BRITISH STANDARD

BS 5204-2: 1977
(Reprinted, incorporating Amendment No. 1)

Specification for

Straightedges —

Part 2: Steel or granite straightedges of rectangular section

Confirmed February 2012

UDC 621.753.3:[531.717.862 – 032.521 + 531.717.862 – 034.14]

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This British Standard, having been prepared under the direction of the Mechanical Engineering Standards Committee, was published under the authority of the Executive Board on 29 April 1977

The following BSI references relate to the work on this standard:
Committee reference MEE/59
Draft for comment 75/70860 DC

ISBN 0 580 09623 8

Amendments issued since publication

Amd. No.	Date of issue	Comments
4128	November 1982	Indicated by a sideline in the margin

Contents

Foreword

This Part of BS 5204 is published under the authority of the Mechanical Engineering Standards Committee.

In accordance with the policy of publishing metric versions of British Standards for engineers' precision measuring equipment, those standards for straightedges have now been revised.

Cast iron straightedges, bow shaped and I-section, previously covered by BS 818 "Cast iron straightedges (bow shaped and I-section)" are the subject of Part 1 of BS 5204. Part 2 of this standard deals with steel and granite straightedges and replaces BS 863 "*Steel straightedges of rectangular section*" which is now withdrawn.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 8, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 5204 specifies requirements for steel or granite straightedges up to and including 2 m in length, of rectangular section, with or without a bevelled edge, and with both working faces finished straight and parallel. Two grades of accuracy are provided for: grade A and grade B.

Appendices deal with the method of supporting straightedges of rectangular section and methods of testing straightness of a straightedge.

2 References

The titles of the publications referred to in this standard are listed on the inside back cover.

3 Definitions

For the purposes of this Part of this British Standard the following definitions apply.

straightness tolerance of working face

the straightness tolerance is the maximum permissible separation of two parallel planes between which the face lies

tolerance on parallelism of working face

the tolerance on parallelism is the maximum permissible variation in width between the surfaces under consideration

4 Material and manufacture

4.1 Steel straightedges. Grade A straightedges shall be made from high quality steel. Their working faces shall be hardened to not less than 500 HV.

Grade B straightedges may be supplied hardened or unhardened. If supplied hardened they shall be made from high quality steel and their working faces shall be hardened to not less than 500 HV. If supplied unhardened they shall be made from cast steel.

NOTE If the purchaser specifically requires grade B straightedges to be hardened he should state this in his enquiry or order. In the absence of such specific requirements the straightedges may be supplied hardened or unhardened at the option of the manufacturer.

Manufacturers are required to take reasonable precautions to ensure that finished straightedges are free from internal stress.

4.2 Granite straightedges. Grade A or grade B straightedges may be made of granite. The rock shall be close grained and of uniform texture, free from flaws and fissures and from inclusions of softer materials. The colour of the granite, which is dependent on the mineral composition, is of no importance, but the colour of any individual straightedge shall be uniform.

Granite straightedges may be supplied with handles and with threaded inserts if required. The positions of the inserts may be specified by the manufacturer or as requested by the customer, but no insert periphery shall be less than 20 mm from any edge.

When threaded inserts are provided they shall be M6 to class 6H tolerance, or in the case of straightedges longer than 1 000 mm, M10 to class 6H tolerance, in accordance with BS 3643-2:1966.

5 Recommended sizes and design

Recommended lengths are 300, 500, 1 000, 1 500 and 2 000 mm.

Minimum sections shall be as shown in Table 1.

Straightedges of intermediate lengths should be ordered only when it is not practicable to adopt one of the recommended lengths. Such straightedges shall comply with the minimum depths and thicknesses given in Table 1 for the next longer recommended length.

The side surfaces may be slightly relieved (I-section) to reduce weight, and long straightedges may be provided with two slots for ease in handling; the centres of these slots should be at points two-ninths of the length from each end of straightedges (see Figure 1).

6 Finish

The working faces shall be finished by grinding or lapping. All sharp edges shall be removed.

7 Points of support for straightedges of 1 m length and over

To ensure minimum deflection on straightedges of 1 m length and over, the positions for supporting the straightedges when used on edge should be located two-ninths of the length from each end (see Appendix A) and shall be marked on one or both side faces by arrows and the word “support” engraved on the face, as shown in Figure 2.

NOTE The attention of manufacturers is drawn to the recommendation in **A.2**.

Table 1 — Minimum section

Dimensions in millimetres

Length	Steel				Granite Grades A and B	
	Grade A		Grade B			
	Depth	Thickness	Depth	Thickness	Depth	Thickness
L	*d*	*t*	*d*	*t*	*d*	*t*
300	40	6	30	5	75	25
500	50	10	45	6	100	35
1 000	75	10	60	8	125	40
1 500	100	12	70	10	150	50
2 000	125	13	80	12	150	50

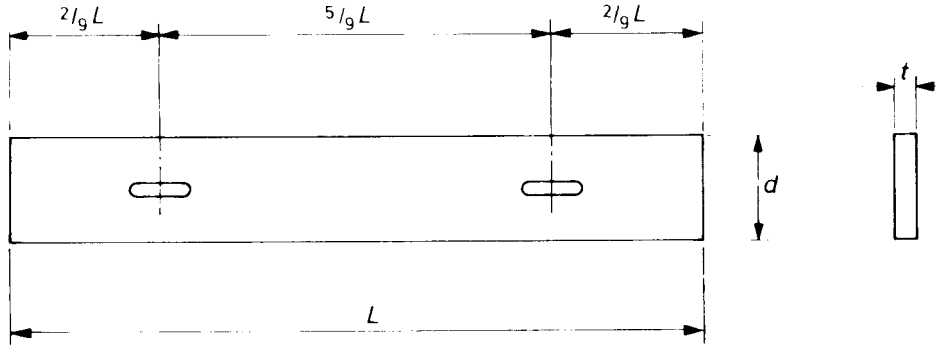

Figure 1 — Position of handling slots

8 Accuracy

Each straightedge shall comply with the requirements of **8.1** to **8.4** for grade A or grade B accuracy.

8.1 Straightness tolerance of working face. When the straightedge is lying flat on a grade AA surface plate (as specified in BS 817:1972) or standing "on edge" supported at two points two-ninths of the length from each end, the permitted tolerances on straightness are given in Table 2.

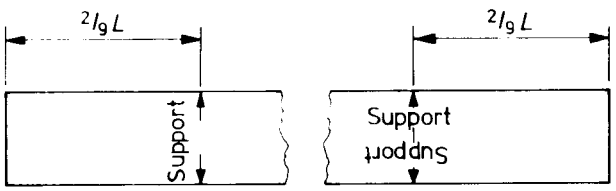

Figure 2 — Alternative methods of indicating the position of support

8.2 Tolerance on parallelism of working face. The tolerances on parallelism are given in Table 3.

Table 2 — Tolerance on straightness of working face

Dimensions in millimetres

Length of straightedge or length under test	Tolerance	
	Grade A	Grade B
300	0.005	0.010
500	0.005	0.010
1 000	0.008	0.015
1 500	0.012	0.025
2 000	0.015	0.030

NOTE 1 The tolerances above apply to the overall length and to intermediate lengths of a straightedge.

NOTE 2 Recommended methods of testing straightness are dealt with in Appendix B.

NOTE 3 Tolerances on straightness of the working face for straightedges with lengths other than those listed in Table 2 can be calculated at the rate of 0.00075 mm per 100 mm for grade A and 0.0015 mm per 100 mm for grade B, with a minimum of 0.005 mm for grade A and 0.010 mm for grade B. Grade A tolerances are to be rounded up to the nearest 0.001 mm and grade B tolerances expressed to the nearest 0.005 min.

Table 3 — Tolerance on parallelism of working face

Dimensions in millimetres

Length of straightedge	Tolerance	
	Grade A	Grade B
300	0.005	0.010
500	0.005	0.010
1 000	0.008	0.015
1 500	0.012	0.025
2 000	0.015	0.030

8.3 Combined flatness and parallelism of side faces. When the straightedge is laid flat with either of its side faces on a true surface (see **8.1**) the upper face shall be parallel to the plate to within the tolerances given in Table 4.

8.4 Squareness of side faces to working faces. The squareness of the side faces to the working faces shall be within 0.001 mm per millimetre of depth for grade A and within 0.002 mm per millimetre of depth for grade B.

Table 4 — Combined tolerance on flatness and parallelism of side faces

Dimensions in millimetres

Length of straightedge	Tolerance	
	Grade A	Grade B
300	0.05	0.07
500	0.05	0.07
1 000	0.07	0.10
1 500	0.09	0.14
2 000	0.11	0.17

9 Case

It is recommended that each straightedge be provided with a suitable case or protective cover of substantial construction.

10 Protection against climatic conditions

All finished surfaces of the straightedge shall be protected against the effects of climatic conditions.

11 Marking

Each straightedge shall be legibly and permanently marked with the following particulars.

a) The manufacturer's name or trade mark.

b) The number of this British Standard, i.e. BS 5204-2.

c) Grade A or B, as appropriate.

d) When hardened in accordance with **4.1**, the word "Hardened".

e) The year of manufacture.

NOTE 1 The mark BS 5204-2 on the product is a claim by the manufacturer that it complies with the requirements of Part 2 of this standard.

NOTE 2 Inspection of straightedges and certification that they comply with the requirements of this standard may be undertaken by laboratories approved by the British Calibration Service; addresses can be obtained on application to the Director, British Calibration Service, National Physical Laboratory, Teddington, Middlesex, TW11 0LW.

Appendix A Note on supporting straightedges of rectangular section

A.1 General

When straightedges are used on edge, it should be realized that although they may be of comparatively deep section, they are liable to deflect under their own mass. The amount of deflection will vary according to the number and the positions of the supports along the length of the straightedge. Consider, for example, the case of a grade A steel straightedge, 1 500 mm long with a section of 100 mm × 12 mm. If this rests on edge on two supports placed at its extremities, as in Figure 3, it will sag at the middle by 0.025 mm. Alternatively, if the supports are brought close together at the middle of the bar, as in Figure 4, the ends will droop by 0.012 mm. Thus, if such a straightedge were rested on edge on a surface which happened to be concave by as much as 0.025 mm, or convex by as much as 0.012 mm, over 1 500 mm, the straightedge would rest in contact with the surface in both cases over its whole length, and one might be deceived into considering the surface as being free from any appreciable errors in straightness.

However it is evident from Figure 3 and Figure 4 that there is an intermediate position for the two supports at which the distortion of the straightedge under its own mass is reduced to a minimum. This position is shown in Figure 5. With the supports in this optimum position, the deflection of the straightedge under consideration is reduced to as low as 0.0007 mm.

The disposition of the supports shown in Figure 5 should always be adopted when using steel straightedges of rectangular section on edge. For example, when testing the straightness of a horizontal surface with such a straightedge, the latter should be supported at the positions indicated in Figure 5 on two gauge blocks of equal height (say 2.5 mm) and the parallelism of the gap between the surface and the lower edge of the straightedge should be tested by means of other gauge blocks.

Table 5 shows the best positions for supporting straightedges of various lengths from 300 mm upwards.

Table 5 — Best positions for supporting straightedges

Dimensions in millimetres

Length of straightedge	300	500	1 000	1 500	2 000
Distance of each support from end	67	111	222	333	444

A.2 Advice to manufacturers

In order to acquaint users of straightedges with the significance of the arrows engraved to indicate the supporting points, and to emphasize the importance of so supporting the straightedge, it is recommended that manufacturers should paste inside the lid of the case of each straightedge of 1 000 mm length and over a printed slip to the following effect.

> When this straightedge is used on edge it should not be placed directly upon the surface to be tested, but should preferably be supported off the surface on two equal gauge blocks placed opposite the arrows marked “support”. By this means the distortion of the straightedge is reduced to a minimum.
>
> The truth of the surface to be tested can then be determined either by gauging the width of the gap underneath the lower working face of the straightedge, or by traversing an indicating surface-gauge along its upper working face. If the latter method of test is adopted, it is an advantage to repeat the test after turning the straightedge end for end so as to average out as far as possible any slight errors in the parallelism between the two working faces.

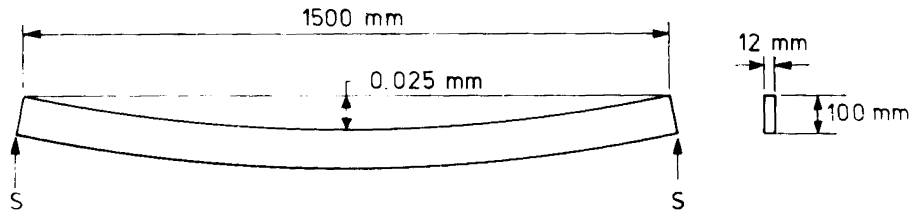

Figure 3 — Deflection with supports at ends

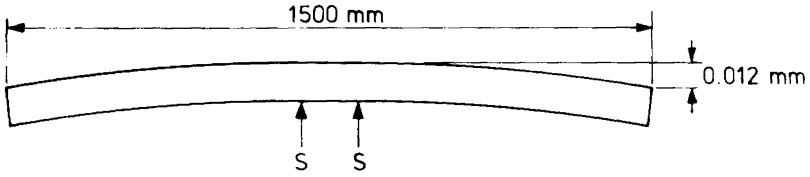

Figure 4 — Deflection with supports near the centre

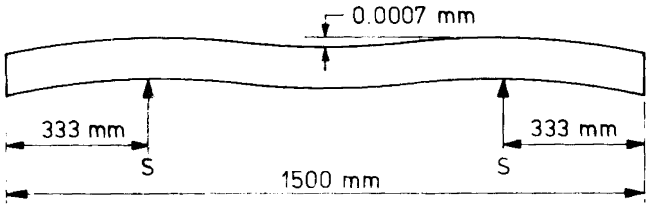

Figure 5 — Optimum position for supports

Appendix B Recommended methods of testing straightness of a straightedge

B.1 General

The whole surface of a straightedge may be used as a datum flat surface; alternatively, a central longitudinal band or track may be used for establishing a datum straight line. Although tests for straightness may often be made by comparison with a datum straight line it is necessary to use the inclination method to determine the errors in straightness of the datum straight line and in all instances where the highest possible accuracy is required.

B.2 Inclination method

This method of test requires a type of instrument which will measure very small angular variation of a carriage or block as it is moved step by step along the centre line of the working surface of the straight edge. It may be a spirit level, an electric level, an autocollimator or, in fact, any instrument which will measure small angular variations. It is important to note, however, that the mass of the equipment should be kept to a minimum in order to avoid distortion of the surface under test. The measurements should also be made in a controlled environment to ensure that rapid temperature variations and temperature gradients are kept to a minimum.

The principle of the inclination method is illustrated in Figure 6 and Figure 7. The carriage may consist of a plate or block to the underside of which may be fitted (by wringing or otherwise) parallel blocks of equal thickness. These blocks are placed at a span suited to the step chosen for measurement and the carriage is moved along the line in steps of this value (see Figure 6). It is also quite satisfactory to use a carriage with feet at a fixed distance; a block level with fixed feet, for example, provided the pitch covered by the feet is suitable for the measurement in hand. In either case, the span may be marked on the feet of the carriage.

To carry out a test, the straightedge is stood on a firm support and the working surface under consideration is approximately levelled in both longitudinal and transverse directions. The carriage to be used for making the flatness test is placed at one end of the straightedge with its length in the same direction as the latter. After making the first reading, the carriage is advanced along the straightedge through a distance equal to the span of its feet and the second reading is made. In this way, the carriage is advanced step by step along the straightedge until the other end of the working surface is reached, when it is usual to move the carriage backwards over the same path and to obtain a check series of readings terminating at the starting position. The inclination of each span relative to the first setting can therefore be found and the continuous angular contour recorded. No absolute datum, such as true level, is necessary. The datum is the first angular reading, all other inclinations being initially related to this.

Assume, for example, positions A, B, C, D, etc. in Figure 7 are laid out 250 mm apart along the centre line of the carriage. A 250 mm span will also be marked out on the feet or base of the carriage. The first span will be from A to B and this will be taken as the initial datum from which the other inclinations will be measured. Assume also that the span B – C shows an upward tilt of 5 seconds and C – D a downward tilt of 2 seconds when the carriage is moved to these positions. On a 250 mm base 1 second of arc represents a vertical displacement of 0.001 21 mm; C will therefore be 0.0060 mm above the datum line through A – B, and D will be 0.0024 mm below C or 0.0036 mm above the datum, and so on. The end point of the line will generally not be zero although it is usually convenient to take as a datum line the one between the extreme points. The final graphs should therefore be tilted about the origin, either arithmetically or graphically, to bring the end point to zero (see Figure 7).

Table 6 shows the method of recording observations and working up the results. It will be noted that an additional zero is placed above the first reading in column 5; this is because the first reading, although taken as datum zero, represents the relative levels of two points A and B. In this case the error at B will not therefore be zero in column 7 if the graph has to be swung about the origin.

Although the span used may be any value within reasonable limits, it is convenient to make it about one-tenth of the length of the straightedge, giving 10 steps of measurement.

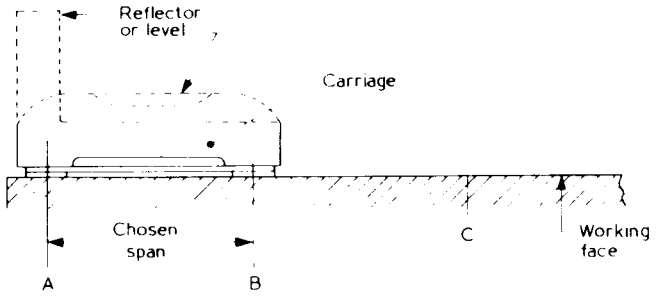

Figure 6 — Test by inclination method

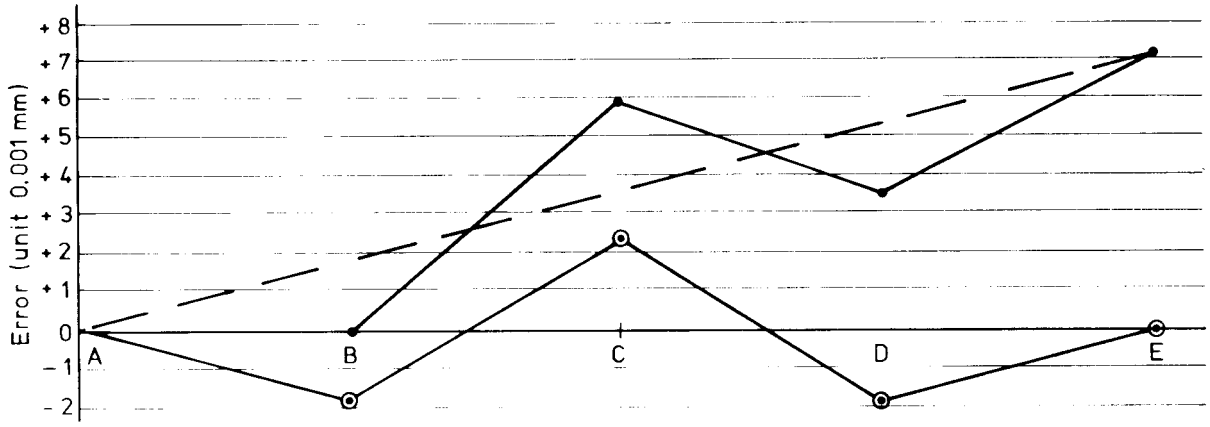

Figure 7 — Plotting of readings

Table 6 — Example of recording observations

1	2	3	4	5	6	7	8
Position of carriage	Angular reading	Difference from first reading at position A–B	Tilt over 250 mm span	Cumulative deviations from plane A–B	Proportional adjustments to bring E to zero	Error (algebraic sum of columns 5 and 6)	Position along straightedge
			Unit 0.001 mm				
	Second	Second					
—	—	—	—	0	0	0	A
AB	15	0	0	0	– 1.8	– 1.8	B
BC	20	+ 5	+ 6.0	+ 6.0	– 3.6	+ 2.4	C
CD	13	– 2	– 2.4	+ 3.6	– 5.4	– 1.8	D
DE	18	+ 3	+ 3.6	+ 7.2	– 7.2	0	E

In addition to the above test, which is usually carried out along the centre line of the working surface, it is necessary to test the face for a transverse twist (wind). This is most conveniently done with a level, an autocollimator being unsuitable for this test without certain special equipment. The level is turned so as to lie transversely across the surface of the straightedge and any variations in its readings are noted as it is moved from one end of the surface to the other.

B.3 Comparison methods

These methods of test require a datum reference surface of known accuracy against which the straightedge under test can be compared. For this purpose either a grade A rectangular steel or granite straightedge complying with the requirements of this standard (referred to as the reference straightedge hereafter) or a calibrated reference track of a grade AA surface plate (as specified in BS 817:1972) is suitable.

B.3.1 *Comparison with a reference straightedge.* The reference straightedge is stood on its edge and supported on the working surface of the straightedge under test by two equal gauge block combinations placed at the positions of support marked on the reference straightedge. A suggested combination is 2.005 mm plus 2.05 mm, i.e. 4.055 mm. A gap is thus formed between the two straightedges. The width of this gap is then measured at any desired number of positions by fitting gauge blocks into it.

To obtain the true errors of the working surface or the straightedge being tested from the results thus obtained, it is necessary to allow for the errors in the reference straightedge.

If the actual errors of the reference straightedge are not known, this method of test can still be used, but it becomes necessary to repeat the measurements of the gap between the two straightedges after inverting the reference straightedge and to measure the width of the latter at a number of positions so as to determine any errors of parallelism between its two working edges.

B.3.2 *Comparison with a reference line of a grade AA surface plate.* It is necessary first to establish the errors in the straightness of a track of the surface of a grade AA surface plate (as specified in BS 817:1972) using the inclination method as described in **B.2**. Comparison between the reference track and the working surfaces of straightedges may then be made by means of a test indicator complying with the requirements of BS 2795-1, and mounted on a suitable block. The test indicator block is moved along the reference track and the difference between the known errors of the reference track and the errors of the straightedge are registered on the test indicator. To ensure that the readings obtained relate only to the bearing surface of the working surface of the straightedge, a block gauge may be interposed between the working surface and the stylus of the test indicator. Where it is required to measure a large number of straightedges it is advantageous to replace the test indicator block with a carriage which just straddles the straightedge and bears on two tracks located close to either longitudinal side of the straightedge. In this instance, in addition to measuring the straightness of each track, it would be necessary to verify that the transverse twist (wind) relationship between the two tracks will not influence significantly the test indicator reading.

B.4 Local deviations from straightness

Tolerances for local deviations from straightness are given in **8.1** and the methods described in **B.3** may be used for checking compliance.

B.5 Flatness

Twist or wind may be checked by observing the variations of reading of a precision level placed transversely on the straightedge at various positions in its length. A small level of sensitivity, 5 seconds or 10 seconds per division and mounted in a light frame, may be used.

B.6 Deflection compensation

Deflection of the straightedge due to the mass of the level may be compensated for by application of an equal force acting vertically upwards on to the bottom edge of the straightedge. This compensating force should be applied in the vertical plane which passes through the centre of gravity of the level (see Figure 8).

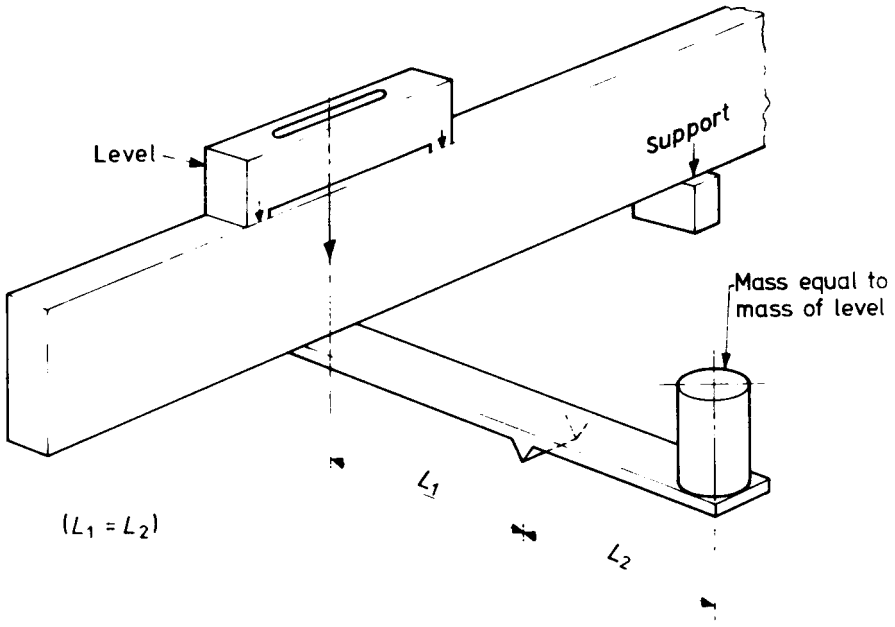

Figure 8 — Method of compensation for mass of level

Publications referred to

BS 817, *Surface plates and tables.*
BS 2795, *Dial test indicators (lever type) for linear measurement.*
BS 2795-1, *Metric units.*
BS 3643, *ISO metric screw threads.*
BS 3643-2, *Limits and tolerances for coarse pitch series threads.*
BS 5204, *Straightedges.*
BS 5204-1, *Cast iron straightedges (bow shaped and I-section).*

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