For Departmental Use

Survey of India

DEPARTMENTAL PAPER No. 10

THE HUNTER SHORT BASE

FIRST EDITION COMPILED BY MAJOR C. M. THOMPSON, I.A., 1928.

SECOND EDITION COMPILED BY H. C. BANERJEA, B.A., 1931.

PUBLISHED UNDER THE DIRECTION OF
BRIGADIER R. H. THOMAS, D.S.O.,
SURVEYOR GENERAL OF INDIA.

PRINTED AT THE GEODETIC BRANCH OFFICE,
SURVEY OF INDIA, DEHRA DUN, 1931.

For Departmental Use

Survey of India

DEPARTMENTAL PAPER No. 10

THE HUNTER SHORT BASE

FIRST EDITION COMPILED BY MAJOR C. M. THOMPSON, I.A., 1928.

SECOND EDITION COMPILED BY H. C. BANERJEA, B.A., 1931.

PUBLISHED UNDER THE DIRECTION OF
BRIGADIER R. H. THOMAS, D.S.O.,
SURVEYOR GENERAL OF INDIA.

PRINTED AT THE GEODETIC BRANCH OFFICE,
SURVEY OF INDIA, DEHRA DUN, 1931.

PREFACE TO THE FIRST EDITION.

The idea of using short bases for topographical purposes was first put forward by Dr. J. de Graaff Hunter, M.A., Sc.D., F.Inst.P., in notes circulated to the Directors of Survey Circles under Geodetic Branch letter 5151/65 dated 11th August 1925. The type of short base therein suggested consisted of a single span of the measuring tape, pulled taut by means of a simple straining device between posts, the tension of the tape being tested by a spring balance. Further experiments led to the evolution of the "Hunter Short Base" in its present form, in which the tape is suspended in 4 sections on posts, each section being one chain in length. This pattern of short base has been tested on the Frontier and found satisfactory. The explanations in this booklet are derived from Dr. Hunter's original notes and some notes by Major E. A. Glennie, D.S.O., R.E. They have been revised and compiled by me in a form suitable for the use of R.A. Survey Sections and Survey Officers in the field. Mr. R. B. Mathur of the Observatory Section of the Computing Office carried out the comparison of the tapes and assisted in preparing the diagrams and reading of the proofs, and Mr. A. Francis of the Photo-Zinco Section carried out the reproduction.

DEHRA DŪN,
18th August, 1928.

C. M. THOMPSON, MAJOR, I.A.,
Superintendent, Survey of India.

PREFACE TO THE SECOND EDITION

The first model of the Hunter Short Base was found rather fragile for field work, and various changes were suggested by Major E. O. Wheeler, M.C. R.E., Officer Commanding 'E' Company. These and other improvements have been incorporated in a second model to which this booklet has been adapted. The revised compilation has been undertaken by Mr. H. C. Banerjea, B.A.

DEHRA DŪN,
14th May, 1931.

F. J. M. KING, LT.-COLONEL, R.E.,
Director, Geodetic Branch.

CONTENTS

LIST OF PARTS AND TOOLS WITH THE SHORT BASE

Name of part or tool	Purpose	Number
Jointed steel tape 264 ft. long on drum, (in canvas case)	For measuring	1
Posts A and B with tripod heads ...	End supports	2
Post C with tripod head	Support for target C	1
Posts P, Q and R	Intermediate supports	3
Weight	For lever on post B	1
Small targets A_1, B (fixed on lever of post B) and D	For close observation and for observing slope	3
Big targets A_2 and C	For base extension	2
Metal rods with socket joints (in a tube) ...	Supports for target D	3
Thermometer	For taking temperature of tape ...	1
Scale and Dividers	For measuring terminal and intermediate links of tape	1
Box (in canvas case)	To contain the tripod heads, targets, weight, theromometer, scale and dividers	1
Ruck sacks	To contain the posts and tube with pins	2

THE HUNTER SHORT BASE

1. Introduction.—This apparatus is useful in time of war or under circumstances in which triangulation cannot be connected to a geodetic framework, or where topographical triangulation is carried a long way without any check on its sides.

It will provide a base of sufficient accuracy for transfrontier triangulation, or triangulation with an expeditionary force or boundary commission. It may also be used as a subtense for traverse operations.

Its advantages are:—

(1) One observer with menial help can set it up.

(2) It carries its own marks and so saves labour and errors of transfer.

(3) It avoids the need for line clearing, and is workable on sloping, undulating or broken ground.

2. Description.—The apparatus consists of a jointed steel tape made up of four sections, with swivel junctions at one chain intervals, the total length being four chains (264 feet) approximately. Each one chain section is painted with a distinctive colour (red, white, blue or green) for a length of one link at either end, and the whole tape is rolled on a drum. Generally the whole length of the tape will be extended and supported, not only on the terminal posts A and B but on the intermediate posts P, Q, R at intervals of one chain (see the general diagram at end). Occasions may arise, however, when the ground admits of only two or three sections of the tape being used, or when the whole tape has to be slung across a ravine with only the end supports.

3. End Supports.—The end supports A and B of the steel tape are each made of three wooden posts 1 inch in diameter and about 3 feet in length, made stable with a canvas bag filled up with stones. The two tripods are placed with the longest post under the tape. The tripod heads of A and B are slipped on and are each clamped with two set screws. (The fitting of these parts admits of use with rough improvised posts). These supports can be distinguished by their painting and letters, A being red and B green. B, in addition, has a detachable bell crank with a target, fixed on its top by means of a pin. A has a hook on top to which the red end of the tape is attached while the green end of the tape is fixed to a similar hook with B.

A weight hooks on to the long arm of the bell crank of B in order to apply the proper tension to the tape when hanging in catenary. This tension (about 12 lb. for a tape of 0·002 square inches cross-section) is equal to that given to the tape AB on the flat at the time of its standardisation at Dehra Dūn. The exact weight used varies with tapes of different cross-sections, in order that the catenary correction (Table B) may be constant for all tapes. The appropriate weight is stated in Table A and other weights must not be used. In order to apply this tension correctly, when hanging in catenary, the bell crank on B is made roughly horizontal by pulling the iron tripod head up or down and clamping it in position.

4. Post C.—Post C for target C is similar in construction to post A without the canvas bag or any hook or pin.

5. Intermediate Posts.—Each of the intermediate posts P, Q or R consists of two jointed wooden rods similar in size to A with a pin on top, which passes through a hole in the small oblong brass double swivel between the junction links of the tape. The pin further serves to carry target D on the three metal rods with socket joints, for observing the slope.

6. Targets.—There are five targets supplied with the base, viz. 3 small targets A_1, B, (size 3″ × 2″) and D (size 2″ × 1″), and two large targets A_2 and C (size 8″ × 5″), made of sheet tin and painted diagonally black and white. Targets A_1, A_2 and C each fix by means of a slot and hole to rivets on posts A and C, the lettering on post A showing the positions where the targets A_1 and A_2 should be attached, A_2 being put on the end away from the tape and A_1 on either side. Target B is painted on the bell crank. Target D can be fixed in turn on the intermidiate post P, Q, R or on A and B.

7. Setting up the base.—The setting up of the base and the use of the targets are more fully explained in the instructions which follow, which are primarily concerned with the case when the tape is in four sections, supported at each chain length (see the general diagram at end).

8. Setting up post A.—Take the tripod marked red and spread it so that the longest rod is towards the proposed lay-out of the base i.e. towards B. Take its head, slip it on the longest rod and put it so that the hook is also towards B. Fill the canvas bag with stones to make it stable. Next, attach the red end of the tape to the hook and unreel the whole tape from its drum along the ground in the required direction, holding the tape drum by the leather strap, so that the tape unwinds freely without kinking.

9. Setting up post B.—Take the green tripod and spread it so that the longest rod is towards A. Take its head with the lever attached and slide it over the longest rod. Clip B on to the green end of the tape. Fill the bag with stones, and put the weight at the far end of the lever, which should point away from A.

10. Adjusting Tension.—Correct tension on AB will be applied when the bell crank on B is horizontal. Its final adjustment is made by clamping it at the correct height, after the intermediate posts have been set up (see para 11). Great accuracy is unnecessary. It is sufficient if the crank looks approximately horizontal.

11. Setting up Intermediate Posts P, Q and R.—Now if the ground permits, set up the intermediate supports between the sections of tape (see para 5). These should be aligned by eye on AB.

12. Setting up small targets A_1 and B.—Small target A_1 fastens by means of a slot and hole to projecting rivets on either side of post A (see para 6), while target B is painted on the bell crank of post B.

13. Setting up target D.—The small target D which is intended for observing the slope of the sections of the tape is set up on one of the three metal rods provided for the purpose, which fit one into the other, the last fitting on tops of the pins at the heads of posts A, P, Q, R or B. The height of the target itself is set by means of a set screw at such a point on the metal rod that when placed on A it is at the same height above the tape as the horizontal axis of the theodolite.

14. Setting up big targets A_2 and C.—The two targets A_2 and C are used when carrying out base extension. Target A_2 is fitted to the pair of rivets on the side of post A opposite to the tape by means of a slot and hole. Similarly target C fastens on the only pair of rivets on the head of post C, which is set up nearly on a line at right angles to the short base AB at a distance of 400 to 1,000 yards.

15. Measurement of the junction and end links.—As the junction and end links of the tape are liable to slight extension under rough use, they should be measured occasionally. The measurement should be taken between the terminal marks at the end of each tape in case of the junction links, and between the terminal marks and the centre of the pivots of the hooks on posts A and B in the case of the end links, by means of the scale and dividers provided for the purpose. The scale is graduated to 1,000ths of a foot.

16. Taking temperature readings of tape.—As the base is standardised at 90° F (see Table A), the temperature of the tape is wanted when measuring the small angle α at C (see para 18). For this purpose it will be sufficient if the air temperature in the shade is taken a number of times at C and the mean of the readings taken when applying the temperature correction from Table C. To avoid appreciable difference of temperature between the tape and the air and also for favourable measurement of the angle ACB it is preferable to observe the base on a dull day or early in the morning or late afternoon. It may be added that an error of 8° F in the temperature of the tape will cause an error of 1 : 20,000 in the length of the short base.

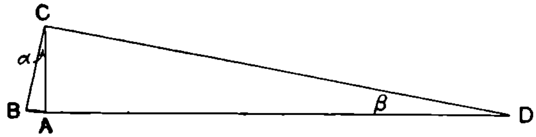
17. Marking Sites of A, B and C.—It is essential to use the small targets at A and B when measuring the small angle α (see para 18). It will be understood that the object of marking the sites of A, B and C is only for subsequent operations.

Put a peg flush with the ground, centre a theodolite over it and erect the post A so that its target is centred under the theodolite. Alternatively, the target may be centred over a peg by means of a plumb bob before filling the bag with stones, but in this case it is liable to be disturbed when fixing the other extreme end of tape to B: whereas, with a theodolite at A this can be checked and corrected, if required. It is not necessary to mark the position of B unless the base is extended from B, in which case post B is marked as above while A is left unmarked. Similarly, the site of C is marked with a peg after the small angle α has been measured.

The pegs are driven flush with the ground so that helios instead of targets may be put over them, if necessary, when observing angle β from D (see para 18).

18. Theory and use of the Apparatus.—By means of the apparatus a base can be rapidly fixed between two points A and B on almost any type of ground. Preferably the base should not be set up on a slope over 20°, for in this case the slope of each section requires direct measurement and cannot be easily deduced by the methods given below. The short base AB should not be set up until the site for post C has been selected, as it is *essential* that the small angle α (see figure below) is measured with the small targets at A and B.

The first theodolite measurment is that of the slopes of AP, AQ, AR, AB as mentioned in para 13. This is done immediately after the base is erected. Data are then sufficient to compute the precise distance between the two targets A and B except for the temperature correction which will be deduced from the mean temperature observed (see para 16).



In the figure, CA may be any distance from 400 to 1,000 yards roughly at right angles to AB, and DA from 1 to 6½ miles according to the length of CA, nearly in the same line as BA. Grazing rays (i.e. rays passing within 20 feet in height above intervening ground) should be avoided in the case of CD and AD. If the ground admits, the point C may be chosen on an elevation so that the rays CA, CB are well above the intervening ground.

Next, with the theodolite still at A, measure the angle BAC, keeping the large target at C facing towards A. As this angle will be nearly a right angle a beacon or flag at C may alternatively serve the purpose. Again, if the site for station D has been selected and marked with a beacon, the angle CAD will also be observed. If not, the angle ACD may be measured subsequently instead of the angle CAD.

Now move the theodolite from A to C and observe the angle α with targets at A and B by the method of repetition (see para 19).

Similarly, the small angle β at D is observed by repetition with the targets at A and C. But if the targets are not visible, helios may be put at A and C; or beacons may have to serve this purpose, although they are likely to introduce some reduction in precision, due to centring difficulties.

The extension being from a short base, the angles α and β will be between 5° and 12°. The smaller the angles the more measures are made by repetition in the manner described in para 19, the rule being to measure round the limb 180°. The rest of the angles of the figure are of minor importance and normally only two measures are made of the angles DAC and CAB. The angles DCA and ABC are not generally observed. If three angles of a triangle are observed (which is quite unnecessary) no share of the triangular errors must be distributed to the small angles α and β.

19. Method of measuring small angles by repetition.—It is necessary to measure the small angles with higher accuracy than is usual with the ordinary angles of triangulation. This is done by measuring them by repetition round the whole circle thus eliminating graduation error, and without reading the limb at each intersection. By this method the error should not exceed 1 in 20,000 for the sides DC or DA, even with a vernier theodolite, provided it has two good clamps, a fine vertical wire, a rigid stand, and a freely moving axis. The horizontal collimation and the levelling of the transit axis of the theodolite should be correct to about half a minute. The actual procedure is as follows :—

(a) Unclamp the upper plate of the theodolite, set it to 0° approximately and clamp it again.

(b) Unclamp the lower plate and intersect the left hand target A with the lower tangent screw. Unclamp the upper plate and rotate the theodolite several times to take up back-lash, reclamp the upper plate, intersect with the upper tangent screw and read the limb.

(c) Unclamp the upper plate, point at target B, clamp and intersect with the upper tangent screw. Read the limb and take out this first measure of the subtended angle, which will be a check against gross errors later. It is not essential to read the limb again until the whole series of intersections has been completed, but as a guard against blunder it is wise to record readings after every fifth repetition.

(d) Unclamp the lower plate, swing right round the circle (nearly 360°) on to A (instead of swinging backwards) clamp and intersect with the lower tangent screw.

(e) Repeat (c) and (d) a sufficient number of times, so that finishing on B the reading of the limb is about 180°. Subtract the mean of the first reading taken as in (b) from the mean of this final reading, and divide the result by the number of

Corrections to Departmental Paper No. 10 (2nd Edition, 1931).

Page 5.

After para 21, *add* a new para 21A as follows :—

21A. Field Standardization. The lengths of the four 66-foot sections of the tape must be verified from time to time: either by returning them to Dehra Dūn for re-standardization, or by comparing them one at a time with any more trustworthy standard tape which may be locally available. For this purpose it is necessary to know :—

(*a*) The distance between the 0 and 66-foot marks on the standard tape, in catenary, under a specified tension, and at a specified temperature.

(*Note*:—An error of 1/10 inch in 66 feet corresponds to 1 : 7920).

(*b*) Similar information for the tape on the flat (in case it is more convenient to standardize on the ground).

(*c*) The temperature coefficient of the tape.

A spring balance (graduated to pounds) will be required to strain the tape at the specified tension.

The comparison may be done in catenary or on the flat. For comparison in catenary two strong posts should be driven into the ground projecting from it to about the normal height at which the base-tapes hang. The standard tape is then hung in catenary so that its 0 and 66-foot marks lie on the posts, while corresponding marks are simultaneously made on the two posts. The four base-tapes are then successively hung in position, one end being held carefully level with the mark, while the distance between the other end and the corresponding mark is measured with the dividers and scale supplied with the set. The standard should then be hung in place again, to make sure that the posts have not moved. The temperature of each tape should be noted, but provided the standard is of the same metal as the base-tapes, and provided their temperatures are sensibly the same, it is not necessary to apply any correction. For hanging the tapes it will probably be convenient to make use of the base end-supports A and B, although a piece of connecting cord will be required at each end to enable the end-supports to be set back from the posts. Whatever arrangement is employed, the standard tape must be hung under the tension for which its length is known, and the base-tapes under the tension specified in their Table A. The length of each 66-foot base-tape as determined in catenary must be increased by 0·004 feet to convert it to the length on the flat, which is required in the computation form. When a 100-foot tape is used for the standard, it should be suspended at its two ends, in such a way that the 0 and 66-foot marks lie on the two posts.

If two theodolites are available, the driving of the posts may be avoided as follows :— The two theodolites are set up with their axes a tape length apart. The base end-supports are set up on a line roughly parallel to the theodolite base and about 20 feet away, so that when a tape is hung on the supports its end-marks and the theodolite axes make a rectangle. The standard tape and the base-tapes are successively hung in place, and simultaneous readings of the theodolites are taken to the marks of each. The distance from each theodolite axis to the tape alignment is measured with an ordinary tape, and the differences in the lengths of the tapes are readily computed, but care must be taken with the signs of the corrections. To verify that the circles of the theodolites have not moved, the standard tape should again be hung in position at the end, or a distant mark may be intersected with each theodolite before and after the comparison.

If good flat ground is available (e.g. a rail, flat *pat* or 1st class metalled road) the comparisons can most conveniently be done on the flat. Two pegs should be driven into the ground 66 feet apart with their tops almost flush with the surface (unless the surface is such that fine marks can be made on it direct), and the standard and base-tapes should be successively stretched between them under their standard tensions as before.

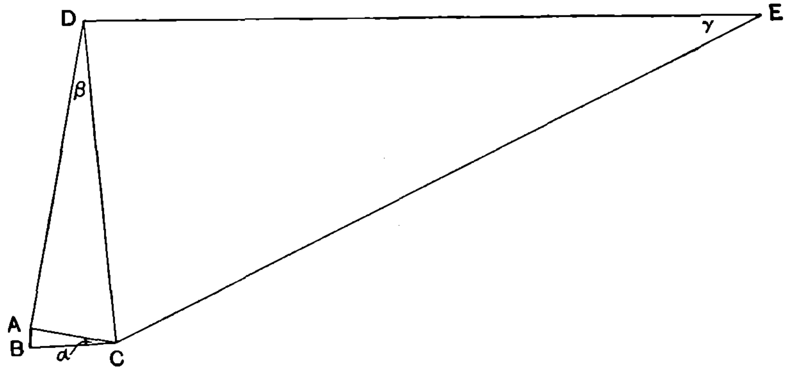
Comparisons should, if possible, be carried out on a cloudy day, or in the early morning or late evening, to avoid temperature errors. This is especially necessary if the tapes are laid on an iron rail or similar surface.

No. 1, dated 6-7-34.

measures made; this gives the final value of the subtended angle, which should be checked against the first measure found by (*c*), lest the number of repetitions has been wrongly counted, or a gross error made in reading.

This method of repetition does not apply to the Wild type theodolites which have no lower plate clamps. With such instruments each angle must be observed separately and the telescope swung round on to the left hand target for the next zero. The zeros should be spaced uniformly round the circle roughly at 0°, a°, $2a$°, $3a$°, etc. until 180° of the limb is traversed. The mean of all these angles is the final subtended angle.

In all cases the theodolite telescope should be swung in one direction only until the whole operation of repetition is completed.



20. Further extension.—Under certain circumstances, the base can be further extended by three triangles as in the above figure. The small angles α, β & γ are observed according to the method of repetition (para 19) the normal number of observations being made of the angles EDC, DAC and CAB. If this is done the angles α, β & γ need not be so small, and the precision will be greater. Other variations of the lay-out and extensions are readily imagined.

21. Computation of the base. Table A.—This table supplied with each base, gives its exact length, as measured on the flat, with the proper tension (see para 3). The junction and end links should be re-measured occasionally (see para 15), and the correct values, as remeasured, substituted for those enclosed by a square in Table A. When the full base is not laid out, take the appropriate values of the part used.

22. Table B.—This table contains the catenary correction for the full length or part of the base with or without intermediate supports. This correction is always negative.

23. Table C.—This table contains corrections to the whole or part base length for variation of temperature, the tape being standardised at 90° F. (see Table A).

24. Table D.—This table contains the correction factor for slope from which slope corrections can be taken out.

25. Table E.—This table contains the reduction factor of the base for height above mean sea-level.

26. Reduced length of base.—Thus the reduced length L of the base is:— {l, its length on the flat (from Table A) — catenary correction C_c (from Table B) $\pm$ temperature correction, C_t (from Table C)} $\times$ slope factor S (from Table D) $\times$ factor H for correction to mean sea-level (from Table E), i.e.

$$L = (l - C_c \pm C_t) \times S) \times H.$$

Form 15 Lamb. on which this computation can be done is appended at the end of this booklet. The log scale factor on this form is only required if the base is being used for computations directly in terms of the Lambert Grid.

TABLE A.

The following is an example:—

Lengths of sections of tape between marks under the proper tension on the flat, and of intermediate junction links, at 90° F.

TAPE No. 1

Section & colour at ends	Section length	Junction links *	End links *
	ft.	*ft.*	*ft.*
Target A	...	...	0·287
AP Red	65·752		
PQ White ...	65·667	0·317	
QR Blue	65·655	0·326	
RB Green ...	65·798	0·321	
Target B... ...	...	...	0·291
TOTAL ...	262·872	+ 0·964	+0·578

The weight for base Tape No. 1 is 2 lb. 0 oz. The resulting tension is 12 lb.

* These should be re-measured occasionally, and the correct values should be substituted for those enclosed by the square.

Note.—The tension given on the flat is equal to that given by the weight supplied with each base, when hanging at the end of the bell crank, (see para 3).

TABLE B.

Catenary correction (always negative).

Total length	Supported at every chain	Supported at every two chains	No intermediate support
chains	*ft.*	*ft.*	*ft.*
1	−0·004	...	...
2	·008	−0·031	...
3	·012	...	−0·104
4	·016	·062	·248

Example.—Base of 4 chains is used with only one intermediate support at 3 chains; catenary correction $= -0{\cdot}104 - 0{\cdot}004 = -0{\cdot}108$ feet.

Note.—The catenary correction, expressed as a fraction of total length $= -\frac{1}{6}\left(\frac{X_0}{2C}\right)^2$, where X_0 = length of tape between supports, and C = that length of tape whose weight is equal to the tension applied. Thus if 1760 feet of tape weighs 12 lb. (the tension), the total catenary correction to a four-chain base without any intermediate support $= -\frac{1}{6}\left(\frac{264}{2 \times 1760}\right)^2 \times 264$ feet.

$= -\ 0{\cdot}248$ feet.

TABLE C.

Correction for temperature.

Temperature	1-chain tape	2-chain tape	3-chain tape	4-chain tape
°*F*	*ft.*	*ft.*	*ft.*	*ft.*
30	– 0·026	– 0·052	– 0·077	– 0·103
40	·022	·043	·064	·086
50	·017	·034	·052	·069
60	·013	·026	·039	·052
70	·009	·017	·026	·034
80	– ·004	– ·009	– ·013	– ·017
90	nil	nil	nil	nil
100	+ ·004	+ ·009	+ ·013	+ ·017
110	·009	·017	·026	·034
120	·013	·026	·039	·052
130	+ ·017	+ ·034	+ ·052	+ ·069

Note.—The formula for the temperature correction for the 4-chain base length is + 0·001,716 (t – 90) where t is the temperature F the tape being standardised at 90° F, and the coefficient of expansion of steel being taken as 0·000,006.5 per degree F.

TABLE D.

Value of S, the correction for slope.

The following are the possible cases :—

When the full base is used {
1. with all intermediate supports.
2. with some intermediate supports.
3. without any intermediate support.

When part base is used {
4. with all intermediate supports.
5. with some intermediate supports.
6. without any intermediate support.

These six cases are dealt with separately below. But it is recommended that with both the whole and part base, either all or no intermediate supports should, if possible, be used, in order to simplify computation of the slope correction.

Case 1—General case when the full length (4-chain) base is used, with all intermediate supports.

If slope of AP = a_1
AQ = a_2
AR = a_3
AB = a_4
} obtained by theodolite readings from A to a target at correct height above the tape (see para 13)

and slope of each section
AP = β_1
PQ = β_2
QR = β_3
RB = β_4

then
$$\left.\begin{aligned}\beta_1 &= a_1\\ \beta_2 &= 2a_2 - a_1\\ \beta_3 &= 3a_3 - 2a_2\\ \beta_4 &= 4a_4 - 3a_3\end{aligned}\right\}\text{ for slopes not greater than } 6^\circ \text{ or 1 in 10.}$$

For larger slopes up to 20°, β_3 and β_4 must be determined more rigorously from the following equations:—

$$\begin{aligned}\sin(\beta_3 - a_3) &= \sin(a_3 - \beta_1) + \sin(a_3 - \beta_2)\\ &= 2\sin(a_3 - a_2)\cos(a_2 - a_1).\end{aligned}$$

$$\sin(\beta_4 - a_4) = \sin(a_4 - \beta_1) + \sin(a_4 - \beta_2) + \sin(a_4 - \beta_3).$$

For slopes more than 20°, see para 18.

Having obtained the values β_1, β_2, β_3 and β_4 the correction factor S is $\frac{1}{4}(\cos\beta_1 + \cos\beta_2 + \cos\beta_3 + \cos\beta_4)$.

Expressed logarithmically, it may be taken as

$$\log S = \tfrac{1}{4}(\log\cos\beta_1 + \log\cos\beta_2 + \log\cos\beta_3 + \log\cos\beta_4).$$

5-figure logarithms will be sufficient.

Case 2.—Enter the slope angle in two or more appropriate places and use the following angles in the computations as though actually observed.

Thus:—

(*i*) When only support P is omitted, $a_1 = a_2$.

(*ii*) When supports P & Q are omitted, $a_1 = a_2 = a_3$.

(*iii*) When only support Q is omitted, $a_2 = \dfrac{3a_3 + a_1}{4}$.

(*iv*) When only support R is omitted, $a_3 = \dfrac{2a_4 + a_2}{3}$.

(*v*) When supports Q & R are omitted, $a_2 = \dfrac{2a_4 + a_1}{3}$; $a_3 = \dfrac{8a_4 + a_1}{9}$.

(*vi*) When supports P & R are omitted, $a_1 = a_2$; $a_3 = \dfrac{2a_4 + a_2}{3}$.

Case 3.—When all intermediate supports are omitted, the slope factor for base of any length (1, 2, 3 or 4 chains) is cosine of the observed slope angle.

Case 4.—Same as Case 1, some angles being omitted. Thus with 3-chain base, fill up slopes for AP, AQ and AR (taking place of AB which is left blank)

For 3-chain base, log slope factor

$$= \tfrac{1}{3}(\log\cos\beta_1 + \log\cos\beta_2 + \log\cos\beta_3).$$

For 2-chain base, this factor

$$= \tfrac{1}{2}(\log\cos\beta_1 + \log\cos\beta_2).$$

Case 5.—Same as Case 2, some appropriate angles being omitted.

Case 6.—Same as Case 3.

The essential point is that each section requires to be multiplied by cosine of the slope of the line joining its two ends. The log slope factor of the whole base is the mean of log cosines of the slope of each section, any section of more than one chain being duly weighted when taking the mean.

TABLE E.

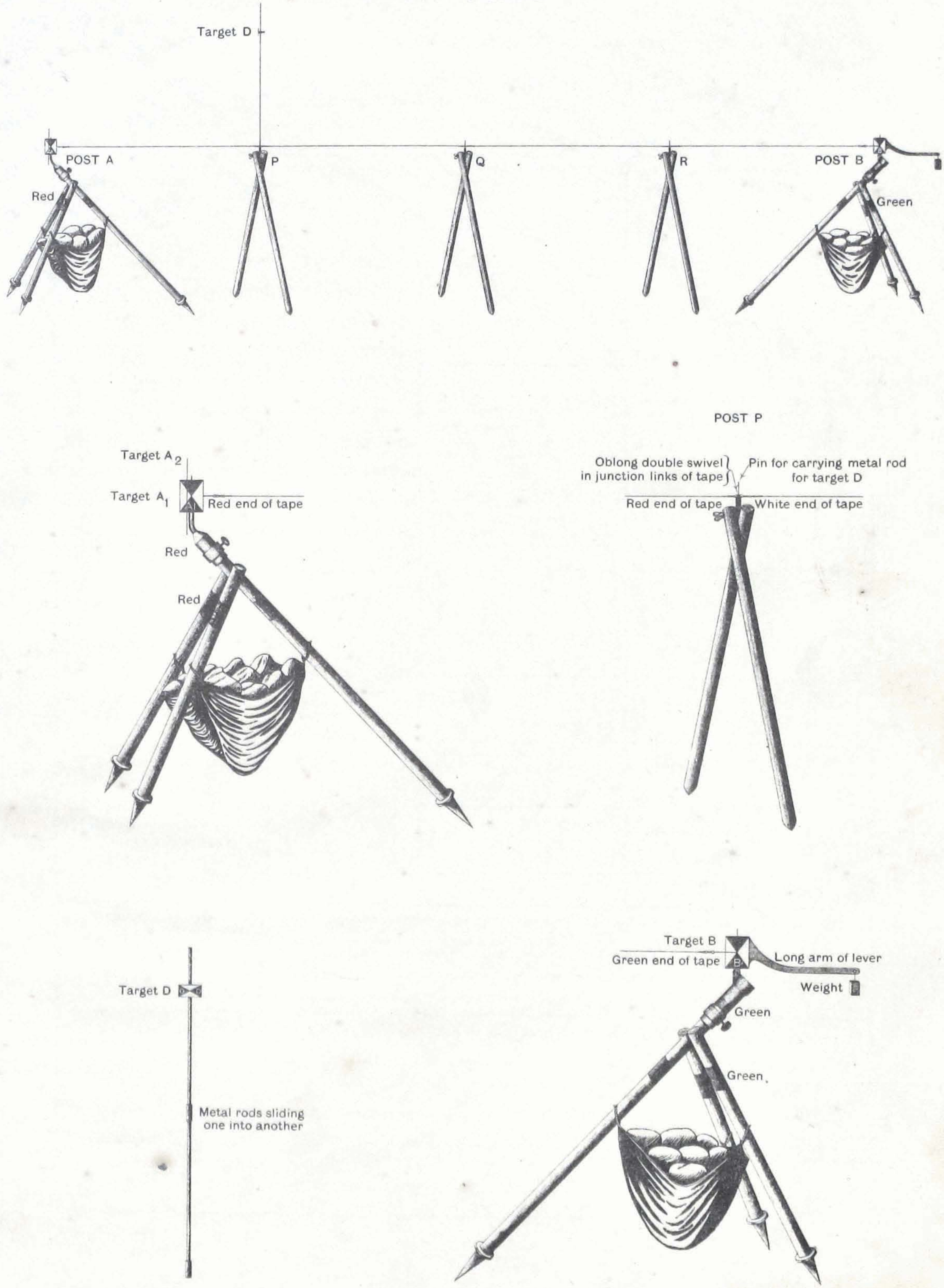
Correction for height above mean sea-level.

Height	Log correction	Proportional Parts	
ft.		*ft.*	*Difference*
0	0·000,000		
1,000	$\bar{1}$·999,979		
2,000	958	100	2
3,000	937	200	4
4,000	917	300	6
5,000	896	400	8
6,000	875	500	10
7,000	854	600	13
8,000	834	700	15
9,000	813	800	17
10,000	792	900	19

Note.—The reduction factor is $1 - \frac{h}{R}$, where h = height of ground in feet, and R = mean radius of the earth = 20,900,000 ft.

DIAGRAM OF HUNTER SHORT BASE AS ERECTED

NOT TO SCALE



Grid No. I { λ_0 32° 30′ ; L_0 68° 00′ }

2. SECTION X COMPANY. DATE August 1929 TIME 11 A.M.

Reduction of Hunter Short Base

Height[3] 3,500 ft.

Base No. 03 Tape No. 03 Temperature[1] 76 °F Latitude[2] 33° 17′

Correction for Temperature				Correction for Height above M. S. L.[5]			
Temp.	For 1-Chain Tape	For 2-Chain Tape	For 4-Chain Tape	Height	log Correction	Difference	
°F	feet	feet	feet	feet			
30	−0·0258	−0·0515	−0·1030	0	0·000000		
40	−0·0215	−0·0429	−0·0858	1,000	$\bar{1}$·999979		
50	−0·0172	−0·0343	−0·0686	2,000	$\bar{1}$·999958	100	2
60	−0·0129	−0·0258	−0·0515	3,000	$\bar{1}$·999937	200	4
70	−0·0086	−0·0172	−0·0343	4,000	$\bar{1}$·999917	300	6
80	−0·0043	−0·0086	−0·0172	5,000	$\bar{1}$·999896	400	8
90	Nil	Nil	Nil	6,000	$\bar{1}$·999875	500	10
100	+0·0043	+0·0086	+0·0172	7,000	$\bar{1}$·999854	600	13
110	+0·0086	+0·0172	+0·0343	8,000	$\bar{1}$·999834	700	15
120	+0·0129	+0·0258	+0·0515	9,000	$\bar{1}$·999813	800	17
130	+0·0172	+0·0343	+0·0686	10,000	$\bar{1}$·999792	900	19

Correction for Slope	°	′	″
α_4[4]	3	07	20
α_3[4]	2	50	10
α_2[4]	3	15	40
α_1[4]	4	32	50
$4\alpha_4$	12	29	20
$3\alpha_3$	8	30	30
$2\alpha_2$	6	31	20
α_1	4	32	50
$4\alpha_4 - 3\alpha_3 = \beta_4$[5]	3	58	50
$3\alpha_3 - 2\alpha_2 = \beta_3$[5]	1	59	10
$2\alpha_2 - \alpha_1 = \beta_2$[5]	1	58	30
$\alpha_1 = \beta_1$[5]	4	32	50
log cos β_4	$\bar{1}$	998	95
log cos β_3	$\bar{1}$	999	74
log cos β_2	$\bar{1}$	999	74
log cos β_1	$\bar{1}$	998	63
Sum	$\bar{1}$	997	06
Mean	$\bar{1}$	999	27

Measured Lengths			
Junction[6]	0·271		
Tape A	65·741		
Junction[6]	0·266		
Tape B	65·738		
Junction[6]	0·262		
Tape C	65·746		
Junction[6]	0·266		
Tape D	65·826		
Junction[6]	0·280		
Total length	264·396		
Temp. Corrn. (with corrt sign)	− 0·024		
Catenary Corrn.	− 0·016		
Sum = Length in ft.	264·356		
Length in yds.	88·119		
log length (yds.)	1	945	07
log slope corrn.	$\bar{1}$	999	27
Corrn. for height	$\bar{1}$	999	93
log scale factor	$\bar{1}$	999	51
Sum = log Base in grid yards	1	943	78

Catenary Correction

(I) Supported at every chain

Total length	Correction
1 Chain	−0·0039 ft.
2 Chains	−0·0078 ,,
3 Chains	−0·0117 ,,
4 Chains	−0·0155 ,,

(II) Supported at every 2 chains

Total length	Correction
2 Chains	−0·0310 ft.
4 Chains	−0·0619 ,,

(III) No intermediate support

Total length	Correction
3 Chains	−0·1043 ft,
4 Chains	−0·2475 ,,

In any emergency the value of the log Base in grid yds. may be taken

Base No. 03 1·94450 (38—)

Base No.

Observed Temperature

Hour	Temp. °
10-30	75·3
10-40	76·1
11-05	76·7

(1) The temperature should be observed at intervals during the measurement and the mean of all readings used for computation.
(2) The latitude must be estimated from the data available.
(3) The height above mean sea-level must be estimated from the data available.
(4) Provided α_1 α_2 α_3 and α_4 are not greater than 4′ (minutes), the slope correction can be ignored.
(5) If β_1 β_2 β_3 and β_4 are greater than 6° or 1/10, the slope correction must be calculated by more precise formulæ, see page 8 of Booklet of Instructions for measurement of Hunter Short Base. If one or more supports have been omitted see page 7 et seq. of this booklet.
(6) These junction lengths should be measured if there is sufficient time.

Description of the Base

The base is on sloping ground outside the north perimeter of SARWEKAI Camp and lies east and west. The east end is marked by a circle and dot cut on a buried stone and a cairn of stones. The other end is unmarked.

Computed by HCB *Date* 5.9.29. *Checked by* R.B. Mathur