and are used for fleet navigations and operational communications. A program was begun to measure the motion of the guyed towers and the guy cable arrays so that the undesirable amplitude and natural frequencies are determined and subsequently eliminated. In the past, accelerometers and velocity gages with hard-wire instrumentation cables were used to measure the response. However, with the heights involved hard-wire cables are impractical, accelerometers had to be double-integrated, and velocity gages single-integrated to obtain displacements. Although a direct displacement measurement technique was more desirable, electrical transducers such as Linear Variable Deflection Transformers (LVDT's) require references near measurement points that were also impractical.

VLF ANTENNA SYSTEMS

Typical of large VLF tower structures is the vertical radiator at the Air Force's Hawes Radio Relay at Hinkley, Calif., shown in Figure 1. This antenna is 380 meters in height, top-loaded, and base-insulated with four levels of structural guys. It is a bolted, steel frame structure (Figure 2) that is an equilateral triangle with 3-meter legs in plan view. The triangle vertices are circular steel sections which serve as the main vertical legs of the tower. The main legs converge at the tower base into a spherical-surfaced pin joint that balances the entire system above the base insulator assembly. A small elevator travels through the steel frame and is used for inspection and maintenance. The Navy has similar VLF towers in operation such as the 360-meter radiator at Annapolis, Maryland, and the 460-meter twin towers at Lualualei, Hawaii.

Slender tower systems have been traditionally designed to resist equivalent static wind loadings. However, since the structures are very flexible and delicately balanced, they can become aerodynamically sensitive to a windy environment. Since 1970 at least four guyed television towers over 400 meters in height (similar to military VLF antennas) have collapsed from wind and ice or accidental severing of guy cables. The Navy has effectively averted catastrophic structural failures through an all inclusive inspection and maintenance routine for the VLF tower systems. However, structurally related component failures, vibration damage, and other maintenance problems have resulted in much down time early in the operational life of the systems, possibly affecting the Navy's mission. Consequently, designing tall towers on the basis of equivalent static loading may not be adequate or may be too conservative in some instances. Many of the problems have been included in an ongoing structural program for VLF towers, which includes:

- Stress analysis and configuration optimization of base insulators to resist the high structural and electrical loads after cracking was discovered in original installations (Ref 1, 2, 3).
- Development of totally enclosed elastomeric bearings to replace the spherical pin joints which become scoured from high contact stresses and rotation (Ref 4).
- Wind force studies on towers and guys (Ref 5).
- Vibration studies of guys to eliminate undesirable resonances after unusual wear was found with subsequent development of tension measurement devices for guys (Ref 6).
- Action of towers subsequent to loss of guys (Ref 7).
- Experimental and analytical studies of the dynamic behavior of towers subject to wind loading.

All of these studies have required acquisition of structural movement data and have emphasized tests on actual VLF towers. Measurement of the aerodynamic sensitivity to wind and guy forces as well as simulated tests of guy failures on small towers proved that analytical techniques such as finite elements can be used to predict dynamic behavior of towers in order to formulate improvements to the current design criteria. Studies are currently in progress at several tower sites. The optical deflection monitor was developed as an alternative to electrical transducers and hard-wire cables for gathering time-deflection information of the guy tower system.

ELECTRO-OPTICAL MEASUREMENT DEVICE

A laser-based method for direct measurement of deflection was developed that employs commercially available photodiodes with analog output that is a function of a light-spot position on a sensitive surface. Operational restrictions and characteristics of the deflection device were:

- Elimination of the requirement for instrumentation cables
- Capablility of measuring translation of structure without influence of rotation effects of individual structural elements
- Exclusion of power supplies on the structure
- Noncontact, optically based method
- Capability of continuous monitoring of deflection at frequencies from DC to 5kHz

Several concepts and variations were considered (Figure 3). The first three consisted of a light source, monitor telescope, and sensor combinations with a retroreflector target mounted on the structure. The light illuminated and reflected from the target, minimizing the effect of atmospheric refraction. Concepts (d) and (e) were more simplified but would have compromised the first three operational requirements. Thus, they were excluded from further consideration. Concept (a) was excepted because of the difficulty and expense of obtaining a lateral corner reflector. Models of concepts (b) and (c) were fabricated for evaluation (Figures 4 and 5).

The deflection devices consisted of helium-neon laser light source with beam expander telescope, a Schmidt-Cassegrain lens system, and a photodiode position sensor with control unit and power supply. The optical components were mounted in phenolic tubing.

The device concepts shown in Figures 4 and 5 were laboratory- and field-tested to evaluate light transmission characteristics, sensitivity, accuracy, and resolution. The tests included static and dynamic known deflection responses, VLF and small tower random deflection responses, as well as other structural deformation applications.

The deflected coaxial concept (b), although more compact, was found to be less efficient as a transmitter of the laser light source. As the light was manipulated from the laser head to the coaxial position, 30% to 50% of the power was lost in each of the reflector elements. This limited the long-distance capability required between the deflection monitoring device and the reflector target mounted on a tower structure without resorting to the use of a more powerful (and larger) laser light source. Thus, this concept received only limited use in the field. The remainder of this report, although generally applicable to concept (b) (Figure 4), refers specifically to concept (c) (Figure 5), which was employed with more success at longer distances in the field.

All the optical components and laser of the deflection device are shown in Figure 5 mounted inside phenolic tubing (23 cm in diameter and 110 cm in length). The tubing is fixed onto a cast steel pedestal. The laser is a 7-mW HeNe (633-nm wavelength) manufactured by CW Radiation. Since the beam is monitored after reflection as well as after it passes through optical elements, a linearly polarized light source was utilized. Linear polarization eliminated that form of output power fluctuation which is possible when randomly polarized beams reflect from surfaces or which transmits through elements that are sensitive to polarization. A laser with a separate power supply was selected in order that the laser tube (about 7 cm in diameter) could be mounted in front of the receiver telescope. The expanding lens-telescope was mounted to the laser.

A schematic of the sensor, the principal component of the system, with its equivalent circuit diagram is shown in Figure 6. The sensor is a dual-axis PIN (Positive, Intrinsic, Negative) lateral-effect photodiode that provides continuous X- and Y-axis position information of a nonuniform light spot on the sensor's active area by monitoring photogenerated current from each pair of lateral contacts for each axis (Ref 8, 9, 10). The total photocurrent injected into the diode substrate is

$$i_s = P_i R \tag{1}$$

where P_i is the monochromatic incident power and R is the sensor responsivity (intensity sensitivity). The current distribution between the lateral contacts of each axis is linear. That is, the current through contact 1 is

$$i_1 = i_s \left[1 - \frac{a}{e} \right] \tag{2}$$

where a is distance from the edge of the active area to point of light incidence and e is the width of the active area. The ratio of the two contact currents is a function of the position of the light beam.

The split rear (lateral) contacts for each axis is such that equal photocurrents ($i_1 = i_2$) will flow through both legs of the circuit when a light spot is incident on the center of the diode's active area. This is called the null position and can be shifted electronically within the sensor's control unit. The position sensitivity, S, of the sensor is defined as the current imbalance created per milliwatt of power per centimeter of movement from the null position (A/mW/cm).

$$S = \frac{2R}{e} \tag{3}$$

The position sensitivity for the diodes was approximately 0.4 A/mW/cm for 633 nm wavelength. The current imbalance from the null position, ΔI_x, produced by an incremental change in position along the X-axis (or ΔI_y on the Y-axis) is:

$$\Delta I_x = S\ P\ \Delta x$$
$$(\Delta I_y = S\ P\ \Delta y) \tag{4}$$

Compared to quadracell position sensors, the PIN lateral-effect sensor provides linear position information independent of the illumination intensity profile while the quadracell types produce nonlinear position information with most intensity profiles. The disadvantages of the lateral-effect detector are slow speed and high noise. Properties typically include: frequency response of 1.5 MHz, position linearity of 0.5% to 5%, and resolution as high as 0.002 mm.

Schottky barrier silicon sensors from United Detector Technology and diffused junction silicon sensors from Quantrad were employed. Diode active areas were 1 x 1 cm and the spectral response range was 400 to 1,170 nm (5% points). Sensors with 2 x 2-cm active area were also employed in laboratory tests but were not used in the field. The two sensors obtained from United Detector Technology are shown in Figure 7.

A block diagram of the amplifier/control unit circuit for each axis of the sensor is shown in Figure 8. From Equation 4, the output from the sensor is proportional to the power level of the incident light beam. However, the control unit obtained from United Detector Technology features a unique divider circuit network within the amplifiers which corrects for power fluctuations in the incident light. In addition, input load resistors and bias are built into the preamplifier network for various light levels. With the bias and divider network, a 200% change in the incident light level will result in a maximum position error of only 2% of full scale. However, the light level should be at least 15 μW, or resolution and sensitivity of the assembly will be reduced. The control unit also features multirange, variable gain, zero balance, and multioutput. BNC outputs provide an analog of ±5 volts with frequency response of 5 kHz and impedance of 10K ohms for magnetic tape, oscillograph, or X-Y plotter.

The position sensitivity (in millimeters per volts) of the small sensor with control unit was calibrated as follows in dim background light:

Gain	Low Range	Medium Range	High Range
Lowest	13.2	1.32	0.132
Highest	6.6	0.66	0.066

Linearity is ±5% to the sensor's edge without any detectible hysteresis. Temperature drift is approximately 0.5%/°C of the full scale reading of the most sensitive range (approximately 0.002 mm/°C).

ASSEMBLY OPERATION

The laser beam is expanded by lens-telescope to form a cone of light within which is positioned the retroreflector target on the structure. The reflected (return) beam is gathered by the receiver telescope and focused onto the position sensor mounted behind the primary mirror. The return beam is passed through a very narrow spectral band-pass filter at 633 mm to filter background light that could lower the resolution and sensitivity of the sensor. Further, the sensor is shielded from ambient light by closing the phenolic tubing in which the diode is mounted. To insure that the power level incident on the sensor is sufficient for best resolution and sensitivity, the laser beam divergence was controlled by a variable expanding telescope. Retroreflectors were selected for their compatibility to the diverging beam and for their capability in reflecting an optimum return beam.

The angle of divergence of the outgoing beam was decreased with increased distance between the assembly and the target such that sufficient deflection could be monitored while maintaining the necessary light intensity at the target. For example, a divergence of 12 arc seconds provided sufficient return light intensity of 15 to 20 μW to monitor X- and Y-deflection within a 60-cm circle at a distance of 360 meters from the monitoring assembly. However, the intensity of the return beam was very much dependent on the properties of the reflector target.

Corner-cube retroreflectors were chosen as targets since they reflect light back to the source (the receiver telescope) regardless of alignment (within limits) with the axis of the incident beam. Thus, gross X-Y translations could be measured without rotation effect of individual structural elements and the target. Several retroreflectors were obtained and experimentally evaluated for reflected beam characteristics and efficiency at distances up to 360 meters. Reflectors with slight divergence were more suitable than those which were more accurately machined with little or no angular deviations. Single reflectors with large apertures were more efficient than combinations of several reflectors with smaller apertures and equal reflectance area. The aperture diameters of the reflectors used on the towers at distances over 100 meters were 15 cm. For separation distances less than 100 meters, retroreflectors with 5-cm apertures were sufficient. Tests showed that the angle of acceptance of the retroreflectors could be rotated ±15 degrees without any noticeable change in the intensity of the reflected light. Examples of the retroreflectors used in this study are shown in Figure 9.

The sensitivity of the deflection device assembly was determined by that of the sensor with the control unit as well as the ratio of the effective focal length, f, of the receiving telescope to the distance, L, from the device to the reflector target. The measured deflection, d, on the sensor is related to the target deflection, D, by

$$D = d\frac{L}{f} \tag{5}$$

The effective focal length was determined as approximately 230 cm.

The assembled deflection device for use at VLF tower sites is shown in Figure 5, along with power supply, amplifier/control unit and oscillograph with active filter. A magnetic tape deck is also usually employed for data conditioning and analysis at a later time.

With its stand set firmly in place, the assembly is aligned on the target using a 9X spotting telescope mounted outside the phenolic tubing. After the target is centered, and the laser has been warmed up for approximately 30 minutes, the laser beam divergence is set in accordance with target distance and expected deflection range as well as to provide a return light power level at least 15 μW measured at the sensor. With the sensor in position and its axis aligned as desired, the sensitivity is checked for influence of background lighting.

Normally, calibration is not required, but if the return beam intensity is low compared to the background light, the device can be calibrated by inputting known deflections. Nonlinearity errors can also be calibrated out by this manner while installed in an actual test setup. An example of a measured calibration/sensitivity relationship is shown in Figure 10. It is more difficult if the target is mounted on a continuously dynamic structure such as a slender tower in a wind environment. However, since the sum of the two outputs from the sensor's leads (of each axis) is constant with a constant light intensity (Figure 3, Equation 1), a full scale in-place calibration can be simulated electronically by disconnecting one lead from each axis of the sensor. With one lead of each axis disconnected, all of the current passes through the other. The output of the diode circuit is the same as if the light beam had been moved to the edge of the active area with all leads connected. This is equal to the full-scale output of the sensor and provides a simple means of obtaining a full-scale calibration while in place in a continuous dynamic environment.

TIME-DISPLACEMENT MEASUREMENT APPLICATIONS

Field-test arrangements and examples of test results using the deflection device are shown in Figures 11 through 17. The tests included remote measurement of structural deflections of the Hawes VLF tower at distances up to 400 meters from the monitored point. Time-displacement data were obtained while the VLF tower shown in Figure 1 was subjected to wind loads and temperature variations. A diagram of the experimental arrangement for measuring gross movement of a VLF tower about its vertical axis is shown in Figure 11. Multipoint information was obtained by mounting targets at desired points near and between guy levels. The targets were bolted to structural sections and extended out and away from the tower frame and clamped in place such that they were visible from the monitoring position (Figure 12). A target mounted at a station between guy levels as viewed from the deflection device is shown on the right side of Figure 13. The photograph was taken with a 1600-mm telephoto lens on a 35-mm camera. The reflectors were mounted as far as 400 meters from the monitoring position, which was approximately 60 meters from the tower base and near a building on the VLF station compound with electrical power and target visibility. The deflection monitor assembly was set up on a concrete slab for stability (Figure 14). Data were recorded on magnetic tape for conditioning and time series analysis with correlation to wind conditions at a later time.

A time-deflection history of the tower is shown in Figure 15. These data were taken between guy levels at a height of 300 meters on a relatively calm day (winds less than 10 knots) while the X-axis of the sensor was aligned with the east-west axis of the tower. Similar tests have shown tower deflections up to 30 cm under strong wind loads. Resolution for these tests vary from 3 to 5 mm, depending on atmospheric conditions. Resolutions were generally better than those obtained in tests running the light parallel to the ground surface. A spectrum analysis indicated most of the frequency components in the region below 0.3 Hz.

The time-deflection sample in Figure 16 was taken from a portion of a simulated test of tower response to a sudden guy cable loss. The test was made on a 76-meter tower with the severed guy aligned with the X-axis. A comparison with single-integrated velocity gage data and double-integrated accelerometer data is also provided.

Other structural applications in progress include cable vibration measurements, stiffness, and load certification measurements of large shipping cranes, and deflection measurement of reinforced concrete structures subjected to blast loading. The data sample in Figure 17 is the time deflection from the center of a wall of a reinforced concrete cell (box) subjected to an internal explosion. This was measured from a distance of 55 meters. The theoretical natural frequency of the wall was approximately 80 Hz. Future tests will employ the optical deflection device with and in place of LVDT's.

During long periods such as the VLF tower tests, temperature consistency was maintained as close as possible while also being monitored.

CONCLUSION AND RECOMMENDATIONS

The laser-based package, which utilizes a biaxial position sensor, is suitable for measuring large deflections (up to 30 cm at distances of 400 meters) of slender VLF tower structures with applications possible in other dynamic testing when hostile environments or inaccessibility are factors. Sensitivity and resolution are functions of distance from monitoring device to the reflector; however, resolutions as high as 3 to 5 mm were obtained at a distance of 360 meters. Continuous time-deflection histories were obtained in intense electric fields without using instrumentation cables, transducers, and portable power supplies on the tower structures. The most restricting characteristic of the system is the loss of light intensity at greater distances.

Further development will include investigation of more compact and powerful light sources such as infrared devices. The feasibility of measuring triaxial deflections will also be studied. Triaxial deflection measurement investigation will include alternatives of a single triaxial device or using two or more biaxial measurement devices.

REFERENCES

1. G. E. Warren, "Photoelastic analysis of Navy VLF tower insulators," paper presented at 1975 SESA Spring Meeting, Chicago, Ill., Society for Experimental Stress Analysis, May 11-16, 1975.

2. Civil Engineering Laboratory Technical Note 1427: Stress concentration determination in station post insulator, by D. T. Corrente. Port Hueneme, Calif., Feb 1976.

3. __________. Technical Report 839: Stress analysis of Navy VLF antenna insulators, by G. E. Warren. Port Hueneme, Calif., Apr 1976.

4. __________. Technical Note N-1461: Evaluation of totally enclosed elastomeric bearing as a hinge joint base of guyed VLF tower, by G. E. Warren. Port Hueneme, Calif., Nov 1976.

5. __________. Technical Memorandum TM51-76-20: Wind forces on guyed towers, by A. N. L. Chiu et al. Port Hueneme, Calif., Nov 1976.

6. __________. Technical Memorandum TM51-76-04: Split-ring guy tension measurement device, by V. J. Gerwe. Port Hueneme, Calif., Dec 1975.

7. __________. Technical Memorandum TM51-77-04: Dynamic action of a guyed tower subsequent to loss of a guy wire, by J. Rollins et al. Port Hueneme, Calif., Apr 1977.

8. B. O. Kelly. "Lateral-effect photodiodes," Laser Focus Magazine, vol 12, no. 3, Mar 1976, p. 38.

9. G. Lucovsky. "Photoeffects in nonuniformly irradiated P-N junctions," Journal of Applied Physics, American Institute of Physics, vol 31, no. 6, Jun 1960, p. 1088.

10. J. T. Wallmark. "A new semiconductor photocell using lateral photoeffect," in Proceedings of Institute of Radio Engineers, vol 45, 1957, p. 474.

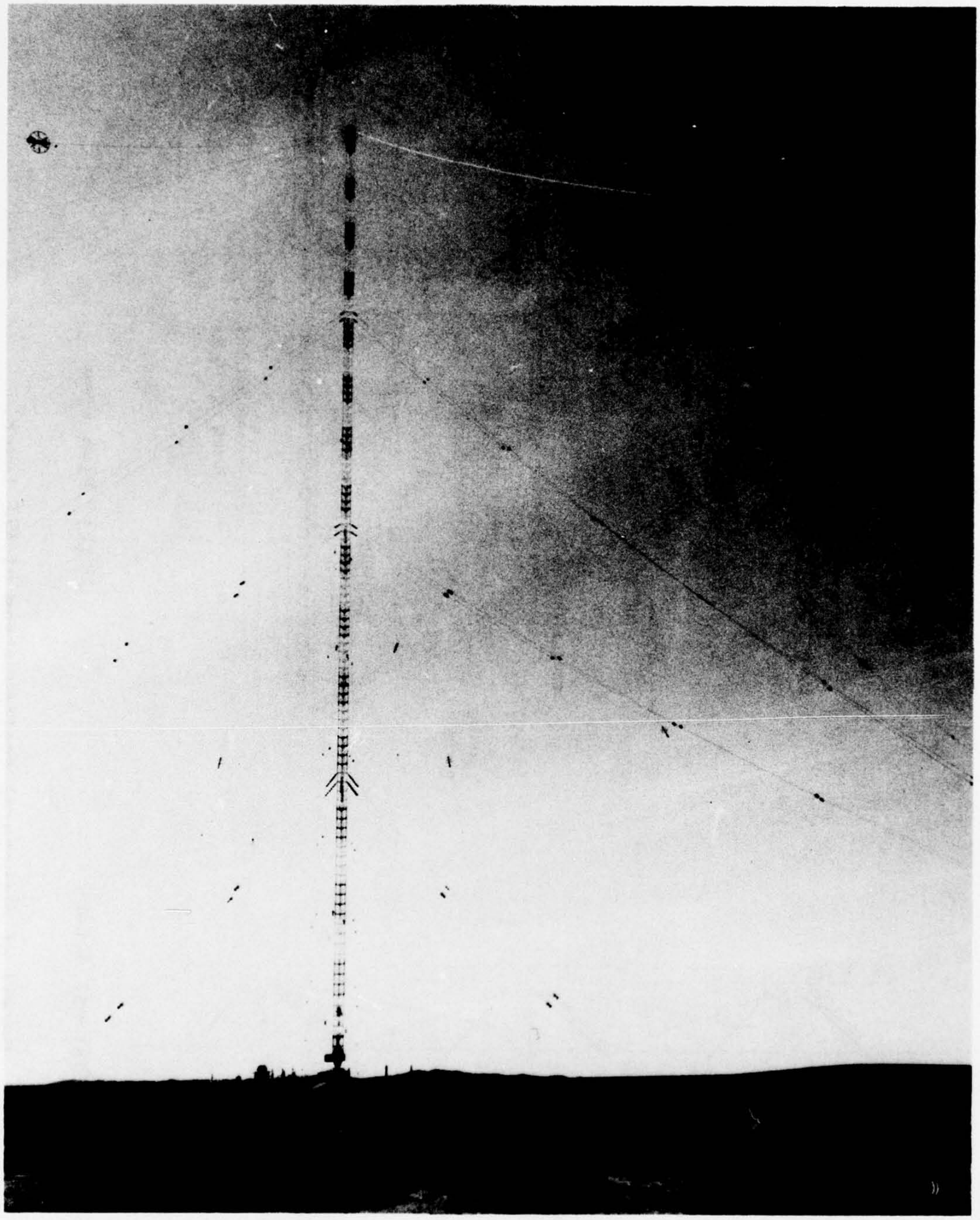
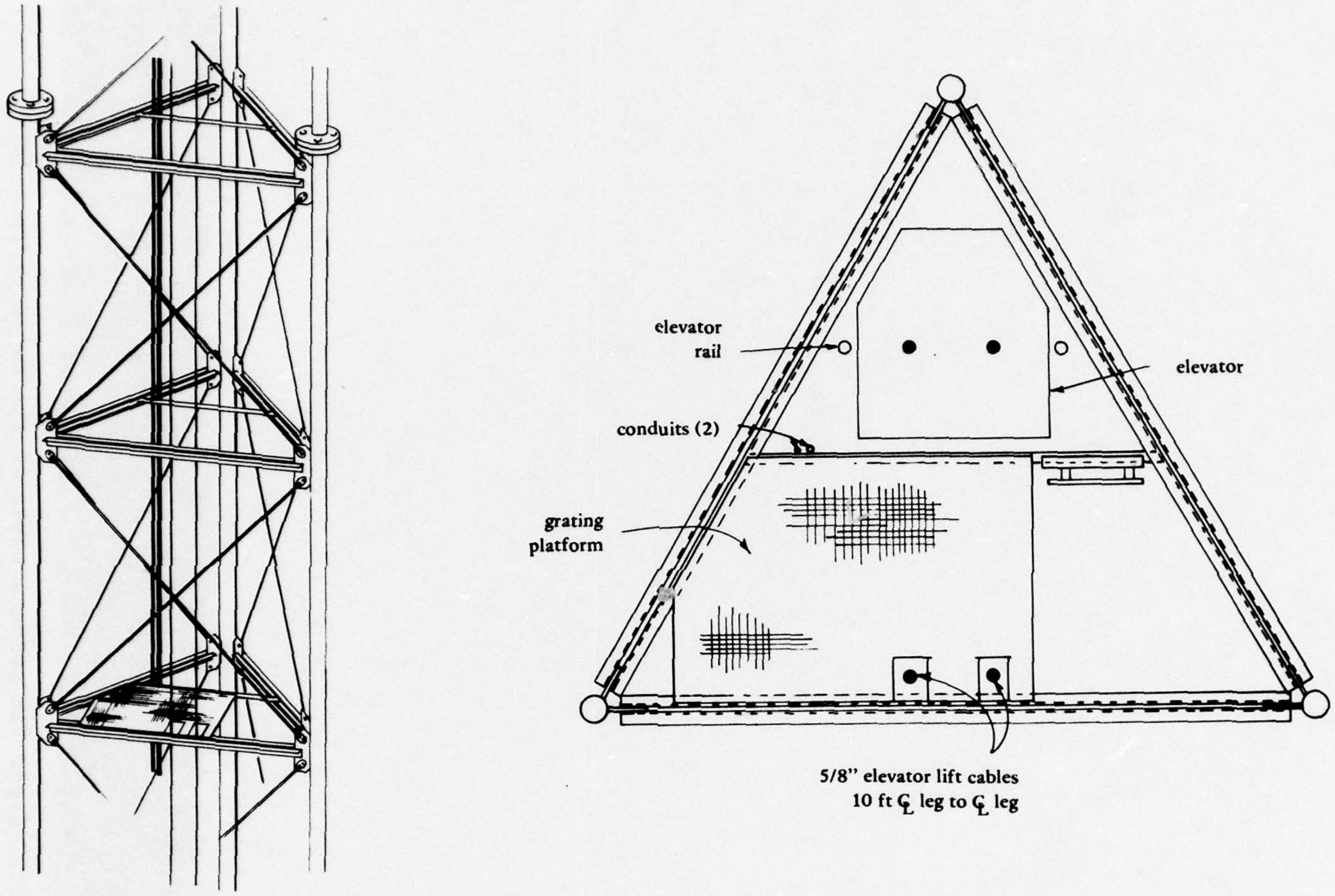


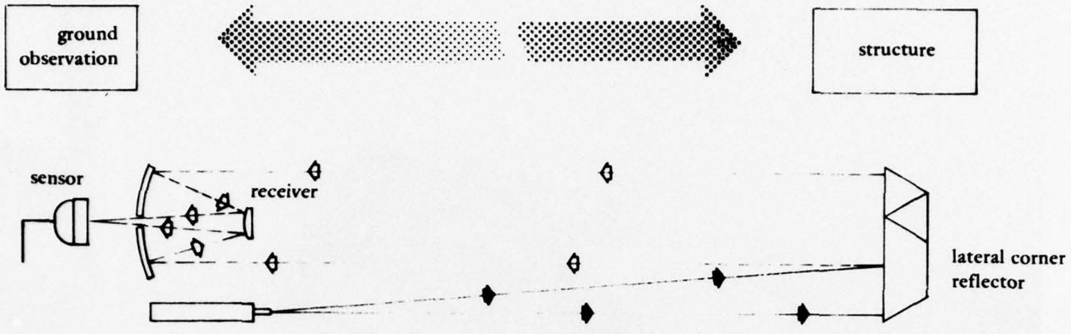
Figure 1. Guyed VLF antenna tower at the Hawes radio relay facility near Hinkley, Calif.



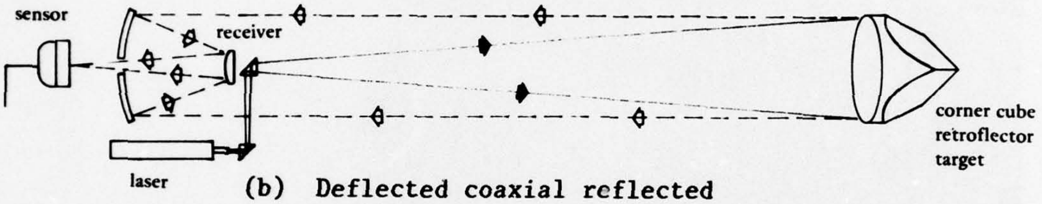
(a) Three-dimensional detail

(b) Plan view

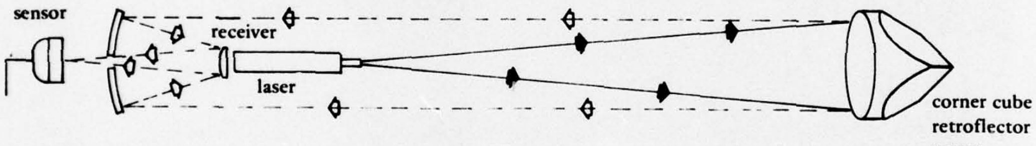
Figure 2. Detail of structural configuration of VLF tower.



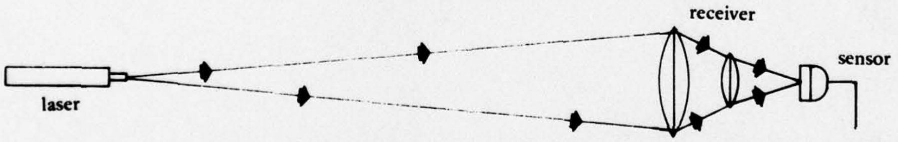
(a) Lateral offset reflected



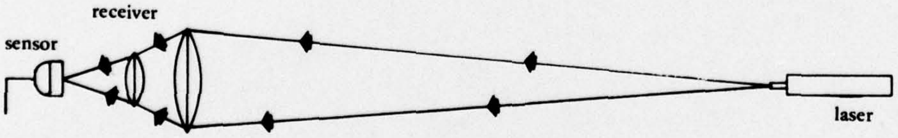
(b) Deflected coaxial reflected



(c) Coaxial reflected



(d) Light one way-sensor on structure



(e) Light one way-source on structure

Figure 3. Electro-optical deflection measurement concepts and variations.

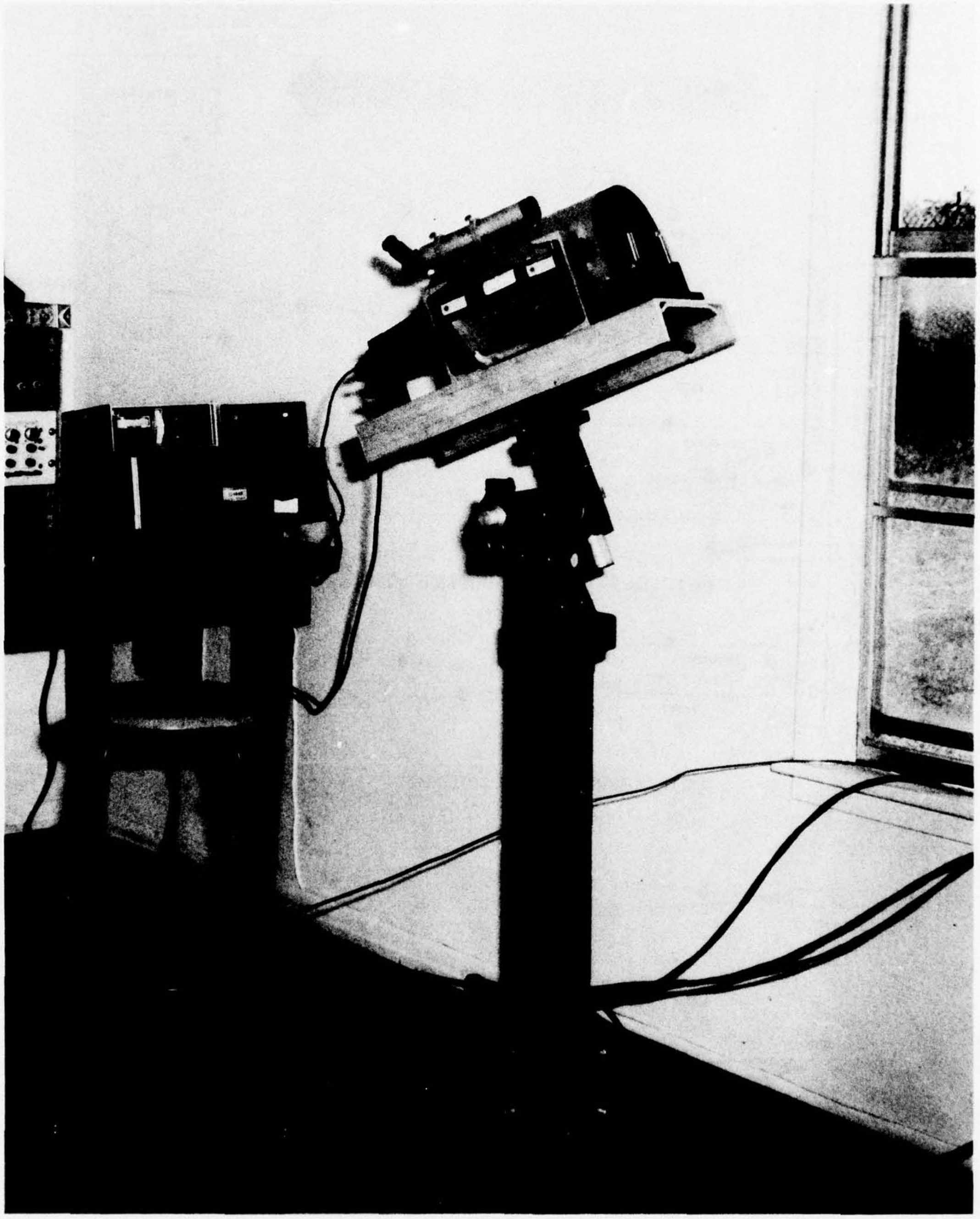


Figure 4. Deflection monitoring concept - deflected coaxial reflected - during evaluation tests at small tower site.

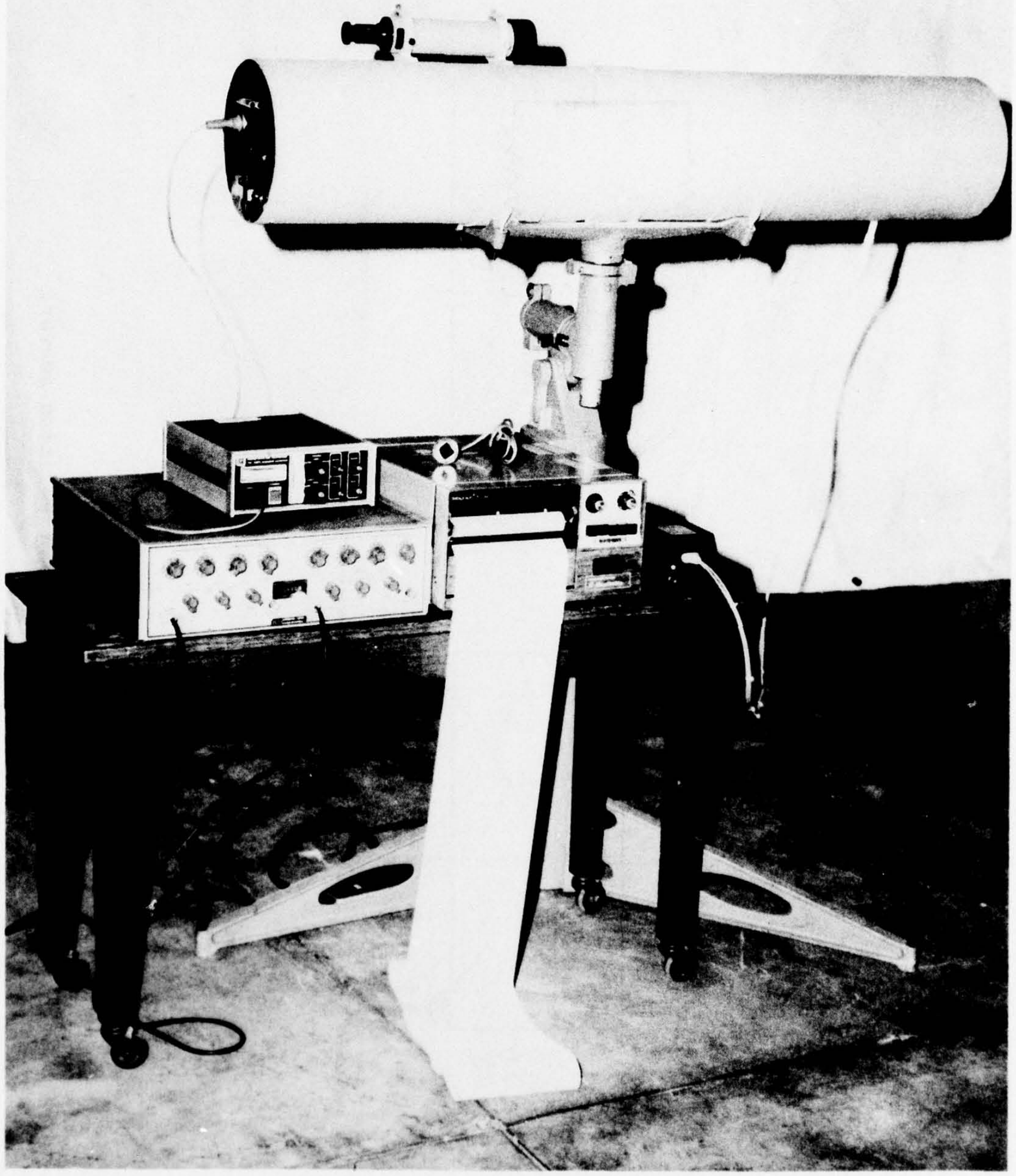
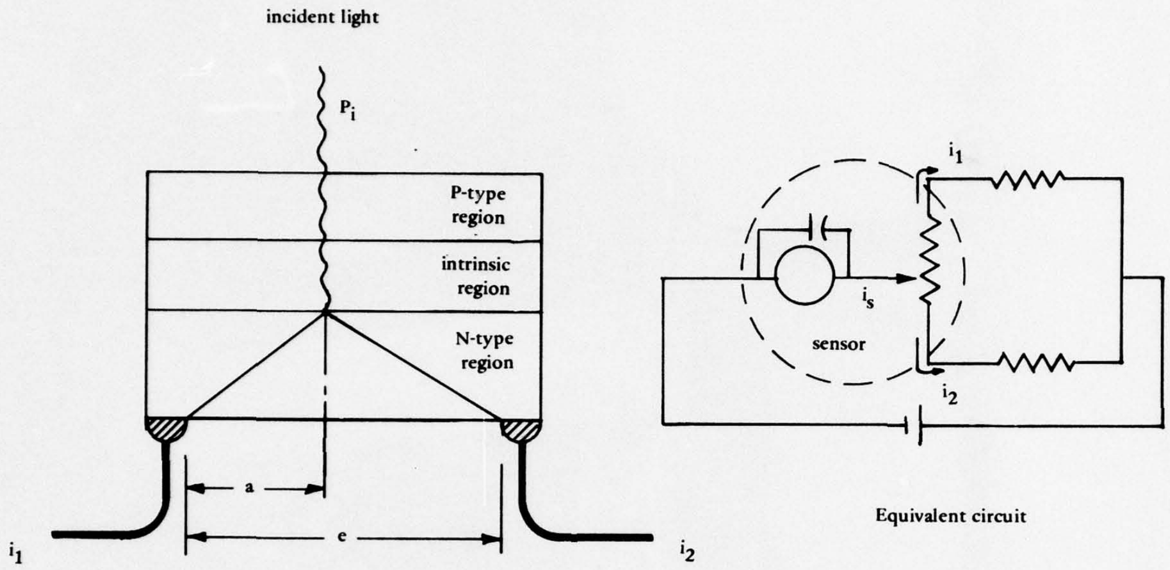


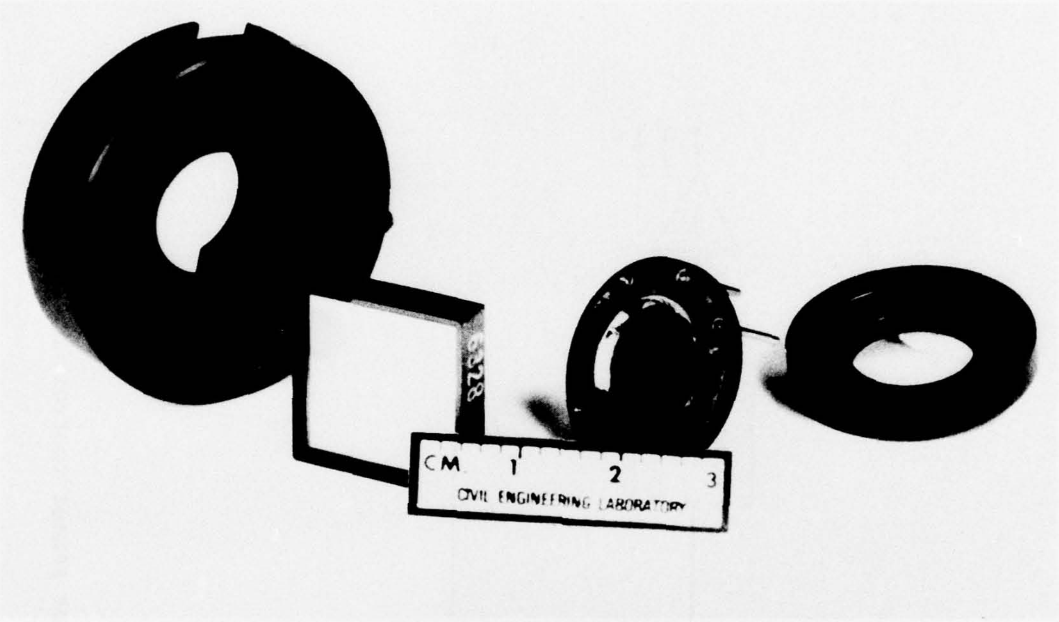
Figure 5. Test configuration of electro-optical deflection monitor concept - coaxial reflected.



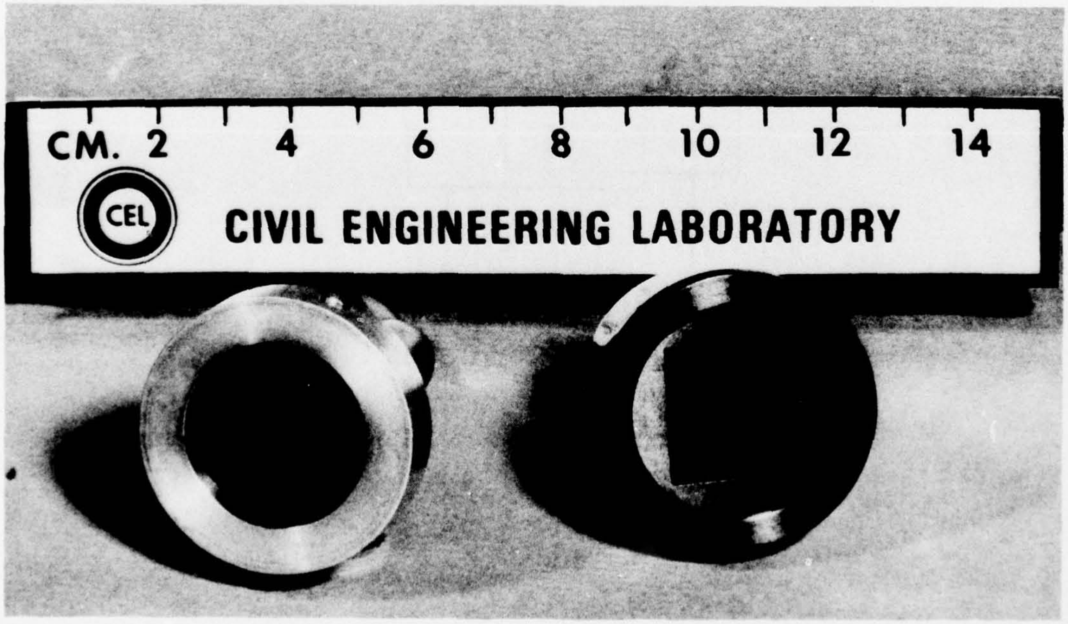
Cross-section showing sensor characteristics

Equivalent circuit

Figure 6. PIN lateral - effect position sensor.



(a) Sensor components



(b) Assembled sensors

Figure 7. Position sensors.

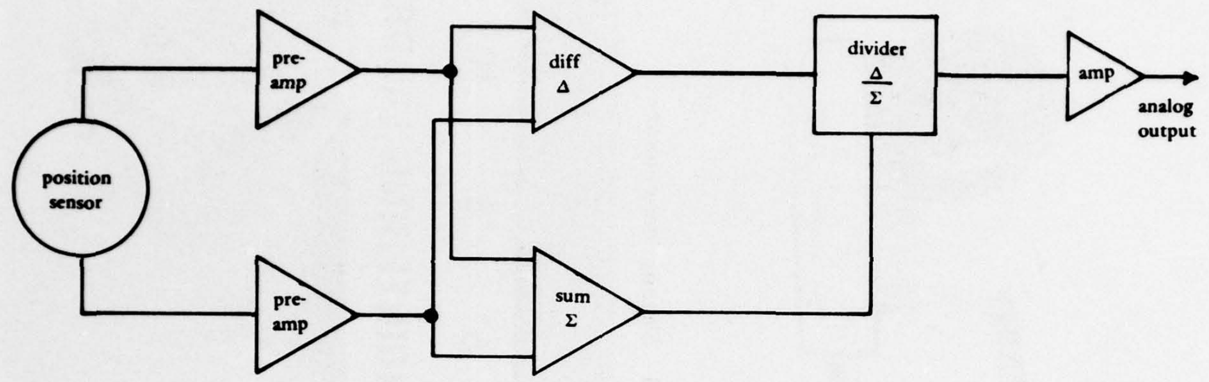


Figure 8. Amplifier diagram for sensor control unit.

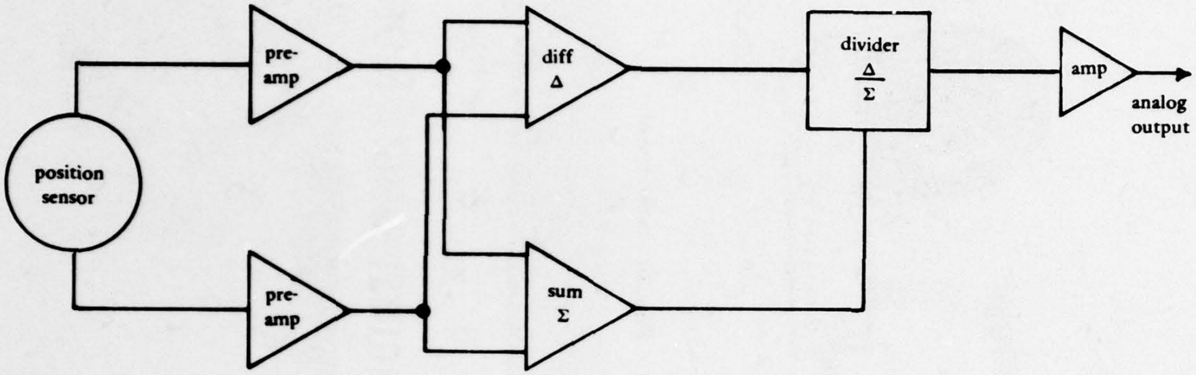


Figure 8. Amplifier diagram for sensor control unit.

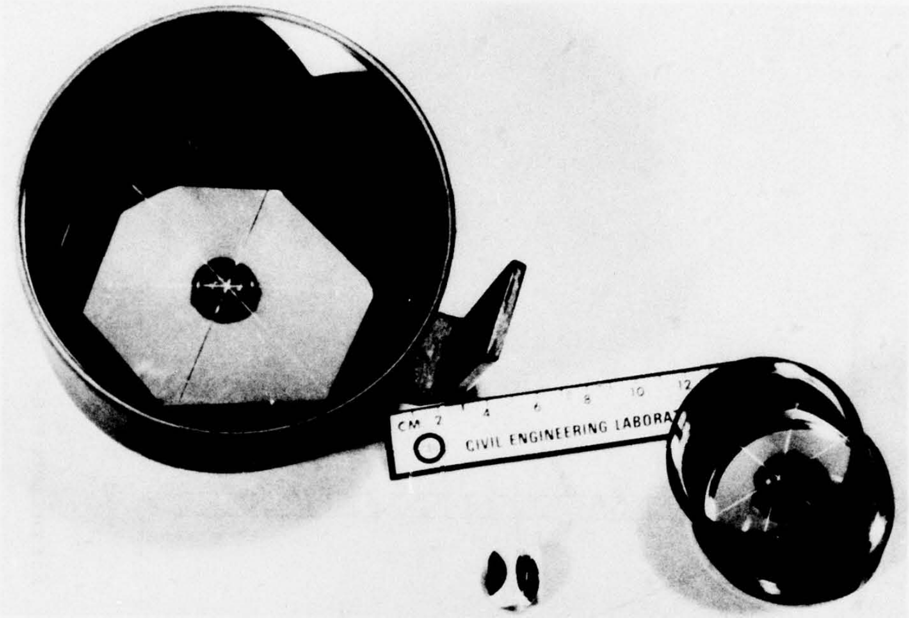


Figure 9. Retroreflector targets.

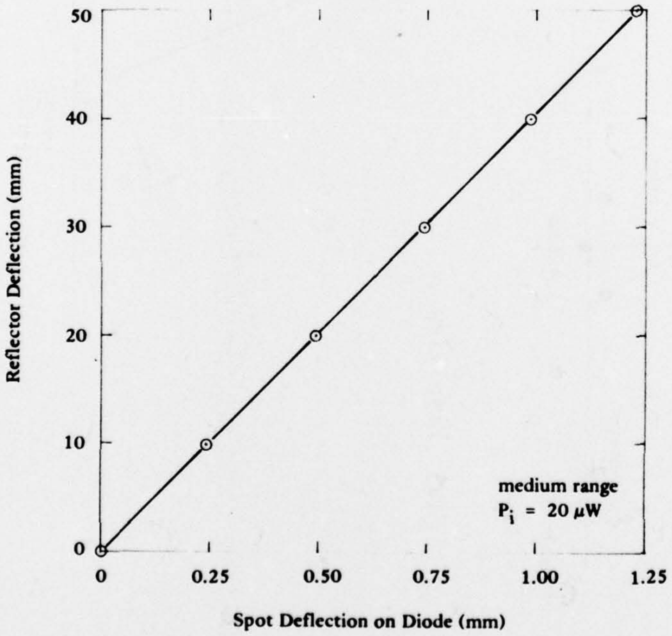
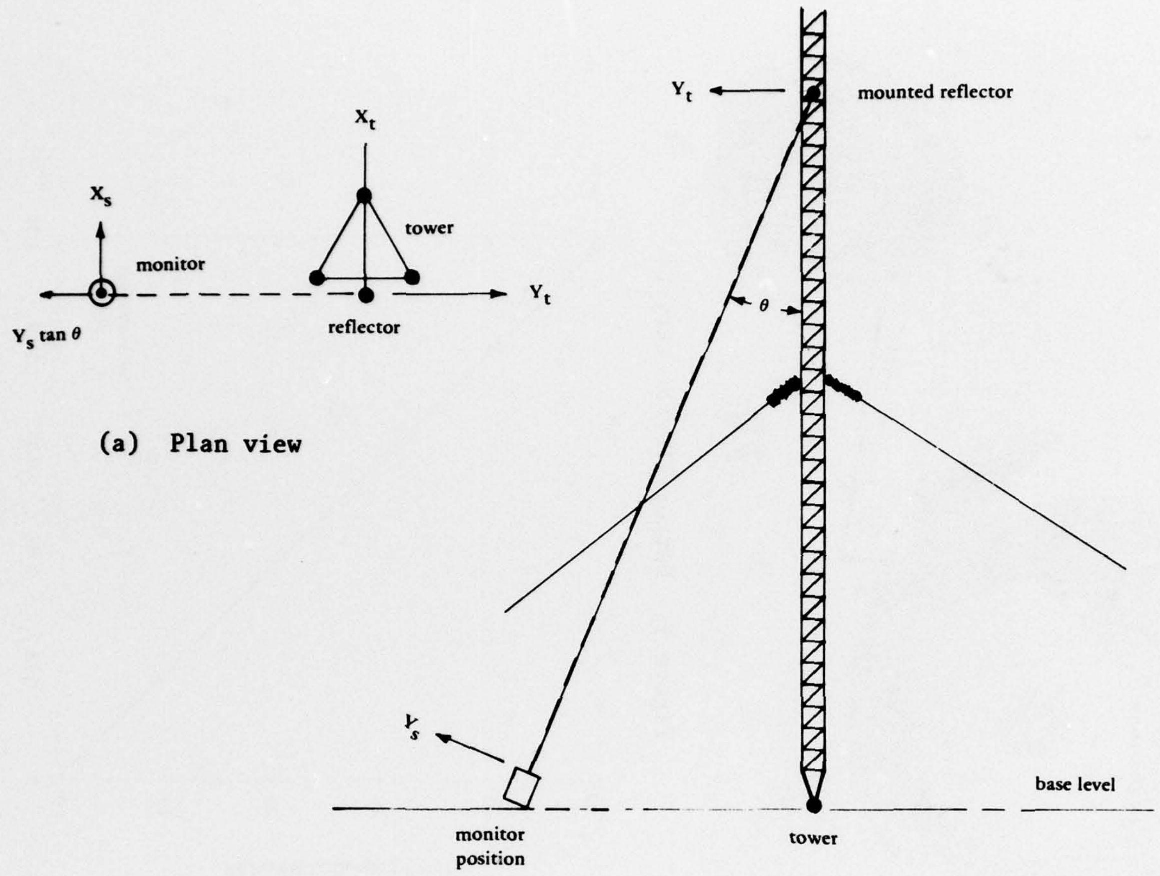


Figure 10. Deflection calibration measured from 100 meters.



(a) Plan view

(b) Elevation view

Figure 11. VLF site layout for monitoring deflections.

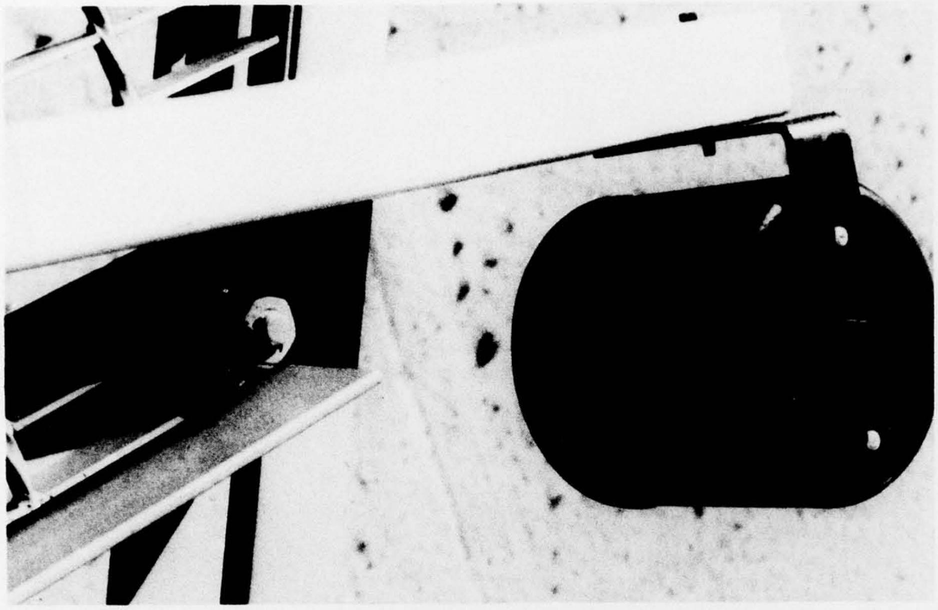


Figure 12. Fifteen-cm retroreflector target mounted to Hawes VLF tower.

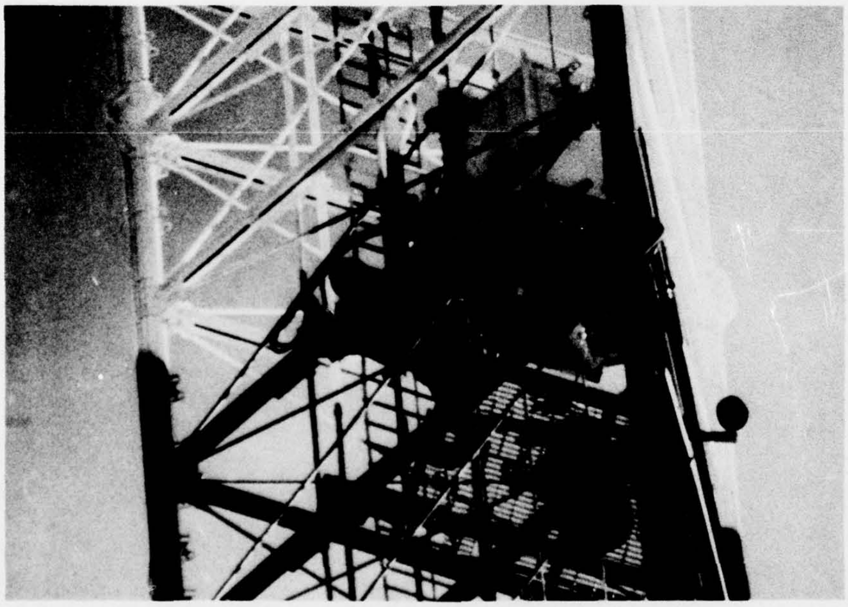


Figure 13. Retroreflector target mounted at 250-meter height of Hawes VLF tower (right edge of tower).

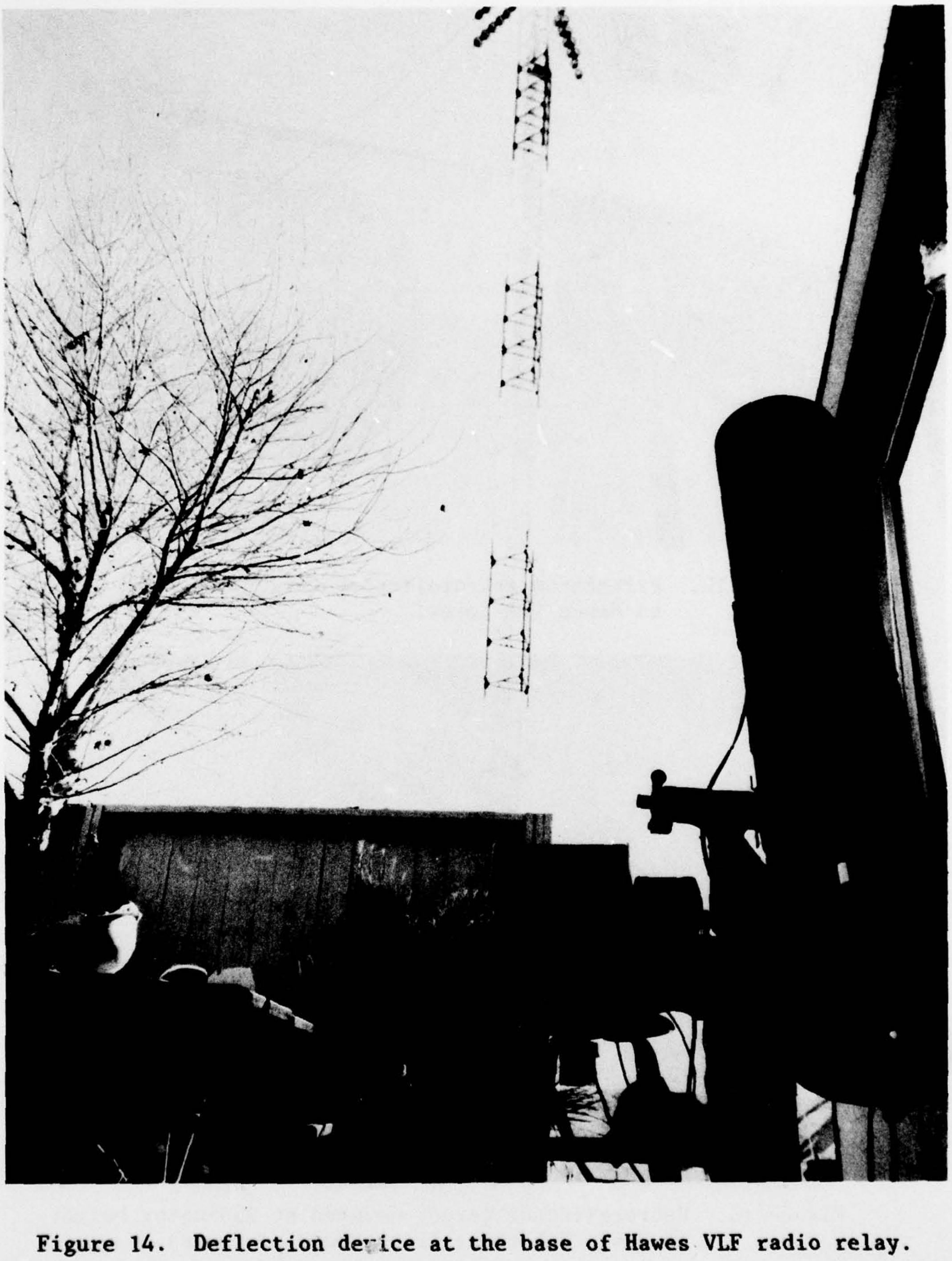
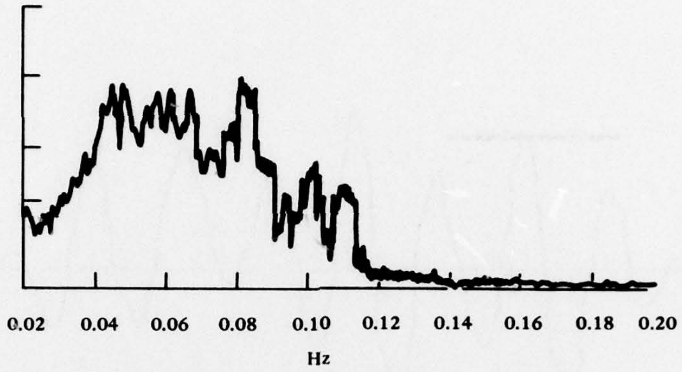


Figure 14. Deflection device at the base of Hawes VLF radio relay.



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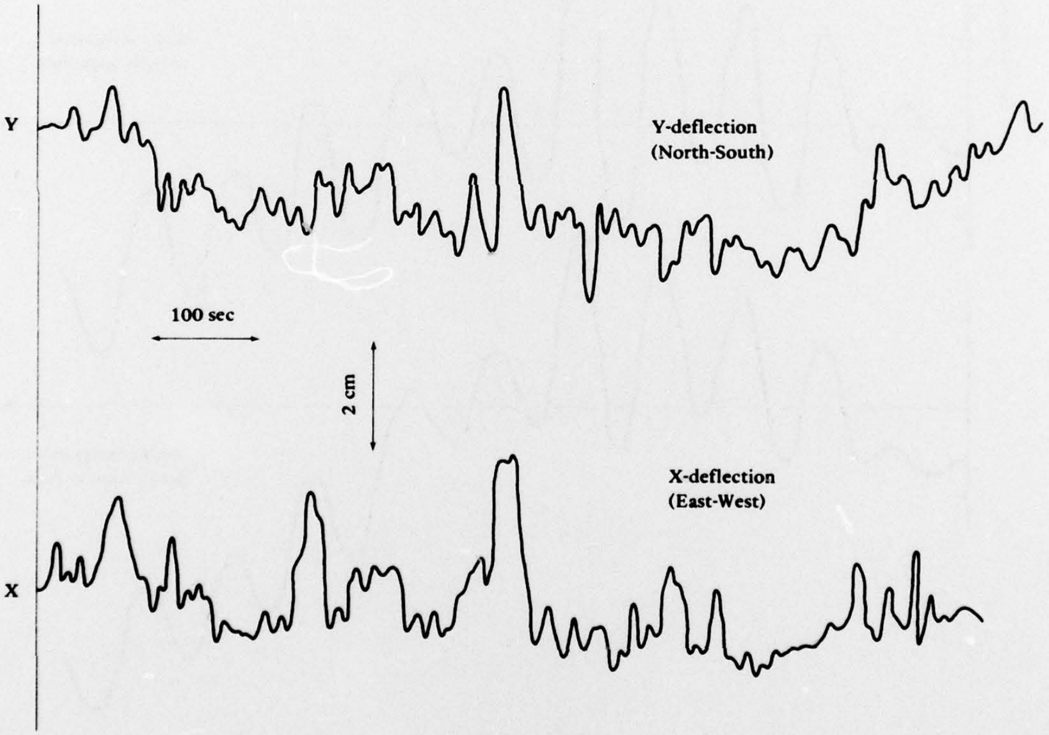

Figure 15. Dynamic response of VLF tower to 0 to 8-km/h wind from the southwest.

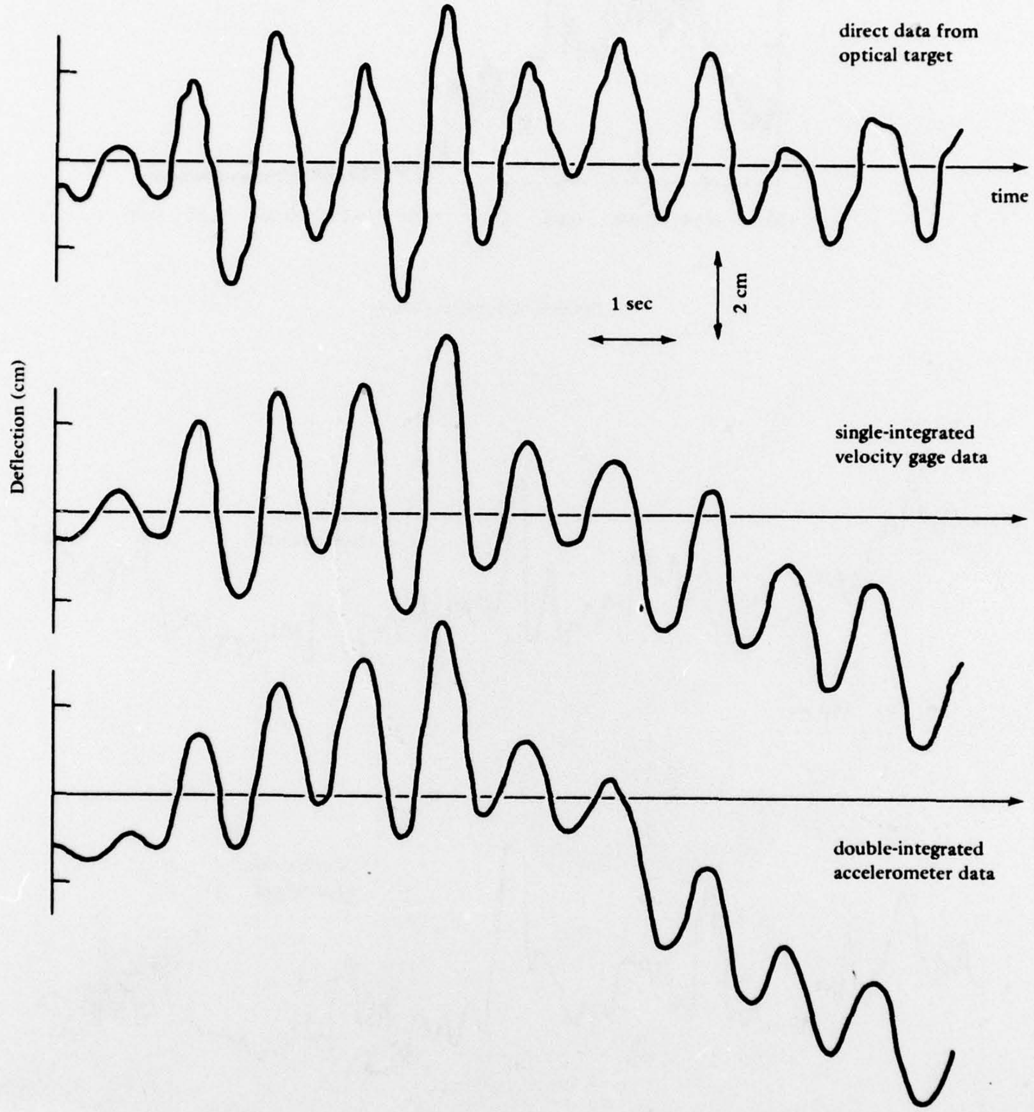

Figure 16. Tower response to simulated loss of guy cable - X-axis.

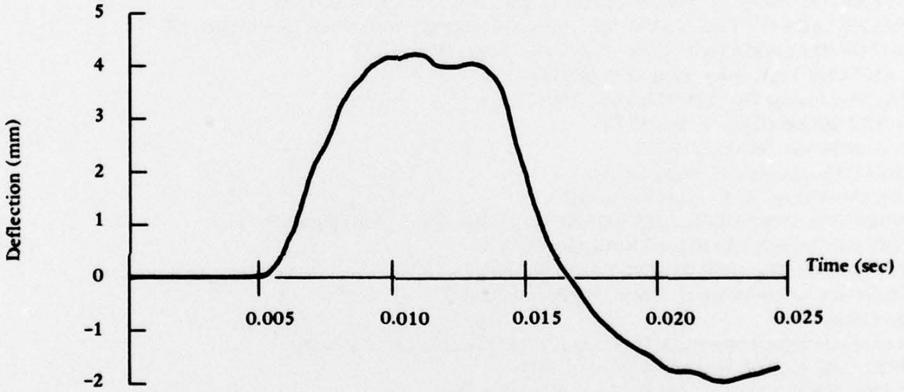

Figure 17. Horizontal response of concrete wall to explosion (840 kPa-ms impulse).

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