



# Manual of Land Surveying

Compiled by R. G. GORDON, Esq., I.C.S.  
*Superintendent of Land Records and Registration, C. D.*

WITH THE APPROVAL OF THE

Settlement Commissioner and  
Director of Land Records  
1912

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*Corrected up to 31st May 1951 and Reprint in 1951*

(G.M., R.D., No. 9570/49-L, dated 30th May 1951)

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# MANUAL OF LAND SURVEYING

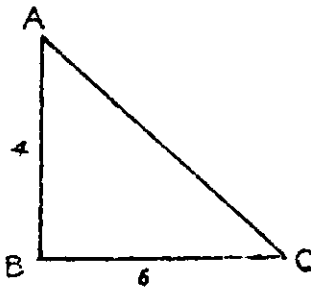
## CHAPTER I

### GENERAL PRINCIPLES

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

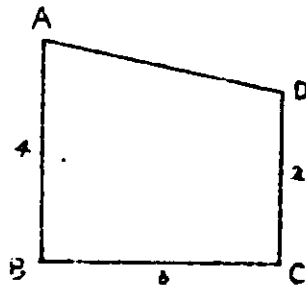
- (a) that the area of a right-angled triangle is equal to the base multiplied by half the perpendicular,
- (b) that the area of a trapezium is equal to the base multiplied by half the sum of the perpendiculars.

Thus



$$\text{the area of } ABC = 6 \times \frac{4}{2} = 12,$$

$$\text{and the area of } ABCD = 6 \times \frac{4+2}{2} = 18.$$



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.

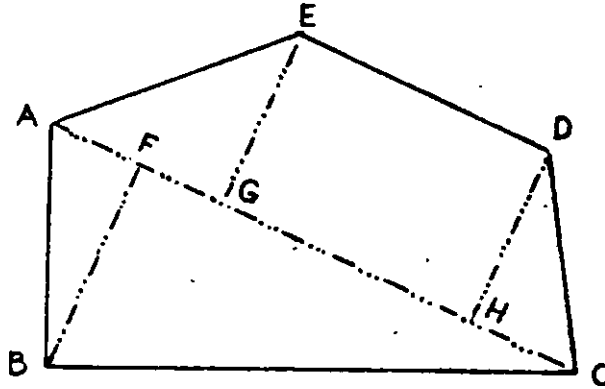
3. Two instruments are therefore required—

- (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*.

This consists in its simplest form of two pieces of wood 12 inches long  $\times$  1½ inch broad with a groove down the centre set at right angles to each other horizontally on the top of an iron shod pole some 5 feet high. 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

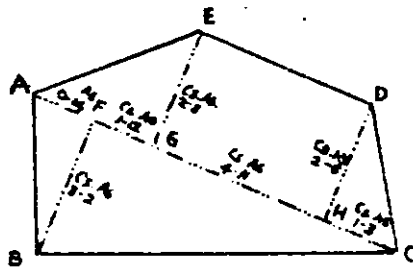


To divide the area A B C D E into right-angled triangles and trapezia it is only necessary to fix a base line AC : then by moving along from A to C right angles can easily be formed to the points B, E & D and the points F, G & H fixed.

The area is now divided into the right-angled triangles AFB, FBC, DHC and EGA and the trapezium E G H D. 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* is made of iron and consists of 16 *links* joined together by iron rings. Each link is  $2 \frac{1}{16}$  feet in length and as a measure of length is called an *anna*. Measurements of lengths are expressed in *chains* and *annas* : thus 3 Chs. 2As., 4Chs. 8As. and so on.



To return to the example given. Taking the chain we measure from A — F and the length is found to be 14 annas. We next measure from F — B and the length is 3 Chs. 2 As. From F — G the length is 1 Ch. 12 As. and from G — E 2 Chs. 8 As. Similarly G — H, H — D and H — C are measured the lengths being 4 Chs. 11 As., 2 Chs. 6 As. and 1 Ch. 3 As., 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*.

Here it is necessary to state the square measures of the Bombay Survey. They are :

Prati annas  
Annas  
Gunthas  
Acres.

The table of square measures is

16 Prati annas = 1 Anna  
16 Annas = 1 Guntha (121 sq. yds.)  
40 Gunthas = 1 Acre (4,840 sq. yds.)

Their relation to the measures of length is

Annas  $\times$  annas = Prati annas  
Chains  $\times$  annas = Annas  
Chains  $\times$  chains = Gunthas  
40 square chains = 1 Acre.

Thus :—

Ex. 1.—To multiply  $\begin{matrix} \text{Chs.} & \text{As.} \\ 3 & - 6 \end{matrix}$  by  $\begin{matrix} \text{Chs.} & \text{As.} \\ 2 & - 5 \end{matrix}$ .

$\begin{matrix} \text{Chs.} & \text{As.} \\ 3 & - 6 \\ 2 & - 5 \\ \hline 1 & - 0 & - 14 \\ 6 & - 12 & - 0 \\ \hline 7 & - 12 & - 14 \end{matrix}$	$\begin{matrix} \text{Gs.} & \text{As.} & \text{pr. as.} \\ 7 & - 12 & - 14 \end{matrix}$
$= \begin{matrix} 7 & - 12 & - 14 \end{matrix}$	

Ex. 2.—To multiply  $\begin{matrix} \text{Chs.} & \text{As.} \\ 10 & - 12 \end{matrix}$  by  $\begin{matrix} \text{Chs.} & \text{As.} \\ 5 & - 9 \end{matrix}$

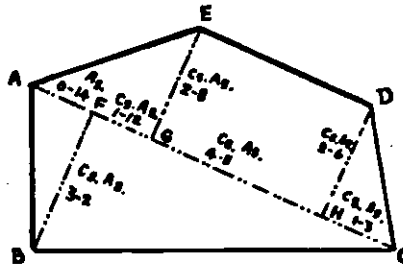
$\begin{matrix} \text{Chs.} & \text{As.} \\ 10 & - 12 \\ 5 & - 9 \\ \hline 6 & - 0 & - 12 \\ 1 & - 13 & - 12 & - 0 \\ \hline 1 & - 19 & - 12 & - 12 \end{matrix}$	$\begin{matrix} \text{Ac.} & \text{Gs.} & \text{As.} & \text{pr. as.} \\ 1 & - 19 & - 12 & - 12 \end{matrix}$
$= \begin{matrix} 1 & - 19 & - 12 & - 12 \end{matrix}$	

As a matter of fact in making up areas after calculation over 8 Prati as. are counted as 1 anna and 8 Prati as. or under discarded. Hence in the above two cases the actual areas would be stated as :—

Ex. 1.—  $\begin{matrix} \text{Gs.} & \text{As.} \\ 7 & - 13 \end{matrix}$  (14 Prati as. being counted as 1 anna.)

Ex. 2.—  $\begin{matrix} \text{Ac.} & \text{Gs.} & \text{As.} \\ 1 & - 19 & - 13 \end{matrix}$  (12 Prati as. being counted as 1 anna.)

7. To return once more to our example. We have to find the areas of



AFB }  
 FBC } right-angled triangles  
 DHC }  
 EGA }  
 EGH D } trapezium

As explained in para. 1 the area of a right-angled triangle = the base  $\times$  half

As. Chs. As. Ch. As.

the perpendicular. The area of AFB therefore =  $14 \times 3 - 2$  or  $1 - 9$

2

Working out this sum

Chs. As.	
0 - 14	
1 - 9	
<hr/>	
7 - 14	
14 - 0	
<hr/>	
1 - 5 - 14	Gs. As.
	1 - 6

Chs. As. Chs. As. Ch. As.

Similarly the area FBC equals  $7 - 10 \times 3 - 2$  or  $1 - 9$

2

Chs. As.	
7 - 10	
1 - 9	
<hr/>	
4 - 4 - 10	
7 - 10 - 0	
<hr/>	
11 - 14 - 10	Gs. As.
	11 - 15

Ch. As. Chs. As. Ch. As.

and the area DHC equals  $1 - 3 \times 2 - 6$  or  $1 - 3$

2

$$\begin{array}{r}
 \text{Chs. As.} \\
 1 - 3 \\
 \hline
 3 - 9 \\
 1 - 3 - 0 \\
 \hline
 1 - 6 - 9 = \text{Gs. As.} \\
 \hline
 1 - 7
 \end{array}$$

and of E G A

$$\begin{array}{r}
 \text{Chs. As.} \\
 2 - 10 \\
 \hline
 10 - 8 \\
 2 - 10 - 0 \\
 \hline
 3 - 4 - 8 = \text{Gs. As.} \\
 \hline
 3 - 5
 \end{array}$$

There remains the trapezium E G H D. As explained in para. 1 the area of a trapezium = the base  $\times \frac{1}{2}$  the sum of the perpendiculars. Hence the area of

$$\begin{array}{r}
 \text{E G H D} = \text{Chs. As.} \\
 4 - 11 \times (2 - 8 + 2 - 6) \text{ or } 2 - 7 \\
 \hline
 \text{Chs. As.} \\
 4 - 11 \\
 2 - 7 \\
 \hline
 2 - 0 - 13 \\
 9 - 6 - 0 \\
 \hline
 11 - 6 - 13 = \text{Gs. As.} \\
 \hline
 11 - 7
 \end{array}$$

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

	Gs.	As.	
A F B	=	1	6
F B C	=	11	15
D H C	=	1	7
E G H D	=	11	7
E G A	=	3	5
		<hr style="width: 50%; margin: 0 auto;"/>	
		29	8
	=	<hr style="width: 50%; margin: 0 auto;"/>	<hr style="width: 50%; margin: 0 auto;"/>
		29	8

But in making up the *final* area over 8 annas count as 1 guntha and 8 annas or under are discarded. Hence in the present example the final area will be Gunthas 29.

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 measurement by chain and cross-staff is the same. Other details are merely refinements.



# THE USE OF THE CROSS-STAFF AND CHAIN

## 1. The Cross-Staff

1. 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 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 A B 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 groove of the cross-staff points directly down the base A B and the other groove at right angles directly to the point C. Now if the chain be driven properly in the manner described later on there can be no difficulty in keeping straight down the base line A B. If however the chainmen be allowed to wander about as many measurers allow them to do then a large amount of time is wasted in going from side to side before the cross-staff can be properly fixed in the base line. The first principle to be observed therefore is *always to keep the chain moving absolutely straight down the base line*. The measurer will then always be on the base line.

Next to take the angle. It might appear unnecessary to tell the measurer to select a spot which is fairly likely to be correct before striking in the cross-staff; but it certainly is not so. The cross-staff is often set in the ground

1 or 2 chains from the right spot. 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 should 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 the simplest thing in the world to say in a second whether the angle has been taken correctly or not, yet Circle Inspectors often stand with their eyes glued to the cross-staff gazing down the grooves with an intensity which would be amusing if it were not idiotic. Again from neglect to use their wits measurers go dodging backwards and forwards time after time often driving the cross-staff into the old discarded positions because they will not take the trouble to use their eyes and think what they are doing.

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 be wrong, decide quickly how far you are out. The longer the offset of course the greater the distance the measurer will have to move backwards or forwards if incorrect the first time.

#### 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 an anna or two but carelessness in using the chain may often make a difference of a chain or more.

5. As already stated the chain is of iron and is composed of 16 links (called annas) joined together by iron rings. It has an iron handle at each end. Its total length is 33 feet. To the 4 annas ring from either end is attached a short piece of iron wire and at the 8 annas ring a larger piece is attached. This facilitates the counting of the annas. The chain is liable to many errors chiefly on account of the 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 by means of the 4 annas rod. This is a piece of wood exactly 4 annas in length. The chain should be laid out on the ground and measured with this instrument. 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.

- (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 × ) and lays the arrow 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 hand of the Backman (those in the hand of the Foreman being also counted as a measure of check) and the number of annas reckoned from the chain as it lies on the ground a half anna or under being disregarded, and over half an anna being taken as one full anna (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 anna. Thus if the measurement on the chain reads  $14\frac{1}{2}$  or  $14\frac{1}{4}$  annas this will be taken as 14 annas and the pit dug at the end of the 14th anna : but if the measurement reads between  $14\frac{1}{2}$  and 15 annas then this will be taken as 15 annas and the pit dug accordingly.
- (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 chainmen. 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,

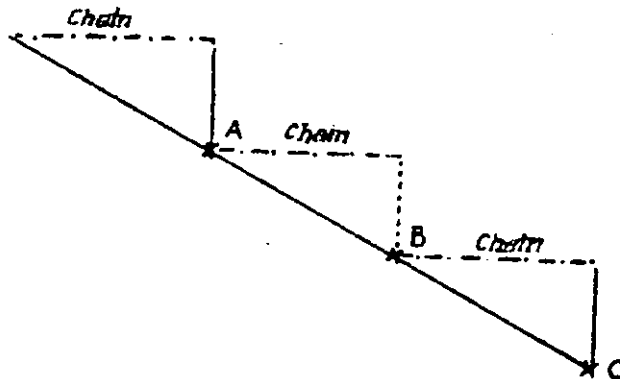
and on the completion of a measurement

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 shewn 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.

## CHAPTER III

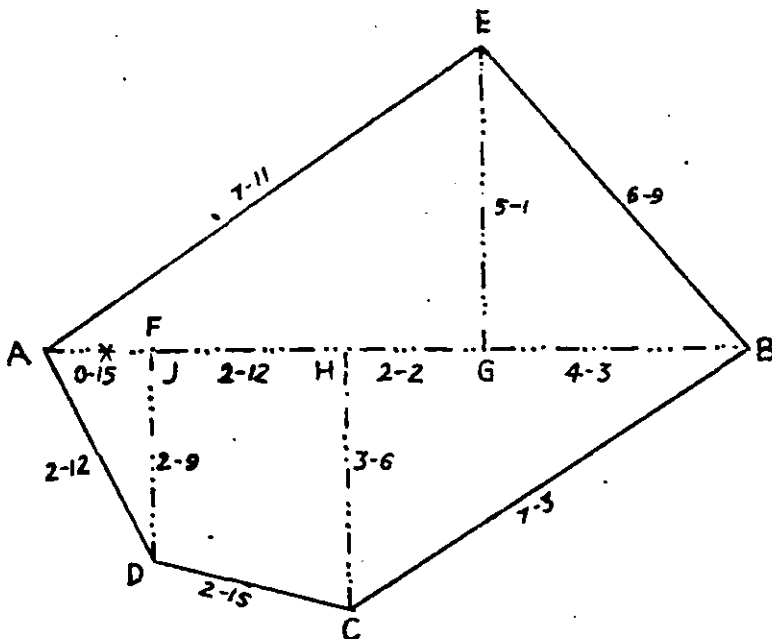
### THE MEASUREMENT OF FIELDS

1. Having learnt the proper methods of using the cross-staff and chain the measurer can now proceed to the measurement of a field. It may be noted that all the *practical* work which will have to be carried out by Circle Inspectors will usually be in connection with areas already surveyed and mapped, *i.e.*, Survey Nos. Before however he can proceed to the study of the special problems involved thereby the Circle Inspector 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 Circle Inspector 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 a number of flag-holders bearing poles to mark the base line and offsets, 2 chainmen and a pickmah.
- (b) He will first *go round the boundaries of the field* and station a flag-holder at every *corner*. A 'corner' is any point at which the boundary of the field bends more than 2 annas \*out of the straight line.




---

\*This is a good general rule but there are 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 poles 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 number: as AB.
- (d) Having decided on the base line the *Base line pole* will next be fixed. Proceeding to A and looking along the line AB the measurer will have a pole 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 there 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 annas.
- (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 filed 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 will be given.

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

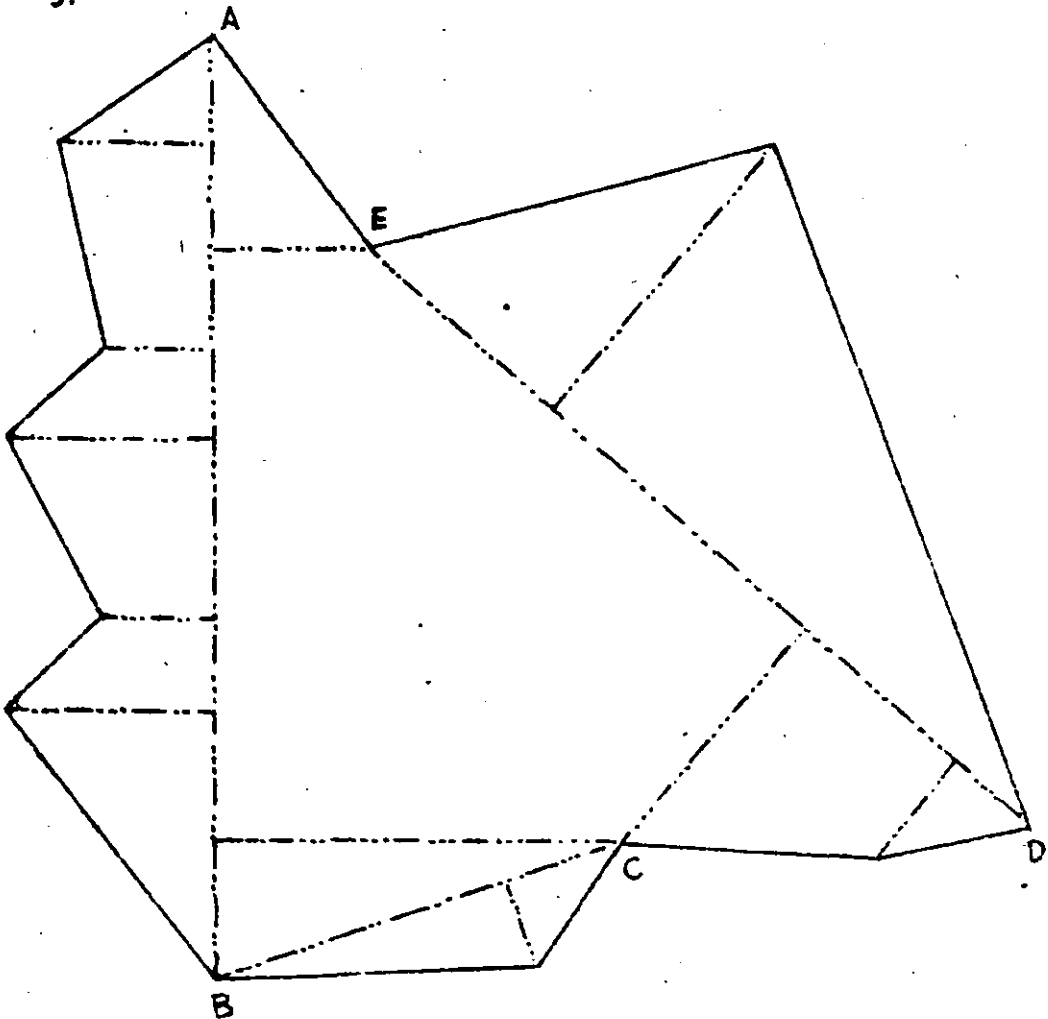
2. In the Konkan the Bandh Maps are not measured.

### 3. Measurement of a field on two 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.

In such cases the measurer will select 2 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 3 base lines, *i.e.*, AB, BC and DE. Had one base line only been selected some of the offsets would have been very long.

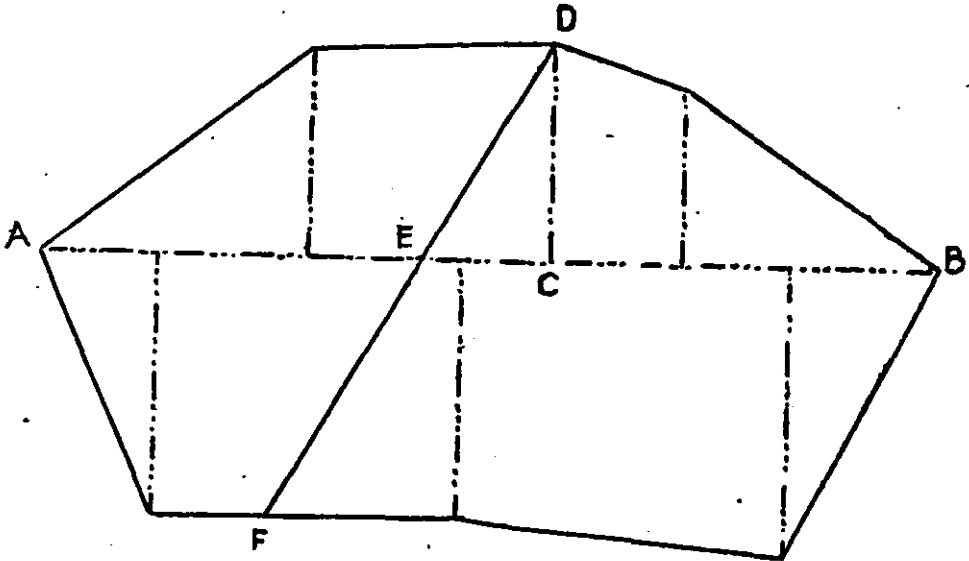
3.



### 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

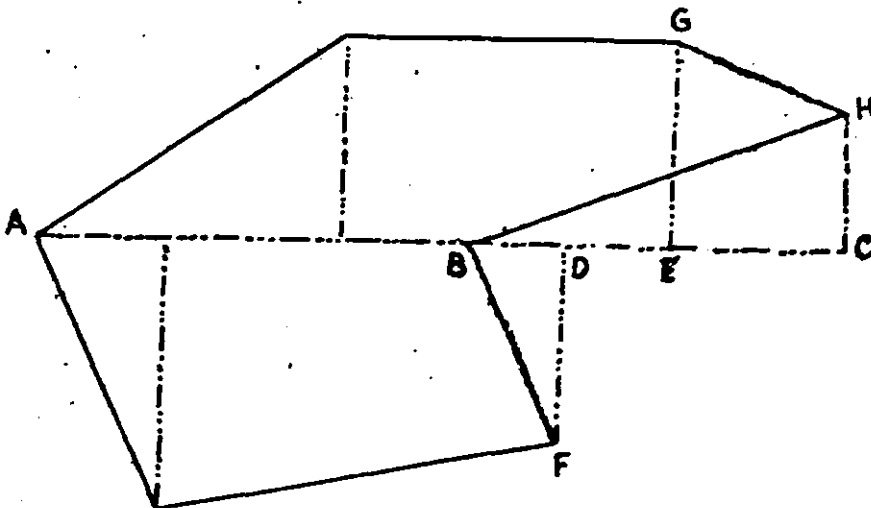
From C to D to go to the point D and move a flag-holder up the base line till the flag post is in a straight line on the base line at E between D and F which will be the point required.



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 AB will be extended to C and offsets taken at D, E and C to the corners at F, G and H.

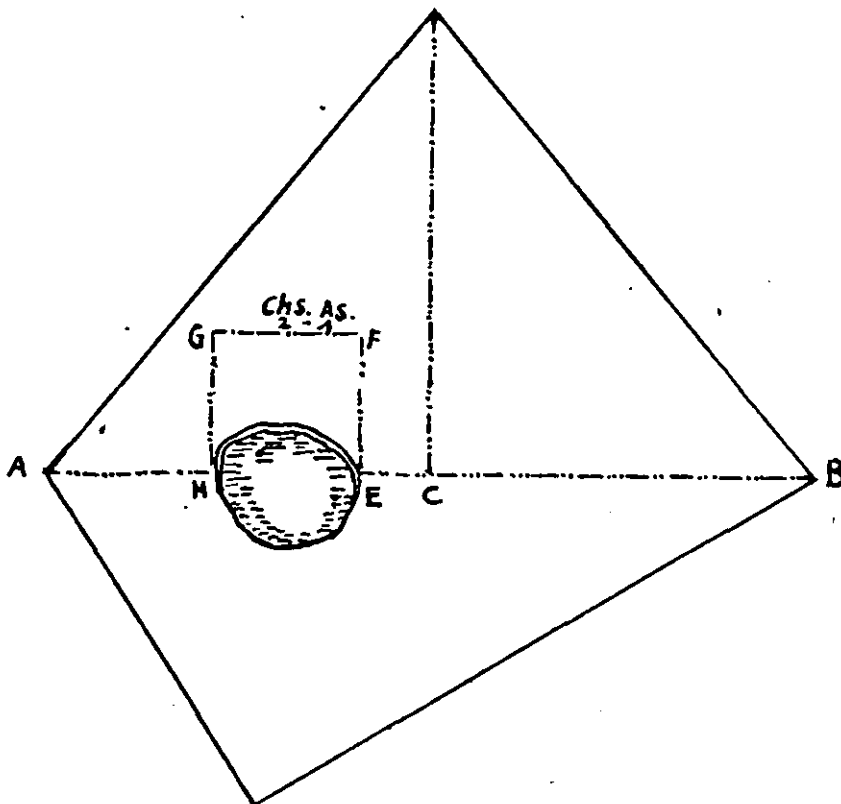
The measurer must in such instances take great care in drawing in the boundary lines of the field in his field book: otherwise he will be very liable to draw the boundary from F to C and C to H instead of from F to B and B to H.



6. Avoiding an obstacle in the base line.

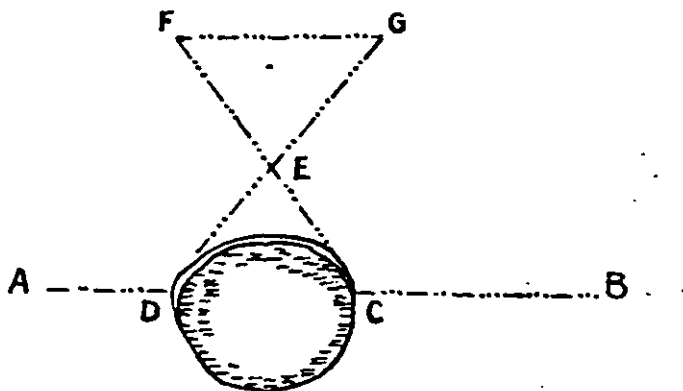


It occasionally happens that the most convenient base line is obstructed by an obstacle such as a well or small tank, etc., which cannot directly be chained across. The measurer therefore has to go round it as shown in the sketch attached. After taking the offset at C he chains to any convenient point 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 EF he sets off a right angle to any point G and from GF a right angle to the base line cutting it at H. Then GF (2 Chs.—4 As.)=HE which is the distance required to be measured.



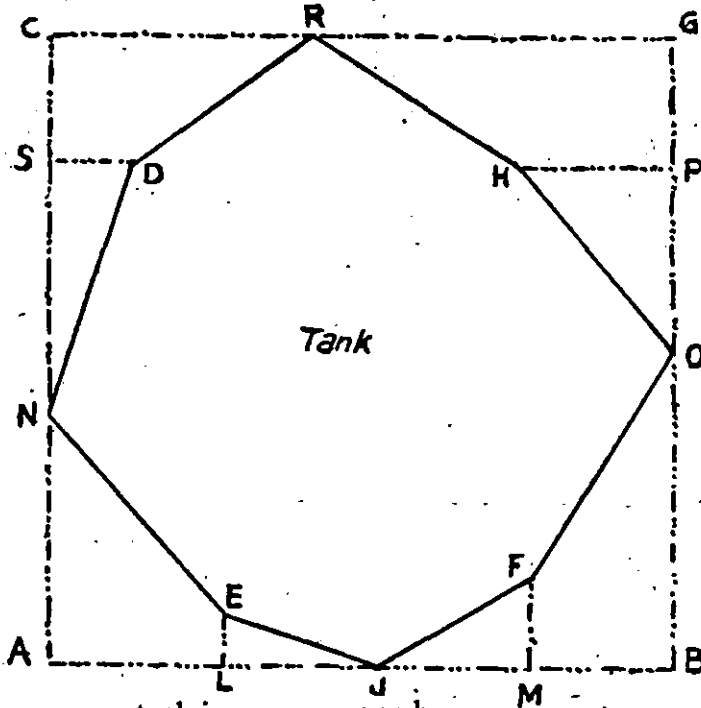
7. A second method is as follows :—

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  $FG = DC$ .





ELJ, FJM, etc., and deduct them from the total area of ACGB. The remainder will be the area of the tank.

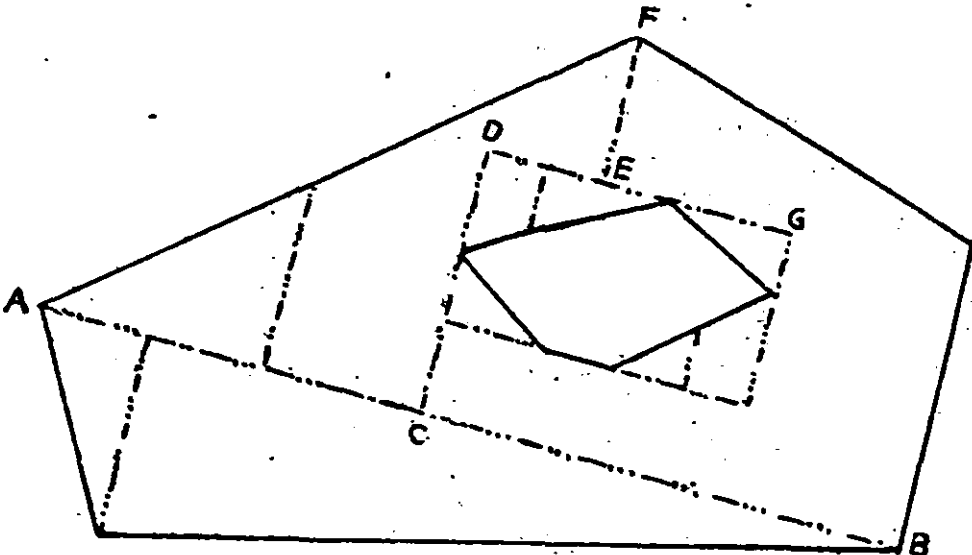


10. To measure a tank in a survey number.

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.

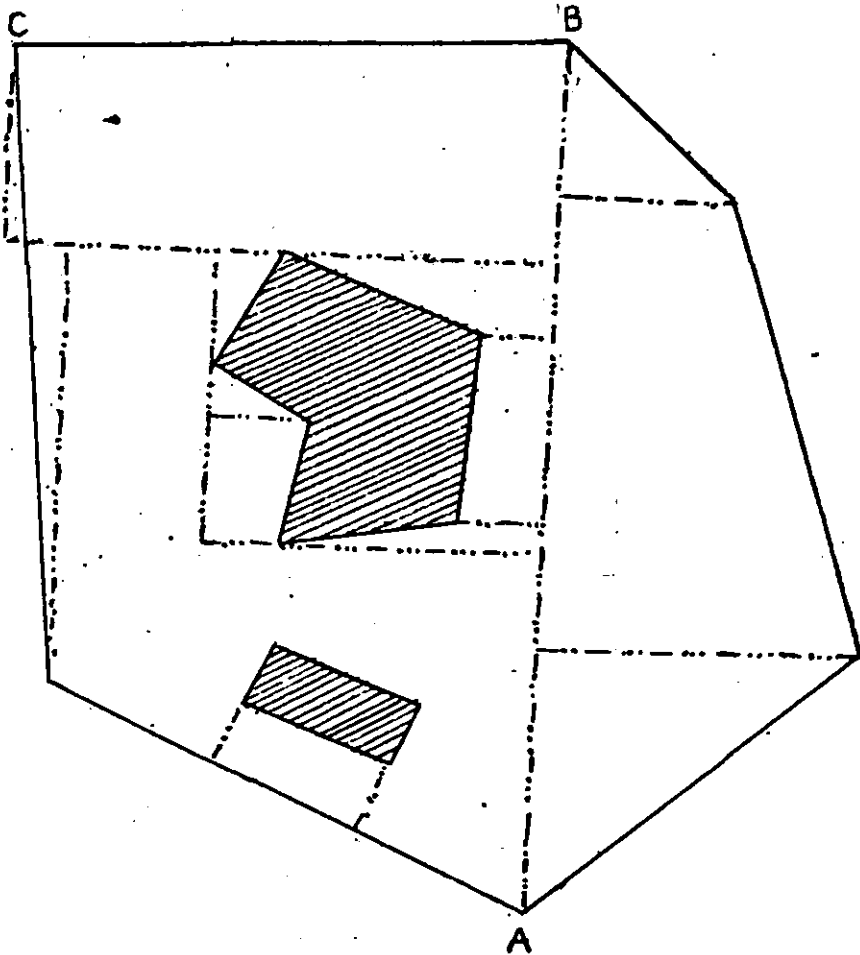
It may be noted that in order to find the area of the number an offset is required to F from the base AB.

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.



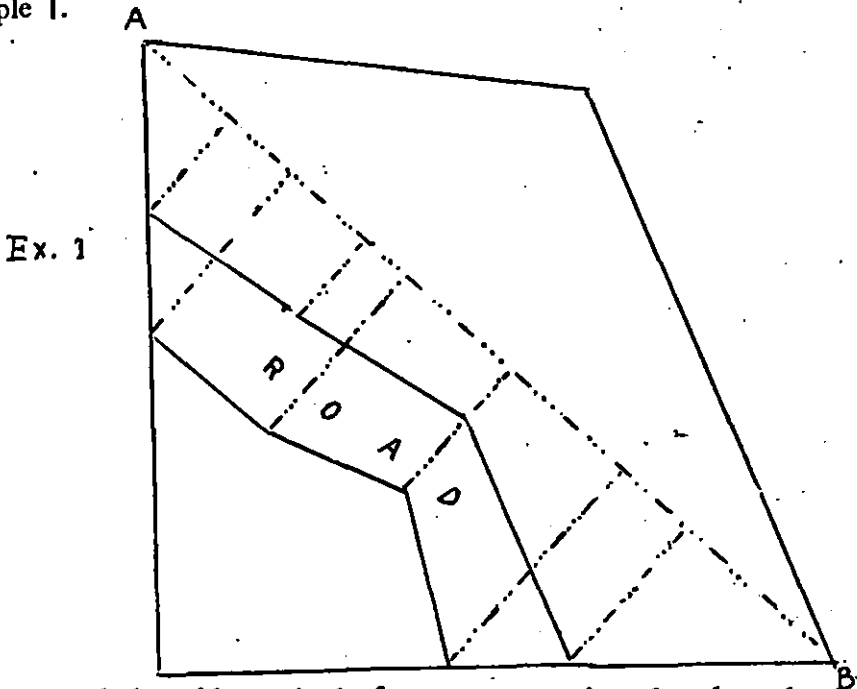
**11. To measure houses in a survey number.**

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.

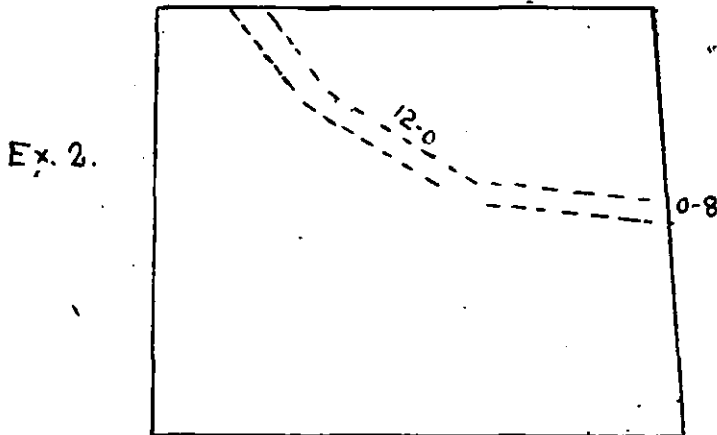


## 12. To measure a road in a number.

All that the measurer has to do is to take offsets to the corners of the road as in example 1.



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 Nos. 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).

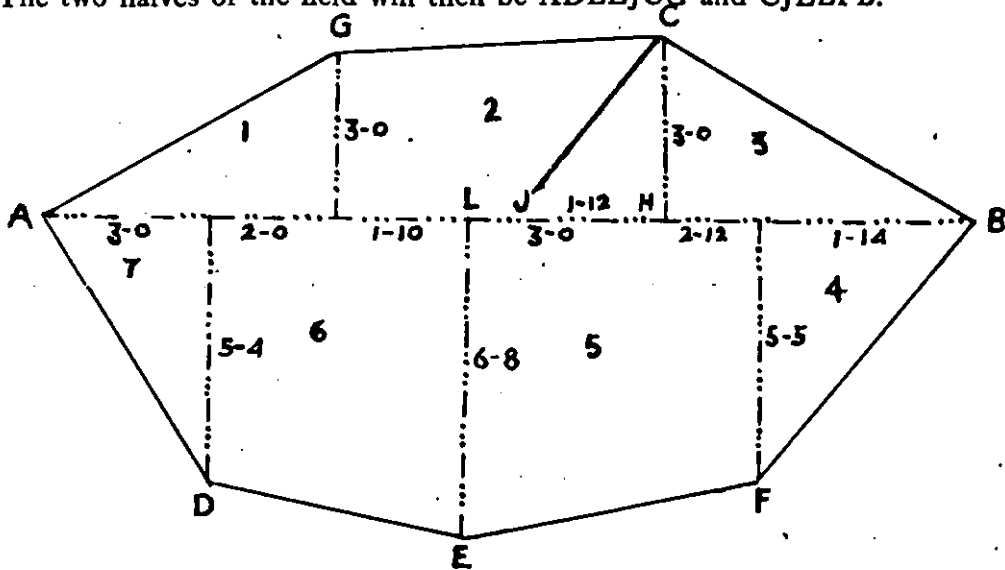


## 13. To divide a field into 2 or more parts.

Let ADEFBCG be the field to be divided.

First measure the whole field. Its area will be 2 acres 16 gunthas 10 annas. Suppose it has to be divided as nearly as possible into two parts measuring 1 acre 8 gunthas 5 annas. Now inspection of the measurements made will show that the area or vaslas 3, 4 and 5 together equal 1 acre 5 gunthas 4 annas. If an area of 3 gunthas 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 1 Ch. 12 As. Then the area of the triangle CHJ is 3 gunthas 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.

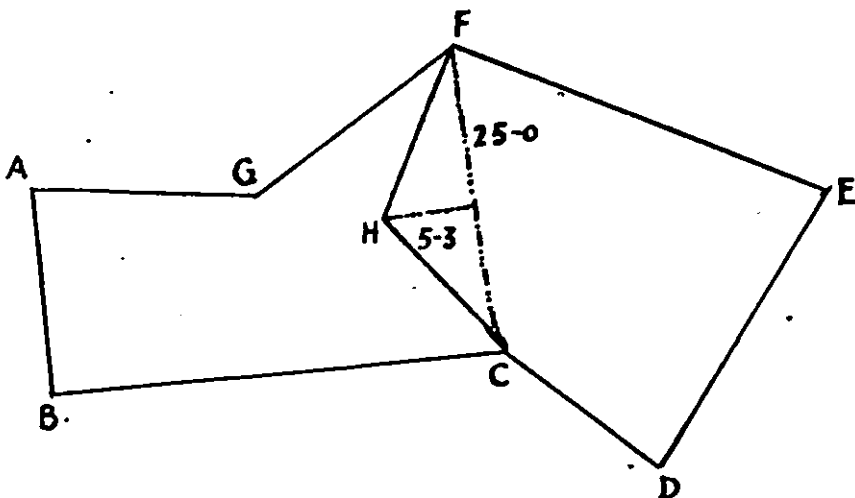
14. To cut off a given portion from a plot of land.

Let A B C D E F G be the plot of land containing 11 acres; it is required to take off a piece that shall contain 5 acres.

Join any points such as C F (which we may suppose to be nearly the partition line) and find the area of D E F C which suppose may want 1 acre 25 gunthas of the quantity required to be cut off.

Measure the line F C which suppose to be 25 chs. Divide 1 acre 25 gunthas by  $12\frac{1}{2}$  (— half of F C —) and the quotient  $5\frac{1}{2}$  chs. will be a perpendicular for a triangle whose base is 25 chs. and area 65 gunthas = 1 acre 25 gunthas. Draw the lines F H, H C and D E F H C will be the area required.

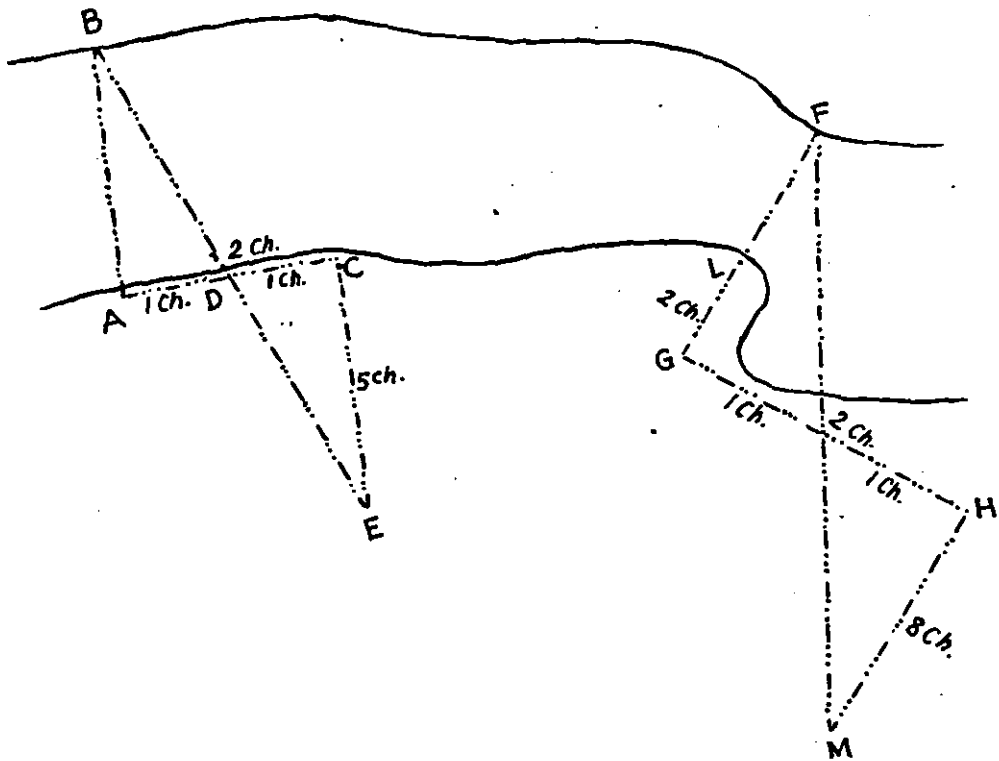
If the area D E F C is found to be more than is required to be taken off, then the triangle should be measured on the opposite side to that shown in the sketch.



## 15. To measure over an obstacle which cannot be crossed.

It is desired to measure the breadth of the river at  $A B$ . - At the point  $A$  a perpendicular of a convenient length  $A C$  — say 2 chains — should be set out to  $A B$ . Then at half of  $A C$ , *i.e.*, 1 chain a flag should be set up at  $D$ . Then from  $C$  a perpendicular  $C E$  should be set out to  $A C$  and a point  $E$  fixed thereon in such a way that  $B D E$  are in one straight line. Then  $C E$  (5 chs.) =  $A B$  which is the distance required.

Had the breadth at  $L F$  to be found then the line  $L F$  would be extended to  $G = 2$  chs., the perpendicular  $G H$  drawn and the point of  $M$  found as described. Suppose  $H M$  to be 8 chs. Then  $H M = F G$ . Deduct from  $H M$  the length of  $L G$  (2 chs.) and the remainder 6 chs. is the length of  $F L$ .



## CHAPTER IV

### THE USE OF THE SURVEY TIPPAN

1. The practical measurement work of the Circle Inspector has to do chiefly with areas already measured and included in Survey Nos. and Pot Nos. which have either to be subdivided (*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 the formation of alluvial lands on the banks of rivers or streams). Now in the case of the subdivision of or addition to Survey Nos., it is obviously necessary that the boundaries of the Nos. should be known before measurement is made otherwise the measurements of the Circle Inspector 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 recognize boundaries of Survey Nos. 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 Circle Inspector should know how to fix the missing boundaries otherwise he will be unable to say where one Survey No. ends and another begins.

2. Again in the case of boundary disputes by the very nature of the case the Circle Inspector must know how to fix the boundaries of the Survey No. as that is the matter in dispute.

3. But further in the case of mixed Nos., *i.e.*, 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 Nos. are subdivided, to know the proportions of each class of land in each of the subdivisions for the purposes of assessment. Where the survey tippans are in existence, these areas can be worked out in the Survey Office but, where the tippans are not in existence as is often the case in Gujarat, measurement must be made of each class of land within the Survey No. though this is often difficult and sometimes impossible where cultivation of either class has spread or contracted.

4. Hence before proceeding further the Circle Inspector must learn how to fix the boundaries of Survey Nos. 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 Nos. and also the 'bandh maps' and boundary marks. The adjoining Nos. etc., are also shown and the class of the land. By means of the tippan the Circle Inspector 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.

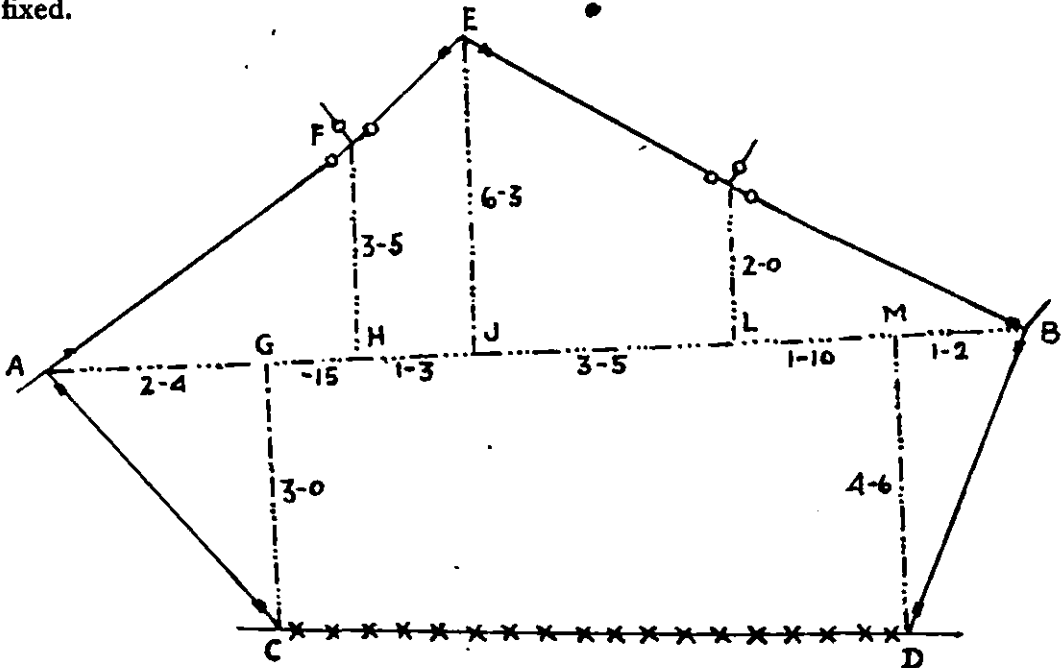


NOTE.—In the following examples only the details necessary for the case in point are given.

6. To fix the boundaries of a field in accordance with the tippan.

To do this the Circle Inspector 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 No. A C D B E F according to the measurements shown. To accomplish this he will first find in the field the two ends of the old base line A B and set up flags in the ordinary way. Then starting from A he will measure 2 Chs. 4 As. to the point G and from G will lay out an offset measuring 3 Ch. 0 As. thus fixing the point C according to the tippan. Similarly by measuring 0 Ch. 15 As. from G to H and laying out therefrom an offset of 3 Ch. 5 As. 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 Nos. since the original measurements were made or to the incorrectness of the original measurements themselves:—

- (a) the present position of 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. (a) To fix the boundary when a corner is found out of place.  
1st Example:

Fig. 1.

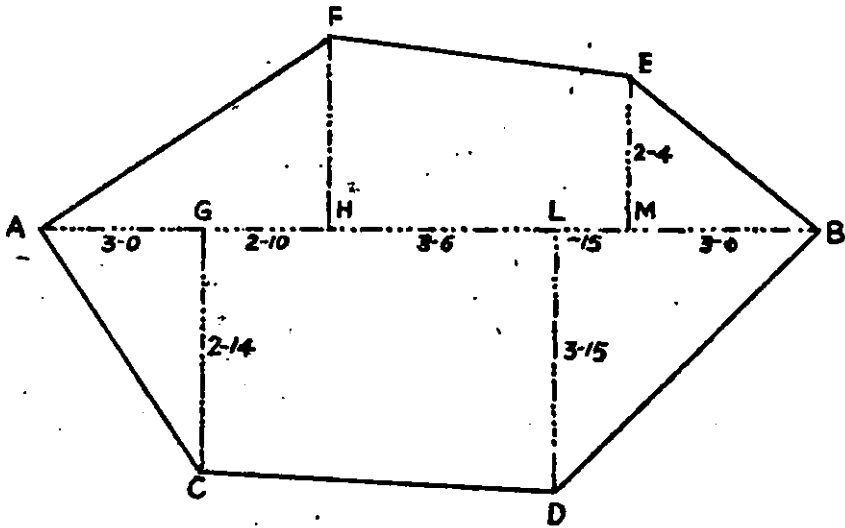


Fig. 2.

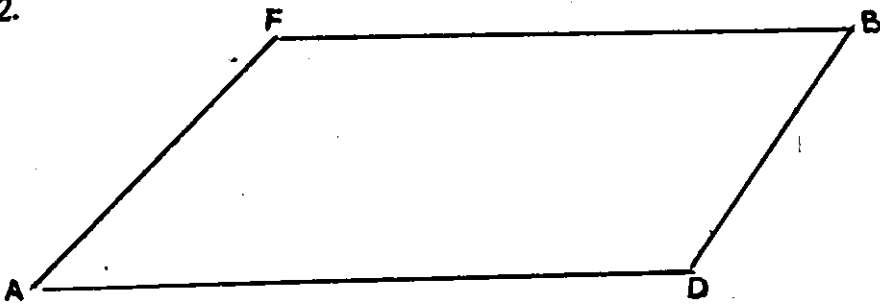
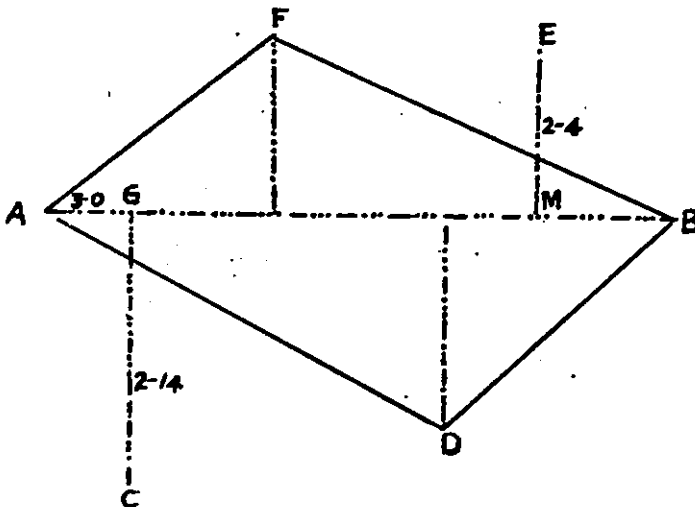


Fig. 3.

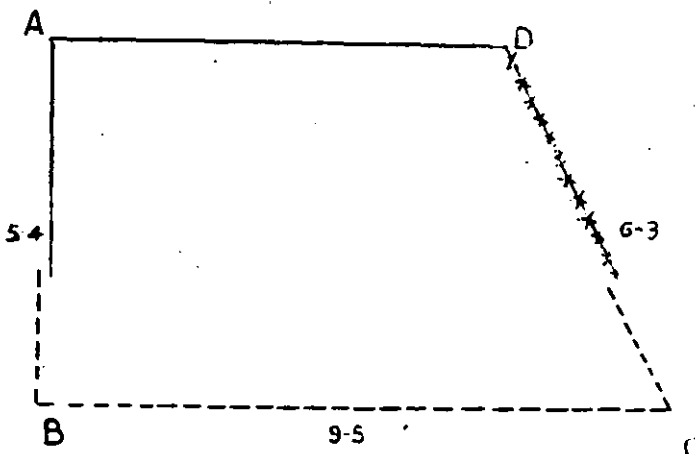
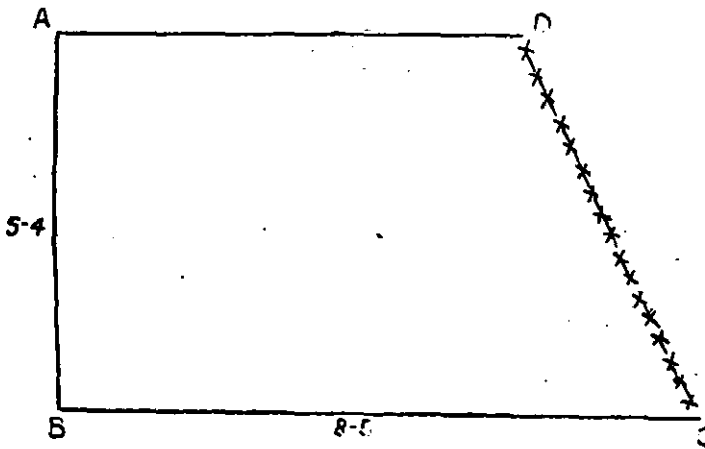


In the instance given the boundary according to the tippan is as shown in figure 1 but in the field is as shown in figure 2, *i.e.*, the corners A, D, B, F, are correct but the corners C and E have disappeared.

To relay the old boundary the measurer has only to set up the old base line A B. Then by starting from A and measuring 3 Ch. 0 As. along A B and laying out an offset of 2 Ch. 14 As. the missing point C is fixed and by fixing the point M on the base line and laying an offset of 2 Ch. 4 As. the point E is fixed.

*2nd Example :*

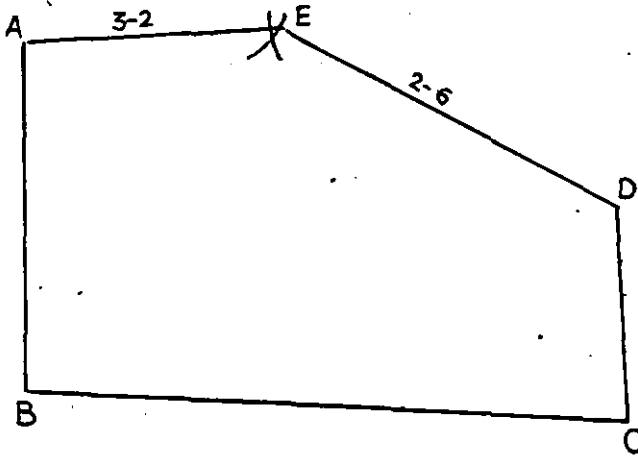
It may however be not necessary to fix the old base line in order to find a missing corner, *e.g.*, suppose the corners A and D are in existence, that B and C cannot be found but that there are in the field boundary strips or hedges running in the direction of A B and D C : then the measurer has only to measure 5 Ch. 4 As. from A along the strip or hedge and 6 Ch. 3 As. from D and the points B and C may be taken as fixed, B C 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 Ch. 6 As. from D and 3 Ch. 2 As. 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 2 Ch. 8 As. from B and 3 Ch. 0 As. from E and finding the point where they meet (first stage). He will then produce the line BH (2nd stage) and if the offset therefrom at J to the point D comes at 1 Ch. 4 As. and is 3 Ch. 4 As. in length he will know that he has found the old base line correctly and can proceed to fix the other corners of the No. 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 2 Ch. 12 As. from the point L at the offset to C.

*Fig. I—According to the Tippan.*

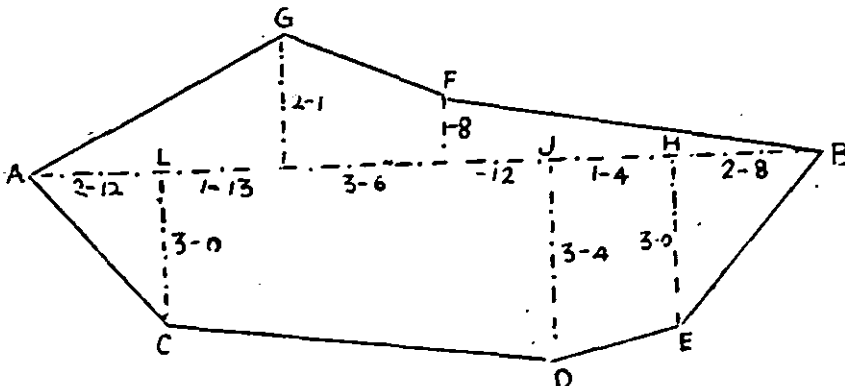


Fig. II—As in the Field.  
G

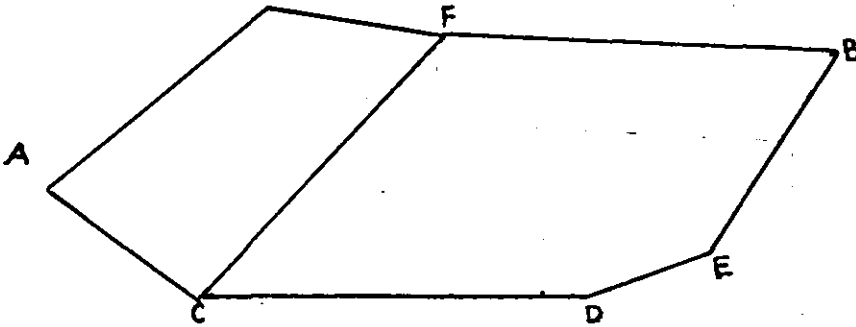
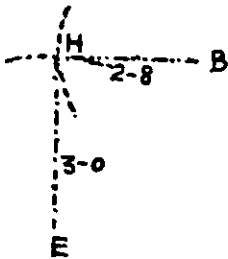
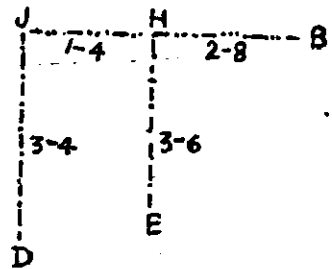


Fig. III—Method of measurement.  
1st. Stage.

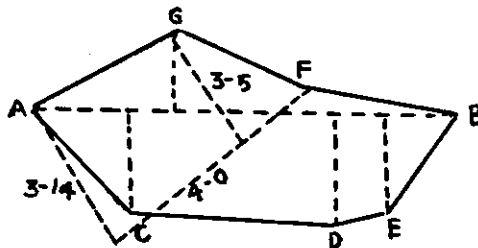


2nd Stage.



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 No. and fix the point from the measurements given therein. Other methods will also suggest themselves, e.g., a scale map of the No. 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.

Fig. IV—Alternative method of measurement.



Scale 5 Chains to 1 Inch.

In such cases the mesurer 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 Circle Inspector 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 Ch. 6 As. and 2 Ch. 8 As.) from G and C to find A and of 3 Ch. 4 As. and 4 Ch. 1 As. from D and E to find B as in Fig. III

Fig. I—According to the Tippan.

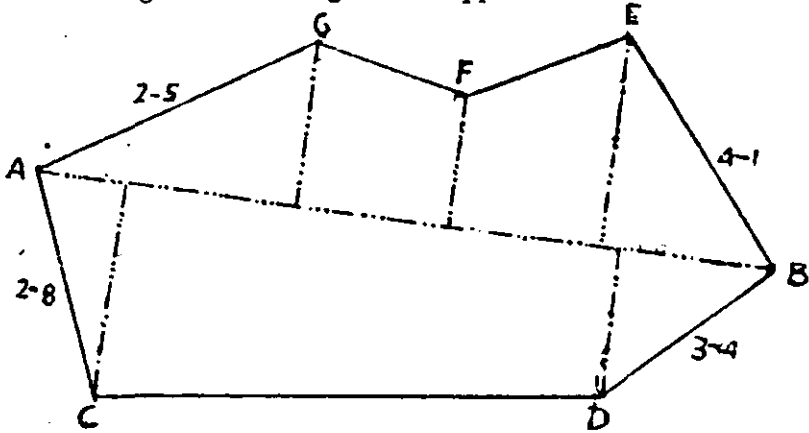


Fig. II—As in the Field.

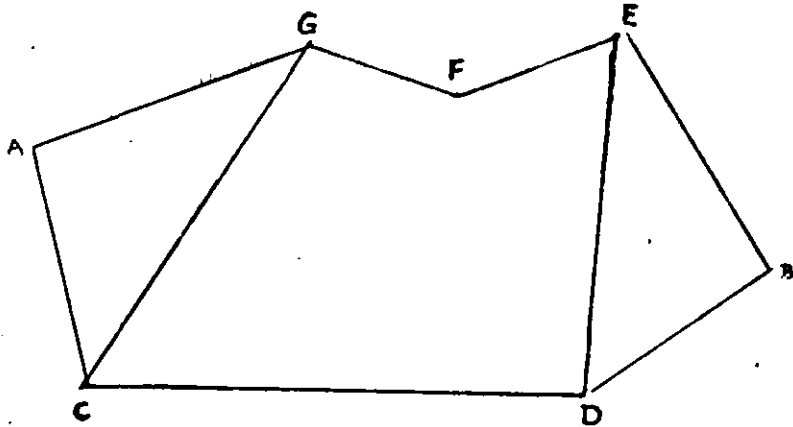
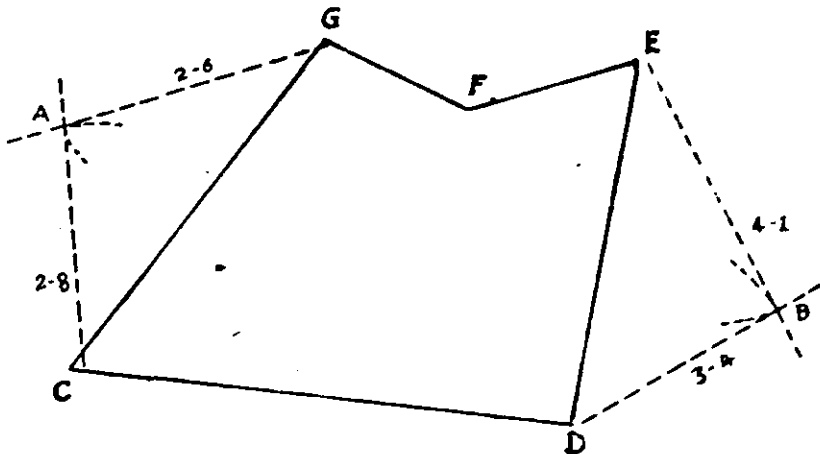


Fig. III—Method of measurement.



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 C E. 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 Nos. may be obtained and the points fixed from these Nos.

### 11. The *village map and Sud*.

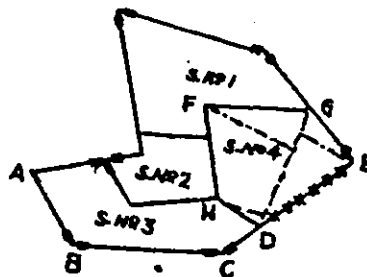
The village map is a Survey record inasmuch as it purports to show all the Survey Nos. of a village drawn to scale either 20 or 10 chains to an inch. Hence if it were accurate it would be exceedingly valuable in cases where the Survey record had been lost as the measurements of the Nos. could be reconstituted by scale therefrom. For many reasons, however, the map must be considered inaccurate and hence to be used with great caution. Use it we must, however, where the Survey record is lost.

In the Konkan all villages are provided with village Suds containing sketches of Survey Nos. and Pot Nos. on a scale of 5 or 10 chains to the inch. These may be taken as fairly accurate and used as a Survey tippan in the manner described for the village map.

### 12. To use the village map as a Survey Record.

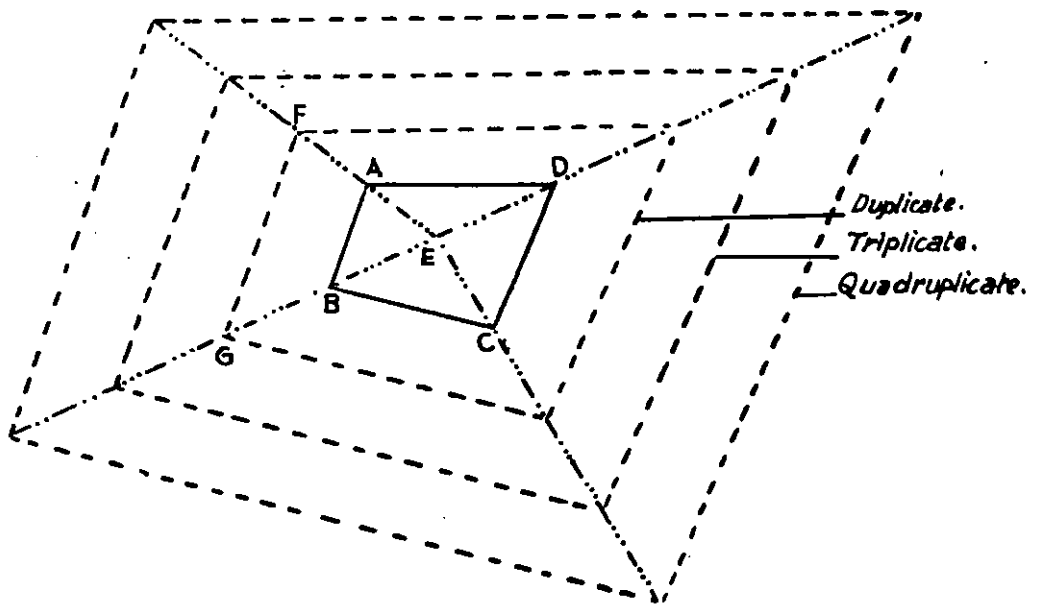
The village map being drawn to scale it follows that we have only to apply the scale to the figures of the Nos. contained therein in order to extract the measurements. Thus in the figure given which is drawn on a scale of 20 chains to the inch by applying the scale to the side AB, we find that its length is 8 chains. Similarly, the length of BC will be found to be 13 Ch. 8 As. of DC 5 Ch. of DE 11 Ch. and of EG 6 Ch. 4 As.

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 there from to the corners H, F 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.



## 13. 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

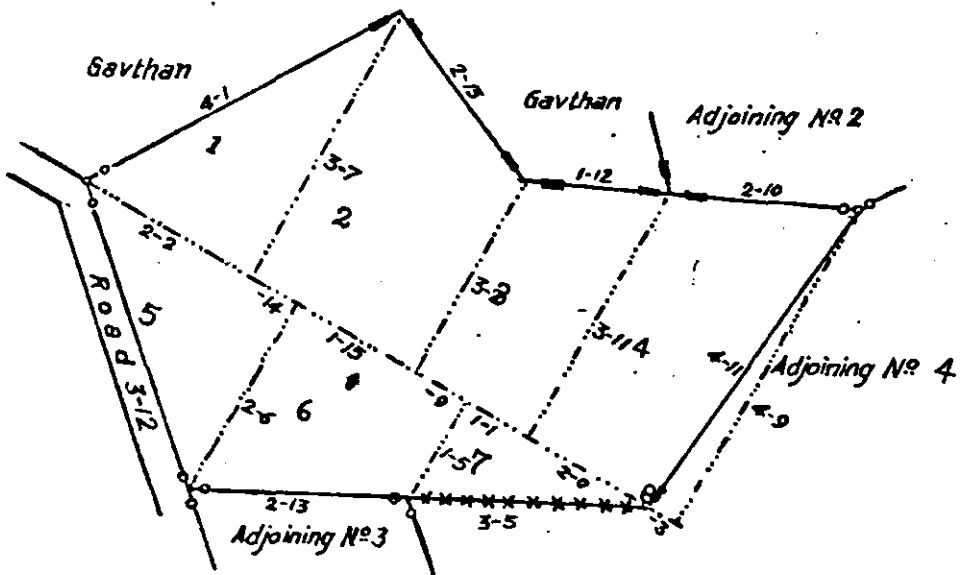
1. Simultaneously with the training in the actual field work of measurement the Circle Inspector must learn how to prepare the measurement record. This consists of —

- (a) The *kacha tippan*.
- (b) The *pukka 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 details given therein are shown below. These details comprise—

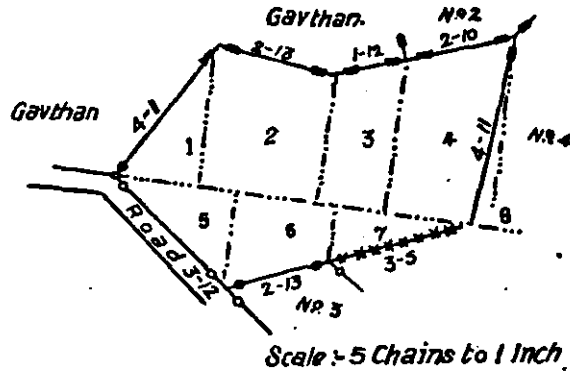
- (a) The outline of the No. in unbroken lines and the base line and offsets in broken lines.
- (b) The measurements.
- (c) The Vasla Nos., *i.e.*, the Nos. of the different trapezia or triangles in red ink.
- (d) The Nos. of the adjoining Survey Nos.
- (e) The boundary marks.



### 3. The *pukka tippan* or *Kshetra*.

This contains the same details as the *Kacha tippan* except that—

- (a) the sketch of the No. is drawn to scale.
- (b) no measurements are shown except those of the *Bándh* Maps (except in the *Konkan* where the *Bándh* maps are not measured).

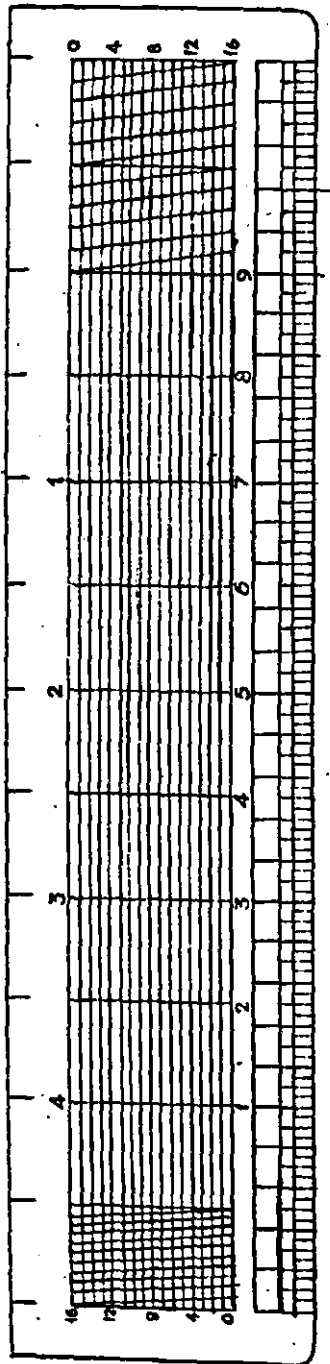


### 4. *Plotting*.

In order that a Survey No. 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 'scale' which is the basis of plotting in the *Bombay Survey* is that of 20 chains to 1 inch, that is to say, every inch of the brass scale used is divided into 20 parts, each of which equals 1 chain when plotting on this scale. If the scale is doubled, *i.e.*, when it is desired to plot 10 chains to the inch then each division represents  $\frac{1}{2}$  chain = 8 annas; on a scale of 5 chains = 4 annas; on one of  $2\frac{1}{2}$  chains = 2 annas; and on one of  $1\frac{1}{2}$  chains = 1 anna.

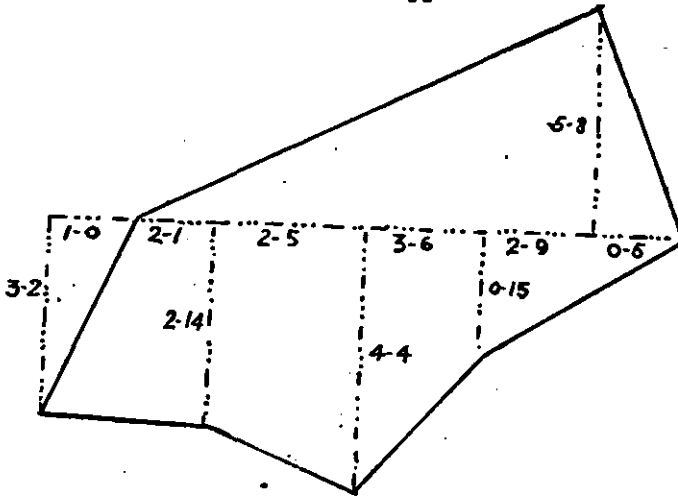
5. Below is given an illustration of the brass scale used in the *Gujerat survey*. The cross-lined figures at either end are used for taking off annas, that on the left when the scale is 20 chains and that on the right

when the scale is 10 chains. The distances between the two lines on the extreme right represent 'annas' beginning from the top with 16 annas; on the extreme left the anna scale runs upwards from the bottom.



The large divisions in the middle of the scale marked by Nos. are each 10 chains on the 20 chains scale, 5 chains on the 10 chains scale,  $2\frac{1}{2}$  chains on the 5 chains scale and  $1\frac{1}{4}$  on the  $2\frac{1}{2}$  chains scale. Hence by means of these large divisions combined with the cross-lined figures at the end distances of any length to any scale can be taken off with ease.

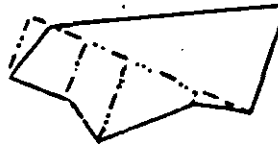
*Tippan*



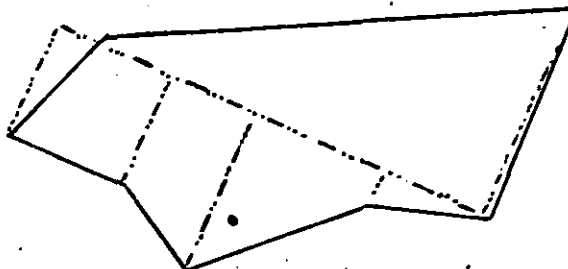
*Kshetra*

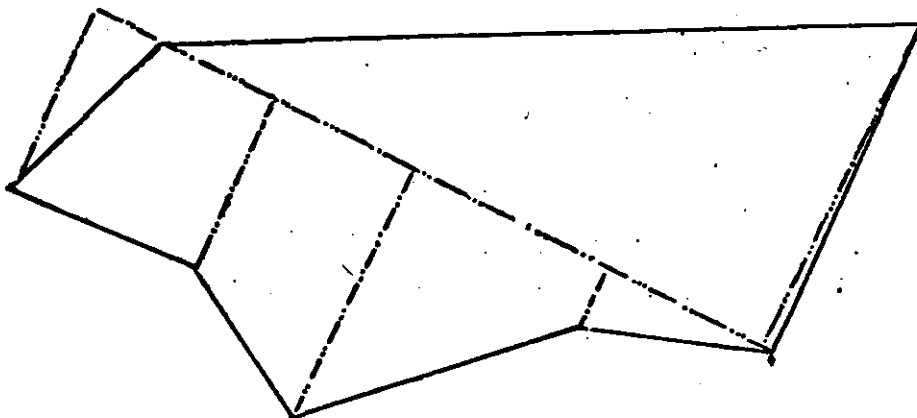
*Scale of 20 chains.*

*Scale of 10 chains.*



*Scale of 5 chains.*



*Scale of 2½ chains*

6. To plot a number on one base line.

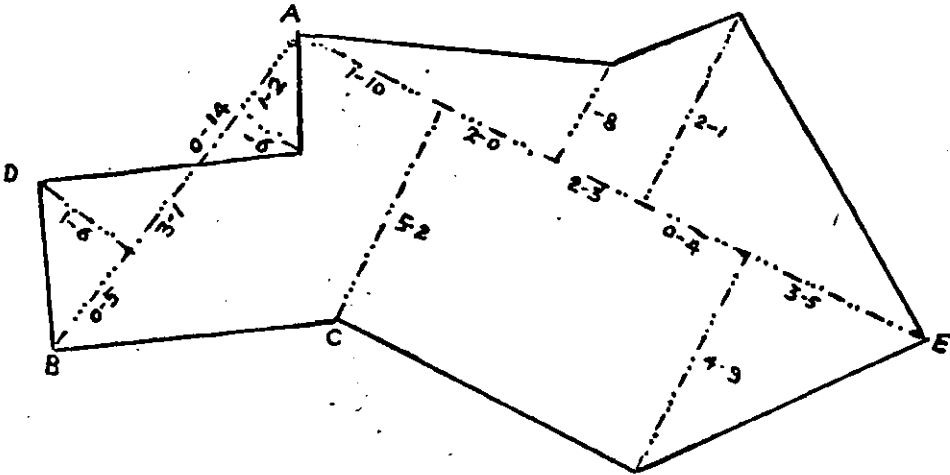
- (a) First any broken line is drawn to represent the base line.
- (b) Next starting from one end of the base line the distance to each of the offsets is taken off the scale with the compasses and laid down on the base line. In order to check the correctness of the *work* the total length of the base 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 Nos.* 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.

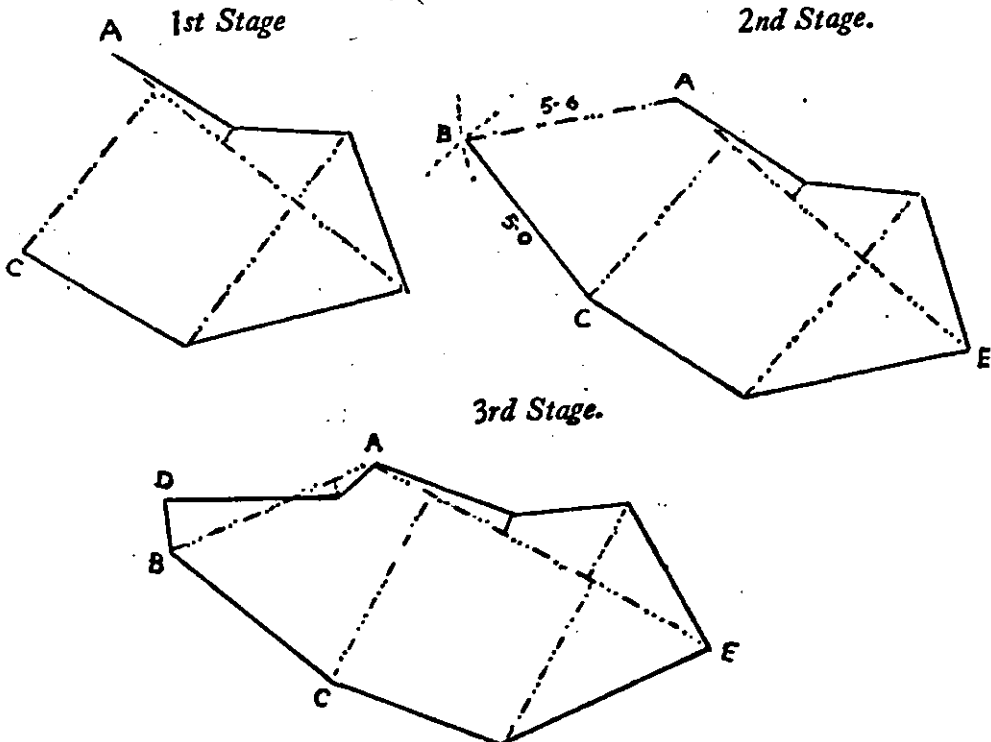
When a number has been measured on two base lines both cannot be laid down *direct* on the plotting paper as they are independent. In the example given the base line A E would first be laid down and the offsets plotted from it (1st stage). Thus the points A and C will be fixed. These points being fixed the point B can also be fixed by intersection of the lines C B and A B taken off by scale (2nd stage). A B is then joined and forms the second base from which the remaining offsets can be plotted (3rd stage).

*The Tippan*



*The Kshetra*

Scale of 5 chains to 1 inch.



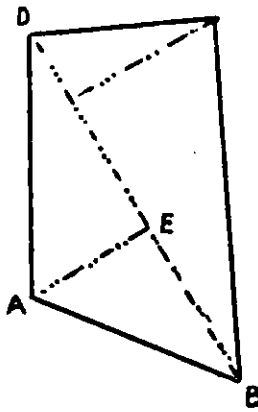
8. To plot together two or more Nos. measured on individual base lines.

Occasionally it is found necessary to make a consolidated map of 2 or more Nos., 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 3 Nos. shown below have to be plotted together. Then:

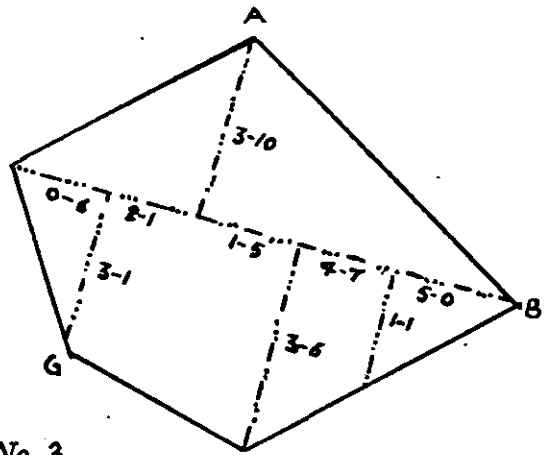
- (a) first plot Survey No. 2.
- (b) then from the points A and B fix the point E by the intersection of the two lines A E, B E.
- (c) the base line B E D of Survey No. 1 can then be drawn and the number plotted upon it.
- (d) in order to plot in No. 3 the point H must be fixed by intersection of the lines D H, A H. The base line D H F can then be drawn through the point H and the No. plotted upon it.

*The Tippan*

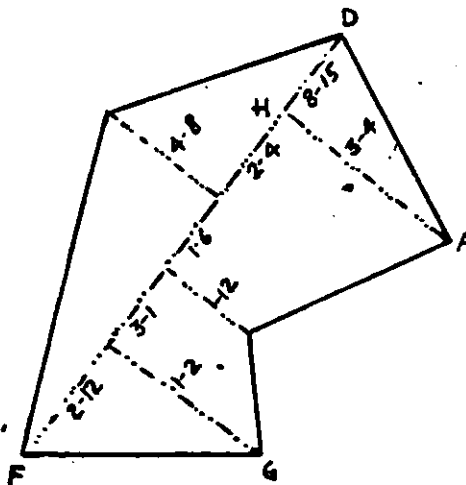
Survey No. 1

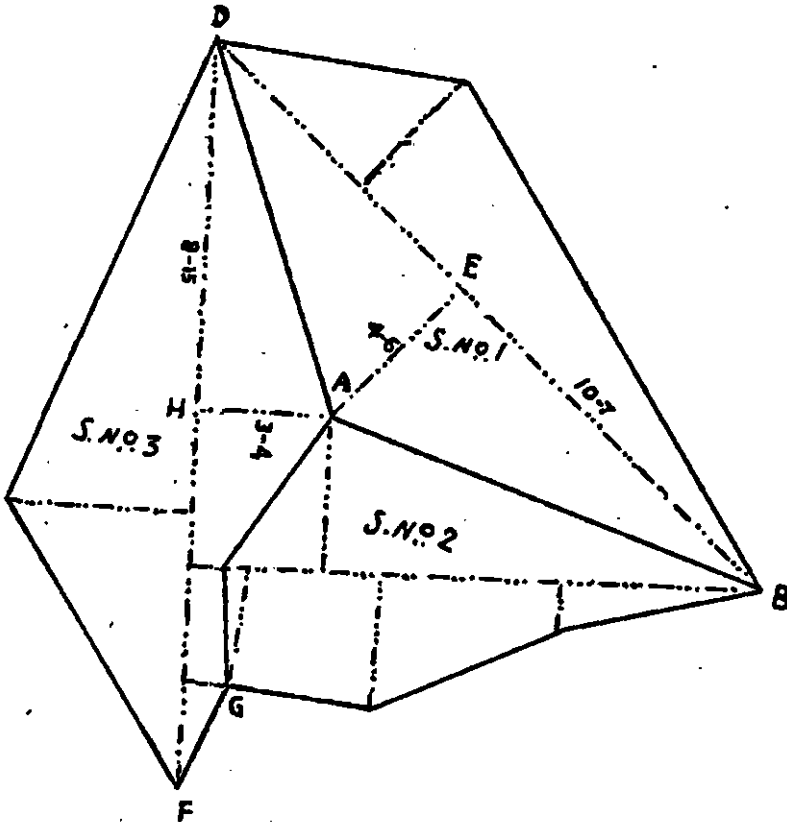


Survey No. 2



Survey No. 3.



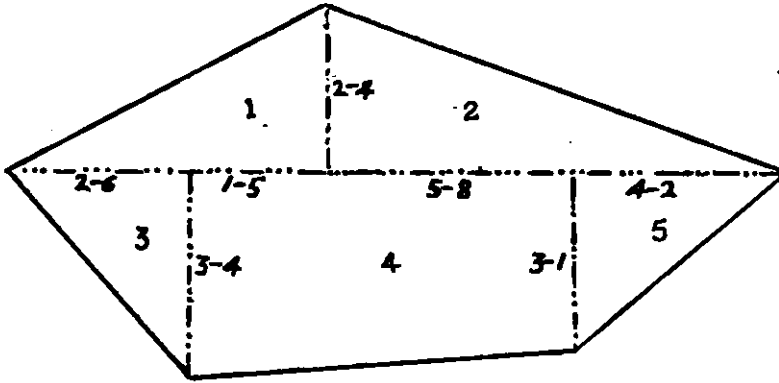
*The Kshetra.**Scale 2½ chains.*

## 9. Calculation of areas.

- (a) The general method of calculating 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 areas 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, areas over 8 prati annas are counted as 1 anna and 8 prati annas or under are discarded.
- (c) In making out the final areas of the number area over 8 annas are counted as 1 guntha and 8 annas or under are discarded. An exception to this rule is the case of the Konkan Survey where, owing to the small size of the Pot Nos., annas are in certain limited areas not discarded.



(d) The method of working out the area in the form generally used is given below.



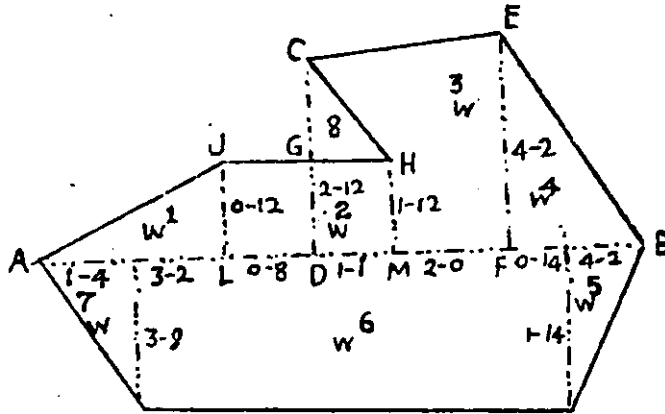
Number of Vasas	Kind of Vasas	Base		Offset			Area		
		Lengths	Sum of the Lengths	Offset	Sum of the Offsets	Half the sum of the Offsets	Gunthas	As.	Practi As.
1	△	2-6 } 1-5 }	3-11	2-4	2-4	1-2	4	2	6
2	△	5-8 } 4-2 }	9-10	2-4	2-4	1-2	10	13	4
3	△	2-6	2-6	3-4	3-4	1-10	3	13	12
4	□	1-5 } 5-8 }	6-13	3-4 } 3-1 }	6-5	3-2	21	4	10
5	△	4-2	4-2	3-1	3-1	1-8	6	3	0
Total ..							46	5	0
i. e. 1 acre							6 guns.		

10. *Vasa Vaslas.*

Complications are however introduced when an offset goes outside the number.

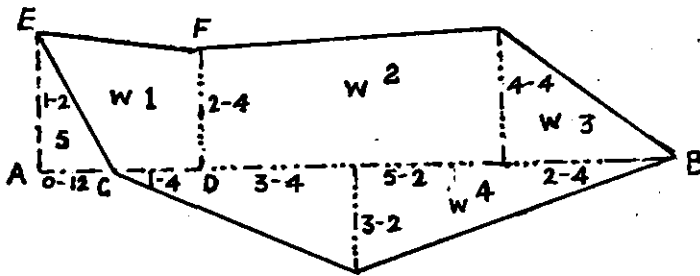
Example 1. In this case from the base line A B an offset to the point C passes outside the number. Hence if the trapezium C D F E were taken as a Vasla it would include the area C G H which does not form part of the number.

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		Offset			Area			
		Lengths	Sum of the Lengths	Offset	Sum of the Offsets	Half the sum of the Offsets	Gunthas	As.	Prati As.	
1	△	1-4	4-6	0-12	0-12	0-6	1	10	4	
2	□	3-2 0-8		1-9	0-12	1-14	0-15	1	7	7
3	□	1-1 1-1	3-1		1-2 2-12					
4	△	2-0 0-14		5-0	4-2	4-2	2-1	10	5	0
5	△	4-2 4-2	4-2		1-14					
6	□	0-14 2-0 1-1 0-8 3-2		7-9	1-14 3-8	5-6	2-11	20	5	3
7	△	1-4	1-4		3-8					
								50	5	3
8	□	1-1	1-1	2-12 1-2	3-14	1-15	2	0	15	
								48	4	4
							i. e.	8 guns.		
								1 acre		

Example 2. In this case the offset A E falls outside the baseline. 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		Offset			Area		
		Lengths	Sum of the Lengths	Offset	Sum of the Offsets	Half the sum of the Offsets	Gunthas	As.	Prati As.
1	□	0-12	} 2-0 {	1-2	} 3-6 {	1-11	3	6	0
		1-4		2-4					
2	□	3-4	} 8-6 {	2-4	} 6-8 {	3-4	27	3	8
		5-2		4-4					
3	△	2-4	2-4	4-4	4-4	2-2	4	12	8
4	+△	2-4	} 11-14 {	3-2	3-2	1-9	18	8	12
		5-2							
		3-4							
5	△	1-4	0-12	Deduct 1-2	1-2	0-9	53	14	14
		0-12					0	6	12
							53	8	2
					i.e.	1 acre	13 guns.		

## 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 a 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 a 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. Such tables can be purchased in the Bazar for an anna or two and except in the Konkan no good measurer thinks of working without one.

4. A portion of such a table is shown overleaf. In Col. I are shown vertically measurements by chains: in Col. I horizontally are shown measurements by annas. In horizontal Col. II are shown the squares of the chains in vertical Col. I converted of course into square measure. In the remaining Cols. are shown the squares of the chains in the vertical combined with the annas in horizontal Col. I. Thus the square of 2 Ch. 3 As. is 4 Ch. 12 As. 8 Pr. as. which will be found opposite the entry for 2 ch. and below the entry for 3 annas. In order

to find the square root of an area the same method must be worked backwards. Thus to find the square root of 18 gunthas the figure will be found opposite the entry for 4 chs. and below the entry for 4 annas : hence the square root is 4 ch. 4 as.

Varga Mul

		ANNA 1	ANNAS 2	ANNAS 3	ANNAS 4	ANNAS 5	ANNAS 6	ANNAS 7	
		prati		prati		prati		prati	
Chains	Gunthas	Gs. As. as.	Gs. As. as.	Gs. As. as.	Gs. As. as.	Gs. As. as.	Gs. As. as.	Gs. As. as.	
..	..	0 0 0	0 0 4	0 0 8	0 1 0	0 1 8	0 2 4	0 3 0	
1	1	1 2 0	1 4 4	1 6 8	1 9 0	1 11 8	1 14 4	2 1 0	
2	4	4 4 0	4 8 4	4 12 8	5 1 0	5 5 8	5 10 4	5 15 0	
3	9	9 6 0	9 12 4	10 2 8	10 9 0	10 15 8	11 6 4	11 13 0	
4	16	16 8 0	17 0 4	17 8 8	18 1 0	18 9 8	19 2 4	19 11 0	
5	25	25 10 0	26 4 4	26 14 8	27 9 0	28 3 8	28 14 4	29 9 0	

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 Bāndh Māp 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 Bāndh Māp 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 Bāndh Māp 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.

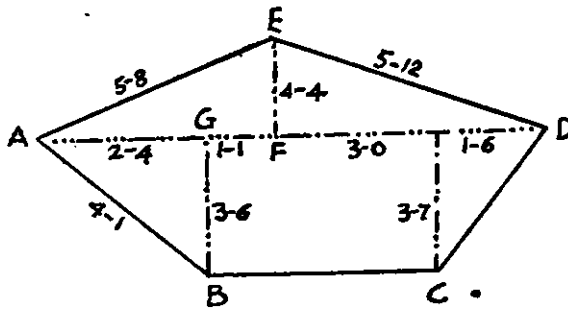
(5) To find the base of a trapezium.

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 subtracting 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 and the Bandh Map from A to B compares the measurement of the base line (2 — 4) and offset (3 — 6) with that of the Bandh Map according to Rule 1 laid down above thus :—

	Ch.	As.	Gs.	As.	Pr.	as.
Square of Base	(2	4)	=	5	1	—
Do. offset	(3	6)	=	11	6	4
			<hr/>			
Add together			=	16	7	4

	Ch.	As.	Pr.	As.		Ch.	As.
Square root of	(16	7	4)	=	4	1	Bandh Map.

This calculation proves that the measurements are correct as they agr when worked out theoretically.

Similarly after measuring the offset from F-E the measurer may compare the measurement of the Bandh Map and offset with that of the base according to rule 3 thus:—

	Ch.	As.	Ch.	As.	Pr. as.
(a) Square of Bandh Map	(5	6) =	28	14	4
(b) Do. Base	(2·4+1·1 = 3·5)	=	10	15	8
<hr/>					
Deducting (b) from (a) = 17 14 12					

Square root of 17 Gs. 14 As. 12 Pr. as. = 4·4 = offset EF. Hence the measurements again are proved accurate.

On measuring up to the point D however and taking the Bandh Map (5·12) to E the measurer on comparing the measurements of the base (3·0+1·6=4·6) and the offset (4·4) with the Bandh Map (5 — 12) by rule 1 finds

	Ch.	As.	Gs.	As.	Pr. as.
Square of base	(4	6) =	19	2	4
Do. offset	(4	4) =	18	1	0
<hr/>					
Add together	= 37 3 4				

Then square root of 37 Gs. 3 As. 4 Pr. as. = 6 Ch. 1 As. which should agree with the Bandh Map (5·12) but does not. Hence there must be an error in measurement somewhere which the measurer can then 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.

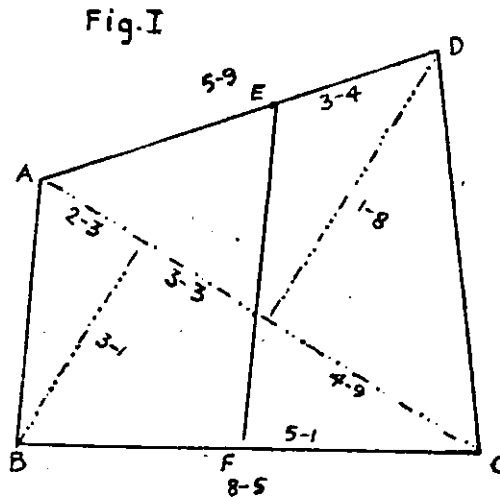
7. In the same way the whole of the measurement can be compared by the measurer as he goes along and at the end he can be certain of the absolute accuracy of his work.

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. But there is another alternative method, viz., measurement on the *Phalni* system. 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. The principles of the system may best be explained by an illustration.

Let A B C D be the tippan of a Survey No. (vide Fig. 1) 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 Circle Inspector 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.



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

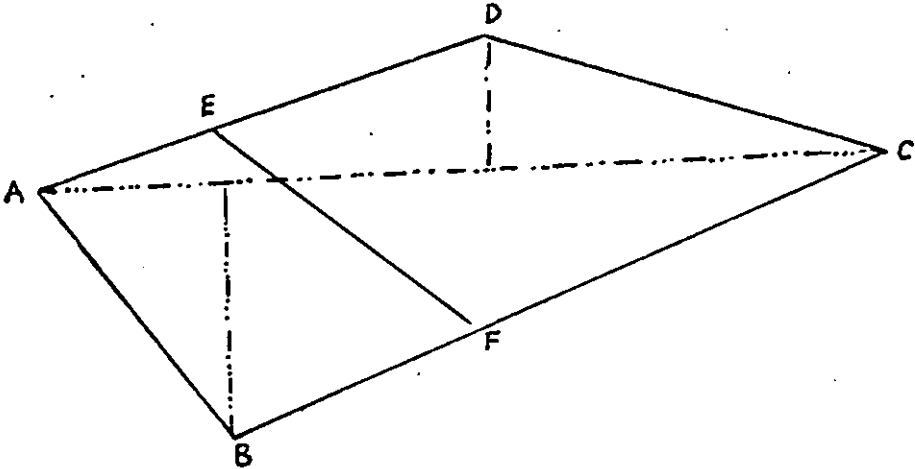
According to the Phalni system however he would proceed as follows :—

- (1) *In the field* he would take measurements from D E (which-say-is 3 chains 4 annas) and from C F (which-say-is 5 chains 1 anna) only.



(2) *In the office* he would draw a map of the No. on a scale of  $2\frac{1}{2}$  chains to the inch and plot in the measurements taken in the field (vide Fig. 2).

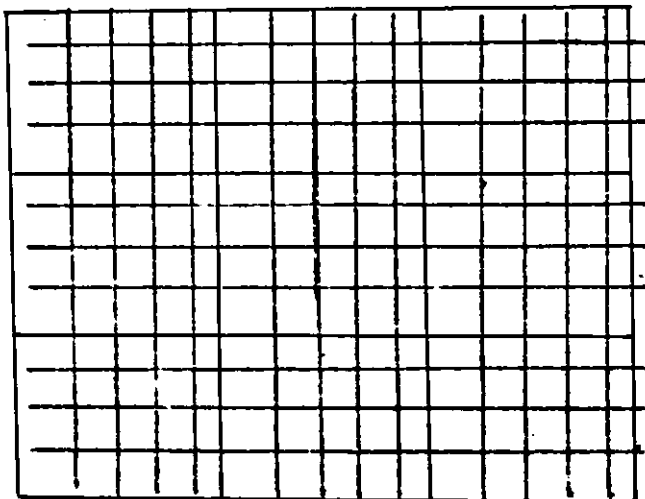
Fig. II.



(3) Lastly in order to find the *area* he will use *the Area square* (vide Fig. 3). This is a sheet of paper divided into small squares the sides of which are each  $\frac{1}{5}$  inch 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 No. of squares which the sketch covers. Now when the scale of the sketch is—

		Acres
20 Chains	each small square = 16	Gunthas—each red rectangle = 8
10 .....	= 4	= $\frac{1}{2}$
5 .....	= 1	= 2
$2\frac{1}{2}$ .....	= $\frac{1}{4}$	= $\frac{1}{8}$

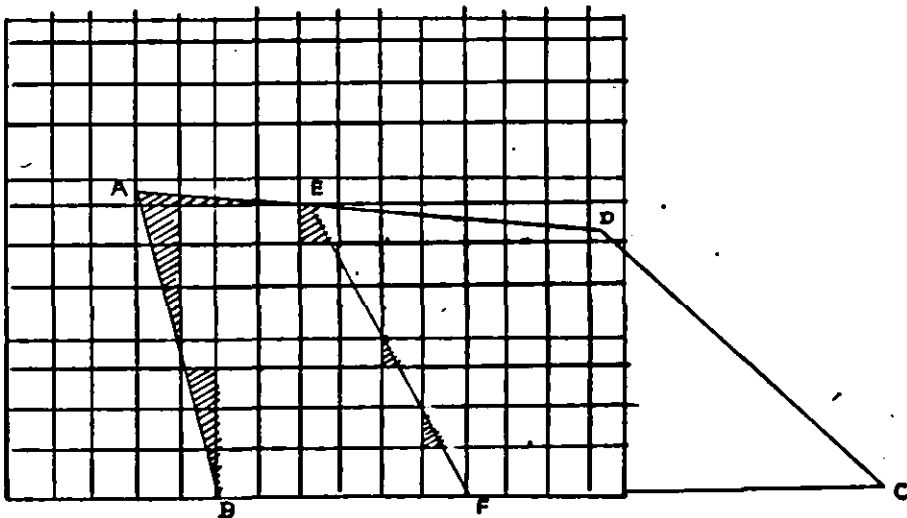
Fig. III.



Hence the No. 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 No. in question the area square is first superimposed upon the part A B F E as shown in Fig. IV. Then if the No. of whole and practically whole squares be added up they come to 33. There remain, however, parts of squares (shaded thus in the sketch) which have to be added together to make whole squares. They come to approximately 6; hence the total No. of squares is 39. The scale of the sketch is  $2\frac{1}{2}$  chains hence the value of each small square is  $\frac{1}{4}$  guntha. Hence the area of A B F E is 10 gunthas.

Fig. IV.



The area square will now be moved on to E F C D and the area discovered in the same way. The No. of squares will then be found to be 51 and the area consequently 13 gunthas.

If these two areas be added together they will be found to be 23 gunthas and to equal the area of the field as found by calculation.

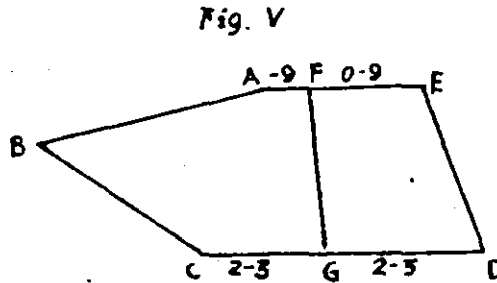
The foregoing example illustrates sufficiently the principles of the system. It is now however necessary to go into more detail regarding the methods to be employed.

#### *Measurement.*

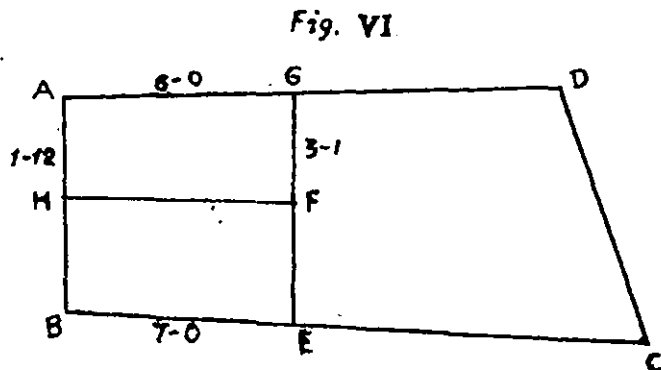
(1) Where the boundary marks of the Survey No. are in existence it is not necessary to fix the boundaries of the No. according to the old tippan before measurement.

(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.

Fig. V. If this No. has to be divided into 2 parts at F G then if the mark at B is out of place or missing it is not necessary to fix it, nor again if E and D are in place and the direction of the boundary from E-A and D-C 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.



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



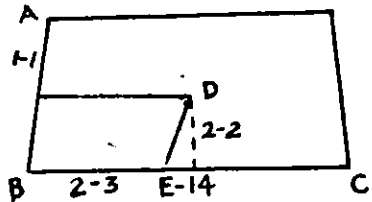
In this example as GE is a straight internal boundary it is only necessary to measure B E, H A, A G and G F.

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

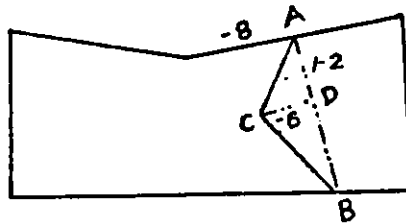
quickest way. In the following examples shown in Fig. VII different kinds of base lines are shown each of which is the most convenient for the particular case:—

Fig. VII.

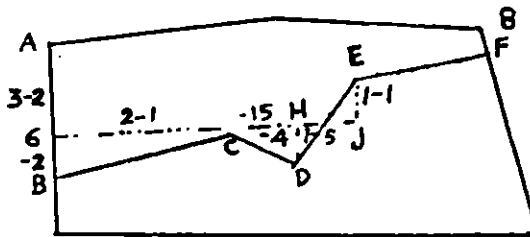
Ex. 1.



Ex. 2.



Ex. 3.

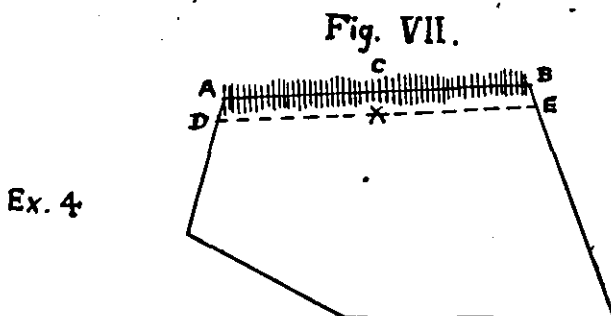


Ex. 1.—In this case the base line is the boundary of the number.

Ex. 2.—In this case the No. has to be divided into two parts along A C B. Here the base line is taken along AB 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.

Ex. 3.—In this case the point is fixed by an offset from the boundary of the No. and the points D and E from offsets taken from the original offset as a base line.

5. If the boundaries of the No. 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.



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 20 chains to the inch 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 No. 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 Varga Mul. If they are accurate then the area should be re-calculated from the old tippan. A mistake is sure to be discovered somewhere.

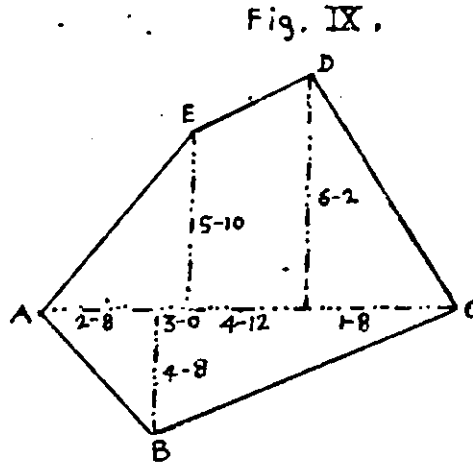
### Practical Applications of the Method

(1) *To divide a No. into two or more parts according to possession, e.g., under orders of the Civil Court.*

This had already been described above.

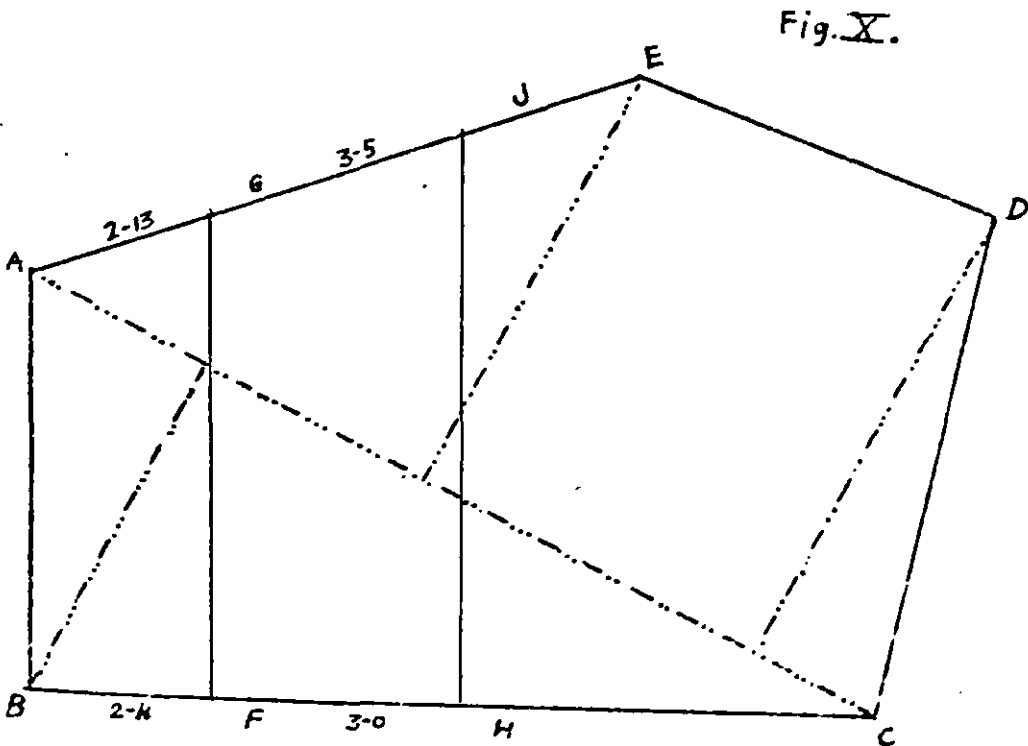
(2) To divide a No. into two or more parts according to certain areas, e.g., according to the orders of a Civil Court or for purposes of cultivation.

Let A B C D E, Fig. IX, be Survey No. whose area is 1 acre 35 gunthas: it is desired to divide it into 3 parts measuring 1 acre, 20 gunthas and 15 gunthas, respectively.



To do this:

(a) Plot the number on a scale of  $2\frac{1}{2}$  chains as in Fig. X.



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

viz., for 15 gunthas 60 squares as ABFG.

20 gunthas 80 squares as GFHJ.

1 acre 160 squares as JHCDE.

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

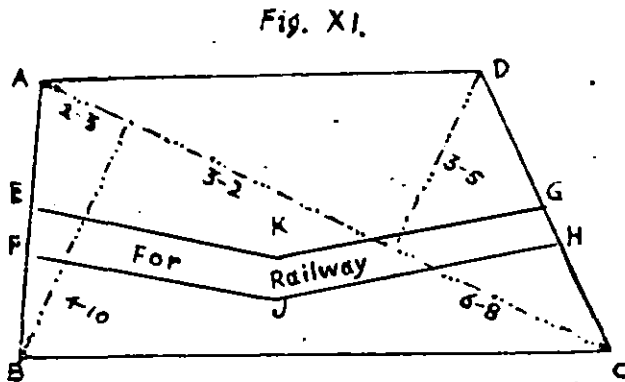
				Ch. As.
A-G	..	..	..	2 13
G-J	..	..	..	3 5
B-F	..	..	..	2 11
F-H	..	..	..	3 0

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

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

*Example.*

Let ABCD, Fig. XI, be a No. from which an area as shown in red ink is to be taken up for a Railway.

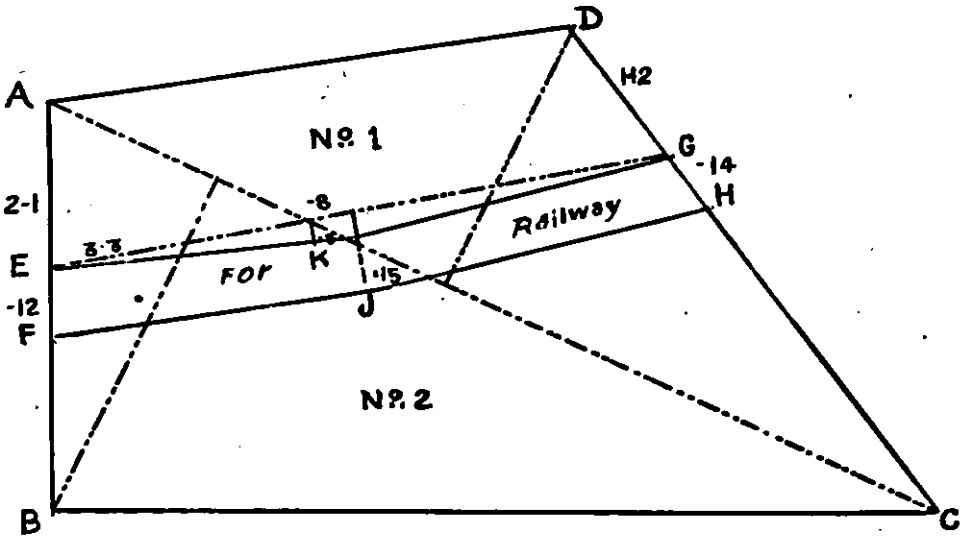


(a) Measure from A-E (2 chains 1 anna) and from E-F (12 annas) : set up base line from E-G and fix points K and J therefrom as shown : lastly measure D-G (1 chain 12 annas) and G-H (14 annas).

(b) Plot these measurements on a scale of  $2\frac{1}{2}$  chs. as in Fig. 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:—

			Ac.	Gs.
No. 1	..	..	..	15
Railway land	..	..	..	6
No. 2	..	..	..	26
			1	7

Fig. XII.



NOTE

The Phalni system cannot be used in Gujarat districts because in these districts the greater part of the Survey Record including the Survey Tippans has been lost.



## CHAPTER VIII

### PRACTICAL MEASUREMENT

1. The practical measurement work of the Circle Inspector chiefly consists of the following kinds:—

- (1) Partition either on application 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 Nos.
- (7) Measurement of alluvial lands formed on the bank of nalas and either added to adjoining Nos. or formed into new Nos.

In sending up the correspondence after disposal the Circle Inspector 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 or Court's decree.*

- (a) In partition cases the areas partitioned will usually be divided into pot hissas and not into fresh survey Nos. 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 [except in Gujarat Districts.]
- (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 Circle Inspector will state the number of days spent by him in the work and if hired labour has been employed will forward a muster roll signed by the patel and kulkarni and by the payees. He will also refer to and explain all discrepancies between the new and original measurements.

### 3. *Fixing the position of missing marks.*

- (a) In this case the Circle Inspector 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 *Kabulayat* taken.
- (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.
- (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.*

These will be settled in a similar manner. The *Kabulayat* of the parties must invariably be taken.

### 5. *Acquisition of land for public purposes.*

- (a) In such cases the measurement work will be carried out according to the *Phalni* system [except in Gujarat districts].
- (b) In all cases where land is acquired for public purposes new survey 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 portions, thus formed, should not be made into separate survey numbers. 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 limekilns, quarries, etc.*

- (a) In this case the areas measured have to be made into separate survey Nos. and boundary marks erected.
- (b) In making the measurement the Circle Inspector after fixing the boundary of the No. so far as is necessary will measure that part only which is to be used for non-agricultural purposes according to the *Phalni* system [except in Gujarat districts].
- (c) If 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 Circle Inspector 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. 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 following regulations have been laid down for the measurement of waste lands to be given out for cultivation :—

1. On an application being received for waste lands for cultivation the Mamlatdar shall call for a report from the Circle Inspector.

2. In submitting his report the Circle Inspector will state—

- (a) whether there is any objection to giving out the land for cultivation.
- (b) its approximate area.
- (c) a rough sketch of the land asked for.

3. If the approximate area is less than the minimum area prescribed for a survey No. of the particular class of land for the District in question he shall report whether it would not be possible to form a number of the standard size or approximating thereto from the adjoining waste land—if any—by including land not actually asked for by the petitioner and shall forward a statement of the applicant agreeing that this shall be done.

4. He shall at the same time state whether the land asked for adjoins a survey No. or part of a number belonging to the applicant and whether it can be joined to it.

5. If the land asked for be irregular he shall state whether it can be made of regular shape by including adjoining waste land and shall forward a statement of the applicant agreeing to this course.

6. If the applicant declines to allow more waste land to be included his petition may be refused.

7. On receipt of sanction the Circle Inspector shall measure the land according to the Phalni system and shall after measurement erect boundary marks there and then and not leave it to the occupant to erect them afterwards. In his forwarding report he shall certify that this has been done. If delay occurs for any reason, possession of the land shall not be given till the boundary marks are put up.

*8. Measurement of alluvial lands.*

(a) Such lands are usually amalgamated with the adjoining survey No.; hence the adjoining boundary of the number must be first fixed before the alluvial land is measured.

(b) Measurement 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 in coloured pencil.

(c) The Circle Inspector must note that according to section 64, 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 Circle Inspector 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 No. 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  $\frac{1}{2}$  acre, and in making his report the Circle Inspector should draw attention to such facts if they exist.

## GLOSSARY OF MEASUREMENT TERMS

Marathi	Explanation	Gujarati Equivalent
Bandh Map	.. The length of the boundary of a field between any two corners.	Bandh Map.
Gunakar	.. The calculation of the area of a field ..	Gunakar.
Kshetra	.. The measurement sketch of a Number drawn to scale.	Pakun tippan.
Kshetra Book	.. The measurement book containing such kshetra.	Paki Book.
Lambi	.. The base line ..	Lambi.
Rundi	.. An offset ..	Rundi Paholi.
T'ippan	.. The measurement sketch of a No. not drawn to scale but showing the measurements.	Kachun tippan.
T'ippan Book	.. The measurement book containing such t'ippans.	Kachi Book.
Varga Mul	.. The ready-reckoner of squares and square roots ( <i>vide</i> chapter VI).	Varga Mul.
Vasla	.. The triangles and trapezia into which Nos. are divided by the cross-staff.	Vaslo.
Vaza Vasla	.. A Vasla due to an offset passing outside the No. and which has to be deducted in making out the area.	Bad Vasla.