Design of a dynamic weighbridge for recording vehicle wheel loads

by

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# CONTENTS

<table>
<thead>
<tr>
<th>Abstract</th>
<th>1. Introduction</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. The Problems of Recording Wheel-Loads</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3. Design of the Weighbridge Platforms Load Cells and Recording Equipment</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4. Vehicles with Heavy Wheel-Loads</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>5. References</td>
<td>10</td>
</tr>
</tbody>
</table>

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Design of a dynamic weighbridge for recording vehicle wheel loads

ABSTRACT

A description is given of the apparatus developed at the Road Research Laboratory for weighing the axle loads carried by traffic travelling along roads at normal speeds, classifying the loads into various preselected weight groups, and counting the number in each group. The design of the weighbridge platform is discussed in detail.

When the apparatus was used at some of the Laboratory’s full-scale experimental road sites a number of axle loads exceeding 24,000 lb, were measured. Ancillary equipment was therefore developed for recording the speeds of these heavy vehicles and photographing them in order to see whether they were of normal type or specially constructed to carry extra heavy loads.

1. INTRODUCTION

Information is required on the wheel-loads of the vehicles using British roads for the following purposes:

1. to design road structures to carry given traffic,
2. to design bridges and flyovers,
3. to study trends in traffic loading,
4. to investigate impact loading by vehicle wheels in relation to the surface profile of the road,
5. to study the effectiveness of the regulations governing axle loads.

The first dynamic weighbridge for measuring the axle loads of moving vehicles was developed in the U.S.A. about 1952. Other forms of platform have since been produced, notably in Germany and Sweden, and more advanced designs were also developed in the U.S.A. A programme of research on the problems of weighing vehicles in motion and the relative merits of various types of platform has been carried out at the University of Kentucky.

The first experimental dynamic weighbridge developed by the Road Research Laboratory was put into use in 1958, and the present, improved, version was developed in 1963. A brief description of this apparatus, with some results, was published in 1965. The present paper is intended
to describe the apparatus and its recording system in greater detail, together with a discussion of
the principle involved in the design of a platform for weighing moving vehicles.

2. THE PROBLEM OF RECORDING THE WHEEL-LOADS

2.1 Dynamic loading by moving vehicles

The dynamic loading produced by the passage of the wheels of a moving vehicle along a road
surface is being investigated at the Road Research Laboratory, using both analogue and digital
computer simulations of a simplified model of the suspension system of a 2-axle vehicle\(^{10,11}\) (Fig 1),
and field tests have been carried out with both loaded and unloaded vehicles \(^{12,13}\). Results so
far indicate that variations of dynamic load are governed mainly by the surface irregularity and by
the tyre stiffness,\(^{14}\) so that the percentage variation of load is generally greater for a lightly-
loaded vehicle than for a heavily-laden one. Recent developments on the digital computer
programme\(^{11}\) enable the road profile to be analysed at a proposed weighbridge site, and the varia-
tion of dynamic loading to be computed for a simulated vehicle.

A position in the roadway for the weighbridge can then be selected where the dynamic loading
effects are at a minimum. Then, provided the weighbridge platform is installed flush with the
road surface and is used with an electronic recording system of adequate frequency response the
loads recorded from vehicles will approximate to the static wheel loads.

Experience on a number of sites, and tests with Laboratory vehicles of known static wheel
loads, indicate that under good conditions, loads recorded will be within ± 10% of the static wheel
loads, over a wide range of vehicle speeds.

2.2 Weighbridge platform dimensions

Dynamic weighbridges are, in most cases, basically rigid platforms carried on electrical
load-sensing devices (usually load cells containing resistance strain gauges) and set in the roadway
so that the platform is flush with the surface.

The platform dimensions must be chosen from the point of view of the following considerations:

(a) The width (i.e. in the direction of vehicle motion) must be such that the largest tyre
passing over it can be completely supported by it. This point is illustrated in Fig. 2.
If the weighbridge is too narrow, the full wheel load will never be exerted on the
platform, as part of it will be carried by the surround.

(b) The length of the platform (i.e. transverse to the roadway) will depend upon whether the
intention is to record complete axle loads, or those carried by the wheel or pair of
wheels at one end of the axle. In the former case, the total width of the traffic lane
must be spanned, but for recording nearside wheel loads, it is possible to place the
platform in such a position that the majority of the wheels travelling along the near-
side wheel track pass over it. Fig. 3 shows the two possible arrangements, and indi-
cate errors which may occur in either case.

(c) The need for maximum rigidity in the structure of the platform.
Experience has shown that the rapid passage of vehicle wheels over a non-rigid platform can cause it to resonate at its natural frequency, which produces spurious signals from the load cells. These are superimposed on the pulses produced by the wheel loads.

These considerations have led to the use of a platform installation 2 ft (0.60 m) wide by 6 ft (1.8 m) in length. Initially the practice was adopted of installing it in the left hand ('slow') lane with its centre line at 4 ft (1.2 m) from the road edge, since earlier studies had indicated that the mean tracking distance of vehicle nearside wheels from the kerb had this value. Later experience has suggested that this value may be modified somewhat near road junctions. The alternative of making the platform span the whole lane, to record axle loads, was rejected on grounds of cost and the size of the installation necessary.

The errors introduced by the type of axle configuration shown in Fig. 3 (b) have proved to be very small on most sites. The use of an automatic camera in association with the weighbridge, has enabled some estimate to be made of this type of error.

The decision to record nearside wheel loads in the 'slow' lane is justified on the grounds that maximum deformation of the roadway tends to occur in this lane, which is used by the majority of heavy commercial vehicles. The errors introduced by the type of axle configuration shown in Fig. 3 (b) have proved to be very small on most sites. The use of an automatic camera in association with the weighbridge, has enabled some estimate to be made of this type of error.

3. DESIGN OF THE WEIGHBRIDGE PLATFORMS
LOAD CELLS AND RECORDING EQUIPMENT

3.1 Early design

The original platform, put into use in 1958 was 6 ft by 2 ft (0.6 by 1.8 m) of steel construction and weighed about 1000 lb (453 Kg). It was supported at the corners by four load cells. Its main disadvantages were its excessive weight, necessitating the use of a crane to lift it into its pit, the difficulty of servicing the load cells, cabling, etc. which had to be carried out in the pit, and the lack of rigidity.

3.2 Present system

The revised form of weighbridge at present in use by the Road Research Laboratory was introduced in 1963, and uses three portable platform modules each 2 ft (0.6 m) square and forming a self-contained weighbridge. The module can be assembled, calibrated and tested in the laboratory, and installed at a site by only two men, without lifting equipment. Its main advantages over the
older system are ease of installation and maintenance, since faulty units can be returned to the laboratory, and much greater rigidity over the 2 ft (0.6 m) span than the steel platform.

The modules are usually installed in groups of three, to give a length of 6 ft (1.8 m) but any number can be used to give any required length of weighbridge, in increments of 2 ft (0.6 m).

3.3 Mechanical design of platform modules

The platform modules were designed to meet the following requirements:

(a) Capable of being lifted by two men i.e. to weigh not more than 250 lb each.
(b) Ease and cheapness of manufacture and servicing.
(c) Rigidity.
(d) Resistance to wear by traffic coupled with a non-skid surface.

The material used for the castings is Hiduminium, an aluminium alloy, which is light, non-corrosive, and does not require painting. Each module consists of two castings, the upper unit constituting the platform, which is formed with a box section, for rigidity, and a lower unit which is deliberately made to be less rigid than the platform. A checkered pattern is provided on the top surface of the platform, to give non-skid characteristics. Plate 1 shows the assembly of the module.

Steel inserts are provided in the corners as seatings for the four load cells which carry the upper platform, one of these being adjustable, to ensure that the load is carried equally on all four load cells. Fig. 4 shows a load cell held between the upper and lower ball seating.

The top and bottom castings are held together by four bolts carrying compression springs of about 1600 lb/in (2800 N/cm) rate, whose function is to provide a pre-load on the load cells and to increase the lateral stability of the unit.

The lower casting is made fairly weak, so that it can distort slightly when bolted down, to accommodate any lack of alignment in the bottom of the pit.

All machining operations are as simple as possible, requiring only readily available machine tools i.e. power drill and lathe. No components require precision fits or tolerance. A single jig plate is used to drill each casting for load cell seatings, spring-loaded bolts, etc, so that all units are interchangeable.

3.4 Construction of pit and steel frame

For locating the modules in the roadway, a pit is constructed into which is fitted a steel frame. The frame is fabricated from standard RSJ sections welded together to a tolerance of ± 1/16 in (± 1.6 mm). Studs for holding down the modules and located in the frame using the jig used for machining the castings. The frame is cast into a reinforced concrete block, with the upper flanges flush with the road surface. Plate 2 shows the pit, with the frame in position, and the studs for locating the platforms. Ducts for carrying the cables from the load cells and for drainage are introduced at the end of the pit nearest to the kerb. Details of these depend upon individual site condi-
tions, care being taken that no standing water collects in the cable ducts.

3.5 Dummy platforms

Since the weighbridge platform modules are easily installed in, and removed from, the pit, dummy platforms, constructed simply from steel joists and plate are normally bolted down into the pit, in order to fill it, until measurements are required on the site. The dummy platforms are then removed and replaced by weighbridge modules. This technique has the advantage that the weighbridge load-cells are only exposed to moisture and dirt in the roadway while measurements are actually in progress. Plate 3 shows a dummy platform unit.

The process of installing a set of three modules is shown in Plates 4 - 6. In Plate 4 the platform module is shown being dropped into position on the holding studs in the pit. Plate 5 shows the tightening of the nuts after the modules have been positioned, and in Plate 6 a final adjustment is being made to the adjustable load-cell seating at one corner of a platform, to remove any tendency for the platform to rock, and thus ensure that all the four load cells are carrying a share of the load.

3.6 Design of load cells

The four load cells supporting each platform consist of square-section steel pillars, each carrying four 120 ohm foil strain gauges, two cemented longitudinally and two transversely to the pillar, and hardened end-caps are inserted. The pillar is bored out to give the required cross-sectional area. Figs. 5 and 6 give details of the pillar and end caps, which are shown assembled in Fig. 4, and Fig. 7(a) shows the arrangement of the strain gauges.

The cross-sectional area of one load cell is about 0.55 sq. in (9 sq.cm) giving a total of 2.2 sq. in for the four load cells carrying the platform. Assuming a maximum load of 20,000 lb F, this would produce a stress of $\frac{20,000}{2.2}$ lbF/in$^2$ (62.6 x $10^6$ N/m$^2$).

Assuming the elastic modulus of steel to be $30 \times 10^6$ lbF/in$^2$ ($2.07 \times 10^{11}$ N/m$^2$), this gives a strain in the load cells of 303 microstrain, which is a conservative rating for mild steel. The load cell gives an output of 0.413 millivolts per volt for this load. With a d.c. excitation voltage of 20 volts, this gives a full-scale output of 8.26 millivolts. The circuit used to connect the four load cells into one complete bridge is shown in Fig. 7(b). By this means the gauges are connected in series, thus enabling a high excitation voltage to be used.

Waterproofing the load cells has presented a major problem, but reasonably good results have been obtained by coating the surfaces of the pillars with a silicone rubber layer. Using this technique it has been possible to operate platforms on sites for up to 3 - 4 months before the insulation to earth begins to deteriorate.

The load cells are connected to a junction box which carries a socket to which the cable is connected, using a high-grade waterproof and vibration-proof plug. In some cases, the plug and socket connexion is eliminated, and the cable is brought straight into the junction box. The connections in the box are encapsulated in epoxy resin, as an additional precaution against moisture.
Very great care is essential in the sealing of the load-cells and junction box, as the pit in the road-way is often subject to moisture, dirt and vibration, all of which can cause spurious loading signals, or failure of the bridge circuits to balance.

3.7 Signal amplifiers

Normally, three weighbridge platforms are operated together in the pit. These can have their load cells either operated together in parallel, using one amplifier, or they can be operated separately, each with its own pre-amplifier, and the signals can be summed together by an operational amplifier acting as a driver for the classifying system.

The method of connexion for the first system is shown in Fig. 8. In order to reduce zero drift, which cannot be tolerated if a classifying system is being used, a resistance - capacity coupling is introduced between the pre-amplifier and the driver amplifier. The time-constant of this coupling is chosen to be long compared with the duration of the loading pulses produced by vehicles crossing the weighbridge at normal road speeds, and a diode is introduced to produce a rapid return to zero after each pulse. This coupling can be cut out by the switch when it is required to calibrate the weighbridge platforms statically. Usually an overall gain of the order of 1000 is required, in order to raise the signal level sufficiently to operate the classifying system. A differential amplifier is essential, in order to eliminate 'pick-up' signals from the electricity mains, etc.

Calibration of the system is provided by the resistance R, which can be switched across one arm of the bridge circuit.

An alternative system, using individual pre-amplifiers for each platform, has recently been introduced, using the newly available low-cost packaged operational amplifiers. The arrangements is shown in Fig. 9. This system has the advantage that each platform, with its associated pre-amplifier, can be fully calibrated on a loading rig in the laboratory. The reversing switch S1 enables the calibration potentiometer P2 to produce either a positive or negative out-of-balance signal. Thus it can be used to 'back off' to zero the signal produced by loading the platform, and the calibrated dial on P2 can be set to read load directly, by adjustment of the variable resistance R. If the load is then taken off the platform, and the switch S1 reversed, a signal corresponding to any desired load can be produced at the amplifier output by setting the dial of P2. The potentiometer P1 is used initially to set the bridge to zero output. The outputs from the three pre-amplifiers are added together by a summing amplifier, which drives the classifying equipment.

The gains of the signals from the pre-amplifiers can be separately adjusted to give the required output for a given load, in order to set the scale factor for the classifying equipment.

3.8 Load classifying equipment

The load classifying system was developed to R.R.L. specification by MEL Equipment Ltd. Its function is to divide the wheel load signals into ten levels, usually in increments of 2000 lbF (8896N) and count and print out the numbers of wheel loads in each level at hourly intervals. The complete recording system is shown in Fig. 10.
The method of operation is as follows:

The positive-going signals from the platforms, after amplification as previously described, are sampled (at about 1000 samples/sec) by an analogue-digital converter (ADC). The digital code corresponding to the voltage level of the sample is compared with the previous value, held in a register. The larger of the two values is then held, and thus the peak value of the pulse due to a wheel load is selected and held. When the ADC samples a level below some pre-determined value, and this has previously been exceeded, the code is read out, and decoded into one of ten lines. Each line is connected to a counter in the printer unit. A master clock controls the print-out, and can be set to print out all ten channels hourly or at any other preselected interval. As operated, the ten levels correspond to ten increments of 0.3 volts. The threshold of operation is normally set at 45 millivolts.

Thus, if the weighbridge amplifier system is set to give an output of 0.3 volts per 2000 lbF increment, the scaling of the classifier is given in Table 1.

<table>
<thead>
<tr>
<th>Output Level (Volts)</th>
<th>Wheel Load (lbF)</th>
<th>Axle Load (lbF)</th>
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<tr>
<td>(1) 0.045 (threshold)</td>
<td>300 (1334.4N)</td>
<td>600 (2668.8N)</td>
</tr>
<tr>
<td>(2) 0.3</td>
<td>2,000 (8896N)</td>
<td>4,000 (17792N)</td>
</tr>
<tr>
<td>(3) 0.6</td>
<td>4,000 (17792N)</td>
<td>8,000 (35584N)</td>
</tr>
<tr>
<td>(4) 0.9</td>
<td>6,000 (26688N)</td>
<td>12,000 (53375N)</td>
</tr>
<tr>
<td>(5) 1.2</td>
<td>8,000 (35584N)</td>
<td>16,000 (80064N)</td>
</tr>
<tr>
<td>(6) 1.5</td>
<td>10,000 (44480N)</td>
<td>20,000 (88960N)</td>
</tr>
<tr>
<td>(7) 1.8</td>
<td>12,000 (53376N)</td>
<td>24,000 (106,752N)</td>
</tr>
<tr>
<td>(8) 2.1</td>
<td>14,000 (62272N)</td>
<td>28,000 (124544N)</td>
</tr>
<tr>
<td>(9) 2.4</td>
<td>16,000 (71168N)</td>
<td>32,000 (142336N)</td>
</tr>
<tr>
<td>(10) 2.7 (and above)</td>
<td>18,000 (80064N)</td>
<td>36,000 (160128N)</td>
</tr>
<tr>
<td></td>
<td>(and above)</td>
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The threshold level of 45 mV determines the maximum noise and extraneous signals from the platforms and amplifiers which can be tolerated. If this level is exceeded, spurious counting will occur in the first load class.

VEHICLES WITH HEAVY WHEEL LOADS

In order to collect information on the types of commercial vehicles carrying the heaviest wheel loads a photographic recording system was developed early in 1966 incorporating an automatic camera triggered by any one of the four highest levels on the load classifier. The camera records a view of the vehicle passing over the weighbridge on 35 mm film. On each frame is also recorded the following data:

(a) Vehicle speed, shown as a meter reading.
(b) The load level recorded by the weighbridge, shown by operation of one of four light bulbs, representing the four highest load classes.
(c) The time of occurrence, indicated by a clock face.
For night operation, an ultra-violet flash unit is used to illuminate the area adjacent to the weighbridge. This flash does not attract the attention of drivers, as it is invisible unless the driver is looking directly at the flash unit when it fires.

4.1 Camera control unit

This is shown schematically in Fig. 11 Pulses from the four highest levels of the load classifier are fed to four monostable circuits (M1 - M4) which produce a 1 second pulse when triggered. This pulse closes a reed relay (RL1 - RL4) which actuates the appropriate light bulb (L1 - L4) to indicate on the film frame the load class being recorded. A resistance R across the relay contacts ensures that the lamp filaments are kept partly energised, so that faster operation of the bulb is achieved when the contacts are closed. The pulses from any one of the circuits M1 - M4 can trigger the monostable M5, which actuates a heavy-duty relay RL6 which controls the camera shutter and wind-on mechanism. A further monostable M6 is also actuated, which opens a relay RL5, for a predetermined time. This introduces a controlled 'dead time' before the camera can be fired again, by disconnecting the input line of M5. This 'dead time' of a few seconds is necessary to allow the camera to wind on, and, at night, to allow the flash unit to re-charge. This delay can be tolerated, as only the heaviest vehicles are being recorded, and only a few per hour occur on most sites.

4.2 Vehicle speed indicator

A recording of vehicle speed is put on to the film frame by means of a small edge-reading meter which shows a reading proportional to the time of passage of the vehicle wheel over two counter-tubes placed a known distance apart on the road surface. The circuits are arranged so that the meter shows the reading for a few seconds spanning the firing of the camera and then resets. The timing circuit is basically an electronic integrator to which is fed a constant voltage for a time period which is controlled by the passage of a vehicle between the two counter tubes. The circuit used is shown schematically in Fig. 12. Two counter tubes are installed 7.33 ft (2.23 m) apart on the roadway. When a vehicle wheel operates the 'start' tube, the monostable M is triggered, opening relay RL1 and closing relay RL2. The bistable circuit B is also triggered, closing relay RL3. The effect of this is to actuate the integration circuit formed by the operational amplifier A and the capacitor C. The output voltage of the amplifier is the time integral of the applied voltage V. When the vehicle wheel reaches the second counter tube, it resets the bistable B, opening relay RL3. This cuts off the voltage V, and the integrator is then in the 'hold' conditions, the meter M indicating elapsed time. Finally, after a few seconds, the monostable circuit M resets itself, closing RL1, opening RL2, and thus discharging capacitor C.

The meter readings recorded on the camera film are thus proportional to time, but these can be readily converted to speed.

4.3 Indication of time of occurrence

This is given by means of an accurate watch which is installed in a small illuminated panel, together with the indicator lamps L1 - L4 and the speed meter, so that they are photographed on one-quarter of the film frame together with the vehicle as it crosses the weighbridge.
4.4 Arrangement of camera, flash unit and mobile laboratory

The arrangement generally used for recording heavy vehicles photographically is shown in Fig. 13 and Plate 7. The automatic camera (a Robot 35 mm single-shot camera) is mounted in a special turret built into the roof of the mobile laboratory, and the U.V. Flash unit is mounted in the front offside wing of the vehicle. This arrangement, as shown in the figure, gives a rear three-quarter view of the vehicle immediately after the passage of the heavily-loaded axle which triggers the camera. This arrangement has been chosen because

(1) The flash is then fired at the rear of the vehicle, where it is less likely to be seen by the driver,
(2) The rear axles are usually the most heavily-loaded.

Inspection of the film record makes it possible to decide whether the axle was correctly placed in relation to the weighbridge, and then to reject spurious records produced by more than half the number of wheels on the axle passing over the weighbridge, as mentioned earlier.

4.5 Analysis of the photographic records

The 35 mm film records obtained from the automatic camera are analysed on a high-quality film projector. The following data are noted from each frame:

(1) Time of occurrence.
(2) Axle distribution.
(3) Approximate transverse wheel position in relation to weighbridge.
(4) Type of load (if identifiable).
(5) Speed.
(6) Load level (7 - 10 as given above).

The axle distribution classification used follows that developed by RRL in 1956 for manual surveys of vehicle weights. 16

Recordings have been carried out on a number of major road sites where RRL has weighbridge installed. The results form the subject of a report to be published shortly.

5. REFERENCES

14. TROTT, J. J. 'An analogue computer study to determine the influence of vehicle characteristics on the dynamic loading produced by the passage of a vehicle over a surface irregularity', RRL Technical Note No. 89, June 1966.

APPENDIX I

1. **Alconbury By-pass** Trunk Road A1, northbound and southbound carriageways. Trunk Road A14 near entrance to and exit from A1. (4 weighbridges).
2. **Wheatley By-pass** (Oxon). Trunk Road A40, eastbound and westbound carriageways, east and west of junction with A418. (4 weighbridges).
3. **Nately Scures** (Hants). Trunk Road A30, eastbound carriageway (1 weighbridge).
4. **Whitfield** (Glos.) Trunk Road A38, northbound lane. (1 weighbridge).
5. **Harmondsworth**. Trunk Road A4, eastbound lane. (1 weighbridge).
6. **Tamworth** (Staffs.) Trunk Road A4091, southbound lane. (1 weighbridge).
7. **Motorway M1** Near Friar’s Wash interchange, southbound carriageway. (1 weighbridge, to be installed April 1968).
8. **Special installation on R.R.L. track, Crowthorne.** A facility has been constructed on the test track at Crowthorne for investigations of dynamic loading by moving vehicles. This will be the subject of a report to be published shortly.

Printed at the Road Research Laboratory, Crowthorne, Berkshire, England.
Plate 1.
Weighbridge Platform Module, showing load cells, junction box, bolts and compression springs for pre-loading.
Plate 2.
Weighbridge Pit, showing steel frame cast into concrete surround, and studs for locating platforms.
Fig. 3. ’Dummy’ weighbridge platform module used to fill pit, when not in use.
Fig. 4. Weighbridge platform module being placed in pit.
Plate 5.
Tightening Holding-down nuts on the studs with platform modules in position.
Plate 6.
Adjustment of load-cell seating at one corner of platform unit, to eliminate 'rock'.
Plate 7.
Complete weighbridge in operation, showing automatic camera in root, and flash unit in offside wing of mobile laboratory.
Fig. 1. DYNAMIC MODEL OF 2-AXLE ROAD VEHICLE

Fig. 2. ELECTRICAL SIGNAL GENERATED BY THE PASSAGE OF A VEHICLE WHEEL OVER A WEIGHBRIDGE PLATFORM (PERFECTLY SMOOTH ROAD SURFACE)
Fig. 3. ERRORS IN RECORDING AXLE LOADS

(a) With weighbridge spanning complete lane, tracking error when vehicle is straddling two lanes.

(b) With weighbridge set for nearside wheels only, error can arise from vehicles with twin half axles, as shown, if readings are treated as "half axle loads."
Fig. 4. CORNER ASSEMBLY SHOWING LOAD CELL BETWEEN BALL SEATINGS
Fig. 5 LOAD CELL PILLAR

Ground square to box

Material
M.S.

Milled and sand blasted

0.925

Fig. 6 HARDENED END CAPS

Undercut

Ground

0.625 dia. 0.007" for grinding to size

1/2

0.750

120°

1 1/2 OD.

Material
Nitralloy
EN. 41B
Fig 7(a) ARRANGEMENT OF STRAIN GAUGES ON LOAD CELL PILLAR

Fig 7(b) METHOD OF CONNECTING FOUR LOAD CELLS INTO ONE COMPLETE BRIDGE CIRCUIT
FIG. 8. ARRANGEMENT FOR USING THREE WEIGH-BRIDGE PLATFORMS IN PARALLEL WITH A SINGLE PRE-AMPLIFIER.
Fig. 10. COMPLETE RECORDING SYSTEM WITH CLASSIFIER, PRINT-OUT AND (OPTIONALLY) AUTOMATIC CAMERA FOR RECORDING ON THE FOUR HIGHEST LOAD LEVELS
Fig. 11. Control unit for automatic camera with indicator bulbs.

Load level - indicating light bulbs.
FIG. 12 CIRCUIT FOR INDICATING VEHICLE SPEED ON FILM FRAME
ABSTRACT

Design of a dynamic weighbridge for recording vehicle wheel loads: J. J. Trott and J. W. Grainger: Ministry of Transport, RRL Report LR 219: Crowthorne, 1968 (Road Research Laboratory). A description is given of the apparatus developed at the Road Research Laboratory for weighing the axle loads carried by traffic travelling along roads at normal speeds, classifying the loads into various preselected weight groups, and counting the number in each group. The design of the weighbridge platform is discussed in detail.

When the apparatus was used at some of the Laboratory's full-scale experimental road sites a number of axle loads exceeding 24,000 lb, were measured. Ancillary equipment was therefore developed for recording the speeds of these heavy vehicles and photographing them in order to see whether they were of normal type or specially constructed to carry extra heavy loads.