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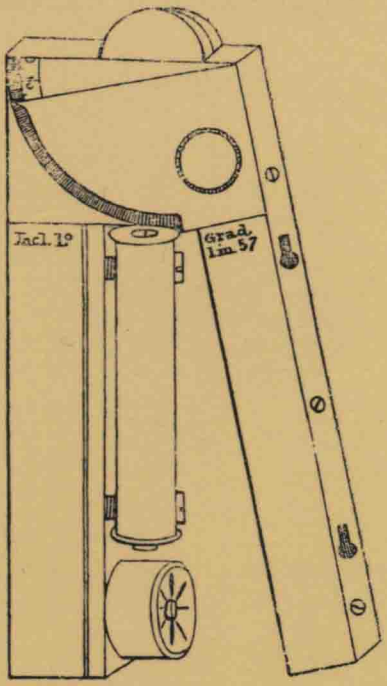
# A TREATISE ON ENGINEERING FIELD-WORK

VOLUME 1

PETER BRUFF

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# A Treatise on Engineering Field-Work

*Comprising the Practice of Surveying, Levelling, Laying Out Works, and Other Field Operations Connected with Engineering*

VOLUME 1



CAMBRIDGE
UNIVERSITY PRESS

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## Technology

The focus of this series is engineering, broadly construed. It covers technological innovation from a range of periods and cultures, but centres on the technological achievements of the industrial era in the West, particularly in the nineteenth century, as understood by their contemporaries. Infrastructure is one major focus, covering the building of railways and canals, bridges and tunnels, land drainage, the laying of submarine cables, and the construction of docks and lighthouses. Other key topics include developments in industrial and manufacturing fields such as mining technology, the production of iron and steel, the use of steam power, and chemical processes such as photography and textile dyes.

## A Treatise on Engineering Field-Work

In the 1840s, the civil engineer Peter Bruff (1812–1900) designed what was then the largest brick structure in Britain, the 1,000-foot-long Chappel Viaduct in Essex. He went on to become a railway entrepreneur and developer, and was responsible for the creation of the resort town Clacton-on-Sea, where he also designed many of the buildings. In this illustrated guide, first published in 1838 and here reissued in the revised and expanded two-volume second edition of 1840–2, he discusses the theory and practice of surveying (calculating the accurate position of points in the landscape) and levelling (calculating the accurate height of points). Volume 1 covers surveying; Bruff discusses different methods for calculating bearings and distances, and the equipment required. He explains the various errors to which each method is prone, how to avoid or minimise them, and gives example surveys of land boundaries, parishes and railway lines.

# A TREATISE

ON

# ENGINEERING FIELD-WORK,

COMPRISING

THE PRACTICE OF

SURVEYING, LEVELLING, LAYING OUT WORKS,

AND OTHER

FIELD OPERATIONS CONNECTED WITH ENGINEERING.

With numerous Diagrams and Plates.

BY PETER BRUFF, C.E.,

ASSOCIATE INST. CIVIL ENGINEERS.

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SECOND EDITION, CORRECTED AND ENLARGED.

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TO

# JOHN BRAITHWAITE, ESQ.,

CIVIL ENGINEER,

ENGINEER IN CHIEF OF THE EASTERN COUNTIES RAILWAY,
MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS,
ETC. ETC.

DEAR SIR,

From my knowledge of your perfect acquaintance with Engineering Field Operations, and in testimony of the numerous acts of kindness which I have received at your hands while employed on some of the Public Works executed under your direction, I am induced to DEDICATE to you this *Second and Enlarged Edition* of a TREATISE ON ENGINEERING FIELD-WORK.

I remain,

Dear Sir,

Your obliged and very obedient Servant,

PETER BRUFF.

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## NOTICE.

Part 2 (which is far advanced, and will be issued as early as possible) will contain an elaborate Treatise on Levelling. Also a new Division which has been added to this edition on the subject of Laying out Works, &c.; the whole comprising a mass of *original* and *practical matter*, which it is presumed will be found useful to all engaged in the direction of Engineering Operations. The complete work will be very fully illustrated by diagrams and plates, and accompanied by a copious Index and Glossary.

ERRATA.—Page 35, last line but one from bottom, for "inner," read "outer." Page 47, for "plate 5," read "plate 4."

THE

# THEORY AND PRACTICE

OF

# SURVEYING.

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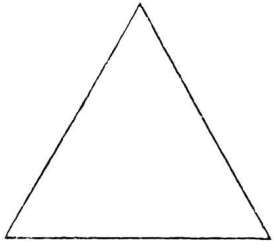
## CHAPTER I.

EXPLICATION OF THE TERM "SURVEYING."— SIMPLE CASE OF SURVEYING.— MEASURING A RIGHT LINE. — TAKING OFFSETS.

SURVEYING, in a general sense, denotes the art of measuring the angular and linear distances of objects so as to determine their several relative positions and draw a correct delineation of them, and to ascertain the superficial area or space included. It is a branch of applied mathematics, and supposes, in the operation, a good knowledge of arithmetic and the elements of geometry. As applied to the measurement of land, either for the purposes of computation, or for delineating the different natural or artificial objects which occur on its surface, it is performed by the measurement of several lines parallel to the horizon, passing in various directions, and which, being connected at their extremities, form some geometrical figure, either inscribing or circumscribing the object or space required. Thus,—suppose the following triangular space to represent a field, and the lines enclos-

ing it, an open ditch: to survey such a piece of land, all that is requisite would be to measure the lengths of those ditches with some convenient unit of measurement, as a wooden rod of some ascertained length, as one, two, three yards, or more; or with a cord or chain of several of such units in length, instead of the wooden rod; and the operation of land-surveying in its simplest case will be thereby understood. Now, although the contents or superficial area of such a piece of land as that represented in the diagram could be easily computed on the ground, from the circumscribing measured lines, without drawing a plan or map of it, yet, for the purposes even of computation, as it will be seen, and of easy reference, it would be more convenient to lay down a plan of it on paper.



It will at once be evident that a plan of the ground cannot be drawn on paper to the natural or full size: a reduced or miniature copy only,—which should be one hundredth, one thousandth, or any convenient part of the full size, can be drawn, and the process is this:—Take a strip of paper or thin wood, divided into inches, which divisions might represent on paper the yards measured on the ground, if the unit with which the ground is measured be a yard; or each inch might represent two yards, or ten yards, or any number at pleasure. Now, supposing the measurement of the longest line in the diagram to be one hundred yards, that quantity might be represented on paper by one hundred inches, or fifty inches, or ten inches, or any value that may be assigned to the inches marked on the strip of paper or wood, which, thus used, is termed a scale. If the line on the paper is drawn one

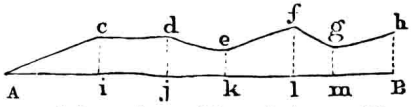
hundred inches, the scale would be one yard to an inch; if drawn ten inches, it would be ten yards to an inch, and so on. For convenience of measuring in the field, and for reducing the results of such measurement to the customary standard of acres, roods, and perches, which is universal in this country (except in land intended for building purposes, which it is usual to compute in superficial yards), a chain, twenty-two yards in length, is used, called "Gunter's chain," so named from the inventor, the Rev. Edmund Gunter.* This chain is formed of one hundred links, having a handle at either end for convenience of use. The links are joined together by three small rings, the whole thereby becoming very flexible. To measure with the chain, two persons are necessary, one to draw the chain, and another to follow, the last of whom, by a strange anomaly, is frequently called the leader, although we shall term him the follower. Accompanying the chain are ten iron arrows or pins, which, with the chain, are used in the following manner: —The point from which the measurement is to commence being determined, as well as the direction in which the line is to be measured, the leader takes one end of the chain in his right hand, passing his fingers through the handle of the chain and the eye of the arrow or pin, which he confines *within* the handle, but at its *extreme* part. Being thus prepared, he moves forward in the direction of the line to be measured, until he has drawn out the length of the chain; the follower, holding the handle at the other extremity, checks him as he draws it tight, and motions him right or left until his right hand, holding the chain, is exactly in the line, or straight to the

* By the use of this chain a considerable portion of the arithmetical calculations for finding the superficies in acres, roods, and perches, is performed in decimals. See description of the chain, and the computation of areas.

object to be measured to. When the follower has effected this, he holds the *outside* of the handle of his end of the chain to the starting point, and tells the leader to "put down," which order he obeys by fixing one of the iron pins in the ground, and immediately proceeds onward, drawing the chain with him, except he be desired to stop for the purpose of allowing the follower to take offsets, &c., the meaning of which will be presently explained. When another chain's length has been drawn on, the same operation is to be pursued, the leader holding the handle with the pin *within it*, and obeying the signals of the follower, moving right or left, as desired; the leader, in the same manner as at the commencement, holds the *outside* of his handle to the *outside* of the pin, and desires the leader, when in correct position, to put down another pin, at the same time picking up the one first put down, which should be hung on the *thumb* of his left hand. This operation is to be repeated until the whole distance to be measured is gone over, the leader putting down a pin at the end of each chain, which the follower, on arriving at, picks up, taking especial care *not* to pick it up until the leader has put down another. At the end of a line thus measured the number of chains will be denoted by the number of pins in the follower's hand, and the fractional part, if any, over and above the number of chains, by the number of links counted from the follower's end, the counting of which is facilitated by brass marks in the chain at every ten links, as will be hereafter described. If the measurement of a line should exceed the length of ten chains, it will be necessary, on the measuring out of the eleventh chain, for the follower (in whose hands the ten pins will then be) to go forward and put down a pin at the leader's end, or give him one for that purpose, after which, the remaining nine pins

must be given up to the leader, the next one picked up by the follower being the eleventh: — In this way any distance can be measured, without difficulty or confusion, taking care to notice in the field-book each change of the pins, which, of course, represents ten chains. In describing the measurement of the above triangular piece of ground, it is presumed that the open ditches are straight from their extremities, and it should be distinctly understood that all lines must be measured straight from end to end. In the example just referred to, had the land been enclosed by a hedge or bank, instead of an open ditch, it would have been necessary to measure each side of the triangle a little *within* or *without* the bounding fence; in the one case the triangle formed by the measured lines would have been smaller, and in the other larger, than the enclosure; the quantity or distance of the measured lines from the boundary fence on each side, (for it is not necessary that the lines on each side the enclosure should be equidistant from the fences), would be determined at the extremity of each line, by a rod carried by the follower for such purpose, called an offset staff, the method of using which is easily explained.

It is evident that an enclosure bounded by crooked irregular fences cannot be defined by a single right line measured by the side of it. Its length can be determined by the measurement of a single right line, but the bends or crooks in the hedges cannot be so measured, although the omission of them would materially affect the measurement of the area or contents of the field. The bends in a crooked hedge or brook are determined by short measured lines, termed offsets, while a straight line is measured by the side of it to ascertain its length. The method of procedure is thus: — Let




A c d e f g h be a brook or crooked hedge, and A B a straight line, measured by the side of it. From A measure towards B, stopping occasionally to observe if there are any bends in the fence. From A to c it appears to be straight; but, as it changes its direction at c, it is necessary to measure with the offset staff from the chain line, the length i c, at right angles to the chain line A B from the point i. The distance of i from A must be marked down in a book, as well as the offset i c; after which, the measurement of the line A B will be continued until opposite to another bend in the fence, as at d, where j d must be measured and entered in the book as before. In this manner as many offsets are measured as are necessary. To plot these offsets, or draw a plan of them, showing the crookedness of the fence, it is necessary to mark off, with the proper scale, the distances on the line A B, with the corresponding offsets thereto; a line drawn through the extremities of the offsets will represent the crooked fence A c d, &c.