CHAPTER 5
PAVEMENT DEFLECTION EQUIPMENT

5.1 INTRODUCTION

Two deflection measurement devices were used on this project to aid in determining pavement strength and to predict pavement performance. They were the Benkelman Beam and the Dynaflect.

The Benkelman Beam is used manually, resulting in a slow collection of deflection data. It does allow deflection measurements to be taken under a great variety of loading conditions. The Benkelman Beam is widely used throughout Brazil.

The Dynaflect is a rapid data gathering system which exerts its own load on the pavement and automatically records the deflection data on a teletype machine. The load exerted is relatively small, being 1000 pounds.

5.2 BENKELMAN BEAM

The Benkelman Beam is a long lever. One end is placed in contact with the pavement surface between the test vehicle's tandem wheels. The other end of the beam is fitted with a dial gauge to measure the displacement of that end when the pavement deflects due to the load. The reading on the dial gauge is then multiplied by the ratio of lever arms to obtain the actual deflection of the road surface. Figures 5.1 and 5.2 illustrate the Benkelman Beam.

A detailed description of the use of the Benkelman Beam and the Dynaflect is covered in a Project Technical Memo (Visser, "Pavement Performance and Maintenance Experimental Sections").

5.2.1 *Maintenance*

The major source of beam failure was rough handling by the operating crew. The original bearings were replaced with sealed, precision, industrial bearings after the original cone-and-cup bearings fell apart. The beams are fitted with electric buzzers that vibrate the beams to reduce bearing static friction. The buzzers needed periodic attention to keep them operational.

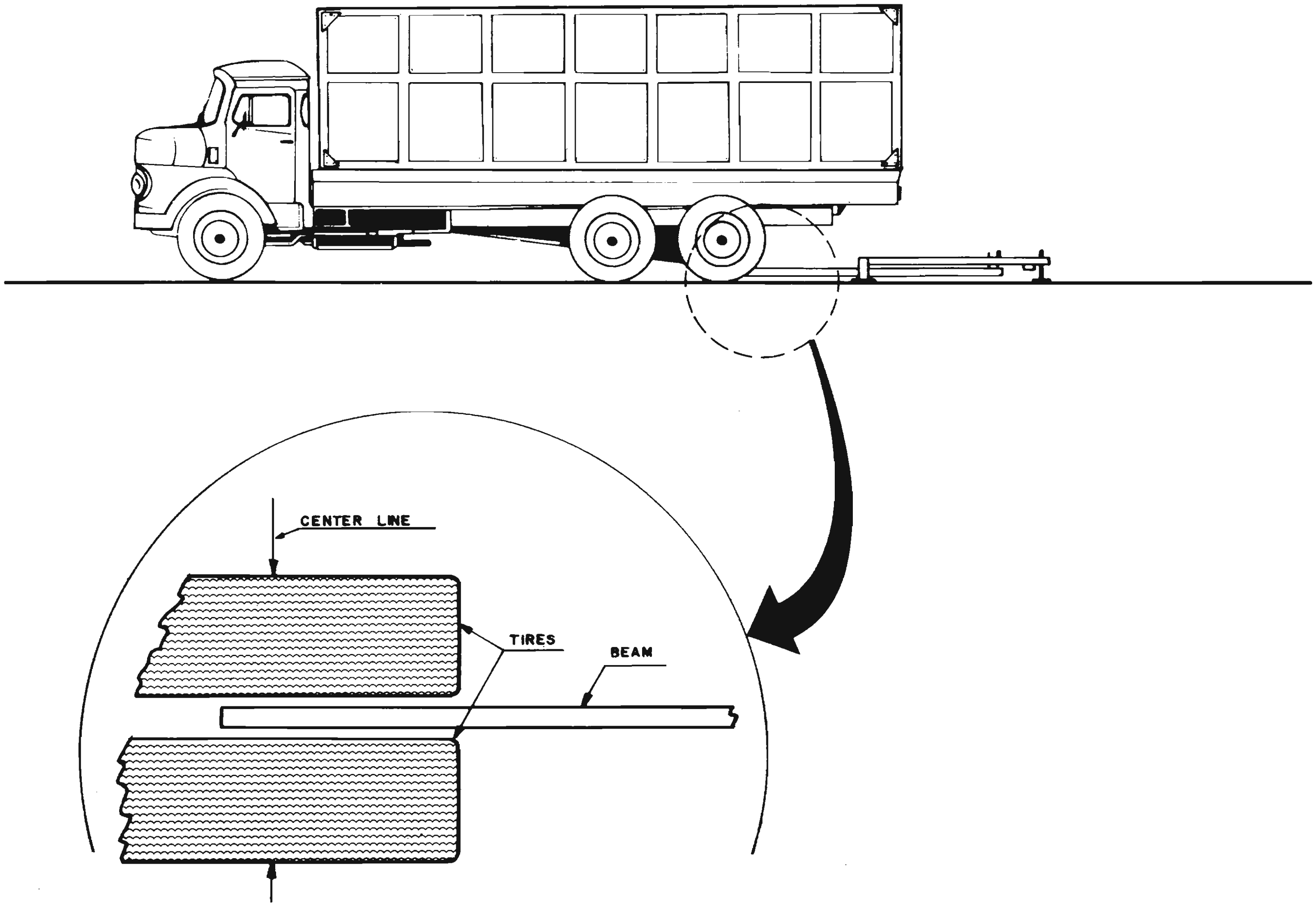

FIGURE 5.1 - BENKELMAN BEAM

FIGURE 5.2 - BENKELMAN BEAMS BEING USED TO MEASURE PAVEMENT DEFLECTIONS

Each beam was fitted with a precision dial gauge. The gauges were sensitive to rough handling and consequently needed frequent repairs.

5.3 DYNAFLECT

The Dynaflect consists of a dynamic force generator mounted on a small two-wheel trailer, a control unit and teletype, a sensor assembly, and a sensor calibration unit. It is manufactured by SIE, Inc.

The system is designed to operate behind a vehicle that has a rigid trailer hitch and a 12 volt battery system. After initial calibration, successive measurements can be made at different positions by a single operator/driver without leaving the towing vehicle. The Dynaflect is depicted in Figure 5.3 at a test location in test position. Its specifications are outlined in Table 5.1.

5.3.1 *Operating Principle*

The Dynaflect applies a repeated force of 1000 pounds (peak-to-peak) to the surface of the pavement through two rigid wheels. The resulting periodic deflection of the surface is sensed by an array of 5 geophones, spaced 12 inches apart in a line perpendicular to the center of the trailer's axle as shown in Figure 5.4. The signals from the geophones are filtered, scaled and then converted to digital form displayed on the face of the control unit, Figure 5.5. The operator may either copy the digitized sensor data on a recording form or on the teletype in the form of a punched paper tape and printed paper.

5.3.2 *Field Operation*

The Dynaflect crew consisted of a driver and an observer, although the operation is simple enough to allow the driver to perform both functions. Because of the required slow towing speed (less than 10 km/h) while in operation) and the frequent stops, it is advisable to provide highway police or other road guards, to prevent accidents.

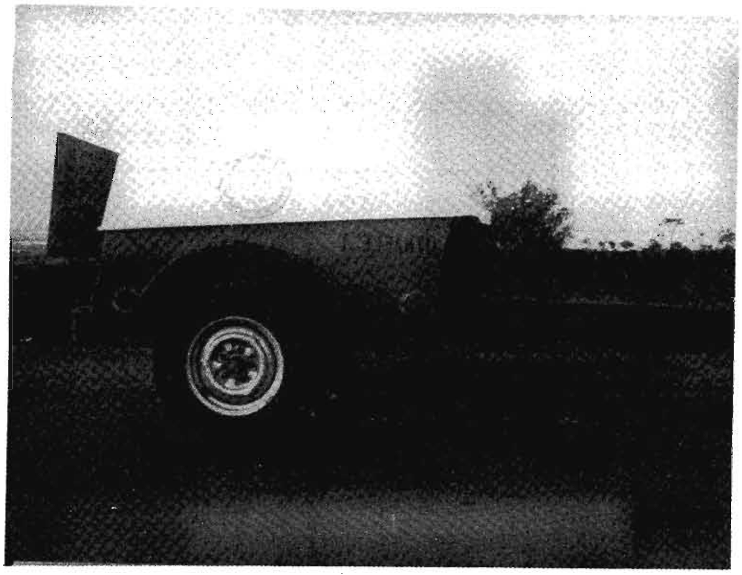

FIGURE 5.3 - DYNAFLECT IN MEASUREMENT POSITION ON A TEST SECTION

FIGURE 5.4 - DYNAFLECT SENSORS IN POSITION AND READY FOR TESTING

TABLE 5.1 - SPECIFICATIONS FOR DYNAFLECT

POWER:	12 VDC, 100 amp (starting current) 8 amp (running current)
TOWING SPEED:	
Pneumatic Tires	Legal Speed Limit
Rigid Wheels	10 km/h maximum on smooth surface, proportionally lower speeds for irregular surfaces
TRAILER WEIGHT:	
Static	1600 lbs
Dynamic	Varies sinusoidaly from 2100 lbs to 1100 lbs at 8 Hz
TIRE SIZE:	7.50 x 14
TRAILER DIMENSIONS:	69" wide 46" high 124" long
TREAD WIDTH:	59 1/2"

Source: manufacturer, SIE, INC.

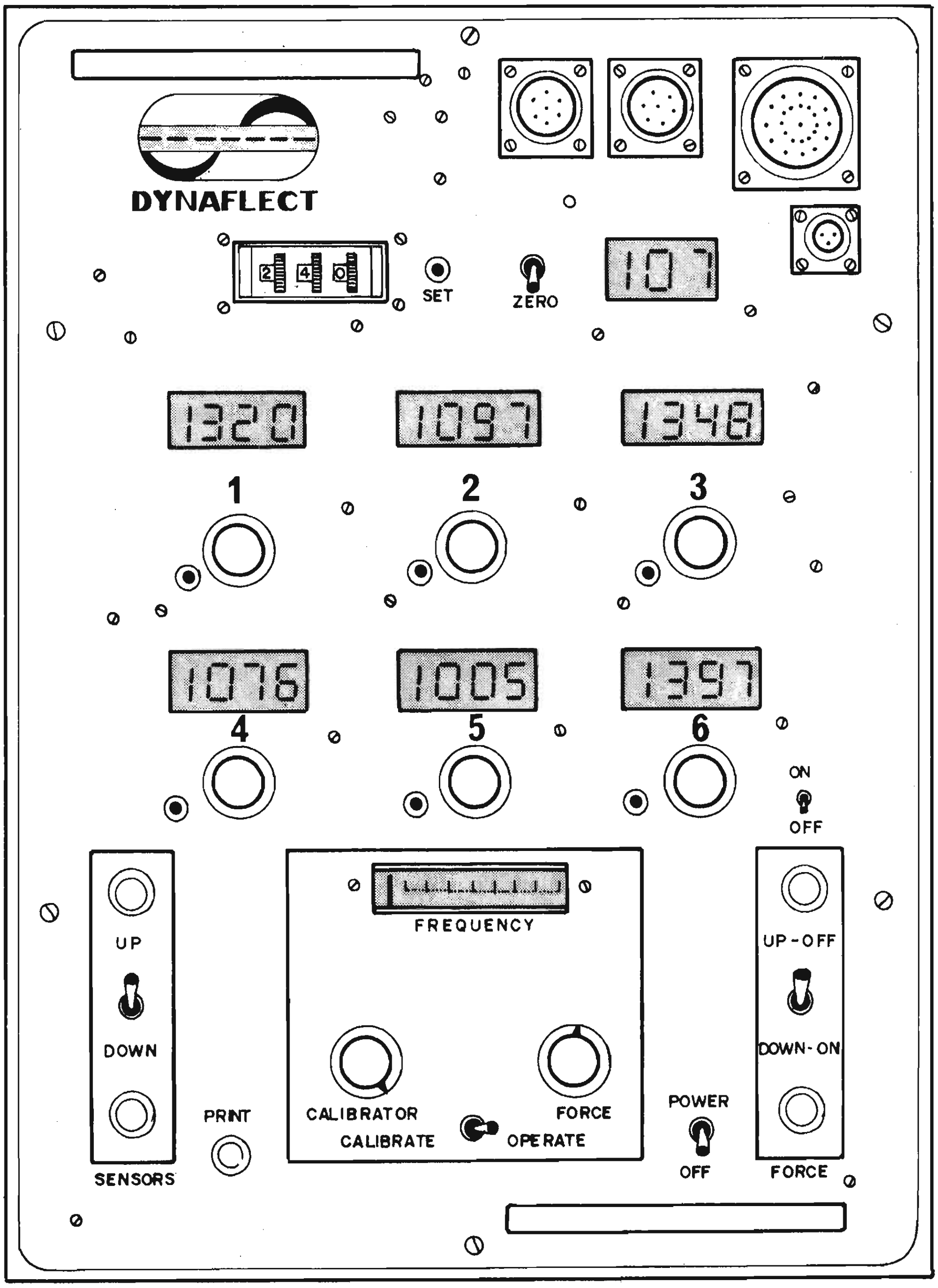

FIGURE 5.5 - DYNAFLECT CONTROL UNIT

The operating steps include the following:

1. The geophone/control unit is calibrated on site by the crew.
2. The force wheels are lowered into position once the Dynaflect is at its measurement site.
3. The operator lowers the geophone array, records the deflection data, then raises the geophone array.
4. The driver then moves up the road at a slow speed of 10 km/h (short distances only) to the next measurement site.
5. When all data are taken at a particular section the force wheels are raised and the equipment and crew proceed to the next section at normal highway speed.
6. The copied data is returned to the office for analysis.

5.3.3 *Recommended Maintenance Facilities*

Electronics Engineer
Electronics Technician
Mechanic
Volt-ohm meter
Oscilloscope
Adjustable strobe lamp
Normal hand tools

5.3.4 *Major Sources of Maintenance Problems*

The Dynaflect was hauled between test sites at excessive speeds, which was the major reason for maintenance and repair. The most serious problem involved the trailer suspension spring, which broke a number of times. This occurred when the trailer hit a hole in the road at high speeds, and happened on three separate occasions, requiring replacement of the springs. The Dynaflect manufacturer did not anticipate spring breakage and provided no means for spring replacement short of cutting the axle in half, sliding on new springs and then soldering the axle back together.

Providing sufficient electrical power to lift the trailer onto its rigid measurement wheels was an early problem. An extra heavy duty (100 amp, 12 volt) alternator was fitted on the towing vehicle's engine and extra heavy cables were run from the battery to the trailer. It was found that the trailer control unit needed a full 12 volts DC to function, which means that the alternator, battery, and cables must be in top condition, requiring service at frequent intervals.

Electronic problems developed in the main control unit but were remedied without excessive down-time. Also, the force generator position sensor switches required replacement twice.

In early trials, the operators frequently forgot to disconnect the trailer-to-towing-vehicle electric cables during transport, which resulted in the wires being ripped out of their sockets.

The Dynaflect was hit from behind once by another vehicle which bent the trailer towing arm. It was restraightened and strengthened.

The Dynaflect was in use constantly and subjected to considerable travel. It proved to be a valuable tool in terms of its durability and productivity. However, the data collected proved difficult to use in practice. Recent analysis (Queiroz, "Performance Prediction Models for Pavement Managament in Brazil") indicate that the data collected with the Benkelman Beam correlate better than the data collected by the Dynaflect with the behavior of Brazilian pavements. For a comparison between the two methods used for measuring pavement deflection in the PICR see Queiroz, *et al.*, "Resultados de Deflexões com Vigas Benkelman", p. 12.