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PAVEMENT DEFLECTION: EQUIPMENT FOR MEASUREMENT IN THE UNITED KINGDOM

by

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ABSTRACT

Significant relationships have been established between the deflection of roads measured under a standard rolling wheel load moving at creep speed and their structural performance under traffic. This research is described in LR 832 and provides the basis for the prediction of the unexpired lives of pavements and for the design of bituminous overlays.

Essential to the research studies and to the implementation of a design system for strengthening pavements is a convenient and reproducible method of deflection measurement. The report describes the Deflection Beam, which was used in the original studies, and its standardised method of operation in the United Kingdom.

The Lacroix Deflectograph, an automatic technique of measuring deflections under a rolling wheel, is suitable for carrying out deflection surveys on long lengths of road. The machine as modified for use in the United Kingdom is described together with details of ancillary equipment required for carrying out deflection surveys.

1. INTRODUCTION

Research carried out over a number of years at the Transport and Road Research Laboratory has established that a significant relation exists between the magnitude of the deflection of a road pavement under a rolling wheel moving at creep speed and the structural performance of that road under traffic. Systematic measurements of deflection obtained on both original and overlaid pavements has provided the basis for prediction of the unexpired lives of pavements and for the design of bituminous overlays to extend their lives. This research is described in LR 832[1].

Essential to the research studies and to the implementation of a design system for strengthening road pavements is a convenient and reproducible method of measuring deflection.

In practice, equipment for measuring deflection records displacements that are related, but not equal, to the absolute deflection of a road surface under the action of a rolling wheel. Those techniques that deflect the road surface by means of a pulse load applied singly or repeatedly generate stresses and strains that differ in several respects from those generated by the rolling wheels of traffic and the measured deflections are consequently affected. Devices that have the greater realism conferred by the use of a rolling wheel to generate deflection, do not, in general, provide a datum from which absolute measurements can be made.

In selecting a method of measurement the Laboratory opted for the realism of the rolling wheel and given the empirical approach originally planned, accepted the non absolute nature of the deflection values measured. The Deflection Beam originally designed by Benkelman[2] was selected for development into a standard measurement technique[3]. This simple manually operated device measures the deflection of the road brought about by the dual rear wheels of a loaded lorry moving at creep speed.

The original research studies and a number of deflection surveys associated with strengthening programmes on actual roads were carried out with this equipment. However extended surveys over long lengths of Motorway and Trunk Road demonstrated the need for a measurement technique of greater capacity than that provided by the Deflection Beam which, testing at 10m intervals, can cover only 1km of road in a working day.

The Laboratory therefore purchased an early version of the Lacroix Deflectograph, an automatic technique of measuring deflections which was originally designed in France by the Laboratoire Central des Ponts et Chaussees. Measurements of deflection are made at closely spaced intervals as the lorry which provides the load reaction and which also carries the measuring and recording equipment moves continuously along the road at creep speed. Eight to ten kilometres of road can be surveyed in a working day.

The Deflection Beam and Deflectograph and their methods of operation in the United Kingdom are described in this Report. Details of suitable equipment, including vehicle specifications are included. At this time the version of the Deflectograph manufactured in the United Kingdom (see Appendix 1) has not been subject to acceptance trials.

Ancillary equipment required for use in deflection surveys is also described.

2. THE DEFLECTION BEAM

2.1 Details of the Deflection Beam

The Deflection Beam was developed by A C Benkelman in the United States and is often referred to as the Benkelman Beam. Deflection of the road surface as a wheel passes over it is measured by the rotation of a long pivoted beam in contact with the road at the point where deflection is to be observed. A long beam is essential to ensure that the pivot supports are remote from the influence of the loaded wheel at the time of measurement.

The design of the Beam that has been evolved at the Laboratory is illustrated in Plate 1. This is currently manufactured by suppliers listed in Appendix 1. Detailed drawings are available from the Transport and Road Research Laboratory.

The aluminium alloy beam is sufficiently slender to pass between the dual rear wheels of a loading truck. It is 3.66m in length and is pivoted at a point 2.44m from the tip giving a 1:2 length ratio on either side of the pivot. The pivot is carried on a frame made of aluminium angle supported by three adjustable legs. The frame also carries a dial-gauge arranged to measure the movement of the free end of the beam. Figure 1 shows the principal dimensions.

The dial-gauge used has a 75mm diameter face, a travel of 25mm and is calibrated in 0.01mm graduations. It is reverse printed to enable it to be read from above using a 45° mirror. For travelling purposes, the beam is locked by the rotating handle grip as shown in Plate 2. To minimise sticking at the pivot during recording, vibration of the beam is desirable; this is provided by an electric 'buzzer' mounted on the frame close to the pivot (see Plate 1). The battery providing the current is clamped to the rear end of the frame and the system is controlled by a hand-switch.

Two Deflection Beam designs are recommended. In one, the beam is a single unit as shown in Plate 1, in an alternative design, the beam is split into two parts at a point in front of the pivot; this is for greater ease of packing. The split-beam system must be carefully checked when assembled for use in order to eliminate unwanted movement at the joint which would otherwise be reflected in "lost" movement in a measurement of deflection.

It is important to ensure that the adjustable legs that are used to vary the height of the beam do so by screwing the shaft of the legs while maintaining the feet captive. If the feet themselves rotate, rocking of the frame can occur during adjustment which may move the beam out of line with the vehicle. The vehicle may then touch the beam and this can substantially reduce the number of measurements achieved per day.

When in its initial position at the beginning of a deflection test, the test lorry often shades the beam from strong sunlight. Subsequent exposure of the beam as the lorry moves away during the measurement can slightly warp the beam and thus affect the deflection results obtained. To protect the length of beam which has proved to be most susceptible to the effects of these temperature changes, a sunshade is attached to the frame of the Beam to shield the beam on either side of the pivot point: the shades are shown dismounted on Plate 1.

2.2 Calibration of Deflection Beam

To ensure that the dial gauge is operating correctly and that the beam is moving freely it is desirable to calibrate the beam before use. Plate 3 shows a simple calibration rig, supplied by the firms manufacturing the Deflection Beam (see Appendix 1).

A hand-wheel operating through an eccentric bush and hinged bar raises and lowers a horizontal platform which, in use, supports the beam tip under a reference dial-gauge; the arrangement is illustrated in Plate 3. Two operators are required to observe the two dial-gauges for maximum deflection as the hand-wheel is slowly rotated. Different eccentric bushes are available to give a range of beam movement. The vibrator is used during the calibration process. Because of the 1:2 length ratio of the beam about the pivot, the dial-gauge reading on the Deflection Beam needs to be doubled to give the deflection at the beam tip. The mean of not less than 10 consecutive readings on the two dial-gauges is used as the basis for comparison. If satisfactory agreement is not obtained during calibration, the pivot should be cleaned and oiled and if necessary the dial-gauge serviced. If the Deflection Beam is of the split-beam design the tightness of the fixing bolts should be checked.

2.3 The loaded lorry

The 2-axle lorry used for deflection measurements should have a rear axle load of 6350 kg, the load to be equally divided between the twin wheel assemblies at each end of the axle. An open-bodied vehicle, loaded with concrete blocks is satisfactory; it is essential that the load should not shift during testing and for this reason loading with sand or gravel is unacceptable; any vehicle complying with the dimensions and weights given in Table 1 will be suitable. The tyre size should be 7.50 x 20 or 8.25 x 20. The inflation pressure should be 590 kN/m^2 and the spacing between the tyre walls approximately 25mm. If radial tyres or crossply tyres other than those specified are used, the dimensions given in Table 1 should be complied with. In these circumstances it may be necessary to modify the tyre inflation pressure to maintain a contact area similar to that shown in Figure 2.

The lorry should be fitted with adjustable pointers fixed to the chassis on the nearside and offside in line with the rear wheel paths and directed towards a point on the road approximately 1.2m in front of the rear axle. Plate 4 shows a pointer in position. The design and fixing of these pointers will depend on the type of vehicle used. They must be adjustable both vertically and horizontally.

TABLE 1

Details of vehicles suitable for use as a test vehicle in conjunction with the Deflection Beam

Characteristic	Satisfactory range*
Rear axle load	6350 kg ± 10%
Dual rear wheel load	3175 kg ± 10%
Front axle load	Between 2300 and 3300 kg
Wheel base	Nominally 3.85m
Tyre size	8.25 x 20 } Preferred 7.50 x 20 } 9.00 x 20 Acceptable
Tyre pressure	590 kN/m^2 (85 psi)
Minimum gap between walls of twin rear wheels	Not less than 20–30mm
Gap between contact area of twin rear wheels	90–140mm
Contact area of twin rear wheels	Similar to that shown in Figure 2

2.4 Deflection measurements with the Deflection Beam

With the lorry in the initial position, the Deflection Beam in the locked condition is placed with the beam tip over the point of measurement and the beam centrally located between the twin tyres. The alignment is finally adjusted by careful sighting through the tyre gap to ensure that the tyres will not foul the beam when the truck is driven forward at creep speed. When this alignment is completed, the movable pointer is adjusted to be a few millimetres directly above the tip. Subsequent alignment can then be achieved using the pointer. When the beam is in position the lock is released, and with the vibrator running, the dial-gauge reading is set to zero by rotating the scale. At a signal from the operator, the vehicle is driven forward at creep speed to a position where the rear wheels are at least 3m beyond the test point. The speed should be such that the total time required to travel a distance of 5m is 10 ± 1 sec. This speed should be regularly checked against a stop watch. The maximum reading of the dial-gauge is noted together with the final reading after the rear wheels of the truck have reached a point 3m from the beam tip. The magnitude of the pavement deflection is obtained by adding the maximum reading to the difference between the maximum and final readings. (The sum of deflection is not meaned because of the 2:1 ratio of the beam arms.) Plate 5 illustrates a complete measurement cycle.

* Compatibility has been checked only within the ranges indicated. For vehicle characteristics outside these ranges, comparative testing will be necessary to ensure compliance.

Differential thermal expansion within the beam can cause significant errors particularly on stiff pavements. In sunny weather the beam may pass from shade into sunshine as the vehicle moves; the thin metal shield carried by the frame of the beam and covering much of its length (shown on Plate 1) helps to reduce the effect.

If measurements are also required in the offside wheel track the procedure is repeated with the beam transferred to the offside rear wheel assembly of the truck.

Deflection measurements taken with the Deflection Beam are not absolute. On most road pavements the bowl of deflection surrounding the load wheels extends to a radius of greater than about 1.5m. With the load wheels in their initial position, the beam tip and the forward feet of the beam frame are then within the bowl. On strong pavements, particularly those founded on weak subgrades, the rearward feet are also affected and the more lightly loaded front wheels of the lorry may also be influencing the beam tip. The initial reading of the dial-gauge does not therefore normally correspond to that associated with an absolute reference datum. As the load wheels move away from the beam during a deflection measurement, the deflected bowl ceases to influence the feet of the frame and the final reading is taken with the wheels remote from the equipment.

Analysis of the response of the dial-gauge to the combined movements of the beam tip and the feet of the frame brought about by the moving bowl of deflection during a measurement, indicates that measured deflections will be less than absolute values and that the proportion of the absolute value that is measured will also change according to the location of the Deflection Beam in relation to the load wheels in their initial position; care must therefore be taken to position the Beam according to the recommendations.

In some countries 'rebound' deflections are measured by placing the tip of the beam centrally in the gap between the loaded dual wheels. The recovery or rebound deflection is then measured as the lorry is driven forward to a point at least 2m beyond the beam tip. Because of the visco-elastic properties of road materials the rebound deflection depends on the exact procedure used; in particular it is influenced by the length of time during which the load wheels are stationary on the point of measurement. The results obtained can differ considerably from the deflections measured by the method described above[3]. Although simpler in some respects, the rebound procedure is not recommended and should not be used in conjunction with charts of the TRRL method of overlay design.

The French Deflection Beam technique involves reversing the loaded lorry from a point at which the load wheels are approximately 2m in front of the Deflection Beam to a point at which the dual wheels straddle the tip of the beam and are 0.5m behind it. The vehicle is then driven forward to its original position. This technique will also produce a deflection value which is different from that obtained using the recommended procedure. It should not be used therefore with the TRRL method for overlay design.

3. THE DEFLECTOGRAPH

3.1 Details of the Deflectograph

The Deflectograph consists essentially of two automated Deflection Beams, one operating with each pair of loaded dual rear wheels of a two axle lorry. The beam mechanisms are mounted on a common frame to form the beam assembly located directly beneath the lorry and deflections are measured as the rear wheels approach the tips of the beams, which during this period are at rest in contact with the road surface. After the maximum deflection has been recorded by electrical transducers located near the beam pivots, the beam assembly is pulled forward at approximately twice the speed of the vehicle by an electromagnetic clutch and winch system, to the initial position appropriate for the next cycle. An arrangement of guides ensures that the beams are 'aimed' at the centre of the space between the rear twin tyres, even when the vehicle is negotiating bends.

The working speed of the Deflectograph is about 2 km/h and the points of measurement are about 4m apart on the road.

The Deflectograph was developed in France by the Laboratoire Central des Ponts et Chaussées (LCPC); the first prototype machine was built in 1956[4]. By the late 1960s it was in general use in France monitoring the structural condition of the road network on a comparative basis[5]. It is currently manufactured by MAP SA of Basle, Switzerland, and a version is also manufactured by WDM Ltd, Bristol (see Appendix 1).

The Laboratory purchased a Deflectograph from LCPC in Paris during 1967 for evaluation. Extensive modification was required to make the machine suitable for use in the United Kingdom.

In 1970 the Laboratory purchased a second machine from LCPC to a modified format based on the early evaluation studies. This modified machine, Plate 6, is standard for use in the United Kingdom and the Laboratory's first machine has been modified to conform with its specifications.

Both the machines use a Berliet GLM 12 M3 chassis. Machines imported into the country since 1971 are based on a Berliet GLR 160L chassis. The United Kingdom version of the Deflectograph produced by WDM Ltd uses a Mercedes 16/17 chassis.

3.2 The vehicle

The essential dimensions of the wheel arrangements of the above types of chassis and details of suitable tyres are given in Figure 3 together with the working range over which dimensions and tyre pressures may be varied so as not to cause a significant variation in measured deflection level. Alternative specifications will be satisfactory if it can be shown that measured deflections obtained are compatible with measured deflections from the Berliet GLM 12M3 configuration.

The standard rear-axle loading is provided by concrete blocks fixed in the open portion of the vehicle. This area can also be used to carry signs and cones for use with the Deflectograph but these must be removed before testing commences.

3.3 Beam assembly

The beam assembly is located by a tubular-steel steering frame and guides to ensure that the deflection beams pass safely between the rear twin tyres without fouling the wheels. Whilst in motion, the beam assembly is guided by a vertical roller on the centreline at the front of the T-frame (Plate 7) into the neck of the steering frame, whilst the rear of the T-frame is located by a pair of guides, which are retractable upwards about the vehicle centreline. The steering frame is pivoted near the rear axle and is positioned transversely by a chain system connected to the drop-arm of the vehicle steering system. This enables the vehicle to negotiate bends and roundabouts with automatic alignment of the beams.

When the vehicle is travelling at normal road speed and is not recording, the steering connection is isolated by the removal of a pin and locking screw and the beam assembly is raised from the road. The beam assembly and steering frame are raised so that three suspension hooks, fixed rigidly to the chassis, engage with the towing lugs fixed in front of the measuring heads and with one of the cross members at the rear of the T-frame. During this process the front pin on the steering frame disengages from the steering chain to allow lateral movement of the beam assembly to prevent fouling with the vehicle transmission. To permit this lateral movement, the rear guides must be retracted upwards. To prevent strain in the beams when the assembly is in the raised position, cables fixed to the chassis are engaged by hooks to the beam tips.

Various alternative forms of the beam assembly have been used by the Laboratoire Central des Ponts et Chaussees and by MAP SA. The chief variation has been to transfer the third support point from the rearward position shown in Plate 7 to a forward position by moving the stalk of the T to the forward-facing side of the transverse bridge supporting the beams. The principal dimensions of the beam assembly used in the United Kingdom are shown in Figure 4; it utilises a rearward-facing T-beam assembly.

3.4 Deflection measurements with the Deflectograph

The cycle of operation is illustrated in Figure 5; this shows the relative positions of the loaded wheels and the measuring arms at the beginning and end of the measurement sequence.

At the start of the measuring cycle the dual rear wheels are in position A and the measuring-beam assembly is stationary. The tips of the measuring arms are then at a position approximately 1100mm ahead of the centreline of the rear axle. To connect the beam arm extension to the transducer core, a solenoid is energised; this causes two anvils to grip the vertical spring shown in Plate 8. The tips of the measurement arms are, by then, approximately 990mm in front of the centreline of the rear axle and it is from this point, B in Figure 5, that the measurement of deflection begins. As the rear wheels continue to move towards the measuring arms, the road surface at point C senses the bowl of deflection moving forward with the wheel. This downward movement is detected by the measuring arm and is transferred to the measurement transducer via the extension arm and the clamping solenoid in the recording track (see Plate 8). When the centreline of the rear wheels has reached a point D, 230 mm in front of the tip of the measurement arms, the clamping solenoids are de-energised; this allows the transducer armature and vertical spring to fall back to their rest position.

An electromagnetic clutch is then engaged to draw the beam assembly forwards at approximately twice the speed of the vehicle, to the starting position for the next cycle; the measurement frame comes to rest and the cycle of operation is repeated.

The deflection measured by the Deflectograph is recorded relative to the datum provided by the T-frame. Consideration of the layout of the Deflectograph assembly given in Figure 4 indicates that all the supports of the T-frame will be affected by the loaded wheels during the measuring cycle and that the front wheels will play a greater part in influencing the measured values of deflection than is the case with the operation of the Deflection Beam.

An analysis of the response of the Deflectograph to deflection bowls of known shape and size indicates that measured deflections will always be less than absolute values and that they will normally be less than those measured with the Deflection Beam.

The forward-facing T-frame adopted in France will radically alter the influence of the front wheels of the lorry on measured deflections and hence on the relation between deflections measured with the Deflectograph and Deflection Beam.

These considerations emphasise the importance of standardising both the frame layout and its position at the start and finish of the measurement cycle in obtaining deflections that are suitable for use in conjunction with a design method.

3.5 Deflection recording

The displacement transducer output is fed, after demodulation and amplification, to a graphical recorder. The most common recorder in use is a Siemens pen recorder modified by MAP SA for use in the Deflectograph, shown in Plate 9. Galvanometer recorders are used satisfactorily on some of the earlier Deflectograph models and the WDM design incorporates a hot-wire recorder.

To enable readings to be presented in directly readable form, or for use in data-processing, electronic equipment is available which presents the results both in tabulated printed format and on 8-hole paper-tape for direct computer access. The equipment is described briefly in Appendix 1.

3.6 Calibration

Calibration entails relating the movement of the beam tip to the associated chart movement and digital output. The simple calibration device shown in Plate 10 can be used. The beam assembly is positioned so that the beam tips are sufficiently forward of the rear wheels of the lorry to allow the calibration device to be placed under the beam as shown in the Plate; for simplicity Plate 10 shows the beam assembly removed from the lorry.

With the electrical equipment switched on and the various switches on the control panel set manually to the operating condition, the micrometer screw of the calibrator is wound upwards for several turns and then turned back for a fraction of a turn to take up backlash in its screw thread. The beam tip is lowered in equal increments, as indicated by the dial-gauge, until full-scale deflection is achieved on the chart recorder. The size of the increments should allow at least five steps to be used for each sensitivity range. Recommended maximum increments are given in Table 2.

TABLE 2

Recommended maximum deflection increments for the calibration of a chart recorder

Approximate beam movement for chart recorder full-scale movement mm x 10^{-2}	Incremental step size mm x 10^{-2}
200	25
100	20
50	10

For digital equipment the incremental step size used should be no greater than 20 x 10^{-2}mm.

Separate calibrations are necessary for the nearside and offside beams. The six individual calibrations thus obtained represent one calibration set. The height of the chart recorder trace or digital output, which is produced by a given beam movement during a series of calibrations can vary by up to ± 8 per cent of its mean value. This variation in calibration value is primarily the result of employing a mechanical system for monitoring very small displacements and not variation in the response of the system. Individual calibration values used for the interpretation of data should, therefore, be the mean of at least ten determinations; these ten calibration values should form part of at least ten calibration sets determined prior to the commencement of a testing programme. These sets of data should not be obtained by moving the beam tip up and down repeatedly; some attempt should be made to represent the variation likely to occur in the survey period. Because the greatest source of variation arises from the actual setting-up procedure this should be repeated between each successive calibration set. Ideally the calibration should be repeated on several successive days. During the period of the testing programme, one calibration set should be made daily. When the calibration proves to be unsatisfactory the subsequent procedures to be adopted are described in Appendix 1 of LR 835[6].

In addition to mean calibration values for each of the increment steps input, the pre-survey calibration data can be used to produce control or action limits about the means, within which subsequent increment step calibration values would be expected to lie, if no change in calibration occurs. The procedure is described in Appendix 1 of LR 835.

4. OTHER METHODS OF MEASURING PAVEMENT DEFLECTION

The recognition of deflection as a valuable indicator of pavement performance has led to the development of a number of types of equipment which can measure reproducibly, and relatively rapidly, displacements which are related in different ways to the absolute deflection of the road under a rolling wheel. The Deflection Beam and Deflectograph are two generally similar devices which use a rolling wheel load. A number of other types of equipment which apply a pulsed load, either singly or repeatedly, are described elsewhere[7].

The TRRL design method for overlay design is empirical and is based on measurements which are related to absolute deflection in a manner which is specific both to the measuring equipment and also to the way in which it is used. Input from other types of measuring equipment cannot therefore be made directly. In principle, cross-correlation between the results of different types of equipment is possible but the wide range of factors influencing the result makes authoritative correlation in a practical form either difficult or impossible.

5. ANCILLARY EQUIPMENT

5.1 Temperature measurement

Because deflection is affected by pavement temperature, the latter must be measured at frequent intervals during a survey. The measurement is made at a depth of 40mm using a stirring thermometer 150 mm in length and having a temperature range of 0 to 50°C. A percussion-type masonry drill 7 mm in diameter is used to make a hole to the appropriate depth (about 45mm to allow for the length of the thermometer bulb); this is filled with glycerol before the thermometer is inserted. As an alternative to the thermometer any direct reading thermistor or thermocouple device with a resolution to 0.5°C is suitable. All measurement devices should be checked frequently against readings given by a standard thermometer.

5.2 Pavement condition

In order to assess the permanent deformation at the time deflection measurements are made, a 2m straightedge should be used in conjunction with a graduated wedge.

Access to coring equipment will be desirable in order to obtain information about the pavement on those lengths of road for which construction data are not available.

6. ACKNOWLEDGEMENTS

The work described in this report was carried out in the Pavement Design Division (Head of Division: Mr N W Lister) of the Highways Department of TRRL.

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Dimensions	Metres	Feet	Dimensions	Metres	Feet
a	2.44	8	d	0.92	3
b	1.22	4	e	0.61	2
c	0.30	1	f	1.30	4.25

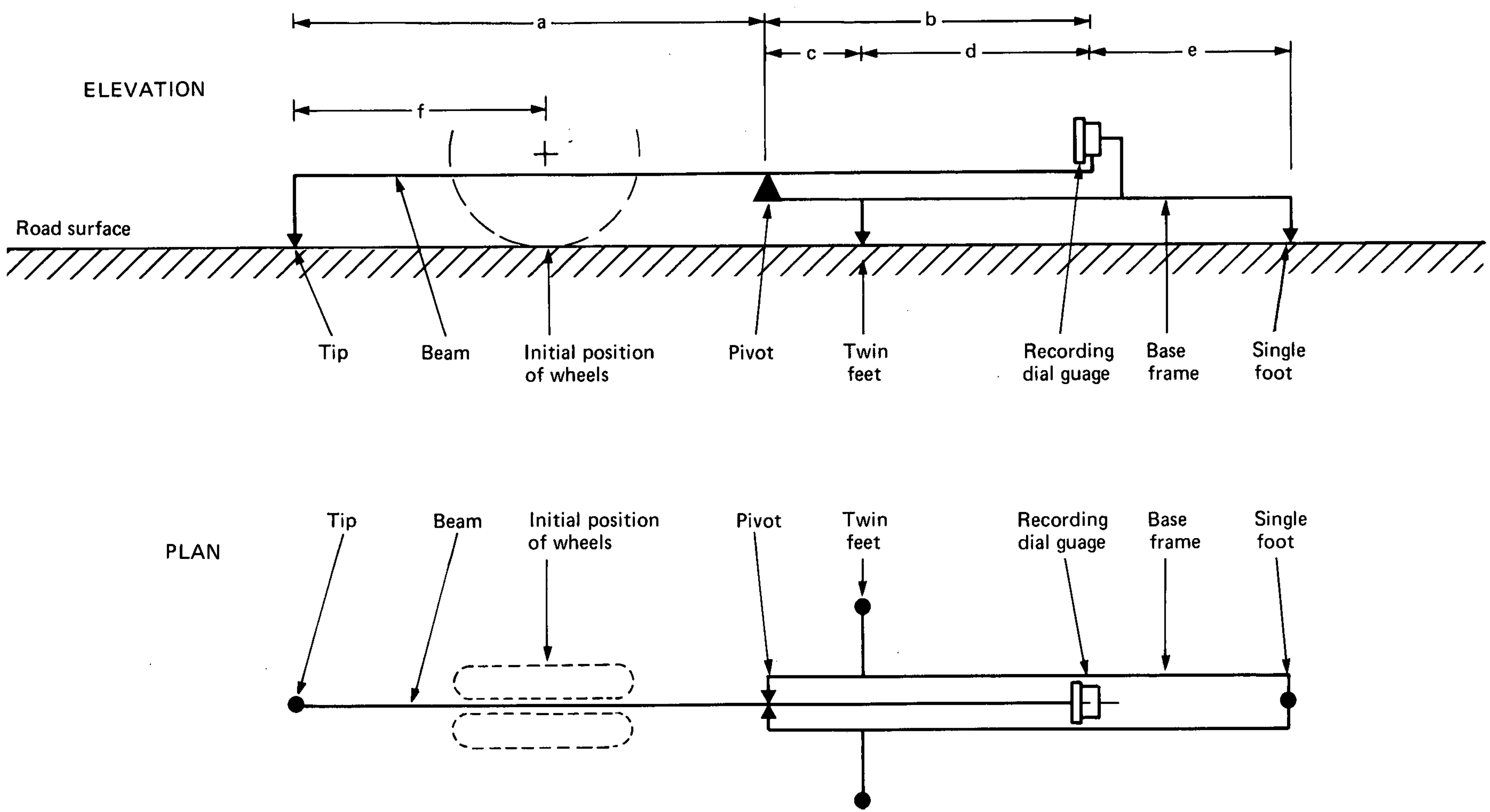
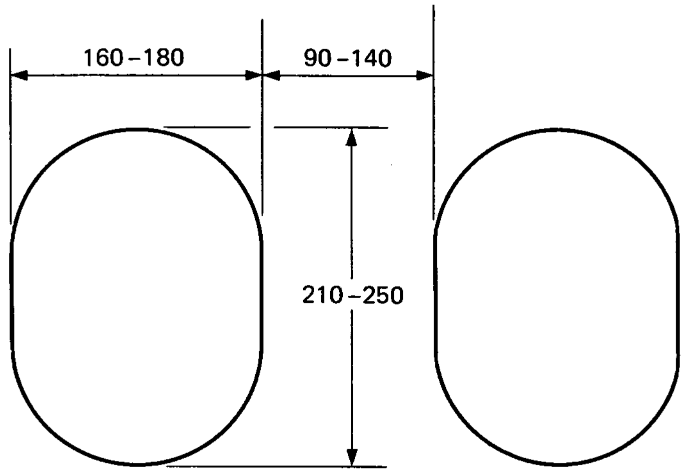
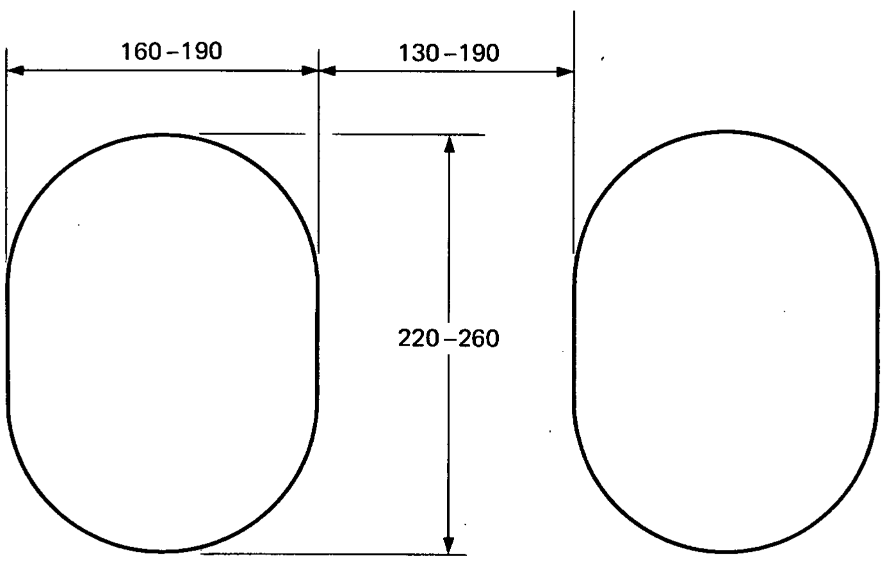


Fig. 1 DIAGRAMMATIC REPRESENTATION OF THE DEFLECTION BEAM



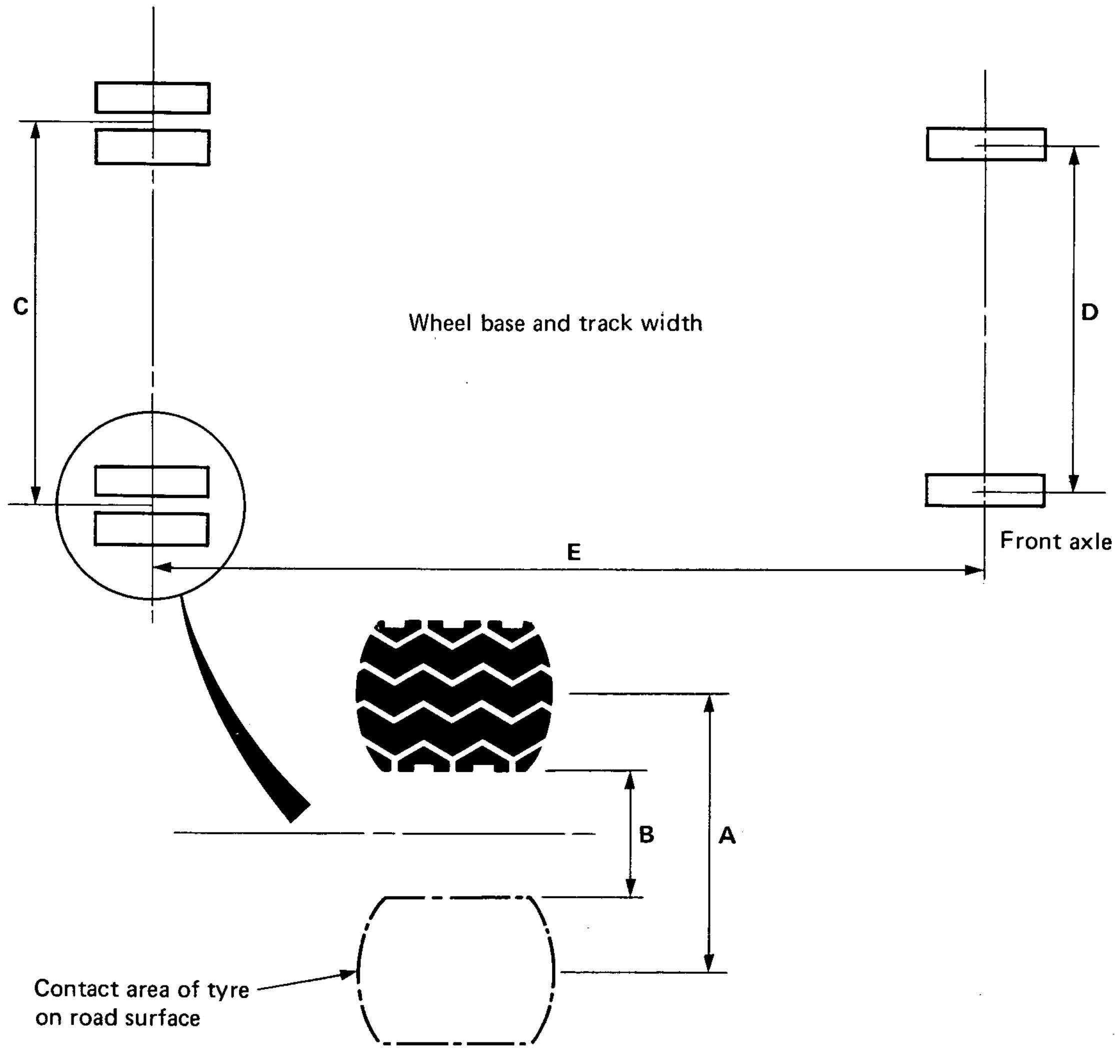
DEFLECTION BEAM TYRE PRINT



DEFLECTOGRAPH TYRE PRINT

(Dimensions in mm)

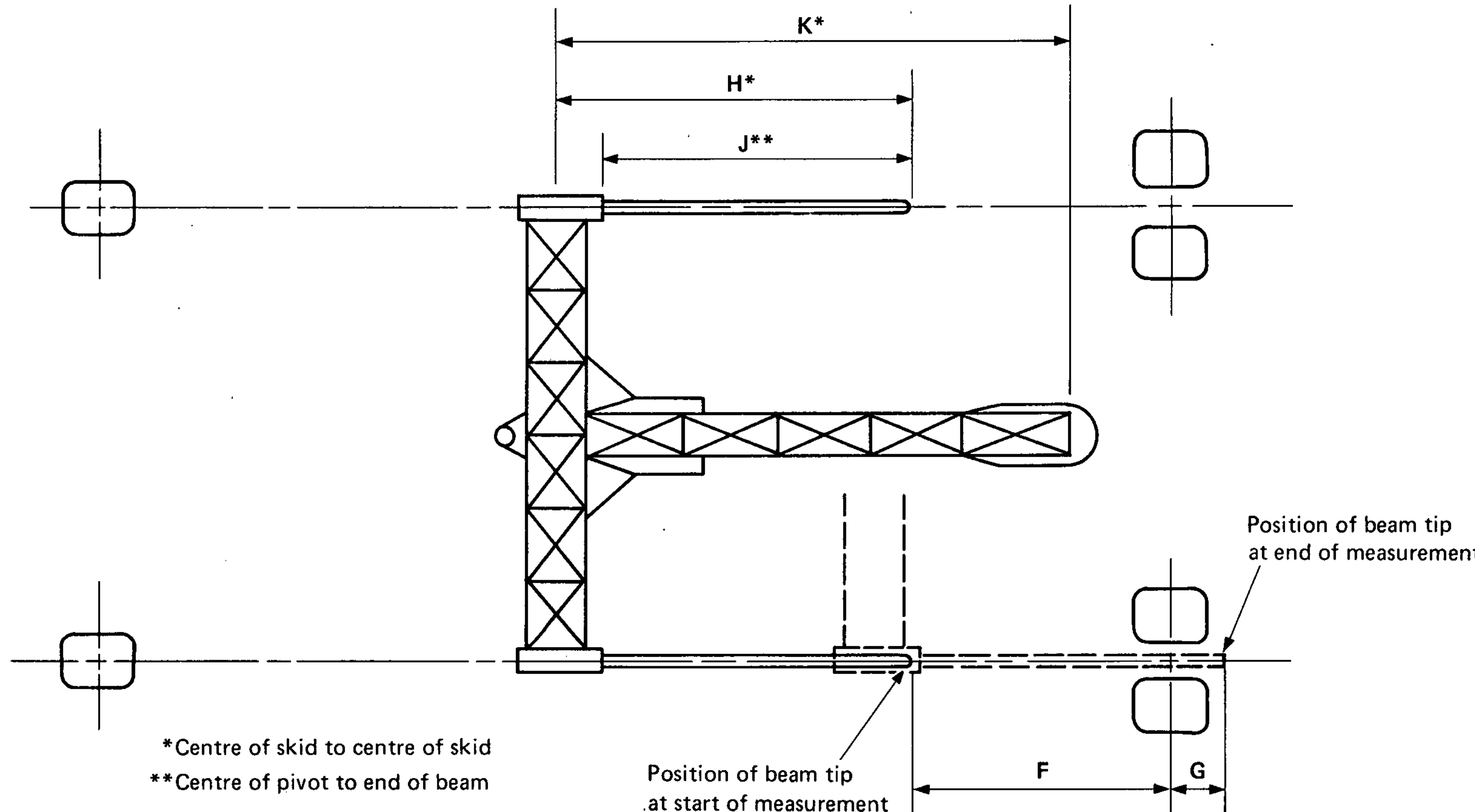
Fig. 2 RANGE OF TYRE CONTACT DIMENSIONS OF THE DEFLECTION BEAM AND DEFLECTOGRAPH



Dimensions and tyre contact area on one pair of rear wheels

Detail	Satisfactory range
Dimension A	290–380mm
Dimension B	130–190mm
Dimension C	1830–1875mm
Dimension D	1980–2013mm
Dimension E	4445–4510mm
Front axle load	4500kg ± 5%
Rear axle load	6350kg ± 10%
Twin rear wheel load	3175kg ± 10%
Tyres	12.00 X 20
Tyre pressure	690kN/m^2 (100psi)

Fig. 3 ESSENTIAL CHASSIS DETAILS FOR DEFLECTOGRAPH VEHICLES



*Centre of skid to centre of skid
**Centre of pivot to end of beam

Dimension	Satisfactory range (mm)
F	990 ± 20
G	220–230
H	1530 ± 5
J	1400 ± 1
K	2130 ± 5

Fig. 4 DIAGRAMMATIC REPRESENTATION OF DEFLECTOGRAPH

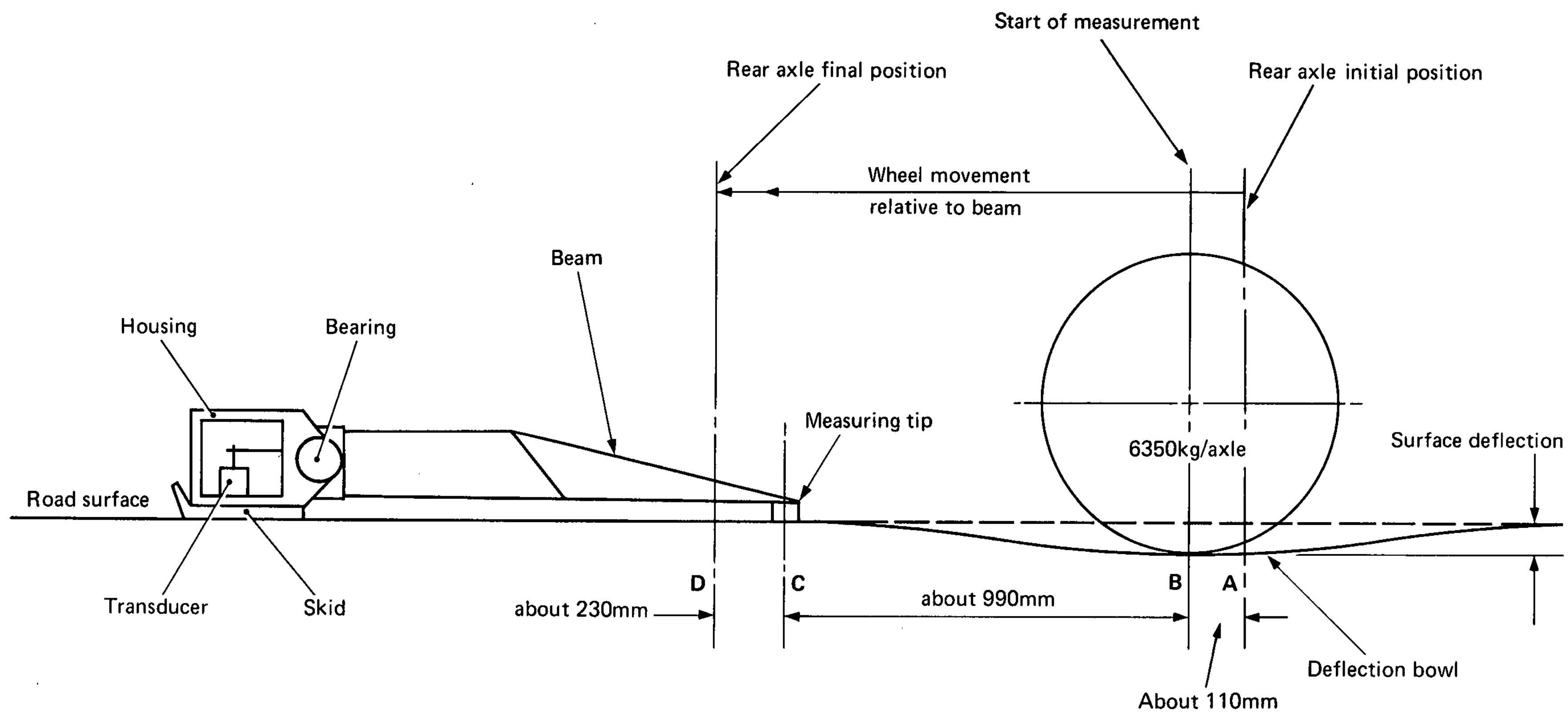
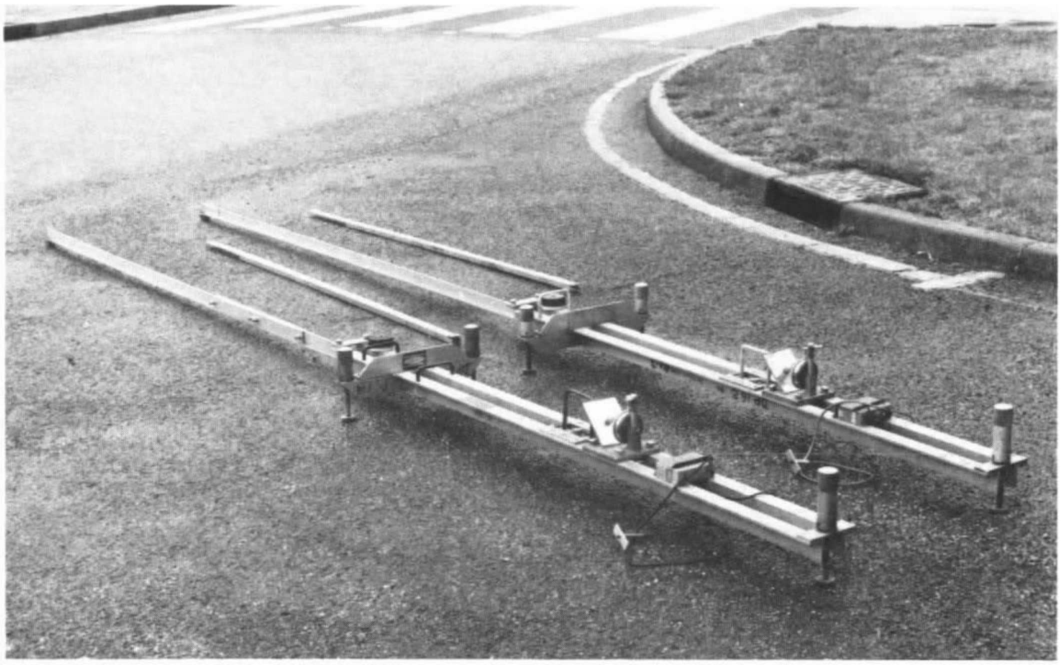


Fig. 5 CYCLE OF OPERATION (DIAGRAMMATIC)



Neg. no. R1478/77/7

Plate 1 TWO MODELS OF THE DEFLECTION BEAM
(THE SPLIT BEAM STANDS ON THE LEFT)

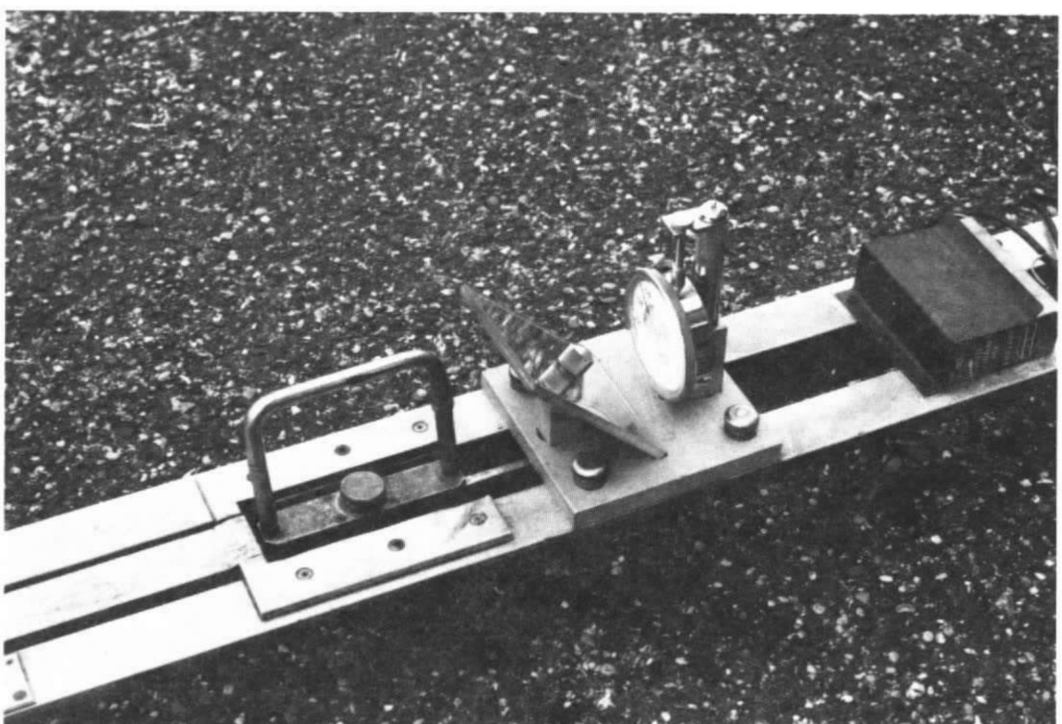


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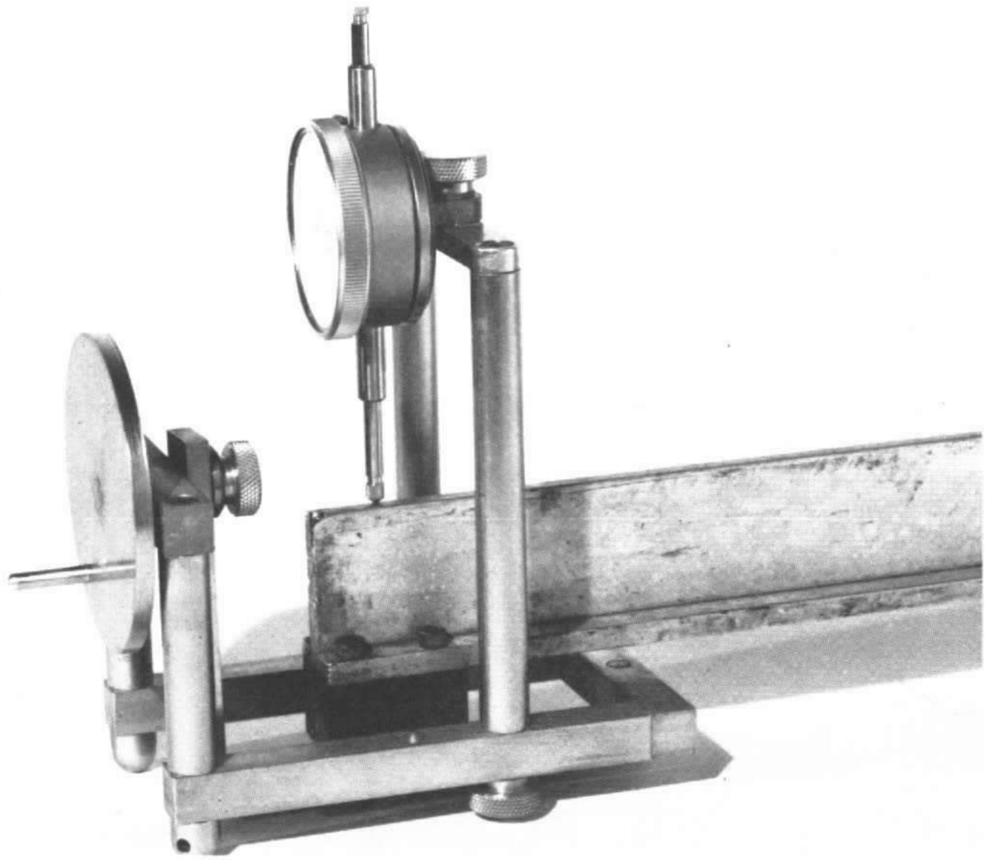
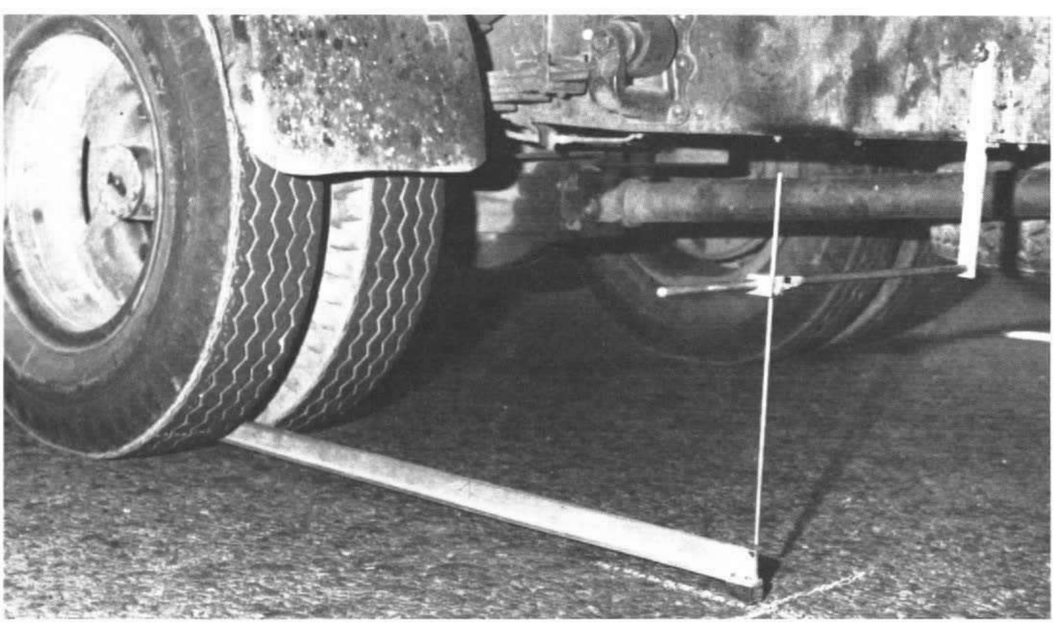
Plate 2 CLOSE UP VIEW OF MIRROR AND DIAL GAUGE



Neg. no. B3270/70

Plate 3 TIP OF DEFLECTION BEAM IN POSITION ON PLATFORM OF CALIBRATOR



Neg. no. R1340/77/8

Plate 4 DEFLECTION BEAM TRUCK FITTED WITH ADJUSTABLE POINTER

Neg. no. R1340/77/2

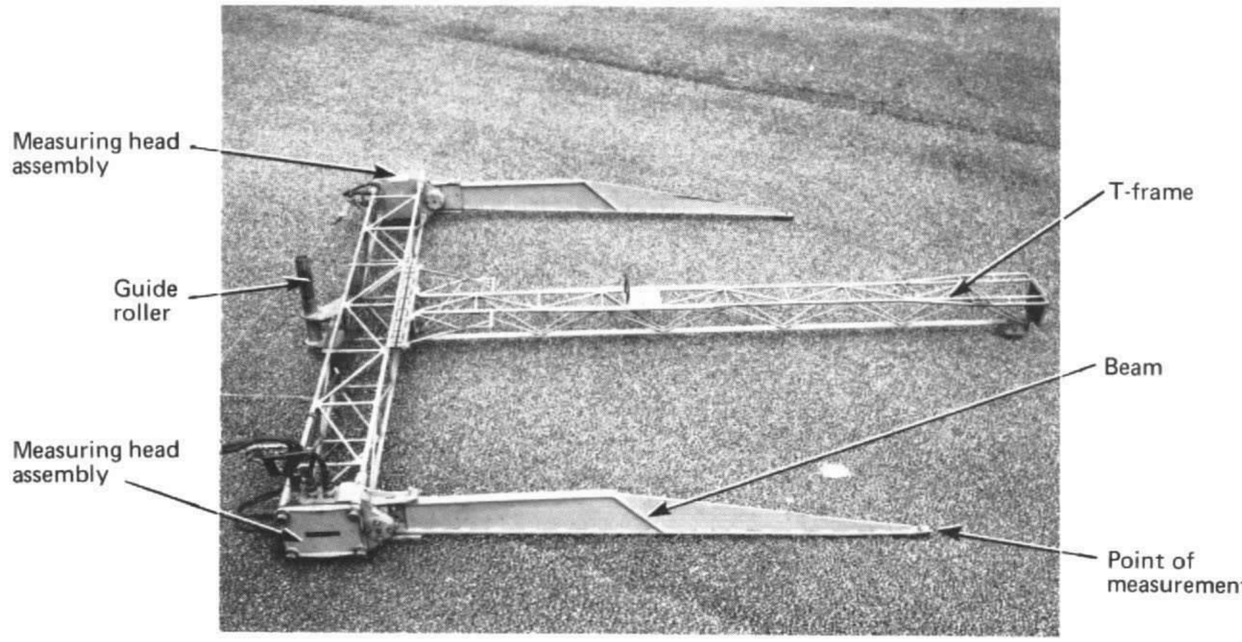
Neg. no. R1340/77/3

Neg. no. R1340/77/4

Plate 5 DEFLECTION BEAM – TEST SEQUENCE

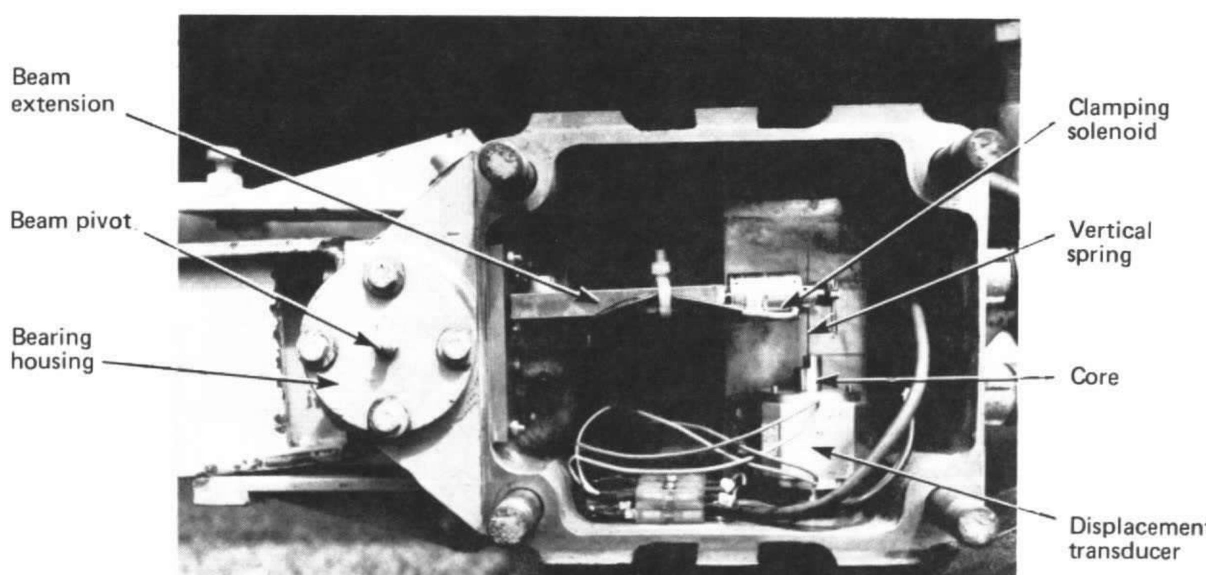
Neg. no. B1085/72

Plate 6 THE DEFLECTOGRAPH



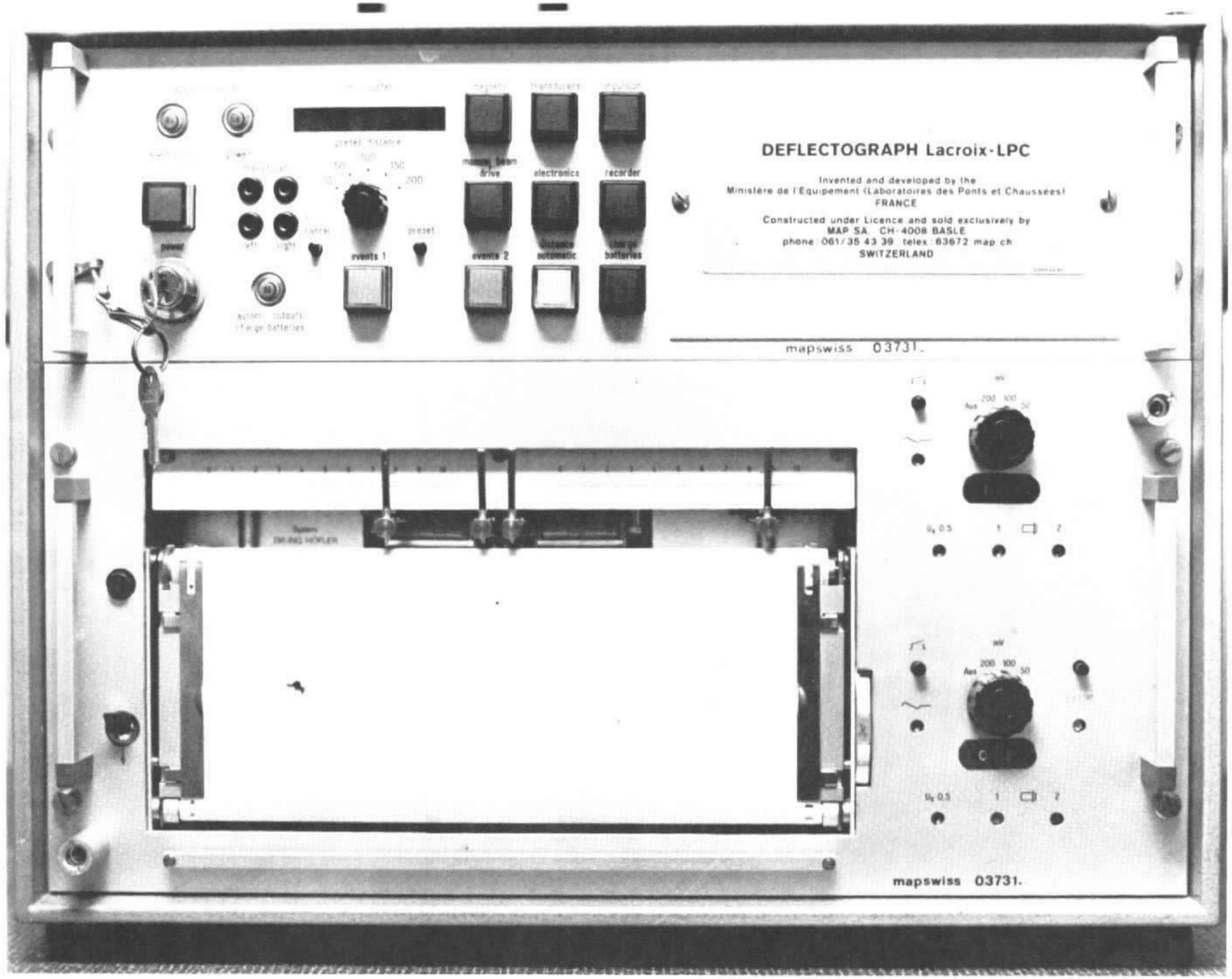
Neg. no. B3150/71

Plate 7 DEFLECTOGRAPH – BEAM ASSEMBLY



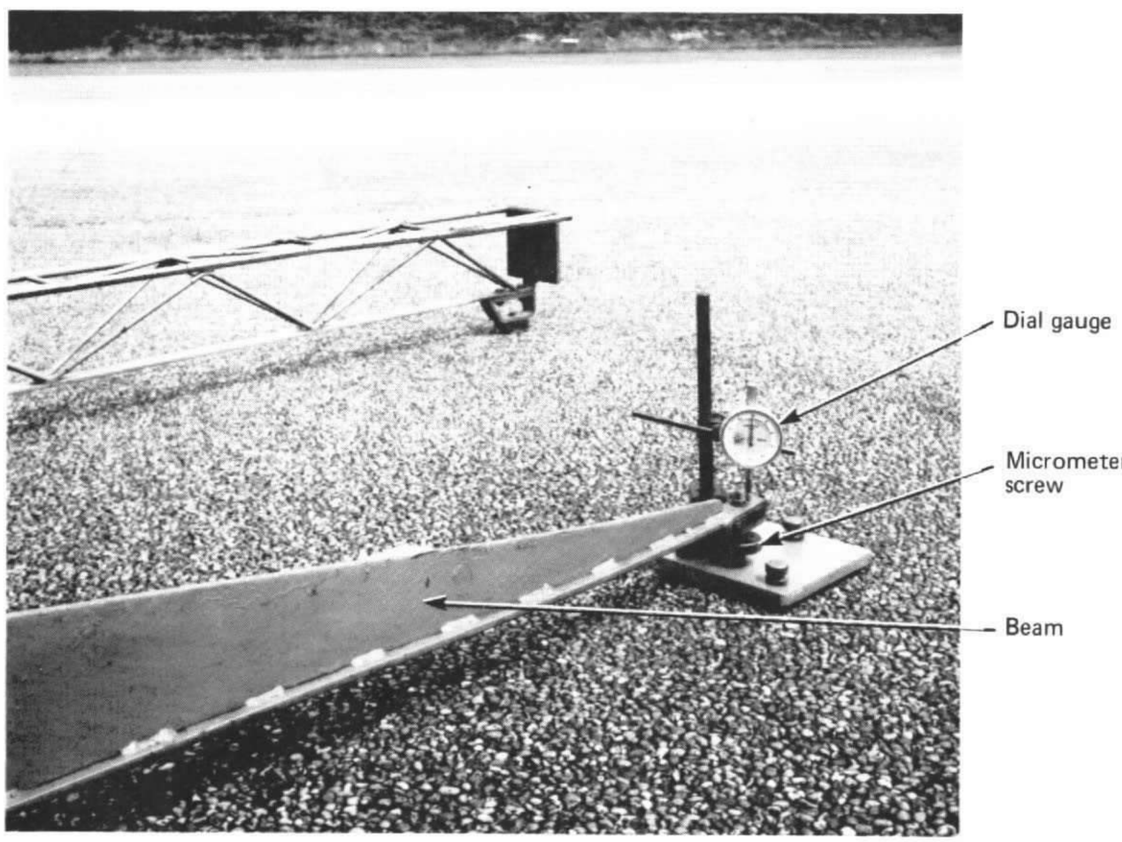
Neg. no. R3153/71/8

Plate 8 DEFLECTOGRAPH – RECORDING HEAD



Neg. no. R2071/73/2

Plate 9 MAP MH100 RECORDER



Neg. no. B3149/71

Plate 10 DEFLECTOGRAPH – TYPICAL CALIBRATION DEVICE

8. APPENDIX 1

SUPPLIERS OF DEFLECTION EQUIPMENT

Deflection Beam and Calibrator:

Leonard Farnell and Co Ltd
North Mymms
HATFIELD
Herts

Deflectograph and Calibrator:

MAP SA
Solothurnerstrasse 45
BASLE
Switzerland

Letters:

P O Box 4008
BASLE
Switzerland

Sole UK sales & service agents:

WDM Ltd
Western Works
Staple Hill
BRISTOL BS16 4NX

Deflectograph digital recording equipment:

WDM Ltd Western Works Staple Hill BRISTOL BS16 4NX	Equipment:	Hot-wire recorder Paper-tape punch
RAPCO Electronics Ltd 10 Joule Road Houndmills Nth BASINGSTOKE Hants	Equipment:	Compatible with any of the standard Deflectograph Chart Recorders Drum Printer Paper-tape punch

Thermometer for measuring pavement temperature (Catalogue No. P10683):

Scientific Supplies Co Ltd
Scientific House
Vine Hill
LONDON EC1

(546) Dd443233 1,600 4/78 HPLtd So'ton G1915
PRINTED IN ENGLAND

ABSTRACT

Pavement deflection: equipment for measurement in the United Kingdom: C K KENNEDY, P FEVRE and C S CLARKE: Department of the Environment Department of Transport, TRRL Laboratory Report 834: Crowthorne, 1978 (Transport and Road Research Laboratory). Significant relationships have been established between the deflection of roads measured under a standard rolling wheel load moving at creep speed and their structural performance under traffic. This research is described in LR 832 and provides the basis for the prediction of the unexpired lives of pavements and for the design of bituminous overlays.

Essential to the research studies and to the implementation of a design system for strengthening pavements is a convenient and reproducible method of deflection measurement. The report describes the Deflection Beam, which was used in the original studies, and its standardised method of operation in the United Kingdom.

The Lacroix Deflectograph, an automatic technique of measuring deflections under a rolling wheel, is suitable for carrying out deflection surveys on long lengths of road. The machine as modified for use in the United Kingdom is described together with details of ancillary equipment required for carrying out deflection surveys.

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