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PAPUA NEW GUINEA ISOGAL GRAVITY SURVEY, 1967

by

J.S. Milsom

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FOREWORD

This report was written by Dr J.S. Milsom about 1968, and since then has been only slightly modified. The following papers summarise subsequent work between 1968 and 1979 on gravity datum, scale, and intervals in Papua New Guinea.

COUTTS, D.A., WELLMAN, P., & BARLOW, B.C., 1980 - Calibration of gravity meters with a quartz mechanism. BMR Journal of Australian Geology and Geophysics, 5(1).

ARNAUTOV, G.P., BOULANGER, Yu.D., KARNER, G.D., & SHCHEGLOV, S.N., 1979 - Absolute determinations of gravity in Australia and Papua New Guinea during 1979. BMR Journal of Australian Geology and Geophysics, 4(4).

WELLMAN, P., BOULANGER, Yu.D., BARLOW, B.C., SHCHEGLOV, S.N., & COUTTS, D.A., 1974 - Australian and Soviet gravity surveys along the Australian Calibration Line. Bureau of Mineral Resources, Australia, Bulletin 161.

WELLMAN, P., & McCRACKEN, H.M., 1975 - Gravity measurements on Papua New Guinea crustal movement markers, and along the Australian Calibration Line, 1975. Bureau of Mineral Resources, Australia, Record 1975/126 (unpublished).

ABSTRACT

During June, July, and early August 1967 a network of gravity base stations was established throughout Papua New Guinea. Three gravity meters were used to make ties between stations at roughly equal values of observed gravity. Transport was by light aircraft. Some stations occupied on previous surveys by BMR and the Universities of Wisconsin, Hawaii, and Tasmania were incorporated in the network. A tie was made to the Solomon Islands gravity base station in Honiara.

1. INTRODUCTION

During 1964 and 1967 a number of regional gravity surveys were made with the object of strengthening the Australian National Gravity Network. In these surveys, known collectively as the Isogal project, a light aircraft was used to make multiple-meter ties between stations at airfields roughly 240 kilometres apart. In order to keep the observed gravity intervals small and to avoid the necessity for frequent resets of the non-geodetic meters, flights were made roughly along the isogals of observed gravity, i.e. within a range of 50 to 60 mGal (1 mGal $\equiv$ 10 μm s^{-2}). Three meters were used on this survey: Master Worden 548, Sharpe 145 (both quartz meters) and LaCoste & Romberg G20.

In May 1966 a tie was made, using the same three meters, between the Isogal station on the Australian mainland at Weipa, and stations on Thursday and Horne Islands, and at Daru in Papua New Guinea (Barlow, 1966). During June, July and August 1967, the Isogal network was extended throughout Papua New Guinea, using the gravity value at Daru as a reference datum. As further work on the Australian Isogal Project was being carried out at the same time, different meters were used in Papua New Guinea; they were Wordens 169 and 260, and LaCoste & Romberg G101.

Considerable difficulties were encountered in planning a reasonable and economic network of Isogal lines in Papua New Guinea. Because of the high relief of the island and the steep gravity gradients encountered, very large gravity differences exist between adjacent airfields, and it proved impossible to plan any lines of reasonable length along which the gravity range was less than 100 mGal. Some of the longer lines include gravity differences of 150 mGal. However, the curvature of the planned Isogal lines, coupled with the comparatively small size of Papua New Guinea, permitted a relatively greater number of closed loops than had been the case in Australia.

In addition to covering the whole of Papua New Guinea, the Isogal network was extended to Honiara in the Solomon Islands. The base gravity stations in Honiara have been used in a large number of surveys carried out by the Universities of Hawaii and Wisconsin, and by the Geological Survey of the Solomon Islands. In the course of this work, which also covered the island of Bougainville, the Honiara base station had been tied by repeated observations with geodetic meters to gravity bases in the United States.

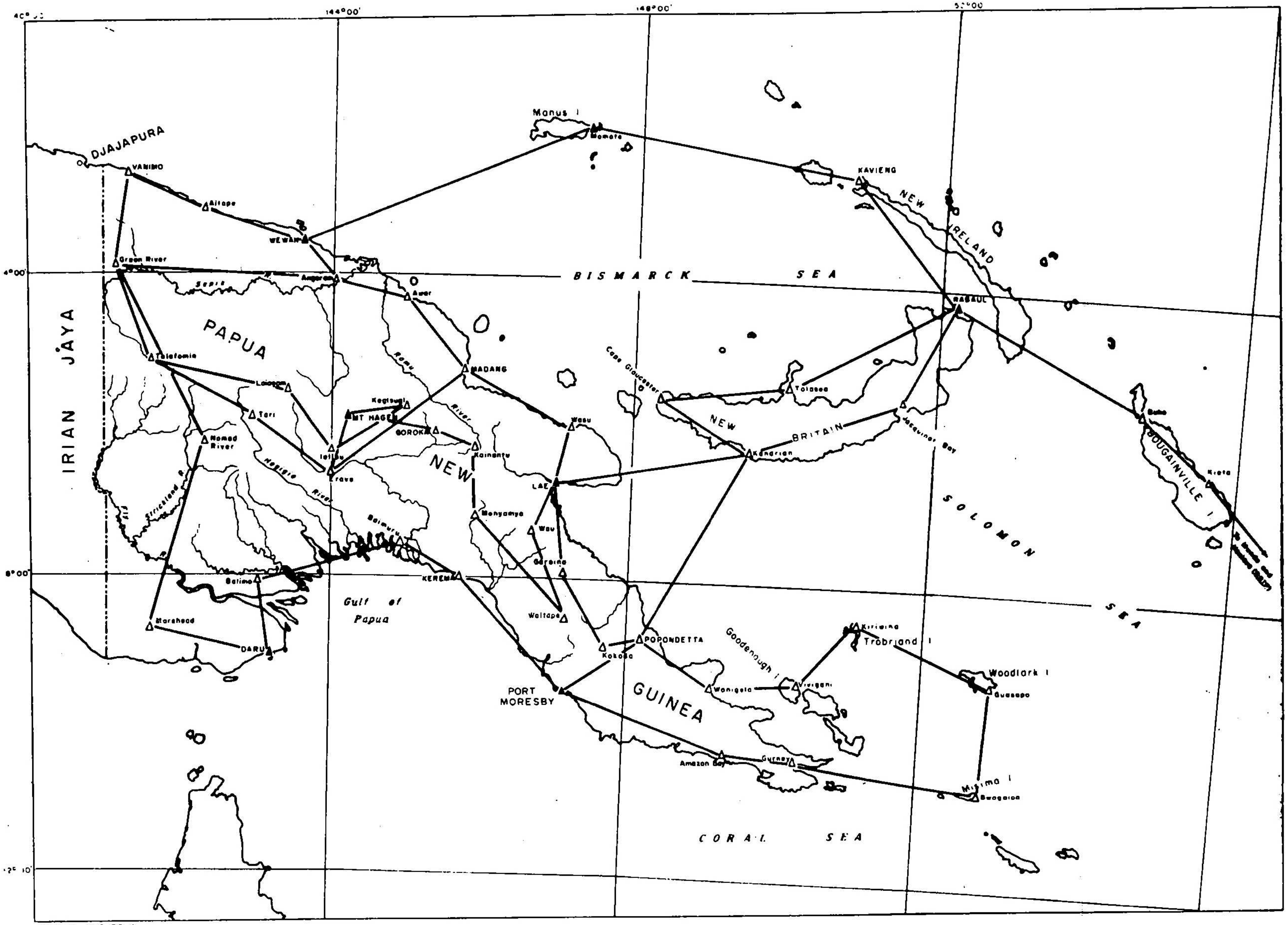
The traverses flown are shown in Figure 1. Closure diagrams for meters W169, W260 and G101 are shown in Figures 2, 3, and 4 respectively. A composite closure diagram for the mean of the three meters is shown in Figure 5. In these figures, airfields are identified by the last two figures of the gravity station number (see section 3, below, for station numbering system) and by the former Department of Civil Aviation (DCA) abbreviation of two or three letters. Appendix 1 contains a list of these numbers and abbreviations. Gravity values of all stations read during the survey are given in Appendix 2, and, for those stations reoccupied during the survey, are compared with previously observed values in Appendix 3.

2. TRANSPORT

The forward and return flights to Papua New Guinea were made by commercial aircraft. The great majority of the flights in the course of the survey were made in a Cessna 310J, VH-ATL, under charter contract from Aerial Tours Pty Ltd of Port Moresby. Two flights were made in a Cessna 337, VH-ATK, while VH-ATL was unserviceable. Flights between Mount Hagen, Keglsugl and Ialibu were made in a Cessna 185 chartered from Territory Airlines Pty Ltd in Mount Hagen. This was necessary as Keglsugl airstrip is not cleared for operations by category C aircraft such as the Cessna 310.

3. STATION NUMBERING

Isogal stations are named and numbered on a uniform principle. Isogal primary bases are stations established on enclosed premises, in which mains power is available, and are suitable for future occupation by pendulum or absolute gravity determination apparatus. Primary bases are established in major centres and at important nodal points on the Isogal network. At all other places on the Isogal network, secondary bases are established. These are stations at airfields, within a short distance of the normal aircraft parking area. They are the first stations to be occupied in each place, and hence are the most accurately known. Other stations established in places containing either primary or secondary bases and connected to them by multiple meter ties are termed excentres.



Based on PNG/B0-4
Base map: Geological Map of the World, Australia and Oceania sheet 7

0 100 200 300 km

LEGEND

▲ Isogal Primary Station

Δ Isogal Secondary Station

— Isogal traverse

Fig.1 Locality map

All stations occupied in BMR surveys are given eight-figure numbers, the first four of which indicate the survey on which the station was first occupied: the first pair of figures indicates the year of the survey, and the second pair the number of that survey within the year. Surveys are usually numbered in chronological order, but numbers 90 to 99 in each year are reserved for Isogal or other control surveys. The last two figures of the eight-figure number is the isogal number (Appendix 1); it is unique for each town or locality.

The last four figures characterise the station itself. Primary bases are indicated by numbers commencing with two nines, and have been numbered in order as occupied, irrespective of survey. During the 1967 Isogal survey primary bases numbered 6791.9976 to 6791.9982 were established. In addition, the primary base established at Daru in 1966 and numbered 6691.9972 was reoccupied.

The last four figures of secondary Isogal bases are an initial nine, followed by three numbers - usually allotted to the town in the order occupied; the last two numbers are the Isogal number (see Appendix 1). Excentres to secondary bases retain these last three figures, but the initial nine is replaced by some other number - e.g., one for the first excentre occupied, and so on to a maximum of eight.

Excentres to primary bases are numbered on a similar, but slightly different system. The initial nine is replaced by a zero and the second nine by some other number, this being one for the first excentre occupied and so on. It should be noted that, because of the requirement for enclosed premises, the primary base is frequently not the first station occupied in its locality, and the first excentre - e.g., 6791.0186 at Mount Hagen - may be the station that corresponds in accuracy to the secondary bases in other places.

Stations occupied and numbered on previous surveys retain their original numbers when incorporated in an Isogal survey. In the Papua New Guinea Isogal Survey, the stations first read by members of the University of Tasmania on surveys numbered 6351 and 6451 (University of Tasmania numbers 63 and 64, St John, 1967), and by myself on surveys 6615 and 6701 were reoccupied. Some of these stations became secondary bases. For excentres to such bases the last two digits of the station number is the Isogal number not the University of Tasmania number. The stations read with the Cambridge Pendulums during 1950 and 1951 (Dooley & others, 1961) form a special group, but in general can be regarded as Isogal primary bases; there are none of these stations in Papua New Guinea.

At Port Moresby, the station at the airport (6351.0195) was destroyed towards the end of the survey, but not before a tie was made to a nearby station (6791.0476). Previous readings at Port Moresby airport by university observers were made at 6351.0195.

4. GRAVITY METERS AND CALIBRATION

Three gravity meters were used on the 1967 Papua New Guinea Isogal Survey. These were LaCoste & Romberg G101 and Wordens 169 and 260. The LaCoste is a geodetic meter, with a range of 7000 mGal attainable along a single long micrometer screw. The steel spring system is kept at a constant temperature of about 50°C by a thermostatically controlled electric heating element. The Wordens have quartz springs and rely on the insulation provided by the evacuated case to minimise temperature effects. They have a range, without reset, of about 220 mGal.

Serviceability was generally good, but some trouble was experienced with the lighting system of Worden 169. The LaCoste meter, G101, functioned satisfactorily throughout the survey.

All meters were calibrated on the Canberra calibration range before and after the survey and the calibration factors for the two Wordens are those obtained by averaging the two results. A Canberra range interval of 54.72 mGal was used (Milsom & Mohamed, 1969). Runs were also made during the survey on the Port Moresby range. As the value of the Moresby range was not well known the runs on it were used only as a check on the constancy and relative accuracy of the calibration factors in use.

The results are summarised below:-

	W169	W260
Calibration factor (Canberra range 25.05.67)	.10113	.10878
Calibration factor (Canberra range 14.08.67)	.10101	.10877
Average calibration factor	.10107	.10878
Interval (mGal) Port Moresby 17.06.67	48.81	48.81
Interval (mGal) Port Moresby 06.07.67	48.84	48.80
Interval (mGal) Port Moresby 25.07.67	48.82	48.87
Interval (mGal) Port Moresby Average	48.82	48.83

Previous calibrations with LaCoste G20 gave an average value of 48.83 for the Port Moresby range. G101, which was taken over the range on the same days as the Wordens, gave 48.80 mGal on each occasion. These values, and all other G101 intervals in this report, are based on the maker's calibration factor, corrected to the Australian milligal. The correction factor, 0.999675, was experimentally determined by Shirley (1966) in cooperation with the United States Air Force.

5. DISCUSSION OF RESULTS

The basic Isogal 'flight' consists of a flight from a start point A to a second point B, the return flight from B to A, and a further flight back to B. Gravity readings are taken at A and B, the whole flight ABAB being carried out in the shortest possible time to minimise the effects of meter drift. Normally the flight is followed by ground work at B to establish excentres to the airfield base station.

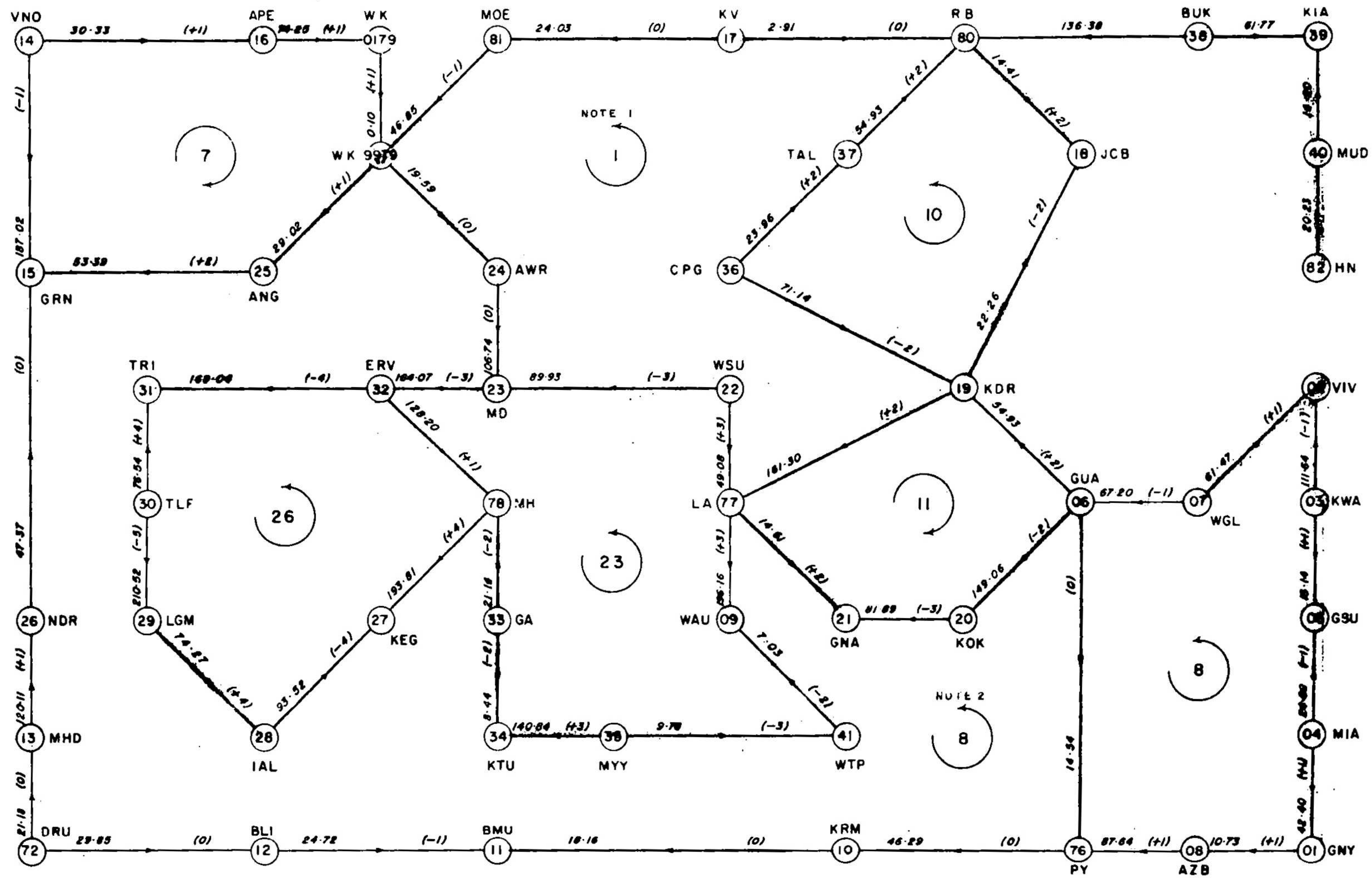
If inspection of the drift curves on completion of the second reading at B indicates that some readings are suspect, a further double leg BAB may be flown. This was never done on the Papua New Guinea Isogal survey as, on the few occasions when it would have been desirable, weather conditions would not allow the extra flying. A complete ABAB refly was carried out in some places, usually after a large misclosure had been found for a completed loop.

A number of flights departed from the normal pattern because of operational difficulties. Keglsugl, which is closed from 10.30 a.m. because of severe cross-winds, presented a special problem, and the Mount Hagen-Keglsugl link was effectively flown twice. The uncertainties of fuel supplies in the remoter areas were such that unscheduled diversions had to be made occasionally. Advantage was taken of such diversions to make additional observations. These single readings were used only as a check on the other results and revealed no significant errors.

The base network, excluding single readings, is shown diagrammatically in Figures 2 to 6. In Figures 2 to 4, the intervals and misclosures are shown for the three meters individually. The interval values are all shown, together with the misclosures for the average values, in Figure 5. Figure 6 shows the accepted intervals after the misclosure adjustments have been made.

It is normal practice in BMR to distribute loop misclosures by a least-squares procedure, and a computer program was available for this purpose. Usually the total misclosure around a loop is not exactly divisible by the number of links in it, and the 'left-over' few-hundredths of a milligal are distributed by the computer on a regular pattern. But I have distributed these few-hundredths of a milligal by making the largest corrections to links, in which the flight time was long; the drift pattern comparatively poor; or the values of the interval as determined by the three meters differed quite widely.

Large misclosures (i.e., misclosures involving the distribution of more than 0.01 milligal to all or most of the links in the loop) occurred with the Worden meters when used in or near the highlands. It is also noticeable that the misclosure for Worden 169 on such loops was much larger and in the same sense as those for Worden 260. This suggests that there may be some systematic cause of these errors, affecting Worden 169 more than 260. On highland loops there may be as much as 1000 m difference in elevation between adjacent stations, and temperature differences of more than 10°C. Several authors (Caputo, 1957; Gantar & Morelli, 1960) have shown that errors of several tenths of a milligal may be introduced by either temperature or pressure changes. Investigations

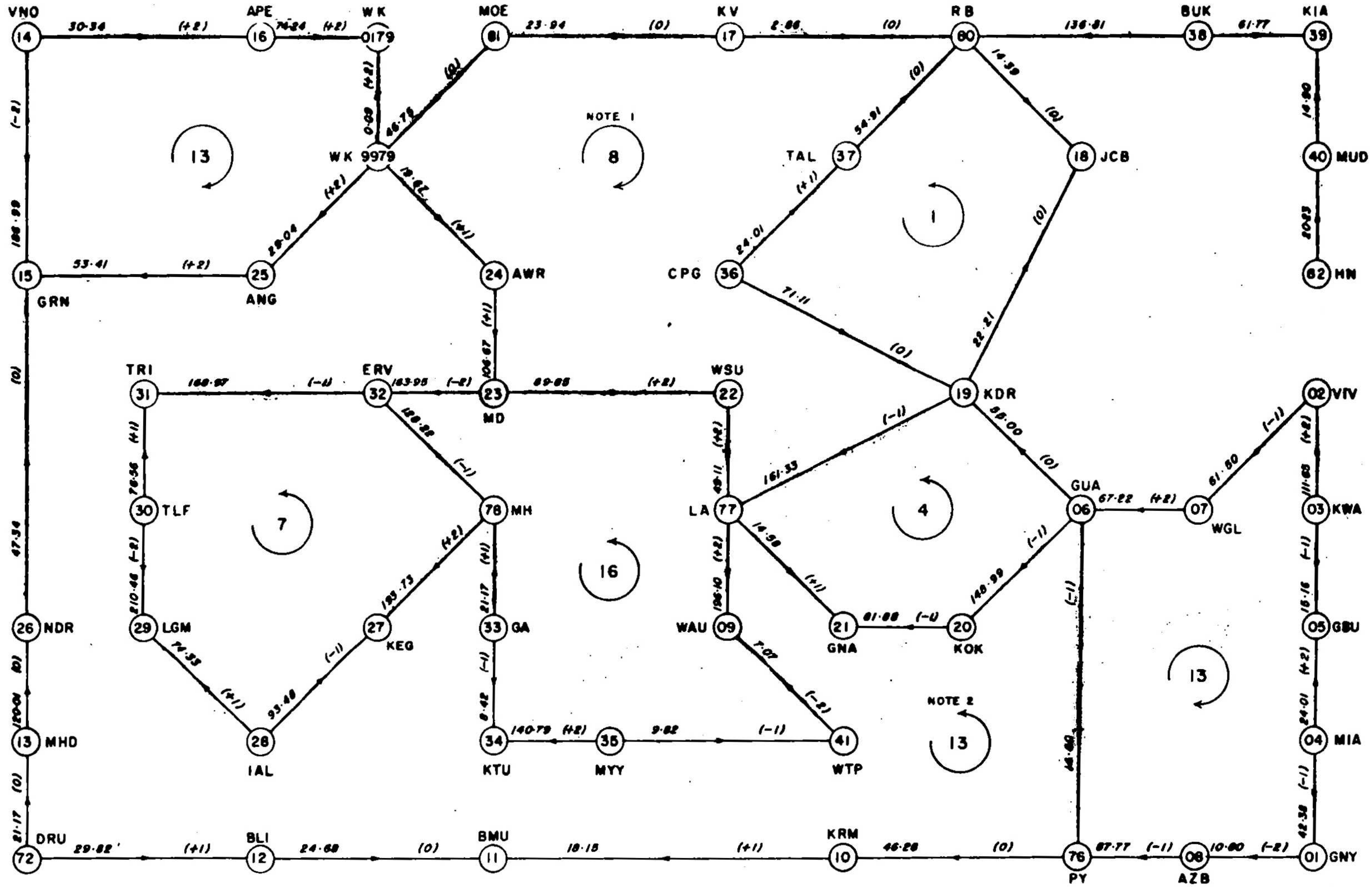


Note1. This misclosure is that for the loop taken via 18, not via 36 and 37
Note2 " " " " " " " " " 24–23–22–77–19–06–76

The figure beside the arrow on each link is the observed value, in milligals, of that interval. The figure in brackets beside the interval value is the correction to be made to that value to reduce the loop misclosure to zero.

Misclosures (magnitude in hundredths of a milligal and direction) are shown inside each loop.

Fig. 2 Intervals, loop closures, and corrections, Worden 169



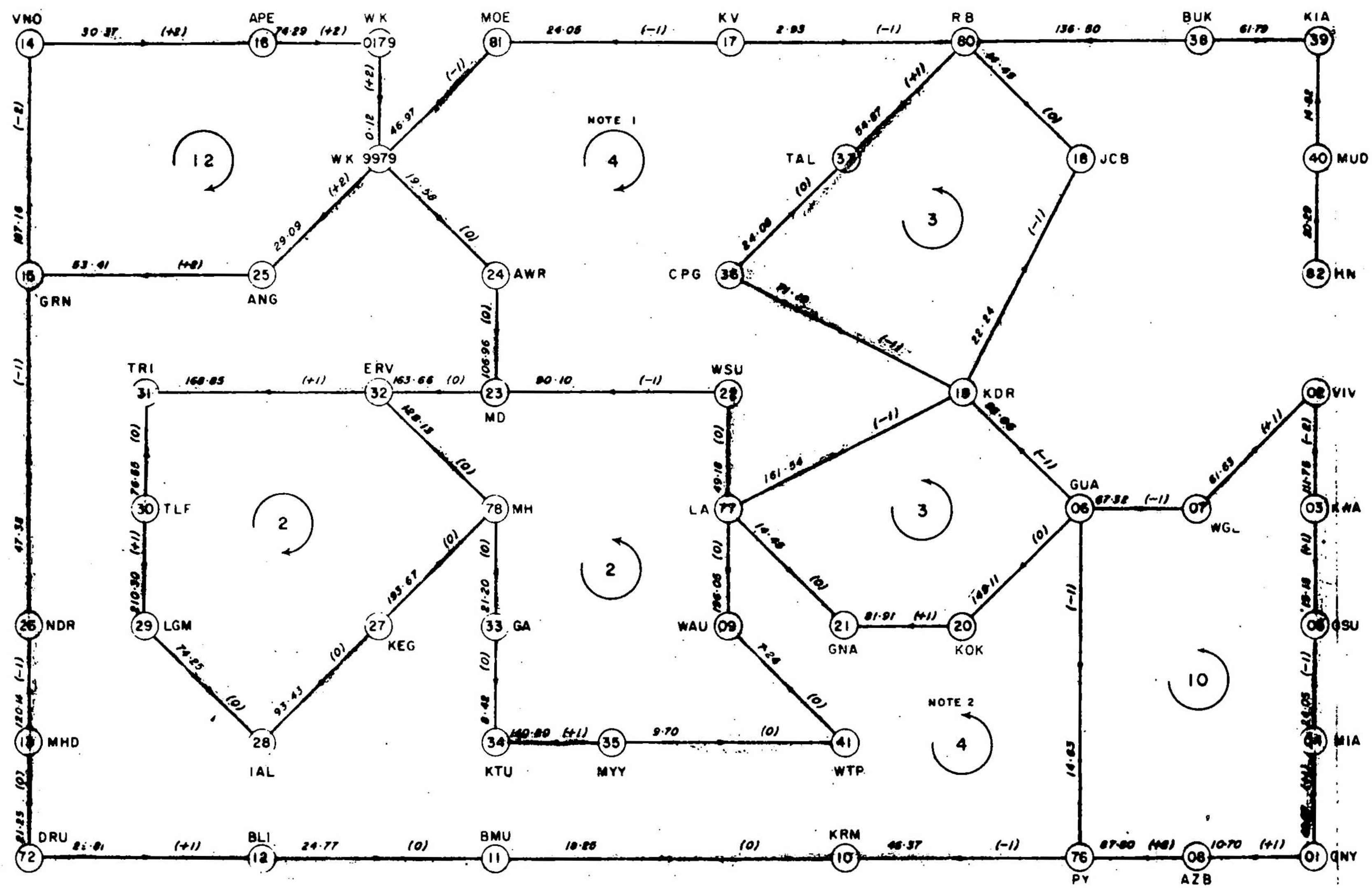
Note1. This misclosure is that for the loop taken via 18, not via 36 and 37

Note2 " " " " " " " " " 24–23–22–77–19–06–76

The figure beside the arrow on each link is the observed value, in milligals, of that interval. The figure in brackets beside the interval value is the correction to be made to that value to reduce the loop misclosure to zero.

Misclosures (magnitude in hundredths of a milligal and direction) are shown inside each loop.

Fig. 3 Intervals, loop closures, and corrections, Worden 260



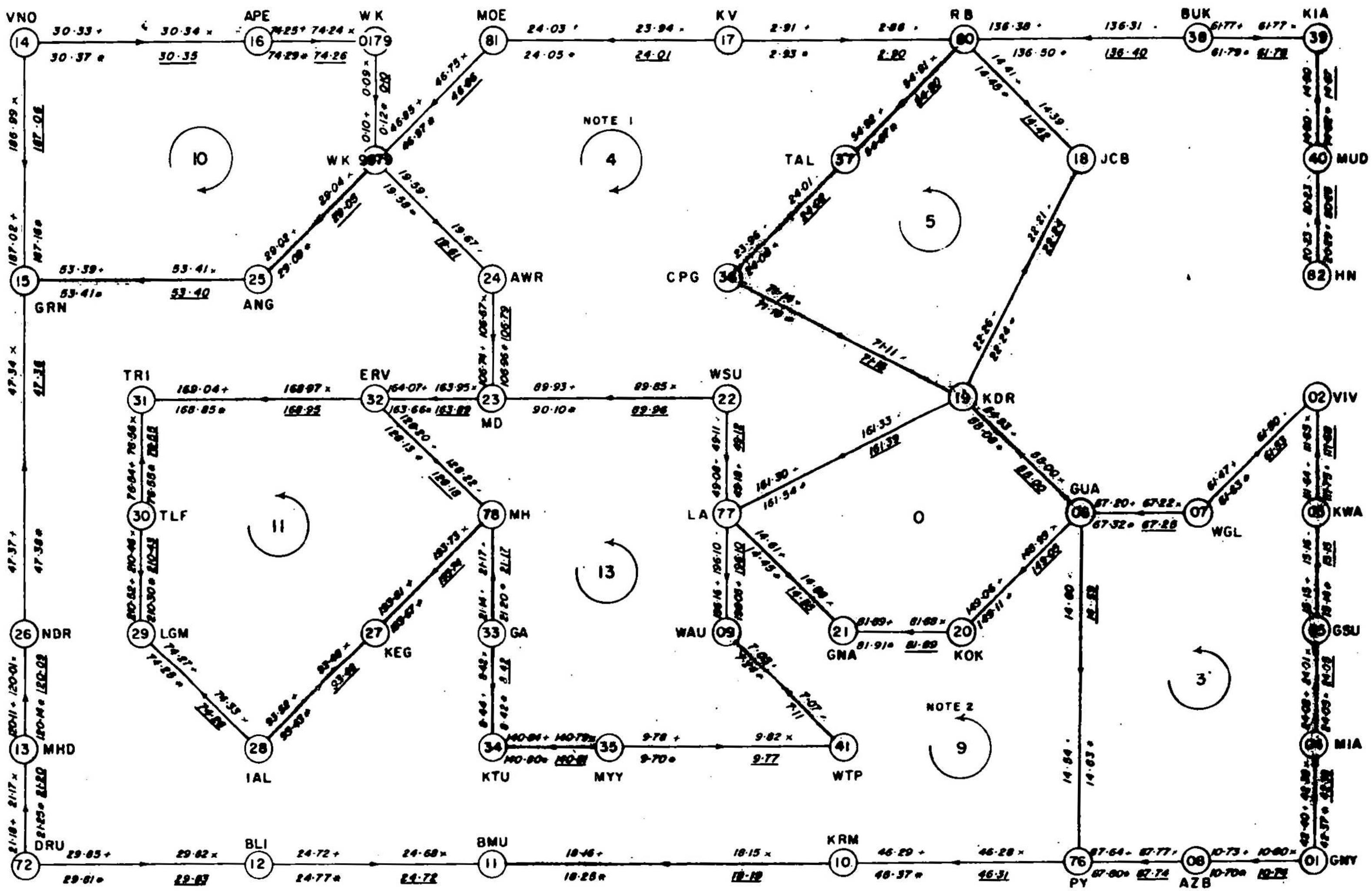
Note1. This misclosure is that for the loop taken via 18, not via 36 and 37

Note2 " " " " " " " " " 24—23—22—77—19—06—76

The figure beside the arrow on each link is the observed value, in milligals, of that interval. The figure in brackets beside the interval value is the correction to be made to that value to reduce the loop misclosure to zero.

Misclosures (magnitude in hundredths of a milligal and direction) are shown inside each loop.

Fig.4 Intervals, loop closures, and corrections, La Coste and Romberg G101

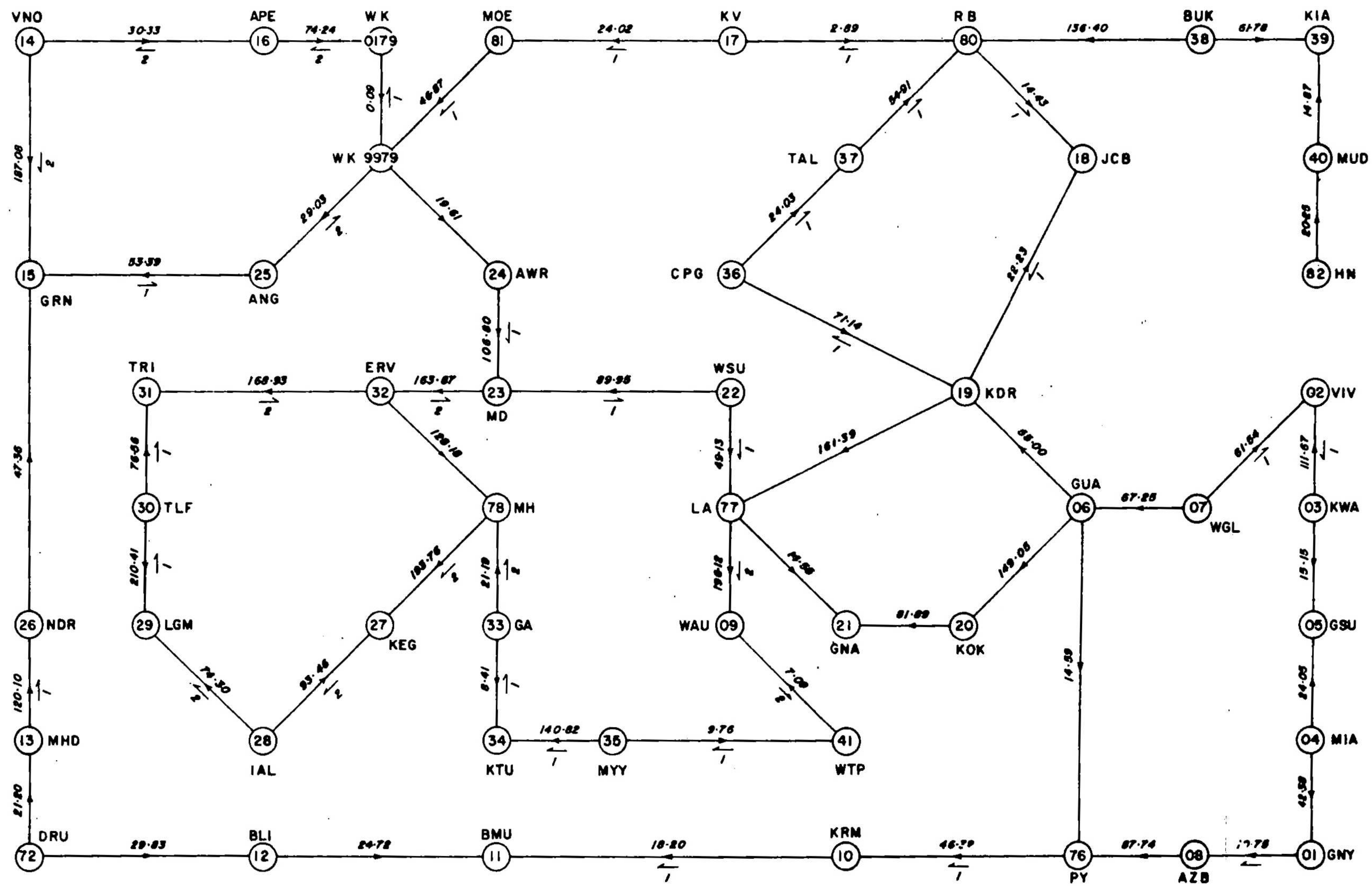


LEGEND
+ = W169
× = W260
• = G101
24·72 = Mean

Note1. This misclosure is that for the loop taken via 18, not via 36 and 37
Note2. " " " " " " " " 24–23–22–77–19–06–76

Misclosures (magnitude in hundredths of a milligal and direction) are shown inside each loop

Fig.5 Composite loop closure diagram



Interval values shown are values in milligals after correction. The corrections applied, in hundredths of a milligal are shown, together with direction.

Fig.6 Adjusted intervals, and corrections of the effects of such changes on LaCoste meters have also been carried out (Woollard, 1964a, b). Hamilton & Brule, 1967 have shown that erratic effects of the order of 0.1 mGal may result from vibration caused by aircraft or helicopters. Although the misclosures shown in Figure 4 suggest that vibration-induced drift has not been significant in the LaCoste meter, the Worden meters may have been affected in this way.

A vibration-induced shift of zero has been noted by BMR geophysicists engaged in helicopter surveys. High-frequency ground vibrations, such as those due to a helicopter or stationary engine, may cause a shift in reading of several-tenths of a milligal without affecting the stability of the beam. This effect, which has not yet been fully investigated experimentally, usually varies in magnitude from meter to meter, but may be responsible for the apparent systematic error in the closed loop, Vanimo-Aitape-Wewak-Angoram-Green River. All three misclosures of this loop are of the order of 0.1 mGal, and are in the same sense. In view of the small misclosure of the large loop through Angoram and Wewak to Madang, it seems likely that there is an error in the Green River-Vanimo-Aitape-Wewak section. The misclosures of the loop through Amazon Bay and the Papuan islands are also rather large. Observer inexperience is possibly the explanation here, this being the first loop completed.

The largest adjustment made to any interval for a single meter was 0.05 mGal (Worden 169), and for any interval averaged for the three meters 0.02 mGal. Though larger than had been hoped, these adjustments are small compared with the scatter of measurements of some of the intervals with the different meters. In Figure 7, three histograms are drawn showing the frequency of occurrence of various degrees of scatter (scatter being here defined as the difference between the largest and smallest values measured for a given interval. Although the scatter is generally greater for the large intervals, the relation is not a simple one. There are about the same number of cases of scatter in the 0.01 to 0.05 mGal range in the large and small interval groups. Also it must be remembered that large gravity intervals are usually accompanied by large pressure and temperature changes.

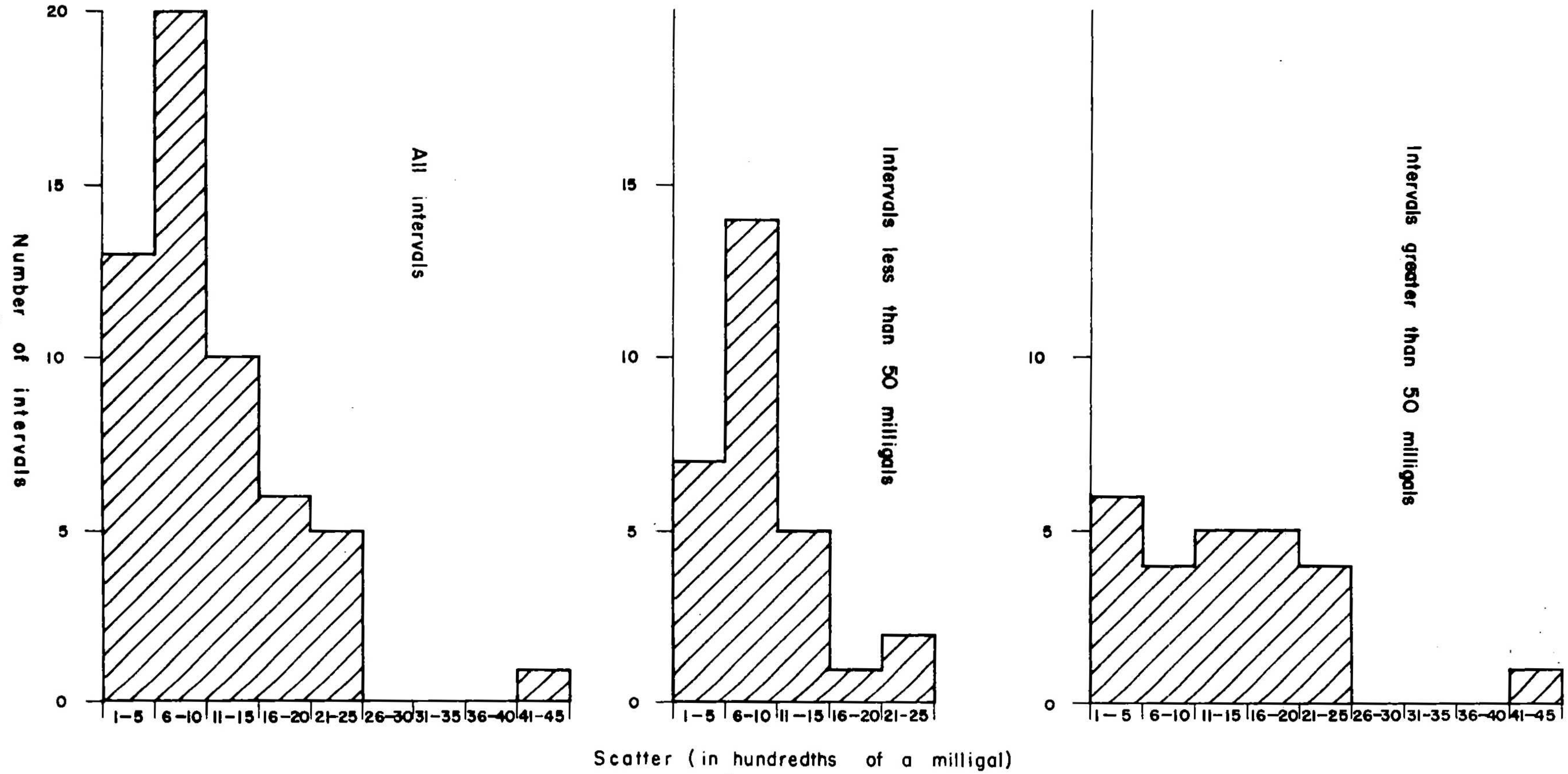


Fig. 7 Histograms showing scatter of gravity readings

Scatter can, of course, be simply due to wrong selection of calibration factor, and some estimate of the mutual consistency of the factors used is necessary. The interval Keglsugl-Buka covers almost the whole range of gravity field encountered in Papua New Guinea, and was directly measured in only nine links. The sums of these nine intervals are 816.76, 816.38, and 816.59 mGal for Worden 169, Worden 260, and LaCoste G20 respectively, a scatter of 0.38 mGal. Since the meters were calibrated in ranges with an interval of about 50 mGal, an error of 0.01 mGal in a calibration run would give an error of $2:10^4$ in calibration factor, or about 0.16 mGal in 816 mGal. The result quoted above suggests that the factor adopted for Worden 169 is too large and for Worden 260 too small by about this amount, but the evidence is not conclusive, and the original factors have been allowed to stand.

The most usual scatter for intervals less than 50 mGal (Fig. 7) is between 0.05 and 0.1 mGal, of which at the most 0.02 mGal can be accounted for by wrongly selected calibration factors. The remaining sources of scatter are observer error and irregularities in meter measuring screws. The observed misclosures suggest an observer error of ± 0.02 mGal on most links; it seems unlikely that errors of as much as 0.1 mGal were made. A large part of the scatter is therefore attributed to irregularities in the measuring screws of the meters.

Irregularities in calibration factor are well known for LaCoste meters (c.f. Milsom & Mohamed, 1969). In many instances, the value of an interval measured by the two Wordens is different from that measured by the LaCoste, but large differences between the Wordens are less common - e.g., for the interval Wau-Woitape, is one of the smallest intervals measured, the observed values were 7.03 (W169), 7.07 (W260), and 7.24 mGal (G101); the misclosure around the entire loop was 0.02 mGal for the LaCoste, and it seems unlikely that this could conceal an error of the order of 0.19 mGal. The drifts of all three meters were low and uniform for this flight. The only possible conclusion seems to be that a sharp spike exists on the calibration curve of LaCoste G101 when operating at this place on the micrometer screw.

In the LaCoste instruction manual a calibration factor is given for each 100 mGal section of the range of the meter, and such spikes are presumably averaged out in the table. An example of such averaging may exist in the interval Lae-Wau, in which the LaCoste value differs from the mean of the Worden values by 0.08 mGal. The range of screw movement of the LaCoste in measuring this interval includes the ranges involved in measuring the intervals Woitape-Wau (discussed above, LaCoste interval 0.19 mGal more than average Worden interval) and the interval Lae-Garaina (LaCoste interval 0.15 mGal less than average Worden interval). A further point of interest is that in all flights into Madang large scatters (including the largest) are observed, and each LaCoste value differs widely from the average of the Wordens.

Screw irregularities must also exist with the Worden meters but are not easily identified, as these meters were frequently reset to different ranges during the survey. It is at least possible that some of the differences between the two Wordens are due to irregularities in the calibration factor. If resets are involved in a closed loop, and this is so with all loops except that in eastern Papua, large misclosures may result.

The final values for all intervals have been obtained by averaging the values obtained with each of the three meters. Any attempt to select a 'best' value in some other way for any interval would seem to be dubiously based. By averaging it is hoped that an accuracy of 0.1 mGal has been obtained for any interval, and 0.2 mGal for the value of any station with respect to the total Australian network.

The presently accepted observed gravities at all Papua New Guinea Isogal stations are given in Appendix 2. All values are based on an observed gravity of 978202.62 mGal at the Isogal primary base, 6691.9972, at Daru. In accordance with previous practice these values, which are ultimately based on the results of the 1964-65 Australian Isogal surveys, are to be referred to as the 'May 1965' observed gravities.

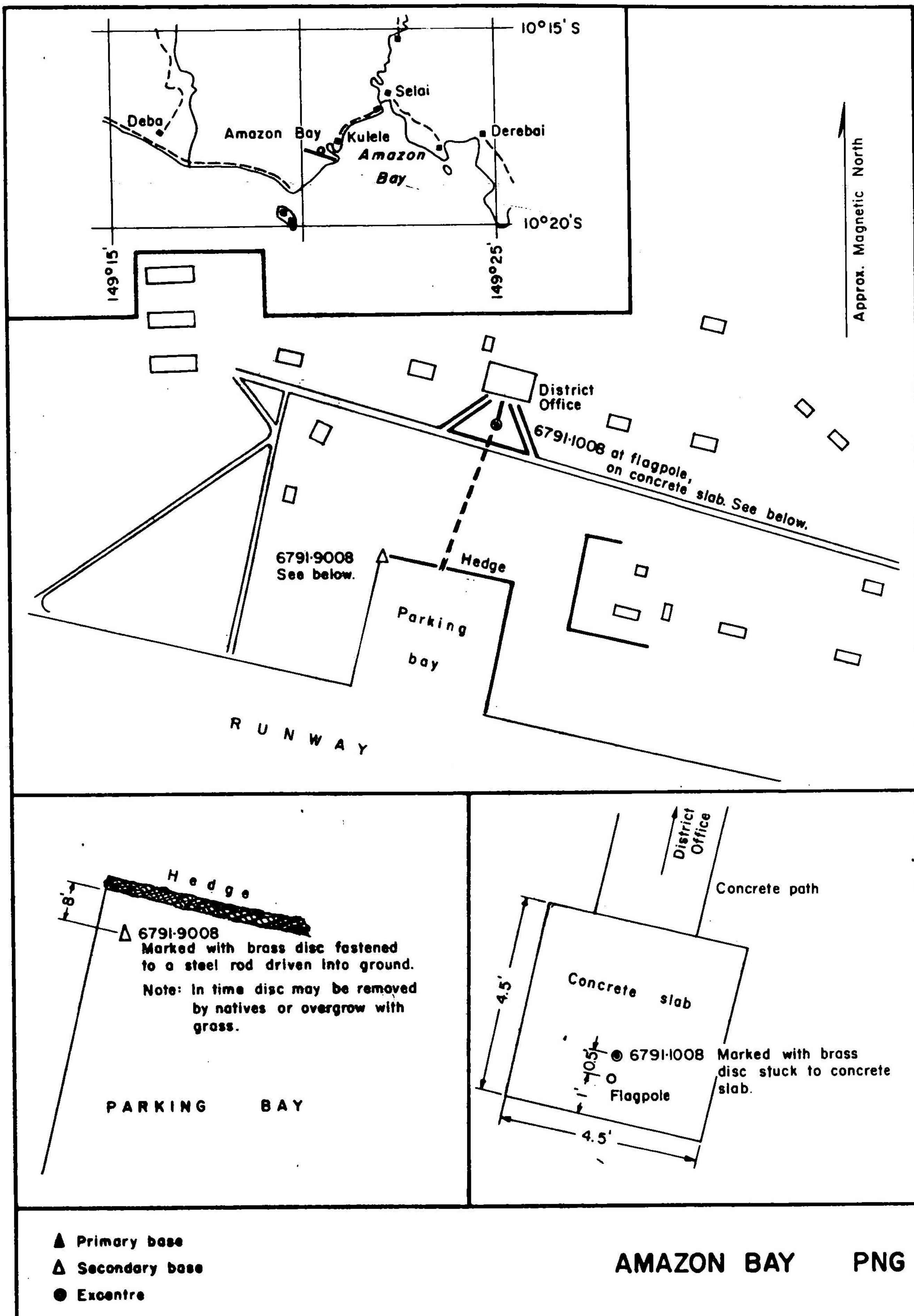


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Fig. 8 Example of station description diagram

6. STATION DESCRIPTIONS AND DATA STORAGE

Station location diagrams of all Papua New Guinea Isogal stations and the stations read in the Solomon Islands have been drafted and are held in BMR and by the Geological Survey of Papua New Guinea. An example of a station description diagram is given in Figure 8. Additional descriptive data, including photographs, pin-pricked airphotos, charts, and maps, are held by BMR. All stations were originally marked with brass discs, but these may not have remained long in place.

The meter calibration data are stored in the BMR calibration files for the appropriate meters. Field and drift sheets are filed in the New Guinea section of the BMR Isogal files, and station descriptive data under the appropriate station names.

7. ACKNOWLEDGEMENTS

Acknowledgement is made of the assistance given by the following organisations and people. It should be noted that the titles of individuals and the names of organisations used are those current when the survey was made (1967).

Observer-in-Charge and staff, BMR Geophysical Observatory Port Moresby

Senior Resident Geologist and staff, Geological Office, Port Moresby

Resident Geologist, Geological Office, Wau

Vulcanologist-in-Charge and staff, Vulcanological Observatory, Rabaul

Chief Geologist and staff, British Solomon Islands Geological Survey, Honiara

Department of Civil Aviation

District Commissioners at Daru, Kavieng, Kerema, Lae, Madang, Mount Hagen, Popondetta, Rabaul, Vanimo, and Wewak

Assistant District Commissioners at Aitape, Alotau, Amazon Bay, Angoram, Balimo, Green River, Ialibu, Kandrian, Kokoda, Laiagam, Losuia, Menyamya, Misima, Morehead, Tari, and Telefomin.

Patrol Officers at Bola-Bola, Guasopa, and Nomad River

Agriculture Officer at Garaina

STOL Air Services Pty Ltd (Daru)

Ansett-MAL (Wewak)

Earthworm Construction Pty Ltd (Popondetta)

I would also like to thank the three pilots, Mr Arthur Callard, Mr Ian Cruikshank, and Mr B. Rerecich, without whose skill and cheerful co-operation the survey would have lasted a great deal longer and been much less enjoyable.

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APPENDIX 1. STATION SYMBOLS AND NUMBERS

Airstrip	DCA symbol	Isogal number	Airport station number (see note)
Aitape	APE	16	
Amazon Bay	AZB	08	
Angoram	ANG	25	
Awar	AWR	24	
Baimuru	BMU	11	
Balimo	BLI	12	
Buka	BUK	38	
Cape Gloucester	CPG	36	
Daru	DRU	72	6691.9972
Erave	ERV	32	
Garaina	GNA	21	
Girua	GUA	06	
Goroka	GA	33	6791.9033
Green River	GRN	15	
Guasopa	GSV	05	
Gurney	GNY	01	
Honiara (Solomon Islands)	HON	82	6791.0182
Ialibu	IAL	28	
Jacquinot Bay	JCB	18	
Kainantu	KTU	34	
Kandrian	KDR	19	
Kavieng	KV	17	
Keglsugl	KEG	27	
Kerema	KRM	10	
Kieta	KIA	39	
Kiriwina	KWA	03	
Kokoda	KOK	20	
Lae	LA	77	6791.0177
Laiagam	LGM	29	
Madang	MD	23	
Menyamya	MYY	35	
Misima	MIA	04	
Momote	MOE	81	6791.0181
Morehead	MHD	13	

APPENDIX 1 (contd.)

Airstrip	DCA symbol	Isogal number	Airport station number
Mount Hagen	MH	78	6791.0178
Munda 2	MUD	40	
Nomad River	NDR	26	
Port Moresby	PY	76	6791.0176
Popondetta (Givua)	GUA	06	
Rabaul	RB	80	6791.0180
Talasea	TAL	37	
Tari	TRI	31	
Telefomin	TLF	30	6451.0642
Vanimo	VNO	14	
Vivigani	VIV	02	
Wanigela	WGL	07	6351.0113
Wasu	WSU	22	
Wau	WAU	09	
Wewak	WK	79	6791.9979
Woitape	WTP	41	

Note: Listed only if different from Isogal number. At primary stations, number of airport station is given to indicate position of primary base.

APPENDIX 2. 'MAY 1965' VALUES OF OBSERVED GRAVITY

Place	Station number	Observed gravity (mGal)	Informal name and/or previous station number(s)
AITAPE	6791.9016	978,170.71	A/S, Mission hangar
	6791.1016	171.51	Sub-district office
AMAZON BAY	6791.9008	978,300.33	A/S, parking bay
	6791.1008	300.12	District office
ANGORAM	6791.9025	978,067.35	Police station
	6791.1025	068.80	Near A/S, house
AWAR	6791.9024	978,076.77	A/S, windsock
	6791.1024	076.73	A/S
BAIMURU	6791.9011	978,148.07	A/S, shelter
	6791.1011	148.02	Ollie Goodwin's residence
BALIMO	6791.9012	978,172.79	A/S, parking bay
	6791.1012	171.32	Assistant District Commissioner's house
BUKA	6791.9038	978,300.78	A/S, parking bay
	6791.1038	304.84	Guest House
CAPE GLOUCESTER	6791.9036	978,243.32	A/S, PWD store
	6791.1036	243.58	A/S, windsock
DARU	6691.9972	978,202.62	A/S, hangar
	6691.0172	202.56	District office
ERAVE	6791.9032	977,806.10	A/S, shed
	6791.1032	804.94	Monument
GARAINA	6791.9021	977,996.24	A/S, windsock
	6615.0143	986.99	Post Office
GOROKA	6791.9033	977,699.11	A/S, pass. term; 6351.0189, 630189
	6791.1033	699.63	Post Office
GREEN RIVER	6791.9015	978,013.96	A/S, shed
	6791.1015	014.04	Power house
GUASOPA	6791.9005	978,329.41	Patrol officers residents
	6791.1005	329.20	A/S, on "G" of Guasopa sign
GURNEY AND ALOTAU	6791.9001	978,311.08	A/S, Gurney
	6791.1001	304.34	Store, Alotau
HONIARA (BSIP)	6791.9982	978,243.93	Geological Survey office
	6791.0182	274.12	A/S, pass. term.
IALIBU	6791.9028	977,577.62	A/S
	6791.1028	577.19	Hospital ward
JACQUINOT BAY	6791.9018	978,149.95	A/S, hut
	6791.1018	149.09	A/S, windsock
KAINANTU	6791.9034	977,690.70	A/S, apron
	6791.1034	687.43	Burnes Phillip store
KANDRIAN	6791.9019	978,172.18	A/S, pass. term
	6791.1019	195.79	Office

APPENDIX 2 (contd.)

Place	Station number	Observed gravity (mGal)	Informal name and/or previous station number(s)
KAVIENG	6791.9017	978,167.27	A/S, pass. term
	6791.1017	165.74	Hotel
KEGLSUGL	6791.9027	977,484.16	A/S, hut of native materials
	6791.1027	486.14	A/S, hut of iron
KEREMA	6791.9010	978,166.27	A/S, windsock
	6791.1010	161.41	District office
KIETA	6791.9039	978,239.00	A/S, shed; 630796, 631017, 6351.1017, 6351.0796
	6791.1039	239.38	A/S, concrete marker
KIRIWINA	6791.9003	978,344.56	A/S, near Kunai shed
	6791.1003	322.47	District Office
	6701.0101	333.86	Gusoeta Guest House
KOKODA	6791.9020	978,078.13	A/S, shed
	6791.1020	089.87	Monument to Native Carriers
LAE	6791.9977	978,006.25	Store No. 10
	6791.0177	010.79	A/S, pass. term, verandah
	6351.0197	010.86	A/S, pass. term.
LAIAGAM	6791.9029	977,503.32	Post Office
	6791.1029	504.45	Courthouse
MADANG	6791.9023	977,969.97	MAL hangar
	6791.1023	964.63	Smugglers Motel
	6351.0202	969.79	MAL cargo
MENYAMYA	6791.9035	977,831.52	A/S, hut
	6791.1035	833.14	Sub-District Office
MISMIA	6791.9004	978,353.46	A/S, parking bay, iron rails
	6791.1004	355.97	Assistant District Commissioner's house
MOMOTE	6791.9981	978,141.39	A/S, DCA store shed
	6791.0181	143.25	A/S, pass. term.
MOREHEAD	6791.9013	978,181.44	Soccer ground
	6791.1013	181.48	District office
MOUNT HAGEN	6791.9978	977,653.42	Post Office (inside)
	6791.0178	677.92	A/S, pass. term.
	6451.0900	653.44	Post Office (outside)
MUNDA (BSIP)	6791.9040	978,253.81	A/S, Customs shed
NOMAD RIVER	6791.9026	978,061.32	A/S, shed
	6791.1026	061.48	Patrol Post Office, notice board
POPONDETTA/CIRUA AERODROME	6791.9006	978,227.18	A/S, Gents toilet
	6615.0041	241.67	A/S, pass. term.
	6615.0042	247.95	Hotel Lamington
PORT MORESBY	6791.9976	978,208.96	Geophysical observatory
	6791.0176	212.59	A/S, old pass. term: 6351.0195, 630195
	6791.0276	216.61	BMR observatory office: 6351.0194, 630194
	6791.0376	167.78	Near DCA Radar shack
	6791.0476	212.36	A/S, DCA offices

APPENDIX 2 (contd.)

Place	Station number	Observed gravity (mGal)	Informal name and/or previous station number(s)
RABAUL	6791.9980	978,135.03	Observatory, store
	6791.0180	164.38	A/S, pass. term.
	6351.0170	164.42	A/S, DCA building
TALASEA	6791.9037	978,219.29	A/S, pass. term.
	6791.1037	219.32	A/S
TARI	6791.9031	977,637.17	A/S, parking area
	6791.1031	629.16	Assistant District Commissioner's house
TELEFOMIN	6451.0642	977,713.73	Monument
	6791.1030	713.70	Sub-District office
VANIMO	6791.9014	978,201.04	A/S, shed
	6791.1014	199.51	Shelter, near hotel
VIVIGANI AND BOLU BOLU	6791.9002	978,232.89	A/S, taxiway
	6791.1002	243.41	Assistant District Commissioner's house, Bolu Bolu
WANIGELA	6351.0113	978,294.43	A/S, parking bay; 630113
	6791.1007	299.94	Cridlans Guest House
WASU	6791.9022	978,059.92	A/S, concrete slab
	6791.1022	059.75	A/S, store
WAU	6791.9009	977,814.67	A/S, pass. term.
	6791.1009	816.41	Lands Department Office
WEWAK	6791.9979	978,096.38	MAL hangar, office
	6791.0179	096.47	A/S, pass. term.
	6791.0279	097.35	Tambara lodge
	6351.0211	096.34	MAL hangar; 630211
WOITAPE	6791.9041	977,821.76	A/S, shed
	6351.0632	820.59	Road intersection, permanent survey mark; 630632.

APPENDIX 3. COMPARISON OF GRAVITY VALUES AT STATIONS REOCCUPIED DURING THE 1967 PAPUA NEW GUINEA ISOGAL SURVEY

A number of the stations occupied in the course of the Papua New Guinea Isogal survey had been previously established by observers from other organisations. There are two major sources of information by Woollard & Rose (1963) and by St John (1967); the former covers the results of surveys, mainly by the members of the University of Wisconsin, to 1962, whereas the latter covers surveys between 1963 and 1965.

In the table below the values from Woollard & Rose (1963) are indicated by survey numbers beginning WA, and those from St John (1967) by (T) following the survey number. Most of the Isogal Numbers were obtained from the University of Tasmania number by inserting 51 after the figures denoting year of survey. This was not done at Port Moresby (Observatory and Burns Peak), where the Tasmanian numbers were not known until some time after completion of the Isogal survey, or at Kieta, where the reoccupation was only approximate.

Other previously established stations could not be reoccupied because of poor descriptions or later alterations to the site.

The values obtained by St John are all based on the value of 978 216.90 mGal for the Observatory garage in Port Moresby. Since this differs from the 'May 1965' value by 0.29 mGal, a better comparison of the surveys is obtained by subtracting this amount, as in difference column B. This reduces the discrepancy for most values to a small amount, but actually increases it for the high-altitude stations at Mount Hagen, Telefomin, and Woitape. The discrepancy of 0.07 in the intervals obtained for the Port Moresby calibration range (Observatory to Burns Peak) shows that these differences are due to gravity meter calibration erros.

APPENDIX 3 (contd.)

Location	Isogal number	Previous number(s)	Published value(s) (mGal)	'May 1965' value (mGal)	Difference A mGal	Difference B
Port Moresby (Observatory)	6791.0276	630194 (T)	978 216.90	978 216.61	+.29	0
Port Moresby (Burns Peak)	6791.0376	630219 (T)	978 168.00	978 167.78	+.22	-.07
Port Moresby (Jackson's)	6351.0195	630195 (T) WA 3069	978 212.9 978 212.9	978 212.59	+.31 +.31	+.02
Lae	6351.0197	630197 (T)	978 011.10	978 010.86	+.24	-.05
Madang	6351.0202	630202 (T)	977 970.10	977 969.79	+.31	+.02
Woitape	6351.0632	630632 (T)	977 820.50	977 820.59	.09	-.38
Rabaul	6351.0170	630170 (T)	978 164.40	978 164.42	-.02	-.31
Wewak	6351.0211	630211 (T) WA 3082	978 096.50 978 096.30	978 096.34	+.16 +.02	-.13
Kieta	6791.9039	6351.0796	978 239.30	978 239.00	+.30	-.01
Mount Hagen	6451.0900	640900 (T)	977 653.10	977 653.44	-.34	-.63
Telefomin	6451.0942	640942 (T)	977 713.30	977 713.73	-.43	-.72
Honiara	6791.0182	WA 3075	978 274.20	977 274.12	+.08	