THE

THEORY AND PRACTICE

OF

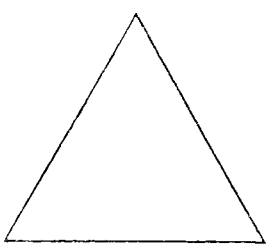
SURVEYING.

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

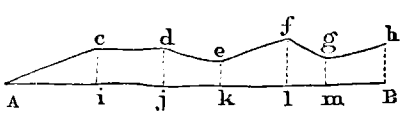
hundred inches, the scale would be one yard to an inch; if drawn ten inches, it would be ten yards to an inch, and so on. For convenience of measuring in the field, and for reducing the results of such measurement to the customary standard of acres, roods, and perches, which is universal in this country (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.

CHAPTER II.

ON SURVEYING WITH THE CHAIN.—A TRIANGLE THE ONLY CORRECT FIGURE EMPLOYED IN SURVEYING.—DIRECTIONS FOR LAYING OUT LINES.—SURVEY OF A FIELD, DIAGONALLY.—DIRECTIONS FOR PLOTTING.—THE FIELD-BOOK OR REGISTER.—SURVEY OF A FIELD WITHOUT A DIAGONAL.—SURVEY OF A WOOD.—IRREGULAR SURVEYING.—SURVEY OF A ROAD.—MEASURING A LINE ON UNDULATING GROUND HORIZONTALLY.

THE observations contained in the last chapter having been carefully read, practical directions will now be given for surveying a single field with the chain alone.* In making a survey with the measuring chain only, we are confined to one geometrical figure—a triangle; for this reason, that, of all plane geometrical figures, it is the only one which, without altering the dimensions of its sides, cannot alter its form;† and, as in this case we only determine its form by the measurement of its sides, it follows that the correctness of the whole depends on the extreme accuracy with which the parts are measured, as well as in the judgment displayed in arranging or laying out the sides of the triangle on the ground. In the operation of surveying a single field, but little choice in this latter respect can be observed; but, where a choice can be had, the triangle should be as nearly equilateral as

* We say here "with the chain *alone*," because as the reader proceeds he will find other means accompanying the chain in effecting a survey. Reference must also be made to another part of this volume for an explanation of the various methods of computing the superficial contents of land.

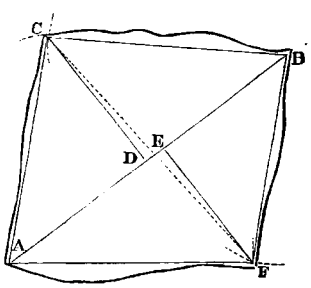
† This follows from Euclid's proposition, "That upon the same base, and upon the same side of it, there cannot be two triangles having their two sides terminated at one extremity of the base equal to one another, and likewise their sides terminated at the other extremity."

possible (*i. e.*, equal sided, and, of course, equal angled), for, if either of the angles be very obtuse or acute, a very trivial error in the admeasurement of any one of the sides will materially alter the figure, and, consequently, the area enclosed within it. We consider it best to proceed gradually; we will commence, therefore, with a single field, as the same system is to be pursued throughout, whether it be a small enclosure, or a large estate, comprehending many enclosures, that is to be surveyed. The first operation to be done in the field is the arranging of the ground to be surveyed, into one or more triangles, according to its shape and circumstances. Thus,—suppose the field to be a four-sided figure; fix at the starting point, in one corner of the field on the longest diagonal or straight line that can be conveniently drawn from one angle to another, a conspicuous mark,* the top or visible part of which must be exactly over the point of commencement. Then look to the opposite corner of the field, and, if no natural mark can be seen sufficiently distinct and defined to be measured to, as a tree, the corner of a house, or other object on the diagonal line intended to be measured, erect a mark, as at the commencement; having done which, commence chaining from the first mark in the direction of the second, always observing to measure in a perfectly straight line. Leave marks on this diagonal or principal line, when arrived at D and E, opposite the other corners of the field, for the purpose of measuring tye or proof lines from those points to the vertex of each triangle, to verify the measurement of the sides. It must be noted in the field-book at what distance from the station or starting point these marks, or

* Generally a stick cut from the hedge, from four to five feet in length, as straight as can be had, with a piece of paper inserted in a slit in one end, from its appearance termed a "white."

"false stations," as they are termed, are put down. When arrived at the opposite corner of the field to that started from, put down another mark, if necessary, and from this station commence measuring a line by the side of one of the fences, without regard to the angle it makes with the preceding line beyond what we have previously mentioned, that it is to be neither very obtuse or acute. Offsets are to be taken to all the bends of the hedge as the measurement is proceeded with. At the termination of this line a mark is to be put down as before, from which a new line is to be measured to the first station. Then measure the tye line from the vertex of the triangle, or junction of the side lines, to one of the previous marks left on the diagonal, which will be a necessary and efficient check on the accurate measurement of the sides.

The same operation is to be repeated on the other side of the diagonal, and the survey of the field will be complete. The following diagram will at once show the manner of proceeding in surveying such a field.



A B is the diagonal or base line; D E the false stations left when measuring the base line; B C one side of the triangle, commenced from the termination of the diagonal; and C A the remaining side, completing the triangle;—having arrived at the point from whence we started.—The measurement of the proof or tye line C D, however, remains to be done, to verify the measurement of the triangle A C B. The same method of procedure is also to be adopted on the other side of the line A B, measuring respectively the sides B F and F A, and the

proof or tye line F E; or these separate measurements of the tye lines might be performed in one operation by measuring from C to F, as shown by the dotted line; taking care to ascertain the distance on the base line at which it crosses, as well as the distance from the same to the vertex of each triangle. This done, the measurement is completed. The next operation is, to lay down these lines (from which the field is to be plotted) on paper; to do which, select a scale to plot the field to, as one, two, three, or more chains to an inch, according to circumstances; but two and a half, or three chains to an inch, is the least scale from which quantities can be correctly computed.* The scale being determined on, draw the line A B in any position, and measure off the length or distance measured in the field with the scale, being careful to mark the position of the false stations D and E. Then take the length B C with a pair of compasses, and describe an arc of a circle from B as a centre. Also take the length A C in the same manner, and describe an arc of a circle from A as a centre. The intersection of these arcs will fix the relative positions of the lines A C and B C, to which point draw them from A and B. The same method of proceeding is to be observed on the other side of the diagonal, in laying down the lines A F and B F. When this is done, measure by the scale the distance from D to C; and in like manner from E to F. If these distances are the same on the plan as measured in the field, their agreement proves that the field-work was correct. If not, an error must have been committed either in laying off the lines on the plot, or measuring them in the field; in which case the

* The reader will bear in mind, we stated, in our first article, that land irregularly bounded was generally, and more readily, computed from a plan, than in any other way. The various methods of computing land are hereafter explained.