THE COMPLEAT SURVEYOR

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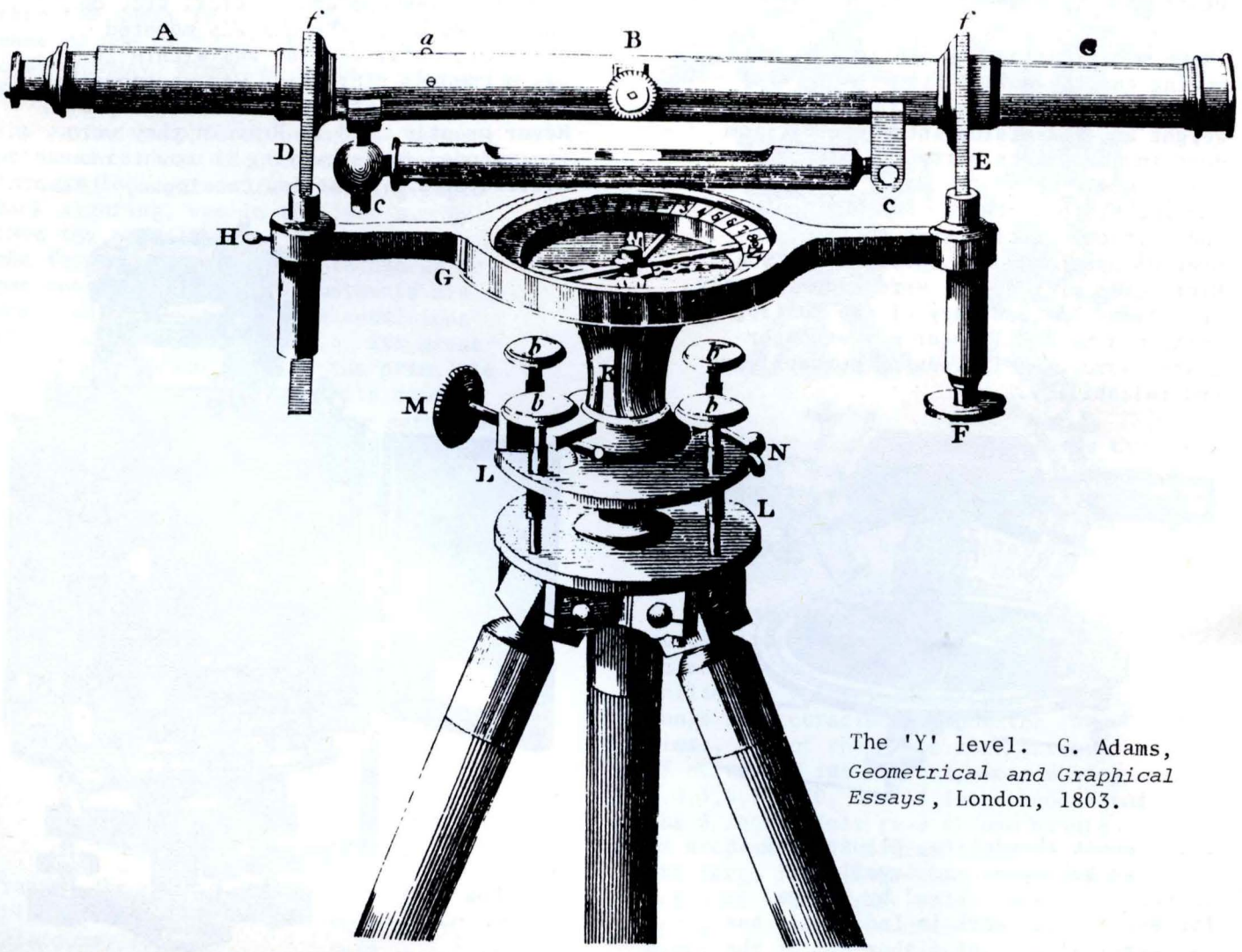
Development of the Level

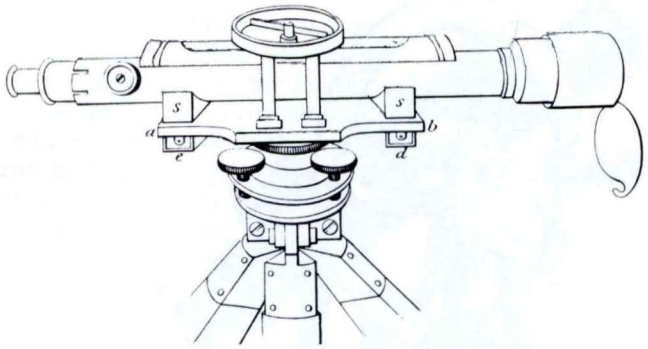
The level described by Hammond and made by Heath (see p 13) employed a double telescope to facilitate fore and back sighting, a technique essential in checking the setting of the instrument. However, any inconsistency found in the level with a double telescope left the surveyor none the wiser as to which telescope was inaccurate. Gardiner pointed this out when he described the new improved level made by Sisson in which the telescope was mounted in 'Y' shaped bearings enabling the tube to be reversed and a back sight observed, without altering the setting of the instrument.

Sisson's 'Y' pattern, which included a compass mounted on the telescope support, was still standard when Adams described 'the best constructed spirit level' in 1803. A 24 inch telescope was mounted in 'Y' bearings with straps fastening over the tube to hold it in position. A longitudinal bubble, slung below the telescope was levelled by a tilting screw, and four foot screws through parallel plates levelled the instrument. Although accurate once adjusted, the process of checking the alignment of the cross-hairs and the setting of the telescope was a long and tedious operation. The manufacture of more convenient and increasingly accurate instruments was inspired by the railway boom of the early years of the nineteenth century and resulted in several alternatives to the 'Y' level.

Edward Troughton's improved level achieved far greater stability by mounting the telescope ridgidly on the support, partially embedding the long bubble in the telescope tube, and mounting the compass, on four pillers, over the telescope. Having no erecting lens, the telescope showed an inverted image 'which has the advantage in point of brilliancy, and when an observer is accustomed to it, the apparent inversion will make no difference to him.' (F.W. Simms, *A Treatise on mathematical instruments*, London, 1865.)



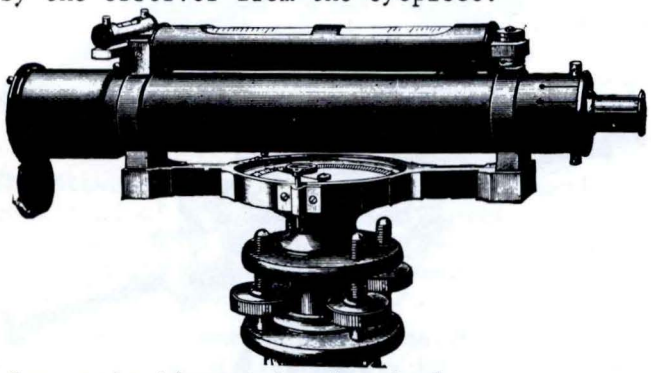
The 'Y' level. G. Adams, *Geometrical and Graphical Essays*, London, 1803.



Troughton's improved level. H.J. Castle, *Surveying and levelling*, London, 1847.

Troughton's improved level was described in most early nineteenth century textbooks as an improvement on the 'Y' level 'an altogether very flimsy affair', (W.F. Stanley, *Surveying and levelling instruments*, London, 1890) but it was William Gravatt's level, developed in the 1830's which achieved lasting popularity.

With a telescope only 12 inches long, it quickly became known as the 'dumpy' level since Gravatt, by using a large aperture object-glass and short focal length, had obtained the light and power of a large instrument without the inconvenience of length. His other improvements were the addition of a transverse bubble, and a hinged mirror over the bubble so that it could be read by the observer from the eyepiece.

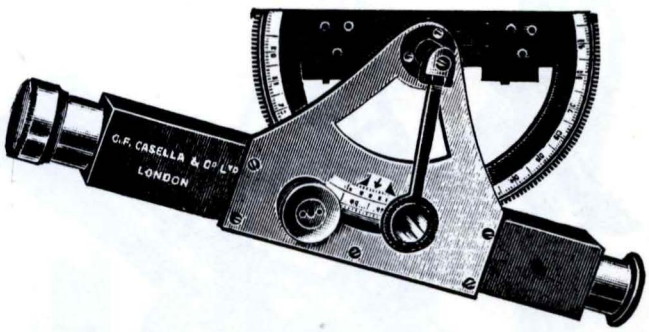


Gravatt's 'dumpy' level. Barker, *Catalogue*, n.d.

The optical principles of the dumpy level were applied to the 'Y' level, and both were produced until the end of the century with the dumpy steadily increasing in popularity: 'The dumpy level is essentially English as it is not appreciated anywhere else ... In England it has reigned supreme for many years, but signs are not wanting that in company with the plain theodolite, it is doomed to extinction.' (Bligh, *Notes on instruments best suited for engineering field-work in India and the colonies*, London, 1899) Although Bligh was, in the long run, right about the plain theodolite, the dumpy level is still in use as a basic tool of the modern engineer.

For the calculation of base area in mountainous districts it was necessary for the surveyor to be able to measure degrees of slope, and for this purpose several small pocket clinometers were developed. One of the most popular of these was the Abney level (illustrated). A bubble, mounted on the axis of a vertical semicircle, could be viewed by mirrors through the sighting tube. A knurled ring rotated the bubble and the index arm, which moved over the graduated arc. Other clinometers were combined with compasses or rulers, and many of the military 'rapid sketchers' included a simple clinometer.

The Abney level. C.F. Cassella, *Catalogue*, 1928.



One basic but popular pocket level was the reflecting level. A diamond shaped aperture with a half mirror, weighted at the base and mounted in gimbals, was held at arms length and the pupil, when reflected in the mirror was level with the object viewed through the aperture. 'The reflecting balance level, is to my mind, one of the most simple and effective for rough trial work over a new country that has ever been placed in the hands of the engineer.' (T. Holloway, *Levelling and its general application*, 2nd edition, London, 1895).

The Cassella Pocket Altazimuth which combines a compass and a clinometer in one instrument. C.F. Cassella, *Catalogue*, 1928.