# Manual
# Of
# Land Surveving

R.G Gordon ICS

सप्तर्षी प्रकाशन


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# MANUAL OF LAND SURVEYING

## CHAPTER 1

## PRELIMINARY AND GENERAL PRINCIPLES

**Preliminary :**

The surveys conducted by this Department are technically called Cadastral and City Surveys. The Cadastral Survey is a field by field survey of a Revenue Village or an estate undertaken by Government, to ascertain the position of boundaries, area and quality of each field. It provides the data for the Settlement of Land Revenue and the preparation and maintenance of Record-of-Rights.

All our Cadastral Surveys excluding those in the Central Provinces districts of Nagpur, Chanda, Wardha and Bhandara are conducted on the Cross-Staff System. In the Western Maharashtra districts Plane Table is used for maintenance and in other districts the Cross-Staff System is still used even for the maintenance. It is being gradually replaced by the Plane Table System. In the Central Provinces districts, the survey is done by the Theodolite and Plane Table, and the maintenance, so far done by optical square is now replaced by Plane Table.

The work of the Revenue Survey is divided into two sections—

(i) The Traverse.

(ii) The Cadastral.

The Traverse Section comprises the measurement of the angular and linear distances with the help of Theodolite and Chain and it furnishes the skeleton for detailed field work to follow.

The Cadastral Section relates to the measurement of detailed topography on the skeleton provided by the traverse survey by the Cross-Staff or Plane Table.

Detailed instructions about the Theodolite and Plane Table Surveys are contained in the City Survey Manual. The present Manual is restricted to the instructions on Cross-Staff Survey only.

All our Revenue Surveys are conducted on foot-pound system: The Unit of measurement was a Gunter Chain measuring 33 feet divided into 16 parts, called annas, each measuring $2\frac{1}{16}$ feet

The unit of area used is an English Acre with its sub-multiple the Gunter. In Central Provinces districts, a chain measuring 66 feet divided into 100 links was used and the area is calculated in Acres and Cents. After the enactment of the Standards of Weights and Measures Act, 1956 (Act No. LXXXIX of 1956), introducing the Metric System. the Unit of Measure prescribed for the measurement of agricultural lands is the Standard Metric Chain measuring 20 Metres divided into 100 parts, called links. The primary Unit of area is the Square Metre. The derived Units for recording the areas of agricultural lands are the Hectares and Ares.

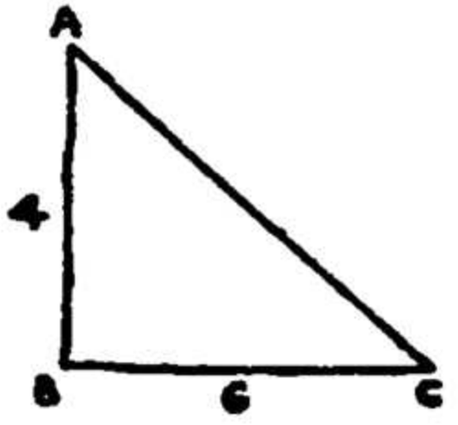
**General Principles:**

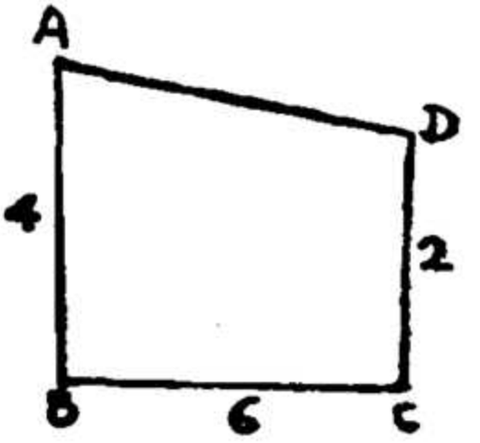
1. Measurment by chain and cross-staff is based upon two simple propositions—

(*a*) that the area ot a right-angled triangle is equal to the base multiplied by half the perpendicular,

(*b*) that the area of a trapezium is equal to the base multiplied by half the sum of the perpendiculars.

*Thus* :




The area of ABC=$6\times4/2=12$ and the area of ABCD=$6\times\frac{4+2}{2}=18$

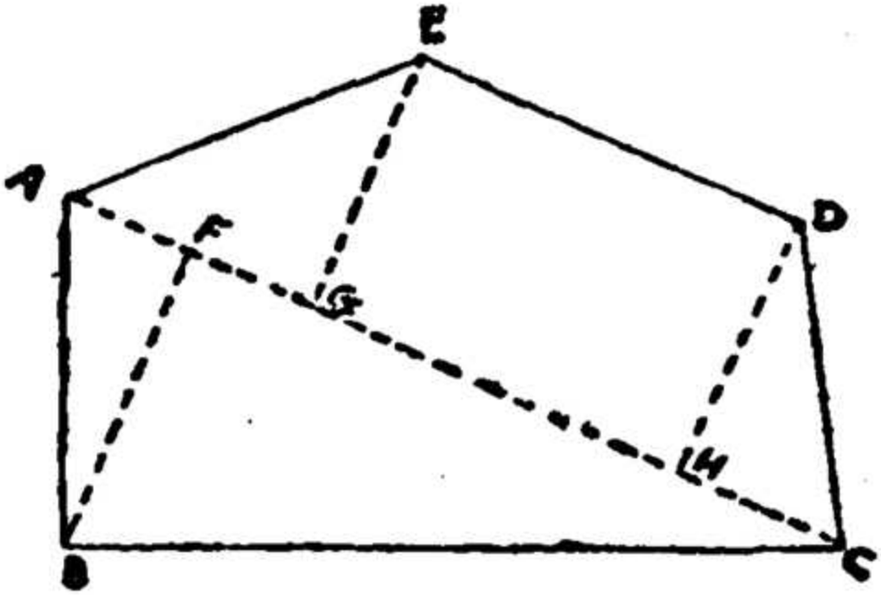
2. In order, therefore, to measure any piece of ground it is only necessary to divide up the area into right angled triangles and trapezia and measure their bases and perpendiculars; and the

areas of these triangles and trapezia individually can then at once be found by multiplication and the area of the whole by adding them all together.

3. Two instruments are, therefore, required—
   (*a*) one to divide the area into triangles and trapezia,
   (*b*) a second to measure the lengths of the bases and perpendiculars. The instruments are the Cross-Staff and the Chain.

4. **The Cross-Staff.**—The Cross-Staff is a very simple instrument for laying of perpendiculars to a given chain line. This consists of a staff about 1.50 metres long and about 1.5 centimetres in diameter having a piece of wood at the top, called the head about 10 centimetre square. On the upper surface of the head two grooves are cut about a centimetre deep and at right angles to each other crossing in the centre. The staff is sharply pointed at the lower end so that it can be stuck into the ground. In an improved form the head is made of iron with 4 flaps bent up at right angles and containing slits which serve the purpose of the grooves in the simpler form of instrument. To divide up any area into right-angled triangles and trapezia with this instrument it is only necessary to take a base line from one corner of the area to another; then by moving down this base line with one groove of the Cross-Staff in the same straight line, right angles can be observed to all the corners of the area in turn by means of the other groove and the whole area thus divided up into right-angled triangles and trapezia.

*Thus* :—

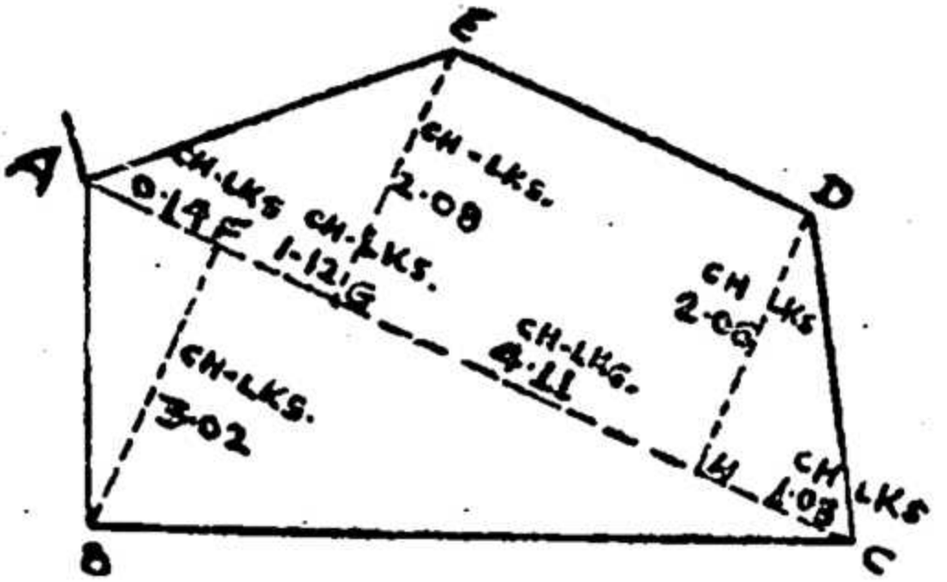


To divide the area ABCDE into right-angled triangles and trapezia, it is only necessary to fix a base line AC: then by moving along from A to C right angles can easily be formed to the points B, E and D and the points F, G and H fixed.

The area is now divided into the right-angled triangles AFB, FBC, DHC and EGA, and the trapezium EGHD. We have now, therefore, only to measure their base lines and perpendiculars and the area of the whole can at once be found. This measurement is done by means of

5. **The Chain.**—The Chain prescribed under the Bombay Weights and Measures (Enforcement) Rules is the Standard Metric Chain measuring 20 Metres divided into 100 links. Measurements of lengths are to be expressed in terms of chains and links. The mode of writing prescribed is as shown below :—

3 Chains and 6 links is written as 3.06.




To return to the example given. Taking the chain we measure from A—F and the length is found to be 0.14 links. We next measure from F—B and the length is 3 chains 02 links. From F—G the length is 1 chain 12 links, and from G—E 2 chains 08 links. Similarly, G-H, H-D and H-C are measured, the lengths being 4 chains 11 links, 2 chains 06 links and 1 chain 03 links, respectively.

The area A B C D E has now been divided into 4 right-angled triangles and one trapezium and their bases and perpendiculars have been measured. It only remains, therefore, to find—

6. The Area.—The square measures adopted in the Bombay Survey in the past are :—

Prati anna

Anna

Gunter

Acre

The table of square measure is :

| | | |
|---|---|---|
| 16 Prati annas | = | 1 Anna. |
| 16 Annas | = | 1 Guntha (121 Sq yards) |
| 40 Gunthas | = | 1 Acre (4840 Sq. yards). |

Their relation to the measures of length is ;

| | | | | |
|---|---|---|---|---|
| Annas | × | annas | = | Prati annas. |
| Chains | × | annas | = | Annas. |
| Chains | × | Chains | = | Gunthas. |
| 40 Square Chains | | | = | 1 Acre. |

According to the metric system the primary Unit of area is the square metre.

This Table of squre measure in Metrice units is—

| | | |
|---|---|---|
| 100 Square Millimetres | = | 1 Sq. Centimetre. |
| 100 Square Centimetres | = | 1 Sq. Decimetre. |
| 100 Square Decimetres | = | 1 Sq. Metre. |
| 100 Square Metres | = | 1 Are or 1 Sq. Decametre. |
| 100 Ares | = | 1 Hectare or 1 Sq. Hectometre. |
| 100 Hectares | = | 1 Sq. Kilometre. |

Thus to find out the product of 3 chains and 6 links and 2 chains and 5 links :

$$\begin{array}{r} 3{\cdot}06 \\ \times 2{\cdot}05 \\ \hline 1530 \\ 612\times\times \\ \hline 6{\cdot}2730 \end{array}$$

The product is 6.27 square chains. Each chain is equal to 4 Ares. The area is, therefore, 25 Ares or 0.25 Hectares.

The areas are being rounded off to the different degrees of accuracy according to the class of land and its non-agricultural use and value —

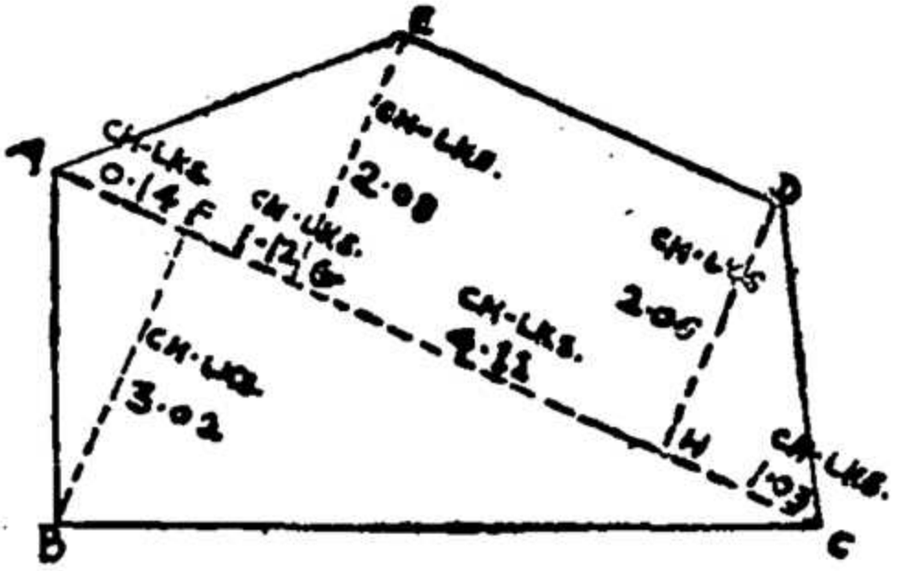
(1) In case of Dry crop class, the areas are to be rounded off to the nearest Are.

(2) In case of rice and garden classes, the areas are to be rounded off to the nearest one digit of demical of an Are.

(3) In case of land used for non-agricultural purposes, the area is to be worked out to two digits of demicals of an Are.

(4) In case of city survey properties the areas are to be worked out in square metres up to one digit of decimal.

7 To return once more to our example, we have to find the areas of—




AFB
FBC
DHC
EGA } Right-angled triangles

EGHD Trapezium

As explained in paragraph 1, the area of a right-angled triangle = the base × half the perpendicular

The area of AFB therefore $= 0{\cdot}14 \times \frac{3{\cdot}02}{2}$ or 1·51

Working out this sum

$$\begin{array}{r} 0{\cdot}14 \\ \times 1{\cdot}51 \\ \hline 014 \\ 070\times \\ 014\times\times \\ \hline 0{\cdot}21114 \end{array}$$

Square chains.

Similarly, the area FBC equals

$$6{\cdot}26 \times \frac{3{\cdot}02}{2} \text{ or } 1{\cdot}51$$

$$\begin{array}{r} 6{\cdot}26 \\ \times 1{\cdot}51 \\ \hline 626 \\ 3130\times \\ 626\times\times \\ \hline 9{\cdot}4526 \end{array}$$

Square chains.

and the area of DHC equals

$$1{\cdot}03 \times \frac{2{\cdot}06}{2} \text{ or } 1{\cdot}03$$

$$\begin{array}{r} 1{\cdot}03 \\ \times 1{\cdot}03 \\ \hline 309 \\ 103\times\times \\ \hline 1{\cdot}0609 \end{array}$$

Square chains

and of EGA

$$(0{\cdot}14)+(1{\cdot}12)=1{\cdot}26\times\frac{2{\cdot}08}{2}\text{ or }1{\cdot}04$$

$$\begin{array}{r} 1{\cdot}26 \\ \times 1{\cdot}04 \\ \hline 5\,0\,4 \\ 1\,2\,6\times\times \\ \hline 1{\cdot}3\,1\,0\,4 \end{array}$$

Square chains.

There remains the trapezium EGHD. As explained in paragraph 1 the area of a trapezium = the base $\times$ ½ the sum of the perpendiculars. Hence the area of EGHD =

$$(4{\cdot}11)\times\frac{(2{\cdot}08+2{\cdot}06)}{2}\text{ or }2{\cdot}07$$

$$\begin{array}{r} 4{\cdot}11 \\ \times 2{\cdot}07 \\ \hline 2\,8\,7\,7 \\ 8\,2\,2\times\times \\ \hline 8{\cdot}5\,0\,7\,7 \end{array}$$

Square chains

8. Adding these totals together the result is the area of the whole.

| | | |
|---|---|---|
| AFB | = | 0·2114 |
| FBC | = | 9·4526 |
| DHC | = | 1·0609 |
| EGHD | = | 8·5077 |
| EGA | = | 1·3104 |
| | | 20·5430 Square chains |
| | | × 4 |
| | | 82·1720 |

But in making up the final area the rounding is to be done up to the full Are. Hence in the present example the final area will be 82 Ares, *i.e.*, 0.82 Hectares.

- - - - -

By the means described above the area of any piece of ground of a reasonable size can be found. There are of course intricacies which will be dealt with later on but the basis of all measurements by chain and Cross-Staff is the same. Other details are merely refinements.

## CHAPTER II

## THE USE OF THE CROSS-STAFF AND CHAIN

1. The Cross-Staff.—The use of the Cross-Staff is to take right angles from the base line to the corners of the plot which is to be measured. Five minutes practice in the field with the instrument is of course worth pages of talk on the method of doing it, but there are certain points to which attention may here be particularly directed.

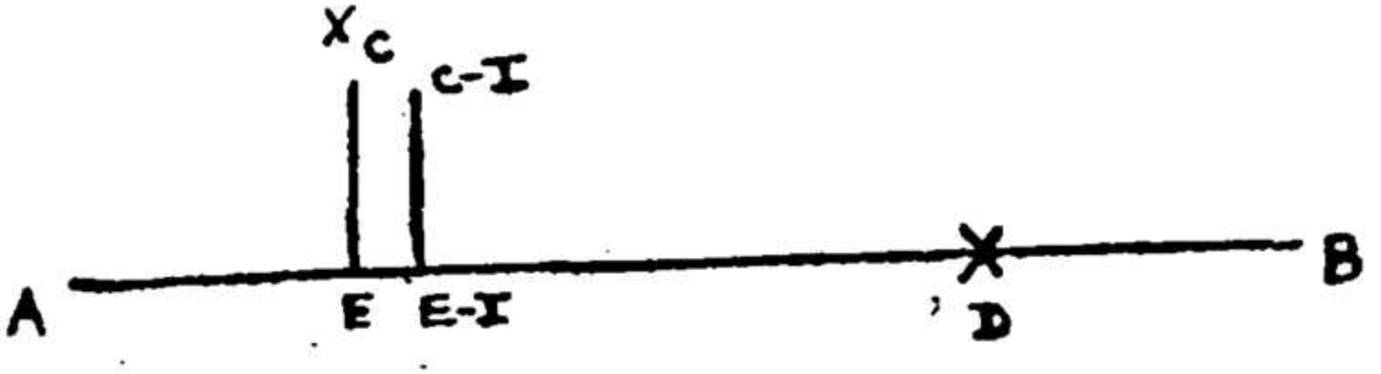
2. In using the Cross-Staff the first essentials are—

(*a*) accuracy.

(*b*) quickness.

Upon the point of 'accuracy' there is no need to dwell. Inaccuracy in taking an angle can only be due to mere carelessness to guard against which no rules can be framed.

3. Quickness, however, is a different matter and on this point help can be given—




If AB be the base line and C the point to which an offset is to be taken then the object is to find the point E as quickly as possible. D is a third flag placed on the base line close to the end towards which the measurer is proceeding to save him the trouble of constantly verifying the relative positions of A and B. The point E is that place where the one grcove of the cross-staff points directly down the base AB and the other grcove at right angles directly to the point C. For the purpose it is necessary for the Surveyor to move on the base line. To guide the cross-staff surveyor to remain on the line AB, a third flag is always placed

on the base line close to the end towards which the measurer is proceeding. For walking on the base line, it is always necessary for the surveyor to be guided by two flags in front of him.

The next step is to take the angle. The simplest way to get the approximate position is for the measurer to stand in the base line and take the approximate angle across his chest to the offset flag. Having done this he can then drive in the cross-staff and the position will not be far wrong.

If it is wrong then he should at once decide how far forwards or backwards he should go to find the correct position. It is a simple thing to decide whether the angle has been taken correctly or not. If it is found that the object is to the left or right from the approximate position he has selected he must at once move towards left or right as the case may be. For this purpose it is necessary to use the judgment as to how far is the object from the point he has sighted and to immediately move forward or backward approximately that much distance to arrive at the desired point.

In the above figure supposing that the surveyor is standing on the point E-I and seeing the object C-I instead of C, then the surveyor should at once judge as to what would be the probable distance between C and C-I and move back that much distance on the base line to arrive at the correct position C because the distance between C and C-I is equal to the distance between E-I and E. It is no use dodging backwards and forwards time after time driving the cross-staff into the same discarded positions without using properly ones eyes and judgment in deciding as to how far he is away from the correct position on the base line.

To sum up.

(*a*) keep the chain straight down the base line,

(*b*) before attempting to take the angle, fix upon a position approximately correct,

(*c*) if it is wrong, decide quickly how far you are out.

The longer the offset greater the difficulty in correctly judging how far one is away from the correct position.

Hints to be observed in the use of Cross-Staff—

(i) Plant the cross-staff upright in the ground so that it does not incline in any direction.

(ii) When the forward or back station has been sighted through one groove, the staff must not be held or touched while observing the right angle.

(iii) If the ground is very hard observations may be made by two men who must look through the grooves simultaneously and the cross-staff may be held firmly by one of them.

(iv) Always check the correctness of the chain-line by sighting both forward and back stations.

(v) Taking of long offsets should be avoided. Offsets of three chains and upwards in length should be observed and measured with special care by reason of the possibility that error in the instrument or in observation may seriously affect the accuracy of the results at such distance.

4. **The Chain.**—The proper manipulation of the chain is of far more importance than that of the cross-staff. Carelessness in the use of the latter can seldom make a difference of more than link or two but carelessness in using the chain may often make a difference of a chain or more.

5. As already stated the standard metric chain measures 20 metres and is divided into 100 parts called links. It is made of galvanised steel wire with brass swivel jointed handles at both ends which are included in the total length measurement. The links are jointed by oval rings to give 2 metre reading and tallied at every two metres with knotched tags. At every tenth link there are brass indices to facilitate the counting of the number of links. The chain is liable to many errors chiefly on account of rough usage to which it is often subjected resulting in bent links, broken rings, etc. Before commencing to measure, therefore, every measurer should test his chain with the steel tape. The chain should be laid out on the ground and measured with the steel tape. If it is found incorrect the measurer must be careful to make the necessary allowances in the ensuing measurement and also to have the chain repaired correctly at the earliest opportunity.

6. The chain is driven by two chainmen called, respectively, the Backman and the Foreman. The latter is provided with 10 iron spikes (called arrows) with which to mark off chains as they are measured.

In driving the chain,

(*a*) The Backman places the handle at his end against the flagstone pit, etc., which marks the point of departure the measurer standing behind him.

(*a-i*) The point from which the measurement begins is called the starting point and the other end of the straight line to be measured is called the closing point.

(*b*) The Foreman then stretches out the chain tight and flat upon the ground the measurer directing him to move right or left until the chain lies quite straight in the desired direction.

(*c*) The Foreman then sticks an arrow into the ground at his end of the chain (or if the ground be very hard makes a cross thus X) and lays the arrows beside it.

(*d*) The chain is then moved forward at the order of the measurer pulled by the Foreman, being swung a little on one side that the arrow may not be moved from its position. The process described above is then repeated.

(*e*) As the chain is moved forward the Backman picks up the arrows one after the other until the measurement is complete. The total number of chains measured can then be found from the number of arrows in the hands of the Backman (those in the hands of the Foreman being also counted as a measure of check) and a number of links reckoned from the chain as it lies on the ground a half link or under being disregarded, and over half a link being taken as one full link (of course if the measurement completes a full chain then one more chain must be added to those reckoned by the arrows).

(*f*) In order to mark the point on the base line to which the measurement is taken, a pit is then dug by the Pickman at the end of the complete link. Thus if the measurement on the chain reads 34$\frac{1}{2}$ links this will be taken as 34 links and the pit is dug at the end of the 34th link. The measurement is reckoned in terms of full links. The distance up to half the link is discarded and more than half the link counted as full link.

(*g*) The arrows in the hands of the Foreman are then returned to the Backman after the base line has been measured. The offset line is measured in the same way the cross-staff being placed in the pit to mark the point to be measured to.

7. All this sounds very complicated but after a little practice the work becomes mechanical. It is essential, however, that it should become mechanical in the right way, and in this connection the following points are worthy of particular notice :—

(*a*) The measurer must invariably walk behind the chainmen and direct them what to do. The practice of certain measurers who go on ahead taking offsets and leave their chainmen to follow at their leisure is strongly to be deprecated. Incorrect measurement is bound to be the result.

(*b*) After a measurement is taken the measurer should invariably ask both chainmen how many arrows they have got and see that their answers are correct. This is the only way to check mistakes arising from dropped arrows, mistakes in counting on the part of the Backman, etc.

(*c*) The measurer must always see that the Backman returns his arrows to the Foreman before a new measurement is commenced. Many mistakes arise from the Backman omitting to give back his arrows with the result that they are wrongly counted in the next measurement also.

(*d*) The measurer should use as few words as possible in issuing orders to the chainman. The only words necessary to be used are the following :—

Stretch out the chain,—
Right or left (to the Foreman),
Stick in the arrow,
Move on,

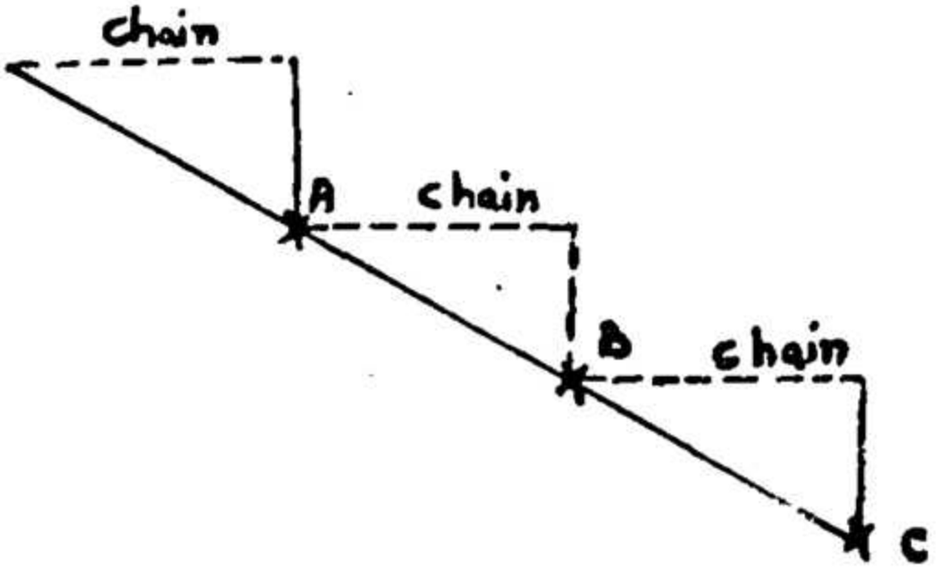
and on the completion of a measurement

How many arrows have you ? (to the Backman)
How many arrows have you ? (to the Foreman)
Return the arrows (to the Backman)
Dig a pit (to the Pickman)

If the measurer learns to use these words mechanically in their invariable sequence the chance of mistakes occurring will be very considerably lessened.

8. It may be noted that chain measurements are meant to be taken over flat superficial areas only. Hence, if a measurement has to be made, *e.g.*, over a mound or other obstacles the chainman must be ordered to hold the chain horizontally in the air and the measurement fixed by dropping the arrow perpendicularly from the end of the chain.

9. Again chaining up or down the side of a slope which is at all steep should be carried out as shown in the sketch attached.




In a series of steps the chain being held out horizontally by the Backman or Foreman according as measurement is proceeding up or down hill and the points A, B and C fixed by dropping the arrow as described above. This process is called stepping or levelling or breaking the chain.

10. If the distance to be measured is very long intermediate flags should be placed so that the chain may not deviate from the line required.

11. It sometimes happens that in the course of measurement the closing station becomes invisible after a certain length. The follower cannot, therefore, direct the leader. The latter should then fix his position in the line with reference to the starting station. Where the starting station also becomes invisible, the surveyor should plant flags at either end of the chain wherefrom it was last visible and the chainman should find his position with reference to those flags.

# CHAPTER III

## THE MEASUREMENT OF FIELDS

1. Having learnt the proper methods of using the cross-staff and chain, the measurer can now proceed to the measurement of a field. All the Revenue villages in this State except a few in the forest sticken areas in West Khandesh are since surveyed and mapped. It may, therefore, be noted that all the practical work which will have to be carried out by the surveyors will usually be in connection with areas already surveyed and mapped, *i.e.*, survey numbers. Before, however, he can proceed to the study of the special problems involved thereby the surveyor must learn the ordinary technique of field measurement and how to avoid ordinary difficulties involved in the use of the cross-staff and chain.

2. The measurement of an ordinary field being the foundation of the art, this will be described in detail.

**Measurement of a field :**

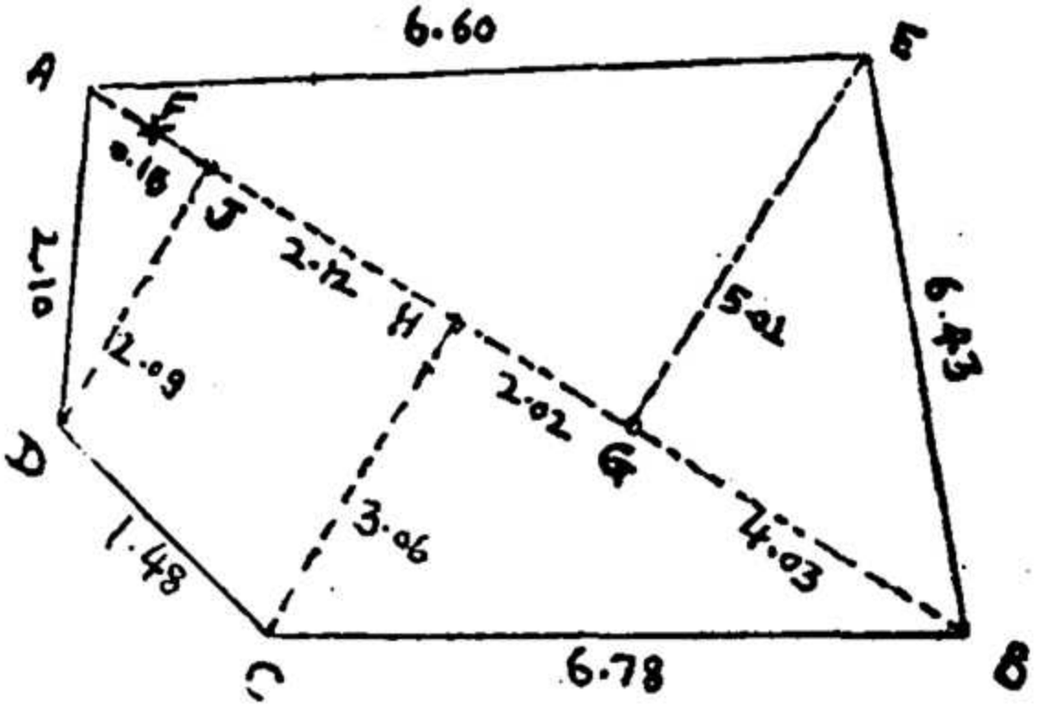
(*a*) The surveyor will be provided with a cross-staff, chain and 10 arrows and a field book in which to note the measurements. He will also have flag holders bearing poles to mark the base line and offsets, chainman and a pickman.

(*b*) He will first go round the boundaries of the field and draw a rough sketch of the field he has to measure and station a flag at every corner to be plotted. The sketch should show all bends, the positions of tri-junctions of the adjoining fields and the most conspicuous objects such as wells, houses, temples, roads and streams and important fruit trees. To get a tolerably good eye sketch, the following instructions should be borne in mind while preparing the rough sketch :—

(1) The North point should always be indicated first.

(2) The surveyor should start from one corner of the field and proceed round the field keeping always to the same direction either right or left. As he goes he should send a man in advance to the next stone. He should then walk towards the man preferably counting paces as he goes. This will give him an approximate idea of the distance between the two stones. He should next determine roughly the length of the line to be

drawn by him on paper for the distance paced by him and he should accordingly draw the line between the first and the second mark. This process should be repeated at each mark until the starting station is reached. The above procedure applies to the survey of isolated fields in surveyed tract. In initial survey the demarcation sketches should be drawn as the demarcation progresses. As a general rule every bend more than 6 links out of the straight line is treated as a bend and plotted. There are however, variations in different surveys.




It is entirely wrong for the measurer to stand in the middle of the field and tell the flagman vaguely to go to a certain corner He must personally station the man at the exact spot. In the sketch given, flags will be placed at the points A D C B and E. In order to mark these points pits will be dug by the pickman and the flags stationed in them.

(c) The measurer will next proceed to select the Base line. This should generally be the longest line between any two corners of the numbers : as AB.

(*d*) Having decided on the base line the base line flag will next be fixed. Proceeding to A and looking along the line AB the measurer will have a flag fixed directly upon the base line close to its further end as at F. A pit will be dug to mark the place.

(*e*) The measurer will next draw a long broken line in his field book to represent the base line in such a way that the north will come at the top of the page.

(*f*) He can now start to measure taking care first to count the arrows in the hands of the Foreman to see that these are exactly 10. Beginning from the point B he will measure up to and take the offset at the point G, chaining and offsetting being carried out as described in Chapter II.

(*g*) After the point G, he will enter in his field book the measurement in chains and links.

(*h*) He will then go to E and measure from E G, draw the offset in his field book in a broken line and write down the measurements. EB will then be joined by an unbroken line.

(*i*) All the base lines and offsets at H and J will then be measured in a similar way and entered in broken lines in the field book, the boundaries of the field being shown in unbroken lines.

(*j*) After the offsets and base lines the boundaries of the field will be measured and the measurements entered in the field book.*

Care and regularity in carrying out the measurement of a simple field are the basis of the art of good measurement. Once this is thoroughly learnt so that every operation becomes automatic then the rest is easy. Every measurer in training should, therefore, be thoroughly grounded in simple measurement before he is allowed to proceed further. In the following pages it will be presumed that this has been done and only the details necessary to explain the particular case wil be given.

3. **Measurement of a field on two or more base lines.**—It will sometimes be found inconvenient for various reasons to measure a number on one base line, *e.g.*, the offsets from one base line may be very long and long offsets are to be avoided as making for inaccuracies.

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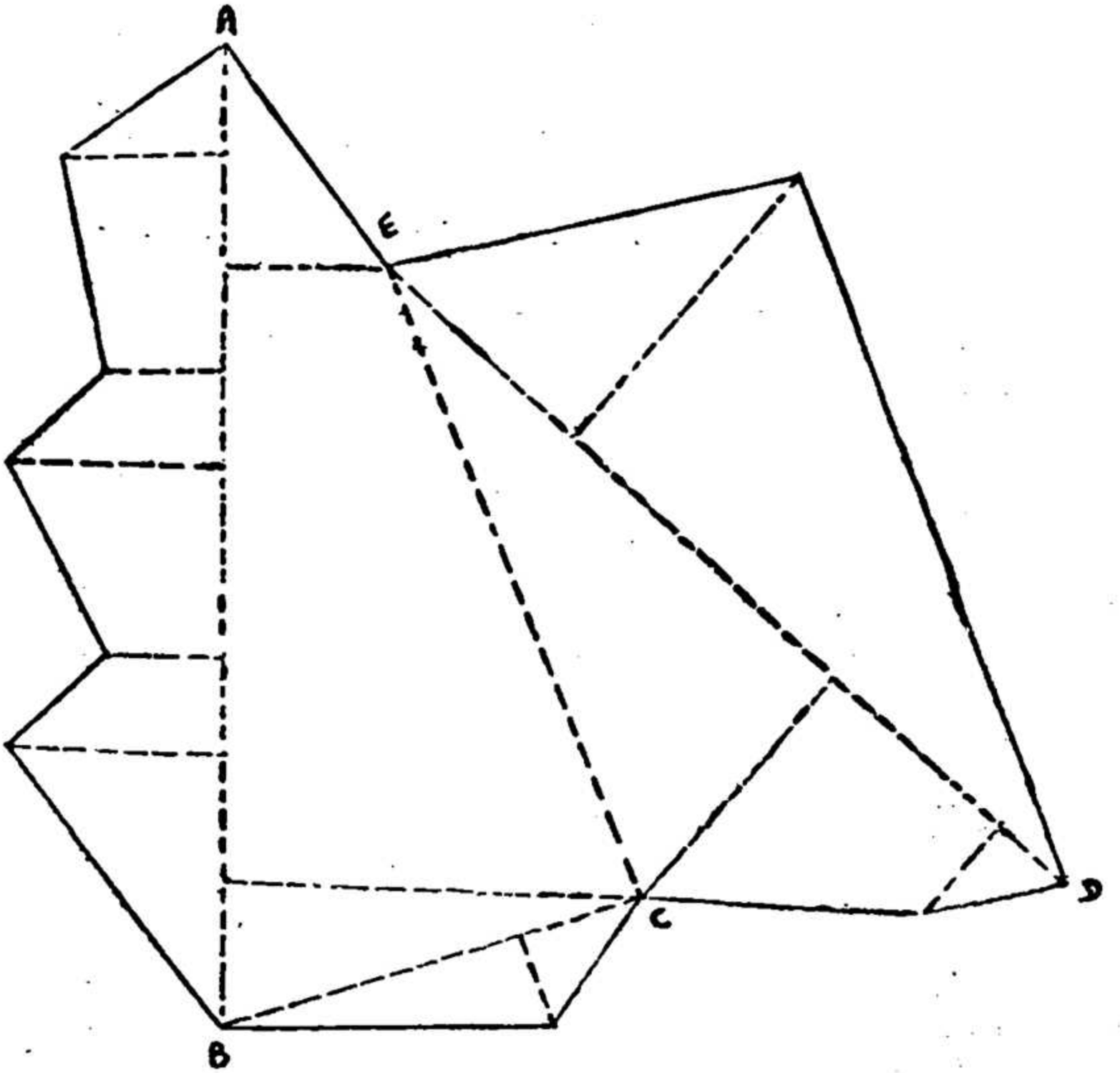
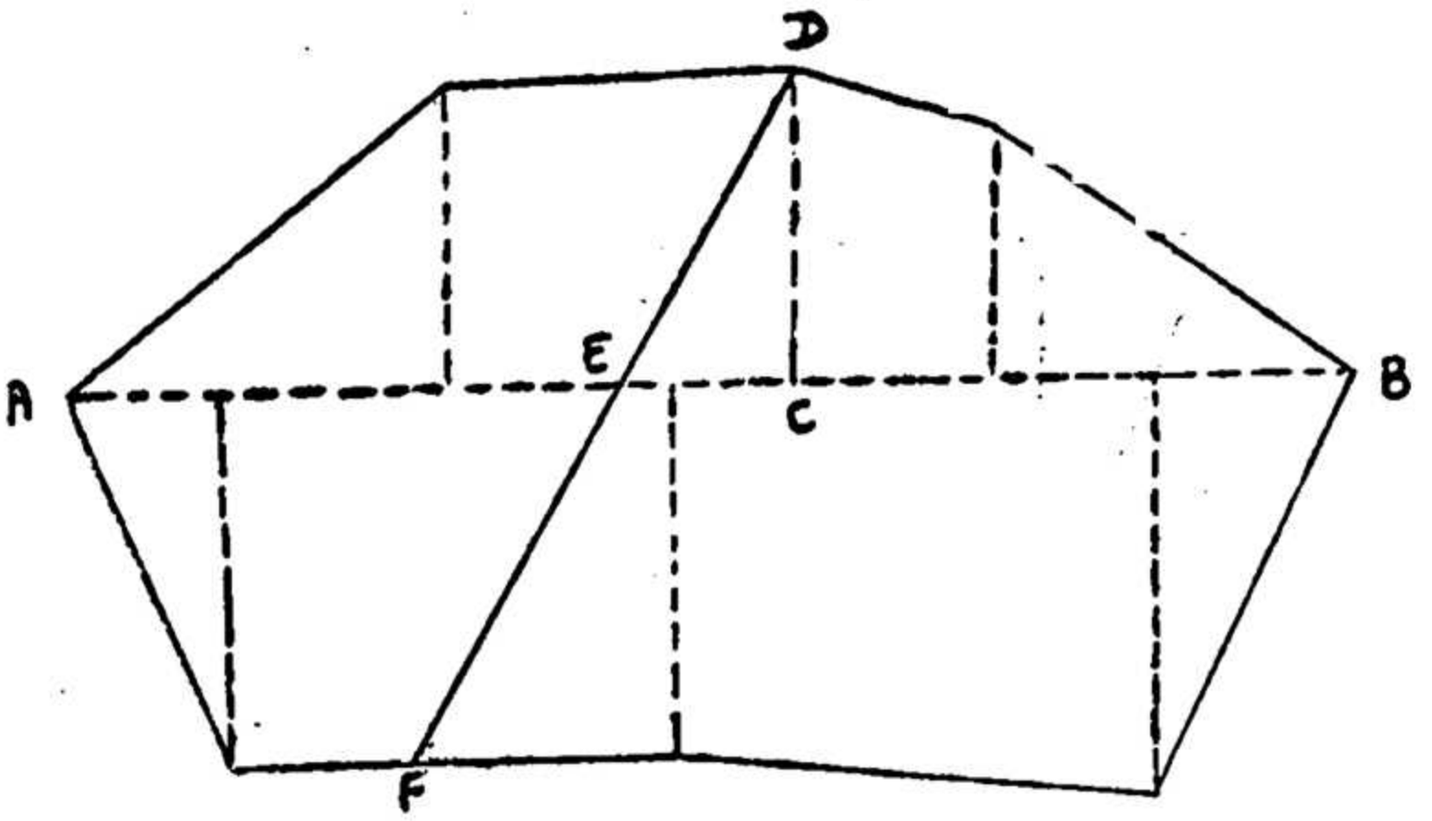
*1. If the measurer has two chains the Bandh Maps may be measured simultaneously with the base line and offsets.

2. In the Konkan the Bandh Maps are not measured.

In such cases the measurer will select two or more base lines as may be necessary and take the offsets to the corners from them. In the example given it will be seen that there are three base lines, *i.e.*, AB, BC and DE. Had one base line only been selected some of the offsets would have been very long.

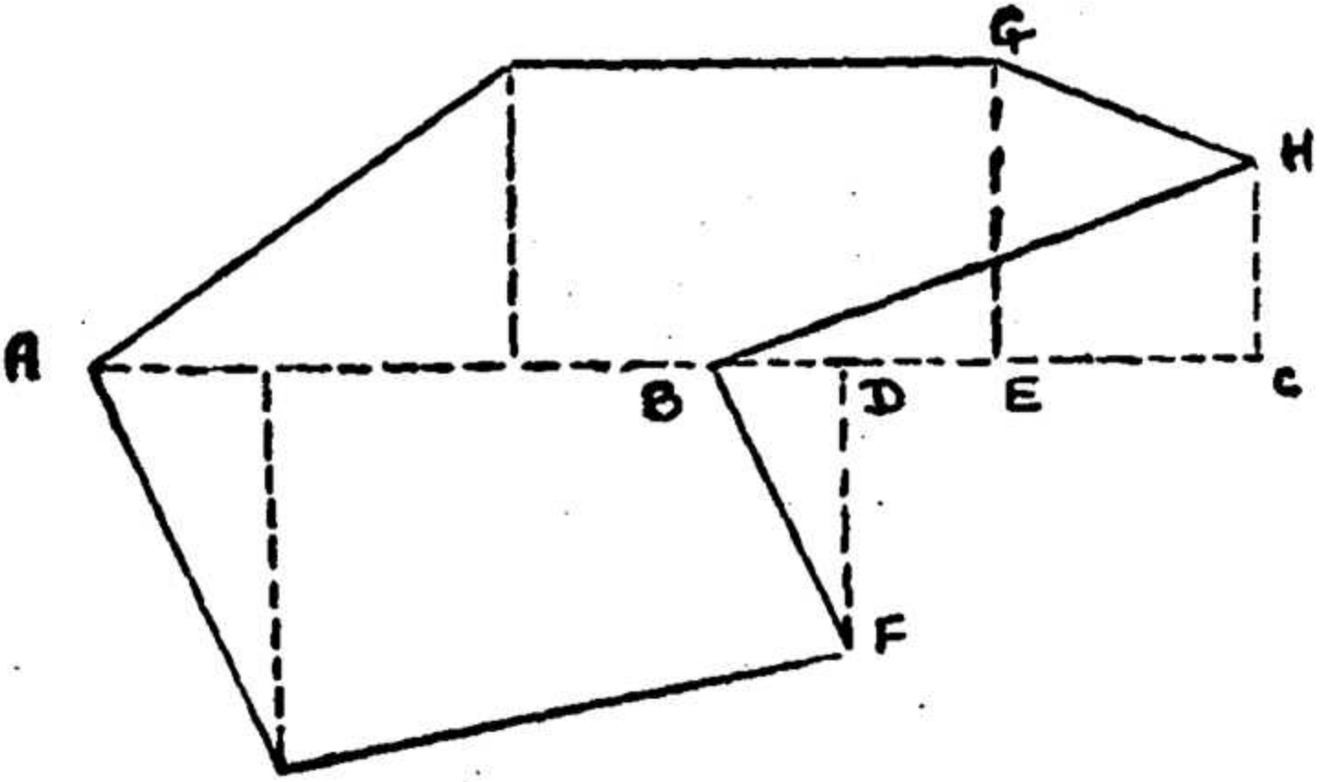


**4. To measure two numbers on one base line.**—The only precaution to be observed is that the measurer must mark the point where the dividing boundary of the numbers cuts the base line. The quickest way to find this point is for the measurer after taking the offset at C to D to go to the point D and move a flag-holder up the base line till the flag-post is in a straight line on the base line at E between D and F which will be the point required.

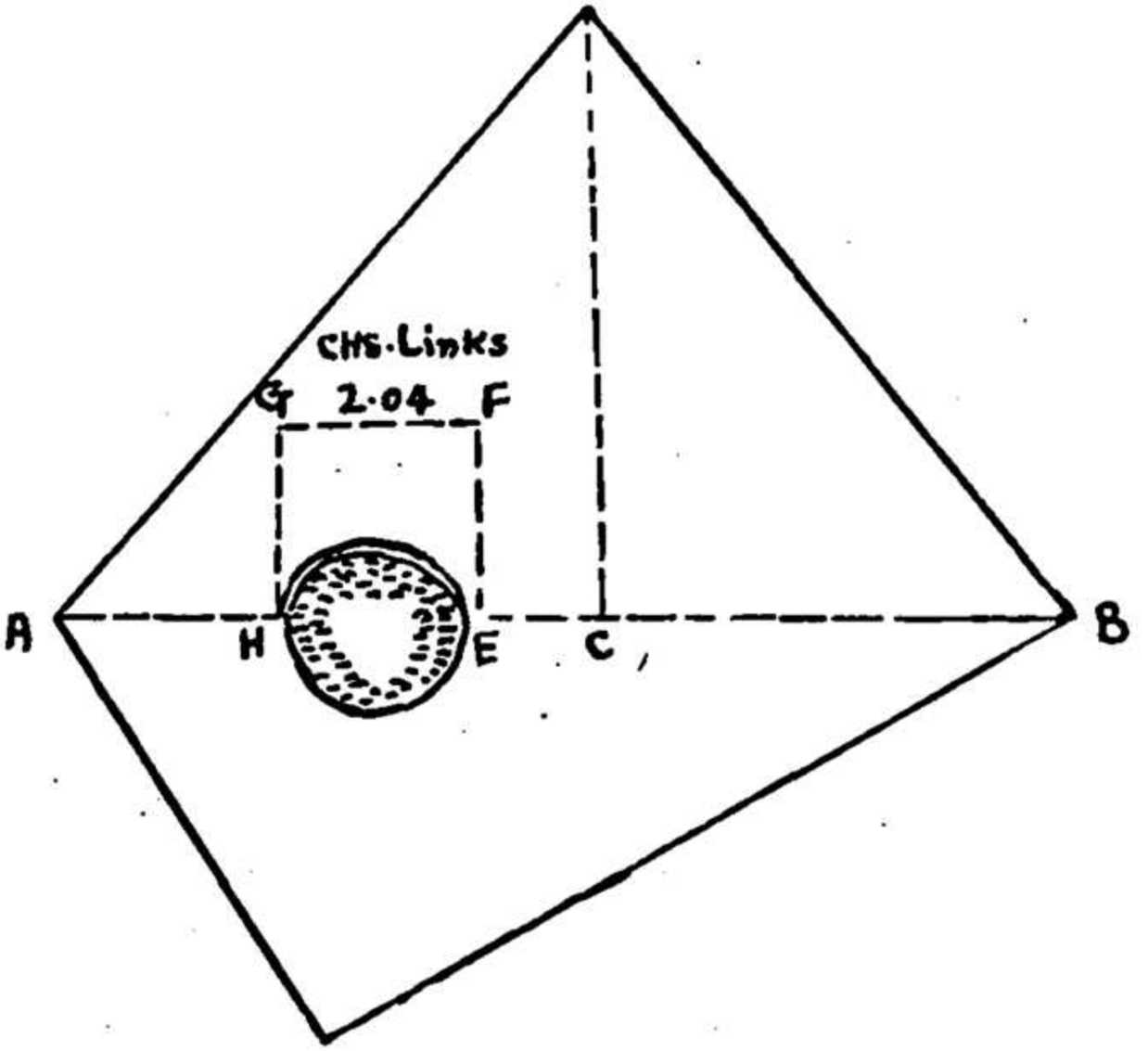



**5. Measurement on an extended base line.**—Some fields are so irregularly shaped that an offset cannot be taken conveniently to some of the corners from a base line lying wholly within the field. In such cases the base line must be extended and the necessary offsets taken from the extended line. Thus in the example given the base line A B will be extended to C and offsets taken at D, E and C to the corners at F, G and H.

The measurer must in such instances take great care in drawing in the boundary lines of the field in his field book; otherwise he will be very liable to draw the boundary from F to C and C to H instead of from F to B and B to H.

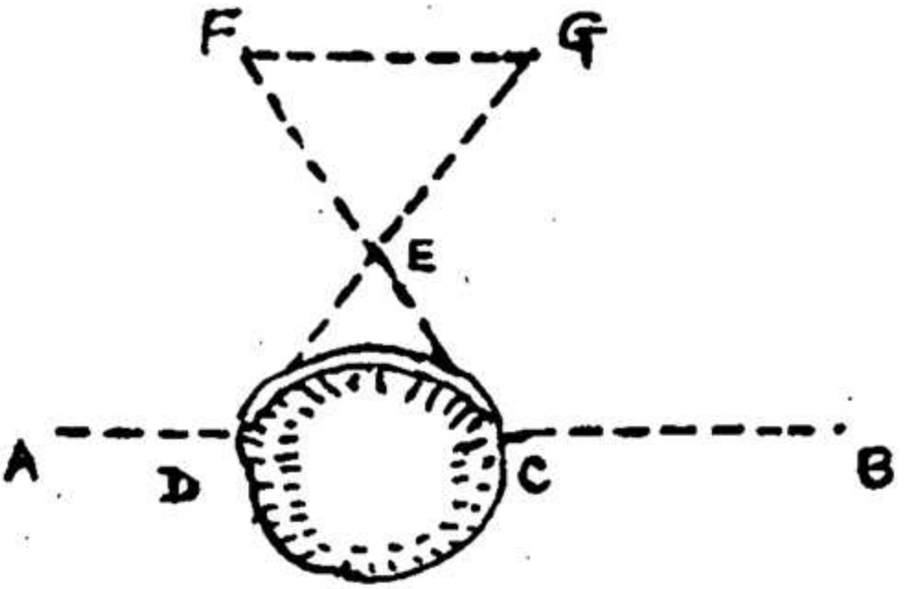



**6. Avoiding an obstacle in the base line.**—It occasionally happens that the most convenient base line is obstructed by an obstacle such as a well or small tank, etc., which cannot directly be chained across. The measurer, therefore, has to go round it as shown in the sketch attached. After taking the offset at C he chains to any convenient point E short of the obstacle. From E he sets off right angle with the cross-staff from the base line to any point F and from E F he sets off a right angle to any point G and from G F a right angle to the base line cutting it at H. Then G F (2 chains 04 links) = H E which is the distance required to be measured.




**7. A second method is as follows :—**

Fix on two convenient points C and D. Measure CE and DE and prolong these lines till EF = EC and EG = ED. Then the distance between FG = DC.

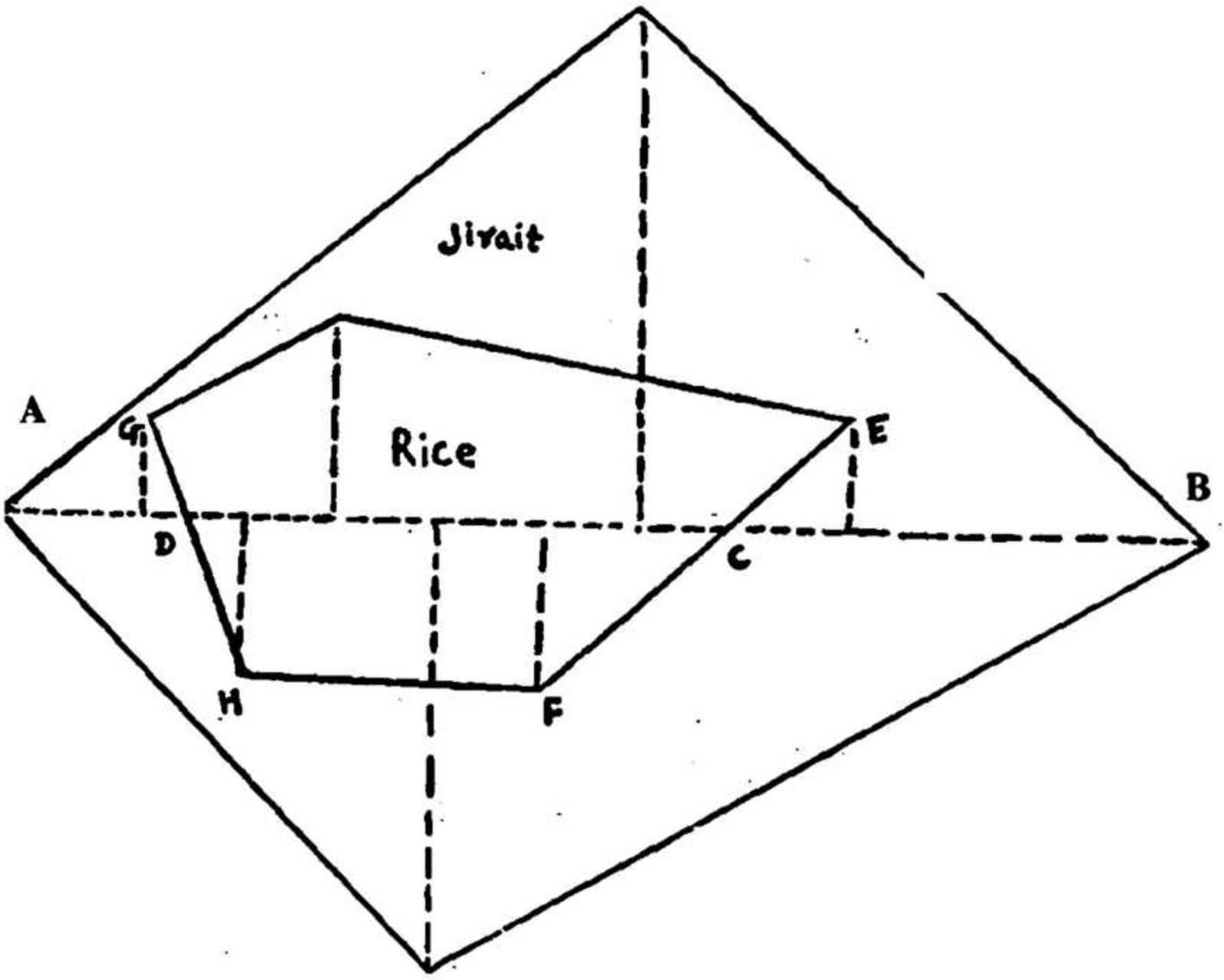



**8. Measuring different classes of land in the same field.**— Sometimes different classes of land are included in the same field and it becomes necessary to find the area of each separately. Thus the example given shows a piece of Rice land enclosed within a Jirait Number.

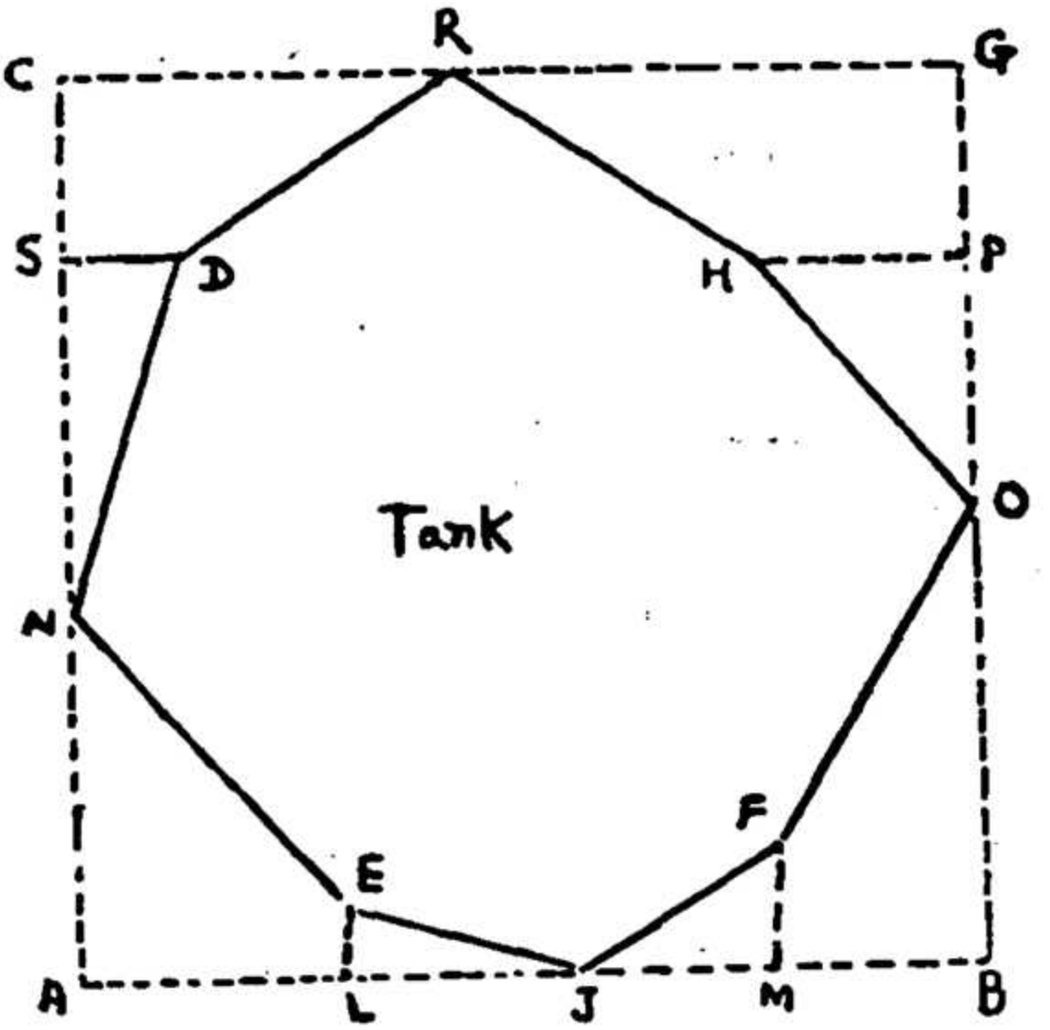
In order to measure these areas separately, the measurer has only—

(*a*) to fix the corners of the boundary between the different classes of land and take the usual offsets to them from the base line ;

(*b*) to mark and fix by measurement on the base line the point at which the dividing boundary of the different areas crosses it, if it does cross. Thus in the example given in addition to fixing the corners from the base line AB in the ordinary way the points C and D where the boundary of the rice land crosses the base will be fixed from EF and GH as described in example 4 above.



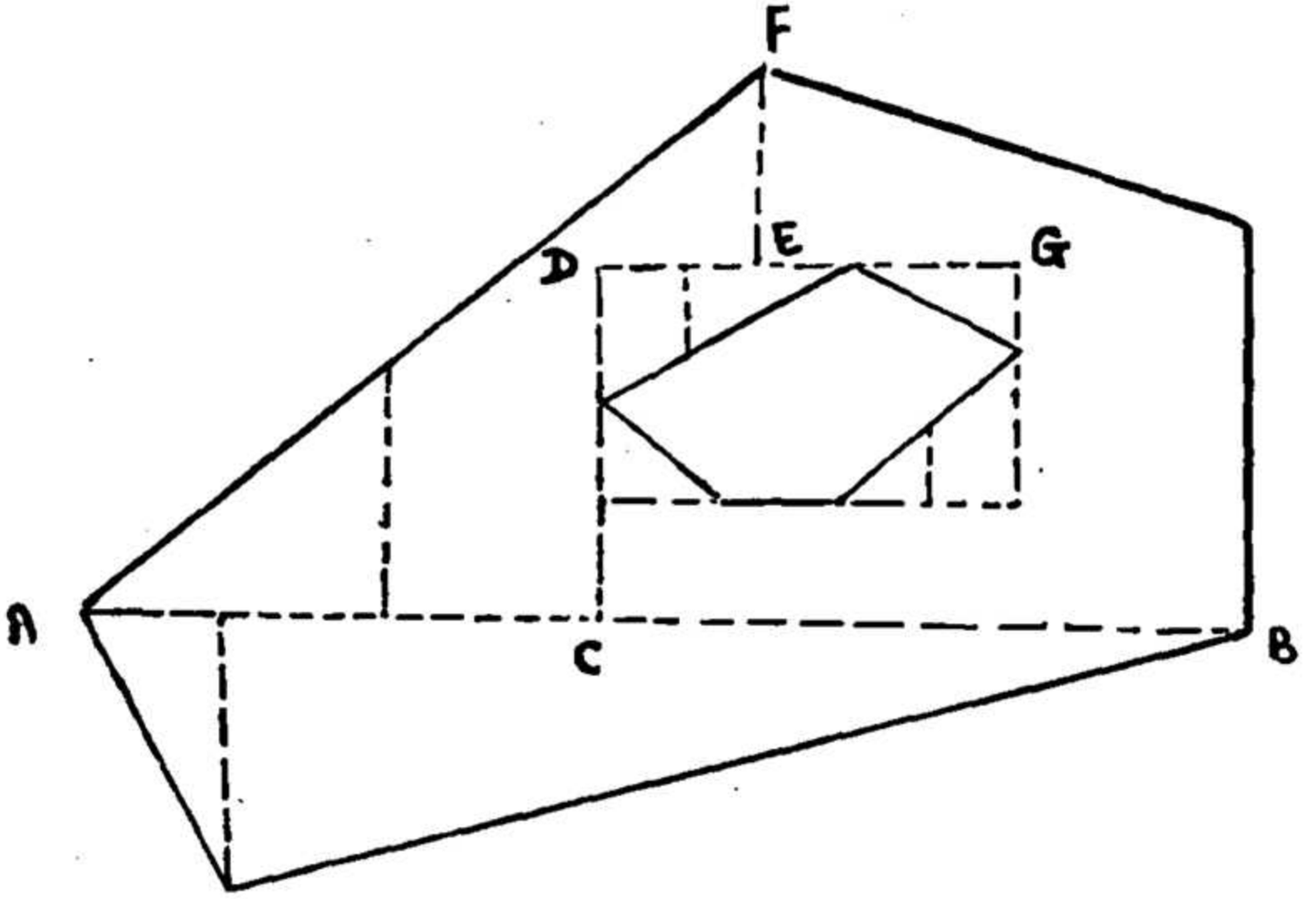

9. **To measure a tank.**—As it is impossible to measure through a tank the measurer has to go round it. He should select a base line—as AB in the example given—and take offsets to the proximate corners of the tank as at E and F. He will then raise another base line at right angles from AB—as AC—and take an offset to the corner at D. Similarly, the base CG will be raised at right angles to AC, and the base GB at right angles to CG and offsets taken to the corners of the tank: then AC GB is a rectangle and its area can be found at once. Then to find the area of the tank it is only necessary to calculate the area of the small figures NALE, ELJ, FJM, etc., and deduct them from the total area of ACG-B. The remainder will be the area of the tank.



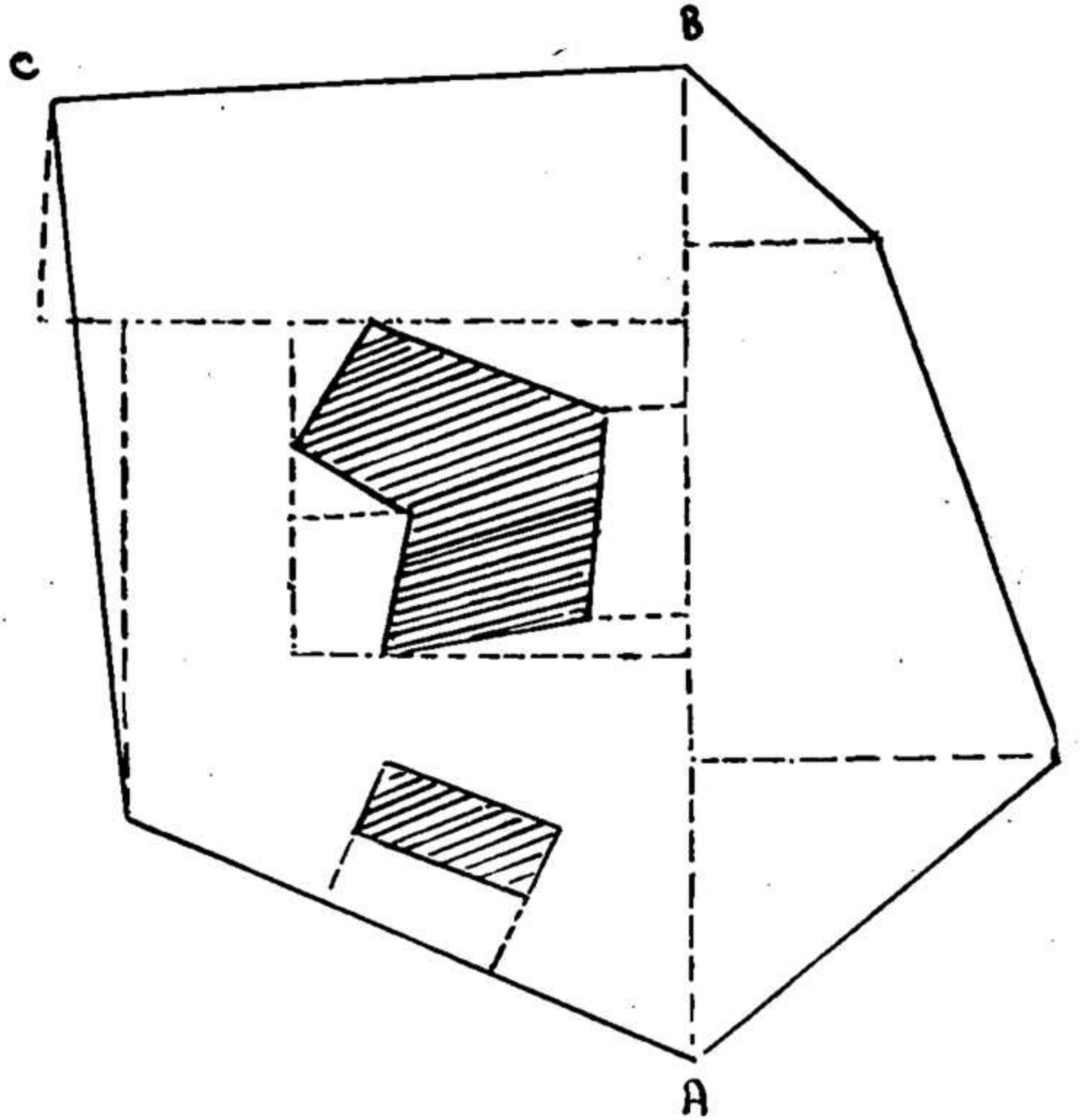

**10. To measure a tank in a survey number.**—In a case such as that shown on the opposite page, it is only necessary to take an offset such as CD—as the base and measure round the tank as described in the last example.

It may be noted that in order to find the area of the number an offset is required to F from the base AB.

The length of this offset can be found easily by taking an offset at E to F from DG as base line and adding the length EF to the length DC which will give the length of the offset required.

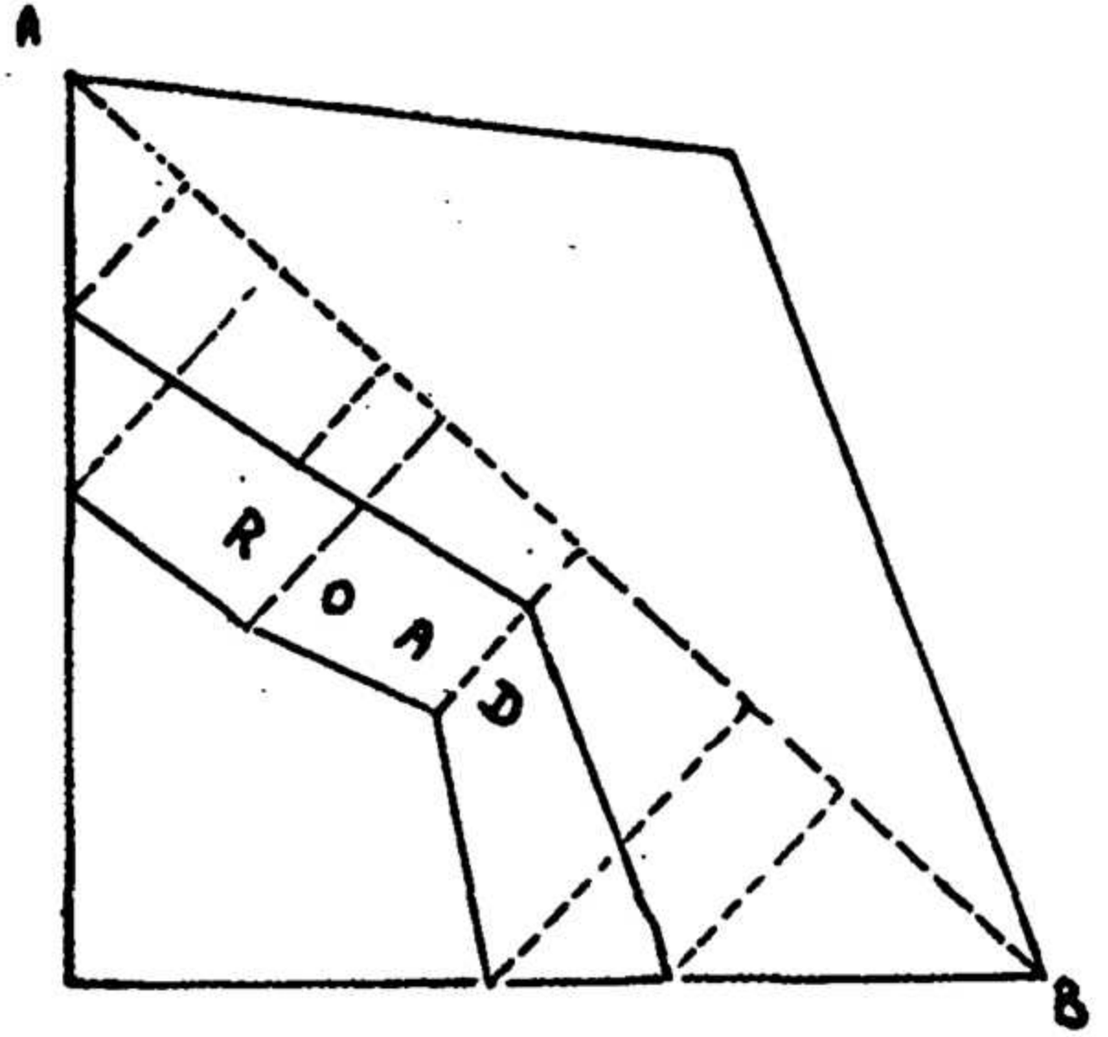



**11. To measure houses in a survey number.**—The principle is the same as in the last example with the difference that you cannot see through a house and hence more intricate base lines are required. Thus in the example given had the houses been tanks one base line could have been taken from A—C, whereas two base lines are actually required. The measurements, however, are made in the same way as in the case of a tank, *i.e.*, by raising subsidiary base lines from the original base, taking offsets to all the corners and finding the area of the house by deduction.



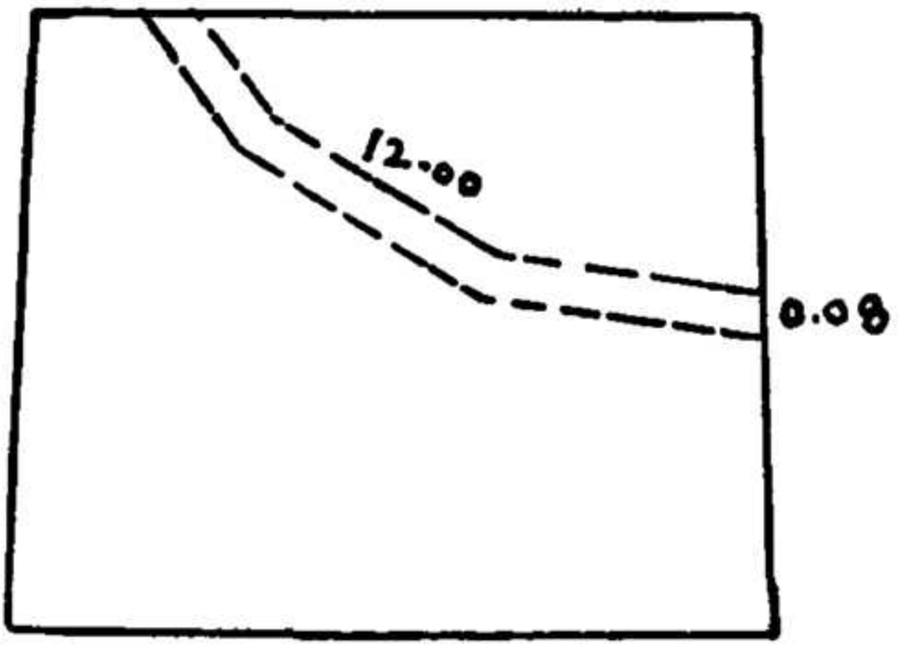

12. **To measure a road in a number.**—All that the measurer has to do is to take offsets to the corners of the road as in example 1.

Exmple 1

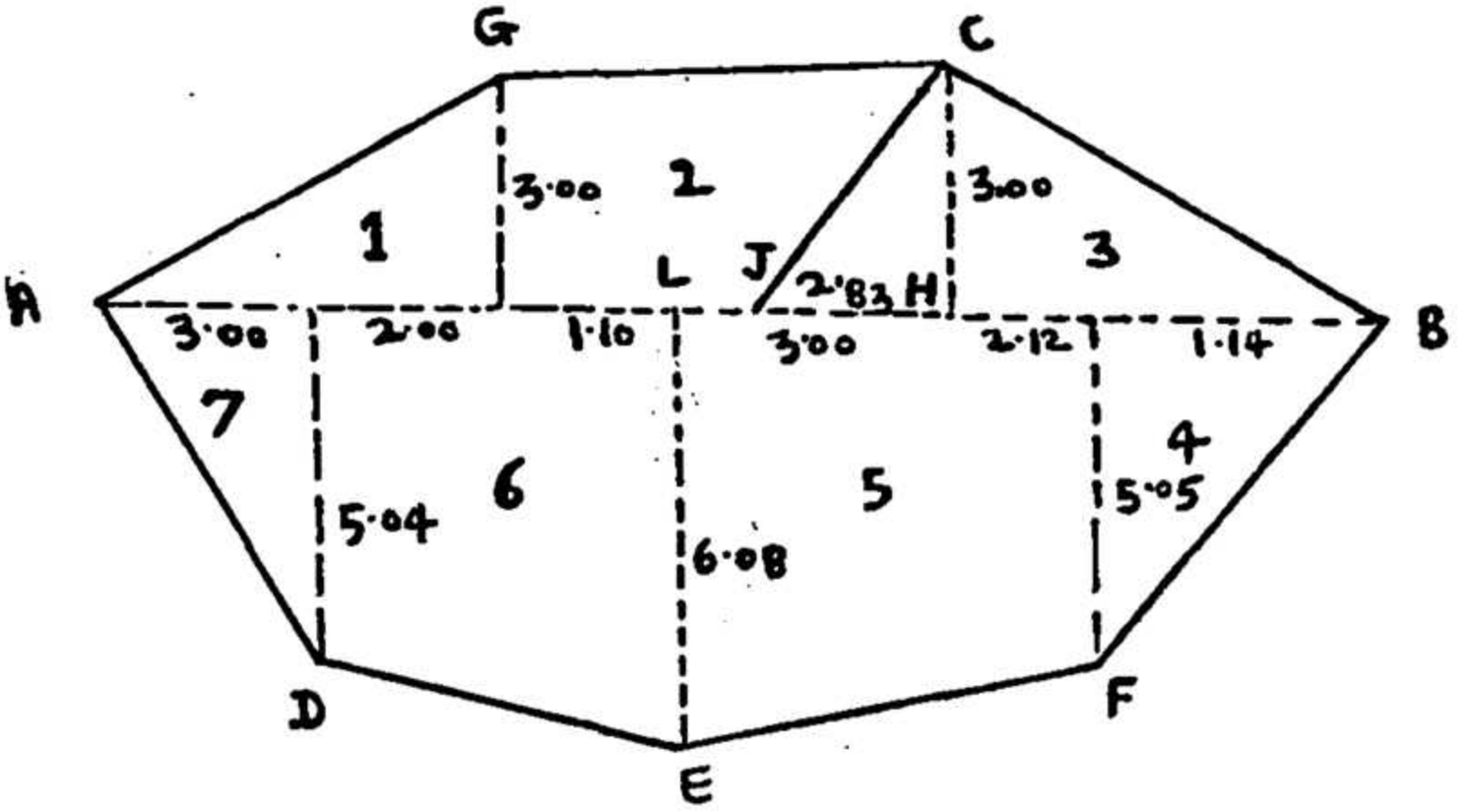



It may be noted that this method of measurement is only adopted in the case of pukka built roads, the area of which is not included in the numbers through which they run. In the case of cart tracks for which Kharab is given merely the length and breadth of the track is measured roughly after the whole number has been measured and the area shown as kharab included in the number (*vide* example 2)

Example 2




13. **To divide a field into two or more parts.**—Let ADEFB CG be the field to be divided. First measure the whole field. Its area will be 3 Hectares and 23 Ares. Suppose it has to be divided as nearly as possible into two equal parts. Now inspection of the measurements made will show that the area of Vaslas 3, 4 and 5 together equal 1 Hectare and 45 Ares. If an area of 17 Ares, therefore, be added to this portion of the number the total will come to the area required. This will be done easily by measuring off along the base line from H-J a length of 2 chains and 83 links. Then the area of the triangle CHJ is 17 Ares which added to Vaslas 3, 4 and 5 will make up half the field. The two halves of the field will then be ADELJCG and CJLEFB.




In dividing a field into more than two parts the same procedure should be followed.

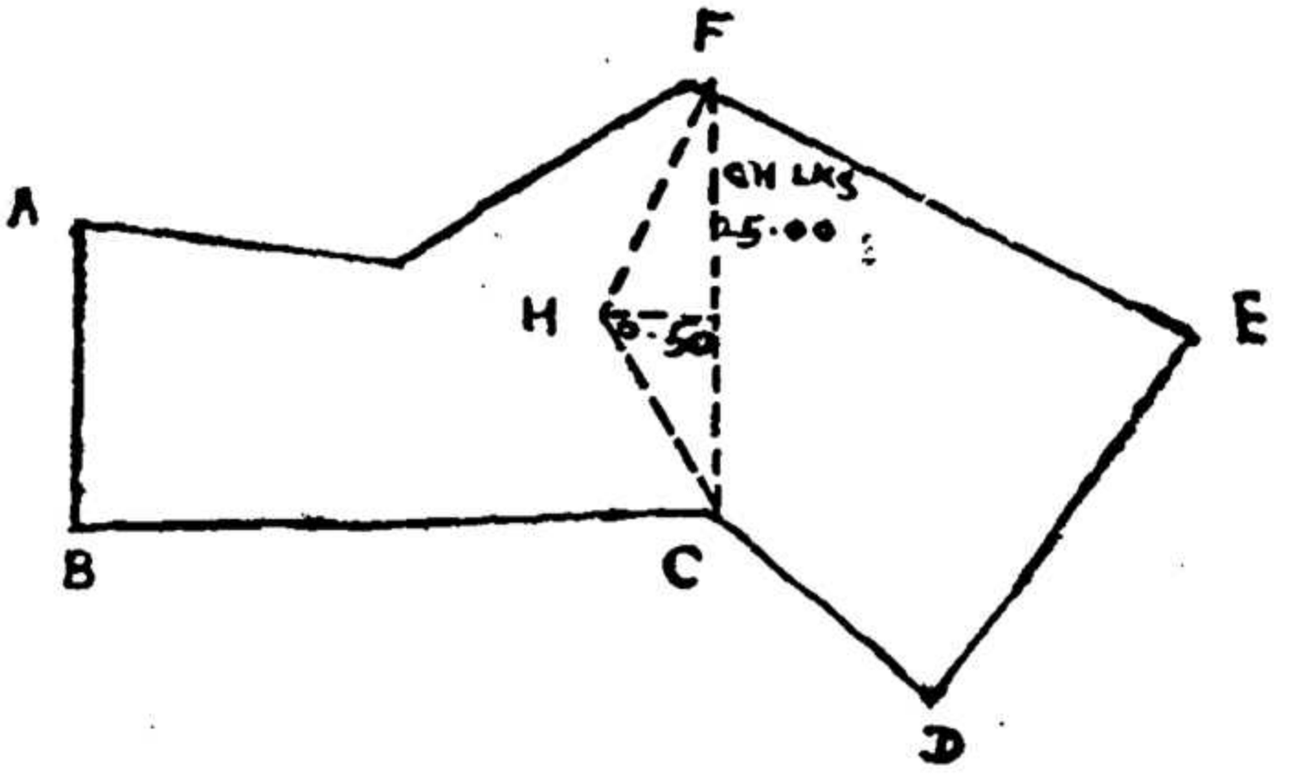
**14. To cut of a given portion from a plot of land.**—Lot ABCDEFG be the plot of land containing 11 Hectares; it is required to take off a piece that shall contain 5 Hectares.

Join any points such as CF (which we may suppose to be nearly the partition line) and find the area of DEFC which suppose may want 25 Ares. of the quantity to be cut off.

Divide 25 Ares by 4 to reduce it to square chains. The quotient is 6·25.

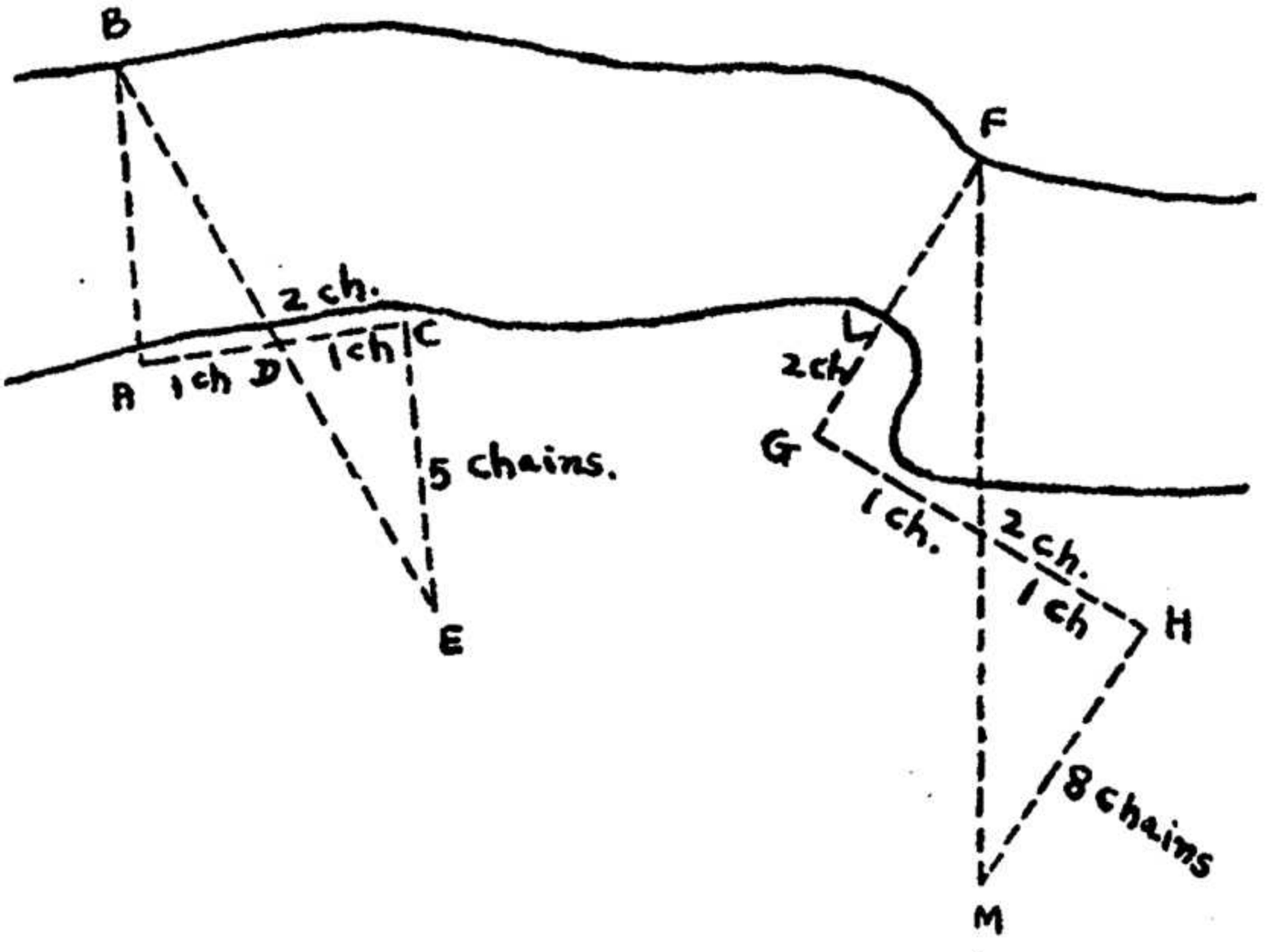
Measure the line FC which suppose to be 25 chains. Divide 6·25 by 12·5 (half of FC) and the quotient 0·5 chains will be a perpendicular for a triangle whose base is 25 chains and area 25 Ares. Draw the lines FH, HC and DEFHC will be the area required.

If the area DEFC is found to be more than is required to be taken of, then the triangle should be measured on the opposite side to that shown in the sketch.




15. **To measure over an obstacle which cannot be crossed.**—It is desired to measure the breadth of the river of AB. At the point A, a perpendicular of a convenient length AC—say 2 chains—should be set out to AB. Then at half of AC, *i.e.*, 1 chain a flag should be set up at D. Then from C a perpendicular CE should be set out to AC and a point E fixed thereon in such a way that BDE are in one straight line. Then CE (5 chains) = AB which is the distance required.

Had the breadth at LF to be found then the line LF would be extended to G = 2 chains, the perpendicular GH drawn and the point of M found as described. Suppose HM, to be 8 chains. Then HM = FG. Deduct from HM the length of LG (2 chains) and the remainder 6 chains is the length of FL.


B
F
2 ch.
A
1 ch
D
1 ch
C
5 chains.
E
2 ch
G
1 ch.
2 ch.
1 ch
H
8 chains
M

## CHAPTER IV

## THE USE OF THE SURVEY TIPPAN

1. The Practical measurement work of the Surveyor has to do chiefly with areas already measured and included in Survey Numbers and Pot Numbers which have either to be sub-divided (*e.g.*, when land is acquired for a public purpose or on partition) or remeasured (*e.g.*, in the case of boundary disputes) or to which land has to be added (*e.g.*, in the case of formation of alluvial lands on the banks of rivers or streams). Now in the case of the sub-division of or addition to Survey Numbers, it is obviously necessary that the boundaries of the Numbers should be known before measurement is made otherwise the measurements of the Surveyor will not correspond with those recorded in the Survey records and discrepancies will arise which will have to be reconciled. In the majority of cases, it is easy to recognise boundaries of Survey Numbers by the boundary marks though even these are often wrong but sometimes either some or all the boundary marks of a field are missing. In such cases it is necessary that the Surveyor should know how to fix the missing boundaries otherwise he will be unable to say where one Survey Number ends and another begins.

2. Again in the case of boundary disputes by the very nature of the case the Surveyor must know how to fix the boundaries of the Survey Number as that is the matter in dispute.

3. But further in the case of mixed Numbers, *e.g.*, those containing two or more different classes of land, *e.g.*, both Jirait and Rice land or Jirait and Bagait, it is necessary, when such Numbers are sub-divided, to know the proportions of each class of land in each of the sub-divisions for the purposes of assessment. It is also useful for the fixation of assessment at the time of next Revision Settlement. Where the Survey Tippans are in existence, these areas can be worked out in the Survey Office but for the latter purpose measurement must be made of each class of land particularly Rice to ascertain the new area converted to Rice after the Revision Survey. The mapping of rice area as it exists at the time of mapping of sub-divisions has been prescribed by the Settlement Commissioner and Director of Land Records.

4. Hence before proceeding further the Surveyor must learn how to fix the boundaries of Survey Numbers according to the survey measurement records. These are—

(*a*) the Survey tippan,

(*b*) the Village map,

(*c*) the Sud (in the Konkan).

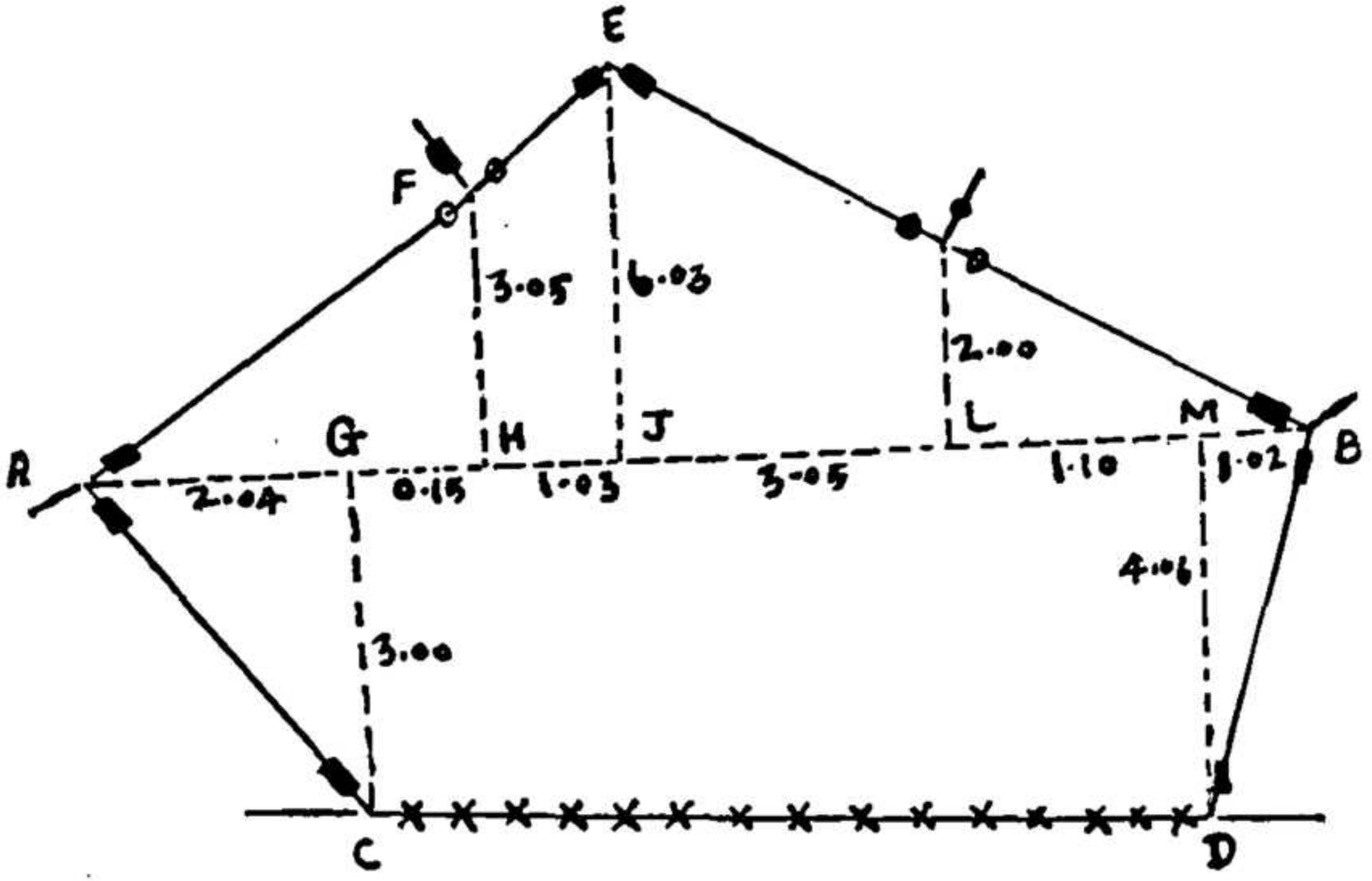
## THE SURVEY TIPPAN:

5. This shows the old base lines and offsets with their measurements and vasla Numbers and also the " bandh maps " and boundary marks. The adjoining Numbers, etc., are also shown and the class of the land. By means of the tippan the Surveyor can compare the measurements shown therein with the condition of things existing in the field. The actual form of book on which the tippan is drawn differs in the different surveys but the details given are the same in all.

*Note*—In the following examples only the details necessary for the case in point are given.

6. **To fix the boundaries of a field in accordance with tippan.**—To do this the Surveyor has first to set up the old base line (or lines) at the corner or other points shown in the tippan. Then measuring along these lines he takes offsets at the distances shown therein and measures out the length in accordance with the tippan measurements. The points thus fixed will be the corners of the number according to the survey measurements. If the corners of the field as now in existence do not agree with those fixed in accordance with the survey measurements, then either there is encroachment or else the original measurements were wrong.

Thus in the example given below the measurer has to fix the boundaries of a Survey Number—ACDBEF according to the measurements shown. To accomplish this, he will first find in the field the two ends of the old base line AB and set up flags in the ordinary way. Then starting from A he will measure 2 chains 04 links to the point G and from G will lay out an offset measuring 3 chains 00 links, thus fixing the point C according to the tippan. Similarly, by measuring 0 chains 15 links from G to H and laying out therefrom an offset of 3 chains 05 links, the point F will be fixed. In the same way the remaining points can also be fixed.




7. In cases where the boundaries of the number as found in the field agree with the measurements recorded in the tippan no difficulty is experienced. This is, however, not always the case and the following complications may arise due either to changes in the boundaries of Survey Numbers, since the original measurements were made or to the incorrectness of the original measurements themselves :—

(*a*) The present position of the corners may not agree with the measurements ;

(*b*) Owing to a similar change either one or both ends of the original base line may not be discoverable.

These difficulties may, therefore, now be considered.

8. **To fix the boundary when a corner is found out of place.**—In the instance given, the boundary according to the tippan is as shown in figure 1 but in the field is as shown in figure 2, *i.e.*, the corners A, D, B, F, are correct but the corners C and E have disappeared.

First Example

Figure 1

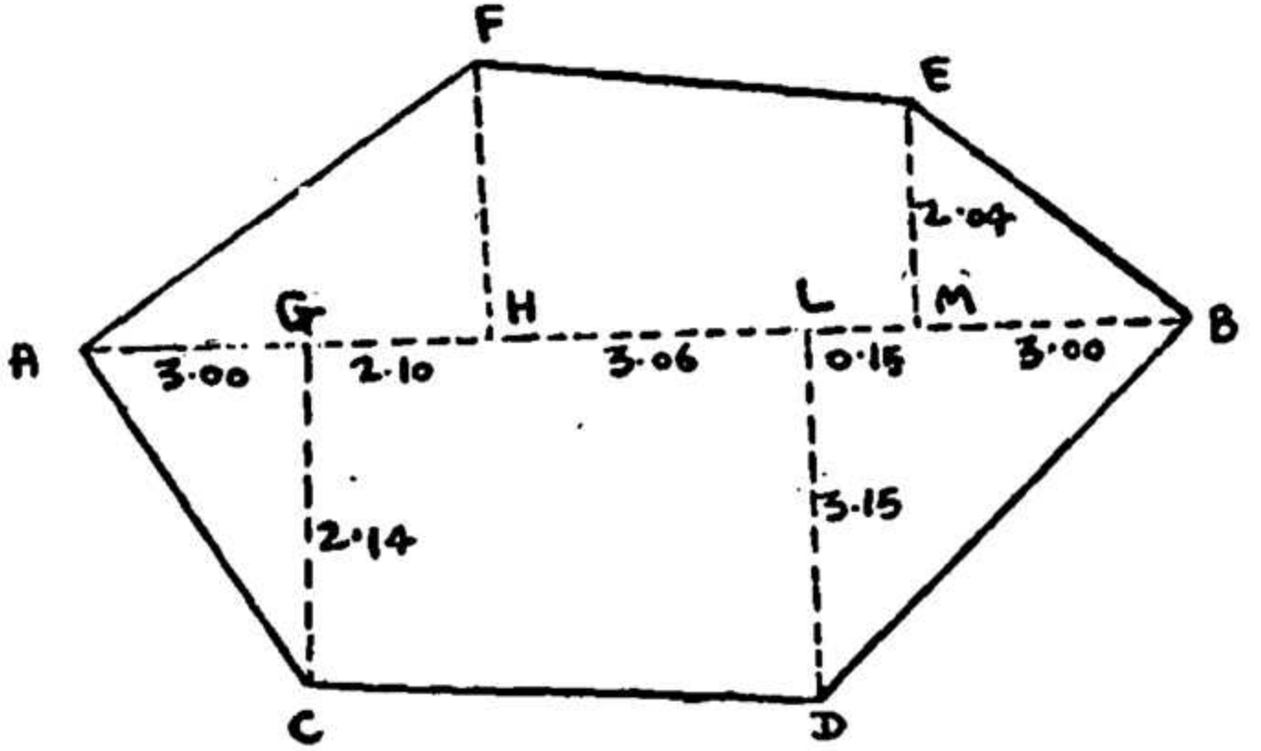



Figure 2

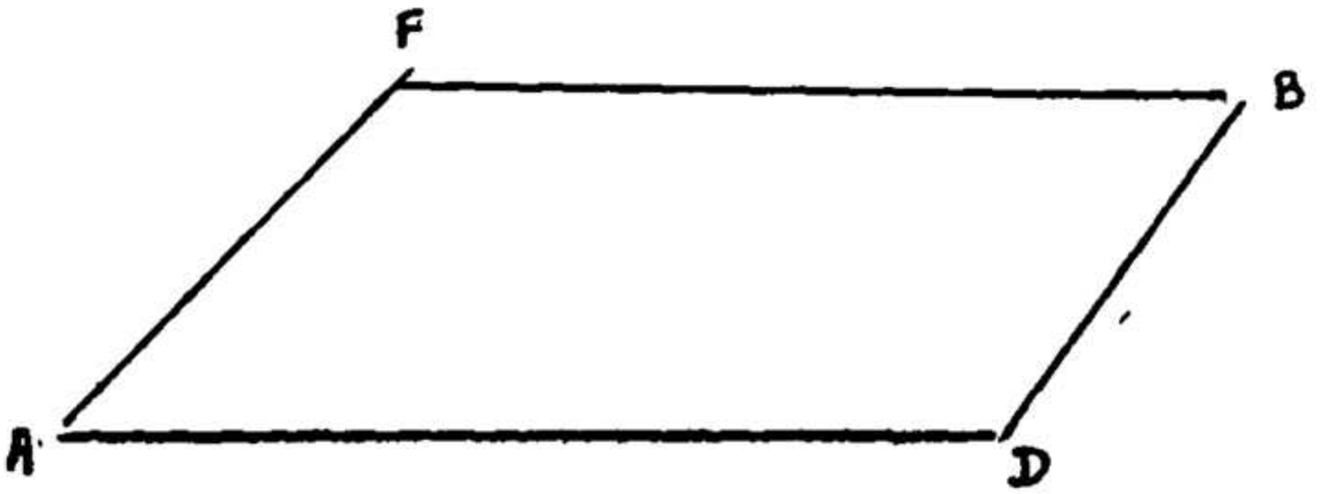
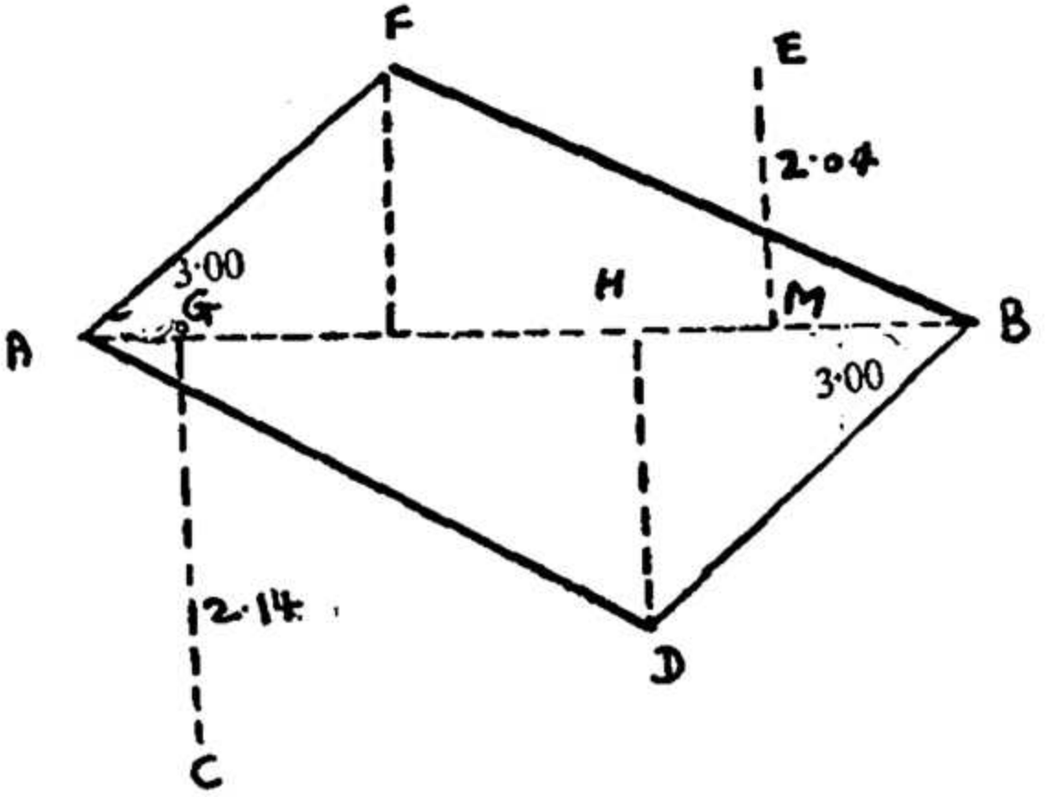


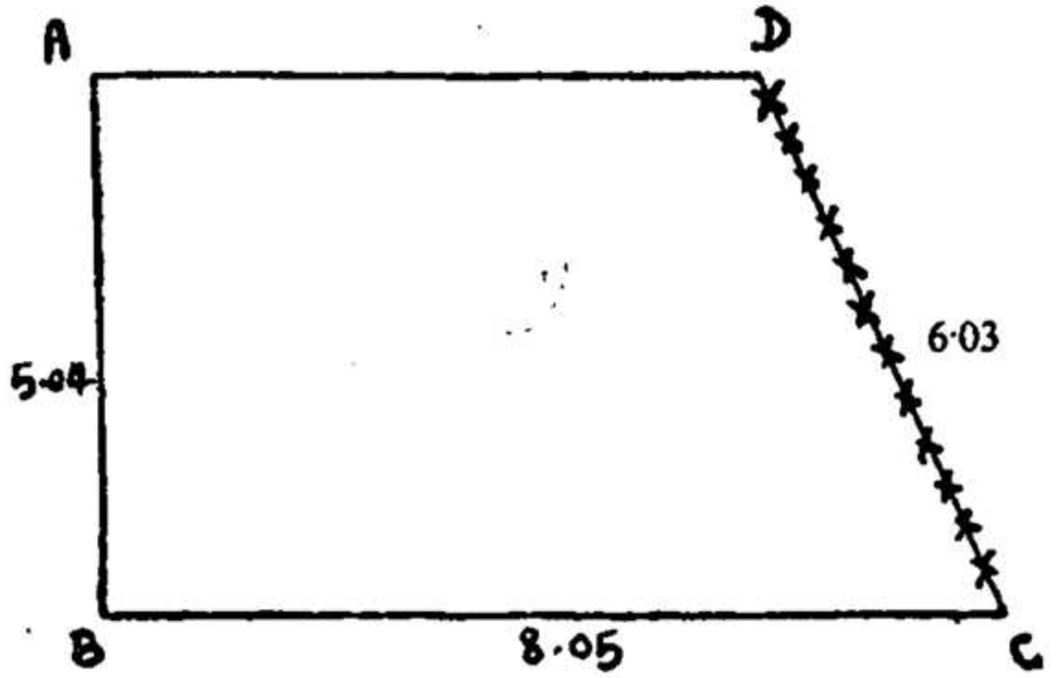
Figure 3.

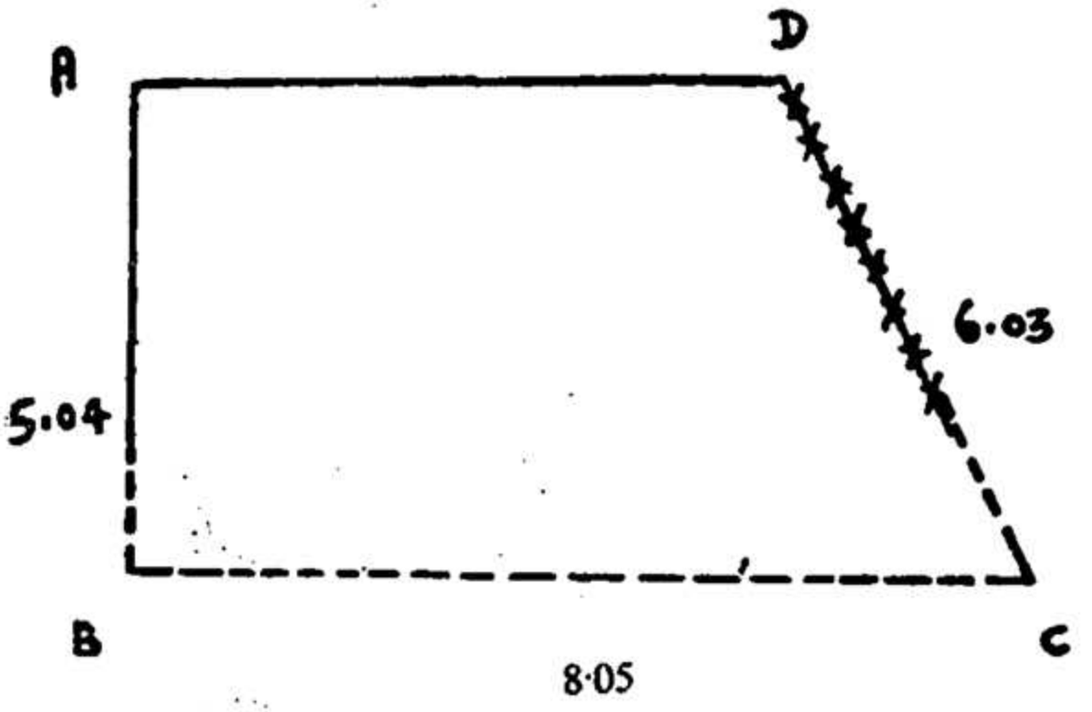



To relay the old boundary the measurer has only to set up the old base line AB. Then by starting from A and measuring 3 chains 00 links along AB and laying out an offset of 2 chains 14 links the missing point C is fixed and by fixing the point M on the base line and laying an offset of 2 chains and 04 links, the point E is fixed.

*2nd Example.*

It may, however, be not necessary to fix the old base line in order to find a missing corner, *e.g.*, suppose the corners A and D are in existence, that B and C cannot be found but that there are in the field boundary strips or hedges running in the direction of AB and DC then the measurer has only to measure 5 chains 04 links, from A along the strip or hedge and 6 chains 03 links from D and the point B and C may be taken as fixed, BC being measured as a check.

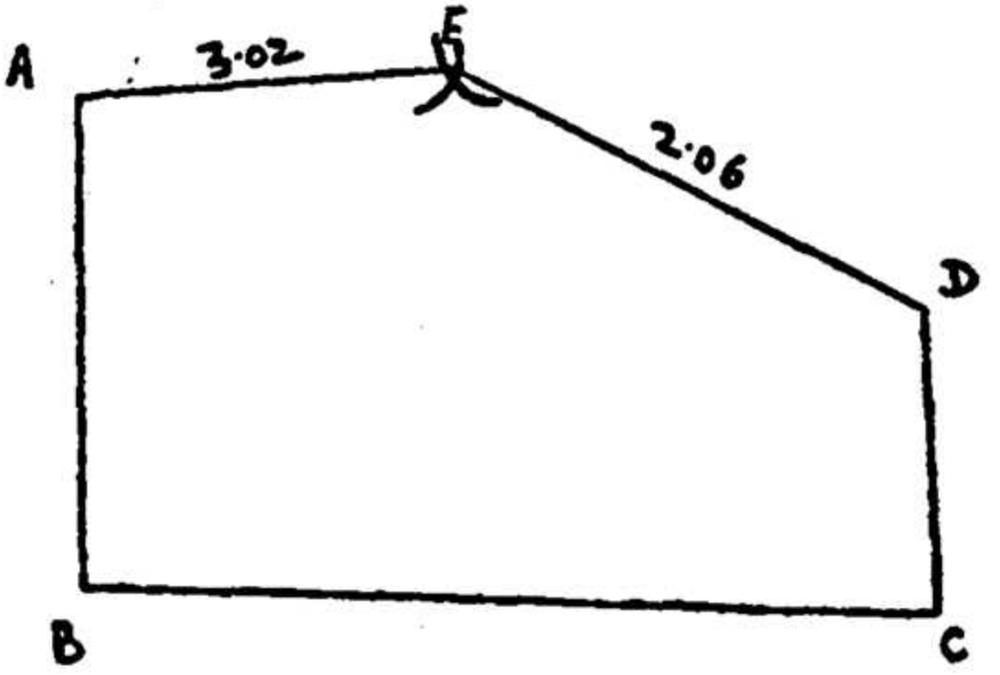



*3rd Example.*

This example shows how corners may be fixed by intersection.

Suppose the corner E be lost. Then measuring 2 chains 06 links from D and 3 chains 02 links from A, the corner E will be found at their point of intersection.




**9. To fix the boundary when one end of base line is not in existence.**—Sometimes, however, the old base line cannot be set up directly as one end may have been lost owing to a change of boundary. In this case the measurer has to set it up by means of the offsets.

Thus in the example given, the points A and G are lost; but the points C D E B F are still as they were. In this case, the measurer will first fix the point H by intersection by measuring 1 chain and 26 links from B and 1 chain 51 links from E and finding the point where they meet (first stage). He will then produce the line B H (2nd stage) and if the offset therefrom at J to the point D comes at 63 links and is 1 chain 63 links in length, he will know that he has found the old base line correctly and can proceed to fix the other corners of the Number by producing the base line and taking the necessary offsets according to the tippan. The point A will finally be fixed by a measurement of 1 chain and 38 links from the point L at the offset to C.

Figure I · According to the Tippan.

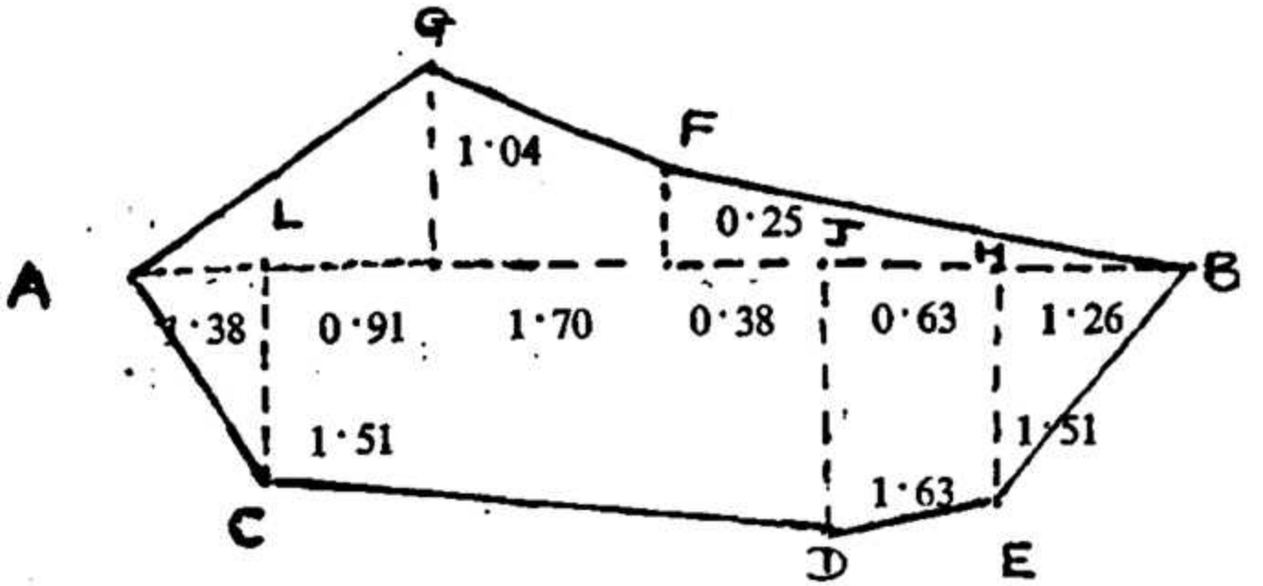



Figure II = As in the Field.

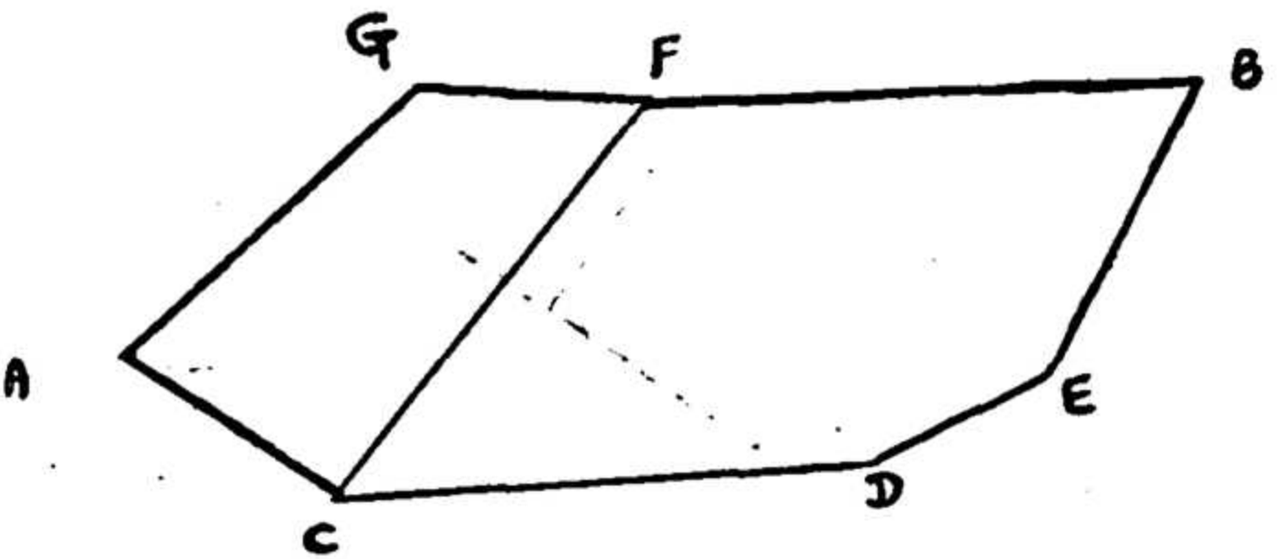
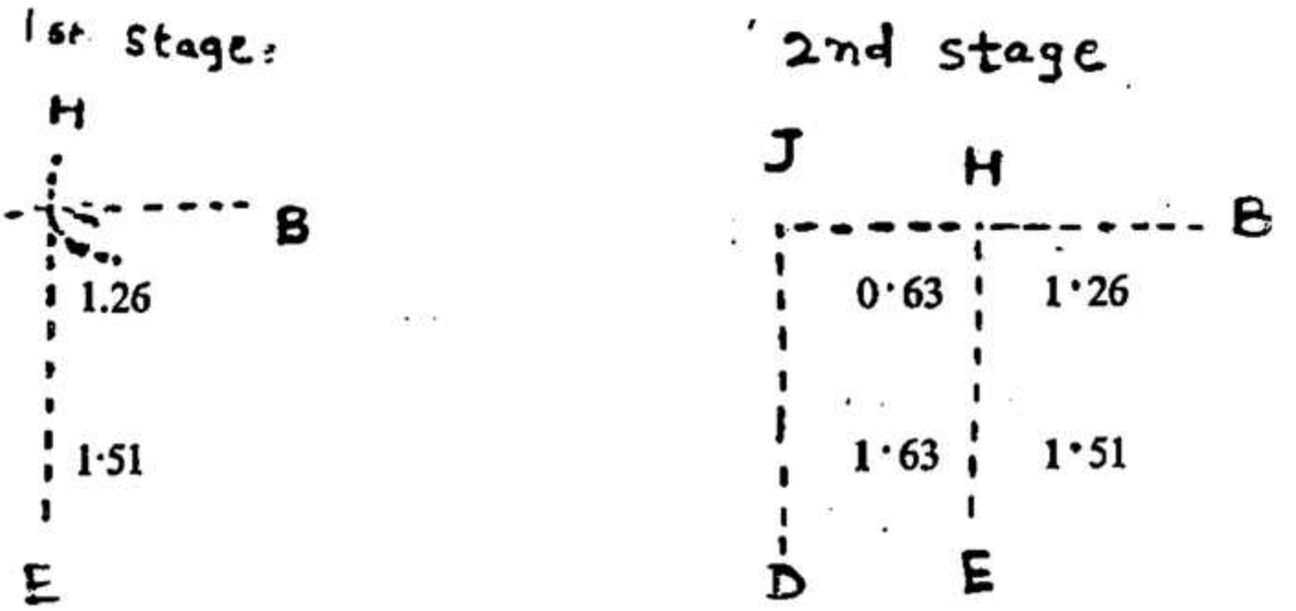
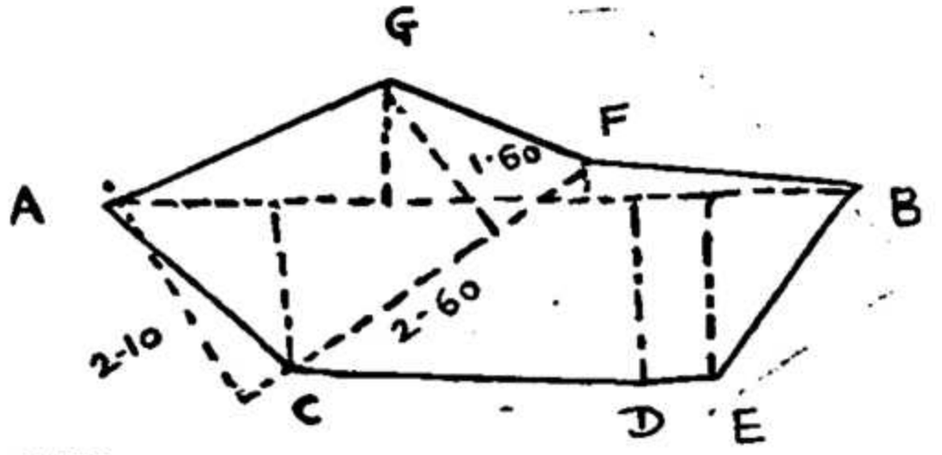


Figure III Method of measurement.




It may, however, be for some reason impossible to find the point A in the method just described. In which case the safest way of solving the difficulty is to obtain the tippan of the adjoining Number and fix the point from the measurements given therein. Other methods will also suggest themselves, *e.g.*, a scale map of the Number can be drawn and taking C F as a base line, the distance of an offset required to fix the point A can be taken out by scale (*vide* figure 4) or again the length of F A can be found by Varga Mul (*vide* Chapter VI) and the point A fixed by the intersection of C A and F A.

Figure IV—Alternative method of measurement.




Scale :—1 : 2,000

In such cases, the measurer must use his ingenuity to get out of his difficulties.

10. **To fix the base line when both ends of the base line are lost.**—In such cases also the Surveyor has to rely more or less on his own ingenuity. Thus in the example given both A and B are lost: the corners C, D, E, F and G alone remain fixed. In this case probably the simplest way of discovering the points A and B would be to make intersection of measurements (2 chains 06 links and 2 chains 08 links) from G and C to find A and of 3 chains 04 links, and 4 chains 01 link from D and E to find B as in Figure III.

Figure I. According to the tippan.

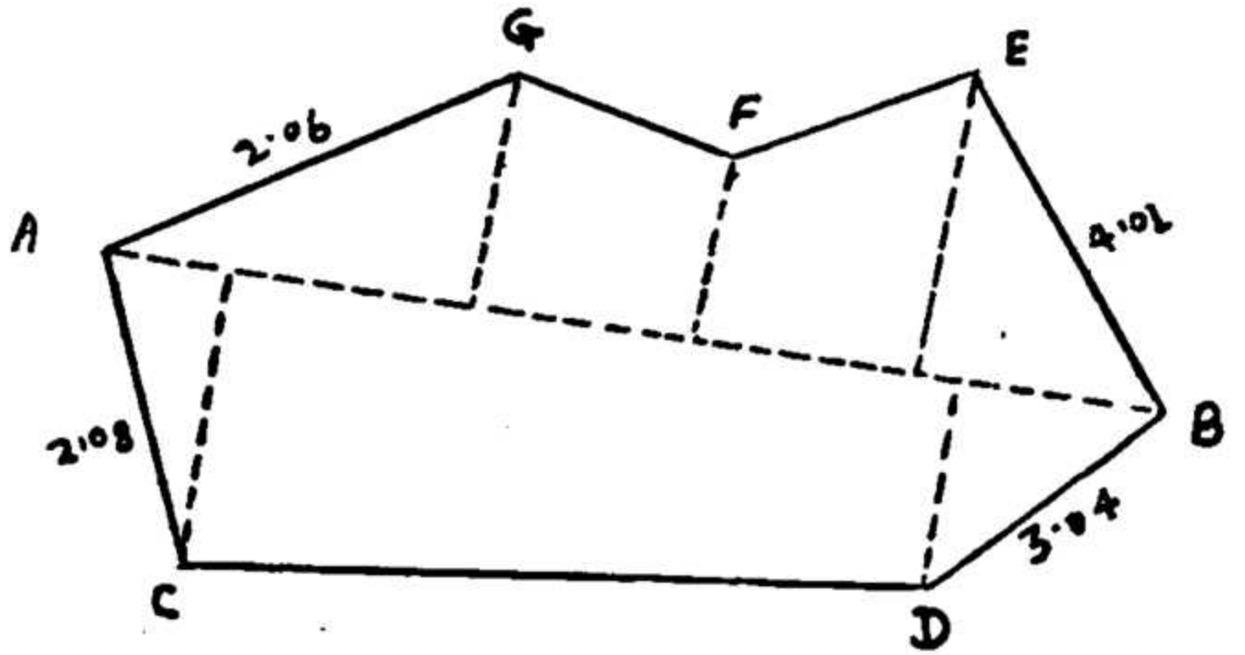


Figure II = as in the field

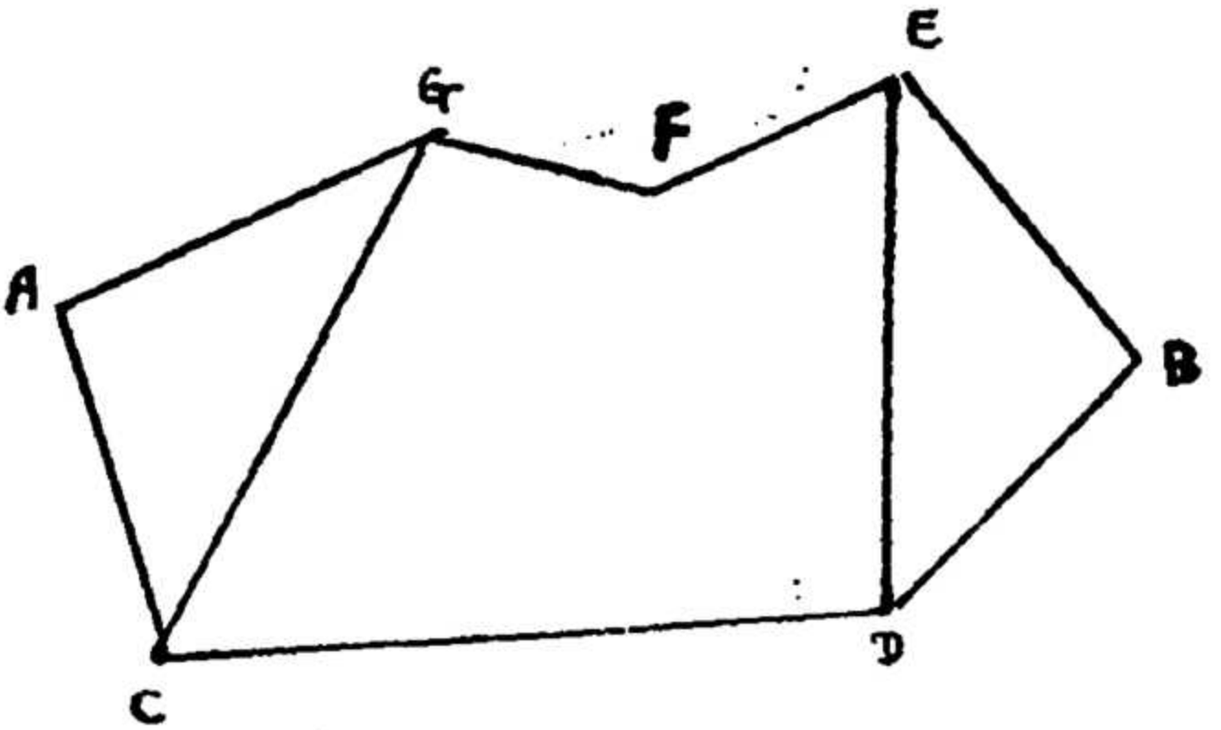
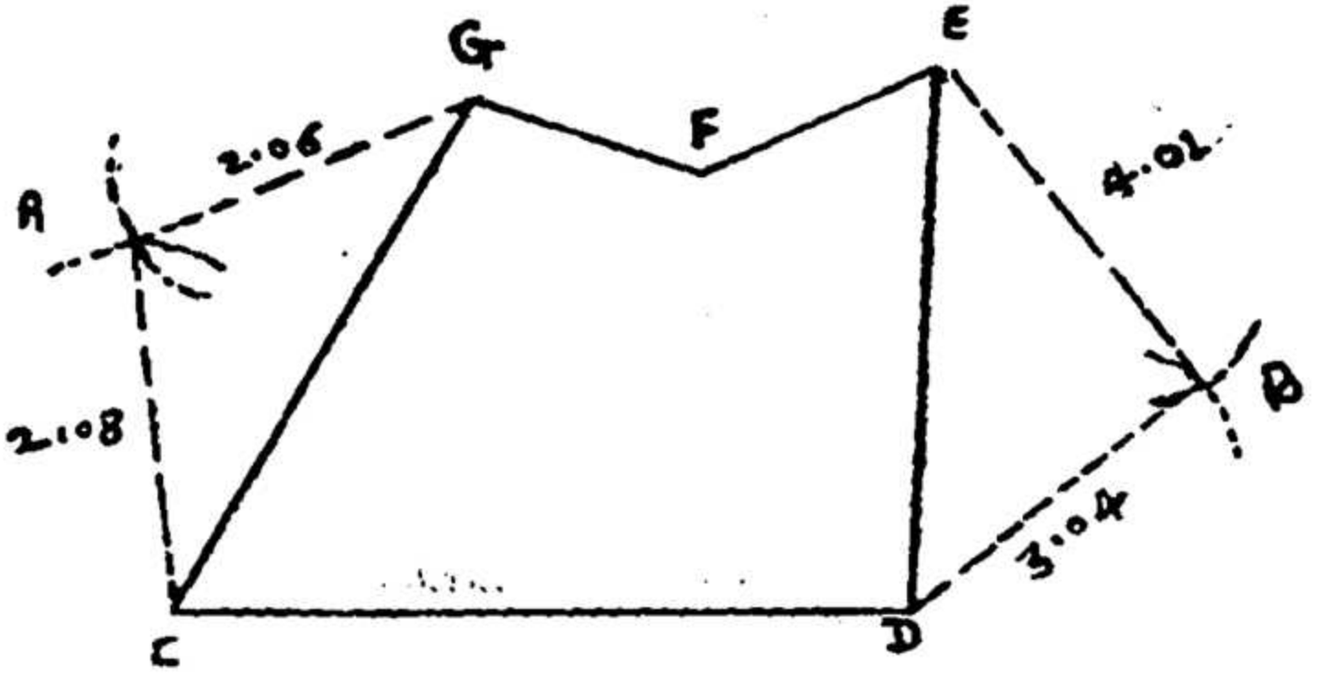



Figure III = method of measurement.



Again the measurer might draw a sketch of the number to scale. The points A and B can then be fixed by scale from a base line taken from CE. This base line can then be set up in the field and these points fixed accordingly. This will give the old base line.

Or the tippans for the adjoining Numbers may be obtained and the points fixed from these Numbers.

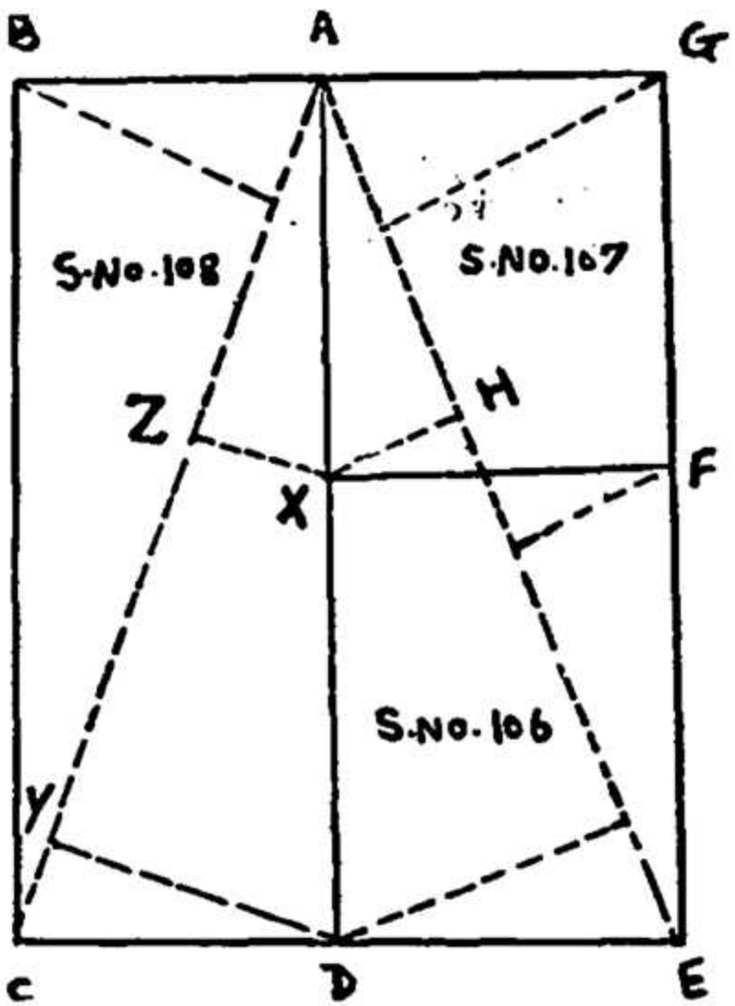
11. A certain amount of common sense is required for replacing missing stones correctly. It is usually possible to tell from the ground the spot where the stone should be. Unless the measurements lead to somewhere near this spot, it is to be suspected that some mistake has been made either in noting or reading the measurement in the tippan which should be rectified before proceeding further. In a boundary dispute case, the surveyor should first go round the field and find out what boundary marks are available on the spot and how many of these marks can be treated to be intact and can be relied upon for refixing the lost corners or boundary under dispute. After the boundary marks are inspected and the boundary marks that can be relied upon are ascertained, the next step would be to find out the best method by which the location of the lost corners can be found out quickly and correctly. While fixing the lost corner or the boundary under dispute, it is always necessary to see that the location of the lost corner is fixed with reference to the tippans of the Survey Number under dispute as well as the adjoining Survey Number. If this is not done, there is likelihood of the same point being fixed at two different places on the spot even though not far too part, with reference to the tippans of individual Survey Numbers, separately.

*For Example—*

In the below mentioned case the boundary mark of Survey Number 108 at 'X' is lost and is to be refixed. Then looking to the map, it will be seen that corner falls on the common boundary between Survey Numbers 107 and 106. On reference to the tippan, it is seen that both the Survey Numbers are measured in the past on a common base line AE. On going round the fields, it is seen that the boundary marks ABDEG are only available and that at CF and X lost. As one of the corners of the base line of Survey Number 108 is lost, the point C will have to be first determined. It can be determined by intersection of AY and YD and extending AY to C but as any

slight difference in the correct determination of point C is also to affect the determination of point X, to have a further check, it is necessary to erect the base line AE and find out the location of point X with reference to the offset HX. If there is a slight difference, it will have to be adjusted by giving preference to the offset HX. There is not likely to be any appreciable difference unless there is a mistake in the old measurement but the location must be fixed with reference to offset HX, and ZX. So that even if the adjoining holder applies for the fixation of the same point the location once fixed would be final and there will be no scope for complaint.

## Sketch




In some districts where the Plane Table method is introduced eventhough the old surveys are conducted on cross-staff method, the measurement is done by Plane Table and the tippan is superimposed

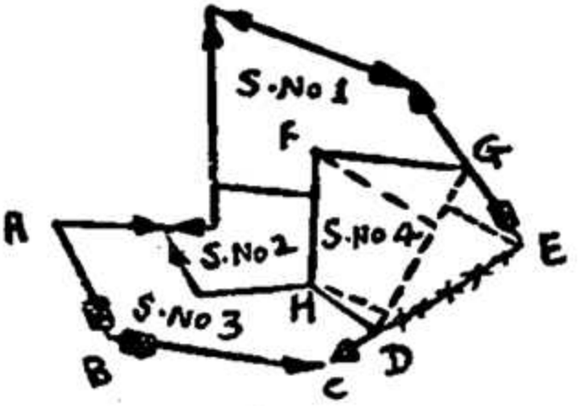
and the location of the lost boundary mark is first fixed on the plane table sheet and then the location is determined on the ground. For example, if the boundary mark at X of Survey Number 108 is to be relaid, the Survey Numbers 108, 107 and 106 are measured in a group. For the sake of measurement, a mark 'X' is put on the ground where the Surveyor thinks that the location of the lost corner is likely to be. After the Survey Numbers 108, 107 and 106 are measured in a group, he marks on the plan the permanent boundary marks that are existing on the spot. Suppose A B D E G are the points where the boundary marks are existing and at C and F they are not in a reliable condition and at X it is altogether lost. The best way in the above case is to rely on the points A and E as they are the points of base line. This base line should be first drawn and the point X determined with reference to offset HX. The base line AC may afterwards be drawn by obtaining the point Y by intersection of AY and YD, and by extending AY to point C. After this is done the offset ZX may be drawn and it should be seen whether ZX and HX meet. If there is any slight difference, it should be adjusted by relying upon the offset HX rather than ZX and the location of point X determined.

12. **The village map and Sud.**—The village map is a Survey Record inasmuch as it purports to show all the Survey Numbers of a village drawn to scale. All our old surveys are conducted on foot pound system and the village maps are either drawn to a scale of 20 chains or 10 chains to an inch. As the scale on which these village maps are drawn is very small, they are not useful for relaying the lost boundary mark. However, they are very useful for giving the correct idea of the location of the field. In Konkan all villages are provided with village-Suds containing sketches of Survey Numbers and Pot Numbers on a scale of 5 or 10 chains to an inch. After the introduction of Metric System, the measurements are now conducted in terms of Standard Metric Chains and the village maps are being prepared on the scale of 1 : 5 000 and 1 : 10,000. In case of old maps conversion tables are given to enable the reader to convert the measurements in terms of old chains into Standard Metric Chains.

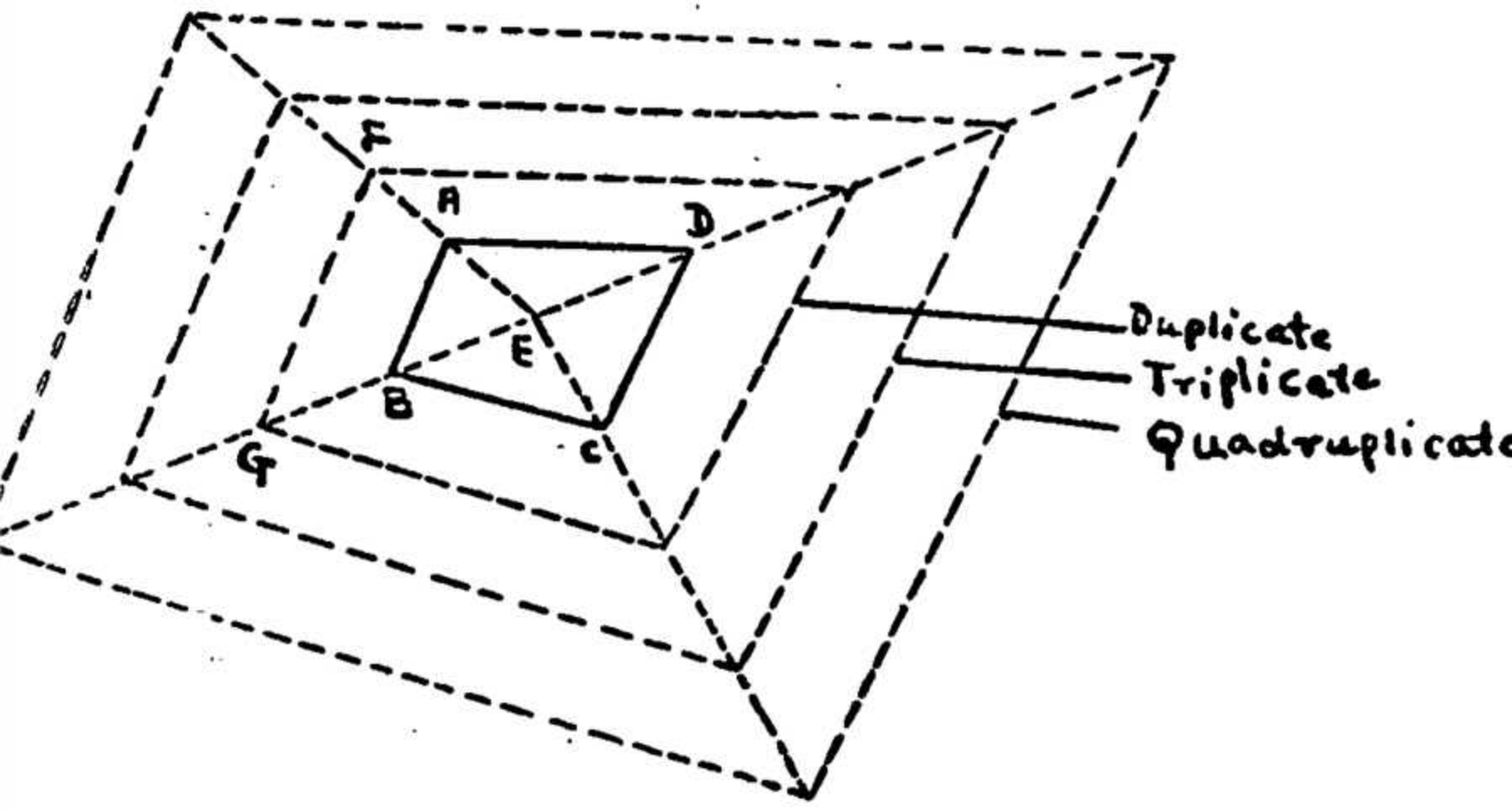
13. **To use the village map as survey record.**—The village map being drawn to scale, it follows that we have only to apply the scale to the figures of the Numbers contained therein in order to extract the measurements. Thus in the figure given which is drawn on a scale of 20 chains to an inch or in Metric Terms 1 : 7,920 by

applying the scale to the side AB, we find that its length is 10 millimetres, *i.e.*, 79,200 or 79·2 metres which is equal to 3 chains and 96 links. Similarly, the lengths of sides BC, DC, DE and EG can be found by scaling off the distance.

Again a survey tippan can be formed by drawing a base line and offsets and writing the measurements after scaling them off. Thus in S. No. 4, the base line DG is drawn and offsets therefrom to the corners HF and E. The measurement of the base lines, offsets and Bandh maps can then at once be scaled off and a survey tippan is ready.




**14. To enlarge a number to scale from the village map.**— (1) It is occasionally found necessary to obtain a scale map on a larger scale than that of the ordinary village map and by the method illustrated below the necessary enlargement can be made to any scale required.




The number is first pricked off from the village map *i.e.*, the map is laid on a clean sheet of paper and pin holes pricked on to the latter through the corners of the number in the map. These pin holes are then joined up and a duplicate of the map thus produced. Any central point is then selected and rays drawn out through the corners of the number. Lengths are then marked off thereon equal to the distance from the central point to the corners as many times as the enlargement requires. By joining up these points the enlargement required is produced.

(2) Another method is to draw base line and offset inside the pricked off sketch and then by doubling or trebling the lengths so obtained, the original can be reproduced on double or treble scale.

# CHAPTER V

## THE MEASURER'S RECORD

1. Simultaneously with the training in the actual field work of measurement, the Surveyor must learn how to prepare the measurement record. This consists of—

(*a*) The Kacha tippan.
(*b*) The Pakka tippan or Kshetra,
(*c*) The calculation of the area.

2. **The Kacha tippan.**—This is the rough sketch not drawn to scale showing the measurements as recorded in the field. The form in which it is usually prepared and the de ails given therein are shown below. These details comprise—

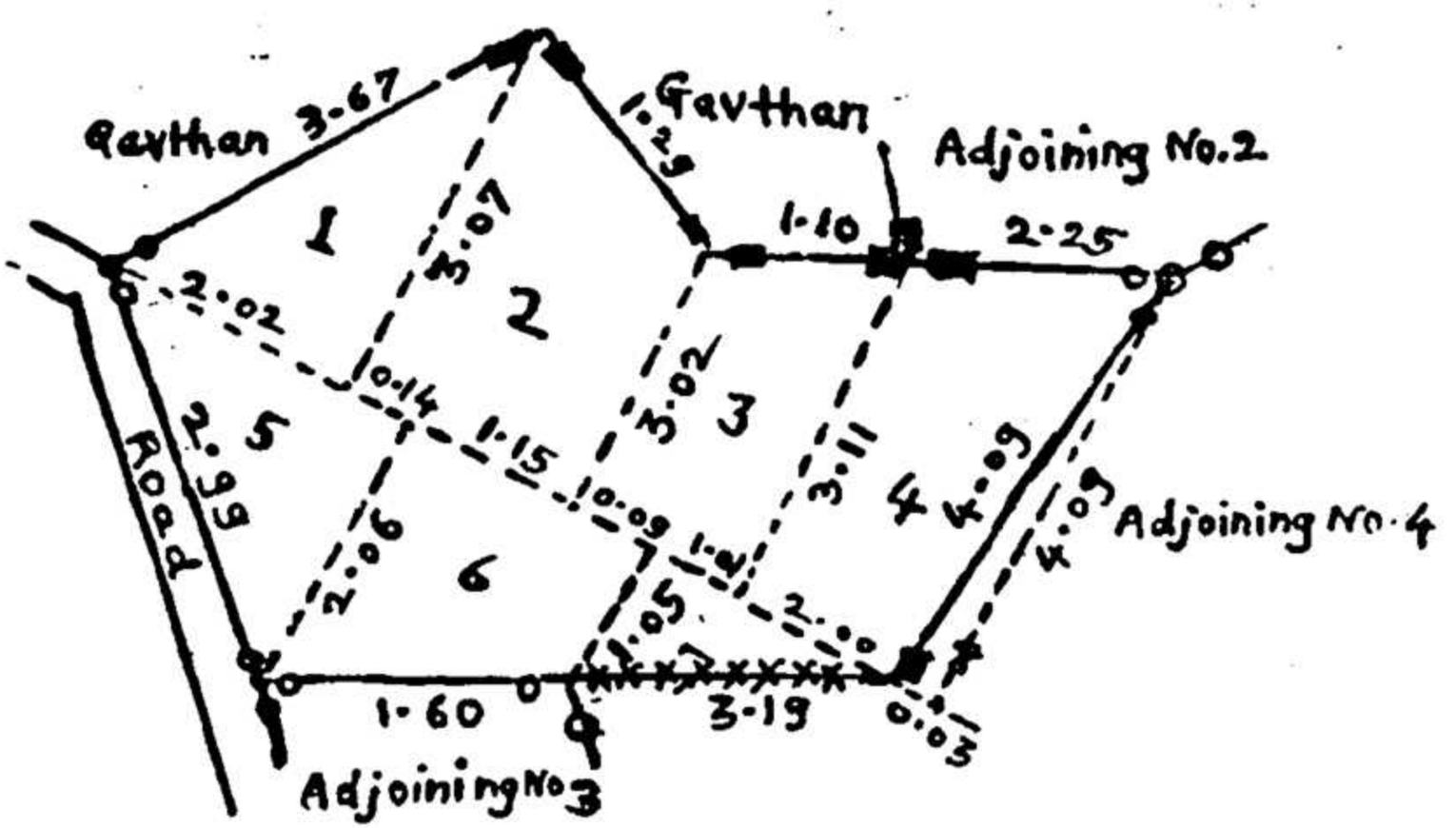
(*a*) The outline of the Number in unbroken lines and the base line and offsets in broken lines.

(*b*) The measurements.

(*c*) The Vasla Numbers, *i.e.*, the Numbers of the different trapezia or triangles in red ink.

(*d*) The Numbers of the adjoining Survey Numbers.

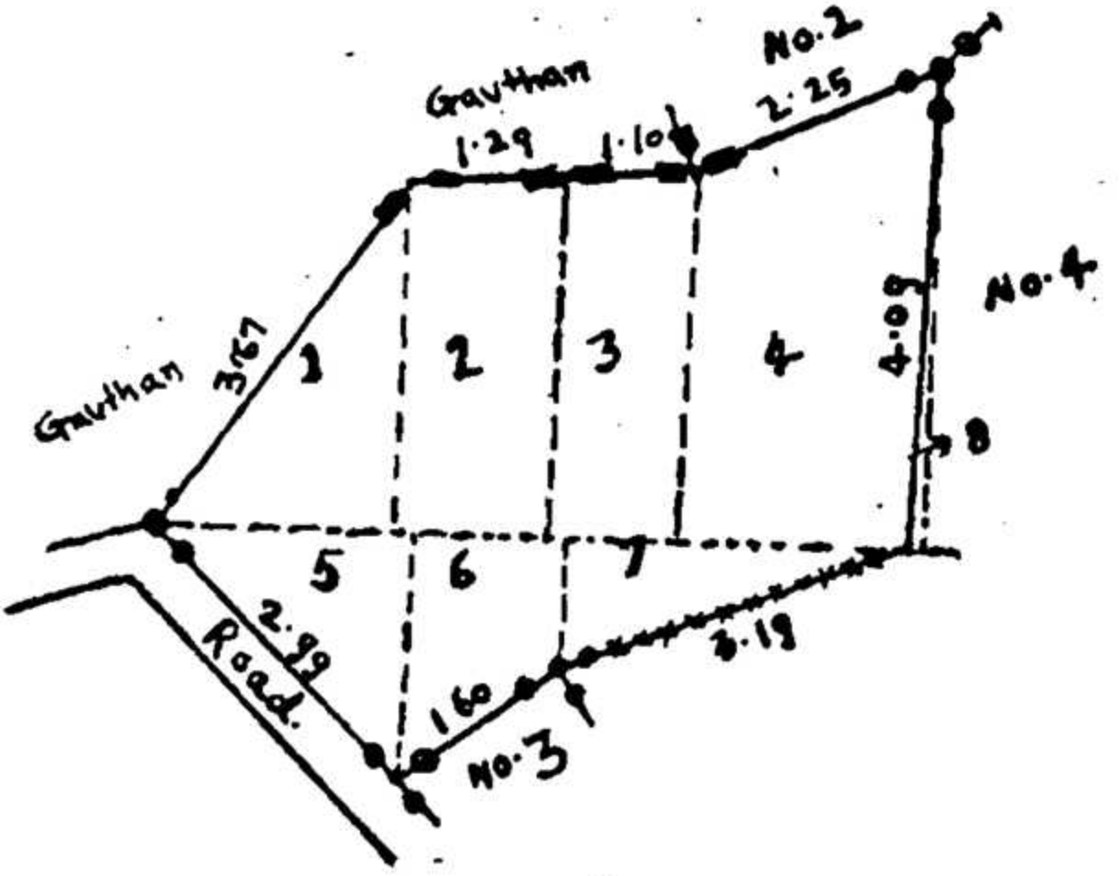
(*e*) The boundary marks.



3. **The Pakka tippan or Kshetra.**—This contains the same details as the Kacha tippans except that—

(*a*) the sketch of the Survey Number is drawn to scale.

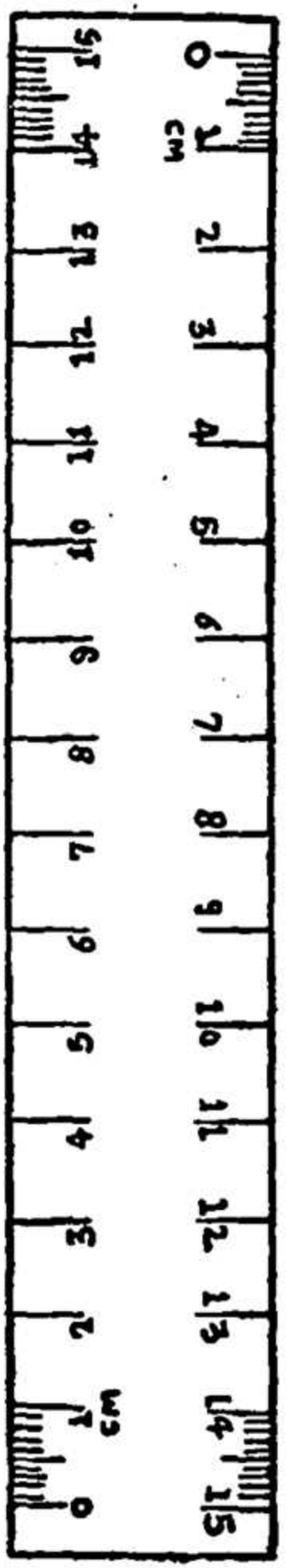
(*b*) no measurements are shown except those of the Bandh Maps. (Except in the Konkan where the Bandh maps are not measured.)




Scale 1 : 2,000

4. **Plotting.**—In order that a Survey Number may be drawn to scale, a knowledge of plotting is necessary. By plotting is meant the drawing of a number to any specified scale from given measurements. The plotting can be made on any desired scale but for the purposes of cadastral survey, the following scales are recommended by the Surveyor General—

1 : 1,000
1 : 2,000
1 : 5,000
1 : 10,000 and
1 : 25,000.



In addition to these scales, the scales of—

1 : 500

1 : 3,000 and

1 : 4,000

are also permitted where absolutely necessary.

The general scales for the village maps would be 1 : 5,000 and 1 : 10,000, and for plotting of Gat-Books and Kshetra-Books 1 : 2,000.

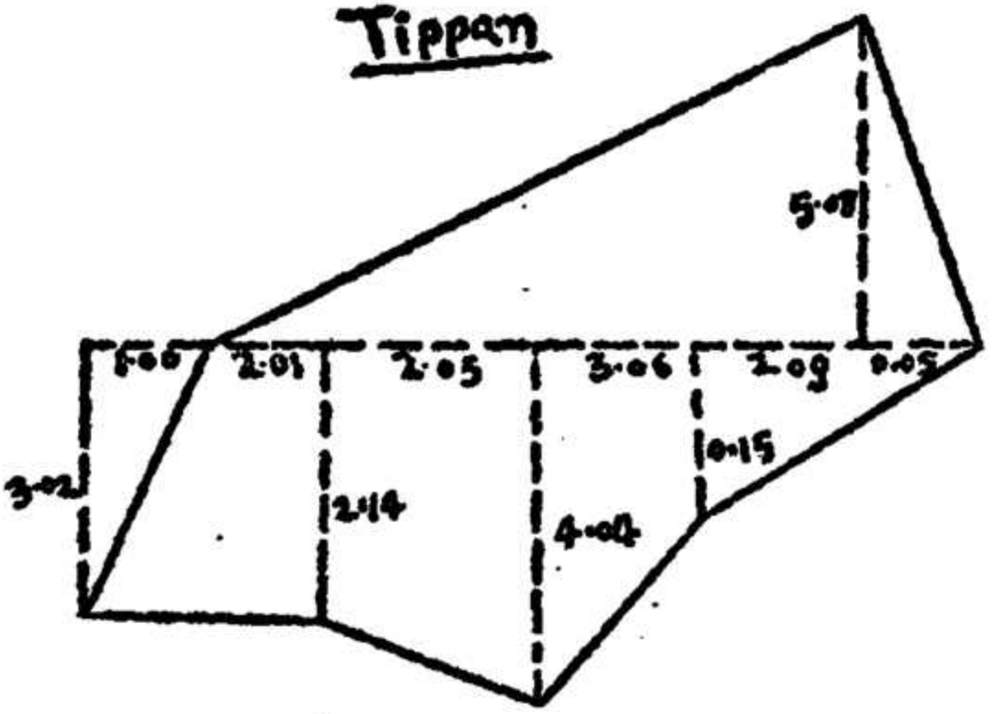
The scale will usually show division up to millimetres and in cases of plans drawn on the below-mentioned scales each division, *i.e.*, millimetre will be equal to the scale shown against each—

| Divisions will be equal to | |
|---|---|
| 1 : 500 | 1 = ½ Metre. |
| 1 : 1,000 | 1 = 1 Metre. |
| 1 : 2,000 | 1 = 2 Metres. |
| 1 : 5,000 | 1 = 5 Metres. |
| 1 : 10,000 | 1 = 10 Metres. |

5. An illustration of the scale in common use is given below :—

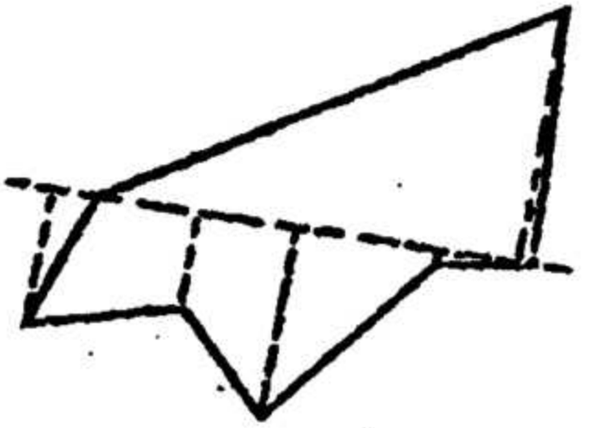
The large divisions of the scale marked by Numbers denote centimetres each divided into ten parts equal to one millimetre each. Hence by means of these small and large divisions distance of any length to any scale can be taken off with ease.

## Tippan

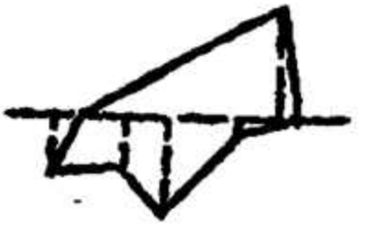



## Kshetra

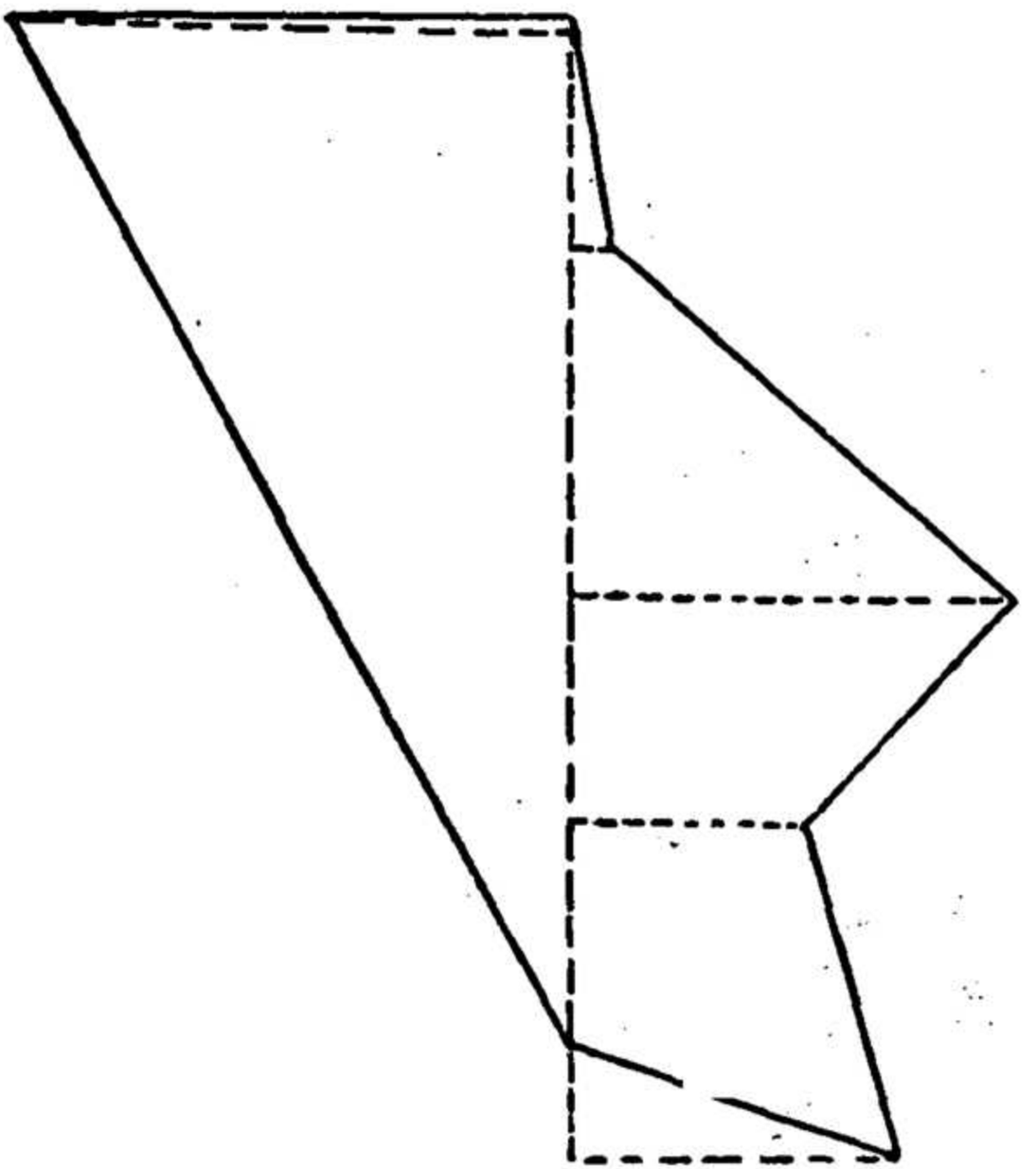
scale 1 = 5,000



scale - 1 = 10,000



Kshetra
Scale - 1 = 2,000



**6. To plot a number on one base line.**—(*a*) First any broken line is drawn to represent the base line.

(*b*) Next starting from one end of the base line the distance to each of the offsets is taken off the scale with compasses and laid down on the base line. In order to check the correctness of the work the total length of the base line should be taken off the scale and compared with the sum of the lengths of the bases of the Vaslas.

(*c*) Next the offsets should be plotted in. Great care should be taken in laying off the right angles for the offsets. By means of the lines on either side of the scale this can easily be done.

(*d*) In order to check the correctness of the offsets plotted, the measurements of the "Bandh Maps" should be scaled off.

(*e*) Lastly the boundaries of the number should be drawn in.

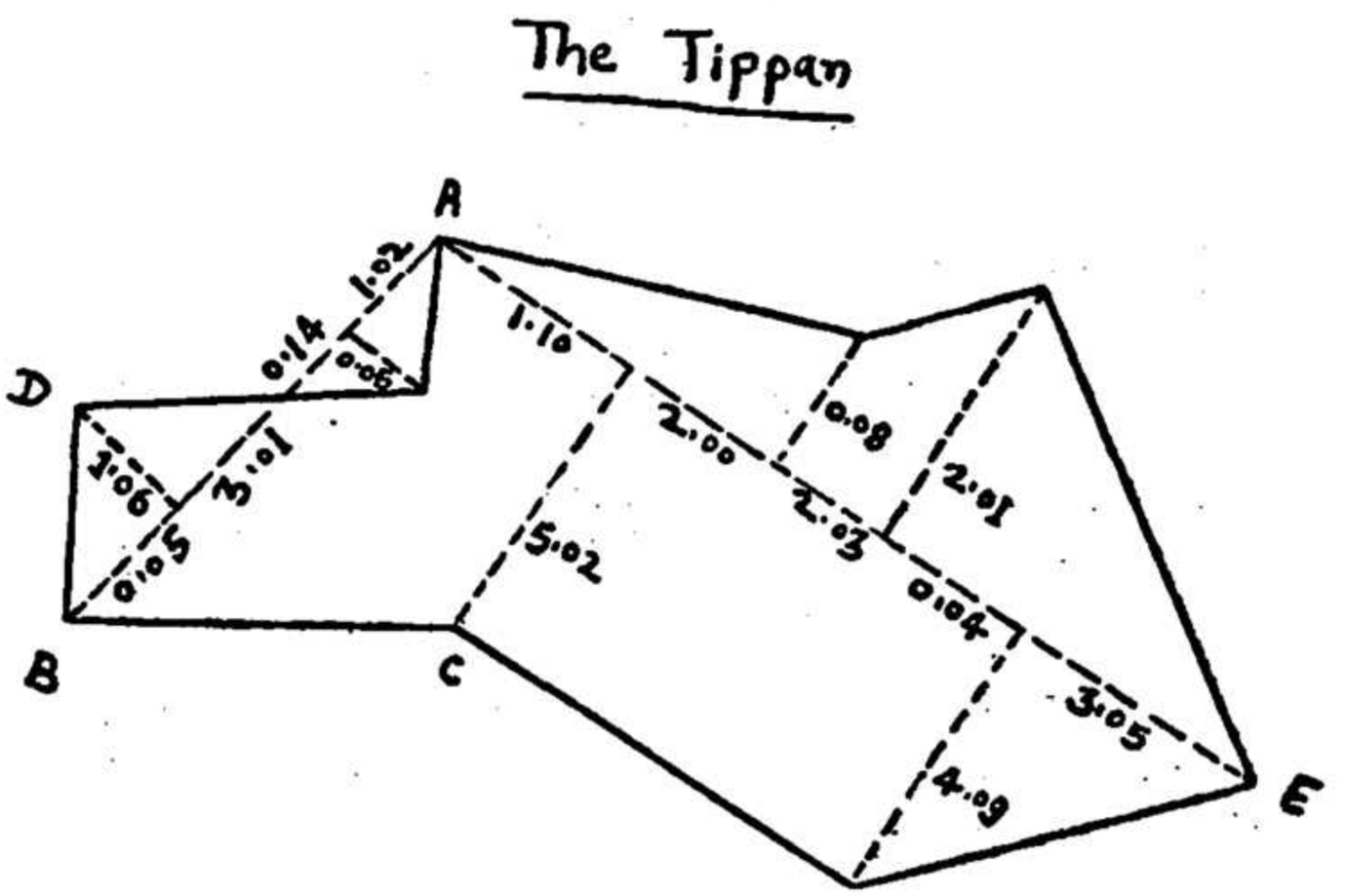
(*f*) After looking the pencil work over carefully the whole should be inked in, the base line and offsets being shown in broken, and the boundaries in unbroken lines.

(*g*) The Vasla Numbers should be then written in red ink, the measurements of the Bandh maps only shown thereon and the other details added as given in para. 3.

NOTE—In the present and following examples only the actual plotting is shown details being omitted for the sake of clearness.

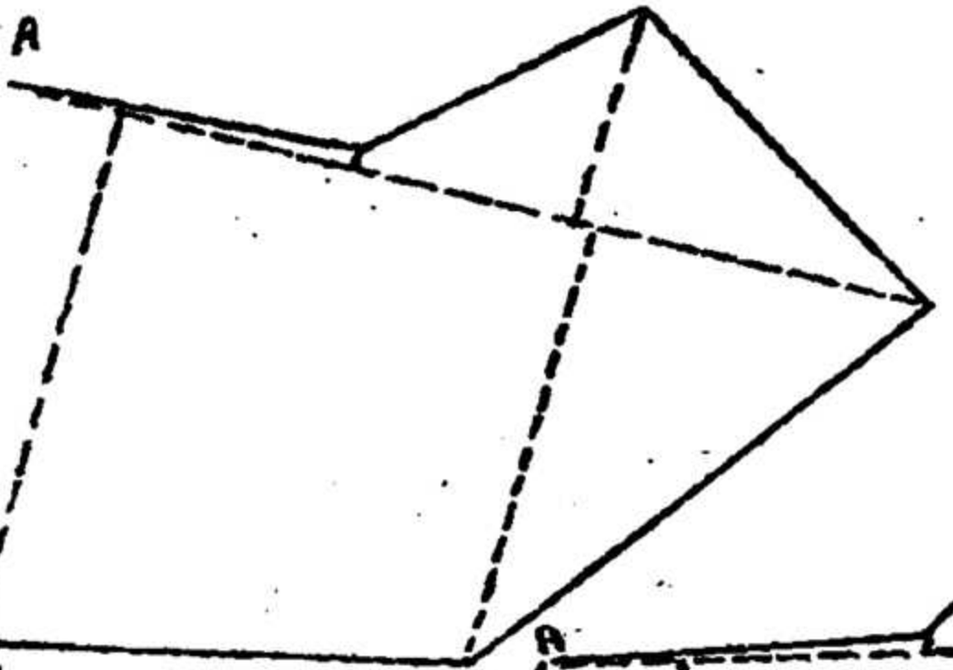
**7. To plot a number on two base lines.**—When a number has been measured on two base lines both cannot be laid down direct on the plotting paper as they are independent. In the following example, the base line AE would first be laid down and the offsets plotted from it (first stage). Thus the points A and C will be fixed.

These points being fixed the point B can also be fixed by intersection of the lines CB and AB taken off by scale (Second stage). AB is then joined and forms the second base from which the remaining offsets can be plotted (Third stage).

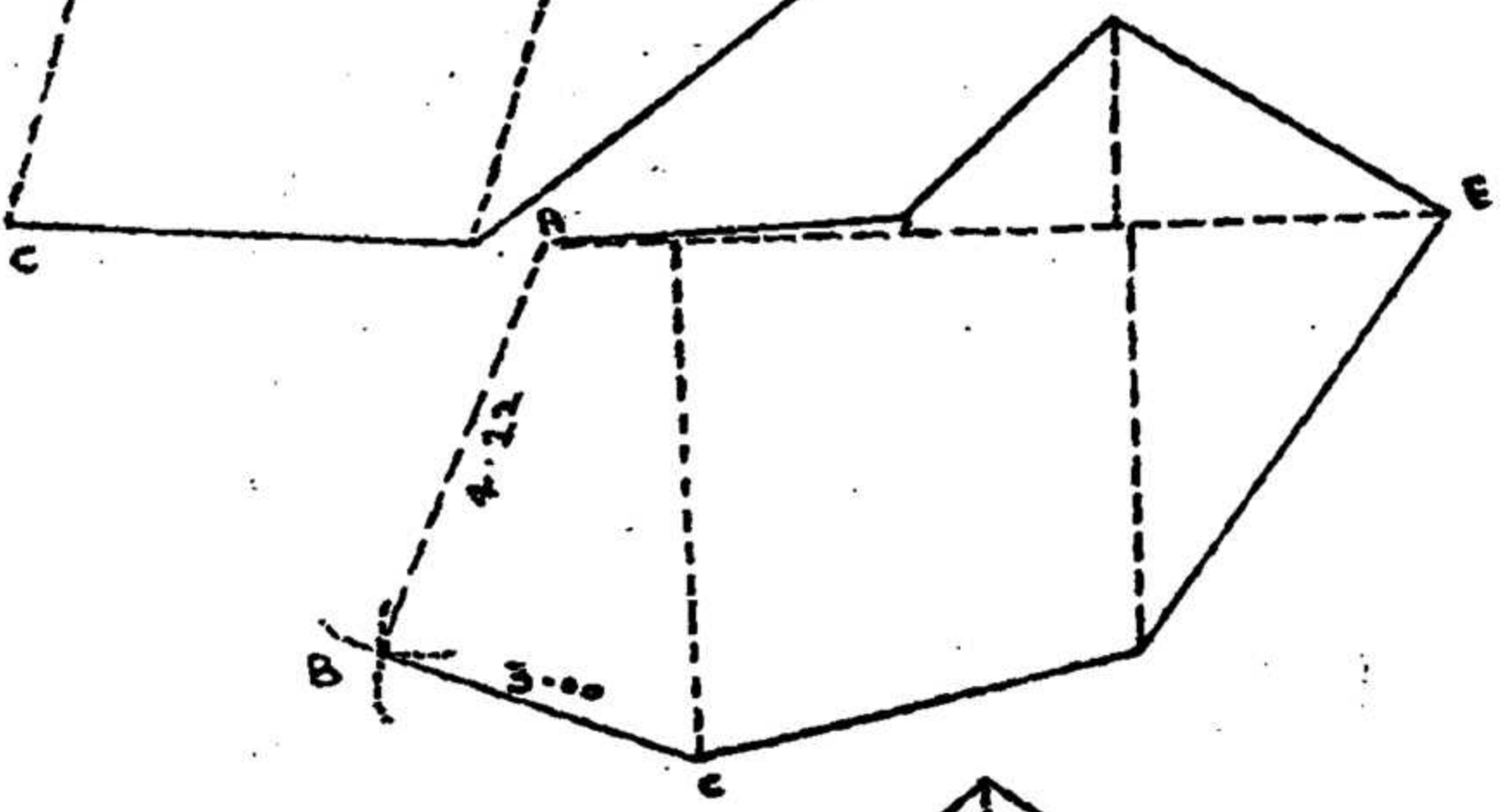


1st stage The Kshetra.

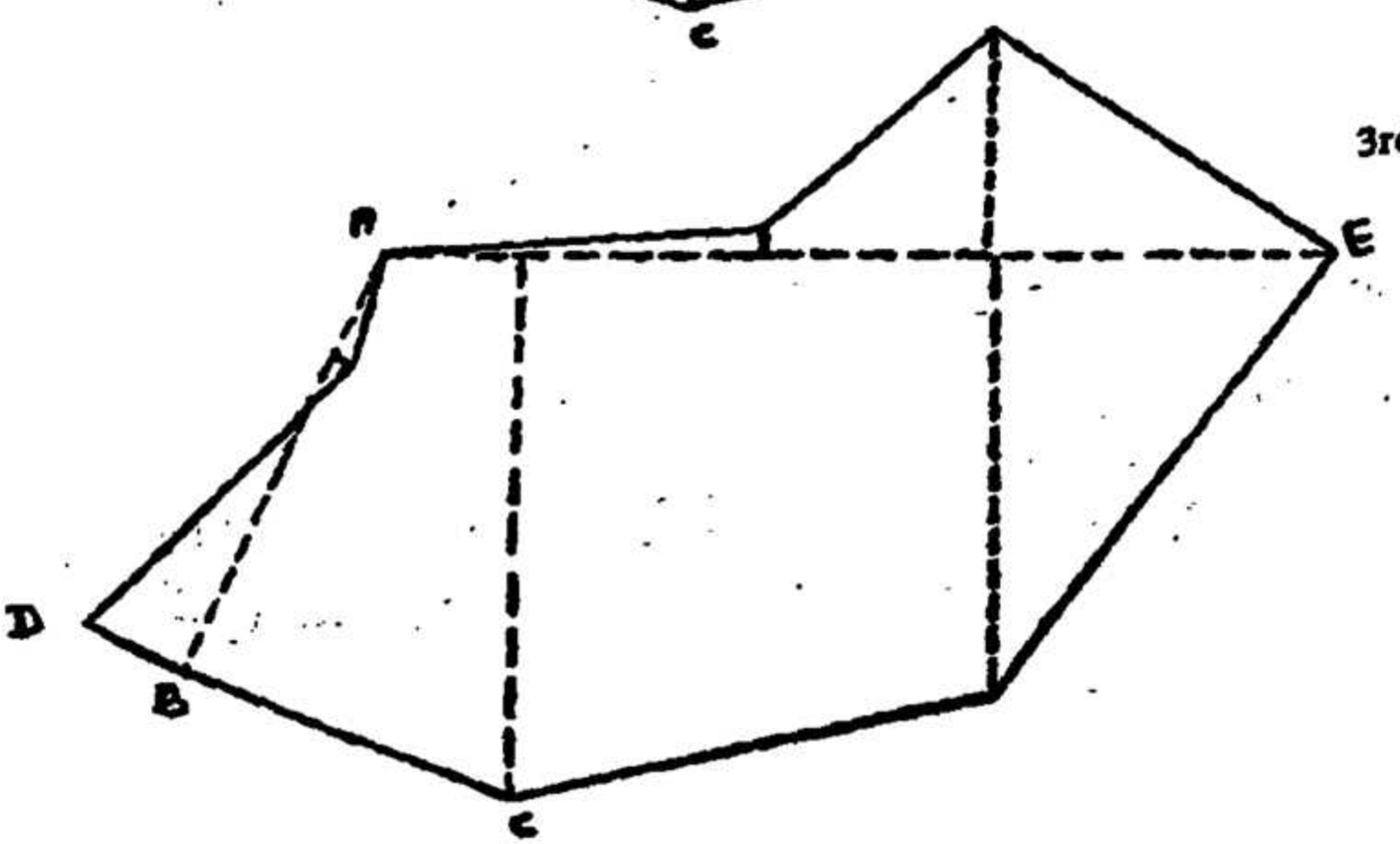
Scale 1·2,000



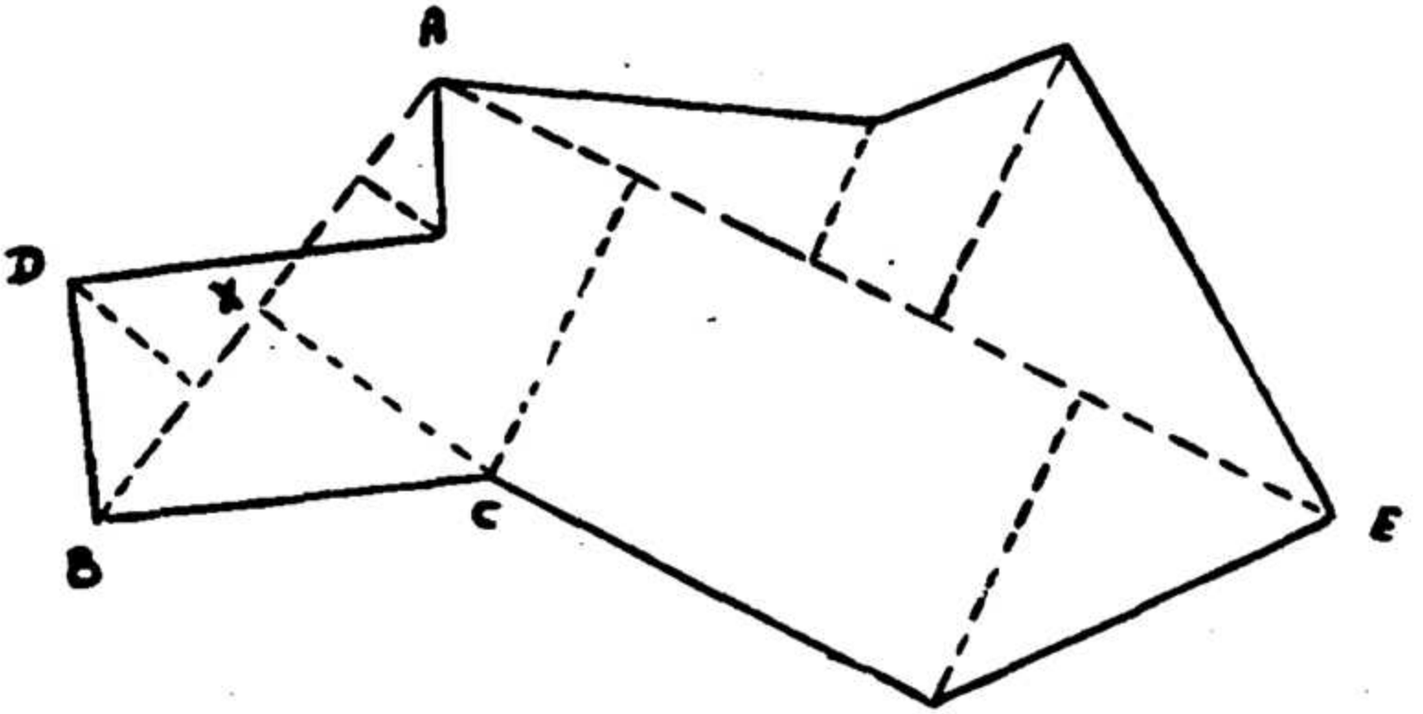

2nd stage




3rd stage



In case where the part of the Survey Number is measured on one base line and part on the other base line, it is always desirable to take an offset to a common point from both the base lines to facilitate plotting and area calculation, *vide* offset XC.




8. **To plot together two or more Numbers measured on individual base line.**—Occasionally it is found necessary to make a consolidated map of two or more Numbers, *e.g.*, as in the village maps. When they have all been measured on the same base line plotting can be done in the ordinary way but when the base lines are independent a different method has to be employed, *e.g.*, say the three Numbers shown below have to be plotted together. Then :

(*a*) first plot survey number 2,

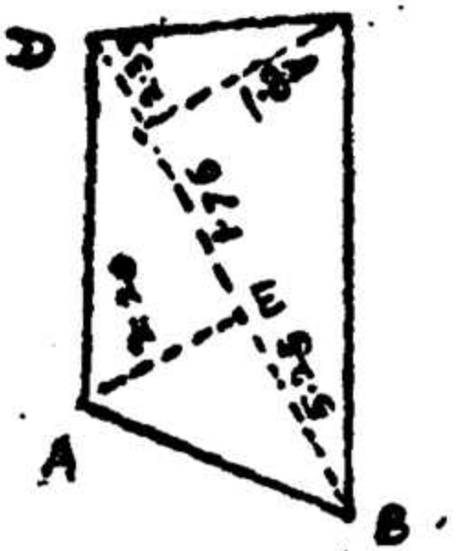
(*b*) then from the points A and B fix the point E by the intersection of the two lines AE, BE,

(*c*) the base line BED of Survey Number 1 can then be drawn and the number plotted upon it,

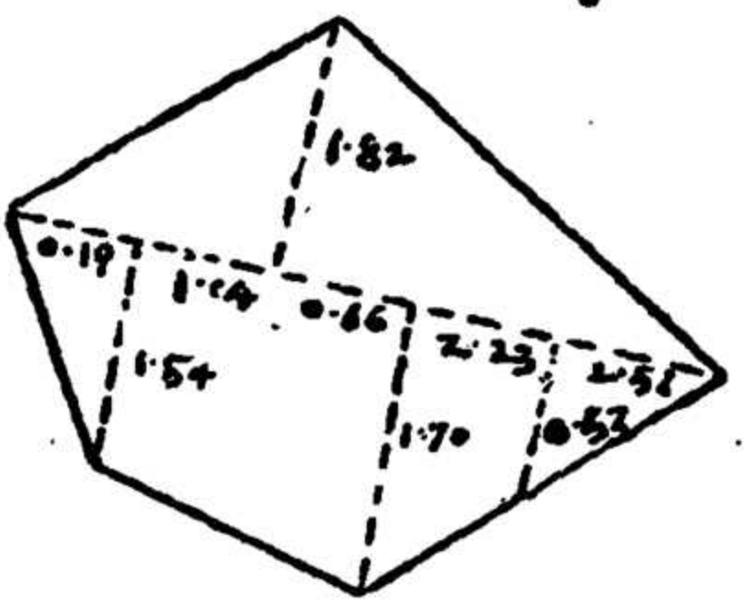
(*d*) in order to plot in Number 3 the point H must be fixed by intersection of the lines DH, AH. The base line DHF can then be drawn through the point H and the Number plotted upon it.

# The Tippan

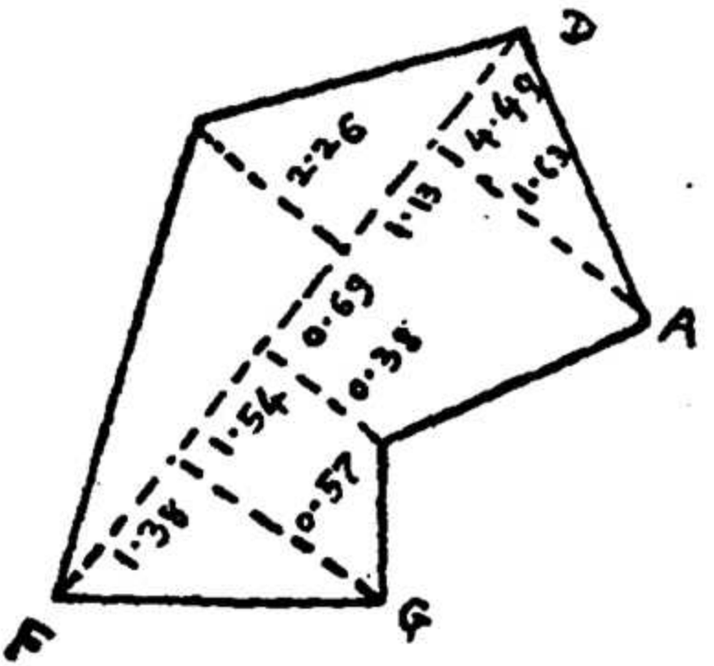
## Survey No. 1

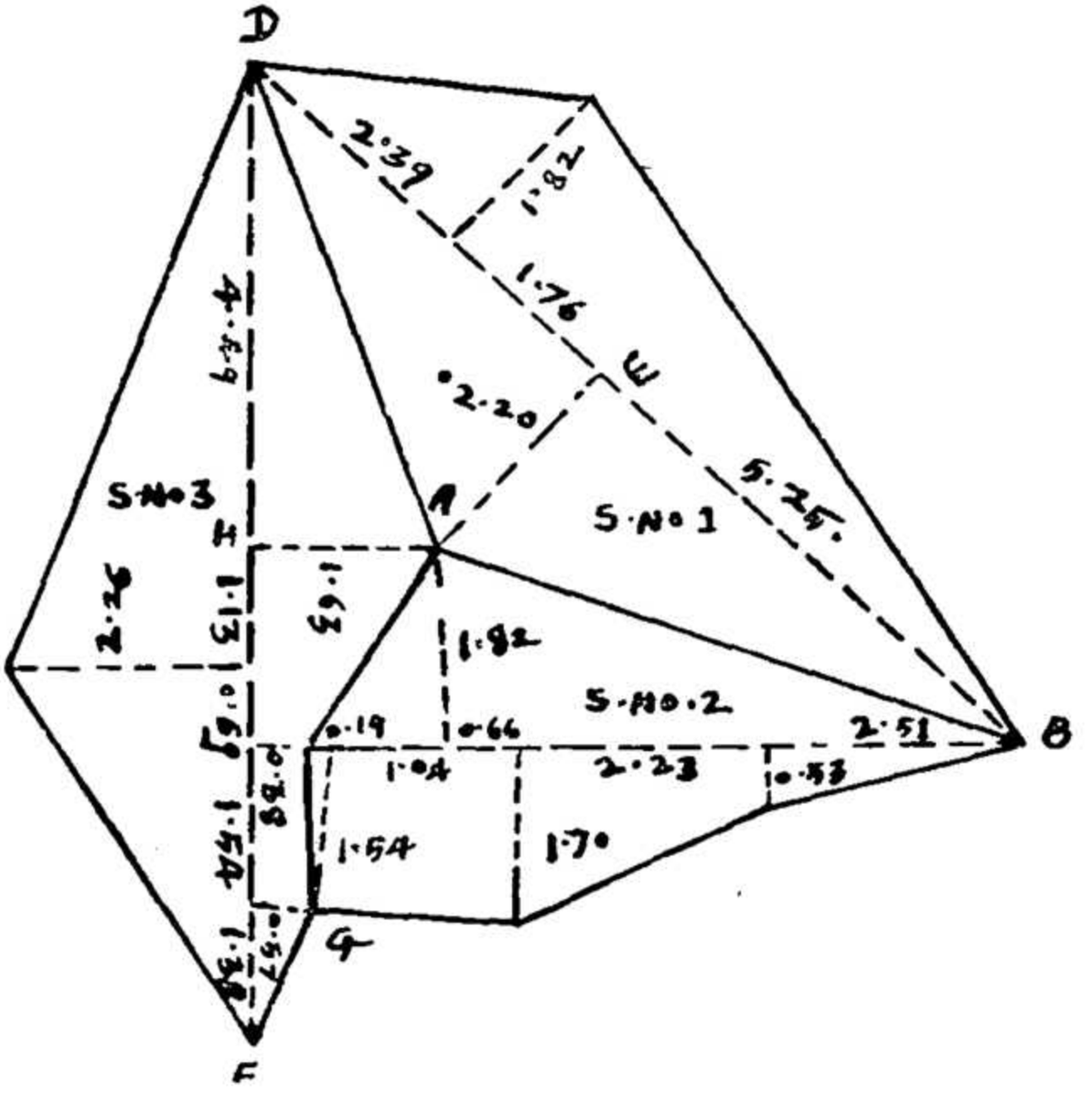



## Survey No. 2




## Survey No. 3



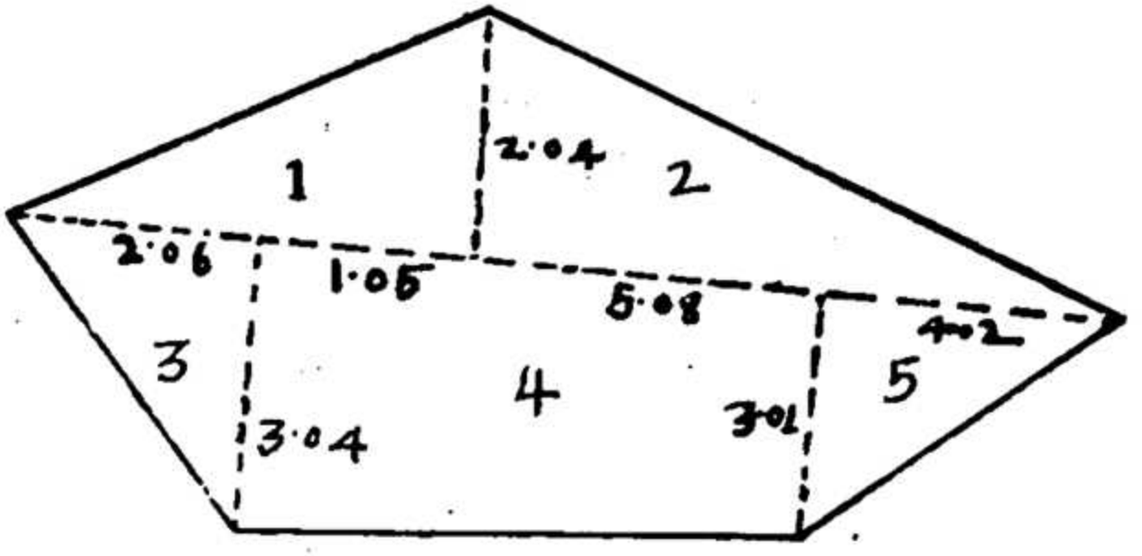



9. **Calculation of Areas.**—(*a*) The general method of calculating the areas has already been explained in Chapter I. To recapitulate shortly in order to find the area of a simple field, it is only

necessary to find the area of the trapezium and triangles composing it by multiplying the base by half the perpendicular in the case of triangles and by half the sum of the perpendiculars in the case of trapezium and to add up the totals.

(*b*) In working out the areas of the Vaslas, the ordinary rule of rounding is to be observed, *i.e.*, when the area relates to the Dry Crop class, the areas of and up to ·5, are to be discarded and the areas above ·5 are to be rounded off to the next higher Are. Similarly, in case of Rice Class of land as the area is to be rounded off to the nearest one digit of decimal of an Are, 6·301 is to be rounded off to 6·3.

(*c*) The method of working out the area in the prescribed form is given below :—

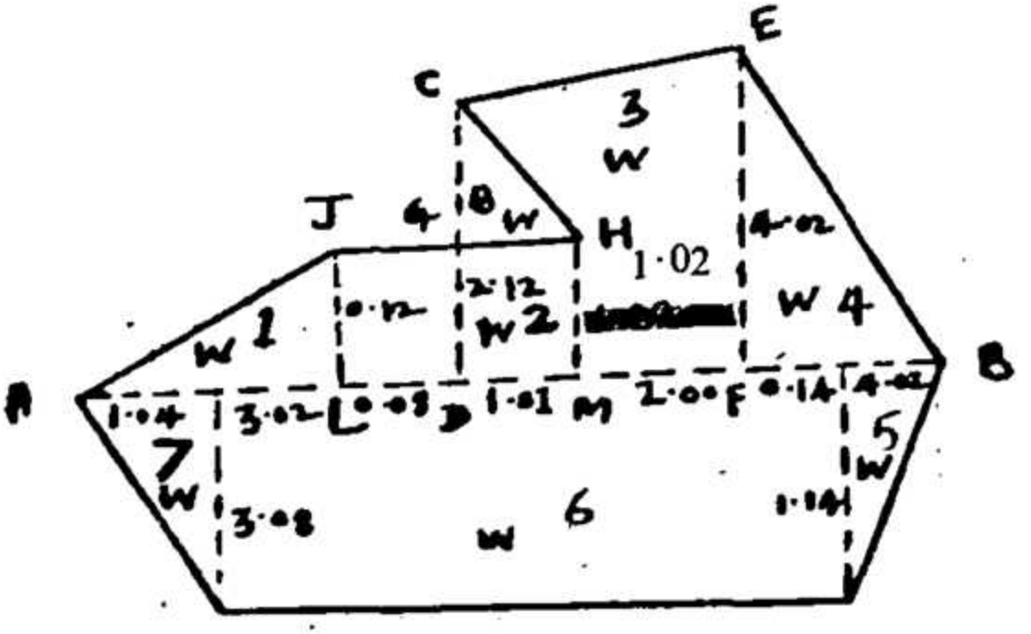


| Number of Vasla | Kind of Vasla | Base | | Offsets | | | Area | |
|---|---|---|---|---|---|---|---|---|
| | | Lengths | Sum of the lengths | Offsets | Sum of the offsets | Half the sum of the offsets | Hectares | Area |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 1 | △ | 2·06<br>1·05 | 3·11 | 2·04 | 2·04 | 1·02 | .. | 3·1,722 |
| 2 | △ | 5·08<br>4·02 | 9·10 | 2·04 | 2·04 | 1·02 | .. | 9·2,820 |
| 3 | △ | 2·06 | 2·06 | 3·04 | 3·04 | 1·52 | .. | 3·1,312 |
| 4 | □ | 1·05<br>5·08 | 6·13 | 3·04<br>3·01 | 6·05 | 3·02 | .. | 18·5,126 |
| 5 | △ | 4·02 | 4·02 | 3·01 | 3·01 | 1·50 | .. | 6·0300 |
| | | | | | | | Total .. | 40·1280 Sq. Chains x 4(4 Ares = 1 Sq. Chain) |
| | | | | | | | | 160·5120, *i.e.*, 161 Ares or 1·61 Hectares |

**10. Vaza Vaslas.**—Complications are, however, introduced when an offset goes outside the number.

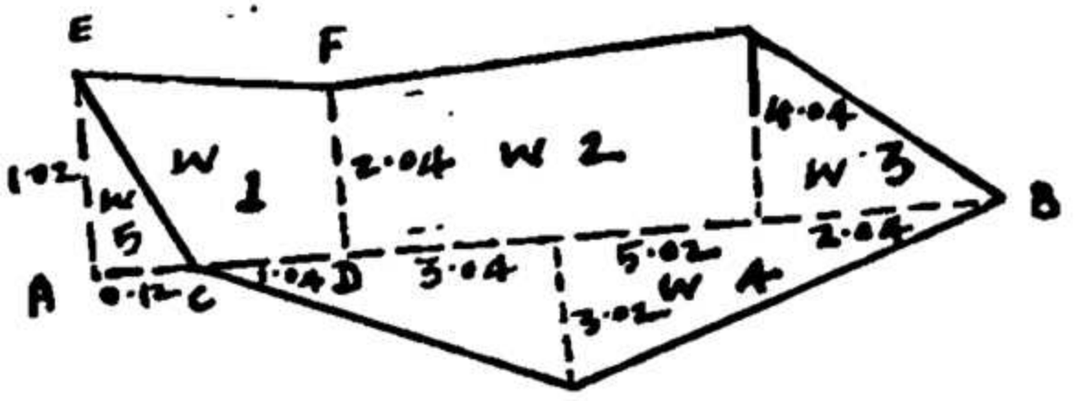
*Example 1.*—In this case from the base line A B an offset to the point C passes outside the number. Hence if the trapezium C D F E were taken as a Vasla, it would include the area C G H which does not form part of the number.

The way to get round the difficulty is after taking the trapezium J L M H to take C D F E also. The area G D M H has thus been taken twice over. Then by deducting the trapezium C D M H the redundant areas C G H and G D M H are excluded.



| Number of Vasla | Kind of Vasla | Base | | Offsets | | | Area | |
|---|---|---|---|---|---|---|---|---|
| | | Lengths | Sum of the lengths | Offsets | Sum of the offsets | Half the sum of the offsets | Hectares | Area |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 1 | △ | 1·04<br>3·02 | 4·06 | 0·12 | 0·12 | 0·06 | .. | 0·2436 |
| 2 | □ | 0·08<br>1·01 | 1·09 | 0·12<br>1·02 | 1·14 | 0·57 | .. | 0·6213 |
| 3 | □ | 1·01<br>2·00 | 3·01 | 2·12<br>4·02 | 6·14 | 3·07 | .. | 9·2407 |
| 4 | △ | 0·14<br>4·02 | 4·16 | 4·02 | 4·02 | 2·01 | .. | 8·3616 |
| 5 | △ | 4·02 | 4·02 | 1·14 | 1·14 | 0·57 | .. | 2·2914 |
| 6 | □ | 0·14<br>2·00<br>1·01<br>0·08<br>3·02 | 6·25 | 1·14<br>3·08 | 4·22 | 2·11 | .. | 13·1875 |
| 7 | △ | 1·04 | 1·04 | 3·08 | 3·08 | 1·54 | .. | 1·6016 |
| | | | | | | | Total .. | 35·5477 |
| | | | | *Deduct* | | | | |
| 8 | □ | 1·01 | 1·01 | 2·12<br>1·02 | 3·14 | 1·57 | .. | —1·5857 |
| | | | | | | | | 33·9620 Sq. Chains ×4 (4 Ares = 1 Sq. Chain) |
| | | | | | | | | 135·8480, *i.e.*, 136 Ares or 1·36 Hectares. |

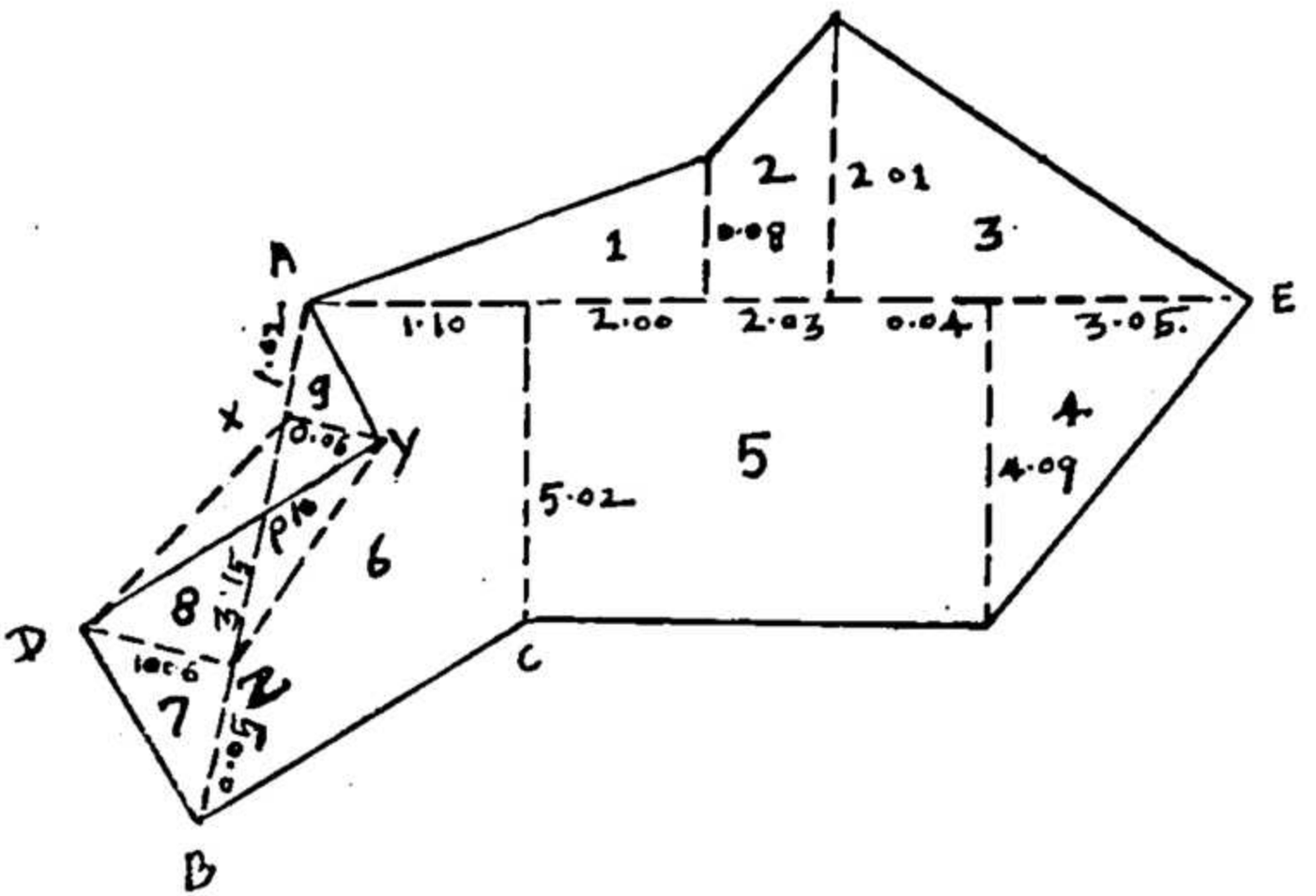
*Example 2.*—In this case the offset A E falls outside the base line. In order, therefore, to find the area of E C D F the area of the trapezium E A D F should first be found and then the area of the triangle E A C deducted from it.



| Number of Vasla | Kind of Vasla | Base | | Offsets | | | Area | |
|---|---|---|---|---|---|---|---|---|
| | | Lengths | Sum of the lengths | Offsets | Sum of the offsets | Half the sum of the offsets | Hectares | Area |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 1 | ▭ | 0·12<br>1·04 | 1·16 | 1·02<br>2·04 | 3·06 | 1·53 | .. | 1·7748 |
| 2 | ▭ | 3·04<br>5·02 | 8·06 | 2·04<br>4·04 | 6·08 | 3·04 | .. | 24·5024 |
| 3 | △ | 2·04 | 2·04 | 4·04 | 4·04 | 2·02 | .. | 4·1208 |
| 4 | △ | 2·04<br>5·02<br>3·04<br>1·04 | 11·14 | 3·02 | 3·02 | 1·51 | .. | 16·8214 |
| | | | | | | Total | .. | 47·2194 |
| | | | | *Deduct* | | | | |
| 5 | △ | 0·12 | 0·12 | 1·02 | 1·02 | 0·51 | .. | — 0·0612 |
| | | | | | | | | 47·1582 Sq. Chains × 4 (4 Ares = 1 Sq. Chain.) |
| | | | | | | | | 188·6328, *i.e.*, 189 Ares or 1·89 Hectares |

*Calculation of area when offsets fall within or outside the field boundary on the same diagonal.*

*Example 3.*—In some cases, however, it happens that some of the offsets taken on a diagonal line to the bends fall within, and others outside the figure formed by the diagonal. In such cases the field boundary line crosses the diagonal. The point of intersection of these two lines should be noted as far as possible to facilitate the calculation of the area of the field mathematically. But if it is not done, in the field, the area can be calculated in the following manner :—



In this case the boundary of the Survey Number crosses the base line. To facilitate calculation of area, separate measurements of the base line from X to P and from P to Z should have been taken but if instead of two separate measurements the measurement from X to Z only is taken the area can be calculated as shown below :—

Multiply the distance between the two offsets by the difference of the lengths of the two offsets and divide the product by two. The product is to be substracted from the area of the Survey Number, if the length of the offset falling outside the triangle is longer and to be added to the area of the Survey Number, if it is shorter. While calculating the area by vaslewar system, this is to be done by adding the area of a triangle DZX and substracting the area of the triangle ZXY. When we add the area of a triangle DZX we add the area of a portion DPX which is not included in our triangle but when we substract the area of XYZ we substract the area XYP, which is outside the triangle and the area ZPY. The area of the portion ZPY and the portion XPD is equal to each other deducting common △ DPZ from △s DXZ and DYZ standing (on the same base and between the same altitudes). So, when we substract the portion of the area DPX which is outside the triangle and which was added while adding the area of the triangle DZX is now substracted The examples given above are illustrative and not exhaustive but they cover instances of general occurrence.

In the above illustration the area would be worked out as shown below :—

| Number of Vasla | Kind of Vasla | Base | | Offsets | | | Area | |
|---|---|---|---|---|---|---|---|---|
| | | Lengths | Sum of the lengths | Offsets | Sum of the offsets | Half the sum of the offsets | Hectares | Area |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 1 | △ | 1·10<br>2·00 | 3·10 | 0·08 | 0·08 | 0·04 | .. | 0·1240 |
| 2 | ▭ | 2·03 | 2·03 | 0·08<br>2·01 | 2·09 | 1·04 | .. | 2·1112 |
| 3 | △ | 0·04<br>3·05 | 3·09 | 2·01 | 2·01 | 1·00 | .. | 3·0900 |
| 4 | △ | 3·05 | 3·05 | 4·09 | 4·09 | 2·04 | .. | 6·2220 |
| 5 | ▭ | 2·00<br>2·03<br>0·04 | 4·07 | 5·02<br>4·09 | 9·11 | 4·55 | .. | 18·5185 |
| 6 | ▭ | 1·10 | 1·10 | 5·02<br>1·02<br>3·15<br>0·05 | 9·24 | 4·62 | .. | 5·0820 |
| 7 | △ | 0·05 | 0·05 | 1·06 | 1·06 | 0·53 | .. | 0·0265 |
| | | | | | | | Total .. | 35·1742 |
| | | | | *Add* | | | | |
| 8 | △ | 3·15 | 3·15 | 1·06 | 1·06 | 0·53 | .. | +1·6695 |
| | D2X | | | | | | Total .. | 36·8437 |

| Number of Vasla | Kind of Vasla | Base | | Offsets | | | Area | |
|---|---|---|---|---|---|---|---|---|
| | | Lengths | Sum of the lengths | Offsets | Sum of the offsets | Half the sum of the offsets | Hectares | Ares |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| | | | | | | | B. F. .. | 36·8437 |
| | | | | *Deduct* | | | | |
| 9 | △ AXY | 1·02 | 1·02 | 0·06 | 0·06 | 0·03 | .. | 0·0306 |
| 10 | △ ZXY | 3·15 | 3·15 | 0·06 | 0·06 | 0·03 | .. | 0·0945 |
| | | | | | | | | —0·1251 |
| | | | | | | | Balance | 36·7186 Sq. Chains. |
| | | | | | | | | × 4 (4 Ares = 1 Sq. Chain.) |
| | | | | | | | | 146·8744. *i.e.*, 147 Ares or 1·47 Hectares.. |

## CHAPTER VI

## THE VARGA MUL

1. The meaning of Varga Mul in Vernacular is "Square root" but the expression is used by native Surveyors with reference to the Jantri or table of Square roots by means of which the correctness of the measurements of the base line and offsets are checked by the measurement of the Bandh Maps and *vice versa*; and in this Chapter it will be used in this sense.

2. The use of this table is based upon the following propositions:—

(1) That the hypotenuse (Bandh Map) of a right-angled triangle = the square root of the square of the base (Lambi) added to the square of the perpendicular (Rundi).

(2) That the base of a right-angled triangle = the square root of the difference between the squares of the hypotenuse and of the perpendicular.

(3) That the perpendicular of a right-angled triangle = the square root of the difference between the squares of the hypotenuse and of the base.

(4) That the Bandh Map of the trapezium = the square root of the sum of the square of the base and the square of the difference between the two perpendiculars.

(5) That the base of a trapezium = the square root of the difference between the square of the Bandh Map and the square of the difference between the two perpendiculars.

(6) That the difference between the perpendiculars of the trapezium = the square root of the difference between the square of the Bandh Map and the square of the base.

3. The measurer, therefore, who has a table of squares and square roots, can by a simple calculation check all his measurements as he goes along by comparing the measurements of the Bandh Maps with those of the Lambis and Rundis with the certainty that if they all agree his measurement work is correct. The table is so useful and also in common use that no good measurer thinks of working without one.

4. A portion of such a table is shown overleaf. In column one are shown vertically measurements by chains; in column one horizontally are shown measurements by links. In column two are shown the squares of the full chains shown in vertical column one and in the remaining columns are shown the squares of the chains in the vertical column combined with the links in horizontal column one. Thus the square of 2 chains and 08 links is 4·33 or four square chains and 33 square links which will be found opposite the entry for 2 chains and below the entry for 8 links. In order to find the square root of an area the same method must be worked out backwards. Thus to find the square root of 25·50, the figure will be found opposite the entry of 5 chains and below the entry for 5 links. Hence the square root of 25·50 square chains is 5 chains and 5 links.

| Chains | Squares | Links 1 | Links 2 | Square 3 | Links 4 | Links 5 | Links 6 | Links 7 | Links 8 |
|---|---|---|---|---|---|---|---|---|---|
| | | ·0000 | ·0004 | ·0009 | ·0016 | ·0025 | ·0036 | ·0049 | ·0064 |
| 1 | 1 | 1·02 | 1·04 | 1·06 | 1·08 | 1·10 | 1·12 | 1·14 | 1·17 |
| 2 | 4 | 4·04 | 4·08 | 4·12 | 4·16 | 4·20 | 4·24 | 4·28 | 4·33 |
| 3 | 9 | 9·06 | 9·12 | 9·18 | 9·24 | 9·30 | 9·36 | 9·42 | 9·49 |
| 4 | 16 | 16·08 | 16·16 | 16·24 | 16·32 | 16·40 | 16·48 | 16·56 | 16·65 |
| 5 | 25 | 25·10 | 25·20 | 25·30 | 25·40 | 25·50 | 25·60 | 25·70 | 25·81 |

*N. B.*—The figures in the table from one chain onwards are rounded off to the nearest square link.

5. The method of using such a table as expressed in the practical language of the Varga Mul is as follows :—

(1) *To find the Bandh Map of a right-angled triangle.*—Square the base and offset, add the results together and find the square root.

(2) *To find the base of a right-angled triangle.*—Deduct the square of the offset from the square of the Bandh Map and find the square root of the remainder.

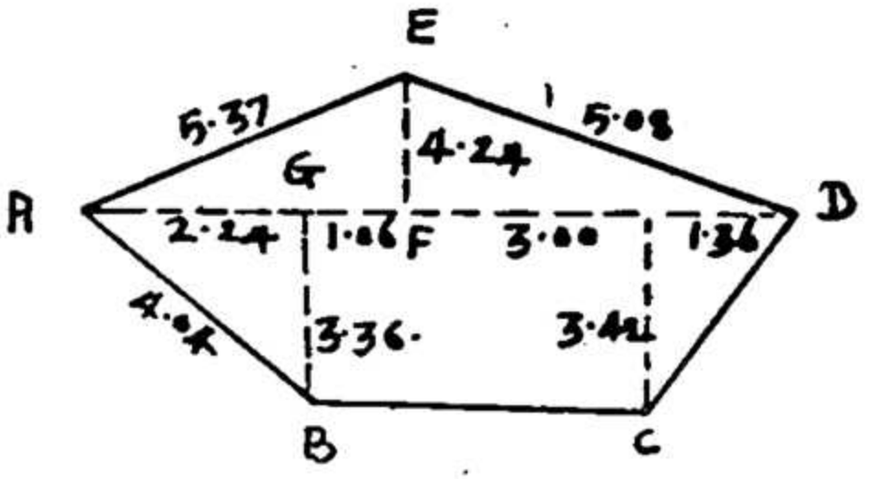
(3) *To find the offset of a right-angled triangle.*—Deduct the square of the base from the square of the Bandh Map and find the square root of the remainder.

(4) *To find the Bandh Map of a trapezium.*—Deduct the shorter from the longer of the two offsets, square the remainder and add it to the square of the base; then find the square root of the total.

(5) *To find the base of a trapezium.*—Deduct the shorter from the longer of the two offsets, square the remainder and deduct it from the square of the Bandh Map, then find the square root of the remainder.

(6) *To find the offset of a trapezium.*—Deduct the square of the base from the square of the Bandh Map, the square root of the remainder will be the difference between the two offsets. Hence if one of the offsets is known the other can be found either by adding the difference to, or by substracting the difference from, the length of the known offset according as the known offset is shorter or longer.

6. To give a practical illustration of its use.



In this case, the measurer after measuring the offset at G to B compares the measurement of the base line (2·24) and offset (3·36) with that of the Bandh Map. According to Rule one laid down above thus—

| | | |
|---|---|---|
| Square of the base line .. .. .. | 2·24 = | 5·02 |
| Square of the offset .. .. .. | 3·36 = | 11·29 |
| *Add* together .. | | 16·31 |

Square root of 16·32 = 4·04, which should be the Bandh Map. This calculation proves that the measurements are correct as they agree when worked out theoretically.

Similarly, after measuring the offset from FE, the measurer may compare the measurement of the Bandh Map and offset with that of the base according to Rule 3 thus—

| | | |
|---|---|---|
| (*a*) Square of Bandh Map .. .. | 5·37 = | 28·84 |
| (*b*) Square of the base .. .. | 2·24 + 1·06 = | 10·89 |
| | 3·30 | |
| *Deduct* (*b*) from (*a*) = | | 17·95 |

Square root of 17·95 = 4 Chains, 24 Links = offset EF. Hence the measurements again are proved correct.

On measuring up to the point D, however, and taking the Bandh Map 5·08 from D to E, the measurer on comparing the measurements of the base (3·00 + 1·36 = 4·36) and the offset 4·24 with the Bandh Map 5·08 by Rule one finds—

| | | |
|---|---|---|
| Square of the base .. .. .. | 4·36 = | 19·01 |
| Square of the offset .. .. .. | 4·24 = | 17·98 |
| *Add* together .. | | 36·99 |

The square root of $36 \cdot 99 = 6 \cdot 08$ which should agree with the Bandh Map 5·08 but does not. Hence there must be an error in measurement somewhere which the measurer can proceed to investigate at once, instead of waiting to discover it when he comes to plot the number in office, the result of which would be either a second visit to the field or else tampering with the measurements to make them agree.

7. In the same way the whole of the measurements can be compared by the measurer as he goes along and at the end he can be certain of the absolute accuracy of his work.

# CHAPTER VII

## MEASUREMENT ON THE PHALNI SYSTEM

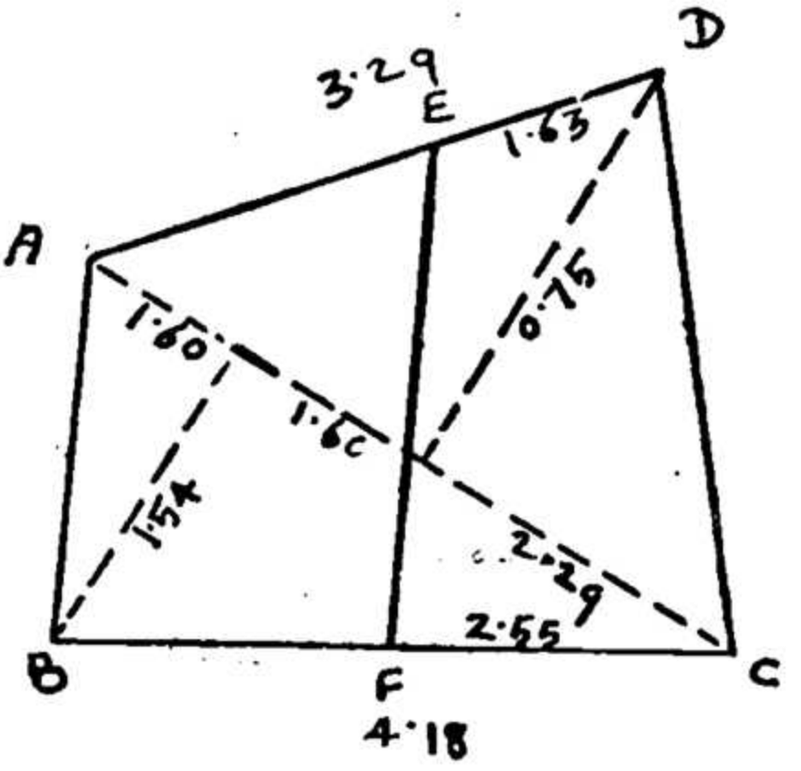
1. The chain and Cross-staff system is the foundation of all measurement work and every measurer must receive a thorough training therein. All our Original and Revision surveys are conducted on Cross-Staff System. In the pre-reorganised Bombay State districts the Plane Table System is introduced between 1910 to 1920 but in the five Marathwada districts and four Berar districts, the method of measurement was Cross-Staff but now it is replaced by the Plane Table System. Even after introduction of the Plane Table System a thorough knowledge of the Cross-Staff System is indispensable because all our survey records will continue to be in Cross-Staff System. Moreover, even where the Plane Table System is introduced, in case, any holder applies for the refixation of the boundary of his holding which is originally measured by Cross-Staff with the Cross-Staff method only, such applications are to be entertained and the measurement is to be carried out on Cross-Staff System. The necessity of a thorough knowledge of Cross-Staff Survey to a surveyor is thus quite evident.

In areas already surveyed, for measuring subsequent sub-divisions, a system commonly known as Phalni System is generally adopted This method is much quicker than measurement by chain and cross staff and for all practical purposes is quite as accurate Hence it must be employed in practical work so far as possible

2. This not a new system. It is one of the methods of the cross staff System. The principles of the system may best be explained by an illustration.

Let A B C D be the tippan of a Survey Number (*vide* Figure I) and let it be supposed that according to the decree of a civil court it has to be divided into two parts in accordance with possession. On coming to the field the Surveyor finds that the dividing line of possession runs from E F. He has, therefore, to divide up the field into 2 parts A B F E and E F C D and to find the area of each.

## FIGURE-I



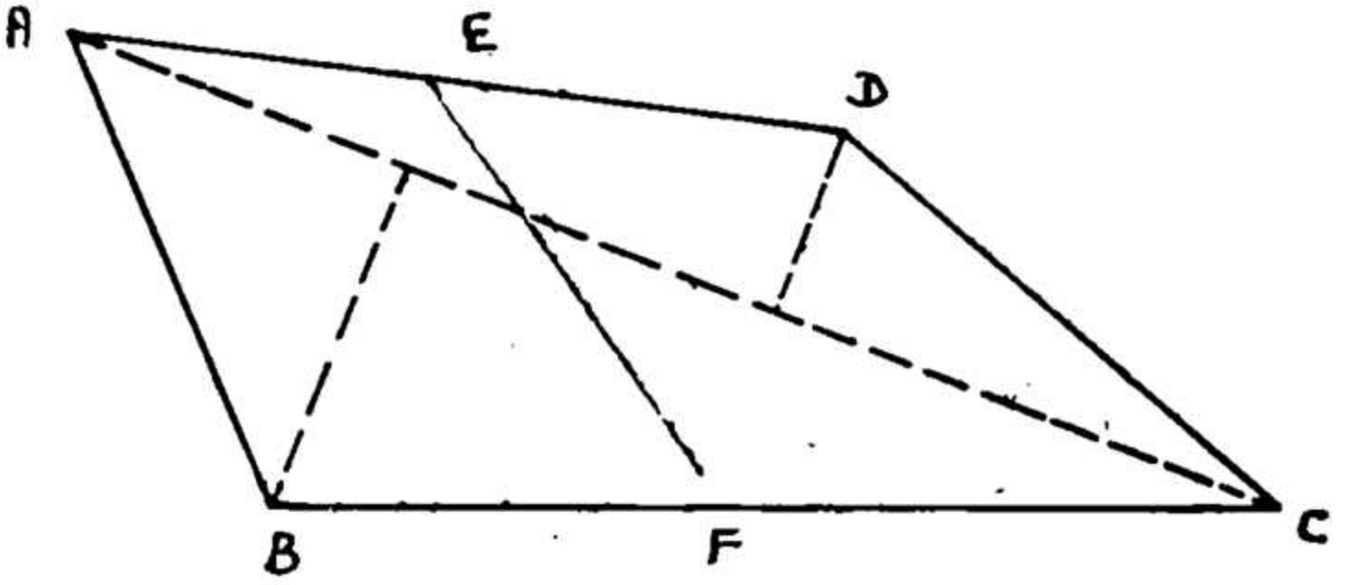

3. Now according to the method of chain and Cross-Staff, he would first have to set up the old base line AC and then take offsets to the points F and E. In office he would have to work out the area by Gunakar.

According to the Phalni System, however, he would proceed as follows :—

(1) In the field he would take measurements from D E (which—say—is 1 chain and 63 links) and from C F (which—say—is 2 chains and 55 links) only.

(2) In the office he would draw a map of the number on a scale of 1 : 1,000 and plot in the measurements taken in the field (*vide* Figure II).

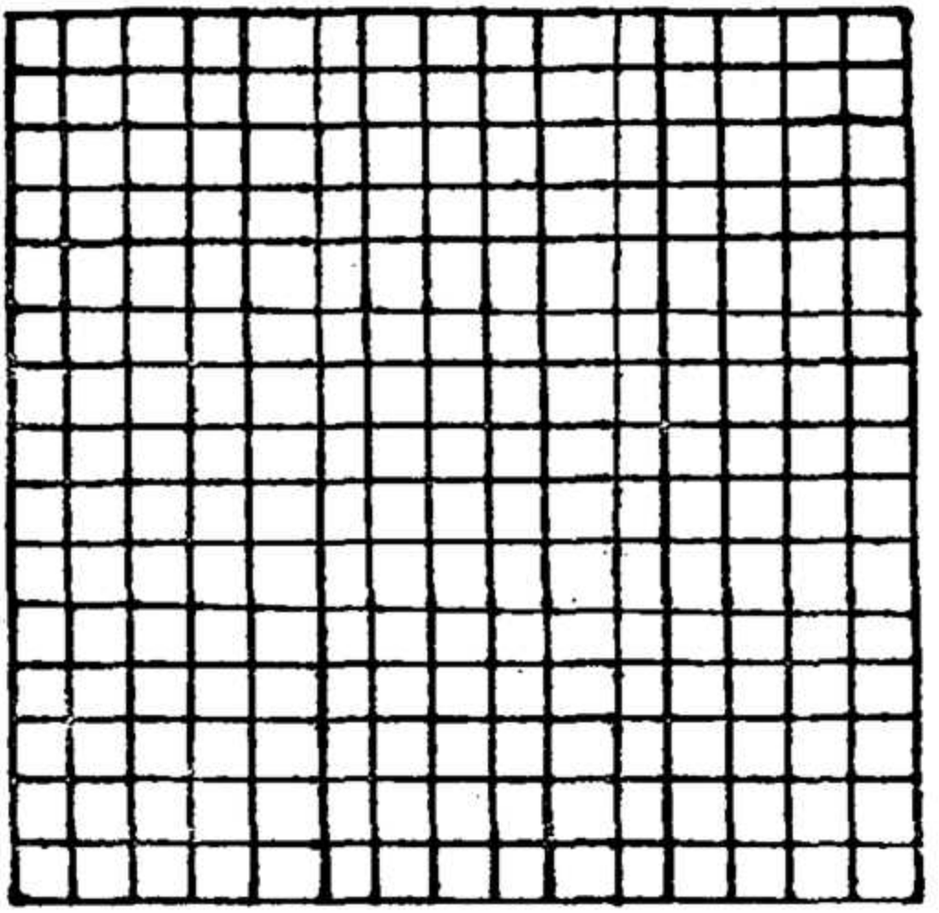
FIGURE 2.




(3) Lastly in order to find the area he will use the area square (*vide* Figure III). This is a sheet of paper divided into small squares, the sides of which are each 5 millimetres as the example shows. To find the area, it is only necessary to superimpose the area square over the scale drawn sketch and count the number of squares which the sketch covers. Now when the scale of the sketch is—

| | | | Small Squares Ares | Red Squares Ares |
|---|---|---|---|---|
| 1 : 10,000 or 1 Centimetre | = 100 Metres | each = | 25·00 | 625·00 |
| 1 : 5,000 or 1 Centimetre | = 50 Metres | „ = | 6·25 | 156·25 |
| 1 : 2,000 or 1 Centimetre | = 20 Metres | „ = | 1·00 | 25·00 |
| 1 : 1,000 or 1 Centimetre | = 10 Metres | „ = | 0·25 | .6·25 |

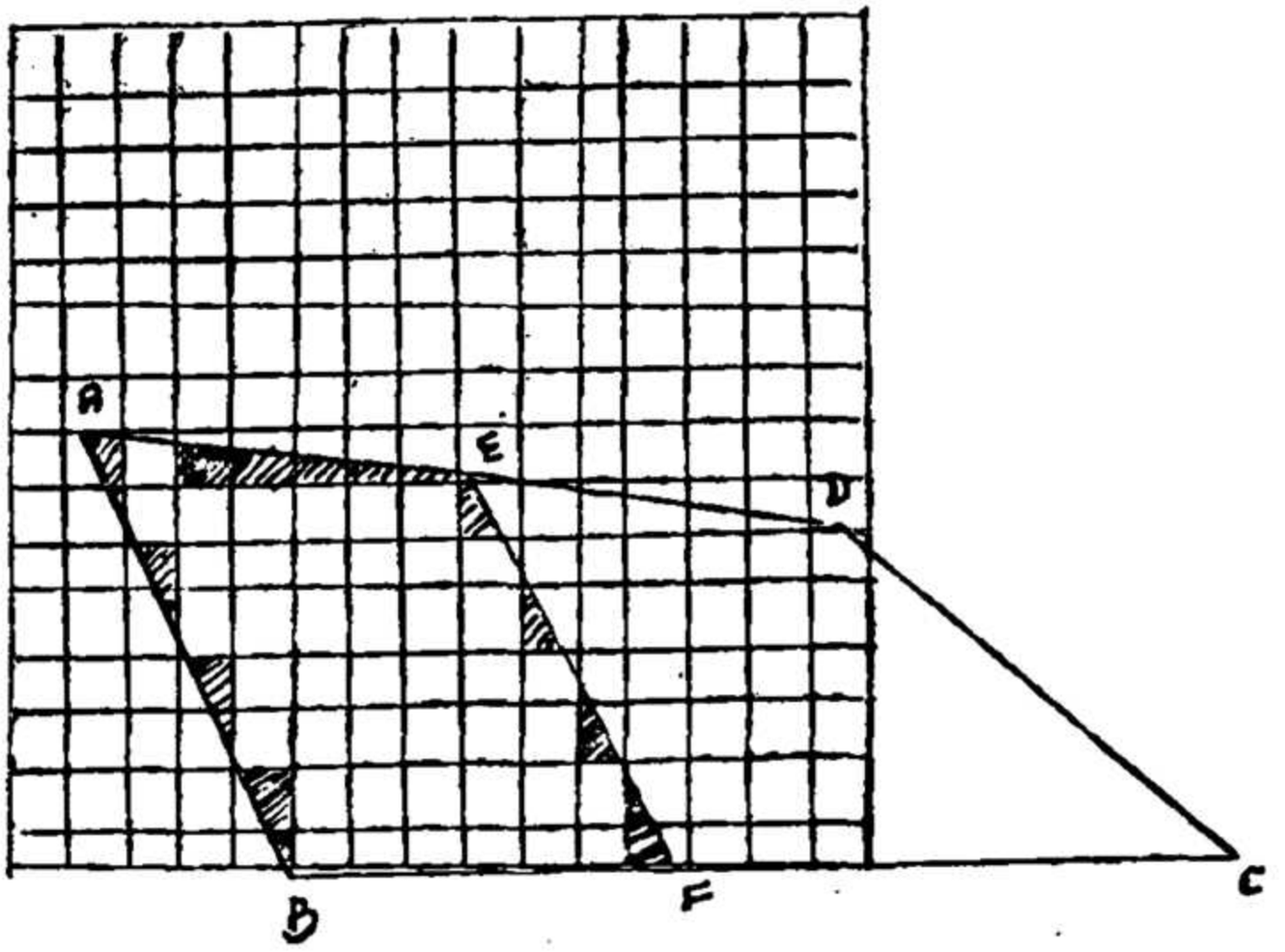
FIGURE - III



Hence the number of squares covered by the sketch multiplied according to the scale of the sketch by the area per square given above will give the area of the plot.

Applying the method to the number in question the area square is first superimposed upon the Part ABFE as shown in Figure IV. Then if the number of whole and practically whole squares be added up they come to 43. There remain, however, parts of squares (shaded by cross lines in the sketch) which have to be added together to make whole squares. They come to approximately 6, hence the total number of squares is 49. The scale of the sketch is 1 : 1,000 hence the value of each small square is 0·25 or 1/4 Are. Hence the area of ABFE is 12·25 Ares.

FIGURE IV




The area square will now be moved on to EFCD and the area discovered in the same way. The number of squares will then be found to be 53 and the area consequently 13·25 Ares.

If these two areas be added together they will be found to be 25·50 Ares and to equal the area of the field as found by calculation.

The foregoing example illustrates sufficiently the principles of the system. It is now, however, necessary to go into more detail regarding the methods to be employed.

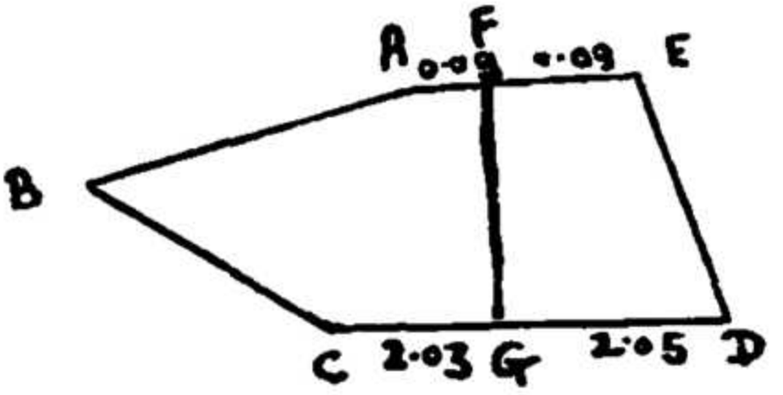
*Measurement*

(1) Where the boundary marks of the survey number are in existence, it is not necessary to fix the boundary of the number according to the old tippan before measurement.

(2) Where some of the boundary marks are either missing or out of place, it is only necessary to fix the marks which are essential for purposes of measurement.

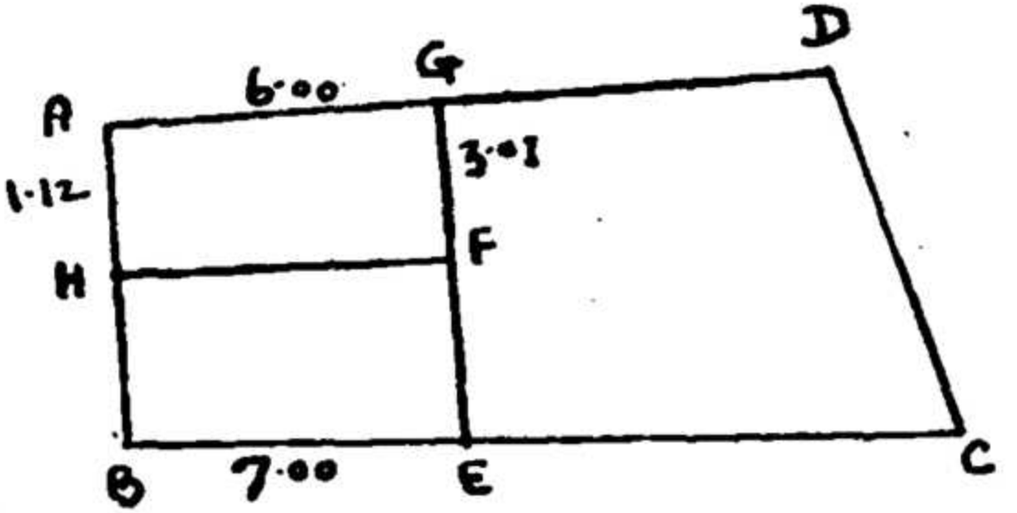
*Figure V.*—If this number has to be divided into two parts at FG then if the mark at B is out of place or missing it is not necessary to fix it, nor again if D and E are in place and the direction of the boundary from EA and DC can be traced in the field is it necessary to fix the marks at A and C as the only measurements required are from E—F and D—G.

FIGURE : V




(3) Measurements on straight internal boundaries will be made as shown in Figure VI.

Figure- VI

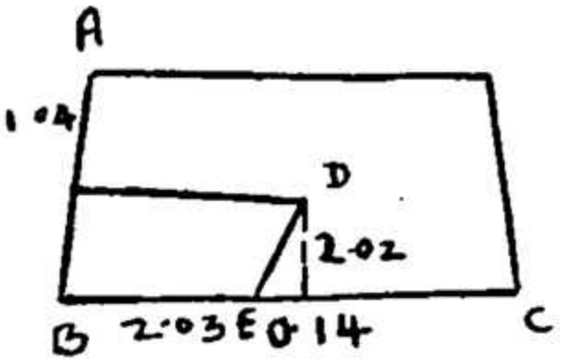


In this example as G E is a straight internal boundary it is only necessary to measure BE, HA, AG and GF.

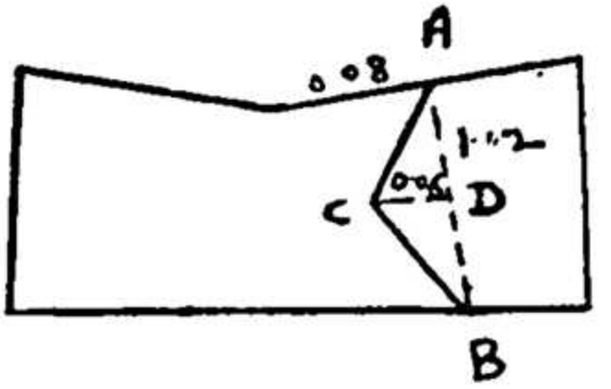
4. Internal bends must be fixed from a base line which must rest on fixed points but otherwise must be that which will enable the work to be done in the quickest way. In the following examples shown in Figure VII different kinds of base lines are shown each of which is the most convenient for the particular case—

FIGURE VII

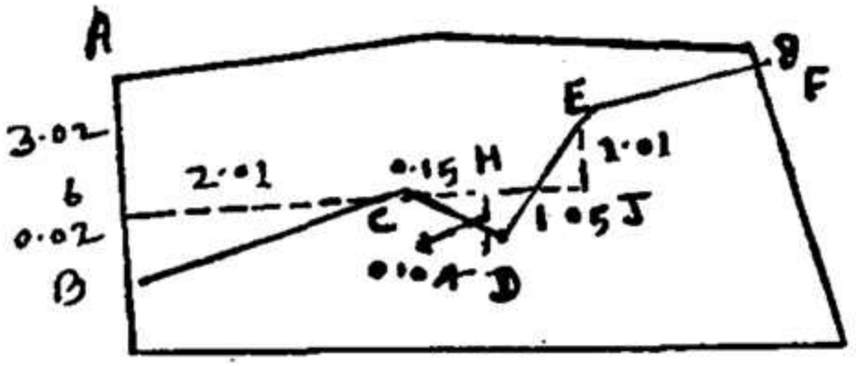
Example-1




Example 2



Example 3.



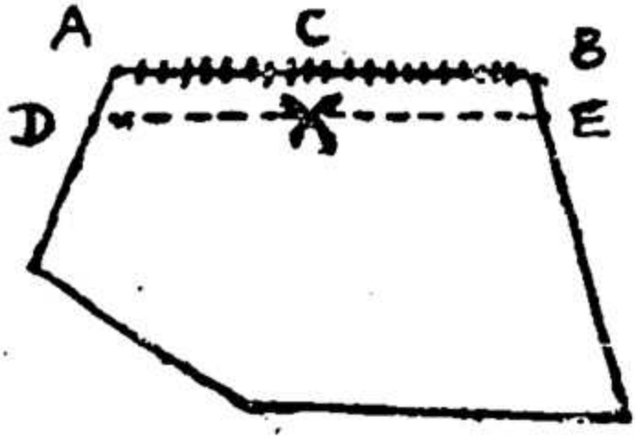

*Example 1.*—In this case the base line is the boundary of the number.

*Example 2.*—In this case the Number has to be divided into two parts along A C B. Here the base line is taken along A B to fix the point C by an offset at D. It will be seen that it is not necessary to measure DB as well as A D.

*Example 3.*—In this case the point is fixed by an offset from the boundary of the Number and the points D and E from offsets taken from the original offset as a base line.

5. If the boundaries of the number are so covered with prickly pear or other obstructions that it is not possible to measure along them, then if it be possible measurement may be made on unobstructed ground parallel with the boundary line, Fig. VIII.

Example. 4.




If in order to fix C, it is not possible to measure exactly along A B measurement may be made along the line D E parallel to A B.

## Office Work

1. In plotting it should be a rule to take the largest scale possible as the larger the scale the smaller the chance of error in calculating the area. The scale of 1 : 10,000 must never be used. Plotting must be done very carefully as everything depends upon its accuracy.

2. In calculating the area, it must be remembered that if the plotting has been done correctly then the area of the whole number as worked out by area square must tally with that recorded in the Survey Records unless of course the latter are for some reason or other incorrect.

If, therefore, the difference between these areas works out at more than 5 per cent or the value of 4 small squares at the scale—whichever may be least—mistakes must be looked for either in the plotting or in the old measurement as recorded in the tippan or in the calculation of area by the Survey. If the plotting is correct then the old measurements should be mutually tested by means of the vargamul. If they are accurate then the area should be recalculated from the old tippan. A mistake is sure to be discovered somewhere.

*Practical Applications of the Method.*

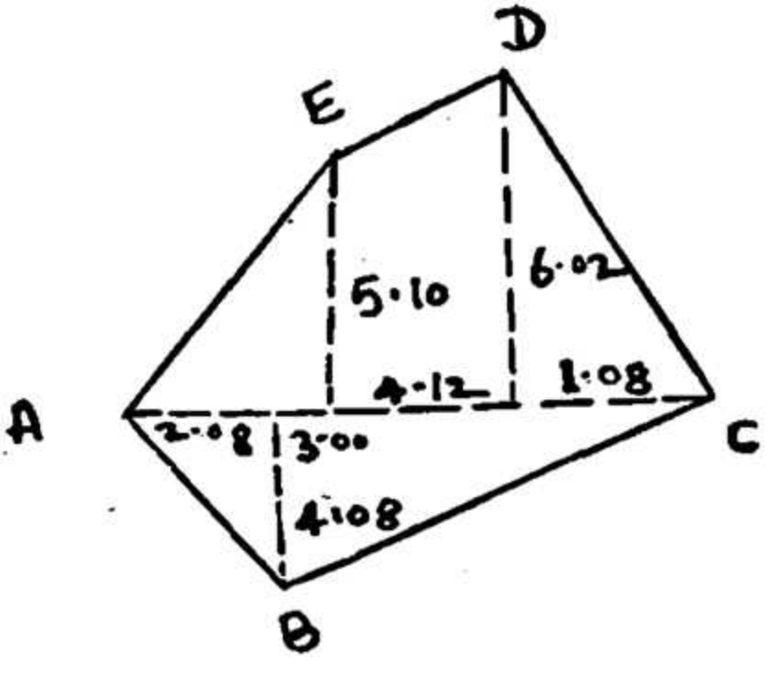
(1) To divide a number into two or more parts according to possession, *e.g.*, under orders of the Civil Court.

This had already been described above.

(2) To divide a number into two or more parts according to certain areas, *e.g.*, according to the orders of a Civil Court or for purposes of cultivation.

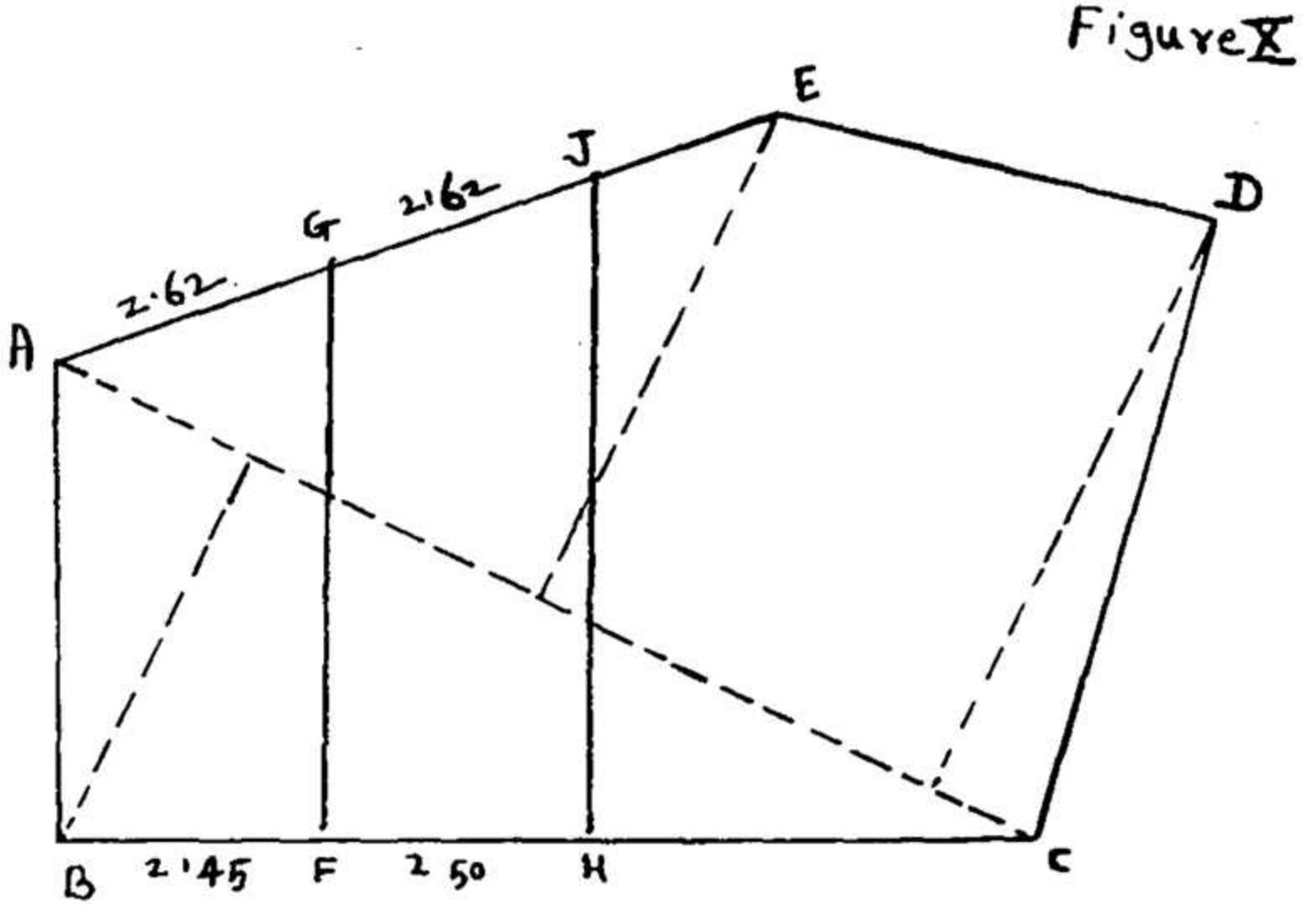
Let A B C D E, Figure IX, be the Survey number whose area is 2 Hectares and 40 Ares. It is desired to divide it into 3 parts measuring 1 Hectare and 32 Ares, 58 Ares, and 50 Ares.

FIGURE IX



**To do this :**

(*a*) Plot the number on a scale of 1 : 2,000 as in Figure X.



(*b*) Then with the area square lay down the required areas on the plotted sketch.

| | | | |
|---|---|---|---|
| *viz.*, for | 50 Ares | 200 | Squares as ABFG. |
| | 58 Ares | 232 | Squares as GFHJ. |
| 1 Hectare and | 32 Ares | 528 | Squares as JHCDE. |

(*c*) Next take off the distances along the boundary by scale from

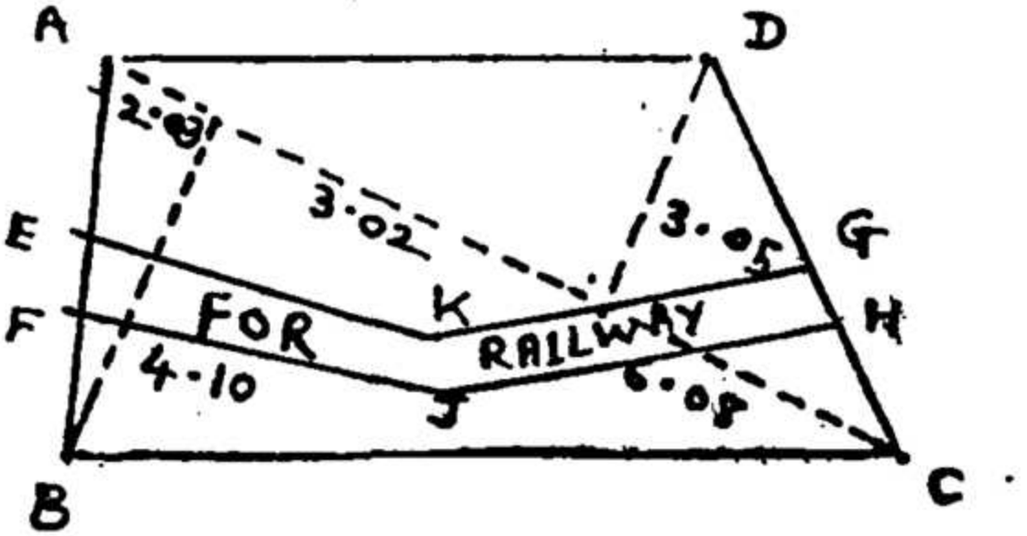
| | | Chains | Links |
|---|---|---|---|
| A—G | .. .. .. | 2 | 62 |
| G—J | .. .. .. | 2 | 62 |
| B—F | .. .. .. | 2 | 45 |
| F—H | .. .. .. | 2 | 50 |

(*d*) Lastly, measure these distances in the field and mark the corners so arrived at.

(*e*) To measure land to be taken up, *e.g.*, for a Railway road, etc.

*Example.*—Let A B C D, Figure XI, be a Number from which an area as shown in red ink is to be taken up for a Railway.

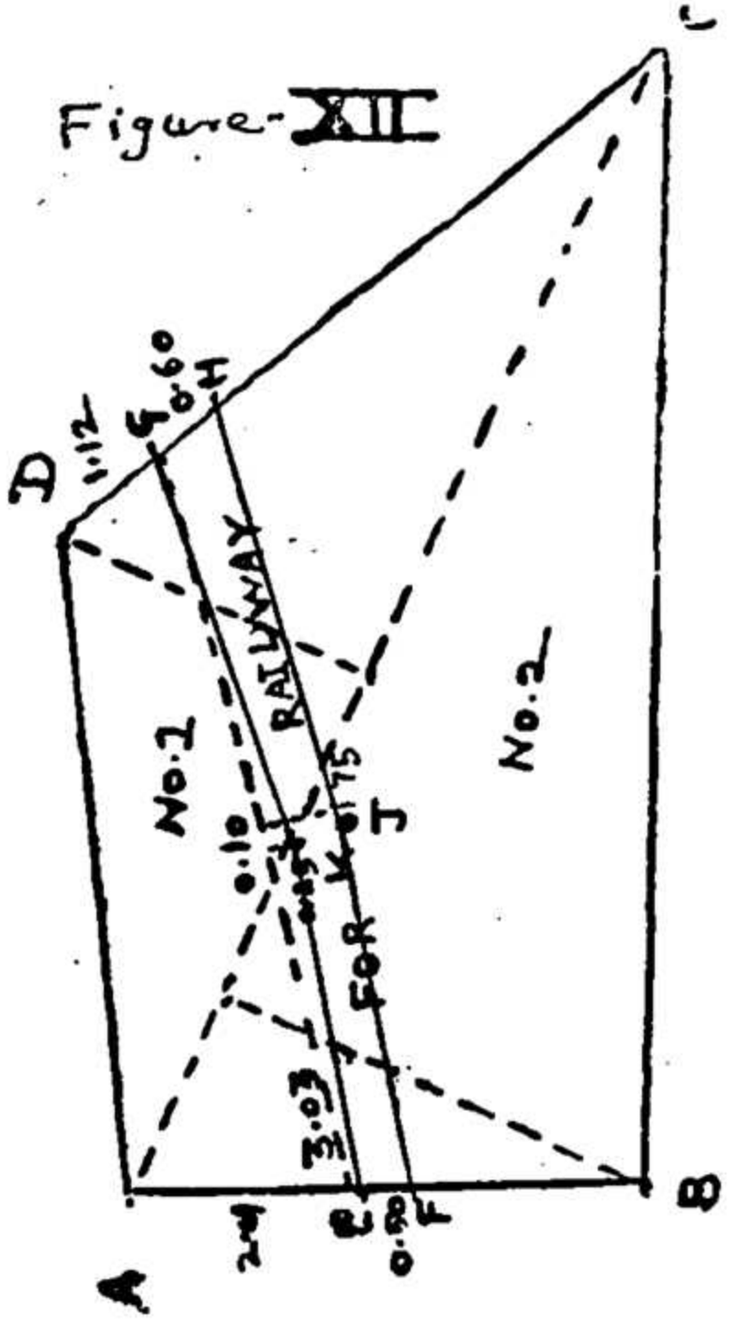
FIGURE XI



(*a*) Measure from A E (2 chains 1 link) and from E F (50 links). Set up base line from E G and fix points K and J therefrom as shown : lastly, measure D G (1 chain 12 links) and G H (60 links).

(*b*) Plot these measurements on a scale of 1 . 2,000 as in Figure XII, and take out the area of the land for the Railway and of the remaining portions by area square. These will be found to be—

| | | Hectares | Area |
|---|---|---|---|
| No. 1 | .. .. | 0 | 42 |
| Railway land | .. .. | 0 | 14 |
| No. 2 | .. .. | 1 | 03 |
| | Total .. | 1 | 59 |



# CHAPTER VIII

## PRACTICAL MEASUREMENT

**1. The practical measurement work of the Surveyor chiefly consists of the following kinds :—**

(1) Partition either on application due to new pot-hissas or in execution of a Court's decree.

**(2) Fixing the position of missing marks in a Survey No. either on application of the occupants or in the course of ordinary work such as repair of boundary marks.**

**(3) Boundary disputes.**

**(4) Acquisition of land for public purposes such as roads, schools, dharmashalas, etc.**

**(5) Measurement of lands for non-agricultural purposes.**

**(6) Measurement of lands to be given for cultivation out of unassessed waste numbers.**

**(7) Measurement of alluvial lands formed on the bank of nalas and either added to adjoining numbers or formed into new numbers.**

In sending up the correspondence after dispcsal the Surveyor must of course attach Kacha and Pakka tippans showing all the necessary details. On these tippans all new boundary lines must be shown in red ink.

In each class of case the following procedure must be adopted.

**2. Partition on application due to new pot-hissa or Court's decree.—**

(*a*) In partition cases the areas partitioned will usually be divided into pot-hissa and not into fresh survey numbers. Hence, boundary marks need not be erected unless the parties desire that this should be done.

(*b*) Measurement will in such cases be made according to the phalni system described in the preceding chapter

(*c*) In the Kacha and Pakka tippans the new boundaries will be shown in red ink and the pot-hissas numbered from left to right and from north to south. One tippan will be drawn for the whole number and not separate tippans for each pot-hissa.

(*d*) If boundary marks are to be erected they must be put up on the spot and not left for the occupants to put up afterwards.

(*e*) In his forwarding endorsement the Surveyor will state the number of days spent by him in the work and if hired labour has been employed will forward a muster roll or receipt of payment, if the amount is paid from the permanent advance amount. The muster roll or the receipt must be signed by the patil and the talathi and by the payees. He will also refer to and explain all discropancies between the new and original measurements.

(*f*) In carrying out the partition, he is to see that the provisions of the Bombay Prevention of Fragmentation and Consolidation of Holdings Act are not breached and fragments are not created in the process of partition.

(*g*) In the districts where the Plane Table System is introduced all holdings physically partitioned are measured and papers in connection with the formation of new pot-hissa are prepared.

3. **Fixing the position of missing marks and boundary disputes.**—(*a*) In this case the Cadastral Surveyor has only to fix the missing marks by means of the old measurements as explained in Chapter IV.

(*b*) Where the work is done on application it must be carried out in the presence of the parties and their Kabulayats taken. The parties on both sides of the common boundary under dispute must be intimated 15 days in advance about the date fixed by the Surveyer for carrying out the measurement to enable the parties to remain present at the time of measurement.

(*c*) If there is no difficulty, no Kacha or Pakka tippans need of course be sent but if there be some dispute on the ground then Kacha and Pakka tippans must be sent showing the old boundary in black ink and the new or disputed boundary in red ink. In the districts where the Plane Table System is introduced the Survey Number on both the sides of the common boundary must be measured and the common boundary refixed. The Wahiwat boundary or the actual possession on the spot as noticed at the time of measurement must be shown clearly by dotted lines. All permanent boundary marks noticed and those missing clearly shown by the usual conventional signs.

(*d*) If the work is done on application the usual details regarding the time spent on the work, the cost of labour, etc., should be given.

**4. Boundary disputes in case of reconstituted blocks formed after consolidation of holdings.**—These will be setfled in a similar manner. As the block will consist at times of various hissas or parts of hissas from different Survey Numbers, the Surveyor must carefully see of what original Survey Numbers and Hissas, it is formed and determine the boundary with reference to the tippans of these Survey Numbers till a fresh tippan of a block is available.

**5. Acquisition of land for public purposes.**—(*a*) In such cases the measurement work will be carried out according to the Phalni System.

(*b*) In all cases where land is acquired for public purposes new numbers should be formed and boundary marks erected except in the case of survey numbers, divided into two or more parts by railway, canal or road passing through it. The road, canal or railway should be treated as Kharab and excluded from the total area of the survey number.

**6. Measurement of land for non-agricultural purpose, such as bungalows, lime kilns, quarries, etc.**—(*a*) In this case the areas measured have to be made into separate survey numbers and boundary marks erected.

(*b*) In making the measurement, the Surveyor after fixing the boundary of the Survey number will measure that part only so far as is necessary to correctly locate the position of the area converted to non-agricultural purpose in that survey number according to the Phalani System. When the area stands included in the City Survey limits, the measurement is to be done on the same scale on which City Survey is done, otherwise the most common scale is 1 : 500.

(*c*) If the boundary marks are to be erected this should be done there and then and not left to the occupant to put up afterwards. In his forwarding endorsement the Surveyor must certify that this has been done.

(*d*) The Kacha and Pakka tippans must show the boundary of the old Survey Number in black ink and of the new Survey Number in red ink. If the Wahiwat boundary differs from the recorded

boundary, the wahiwat boundary should be shown in dotted line and the recorded boundary by thick continuous line. Houses, etc., should be coloured with red or blue pencil so as to distinguish the areas under them.

7. **Measurement of waste land for cultivation.**—The cases of grant of land for cultivation are generally received after the land grant is sanctioned by the Prant Officer or Collector on the basis of the rough sketch prepared by the Mamlatdar or Circle Inspector. In that case the Surveyor has to measure the land according to the Phalni System and erect boundary marks if not already erected. In his forwarding report he shall certify that this has been done.

If the case is received only for the opinion whether the land proposed to be granted is fit for cultivation, the Surveyor should obtain the specific instructions from the District Inspector of Land Records and supply that information by inspecting the spot.

8. **Measurement of alluvial lands.**—(*a*) Such lands are usually amalgamated with the adjoining Survey Number; hence the adjoining boundary of the number must be first fixed before the alluvial land is measured.

(*b*) Measurements should be carried out by chain and cross-staff and boundary marks erected on the spot. In the tippans the boundary of the adjoining number should be shown in black ink and of the land newly added in red ink. The area should also be hatched in coloured pencil.

(*c*) The Surveyor must note that according to Section 33, Maharashtra Land Revenue Code, if the area of the alluvial land is less than one acre then the occupant has the right to the free use of it.

In his forwarding report the Surveyor must call the attention of the Mamlatdar to these rules, if they apply to the particular case in point.

(*d*) It may here be noted that a similar rule applies in the case of *diluvian*, *e.g.*, where an occupant applies for reduction of assessment because part of his Number has been washed away by a river or stream. In such a case he is not entitled to remission unless the area washed away exceeds ½ acre and in making his report the Surveyor should draw attention to such facts if they exist.

# CHAPTER IX

## THE MEASUREMENT SYSTEM IN THE C. P. DISTRICTS (PREVIOUSLY FOLLOWED)

In the four Central Provinces districts of Nagpur, Chanda, Wardha and Bhandara for the purpose of measurement a slightly different method is followed. The method of recording the measurements is also different. In these districts the theodolite framework is done on traverse system and detailed measurement is done either by Plane Table or optical square. The detailed measurements of individual Survey Numbers are not preserved. The only measurement records available are (i) Traverse framework and (ii) Village maps drawn to the scale of 1" = 5 Chains or 1 : 3960, the chain being of 66 feet. The village maps are not printed. They are traced by the tracers and only one copy is preserved with the Settlement papers and the other supplied to the Village Officers. The copy supplied to the Village Officers is commonly called as working copy of the map. The corrections subsequent to the Settlement which take place due to sub-divisions, land acquisition, and the like, are provisionally measured by the Patwaries and working copies of the maps are corrected for day to day use. The Survey Records are not maintained up to date by a separate professional agency, as is done in the rest of the Districts but elaborate resurveys are undertaken at each periodical settlements and all changes which have taken place since the last settlement are measured and mapped and maps are brought up to date at the time of introduction of fresh settlement. For the purpose of provisional day to day maintenance of the working copies of the map, the Patwaries are trained in Survey and they conduct the Survey mostly by the optical square on the basis of the traverse framework. The traverse framework is also checked by the Patwaries, Revenue Inspectors and Assistant Superintendent of Land Records, and Superintendent of Land Records. If any station is

missing, it is reported to the Superintendent of Land Records, Nagpur Circle, Nagpur, who has special staff of Traversers to replace such missing stones, etc.

The optical square serves the same purpose as that of the cross-staff, *i.e.*, dividing the field into right-angled triangles or trapeziums'

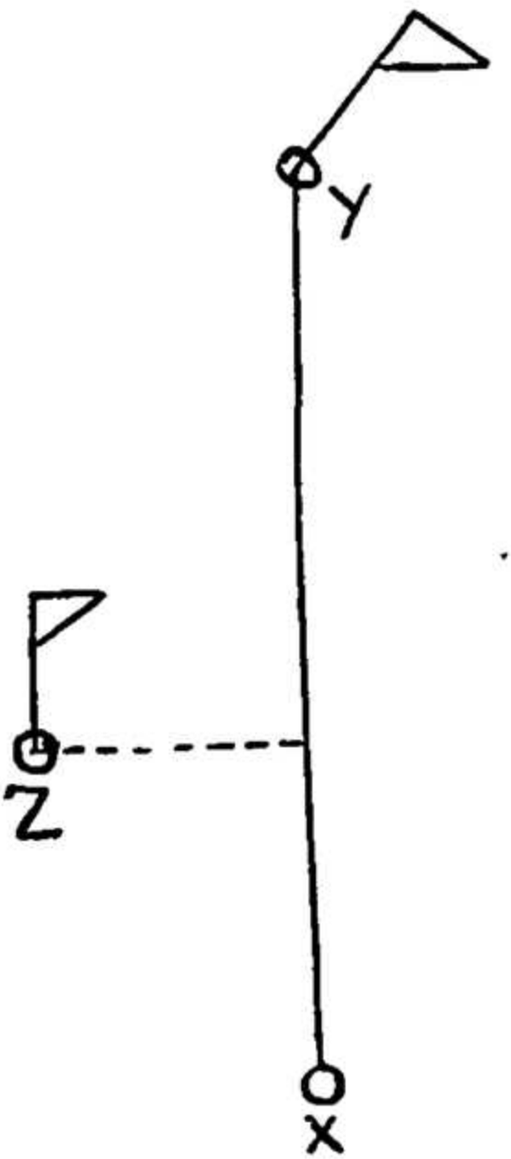
## The Principle of the Optical Square:

The optical square is a triangular metallic case within which two mirrors are set at an angle of 45° to each other. Half the mirror is un-silvered or kept open so that an observer looking through the eye-hole at the side of the case can directly see through the open or un-silvered portion of the mirror the flag planted on the chain line or base line. When a point is reached on the chain line where an offset should fall from the flag posted on any given mark on the field corner, it is reflected through the opening on the side of the case from one mirror to the other mirror and this reflection is seen through the eye-hole to be coincident with the flag on the chain line.

## The Indian Optical Square:

It is a hollow brass box of 5 centimetres sides and 3 centimetres depth with a handle. It contains two rectangular mirrors, X and Y, fixed at an angle of 45° to the inclined sides. Above these mirrors there are two rectangular openings. For taking an offset with this instrument the Surveyor should stand on the chain line and hold the instrument quite erect with the face of the instrument towards the direction of the object to be offsetted. Then the Surveyor should put his right eye to the opening over the mirror and look through the opening over the other mirror to the flag to be offsetted. Then move slowly along the base line until the base line flag and the offset mark flags coincide. The point at which you will see both the flags coinciding is the point on the base line which is at right angles to the flag to be offsetted.

**The Use of the Optical Square:**




Suppose XY to be a chain line proceeding in the direction of Y at which a flag is planted and Z an object to the left where a pole is set up and to which an offset is to be taken. Stand at X looking towards the flag Y and hold the optical square in hand having its open face towards the flag at Z. Start moving on the line XY towards Y. Put your right eye to the opening over the mirror and look through the opening over the other mirror to the flag. The image of the pole after reflection from the mirrors will be seen by you either to the right or to the left of the flag at Y. If it is to the right you must advance slowly towards Y until the flag at Z coincides with the flag at Y. If it is to the left you must go back towards X in the same way until the coincidence occurs. The point on the base line XY where the flags at Y and Z coincide is a point of offset line on XY to the point Z. In using the instrument hold it quite straight.

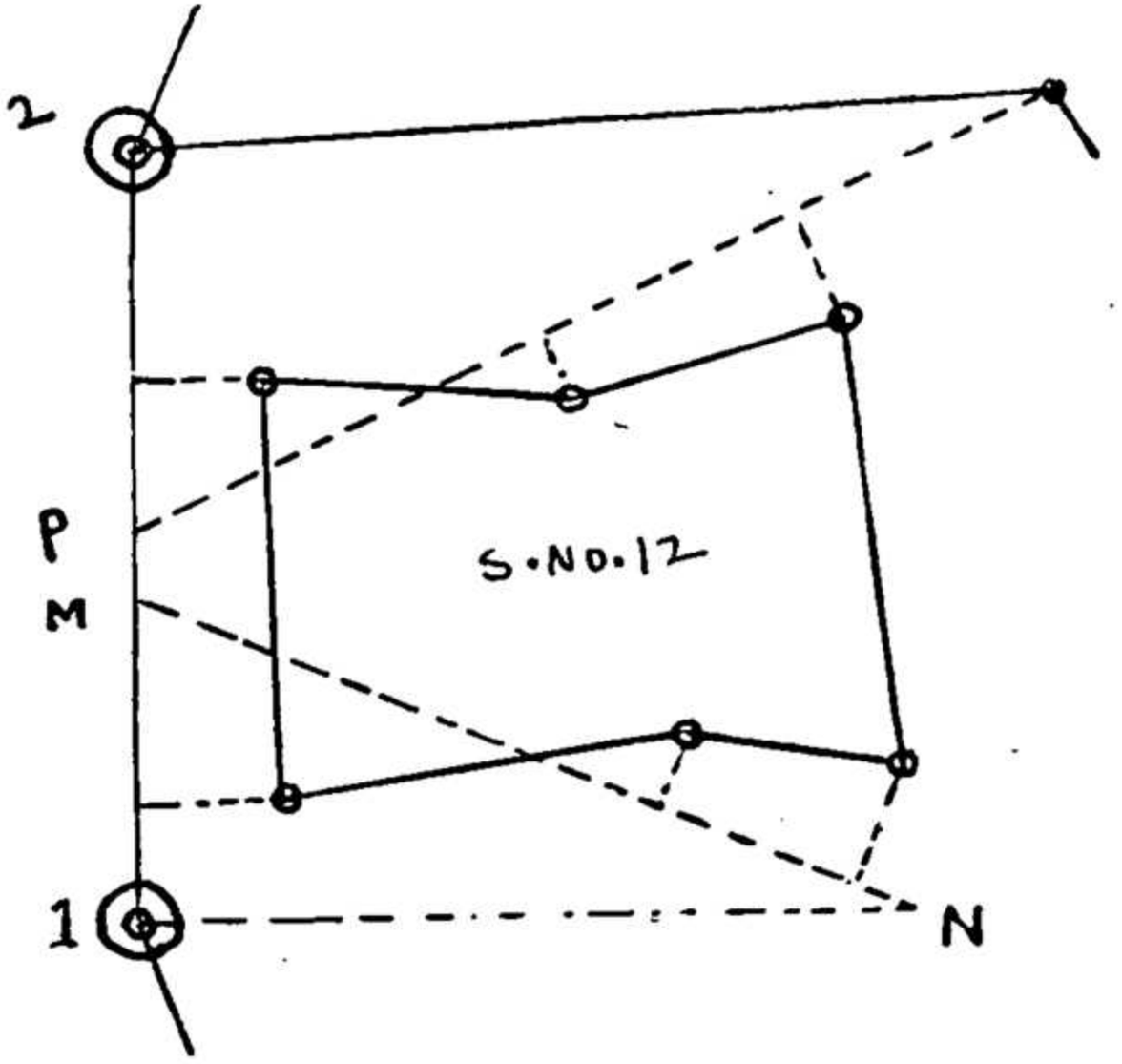
**The Method of Survey:**

The procedure of Survey and the form of the field look in common use and the method of calculating area are given below :—

In the Ex-Central Provinces districts, *viz.*, Nagpur, Bhandara, Wardha and Chanda, the chain recognised is of 66 feet unlike the 33 feet chain in vogue in the remaining (4) districts of Vidarbha region, *viz.*, Amravati, Akola, Buldhana and Yeotmal. The chain of 66 feet is divided into 100 parts (called links), one link being equal to 7·92 inches.

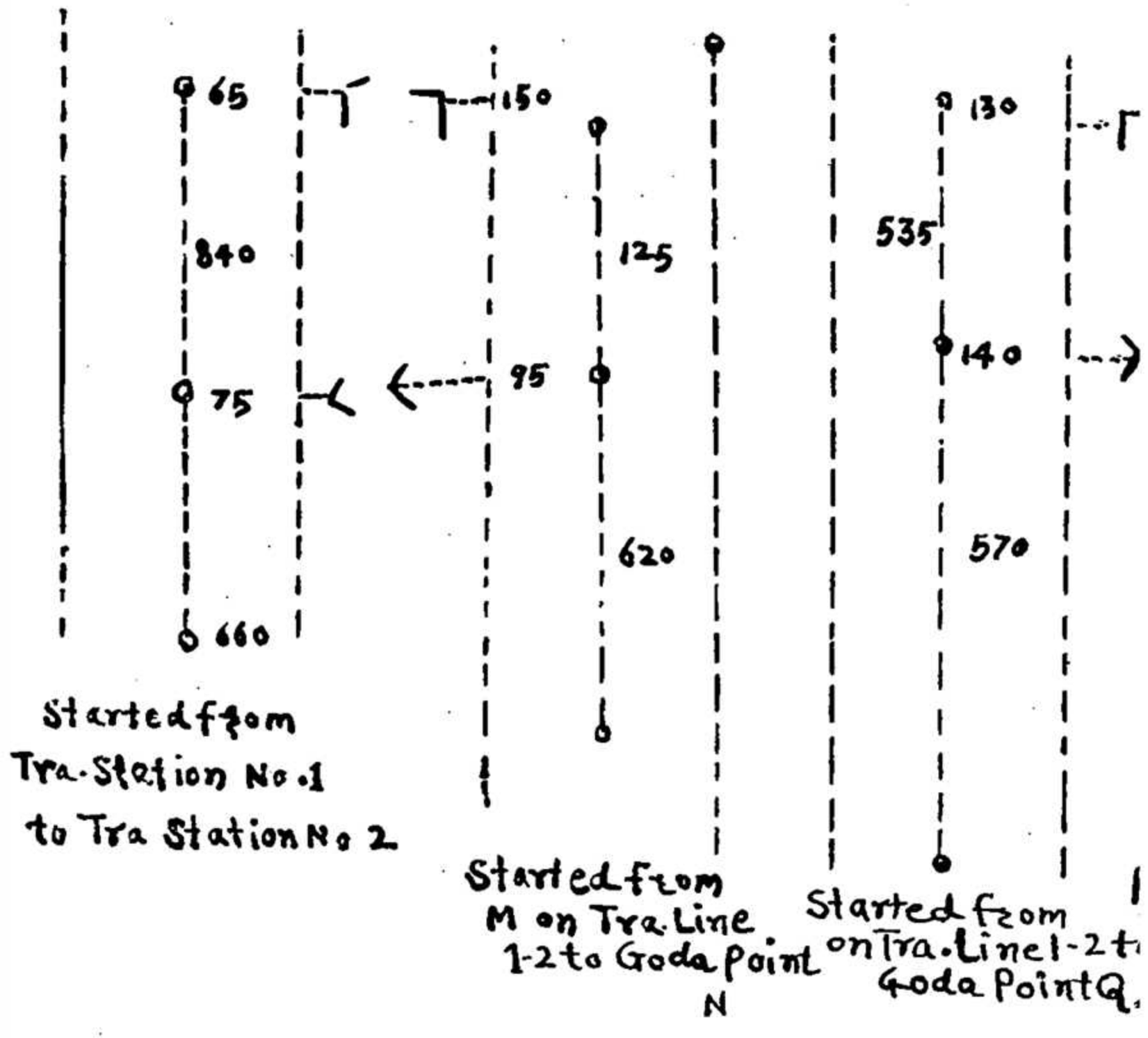
The square ruled sheet (known as Sectional-sheet) with Traverse Stations plotted thereon is used by the Surveyor on the spot for preparing the village-map to the scale of 16 inches to a mile (*i.e.*, 1 Inch = 10 Chains of 33 feet). He records the measurements in

links by observing offsets to corners of fields and other topographical details, from the traverse line, with the optical square. The measurements on the base line (traverse line) are progressive. The field-book does not show the sketch of the field under Survey but only the position of the corner to which offset is taken. Offsets from the traverse lines are taken to corners situated within 500 links, the other corners being sighted from subsidiary base lines, without dividing the field into triangles and trapezia. In order to form subsidiary base lines, a suitable point is fixed by inter section from two fixed points on the traverse line and this new point is called "Goda" point used for subsidiary base line thus :—




Circles marked 1 and 2 denote the traverse stations. Points N and Q are "Goda" points fixed by intersection from the traverse stations and other points M and P (at known distances on the

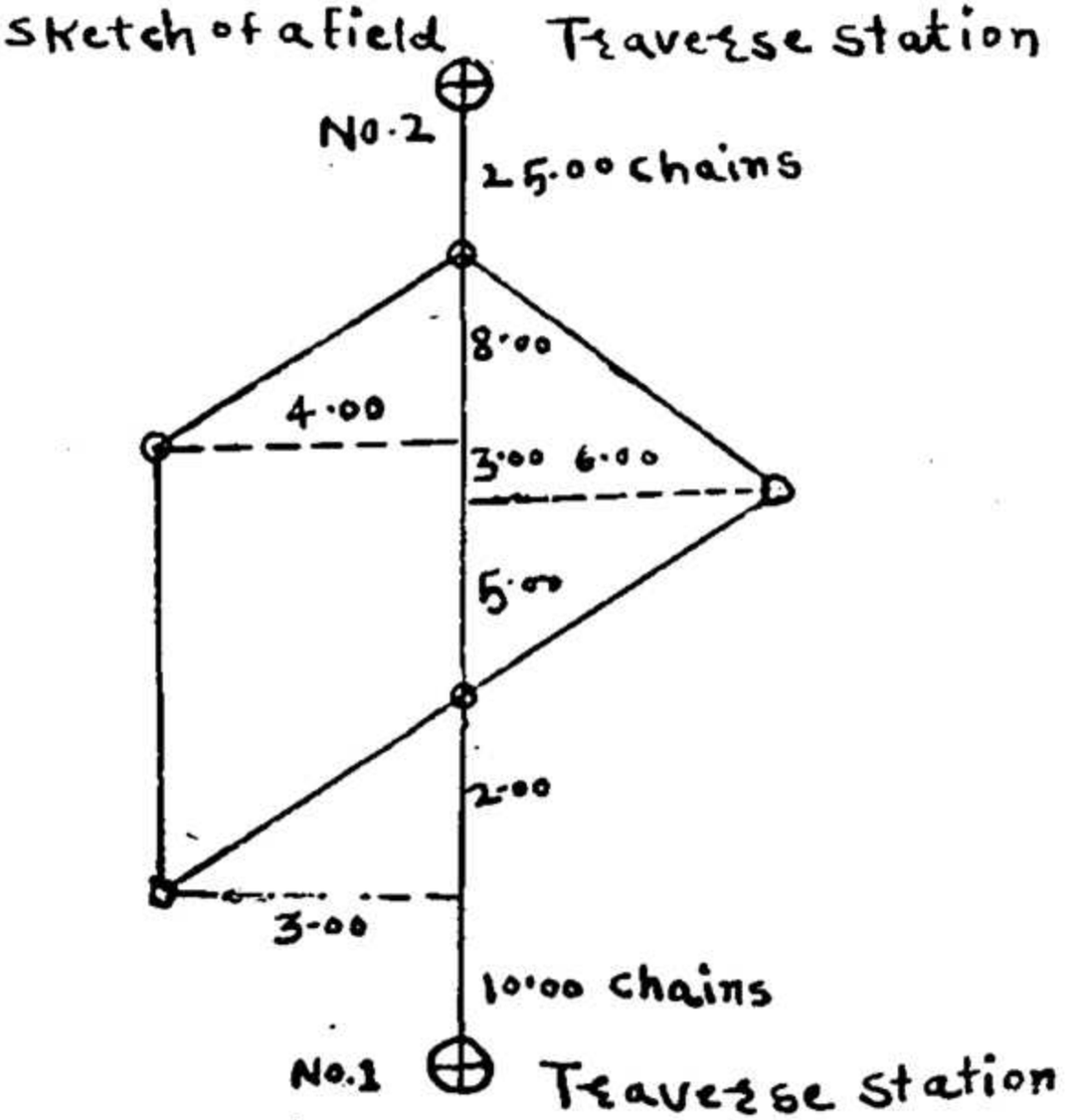
traverse line). These subsidiary base lines are shown on the sectional sheet in pencil only. The field-book will show the measurements of base line and offsets on the 3 base lines thus:—

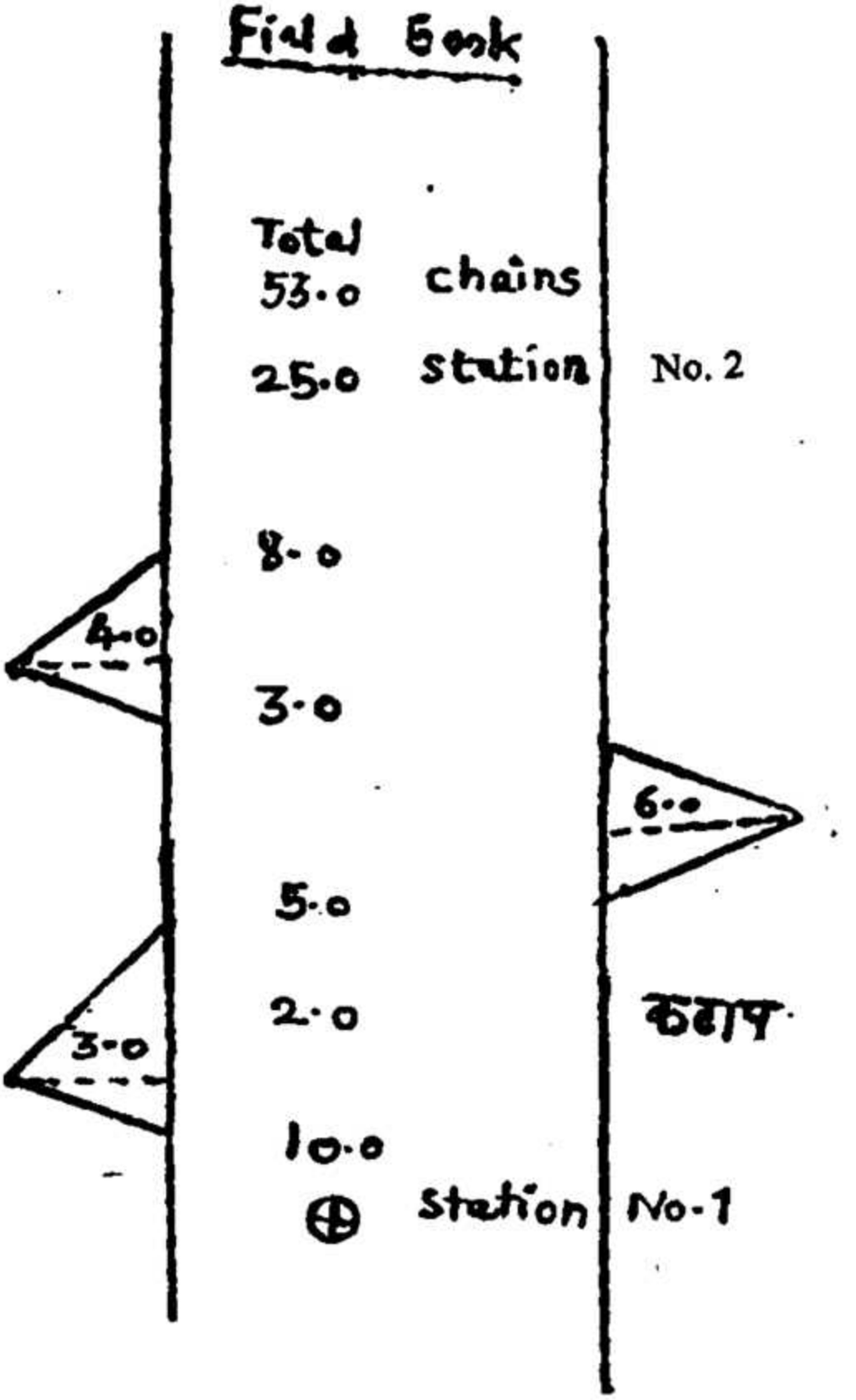



Area is calculated by area-comb from the sketches plotted on the village-map on the sectional-sheets to the scale of 16 inches to a mile, which is fairly accurate, though not exact as in Vaslewar method.

**The Method of Survey:**

The form of the field-book, with a sketch of the area uuder survey and the method of area calculation feilowed in Chanda Survey are given—




Field Book
Total
53.0 chains
25.0 station No. 2
8.0
4.0
3.0
6.0
5.0
2.0
3.0
कदाप
10.0
station No-1

*Area calculation*

| Chain-Line | Offset | Product + | Product − |
|---|---|---|---|
| 2·0 .. .. .. | $\frac{3·0}{2}$ | .. | 3·0 |
| 5·0 .. .. .. | $\frac{6·0}{2}$ | 15·0 | .. |
| 10·0 .. .. .. | $\frac{7·0}{2}$ | 35·0 | .. |
| 11·0 .. .. .. | $\frac{6·0}{2}$ | 33·0 | .. |
| 8·0 .. .. .. | $\frac{4·0}{2}$ | 16·0 | .. |
| | Total .. | 99·0 | 3·0 |
| | Deduct .. | 3·0 | |
| | Balance .. | 96·0 Sq. Chains | |
| | | ×4 (1 Sq. Chain = 4 Ares) | |
| | | 384 Ares, *i.e.*, | |
| | | 3·84 Hectares | |