ASSOCIATION INTERNATIONALE DE GÉODÉSIE

BUREAU GRAVIMÉTRIQUE

INTERNATIONAL

BULLETIN D'INFORMATION

N° 42

MAI 1978

B U R E A U   G R A V I M E T R I Q U E

I N T E R N A T I O N A L

Paris

B U L L E T I N   D ' I N F O R M A T I O N

Mai 1978

N° 42

T A B L E   des   M A T I E R E S

1ère Partie

2ème Partie

OBITUARY

William BULLERWELL

(1916 - 1977)

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            The sudden death of William BULLERWELL on 25th November
1977 not only deprived the Institute of Geological Sciences of
an exceptionally able and loyal Deputy Director, but also robbed
the geophysical community of one of its most dedicated practitioners.

            Born in Newcastle-upon-Tyne in 1916, he graduated in 1937
in Physics at King's College, Newcastle (Durham University) and
followed that in 1939 with a second degree in Geology, being awarded
the Labour Prize for Field Geology. His doctorate, on mining geo-
physics, was completed in 1951 having been interrupted by war
service from 1940 - 1946. During this period he was concerned with
the development and operation of radar, serving in the Ministry of
Supply, the RAOC and REME and being Mentioned in Despatches.

            His professional career began in 1946 when he joined the
field staff of the Geological Survey of Great Britain. Soon after-
wards his geophysical talents were directed towards the introduction
of geophysical methods as a component of the Survey's activities and
subsequently to the establishment of a Geophysical Department. As
well as organising many local geophysical investigations he initiated
systematic gravity and aeromagnetic surveys over the UK mainland and
surrounding waters. Publication of transparent overlays of the
gravity measurements at a scale of a quarter inch to one mile took
place under his supervision from 1954 and these were followed by
interim aeromagnetic maps at the same scale, and in 1955 and 1972
by the "Ten-mile" coloured aeromagnetic maps. In addition to these
official duties his energy enthusiasm led him, between 1953 and
1956, to undertake a reconnaissance gravity survey of Scotland
jointly with his wife, Eileen, whom he married in 1942, and Dr.
and Mrs J. PHEMISTER. His researches also led to the publication
of a standard geophysical reference on the Tertiary volcanic centres
of the Western Isles.

            Appointed Chief Geophysicist in 1962, he was instrumental
in broadening the scope of the Geophysical Division for which he
was responsible within the Survey and its successor, the Institute
of Geological Sciences formed in 1966 as a component body of the
Natural Environment Research Council. To the systematic surveys and
applied geophysical studies was added research work on geomagnetism
and global seismology.

This broadly based Geophysical Division formed the foundation from which work extended into marine geophysics as the hydrocarbon search moved into the offshore domain. His contribution to the organisation and implementation of the offshore programme commissioned by the Department of Energy was considerable. He was also heavily involved in initiating the current Department of Energy and EEC assessment of the geothermal potential of the UK and, through his service on the EEC's Advisory Committee on Programme Management, of the EEC states as a whole. For many years he represented the Ministry of Overseas Development at various multi-national conferences on mineral exploration and offshore prospecting in the Far East.

He was awarded the Lyell Fund in 1955 by the Geological Society whom he served as Treasurer from 1963 to 1971. His extensive geophysical knowledge and contributions were recognised by his election to the Royal Society in 1972 and in the following year to the Royal Society of Edinburgh. He was Chairman of the Advisory Board on Geophysics of the University of London and was a member of the Bureau of the International Gravity Commission. He served on, and submitted evidence to, numerous Governmental, Parliamentary, institutional and professional committees.

William BULLERWELL - Bill to his many friends and colleagues - was a very positive personality whose generosity, loyalty and kindness were complemented by the dedication, integrity and professionalism shown in all his scientific activities.

D.A.GRAY

Alfred SCHLEUSENER

(1898 - 1978)

On April 13, 1978, Professor Dr. Ing. Alfred SCHLEUSENER, a pioneer of applied geophysics, died in Hannover, after a short severe illness.

Born on the 1st March 1898, SCHLEUSENER studied mining sciences at the Technical University of Berlin-Charlottenburg in the early twenties. Having received his Dipl.-Ing. degree, he turned immediately to the field of exploration geophysics, which was in rapid development at that time. From 1925 to 1963 he was actively engaged mainly in gravimetric investigations, in many regions of the world, including Africa, North America and Western Asia. Since 1928 he was with Seismos company, Hannover, where he became head of the department for gravimetric and other non-seismic methods. While until the beginning of the thirties, the torsion balance was nearly exclusively used at gravimetric prospecting, the development of gravity meters changed the situation completely. Here SCHLEUSENER made an important contribution by the development together with St. von THYSSEN-BORNEMISZA - of an astatized gravity meter suitable for practical field work. Numerous instruments of this type have been built by Seismos GmbH, and employed for instance at the regional gravimetric survey of Germany, carried out between 1934 and 1945 under the supervision of SCHLEUSENER. The gravity maps resulting from this extensive survey today still serve as a basis for regional gravimetric investigations. After the second world war, SCHLEUSENER was one of the persons who reestablished the Seismos Company and brought her to another worldwide activity in geophysical exploration.

The scientific work of Alfred SCHLEUSENER is characterized by numerous publications, following his thesis about deformations of level surfaces, produced by artificial mass shifts, which was the basis for obtaining the Dr.-Ing. degree at the University of Breslau in 1936, under Professor Ludger MINTROP. These publications deal practically with all fields of applied gravimetry, from instrumental construction and calibration problems, design of gravity networks and accuracy estimation, to the calculation, presentation and interpretation of local and regional gravity anomalies. But SCHLEUSENER was also interested in more general geophysical problems. So he took part in a German geodetic, geophysical and geological expedition to northern Iceland in 1938, and carried out a gravity survey along an east-west profile crossing the axial rift zone. The idea, to get detailed information about the regional and the time behaviour of gravity at this part of an active spreading zone, could be taken up by him again in 1964/1965. From this work, and from the evaluation of the gravity field in Germany, SCHLEUSENER came to a close cooperation with geodesy, especially with the geodetic department of the Technical University of Hannover. In collaboration with this department, he continued the Iceland gravity survey in 1967 and 1970, and could present the first indications of secular gravity variations at the IUGG-IAG General Assembly at Moscow 1971.

Because of SCHLEUSENER's scientific merits and practical experiences, the Technical University of Hannover invited him to teach applied geophysics, and awarded him a honorary professorship. During that activity period, which lasted from 1954 to 1968 he gave the students of geodesy a sound background especially of gravimetric techniques and methods, and fascinated some of them - including the author - so much that they later went to exploration geophysics or to gravimetric geodesy. The author personally feels happy to have had the chance of a close and fruitful cooperation with Alfred SCHLEUSENER at Seismos GmbH and, since 1968, at the Institute of Theoretical Geodesy, T.U. Hannover. The outstanding work of SCHLEUSENER in Iceland is continued by this Institute now.

Alfred SCHLEUSENER was one of the founder members of the European Association Exploration Geophysicists, and he was also member of the Society of Exploration Geophysicists, of the International Gravimetric Commission, and of the Deutsche Geophysikalische Gesellschaft, of which he was president from 1964 to 1966.

The gravimetric community will not forget Alfred SCHLEUSENER, who promoted gravimetry in theory and practice.

Wolfgang TORGE, Hannover.

INTERNATIONAL GRAVITY COMMISSION

As it was already announced in the Bulletin d'Information N° 41, the eighth International Gravity Commission will be held in Paris :

from September 12th to 16th, 1978

Meetings will take place at the University Pierre et Marie Curie 4, Place Jussieu⁺ , 75005 PARIS, in the amphitheatre 25, next to the Office of the I.G.B. (Tour 14).

Métro : Jussieu or Cardinal Lemoine

Entrances : 4, Place Jussieu, or
Rue des Fossés Saint-Bernard (in front of Tour 14), or
⁺11, Quai Saint-Bernard (same place).

We give, here-after, the main scientific items included in the agenda with the title of the various papers already proposed to the I.G.B. and which will be presented at the meeting.

Item I   - C. MORELLI : Report of the International Gravity Commission
            J.J. LEVALLOIS : Report of the International Gravity Bureau

Item II   - International Gravity Bureau
            J. TANNER : Report of the I.G.B. Working Group I
            U. UOTILA :   "   "   "   Working Group II
            Yu.D. BOULANGER :   "   "   Working Group III

Item III - ABSOLUTE GRAVITY MEASUREMENTS   Chairman : A. SAKUMA

    - A. SAKUMA (B.I.P.M., France) / Absolute gravity measurements

    - Yu.D. BOULANGER (U.S.S.R.) : Results of absolute gravity measurements in
      Ledovo, Potsdam and Paris.

    - J.E. FALLER (U.S.A.)⁺: Plans and progress in the development of a portable
      absolute gravimeter with a few parts in 10⁹ accuracy.
      ⁺R.L. RINKER and M.A. ZUMBERGE.

    - I. MARSON & C. MORELLI (Italy) : Results of absolute gravity measurements
      in Europe and U.S.A., 1976/77.

    - B. DUCARME (Belgium) : Precise tidal corrections for absolute gravity
      measurements.

Item IV - INTERNATIONAL GRAVITY STANDARDIZATION NETWORK   Chairman : C. MORELLI

    - C. MORELLI (Italy) : General Report

    - G. BOEDECKER (G.F.R.) : The new gravity base net of the Federal Republic
      of Germany.

    - KANN GIESER (G.F.R.) : Direct comparison of absolute and relative gravity
      measurements in the Federal Republic of Germany.

    - H.G. WENZEL (G.F.R.) : Establishment of a high precision gravity network for
      detecting secular gravity variations in Northwestern Europe.

    - J.C. BHATTACHARJI (India) : Proposed absolute datum for Indian geodetic
      system.

Item V - GRAVITY MEASUREMENTS AT SEA   Chairman : J. WOODSIDE

    - J. WOODSIDE (U.K.) : General view on the sea gravity measurements
    - C. BOWIN (U.S.A. :   ...
    - G.L. STRANG van HEES (Netherlands) : On recent gravity measurements on the
      Atlantic.

Item VI - NON-TIDAL VARIATION OF G
        Special Study Group N° 3.40   Chairman : Yu.D. BOULANGER

    - Yu.D. BOULANGER (U.S.S.R.) : An international program of global studies of
      non-tidal gravity variations as indicator of mass centre movement.
    - G. BARTA (Hungary) : Mass distribution of the Earth on the surface and at
      depth and the global secular variation of the gravity field.
    - R.S. MATHER (Australia) : On the recovery of geodynamic information from
      secular gravity changes.
    - L. PETTERSON (Sweden) : High precision gravity measurements for studying the
      secular variation of gravity in Fennoscandia.
    - C. GERSTENECKER (G.F.R.) : Investigation of non-tidal gravity changes.
    - I. NAKAGAWA (Japan) : Gravity changes observed in the Kindi District, Japan.
    - J.M. CALDERA & M. MENA (Mexico) : Secular variations of gravity in Latin America.
    - Sh.K. SINGH (Mexico) : Secular variations of gravity in Mexico.
    - W. TORGE (G.F.R.) : Local gravity variations in Northern Iceland connected
      with earthquake and volcanic activity.
    - H. DREWES (Venezuela) : Regional subsidence of the Lake of Maracaïbo as
      determined by repeated gravimetric measurements.

Item VII - HIGH PRECISION GRAVIMETRY
        Special Study Group N° 3.37   Chairman : C. GROTEN

    - C. GROTEN (G.F.R.) : Report of Sp. St. Gr. 3.37 "Special techniques of
      gravity measurements".
    - C. GROTEN (G.F.R.) : High precision gravity campain in the Rhine graben net.
    - DEICHL, GROTEN, KIVINIEMI, WEICHEL.   ...
    - I. NAKAGAWA (Japan) : An accuracy of scale constant of LaCoste-Romberg
      gravimeters (model G) revealed by international and domestic gravimetric
      connections.
    - Z. SZABO (Hungary) : Investigations of environmental effects on gravity
      measurements.

Item VIII - SECOND DERIVATIVES OF THE POTENTIAL (Vertical Gradient of Gravity)
      ...

Item IX - NEW GRAVIMETRIC INSTRUMENTATION   Chairman : O. WILLIAMS
      ...

Item X - GRAVITY FIELDS ON THE MOON AND PLANETS
      ...

Item XI - PREDICTION OF GRAVITY VALUES   Chairman : U. UOTILA

    - A. MESKO (Hungary) : Interpolation of gravity data with practical applications.
    - C. TSCHERNING (Denmark)   ...

Item XII - COMPARISON AND COMBINATION OF SATELLITES RESULTS WITH SURFACE DATA
Chairman : R. RAPP

- R. RAPP (U.S.A.) : Ocean gravity data from Geos 3 altimeter data.
- G. DESVIGNES (France) : Some numerical results on statistical behaviour
  of gravity anomalies and geoïd undulations.

Item XIII - PHYSICAL INTERPRETATION OF GRAVITY ANOMALIES
Special Study Group N° 5.46   Chairman : S. SAXOV

- S. SAXOV (Denmark) : General Report
- S. SAXOV (Denmark) : Gravity applied to geology.
- G. DESVIGNES (France) : Geophysical interpretation of some large scale
  gravity anomalies and geoïd undulations.
- H.G. KAHLE (Switzerland) : Swiss Alps : gravity field and geodynamic
  implications.
- V. VYSKOČIL (Czechoslovakia) : On the construction of the density models
  of the Lithosphere.
- S. RIAD (Egypt) : On the downward continuation of the gravity field.

V A R I O U S

- H. MEYERS (U.S.A.) : U.S. land and sea gravity data.

- A. KIVINIEMI (Finland) : National Report on gravimetric activities in
  Finland 1974-77.

- D.E. AJAKAIYE (Nigeria) : Bouguer anomaly map of Nigeria.

- M.J. ABBAS (Iraq) : National Report on gravity activity in Iraq.

- M.G. ARUR (India) : National Report on the gravimetric work done in India.

- K.L. KHOSLA (India) : Future program of survey of India.

- G. MARFÖLDI (Hungary) : Physical interpretation of the relativistic
  variation of gravity constant.

I. NAKAGAWA, M. SATOMURA

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and

T. SETO

Geographical Survey Institute, Tokyo 153, Japan

AN ACCURACY OF SCALE CONSTANT OF LA COSTE & ROMBERG

GRAVIMETERS (MODEL G) REVEALED BY INTERNATIONAL

AND DOMESTIC GRAVIMETRIC CONNECTIONS

Abstract

In gravity measurements, a discrepancy among the scale constants of gravimeters used is one of the most important but inevitable problems, especially when a difference of gravity values among the measuring stations is large. After the data that were obtained by two sets of international gravimetric connections amounting to about 1.8 gals and 2.1 gals, respectively, and one set of domestic gravimetric connection amounting to about 1.6 gals in gravity differences were adjusted by referring to the IGSN 71, the following values of correction factor for scale constants of LaCoste & Romberg gravimeters G-29, G-118 and G-196 were determined.

For the gravimeter G-29 : $1.000663 - 0.000042 \Delta g_{obs}$.

For the gravimeter G-118 : $1.000215 - 0.000061 \Delta g_{obs}$.

For the gravimeter G-196 : $1.000640 + 0.000121 \Delta g_{obs}$.

Using these correction factors, the gravity value at each measuring station was re-calculated. The discrepancy between the value thus obtained and that of the IGSN 71 was almost less than $\pm$ 0.03 mgals at all stations.

1. Introduction

A great many gravity measurements of high accuracy which investigate the time change of gravity are being carried out by many researchers at various regions in the world (Honkasalo, 1975). All possible efforts have been made to be sure that the accuracy of measuring is as high as possible.

One of the problems which hinder the advancement in the accuracy of measurement is an uncertainty in the scale constants of gravimeters which are used. In order to avoid this uncertainty, precise gravity measurements at stations of small gravity difference have recently been made in various regions (e.g., Kiviniemi, 1974 and Nakagawa and Satomura, 1975). However, their measuring areas were limited to special regions because of the small gravity difference. It is therefore necessary to carry out an accurate calibration on the scale constant of gravimeters used in gravity measurements not only for large gravity differences but also for small gravity differences.

An accuracy of scale constant of LaCoste & Romberg gravimeters (model G) was investigated by comparing the data of gravity connections for large gravity differences amounting to about 3.5 gals with gravity values of the International Gravity Standardization Net 1971.

2. Employed Data

An international connection of gravity was carried out by

means of three LaCoste & Romberg gravimeters G-29, G-118 and G-223 in 1974 at Tokyo, Moscow, Potsdam and Paris (Soto and Tazima, 1975). Another international connection of gravity was undertaken by means of two LaCoste & Romberg gravimeters G-29 and G-196 in 1975 at Kyoto, Tokyo, Oahu-Honolulu, Los Angeles, Mexico City, Lima, Arequipa and Santiago (Nakagawa et al., 1977b). In addition, a domestic connection of gravity was carried out in Japan by using eight LaCoste & Romberg gravimeters involving the G-29, G-118 and G-196 in 1976 (Nakagawa et al., 1977a). The gravity differences were about 1.8 gals, 2.1 gals and 1.6 gals, respectively.

Data obtained by these three sets of gravimetric connections were employed in the present investigation. The results obtained by applying the scale constant of the gravimeters given by the manufacturer are shown in Table 1. As a reference, gravity values at measuring stations for the international gravimetric connections were referred to the International Gravity Standardization Net 1971 (IGSN 71) (Morelli et al., 1974) and those for the domestic gravimetric connection were referred to the IGSN 71 and the Japan Gravity Standardization Net 1975 (JGSN 75) (Geographical Survey Institute, 1976). The gravity values at the Japanese gravity stations based on the JGSN 75 are perfectly consistent with those based on the IGSN 71. The gravity values based on the IGSN 71 and the JGSN 75 are also shown in Table 1.

T A B L E   I

Gravity values referred to the IGSN 71/JGSN 75 and
gravity differences obtained by applying the scale
constant of the gravimeters given by the manufacturer.

Gravity values referred to the IGSN 71 / JGSN 75

applying the scale constant of the gravimeters

Station	IGB N° +	Gravity value (IGSN 71/ JGSN 75)	Gravity difference referring to the IGSN 71	Gravity difference obtained G-29		
				Japan ∼ Europe	Japan ∼ South America	Within Japan
		mGal	mGal	mGal	mGal	mGal
Tokyo C	13159 C	979763.19	0	0	0	0
Moscow		981551.35°°	+1788.16	+1786.92		
Potsdam A	21523 A	981260.19	+1497.00	+1495.97		
Potsdam B	21523 B	981260.70	+1497.51	+1496.48		
Potsdam L	21523 L	981257.09	+1493.90	+1492.86		
Paris A	18082 A	980925.97	+1162.78	+1161.96		
Paris O	18082 O	980898.44	+1135.25	+1134.40		
Kyoto C	13155 C	979707.75	- 55.44		- 55.42	- 55.43
Tokyo B	13159 B	979788.72	+ 25.53		+ 25.56	+ 25.55
Tokyo N	13159 N	979758.08	- 5.11		- 5.08	- 5.12
Oahu-Honolulu B	08817 B	978938.35	- 824.84		- 824.22	
Mexico City C	04699 C	977926.71	-1836.48		-1834.86	
Mexico City D	04699 D	977927.15	-1836.04		-1834.40	
Lima O	36827 O	978292.37	-1470.82		-1469.42	
Arequipa K	36861 K	977701.73	-2061.46			
Santiago A	44030 A	979414.11	- 349.08			
Nemuro		980683.63 X	+ 920.44			+919.89
Kushiro		980596.51 X	+ 833.32			+832.83
Sapporo		980477.57 X	+ 714.38			+713.97
Sapporo K	16631 K	980426.52	+ 663.33			+662.91
Hachinohe		980360.84 X	+ 597.65			+597.30
Kakioka		979966.43 X	+ 203.24			+203.10
Kyoto A	13155 A	979707.27 °X	- 55.92			- 55.95
Kumamoto A	13120 A	979551.62 °X	- 211.57			-211.34
Kagoshima A	13110 A	979472.15	- 291.04			-290.79
Naha		979099.42 X	- 663.77			-663.30

+ International Gravimetric Bureau Number.

°° After Elstner, 1974.

X Referred to the Japan Gravity Standardization Net 1975 (JGSN 75).

°X The surroundings around the measuring station were recently changed, and the gravity value was subject to have some change.

and gravity differences obtained by

given by the manufacturer.

by the present investigation				Remarks
G-118		G-196		
Japan ∿ Europe	Within Japan	Japan ∿ South America	Within Japan	
mGal	mGal	mGal	mGal	
0	0	0	0	Geogr. Surv. Inst.
+1787. 4				Grav. St. N°5035, Geod. & Cartogr. Surv.
+1496.76				Cent. Inst. of Geophys.
+1497.29				near Cent. Inst. of Geophys.
+1493.67				near Potsdam Int. Airport
+1162.59				Int. Bureau on Weights & Measures
+1135.05				Paris Orly Airport
	- 55.44	- 55.43	- 55.41	Geophys. Inst., Kyoto Univ.
	+ 25.51	+ 25.49	+ 25.50	Dept of Chemistry, Univ. of Tokyo
	- 5.09	- 5.10	- 5.09	Tokyo Int. Airport
		- 824.39		Bishop Museum
		-1835.51		Nat. Univ. of Mexico
		-1835.11		Tacubaya Obs.
		-1470.01		Lima Int. Airport
		-2060.37		Arequipa Airfield
		- 348.84		Military Geogr. Inst.
	+920.28		+919.80	Nemuro Weather Station
	+833.21		+832.78	Kushiro Local Meteo. Obs.
	+714.22		+713.85	Dept. of Geophys., Hokkaido Univ.
	+663.18		+662.86	Sapporo Int. Airport
	+597.55		+597.26	Hachinohe Weather Station
	+203.17		+203.06	Geophys. Res. Lab., Univ. of Tokyo
	- 55.95		- 55.92	Nat. Fund. St. of Grav., Kyoto Univ.
	-211.47		-211.37	Faculty of Education, Kumamoto Univ.
	-290.95		-290.84	Kagoshima Local Meteo. Obs.
	-663.61		-663.42	Okinawa Meteo. Obs.

Table 1 - p. 13-14

Tokyo C was adopted as the base station in the present investigation. The discrepancy between the gravity difference from the base station obtained and that referring to the IGSN 71 is shown in Figures 1, 2 and 3 for the gravimeters G-196, G-118 and G-29, respectively.

Figure 1 - p. 16
Figure 2 - p. 17
Figure 3 - p. 18

3. Correction Factor for Scale Constant

Each gravimetric connection employed in the present investigation consists of a perfectly going and returning measurement. Generally speaking, if there were jumps in the readings of the gravimeter on any section within a single series of measurement, it is possible to make a correction for such jumps in calculation. However, when the reading jumps took place on the same section of both the going and returning measurements, it is impossible to correct the jumps in calculation.

The gravimeters were transported by commercial jet aircrafts and passenger cars, and were always kept on the observers' knees during transportation in order to avoid severe shock to the

$$\Delta G_{IGSN71} - \Delta G_{obs}$$

Fig. 1.

The relation between gravity difference of each station from
the base station (Tokyo C) and deviation of the obtained
gravity value from the IGSN 71/JGSN 75, for the gravimetric
G-196. The straight lines were obtained by least squares
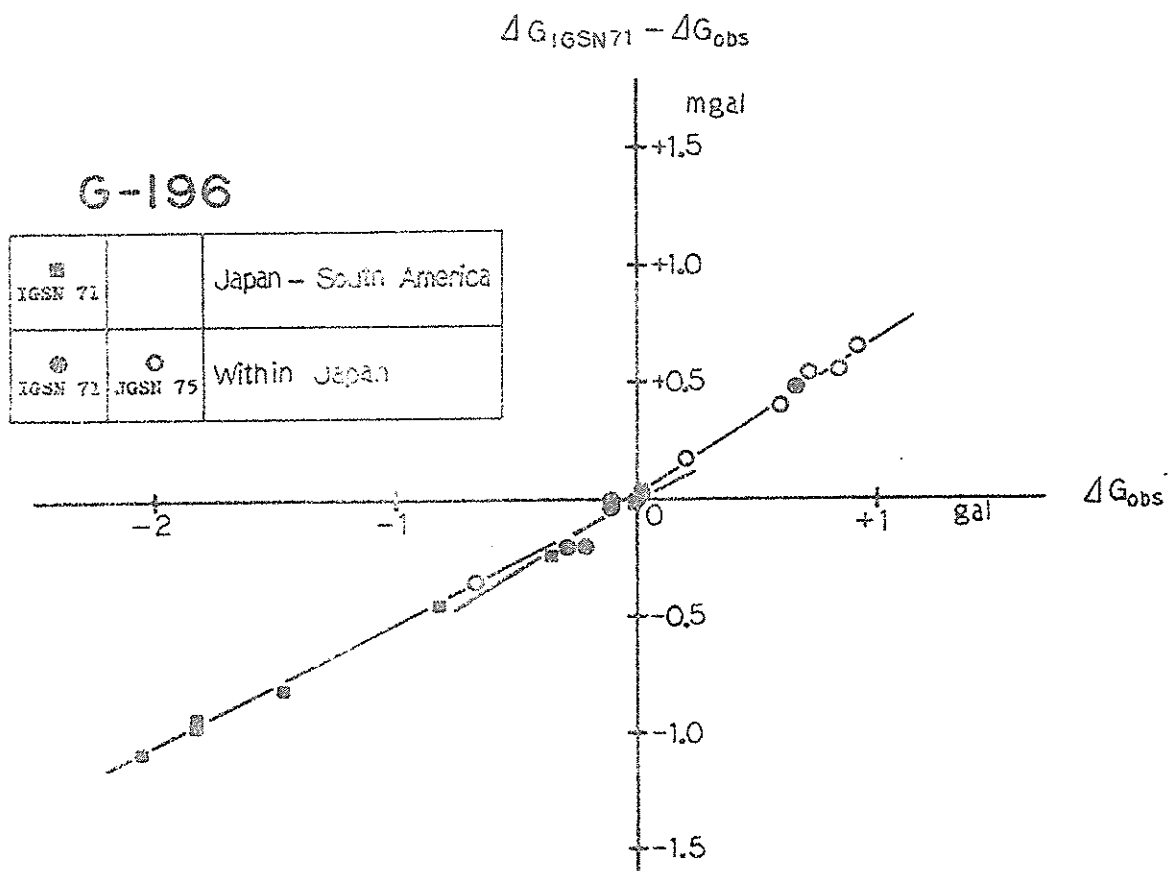method for each gravimetric connection.

Fig. 2.

The relation between gravity difference of each station from the base station (Tokyo C) and deviation of the obtained gravity value from the IGSN 71/JGSN 75, for the gravimeter G-118. The straight lines were obtained by least squared method for each gravimetric connection.
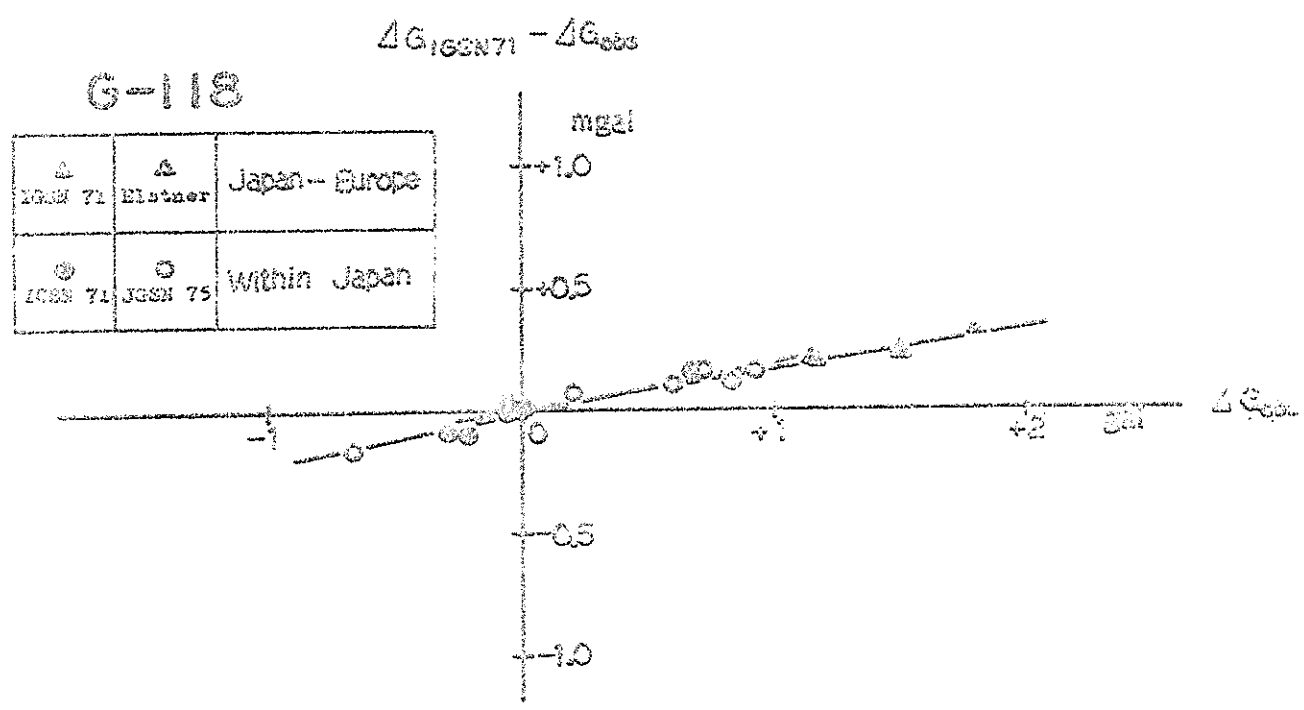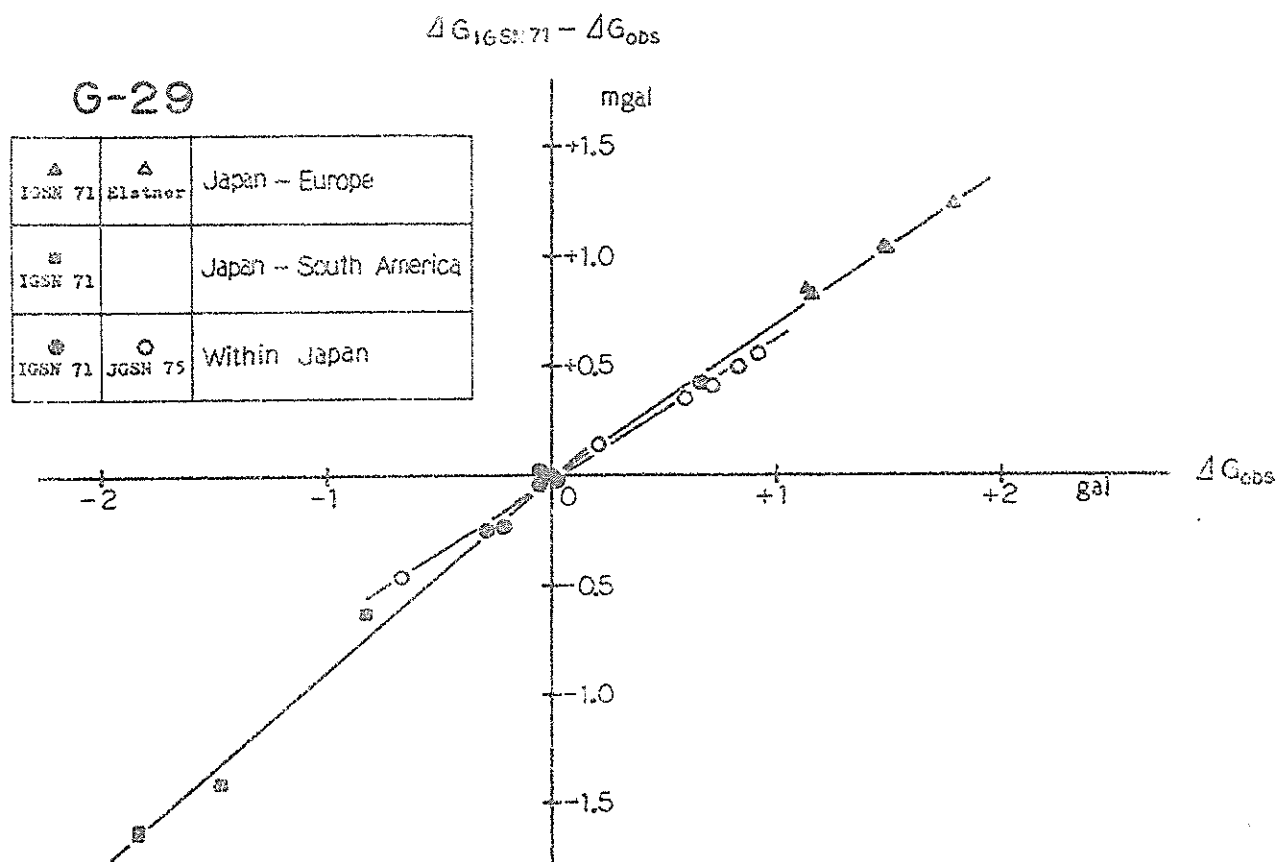
Fig. 3.

The relation between gravity difference of each station from the base station (Tokyo C) and deviations of the obtained gravity value from the IGSN 71/JGSN 75, for the gravimeter G-29. The straight lines were obtained by least squares method for each gravimetric connection.

gravimeters. On the trip to South America, however, the gravimeters could not be carried into the plane cabin on the way from Los Angeles to Mexico City and back because the plane crew did not understand the problem. It is, therefore, doubtful that a jump in the readings of the gravimeter took place on both the going and returning measurements between Los Angeles and Mexico City.

As can easily be seen in Figures 1, 2 and 3, no step is found for the gravimeters G-196 and G-118, while there exist two steps for the gravimeter G-29. Taking these steps into consideration and under the assumption that the gravity value of the IGSN 71 and the JGSN 75 is correct, the scale constants of the gravimeters G-196, G-118 and G-29 seem to be slightly small.

Assuming that the discrepancy has a linear relation to gravity difference, correction factors for the scale constant were determined by applying the least squares method for each gravimetric connection, as shown in Table 2.

Table 2 - p. 20.

Since Tokyo C was adopted as the base station, the gravity values of the international gravimetric connection between Japan and Europe were found to range from 0 to + 1.8 gals, those of the international gravimetric connection between Japan and South America from - 2.0 gals to + 0.1 gals, and those of the domestic gravimetric connection from - 0.7 gals to + 0.9 gals. It may

Table 2

Correction factors for the scale constant

Gravimeter	Gravimetric connection	Correction factor
G-29	International (Japan ~ Europe) International (Japan ~ South America) Domestic (within Japan)	1.000693 ± 0.000016 1.000893 ± 0.000030 1.000644 ± 0.000022
G-118	International (Japan ~ Europe) Domestic (within Japan)	1.000157 ± 0.000009 1.000205 ± 0.000017
G-196	International (Japan ~ South America) Domestic (within Japan)	1.000526 ± 0.000012 1.000668 ± 0.000023

therefore be thought that there exists a discrepancy of correction factor for the scale constant depending on its scale range.

As for the gravimeter G-196, the discrepancy between the gravity difference obtained and that referring to the IGSN 71 and the JGSN 75 seems to be expressed by a second order function in the gravity difference obtained. This can clearly be seen in Figure 1. The discrepancy $(\Delta g_{IGSN} - \Delta g_{obs})$ is expressed by the following formula, by applying the least squares method.

$$\Delta g_{IGSN} - \Delta g_{obs} = (0.000060 \pm 0.000010) \times \Delta g_{obs}^2$$
$$+ (0.000640 \pm 0.000015) \times \Delta g_{obs} + (0.000004 \pm 0.000010) ,$$

where Δg_{IGSN} is the gravity difference from the base station (Tokyo C) referring to the IGSN 71 and the JGSN 75, and Δg_{obs} is the gravity difference from the base station obtained (unit in gals). This relationship is shown in Figure 4.

Figure 4 - p. 22.

The correction factor (C_{196}) was finally determined for the whole scale range amounting to about 3.0 gals as follows :

$$C_{196} = (1.000640 \pm 0.000015) + (0.000121 \pm 0.000020) \times \Delta g_{obs}$$

As for the gravimeter G-118, the situation is similar to the gravimeter G-196. The discrepancy $(\Delta g_{IGSN} - \Delta g_{obs})$ is expressed by the following formula, by applying the least squares method.

$$\Delta g_{IGSN} - \Delta g_{obs} = - (0.000031 \pm 0.000014) \times \Delta g_{obs}^2$$
$$+ (0.000215 \pm 0.000019) \times \Delta g_{obs} - (0.000007 \pm 0.000009) .$$

$$\Delta G_{IGSN71} - \Delta G_{obs}$$

Fig. 4.

(Upper). The relation between gravity difference of each station from the base station (Tokyo C) and deviation of the obtained gravity value from the IGSN 71/JGSN 75, for the gravimeter G-196. The curved line was obtained by fitting the second order function.

(Lower). Scale constant given by the manufacturer and revised scale constant.

This relationship is shown in Figure 5.

Figure 5 - p. 24.

The correction factor (C_{118}) was determined for the whole scale range amounting to about 2.5 gals as follows :

$$C_{118} = (1.000215 \pm 0.000019) - (0.000061 \pm 0.000028) \times \Delta g_{obs} .$$

As for the gravimeter G-29, it was concluded from Figure 3 that the discrepancy between the gravity difference obtained and that referring to the IGSN 71 is expressed by a second order function in the gravity difference obtained, which is also the same as that for the gravimeter G-196, and that there exist two unquestionable steps; namely, one is between Tokyo and Moscow and the other is between Los Angeles and Mexico City.

The results obtained by applying the least squares method are expressed in the following formula and are also shown in Figure 6.

$$\Delta g_{IGSN} - \Delta g_{obs} = - (0.000021 \pm 0.000015) \times \Delta g_{obs}^2$$
$$+ (0.000663 \pm 0.000016) \times \Delta g_{obs} - (0.000032 \pm 0.000010) .$$

The amount of the steps was determined to be (0.129 ± 0.032) mgals on the section between Tokyo and Moscow, and (0.323 ± 0.059) mgals on the section between Los Angeles and Mexico City.

Figure 6 - p. 25.

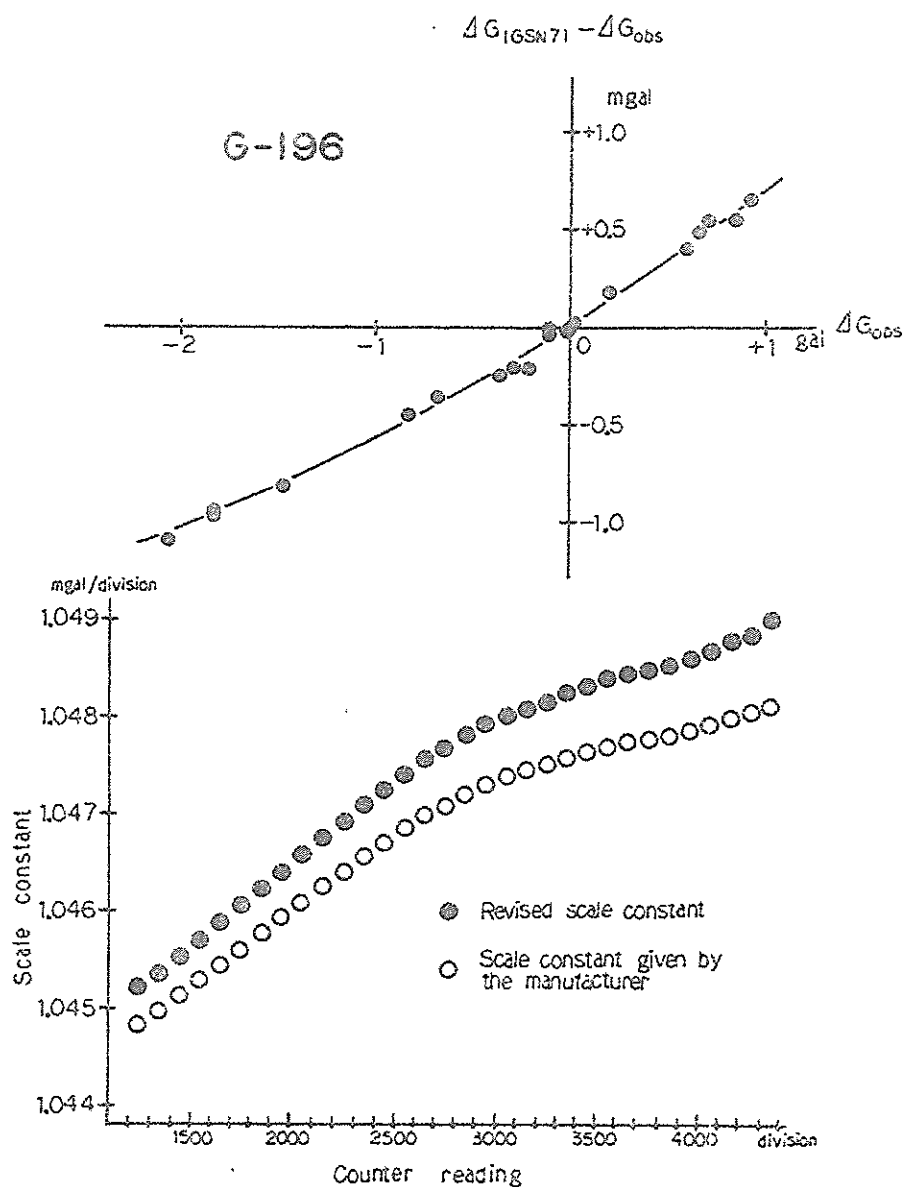The correction factor (C_{29}) was, therefore, determined for

Fig. 5.

(Upper). The relation between gravity difference of each station from the base station (Tokyo C) and deviation of the obtained gravity value from the IGSN 71/JGSN 75, for the gravimeter G-118. The curved line was obtained by fitting the second order function.

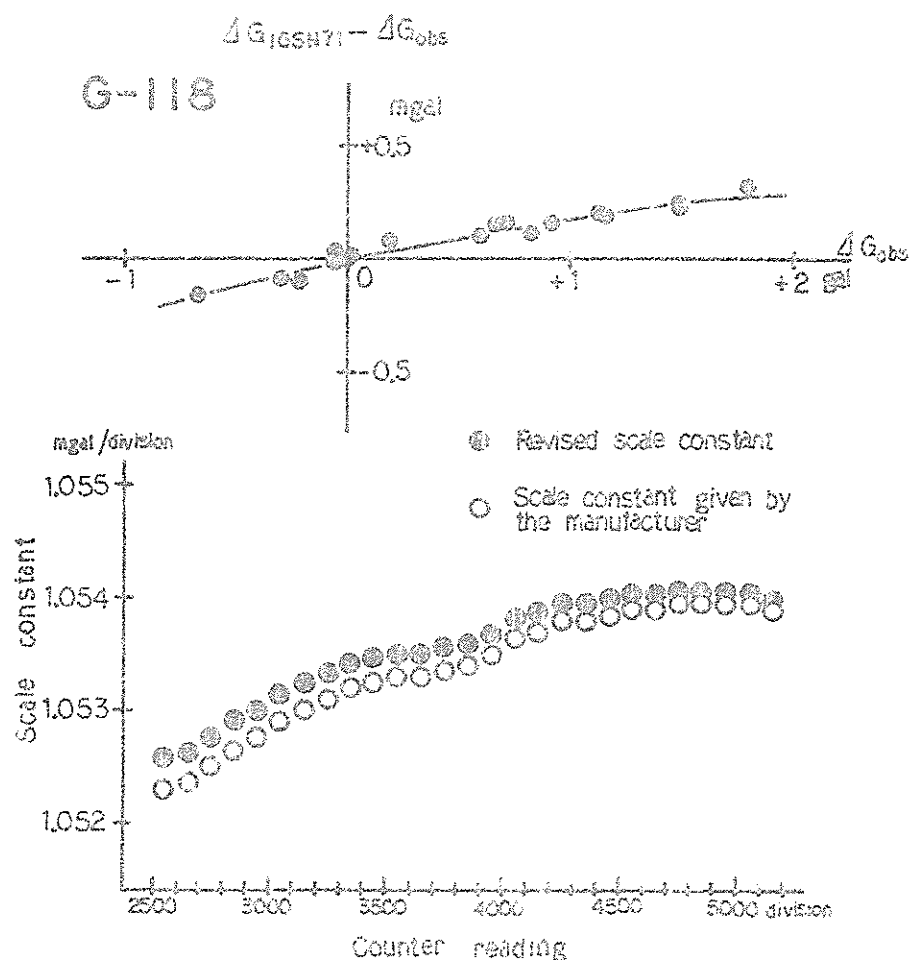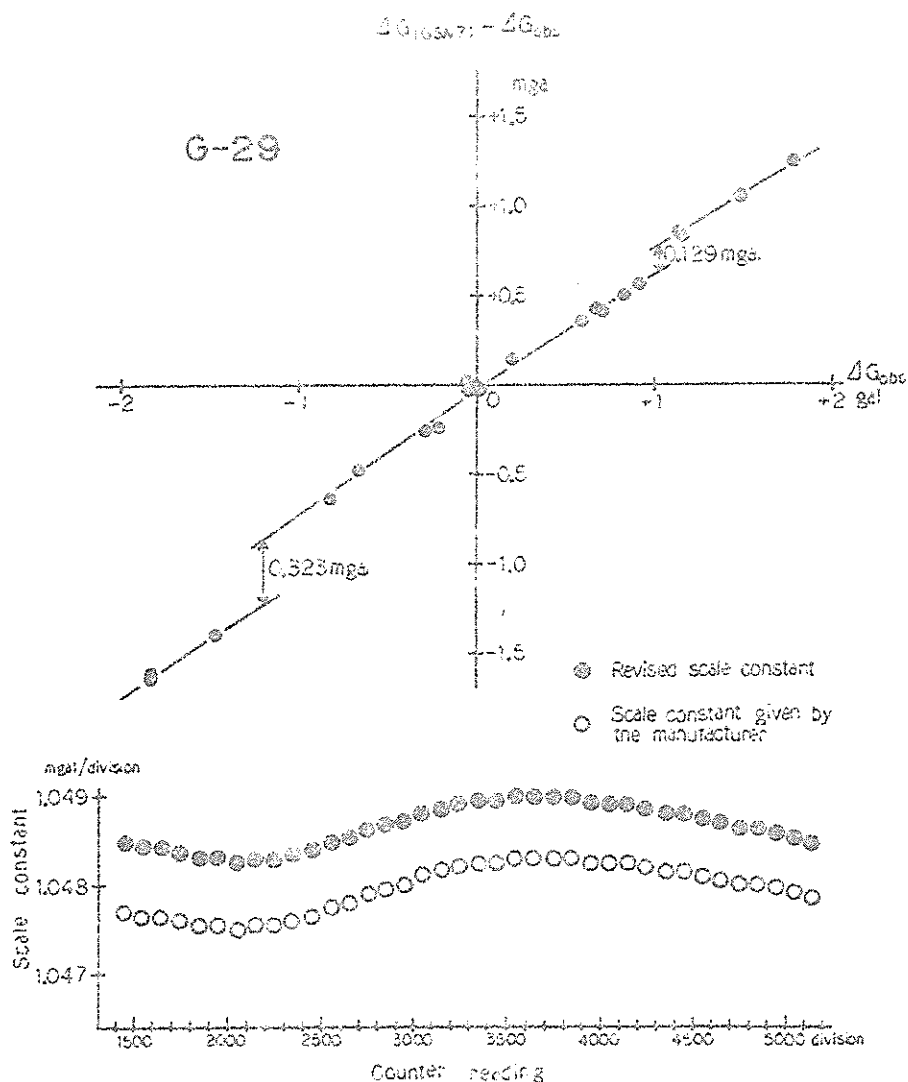(Lower). Scale constant given by the manufacturer and revised scale constant.

Fig. 6.

(Upper). The relation between gravity difference of each station from the base station (Tokyo C) and deviation of the obtained gravity value from the IGSN 71/JGSN 75, for the gravimeter G-29. The curved line was obtained by fitting the second order function.

(Lower). Scale constant given by the manufacturer and revised scale constant.

the whole scale range amounting to about 3.6 gals as follows :

$$C_{29} = (1.000663 \pm 0.000016) - (0.000042 \pm 0.000030) \times \Delta g_{obs} .$$

Using the correction factors obtained above, the gravity value at each measuring station was re-calculated under the assumption that the mean value of gravity at twenty-two (for the G-29) or eighteen (for the both G-118 and G-196) stations involved in the IGSN 71 and the JGSN 75 is assumed to have undergone no change; its result is shown in Table 3. Except for Kyoto A and Kumamoto A, the discrepancy between the value thus obtained and that given in the IGSN 71 and the JGSN 75 is generally less than ± 0.03 mgals.

Table 3 - p. - 27.

As for the station Kyoto A, the building in which the National Fundamental Station of Gravity in Japan (Kyoto A) was established was rebuilt in 1968, but the station was reconstructed at the same position and height as for the former one. The gravity value observed at the former station was used to the adjustment of the IGSN 71. According to the precise gravity measurements, the recent value of gravity at the Kyoto A is about 0.06 mgals smaller than the former one (Nakagawa et al., 1970), because of the difference of attractions between the former and the present buildings. Taking this difference into consideration, the difference between the mean value obtained and the gravity value for the Kyoto A given in the IGSN 71 and

T A B L E   3

Results of gravimetric connections

Station	IGB N°	Gravity value (IGSN 71/ JGSN 75)	Gravity value corrected				Dif.[+]
			G-29	G-118	G-196	Mean	
		mGal	mGal	mGal	mGal	mGal	mGal
Tokyo C	13159 C	979 763.19	763.16	763.18	763.19	763.18	-0.01
Moscow		981 551.35	551.33	551.31		551.32	-0.03
Potsdam A	21523 A	981 260.19	260.20	260.20		260.20	+0.01
Potsdam B	21523 B	981 260.70	260.72	260.72		260.72	+0.02
Potsdam L	21523 L	981 257.09	257.09	257.11		257.10	+0.01
Paris A	18082 A	980 925.97	925.99	925.99		925.99	+0.02
Paris O	18082 O	980 898.44	898.42	898.43		898.43	-0.01
Kyoto C	13155 C	979 707.75	707.69	707.73	707.74	707.72	-0.03
Tokyo B	13159 B	979 788.72	788.73	788.70	788.69	788.71	-0.01
Tokyo N	13159 N	979 758.08	758.05	758.09	758.09	758.08	0.00
Oahu-Honolulu B	08817 B	978 938.35	938.38		938.31	938.34	-0.01
Mexico City C	04699 C	977 926.71	926.69		926.71	926.70	-0.01
Mexico City D	04699 D	977 927.15	927.15		927.11	927.13	-0.02
Lima O	36827 O	978 292.37	292.40		292.37	292.38	+0.01
Arequipa K	36861 K	977 701.73			701.74	701.74	+0.01
Santiago A	44030 A	979 414.11			414.13	414.13	+0.02
Nemuro		980 683.63	683.64	683.64	683.62	683.63	0.00
Kushiro		980 596.51	596.53	596.55	596.54	596.54	+0.03
Sapporo		980 477.57	477.60	477.54	477.52	477.55	-0.02
Sapporo K	16631 K	980 426.52	426.50	426.49	426.49	426.49	-0.03
Hachinohe		980 360.84	360.85	360.85	360.85	360.85	+0.01
Kakioka		979 966.43	966.39	966.39	966.38	966.39	-0.04
Kyoto A	13155 A	979 707.27	707.18	707.22	707.23	707.21	-0.06
Kumamoto A	13120 A	979 551.62	551.68	551.66	551.68	551.67	+0.05
Kagoshima A	13110 A	979 472.15	472.18	472.16	472.17	472.17	+0.02
Naha		979 099.42	099.41	099.42	099.37	099.40	-0.02

[+]Dif. : Difference between the mean value obtained and the gravity value given in the IGSN 71 / JGSN 75.

the JGSN 75 should be changed from - 0.06 mgals to 0.00 mgal.

On the other hand, as can be seen in Table 3, there exists
a large difference between the value obtained and the gravity
value for the Kumamoto A given in the IGSN 71 and the JGSN 75.
The building, in which the Kumamoto A was established, was
recently demolished, and it is therefore conceivable that the
recent value of gravity is slightly larger than the former one.
Therefore, the difference of + 0.05 mgals can be reduced.

4. Conclusion

Using the data obtained by two sets of international
gravimetric connection and one set of domestic gravimetric
connection, correction factors for the scale constant of the
LaCoste & Romberg gravimeters G-29, G-118 and G-196 given by
the manufacturer could be determined.

The international gravimetric connection between Japan and
Europe and the domestic one in Japan were carried out as a
project.   But the international gravimetric connection
between Japan and South America was supplementarily carried out
during of travel to Peru and Chile to undertake observations of
crustal movement.

The discrepancy between the value obtained in the present
investigation and that given in the IGSN 71 and the JGSN 75 is
generally less than ± 0.03 mgals.   This may mean that the
present result is accurate in spite of unfavorable conditions.

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AUXILIARY GRAVITY STATIONS

at the "BUREAU INTERNATIONAL DES POIDS ET MESURES" (B.I.P.M.)

The fundamental gravity station is Sèvres Point A, on a concrete pier about 0,20 m below the level of the floor, in the room of the absolute gravity apparatus.

This site is highly recommended for all connections and more specially for the international measurements.

However in order to facilite the current connections, excenters have been established, i.e. :

excenter B and C inside the limits of B.I.P.M. in the main yard, excenter E outside the B.I.P.M. close to the entrance gate. (See diagrams).

The connections of these sites to the A station have been observed by the International Gravity Bureau using the LaCoste-Romberg gravimeter G.225 kindly lent by the "Centre Géologique et Géophysique" of Montpellier (Mr. Louis).

Two circuits have been observed clockwise and anticlockwise with closure on the A point.

$$g\ (A - C) = -\ 0.25\ mGal$$
$$g\ (C - E) = -\ 0.12\ "$$
$$g\ (E - B) = \ \ \ 0.09\ "$$
$$g\ (B - A) = \ \ \ 0.28\ "$$

The gravity values referred to the absolute A point run then :

$$g_A = 980.925,96\ mGal$$
$$g_B = 980.926,24$$
$$g_C = 980.926,21$$
$$g_E = 980.926,33$$

$$\pm\ 0,02$$

It should be noted that the $\Delta\ g_{AB}$ value referred to A, differs from the previous value ($\Delta g = 0,33$) due likely to some changes in the site (rise of the pavement).

Furthermore, a new site A_3 has been chosen by Dr. SAKUMA for the absolute gravity measurements performed with transportable apparatus.

PAVILLON de BRETEUIL

C

Parc ⟵

Sévres ⟶

E

B• Chenil

LABORATOIRES

A

Labo

Chenil

1m90

2m22

1m10

0m90

B

SEVRES - pt B

PAVILLON de BRETEUIL

C

0^m25

0^m15
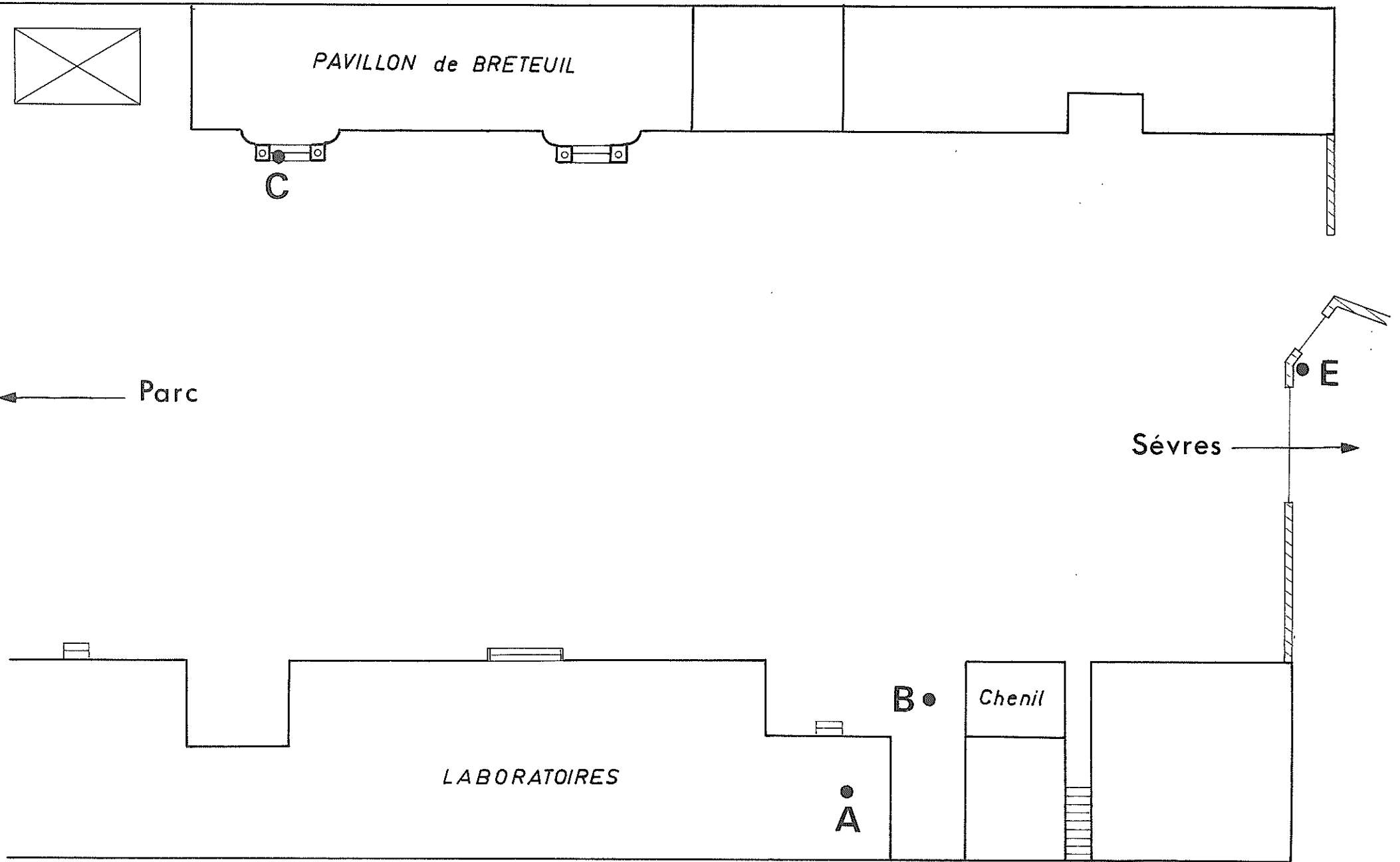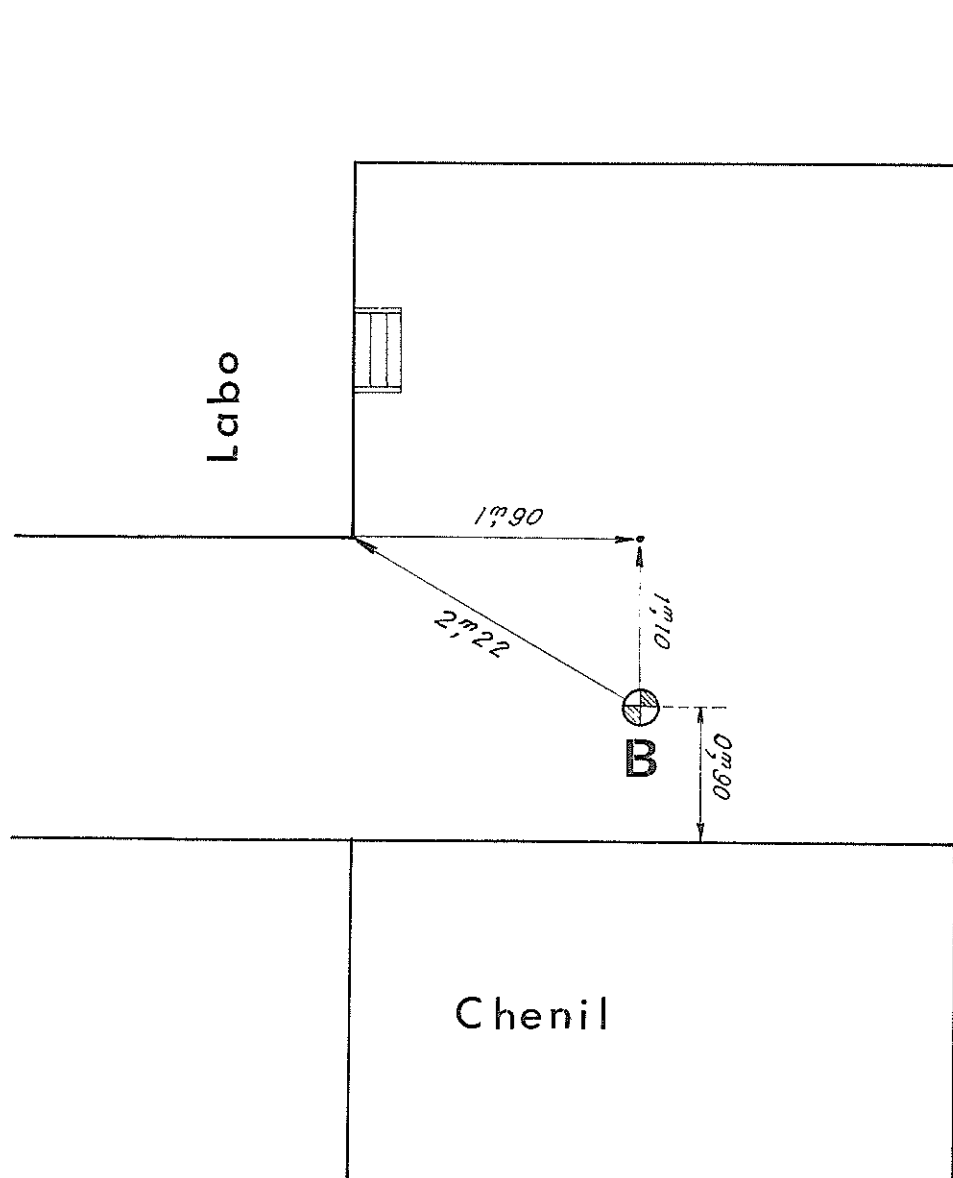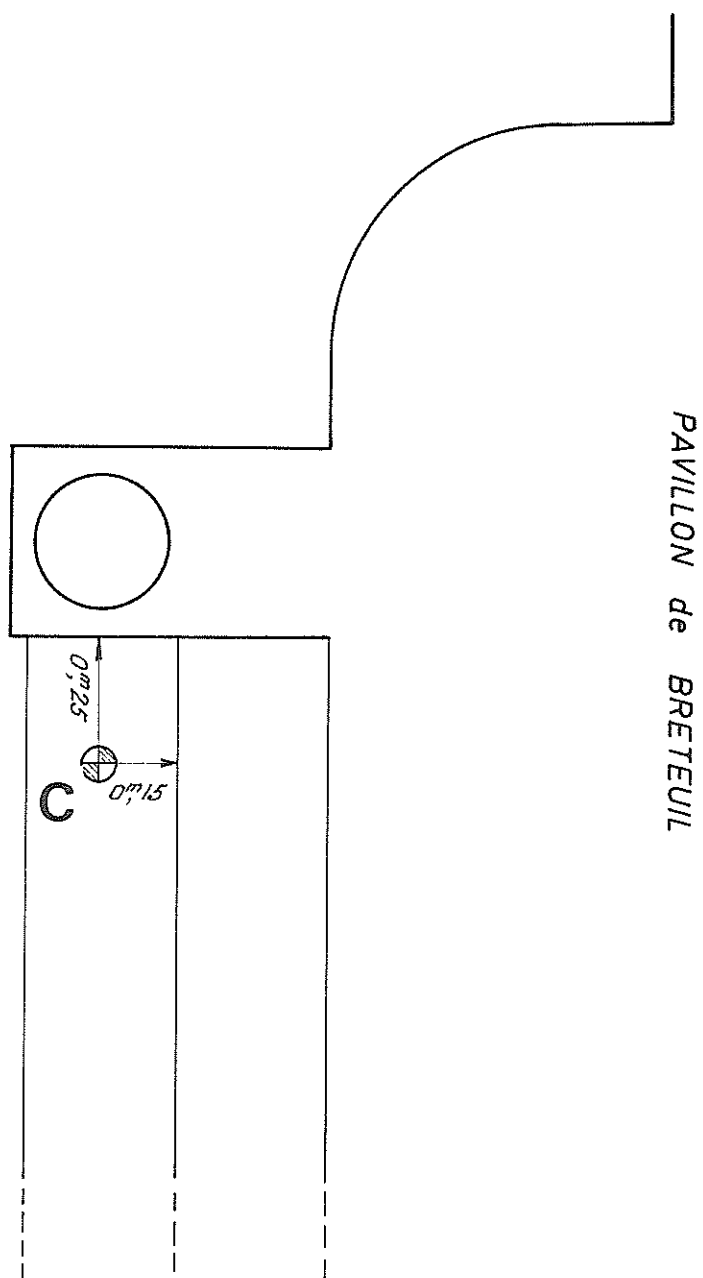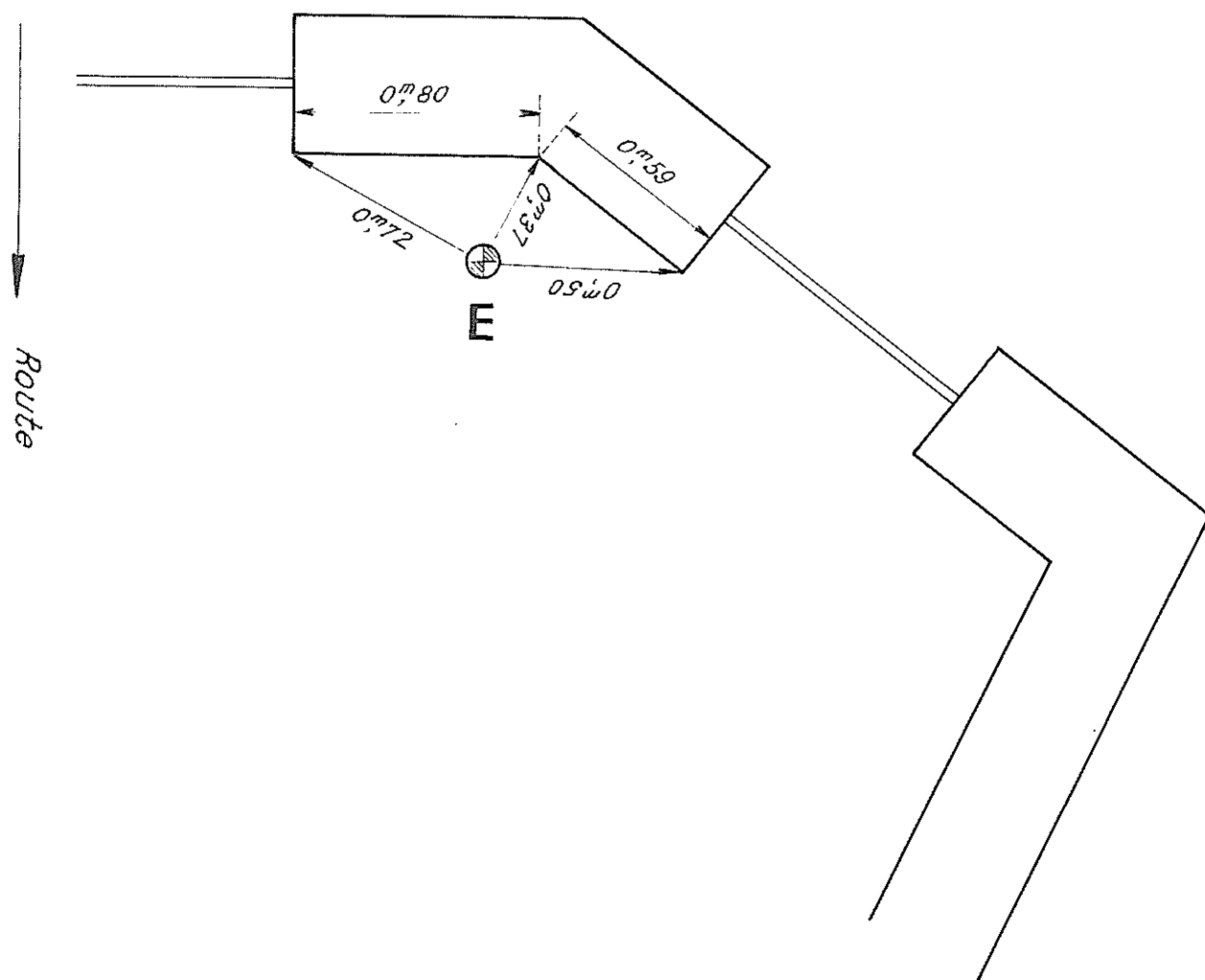
S E V R E S - pt C

SEVRES - pt E

CREATION DE 2 BASES GRAVIMETRIQUES

A L'AEROPORT CHARLES DE GAULLE (France)

ROISSY

_____

L'Aéroport du Bourget étant sur le point d'être fermé au trafic international, le B.G.I. a créé 2 bases gravimétriques au nouvel aéroport "Charles de Gaulle" à Roissy en France.

Cet aéroport est situé au Nord Est de Paris, à Roissy, à 23 kilomètres du centre de Paris.

On y accède par l'Autoroute du Nord A.1 de Paris à Lille et Bruxelles, et également par des trains, bus et des cars Air France.

Deux stations ont été choisies dans l'aérogare, l'une en zone internationale, située vers les boutiques hors-douane, facilement accessible par les observateurs venant de l'étranger (sans formalités de douane et de police) et l'autre en zone française, au pavillon de réception (cour anglaise).

DETERMINATION OF 2 GRAVITY BASE STATIONS

AT CHARLES DE GAULLE AIRPORT (France)

ROISSY

_____

The Bourget Airport being about to be closed to the international traffic, the I.G.B. determined 2 new gravity bases at the new "Charles de Gaulle" airport at Roissy en France.

This airport is located in the Northeastern suburb of Paris at Roissy, at about 23 kilometers of Paris-Center.

Means of access : Northern speedway A.1, from Paris to Lille and Brussels, and also trains, busses and Air France coaches.

Two stations have been chosen in the air-terminal, one in the international zone, in the duty free-shops area, easily accessible by any Observers coming from abroad (without authorization of Customs and Police Offices), and the other in french zone, at the welcome house (Pavillon de réception, "cour anglaise").

STATION R

Aérogare N° 1. Oratoire catholique en zone internationale, étage transfert, dans la zone des boutiques hors-douane.
La station se situe à 70 cm devant le pilier de l'autel, et à 165 cm du mur gauche de l'oratoire.
Pour tous renseignements, demander l'Aumonier de l'aérogare ou téléphoner au Service des Relations Extérieures de l'Aéroport :
862.17.91 ou 862.10.31

R STATION

Air terminal N° 1. Catholic oratory located in international zone, at transfer level, in the duty free-shops area.
The gravity point is situated at 70 cm in front of the altar pillar, at 165 cm of the wall of the oratory.
For all information, ask the Chaplain of the Air Terminal or call to "Service des Relations Extérieures de l'Aéroport": 862.17.91 or 862.10.31.

Altitude of the station : 104,80 m

Latitude : 49°00'82
Longitude : 2°32'50 E.G.

g observed : 980 915,49 mGal

STATION S

Pavillon de réception, situé dans la zone technique de l'aéroport (zone française).
La station est située à l'extérieur, dans la cour anglaise, sous l'escalier conduisant au sous-sol du bâtiment.
Pour tous renseignements, téléphoner au Service des Relations Extérieures :
862.10.31 ou 862.10.33

S STATION

"Pavillon de réception" (welcome house), located in the technical zone of the airport (french zone).
The gravity point is situated outside, in the "cour anglaise", under the staircase, leading to the basement of the building.
For all information, call to :"Service des Relations Extérieures"
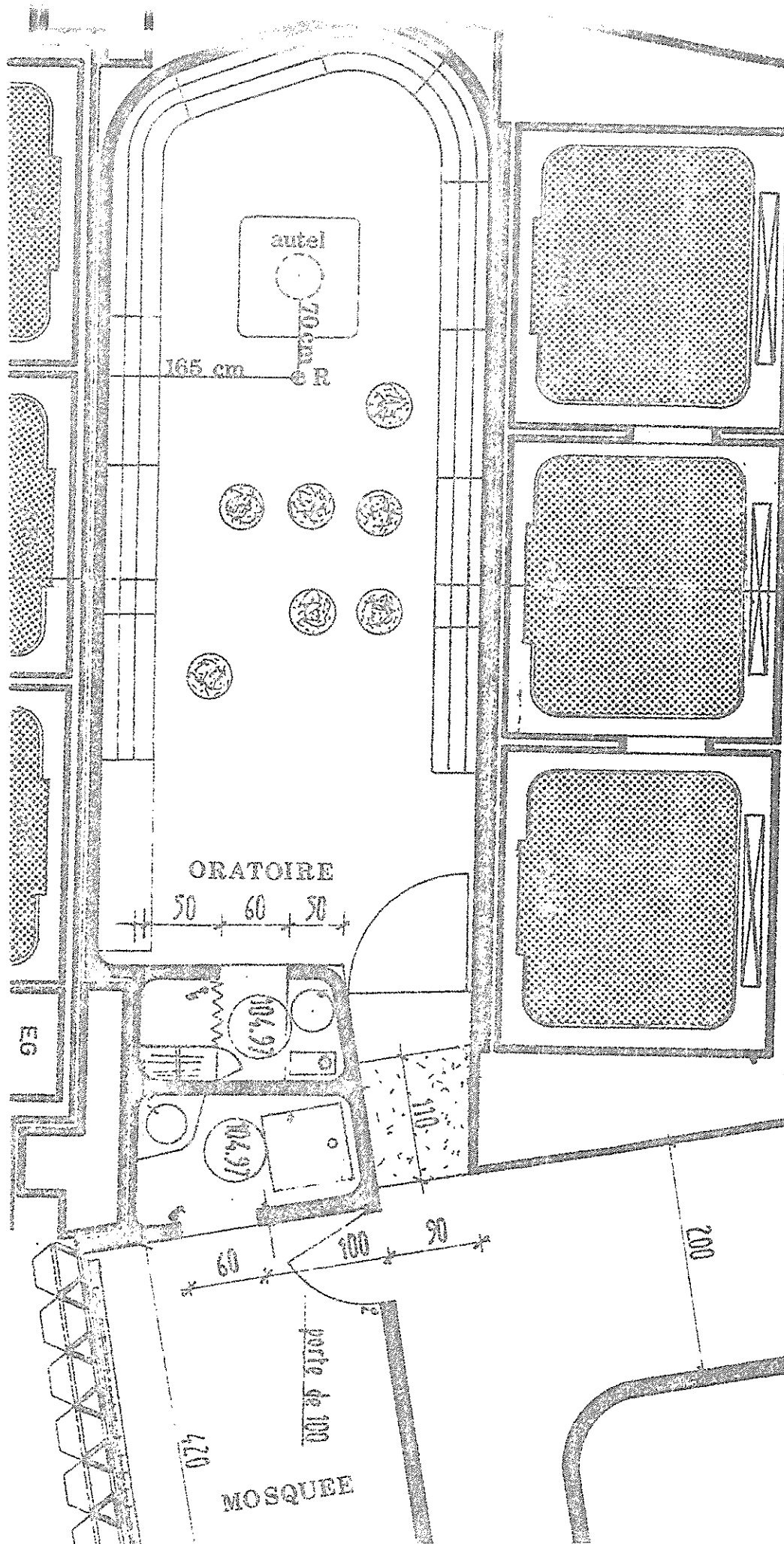862.10.31 or 862.10.33

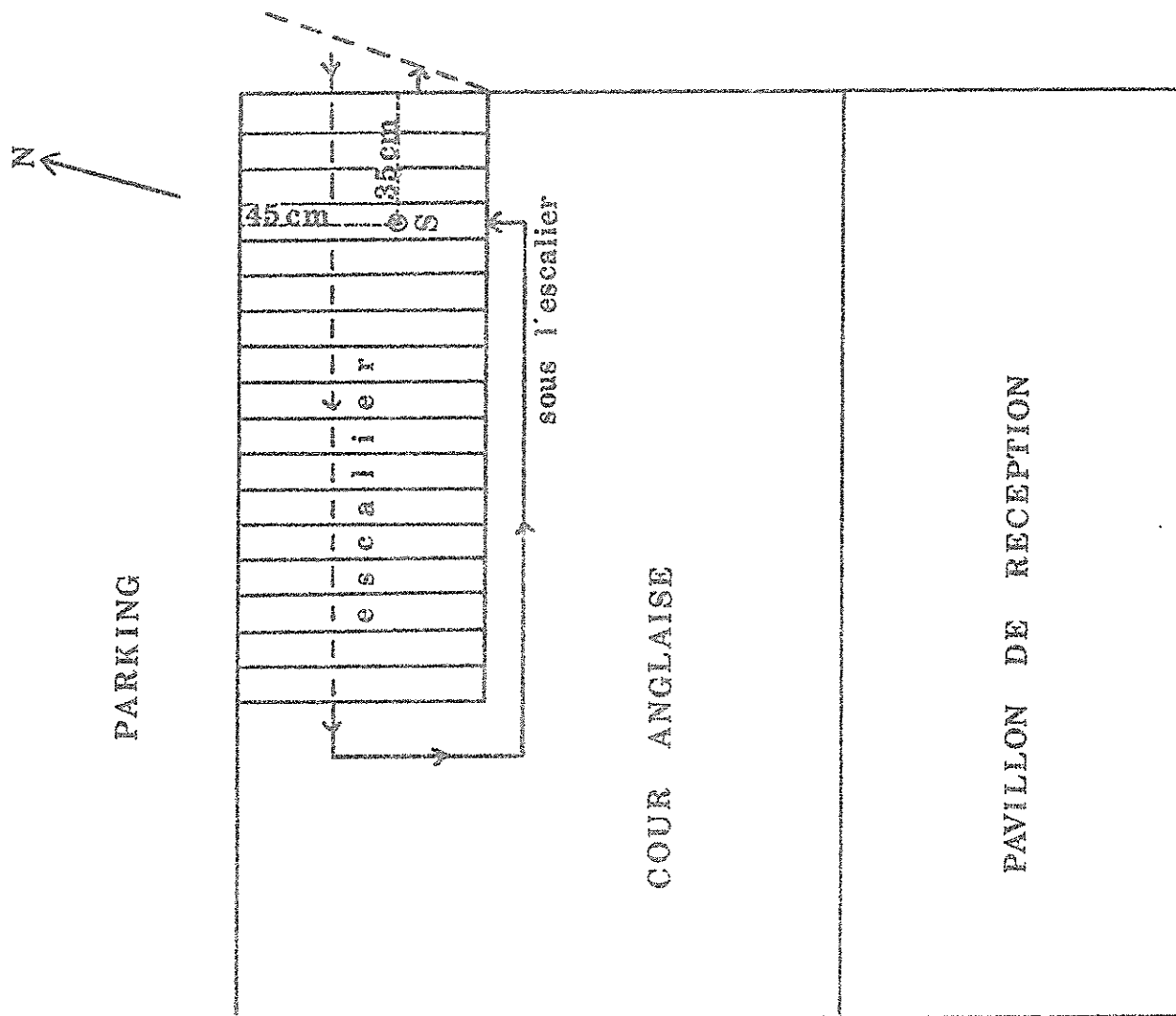Altitude of the station : 99,60 m

Latitude : 49°00'76
Longitude : 2°32'09 E.G.

g observed : 980 917, 93 mGal

autel

165 cm.

ORATOIRE

50 60 50

EG

(100)

(620)

110

ORATOIRE

60 100 90

200

porte de 100

470

MOSQUEE

ROISSY - STATION R

N

PARKING

45 cm ⊕ S

35 cm

sous l'escalier

r
e
i
m
r
a
c
s
e

COUR ANGLAISE

PAVILLON DE RECEPTION

ROISSY - STATION S

Gravimetry connections between

ROISSY Stations and 2 IGSN 71   Stations

The 2 ROISSY stations have been connected on one hand, to the absolute gravity station SEVRES, on the other hand, to the IGSN 71 station : LE BOURGET airport. (Hall, code 180 82 K).

The gravity connections have been carried out into two steps.

- Sèvres (Point B)$^{+}$- Le Bourget (point K) and Roissy (point S) :

These measurements have been made on 21.03.1977 by "Le Bureau de Recherches Géologiques et Minières" (B.R.G.M., Mr. Ogier) with a LaCoste-Romberg gravimeter, model G, calibrated on american bases of the IGSN 71, in February 1976.

The details of the measurements and the results are published in :
"Base gravimétrique fondamentale française : Paris - Toulouse - Pic du Midi de Bigorre - liaison 1977", Mr. Ogier, B.R.G.M., Département Géophysique ; 77 SGM 431 GPH .

The results Δ g are as follows :   Adopted value

Roissy (S) - Le Bourget (K) = - 17,410 $\left.\begin{array}{l}\\\\\end{array}\right\}$ - 17,397   - 17,40 mGal
                             - 17,395
                             - 17,385

Le Bourget (K) - Sèvres (B) =   9.105 $\left.\begin{array}{l}\\\\\end{array}\right\}$ 9,085   9,09 mGal
                                9,085
                                9,090

Sèvres (B) - Roissy (S)   =   8,310 $\left.\begin{array}{l}\\\end{array}\right\}$ 8, 305   8,31 mGal
                                8,300

Referring to Sèvres (point A), with g = 0,28 mGal^{+} for the difference Sèvres (B-A), it is obtained :

ROISSY (S) = 980 925,96 (SAKUMA value) $\left.\begin{array}{l}\\\\\end{array}\right\}$ 980 917,93 mGal
                  0,28
                 -8,31

Referring to Le Bourget (K), it is obtained :

ROISSY (S) = 980 935,33 (IGSN 71 value) $\left.\begin{array}{l}\\\\\end{array}\right\}$ 980 917,93 mGal
                -17,40

- Sèvres (point A) with   Roissy (S) and (R) :

These measurements have been carried out on 15.11.1977 by the B.G.I. with the LaCoste-Romberg, model G-225, already used for the relative gravity measurements at the B.I.P.M. The calibration factor was the one given by the manufacturer.

$^{+}$See p. I-31.

Two there and return have been made between the 2 Roissy sites. The $\overset{\wedge}{\Delta}$ g results are :

$$\text{Sèvres} \quad (A) \quad - \quad \text{Roissy} \quad (S) = 8,06 \text{ mGal}$$
$$\text{Roissy} \quad (S) \quad - \quad \text{Roissy} \quad (R) = 2,44_5 \qquad \pm 0,02$$

This first difference was neglected, the difference previously measured by the B.R.G.M. (8,03) was adopted.

Gravity value at ROISSY

Referring to Sèvres (point A) : 980 925 96 mGal (Sakuma's value), it is obtained :

ROISSY (S, Pavilion, staircase : 980 917, 93 mGal
ROISSY (R, catholic oratory)   : 980 915 49 mGal

S. CORON

M.F. ESNOULT

Yu.D.Boulanger, G.Arnautov, E.Kalish,

Yu.Stus, V.Tarasiuk

DETERMINATION OF THE ABSOLUTE VALUE OF GRAVITY
IN SINGAPORE

One of the most important problems of modern gravimetry is
a study of non-tidal gravity variations in time. At present there
are various estimations of possible variations based on these or
those assumptions on geodynamic processes occurring in the Earth.
The values of annual gravity variations are thought to be of from
several to many hundred mc gal per year. Therefore it is of a
great scientific interest to carry out special high-precision
repeated gravity determinations in those regions of the globe
where the maximal variations of its value could be anticipated.
The equatorial zone is the first such region.

Bearing in mind the abovesaid, the Institute of Physics of
the Earth, USSR Acad. of Sci., jointly with the Institute of
Automatics and Electrical Telemetry, Siberian Branch, USSR Acad.
of Sci. made a determination of the absolute gravity value in
Singapore in December, 1976. Measurements were performed with
a laser gravimeter developed at the Institute of Automatics and
Electrical Telemetry. The instrument and methods of its operations
are described in /I/ /2/. These measurements were different from
the earlier ones due to vibroprotection used in the instrument
against the effect of vertical disturbing accelerations caused
by micro- and vibroseisms.

In Singapore measurements were carried out on the territory
of Singapore University in a separate pavilion where earlier
radioactive substances were kept. The pavilion is on a bank of

a rather large swamp. The device was installed on a concrete floor. The installation site is shown on Fig. I.

Before the departure to Singapore and after the return to Moscow control measurements of the absolute value of gravity in Ledovo (Moscow) were carried out at the International Gravimetric Point to control stability of the instrument operation. The device was installed on a concrete pillar directly above the mark N 5035 /3/.

Measurements with the absolute gravimeter were carried out as before in the following order. Each result of measurement introduced into processing was deduced as an arithmetical mean from 140-150 observations of free fall angular reflector. The drops followed one another each 15-20 seconds. These observations are completely automatized and at the end of each measurement we recorded the value of g measured, its mean quadratic error and the number of performed drops. Such a measurement lasts about 40 minutes. After each measurement the control of the instrument adjustment is made. Then the instrument was switched on again and the subsequent measurement began. Two independent series of observations were made at each point. Each series consisted depending on observational conditions of 7-15 measurements.

To the measured g values corrections were introduced for the Δg_i time interval, Δg_t Doppler effect, residual air resistance Δg_p, laser beam deviation from the vertical Δg_φ, laser wave length Δg_λ, tidal gravity variations Δg_σ and the vertical gravity gradient to adjust the measured g value to the surface of the pillar where the instrument was installed Δg_η. In Ledovo this correction was obtained from direct measurements made by a group of gravimetres. Its value appeared

to be equal to $+$ 489 $\pm$ 5 mcgal. In Singapore the correction for the gradient was calculated assuming the vertical gradient equal to the normal value of 308.6 mcgal per metre. Since the effective height of the gravimeter $H = 153$ cm, the correction was assumed to be equal to $\Delta g_H = +472$ mcgal. Corrections Δg_i, Δg_t and Δg_φ remained unchanged during all observations both in Singapore and in Ledovo. The correction for tidal gravity variations was introduced according to specially calculated tables.

The arithmetical mean was calculated for each series of measurements and by their convergency within the series — mean quadratic errors of the arithmetic mean for this series.

Table I gives a summary of the results of all measurements accomplished in Singapore and Ledovo. From these data it follows that in Singapore a random error of measurements increased essentially as compared with that in Ledovo. Its mean value for Singapore appeared to be equal to $\pm$38 mcgal whereas in Ledovo it was $\pm$14 mcgal. This was the result of large microseisms generated by the Pacific ocean which could not be eliminated entirely by seismic vibrational protection. As a result of this a random error of g determination in Singapore appeared to equal $\pm$ 7.0 mcgal, and in Ledovo $\pm$ 3.0 mcgal inspite of the fact that in Ledovo the number of drops was by 454 less than in Singapore.

A total error of the absolute g value on definite points is as follows:

	Singapore	Ledovo
— random error of g measurements	$\pm$ 7 mcgal	$\pm$ 3 mcgal
— laser wave length determination error	8	8
— error of the vertical	10	10

	Singapore	Ledovo
— error of correction determination due to air resistance	8	8
— error introduced by electron-computer block	3	3
— error of tide correction determination	2	2
— error of measured value reduction to the pillar surface	5 (?)	5

Hence the total error of determination of the g absolute value as the quadratized sum of all mentioned errors for Singapore will be $\pm$ 17.7 mcgal and $\pm$ 16.6 mcgal for Ledovo.

An excellent convergence of the results of measurements in Ledovo before and after measurements in Singapore indicates a high stability of parameters of the absolute gravimeter. This allows to hope that the error of measurement of gravity value difference by this gravimeter can be reduced to the value of a random error of g determination i.e. to the error on the order of $\pm$ 5 mcgal.

So we have for

Singapore g = 978 069.792 $\pm$ 0.017.6 mcgal

Ledovo g = 981 551.337 $\pm$ 0.016.5 mcgal

Unfortunately due to technical reasons independent of executors of these measurements it was not possible to make this gravimetric connection of the new point with the IGSN-71 point. It is intended to be done during repeated determinations which are planned for the end of 1978 or beginning of 1979.

In conclusion I should like to express my deep gratitude to Prof. Radjaratnam, professor of the Singapore university for great assistance rendered to us during measurements and exceptionally cordial hospitality which made the stay of the participants of the expedition pleasant and interesting.

Moscow, October 22, 1977.

Yu. D. BOULANGER

Results of Measurements in Singapore (series I)

NN	Date	Time of measurements	number of drops	measured value	corrections Δg_ρ	Δg_λ	δg_δ	CORRECTED value	error of determination
1	1976.12.18	16 20 – 16 50	110	978 069.410	+53	−11	−72	978 069.799	± 45
2		17 10 – 17 45	120	.422	+53	−11	−68	.815	37
3		20 45 – 21 45	100	.262	+42	− 6	+117	.834	37
4		21 30 – 22 00	102	.172	+43	− 6	+147	.775	38
5		22 20 – 22 50	102	.172	+42	− 6	+162	.789	41
6		23 25 – 24 10	128	.225	+40	−26	+147	.805	40
7	1976.12.19	0 20 – 0 55	123	.295	+41	−26	+110	.839	39
8		1 10 – 1 50	145	.255	+40	−20	+62	.756	37
9		2 10 – 2 50	130	.333	+42	−11	− 2	.781	34
10		3 10 – 3 50	137	.421	+42	−20	−56	.806	36
11		4 10 – 4 50	142	.463	+41	−26	−87	.810	33
12		5 10 – 5 50	141	.429	+41	−26	−88	.775	34
13		6 10 – 7 20	234	.427	+41	−26	−45	.816	28
14		7 40 – 8 20	136	.261	+40	− 6	+31	.745	36
15		8 40 – 9 20	145	.282	+40	−11	+95	−825	32
							Mean:	978 069.798	± 7.2 mcgal

Corrections: for time interval Δg_i = −17 mcgal; for the Doppler effect Δg_t = 26 mcgal; for the deviation from the vertical Δg_ψ = −10 mcgal; for the vertical gradient Δg_H = +472 mcgal.

Results of measurements in Singapore (Series II)

NN	Date	Time of measurements	number of drops	measured value	Corrections			Corrected value	Error of determination
					Δg_P	Δg_λ	$\Delta g_{\delta'}$		
1	1976.12.19	11 30 – 12 10	136	978 069.191	+ 43	– 11	+ 118	978 069.760	± 36
2		14 30 – 15 00	135	.384	43	6	– 10	.830	40
3		15 30 – 16 10	137	.361	43	11	– 65	.747	43
4		17 35 – 18 15	141	.446	40	26	– 92	.787	36
5		18 30 – 19 10	130	.388	40	26	– 56	.765	43
6		19 30 – 20 10	123	.341	40	11	0	.789	41
7		20 30 – 21 10	110	.316	40	11	+ 66	.830	42

Mean: 978 069.787 ± 12.4 mcgal

Constant corrections: for time interval Δg_i = –17 mcgal; for the Doppler effect Δg_t = –26 mcgal; for the deviation from the vertical Δg_φ = 10 mcgal; for the vertical gradient Δg_η = +472 mcgal.

Table 2

Point	N of series	Date	Number of measurements	Number of drops	$\bar{m}$ mcgal	g mgal	m_g mcgal
Ledovo I	I	1976.12.08	7	990	± 14	981 551.334	± 4.3
	2	1976.12.08	4	558	± 14	.338	4.5
Ledovo I			11	1548	± 14	981 551.336	± 3.1
Singapore	I	1976.12.18/19	15	1995	± 36	978 069.798	± 7.2
	2	1976.12.19	7	912	40	.787	12.4
Singapore (mean)			22	2907	± 38	978 069.793	± 7.0
Ledovo 2	I	1976.12.27	8	905	± 26	981 551.339	± 5.1
Ledovo (mean)			19	2453	± 20	981 551.337	± 3.0
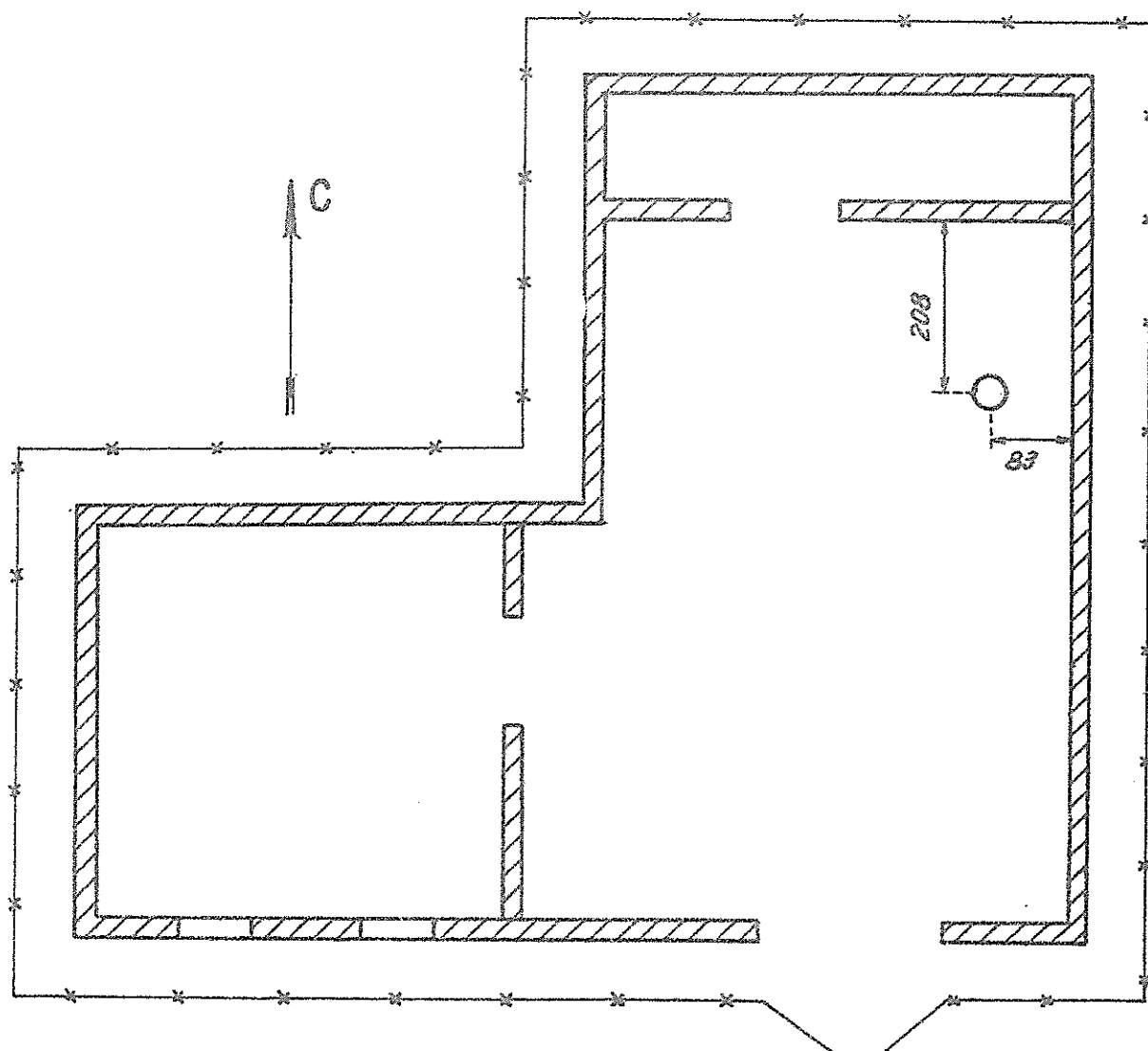
SINGAPORE University

The point of absolute determinations of gravity is
located in the pavilion 250 m to south-west of the
building of the Geographical Faculty of the University,
where the gravimetrical point Singapore A is situated.
Previously the pavilion was used for storage of
radioactive substances.

References

/I/ Measurements of the absolute value of gravitational acceleration. Sbornik nauchnykh statei pod redaktsiei Yu.E.Nesterikhina, IEiA SO AN SSSR, Novosibirsk, 1972.

/2/ Boulanger Yu., Arnautov G. et al. New determination of the absolute value of gravity acceleration in Potsdam, Gerlands Beiträge zur Geophysik, H., 1977.

/3/ Boulanger Yu., Gusev N. Gravity acceleration at the International Gravimetric point in Ledovo (Moscow) Sbornik statei "Resultaty vysokotochnykh gravimetricheskikh izmerenii" Sovetskoye radio, M., 1977.

Yu.Boulanger, G.Arnautov, E.Kalish, Yu. Stus,

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THE ABSOLUTE VALUE OF GRAVITY ACCELERATION ON THE A_3 POINT AT SÈVRES

To compare the Soviet absolute ballistic gravimeter developed at the Institute of Automatics and Electrometry, Siberian Branch, USSR Academy of Sciences with the stationary absolute gravimeter of Prof. A.Sakuma a determination of the absolute value of gravity acceleration was made by a Soviet instrument on the A_3 point at Sèvres in September, 1977.

Before going to Paris and upon the return to Moscow with controlling purposes in view absolute gravity determinations were made on the International Gravimetric Point in Ledovo. The instrument was installed on a concrete pillar above the mark 5035 (2).

Measurements were accomplished by the same program as before /3/, /4/. Each measurement, received to the processing, was obtained as the arithmetical mean out of 120-150 observations of the free incidence of angular reflector in vacuum. Drops followed one another each 15-20 seconds. Observations with gravimeter are completely automatized and at the end of each measurement the value of measured g, its mean quadratic error and the number of drops performed were recorded.

Such a measurement lasts for about 30 minutes. Upon the end a control of the adjustment of the instrument is being made for about 20 minutes. Then the instrument is switched on again and a new measurement begins. At Sèvres 3 series of such measurements were performed. In tables 1,2 and 3 the results of all measurements done in Sèvres are given. Table 4 gives a summary of measurements made in Sèvres and Ledovo.

To measured g values corrections were introduced for
Δg_t time interval, Δg_τ Doppler effect, Δg_p residual air
resistance, Δg_φ deviation of the laser beam from the vertical,
Δg_λ laser wave length variation, Δg_g tidal gravity
variation, vertical gravity gradient for the adjustment of the
measured g_o value to the pillar surface where the instrument
is installed Δg_h and Δg_H Honkasalo correction.

When calculating the correction for the vertical gradient
in Sèvres its value according to Prof. A.Sakuma's data was
assumed to be equal to 273 mcgal/m. The vertical gradient in
Ledovo was measured in 1975 by a group of gravimeters /3/ and /5/
and appeared to be equal to 320 $\pm$ 4 mcgal/m. The effective height
of the instrument is both in Sèvres and in Ledovo equal to 132 cm.

The arithmetical mean was calculated then for each series
of measurements. Within each series according to their convergence
the mean quadratic error of the arithmetical mean of the given
series was computed. A random error of the result was deduced
by the convergence of series.

The total error of the absolute value of gravity on the
points in Sèvres and Ledovo was deduced by summing up the fol-
lowing:

	Sèvres	Ledovo
- a random m_{g_o} error of g_o deter- minations	± 2.4mcgal	± 4.2mcgal
- an m_λ error of the laser wave length determination	± 8	± 8
- an m_φ error of the vertical representation	± 10	± 10
- an m_p error in determination of the correction for air resistance	± 8	± 8
- an m_j error introduced by electron- computing blocks	± 3	± 3

	Sèvres	Ledovo
– an m_g error of determination of the correction for the tide	± 2	± 2
– an m_h error of determination of the correction gradient	± 2	± 4

Hence the M_g total error of determination of absolute value obtained as quadrated sum of all the mentioned errors will be ± 15.8 mcgal for Sèvres and ± 16.5 mcgal for Ledovo.

A good convergence of the results of measurements in Ledovo after and before measurements in Sèvres and also with measurements performed earlier /3/, /4/ point to a rather high stability of parameters of the Soviet absolute gravimeter. This allows to assume the value of the total error of gravity determination by this instrument to be somewhat exaggerated and in reality it must be evidently close to its random part.

Thus we have obtained the following values of the absolute value of gravity for the points:

Sèvres A_3 g = 980925938 ± 16 mcgal

Ledovo 5035   g = 981551380 ± 16 mcgal

Let us compare the measured g value with similar g values obtained by Prof. Sakuma and by an italian instrument, the data on which were given to us by Prof. A.Sakuma (Table 5).

Table 5

Results of g determination on the point Sèvres A_3

NN	Instruments		g	M_g	P
1.	A.Sakuma	1976–1977	980925926	± 7	20
2.	Italian	1976–1977	980925925	± 10	10
3.	Soviet	1977	980925938	± 16	4
	the weight mean		980925927	± 5.4	34
	the arithmetical mean		980925930	± 4.2	–

The convergence of all three determinations appeared to be a very good one. Discrepancies between the instruments appeared to be less than the total errors ascribed to them.

In conclusion let us compare the mean g obtained by three instruments with the g value given in the catalogue IGSN-71 for Sèvres.[+] We have:

Determinations 1976-1977	980925930 ± 4 mcgal
IGSN-71	980925880 ± 14 mcgal
Difference	+ 50 ± 15 mcgal

The obtained result is of a very high scientific interest. A question arises: what is it - a systematic error which penetrated to earlier determinations or a result of gravity variation in Sèvres caused by deep tectonic reasons or reasons of local character?

*   *   *

The authors express their most sincere gratitude to Prof. A. Sakuma and Prof. J. Terrien, Director, Bureau International des Poids et Mésures for the opportunity they have given us to carry out the described measurements in Sèvres and for a great assistance in their organization.

[+] Reduced to the A_3 point, new site chosen for the absolute measurements made with transportable apparatus.

Table 1

Point: Sèvres A$_3$

Series: 1   Date: September 12-13, 1977   h = 132 cm Gradient: 273 mogal/m

g = 980925934 mogal

NN	Time of observations	g_0	m	n	Δg_i	Δg_t	Δg_p	Δg_φ	Δg_ι	Δg_h	Δg_s	Δg_H	g
I	$19^h 30^m - 20^h 00^m$	629	± 25	129	− 18	− 24	+ 38	− 10	0	+ 360	− 96	+ 26	905
2	20 15 − 20 35	634	26	83	18	24	38	10	0	360	91	26	915
3	20 50 − 21 25	650	17	146	18	24	36	10	0	360	80	26	938
4	21 40 − 22 10	651	17	132	18	24	36	10	0	360	61	26	962
5	2 35 − 3 05	564	24	128	18	24	43	10	0	360	0	26	941
6	3 35 − 4 05	609	20	135	18	24	40	10	0	360	24	26	959
7	4 15 − 4 45	603	18	136	18	24	40	10	0	360	42	26	935
8	5 05 − 5 35	635	18	130	18	24	39	10	0	360	66	26	942
9	5 50 − 6 20	637	20	136	18	24	37	10	0	360	83	26	925
10	7 50 − 8 20	640	21	131	18	24	35	10	0	360	95	26	914
11	8 35 − 9 10	652	18	146	18	24	34	10	0	360	82	26	938

$\overline{m} = \pm 20$ 1432

g = 980 925 934 mogal.

$m_g = \pm 17.7$ mogal

$M_g = \pm 5.4$ mogal

n = number of drops

Table 2

Point: Sèvres A_3

Series : 2   Date :   September 13-14, 1977   h=132 cm   Gradient = 273 mcgal/m

$= 980\ 925\ 941$ mcgal

NN	Time of observations	g_o	m	Number of drops	Δg_i	Δg_t	Δg_p	Δg_φ	Δg_λ	Δg_h	Δg_e	Δg_H	g
1	$15^h17^m - 15^h47^m$	568	$\pm$ 17	125	- 18	- 24	+ 31	- 10	- 10	+ 360	+ 14	+ 26	937
2	16 15 - 16 45	607	18	125	18	24	30	10	- 10	360	- 18	26	943
3	17 05 - 17 35	607	23	126	18	24	30	10	0	360	- 47	26	924
4	18 05 - 18 35	668	17	125	18	24	30	10	- 5	360	- 77	26	950
5	20 15 - 20 45	701	20	125	18	24	28	10	- 15	360	- 97	26	951
6	21 05 - 21 35	660	19	125	18	24	28	10	- 10	360	- 84	26	928
7	1 45 - 2 15	551	16	123	18	24	37	10	0	360	+ 28	26	950
8	2 35 - 3 05	546	18	122	18	24	34	10	0	360	+ 23	26	937
9	3 30 - 4 00	584	16	127	18	24	32	10	- 10	360	+ 7	26	947
10	4 35 - 5 10	625	16	134	18	24	30	10	- 10	360	- 24	26	955
11	6 20 - 6 50	651	17	125	18	24	29	10	- 5	360	- 76	26	933
12	7 05 - 7 30	670	18	107	18	24	29	10	0	360	- 91	26	942

$\bar{m} = \pm 18$ 1489

$g = 980\ 925\ 941$ mcgal
$m_g = \pm 9.8$ mcgal
$M_g = \pm 2.8$ mcgal

Table 3

Point: Sèvres A_3

Series : 3; Date: September 19-20, 1977; h = 132 cm;   Gradient = 273 mcgal/m

g = 980 925 939 mcgal

NN	Time of observations	g_0	m	Number of drops	Δg_i	Δg_t	Δg_p	Δg_φ	Δg_1	Δg_h	Δg_γ	g_N	g
1	$16^h 20^m - 16^h 50^m$	644	+ 21	125	- 20	- 24	+ 51	- 10	- 10	+ 360	- 69	+ 26	948
2	19 15 - 19 45	669	22	116	20	24	37	10	10	360	- 73	+ 26	955
3	20 15 - 20 45	663	22	139	20	24	35	10	10	360	- 78	26	942
4	21 15 - 21 45	670	19	139	20	24	34	10	10	360	- 82	26	944
5	22 15 - 22 45	666	17	135	20	24	34	10	10	360	- 83	26	939
6	23 15 - 23 45	657	15	135	20	24	33	10	10	360	- 80	26	932
7	0 15 - 0 45	647	23	141	20	24	32	10	10	360	- 70	26	931
8	1 15 - 1 45	653	21	140	20	24	30	10	10	360	- 53	26	952
9	2 15 - 2 45	599	22	125	20	24	30	10	10	360	- 31	26	920
10	3 15 - 3 45	580	14	133	20	24	29	10	10	360	- 6	26	925

$\overline{m} = \pm$ 20   1328

$g = $. 980 925 939 mcgal

$m_g = \pm$ 11,6 mcgal

$M_g = \pm$ 3,7 mcgal

Table 4

A summary of absolute measurements in Ledovo and in Sèvres

Point	NN of the series	Date of measurements	Number of measurements n	a number of drops k	Mean error of one determination	g	Mg	P
					mcgal	mcgal	mcgal	
Ledovo I	I	29 – 30.VIII.1977	12	1582	± 20	981 551 383	± 5,8	30
Ledovo 2	I	30.IX.1977	11	1448	± 19	981 551 379	± 6,5	24
Ledovo mean	–	–	23	3010	± 20	981 551 381	± 4,5	54
Sèvres A_3	I	12 – 13.VIII.1977	11	1432	± 20	980 925 934	± 5,4	34
	2	13 – 14.VIII.1977	12	1489	± 18	980 925 941	± 2,8	128
	3	19 – 20.VIII.1977	10	1328	± 20	980 925 939	± 3,7	73
Sèvres A_3: the weight mean	–		33	4249	± 19	980 925 939	± 2,0	235
arithmetical mean			33	4249	± 19	980 925 938	± 2,2	–

References

1. Measurement of the absolute value of gravity acceleration. Sb. pod red. Yu.E.Nesterikhina, Novosibirsk, 1972.

2. Boulanger Yu.D. et al. Determination of gravity acceleration at Moscow (Ledovo), Murmansk, Odessa and Nakhodka. Bull. d'Information, IGB, Paris, 1974, n.34.

3. Boulanger Yu. et al. A new determination of the absolute value of gravity acceleration in Potsdam.Gerlands Beiträge zur Geophysik 1978, n.1, S.9-18.

4. Boulanger Yu. et al. A determination of the absolute value of gravity in Singapore. Bull. d'Information, IGB, Paris, 1978,n.42.

5. Arnautov G. et al. Measurement of the absolute value of gravity acceleration on gravimetric points in Ledovo, Tallin, Tbilisi. In the book: "Rezultaty vysokotochnykh gravimetritcheskikh izmerenii". Sov. Radio, M., 1977.

LISTE des PUBLICATIONS

reçues au

BUREAU GRAVIMETRIQUE INTERNATIONAL

(Juin à Décembre 1977)

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CONCERNANT LES QUESTIONS DE PESANTEUR

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LISTE DES PUBLICATIONS

*438 - RAPP R.H. - "Potential coefficient determinations from 5° terrestrial gravity data".
The Ohio State Univ., Dept. Geod. Sci., Rep. N° 251, 77 p, Columbus, 1977, for NASA, GSFC, Greenbelt.

A set of 38406 1° x 1° anomalies were compiled starting from a smaller set supplied by the Defense Mapping Agency Aerospace Center. These anomalies using least squares prediction techniques and a direct mean approach. Several different covariance functions were used to examine their effect on the resultant prediction and accuracy. On the average the estimation is insensitive to the covariances used with the largest differences occuring when there was only a few known 1° blocks within the 5° block. The direct mean estimation process was not considered as good as the least squares estimation because the estimated anomaly field was too rough when compared through anomaly degree variance data derived from satellite data. A complete 1654 5° anomaly set was formed by estimating the 157 remaining blocks using the 10 closest previously predicted values.

The determination of potential coefficients from this data was made considering a smoothing operator as well as the effects of the atmosphere; a spherical approximation ; and the effect of the terrain. The smoothing operator is important in these studies above degree 10. The terrain correction effects amount to 10 to 25 % of the low degree coefficients ; however, the actual corrections can only be approximated with such approximations not yielding improved solutions at this time. Potential coefficients and their accuracy were computed and listed to degree 52. Tests indicate that it is imperative to use integrated kernal expressions in these computations above degree 5. Anomalies were computed from the potential coefficients for comparison to the original anomalies. Tests showed that the agreement improved considerably as the degree increased to the maximum considered. These tests shed some doubt on the rule of thumb that a block of size theta can be represented by a spherical harmonic expansion to 180°/theta.

439 - SOLER T. - "Global plate tectonics and the secular motion of the pole".
The Ohio State Univ., Dept. Geod. Sci., Rep. N° 252, 210 p, Columbus, 1977, for NASA, Washington.

Astronomical data compiled during the last 70 years by the international organizations (ILS-IPMS, BIH) providing the coordinates of the instantaneous pole, clearly shows a persistent drift of the "mean pole" (= barycenter of the wobble).

This study was undertaken with a specific objective in mind : to investigate the possibility of a true secular motion of the barycenter ; that is, an actual movement of the Earth pole of figure resulting from differential mass displacement due to lithospheric plate rotations.

The method developed assumes the Earth modeled as a mosaic of 1° x 1° crustal blocks, each one moving independently in accordance with their corresponding absolute plate velocities.

* Les numéros font suite à ceux indiqués dans le Bull. Inf. N° 41, Novembre 1977.

The differential contributions to the Earth's second-order tensor of inertia were obtained and applied, resulting in no significant displacement of the Earth's principal axis.

In view of the above, the effect that theoretical geophysical models for absolute plate velocities may have on an apparent displacement of the "mean pole" as a consequence of station drifting was analyzed.

The investigation also reports new values for the crustal tensor of inertia (assuming an ellipsoidal Earth) and the orientation of its axis of figure, reopening the old speculation of a possible sliding of the whole crust over the upper mantle, including the supporting geophysical and astronomic evidence.

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Géodésie et Astronomie, Série 52.

440 - N° 12, 45 p, Moscou, 1976.

441 - N° 1, 39 p,   "   1977.
442 - N° 2, 32 p,   "   1977.
443 - N° 3, 33 p,   "   1977.
444 - N° 4, 38 p,   "   1977.
445 - N° 5, 45 p,   "   1977.
446 - N° 6, 38 p,   "   1977.
447 - N° 7, 54 p,   "   1977.
448 - N° 8, 52 p,   "   1977.
449 - N° 9, 42 p,   "   1977.
450 - N° 10, 32 p,   "   1977.
451 - N° 11, 36 p,   "   1977.
452 - N° 12, 34 p,   "   1977.

453 - Index par matières 1975.
      38 p, Moscou, 1977.

454 - Index par auteurs 1976
      12 p, Moscou, 1977.

455 - Index par auteurs 1975
      71 p, Moscou, 1977.

CENTRE NATIONAL pour l'EXPLOITATION des OCEANS - Bulletin d'Information,

456 - N° 102, 22 p, Paris, Juin 1977.
457 - N° 103-104, 32 p, Paris, Juillet / Août 1977.
458 - N° 105, 19 p, Paris, Septembre 1977.
459 - N° 106, 28 p, Paris, Octobre 1977.
460 - N° 107-108, 20 p, Paris, Novembre / Décembre 1977.

461 - N° 109, 20 p, Paris, Janvier 1978.
462 - N° 110, 20 p, Paris, Février 1978.

463 - DEPARTMENT of SCIENTIFIC and INDUSTRIAL RESEARCH - Gravity map of New
      Zealand - 1/250 000, Bouguer anomalies, isostatic anomalies, isostatic
      vertical gradient anomalies, sheet 16 : KAIKOURA.
      Geophys. Div., Wellington, 1977.

464 - ANDERSEN O. & K. ENGSAGER - "Surface ship gravity measurements in Danish
      Waters 1970-1975".
      Mémoires de l'Inst. Géod. Danemark, 3ème sér., 43ème tome, 73 p + maps :
          I - Navigation tracks
          II - Free-air anomaly contours   E = 10 mGal
         III - Bouguer anomaly contours   E = 5 mGal
      Copenhagen, 1977.

          List of about 7000 points with geographical coordinates, depth and
      the free-air and the Bouguer anomalies.
          In the period 1970-75 sea gravity measurements were carried out by
      the Danish Geodetic Institute with the purpose of procuring a uniform
      gravity survey of the waters around Denmark. This project was carried out
      in continuation of the early Skagerrak Survey of 1965-66.
          The results of the project are presented in this paper.

465 - SWAIN C.J. & M. AFTAB KHAN - "A catalogue of gravity measurements in Kenya".
      Dept. of Geol., Leicester Univ., 84 p + Bouguer gravity map, 1977.

          This compilation is one of the end products of a research programme
      which began at Leicester University in 1965. It supersedes previous
      catalogues by SEARLE and DARRACOTT (1971) and KHAN, MANSFIELD and SWAIN
      (1972), although, for reasons to be discussed later, not all the data
      listed in those catalogues are included here.
          A pre-print of the gravity map on the scale 1/2 000 000 and based
      on the 8709 stations listed is included here.
          The data are catalogued in one degree squares in order of source and
      station number. The datum used in reducing the gravity observations is
      defined by the IGSN 71 together with the 1967 gravity formula (IAG 1967).
      Terrain corrections have been made for 6447 stations, that is for all
      except the oil company data. Gravity units (g.u.) have been used
      throughout. (1 g.u. = 0.1 mGal = 10^{-6} ms^{-2}).

466 - ROTSTEIN Y., J. COMBS & S. BIEHLER - "Gravity investigation in the
      southeastern Mojave Desert, California".
      from : Geol. Soc. America, Bull. v. 87, n° 7, p. 981-993, Doc. N° 60704,
      July 1976.

          A gravity investigation consisting of some 900 stations was conducted
      over an area of approximately 3 500 km2 between the Eagle Mountains and
      the Colorado River in the southeastern Mojave Desert to define the major
      anomalies. The data were reduced to the complete Bouguer anomaly and
      presented on a contour map. The density contrasts that exist between
      the basin sedimentary rocks and the underlying basement rock produce
      gravity anomalies that can be readily delineated by gravity surveys.
      Several gravity anomalies are associated with regional structural trends
      particularly faults. Two-dimensional model analyses along profiles across
      five major anomalies are presented to show the distribution and depth of
      sedimentary deposits.

Subsurface geology in the area is poorly known. Analysis of the gravity anomalies, however, indicates that the basement beneath the sedimentary basins is highly faulted, consisting of complex structures and rapidly varying rock types similar to those in the mountain ranges of the area. In the center of the several subdivisions of the Chuckwalla Valley, depths to basement range from less than 200 m to more than 2 km. The Palen Valley is shallow in the northern section yet reaches a probable depth of over 1.5 km in its southern portion. The Palo Verde Valley east of the Chuckwalla Valley is divided into two separate structural styles. A northwest trending sedimentary basin in the north has a maximum depth of at least 2 km, while basement to the south is generally more flat and less deep. The structural and geological information inferred from the gravity data and resultant anomalies provides important input toward a better understanding of the geology in the area.

467 - BUCKLEY J.S. & R.J. BAILEY - "A free-air gravity anomaly contour map of the Irish Continental margin".
from : Marine Geophys. Res., v.2, n°3, p.185-194, 1975.

Compilation of currently available gravity data permits the construction of a free-air anomaly contour map of the continental margin west of Iceland (51° - 54°N). Major elements in the structure of the margin, previously delineated on the basis of seismic reflection and magnetic surveys are clearly seen on the FAA contour map, notably the Porcupine Seabight Trough, and Porcupine Ridge. However, contrary to earlier ideas, the gravity data imply that the Seabight Trough extends northwards onto the Slyne Ridge, and the Slyne Trough, formerly regarded as northeasterly prolongation of the Seabight Trough, appears to be a discrete, fault-bounded, feature separated from the latter by a basement ridge. East-west gravity profiles are modelled in terms of thinned crust with the Moho at a minimum depth of 15 km beneath the axis of the Seabight Trough. The models tend to support hypotheses invoking formation of the Seabight Trough by simple westward translation of Porcupine Ridge with respect to the Irish Mainland.

468 - SABET M.A. - "Gravity and magnetic investigation, Eastern shore area, Virginia".
from : Geol. Soc. America, Bull., v. 84, N° 6, p.2119-2126, 1973.

A simple Bouguer gravity map and a total magnetic intensity map were made for the Eastern Shore area of Virginia. Both maps exhibit a great similarity, thus suggesting that the density contrast between the crystalline basement and the overlying sediments is the main source of the gravity anomalies. The maps show two major anomaly trends, north, and N. 30°W. The northwest end of a trough that trends N. 30°W. appears to occupy the northern half of the area and extends southeastward toward the Atlantic Ocean. It also appears to be separated from the adjacent Salisbury embayment, on the subaerial coastal plain, by a large basement uplift centered over the town of Girdletree, Maryland.
Quantitative interpretations of the gravity map were made along three profiles.

.../...

The thicknesses of the sedimentary rocks in the vicinity of the town
of Cheriton, between the towns of Exmore and Melfa, and near Wallops
Island are estimated to be 7,200 ; 2,200 ; and 6,300 ft (2,195 ; 670
and 1,920 m), respectively. A fault trending N. 30°W. through Exmore is
also suggested ; if present, its structural throw would be about 1,300 ft
(400 m).

469 - INSTITUTO GEOGRAFICO MILITAR, Departamento Geofisico -
"Mediciones gravimetricas en Bolivia".
165 p + mapas de anomalias de Bouguer y Air Libre, La Paz, 1974.

La presente publicacion, preparada por el IGM e IGB de Bolivia,
incluye la relación de objetivos que nos proponemos con ella, un breve
bosquejo historico, la relación de datos de las estaciones fundamentales
de Bolivia y de la Red Nacional (La Paz - Santa Cruz), trabajos ejecutados
en prospección petrolera, enlaces internacionales, los gravimétros emple-
ados, y la relación de los datos observados y calculados para las
estaciones ocupadas en 16 años de trabajo. Asimismo, se adjunta a
escala reducida los mapas de Bolivia de Anomalias de Bouguer y Air Libre
(mas ó menos de 7300 estaciones).

470 - LODDO M. - "The gravitational attraction of a right polygonal prism".
Boll. Geof. teor. appl., v. XIX, n° 71, p. 184-190, Set. 1976.

Closed formulae are presented for calculating the vertical component
of the gravitational attraction of a right polygonal prism. They offer
large possibilities of approximating a buried body and need short
calculation times on an electronic computer.

478 - COCHRAN J.R. & M. TALWANI - "Free-air gravity anomalies in the world's
oceans and their relationship to residual elevation".
Geophys. J. R. Astr. Soc., n° 50, p. 495-552, 1977.

Surface-ship gravity measurements were used to obtain 5° x 5° average
free-air gravity anomalies over much of the world's oceans. Comparison of
the surface data with the recent GEM 6 "combination" field shows the
combination solution to be in reasonable agreement with the surface data
in most areas in the general location and amplitude of major features of
the Earth's gravity field. There is, however, significant disagreement
on the location of extrema and on the exact values at specific points.
It is thus necessary to use surface data to make detailed studies of the
relationship of the gravity field to surface features at wavelengths of
less than 4000 km. Mid-ocean ridges are consistently characterized by a
gravity maximum. The gravity anomaly across mid-ocean ridges can be
described by an empirical 1° x 1° average gravity-age relationship which
shows a positive gravity anomaly of about 25 mGal falling off to zero by
about 40 my. The observed gravity-age relationship is generally compatible
with current thermal models of the lithosphere. The empirical gravity-age
curve was removed from the free-air anomalies to produce residual gravity
anomalies which can be compared to similarly obtained residual depth
anomalies.

A correlation between the two is found over some features. The most prominent of these are intermediate wavelength positive features associated with areas of extensive off-ridge volcanism. This applies not only to recently active areas but also to inactive areas such as Bermuda and aseismic ridges. On the other hand, areas of unusual elevation and volcanic activity located at a mid-ocean ridge crest such as Iceland and the Azores do not have a corresponding gravity anomaly at intermediate wavelengths. The long-wavelength component of the Earth's gravity field is characterized by large areas in which significant anomalies of constant sign are found. There is no apparent relationship between the long-wavelength gravity anomalies and oceanic depths. If the gravity anomalies have their origin within the asthenosphere, the lithosphere must in effect be decoupled from the main body of the asthenosphere. This could result from the effects of a strongly depth-dependent viscosity on the convection pattern under the elastic plates.

479 - MORITZ H. - "Der Begriff der mathematischen Erdgestalt seit Gauss".
Zeits. : AVN N° 4, p. 133-138, 1977.

480 - DOYLE F.J., A.A. ELASSAL & J.R. LUCAS - "Selenocentric geodetic reference system".
U.S. Dept of Commerce, NOAA Tech. Rep. N° 7ONGS 5,53 p, Rockville, 1977.

481 - MORITZ H. - "Least-squares collocation and the gravitational inverse problem".
from : J. Geophys., N° 43, p. 153-162, 1977.

The paper presents a unified least-squares method (collocation) which encompasses least-squares adjustment and least-squares prediction. This method is being applied to the determination of the terrestrial gravitational field and of geodetic position by combining data of different kind. The relationship between this method and geophysical inverse problems is discussed.

482 - LACHAPELLE G. - "Estimation of disturbing potential components using a combined integral formulae and collocation approach".
Geod. Surv. Div., Surv. & Map. Branch, Dept. Energy, Mines & Res., 33 p, Ottawa, 1977.

The deviation of the vertical and geoid undulation components of the disturbing potential are estimated using a combination of geopotential coefficients and surface gravity data. Least squares collocation is used in the inner-zone and Vening Meinesz's and Stokes' integral formulae in the outer-zone. The radius of the inner-zone depends upon the density of the gravity data in this zone and the capabilities of the computer available. The radius of the outer-zone is a function of the set of geopotential coefficients used to calculate the global effects of the disturbing potential on the two components of the deviation of the vertical and the geoid undulation at the computation point.

.../...

The method is tested by estimating components of the deviation of the vertical and geoid undulations at several points located in Canada. The corresponding astrogeodetic deviations of the vertical and Doppler derived geoid undulations provide external comparison standards to obtain realistic accuracy estimates. Goddard Earth Model 8 is used to calculate the global effects of the disturbing potential. A radius of 8° for the outer-zone is found to be appropriate ; the radius of the inner-zone varies between 0°7 and 1°5 depending on the density of the gravity data in the inner-zone.

483 - MATHER R.S., E.G. MASTERS & R. COLEMAN - "The role of non-tidal gravity variations in the maintenance of reference systems for secular geodynamics". Presented at the Int. Symp. on Non-tidal variations in gravity, Trieste 20-23 June 1977.
UNISURV G 26, p. 1-25, Univ. NSW, Sydney, 1977.

It has been suggested (MATHER 1973) that the changes in absolute gravity measured at a global network of stations, could be used to monitor the motion of the geocentre in relation to this network. Such information is of value in high precision geodesy as dynamic satellite techniques are always referred to the instantaneous geocentre. Gravity changes are simulated at such a network of stations over epochs upto 10^2 yr.
These changes in gravity, in addition to contributions from the seasonal, Chandler period and secular motion of the pole, together with those due to models of Earth expansion and changes in the flattening of both the meridian and equatorial ellipses concomitant with current estimates of plate motion, also take into account variable amounts of random noise as well as the effects of seasonal phenomena.
The simulated data banks were analysed to study the effect of the following factors on the resolution with which the above quantities of geodynamic interest are determined :
. The interval of time over which the changes are measured.
. The extent of random noise in the data.
. The distribution of the absolute gravity measuring sites at the surface of the Earth.
It is concluded that information of adequate accuracy for maintaining geodetic systems of reference for secular geodynamics could be obtained from a network of 25 well distributed stations using data collected over at least 10 years in the presence of noise at the 10 μGal level even if the representation in polar and oceanic regions were non-existent. The resolution drops by a factor of two if the noise level were increased to 20 μGal. Even such results could be helpful in modelling secular geodynamic phenomena of relevance in maintaining geodetic reference systems in four dimensions.

484 - BERG E. - "Geoid heights and geodetic positions of Pacific Harbors and deep sea drilling sites".
HIG-76-15, Prepared for Office of Naval Res.,
Final Rep., 147 p, 1976.

A relatively simple double pass method is used to
a) reduce longitudinal spread of satellite navigation fixes and,
b) obtain antenna height or sea level height on board a ship in a fixed harbor or fixed open-sea position (over an acoustic beacon).

Required are the satellite navigator output of latitude, longitude, elevation angle, and path geometry for two consecutive passes (one E and one W of the site) of the same satellite.

Sea level height thus determined on Board the R.V. Kana Keoki in harbors around the Pacific and on board the Glomar Challenger in position over Deep Sea Drilling Project sites in the Atlantic show good agreement with geoidal height models.

Determining sea level (with respect to the Navigation Satellite Reference) using the double pass method thus provides an important independent alternative to Sky Lab Radar Altimetry for the measurement of geoidal height over the open oceans.

485 - A.I.G. - Bulletin Géodésique - v. 51, n° 3, Paris, 1977.

a) SCHWARZ K.P. & J. KRYNSKI - "Improvement of the geoid in local areas by satellite gradiometry".
   p. 163-176.

   Satellite gradiometry is studied as a means to improve the geoid in local areas from a limited data coverage. Least-squares collocation is used for this purpose because it allows to combine heterogeneous data in a consistent way and to estimate the integrated effect of the attenuated spectrum. In this way accuracy studies can be performed in a general and reliable manner.

   It is shown that only three second-order gradients contribute significantly to the estimation of the geoidal undulations and that it is sufficient to have gradiometer data in a 5° x 5° area around the estimation point. The accuracy of the geoid determination is strongly dependent on the degree and order of the reference field used. An accuracy of about $\pm$ 1 m can be achieved with a reference field of (12,12). There is an optimal satellite altitude for each reference field and this altitude may be higher than 300 km for a field of low degree and order. The influence of measuring errors is discussed and it is shown that only gradiometer data with accuracies better than $\pm$ 0.05 E will give a significant improvement of the geoid. Finally, some results on the combination of satellite gradiometry and terrestrial gravity measurements are given.

   The proposed method seems to be well suited for local geoid determinations down to the meter range. It is especially interesting for unsurveyed and difficult areas because no terrestrial measurements are necessary. Furthermore, it has the practical advantage that only a local data coverage is needed.

b) NAKAGAWA I. & M. SATOMURA - "Gravity change observed near Lake Biwa, Japan"
   p. 213-218.

   Precise gravity measurements have repeatedly been carried out in the area around Lake Biwa in Japan since 1950 in order to detect the secular change of gravity. The results obtained so far show that gravity change observed on the west line of the first order levelling route around the lake during the period of 1971 - 1975 was consistent with the results of levelling surveys. This evidence shows that precise gravity measurement is one of the powerful methods for detecting vertical crustal movement.

c) DUFOUR H.M. - "Fonctions orthogonales dans la sphère - Résolution
théorique du problème du potentiel terrestre".
p. 227-238.

Il est possible de définir des fonctions orthogonales dans la sphère,
capables d'approximer en norme euclidienne toute fonction à variation
bornée (potentiel, densité).
La représentation de la densité étant supposée donnée, on trouve le
potentiel intérieur et extérieur, et l'on montre notamment que seul le
sous-ensemble harmonique de la densité interne produit un potentiel
externe non nul.
Cet article a été présenté à Oberwolfach (République Fédérale
Allemande) au cours des journées d'études sur les problèmes mathématiques
en géodésie (Mars 1976), organisées par E. GRAFAREND et R. LEIS (Tagung
über Mathematische Probleme der Geodäsie, Mathematisches Forschungsinstitut,
Oberwolfach).

486 - A.I.G. - Bulletin Géodésique - v. 51, n° 4, Paris, 1977.

a) JOO I. - International Symposium on Satellite Geodesy in Budapest,
June 28 - July 1, 1977.
p. 249-252.

b) RAPP R.H. - "Determination of potential coefficients to degree 52 from
5° mean gravity anomalies".
p. 301-323.

A set of 38406 1° x 1° mean free-air anomalies were used to derive a
set of 1507 5° equal area anomalies that were supplemented by 147 predic-
ted anomalies to form a global coverage of 1654 anomalies. These anomalies
were used to derive potential coefficients to degree 52 using the summation
formulae. In these computations, a smoothing operator was introduced and
found to significantly effect the results at higher degrees. In addition,
the effects of the atmosphere, spherical approximation and terrain were
studied. It was found that the atmospheric effects and spherical approxi-
mation effects were about 0.3 % of the actual coefficients. The terrain
correction effects amounted to 10 to 25 % of the low degree coefficients
depending on a specific terrain correction model chosen ; however, the
correction terms found from the models did not yield solutions that
agreed better with current satellite derived potential coefficient
determinations.
Anomalies were computed from the derived potential coefficients for
comparison to the original anomalies. These comparisons showed that the
agreement between the two anomalies became significantly better as the
degree of expansion increased to the maximum considered. These comparisons
shed some doubt on the rule of thumb that a block of size 8° can be
represented by a spherical harmonic expansion to 180° / 8°

487 - ISAEV E.N. & M.A. MITWALLI - "Gravity studies in the Sudan, Part I :
Gravity Bases".
Ministry of Ind. & Mining, Geol. & Mineral Res. Dept, Bull. n° 26,
17 p, Khartoum, 1974.

.../...

This bulletin is mainly a reference to gravity base stations in Sudan. Establishment of these base stations was an effort of several observers including the authors who tried to collect these base stations in a bulletin and analyze them so that they can readily available in a better form to anyone who is interested in them. In such a collection, these bases can also be a start point for further development of more base stations in the country.

488 - BEHRENDT J.C. C.S. WOTORSON - "Geophysical surveys of Liberia with tectonic and geologic interpretations".
U.S. Dept of the Interior, Geol. Surv. Prof. Paper 810, 33 p, + maps, 1974.

Interpretation of the results of aeromagnetic, total-gamma radioactivity, and gravity surveys, combined with geologic data for western Liberia and other geologic information, allows the construction of a tectonic map of Liberia. ...
A regional gravity survey was made of the country along the coast using available roads and along tidewater rivers in western Liberia and showed a 50 to 60 mGal (milligal) positive Bouguer anomalous area extending along the coast from Sierra Leone to Ivory Coast. This anomaly correlates with mafic granulites in the Monrovia region, where the gradient is too steep to be entirely due to crustal thickening at the continental margin. The only major break in this positive anomaly above basement rocks along the entire coast of Liberia is above granitic gneiss adjacent to (and presumably underlying) the only onshore basins of the coast. Local negative Bouguer anomalies exist over two Cretaceous basins in the coastal area. The high mean free-air anomaly of + 22 mGal (exclusive of the coastal anomaly) suggests that the approximately 200 m mean elevation of Liberia is not compensated, at least over the Liberia region. A linear regression, showing a significant correlation of elevation with Bouguer anomaly, has a zero elevation intercept of + 18 mGal, again indicative of an isostatic anomaly. The standard deviation of + 14 mGal from the Bouguer anomaly elevation regression line is indicative of the amplitude range of local geologic anomalies. These include a 30 mGal anomaly above an ultramafic intrusion near Juazohn and an approximate 30 mGal anomaly associated with a mafic intrusion at Cape Mount. A suggested crustal model computed to fit observed marine and land Bouguer anomalies shows an abrupt thickening at the continental margin, several kilometers of sedimentary rock on the continental slope, uplifted dense lower crustal rocks at shallow depths beneath the continental shelf southeast of Greenville, and a high mean crustal density.
A suggested sequence of events indicates particularly uplift of Liberia to a mean elevation of about 200 m without apparent isostatic compensation.

489 - UOTILA U.A. (Editor) - "The changing world of geodetic science". Volume I
The Ohio State Univ., Dept. Geod. Sci., Rep. n° 250, 234 p, 1977.
Proc. of the Int. Symp. held Oct. 6-8 1976, Fawcett Center for Tomorrow.

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This report contains the invited papers which were presented at the International Symposium "The Changing World of Geodetic Science" which was held October 6-8, 1976, at the Fawcett Center for Tomorrow, The Ohio State University, Columbus, Ohio.

The Symposium was arranged as the culmination to the 25th year celebration of the teaching of geodetic science at The Ohio State University. The theme of the Symposium was developments in geodetic science during the past 25 years and those to be expected in the next 25 years with emphases on current and future developments.

Among the papers presented, it can be mentioned :

Session II

CORDOVA W.R. - "New concepts in Geodetic Instrumentation".
p. 73-97.

SAVAGE J.C. - "Geodetic measurements of crustal motions".
p. 99-118.

KAULA W.M. - "Geophysical inferences from statistical analyses of the gravity field".
p. 119-141.

Session III

MORITZ H. -"Changing techniques of gravimetric geodesy".
p. 142-149.

GRAFAREND E.W. - "Space-time differential geodesy".
p. 150-216.

WILLIAMS O.W. - "Does geodesy have a future ?".
p. 230-234.

490 - UOTILA U.A. (Editor) - "The changing world of geodetic science". Volume II
The Ohio State Univ., Dept. Geod. Sci., Rep. n° 250, p.235-458, 1977.
Proc. of the Int. Symp. held Oct. 6-8 1976, Fawcett Center for Tomorrow.

491 - SCHWARZ K.P. - "Simulation study of airborne gradiometry".
Ohio State Univ., Dept. Geod. Sci., Rep. n° 253, 52 p, 1977.
AFGL-TR-77-0129, Sci. Rep. n° 8.

A simulated field of gravity anomalies and second-order gradients is used to study the recovery of gravity anomalies at ground level from measurements at flight level.

The spectral properties of gravimetric quantities simulated by an array of mass points are discussed for first and second order gradients and some rules are derived for generating such fields. To study the effect of observational errors, uncorrelated normally distributed errors and correlated errors from a stationary Markov sequence are used. Results agree well with estimates obtained in a previous accuracy study.

Computations show that a fast operational program can be obtained by using a least-squares collocation procedure. The programs and a sample computation are part of the report.

492 - RAPP R.H. - "The use of gravity anomalies on a bounding sphere to
      improve potential coefficient determinations".
      The Ohio State Univ., Dept. Geod. Sci., Rep. n° 254, 18 p, 1977.
      AFGL-TR-77-0146, Sci. Rep. n° 9

      The precise determination of potential coefficients from terrestrial
gravity data requires that, among other things, the topography of the
Earth's surface must be considered. This paper first formulates a pro-
cedure where the potential coefficients can be determined using anomalies
determined on a sphere that encloses the mass of the Earth. The resultant
equations can also be formulated to compute correction terms to potential
coefficients derived from uncorrected surface free-air anomalies. In order
to obtain the anomalies on the bounding sphere the method of least
squares collocation was investigated. The computation of anomaly cor-
rection terms for 1654 5° equal area blocks was carried out with the
largest correction being 5.1 mGal with the root mean square value being
$\pm$ 0.9 mGal. Using these correction terms and previously derived potential
coefficients from terrestrial gravity data, an improved set was derived.
From degree 5 to degree 20, the improved set showed slightly better
agreement with the GEM 9 (satellite derived) potential coefficients
than the original coefficients. The correction of the original coef-
ficients was small, however, being 1.8 % of the original coefficients
at degree 2, rising to 7.5 % at degree 40.
      Finally, the anomaly correction terms were used to obtain an improved
comparison of satellite derived 5° anomalies and terrestrial data. This
was done by using the satellite determined potential coefficients to
derive anomalies on a bounding sphere which were then downward continued
to the surface. These anomalies showed a better agreement with the ob-
served anomalies than did anomalies computed directly on the surface
(mean square difference : 109 mGal^2 vs. 91 mGal^2).

493 - MORITZ H. - "On the computation of a global covariance model".
      The Ohio State Univ., Dept. Geod. Sci., Rep. n° 255, 36 p, 1977.
      AFGL-TR-77-0163, Sci. Rep. n° 10.

      The report treats the problem of determining a global covariance
function if the following data are given : the variances of the gravity
anomalies, the variance of second-order gradients, the correlation length,
and the lower degree variances. The proposed covariance model is a linear
combination of the reciprocal distance covariance function and a covari-
ance function of logarithmic type.
      It is found that the correlation length is already fixed, within
rather narrow limits, by the remaining data.

494 - AMES C.B., R.B. CLARK, P.M. LAHUE & R.W. PETERSON - "Rotating gravity
      gradiometer development".
      AFGL-TR-77-0098 (I) Final Rep. Period 1 Aug. 1975 through 31 Jan. 1977,
      Volume I, 180 p, Hanscom AFB, 1977.

      The purpose of this contract was to further the development of the
Hughes Rotating Gravity Gradiometer (RGG) ; this effort is a direct
continuation of two prior Air Force contracts. The stated performance
objective for these contracts was the design, construction and demons-
tration of the Rotating Gravity Gradiometer capable of operating in an
airborne environment and producing no more than one (1) Eötvös Unit (EU)
of noise, at an equivalent ten second integration time, in the
determination of the components of a gravity gradient tensor.

The scope of effort in this contract was limited to studies and performance tests and demonstrations in the laboratory environment. Two RGG sensors were involved. The first, RGG-1, was built in 1974 and 1975 under the prior contracts. The second, RGG-2, was designed and built during the course of this contract. The initial scope of work included various tasks to test and modify RGG-1, with the goal of determining configuration changes to be incorporated in RGG-2.

The design for RGG-2 was frozen in April 1976 ; however, RGG-1 testing continued through November 1976. RGG-2 was assembled and ready for grooming and initial performance evaluation by December 1976. Since this contract was completed on 31 January 1977, the period of RGG-2 performance evaluation was limited to a brief span of a few weeks. However, during that short time, it was conclusively demonstrated that significant progress had been made toward achieving the ultimate performance goals.

Specifically, the performance results obtained with RGG-2 demonstrate that :
1) The design goals have been met for thermal and electronics noise,
2) The sensor output noise goals have nearly been met for the vertical spin axis orientation ,
3) Considerable optimism is warranted that the sensor output noise goals can be met for the horizontal spin axis orientation,
4) Continued development is both necessary and warranted.

A second purpose of this contract was to study the requirements of a platform needed to stabilize up to three RGG sensors in an airborne mapping environment. The results of this study, conducted under subcontract by Incosym, Inc., is reported in Volume II of this Final Report. The study results are encouraging, particularly because an existing DoD platform has been identified as being suitable to support a triad of RGG sensors.

In summary, the availability of a platform and the performance success of RGG-2 permit immediate consideration of a follow-on program which would test and demonstrate all the components of a gravity gradiometer system. It is the recommendation of this report that the Hughes RGG sensor be integrated with a platform at the earliest possible time, and tested in the laboratory environment. It is also the recommendation of this report that the RGG-1 sensor be retrofitted up to the RGG-2 configuration to permit simultaneous development and test efforts.

495 - AMES C.B., R.B. CLARK, P.M. LAHUE & R.W. PETERSON - "Rotating gravity gradiometer development".
AFGL-TR-77-0096,(II) Final Rep. Period 1 August 1975 through 31 Jan. 1977 Volume II, 74 p, Hanscom AFB, 1977.

496 - PEARLMAN M.R. - "Cooperative laser ranging research program".
AFGL-TR-77-0140, Final Rep. 1 Nov. 1973 - 30 April 1977, 19 p, 1977.

A lunar laser ranging facility was established at Orroral Valley, Australia by the Australian Division of National Mapping with the assistance of the Smithsonian Astrophysical Observatory with equipment obtained from the Air Force Geophysics Laboratory. Range measurements to lunar reflectors are made from this facility regularly. Some equipment problems must still be overcome before this observatory becomes fully operational.

498 - BLAHA G. - "Refinements in the combined adjustment of satellite
altimetry and gravity anomaly data".
AFGL-TR-77-0169, Final Rep., Period : 29 Sept. 1975 - 31 Aug. 1977,
246 p, 1977.

One of the most important objectives accomplished during the present
analysis has been the upgrading of the AFGL computer program SAGG
(Satellite Altimetry and Ground Gravity). This program serves in the
determination of the global geoid and the Earth's gravity field, based
on the combination of satellite altimetry observations and gravity
anomalies. A typical feature of SAGG is the simultaneous recovery of
both the orbital parameters and the spherical harmonic potential coef-
ficients. The short arc adjustment mode makes these determinations
possible without the requirement of highly precise reference orbits.
Perhaps the most important refinement in SAGG has been the differen-
tiation of the radial distance to a sub-satellite geoidal point with
respect to the state vector parameters. A practical benefit of this
feature is faster convergence in the adjustment, which as removed the
need for iterated solutions.

The new version of SAGG has been used in a combined adjustment of
real data, in conjunction with a (14, 14) geopotential model. A compa-
rison of internal precision has demonstrated the beneficial effect of
adding altimetry data to the existing body of gravity anomaly data.
However, adding this relatively new and completely independent source
to a more traditional type of data in a combined adjustment is benefi-
cial also for other reasons, such as increasing the external reliability
of the results. The recovered geoid over most of the globe shows good
agreement with gravimetric geoids obtained from independent sources.
This is especially true of the areas covered by the GEOS-3 satellite
when compared with the earlier reported results of the AFGL computer
program SARRA (Short Arc Reduction of Radar Altimetry).

As a separate task, a theoretical study has been performed in
comparing the spherical harmonic representation of the potential with the
spheroidal harmonic representation. The outcome of this study has indi-
cated that truncated expressions in any coordinate system other than
the spherical (e.g., in a spheroidal coordinate system) would be
essentially equivalent to using spherical harmonics, and they would be
far less convenient.

The last, independent part of the present effort has been devoted to
an analysis of the point mass technique. The purpose of introducing the
point mass parameters into the adjustment is to add fine structure to
a geopotential model that is based on spherical harmonic coefficients.
The main attractive attributes of such an approach are its economy and
its flexibility. In particular, in areas where an accurate geoid deter-
mination is not required or cannot be accomplished due to the lack of
data, no point masses would be introduced ; the geoid in such areas
would accordingly be described by potential coefficients alone. This
means that on the whole, the number of parameters could be kept relatively
small. The point masses would be employed in areas where, for various
reasons, a more detailed knowledge of geoid features may be required.
The point mass technique has an immediate appeal not only for its
relative simplicity and its practical applicability, but also because
it is founded on a plausible physical concept.

499 - KEARSLEY W. - "Non-stationary estimation in gravity prediction problems",
AFGL-TR-77-0186, Sci. Rep. n° 1, 57 p, Hanscom AFB, 1977.

This report investigates the impact that the assumptions of homoge-
neity and isotropy, when applied to potential related fields, have upon
the stochastic processes which are applied to these fields. After seeing
how these assumptions are incorporated into the statistical model to
produce the familiar covariance function, the investigation centers on
techniques which can be used to detect the presence of anisotropy in the
field. The method found most useful in the two-dimensional covariance
function, and some methods of representing this function are also
investigated.

Numerical studies are then carried out to see the effect the use of
the 2-D covariance function has upon the results of prediction and
collocation computations. It is found that, under certain circumstances,
the 2-D function produces a result superior to that given by the general
function. Recommendations are then given as to when the 2-D covariance
function should be used in practical solutions, and suggestions made as
to the possible areas of further research.

500 - SJOBERG L. - "On the errors of spherical harmonic developments of gravity
at the surface of the Earth ",
AFGL-TR-77-0229, Sci. Rep. n° 12, 74 p, Hanscom AFB, 1977.

The spherical harmonic expansion of the external gravity field of the
Earth is divergent at the surface of the Earth. From the practical point
of view a truncated series can be used if the errors are small. The
errors are of two types : the truncation error and the downward conti-
nuation error. In this report we investigate the latter, which is caused
by the disturbing topography above the point where the series is developed.
This error is studied for potentials, gravity anomalies and for the
vertical gradient of gravity. It is shown that the usual relation
between the spherical harmonics of T and $\frac{\delta \Delta g}{\delta r}$ is also valid for their
errors, while the relation between T_n and g_n does not hold for the
downward continuation errors. The relative errors of Δg are found to be
more serious than those for T.

Some global RMS errors are estimated based on the degree variances of
TSCHERNING and RAPP (1974). Furthermore, formulae are developed for a
numerical integration of the errors over an approximately known topo-
graphy. Finally, these formulae are tested for 1654 5° x 5° mean elevations.
In the Earth model "a level ellipsoid with topography of constant density"
these computations gave the RMS error 0.13 m for global undulations in
an expansion to degree 16. The gravity anomaly errors were generally
within ± 5 mGal except at the edges of the continents and for rough
areas inside the continents, where larger errors might be expected.

501 - INTROCASO A. - "Resultados gravimetricos a traves de la parte media de la Sierra de Cordoba, Republica Argentina".
Inst. Panamericano de Geod. e Historia, Revista Geof. n° 6,
p. 119-130, 1977.

   The gravimetric results obtained crossing Sierra de Córdoba by the middle (roughly parallell 31°30'S) are tentatively explained imputing a lesser part of the negative anomaly to the granitic intrusion of batholithics dimensions of Achala, and the rest (large negative anomaly) to a corthical thickening. Several possibilities are analized such as : density changes and corthical thickness changes, rise of materials from the upper mantle related to the elevation of the set of blocks constituting Sierra de Córdoba, etc. ; together with the difficulties of the gravimetric method in order to obtain a more accurate interpretation.

502 - RUBINCAM D.P. - "General relativity and satellite orbits : the motion of a test particle in the Schwarzschild metric".
from : Celestrial Mechanics, v. 15, p. 21-33, 1977.

   The motion of a satellite with negligible mass in the Schwarzschild metric is treated as a problem in Newtonian physics . ...

503 - "Gravitational potential energy of the Earth : a spherical harmonic approach".
GSFC X-921-77-81, 26 p, Greenbelt, 1977.

   A spherical harmonic equation for the gravitational potential energy of the Earth is derived for an arbitrary density distribution by conceptually bringing in mass-elements from infinity and building up the Earth shell upon spherical shell. The zeroth degree term in the spherical harmonic equation agrees with the usual expression for the energy of a radial density distribution. The second degree terms give a maximum nonhydrostatic energy in the mantle and crust of $- 2.77 \times 10^{29}$ ergs, an order of magnitude below McKenzie's (1966) estimate. This figure is almost identical with Kaula's (1963) estimate of the minimum shear strain energy in the mantle, a not unexpected result on the basis of the virial theorem. If the Earth is assumed to be a homogeneous viscous oblate spheroid relaxing to an equilibrium shape, then a lower limit to the mantle viscosity of 1.3×10^{20} poises is found by assuming the total geothermal flux is due to viscous dissipation. This number is almost six orders of magnitude below MacDonald's (1966) estimate of the viscosity and removes his objection to convection. If the nonequilibrium figure is dynamically maintained by the Earth acting as a heat engine at one per cent efficiency, then the viscosity is 10^{22} poises, a number preferred by some (e.g. Cathles (1975)) as the viscosity of the mantle.

504 - ESTES R.H. - "A computer software system for the generation of global ocean tides including self - gravitation and crustal loading effects".
GSFC X-920-77-82, 59 p, Greenbelt, 1977.

   A computer software system is described which computes global numerical solutions of the integro-differential Laplace Tidal Equations, including dissipation terms and ocean loading and self-gravitation effects, for arbitrary diurnal and semidiurnal tidal constituents. ...

505 - WAGNER C.A. - "The spectrum of the geoid from altimeter data".
GSFC X-921-77-63, 115 p, Greenbelt, 1977.

A variety of sources of detailed information has been analyzed to
arrive at a geoid power spectrum from global altimeter data. Using the
equivalent of only two revolutions of data (mostly from GEOS-3) from all
the major oceans, the high frequency geoid power (rms) is estimated (most
simply) to be

$$80.7n^{-1.47} \text{ meters,}$$

where n is in cycles/global revolutions. This law is valid for all
frequencies above 19 cycles but includes sea state. The (simple) law
has more power than predicted by Kaula's rule for the geopotential.
However, the data shows significantly less power for frequencies below
100 cycles. A closer approximation to the altimetry accumulates 2.18 m
(rss) for all frequencies higher than 19 cycles/rev. (including sea state),
somewhat less power than predicted by the rule. The data permits up to
1 1/4 (rms) non-gravitational departures from the high frequency marine
geoid.

506 - MATHER R.S. - "The analysis of Geos-3 altimeter data in the Tasman and
Coral Seas".
NASA, GSFC, Tech. Memorandum 78032, 34 p, Greenbelt, 1977.

A technique has been developed for pre-processing GEOS-3 altimetry
data to establish a model of the regional sea surface. The algorithms,
as presently used, develop models for a 35×10^6 km^2 area with an inter-
nal precision of $\pm$ 1 m. This figure is substantially influenced by the
data acquisition period and the sea state. There are discrepancies
between the sea surface model so obtained and GEM 6 based geoid profiles
with wavelengths of approximately 2500 km and amplitudes of up to 5 m in
this region. The amplitudes are smaller when compared with GEM 10-based
geoid determinations. However, the comparison of 14 pairs of overlapping
passes in the region indicates altimeter resolution at the $\pm$ 25 cm level
if the wavelength corresponding to the Nyquist frequency were 30 km. In
most cases, the spectral analysis of such comparisons indicates the
existence of significant signal strength in the discrepancies after
least squares fitting, with wavelengths in excess of 200 km. Regional
studies of time varying features of the sea surface in the data analysis
area are not currently possible due to inadequate tracking support and
the limited time span over which a dense data coverage was available.

507 - MARSH J.G. & R.G. WILLIAMSON - "Precision orbit computations for
satellite".
GSFC X-91-77-25, 23 p, Greenbelt, 1976.

The Starlett satellite, launched in February 1975 by the French
Centre National d'Etudes Spatiales, was designed to minimize the effects
of non-gravitational forces and to obtain the highest possible accuracy
for laser range measurements. Analyses of the first four months of global
laser tracking data have confirmed the stability of the orbit and the
precision to which the satellite's position can be established.

.../...

Initial orbit computations using the GSFC GEM-7 gravity model produced rms fits of about 8 to 10 meters for arc lengths of 5 days. Through a series of gravity model improvements these rms fits have been reduced to 1 to 2 meters for the 5 day arcs. An rms fit of 4.3 meters was obtained for a 90 day arc. Five day arcs overlapped by 2.5 days showed rms satellite position differences generally less than 2 meters. Prediction errors at the end of two months were less than 30 milliseconds.

508 - FELSENTREGER T.L., J.G. MARSH & R.G. WILLIAMSON - "Tidal perturbations on the satellite 1967-92 A".
GSFC-X-921-77-22, 22 p, Greenbelt, 1977.

The orbit of the 1967-92A satellite has been studied to ascertain the extent to which tidal forces contribute to orbital perturbations. This study has permitted an estimation of parameters describing the ocean tide potential - in particular for the M_2 and S_2 constituents.

510 - VONBUN F.A., W.D. KAHN, P.D. ARGENTIERO & D.W. KOCH - "Spaceborne Earth applications ranging system (SPEAR)".
from : J. Spacecraft & Rockets, v. 14, n° 8, p. 492-495, 1977.

A technique is discussed for the accurate (i.e., to within fractions of centimeters per year) detection of Earth surface motions utilizing the latest space technology. It is shown that, over a six-day period and assuming a 50 % cloud over (i.e., as experienced over the past few years of laser operation) utilizing spaceborne precision ranging systems, intersite distances on the order of 5 to 15 km (dependent mostly on the beam width of the laser) can be determined in the vertical and horizontal components, with errors in the 0.5 to 1.5 cm range. These errors are almost independent of ground survey errors up to 0.25 m and orbit errors up to 200 m. A spaceborne laser ranging system is assumed to range to two or more ground-emplaced retroreflectors. This can be done either in a simultaneous or nonsimultaneous mode. Hardware is under development for the latter technique.

511 - TORGE W. & H. DREWES - "Gravity variations with time in Northern Iceland 1965-1975".
from : J. Geophys., n° 43, p. 771-790, 1977.

Since 1938 repeated gravity measurements along a west-east profile in northern Iceland ($\emptyset$ = 65°40') have been carried out in order to detect eventual changes of gravity in the young volcanic zone. The latest survey took place in 1975, when 176 stations of the main profile with more than 150 km length have been occupied. Four gravity meters of type LaCoste and Romberg have been used, measuring 1169 gravity differences at the main profile, yielding root mean square errors of the gravity values from $\pm$ 3 to $\pm$ 11 µGal, the average being $\pm$ 7 µGal.

.../...

The comparison of the 1975 survey with the results of 1970/71 and
1965 indicates a lasting increase of gravity in the young volcanic zone
relative to the adjacent tertiary basalt zones. Different mathematical
methods are applied to represent the behaviour of gravity variations with
time along the profile. The maximum gradient of gravity changes occurs
in the Myvatn-Namafjall region with a total difference of nearly
0.01 mgal/year between the adjacent parts of the profile.

512 - DESVIGNES G. - "Potentiel de gravité dû à des structures cylindriques
d'extension limitée".
C.R. Acad. Sci. Paris, t. 285, Sér. B, p. 21-23, 4 Juillet 1977.

Cette Note présente une méthode de calcul du potentiel de gravité créé
par un corps cylindrique d'extension limitée. La méthode peut permettre
l'interprétation quantitative du géoïde obtenu à partir des données des
satellites artificiels. Il est en particulier montré que ces données ainsi
que les mesures gravimétriques sont compatibles avec l'hypothèse de sub-
duction de la plaque Arabique vers le Nord-Est.

513 - BONATZ M. & K. SCHULLER - "Gravimetrische Erdgezeiten-Station Kerguelen
Parameter der Partialtiden für den Beobachtungszeitraum 1973/74".
D.G.K., Reihe B : Angew. Geod. H. n° 218, 36 S, München, 1976.

From 4.1.1973 until 29.1.1974 gravimetric earthtide observations
were performed at Kerguelen island (southern Indian Ocean). Results of
total analysis of data after Chojnicki's and Venedikov's method are
listed. Monthly analysis show variations of tidal parameters of partly
nonstochastic character ; the determination of the reason for these
variation will be the aim of further investigations.

515 - INSTITUTS für ANGEWANDTE GEODASIE - Weitere Beiträge aus der
Bundesrepublik Deutschland zur Vorlage bei der XVI Generalversammlung
der Internationalen Union für Geodäsie und Geophysik, Grenoble 1975.
D.G.K., Reihe B : Angew. Geod. H. n° 221, 138 p, Frankfurt, 1977.

a) DREWES H. - "A method of direct gravimetrical determination of
differences of geoid undulations".
p. 13-20.

The gravimetric levelling reduces the determination of relative geoid
undulations by the formula of Stokes to some simple procedures of least
squares prediction and the summation of the predicted values. Absolute
undulations are obtained by transformation with at least three identical
points. The accuracy of differences of geoid undulations is in good
agreement with practical determinations of several authors (HONKASALO
1974, LELGEMANN 1974).

b) TORGE W., G. BOEDECKER & H.F. WENZEL - "Astrogeodetic geoid determination in the Western Harz".
p. 107-122.

    In the geodetic test network Western Harz (Federal Republic of Germany), relative geoid determinations have been carried out, using different terrestrial methods. The aim of this research work is, to investigate the possibilities of solving the height problem in three-dimensional terrestrial networks of regional extension ...
    The accuracy level obtained by the different methods for the ellipsoidal heights and the relative geoid, is at the order of a few cm.

517 - DOERGE W., E. REINHART & G. BOEDECKER - Das "International Gravity Standardization Net 1971 (IGSN 71)" in der Bundesrepublik Deutschland. (Transformation des Deutschen Schwerenetzes 1962 und Stationsbeschreibungen des IGSN 71).
D.G.K., Reihe B : Angew. Geod. H. n° 225, 59 p, München, 1977.

    For the transformation between the German Gravity Net 1962 (Deutsches Schwerenetz 1962, DSN 62) and the International Gravity Standardization Net 1971 (IGSN 71) parameters (differences in reference level and scale) are determined by least squares adjustment. For the comparison gravity measurements have been made at 111 referring stations. An Appendix comprises 79 sketches of IGSN 71-stations in the Federal Republic of Germany, updated in 1976 and recommended for use.

519 - ACADEMIE des SCIENCES de l'U.R.S.S. - "Catalogue des mesures de pesanteur 15ème croisière du bateau "Akademik Kurchatov" dans l'Atlantique Nord, Juin à Septembre 1973".
Inst. Phys. du Globe O.U. SCHMIDT, 145 p, Moscou, 1975.

    Liste d'environ 5.000 points gravimétriques.

520 - ACADEMIE des SCIENCES de l'U.R.S.S. - Rapport scientifique et technique : Mesures de pesanteur avec satellites navigation, au cours de la 15ème et 20ème croisières du bateau "Akademik Kurchatov" (Atlantique et Océan Glacial Arctique, 1973-75).
Inst. Phys. du Globe O.U. SCHMIDT, 33 p, Moscou, 1975.

521 - WENZEL H.G. - "Zur Optimierung von Schwerenetzen".
Zeits. Vermess. 102, Jahr. 1977, H. 10, S. 452-457, 1977.

    The method of sequential optimization for the optimal design of geodetic networks is described and applied to the planned German gravity basic network 1976 and to the planned gravity network of Lower Saxony. The practical aspects of the optimal design with different target functions are discussed.