

DEPARTMENT OF NATIONAL DEVELOPMENT

DIVISION OF NATIONAL MAPPING

TECHNICAL REPORT No. 8

THE HIGH LEVEL GEODETIC SURVEY OF NEW GUINEA

by

H.A. Johnson

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"I will lift up mine eyes unto the hills, from whence cometh my help."
Psalm 121.

1. Abstract

- 1.1 This article generally describes the field work of the high level geodetic survey which embraces many of the main peaks in that half of the island of New Guinea, East of the International Border, covering the Australian Territory of Papua and the United Nations Trust Territory of New Guinea. In addition, it gives a brief outline of the method of obtaining mapping control over New Guinea and the adjacent islands since 1945.
- 1.2 To avoid the clumsy and bulky terms of "Papua-New Guinea" or "Territory of Papua and New Guinea" in this article "New Guinea" will refer to the Eastern half of the island, unless otherwise specifically mentioned.
- 1.3 The abbreviation "TP&NG" refers to Territory of Papua and New Guinea.

2. Terrain and Climate

- 2.1 For those unfamiliar with the island and unable to research such information, the following may give some appreciation of the task of controlling it for mapping, and of the even more formidable and frustrating work of obtaining usable aerial photography over such a country.
- 2.2 The annual rainfall ranges from about 40 inches in the freak, dry pocket around Port Moresby to over 200 inches in various areas, but in general is rarely less than 100 inches.
- 2.3 In the latitude band of 2° to 11° South covering New Guinea, such rainfall means tropical, dense vegetation over most of the land, with great rivers swamps and deltas. Moreover, the country is geologically young and unbelievably rough - Mount Wilhelm, the highest peak east of the border, is 14,800 feet high and can be snow covered at any time of the year.
- 2.4 Many mountains along the spinal ranges are over 3,000 feet high, and are mostly interconnected with ridges and spurs so steep and knife-edged it would seem only the matted mantle of vegetation holds them up - and failing under some periods of continuous torrential rain, as may be seen in the many landslip scars and waterfalls on aerial photographs or when flying over the country. After every big rain, rock-falls and washed-away low-level bridges often block the few vehicular roads (many of which are suitable for 4 wheel drive vehicles or tractors only) and clearing and maintenance are continuous. Sometimes sections 50 yards or longer of walking or jeep paths, cut into precipitous sidlings, just slide away, leaving a cliff face.
- 2.5 There are some countries with heavier rainfall, and others which are as rugged, but few will present a more formidable combination to surveyors and especially to geodetic surveyors requiring angular and astronomical control on these usually clouded heights.
- 2.6 For most of the year the North-West monsoon or the South-East trade winds, driving in from warm seas and almost at saturation point, have only to be pushed up slightly, as they meet the great wall of ranges, then to be cooled enough to form the clouds and rain so significant of New Guinea.

2.7 Two doldrum periods of varying length and unpredictable arrival, occurring somewhere between mid-November and mid-January, and again between mid-April and mid-July, usually give calmer, less clouded pauses between the wind patterns. These pauses are of one to six weeks duration when survey parties, if in position, get their best chances for angular and astronomical work.

3. Early Geodetic Considerations

3.1 At the beginning of 1944, the first probing investigations and considerations were made towards the establishing, someday, of a geodetic triangulation over New Guinea. In this the United States Air Force helped appreciably and generously by making aircraft available on occasions for reconnaissance flights to allow close examination by the writer of the summits of selected peaks and to check intervisibility along likely rays.

3.2 Some of the main peaks were in error in position on the aeronautical charts by nearly 20 miles and by several thousands of feet in altitude, and during the war they reaped a great harvest of aircraft - most disappearing without trace through the green canopy which folded over them.

3.3 With the aid of ANGAU (Australian & New Guinea Administrative Unit) officers who arranged carriers and Native Police, ground reconnaissances were made of Mount Wilhelm in the Central Highlands and of Mount Balbi and Mount Bagana in Bougainville, to see what would be involved in climbing such high peaks with technical and camping equipment, beaconing them and occupying them over the protracted periods obviously required' to obtain the angles and especially the astronomy data.

3.4 During 1944 and 1945, attention was paid to the occasions when the main peaks and ranges were visible, and it was soon realized that observations to and from these mountains would be possible only in the early hours before sunrise and until about 0900 hrs, after which heavy cloud would be building up to blanket them. Even then, their average appearance would be on about two days per week, or less, with sometimes nothing seen in a fortnight.

3.5 It soon became obvious that the survey could be a lengthy, frustrating project but it seemed possible. Also, whatever else it would be, it would be costly, since the number of recoverably marks emplaced during the 1939-45 operations would be almost negligible. Marks for such a geodetic survey would need to be as permanent as it was practicable to make them so that they would be visible during the brief cloudless periods.

3.6 The beacons on the main peaks would be of paramount importance, since they would command great areas and distances. They would need to be visible for angular ties whenever the clouds allowed and without the help of luminous signals - ties not only for geodetic control but for all survey control.

3.7 At 10,000 feet altitude the vegetation is usually a species of slow-growing gnarled, stunted beech and tree-ferns, which give way at about 11,000 feet to alpine grass and low sparse bushes, presenting no problem for clearing or from re-generation. At 13,500 feet bare rocks, only, prevail.

3.8 With the cessation of military survey activities in 1945, the commencement of a geodetic survey over New Guinea lapsed into abeyance.

4. Control Surveys of New Britain and New Ireland

4.1 Although moves to start the geodetic survey of New Guinea did not commence again until 1958, two important and accurate control surveys were made in New Britain, and in New Ireland and

the adjacent islands - namely Project Xylon and Project Cutlass respectively.

- 4.2 These were long and exacting, high-pressure, difficult surveys, being mainly ship-shore triangulation and traverse, and were combined operations with units of the Royal Australian Survey Corps and of the United States Army Corps of Engineers.
- 4.3 The ships used on the surveys were Fast Supply ships of about 1,000 tons, 130 feet long by 38 feet beam, and were supplied by the United States Government.
- 4.4 The following two sections, 5 and 6, give bald details of this work.

5. New Britain Survey - Project Xylon

- 5.1 This was a ship-shore triangulation survey around the coastline of New Britain, excluding the Gazelle Peninsula which had previously, been covered by conventional triangulation supplemented by some ship-shore work by United States personnel.
- 5.2 Project Xylon was a combined operation undertaken by 24 members of the United States Army Corps of Engineers and 29 members of the Royal Australian Survey Corps.
- 5.3 Operations commenced at Pondo Point on 30th August 1954, and finished on 3rd July 1955. The triangulation extended along 850 miles of coastline and involved the measurement of 19 base lines.

6. New Ireland Survey - Project Cutlass

- 6.1 This survey covered the islands of New Ireland, New Hanover, Dyaul, Tabar, Lihir, Tanga, Anir, Green and the Duke or York group. It involved 926 miles of ship-shore triangulation, 235 miles of 3rd order taped traverse, 5250 square miles of conventional triangulation and the measurement of 14 base lines.
- 6.2 Unlike the New Britain survey, all technical work on Project Cutlass was undertaken by 41 personnel of the Royal Australian Survey Corps, the United States Engineers component being 7 members.
- 6.3 Operations commenced at Kavieng on 10th September 1956, and concluded on 31st October 1957.
- 6.4 In these days of tellurometers, helicopters, good inter-party radio communication, special astronomical theodolites, powerful time signals and field trips of shorter duration the magnitude and expedition of these two tasks can tend to be too readily accepted and pass unnoticed. Mention must be made of those who helped to bring the projects to a successful conclusion, especially those who worked through both Xylon and Cutlass and in particular Major S. W. Snow, the Survey Officer-in-Charge of the two surveys.

7. Planning the Geodetic Control and Mapping of New Guinea

- 7.1 At the conclusion of the war in 1945, some mapping was carried out in New Guinea in selected areas, chiefly by Department of Forests, TP&NG, and by Division of National Mapping. This mapping was governed by the availability of aerial photography.
- 7.2 However, on the request of the Administrator of the Territory of Papua and New Guinea for advice on how best to satisfy the serious mapping needs of the Territories, The Director of National Mapping, Mr B.P. Lambert, flew to Port Moresby in July 1958. He attended conferences of the Technical Committee on Photogrammetric Mapping, and made a wide aerial

reconnaissance of the area and formed an appreciation of the requirements.

- 7.3. From operational experience in New Guinea during 1942 and 1943 and by making use of regular commercial flights, plus one chartered flight from Port Moresby for closer aerial examination of Mounts Victoria and Albert Edward, during the period 13 to 24 July 1958, a very comprehensive aerial reconnaissance was made of the Territories of Papua, New Guinea, New Britain and Bougainville to Guadalcanal, and a scheme of control was planned, which has differed only in minor detail from that which has since been effected.
- 7.4 With the availability of the recently invented tellurometer foremost in mind, two main traverses were planned for New Guinea - one around the coastline and another along the central ranges using the major 10,000 to 14,000 peaks, with selected connections between these high and low surveys.
- 7.5 The fundamental requirement was emphasised in the first instance, of a proper geodetic framework over New Guinea, and for it to be connected to the Australian geodetic network, just as soon as practicable, so that all future mapping would be in its final plottable position on map sheet boundaries.
- 7.6 The geodetic survey of Australia was just beginning to gather momentum with the rapidly spreading use of the tellurometer, which had been introduced in 1957, and it was necessary to divert some of this effort to the important aspect of control for New Guinea.

8. Ground Reconnaissance

- 8.1 In July 1959, 14 years after previous ground reconnaissance had ceased, beaconing of the high level survey commenced near Port Moresby. Although most of the main peaks in New Guinea had been climbed by District and Patrol Officers, such exploratory work had been done, in most instances, many years previously and the officers had either retired, resigned or were in distant postings.
- 8.2 Much help was given by Native Affairs Officers, in particular by Mr. D. Grove and Mr. D. Marsh, in their knowledge of the South Eastern area and in advising the District Officers and Patrol Posts of carrier requirements, Native Police escorts, rations, etc.
- 8.3 Also a fortunate meeting was made in Port Moresby with Father Louis Gremaud of the Sacred Heart Order of the Roman Catholic Church.
- 8.4 This Order has a number of missions in the Goilala area, and from Ononge and Karnulai Missions Father Louis Gremaud and other priests had actually climbed in recent years Mounts Yule, Albert Edward, St. Mary, Strong and Tafa, all proposed geodetic stations, and they knew the best approaches. Moreover, Father Dubuis, previously of Woitape and Ononge where he had done so much track making and pioneering work before his death, had climbed Mount Victoria some years previously on an approach from Ononge along the Vanapa River to Boiine, the small village at the Western foot of this magnificent mountain which watches over Port Moresby and along both sides of its towering range.
- 8.5 A reconnaissance flight was made of these previously mentioned peaks, the writer being accompanied by Father Louis Gremaud and the Chief Surveyor R. G. Matheson of the Department of Lands, Surveys and Mines, TP&NG. After some experience of tropical mountain climbing, a better assessment can be made of the softened, swift moving, aerial look of reduced grades and smooth jungle mantle, which on the ground turn into a fascinating, silent, dripping, half-lighted world of tangled slippery roots, spiny vines and bushes, buttressed trees festooned in moss, and awkward sidlings, long steep climbs and frustrating descents of hard-won altitude.

- 8.6 It was reassuring to hear that there was a climbable route up the spectacular and distinctive Mount Yule. However, thoughts intruded of steel beacons, cement and instruments which somehow had to be man-handled up this apparently sheer-walled fortress.
- 8.7 Reference must be made, too, to the valuable map of the Goilala District, prepared by Mr. C. J. Adamson when he was Assistant District Officer in the area, and the help it gave in planning the Goilala work.
- 8.8 After Mounts Albert Edward and Victoria were reconnoitred on the ground; it was obvious that the one trip should cover not only reconnaissance and preliminary astro-fix, but also beaconing.
- 8.9 Beacons were designed and six were made by the Department of Public Works in Port Moresby. These included two large, steel-framed, box structures for Mounts Yule and Tafa.
- 8.10 Shortage of money and staff brought this phase to a halt in January 1960.

9. Beaconing

- 9.1 At the beginning of 1962, beaconing of the high level survey began in earnest by parties from the Division of National Mapping and from the Department of Lands, Surveys and Mines, TP&NG.
- 9.2 Beacons had to be erected in readiness for intersection by members of the Royal Australian Survey Corps during their geodetic coastal traverse survey. This was scheduled to commence in May 1962, using light aircraft, a helicopter, and a landing craft.
- 9.3 Cessnas were now available for reconnaissance and for air-drops of supplies, and became major factors of support, more especially with airdrops to beaconing parties. This saved the employment of many carriers which were, so often, difficult to obtain in the more sophisticated South Eastern section near Port Moresby.
- 9.4 It has been mentioned that the beacons on the main peaks would be of particular importance. They had not only to be large enough to be seen as opaque and unmanned beacons at great distances between themselves but they had also to be seen from the lower level geodetic and future cadastral, stations. They must also give permanence to this costly survey.
- 9.5 Most of the beacons used were manufactured by Aldo Products of Melbourne and shipped to Port Moresby.
- 9.6 They were designed with a central pole 3 inches by 3 inches in two sections of 7 feet and 8 feet, the latter including a sleeve. This made for easier carrying through the jungle, and they fitted together to form a 14 feet high pole above the ground mark. Four angle-iron struts were bolted above the sleeve with the stone cairn normally covering these struts. Four wire stays, of ¼ inch diameter rod and in 4 feet long jointed links, were guyed from the vanes for additional support. Sometimes two more guys were used along the North-West and South-East directions of the prevailing winds. Four vanes of 18 gauge iron, each 4 feet by 2 feet, formed a square target 4 feet by 4 feet, the top of which was 14 feet high.
- 9.7 All the steel parts in the beacon pole, struts, stays vanes, bolts, cap etc, were heavily galvanised and thickly coated with black paint with a special fish oil base to make it rust-resistant.
- 9.8 The aim was to build stone cairns around the bases of these beacons, if at all possible. Stone was usually available above 11,000 feet, outcropping at times, especially above 12,000 feet. Near the summits of the lower 8,000 to 11,000 feet stations it could generally be obtained by quarrying 2 to 4 feet through matted roots and mossy humus.

- 9.9 Where sufficient stone was obtainable, the cairn was built in the form of a cone, 12 feet in diameter and 10 feet high. A better shape, probably, both for visibility and permanence, would have been a "plum-pudding" form 10 feet in diameter and 9 feet high.
- 9.10 Where stone was unavailable on several 8,000 to 9,000 feet mountains, also on the Finisterre Range, where two members only were landed by helicopter for a limited period, galvanised iron sheeting was used to cover the four triangular areas between the struts, to present the appearance of a solid, opaque pyramid, surmounted by the square-shaped vanes.
- 9.11 Lifting these beacons to the tops of 8,000 to 15,000 feet mountains, with all the lost altitude, which again and again goes with these climbs, carrying the technical and camping equipment, the food, protective clothing, cement, tools, etc., carting the stone, sometimes 100 yards or more, from its quarry under the humus was work, raw work, and something will be mentioned later of the carriers who did it.
- 9.12 The following beacons were erected by parties led by officers from Department of Lands, Surveys and Mines, TP&NG and the Division of National Mapping, mainly in the three years 1962-1964 inclusive.

Department of Lands, Surveys & Mines

Division of National Mapping

Height (ft)

Name

Height (ft)

Name

1060	Aird Hills
5196	Favene
14330	Giluwe
11889	Guruku
12392	Hagen
11369	Ialibu
8428	Karimui
11966	Michael
7395	Murray
10023	Obree
11634	Otto
11990	St. Mary
11770	Strong
14793	Wilhelm

13090	Albert Edward
10755	An-lung-wiwa
13520	Bangeta
7863	Bosavi
11704	Doma
12851	Finisterre
11887	Karoma
11669	Piora
9030	Shungol
9460	Simpson
12061	Suckling
8861	Tafa
13240	Victoria
	Vineuo
	(Goodenough Island)
11756	Wamtakin
11104	Yelia
10750	Yule

10. Beginning the High Level Measurements, 1963

- 10.1 The resident National Mapping surveyor, Mr. D. P. Cook, and the technical officer, who had been engaged on the beaconing, were joined in May 1963 by two surveyors and four technical assistants from Melbourne to start the measurements for the high level work. With the support of a supercharged, high altitude Bell G3B1 helicopter this team commenced the technical work.
- 10.2 The first stations occupied were Mounts Yule and Strong and the Army coastal station AA008 near Yule Island. The work then moved south easterly through Mount Victoria towards Mount Vineuo on Goodenough Island.

- 10.3 This initial period, from the end of May to the middle of July 1963, was the best period of weather encountered on the whole of the high survey. The work moved along better than could ever have been reasonably expected, with the members of the party taking every opportunity to press on.
- 10.4 On 18th July the helicopter became unserviceable through an accident to one of its main rotor blades, and was not air-worthy again until 1st August.
- 10.5 However, on 20th July the weather set completely into the south-east monsoon, with clouds, heavy rain and very strong, dangerous winds, which lasted almost continuously until the end of August.
- 10.6 It was therefore decided to leave, until later, the south-eastern end of the survey, which receives the full brunt of this monsoon, and work north-west from Mounts Yule and Strong towards Mount Hagen.
- 10.7 The initial party of eight was later increased, in August, to eleven, with the addition of three more technical officers. Then in November 1963, two surveyors and a technical officer were attached from the Department of Lands, Surveys and Mines, TP&NG, for experience and to assist in the survey. Over the next two months, when the south-easterlies slowly change to north-westerlies, including a doldrum period, the weather was expected to give the most likely chances of cloud-free observing conditions.
- 10.8 The fourteen members, engaged during these two months formed the largest party operating on the high survey at any period.
- 10.9 On 10th January 1964 the helicopter, chartered for the survey, crashed on Mount Otto, whilst the relief pilot was practising high altitude landings and take-offs prior to change-over. The two pilots escaped serious injury though the machine was written off. Both the main and rear rotors were ripped off when it was thrown on its back and the fuselage was twisted and the bubble smashed. Ironically the wireless which, on occasions, had given considerable, intermittent trouble to the extent of grounding the helicopter, worked magnificently in its inverted position and chaotic surroundings. The crew were thus able to advise the mishap to the Civil Aviation control tower at Goroka. Aid was summoned from another helicopter which was airborne near Madang when the accident happened.
- 10.10 This was the only other high-altitude Bell G3 helicopter available in New Guinea at the time of the smash. It came immediately from Niladang to bring down the two lightly-clad pilots from the 11,600 feet summit of Mount Otto before clouds blanketed it and prevented rescue for that day at least.
- 10.11 With deterioration of the weather and an indefinite delay in arrival of another helicopter from the United States, the field work was concluded on the section from Mount Simpson along the ranges to Mount Hagen, including the Finisterre Range and Cromwell Mountains in the Huon Peninsula, and from Mount Hagen southerly to Aird Hills, near Kikori. The remaining, undamaged helicopter was used to bring down the various parties from the stations then being occupied and the season's work was terminated.
- 10.12 In the period May 1963 to January 1964, 2205 miles were measured by tellurometer, 25 stations were established, and 6 joins were made to the Army coastal, and Markham - Ramu Valley, traverses.



The crashed helicopter on the summit of Mount Otto 11,634 feet, 10 January 1964, with the usual clouds approaching threateningly.

The summit is more restricted and steep than may be judged in this photograph, and the helicopter and occupants were lucky not to have rolled and fallen 1000 feet and more over the side on the right of this picture.

11. Continuation of the High Survey, 1964

- 11.1 A National Mapping party of one surveyor and nine technical officers returned to New Guinea on 1st October 1964. With the resident surveyor, who had beacons on Mounts Bosavi, Doma and Karoma in readiness, this party continued the traverse westwards from Mount Hagen to join the Army traverse at Station AA075, between Green River and Telefomin. A connection was also measured to Hiran Station No. 37 in the Star Mountains, near the Border.
- 11.2 The party, again supported by a high-altitude Bell G3B1 helicopter, met much cloud and poor conditions, without the usual doldrum period of better weather. Then, just after Christmas Day, with five parties waiting in position on Mounts Karoma, Wamtakin, Hiran Station No.37 and the Army stations AA074, the weather let up sufficiently to allow the closing angles and azimuths to be read and the work to be completed by 5th January, 1965.
- 11.3 During this second period, 941 miles were measured by tellurometer and 6 new stations were established, and 2 connections made to the Army traverses.

12. Angular Observations

- 12.1 National Mapping parties have found in Australia that their most accurate horizontal angular work is observed in the late afternoon, about an hour or so before sunset. Azimuths to Sigma Octantis are best observed just as soon as the star is visible after the sun sets.
- 12.2 Also these parties find on the longer lines, which usually occur in geodetic work, that vertical angles are always best read as nearly as possible to simultaneous reciprocals during the period 1400hrs to 1600hrs LMT. This applies both in lower terrain and on stations of high elevation.

- 12.3 On New Guinea mountains, neither horizontal nor vertical angles can be made to meet these specifications, because of the known and almost invariable cloud build-up, before, or soon after, 0900 hrs.
- 12.4 The massive beacons had been erected with one of their chief functions being to avoid, wherever possible, the manning of a station merely to show luminous targets, with all the increases of personnel and of support which are involved.
- 12.5 Opportunity observing, therefore, was to be the only method of obtaining any results at all on New Guinea mountain stations, and it was not without some real concern regarding the final accuracy that the measurements were begun.
- 12.6 Wherever two adjacent stations were both occupied, at the same period, simultaneous reciprocal vertical angles were read, and on most occasions, as may be realized, this was not easily achieved.
- 12.7 It speaks for the determination of the observers that, except on the 115-120 mile lines, simultaneous reciprocal verticals were obtained almost without exception, and many simultaneous reciprocal azimuths were observed also.
- 12.8 Again and again, one station or the other might have its summit and the sky clear enough for observations but its reference station blotted out. At other times both stations might be free of cloud but with thick blankets hanging between them.
- 12.9 Wild T3 theodolites were used by the National Mapping parties on all angular work, horizontal, vertical and astronomical, and all performed satisfactorily, without a hitch, and with all the high standard of precision the Division has learnt to expect from these instruments over the last twenty years.
- 12.10 Directions were read to every beacon which could be seen from a station, regardless of any involved figures which ensued. Usually the opaque beacon was seen, some-times with difficulty, in the haze not far removed from misty clouds. On the longer lines, when a sighted station was being occupied, the beacon was frequently supplemented by a heliograph.
- 12.11 From the low coastal stations the mountain beacons were silhouetted well on clear mornings, but in the reverse direction the mountain observer almost invariably looked down into a featureless murk, even on the finest mornings, where only a heliograph could have any chance of being seen. At times visibility, in each plane, could be wide and good, but with a great layer of cloud, thick and unbroken, lying between the levels. These high-low observations were always difficult and time consuming.
- 12.12 Observing tents, in the shape of a truncated pyramid with a domed top, were designed. They were made of lightweight, waterproof Verylite canvas, with struts and braces of aluminium tubing. This tubing was also used in the domed top bracing which avoided the need for long, awkward-to-carry corner poles. These tents proved very successful and have since replaced a previous design, used in Australia, which had longer main legs joining in a high apex in order to obtain enough room for the observer's movement.
- 12.13 The aluminium tubing needs to be of sufficient diameter and strength so as not to bend too easily, thereby allowing the canvas to belly in strong winds, against the observer. A flap of some 15 inches extended outwards from the foot of the walls. This was heavily weighted with stones to hold the tent down.

- 12.14 Eccentric stations were selected in the most suitable and stable positions near the cairns, and steel pegs, or 3 inch by 3 inch pine pegs, 4 feet long, were driven to support the theodolite tripod on all except the stony tops, where shorter steel pegs were used.
- 12.15 After some early experience, walking planks were placed and supported well away from the theodolite pegs, to avoid any thrust on them in the deep, soft humus.
- 12.16 De-misting cloths and lotions were used to polish all exposed lenses and level tube. This avoided the instant and lengthy fogging of glass through the slightest accidental breathing on it, particularly during astronomical work at night.
- 12.17 The observing techniques used are described in the following notes.

13. Horizontal Angles

- 13.1 Eight to ten sets of horizontal angles, observed over two or more days, were aimed at, for main scheme stations, with three or four sets to 2nd order intersected points. Depending on the conditions, sometimes more, sometimes less sets were obtained.
- 13.2 Each set was of six arcs or zeros, each arc being two pointings either on Face Left or on Face Right, i.e. the target was intersected, the micrometer read and booked, then the cross-wire moved slightly off using the tangent screw and the target re-intersected, the micrometer again read and booked. The next station was then intersected in the same manner.
- 13.3 Two or three, rarely four, and usually only two, stations were observed in a round, the horizon of which was not closed, then the instrument face was reversed and the return swing formed the second arc.
- 13.4 On completion of the second arc on 180°, the circle was moved on by 60° to the 240° setting and the micrometer was also advanced by about 20 divisions.
- 13.5 Similarly, on conclusion of these two arcs, the circle was moved on another 60°, in this instance from 60° to 120°, and the micrometer advanced from about 25 divisions to about 45 divisions, and the procedure repeated for the next two arcs.
- 13.6 To avoid the effects of any drag which might occur and which was more likely because of the cold temperatures on the high mountains, the first Swing of the first set and subsequent odd numbered sets was to the Right; and the first Swing of the second set, and subsequent even numbered sets, was to the Left.
- 13.7 Settings for the first two sets were:

<u>1st Set</u>			<u>2nd Set</u>		
<u>Face</u>	<u>Swing</u>	<u>Setting</u>	<u>Face</u>	<u>Swing</u>	<u>Setting</u>
L	R	00 00 05	R	L	210 02 15
R	L	180 00	L	R	30 02
R	R	240 00 25	L	L	90 02 35
L	L	60 00	R	R	270 02
L	R	120 00 45	R	L	330 02 55
R	L	300 00	L	R	150 02

- 13.8 When the face was reversed for the return Swing, the circle was not reset. The closing reading on the RO was booked to record the difference from the original setting. Collimation error was rarely more than 5 seconds.

13.9 When these two sets were completed, the initial circle and micrometer settings for subsequent sets were as follows:

3rd Set	10 00 05	4th Set	220 02 15
5th Set	20 00 05	6th Set	230 02 15
7th Set	00 00 05	8th Set	210 02 15

13.10 The circle was thus covered by 10° increments, although it was realized that any dividing errors were very small, and each set was also evenly spaced around the circle and over the full range of the micrometer.

13.11 This double pointing method has been standard procedure in the Division for many years. Time is always at a premium for accurate angular observations, and rarely more so than on New Guinea mountain tops. The method saved broken sets, gave more sets, and helped prevent errors both in bad pointings and in micrometer readings.

13.12 A typical set is illustrated

The degrees and minutes on the RO were always booked in each set, but on the other stations, degrees were booked only on the first two arcs of each set. To help avoid a constant blunder, some random setting was made on the circle (e. g. 257° 43' 27", the reciprocal reading whatever it happened to be after changing face, say 77° 43' 31") and two arcs were read in the normal manner to each beacon, at sometime during the observations at a station.

<u>At Station:</u> Bosavi Peaks Ecce				<u>Day & Date:</u> Sat. 14. 11. 64				<u>Time Started:</u> 0625			
<u>Observer:</u> E. Burke				<u>Weather:</u> Cool, slight S. W. breeze				<u>Time Finished:</u> 0737			
<u>Recorder:</u> L. Wilson				<u>Visibility:</u> R. O. good shimmer on Murray & Giluwe				<u>Theodolite:</u> T3 83082			
R. O. Doma Peaks				Mt. Murray				Mt. Giluwe			
210 02	15.4 15.1	30.5	00.0	281 52	41.2 42.0	23.2	52.7	247 14	35.2 34.9	10.1	39.6
30 02	18.3 18.7	37.0		101 52	44.0 43.9	27.9	50.9	67 14	38.5 37.8	16.3	39.3
90 02	33.2 33.5	06.7		54	00.9 00.1	01.0	54.3	14	55.0 54.6	49.6	42.9
270 02	30.2 30.6	00.8		52	57.0 56.6	53.6	52.8	14	50.6 51.0	41.6	40.8
330 02	54.4 54.3	48.7		54	21.4 22.5	43.9	55.2	14	15.7 16.4	32.1	43.4
150 02	58.9 58.9	57.8		54	27.1 27.5	54.6	56.8	14	19.4 18.0	37.4	39.6
	Sum				Sum	22.7			Sum	245.6	
Mean: 00 00 00.00				71 50 53.78				37 12 40.93			

13.13 Bosavi Peaks was a difficult station, with especially deep and spongy, mossy humus and thick vegetation covering the high, narrow rim and very steep walls of an old volcanic crater. It needed a careful set-up for the theodolite, on long pegs.

13.14 A summary of the sets observed is listed. Doma Peaks was RO for most of the sets, but it will be seen that sets were observed to whatever was visible at the time, and a station adjustment made subsequently.

Summary of Horizontal Angles Observed at Bosavi Peaks Eccentric
November - December, 1964

Doma Peaks	Mt. Giluwe	Mt. Ialibu	Mt. Murray	Mt. Karoma
00° 00'	37° 12'	48° 37'	71° 50'	313° 15'
00".00	40".93	14".40	51".50	48".67
	41".42	14".20	53".78	48".05
	41".62	14".72	52".57	47".58
	40".78	13".93	53".22	48".67
	41".13	14".07	52".08	48".63
	40".95	13".63	52".82	46".85
			53".72	47".97
			54".17	
			55".13	
Mean:				
00°00' 00".00	37° 12' 41".14	48° 37' 14".49	71° 50' 53".22	313° 15' 48".06
Mt. Ialibu	Mr. Murray	Mt. Karoma	Mt. Giluwe	Mt. Ialibu
00° 00'	23° 13'	00° 00'	83° 56'	95° 21'
00".00	37".50	00".00	53".90	26":20
	38".30		54".22	
			53".23	
			52".50	
Mean:				
00°0 00' 00".00	23° 13' 37".90	00°0 00' 00".00	83° 56' 53".46	95° 21' 26".20

14. Vertical Angles

- 14.1 The best heights obtainable were naturally being sought during the geodetic survey, being needed for subsequent topographical mapping, for tellurometer distance reductions and for gravity survey which was being undertaken at the same time as the geodetic work.
- 14.2 Prior to the commencement of the measurements, even greater concern had been felt for the doubtful accuracy of the results of the vertical angles than for the horizontal work in view of both the very long lines involved and the time of the day or night when, perforce, the vertical angles must be observed.
- 14.3 Simultaneity was arranged by portable radios, with which all sub-parties were equipped, or by tellurometer speech, just before or just after distance measurements were made.
- 14.4 Two sets, each set of 16 pointings, were observed, with an interval between sets of about an hour or more, and if possible, on different days.
- 14.5 At every pointing, the split-viewed alidade bubble was moved, even if apparently centralised, and relevelled to avoid any stickiness in the tube, which could give a constant error.
- 14.6 Two Face Left and two Face Right pointings formed an arc, of which four arcs were observed to make up the set.
- 14.7 Two typical sets of vertical angles observed from Bosavi Peaks to Mount Murray are shown.
- 14.8 These sets were observed 11 days apart. Some sets observed on different days had a difference of only a few seconds, indicating no doubt, the general homogeneity of the atmosphere, particularly its almost completely saturated condition at most times.

Station: Bosavi Ecce.
 Day & Date: Fri. 13. 11. 64 Time: 0841-0849
 Reliability: Cool, light S. W. breeze; visibility good.
 Simultaneous Reciprocal

At Station: Bosavi Ecce.
 Day & Date: Tues. 24. 11. 64 Time: 0705-0720
 Reliability: Good
 Simultaneous Reciprocal

Station Observed: Mt. Murray
 Target Observed: Heliograph
 Ht. Inst. Above Ecce: 6.10'
 Ht. Inst. Above Station Mark: 5.49'
 Ht. Target Shown Above: Ecce: 6.47'
 Ht. Target above Station Mark: 5.86'

Station Observed: Mt. Murray
 Target Observed: Heliograph
 Ht. Inst. Above Ecce: 6.10'
 Ht. Inst. Above Station Mark: 5.49'
 Ht. Target Shown Above: Ecce: 5.33'
 Ht. Target above Station Mark: 4.72'

L	89 42	15.7 15.5	89 42 31.2	-00 34 58.6	L	89 42	13.7 13.6	89 42 27.3	-00 35 09.0
R	90 16	44.9 44.9	90 17 29.8		R	90 16	48.2 48.1	90 17 36.3	
R	90 16	45.1 44.7	90 17 29.8	-00 34 59.1	R	90 16	47.6 49.1	90 17 36.7	-00 35 11.0
L	89 42	15.2 15.5	89 42 30.7		L	89 42	12.8 12.9	89 42 25.7	
L	89 42	15.8 15.4	89 42 31.2	-00 34 59.6	L	89 42	12.7 11.8	89 42 24.5	-00 35 13.2
R	90 16	45.2 45.6	90 17 30.8		R	90 16	48.7 49.0	90 17 37.7	
R	90 16	45.1 44.7	90 17 29.8	-00 35 00.3	R	90 16	48.8 48.5	90 17 37.3	-00 35 12.4
L	89 42	15.0 14.8	89 42 29.5		L	89 42	12.5 12.4	89 42 24.9	
Mean:				237.6	Mean:				5.6
				-00° 34' 59".40					-00° 35' 11".40

15. Astronomy

- 15.1 Astronomical control, to offset the prevailing conditions and the results likely to be obtained over the work, was obviously essential. Even with low latitudes, the very big deflections, known to exist from experience during the 1942 - 1945 operational surveys, would require due allowance in Laplace corrections, of Difference Longitude Deflection x Sine Latitude.
- 15.2 Undoubtedly the hardest observations to obtain satisfactorily in New Guinea are simultaneous reciprocal azimuth determinations. The requirements are, two stations to be free of cloud, the horizon to the south or to both east and west to be clear, and the ray path between the two stations to be clear - this last condition being not at all certain between mountains 10, 000 feet high.
- 15.3 Despite the clouds and murk usually hanging low around the horizon, the close circum-polar star, Sigma Octantis, was used on all except two of the azimuths observed. This was at Mount Wamtakin and Karoma (latitude about $5\frac{1}{2}^\circ$ south) where east and west stars near the prime vertical were used.
- 15.4 On the first section of the work between Mount Suckling and Mount Karimui, a good deal more astronomical control was obtained than was initially expected, and all the positional observations were made on predicted almucantar (for longitude) and circum-meridian (for latitude) programmes.

- 15.5 In the second period from October 1964 to January 1965, working westwards from Mount Ialibu to the West Irian Border, opportunity for astronomical observations was very limited and only with protracted difficulty were any worthwhile results obtained on several of the lines, where it was necessary to resort to the position line method for latitude and longitude.
- 15.6 On the few occasions when the cloud did clear completely, the temperature fell below freezing and the stars were brilliant and sharp in the frosty air, with refraction values about half those at sea-level. Certainly in these rare circumstances, good observers and bookers could obtain excellent results, which gave some delayed compensation for the discomfort and ordeal of freezing hands and feet, which went towards obtaining them.

16. Tellurometer Measurements

- 16.1 Along with initial interest, not unmixed with anxiety, regarding the reliability of the angular work, there was coupled speculation on the likely accuracy of the tellurometer measurements.
- 16.2 On a high, clear line, anywhere, there is an uneasy feeling that temperatures read at the terminals may not be representative of the mean value prevailing along the line - the mean air line temperature possibly being lower.
- 16.3 In New Guinea, a separation of 50 miles between two places can mean a difference of 100 inches in annual rainfall. Other variations include wide differences of temperature and pressure. A high altitude line, passing closely over several high-walled valleys with irregular conditions and strong thermal currents, can mean that the terminal temperature values gave rise to even more conjecture. A further imponderable was whether the high altitude values would compare at all accurately with lower, coastal work.
- 16.4 Preliminary field checks on the measured sides of triangles in the Yule, Strong, Albert Edward, Victoria figure, where altitudes ranged from 10,750 to 13,240 feet, seemed to indicate no unacceptable disagreement in high rays from stations which were more or less at the same altitude.
- 16.5 With the very first line measured, from Mount Yule (10,750 feet) to the Army coastal station AA008 (860 feet) near Yule Island, it was realised that there would be no rough check on the accuracy of meteorological readings by their approximate similarity at each end. This similarity occurs at stations of approximately equal altitudes.
- 16.6 Four units of the MR A2 model tellurometers, newly purchased in 1963 just prior to the start of the work, were used continuously on the survey. These four units performed outstandingly and reliably. They were serviced in Melbourne in October 1963 after nearly six months continuous tropical service and, of course, at the conclusion of the first and second phases in February 1964 and February 1965.
- 16.7 In November and December 1963, with the attachment of three members from the Department of Lands, Surveys and Mines, TP&NG, two other similar units were borrowed, temporarily, from that Department.
- 16.8 Special wooden, waterproof, carrying boxes were used for all transportation, and storage of each unit between measurements. These boxes were large enough, also, to hold the ancillary equipment consisting of a battery of barometers, psychrometer, 17 inch reflector, etc.
- 16.9 At the beginning, on the first lines measured between Yule, Strong, Victoria and AA008, the 17 inch circular reflectors were employed; the normal small rectangular dishes were not used at all as reflectors. Some difficulty was experienced in measuring the 49 mile line from Yule to AA008, with cloud forming and breaking round Mount Yule, and there was great difficulty

several weeks later on the 70 mile line between Mounts Yule and Victoria.

- 16.10 However, on 21st June 1963, four giant 48 inch diameter reflectors arrived in Port Moresby by air from Melbourne. These dishes had already been tested and proved a few days earlier immediately on their arrival in Melbourne from South Africa on a 100 mile line through heavy cloud from Mount William in the Victorian Grampians.
- 16.11 Two of these reflectors were at once consigned to the Army, near Popondetta, for use on their two coastal stations AA033 and AA034, and the other two were flown to Woiwape, thence by helicopter to Albert Edward (13,090 feet) and Victoria (13,240 feet).
- 16.12 Results were dramatic, immediate and certain, and continued so throughout the whole survey.
- 16.13 These giant reflectors had been ordered, earlier, by the Director of National Mapping especially for the long lines and difficult conditions anticipated in New Guinea. Undoubtedly they made the survey possible in its final form. Many of the lines, even of 50 miles, could not have possibly been measured, through the thick conditions which so often prevailed, without them, as both the Army and National Mapping found.
- 16.14 They were made of fibre glass and were not very heavy, but were awkward to transport and to set up. Guys and a small supporting cradle for the lower lip were needed to prevent accidents and breakage through blowing over. They were attached to the tellurometer studs in the same way as the smaller reflectors.
- 16.15 Before the party returned to the field in October 1964, each giant dish had been carefully cut vertically into three pieces of equal width - a central, curved rectangular portion, and two side pieces. This made them much easier to move by helicopter and light aircraft.
- 16.16 Whenever these reflectors were used a good trace was certain. With two of them loaned to Army and being fully and gainfully employed, National Mapping used its two in conjunction with 17 inch reflectors, with excellent results at both ends. On the three lines over 100 miles long which were measured, namely, Victoria to Suckling (114 miles), Bangeta to Strong (114 miles) and Aird to Bosavi (121 Miles), both ends were equipped with 48 inch dishes.
- 16.17 They were directional and required care in aligning but they were sure, and gave excellent traces under every condition. When measurements were attempted through heavy cloud at either or at both ends of the line, and in the latter case probably right along the line, misty cloud, rain, high and low stations with big differences in temperature and pressure, all of these conditions apparently had little effect and measurements could always be made.
- 16.18 Each had an index error of 0.54 feet, and if two were used, of - 1.08 feet, which had to be subtracted from the measured distance.
- 16.19 The total cost of the four reflectors was £1,060 (\$2,120), or \$530 each, and they paid for themselves many times over.
- 16.20 There is small doubt that had parties been in simultaneous occupation of Mounts Albert Edward and Suckling, and again of Mount Bosavi and Hiran Station No. 37, these two 150 mile lines could have been measured readily enough with the giant dishes.
- 16.21 It was desired to measure by tellurometer every line which was possible in the combined triangulation/trilateration scheme, but with three sub-parties only in operation in the early part of the survey, it was not always economically practicable for a tellurometer party to be moved to, or to be retained on, every station to which angles were read from other stations at sometime during the work. Many lines were measured, however, as the scheme diagram indicates.

16.22 The line of sight from Mount Karimui (8428 feet) to Aird Hills (1060 feet) passes about 400 feet below the ridge on which Mount Favenc (5196 feet) is situated, but the radio wave of the tellurometer cleared it to give a very satisfactory trace. In the final adjustment, one of the larger corrections was applied to this distance but whether it is significant, or a coincidence, cannot be stated with any real assurance.

16.23 Special attempts were made near Telefomin to measure the non-intervisible rays from Mount Karoma to Army station AA075, and also from Hiran Station No. 37 to AA075, but the masking ridges were too close to the stations and prevented any sign of success in either instance.

16.24 With the great variation of vapour pressure along many of the rays due to the widely differing heights of the terminal stations, e. g.

	<u>Mount Victoria</u>	<u>AA006</u>
Altitude	13,240 ft	1,246 ft
V. P.	0.088	0.576

as already mentioned, there was no rough check to warn of a possible blunder in atmospheric (say in wet bulb temperature readings at the beginning of a set, through an imperfectly soaked sock, etc).

16.25 Accordingly, to avoid loss of a set of fine readings achieved with great difficulty, initially, when both stations were equipped with 17 inch reflectors, a preliminary set of atmospheric was always read, before the main measurement.

16.26 The measuring procedure was:

Preliminary Set of Atmospheric;
Coarse Readings on cavities 5, 2½, 10;
Atmospheric;
Fine Readings - 20 cavities from 1.0 to 0.5;
Atmospheric;
Changeover of Master and Remote functions;
Fine Readings - 20 cavities from 10 to 0.5;
Atmospheric;
Coarse Readings on cavities 2½, 5, 10.

16.27 At the start of the survey, these 40 cavities were calculated as one measurement, but in order to increase the number of comparisons, in case of some anomaly in conditions, and for interest, this measurement of 40 cavities was broken into two measurements, each of 20 cavities.

16.28 A second measurement of 40 cavities would be made some hours later, probably next day and, if possible, under quite different conditions - for instance, if one of these measurements was carried out during the day, the second might be attempted at night.

16.29 Where there was a disagreement between the two measurements, a third would be taken, sometimes a fourth, giving four, six or eight comparisons, when broken into their forward and backward portions, each of 20 cavities.

16.30 In examining the graphs of the plotted fine readings, it was seen that those below cavity 2 (which in most cases in the field had been difficult to obtain) fell away erratically and gave an unbalanced result if meaned arithmetically.

16.31 This was confirmed later in Australia on the test line near Melbourne, and accordingly the readings made below cavity 2.5 were removed from the meaned values, and future readings were confined to the 16 cavities between 10 and 2.5, where swings were usually in the order of 2 to

4μs, with no wide swings encountered.

16.32 Early in the survey, Army parties were occupying AA033 and AA034, two coastal stations 694 and 1320 feet altitude, whilst National Mapping parties were simultaneously occupying Mounts Albert Edward (13,090 feet) and Victoria (13,240 feet). It was hoped to measure all distances and directions in this braced quadrilateral, to allow an investigation into the meteorological values under such interesting and widely divergent conditions, but unfortunately two angular directions were still unread when the lower stations had to be vacated.



The camp on Mount Wilhelm on 25 December 1963. The party was fortunate to find this ledge only 300 feet below the summit and up and down which there was a very awkward climb, especially in the night, when it was generally made.



Mount Victoria, 13,240 feet, looking westwards, with the observing tent and camping tents separated by about 100 yards. It was difficult as a rule on most mountains to find sufficient fairly level area for tent erection.

16.33 However, there are other rays with large differences in heights, and other figures with redundancies, which offer a variety of low level values carried through trigonometrically to high level values (or vice versa) - that is, deduced values compared with actual measured distances. Even allowing for the difficulties of angular work on these mountains, the clouds, the murk, the mossy standpoints, it should be possible to deduce quite strong values for comparison and exclude the distance measurements which it is wished to investigate.

16.34 The average distance correction of 0.48 feet in the adjustment seems surprisingly small when the long lines and varied conditions are considered; so also are the close agreements in measurements on different days and at different times of the day or night, such as the 121 mile line from Aird Hills (1,060 feet) to Mount Bosavi (7,863 feet). These stations are just intervisible above the horizon on very clear and rare days. This ray travels low over the hot, humid and hazy delta swamps for much of its distance before climbing into the cooler atmosphere nearer Bosavi. Another example is the line Mount Karimui (8428 feet) to Aird Hills (1,060 feet), where the direct line would pass about 300 to 400 feet below the intervening Mount Favenc range (5196 feet), and thence over the hot delta swamps to Aird Hills.

16.35 Investigations and research are being made into these measurements and data and it is expected that a separate report will be published later.

16.36 Some of these field data are listed in Appendix 2. Typical examples are given of differences of heights, temperatures, vapour pressures, weather and terrain conditions, and the individual means of each set of 16 cavities. Also shown are the corrections made to each line in the final computer adjustment.

17. Corrections to Field Measurements

Angular Corrections

17.1 The average triangular misclosure in New Guinea was 01.75", the largest triangular misclosure being 05.55" in the triangle Wilhelm, Otto, Karamui. An examination of the side equations around this figure resulted in the rejection of the ray from Wilhelm to Otto. During the occupation of Mount Wilhelm, there was a heavy snow storm, and severe physical conditions may have contributed to the poor value of this direction, since the theodolite standpoint at such an altitude of nearly 15,000 feet was on bare, solid rock. Rejecting the ray Wilhelm to Otto, the largest correction then on any direction, which was accepted for the final adjustment, was the direction from AA034 (Cone Hill) to Mount Albert Edward - a correction of 03.76".

17.2 The average correction to all directions in the adjustment regardless of sign, was 00. 69".

Distance Corrections

18.1 The maximum correction to a distance accepted for the final adjustment was from AA034 (Cone Hill) to Mount Victoria - a correction of 3.83 feet.

18.2 The average correction to all distances in the adjustment regardless of sign was 0.48 feet (See Appendix 2 for examples of corrections applied in the adjustment).

18.3 Of interest are the corrections made by the adjustment to the three long lines, each over 100 miles, these corrections being:

Stations	Distance	Correction
Suckling - Victoria	114 miles	2.19 feet
Bangeta - Strong	114 "	1.50 "
Aird - Bosavi	121 "	0.34 "

19. Azimuth Control

- 19.1 Azimuth control obtained during the survey is shown on Appendix 1.
- 19.2 Several of the results were not used in the adjustment in view of inexplicable differences in the forward and back bearings. At Mount Kenevi the value towards Mount Victoria was 7" different from the reverse bearing, and from Mount Karoma to Mount Wamtakin the forward and reverse values disagreed by nearly 12".
- 19.3 The only explanation which may perhaps be given to these wide discrepancies is a bad instrument standpoint on the spongy, mossy ground at Kenevi, with some thrust placed on the tripod leg at the times of pointing on the referring object. The dislevelling of the bubble might have passed unnoticed in the dark, and the bubbles returned to normal when read on the star, when perhaps there was no thrust placed on the tripod leg. In the case of the Wamtakin Karoma value, the lamp may have been placed on the eccentric station instead of on the top of the beacon which was normal practice. The only course open in the circumstances was to discard these offending rays, but with great regret at the lost opportunity and the effort which goes into such work.

20. Heighting Misclosures

- 20.1 The heights observed and adjusted by the Army on the shorter lines of the coastal traverses were adopted and the high traverse adjusted to it, wherever connections were made.
- 20.2 Discrepancies were surprisingly small in the circumstances, except for Mount Hagen, which was intersected from Mounts Murray, Ialibu, and Karimu at the close of 1963 and gave very wide disagreement between the three values. However, in the early part of 1964, the Department of Lands, Surveys and Mines (TP&NG) carried out control in the Mount Hagen area over shorter lines, including reciprocals between Mounts Ialibu and Hagen, and these later values were adopted.
- 20.3 A sea-level check at Kikori, in November 1964, on the adjusted value of Aird Hills over the Port Moresby - Victoria - Hagen - Aird - Port Moresby surround gave agreement within several feet. Coming around from the north on the Army traverse from Vanimu to AA075, thence through Mounts Wamtakin, Karoma, Doma to Islibu, the misclose was 14 feet.

21. Deflections

- 21.1 Some of the largest deflections between geodetic and astronomically observed positions were:

Station	Meridian (")	Prime Vertical (")
Gumboro (AA033)	24.90	- 14.45
Otto	30.32	- 21.94
Piora	22.07	- 13.27
Hiran 37 (Sepik)	04.50	26.46
Shungol	31.28	11.22
Wilhelm	26.08	26.06
Wurung (AA067)	43.80	1.75
Hiran 19 (Kumun)	- 27.70	1.05

22. Geodetic Coastal Traverse and Topographical Control by the Royal Australian Survey Corps

- 22.1 It was initially planned by the Director of National Mapping, in the overall scheme of geodetic control in New Guinea, that the Royal Australian Survey Corps would survey the coastal and

Markham Valley traverses, intersecting the high level beacons wherever these were visible from the lower stations.

- 22.2 Accordingly, in May 1962 Major J. L. Stedman, in charge of detachment of 33 members, arrived in New Guinea to commence this work, supported with a Bell G2 helicopter, equipped with floats, and an LSM (landing ship medium) from which the helicopter operated most of the time.
- 22.3 The party traversed westward from Station AA001 to AA013 and from AA001 around the eastern tip of New Guinea to AA028 (see Appendix I), encountering heavy clearing on many of the stations, and measuring 594 miles of geodetic traverse. In addition, a number of 3rd order control points were emplaced, and topographical detail (such as names, tracks, heights, etc.) collected, with the pattern for future control becoming established by the time the detachment returned to Australia in November, 1962.
- 22.4 Major N. R. J. Hillier, in charge of 31 members, arrived at Lae by Hercules aircraft in April 1963, shortly before their supporting landing-ship and helicopter. Before leaving Port Moresby in November 1963, to complete some of the measurements of the stations on the connecting traverse across Torres Strait from Cape York to Dauan Island, the detachment had measured 1180 miles of the geodetic traverses along the coast and up the Markham and Ramu Valleys from AA027 to AA067 (near the West Irian Border on the northern coast at Vanimo), and from AA013 (near Kerema) to Aird Hills at Kikori. In addition to the geodetic work, 3rd order control and topographical detail were also obtained, as the main traverse progressed.
- 22.5 Major E. U. Anderson, in charge of 33 members, arrived in May 1964, with supporting landing craft and, for some of the period, with two helicopters. The party measured 370 miles of geodetic traverse from AA053 (at Madang) around the Huon Peninsula to AA039 (at Lae), and from PM63, near the West Irian Border southwards to AA075. Preparation was made for Aerodist control in the eastern vicinity of the West Irian Border and 3rd order control and detail were established.
- 22.6 All the Army stations have been well marked with steel quadrupods, supporting galvanised vanes 14 feet high, with concrete ground and reference marks, and steel witness posts of 2" galvanized pipe. It should be realized that in tough terrain, good marking represents about 50% of the survey effort, and without which the marks can be lost in less than a year, together with much of the value of the survey.
- 22.7 In 1965 further Aerodist control was measured by the Army near the Border of Western New Guinea, and a geodetic traverse run from Hiran Station No. 36 (near Wewak) southwards to Damn Peaks.
- 22.8 In the early stages of the work in 1963 the Army with its powerful receiver, and transmitter which could be tuned, would listen in on our daily A510 schedule between our sub-parties, relaying messages and would make voluntary offers of any support which might help. The two agencies could scarcely have worked in closer cooperation had they been one unit, combining with measurements between adjacent stations, and with instruments, fuel and helicopter assistance to each other.
- 22.9 It was a comforting feeling to know, should some major mishap arise, that there was powerful, immediate support, operating nearby with the same single purpose of obtaining control to map the country. When the Army Survey detachments, having made earlier arrivals, returned to Australia in the months of November 1963 and 1964, there was a real feeling of the loss of ready and reliable friends in a common cause. It was always a pleasure to work alongside and together with the Royal Australian Survey Corps.

23. South West Pacific Hiran Survey by the United States Air Force

- 23.1 The United States Air Force, assisted by units of the United States Army and Navy, during the period September 1962 to June 1964, extended their South West Pacific Hiran Survey to join New Guinea and the adjacent islands to the geodetic network on the mainland of Australia.
- 23.2 This was a major operation, entailing the massive support of four B29 Superfortresses fitted with their electronic equipment for the line crossing Hiran trilateration measurements and for the azimuth observations using a brilliant light on cross-line flights. Large helicopters and various medium and small ships were also needed.
- 23.3 It embraced heavy clearing and strong pads to take the large helicopters on such 11,000 feet mountains as Hiran Station No. 22 at Mount Kenevi (known in the United States records as Myola) and Mount Kahan, Hiran Station No. 37 (known in the United States records as Sepik). It required hutage to accommodate the Hiran parties, and also the Army Map Service parties who observed the long-line crossing azimuths and latitude and longitude positions, and who were in occupation of their stations for months whilst awaiting suitable weather.
- 23.4 The network over this section of the project consists of 141 Hiran measured distances and 29 Hiran stations, as shown on Appendix 3. The longest line measured was 545 miles, the shortest was 84 miles, and the average length was 346 miles.
- 23.5 Six of the Hiran stations were installed on stations of the geodetic network on the Australian mainland or nearby islands, and six were embraced as stations in the New Guinea closed loop geodetic control.
- 23.6 Four long-line azimuths were observed by the light-crossing technique, in which procedure the line between two Hiran stations is crossed obliquely by an aircraft bearing a light, which is sighted on simultaneously by observers at each end of the line, using recording theodolites. Laplace corrections are subsequently applied.
- 23.7 Additional orientation was provided by data derived from the Australian and New Guinea geodetic networks.
- 23.8 A comprehensive report, from which these details have been extracted, has been prepared by Headquarters, 1370th Photo-Mapping Wing, Air Photographic and Charting Service (MATS), United States Air Force.

24. Gravity Survey

- 24.1 In March 1963, whilst the helicopter support was being planned in Port Moresby, Mr. J. A. Brooks, Officer-in-Charge of the Port Moresby Bureau of Mineral Resources Geophysical Laboratory, discussed the possibility of obtaining gravity readings on all geodetic stations in New Guinea. Immediate approval was given by the Director of National Mapping for this to be done in conjunction with the forthcoming geodetic survey.
- 24.2 Arrangements were made by Mr. J. A. Brooks with Professor Carey of Hobart University for a graduate observer, Mr. Paul St. John (specializing in gravity work for his Doctorate degree), to carry out these measurements with a BMR gravity meter, fitted with a high altitude geodetic dial. He also contacted Colonel Iverson, the Commanding Officer of the United States Gravity Survey in Tokyo, who supplied a second gravity meter, with high altitude dial, and an Army observer.
- 24.3 These two observers were available throughout both the 1963 and 1964 geodetic surveys and, with the cooperation of the Royal Australian Survey Corps, gravity readings were obtained on all 1st, 2nd and 3rd Order stations established during the periods, and also on the Array traverse

stations established in 1962.

24.4 Generally the observers went in with their meters on helicopter supply trips whilst the stations were occupied, the helicopter giving quick turn-around and short interval checks between bases. Many check readings were obtained with the two instruments on various stations. This whole gravity survey proceeded very smoothly, due in no small measure to the enthusiasm and readiness, often at short notice, of Mr. P. St. John to avail himself of every chance to obtain readings, whether by helicopter, commercial air flights, boat, motor vehicle or on foot, as well as co-operating in any way possible on the whole geodetic operation.

24.5 Combining the gravity and geodetic surveys meant a great saving in costs, since at most stations helicopter pads were constructed of local trees or of light pine timber, after the landing areas had been cleared. These pads quickly rot, of course, as well as becoming rapidly overgrown. Just how rapidly may be gauged by the fact that on some of the coastal stations established by the Army in 1962, within nine months regeneration 8 feet high had to be cleared before the helicopter could land, the observers first coming down a knotted rope to do the clearing.

25. The Technical Observers

25.1 Some time before the measurements were to begin, some of the experienced members of the technical staff of National Mapping were asked if they would care to join the observing party in New Guinea. This was done after first carefully and fully explaining the conditions and difficulties likely to be met, and in no way minimizing or glossing over them especially the likelihood of being caught on some bleak and bare peak for a week or a fortnight, with hammering wind and icy continuous rain, and with visibility never more than 50 to 100 yards, in a dreary world, clammy, damp and cold.

25.2 If visibility between peaks is to occur, then it will most probably be at sometime from about 0000 hours till about 0930 hours. Each man, therefore, had an alarm clock which was set at 4 hour intervals, so that one or the other member of a sub-party would inspect the weather during the night every two hours. If the weather was likely to be suitable, the inspecting member would waken his companion.

25.3 This would be happening on adjacent, occupied stations, and should the line be clear enough between two stations, simultaneous azimuth observations might be attempted, or tellurometer measurements. The latter, however, with the giant 48" reflectors was possible under any conditions of visibility, though differing conditions for two measurements, preferably on different days, was always the aim. If intervisibility with another station was not possible, but the sky overhead was clear enough, latitude and/or longitude observations would be commenced. Simultaneous vertical angles were usually read after dawn to opaque beacons or to hellos. The clear night lines, all too few, were used for the so-hard-to-get rare azimuth observations.

25.4 Where every step in daylight is tentative, uneven and awkward, the frustration may be appreciated, perhaps, of getting up in the clinging damp and the stumbling dark, of making contact with another party (usually by wireless), of putting up the instruments and of being all set to start, and then of having the chance wiped out by a single, slow-forming, drifting cloud, or a sudden armada of them, at one or both ends or across the middle - or worse, about half-wiped out, with sufficient hope of long enough clear breaks to encourage the parties to hang on and end up with useless broken arcs - not once, but again and again, throughout the survey.

25.5 At sea-level in the islands, any breeze in the almost saturated air can be cool enough in the small dark hours to be very uncomfortable as many find out after sleeping uncovered near some opening even in the protection of a building. On the low station, AA008 (864 feet) near Yule Island, members were glad enough, near 0300 hours, to climb into their heavy neoprene suits -

the dry bulb temperature being 72°17, with a light breeze, normally optimum living conditions.

- 25.6 From 10,750 feet high Mount Yule, through the tellurometer speech relay, the chattering teeth of the operators could be heard as they struggled to complete the early, tedious measurements, with small 17 inch dishes only. This told the effect of 40°F of damp, raw cold, thin clouds and saturated, moving air, even fairly slow-moving, under conditions far from extreme in comparison with some subsequent experiences on the high stations.
- 25.7 The sub-parties averaged two to three weeks on each station, though four weeks were not uncommon and five weeks occurred, especially on the western section, from Mount Hagen to the Border. This is the worst area in New Guinea for cloud coverage, with the great basins and swamps of the Sepik to the north and of the Fly to the south, conditions bad enough for control surveys but far more difficult for obtaining mapping photography.
- 25.8 To fly over an occupied station, with the tiny tents perched near the rim of a sheer fall, could make the yellow, waving figurines look indescribably lonely. They looked so vulnerable on the mighty peak and the eyes would blink, a trifle hazy momentarily, at the reminder, never in the background, of the responsibility to these men, loyal, patient and uncomplaining. They were on that stupendous point because they had been invited to help on an important defence and development project, waiting, without heroics, for an opportunity to complete it, and relying on being given any reasonable support.
- 25.9 Or again, on the daily radio call, with day after day of complete overcast on the mountains through the long-range effects of Cyclone Flora, the quick, cheerful voice of the leader of a sub-party which had spent five weeks on one mountain and two days moving to another, with all the attendant heavy packing, and endless loading and unloading in and out of small aircraft and helicopters and on which it was now in its fourth week, "Good morning: Yes, we're all right. Still clouded in. Nothing we need, thanks.", could bring a deep breath and a pause before replying, could prevent the tacit request to stick it out, and could make the day seem suddenly brighter and more assured of success.
- 25.10 Most of the 1963/64 party came up for the 1964/65 work when invited, several eagerly, but some declined. All were well aware of what lay ahead and that they would celebrate their second successive Christmas and New Year on some cheerless eyrie, probably clouded in, however they would have to accept this since this would be the doldrum period when success was most likely.
- 25.11 Spending these long periods, almost all of it under unpleasant conditions and disappointing frustration, cooped in a small tent with restricted visibility and movement, ready to seize on any small chance for observations, a man needed to be well adjusted. The Division was fortunate to have men with the technical knowledge, the calibre and the fibre to do it.

26. Power Generators and Batteries

- 26.1 It has been Division of National Mapping Policy to keep well-charged batteries for tellurometer measurements, and battery chargers have been normal ancillary equipment for each tellurometer.
- 26.2 Recent tests with a frequency counter have shown this to have been a wise and fortunate policy, so far as the accuracy of the measurements have been concerned, since the crystal frequency changed by 11 cycles in one MRA2 instrument, for each one volt drop in battery output, and by 17 cycles per volt in a second MR.A2 unit used in the tests.
- 26.3 The generators most commonly used since 1957 have been the Johnson Chore-Horse, obtained new and cheaply from ex-Army disposals. They have generally been reliable, though very noisy and weighing about 110 lbs in their carrying boxes. Several were opened out of their hermetically sealed sheet-iron containers in 1964, emerging as new, though made in the early

1940's.

- 26.4 To avoid this excessive weight for the helicopter, four small "Tiny Tiger" 12 volt generators were purchased in Port Moresby in 1963. They were high-revving units (about 7000 revolutions per minute) made in Japan, and weighed 12 pounds. Two of them performed well and two blew up very quickly. Initially 100/130 octane avgas was used in all generators, apparently fairly satisfactorily at these high altitudes, though subsequently normal motor spirit was supplied.
- 26.5 A charger now available, the Honda ED 250 12 volt generator, would have been useful on this survey. It is quiet running, charges at about 15 amps and weighs 40 pounds.
- 26.6 A lead-acid Massey battery weighing 45 pounds, with good weight-capacity ratio, was standardized for the survey and performed well. Fibre-glass carrying cases for each battery were specially made, but even within these cases, the carrying of wet batteries was not permissible in fixed-wing aircraft under Civil Aviation regulations, except by prohibitive draining of acid, and packing in absorbent, neutralizing whiting, etc. Accordingly they were usually moved on the outside litters of the helicopter, and by road from Lae to Goroka. Because of their weight and of restrictions on transportation by normal aircraft, they were always a problem.

27. Wireless Inter-communication

- 27.1 In 1962 portable A510 transceiver wirelasses were used in New Guinea on some administration patrols in remote areas. They were also used by our beaconing parties, mainly to arrange airdrops of rice, cement, beaconing materials, etc., which would otherwise have had to be transported by native carriers, who were often difficult to obtain.
- 27.2 Six of these sets were initially obtained on loan from the Department of the Army for use on the high survey in 1963. This type of transceiver weighed 40 pounds in its rather massive wooden, carrying box, but the chief advantage was that the transceiver was dry-battery powered and thus saved the carrying of a heavy lead-acid accumulator and charging motor. This advantage was outweighed, however, by its lesser performance when these accessories were already being carried for other purposes, such as tellurometer battery charging.
- 27.3 At times the A510 wireless worked surprisingly well, as with many wirelasses, depending perhaps on some abnormal atmospheric conditions, and there was a big all-round increase in performance when a new batch of dry batteries was obtained direct from the Exide makers in Australia. These replaced those obtainable in New Guinea, which had apparently been in store under hot, humid conditions for too long.
- 27.4 A dipole aerial of fairly critical length was needed for good clear results at some stations. This was not always easy to erect without the aid of poles.
- 27.5 A few weeks after the survey commenced in May 1963, a 12 volt Traeger TM2 transceiver was sent up from Melbourne to be used as a master set. It weighs about 20 pounds and is equipped with a 35 feet high whip aerial, telescoping to 5 feet. Good clear areas, free of interference and 3 or 4 miles from any sizeable town, were selected for operation of the master set, which called all occupied stations every day.
- 27.6 In November 1963 two more Traeger TM2 sets were used on mountain stations, and in October 1964 all sub-parties at every station were equipped with Traeger TM2 transceivers. They are powerful, compact sets, which generally established communication to each other on the 3 M/cs range for close work between intervisible stations, and on the 6.8 M/cs range for distant calls. On occasions it was necessary to pass messages to one station, through another. There was no trouble in speaking over the 500 miles between Port Moresby and Telefomin with two of these sets on the 6.8 frequency, longer distances sometimes being much better than mid-distances, as

most wireless operators know. Some of the technical discussion, such as comparison of data, atmospheric, etc., was done over the tellurometer system. Mostly, however, the calls at pre-determined times between all sub-parties in occupation of their stations, to discuss weather conditions and arrange reciprocal work, especially chances of intervisibility between stations at night, were made over the wireless 3 M/cs frequency. This saved the heavier battery drain of the tellurometer, with also its lesser convenience of directional pointing from station to station.

- 27.7 The helicopter and survey parties on the New Guinea work were all, equipped with the 6.8 M/cs crystals as a listening security measure when the helicopter was airborne. Transmission from the A510 was not strong enough to be heard by the pilots above the engine, but the Traegers bellowed in, advising them of cloud and wind conditions around the summits. This saved what might otherwise have been many abortive attempts to visit stations and the fruitless consuming of engine hours and avgas, both very costly items in remote areas.
- 27.8 The Traeger transceivers did much to aid the survey, not only in passing data and requests for supplies, etc, but as a help to security, morale and well-being.
- 27.9 It is disturbing to hear no sound from a station known to be equipped with a transceiver, but except for several minor troubles, these sets performed well at all times.

28. Camping Equipment

- 28.1 In late August 1959, an experience on Mount Victoria helped considerably in the design of future equipment. The writer spent nine days on the summit and a further four days on the descent, during which time buffeting, gale force, south-east winds and cold, driving rain continued unceasingly, except for a single break of about six hours. The temperature during almost the whole period on the summit ranged from 34° to 40°F, unpleasant in the rough, strong wind and continuous, pouring rain. It gave warning of what could happen on the survey and how the parties should best be equipped to live, as comfortably as possible, for long periods under such conditions. Even to hold down the 12' x 14' tent and to prevent it tearing to pieces, required a wall of rocks around it and constant attention to the ropes and stakes, because the irregular sloping ground prevented it from being erected squarely and properly. Subsequently camping equipment was carefully selected or specially designed accordingly.

29. Tentage

- 29.1 A light, waterproofed japara silk tent 8' x 10', with aluminium poles was supplied to each member. After a few months in the heavy rains, some of the waterproofing washed out, so flies were added, which then made them quite dry and free of leaks.
- 29.2 They would be well laced up and were fairly warm inside when the kerosene lamp was alight. On some of the lower traverse stations, near sea level, their dark brown colour made them unbearably hot in the full rays of the sun and it was necessary to throw white calico flies over them. They stood up to the frequently boisterous, heavy winds on the exposed summits where the restricted areas often made them difficult to erect and they were generally satisfactory and hard wearing.

30. Bedding

- 30.1 Each member was supplied with two Orlon filled sleeping bags, a Lilo rubber air mattress, rubber air pillow, a Verylite canvas waterproof ground sheet, 9' x 8', and a strong but light, steel and canvas Rest-well stretcher.

31. Lamp and Cooking Stove

31.1 A pressurized Tilley lamp, and a small, one-burner, folding Primus stove were issued to each member. Both were kerosene burning, were economical and supplied quite a deal of warmth in the tent. This, in fact, was the only heating, since any available wood, when a station was not already above the timber line, was either green, or rotten and saturated. Meta-tabs, solid methaldehyde tablets in stick form, were used when available to heat - prime the lamp and stove. This avoided the danger of natives stealing and drinking methylated spirits, on the sale and carrying of which, there were rigid restrictions in New Guinea.

32. Food and Water

32.1 The sub-parties on the summits lived solely on tinned food, supplemented with potatoes, and very occasionally a few bananas and paw-paws. In several instances a little fresh meat was sent in, but in that tropical climate this was always risky, since it had to be taken out of its deep freeze as late as possible in the afternoon, placed in an ordinary refrigerator over night, where it thawed and was then put on the helicopter next morning.

32.2 If the weather prevented the helicopter's departure that morning at daylight, then the thawed meat would certainly be lost.



MOUNT OBREE - 10,022.6 feet.

Helicopter pad of sawn timber has been laid and wired into place. Being a lower mountain than others in the high-level net, there was heavy scrub and timber to be cleared.



Mt Wilhelm 14,793 feet altitude on 27 December 1963, with the temporarily dismantled beacon and domed observing tent, also the tent in which one man could wait and watch for any clearing of clouds before calling the others. Snow-storms can arrive at any time of the year on this mountain, as is indicated.

- 32.3 Three weeks supply of tinned food was taken in to each station at the beginning of the survey, but later this was increased to five weeks, in case of prolonged bad weather with the impossibility of a visit by the helicopter or the possibility of its breakdown.
- 32.4 About 12 gallons of water were flown into a station at its initial occupation, just in case no rain fell for the first few days. Generally, however, the only problem about water was its abundance, and on the rough, restricted steep-sided summits quite often the occupant could well find he had a three feet wide stream, 3 or 4 inches deep flowing through his tent and under his stretcher during the usual afternoon and evening downpours - convenient enough whenever he desired a drink of cold water in a general ambient temperature of about 26° to 40°F.

33. Containers

- 33.1 In the continuously damp atmosphere, most things needed to be kept in waterproof containers, and a large supply of plastic bags in various sizes and thicknesses, from 10" x 18" up to 20" x 48", were used for wrapping books, clothing, instruments, etc. Also bags 20" x 40" were made of the waterproof Verylite canvas with other sizes of Verylite bags made for special requirements. Water was carried in a thick 20" x 48" plastic bag, placed inside a Verylite canvas bag, with the tops of both bags well tied.
- 33.2 Carrying boxes, 19" x 13" x 11" made of 3/16" waterproofed bondwood, were used to carry clothes, field books, etc. They had a lip overlapping the outside edges of the lid by 1" all around, with refrigerator sealing rubber under the lid, which completely moisture-proofed the box. Heavily painted inside and outside a bright yellow, they were useful and successful, so long as they were not used to carry heavy tinned food or tools, which could break through the bottom.

34. Protective Clothing

- 34.1 In the raw, wet, clammy cold on the 8,000 feet and higher summits, accentuated by the slightest breeze, and on a clear night when the breeze drops, frost quickly forms on the ground and on the instruments. The ground is damp, grassy or mossy, and cold, and it frequently turned to mud after a few days occupation, and anyone spending long periods on these exposed stations needed proper protection.
- 34.2 Two sets of waterproof clothing were used:
- 34.2.1 Nyloprene - a fairly thick yellow uniform of pull-on trousers and mid-length, laced-up coat with hood. This was completely waterproof at all times, strong and protective though somewhat heavy for easy movement around the theodolite.
- 34.2.2 Nyloprufe - a light, waterproofed, yellow nylon outfit for working around the instruments, of the type generally used for yachting, with pull-on trousers and short, laced-up coat with hood. The continual heavy rain washed out the water-proofing over the shoulders, but they were good for observing, being light, unrestrictive and warm.
- 34.2.3 Rubber Ankle Boots (Dairy Boots) and Army Gaiters were worn on the summits. The rubber boots were cold but dry under the always wet and usually muddy conditions prevailing on the summits. In case of an accident to the helicopter, all members had their normal heavy hoots fitted with hardened-steel, climbing tricounis for walking out.
- 34.2.4 Thin Woollen Gloves (not mittens) with thin cotton gloves pulled over the woollen ones, to prevent holes wearing quickly, were used by some observers. These were well worth persevering with to become used to them, since cold fingers, devoid of sensitive touch, can strike and bear heavily on the theodolite, whereas the double gloves kept the fingers warm and sensitive, cushioning any impact and acting like cat's whiskers when feeling for the clamps and tangent screws. The small hand warmers, with the slow burning wick, were used by both observers and bookers to some extent.

35. Survival Equipment

- 35.1 Whenever anyone was landed on a mountain, however short the intended stay might be, whilst the helicopter left for more equipment or supplies, the first thing he unloaded was his rucksack, in which he had his heavy Nyloprene clothing, matches wrapped in plastic, sleeping bag, some food and a large sheet of plastic. He was never left unprotected in the event that the helicopter was unable to return. When a sub-party was occupying a station, the first man, usually the assistant, was flown in with this camping equipment, tentage food and water, then the instruments came up and extra food, and finally the sub-party leader and his camping equipment on the last load to ensure that nothing had been forgotten. On several occasions, the first man was on the summit for 4 or 5 days before the weather allowed the second man to join him.

36. Health

- 36.1 The health of all members of the party whilst in New Guinea was good. Injections and inoculations were taken for typhoid, tetanus, smallpox and influenza, and regular preventative weekly dosages of Camoquin or Nivaquin, or daily dosages of Paludrine were taken against malaria. Five of the party developed malaria on their return to Australia, but with no complications, though four went to hospital for treatment.
- 36.2 The helicopter makes for sudden, fierce, climatic changes, from the steaming coastal areas, for example, Port Moresby, to the raw wet cold of say Mount Victoria, 13,300 feet up in less than an hour.

- 36.3 These quick uplifts almost invariably gave a severe headache on the first day, possibly from the adjustment pressures of the sinus and antrum cavities, and a rather dull sick feeling. On the ground, when climbing these mountains, one adjusts over a number of days to the changing altitude - often, only too often, by climbing; to say 6, 000 feet, dropping to 1,500, climbing and sidling to 7,000 feet then back to 3,000, and then the final ascent perhaps to 12,000 or 13,000 feet, with minor falls of 1,000 or 2,000 feet occurring. Although commencing at 5,000 feet at Woitepe, 23,000 feet of elevation were climbed before reaching the summit of 13,300 feet Mount Victoria. In many parts, the steep and slippery sidlings and descents were harder to negotiate and traverse than the ascents.
- 36.4 There was always the real fear that someone might develop a serious illness on a mountain, with the weather closed in and the helicopter unable to reach him, perhaps for a fortnight. This fortunately did not occur, nor were common colds encountered, and there were no accidents to the surveying parties.
- 36.5 The dangers of leaving a camp and becoming fog-bound, or of attempting to walk down most of the mountains should wirelesses fail, particularly without native police or local carriers, were constantly stressed in verbal and written instructions. When the local guides had to stop, to confer and search around on some of the final approaches of 3 or 4 day climbs, there would be small hope for, and little trace of, any European ignorant or rash enough to attempt most of the descents of tracks, which were difficult enough to follow at the time of beaconing, one or two years before, and again grown-over of course.

37. Light Aircraft and High Altitude Helicopter Support

- 37.1 For many years movement and support by aircraft have been a feature of New Guinea. Many people are aware of the opening up of the Wau and Bulolo goldfields between the two world wars, by Junkers aircraft, and the carrying of the massive, great mining equipment and supplies in these lumbering, reliable machines.
- 37.2 In late 1959 the first Piaggio, a light to medium twin engined plane arrived in New Guinea, and in 1960 the light Cessnas, which have done, and continue to do, wonderful work. These were followed by other light twins such as the Piper Aztec and the first Beechcraft Baron, and in 1964, by the push-pull Cessna Skymaster, which has twin engines in line.
- 37.3 It was astonishing what could be carried in these light aircraft, and the manoeuvring which went on to get instruments, long screen and beacon poles, and other awkward packages into them.
- 37.4 The initial survey reconnaissances were done by aircraft, and with the introduction of the first commercially owned Cessnas in 1960, airdrops of food and materials, mostly in double bags - the tight inside one usually bursting and the outside loose one holding, helped administrative patrols in remote parts of New Guinea. Where carriers and local food were hard to get, air dropping became a routine procedure for almost every beaconing expedition, especially in the south-eastern section of New Guinea, where carriers were few and sophisticated.
- 37.5 Pilots of these aircraft in New Guinea were very experienced and determined. They flew as a matter of course under difficult and perilous conditions. Their navigational skill and local knowledge and quick recognition of the country allowed them to locate themselves at times by a single, short break in the thick overcast, and let them carry out their missions and also survive.
- 37.6 Aircraft charters were unobtainable for a week or more before Christmas 1964, however on 22nd December, because it had been booked well ahead, we were able to get a 180 knot Beechcraft Baron. This lovely aircraft was loaded to capacity, carrying equipment, perishables and passengers for the all out effort to complete the traverse and the joins to Hiran Station 37 near

the Border at Telefomin.

- 37.7 Twenty miles out of Mount Hagen, over the DCA radio control network it was heard that the Piaggio from Wewak had turned back from Telefomin, long before reaching its destination, as it was unable to get in. Our pilot asked was it desired to continue. The \$160 decision was made somewhat easier by memory of the remarkable skill, cool confidence and ability of this New Zealand Air Force trained, young pilot, who had a few weeks previously, flown the Cessna Skymaster on reconnaissance for the Telefomin and Star Mountains connection.
- 37.8 At 12,500 feet, by dead reckoning near Telefomin, with nothing visible but the cloud layer just below, he began to ease into it. He was well aware that the clouds in the area, from 13,000 feet downwards, could be full of rocks and big timber. This was confirmed, from time to time, as slightly darker blurs, formless and sinister, slid alongside and past.
- 37.9 About 8,000 feet, breaking abruptly into a valley which could equally well have been an inescapable pound with flanking narrowing walls disappearing into the obliterating fog of universal grey, but recognized by the pilot from his recent work, he weaved his way down valleys and around near-enveloped spurs and ridges to emerge suddenly a few hundred feet above the strip. This revealed the slim, graceful lines of the blue-nosed Baron to the unbelieving gaze of those gathered at Telefomin.
- 37.10 These pilots, almost to a man, were cheerful, co-operative and efficient, and helpful with advice in arranging back-loading wherever possible to reduce the cost of, otherwise, two-way charges. In this matter of efficiency and co-operation, mention must also be made of the oil companies and their agents. They were so often contacted at short notice and requested to send fuel and oil to avoid a helicopter hold-up. They always responded immediately, since clearly a large supply of fuel could not be emplaced instantly in some remote spot, but had to be ordered as the work progressed and delivered when the weather permitted.
- 37.11 The Director of National Mapping, in early discussions with the company of Helicopter Utilities, had advised that there would be a requirement for a light helicopter capable of landing on the 10,000 - 13,000 feet summits of New Guinea with a useful payload. On 21st May 1963 this company made available two high-altitude Bell G3B1 supercharged helicopters which were the first of their type to arrive in Australasia. One was on contract to the Royal Australian Survey Corps and the other to the Division of National Mapping.
- 37.12 After preliminary testing in Port Moresby, the machine allotted to National Mapping, carrying two pilots and a passenger, landed on the summit of Mount Victoria, 13,300 feet high, on the morning of 23rd May. This proved that these light machines would revolutionize movement in New Guinea.
- 37.13 It took a month to climb and reconnoitre Mount Victoria, in 1959, from Woitape, and the same period to beacon it, in 1962, from Port Moresby. In one clear morning, it was now possible to place the two members of an observing party, with all their stores and technical equipment and a month's food, on a 13,000 feet mountain. It was comforting to know, too, that the delicate optical and electronic equipment had been transported carefully and gently, with the minimum of handling, and should function as it was intended to function. In the event of an equipment failure it could be possible, the weather permitting, to send in a replacement next morning.
- 37.14 These Bell G3 helicopters used 15 gallons of 100/130 octane avgas per hour, cruised at about 80 mph and climbed at more than 1,000 feet a minute. Their endurance with a reasonable payload was slightly over 3 hours with full tanks. This could be varied by balancing payload against fuel load. For a safe sortie of about 2 hours (entailing landing on a pad at 10,000 to 13,000 feet altitude) the payable load was 350 lbs, provided there was a clear take-off path running downwards from the pad. Early starts, before the air became hot and thin and before clouds built

up, were of prime importance.

- 37.15 Light helicopters work in conjunction with, and not in competition with, fixed-wing aircraft, the idea with a light helicopter being to use it as a lift, and therefore it was necessary to get bases as close as possible, in horizontal distance, to a station. Where considerable distance was unavoidable, or where there was a poor pad supplying little ground effect to help the helicopter, it might pay to move about 450 lbs, unload half of it at some suitable point at about 7,000 - 8,000 feet, take the half load to the 10,000 - 13,000 feet summit, and then return for the remainder. This avoided the risk of a well-laden machine, with resultant sloppy control, trying to alight on an awkward peak, the alternative being to double travel all the way with light loads.
- 37.16 The ground, even on the peaks with outcropping stone, was usually damp, soft and spongy. To give a firm and even surface for the skids of the helicopter (skids were always used for the mountain work, never floats), pads were constructed by the beaconing and clearing party, wherever suitable local timber was available; otherwise five lengths of undressed pine (to avoid slip) 10 feet by 3 inches by 2 inches were carried on the first helicopter flight to a mountain station, usually underneath on the quick release sling.
- 37.17 The pine lengths were already drilled with oversize bolt holes to form two longitudinal main bearers, spaced the width of the skids apart, with three lateral supports at right angles. On an awkward summit, or where there was plant regeneration these lengths could be dropped and a passenger get out or climb 5 or 10 feet down a thick knotted cotton rope, clear away the bushes or saplings, bolt the pad frame together and allow the helicopter to land.
- 37.18 These manoeuvres with ropes were practised in Port Moresby before attempting them on mountains. They included also some practice with a Sky Genie, in which 150 feet of nylon rope was dropped from the helicopter, the passenger then climbed out of the bubble, from which the door had been removed, and sat on the skid in a seat harness, then lowered himself down the rope with a hand-manipulated friction control.
- 37.19 The original idea was to let one or two men down the rope on a lightly timbered peak, which would then be cleared and thus allow the machine to land,
- 37.20 Fortunately, perhaps, this was not necessary on the survey, other than to use the knotted cotton rope for a few 10 - 12 feet descents, since even the keenest admitted that getting back up the 150 feet without a winch, should the clearing be unfinished before the cloud formed, presented somewhat more difficulty than descending. It was useful practice, in that it gave everyone great confidence in the helicopter and the skill of the pilots in hovering so steadily and landing so smoothly, and it concluded with some members queuing to come down the 150 feet a second time, at which stage it was considered sufficiently demonstrated.
- 37.21 Every item of equipment and all members were carefully weighed, weights were marked on boxes, and this load evenly distributed and balanced, before every flight. The highest lift was to 14,000 feet on 14,800 Mount Wilhelm, where loads were restricted to 250 lbs. It was an anxious sight on this mountain, to watch the helicopter beat in, then suddenly shoot up 50 feet, approach again and see this repeated, and to wonder if, the next time, there would be a down current.
- 37.22 With the engineer, the pilot would thoroughly check the machine at the beginning and end of each day, and briefly before each sortie. Inspections and overhauls for each 25, 50 and 100 hours of flying, as well as the major overhaul at 500 hours, were all rigorously carried out, regardless of the work situation, as was the pilot's rest day each week, since otherwise any insurance claim is void.
- 37.23 Loads were always safely below whatever limits were given by the makers, with due allowance for height and temperature at take-off and landing, and for ground effect of the landing pad and

its area.

- 37.24 Although supercharged, the engines were always kept idling after alighting at altitude where most stops were brief and only to unload or load, anyway. Just how necessary this was, no one ever put to the test not desiring the responsibility of not being able to re-start the helicopter on some remote peak in New Guinea, two or three miles high. It seemed cheaper to pay for the idling time.
- 37.25 No engine failure occurred during the National Mapping contracts, whilst the machine was airborne, however, one did crash during relief pilot practice on Mount Otto, as previously mentioned, and incredibly it did not catch fire.
- 37.26 In the early stages, a relief pilot hastily re-loading, on his own, half a load dumped at 8,000 feet prior to landing on an 11,000 feet pad with little ground effect, placed the timber of a pine pad under his exhaust outlet and reached his destination, fortunately not very far away, trailing fire and with half the 10 feet lengths burnt away. Rear-view mirrors were subsequently fitted.
- 37.27 Fuel for these machines, at 15 gallons per hour, was a major logistic problem. At the time of the survey, and probably they are still so, most of the airstrips were Class D, and useable only by light aircraft of the single-engined Cessna type. Restrictions on carrying fuel in a single-engined aircraft finally ruled out the one and only Otter aircraft in New Guinea, which could take in four 44 gallon drums to Class C aerodromes. This occurred as soon as several of the push-pull Cessna Skymasters commenced operating. These Skymasters were allowed to land on any strip, A to D, but were capable of carrying only two 44 gallon drums. The convenience of being able to bring fuel to a Class D strip, almost offset their smaller load.
- 37.28 The light-medium, two-engined Piaggio, could carry four 44 gallon drums of fuel and this aircraft was used wherever regulations permitted it to land.
- 37.29 It seemed the more remote a base and the less likelihood of sharing costs with back-loading, the more avgas was required for our operations. At Safia in 1963, working in conjunction with CSIRO, thirty 44 gallon drums were flown in. Before any aircraft could use this strip, arrangements had to be made with the Assistant District Officer at Tufi for a Patrol Officer to walk over to and supervise the cutting of the fast-growing grass on the strip. At Telefomin, which had been a DC3 field from the time United States troops landed in gliders in 1944 to construct it, the strip was closed to DC3 aircraft for repairs during November 1964 to January 1965, the exact period of our work on that base. All avgas had to be flown in by Piaggio from Wewak, in four 44 gallon drum lots, to arrive at Telefomin at the staggering cost of \$2 a gallon.
- 37.30 A helicopter pilot's tour of duty in New Guinea on this work was of four weeks duration, an engineer's six weeks, before returning to Sydney by air for a fortnight's rest. In the main, the pilots allotted to National Mapping flew with great skill and determination. They would materialize, at times, dimly and wraithlike from the swirling murk under apparently quite impossible conditions, bearing mail, the so important mail, and food. They might arrive to take a sub-party down from the completed station, maybe after five weeks occupation mostly in a grey, clammy world, and they could be likened to some noisy, flailing Samaritan, hell-bent on good works.
- 37.31 It is the belief of one, who enjoyed the ground climbing of these New Guinea mountains he was privileged to have the opportunity to visit, that the high survey in its final form would have been economically prohibitive without the high-altitude helicopter. This belief is compounded when consideration is given to such factors as failures of the electronic measuring equipments from jolting and knocking in native carrier-transportation and from the damp conditions; the lack, at that time, of a suitable lightweight generator; and quite disregarding the cost and man-power difficulties of emplacing, supporting and removing technical personnel in such terrain and

conditions, even if sufficient carriers could have been obtained and retained in the changing outlook.

37.32 It would seem too, that. the geodetic surveys in New Guinea by the Royal Australian Survey Corps and the Division of National Mapping, using support by light helicopters and particularly the supercharged, high-altitude machines with their capability of landing on any of the mountains with clear enough area, that a climacteric change was introduced, not only in survey and engineering operations but in much administration, movement and support. This country is almost devoid of vehicular roads, and wherever extensive reconnaissance, inspection and movement in such rugged terrain is involved, one cannot afford not to use helicopters.

38. Police Constables and Carriers

38.1 The interlaced triangulation, trilateration and intersection over the highlands have strengthened the New Guinea survey, and with its redundancies and the increased loop traverse closures, have given a better indication of the general accuracy of the whole work.

38.2 The full brunt of carrying and erecting the beacons and cairns on the giant peaks, together with the clearing of stations, often thickly timbered with interlaced jungle, and of the construction of helicopter pads made of local timber, on both high and low traverse points, was borne by- native carriers and police constables.

38.3 Generally, two police constables would be allotted from whatever Patrol Post or District Office the beaconing party was to begin- its approach to a station. Carriers were also recruited from each local area, prior advice having been sent to the Patrol Post of requirements. Numbers ranged from about 25 to nearly 100 - the latter for the big beacons on Mount Tafa and on the abrupt and spectacular Mount Yule, The Patrol or District Officer would ensure that the owners of a mountain area and its summit would be represented with one or two headmen of their village.

38.4 Usually the party would move forward, first traversing contoured Administration or Mission supervised bridle or walking paths, cut into steep and sheer mountain slopes and a delight to use. Frequently though the well-laden carriers would short-cut across some steep valley, shorter in distance and time, but not in exertion, and the carriers would be changed at the overnight village stop, where the population was dense enough to allow for it.

38.5 When the contoured paths ended, the line of carriers would take to the network of inter-communicating paths and finally to the more sparse, and infrequently used hunting tracks. These were so infrequently used in fact on some mountains that the guides might cast around for ten minutes in some places on a widening ridge, or complex of ridges, before the old cuts might be found. Then the line would inch onwards and upwards again cutting its way.

38.6 When Mount Yule was beaconsed, through the advice of the mission at Kamulai to the mountain owners in the small village of Olivi at its foot, an advance party of 10 men set off at once to reopen the route. They lashed handrails near precipitous sections and erected bush ladders on vertical climbs, not so much perhaps for the carriers with their awkward, heavy loads, which included a bag of cement, but for the clumsy whiteman, who would be in the party.

38.7 Up to 11,000 feet, where there is vegetation suitable to built protective huts and good hunting for the natives in the form of possums (cus-cus), which their yapping, hunting dogs indicate by their yelping and scratching on the tree homes of the sleeping occupants, occasional but very wary wild pigs and pretty black and white wild dogs, and birds (including the cassawary and bird of paradise), it was not so difficult in the early 1960's and with the help of Department of Native Affairs' officers, of course, to get carriers.

- 38.8 But over 11,000 feet, where there are no clear tracks and no camping huts, only stunted beeches turning into alpine grass and then into bare crags, the carriers dislike and fear it. They believe this to be the home of unpredictable, easily aroused devils, who should never be awakened by gun shots, calls or even talk much above a whisper. This is a place of devils who kill quickly enough those caught on shelterless rocks in icy winds, rain and blanketing clouds which produce, at least, a solid dose of malaria, even in Highland folk, so many of whom, since the war, have contracted it on trips to lower, coastal areas as plantation workers.
- 38.9 Protective clothing and coverage were necessary for native-born helpers and their camps were pitched only so high as to ensure some protection in the form of hut-building material and wind breaks from the scrub, perhaps a mile or more from the summit.
- 38.10 Equipment and food were normally carried on some Administration patrols in massive tin boxes, weighing empty 30 lbs, and slung along a pole borne by two men. These boxes are initially waterproof and can take the heavy battering they receive, and to which their sheer weight and awkwardness so appreciably contribute. They would be man-busters in Collins Street, Melbourne, and must have done plenty towards producing the reluctant carriers of the Goilala and other sophisticated and well-patrolled areas. Also, they were thoroughly inappropriate for lugging up hunting tracks, or, worse still, up the often almost sheer and rugged slopes and sidlings of trackless summits, where the European, carrying nothing but himself and his conceit, was frequently glad to take the helpful, steady and always ready, dark hand.
- 38.11 Accordingly, the small waterproof bondwood box, previously mentioned, was designed, and the Yukon or Canadian pack, formerly used to carry 25 pounder shells and other war supplies and materials, was re-introduced to this land. Subsequently, a cheap, water-proof, utilitarian, but properly-framed rucksack was obtained and used to carry suitable equipment and supplies. This meant that not only prehensile feet but both hands were free to assist in climbing. Not that the old order was changed lightly, of course, by some of these conservative tigers for punishment, to the extent even of surreptitiously slipping the load from the back, putting it on the shoulder, still tied to the Yukon pack with its wooden outside framework and hooks digging deep into the bone and happily trudging on. Custom can die hard, and what had been good enough for their parents and grand-parents with spear and bilum (a woman's woven carrying net) was good enough in these modern times, an outlook changed with snow-balling rapidity today,



Carriers in an open patch of moss forest about 8000 feet altitude, on the route to Mount Wilhelm in 1964.

38.12 Carriers were issued with woollen pullovers, blankets, groundsheets, waterproof bags of Verylite canvas and large 12' x 14' tents, into which many would crowd, light a fire, sleep together for warmth and pool their two or three blankets each. The fog inside, from the fire of mossy damp wood, trade tobacco and many people, was a solid state, but one man will not forget how thankful he was, on a pelting night at 10,000 feet, to accept the best position by the smouldering fire which these kindly people offered him, whilst he dried his socks and warmed his feet for the first time in days.

38.13 It was incredible how the heavy and still awkward beaconing equipment, despite every effort to make it more transportable, plus instruments and supplies were carried up the great mountains, and the way camps were established on the steep and extremely narrow ridges, if there was any chance and space at all to erect tents and build overnight huts.

38.14 An early start just as soon as it was light enough to move in the deep gloom of the jungle, was vital so that camp could be made soon after midday, on the first area met which was sufficiently wide and level enough for the purpose; and it was even more imperative not to be caught on some exposed, hogsbacked ridge or forced to sleep on a knife-edged spur, unprotected from the customary afternoon deluge, which at great height and driven by an icy blast, could arrive in a blinding assault of furious, freezing, tearing water, when morale just vanished in a moment.

38.15 This happened early in the survey, on an unknown section, where for over two hours of hard, hands and knees, climbing, there was no chance whatsoever of making a stop.



Carriers leaving Waitape Patrol Post 5100 feet elevation with the first Canadian packs introduced since the war. These loads are bulky (blankets, tents, ground sheets, etc.) rather than heavy and are mostly about the 40 lbs which a carrier usually carries. Scales were used to keep them within these limits, as much as possible, and so that a Carrier might see, even if he could or would not apparently understand, that a bulky load was not always the heaviest.

38.16 On a peak, tiny in area, on the top of this spur, the party met such a storm at 11,000 feet. The carriers just sat or fell down, making no move to help themselves. Groundsheets and blankets were pulled out of the loads, the two police constables alone, helped in this, and wrapped them around the men, spurred on by the chilling memory of the account, by a missionary, of a recent hunting party, which was caught by a storm on the high tundra of Mount Albert Edward, with 8 men dying in the unhappy but by no means unparalleled debacle.

- 38.17 The sharpness and limited area of this peak made it no place for a camp, but some tent coverage was dragged over the men, biscuits and meat were handed around, and in time, with the easing wind and rain, a fire was lighted and some shelter and protection achieved. It was easy to see enacted, past the point of safety for the welfare of these carriers, just what chance such a party would have had, devoid of blankets and any protective clothing and other coverage, in a thick storm of cloud, rain and cold, which could prevail for days at this altitude.
- 38.18 Again, the carriers, after establishing the surveyor and his equipment on the summit, had gone down to their village, to return under Police Constable Dubana a week later - doing just this in continuous rain, and caching potatoes and yams as they ascended, at each proposed overnight camp on the descent.
- 38.19 In boisterous wind and unceasing rain, they arrived drenched and shivering, late in the afternoon at the 13,300 feet summit of mighty Victoria, uncompromising, inviolable, but surely at last cynically amused, to help pack and take down the tent and equipment and to reach the camp at 12,000 feet, in the meagre but welcome shelter of a clump of stunted beech, long after dark.
- 38.20 It was still raining next morning and soon after moving, with the next food downwards at that night's camp, when one of the carriers collapsed. Urging him to no avail, he was covered with a blanket and ground sheet and left. After calling and calling from the 11,000 feet top of the spur, where the party had somehow previously made a camp, one of the magnificent Koiari carriers returned, climbing lithely and effortlessly up the spur without his load, picked up the fallen man's pack. This load was distributed when he caught up with the others, who were already well overburdened. The intention was to catch up with the village headman before, or at, the next proposed camp, where the food was, who would send back new men to carry, or somehow or other, get the carrier down.
- 38.21 Fortunately, relieved of his load, the carrier pulled himself together and caught up before the overnight camp was made near 10,000 feet.
- 38.22 A malingerer perhaps, but at 11,500 feet, in ruin and cloud, with an inert man on the ground at the tail end of the carrier line, 3 days hard climb from the nearest little and a further 5 days from the Patrol Post, it did seem at the time that one could recall happier moments, and it was a relief after some hours of wondering how best to get him down, to have him indicated, shamefaced and all walking behind us, by Dubana.
- 38.23 It was a situation, which, firstly the Cessna airdrops and subsequently the helicopter prevented from happening more frequently with perhaps more serious consequences. Had a carrier died on the high work it would have been even more difficult to get future carriers, anywhere. It never ceased to amaze how quickly news, or a messenger, carrying a note otherwise unburdened could travel in a country where the going seemed always straight up or straight down, across roaring torrents and wide rivers and swamps, with their lurking saurians, or over high passes and along, almost sheer ledgeless sidlings.
- 38.24 Even with Cessna airdrops, it must surely be realized that to man-handle the beacon parts, breakable materials, and all equipment both technical and camping for days, up and down high mountains, to quarry and carry, sometimes 100 yards and more, the stone for the cairns and the wood for the helipads, and to do the heavy clearing, was arduous work in some of its rawest arrangements, and most of it was carried out in the cold and frightening altitudes - the only areas where these so self-reliant masters of their jungles and swamps were unhappy and ill at ease, but yet who still did it.
- 38.25 At Telefomin, before Mount Wamtakin had been reconnoitred and beacons by National Mapping, the Army had selected the Three Pinnacles to be a station on the traverse southwards

from Vanimo, near the Border, to link with Hiran Station No. 37 and the central spinal traverse.

- 38.26 Almost unbroken bad weather through the latter half of 1964 had delayed the Army in this section, as it did National Mapping when it reached the area in November 1964, and to whom was mentioned the proposed Three Pinnacles and the prevention, through the weather, of inspection of what had been done.
- 38.27 Initial reconnaissance by National Mapping, to connect to the Army work, showed the massive clearing and effort which had taken place on the highest point of the Three Pinnacles and in the saddle about half a mile to the east, where a substantial pad had been constructed.
- 38.28 Three Pinnacles is not so much a triad as an east-west pentad of peaks 8,550 feet high which are thickly timbered to the summits, steep-sided on the southern slopes and precipitous on the northern. Even to find the highest point in this tangle of vegetation, rocks, and as it seemed almost permanent cloud, would be an achievement of which most surveyors or bushmen would be proud, to the point of insufferability.
- 38.29 From native constable Corporal Nen of Telefomin, who was in charge of the clearing party, it is understood that what was required had been explained by the Army to the previous Assistant District Officer at Telefomin, who was in the area, or was flown there by helicopter and shown. The ADO then flew to Atbalmin, an outpost near the Border, and described carefully to Corporal Nen what was to be done.
- 38.30 Corporal Nen, assisted by L/Cpl Kusino and Constable Pigi, and 20 carriers, including a Lululai or headman who was full of the usual horror tales of mountain devils, left Athalmin and after two days walk reached the suspension bridge over the Sepik, near the confluence of the Din and Non tributaries, where the range of the Three Pinnacles, rising abruptly, confronts one.
- 38.31 On the fourth day, by cutting their way through heavy jungle up this very steep slope, they reached the saddle, where they cleared a site in the thick tall timber for the helicopter pad and constructed it of solid logs of ample size. Running water was found within 300 yards of the pad, which was not so surprising, really.
- 38.32 A lot of heavy clearing was then done along the sharp ridge of the highest point, so that they could see around in all directions. They also cleared where the pad would normally have been located, but then had to construct it lower down because of the sharpness of the ridge with its precipitous northern fail. However, the major work was done with the two clearings and the construction of pad for landing supplies and carriers to do any further clearing should it be necessary near the summit, and to make another pad at the summit for use when erecting the beacon.
- 38.33 Apparently they expected the helicopter to bring in food, supplies and the beacon, but either this was a misunderstanding or the continuous thick overcast prevented it.
- 38.34 After thirteen days on this formidable chain of peaks, they ran out of food and had to come down, which because of the cut tract they did in "one Sun" (one day). Then they walked on to Telefomin, the overall time from Atbalmin to Three Pinnacles to Telefomin being 3½ weeks.
- 38.35 The liberty was taken of thanking Corporal Nen and his two equally companions in the presence of the ADO who acted as interpreter and making it clear to them that their achievement of bushmanship and work was well understood and fully appreciated.
- 38.36 Corporal Nen expressed a wish that he might be flown in when the Army returned to continue their survey, and he wanted to be landed on the pad which he had constructed so well. However, some years earlier he had been shot through the right lung, and this climb and the cold and

dampness on the 8,500 feet summit had troubled him, as had other previous high patrols. The ADO was already arranging to have him located at a lower and warmer area, so it was unlikely that he would have had that wish fulfilled, but which he so faithfully and richly deserved.

38.37 Full acknowledgement, unconditional and grateful is paid to the police constables and carriers who performed their heavy and responsible work, mostly over rarely visited parts of their rugged country, the parts in which they were least happy. A soldier's salute to these men!

39. Conclusion

To those who love the majesty of mountains and hills with their alternating moods, now grand, now delicate, now bold, now shy and with the often strenuous bit of usually thrillingly-rewarding exertion and gratitude they expect from those who approach their presence, it is amusing to hear or read that someone had "conquered" a mountain.

Puny man, gasping and struggling, may climb to a summit, erect his marks and instruments with great cost and difficulty and carry out his work, only as the mountain, and the allies it helps to create, dictate.

For the surveyor, there can be no more attractive undertaking than in helping to lay down the initial geodetic foundations over a country, especially over his own country, or one closely associated, as New Guinea is with Australia.

Of the varied sections of such a project, the reconnaissance and beaconing seem 'particularly stimulating and satisfying, since this initial selection and proving of points in a major framework occurs once, not just in his career, but in the country's lifetime; and what a few years ago could well have taken several generations, because triangulation was so slow and costly that finance restrictions usually brought it to a silent halt more than once during its progress, can now be completed in a comparatively short portion of some privileged surveyor's career.

There is an elementary satisfaction in believing that the costly point which a man is selecting and proving can and will be used these days for the measurement of fine crustal movements and determinations of more accurate parameters of the earth, and for satellite and rocket guidance systems, either in peaceful development or in swift, sure and terrible retaliatory defence of his country - and in believing, too, (however naive such simplicity may seem to the experienced) that, marked solidly and appropriately, as it warrants, it will remain there over many years, indeed for the use, or astonishment, of future generations - if given any reasonable chance of survival and protection, especially by the government bodies.

A surveyor, trained in the old fascinating art of triangulation (a species, which having served its purpose, is now and maybe fortunately, almost extinct, with only a few living fossils feebly extant) and suddenly armed with the magic wand of the tellurometer to extricate himself from the chagrin and embarrassment of a short line, needed to curb his ingrained tendency to indulge in a wholesale dissipation of triangulation and trilateration, over country wantonly inviting it though (and hoping it may now be safely confided) one such antique did harbour the belief that an occasional closed and trilaterated triangle, or even if it degenerated to the depths of a figure sometimes, helped to check and to assess the standard of horizontal and vertical angles as well as the accuracy of distance measurements, and also encouraged observers to keep on the balls of their feet - so some triangles and figures were slipped in, where little extra work and cost were involved, rather furtively but, subsequently, never regretfully.

However, on the high work in New Guinea, there was no need for curb or restraint over such primitive instincts, and any and every ray was angled and measured, whenever this was at all economically possible to achieve, (representing in so many instances, skill, patience and grim determination), to form the daedalian net shown in the overall diagram, from which at the

conclusion of repeated, painstaking checking, testing, adjustment and final adoption of data by the Geoidal Section of National Mapping, only a few frayed threads, as previously mentioned, were reluctantly plucked.

40. Acknowledgement

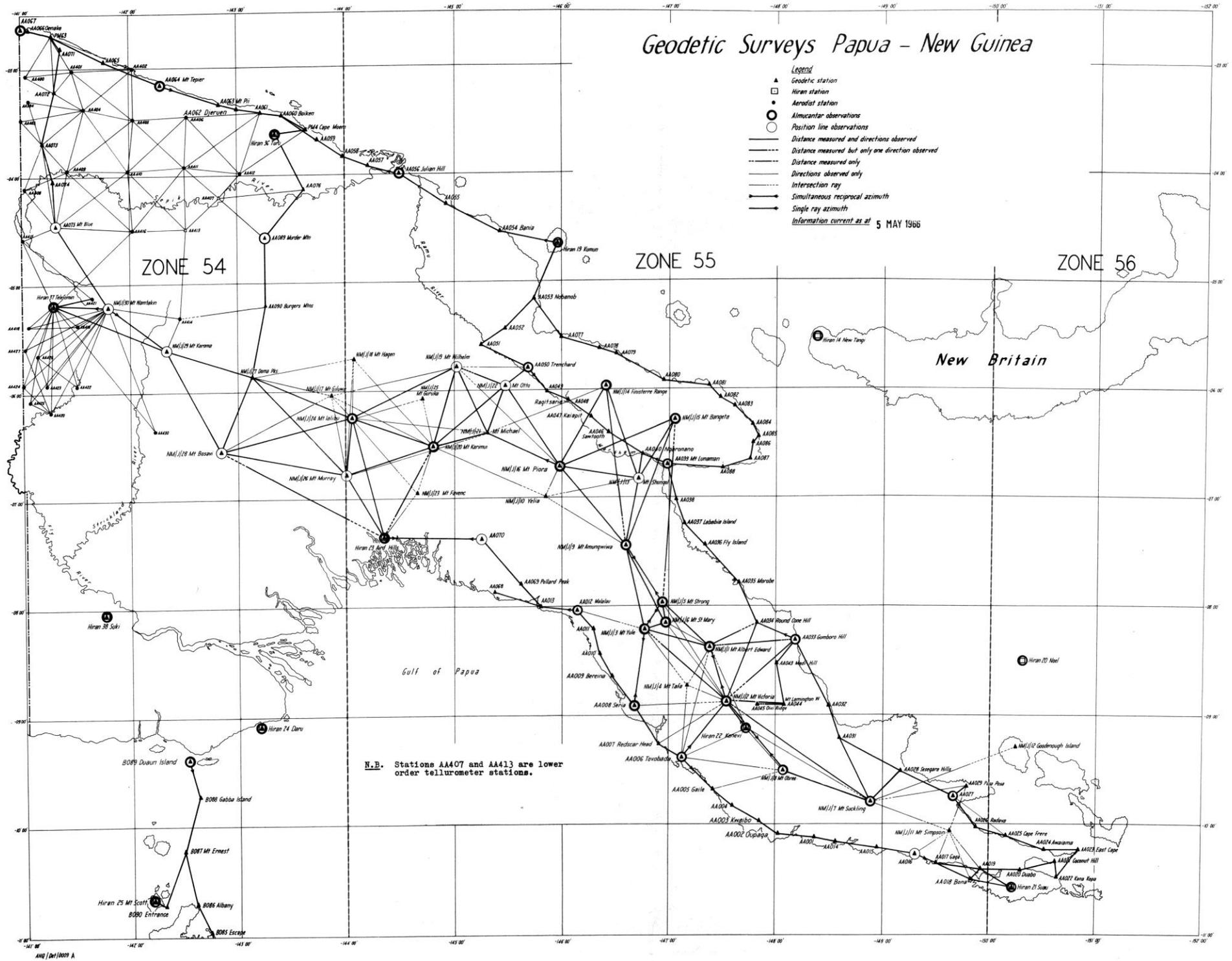
- 40.1 In the sobering undertaking of embracing most of the main mountains in New Guinea in a geodetic survey, many people must help in many different ways - few of which are unessential and all of which in some way affect the final result.
- 40.2 Some people had the opportunity (perhaps "privilege" is a better word for such a nationally important work whose influence will remain as long as maps and scientific measurements of our earth and space continue), the position, the appreciation, the ability, the energy, or the inclination, or other characteristics or set of circumstances, to contribute to, or to influence the outcome more than others, but the scheme could not have been completed without the accumulated physical help and co-operation that were forth-coming from so many sides.
- 40.3 Cooperation really means some sacrifice by any participant for the long-range, lasting benefit of others, most of whom will be quite unaware that such projects even take place anyway - the sacrifice usually being in extra time and effort required to rearrange the priorities of his normal official duties and interests, as well as in the altering of his own personal affairs and obligations, to let him cope with the unexpected new requirement placed on him.
- 40.4 It is not possible to list the individual names of all who aided the venture and who collectively reduced its very considerable cost and its supervisory demands, but in addition to these already mentioned the following are acknowledged with gratitude.
- 40.5 Most especially my wife, who never by look or word, spoken or written, has done else but encourage the interest, absorption and prosecution of work, involving so many hours and so many sustained absences from home, and for her, so much extra and lonely responsibility.
- 40.6 Mr. B. P. Lambert, Director of National Mapping, who drew up the initial overall scheme of geodetic control for New Guinea (as well as previously over Australia) from which there was practically no deviation. Use was made of copies of the many notes and profiles of proposed mountain stations, most of which he made swiftly, surely and accurately from glimpses through the narrow windows of aircraft on routine commercial flights in the shoestring-supported, early National Mapping operations. His advance planning and advice, in suggesting the 48" tellurometer reflectors, and the use of a light, high-altitude helicopter, made the survey practicable in its final form, and are in line with the many other equipments and techniques he has assessed and has had the courage to introduce or develop for Australian mappings His tremendous capacity for work and output, and his enquiring, searching interest can along give him the time and ability to keep in touch with, and to discuss down to operator's level, new survey and photogrammetric and reproduction instruments, equipment and techniques, together with their final mathematical evaluation and adjustment - all of which, with his infectious enthusiasm and his practical encouragement to anyone trying to do worthwhile, essential mapping, have been an inspiration to those fortunate enough to work under his friendly direction.
- 40.7 The technical staff who carried out the field work, especially those who, well aware of the conditions, returned to help complete it - in particular Mr. R. A. Ford, who wrote asking if he could come and assist, as soon as he had completed his season's work in Australia, and whose long field experience and suggestions were so helpful; and Mr. John Allen, who was there over the full periods of both tours doing much of the astronomical work, on which he showed such determination, and skill, as on all of his observing.

- 40.8 The staff in the Melbourne Office of the Division, especially Mr. O. J. Bobroff and Mr. J. W. Witzand, who answered the many requests for instruments and special materials, and who consigned it all, often in many delicate optical and electronic guises, so well packed that there was never any breakage or malfunction on arrival, and so promptly that the field operations were never delayed awaiting its arrival.
- 40.9 Captain George Treatt, who did most of the helicopter flying for the National Mapping party, a magnificent and determined pilot, carrying out many seemingly impossible sorties. Laconic to the stage almost of taciturnity, he could yet smile, when, covered in blood from many cuts and a gash in his leg, he limped across the tarmac after the crash on Mount Otto, in which removed from the controls, he must have lived a hundred years as he realized and watched the inevitability of its approach.
- 40.10 The many officers in the Department of Native Affairs who helped, and in particular Mr. W. E. Thomasetti at Tapini, Mr. H. E. Clark at Abau, Mr. J. M. Wearne at Telefomin. These officers, and others, made their best police constables readily available, instructed the headmen and carriers of their requirements and gave the work the essential aegis of their support. At Mount Hagen, when advised there was no helicopter pilot available over the important Christmas and New Year period in 1964, Commissioner W. Ellis without question instantly put his own pilot at National Mapping's disposal, thus allowing the work to be completed, so that the heavy cost of returning at the end of the north-west monsoon from Australia was obviated.
- 40.11 The Geoidal Section of the Division of National Mapping whose members checked and re-checked, tested and re-tested, lines and formulae, individually and in endless combinations, and along with the astronomical observations, often of stars so fitfully seen - in particular Mr. A. G. Bomford, in charge of the Section and enthusiastic with the new mathematical problems involved, who saw to it that every last molecule of accuracy was wrung from the sometimes still protesting and enigmatic field data, and who wrote the Fortran programmes which sieved and shuffled these new rising mountains of paper, almost as formidable as their distant field forbears; and Mr. H. D. Couchman in Melbourne, who supervised, in his orderly and capable manner, the initial office checking of the field books on their arrival, and also the preliminary checks for accuracy of the data on the Sirius computer (the many programmes for which, in the early computing era, he wrote himself) ready for its first acceptance, in Canberra, by the CDC 3600 computer giant.
- 40.12 Mr. D. P. Cook who was resident surveyor in Port Moresby and who organised much of the National Mapping beaconing - a man of great ability, courteous, equable and friendly with many helpful suggestions, and always a pleasure to work alongside.
- 40.13 Mr. W. Murphy and Mr. H. A. Lauchland of the Finance and Stores Branches of the Department of National Development, both of whom have had extensive field experience in the Northern Territory and in New Guinea, and both of whom put their full and sympathetic support behind the financial requests and unusual proposals such an unpredictable and unbridled climate can produce, as well as giving valuable advice for the recovery, protection and/or disposal of materials and equipment, and, in particular of the liquid gold which helicopters consume so insatiably.
- 40.14 Mr. A. Krisjanis, who extracted and supplied the data of the final corrections and the accuracies mentioned in this article, and on which he had done so much testing, checking and evaluating in the great maze of preliminary final adjustment involved.
- 40.15 Mr. A. Anagnostou, who extracted and collated from the field books the meteorological data, notes and measurements shown in Appendix 2, which illustrate the conditions and comparisons of the tellurometer results; the field books, whose field reductions of every single arc of angle and distance, he had, in the main, machine-checked himself, as he had done on so much of the

Australian scheme.

40.16 The police constables and carriers who did such heavy work and who looked after the comfort, welfare and safety of their European charges as they are never likely to be looked after again, wresting even the lightest load, such as a barometer battery box, from their usually not very unwilling hands or back. In particular Police Constables Dubana, Doriri and Sorer who have made the trips, on which they were both the escorts and interpreters, memorable through their friendly loyalty, cheerfulness, good humour and ability to keep the carrier lines moving, over many a long steep and rugged mountain.

Geodetic Surveys Papua - New Guinea



- Legend**
- ▲ Geodetic station
 - Hiran station
 - Aerodist station
 - Almicantar observations
 - Position line observations
 - Distance measured and directions observed
 - - - Distance measured but only one direction observed
 - Distance measured only
 - Directions observed only
 - Intersection ray
 - ↔ Simultaneous reciprocal azimuth
 - Single ray azimuth
- Information current as at 5 MAY 1966

N.B. Stations AA407 and AA413 are lower order tellurometer stations.

TELLUROMETER MEASUREMENTS

Conditions, Results and Final Adjustment Correction

Appendix 2

<u>Stations</u>		<u>Date</u>	<u>Time</u>	<u>Meteorological Conditions</u>		<u>Topographic Conditions</u>		<u>Vapour Pressure</u>			<u>Temperature</u>		<u>Height Ft.</u>		<u>Slope Dist.</u>	<u>Correction in feet</u>
<u>Master</u>	<u>Remote</u>			<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>	<u>Diff.</u>	<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>		
Yule - AA 008 48.7M		8. 6.63	0500	Cold, clear still	Cool some cloud light breeze	Sharp drop from Mt. top across jungle plains to distant coastal station	From low timbered hill across timbered plain to high peak	.222	.700	.478	44°	70°	10750	864	256995.44	-0.03
		8. 6.63	0540					.217	.696	.479				94.82		
		9. 6.63	0350	Cool, cloudy	Cool some cloud light E breeze			.218	.730	.512				97.23		
		9. 6.63	0505					.233	.714	.481				96.74		
AA 006 - Victoria 43.6M		30. 6.63	0013 0047	Cool scattered clearing cloud	N. wind cloud between stations 4/8 cloud o'head	From hill line across sparsely timbered country to high Mt.	From Mt. top with steep drop away, line passes over jungle covered ridges to coastal station	.592 .590	.196 .197	.396 .393	72°	42°	1246	13240	230271.86 .43	-1.48
		3. 7.63	1117	Cool fine light breeze cloud o'head clear between stns.	Warm light SE wind light cloud o'head			.576	.088	.488				.31		
			1143					.578	.094	.484				.55		
Yule - Amungwiwa 56.2M		4. 9.63	1218 1255	Warm 7/8 cloud SE wind heavy cloud on line	Mild light SE breeze m'ment through cloud and rain	Line across scrub for 500 yds then over valley and scrub covered ridges to distant station	From high peak across grassy ridge 1/4 mile away then to timbered country to isolated peak	.330 .317	.301 .310	.029 .007	52°	48°	10750	10755	296514.49 .50	+0.15
		10. 9.63		Light SW wind 7/8 cloud	Cold some cloud above and below. Line intervisible			.280 .284	.282 .284	.002 .000					.71 .51	

TELLUROMETER MEASUREMENTS

Conditions, Results and Final Adjustment Correction

Appendix 2 Cont'd

<u>Stations</u>		<u>Date</u>	<u>Time</u>	<u>Meteorological Conditions</u>		<u>Topographic Conditions</u>		<u>Vapour Pressure</u>			<u>Temperature</u>		<u>Height Ft.</u>		<u>Slope Dist.</u>	<u>Correction in feet</u>
<u>Master</u>	<u>Remote</u>			<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>	<u>Diff.</u>	<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>		
Yule - Victoria 69.5M		21. 6.63	0643 0715	Cool NW wind clear	W. breeze low cloud	Line from high Mt. to sharp drop then over jungle and ridges to distant high Mt.	From Mt. top with steep descent line passes over jungle covered ridges to distant station	.288 .294	.208 .220	.080 .074	45°	38°	10750	13240	367169.34 68.36	+0.68
		22. 6.63*	0523	Cool NW wind cloud along line	N. breeze low cloud			.292	.214	.078				69.74		
			0638	Cool NW wind line grazing low cloud				.284	.210	.074				68.60		
Shungol - AA 040 16.7M		22.11.63	2029	Fog, cloud light S. breeze	Warm 6/8 cloud strong gusty E. wind	From peak to hill top in Markham valley	From top of grassy hill, line over hill for 30 yds then over valley to the station	.398	.825	.427	51°	74°	9030	1180	88034.07	+0.18
			2049	Cloud on line thunder stormy				.398	.806	.408				.27		
		23.11.63	0416	Occasional cloud on line	Warm 4/8 cloud ground mist			.356	.766	.410				.40		
			0435		Gusty East Wind			.348	.766	.418				33.83		
			1856	Calm mostly clear on line	Strong gusty E wind			.342	.782	.440				34.20		
		1913	Cloud early in m'ment	2/8 cloud			.354	.784	.430				33.94			

TELLUROMETER MEASUREMENTS

Conditions, Results and Final Adjustment Correction

Appendix 2 Cont'd (3)

<u>Stations</u>		<u>Date</u>	<u>Time</u>	<u>Meteorological Conditions</u>		<u>Topographic Conditions</u>		<u>Vapour Pressure</u>			<u>Temperature</u>		<u>Height Ft.</u>		<u>Slope Dist.</u>	<u>Correction in feet</u>
<u>Master</u>	<u>Remote</u>			<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>	<u>Diff.</u>	<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>		
Strong - Bangeta 114.5M		17. 9.63	0922	Cold calm heavily o'cast	Light SW breeze cloud over Mt.	Over flat grassy top of Mt. for 100 yds then over mountainous terrain	From grassy Mt. top line passes through gap in range across jungle ridges to distant station	.261	.206	.055					604554.90	
			0946	Cloud on line				.240	.210	.030					55.20	
		19. 9.63	0431 0455	Fine. cold clear some cloud forming on line	Clear o'cast light cloud between stations mostly clear			.250 .245	.202 .200	.048 .045	42°	36°	11770	13520	57.30 57.90	
		21. 9.63	0412 0438	Cool o'cast SE breeze Light rain near end of measurement	Still clear along most of the line			.250 .254	.182 .180	.068 .074					58.60 58.70	+ 1.50
Ialibu - Aird Hills 85.6M		13. 1.64	0510	West wind cloud at hill	Humid, still	From timbered Mt. top across mainly flat country to distant station near coast	From low hill sharp drop then across jungle and intermediate range to distant station	.269 .272	.798 .798	.529 .526					451968.14 68.54	
			0532 0515	Clear at hill and along line	Humid 4/8 cloud few spots rain			.256	.755	.499					71.66	
			0530	West wind	NW breeze			.256	.757	.501					71.75	
		10. 1.64	0038 0103	Clear, strong W wind	Warm, humid, still 2/8 cloud			.266 .266	.698 .686	.432 .420					67.20 67.55	
		10. 1.64	0928 0945	Clear, sunny, W wind	Warm, humid NW breeze line clear			.269 .277	.720 .696	.451 .449	43°	76°	11369	1060	65.72 67.15	0.00

TELLUROMETER MEASUREMENTS

Conditions, Results and Final Adjustment Correction

Appendix 2 Cont'd (4)

<u>Stations</u>		<u>Date</u>	<u>Time</u>	<u>Meteorological Conditions</u>		<u>Topographic Conditions</u>		<u>Vapour Pressure</u>			<u>Temperature</u>		<u>Height Ft.</u>		<u>Slope Dist.</u>	<u>Correction in feet</u>
<u>Master</u>	<u>Remote</u>			<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>	<u>Diff.</u>	<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>		
Karimui - Wilhelm 57.0M		29.12.63	1709 1725	Cool, heavy cloud very heavy rain. M'ments through cloud	Heavy rain, hail and thunder storm	Sharp drop from peak across jungle ridges to distant peak	From high rocky peak across sheer drop through mountainous country to distant peak	.456 .448	.226 .220	.230 .228	54°	36°			301062.99 62.86	
		31.12.63	0444 0500	Heavy o'cast. Measurement mainly through cloud	Cold SE breeze m'ment through cloud			.365 .358	.191 .192	.174 .166			8428	14793	62.37 62.01	- 0.79
Otto - AA 050 18.1M		13.12.63	1844	Light cloud, wind blowing across hill from SW	Cool. strong gusty W. wind 5/8 cloud	From top of grassy Mt. across timbered slopes to wide valley where stn is located on small rise	From top of grassy hill line over slope for 500 yds then over valley to far station	.251	.727	.476					95645.28	
		13.12.63 14.12.63	1905 0440 0505	N. wind clear between stations	Cold, calm 5/8 cloud			.244 .158 .159	.729 .719 .714	.485 .561 .555	41°	73°	11634	1766	45.02 45.35 44.89	- 0.08

TELLUROMETER MEASUREMENTS

Conditions, Results and Final Adjustment Correction

Appendix 2 Cont'd (5)

<u>Stations</u>		<u>Date</u>	<u>Time</u>	<u>Meteorological Conditions</u>		<u>Topographic Conditions</u>		<u>Vapour Pressure</u>			<u>Temperature</u>		<u>Height Ft.</u>		<u>Correction</u>	
<u>Master</u>	<u>Remote</u>			<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>	<u>Diff.</u>	<u>Master</u>	<u>Remote</u>	<u>Master</u>	<u>Remote</u>	<u>Slope Dist.</u>	<u>in feet</u>
Karimui - Aird Hills 66.9M		5. 1.64	1910	Cool, light cloud blowing across hill mainly clear	Warm, humid, sky almost clear, S breeze, line clear	Sharp drop from hill line apparently passes 450 yds below summit. Mt. Duau which is mid-way	From low hill sharp drop then over close slightly lower hill across undulating terrain then grazing distant range	.406	.816	.410	54°	76°	8428	1060	353135.20	- 1.97
			1930					.411	.809	.398					34.75	
		6. 1.64	0410	Cool, moderate SW breeze clear conditions for measurement	Warm humid 3/8 cloud			.347	.824	.477					35.13	
0435	Light SE breeze		.360		.822			.462			34.27					
Bosavi - Aird Hills		10.11.64	1155	Hot. humid, still	Mist, wind 0.3 knots Westerly	From low hill, across swampy plain, then low ridge to distant peak	From high hill above cliff across crater and across to distant hill	.446	.848	.402					637287.75	+ 0.34
		11.11.64	1150	4/8 cloud Warm, humid still Fog developed around hill	8/8 cloud No wind			.444	.857	.413	55°	76°	7863	1060	87.82	
0438	.414		.797					.383	87.58							
			0455					.413	.804	.391				86.59		

MT. VICTORIA APPROACH FROM WOITAPE

Scale: only very approximately 2 Miles to 1 Inch

LEGEND.

Walking Times shown in Minutes thus: 00 start at Waitape
Kambisi 402 minutes from Waitape
Mt. Victoria 1340 " " Boine

At Indurumu, Boine and Tafade times commence at 00 again

Tracks Cut, contoured, Bridle path shown -----
Native tracks " "

Villages and collection of Huts shown: ⊙ ⊙

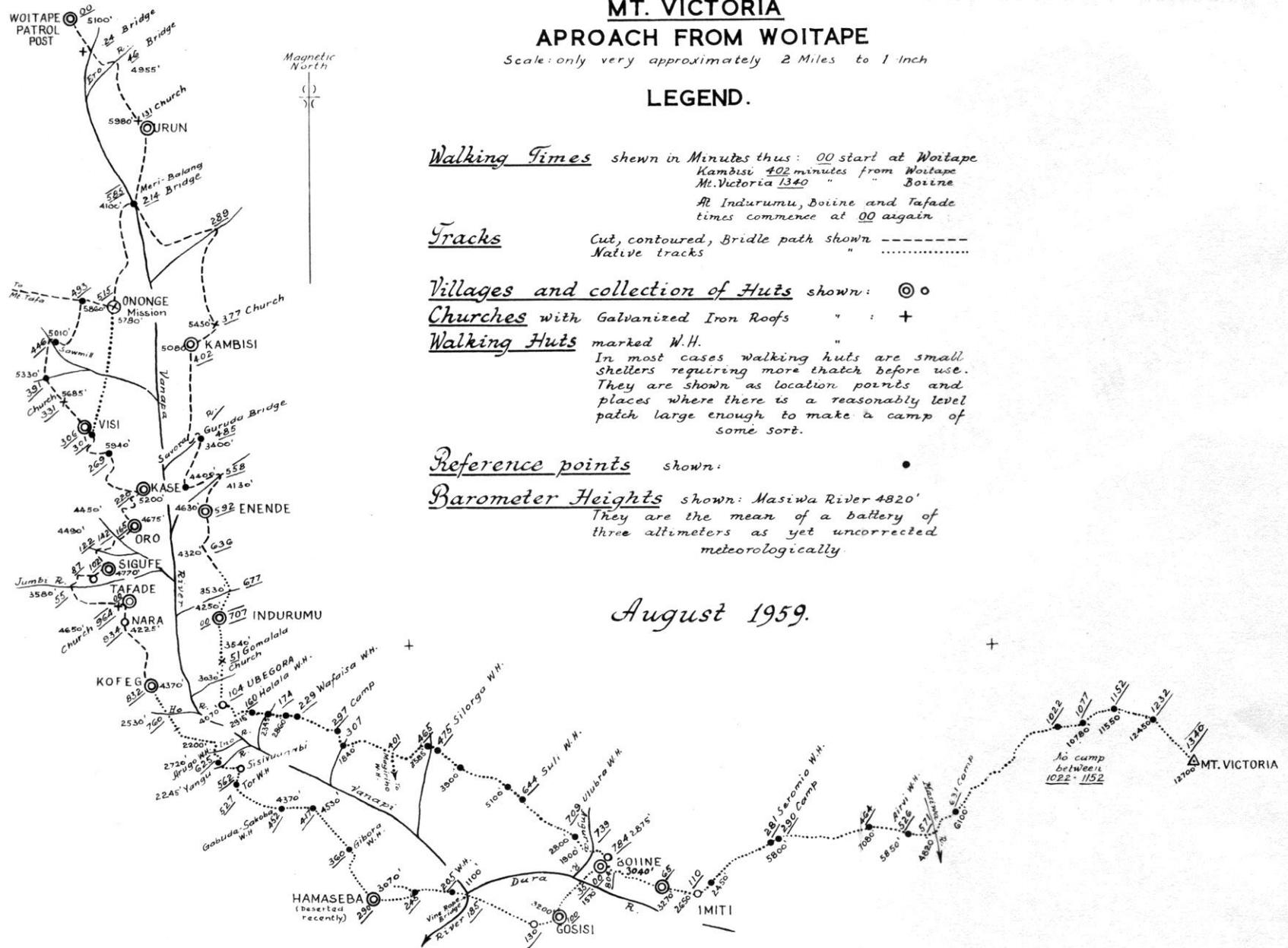
Churches with Galvanized Iron Roofs " : +

Walking Huts marked W.H.
In most cases walking huts are small shelters requiring more thatch before use. They are shown as location points and places where there is a reasonably level patch large enough to make a camp of some sort.

Reference points shown: •

Barometer Heights shown: Masiwa River 4820'
They are the mean of a battery of three altimeters as yet uncorrected meteorologically.

August 1959.



GENERALCHOICE OF ROUTES

It may be possible to approach Mount Victoria from KOKODA, but all available information suggested approach from the BOIINE and IMITI Villages of the KOIARI people. The track to BOIINE, via SOGERI and BEBENI, is almost sure to be better than these routes shown, which were chosen because of being located at WOITAPE at the time.

Of the two routes shown on this sketch, that through ONONGE, TAFADE, KOFEG, HAMASEBA, GOSISI is the better. The section from KOFEG to TOR Walking Hut is steep and downhill walking in either direction would be difficult during or immediately after heavy rain, unless boot stops are new and long - this section would be greatly improved with some log and stake steps. The 200 feet long, vine rope bridge at the confluence of the DARA and VANAPA Rivers badly needs re-roping, and carriers were very nervous of it, crossing one at a time. Other than these points, this track, becoming overgrown, follows the crests of ridges and spurs almost all the way, except for a short amount of sidling between GABUDA -SOKODA and TOR Walking Huts. It would be a pity if use of this track is lost through collapse of the vine bridge over the Vanapa River.

The track from INDURUMU to BOIINE is a continuous series of big rises and falls with a, continuous heavy sidling to the south into the Vanapa River. Any scarcely noticeable ledges would immediately be smoothed off after heavy rain, and the ANGURA River crossing could be a barrier after big rains, also.

Leeches were usually seen between the 3500-5000 feet level, being particularly bad near SULI Walking Hut, near which point carriers mentioned Port Moresby could be seen on a clear day.

NATIVE FOOD

This was available at all villages passed through. After long calling, at HAMASEBA, one native arrived and was paid for food gathered from the nearby overgrowing gardens.

No native food is available between INDURUMU and BOIINE.

With a shot gun quite a number of birds could be obtained, and with accompanying dogs two or three CUS-CUS were found every day, and, on one occasion, a cassowary.

WALKING TIMES

These times are very dependent on the state of the native tracks, either just after rain or if reopening is necessary. Coming downhill after heavy rain below 6500-7000 feet, that is below moss forest level, without new and good boots and heel stops, is much slower than going uphill. Moss forest walking is usually good both ways, at any time.

After leaving IMITI, the track to the 8500 feet level had to be opened most of the way and some time was occasionally spent in looking for it. Times from IMITI to the 8500 feet level would be considerably faster if the track has been recently used, and on the return trip of course.

CARRIERS

There are not many people at BOIINE and IMITI villages and though some should be obtainable (and they are outstanding carriers) most will need to be brought in with the party.

MASIWA RIVER

Masiwa river was nearly waist deep going up to the summit, and after 12 days rain was only crossable on the return trip by the fortunate positioning of a tree, which was felled across its 80 foot width of torrential water.

High Level Geodetic Survey of New Guinea”, Technical Report No. 8, March 1969.

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