PRACTICAL SURVEYING

A Text-Book

FOR

STUDENTS PREPARING FOR EXAMINATIONS

OR FOR

SURVEY-WORK IN THE COLONIES

BY

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AUTHOR OF "THE STATISTICS OF THE WATER SUPPLY OF GREAT BRITAIN," ETC. ETC.

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The necessary rules to be observed with the adjustment of the sextant are :—

1st. That the two mirrors are parallel to each other when the zero of the vernier coincides with that of the graduated arc.

2nd. That the horizon glass is perpendicular to the plane of the instrument.

To correct this latter (*i.e.* the perpendicularity of the horizon glass to the plane of the instrument) it is necessary to observe whether the reflected and the direct images of the distant horizon appear as *one*. If two horizons appear we apply the key at L and

Fig. 112.

Fig. 113.

turn it until they agree. Figs. 112 and 113 illustrate the manner in which this instrument is held and manipulated when taking an observation.

The cost of a box sextant, with telescope and large mirror and sunshades, complete in a sling case, is from £3 15s. to £5 5s.

Hughes's Improved Double Sextant.—This is an instrument which for some reasons may be said to almost supersede the box-sextant, having the advantage of measuring angles nearly double the arc which can be measured by the ordinary sextant. It consists of a five-inch or six-inch circle, with two index glasses mounted in the centre on two index arms with verniers, one measuring the angle to the right and the other to the left. The horizon glass is silvered top and bottom, with a narrow slit in the centre. The centre object is observed with a telescope through this, and the other two objects, to the right and left respectively, reflected by the index glasses into the silvered portions of the horizon glass; the three objects being in contact, the observed angles are read off with the verniers. The adjustments of the index and horizon glasses are made in the regular manner, the upper index glass being adjusted last.

This instrument, as is shown by the accompanying sketch, has a handle by which it is held in the right hand, whilst the index arms

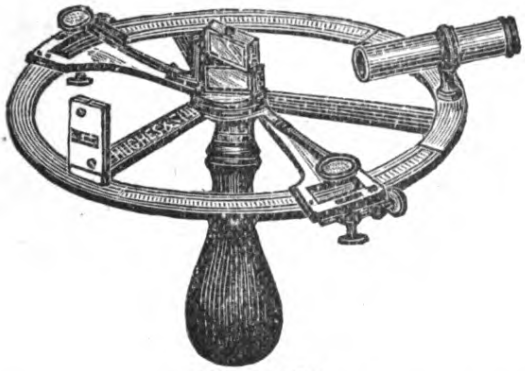


Fig. 113A.

are manipulated with the left. It may also be made to fit on to a tripod-stand, similar to that described for the clinometer.

The price of the five-inch sextant, complete in mahogany box, with two telescopes, is £5 10s., and the six-inch is £6 10s.

Plane Table.—This consists of a drawing board A (Fig. 114), (usually framed, A′, with a movable panel), having a sheet of drawing paper strained on it, mounted on a portable three-legged stand B, and capable of turning about a vertical axis, and of being

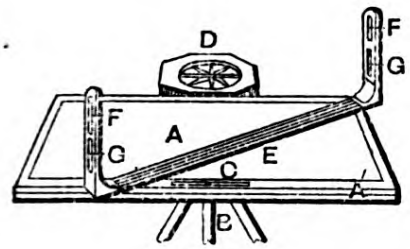
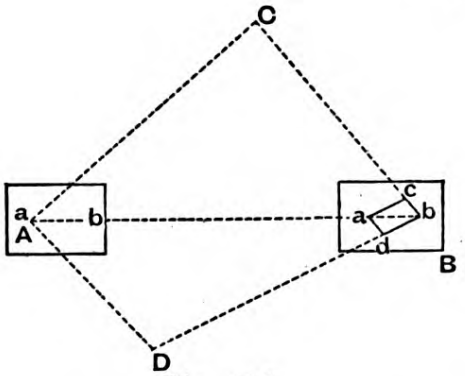


Fig. 114.



Fig, 115.

adjusted by screws to a horizontal position, as indicated by a spirit-level C being attached to the frame. The vertical axis has a clamp and tangent screw to adjust it to any required position. The index E is a flat, straight-edged ruler, having upright sights at its end. These sights have slots (F F G G) similar to those in a prismatic compass or circumferenter.

The use of the plane table resembles trigonometrical surveying on a small scale, except that the angles, instead of being read off on a horizontal circle and then plotted, are at once laid down on the paper in the field.

Fig. 115 is a simple illustration of the use of the plane table in the field. It is required to make a survey of the trapesium A C B D. Having set up rods at C B and D, the surveyor plants his table at A

THE PRACTICE

OF

ENGINEERING FIELD-WORK

APPLIED TO

LAND AND HYDRAULIC, HYDROGRAPHIC AND SUBMARINE SURVEYING AND LEVELLING

FOR

RAILWAYS, CANALS, IRRIGATIONS, ROADS,
TOWNS' WATER SUPPLY, RIVERS, DOCKS, AND HARBOURS,
AND
DEEP-SEA SOUNDINGS.

THE USE OF SURVEYING AND LEVELLING INSTRUMENTS;
OF
BAROMETERS AND THERMOMETERS FOR EXPLORING LEVELS.

A COMPLETE TREATISE ON SETTING OUT CURVES.

Second Edition, Revised, with considerable Additions, and a Supplementary Volume on

WATERWORKS:

OR, THE

DISTRIBUTION OF WATER IN TOWNS UNDER THE CONSTANT AND INTERMITTENT SYSTEMS, GAUGING STREAMS,
SEWERS, SEWAGE AND IRRIGATION.

By W. DAVIS HASKOLL, C.E.

Author of "The Engineer's, Mining Surveyor's, and Contractor's Field Book," "Examples of Bridge Construction in Masonry, Timber, and Iron," "Land and Marine Surveying," "The Civil Engineer's and Contractor's Estimate and Price Book," etc. etc.

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LUDGATE HILL.
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APPENDIX.

CAPTAIN GEORGE'S DOUBLE BOX-SEXTANT.

THIS instrument, invented by Captain C. George, R.N., is such a very important improvement for land or marine surveying, for setting out curves or works at sea, as to deserve particular attention. As we have had occasion to mention several times in the foregoing pages, the box-sextant has always been a favourite instrument from its portability; but unquestionably it has the great defect of being limited as to the extent of angle which it is capable of measuring; an obtuse angle has to be taken in two measurements, and this, practically speaking, is often impossible; with the double sextant, not only this deficiency is entirely removed, but two angles may be measured at the same instant, or we should say simultaneously.

The instrument is illustrated at fig. 142, and is best described as being a special arrangement of two sextants placed one over the other. Each sextant is complete in all its essential details, and, if so required, can be detached and separately used. When joined together as the "Improved Double Sextant," the horizon glass of the upper sextant is placed immediately over and concentrically with the horizon glass of the lower sextant. A small interval or space of the horizon glass of each sextant is left unsilvered, sufficient for the sun, or other object of the like magnitude, to be seen. In observing large angles, the line of sight is turned to a convenient midway direction, and the two objects are reflected from the index glasses into the horizon glasses, where a perfect contact is made by bringing one object immediately over the other. When two angles are to be simultaneously observed, the line of sight is turned to the centre object, to which each of the other objects is reflected.

From the preceding description it will be obvious to those acquainted with the ordinary instrumental operations of astronomy and surveying, that this instrument is capable of being applied to the following uses:—

1st. To the measurement of angles of nearly double the arc which can be measured by the ordinary sextant.
2nd. To the simultaneous measurement of two angles.
3rd. To laying out a base line between any two objects, thus acting as a substitute for a "Raper's instrument."

4th. To laying out curves for railways, harbour works, &c. &c.
5th. It can be used as an improved "Optical Square."
6th. It can be used as a "Dip-Sector."
7th. It can be used on shipboard to measure the supplement of the meridian altitude, in cases where the land intervenes between the observer and the direct meridional horizon.
8th. It can be used on shore with the artificial horizon in obtaining altitudes of objects near the zenith.
9th. It is also available as two distinct sextants, one of which can be used in case of the other being damaged, or one can be used by an assistant, and the other retained by the observer.
10th. It possesses to a considerable extent the advantages of the "Reflecting Circle."

The following detailed notes and directions may prove useful to those who may be about to use the instrument for the first time, and they may also serve to further elucidate its distinguishing characteristics. The instrument is fitted with tubes and slides, and an eye-piece for peculiar sighted observers. Its handle is also adapted to move on a joint, so that the instrument can be placed in a side pocket when not in use. The plate of the lower sextant is made to take off, by turning a screw with a milled head, until it is free of its worm. The plate is then removed, like the lid of a box, by pulling on the handle. This arrangement admits of the glasses being cleaned without the hazard of altering their adjustments, in which matter the Improved (Pocket) Double Sextant, has a great advantage over the ordinary box-sextant.

To measure one large angle.—In practice, it will be found very convenient to set the lower sextant at a fixed angle of 100°; seek the reflected image of the left-hand object, and reflect the right-hand one over it; by this arrangement the upper sextant is made the working one. In reading off, add 100°; thus, if the upper sextant reads 110°, the angle would be 210°.

It will be as well to notice that the index-error of a compound angle measured by the "Improved Double Sextant," is composed of the index-errors proper to each one, and also that the error of parallelism is materially reduced.

To measure two angles by using the instrument as a single sextant.—Take off the largest cover, hold the face of the instrument upwards, and look through the sight aperture at the centre object through the unsilvered part; and by turning the index-handle reflect the object from the right; the angle thus measured is termed the right-hand angle. Reverse the instrument by turning its face downwards, and looking at the centre object as at first, move the index-handle, and reflect the other object from the left; this is termed the left-hand angle. These two operations have executed what the instrument is

capable of performing by one observation, namely, the measurement of two angles.

To observe two angles simultaneously.—Take off the smaller cover; screw on the holding-handle, and keep it in the right hand; set both indexes at zero; and then looking at the middle object, work the index-handles alternately; the reflected objects will be seen to move in the horizon glasses, the right-hand object in the upper glass, and the left-hand object in the lower. Bring them in a vertical line with the middle object. The exact contact is ascertained by giving the instrument vertical motion. When that is obtained, the two angles can be read off at leisure. In fixing soundings, the two angles can thus be obtained at the same time by a single observer. In practice it is desirable to measure, in the first instance, the angle which is changing with least rapidity, and then to screw the vernier a little in advance or in arrear, so as to give time for making the contact with the angle which is changing with greatest rapidity.

To set out a base line between any two objects.—Turn yourself at right angles to the objects; set the lower index to 90°, and seek the reflected image; bring the other object in contact with this reflected image; if the upper index is less than 90°, you must advance, but if more, you must go back.

To range a curve.—Compute the tangential angle in the manner already explained, that is, by dividing the constant 1718·9 by the radius of the curve in chains, either Gunter's, 100 feet, or décamètre; stand with the instrument at the tangent point, as A, fig. 87, or 85, with the total angle of deflection T A *k* set on the sextant; the first angle, *k* A *a*, will be equal to the total angle minus the tangential angle, and for *k* A *b* it will be equal to the angle of deflection minus twice the tangential angle, &c.; if *k* be not visible from A, take half the deflective angle, determined as before explained by the secant, as S A T, fig. 85; it will be observed that all the time we are setting out the stumps *a*, *b*, *c*, *d*, &c., fig. 87, we have in sight the tangent T A and the chord of the whole curve A *k*, or of half of it, as T A, S A, fig. 85.

By the same means we may make use of this double sextant for setting out curves, even if there is a considerable difference of level between the points A, T, and S, for we have only to divide the angle as given by the sloping ground, and divide it in minutes by the length of the curve in chains, to obtain the tangential angle by which to set out under these particular circumstances; it will be evident that in many such cases we may dispense with the use of the theodolite.

To use the instrument as an Optical Square.—Set both indexes to 90°, look at the object and signalize to the flagmen right or left, until they appear reflected in the horizontal glasses, one above, and the other below the object. Thus, two offsets are obtained at the same instant, and a line is set out intersecting a base at perfectly right angles.

To use the instrument as a Dip-Sector.—Set the upper index to 120°, and the lower one at 60°, hold the sextant upwards, with your

head reclining backwards, and find where the reflected horizons approach each other; adjust them by either sextant to form a straight line, and the observation is made;—add the two readings together; subtract 180° and divide by two, and the result will equal the dip.

This observation may be repeated over a portion of the arc equal to 60°.

In observing altitudes with the sea horizon.—1st. Set any angle on the upper sextant; then facing that part of the horizon which is opposite the sun, find his image, and bring up the horizon to the lower limb, by moving the lower index. The sum of the two readings is the supplement of the altitude of the upper limb, affected by the dip and the index-error. 2nd. Set the upper index to an angle less than the altitude; find the image under the sun, and bring up the horizon to the lower limb. The sum of the readings is the altitude of the lower limb, affected by the dip and the index-error.

Half the difference of the two sums is the apparent zenith distance cleared of the dip, semi-diameter, and index-error.

For general astronomical purposes, the "Improved Double Sextant" has some important advantages. It affords two altitudes of the same or different celestial bodies, in quick succession. This is a point of much consequence when the body appears for short intervals only, as between flying clouds; and in observing at night, as it saves the disturbance to the eye caused by reading off. For the accompaning illustration, Fig. 142, we are indebted to the authors and publishers of "Shifts and Expedients, of Camp Life, Travels and Explorations."

THE LIGHT MOUNTAIN THEODOLITE.

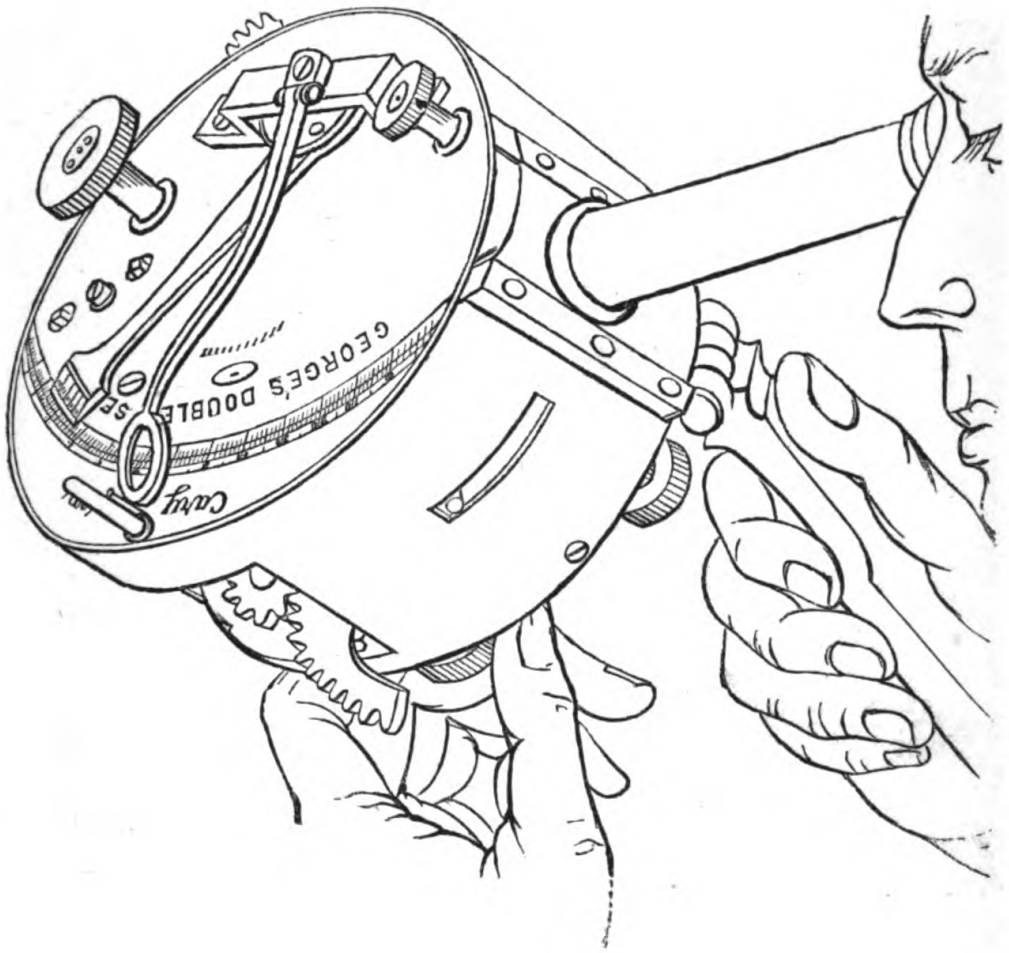
This instrument, lately introduced by Casella of Hatton Garden, and which we illustrate at Fig. 140 B, is a three-inch theodolite of a novel shape; besides the great advantage of portability, it possesses that of being a complete transit, so that it might be employed for the shafts of mines, of being firmer and more steady, by its principle of construction, than the ordinary transit theodolite; there is an unobstructed view of the horizontal limb, and the gold vernier makes the reading very clear. There is also a special disposition for a clear reading of the vertical arc. The instrument is provided with a vertical eye-piece, a reflector to be applied to the object end of the telescope, and shown in drawing under the vertical arc, gives the advantage of most distinct vision of distant objects. The instrument is, of course, provided with a tripod.

ADMIRAL BEECHEY'S REFLECTING STATION POINTER.

This instrument, made under the instructions of the late Admiral Beechey, is in fact a large sextant, by means of which two angles may be taken, though not simultaneously, as with Captain George's double sextant; it may also be used readily for making a complete

FIG. 142.

THE DOUBLE SEXTANT.



INVENTED BY

STAFF-COMMANDER C. GEORGE, R.N.

SIZE 3 inches diameter.
2½ „ depth.

The Book of the Sextant

WITH

Ancient and Modern Instruments of Navigation

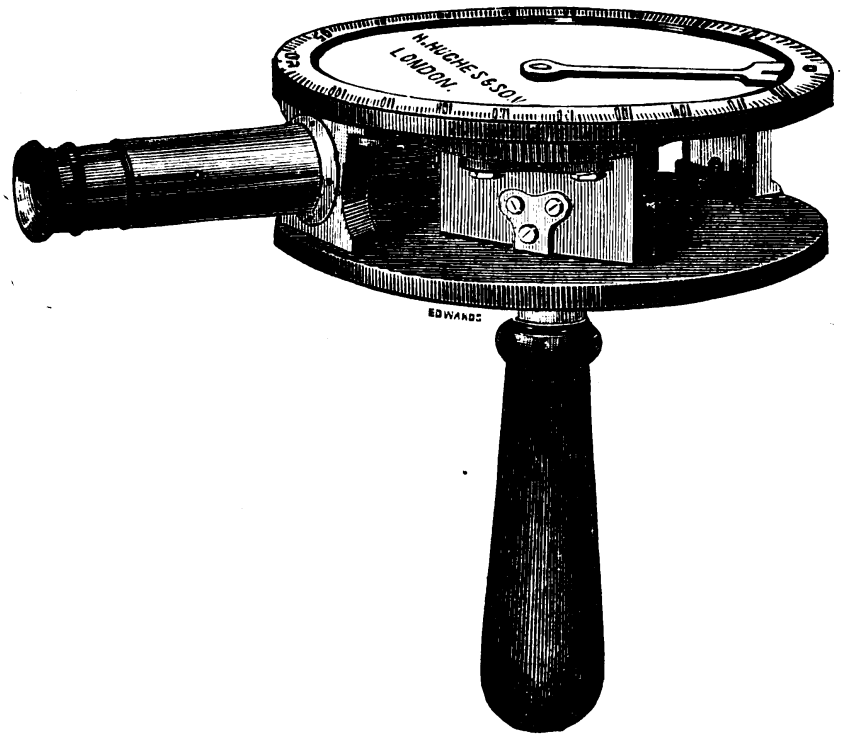
BY

A. J. HUGHES

GLASGOW
JAMES BROWN & SON, The Nautical Press
52 to 58 Darnley Street

1915

and can be read to half that at a glance. The telescope has a clear aperture of an inch and slides in out of the way when not in use, or a plain blank sight can be substituted quite satisfactorily as in the pattern adopted by the British Admiralty. The wooden



ANGLE SEXTANT.

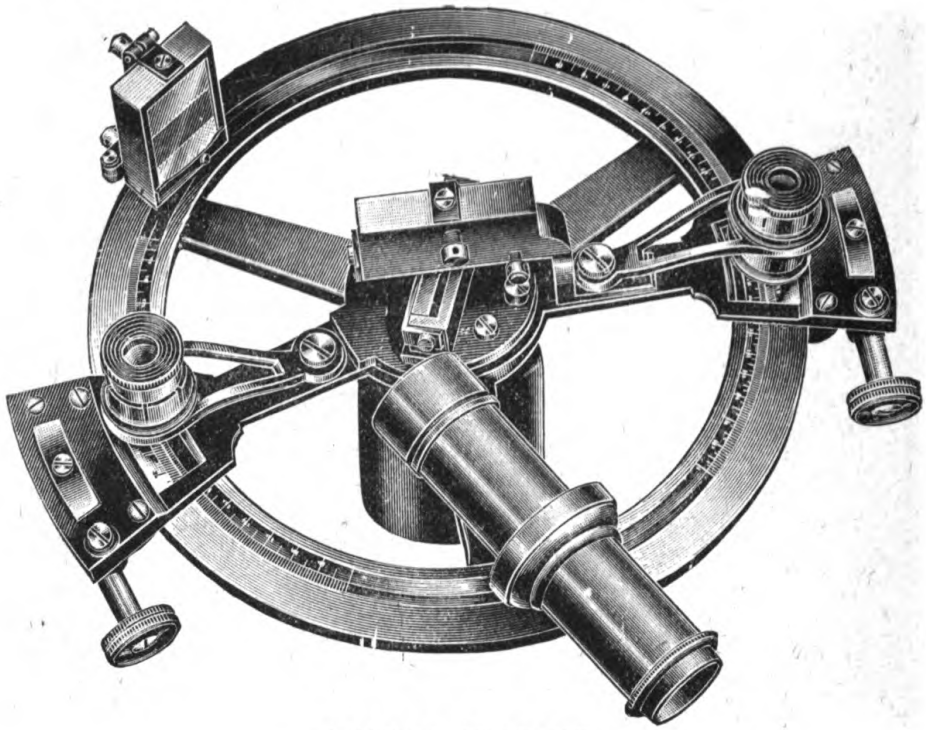
handle underneath unscrews and the whole affair goes into a sling leather case. Its advantages for the work specified as compared with the sextant are cheapness, less liability to injury, larger field of view and quicker reading.

The Double Sextant.

The Double Sextant was designed for taking three points and other shore bearings.

This instrument consists of a whole circle with a 5 or 6-inch arc, fitted with two indices, two index mirrors with one over the other in the middle of the circle. The horizon glass is placed on

the edge of the circle and is silvered top and bottom with a clear cut in the middle to observe the central object. The indices are fitted with clamp and tangent screws and read to 10″. A handle is fitted in the middle of the circle over the centre work. Captain Lecky has described this instrument in his *Wrinkles*.



DOUBLE SEXTANT.

The double sextant can be used for harbour survey and river work and has proved a most valuable instrument in all work where speed, accuracy and portability are required.

The Navigraph.

The navigraph is a novel and ingenious combination of the sextant and station pointer, and a development of the Paget angle sextant which we brought out a few years since, and was adopted by the Admiralty for use on all His Majesty's ships.

The improvement and advantage of the navigraph are that an officer can take with it and plot the two angles required for