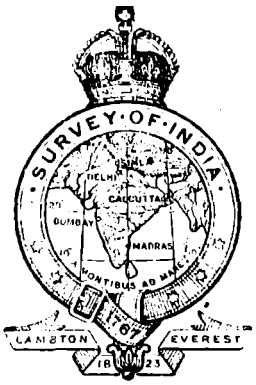
SURVEY OF INDIA



WAR RESEARCH SERIES

PAMPHLET No. 9

THE TRANS-PERSIA TRIANGULATION 1941-44

(linking IRAQ & INDIA)

by

J. de GRAAFF-HUNTER, C.I.E., Sc.D., F.R.S.

and

B. L. GULATEE, M.A. (Cantab.)

With an Appendix

THE PERSIA-INDIA CONNECTION

By MAJOR P. A. THOMAS, I.E.

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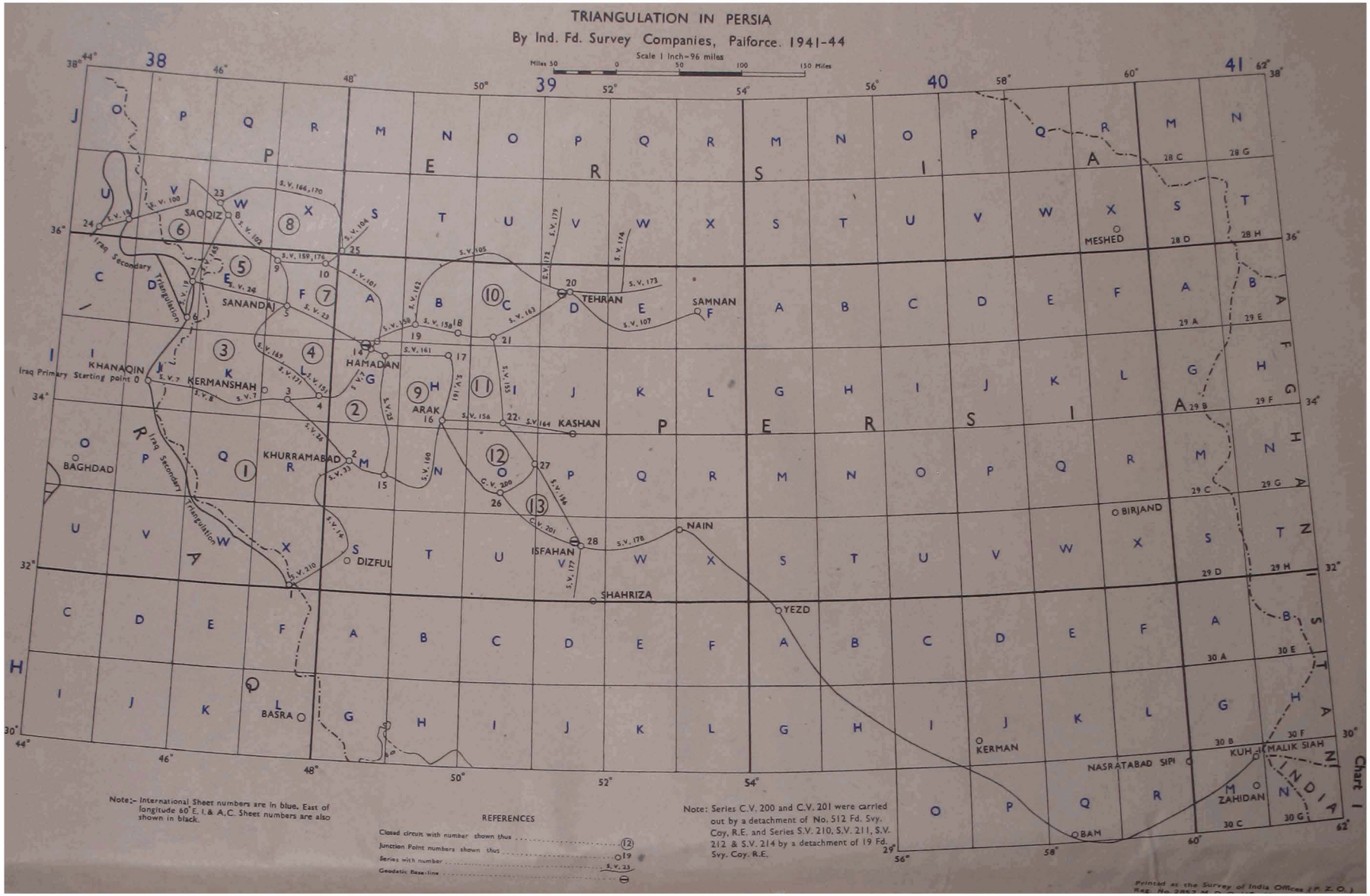
TRIANGULATION IN PERSIA
By Ind. Fd. Survey Companies, Paiforce. 1941-44
Scale 1 Inch=96 miles
Miles 50 0 50 100 150 Miles
38
39
40
41
SAQQIZ
SANANDAJ
KHANAQIN
Iraq Primary Starting point O
KERMANSHAH
HAMADAN
ARAK
KHURRAMABAD
BAGHDAD
DIZFUL
BASRA
TEHRAN
SAMNAN
KASHAN
ISFAHAN
NAIN
SHAHRIZA
YEZD
MESHED
BIRJAND
KERMAN
NASRATABAD SIPI
KUH-I-MALIK SIAH
ZAHIDAN
BAM
Iraq Secondary Triangulation
Chart I
INDIA
PERSIA
Note:- International Sheet numbers are in blue. East of longitude 60° E. I. & A.C. Sheet numbers are also shown in black.
REFERENCES
Closed circuit with number shown thus ..... (12)
Junction Point numbers shown thus 19
Series with number ..... S.V. 23
Geodetic Base-line ..... ⊖
Note: Series C.V. 200 and C.V. 201 were carried out by a detachment of No. 512 Fd. Svy. Coy, R.E. and Series S.V. 210, S.V. 211, S.V. 212 & S.V. 214 by a detachment of 19 Fd. Svy. Coy. R.E.
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TRANS-PERSIA TRIANGULATION 1941–44

(linking IRAQ and INDIA)

The only triangulation in Western Persia existing prior to 1941 was that which had been effected by units of the Survey Party of the Mesopotamia Expeditionary Force of World War No. 1. This was of a piecemeal character : but to some extent it was connected with the Iraq triangulation of the same period which was continuous from Fao, on the astronomically determined position of which the whole system depended. It had no connection whatever with the Indian system of triangulation. It was connected by very rapid triangulation with Aleppo and Palestinian war-time triangulations. Subsequent to 1930 triangulation of a secondary geodetic precision—Iraq Primary as well as of a topographical nature (Iraq secondary and tertiary) had been executed by the Iraq Survey Directorate, which completely superseded the previous war-time work so far as it extended. This Iraq triangulation was based on astronomical values of position and azimuth at Nahrwan near Baghdad. It linked with Iraq-Syrian Boundary Commission triangulation but was otherwise unconnected with any external triangulation.

No attempt to put the old war-time Persian triangulation into the new Iraq terms had been made before 1940. On the outbreak of World War II, however, this had to be done as this was the only triangulation in the area. The corrections were derived from a comparison of common points, including Fao, which had since been connected by Iraq secondary triangulation.

2. In 1941, when Iraq was threatened by the Axis powers, British and Indian Forces (10th Army, later Paiforce) moved into Iraq and Persia and a Survey Directorate was formed at Baghdad. It comprised four Indian Field Survey Companies under a D.D. Survey who received his instructions from the D Survey, India. At first attention was given to revising the existing maps as far as possible along communications : but later it was deemed advisable to carry out a considerable amount of triangulation in N.-W. Persia for control of new mapping. Between 1941–43 some 70,000 square miles of country was covered by triangulation as shown diagrammatically in Chart I. This work was based on the Primary triangulation of Iraq and is connected to Iraq secondary triangulation at 3 places.

In general the triangulation followed motorable communication routes, the stations of observation lying on either side of the route within reasonable walking distance. The figures were mostly elongated quadrilaterals (average length being double that of the breadth)—a type well suited for rapid progress and good maintenance of bearing, while less favourable for maintenance of scale. To safeguard the scale frequent H.S.B's. (Hunter Short Bases) were incorporated. Glass-arc theodolites were used and average triangular errors of the various series ranging from 2″ to 12″ were obtained. The bases were such as to preclude scale error ordinarily exceeding 1/15,000. Such work was done with great rapidity, thanks to precision and speed of reading of the glass-arc theodolites and well organized motor transport. The precision attained, while falling far short of what could be called geodetic, is considerable and of course far above that of the work of the first World War.

Subsequent to the execution of this triangulation network, observations of azimuth combined with longitude (Laplace stations) were made at Hamadan, Isfahan and Teheran. Bases were also measured, at these three places of length about 3½ miles and these showed internal accuracy of 1/200,000. Such accuracy was rapidly lost in the triangulation and the scale depends in the main on the values derived from the frequent short bases.

At its SE. corner, this new network of triangulation reaches longitude 53° latitude 33° in the neighbourhood of Nain some 90 miles East of Isfahan. It bridges half the gap between the Iraq Primary Triangulation and the great Indian system of triangulation, with most westerly terminal at Zahidan, longitude 61° latitude 30°. The desirability of carrying triangulation right through to India for various survey reasons was apparent and even has some geodetic interest, the relatively low precision of the hurried war time triangulation notwithstanding. An opportunity of implementing this occurred when Capt. P. A. Thomas took a detachment overland from Isfahan to India, January to April 1944. A narrative of this work is given in the Appendix at the end. Overcoming very many difficulties, he succeeded in completing this link mainly by good quality triangulation, one unavoidable gap, viz., the quadrilateral 23-24-27-30 in which angles at 27 and 30 could not be observed being made good by a series of H.S.B. traverses and small triangles. The triangle 21-24-23 was also incompletely observed but this does not constitute a break in continuity, as the co-ordinates can be carried forward in terms of the point junction station No. 24.

The outstanding feature is that an adequate and unbroken connection between Mid East and India of creditably high precision has been effected by Captain Thomas in a wonderfully short time and in face of great climatic difficulties which might well have proved insuperable. He is to be very highly commended for his energy and resource in accomplishing this most important junction. At the time of writing (September 1945) the link is complete : but strengthening of a weak portion of Paiforce triangulation between the measured base at Isfahan and the start of Captain Thomas' work would much improve the overall accuracy of the trans-Persian link.

NAIN-ZAHIDAN TRIANGULATION (Chart II)

3. Capt. Thomas was assisted by Subedar M. Z. A. Quraishi as second observer and by Computer Hav. D. C. Kuthari and most of the observations were made with a Tavistock theodolite : Zeiss and Wild theodolites being used occasionally. The triangulation started from the side Nain-Parvis of series S.V. 178 of Paiforce, a single series of elongated quadrilaterals, all told 90 miles long starting from Isfahan. Unfortunately this series has a doubtful ray in the middle and it is not possible to obtain the value of the side Nain-Parvis in terms of the Isfahan base, but even if it were possible to do so the accuracy of the Isfahan base would be rapidly dissipated owing to the poor layout of this series, and the length of this side would not be precise

enough for basing the ensuing work. (It is hoped that this Isfahan-Nain portion will be replaced by triangulation of quality comparable to that done by Capt. Thomas). Capt. Thomas carried a well observed and well conditioned series of triangles (average triangular error $1\frac{1}{2}''$) from the opening side for some 470 miles to Jamali (latitude 29° longitude 59°) and about half way along at Bahramabad (latitude 30° and longitude 56°) he observed for latitude, longitude and azimuth and connected a H.S.B. This base is believed to be accurate to 1/25,000 and has been used to fix the scale of the whole of the section from Jamali to Nain, as well as that of Nain westwards to the doubtful ray between Nain and Isfahan referred to above.

In the neighbourhood of Jamali, circumstances of weather and visibility conspired to render impossible the observation of the angles opposite to side 23–24 at stations 21, 27, 30 (vide Chart II). Lack of measured values of these angles, though not making the figures indeterminate, renders them very weakly determined. Capt. Thomas very properly introduced at this stage an alternative link by means of Extended Short Base Traverse from 24 up to some small triangles connecting up three stations 27, 29, 30. From these latter 3 stations, two well conditioned figures (average triangular error 3″) lead to the terminal side of the (Indian) Kalāt Longitudinal Series.

Inspection of the Chart II would show that azimuth from the Indian side is well carried as far as stations 27, 30 : thence to 25 and through the several angles of the traverse to 24, whence the forward azimuth of 18 is determinate. To control this rather weak azimuth an attempt was made to establish a Laplace station at Jamali. This was unfortunately unsuccessful due to break down of the Chronometer.

The accumulated error of geodetic azimuth as disclosed by Laplace observations at Bahramabad is +11″ which has been distributed between Kūh-i-Malik Sīāh and Bahramabad.

The scale of the triangulation from Kūh-i-Malik Sīāh H.S. to No. 25 is in terms of the Indian side Kūh-i-Malik Sīāh H.S.–Kācha Kūh H.S. converted to International spheroid terms. From 25 to 24, the scale is in terms of the H.S.B's and from 24 to Nain in terms of the measured base at Bahramabad. The incomplete triangle 21-23-24 precludes the utilization of the H.S.B. at Jamali for carrying forward scale to Bahramabad.

4. Computation of co-ordinates has been carried out working from the Indian end in terms of the Indian origin of Kalianpur. The published values of the co-ordinates of the Indian terminals (Kūh-i-Malik Sīāh and Kācha Kūh H.S.) are in terms of Everest spheriod, the deflections at the origin being defined as 0″·31 south and 2″·89 west. These have been converted from terms of Everest spheroid to those of the International spheroid and computation thence has been carried westward in terms of the International spheroid. For this conversion the following differences (International *minus* Everest) have been used :—

δa, difference in semi-major axes	$= +3{,}647$ British feet.
$\delta \epsilon$, difference in ellipticity or flattening	$= +0 \cdot 4255 \times 10^{-4}$
$\delta \eta_0$, difference in meridian deflections at the origin	$= +2'' \cdot 71$
$\delta \xi_0$, difference in P.V. deflections at the origin	$= +0'' \cdot 28$
N_0, difference in height at the origin	$= -31$ feet.

The above deflection* anomalies between the two spheroids result from the deflections at the origin on the International spheroid being accepted as 3″·02 south and 3″·17 west as derived in 1927. They make the closest agreement between the International spheroid and the Compensated Geoid† and are inevitably arbitrary to a certain extent. The additional information gathered later however is not sufficient to justify a revision of these values at present.

5. From Capt. Thomas's work, the derived values of co-ordinates at Nain in International terms, relative to Kalianpur, are as follows :—

λ 32° 54′ 30″·6
L 53 05 41 ·4

The co-ordinates of the same point relative to Nahrwan, the Iraq origin, in International terms are

λ 32° 54′ 23″·5
L 53 05 36 ·8

The discrepancies between these in sense India–Iraq are

$$\delta\lambda = +7'' \cdot 1$$
$$\delta L = +4 \cdot 6$$

which are to be attributed to

(i) deviations of the vertical at Nahrwan (Iraq origin) relative to the International spheroid located by Kalianpur origin of the Indian survey, with

$$\eta = 3 \cdot 02 \text{ S.}, \qquad \xi = 3 \cdot 17 \text{ W.}$$

(ii) errors generated in the triangulation between the two origins.

The probable errors (ii) have been roughly estimated from the characteristics of the intervening triangulation and are found to be

$$\delta\lambda_e = \pm 2'' \cdot 5, \qquad \delta L_e = \pm 3'' \cdot 0$$

These indicate that while the discrepancy in longitude may be entirely produced by errors of observation, the odds are 23 : 1 against the latitude discrepancy, being solely due to this cause. If we neglect (ii), these discrepancies imply plumb-line deflections at Nahrwan (Iraq Origin) of 7″·1 N. and 3″·8 E. It is interesting to note that these are in the direction of visible masses. If at Kalianpur the deflections on the International spheroid are assumed to be the same as on Everest spheroid (viz., 0″·31 S. and 2″·89 W.) the corresponding deflections at Nahrwan are 9″·8 N. and 4″·1 E., which shows that the deflections adopted on the International spheroid at Kalianpur are an improvement on those accepted on the Everest spheroid.

If the results of the Persian work are expressed in terms of Clarke 1880 spheroid in keeping with most of the Mid. East triangulation and are based on triangulation in Iraq origin terms, the co-ordinates of stations Nos. 27, 29 and 30 (close to the meridian of 60° E. which has been chosen as the dividing line between the area of mapping responsibility of Mid. East and India) differ from their values in terms of the published

* A positive value of deflection indicates that geodetic latitude/longitude is in defect.

† Level surface of the Earth, with the effect of visible land masses above sea-level and their compensation (calculated on Hayford system) removed.

Indian triangulation pamphlets by +12″·1 in latitude and −4″·4 in longitude (in the sense Indian *minus* Persian). *These discrepancies are inherent in the different systems and are not for dispersal.* The plane-tables and map sheets of the area containing these stations should have graticules on both the systems indicated by full lines or ticks as thought appropriate. Any triangulation across the junction line of 60° E., however, will have to be computed in whichever terms are more convenient.

6. Heights :—Due to limitations of time, vertical angles have not been observed at the time of minimum refraction and reciprocal observations have not been made at some of the stations. The average triangular error in height of the triangulation net west of Nain is 6 feet and of Nain–Zahidan portion 13 feet on account of the greater lengths of rays. The heights in Iraq terms are based on the height of station Khānaqīn of Iraq Primary Triangulation, (about 40 miles away from a spirit-levelled B.M.") and those in Indian terms are based on trigonometrical height of Kūh-i-Malik Sīāh which is about 400 miles from the nearest spirit-levelled connection. The discrepancy at Nain (in the sense India–Iraq) is 26 feet. In consideration of the great distance—1,100 miles—between basic heights in Iraq and India, this is not large.

The height computations have been carried out with due regard to the length of the rays and some doubtful observations at times considerably removed from the time of minimum refraction have been rejected. It is to be remembered that knowledge of the temperature at the time of observation as well as of the maximum temperature of the day at the station assist in the determination of refraction and such measures should when possible be made by the observer—not done in this case.

The heights given in the list at the end are in Indian terms.

APPRECIATION OF THE POSITION REACHED :

7. The Trans-Persian triangulation work naturally divides into two main portions

(i) the network in NW. Persia reaching as far as Isfahan and Nain in which accuracy of order 1/15,000 is attained :

(ii) a chain of triangulation from Nain to India of present overall accuracy of 1/20,000 ; the accuracy may be stepped up to say 1/50,000 by a small amount of additional work whereby scale, at present less well determined, is toned up :

and (iii)* a minor portion Isfahan–Nain which it is hoped will soon be replaced by work of an accuracy comparable to (ii).

Already the systems of India and Iraq are linked to an accuracy of 1/15,000 in the weakest section.

The Iraq system of Primary triangulation can be considered as of secondary geodetic precision. It has been linked with French Primary triangulation in Syria. Continuous triangulation accordingly exists from Syria to Siam.

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* Unfortunately information has now been received that there is no possibility of this work being done in the near future. Its importance, however, needs no stressing, and its abandonment is regretted especially as the amount of work involved is comparatively small.

List of co-ordinates and heights of stations of Nain-Zahidan Triangulation by Captain P. A. Thomas, 1944

No.	Station or Point		(International Spheroid) Latitude	(International Spheroid) Longitude	Clarke 1880 Spheroid Lat.	Clarke 1880 Spheroid Long.	Everest Lat.	Everest Long.	Height
			° ′ ″	° ′ ″	′ ″	′ ″	′ ″	′ ″	
34	Kāoha Kūh	H.S.	29 31 57·179	61 09 57·569	.. ..	.. ..	32 01·47	49·44	7682
33	Kūh-i-Malik Siāh	H.S.	29 51 27·549	60 52 28·069	.. ..	.. ..	31·95	19·71	5393
32	Buzai	h.s.	29 21 47·815	60 41 48·069	.. ..	.. ..	51·99	39·04	8437
31	Bazgargi	h.s.	29 44 40·342	60 25 51·347	.. ..	.. ..	44·66	42·70	6809
30	Pir Sohran	h.s.	29 07 49·397	60 04 42·151	41·38	37·64	53·43	33·31	8092
29	Saru	h.s.	29 25 29·007	60 00 53·954	21·08	49·44	33·22	45·05	
28	Pakuh	h.s.	29 39 10·357	59 46 00·269	08·44	45 55·67	.. ..		3111
27	Nasratabad	h.s.	29 40 10·960	59 58 21·756	03·07	17·45	15·22	12·80	7876
26	Karir	s.	29 24 42·008	59 31 00·308	33·99	30 55·85	.. ..		1575
25	Kahurak	h.s.	29 17 11·418	59 40 35·973	03·39	31·44	.. ..		2583
	Shurgaz	s.	29 13 10·117	59 25 45·378	02·04	40·87	.. ..		1503
	C	..	29 07 10·858	59 17 09·834	02·70	05·38			
	D	..	29 06 30·237	59 16 20·881	22·12	16·39			
	Milinadri	..	29 04 38·615	59 09 09·405	30·47	04·92	.. ..		1729
	C Jamali Milinadri	..	29 06 28·266	59 02 29·685	20·12	25·20			
	D Jamali Milinadri	..	29 04 51·237	59 02 11·931	43·02	07·49			
24	Jamali	s.	29 07 38·104	58 49 16·086	30·04	11·61	.. ..		3348
	D Jamali Base	..	28 59 39·429	58 39 40·917	31·13	36·51			
23	Rigan	s.	28 44 24·643	58 55 03·912	16·40	54 59·52	.. ..		2222
22	Kuh-i-Kafut	h.s.	29 21 32·578	58 11 25·409	24·46	20·94	.. ..		7924
21	Deh Bakri	h.s.	29 01 26·651	57 57 08·303	18·43	03·86	.. ..		10304
20	Kuh-i-Abariq	h.s.	29 28 56·206	57 52 57·188	48·11	52·73	.. ..		9652
19	Kuh-i-Hazar	h.s.	29 30 37·648	57 16 20·130	29·55	15·69	.. ..		14799
18	Kuh-i-Saguch	h.s.	30 04 08·698	57 28 00·314	00·75	27 55·86	.. ..		13886
17	Band-i-Mumzar	h.s.	29 58 04·279	55 56 00·023	57 56·29	55 55·61	.. ..		10603
16	Kuh-i-Gar	h.s.	30 03 16·236	56 32 33·345	08·27	28·92	.. ..		9043
14	Kuh-i-Girdin	h.s.	30 33 13·557	56 21 27·177	05·72	22·76	.. ..		10550
	E Bahramabad	s.	30 23 49·291	55 58 17·860	41·42	13·45			
15	Kushku	h.s.	30 26 25·367	55 29 33·779	17·51	29·39	.. ..		9481
13	Kuh-i-Aj-i-Pain	h.s.	30 50 04·019	54 50 46·851	49 56·27	42·49	.. ..		9516
12	Kuh-i-Nuk	h.s.	31 03 51·011	55 43 50·408	43·31	46·02	.. ..		9182
11	Kuh-i-Dushar	h.s.	31 15 48·247	54 29 53·059	40·62	48·72	.. ..		9147
10	Narkuh	h.s.	31 29 30·705	54 59 01·392	23·13	58 57·04	.. ..		8492
9	Kuh-i-Buruk	h.s.	31 41 02·506	54 21 01·652	40 54·98	20 57·33	.. ..		8878
8	Kulmard	h.s.	32 03 28·140	54 31 07·537	20·71	03·21	.. ..		8810
7	Sadrabad	s.	32 05 49·731	54 00 12·585	42·29	08·29	.. ..		3817
6	Kuh-i-Hariz	h.s.	32 25 01·584	54 07 54·077	24 54·25	49·77	.. ..		6353
5	Aghda	h.s.	32 18 40·961	53 36 28·825	33·60	24·54	.. ..		7837
4	Chah Nau	h.s.	32 39 32·913	53 39 08·001	25·64	03·73	.. ..		3598
3	Kuh-i-Parviz	h.s.	32 40 23·034	53 05 14·780	15·77	10·52	.. ..		8434
2	Qaleh Nau	s.	32 52 59·825	53 20 45·538	52·61	41·28	.. ..		4142
1	Nain	h.s.	32 54 30·597	53 05 41·366	23·39	37·11	.. ..		5603

Length of H. S. Base at Bahramabad = 265·932 British feet

Results of Astronomical observations at Bahramabad

	(1) Astronomical value	p.e.	(2) Geodetic value	(3) Diff. (1)—(2)
	° ′ ″		° ′ ″	″
Latitude ..	30 24 07·7	±0·8	30 23 49·8	+17·9
Longitude ..	55 58 25·5	±1·5	55 58 18·0	+ 7·5
Azimuth from Polaris ..	108 23 07·2	±1·4	108 23 14·4	- 7·2

Accumulated error of triangulated azimuth at Bahramabad

$$= -\delta G = -(A_A - A_G) + (L_A - L_G)\sin\lambda$$
$$= +7''\cdot2 + (+7\cdot5 \times \cdot5060)$$
$$= +7''\cdot2 + 3''\cdot8 = +11''\cdot0$$

APPENDIX

THE PERSIA–INDIA TRIG. CONNECTION, 1944

BY MAJOR P. A. THOMAS, I.E.

1. The series connects the system of triangulation done in Iraq and Persia during 1941–43 with the Great Trigonometrical series of India. It emanates at Nain, in Central Persia, from the series S.V.-178 of the triangulation done in Oct.–Nov. 1942 by the Survey Service, Paiforce. From Nain it runs SE. for a distance of 700 miles with 34 stations and connects with the Kalāt Longitudinal Series of 1908 at the western boundary of Baluchistān.

The value and objects of the connection were :—

(1) To assess the value of the rapid wartime triangulation of 1941–43 in Paiforce in terms of the practically errorless G.T. series of India.

(2) The strengthening of the Paiforce triangulation.

(3) The provision of a basis for further extensions of triangulation and control for surveys which may follow in hitherto unsurveyed Eastern Persia.

(4) A contribution to geodesy by completing the only missing link in the systems of triangulation extending from Europe to the Far East.

2. The scheme was first envisaged by Dr. J. de Graaff Hunter, Mathematical Adviser to the Survey of India (now Director, War Research, Survey of India) during and after the surveys of the war of 1914–18. It was further referred to in the Handbook of Geodetic Triangulation of the Survey of India, 1929. An actual attempt from the Indian end was made by No. 3 Indian Field Survey company in the winter of 1942–43 but defeated by transport troubles and delays, climatic conditions and the demands of other priority work.

3. During September 1943 a report on No. 3 Company's work and reconnaissance was sent by the Director Surveys, India to the Asst. Director, Surveys, Paiforce with the enquiry as to what could be done from the Persian end. There existed in Paiforce at the time 3 Survey Sections and a Directorate with a Palestinian Map Depôt, a strength considered sufficient for the survey demands of a rapidly diminishing Command. The sections were one General Section, one Ground Survey Section and one reduced Reproduction Section. The report of No. 3 Company was passed on to me as O.C. Ground Survey Section for study and report. I was keen to undertake an important job of this nature and submitted a favourable report, but if the most suitable time of the year, autumn, was to be obtained it was necessary to get moving with preliminaries.

4. The scheme was put up to the Director, Surveys, Middle East who in turn sought the approval of the War Office. Nothing further was heard until War Office approval was signalled by Middle East on 28th. November. Things now began to move and at the instance of A.D. Surveys, Paiforce (Lt.-Col. L. F. de Vic Carey, R.E.) a conference was called for the 2nd. December and was attended by representatives of 17 branches of the Army.

5. I had been asked to prepare a list of additional personnel and equipment that would be required for the job, as the resources of a Ground Survey Section, separated from its parent Company, would not be sufficient. In spite of the realization that the job would be considerably bigger than the normal triangulation that had been done with 3 or 4 vehicles, a few primus stoves and a month's dry rations, the demands for additional personnel and equipment were modest in the extreme. However, it became apparent in the early stages of the conference that the job had acquired a standard of importance equivalent to a hazardous expedition into the unknown with the consequence that no demands were considered unreasonable and were stepped up accordingly. The conference was left with the feeling that if the job was a failure it would not be due to lack of provision of personnel and equipment.

6. The next few weeks were spent in final preparations and the collecting of stores and equipment. All branches were most helpful and gave priorities which avoided all difficulty and delay. It had been realised that the provision of vehicles would constitute the biggest difficulty, as the resources of the Command were very limited in this respect, but this was fortunately solved by an agreement between Paiforce and India by which issue would be made from amongst vehicles due for return to India and awaiting shipment at Basra.

7. Preparations were finally concluded by 28th December and the convoy of 18 vehicles and 75 all ranks, as listed below left Baghdad on the morning of 29th December.

List of personnel

Capt. P .A. Thomas, I.E.	
Capt. F. J. Satur, I.A.M.C.	
Subedar M. Z. A. Quraishi.	
Jemadar Svyr. Mauji Ram.	
,, ,, A. S. Rana.	
,, ,, H. U. Khan.	
,, ,, Autar Singh.	
,, Clerk M. G. Rasul.	
Havildar Computer D. C. Kuthari.	
I.O.Rs. Survey	30
Drivers M.T.	21
Signallers	8
Fitters	3
Electrician	1
Carpenter	1
Nursing orderly	1
Interpreter	1

List of vehicles

Trucks 15-cwt.	1
Dodge	1
Chev.	1
Fordson	1
Ford C.A.T.	1
Bedford	1
Lorries 3-ton Chev.	10
Lorry 15-cwt. water	1
Lorry 2½-ton F.W.D. with winch ..	1
Total ..	18

8. Movement control was much in evidence and after being shepherded to the outskirts of Baghdad, the convoy was again received 10 miles outside Khanaqin by 2 red cap dispatch riders and piloted in, but this unexpected and flattering attention was rather wasted by being led to the wrong staging camp where all knowledge of our identity was disclaimed, necessitating a move on about 4 miles further up the road to some road construction coolie lines. After this effort no more was seen of any movement control until arrival in Quetta four months later, and, apart from making the few necessary official contacts during the journey and the inquisitive attention of Persian urchins, the convoy passed through unheralded and unsung. In three more stages Sultanabad (Arak) was reached on New Year's Day and a stay of one day was made to collect items of winter increases of rations, and to carry out minor repairs to vehicles as this was the last place where military repair facilities would be available. The journey of 400 miles already done had provided an excellent opportunity of discovering early the weaknesses in certain vehicles. Final minor purchases from the last N.A.A.F.I. and bazar were also made. Two more stages brought us to Isfahan, and camp was pitched about 15 miles north of the town, on the site of the south end of the base which had been measured in 1943 and where the Longitude observations had not proved too well, necessitating reobservation. Weather conditions had not been too good since the commencement of the trip, with intense cold, wind and clouds, and it was not till the fifth night that observations were satisfactorily concluded. It had originally been considered desirable to start the series from this base and reobserve the topo triangulation done as far as Nain, but time was short, and this consideration coupled with the possible unnecessary duplication of work were the deciding factors against it. Subsequent events proved that the first consideration, the time factor, was well considered, but that the second consideration was unfortunate.

9. On 8th January Nain was reached in the evening and, as it was from here that the series would commence and a reconnaissance made, camp was pitched in a more permanent manner. A local recce was made next day and visibility was found to be incredibly good, so good in fact, that a distance estimated by 4 experienced surveyors to be 14 miles, turned out to be 36 miles actually. This discovery necessitated a revision of ideas and of the preliminary layout consisting of triangles of 30-mile sides, that had been done on an office table in Baghdad, as these could now be stepped up to 50 to 60 mile sides. The route for the series divided itself naturally into three distinct portions. Firstly, the 40 mile broad valley 500 miles long flanked by snow covered mountain ranges rising from 7,000 feet at Nain to 15,000 feet at Kerman, with the short sharp descent to desert level of 2,000 feet at Bam ; secondly, the 100-mile stretch of flat Lut desert and, thirdly, the 100 miles of massed mountains, averaging 8,000 feet to the west of Zahidan. A recce of the first 250 miles was started on 9th January. Stations were not actually visited and climbed as too much of the short and valuable time would have been spent. By selecting stations on the highest mountains both intervisibility and the requisite long rays were expected. Selection of stations and a recce of the approach routes to them was made from the main road which lay in the broad valley. The recce party included the 4 surveyors whom it was intended to place in charge of the 4 helio parties, two forward and two in rear, and it was trusted that these surveyors, particularly those in advance, would find the best way to the summits of the station sites pointed out to them.

10. On arrival back at Nain, the results of the recce were worked into a very elaborate time table and plan of movements for each observer and helio party. The plan consisted of 2 observers observing simultaneously at stations opposite each other to 2 helios forward and 2 in rear. This necessitated double helios ahead and rear which was arranged by plumbing a low Ordnance pattern helio underneath a Survey of India helio mounted on ordinary plane table legs with the tribach adapted. The time table and plan with the numerous attendant details were very carefully and at great length explained to everybody and issued in writing and several small scale rehearsals were carried out in the camp area.

11. On 14th Jan. all parties had departed for occupation of their positions and the commencement of observations was planned for the 15th. By the 20th Jan. however, an admission of failure had to be made of the over elaborate plans as it had not been possible to cater for the innumerable hinderances and obstacles that would be met with. In these few days it was found that there was so much to interfere and interrupt,—mechanical breakdowns, bogging of vehicles, failure to climb hills on account of physical difficulties such as ice, snow and precipices, variable weather consisting of icy wind of cyclonic intensity, clouds, dust haze, the difficulty of maintaining scattered parties with water, petrol, kerosene, rations and clothing that a breakdown anywhere meant the holding up of the work.

12. The necessity for reorganization was obvious and all parties were called in while new plans were made. Much depended on getting helio flashes which in turn were so dependent on the weather and mechanical failures, that the basis of the new plan was to do without helios and observe to large cairns on lower peaks presenting less climbing difficulties with shorter rays of 30–40 miles. One benefit of the experience of the last few days was the proof that, in good weather, visibility up to 35 miles was always extremely good. Accordingly Subedar Quraishi was taken off observing, and with 2 surveyors and their squads of 4 men and 2 vehicles each, formed an advance recce and cairn building party. Though this plan left only one observer and appeared theoretically to double the observing time it cut out so many other obstacles that it meant in practice an actual saving of time. This plan now released 2 surveyors who were accordingly employed on $\frac{1}{4}$" sketch survey of the road and country 15–20 miles astride it. With their squads of 4 men and 2 vehicles each they followed in rear. The observing party now consisted of myself and computer recorder, 7 sepoys, 4 vehicles with 6 drivers and a fitter, and two signallers.

13. With the new organization observations were commenced on 23rd Jan. and in 5 days 5 stations had been completed. Though 3 of these stations had been low, the other two at 9,000 feet had presented difficulties of a nature that required fairly skilful mountaineering ability, proving that the completion of observations at all future stations, which would be higher, would in each case be an achievement in itself. The height of the valley in this section was 5,000 feet approx., and to complete observations in one day meant a climb of another 5,000 feet from a camp as near to the foot as M.T. could approach, generally a distance of 2 or 3 miles, which took 3 to 4 hours, then observations at the top for 3 or 4 hours and the descent back to camp in the darkness of about 3 hours. As the days were short winter days with about 8 hours daylight, this meant leaving camp in the dark and returning in the dark, a performance not possible very frequently and certainly not on successive days over any considerable period. A big advantage resulted in receiving periodically the results of the forward recce party which also contained descriptions of the best and quickest routes for climbing. For the next 14 stations only on two occasions was camp reached before darkness had fallen.

14. Stations 6 and 7 were completed without much difficulty but, from station 8 onwards serious difficulties and delays were encountered, mainly in the form of adverse weather conditions which seemed to have broken completely, and changes occurred without any accountable reason—rain would precede sandstorms instead of following and clearing them, clouds would appear in a cloudless sky and, after hanging about for a few hours, disappear as rapidly as they came, a dull dark day would occur in between two bright days, hot days would alternate with the bitterest cold, and haze would occur for no apparent reason, hang around, and disappear for no logical reason.

15. On station No. 8 the observing party was benighted and after a long perilous descent in the darkness reached a caravanserai at 01.00 hours and food and warmth were begged from evil smelling camel owners. On station 9 two members of the party were benighted during the descent and spent the night at about 9,000 feet without food or shelter with a temperature well below freezing point. Stations 10 and 11 were successfully completed during a lucky break in the weather. At station 12 the wrong peak was climbed and in consequence 4 days were lost waiting for haze to clear. Another 4 days were lost at the foot of station 13 on account of haze again. A continuous high wind of cyclonic intensity for 5 days delayed station 17. Two lives were nearly lost during the ascent of station 16 which consisted of loose shale and slate making a foothold extremely precarious and dangerous. A night was spent at 13,900 feet on station 18 with no food, warmth or shelter with two cases of snow blindness the next day. Station 19 at 14,500 feet proved too much for all except two of the sepoys and myself and the loads of others had to be shared between us. After a 7 hours climb, observations were completed at about 16.30 hours and a dangerous descent over very difficult precipitous slopes brought us back to camp at 03.00 hours.

16. A base had been measured at Bahramabad with observations for Latitude, Longitude and Azimuth and connected to the series.

On 4th March Kerman was reached where the receipt of the first issue of rations from India was welcomed by the men who had been living on dried dates and biscuits for the last few days. The greater part of the series had now been completed very successfully, but it was very much feared that weather conditions would hamper the continuation for 100 miles across the Lut desert. It was accordingly planned to do the desert portion next leaving a gap of some 100 miles of high mountains to be done later.

17. As feared, a reconnaissance of the desert portion proved heartbreaking, not only on account of the weather with a dense haze and visibility restricted to a maximum of 10 miles, but also on account of the lack of suitable stations, and four days were spent in wandering fruitlessly around in an attempt to find suitable positions. As a result, it was almost decided on the 4th day that the weather had completely broken and impossible observing conditions set in which would necessitate the abandoning of the series. On the 5th day however, after an extremely sultry and oppressive afternoon, a terrific storm burst, with a high wind and heavy rain, and great hopes were placed in a spell of good weather resulting.

18. Plans were made to occupy two previously reconnoitred low stations in the desert area in the hope of getting long shot rays outwards east and west to the high mountains on these sides, thus covering the desert portion in one as it were, with rays of 70 and 60 miles respectively. Hopes proved well founded and two bright clear days provided sufficient time to complete these observations with the satisfaction of feeling that part of a very great obstacle had been overcome. But reciprocal observations had yet to be obtained and subsequent weather conditions never permitted this. Disappointingly, the long rays in the west had to be broken down by small triangles, and those in the east by double extended Hunter Short Base traverse. Ironically enough, when all dispositions had already been set for the traverse work, the weather cleared off sufficiently to have permitted the continuance of triangulation with smaller sides. This took another three weeks and it was not till 6th April that the desert portion was completed and main camp established at Nasratabad Sipi for the last lap of the series with 6 stations remaining to be observed. Another base had been measured and astro observations made about 25 miles SE. of Bam. Unfortunately, the establishment of a Laplace station here proved unsuccessful due to the breakdown of both wireless set and chronometer which had at last been packed in as a result of excess cross country jolting.

19. To ensure completion before the weather completely broke, it was arranged that Subedar Quraishi would observe at the two remaining stations on the south side of the series while I observed at the 4 on the north side, including the two final Great Trigonometrical stations to which connection was being made. Deterioration of weather conditions now became very rapid and it was only on one day in five that observations were possible for a few hours at sunrise. Eventually, on 18th April, the last station was observed and the series completed.

20. The whole party now assembled at Zahidan and, after a halt of four days, during which sufficient running repairs were done to vehicles and two evacuated by rail, the convoy proceeded on its journey to Quetta which was reached on 25th April. The orders awaiting here were that the section was to proceed to Dehra Dūn where disbandment would take place. This would involve a journey of some 1,000 miles and could not be undertaken without extensive major repairs and overhaul of vehicles. This was completed in 10 days and on 6th May the convoy set out its final 11 day journey arriving at Dehra Dūn on 17th May. Personnel were sent off on leave, vehicles returned to Ordnance and disbandment completed in 2 weeks. Angle books and chart were handed in to the Director, War Research, Survey of India in Dehra Dūn.

21. In amplification of the above general report the following details are added.

Rations.—Before leaving Baghdad dry rations for 70 days, at normal field service scale, were drawn and intended to last till 10th March. These completely filled five 3-ton lorries. In addition, sufficient rum for 50 issues per head was drawn. The special winter increases consisting of cocoa, milk, sugar etc., were drawn at Sultanabad, the last supply issue depot in Persia. As the issue of fresh rations was impracticable, authority was given for the local purchase of fresh items, on the appropriate ration scale, at the maximum daily rate of 12 rials (Rs. 1/4) per head for B.T. and 6 rials for I.T. Though this allowance would appear on first sight to be very liberal it turned out to be really insufficient, due to the extremely exhorbitant prices and scarcity of commodities prevailing in an area where local resources proved hardly sufficient for the inhabitants. A sheep cost Rs. 50, chickens Rs. 5, and eggs -/12/- each. Dry rations were issued for a month at a time. This avoided the inconvenience that would be caused by more frequent issues, covered the problem of issue to isolated detachments, and released valuable transport for technical duties. Attached personnel, who had

always been accustomed to having their food cooked and served to them, had now to accustom themselves to survey habits and cook their own food on primus stoves. A welcome concession was the authority for the purchase of three months issue of rationed N.A.A.F.I. supplies, payment for which could be made out of imprest and recovered by sales within the unit. Altogether about Rs. 2,000 worth of requirements, ranging from boot laces to Scotch whisky, were purchased and a mobile canteen formed. Certain items, particularly cigarettes, proved insufficient and certain items that proved in excess of estimated requirements were disposed of to canteens in India.

22. **Pay.**—For the new Imprest account a sum of £ 1,000 was drawn in Iraq Dinars in Baghdad and changed into Persian currency, at the controlled rate of exchange (I. I. D. to 128 rials), by the National Bank of Iran at Isfahan. An advance of two months pay was made to all personnel before leaving, after which no demands for pay were made during the trip, for the two reasons that there was nothing to purchase and no post offices through which money could be sent home, but on arrival at Zahidan, there was an immediate demand for two months pay. Difficulties arose in the exchange from rials to rupees, firstly on account of the low value of the rial involving loss at the public rate of exchange, and secondly, because the Admin. Comdt. did not have sufficient rupees for exchange. This difficulty was overcome by arranging that each man sent a money order of thousands of rials, at the controlled rate of exchange, commission free, addressed to himself in Quetta where it was cashed on arrival. Authority was also given to meet contingent expenditure out of Imprest up to a maximum of £ 150 per month, but contingencies were not many and consisted mainly of coolie labour, repairs to and spare parts for vehicles and primus stoves.

23. **P.O.L.**— Very fortunately, petrol and oil were available at intervals along the route which saved what would have been an organization of some magnitude requiring the carriage of, say 200 miles reserve, by each already overloaded vehicle, and the formation of dumps along the route. By giving notice well in advance, sufficient supplies were made available by the Anglo-Iranian Oil Co. to their outlying depots by tanker lorries, and obtained on presentation of a signed special indent form for use by Allied Forces. Most of the depots consisted of primitive pumps, worked by hand lever out of a barrel, and by the time the tanks of 18 vehicles had been filled with an average of 20 gallons each it is feared that quite a few operators were left suffering from acute tennis elbow. It was also fortunate that ten 40 gallon drums were obtained as these proved of inestimable value when away from the road. It is calculated that about 9,000 gallons of petrol were consumed in the whole trip from Baghdad to Dehra Dūn.

24. **L.A.D.**—All military recovery aid ceased at Sultanabad. The section was equipped with one Ford 2½-ton lorry, four wheel drive, and fitted with a winch. Without this several vehicles would have had to be abandoned in the frequent sand, salt marsh and loam met with. The vehicle also carried the 3 fitters with a tool chest each, electrician and his tool chest, and some of the more important items of the 3 months reserve M.T. stores and spares including the 300 watt Jonhson chore horse for battery charging. Normally it travelled and remained with the H.Q. section when not out on a job of recovery. One fitter sometimes accompanied the forward recce party and one the observing party.

25. **Vehicles.**—Of the 15 cwts, only the Dodge and Chev. stood up to the stiff cross country work required of them. The two Fordsons, Bedford and Ford CAT, which were all a bit old, gave constant trouble and eventually two became 3rd line. It was unfortunate that vehicles were not all of the same type, as this would have meant not only an increase in spares issue, but easier cannibalisation. One Fordson became a casualty in the first month on account of a damaged crankshaft and was towed for the remainder of the trip as a reserve petrol tanker after being fitted up with 40 gallon drums. The 3-ton Chevs. stood the test remarkably well as did the water tank and wrecker, and only one 3-ton was evacuated to 3rd line in the last week. Breakdowns were mostly on account of spring leaves and radiator leakage. There was very little tyre trouble, as all vehicles were fitted with brand new tyres with serrated reinforced tread. Spare tyres were provided on a liberal scale. One 3-ton lorry was fitted up as a caravan with a spring bed, tables, chairs and racking, the hood, sides and ends were reinforced with 2" thatch board which kept out both cold and rain, providing altogether a most comfortable lodging.

26. **Health-Medical.**—On the whole health was very good. Apart from the usual number of temporary minor indispositions due to changes in weather, there were only 2 cases of malaria, one of bronchitis and one of pneumonia, all of which were dealt with successfully by the accompanying M.O. Medical equipment provided was most complete and would have proved adequate for the most serious cases of sickness or injury. In point of fact, the M.O. had so little to do that he was always overcome by the most acute boredom, and it was quite often that he found employment in attention to the numerous local patients that sought his aid. It was impossible to supervise the treatment of drinking water beyond issuing individual sterilising outfits, and in consequence there were quite a few cases of stomach trouble due to the brackish water which was all that was obtainable in the desert portion. It was also impossible to control the V.D. position and 6 cases were contracted during the trip.

27. **Arms-Protection.**—Intelligence reports had indicated that though local unrest was always present, there was little possibility of any exceptional disturbance throughout the route, particularly if there was no straggling or travel at night, and that there should be freedom from isolated raids with a possibility of some local tribal disputes in the Makran area relating to a blood feud concerning a local chief. No trouble was met with, even though small parties with 3 or 4 vehicles were often camped out in isolated areas. It had been proposed at the conference in Baghdad that an armed escort of about 30-40 rifles should accompany the section for guard duties and so release others for technical duties. The proposal was abandoned however, when it was pointed out that it was desirable to keep numbers down, as more bodies would mean more rations, more rations would mean more transport, more transport more driver bodies, and so on. In the early stages guards were mounted every night regularly but found unnecessary later. All I.O.R's. were armed with a rifle and 100 rounds of ball; fortunately, most of the ammunition was from the training allotment and was used only in the provision of gazelle and ibex for the meatless pot. It is interesting to record that the now practically extinct wild ass was met with and one shot.

28. **Postal.**—The unit was cut off postally from Paiforce virtually from the day it left Baghdad. The Postal Directorate, Paiforce had arranged with the Postal Directorate, India that all mail for the party should be forwarded to the accommodation address C/o H.M. British Consul, Zahidan, and it was collected twice

before Zahidan was reached. There existed the Persian Post and Telegraph service but it was not used on account of security and because English was not read. An Assyrian interpreter, by name Adam Dinkha, accompanied the section but was not put to much use in this capacity. His training in the Iraq Levies was found of great value however, as he was a first class signaller proving a great help out on many occasions and his accuracy with a rifle in shooting duck and even pigeon testified to the quality of his training.

29. Weather.—The report by No. 3 Field Survey Company that, as a result of its experience of the weather, Autumn was the most suitable time of the year proved only too true, and the series should have really commenced 3 months earlier. It is doubtful if conditions of visibility are ever stable over a sufficiently long period. According to local inhabitants the weather was unusual during March and April when, it was said, the sun never appeared on account of rain and cloud, though there was some rain and invariably clouds after midday during the latter half of March. As stated previously, every possible kind of weather condition was met with in a most erratic and undependable way and hampered the work more drastically than all other obstacles combined. It was only for very short periods that there was freedom from rain, clouds, wind with a capital W, haze or sandstorms, and it was always a matter of anxiety and uncertainty as to whether observations would be possible. This often entailed climbing a hill two or three times, two hills were climbed five times and Subedar Quraishi spent 6 days camped at 10,000 feet waiting for clear weather. The only reasonable chance of ensuring completion of observations was to camp on top of the hill, but weather conditions at a height of over 10,000 feet at night were worse than the sweat of repeated climbing, even though the ascent of most hills required a mountaineering skill of no mean standard to overcome the obstacles presented.

30. Technical.—When the undertaking of the series was first considered the section possessed one old Wild Universal Theodolite that had seen better days and long hard service. During preparations for the trip, India and Middle East were approached for additional requirements. One brand new C.T.S. Tavistock was flown out from India and one good Zeiss flown over from Middle East. The Tavistock was used almost entirely throughout the series but only because of the extra power in the brand new telescope. Its other features in comparison to the Zeiss were not favoured; the obtaining of incidence of two vertical lines in the Zeiss was preferred to the light gap arrangement of the C.T.S.; one eyepiece for reading verniers preferable to two; the method of changing zeros was more convenient thus making repeat angle measurements quicker and easier; the arrangement for clamping to the tribach was better than the screwing on of the C.T.S. A new arrangements of sights on the Tavistock, consisting of a bead foresight and large rear peepsight was found very useful for star observations. The folding legs of the Zeiss were a help during difficult rock climbing.

The completion of 5 zeros of horizontal angles and two of vertical at each station was aimed at, but this was not always possible mainly through lack of time and weather hindrances. Intersected points were observed to from the first ten stations but later abandoned for the same reasons.

31. About 5 days before departure from Baghdad, the chronometer asked for from Middle East arrived by air and, after a comparison with time signals, found to be in good condition. It was of the sidereal variety and from marks of origin appeared to be Italian booty from the Western Desert. When on the move, during the trip, it travelled under the blankets on the spring bed in the caravan which provided ideal jolt resisting conditions.

32. The Hunter Short Bases asked for from India arrived by air after departure from Baghdad and had to be sent out by road to catch up with the section at Nain. The tapes were invar and had been calibrated in Dehra Dūn before dispatch. Unfortunately the measured lengths of the 4 sections did not accompany, and as it was not till the 27th March that they were received, it was not possible to compute bases measured and so provide a check in scale of the triangulation up to that date.

The section was equipped with a battery or mains wireless receiver and transmitter which, apart from providing the necessary time signals, enabled touch to be kept with the fact that there was still a war going on in other parts of the world.

33. The scheme did not originally envisage any planetabling work and though 4 surveyors formed part of the section, it was intended that they should only be responsible for helio squads. When the reorganization with an advance recce party proved necessary, thus releasing 2 surveyors, it was decided to put them on $\frac{1}{4}$" recce and correction survey of the route and adjacent country. Their planetables consisted of the existing $\frac{1}{4}$" maps on Ahmedabadi paper, published by the Survey of India, compiled from various sources such as route reports, traveller's tales and Oil Company prospecting surveys. The pace of the triangulation permitted of a fairly useful map being made of the country 15 miles on either side of the route, the two surveyors camping together and working one to the north and the other to the south, thus covering about 20,000 square miles. Fixings were made from local detail. It was first intended that the two surveyors in advance would provide sufficient planetable intersected points for the use of those in the rear, supplemented by the triangulated points after computation, but because of the inability of the surveyors in advance to obtain satisfactory resections and the strain on my computer to maintain up to date computations of observations after strenuous hill climbing and recording, the surveyors in rear were only provided with very limited control.

My own planetable consisted of 19 $\frac{1}{4}$" sheets pasted together and then cut down and across in a SE. direction to the width of a planetable, with one right angle bend for the last two sheets. This was then made into a roll, the two ends of which were kept in a rolled position by string underneath the planetable and unrolled from one end to the other as the work progressed. The results of the forward recce in co-ordinates were periodically conveyed back to me and entered on my p.t. section, thus ensuring easy recognition of the forward stations.

The only computations done during the trip were those for log sides, bases and triangular error, in order to keep a check on any large error which might necessitate re-observation. It is necessary for an observer to maintain the closest liaison with his computer's work so as to satisfactorily help in the early investigation of any discrepancies that may arise in computations. It is preferable that the computer is also the recorder and is present at all observations in order to record and remember any unusual facts and conditions which would assist in the location of any error producing causes.

34. Except in a few instances, a reasonable permanency of station marks was ensured by cutting on rock in situ, at distances and bearing that were recorded, three arrows pointing towards the mark. These records form part of the descriptions of stations which will form part of the computed results of the series containing the History Sheet with details as to average triangular error, length of sides, etc. A departure from

customary Survey of India practice in the cutting of actual station marks was the substitution of a T for the usual circle and dot, hoping thus to record a modest contribution to Survey by an observer whose name began with T.

35. Except in the last portion, the factor that contributed more to the success of the series than anything else was the accessibility of stations rendered by the use of M. T. It was nearly always possible, by a clever combination of camel tracks and skilful cross country motoring to get within reasonable distance of the range from where the station could be climbed. The discovery of some routes along stream beds in narrow confined valleys, over steep saddles and spurs, and the avoidance of sand, salt marsh and loam would have done credit to any L.R.P.G. and stresses the importance of having good M.T. drivers who should also be fairly good mechanics. Another major contributing factor was the independence of the section from local resources in the form of food, labour, supplies, transport and equipment. The country, except in the region of Kerman, is sparsely inhabited, dry, bare and barren with extremes of heat and cold and can produce nothing that can be turned to advantage with the exception of petrol and oils. The section was very well equipped and self contained in these respects; and there is no question that a job of this nature and size would otherwise have taken several years to complete. Any detachment employed in this area in the future would have to be similarly well equipped for any work to be possible at all. It will also be essential for an observer to possess a fair degree of mountaineering skill and ability. I was fortunate in having had the benefit of nine months experience, with triangulation station up to 19,000 feet, in the mountains of perpetual snow in Chitral and Gilgit, under the tuition of the tribesmen of these parts who are excellent mountaineers. A less able squad requires to be led with experience and confidence to overcome the fear presented by physical obstacles at great heights. The local Persian is by no means a mountaineer and no help can be expected from him.

A great advantage resulted from the inclusion in the section of trained visual signallers with helio and lamp. The convenience of being able to communicate with a distant camp or party even at night and convey an important and immediate change of order or plans often saved a lot of trouble and delay.

36. While the observing party was engaged in observations on the flanks, the Main H. Q. camp moved in bounds and established itself under the M. O. as near as possible to good water and petrol, and generally attended to the details of administrative requirements such as rations and vehicle repairs. One of the biggest items was the exchange supply of boots, trousers and gloves of the climbing parties which wore out in an incredibly rapid manner, necessitating very frequent replacement. Each member engaged in climbing had need to change at least 3 pairs of boots. The original issue of boots had been at the scale of 2 pairs per man, but the second pair was taken away from non climbers such as drivers and issued as necessary to those who did climb. A three months reserve of clothing was also carried for replacement. Special winter clothing was on the scale of 1 pr. sheepskin gloves, 2 prs. natural grease woollen socks, 1 pr. snow goggles and 1 leather jerkin per man, and one flannel lined greatcoat and 1 pr. Gilgit boots per 10 men.

Tentage used was mostly 40 pounders for ease of pitching and warmth.

No wood was obtainable throughout the trip and all cooking was done on primus stoves for which kerosene oil was obtainable in sufficient quantities.

37. The magnitude of the task was never under estimated from the start. A very good idea is provided by the interesting comparison with the map of England and Scotland at the same scale, from which it will be seen that the length of the series was exactly the same length as from John O'Groats to the Isle of Wight. The difficulties and obstacles proved much greater than was imagined. It resolved into a battle against time and against every conceivable kind of obstacle that Nature could produce in the way of weather and country. The completion of the series was always a matter of the greatest doubt and anxiety and on two occasions the abandonment was seriously considered. The successful completion is due, in the main, to the excellent co-operation and help of all who formed the party, and in particular, to Subedar M. Z. A. Quraishi who proved a staunch and willing supporter, to Hav. (now Jemadar) D. C. Kuthari an indefatigable and keen computer and recorder, and to L/Nk. Zarif Khan and Sepoy Qurban Ali for their never failing energy and willingness under the most trying and difficult conditions met with.

O.B.—P.O.—J.S. 94—7-3-46—500

NAIN–ZAHIDAN TRIANGULATION (PERSIA–INDIA CONNECTION)

By Captain P.A. Thomas I.E., 1944

Chart II

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Frontispiece

INDIA

Primary and Secondary Triangulation

(Corrected to 1938)

REG. No. 3780 O.D. 1938-350

Published under the direction of Brigadier C. G. Lewis, O.B.E., Surveyor General of India.

1938

HELIO. S. I. O. DEHRA DŪN.

Primary and Secondary Triangulation Series

	Name	Date	Classification
	South Pārasnāth Meridional ...	1836–39	Secondary
	Budhon Meridional ...	1833–43	,,
	Amūa Meridional ...	1834–38	,,
	Rangīr Meridional ...	1834–41	,,
	Calcutta Longitudinal ...	1864–69	Primary
	Great Arc Meridional 24°–30° ...	1835–66	,,
(a)	*Bombay Longitudinal East of 75°*	1862–63	,,
(b)	,, ,, *West of 75°*	1837–39	Secondary
	Great Arc Meridional 18°–24° ...	1837–41	Primary
	Great Arc Meridional 8°–18° ...	1866–74	,,
(a)	*Singi Meridional 21°–25°* ...	1860–62	Secondary
(b)	,, ,, *19°–21°* ...	1842–46	,,
(a)	*South Konkan Coast 15½°–19°* ...	1842–44	,,
(b)	,, ,, *15½°* ...	1866–67	Primary
	Karāra Meridional ...	1843–45	Secondary
	North Malūncha Meridional ...	1844–46	,,
	Chendwār Meridional ...	1844–46	,,
	Gora Meridional ...	1845–47	,,
	Calcutta Meridional ...	1845–48	,,
	South Malūncha Meridional ...	1845–53	,,
	Khānpisura Meridional ...	1845–48	,,
	Gurwāni Meridional ...	1846–47	,,
(a)	*North-East Longitudinal West of 80°*	1850–51	Primary
(b)	,, ,, ,, *East of 80°*	1846–51	Secondary
	Hurīlāong Meridional ...	1848–52	,,
	North-West Himālaya ...	1848–53	Primary
(a)	*Gurhāgarh Meridional 24½°–26½°*	1848–50	Secondary
(b)	,, ,, *26½°–32½°*	1859–62	Primary
	East Coast ...	1848–63	,,
	Karāchi Longitudinal ...	1849–55	,,
16	*Abu Meridional* ...	1851–52	Secondary
17	*North Pārasnāth Meridional* ...	1851–52	,,
18	*Kāthiāwār Meridional* ...	1852–56	,,
19	*Gujarāt Longitudinal* ...	1852–62	,,
	Kāthiāwār Longitudinal ...	1853	,,
	Great Indus ...	1853–61	Primary
	Rahūn Meridional ...	1853–63	,,
(a)	*Assam Longitudinal 89°–92°* ...	1854–60	,,
(b)	Assam Longitudinal 92°–96° ...	1934–36	,,
	Cutch Coast ...	1855–58	Secondary
	Kashmīr Principal ...	1855–60	,,
	Jogī-Tila Meridional ...	1855–62	Primary
	Sambalpur Longitudinal ...	1856–57	Secondary
	Bīdar Longitudinal ...	1860–72	Primary
	Eastern Frontier and Cāchār Branch ...	1860–64	,,
	Sutlej ...	1861–63	,,
	Madras Meridional and Coast ...	1860–68	,,
	East Calcutta Longitudinal ...	1863–69	Secondary
	Mangalore Meridional ...	1863–73	Primary
	Kumaun and Garhwāl ...	1864–65	Secondary
(a)	*Burma Coast 16°–23°* ...	1864–74	Primary
(b)	Burma Coast 14½°–16° ...	1876–77	Secondary
(c)	,, ,, 10½°–14½° ...	1877–82	Primary
(d)	,, ,, 10°–10½° ...	1930–31	,,

Serial No.	Name	Date	Classification
53	*Jubbulpore Meridional* ...	1864–67	Primary
54	*Madras Longitudinal* ...	1865–73	,,
56	*Brahmaputra Meridional* ...	1868–74	,,
57	Coimbatore No. 1 ...	1869–71	Secondary
58	*Bilāspur Meridional* ...	1869–73	Primary
61	Malabar Coast ...	1872–80	Secondary
62	Jodhpur Meridional ...	1873–76	Primary
63(*a*)	*South-East Coast* ...	1874–80	,,
63(*b*)	Ceylon Branch ...	1875–76	,,
64	Eastern Sind Meridional ...	1876–81	,,
65	Siam Branch ...	1878–81	Secondary
66(*a*)	*Mandalay Meridional 18°–25°* ...	1889–95	Primary
66(*b*)	Mandalay Meridional 25°–27° ...	1936–37	,,
68	*Manipur Longitudinal* ...	1894–99	,,
69	Makrān Longitudinal ...	1895–97	,,
70	*Mandalay Longitudinal* ...	1899-1900	Secondary
71	*Manipur Meridional* ...	1899-1902 & 1915-16	,,
72(*a*)	Great Salween 21°–24° ...	1900–11	Primary
72(*b*)	,, ,, 20°–21° ...	1929–31	,,
73	Kidarkanta ...	1902–03	Secondary
74	Kalāt Longitudinal ...	1904–08	Primary
75	"Baluchistān" (Bannu) ...	1908–09	Secondary
76	North Baluchistān ...	1908–10	Primary
77	Gilgit ...	1909–11	,,
78	Khāsi Hills ...	1909–13	Secondary
80	Upper Irrawaddy ...	1909–11	Primary
81	Jaintia Hills ...	1910–11	Secondary
82	Bhīr ...	1911–12	,,
83	Rānchi ...	1911–12	,,
84	Villupuram ...	1911–12	,,
85	Sambalpur Meridional ...	1911–14	Primary
86	Indo-Russian ...	1912–13	Secondary
87	Khandwa ...	1912–13	,,
88	Ashta ...	1913–14	,,
89	Buldāna ...	1913–14	,,
90	Naldrug ...	1913–14	,,
91	Nāga Hills ...	1913–14	,,
92	Middle Godāvari ...	1914–15	,,
93	Kohīma ...	1913–15	,,
94	Cāchār ...	1914–15	,,
96	Madura ...	1916–17	,,
97	Bāgalkot ...	1916–17	,,
99	Rangoon ...	1925–27	,,
100	Kurram ...	1927–28	,,
101	Peshāwar ...	1927–28	,,
102	North Wazīristān ...	1927–28	,,
103	Chittagong ...	1928–30	Primary
104	Mong Hsat ...	1929–31	,,
107	Dālbandin ...	1931–32	,,

NOTE:—The series in *italics* were incorporated in the adjustments of 1880 and 1916.