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

Juin 1967

N°16

- I - PREMIERE PARTIE

- II - DEUXIEME PARTIE

- I -

PREMIERE PARTIE

ASSEMBLEE GENERALE de l'U.G.G.I. (LUCERNE, 25 Sept.- 7 Oct. 1967)

- SECTION IV de l'A.I.G. : GRAVIMETRIE -

- PROVISIONAL PROGRAM -

SECTION IV : GRAVIMETRY

September, Tuesday 26, 3.30 - 5 p.m.

- Presidential address, agenda.
  Brief view of general gravity work.
  Work done in accordance with the resolutions previously adopted (1963-65)
- ABSOLUTE MEASUREMENTS of g (Chairman : Dr. COOK).
  Apparatus.

September, Wednesday 27, 9.30 - 11 a.m.

- ABSOLUTE GRAVITY MEASUREMENTS of g (continued).
- Apparatus (continued), results.
- Proposition for a new International Gravity Formula and a new Standard Value of Reference Gravity.

September, Thursday 28, 9.30 - 11 a.m.

- FIRST ORDER GRAVITY NET (Special Study Group n°5, Chairman : Prof. MORELLI).
- Results obtained with the pendulum apparatus.

September, Friday 29, 9.30 - 11 a.m.

- GRAVITY CALIBRATION LINES (Special Study Group n°6)
    - Prof. KNEISSL (Europe)
    - Dr. RICE (N. America)
    - Dr. OKUDA (W. Pacific)
- FIRST ORDER GRAVITY NET (Special Study Group n°5)
  Pendulum results (continued), compensation.

October, Monday 2 (Meeting will be arranged later)

- MEASUREMENTS at SEA (Chairman : Dr. WORZEL)
  Apparatus, results.

October, Wednesday 4, 9.30 - 11 a.m.

- FIRST ORDER GRAVITY NET, results of gravity measurements.

3.30 - 5 p.m.

- AIRBORNE GRAVITY MEASUREMENTS (Chairman : Dr. WILLIAMS).
- GRAVITY VERTICAL GRADIENT (Chairman proposed : Dr. CONSTANTINESCU).

- A -

ABSOLUTE GRAVITY MEASUREMENTS

(Chairman : Dr. COOK)

- BAGLIETTO E. & A. CERRATO. - "Absolute determination of gravity with reversible pendulums (quartz tube) to Buenos-Aires".
- BJERHAMMAR A. - "A device for measurement of absolute gravity".
- COOK A.H. - "The new absolute determination of gravity at the National Physical Laboratory, England". 10 mn.
  - "A brief summary of our results".

  Resolution : On a new International Gravity Formula and on a new Standard Value of Gravity to replace Potsdam.
- GERMAN S. - "PTB, Braunschweig".
- HYTONEN E. & T. HONKASALO. - "Report on progress of the absolute gravity measurement with long wire pendulum". 5 mn.
- PETTERSSON L. - "A portable apparatus for absolute gravity measurements is being constructed at Rikets Allmänna Kartverk".
- SAKUMA A. - "Résultats préliminaires de la mesure absolue de la pesanteur au Bureau International des Poids et Mesures, Sèvres". 20 mn.

BJERHAMMAR A. - "A device for measurements of absolute gravity".

"A new device for measurement of the absolute gravity has been designed. The instrument is based on the falling body principle and measures the time using a counter and the distance using a laser. The falling body is a small corner reflector inclosed in vacuum by an external chamber falling together with the corner reflector.

The operational distance can be varied over a large range because the external chamber is falling in free-air. This makes it possible to obtain an unlimited number of independent observations".

COOK A.H. - "The new absolute determination of gravity at the National Physical Laboratory, England".

"A new absolute determination of the acceleration due to gravity at the NPL has been made by timing the symmetrical free motion of a body moving under the attraction of gravity ; it is the first time this method has been used. The moving body was a glass ball and it was timed at its passage across two horizontal planes by the flashes of light that it produced when it passed between two horizontal slits which served to define each plane optically, the ball focusing light from one of the slits, which was illuminated, upon the other slit which had a photomultiplier placed behind it. The separation of the two planes defined by the pairs of slits was measured interferometrically and referred directly to the international wavelength definition of the metre, while the time intervals were measured in terms of the atomic unit of time scale A 1.

The value of gravity as reduced to the British Fundamental Gravity Station in the N.P.L. is :

981181.75 mGal, s.d. 0.13 mGal (1 mGal = $10^{-5} m/s^2$)

Systematic errors, are believed to be very small ; this is particularly true of the error due to air resistance. The main contribution to the observed scatter of the results comes from microseismic disturbances.

The new result is 1.4 mGal less than that obtained at the fundamental station by J.S. Clark".

from Philos. Trans. R. Soc.
Ser. A, n°1120, v.261, 1967.

SAKUMA A. - "Résultats préliminaires de la mesure absolue de la pesanteur au Bureau International des Poids et Mesures, Sèvres".

"Après la première série de mesures préliminaires de "g", on peut constater les faits suivants :

1) L'appareil du B.I.P.M. a une sensibilité de 0,01 mGal : c'est-à-dire que les valeurs de g obtenues par des lancements successifs du trièdre sont concordantes à 0,01 mGal.

2) Ainsi, pour la première fois, à ma connaissance, la perturbation de "g" due à l'effet "luni-solaire" a été détectée par notre méthode absolue.

3) La différence $\Delta T = Td - Tm$, entre le temps de montée Tm et le temps de descente Td (0,2 s environ) du trièdre lancé (dans un vide de 4×10^{-4} N/m^2) passant par les deux stations (distance $\ell = 40$ cm) reste toujours $+ 15 \text{ ns} > \Delta T > + 5 \text{ ns}$.

Ce fait signifie que le temps de propagation de la lumière : 10,7 ns parcourant une distance de 3,2 m. ($8 \times \ell$) est détecté avec une incertitude de $\pm$ 5 ns, et permet de penser que les diverses erreurs : ambiguité de pointage du centre de la frange achromatique à la station haute, défaut de trajectoire du trièdre, oscillation du trièdre, etc., restent dans le domaine de tolérance admise.

4) Il est prématuré de fixer la valeur de "g" à SEVRES, POINT "A" avec une précision de 0,01 mGal, car il faut éliminer les erreurs systématiques, mais il n'est pas pensable que l'accumulation de ces erreurs dépasse $\pm$ 0,1 mGal et grâce à la haute sensibilité et à la bonne reproductibilité des

mesures cette étude des erreurs systématiques pourrait être achevée assez rapidement.

La valeur actuelle est :

$$g_{\text{SEVRES, POINT "A" PROVISOIRE}} = 9,809\ 260\ \text{m/s}^2$$

Cette nouvelle valeur est inférieure de 13,8 mGal à celle du Système de Potsdam et inférieure de 2,0 mGal à la mesure de 1959 obtenue dans la même salle de gravimétrie par A. Thulin".

NEW INTERNATIONAL GRAVITY FORMULA - POTSDAM ABSOLUTE STANDARD

We reproduce hereafter copies of letters concerning this subject.

COOK A.H., Secretary of the Section III, I.A.G., to the President of the Section IV :

"The adoption by the International Astronomical Union of new fundamental constants, including the equatorial radius of the Earth and the value of the flattening, together with new absolute measurements of gravity, raises the question whether we should adopt a new international gravity formula. I rather think that the adoption of the new international gravity formula is a question apart from that of whether the geometrical size and flattening are adopted for expressing the results of triangulation surveys, and undoubtedly the International Gravity Bureau will have a lot to say on the problem of the convenience of changing to a new formula. It would be very useful on the other hand if we could change the Potsdam absolute standard to one consistent with the I.A.U. constants. This would not change the value of any anomaly, but I am not clear whether it is a wise course to adopt at present. The I.A.U. constants give us an absolute value for the mean value of gravity over the Earth, while new absolute measurements give us absolute values at one or two particular places. The connection between these two types of absolute value is through the mean value of gravity anomalies averaged over the surface of the Earth, and this is a quantity which is uncertain by a good deal more than either the value inferred from the I.A.U. constants or the recent measured absolute values, while from a metrological point of view it would be very desirable to adopt a new constant in the gravity formula based on the apparently consistent I.A.U. values and the new absolute determinations, it is possibly premature to do so".

HOWLETT L.E., Président du Comité International des Poids et Mesures au Président de l'U.G.G.I. :

"La valeur de l'accélération due à la pesanteur intervient dans quelques mesures physiques fondamentales. Pour que les résultats de telles mesures faites en des lieux différents soient comparables, on fait usage du système de Potsdam, mais on sait depuis d'assez nombreuses années que ce système comporte une erreur de plus en plus gênante pour la métrologie.

En 1960, la XIème Conférence Générale des Poids et Mesures (Résolution 11) a donné pouvoir au Comité International des Poids et Mesures "de décider du changement de système de Potsdam lorsqu'il aura estimé que la valeur de cette accélération est connue avec une exactitude suffisante". Le Comité International des Poids et Mesures n'a pas encore pris de décision. Je crois pouvoir résumer l'essentiel de l'opinion actuelle du C.I.P.M. ainsi :

1) En raison des progrès en cours dans l'exactitude des mesures absolues de g et des mesures comparatives d'un lieu à un autre, il serait prématuré d'abandonner le système de Potsdam et de le remplacer par un nouveau système gravimétrique.

2) En attendant et provisoirement, la métrologie pourrait se contenter d'une précision de 1 milligal ; il semble qu'une correction provisoire immédiate de - 13 milligals au système de Potsdam serait satisfaisante pour les usages métrologiques et serait utile.

3) Toute décision concernant un système gravimétrique conventionnel devrait être prise en liaison étroite entre le C.I.P.M. et l'Union Géodésique et Géophysique Internationale (U.G.G.I.) ; les études futures devraient être menées autant que possible conjointement.

Le C.I.P.M. souhaite que les commentaires ci-dessus soient pris en considération par l'U.G.G.I.

Le C.I.P.M. souhaite aussi connaître l'opinion de l'U.G.G.I. à la suite de l'Assemblée Générale de l'U.G.G.I. (25 Septembre - 7 Octobre en Suisse) ; le C.I.P.M. sera en session à Paris à partir du 6 Octobre 1967 et pendant la XIIIème Conférence Générale des Poids et Mesures (10-16 Octobre 1967)".

UOTILA U.A., Prof. at the Ohio State University to the Secretary of the Section IV :

..."I am not sure if we are ready to discuss the new gravity formula as yet but I feel that this will be raised in the meeting. For other scientific research it might be necessary that we recommend in Section IV the new gravity formula ; however, I would like to emphasize that the 1930 formula can still be used in all gravity computations and conversions done later on in connection with computations. If somebody likes to use some other formula, it should be emphasized very strongly that information about the used gravity formula be included in all publications"...

- B -

FIRST ORDER WORLD GRAVITY NET and STANDARDIZATION PROBLEM

(Chairman : Prof. MORELLI)

The Special Study Group n°5 should present a General Report on all the work done until now ; this report will be published in the "Travaux de l'Association Internationale de Géodésie" later on.

The Table of Contents in which you can see the titles of separate reports concerning the pendulum measurements is indicated hereunder.

GENERAL REPORT S.S.G. n°5 - Table of Contents

Annexe 3 : Report about the relative gravity measurements carried out by means of the Italian three-pendulum apparatus C.G.I. N°2 in Europe and America in 1965. By TOMELLERI V.

Annexe 4 : Report on the Gulf pendulum measurements. By WOOLLARD G.P.

Annexe 5 : Report on the USCGS pendulum measurements. By RICE D.A.

Annexe 6 : Report on the GSI pendulum measurements. By HARADA Y.

Annexe 7 : Report on the GIP pendulum measurements. By ELSTNER C.

3. Measurements with gravity-meters

3.1 Advances

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Annexes : Summary Reports for :

APCS,	by	WHALEN C.T.
DO,	"	HAMILTON A.
DGF,	"	KNEISSL M.
EPF - ORSTOM	"	GANTAR C.
HIG, GPRC,	"	WOOLLARD G.
USNOO,	"	
GITH,	"	GROSSMANN W.
ITGTH,	"	HÖPKE W.
OGST,	"	GANTAR C.
IGPM,	"	
AFCRL,	"	
AMS	"	IVERSON R.M.

4. Adjustment.

5. Absolute values.

6. Secular variation of gravity.

Some summaries :

ELSTNER C. - "Pendulum gravity measurements connecting Potsdam with Helsinki and Ivalo (Finland)".

"In the summer of 1966 the Potsdam pendulum apparatuses were used for the determination of the differences in gravity between Potsdam, Helsinki and Ivalo/Finland. The method and the details of the measurements are described. The following final results referred to $g_{Potsdam}$ = 981 275,39 mGal were calculated :

$$g_{Helsinki} = 981\ 914,4 \pm 0,3 \text{ mGal}$$

$$g_{Ivalo} = 982\ 515,9 \pm 0,3 \text{ mGal}$$

The errors of the measurements at a single station amounted to ± 0,05 mGal on an average of seven couples of pendulums. The variance in the gravity differences between two stations yielded an accuracy from 0,1 to 0,2 mGal. Furthermore, the errors of the final results were slightly increased by discrepancies between the repeated stations.
The gravity values agree with the results of other modern pendulum and gravimeter observations within 0,3 mGal".

HARADA Y. - "Gravity observations along the Western Pacific Calibration Line". 10 mn.

"Four series of gravity observations along the Western Pacific Calibration Line has been conducted by the Geographical Survey Institute using GSI pendulum apparatus at the following stations :

- Tokyo, Honolulu, San Francisco and Dever, March - June, 1965.
- Tokyo and Fairbanks, June - September, 1965.
- Tokyo, Manila and Singapore, March - June, 1966.
- Tokyo, Sydney and Canberra, February - June, 1967.

The gravity values at these stations, determined within the accuracy of 0.5 mGal based on the value of Tokyo, are obtained as follows :

Honolulu	978.9585	Manila	978.3956
San Francisco	979.9858	Singapore	978.0810
Denver	979.6111	Sydney	now in calculation
Fairbanks	982.2461	Canberra	" " "

Base station : Tokyo G.S.I. = 979.7770".

WHALEN C.T. - "A report on 1381st Geodetic Survey Squadron world gravity base surveys, 1963-67". 20 mn.

"Between 1963 and 1967 gravity teams from the 1381st Geodetic Survey Squadron made observations with four or more small geodetic model LaCoste and Romberg gravimeters at approximately 270 cities. Measurements were made in ladder sequence along the American, American Secondary, Euro-African, Euro-African Secondary, West Pacific, and Central Asian Secondary Calibration Lines. Other measurements were made between the calibration lines to form a World Gravity Base System. The standard error terms for the adjusted values do not exceed ± 0.10 milligal with respect to Potsdam".

- C -

EUROPEAN GRAVITY CALIBRATION LINE

Special Study Group n°6

(Chairman : Prof. Dr. KNEISSL)

KNEISSL M. - "Report about the works of the I.A.G. Special Study Group n°6. Establishment of a calibration baseline system for gravity meter in Europe".

"Two working sessions (18 Nov. 1963 and 6 March 1964) took place during the reporting period. The original task of the Special Study Group, namely the establishment of a gravity meter calibration line in Europe, has been extended essentially by the performed works :

1) The calibration line has to be strengthened to a line for the world gravity network ;

2) ties have to be made between the European stations of the world gravity net ;

3) the European gravity net has to be densed in order to serve as a test net for different adjustment methods for the later adjustment of the world net.

Some details are given on recent works in Italy, Austria, and Germany, especially about the performance of a direct connection Potsdam - Bad Harzburg. Concluding attention is paid to the paper "On the adjustment of the gravity calibration line" by Professor HONKASALO T. (Helsinki) giving proposals for a new adjustment on the basis of a critique of the existing adjustment of the calibration line, and of a report on a new adjustment in the northern part of the calibration line".

EBERHARD O. - "Gravity measurements 1965 over the ECL : gravimetric connection 1966 Bad Harzburg - Potsdam".

"In the first part of this paper the results of gravity measurements 1965 with two LaCoste Romberg gravity meters over the Munich -Helsingör section of the ECL are discussed. Special attention is paid to the detection of nonlinear errors of scale functions. The comparison of the individual results of both gravity meters shows that there exist periodic errors in scale functions with a main period of $\approx$75 mGal and an amplitude of $\approx$0,003.

The second part contains the results of a gravimetric connection Bad Harzburg - Potsdam, measured in 1966 with three LaCoste Romberg gravity meters. The final results for the measured gravity difference

g (Bad Harzburg S_1) - g (Potsdam S_2) is - 95,16 ± 0,01 mGal".

See also : FIRST ORDER WORLD GRAVITY NET and STANDARDIZATION PROBLEM.

- D -

SEA GRAVITY MEASUREMENTS

Special Study Group n° 20

(Chairman : Dr. WORZEL)

- CHOJNICKI T. - "Gravity measurements in the Southern part of the Baltic Sea".
- FLEISCHER U. - "Test of gyrotables and comparisons of two simultaneously operating seagravimeters". 10 mn.
- FLEISCHER U. - "Work done by the German Hydrographic Institute".
- HENDERSON G.C. - "A gravimeter for marine, airborne, and lunar surface measurements".
- LAGAAY R.A. - "Interpretation of a gravity section over the negative zone North of Curaçao". 15 mn.
- TANNER J.G. - "Regional gravity measurements in Canada (with particular emphasis on measurements over continental platforms)". 10 mn.
- TALWANI M. - "Accuracy of surface ship gravity measurements made on board USNS ELTANIN in the Tasman Sea".

We mention here the few papers which were communicated to the I.G.B. but their presentation at the meeting will depend on Dr. WORZEL's decision.

Others papers to be presented to the Upper Mantle Committee in Zurich

INTERPRETATION of ANOMALIES at SEA (September 29, afternoon)

- FLEISCHER U., O.MEYER & D.VOPPEL.- "Magnetic and gravity anomalies of the Western part of the Romanche fracture zone surveyed by R.V. "METEOR" in 1965.

- TALWANI M. & X. LE PICHON. - "Surface ship gravity observations, comparison with gravity data from satellite observations and relationship with submarine tectonic features".

CHOJNICKI T. - "Gravity measurements in the Southern part of the Baltic Sea".

"The author describes his method of making measurements with gravimeter Askania Gs-11 at points situated on the ice of a frozen sea. He discusses the accuracy of measuring, obtained at experimental points situated several score kilometers away from the shore. He also indicates where these points are locared on the blackground of other places, where measurements have been made by foreign scientific centres in the southern part of the Baltic Sea".

FLEISCHER U. - "Test of gyrotables and comparison of two simultaneously operating seagravimeters".

"Two complete seagravimeter devices were continously operating for five months during two Atlantic expeditions of the German research vessel "METEOR" (2,700 tons). The behaviour of the gyrotables were steadily observed by damped tubular levels. The oil erected gyro from Anschütz Company was reliable up to mean horizontal accelerations of ± 40,000 mGals. The mean error on an equatorial cruise was 2 minutes of arc.

In rough sea on a North Atlantic cruise the electrically erected gyro was successfully used. In laboratory experiments on an escarpolette producing horizontal accelerations up to 125,000 mGals as well as at sea the maximum error was less than 4 minutes of arc.

Two Askania seagravimeters, type Gss-2, mounted antiparallel on separate platforms were operating simultaneously. The gravity results of the two instruments differ in dependence of the ship's course. The amplitude of that difference in moderate, uniform sea conditions, essentially resulting from cross-coupling effects, was about 8 mGals. The behaviour of the gravimeters in rough sea and a comparison with gravity at 30 submarine pendulum stations will be discussed".

HENDERSON G.C. -"A gravimeter for marine, airborne, and lunar surface measurements".

"State-of-the-art technology has supplied geophysicists with a single, precision device to measure variations of the gravity field in the oceans, the atmosphere, and on extra-terrestrial bodies. A sensor derived from an inertial grade, force rebalance accelerometer has been successfully tested in turboprop and rotary-wing aircraft. An extensive marine program has been conducted aboard the USNS SHOUP.

With a range of 966-994 gals, this gravimeter system mounted on a stable platform has consistently exhibited a one -three milligal instrumental accuracy, excluding navigational errors, in dynamic conditions of up to sea-states seven and eight. Static resolution is better than 0.1 milligal with a predictable drift rate of one mgal/mo.

The basic system has been evaluated and found to be a strong contender for an earth-reference, lunar surface gravimeter. This wide dynamic range device can obtain a lunar base-station reading to within one milligal in terms of the absolute referenced to a terrestrial station. The possibility of improving system resolution is being investigated for the feasibility of obtaining tidal variations on the lunar surface".

Information on the improvements carried out on the Graf type Askania Sea Gravimeter Gss-2 since 1963. (ASKANIA - WERKE).

"Changes have been made in all components of the equipment :

1) The sea gravimeter proper : While the field-proven principle of measurement has remained unchanged, several modifications in the design were made, taking into account the accrued experience, in order to enhance the reliability, the robustness and the useful life of the instrument. These modifications followed by high-precision adjustment techniques resulted in improving still further the accuracy of measurement (reference : Gramatzki, Askania-Warte n°64).
2) The electrical accessories to the sea gravimeter have now been accommodated in a single unit. A two-trace recorder indicates the averaged gravity value (direct measuring range 7,000 mGal, reading accuracy $\pm$ 0.5 mGal) as well as the averaged beam position (reference: Thebis, Askania-Warte n°65).
3) The Anschütz Gyrotable for the sea gravimeter : Instead of the oil erection system, the gyro has been equipped by an electrical erection system allowing to adjust the erection parameters in accordance with the conditions of measurement. Essential improvements result therefrom:

the sea gravimeter recording is now to a considerable degree independent of the ship's manoeuvres (prolonged increase of speed, turns) ; further considerably stronger damping of the apparent vertical fluctuations (1 : 1,000 as compared with the previous 1 : 25) extend the range of applicability of the instrument, and it is especially possible now to make measurements at rather long-periodic sea states (reference : Schlichting, Askania-Warte n°70).

4) Accessories : The most important improvement on the sea gravimeter equipment consists of an unpretentious supplementary unit connected in between the gyrotable and the sea gravimeter. It is the "CC-Eliminator". It allows to get rid of the quite disturbing cross-coupling effect, which could cause errors of 3 mGals and more. The CC-Eliminator adjusts the platforms of the gyrotable in accordance with the rhythm of the measuring beam motion in such a manner that the beam always remains horizontal. Horizontal accelerations are thereby, prevented from exerting disturbing torques on the measuring beam (reference : Jacoby and Schulze, Journal of Geophysical Research, v. 72, n°8, April 15, 1967).

Further improvements are : digital indication of the measured values, and fail-safe devices which automatically take all the necessary measures to protect the sea gravimeter under extremely unfavourable conditions, power supply failure, or failure of important components".

- E -

AIRBORNE GRAVITY MEASUREMENTS

(Chairman : Dr. WILLIAMS)

- ANTHONY D. -"Evaluation of aerial gravity measurements". 15 mn.
- MORITZ H. -"Optimum smoothing of aerial gravity measurements". 5 mn.
- SZABO B. -"Recent developments in aerial gravity measurements". 15 mn.

MORITZ H....

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MORITZ H. - "Optimum smoothing of aerial gravity measurements".

"The smoothing of aerial gravimeter records is investigated theoretically using the theory of stationary stochastic processes (time series). Two methods of optimum filtering are considered : first, least-squares filtering, due to Norbert Wiener, where the r.m.s. error is minimized absolutely ; and second, equal-spectrum filtering, where the r.m.s. error is minimized subject to the condition of least distortion as expressed by preservation of spectrum. The equal-spectrum method seems to be more appropriate for aerial gravimetry because of the high noise level and has a considerable practical advantage.

Emphasis is on digital computation, for which practical formulas are given ; analog computation by means of electric networks is outlined".

- F -

GRAVIMETERS

BREIN R. -"Elektrische Messung von Schweredifferenzen mit einem LaCoste Romberg Gravimeter".

"Dans la première partie de son exposé l'auteur décrit les propriétés du gravimètre LaCoste-Romberg, conjointement avec sa structure intérieure. Il explique quelques éléments essentiels qui se distinguent d'autres types de gravimètres utilisés sur le terrain.

Afin de rendre possible l'enregistrement des variations temporaires de la gravité pour la recherche des marées terrestres, nous avons installé dans le gravimètre LaCoste-Romberg un dispositif qui rend possible la compensation des différences de la gravité par voie électrique. De cette manière on peut éliminer largement la fonction usuelle élastomécanique du gravimètre si l'on mesure des différences de la gravité.

Dans la deuxième partie de son exposé l'auteur décrit les dispositifs et les résultats d'essais qui ont été obtenus par l'enregistrement et par la mesure des différences de la gravité sur le terrain".

HAMILTON A.C. & B.G.BRULE. -"Vibration-Induced drift in LaCoste and Romberg geodetic gravimeters".

"Many hitherto unexplained erratic gravimeter measurements can be attributed to the effect of vibration on the gravimeters during transportation between gravity stations. Experiments with four LaCoste and Romberg land gravimeters on a vibrating platform showed that all are affected to some degree by forced vibrations at frequencies and peak accelerations that can occur on common carriers. Two effects were found : all four gravimeters when subjected to vibration in the 35 - to 70 - cps range for 1 min or more at peak accelerations of about ± 1 g drifted erratically in the ± 0.1 mgal range ; at about 48 cps positive drift as rapid as 1 mgal/min sometimes occured. The threshold of acceleration needed to produce this unidirectional drift varied from ± 0.5 to ± 2.0 g for the meters that were tested. As there is extensive documentation to show that vibration of these intensities may occur at frequencies in this range in aircraft or land vehicles, it is concluded that vibration is the major cause of the inconsistent performance that is occasionally observed on these instruments. In experiments with foam rubber and mechanical isolators to minimize the effect of the ambient vibration field, it was found that by using mechanical isolators to support the gravimeter within the carrying case it was possible to eliminate the unidirectional drift at accelerations of ± 2 g"

WHALEN C.T. -"<u>On performance of the new miniature LaCoste-Romberg geodetic gravimeters".</u> 5 mn.

"The size has been reduced, the mercury thermostat has been replaced by a thermistor, a new relay circuit has been built into the instrument, and the leveling screws no longer pass through the case of the new miniature LaCoste-Romberg geodetic gravimeter. Four of these instruments were used on a 1967 calibration trip over the NACL. Some remarks on performance of these instruments are given".

- G -

VARIOUS TOPICS

Mc CONNEL R.K. -"<u>Gravimeter calibration and adjustment of gravity control networks in Canada".</u> 5-10 mn.

"The Gravity Division of the Dominion Observatory has been involved in the establishment and adjustment of gravity control networks in Canada. Block adjustments have been completed for most areas in Canada and have provided a relatively uniform datum for both regional gravity surveys of the Dominion Observatory and local surveys carried out by other institutions. Descriptions and principal facts for several thousand control stations are available on request to mining and petroleum companies and research institutions.

Computer programmes incorporating many data editing features have been developed to analyse and adjust Worden and LaCoste-Romberg gravimeter observations.

Analyses of field and laboratory calibrations have yielded significant information regarding the performance of various types of gravimeters".

TANNER J.C. -"Regional gravity measurements in Canada". 8-10 mn.

"During the past ten years the Dominion Observatory has concentrated on regional gravity coverage, at eight-mile intervals, of the land and inland and coastal water systems of Canada. Approximately 100,000 measurements have been made using land gravimeters and specially constructed gravimeters for use under water and on sea ice. Transportation has been provided primarily by helicopter and fixed-wing aircraft.

Although gravity work has been carried out in all the geological provinces of Canada, the Canadian Shield and the Innuitian Region (Arctic Archipelago) have been the subject of most of the studies because of their interest to the mining and petroleum exploration industries generally. However, the Observatory recently expanded its field program to include a major investigation in the Cordillera of Western Canada. It is hoped that regional coverage of the gravitational field in this interesting region will be available by 1972.

All of the gravity observations completed by the end of 1966 are being compiled on a gravity map of Canada. This map, which will be published in four sections and at a scale of 1/2,500,000, will be available for distribution in late 1967 or early 1968".

GROTEN E. -"Bestimmung der Schwere an der Erdoberfläche aus Fluggravimetermessungen".

Deutsche Geod. Komm. Reihe C, n°94.

HONKASALO T. -"Variation of gravity caused by land upheaval in Fennoscandia".

Theoretical estimation of changes and first measurements for this study are presented. 5 mn

RAPP R.H. -"<u>Procedure for gravimetric computations using a digital computer</u>".

"The use of large scale digital computers has enabled the computation of many gravimetric quantities that would not have been computed on a large scale before. In this report, procedures will be described for computational methods, using digital computers, that are being operationally run for the following quantities : prediction of point and mean gravity anomalies, digitally produced contour maps, upward continuation of gravity anomalies, disturbance components, normal gravity and gravitation, undulation and deflection computations, terrain effect computation, statistical properties of anomalies"...

- II -

DEUXIEME PARTIE

- GRAVITY MEASUREMENTS at SEA
- GRAVIMETRIC TERRAIN CORRECTIONS
- STATIONS GRAVIMETRIQUES

- II -

1° - GRAVITY MEASUREMENTS AT SEA

1-A) Additional Information

et on particle méditerranée

In the Bulletin d'Information n°14 we published some recent information on measurements at sea and a chart : "Open Sea Gravity Measurements" with the tracks of different surveys carried out all over the sea.

We mention, hereafter, information received from Italia (Osservatorio Geofisico Sperimentale, Trieste), Japan (Geographical Survey Institute, G.S.I.) and United States (Lamont Geological Observatory) which reached the I.G.B. too late to be included in the Bulletin n°14.

A remark from Australia (Bureau of Mineral Resources, B.M.R.) is also added below.

AUSTRALIA

"It is to be noticed that the work attributed to B.M.R. in Australian Waters, both on the world map "Open Sea Gravity Measurements" (small cross-hatched area near Perth Basin, South Western Australia) and on page I-14 of the Bulletin n°14, was done by the Lamont Geological Observatory of Columbia University. This organization was the principal authority responsible for the project and the other groups mentioned were co-operating bodies".

from N.G. CHAMBERLAIN
B.M.R. April 1967

ITALIA

The chart 1 (next page) shows the geophysical cruises carried out in 1964-66 by the Osservatorio Geofisico Sperimentale, Trieste, in cooperation with C.N.R. Research Ship "Bannock".

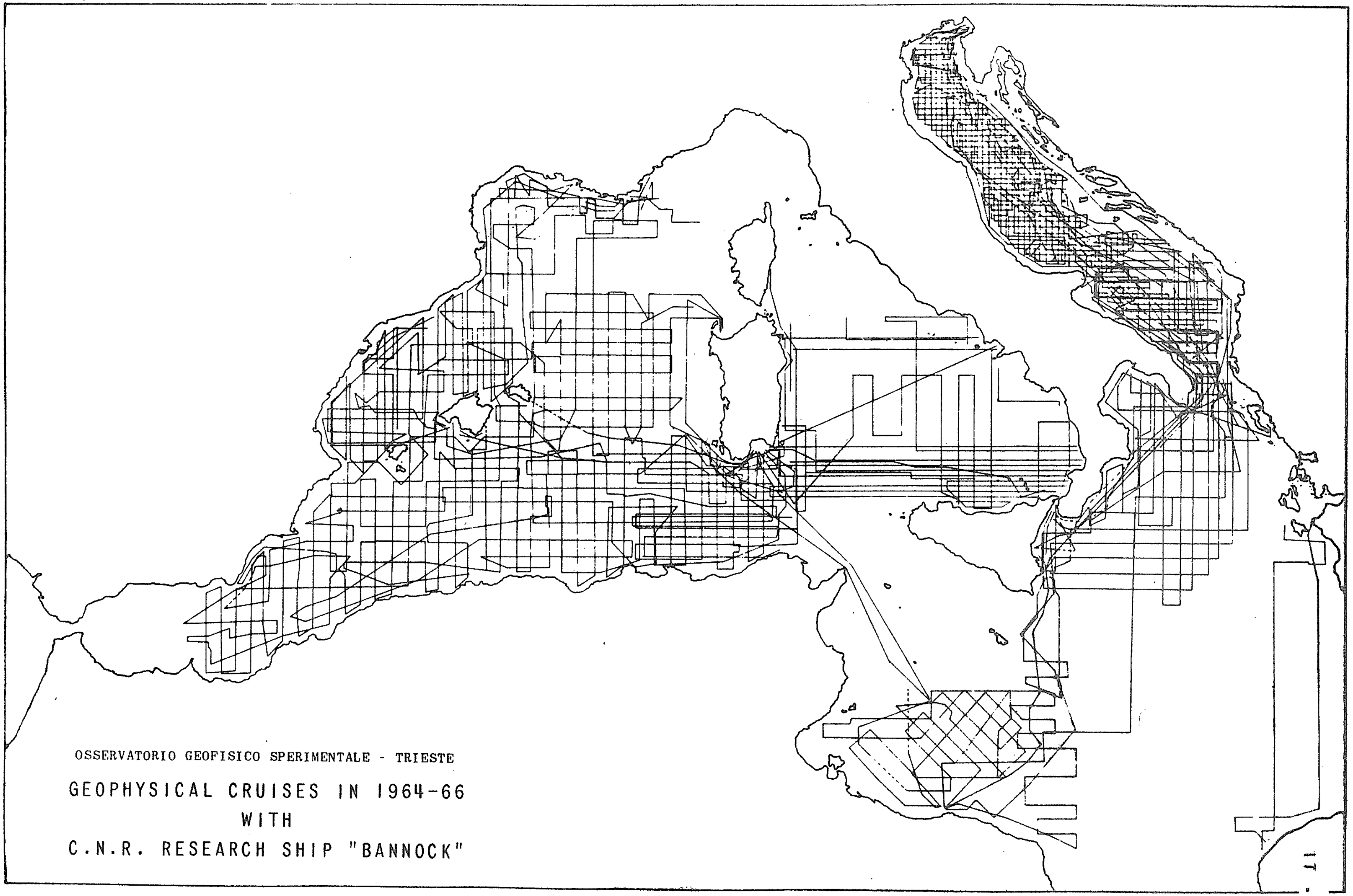

OSSERVATORIO GEOFISICO SPERIMENTALE - TRIESTE
GEOPHYSICAL CRUISES IN 1964-66
WITH
C.N.R. RESEARCH SHIP "BANNOCK"

Chart 1 .

JAPAN

" In Japan, there are three organizations which are carrying out the gravity surveys at sea :

- Hydrographic Office (H.O.), University of Tokyo,
- Ocean Research Institute (O.R.I.), University of Tokyo
- Geographical Survey Institute (G.S.I.)

The two former employ Tokyo Surface Ship Gravimeters, and G.S.I. developed its own dynamic gravimeter which has three strings.

Three charts p.II - 5 , 6 , and 7 show the courses of recent gravity surveys at sea by O.R.I. and G.S.I. Detailed report by the O.R.I. will be published coming Spring.

Unfortunately, gravity values cannot be obtained everywhere on the courses. Observations were made in such a way that a series of recording was made one hour with spacing of 15 - 20 km. A series of recording takes about 15 minutes and a gravity value is obtained as the mean of this time duration. Results are being processed by electronic computer and will be published in the future".

Chart 2 - Gravity survey made by the Ocean Research Institute in 1963-64 and in 1964-65(1).

Chart 3 - Gravity survey made by the Ocean Research Institute in 1964-65(2).

Chart 4 - Gravity survey made by the Geophysical Survey Institute in 1965-66.

from Dr. Y. HARADA
G.S.I.,January 1967

UNITED STATES

"On the chart 5 (p.II - 8) are reproduced the tracks for a major part of the cruises of R/M VEMA (cruises 17-22) and R/V Robert D. CONRAD (cruises 8-10) made by Lamont Geological Observatory of Columbia University.

It is to be noticed that for some "legs" no gravity data were obtained. For others, data were obtained only during a portion of the "leg".

Some details on these cruises are given hereunder :

- R/M VEMA cruise p. II.9 - 12.
- R/V CONRAD cruise p. II.12 - 13.

from Prof. M. TALWANI
L.G.O., February 1967

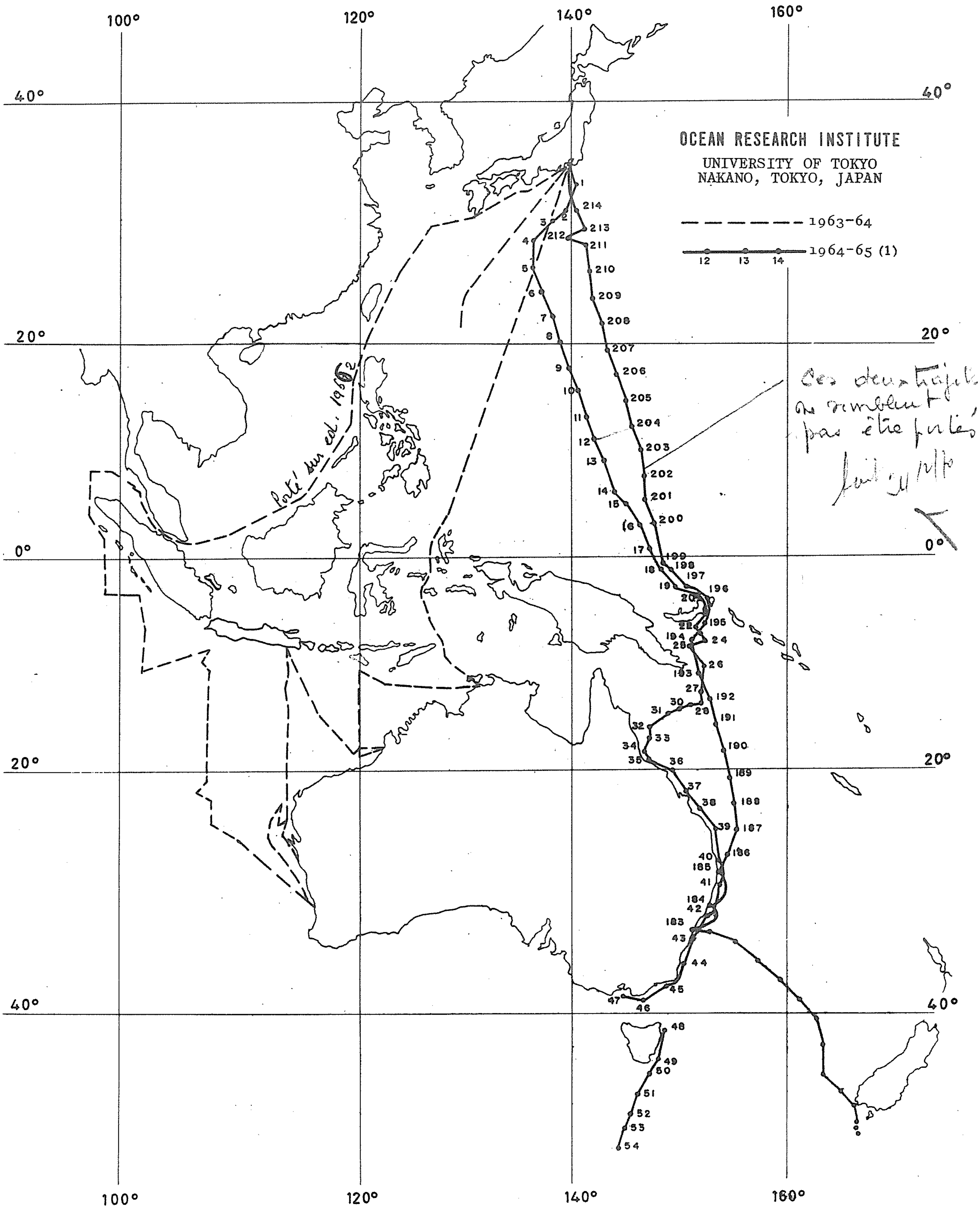

OCEAN RESEARCH INSTITUTE
UNIVERSITY OF TOKYO
NAKANO, TOKYO, JAPAN
1963-64
1964-65 (1)
100°
120°
140°
160°
40°
20°
0°
20°
40°

Chart 2

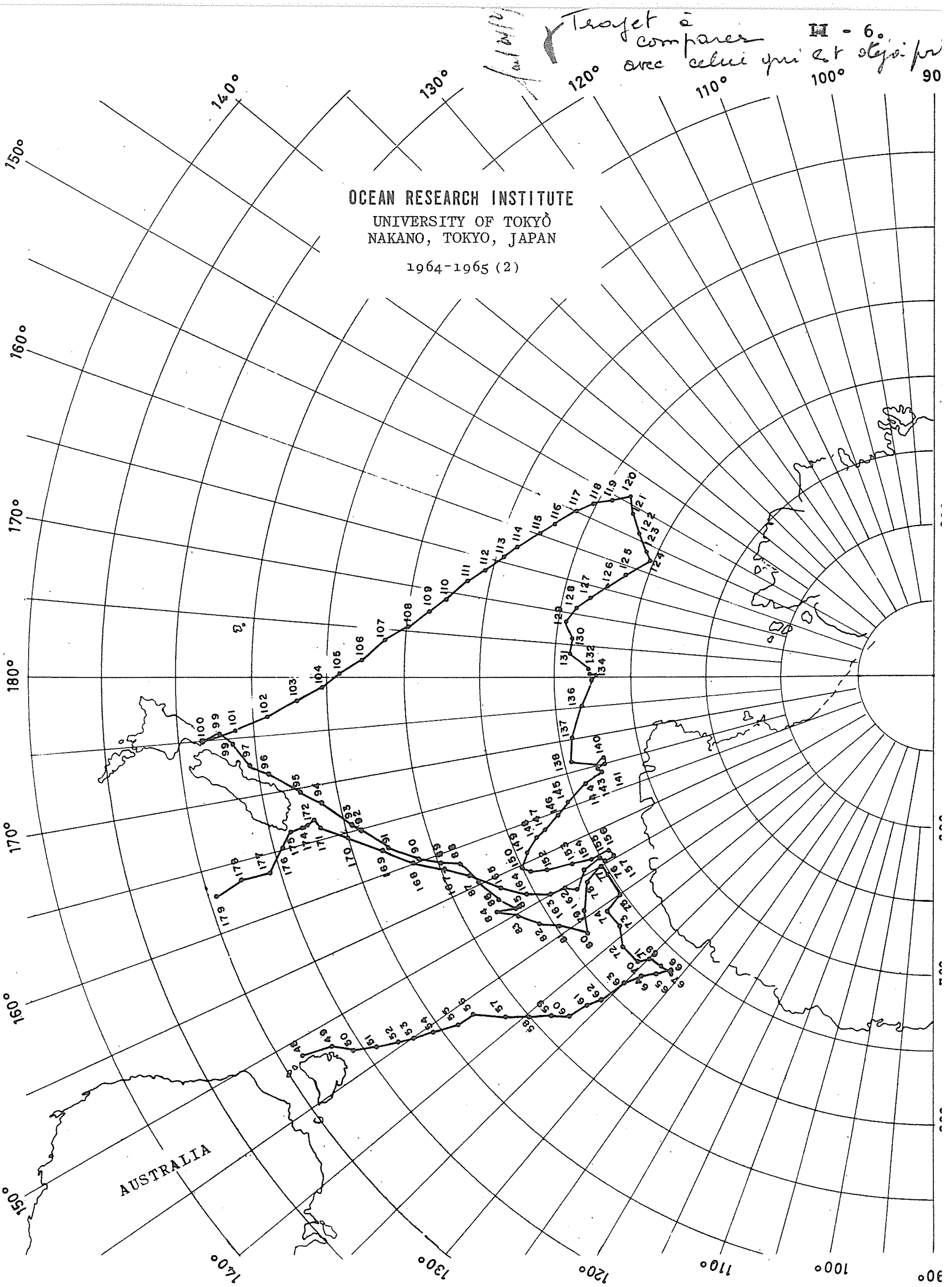

OCEAN RESEARCH INSTITUTE
UNIVERSITY OF TOKYO
NAKANO, TOKYO, JAPAN
1964-1965 (2)
AUSTRALIA
Trajet à comparer avec celui qui est déjà pris

Chart 3

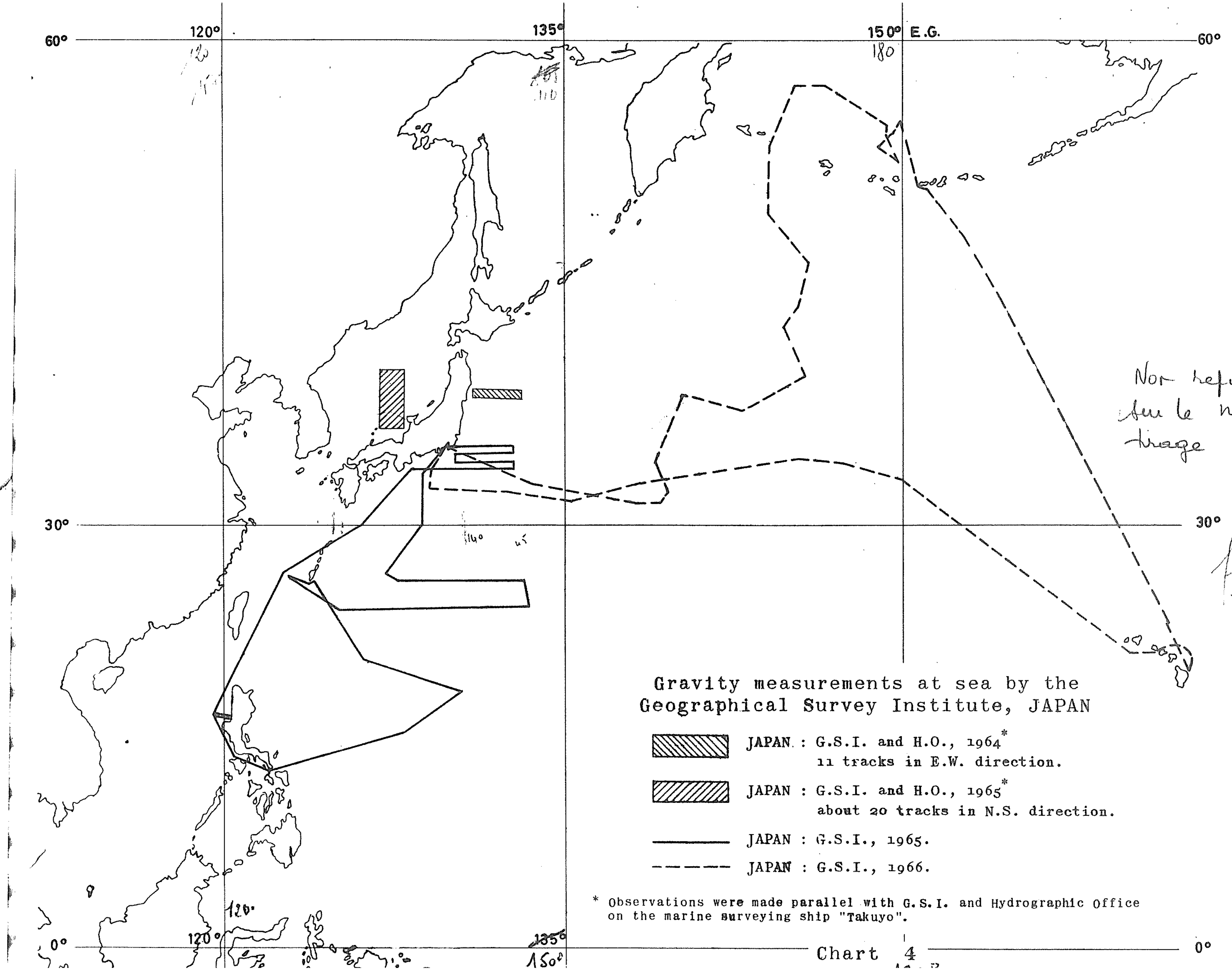
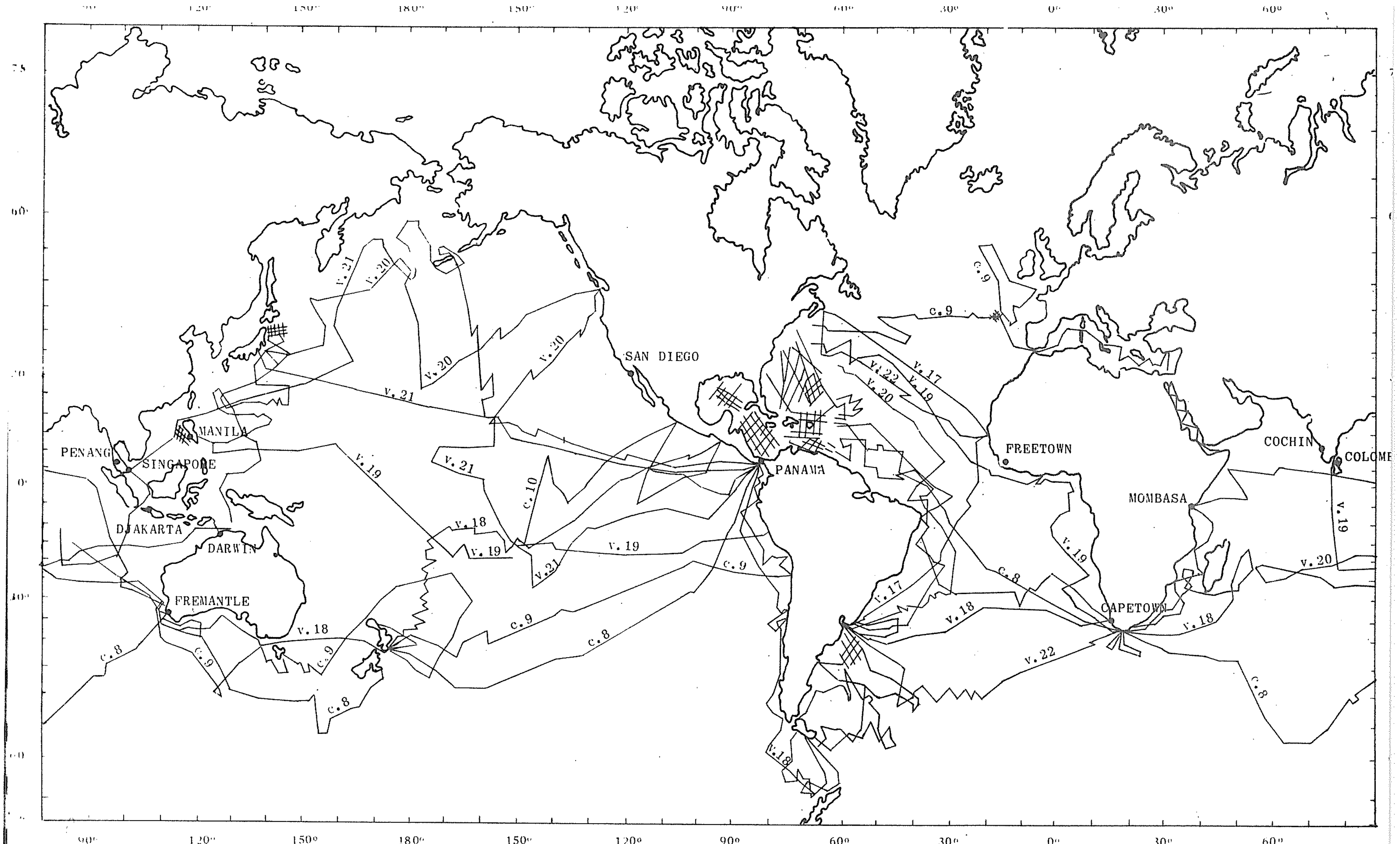

60°
120°
135°
150° E.G.
60°
30°
30°
0°
120°
135°
0°
Gravity measurements at sea by the
Geographical Survey Institute, JAPAN
JAPAN : G.S.I. and H.O., 1964*
11 tracks in E.W. direction.
JAPAN : G.S.I. and H.O., 1965*
about 20 tracks in N.S. direction.
JAPAN : G.S.I., 1965.
JAPAN : G.S.I., 1966.
* Observations were made parallel with G.S.I. and Hydrographic Office on the marine surveying ship "Takuyo".
Non reporté sur le nouveau tirage

Chart 4



LAMONT GEOLOGICAL OBSERVATORY
COLUMBIA UNIVERSITY

Tracks of R/V VEMA (Cruises 17-22) 1960-1965.
Tracks of R/V R.D. CONRAD (Cruises 8-10) Nov. 1963-June 1964.

VEMA CRUISE 17 (Dec. 1960 to Sept. 1961)

Gravity Meter used : Gss2-14 (Graf-Askania)
Stable Platform used : Alidade Stable Table

Leg	Ports	% time gravity data obtained	nautical miles	Comments
4	Galveston-Panama	-	4400	Large tare. Data unreliable
5	Panama-Valparaiso	100%	3200	
6	Valparaiso-Talcahuano	88%	1000	No tie in at Talcahuano
7	Talcahuano-Punta Arenas	70%	1600	No tie in at Punta Arenas
8	Punta Arenas-Punta Arenas	100%	300	No tie in at Punta Arenas
9	Punta Arenas-Puerto Williams	78%	1900	
10	Puerto Williams (Ushuaia)-Puerto Belgrano	50%	2200	Data unreliable
11	Puerto Belgrano-Buenos Aires	65%	4300	No tie in at Buenos Aires
12	Buenos Aires-Dakar	100%	4400	
13	Dakar-Halifax	100%	3200	
14	-	-	-	
15	-	-	-	
16	Halifax-New York	85%	1300	Drift + 19 mGal

Total mileage along which gravity data is obtained - 19,600 nautical miles.

VEMA CRUISE 18 (Dec. 1961 to Sept. 1962)

Gravity Meter used : Gss2-12 (Graf-Askania)
Stable Platform used : Alidade Stable Table

Leg	Ports	% time gravity data obtained	nautical miles	Comments
1	New York-Bermuda	-	1300	
2	Bermuda-San Juan	75%	3500	
3	San Juan-Recife	65%	4000	No tie in at Recife
4	Recife-Buenos Aires	80%	3200	Drift + 13 mGal between San Juan and Buenos Aires
5	Buenos Aires-Punta Arenas	90%	1900	
6	Punta Arenas-Ushuaia	95%	2400	Drift - 11 mGal
7	Ushuaia-Puerto Belgrano	90%	3500	
8	Puerto Belgrano-Buenos Aires	55%	4200	Drift - 24 mGal
9	*Buenos Aires-Capetown	100%	4400	
10	*Capetown-Mauritius	100%	3200	
11	*Mauritius-Fremantle	50%	3500	
12	Fremantle-Wellington	65%	3700	

*Final Plots.

13	Wellington-Samoa	100%	3400
14	Samoa-Tahiti	-	2600
15	*Tahiti-Salina Cruz	95%	4400
16	*Salina Cruz-Panama	100%	1900
17	*Panama-Nassau	100%	3100
18	*Nassau-Bermuda	80%	2000
19	Bermuda-New York	100%	2200

Total mileage along which gravity data is obtained - 45,400 nautical miles.

VEMA CRUISE 19 (Feb. 1963 to Dec. 1963)

Gravity Meter used : Gss2-12 (Graf-Askania)
Stable Platform used : Anschutz Gyrotable, New York to Panama
Alidade Stable Table, Panama to NewYork

Leg	Ports	% time gravity data obtained	nautical miles	Comments
1	New York-Bermuda	-	800	
2	Bermuda-St. Thomas	-	2100	
3	*St. Thomas-Panama	95%	2000	Drift - 12 mGal
4	*Panama-Callao	100%	2300	Drift - 23 mGal
5	*Callao-Tahiti	95%	4500	Drift + 25 mGal
6	*Tahiti-Samoa	100%	1700	
7	*Samoa-Manila	88%	5000	Drift + 13 mGal
8	*Manila-Singapore	93%	2900	
9	*Singapore-Ceylon	90%	4800	
10	*Ceylon-Mombasa	100%	3600	
11	*Mombasa-Capetown	98%	3700	
12	Capetown-Abidjan	88%	5300	Gravity tare + 41 mGal
13	*Abidjan-New York	63%	5200	

Total mileage along which gravity data is obtained - 36,800 nautical miles.

*Final Plots.

VEMA CRUISE 20 (Feb. 1964 to Dec. 1964)

Gravity Meter used : Gss2-12 (Graf-Askania)
Stable Platform used : Anschutz Gyrotable, New York to Panama
Alidade Stable Table, Panama to New York

Leg	Ports	% time gravity data obtained	nautical miles	Comments
1	*New York-San Juan	64%	2300	
2	*San Juan-Panama	93%	3000	Drift - 15 mGal
3	*Panama-Hawaii	97%	5600	
4	*Hawaii-Victoria	100%	2600	
5	*Victoria-Midway	82%	3000	
6	*Midway-Tokyo	88%	4500	
7	*Tokyo-Tokyo	47%	3000	
8	*Tokyo-Darwin	90%	4100	
9	*Darwin-Mauritius	-	4900	Data obtained during entire leg, but reliable only during first 20% of leg
10	*Mauritius-Capetown	97%	3600	
11	*Capetown-Recife	94%	5000	
12	*Recife-Bermuda	74%	4100	
13	*Bermuda-New York	70%	800	

Total mileage along which gravity data is obtained - 35,600 nautical miles.

VEMA CRUISE 21 (Feb. 1965 to Nov. 1965)

Gravity Meter used : Gss2-12 (Graf-Askania)
Stable Platform used : Alidade Stable Table

Leg	Ports	% time gravity data obtained	nautical miles	Comments
1	New York-Bermuda	-	800	
2	Bermuda-Miami	100%	2300	
3	Miami-Panama	92%	2300	Drift + 11 mGal
4	Panama-Tahiti	99%	5900	
5	Tahiti-Hawaii	100%	3700	
6	Hawaii-Tokyo	99%	3600	Drift + 19 mGal
7	*Tokyo-Okinawa	90%	3700	
8	Okinawa-Manila	100%	3300	Drift + 12 mGal
9	Manila-Manila	100%	1100	No tie in data
10	Manila-Adak	100%	5200	
11	Adak-Dutch Harbor	100%	1900	
12	Dutch Harbor-Hawaii	90%	2600	
13	Hawaii-Panama	100%	5700	
14	Panama-New York	100%	5000	

Total mileage along which gravity data is obtained - 45,000 nautical miles.

*Final Plots.

VEMA CRUISE 22 (Jan. 1966 to June 1966)

Gravity Meter used : Gss2-12 (Graf-Askania)
Stable Platform used : Alidade Stable Table, New York to San Juan
"Mabel" Table, San Juan to New York

Leg	Ports	% time gravity data obtained	nautical miles	Comments
1	New York-San Juan	100%	3000	
2	San Juan-Recife	100%	3600	Tare - 15 mGal
3	Recife-Buenos Aires	100%	3500	Tare + 19 mGal
4	Buenos Aires-Capetown	85%	5100	
5	Capetown-Capetown	86%	1700	Drift - 11 mGal
6	Capetown-Dakar	93%	5000	Tare - 55 mGal
7	Dakar-New York	100%	3900	Tare + 26 mGal

Total mileage along which gravity data is obtained - 24,500 nautical miles.

ROBERT D. CONRAD CRUISE 8 (Nov. 1963 to June 1964)

Gravity Meter used : Gss2-6 (Graf-Askania)
Stable Platform used : "Mabel" Table

Leg	Ports	% time gravity data obtained	nautical miles	Comments
1	San Juan-Capetown	95%	6600	
2	Capetown-Freemantle	20%	5300	
3	Fremantle-Christchurch	77%	4400	
4	Christchurch-Auckland	100%	700	No tie in at Auckland
5	Auckland-Wellington	-	800	
6	Wellington-Panama	71%	6700	
7	Panama-San Juan	55%	2000	

Total mileage along which gravity data is obtained - 20,300 nautical miles.

ROBERT D. CONRAD CRUISE 9 (Oct. 1964 to Sept. 1965)

Gravity Meter used : Gss2-6 (Graf-Askania)
Stable Platform used : Anschutz Gyrotable

Leg	Ports	% time gravity data obtained	nautical miles	Comments
1	New York-Galveston	96%	4400	
2	Galveston-Kingston	90%	5400	
3	Kingston-Panama	96%	6700	
4	Panama-Antofagasta	100%	3500	
5	Antofagasta-Wellington	89%	6800	
6	Wellington-Hobart	07%	5100	No tie in at Hobart
7	Hobart-Fremantle	43%	3400	
8	Fremantle-Fremantle	42%	700	
9	Fremantle-Ceylon	03%	3800	
10	Ceylon-Aden	05%	-	
11	Aden-Naples	98%	4100	
12	Naples-Plymouth	60%	4700	
13	Plymouth-New York	99%	5500	

Total mileage along which gravity data is obtained - 40,400 nautical miles.

ROBERT D. CONRAD CRUISE 10 (Dec. 1965-)

Gravity Meter used : Gss2-6 (Graf-Askania)
Stable Platform used : Anschutz Gyrotable

Leg	Ports	% time gravity data obtained	nautical miles	Comments
1	New York-Kingston	100%	4200	
2	Kingston-Panama	100%	5700	
3	Panama-Manzanillo	100%	5200	No tie in at Manzanillo
4	Manzanillo-Tahiti	100%	5200	

Total mileage along which gravity data is obtained - 16,300 nautical miles.

FIRST MARINE GEODESY SYMPOSIUM

September 28-30, 1966

This Symposium sponsored jointly by the U.S. Coast & Geodetic Survey of the Environmental Science Services Administration and the Columbus Laboratories of Battelle Memorial Institute, was held in the Battelle auditorium in Columbus, Ohio.

The most important papers presented during the three days of the Symposium are summarised in the Bulletin Géodésique, n°83, p.68, Mars 1967.

Hereafter is the resolution adopted at the end of the Meeting :

"The participants of the First Marine Geodesy Symposium held at Columbus, Ohio, September 28-30, 1966, under the cosponsorship of Battelle Memorial Institute and the U.S. Coast & Geodetic Survey

recognizing that the Symposium has focused the attention of scientists and engineers on the interrelation of inertial systems and gravity sensing instruments with the earth's gravity field and a geodetic reference network encompassing the environment of the oceans,

and also recognizing the various other interdisciplinary and international aspects of the subject of the Symposium,

recommend that the International Association of Geodesy and the International Association of Physical Oceanography consider the planning of joint meetings on these broad subjects during the 14th General Assembly,

and also consider the establishment of commissions or special groups within the IUGG to provide a forum for future symposia and other means of promoting international cooperation in Marine Geodesy.

1-B) Bibliography (Gravity at Sea)

A - APPARATUS

★
187 - BOWER D.R. - "The determination of cross-coupling errors in the measurement of gravity at sea".
J. Geophys. Res. v.71, n°2, p.487-493. 1966

"The practical significance of cross-coupling effects is suggested through simple first-order theories of ship motion and by actual observations made under a wide variety of sea conditions. Except in very calm seas, errors due to cross-coupling effects are generally significant and increase rapidly with increasing ship motion. Continous determination of these errors by multiplication in an analog computer of the gravimeter beam displacement by the surge acceleration is shown to be accurate and reliable for errors up to 10 mGal".

188 - LACOSTE L., N.CLARKSON & G.HAMILTON - "LaCoste and Romberg stabilized platform shipboard gravity meter". Geophy. vol XXX
Geophysics v.XXXII, n°1, p.99-109. 1967

"The LaCoste and Romberg gravity meter designed for operation in gimbals was redesigned for satisfactory stabilized platform operation and a suitable stabilized platform was made. A major modification of the gravity meter was redesign of the suspension to more nearly restrict motion to a single degree of freedom. Errors due to cross-coupling between horizontal and vertical accelerations and an unsuspected type of cross-coupling due to gravity meter imperfections are important but correctable.

The stabilized platform gravity meter has been tested at sea. Compared to the gimbal type of gravity meter, it is simpler to operate, it will operate in rough weather, and it is considerably more accurate".

189 - LAFEHR T.R. & L.L.NETTLETON. - "Quantitative evaluation of a stabilized platform shipboard gravity meter".
Geophysics v.XXXII, n°1, p.110-118. 1967.

★Ces articles font suite à ceux mentionnés dans le Bulletin n°14, p.I-49.

"A new LaCoste and Romberg surface-ship gravity meter mounted on a stabilized platform was tested over the known gravity field of the San Luis Pass salt dome, about twenty miles southeast of Freeport, Texas. A 100 ft boat was used in sea conditions considered average for the shallow offshore areas, waves running from 2 to 6 ft high.

An average repeatability of 0.7 mGal was determined for 18 lines intersections, of which 14 had differences 1.0 mGal or less. A line by line comparison with the known gravity field indicates an average difference between the known field and the surface meter results of 0.5 mGal. Systematic errors of less than 1.0 mGal were recognized.

The platform meter was tested simultaneously with a LaCoste and Romberg gimbal-supported meter, which proved to be more sensitive to the course direction of the boat and could not make adequate horizontal acceleration corrections in rough seas about 15-20 percent of the total time. The meter on the stabilized platform operated at all times in all six directions".

190 - MASON C.S. - "<u>A geophysical data logging system for shipboard use</u>". Kg 49
J. Ocean.Techno. v.1, n°1, p.35-44. Dartmouth, N.S. 1966

"Gravimeter and magnetometer output, as well as date time, and ship's position are recorded digitally on an 8-level paper tape. Analogue records of the magnetometer, gravimeter, and ship's position, as established by Decca radio navigational aid, are also produced. The data logging system consists of a calendar, a master solid state digital clock with a battery-operated emergency power supply, and analogue to digital converter for the gravimeter output, a digital counter and a digital to analogue converter for the magnetometer output, a 32-channel solid state parallel to serial converter and programmer, and an 8-hole reperforator. Successive words of 64 characters, make up the programmer output ; each word consists of an end of line symbol followed by day, time, gravimeter and Decca readings, and ten magnetometer readings. One word is recorded each minute. Off parity, 1248 systems code, is the recording format although provision is made for other codes. Excluding the Decca encoding unit, the system has been used at sea for about four months during which period no faults occured. Decca unit has been successfully used at sea for about three weeks".

B - RESULTS

191 - ANDERSEN Ole B. - "Surface-ship gravity measurements in the Skagerrak 1965-66". Md 86
Geod. Inst. Denmark. Medd. n°42, paper n°3, 52 p. 1966.

"In 1965 and 1966 gravity measurements were carried out in the Skagerrak using a Graf-Askania shipborne sea gravimeter. The Skagerrak area is covered by interlines spaced five nautical miles apart and several crosslines are run in order to joint together the adjacent tracks. The determination of geographic coordinates during the cruises was based on the application of the Decca Eötvös correction caused by the ship's velocity, was derived. The Eötvös correction caused by the ship's velocity, was derived from the positions.

The depths along the tracks were recorded by means of conventional echo soundings. The free-air anomalies obtained are further reduced into Bouguer anomalies by applying a correction replacing the water column beneath each station by material of 2,67 g/cm3 density. The reduction of the observation material is based on ALGOL-programs developed at the Geodetic Institute. The data processing was accomplished on the digital computer GIER (the Electronic Computer of the Geodetic Institute).

The free-air anomalies and the Bouguer anomalies are tabulated in the last section of the paper, and finally a graphic representation of the Bouguer anomaly pattern is given".

192 - BOWER D.R. & B.D. LONCAREVIC. - "Sea gravimeter trials on the Halifax test range aboard CSS Baffin". Md 91
Publ. Dom. Obs. v.XXXVI, n°1, 137 p. Ottawa. 1967.

Two precisely located and calibrated lines on the Halifax sea gravimeter testing range were traversed back and forth for a total of 100 times while gravity measurements were made with both the LaCoste and Romberg and the Askania-Graf sea-surface gravimeters. During the three-week test, which was conducted in October 1963, the rums heave accelerations experienced varied from 2 to 78 gals with a median value of 13 gals. Useful gravity readings were obtained with the LaCoste gravimeter up to heave accelerations of about 30 gals and up to at least 50 gals for the Askania. (Cross-coupling determinations were not possible at greater accelerations). The LaCoste gravimeter occasionally hit its stops at accelerations greater than 35 gals, and the results in general were "noisier" than those for the heavier-damped Askania gravimeter. Gravimeter errors were determined by subtracting observed values, corrected for Eötvös effect, from reference values determined previously from ocean-bottom measurements.

The mean LaCoste gravimeter error observed during a traverse varied from run to run to form a near normal distribution with mean + 0,6 mgal and standard deviation 3,9 mgal. Corresponding figures for the Askania were : mean - 0,4 mgal and standard deviation 2,7 mgal. The distribution, however, was markedly skewed toward negative values. Long-period accelerations recorded by the horizontal accelerometers used with the LaCoste gravimeter frequently proved to be fictious and the computed Browne corrections accordingly to be too large. Corrections for cross-coupling effect were determined after the test by using magnetic-tape records of heave and surge acceleration. These determinations generally agreed closely with the observed Askania errors except in very rough seas and when course-keeping was poor. Instrument drift, determined by periodic dockside measurements, was negligible for the LaCoste gravimeter and somewhat irregular over a 7,0 mgal range for the Askania".

193 - BROCKS K. - "Die Atlantische Expedition 1965 (IQSY) mit dem Forschungsschiff "Meteor".
Forschungsberichte 11. Gravimétrie p.71-73 et 95-96. Wiesbaden. 1966.

Vue d'ensemble des travaux effectués au cours de l'expédition Atlantique 1965 "Meteor" du 10.8.65 au 16.12.65.

Le parcours suivi a été approximativement : Hambourg, Les Açores, le long du méridien 30°W.G., jusqu'à Récife (Amérique du Sud) en passant par Anker station et Fernando de Noronha.

Le retour s'est effectué approximativement le long du méridien 20°W.G. (avec un rattachement à Dakar).

Des mesures de pesanteur ont été faites avec le Worden-Master 712 dans l'île de Fernando de Noronha (65 stations), v. p.96.

194 - DEUTSCHES HYDROGRAPHISCHES INSTITUT - "Forschungsschiff "Meteor"
Fahrt n°4, Nordatlantischer Ozean. 12 p. Hambourg. 1966.

Fahrt n°4, Berichte über die wissenschaftlichen arbeiten. 30 p.

Ces deux publications donnent une vue d'ensemble :
- du programme du voyage dans l'Atlantique Nord (voir carte),
- des travaux scientifiques réalisés.

~~Cette croisière a été effectuée en 1966 sur le "Meteor",~~ elle comprend les trajets suivants, approximativement : E.W. le long des parallèles 52°-54°N jusqu'au milieu de l'Atlantique (35°W.G.),
- profils nombreux dans cette zone,
- profil aller et retour, jusqu'en Islande ~~avec retour par l'île Bouvet~~,
- profil W.E., vers les parallèles 57°-58° jusqu'au Nord de l'Ecosse.

195 - HYDROGRAPHIC OFFICE OF JAPAN - "Preliminary report of the gravity anomaly in the Japan Sea".
Data Report of Hydro. Observations, ser. Astr. & Geod. n°1, p.43-46. 1966.

Brief view of the campaign made by the Hydrographic Office in the Japan Sea aboard Takuyo Ship. A Tokyo surface ship gravity meter was equiped on board and gravity observation was carried out over the most part of the cruise from April to May 1965.

196 - LONCAREVIC B.D. & G.N. EWING. - "Geophysical study of the Orpheus gravity anomaly". Md 90
Inst. Ocean. Bedford. Rep. Bio. 66-7, 31 p. 1966. (Unpublished manuscript).

"Marine geophysical investigations have been carried out on the eastern seaboard of Canada by the Geological Survey of Canada, the Institute of Oceanography (Dalhousie University) and the Bedford Institute of Oceanography, since 1959. The early investigations were made with a shipborne magnetometer. These studies were followed by shipborne gravimeter and two-ship seismic refraction methods. The most significant discovery to date is an extensive belt of large negative gravity anomalies, that Loncarevic named "Orpheus" after the Orpheus Rocks off Madame Island, Nova Scotia. The Orpheus Rocks are near the presently established western limit of the anomaly".

197 - LONCAREVIC B.D. - "Mid-Atlantic Ridge, July 20 - Sept. 19, 1966". Md 92
Inst. Ocean. Bedford. Cruise Rep. n°154, 82 p. Dartmouth, N.S. 1967.

..."The investigation of the Mid Atlantic Ridge is a continuing research project intended to provide a detailed description of a small section of the world's longest mountain chain, between 45° and 46°N from 27°40 to 29°30W. This study is the continuation of surveys carried out in 1960 by RRS DISCOVERY II and in 1965 by CSS HUDSON"...

198 - MORELLI C. - "The geophysical situation in Italian Waters".
Oss. Geofis. Sperimentale. Contr. n°163bis, p.133-147, Trieste. 1966.

General view of the geophysical work carried out the last few years. Gravity at sea from a submarine, from a bathysphere on the bottom, from surface vessels. Md 87

Terrestrial magnetism. Geothermics at sea...

199 - WEBER J.R. & A.K. GOODACRE. - "A reconnaissance underwater gravity survey of Lake Superior". Canada

Contr. Dom. Obs. v.7, n°11, p.1-10. Ottawa. 1966.

"During September 1964 the Dominion Observatory established 230 underwater gravity stations on a reconnaissance survey of Lake Superior. The Bouguer anomalies, which are presented in the form of an anomaly map, range from - 90 to + 25 mGal and present a complex pattern in the western part of the Lake. Those over the lake may be reasonably explained in terms of surface geology, positive anomalies being produced by middle Keweenawan basalt, and negative by late Keweenawan or Cambrian sediment or Archean granite. The Keweenaw High, a positive anomaly belt between the Porcupine Mountains and Isle Royale, is thought to be an extension of the Midcontinental Gravity High. Although this feature can be explained by near-surface density variations it is also quantitatively interpreted in the light of the results of the Lake Superior seismic experiment, which indicates a thick, high-density crust beneath Lake Superior. The high crustal seismic velocities observed are consistent with the generally positive gravity anomalies over the lake, which indicate the presence of high-density rocks within the crustal column. However, the large variations of crustal thickness determined seismically appear to be localized and due to crustal rifting".

2° - GRAVIMETRIC TERRAIN CORRECTIONS

This rubric was established on Geophysicists'request, interested in the different procedures for calculating terrain corrections with electronic computers.

Hereafter are mentioned the most important publications issued since 1957 on the general subject : "Topographic Corrections".

The papers concerning especially the method with electronic computers have been distinguished by an asterisk (*).

BIBLIOGRAPHY

*1 - ALEXASHINA G.A. - "The effect of the inner zone on the topographical correction to gravity".
Trudy Cniigaik, n°171, p.84-91. 1966.

"The methods for calculation of the influence of topography masses in inner zone on gravity are considered.
The formulas are obtained to express the influence of mass between the reference and physical surfaces and the influence of relief. These formulas can be used for calculation by means of electronic computer under an arbitrary position of the gravity stations in relation to square network, the physical surface presented as an inclined plane passing through the gravity station".

2 - BIBLE J.L. - "Terrain correction tables for gravity".
Geophysics v.XXVII, n°5, p.715-718. 1962.

"The terrain correction table presented by Sigmund Hammer (1939) is herein expanded to accomodate the areas of rugged topography encountered by modern surveys.
The zones and their radii remain the same as proposed by Hammer.
The corrections are in milligals and have been computed for a difference of specific gravity of 2,0 between the ground and air".
See some remarks on these tables in Geophysics v.XXVIII, n°4, p.668, 1963 (Thyssen-Bornemisza S. & W.F. Stackler).

*3 - BOTT M.H.P. - "The use of electronic digital computors for the evaluation of gravimetric terrain corrections".
Geophys. Prosp. v.VII, p.45-54. 1959.

"A method is described here by which the bulk of the work can be done by high speed digital computors. The method is particularly useful for fairly concentrated surveys in mountainous regions and has already been applied with success to surveys of Arran, Mull, the Isle of Man and in Dumfriesshire. The Ferranti Pegasus computor belonging to Durham University has been used, and took about thirteen seconds to calculate each correction for the Isle of Man Survey. It still remains necessary to use conventional zone chart methods for the inner zones".

"The method depends on dividing the region into a grid of equal squares of convenient size, the average heights of which need to be estimated. In Great-Britain, the National grid squares (of one square kilometer each) are of a suitable size. One possible approximation takes the mass of the square to be distributed uniformly along a vertical line attaining the average height and situated at the center...

An alternative approximation is based on the formula for a segment of a hollow vertical cylinder with inner and outer radii given by $r \pm p$, where p is the half width of the square side.

The errors involved in these 2 approximations are discussed and the second approximation is the more satisfactory"...

4 - BURSA M. - "Consideration of influence of near topographic masses in determining terrain corrections".
Inst. Geophys. Acad. Tchecosl. Sci..n°217, p.43-69. Geof. Sbor. 1965. NCSAV, Praha, 1966.

"The theoretical values of the terrain correction Δg_t (0-5-24 km) were calculated for three models of the topographic massifs with relatively large differences in altitude. Five methods of numerical integration were applied to these models : the Gauss method I, the Tchebyshev method II, the method of interpolation polynomials for constant weight function $p(r)=1$, III, the method of interpolation polynomials $\Pi_n(r)$ for weight function $p(r)=r$, IV, and that of orthogonal polynomials with respect to $p(r) = r$ in the interval (0,5.24 km). Methods III, I and II proved suitable from the point of view of the accuracy of $\pm$ 0,1 mgal required. Method III was then applied to 5 real terrains using polynomials $\Pi_n(r)$ of n = 6,8,10. It was found that a degree of n = 10 might suffice but in high mountain areas the necessity for the use of $n > 10$ is not excluded. Templates and tables of the values $\delta g = 2\pi f \delta \nu^{-1} \left[1 - r_k (r_k^2 + h_k^2)^{-\frac{1}{2}}\right] \int_0^{5.24} \left[(r - r_k) \Pi_n' (r_k)\right]^{-1} \Pi_n (r)\, dr$

according to the arguments $h = H - H_o$ were constructed for the practical application of method III for n = 6 (assumed for flat and slightly undulating terrain), n = 8 (hilly terrain) and n = 10 (mountains and high mountains). For height differences h, determined at the respective points of templates, the tabulated values can be interpolated linearly and their total sum ($\sum \delta g$) then represents the calculated part Δg_t (0-5.24 km) of the terrain correction".

*5 - CARROZZO M.T. - "A general formula for the computation of the terrain correction to the gravity measurements by electronic computers".
Boll. Geofis. teor. appl. v.VIII, n°32, p.256-263. 1966.

"A method, which allows the employ of elctronic computers, is suggested for the computation of the terrain correction to gravity measurements. It requires the previous assembly of a "mean heights squared map" covering the area in which the gravity survey is carried out. Two calculation ways are suggested. The proposed method if well employed allows to short the time required by conventional computations and to increase the accuracy. Obviously all that depends on the side of the "mean height squared map" on which it is based".

... an orthogonal cartesian reference system, having origin in the point in which we want to calculate the terrain correction, is established and some parallelepipedes, having square section and the x-axis as common longitudinal axis, are considered.

The generic parallelepiped will be limited by the 4 planes having equation :

$$x = \pm x_i \qquad y = \pm y_i ,$$

with the condition : $x_i = y_i$. Successively, by means of planes parallel to the xz and yz ones, we divide the space between two successive parallelepipeds (zone) into compartments having still form of parallelepiped with square section...

6 - CASSINIS G. - "On the use of the geographical network for reductions of gravity measurements".
Pub. Ist. Geod. Topo. Foto. n°95, Milano.
from : Gedenkboek F.A. Vening Meinesz. 1957.

"L'auteur rappelle les cartes d'altitudes moyennes (en particulier celles du R.P.LEJAY) dans lesquelles les altitudes sont données par rapport à un réseau géographique. Ces cartes sont des documents "numériques absolus" mais qui ne peuvent pas être utilisés convenablement avec la méthode des "cercles" puisqu'il faut estimer des fractions de carré géographique...

Il propose un système de tables numériques calculées en utilisant un réseau géographique "absolu" (c'est-à-dire avec ses pôles dans les pôles de la terre de manière qu'il soit indépendant de la position des stations gravimétriques) et non pas un réseau "relatif" à chaque station (hypothèse de HAYFORD).

Un projet est établi pour une densité unité et des latitudes variant de 5° en 5°, entre - 90° et + 90°.

7 - CHINNERY M.A. -"Terrain corrections for airborne gravity gradient measurements".
Geophysics v.XXVI, n°4, p.480-489. 1961.

"A method is given for the calculation of terrain corrections for airborne measurements of the vertical gradient of gravity. This includes a short account of the theory concerned, a description of the practical procedure, a complete set of numerical tables, and some examples of their application. The method described is shown to be very flexible, both with regard to aircraft height and to complexity of topography. Some discussion is also given of the magnitude of topographic effects on the gravity gradient, and it is shown that terrain corrections are in general more important here than in normal gravity work".

8 - EBERHARD O. - "Theorie und Anwendungsmöglichkeiten eines Geräts zur Bestimmung der Vertikalkomponente der Schwerewirkung von Massenvolumina".
Deutsche Geod. Komm. Reihe A, n°52, 25 S. München. 1966.

"This paper is dealing with the theory and the design of an apparatus determining the vertical gravity component of topographic masses with known constant density in a given point, and the topographic masses being plotted in maps. The apparatus allows the theoretically exact determination of the vertical component of gravity for cylindrical masses with a given height and an arbitrarily formed base. This gives the possibility too for a rapid and sufficiently accurate measuring of the "topographic reduction" in gravimetry. No height estimate is required. Examples show the accuracy of this method".

*9 - EHRISMANN W. - G.MULLER - O.ROSENBACH & N.SPERLICH. - "Topographic reduction of gravity measurements by the aid of digital computers".
Boll. Geofis. teor. appl. v.VIII, n°29, p.3-20. 1966.

"Two programmes in ALGOL are communicated and discussed in detail which permit the computation of the topographic reduction resulting from the distant surroundings of a station. Programme 1 is based on

Programme 1 is based on a subdivision of the earth's surface according to spherical surface coordinates, programme 2 on a subdivision according to plane Cartesian coordinates. The compartments produced by these subdivisions are approximated by vertical prisms with rectangular basis, the attraction of which is calculated exactly as well as approximately. In both programmes the curvature of the earth is taken into account. The density is assumed to be constant in the whole reduction area. The programmes and an example of their results are printed in Sec.8".

*10 - KANE M.F. - "A comprehensive system of terrain corrections using a digital computer".
Geophysics v.XXVII, n°4, p.455-462. 1962.

"The system of terrain corrections uses an electronic digital computer for much of the calculation. A new method using a desk calculator is suggested for terrain effects arising from close-in topography. The present system covers a square area 40 km by 40 km, with the station at the center. A selected group of corrections that were compared with conventionally computed ones agree within 0,1 mGal. The speed of the operation using the Datatron 220 computer is considerably faster than the conventional method of computing".

"The described system (KANE 1960), though developed independently, parallels closely the procedures outlined by BOTT. The principal difference is that the system discussed here limits the correction to a definite area around the station, thereby simplifying the task of combinning the computer correction with the correction for very near and very distant terrain".

11 - KOŽIŠKOVA M. - "Berechnung der topographischen Schwerekorrektionen für eine schiefe Ebene".
Inst. Geophys. Acad. Tchecosl. Sci. n°163, p.25-34. Geof. Sbor. 1962. NCSAV, Praha, 1963.

"In der letzten Zeit wird die Berechnung der topographischen Schwerekorrektionen dadurch beschleunigt und präzisiert, dass man anstatt des Gravitationseffektes der Sektoren mit einer konstanten Höhe für die nahe Umgebung des Punktes den Effekt eines geeignet gewählten Modells berechnet, das die wirkliche Form der Erdoberfläche besser kennzeichnet. In diesem Artikel befasste ich mich mit der Frage, wie sich die beiden Methoden in jenem Falle voneinander unterscheiden, wo eine schiefe Ebene zum Modell wird. Die Schwerewirkung einer aus den Sektoren mit konstanten Höhen bestehenden Zone (dg_i) wird durch die Gleichung, die Schwerewirkung jener Zone, die ein Bestandteil der Schiefen Ebene ist (dg_i'), durch die Gleichung ausgedrückt. Den Unterschied $dg_i - dg_i'$ verfolgte man in Abhängigkeit vom Neigungswinkel α der schiefen Ebene für die Hayfordschen Zonen A - D_2 und für die Gesteindichte $\sigma = 2,67\ gcm^{-3}$

in zwei verschiedenen Schablonelagen und in einer Schablonelage für die in angeführte Zonenverteilung. Aus den graphischen Darstellungen ist ersichtlich, dass die Unterschiede $dg_i - dg_i'$ in der Zone B bedeutende Werte erlangen. Dass angeführte Beispiel erweist, dass es zur Erreichung einer höheren Genauigkeit bei der Berechnung topographischer Korrektionen notwendig ist in der nahen Umgebung des Punktes ein solches Modell zu benützen, das der wirklichen Gestalt des Terrains am besten entspricht. In der Abb. 7 sind die für die Gravitationswirkung der schiefen Ebene dg' aus der Formel für die Dichte $\sigma = 2{,}00\ gcm^{-3}$ berechneten Doppelskalen angeführt".

*12 - KUKKAMAKI T.J. - "Gravimetric reductions with electronic computors". Publ. Isost. Inst. n°30, 9 p. Helsinki. 1955.
from : Ann. Acad. Sci. Fenn. Ser.A.III, 42.

For computing the topographic reduction, the author suggests to use, at least partially, the method of numerical integration. For this purpose, he derives here the formula for attraction of a vertical mass-line, which represents the mass in a frustum of a cone between elevation of depths in question and which has the apex in the center of the Earth.

*13 - NAGY D. - "The prism method for terrain corrections using digital computers".
Contr. Dom. Obs. n°6, p.1-9. Ottawa. 1966.

"In the prism method of making terrain corrections, the topography is approximated by a model consisting of right rectangular prisms. The vertical component of the gravitational attraction of each prism is calculated and the sum of these components gives the terrain correction.
The prism method as programmed has no computational limitations. It can be used on all sizes of computers ; it can be applied to a large area with any fine gird interval ; it can be processed in a single run and yet provides complete flexibility for both research and routine computations. This has been achieved by breaking up larger areas into regions which fit into the computer memory. The contributions of these regions are automatically summed up for each station. While processing each region, various controls may be used at each station to exclude the contribution of a distant part of the area, to use approximate expressions farther from the station, to print out details around the station. There is also provision to refine the model by using smaller prisms around each computation point. Thus full use of elevation control can be made to calculate the terrain correction, the accuracy of which depends only on the quality of the input data.

The prism method has been used to calculate terrain corrections for 130 stations in the New Quebec crater area. For five of these stations terrain corrections were also calculated by using Hammer's template. The two independent sets of values differ by less than four per cent".

*14 - NAGY D. - "The gravitational attraction of a right rectangular prism". Geophysics v.XXXI, n°2, p.362-371. 1966.

"The derivation of a closed expression is presented to calculate the vertical component of the gravitational attraction of a right rectangular prism, with sides parallel to the coordinate axis. As any configuration can be expressed as the sum of prisms of various sizes and densities, the computation of the total gravitational effect of bodies of arbitrary shapes at any point outside of or on the boundary of the bodies is straightforward. To calculate the gravitational effect of the "unit" building element a subroutine called Prism has been developed, tested, and incorporated, in one program to calculate terrain corrections, and in another program for three-dimensional analysis of a gravity field".

Some references on the earlier works in connection with the gravitational attraction of the prism are given in Geophysics v.XXXI, n°5, p.987. 1966.

15 - NEUMANN R. - "Contribution au calcul simplifié des corrections de relief à grande distance en gravimétrie". Geophys. Prosp. v.XI, n°4, p.523-534. 1963.

"In a recent paper, H.A. Winkler developed a suitable method for determining long-distance terrain corrections in gravity by interpolation. Such a technique implies that it is necessary to take into account the changes of the correction g not only with the location (X,Y) but also with the elevation Z of a station. Study of the function g (Z) shows that its curve, with amply sufficient accuracy, may be represented as a parabola. Moreover, the parabolas corresponding to different stations are all equal. From these properties a method has been derived which saves computing time and yields long-distance terrain corrections with convenient accuracy".

The practical procedure is the following :
2 charts are drawn, one with g_o, the other with Z_o (coordinates of the parabola top). These charts permit to distinguish the coordinates g_o and Z_o from the top of the prarabola for each gravity station ; then, from reading, the correction of g(Z) can be determined. It is to be noticed that these 2 charts can be established before each prospection, as the computed points are not necessarily measured points.

16 - PICK M. - "Über eine neue Methode zur Herstellung von Karten topographischer Korrektionen".
Studia Geophys. & Geod. v.2, n°4, p.334-344. Praha. 1958.
Geofiz. Kozl. IX, 1-2, p.41-42. 1960. (Summary only).

17 - PICK M. - "Berechnung der topographischen Schwerekorrektion der nächsten Umgebung eines Punktes mit Hilfe von Modellen".
Inst. Geophys. Acad. Tchecosl. Sci. n°130, p.159-173. Geof. Sbor. 1960. NCSAV, Praha, 1961.

18 - PICK M. - "Einfluss der nächsten Umgebung eines Schwerepunktes auf den Wert der Topographischen Schwerekorrektion".
Studia Geophys. & Geod. v.7, n°2, p.146-155. Praha. 1963.

*19 - PICK M. - "Zur Frage der Anwendung der Rechenautomaten für die Berechnung der topographischen Schwerekorrektion".
Inst. Geophys. Acad. Tchecosl. Sci. n°177, p.43-54. Geof. Sbor. 1963. NCSAV, Praha, 1964.

20 - PICK M. - "The calculation of the topographic reduction in Czechoslovakia".
Inst. Geophys. Acad. Tchecosl. Sci. 2 p. Praha. 1963. (Typewritten text).

"Let us use the equation applied for Bouguer anomalies as a starting point (16) :

$$(1)\quad \Delta g = g - \gamma_o - \frac{\partial \gamma}{\partial H} . H_p - 2\pi f \sigma H_p - B + \Delta g_e^c ,$$

where B indicates Bullard's term and Δg_e^c being the topographic reduction calculated with respect to the spheric layer as far as Hayford zone O_2. The value Δg_e^c will be divided into three parts

$$(2)\quad \Delta g_e^c = \Delta g_o + \Delta g(H_p) + \Delta g(\varphi \lambda).$$

The influence of Hayford zones I-O_2 is included in the term $[\Delta g(H_p) + \Delta g(\varphi, \lambda)]$. The term $\Delta g(H_p)$, depending on the height H_p of the gravity point only was determined for each sheet of the chart 1/200.000 in the form of a single scale. The term $\Delta g(\varphi, \lambda)$ depending on the geographical coordinates only, was drawn as a isoline chart with an interval of 0,2 mgl. The accuracy of the subtraction of the term : $\Delta g(H_p) + \Delta g(\varphi, \lambda)$ is for the known density σ higher than $\pm$ 0,2 mgl.

The influence of Hayford zones A - H indicated by the symbol Δg_0 must be calculated for each gravity point separately. The nearest surroundings of the gravity point may often be replaced by suitable model. Several models of this kind were proposed and their gravity influences were tabulated (17). It turned out further that using the conventional method of the topographical reduction, the replacing of the actual Earth's surface by a horizontal level may bring about considerable errors (11). Thus the actual Earth's surface was replaced by a more suitable model according to the nature of the country and corrections to the values of Cassinis' tables were determined (18). These corrections will be expressed by suitable graphs (KRYSPINOVA I.). If there is a chart of medium heights for squares of 0,5 x 0,5 km at our disposal, then it is advisable to use electronic computers for determining Δg_0 (19). From this chart it is easy to establish the inclination of the generalized Earth's surface and to introduce respective corrections. In the end, the auxiliary functions necessary for the determination of the topographic reductions were tabulated (21)".

21 - PICK M. - J.PICHA & V.VYSKOČIL. - "Gravity topographic correction for the territory of Czechoslovakia".

Inst. Geophys. Acad. Tchecosl. Sci. n°129, p.113-130. Geof. Sbor. 1960. NCSAV, Praha, 1961.

"Chapters 1 and 2 give briefly the theoretical bases for constructing maps of gravity topographic corrections. Chapter 3 deals with the calculations, construction and accuracy of such maps for the territory of Czechoslovakia. In chapter 4 a study is made of near and distant Hayford zones, the effect of which is not included in the maps. The procedure for calculating the gravity is given in chapter 5. The work closes with supplementary tables",

such as :

- allowed deviations in estimating heights for a certain accuracy of the gravity topographic correction ζ and for mean elevations h = 0 and h = 100m. (table 6),
- effect of topographic masses of zones 18 - 1 in mGal,
- conversion coefficients k for conversion from density,
- normal acceleration of gravity according to Helmert's formula (1901-1909)...

22 - PICK M. - J.PÍCHA & V.VYSKOČIL. - "A contribution to the methods of calculating gravity terrain corrections".

Bull. Geod. n°74, p.341-351. 1964.

The paper gives the theoretical results and practical experience obtained in Czechoslovakia in the problem of determining gravity terrain corrections. The maps constructed for the values of $\Delta g \xi'$ (p.352 Bull. Geod.) have already been in use for several years at geophysical, geological and geodetic laboratories and have proved useful. Some calculations on automatic computers have also been made.

"The gravity terrain correction is calculated from the equation :

$$\Delta g_{ter} = \Delta g_{\xi'} + f(H_p) + F(\varphi_p, \lambda_p).$$

Here $\Delta g_{\xi'}$ is the effect of the external masses up to a distance of 5.24 km from the gravity point. This influence must be calculated for each gravity point separately. $f(H_p)$ is the normal part of the terrain correction. It is read from the chart. $F(\varphi_p, \lambda_p)$ is the anomalous part of the terrain correction. It is plotted as a map of contour lines with interval of 0.2 mgl. The numerical values on the map are given in tenths of mgl. The sum of the terms $f(H_p) + F(\varphi_p, \lambda_p)$ contains the influence of external masses from a region from 5.24 to 166.7 km taking into consideration the curvature of the Earth. The density was chosen as 2.67 g/cm^3.

The Bouguer anomaly is calculated from the relation :

$$\Delta g = g - \gamma_o + 0.3086\ H_p - 0.000\ 000\ 072\ H_p^2 -$$
$$- (0.0419\sigma_o\ H_p + B - \Delta g_{ter})\frac{\sigma}{\sigma_o}$$

where $\sigma_o = 2.67$, σ is the real density and B is the Bullard correction. It is recommended that the tables given in the instructions to the map of terrain corrections be used for calculating the latter equation".

23 - PLOUFF D. - "Digital terrain corrections based on geographic coordinates". Abstract in Geophysics v.XXXI, n°6, p.1208. 1966. Paper presented at the 36th annual International SEG Meeting.

"The digital terrain correction program now being used by U.S. Geological Survey incorporates several improvements over systems previously reported. Locations and compartment gridworks are referenced to a geographic rather than a Cartesian coordinate system. Terrain corrections are made on the computer in a range of distances from a circular inner radius, corresponding to Hammer's I-ring, to an outer radius of 166.7 km. The earth's curvature and the effect of compartments in sea water are taken into account. Compartment elevations are grouped according to map boundaries, so that a listing of total terrain correction per map is available ; the locations of maps needed in making corrections but not found in the input to the computer are listed.

This feature permits combination of digital terrain reductions and terrain corrections done by hand, which provides a great saving of time in regions of low station density.

The simple line element formula is used, which is more accurate than formulas based on the assumption of a flat-topped compartment to a distance of about four compartment widths from the station. At farther distances, the line element formula is slightly less accurate, but the change in absolute value is negligible. The computer time per station is one second of less on the Control Data 3600 Computer".

24 - RAMSAYER K. - "Proposal for a gravity map for hilly and medium mountainous areas without the calculation of the terrain correction".
Bull. Geod. n°73, p.253-260. 1964. (English test)
Deutsche Geod. Komm. Reihe B, n°104, 9 S. München. 1963. (German text)

"The calculation of the terrain correction takes up much time. This difficulty may be overcome by reducing the measured gravity g by that part which depends on the altitude z above sea level and by constructing a map for the reduced gravity values. This altitude reduction may be done according to the formula :

$$g_o' = g + \alpha \cdot z + \beta z^2$$

whereby the coefficients α and β may be found together with other unknowns by adjustment. In some cases the quadratic term may be neglected. Then the linear altitude reduction is identical with the simplified Bouguer reduction without terrain correction. It is shown with a practical example that for flat, hilly and medium mountainous areas it is possible to construct gravity maps with lines of equal g_o' -values without difficulties.

From such maps we can determine the gravity g for any desired point, the altitude of which is known, with an accuracy better than $\pm$ 2,5 mGal without the calculation of the terrain correction. This accuracy is sufficient for the most geodetic purposes. Such maps could therefore help for a better geodetic exploitation of the numerous gravity measurements which are already available in hilly and medium mountainous areas".

25 - TAKIN M. & M.TALWANI. - "Rapid computation of the gravitation attraction of topography on a spherical Earth".
Lamont Geol. Obs. Contr. n°916. Palisades, N.Y.
from : Geophys. Prosp. v.XIV, n°2, p.119-142. 1966.

"A brief review of the existing methods of gravity reduction is given and a new method suitable for use on high speed digital computers is described. The method is based on the formula for the gravitational attraction of a frustum of a cone. The topographic contours are represented by polygons and the x and y coordinates of corners of the polygons constitute the input to the computer. The vertical component of the gravitational attraction is calculated by evaluating the cone formula for a number of vertical sections of the topography. Each vertical section is simplified by adopting a procedure of grouping and averaging for the distant points of the section. The effect of the earth's sphericity is taken into account by lowering the distant points of the sections by amounts determined by the curvature. The computations include the area close to the point at which the attraction is required and may be limited to an area defined by a circle centered at this point. The method is therefore compatible with the conventional zone chart methods.

As an illustration of the method the gravitational attraction of Caryn Seamount in the Atlantic Ocean is computed. The total Bouguer correction and the terrain correction are also computed for an area in northwestern South America and comparisons are made with hand computations by a zone chart method. As an example, for work at sea, the Bouguer corrections for an area near the Island of Mauritius in the Indian Ocean are computed and the effects of sphericity and three-dimensionality are calculated.

The gravitational attraction of two-dimensional bodies can be computed in a very similar manner. The attraction of the Puerto-Rico Trench model is computed and the results are compared with other methods. The effects of sphericity and assumptions involved in extending the models to infinity are discussed".

26 - TANNER J.G. & R.J.BUCK. - "A computer-oriented system for the reduction of gravity data".
Publ. Dom. Obs. v.XXXI, n°3, p.57-65. Ottawa. 1964.

"In 1958, the Dominion Observatory expanded its program of regional and local gravity measurements throughout Canada. The regional observations are taken at intervals of 10 km using different makes of gravimeters, and transportation is provided by fixed and rotary-winged aircraft, automobiles and ships. The local surveys consist of detailed investigations of geological features and of areas in which steep horizontal gravity gradients are observed. The resulting increase in the volume of data (tenfold in about 5 years) required that a system of processing, filing and plotting of data from both types of survey be developed. The basic unit of the system is a computer program that reduces field observations to simple Bouguer and free-air anomalies, for use in both geodetic and geophysical investigations.

The computed output data cards are maintained in a Principal

Facts file, which is used to prepare Bouguer anomaly maps on an automatic plotter, and from which data is supplied upon request".

Note : This publication is not dealing with topographic correction but, it seems important to pay attention on it.

27 - VALEK R. - "Determination of topographic corrections in gravimetric research".
Inst. Geophys. Acad. Tchecosl. Sci. n°37, p.21-31. Geof. Sbor. 1956. NCSAV, Praha, 1957.

"In order to calculate topographic corrections more economically we corrected and supplemented the solution given for example in (Sorokin) as follows : We drew a double-scale giving the dependence between the altitude difference of the sector and the topographic correction for an equidistant step H. If we place a strip of paper with an identical altitude scale on the double-scale so that the height of the point above sea level (in fig. 3 this is H = 320 m.) is identified with zero of the double-scale, the absolute heights of the sectors will show the corresponding topographic corrections on the double-scale.

The generalized terrain in the neighbourhood of the point Q can sometimes be depicted by a profile. If we add up the values which this profile shows on the alignment chart depicted in fig. 4, we obtain a topographic correction up to 500 m.

Another substantial saving of time is obtained by not calculating the topographic corrections for each point separately (apart from the immediate neighbourhood of the point) but by constructing a map of the topographic corrections. To draw this it is sufficient to know the topographic corrections merely in the points characteristic for the altitude (the map does not include the effects of the immediate neighbourhood of the point). The isolines of the corrections are then drawn so as to have a similar course as the generalized contour lines. From the map of topographic corrections we then read off the data for an arbitrary point".

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3° - STATIONS GRAVIMETRIQUES

En réponse à la circulaire jointe au Bulletin d'Information n°15 relative aux stations gravimétriques de la "schémathèque" du B.G.I., nous avons reçu plusieurs réponses que nous insérons ci-après.

BELGIQUE

Voir Bull. Inf. n°15, p.77, BRUXELLES-MELSBROËK.

Les stations 21604 52 J et 21604 52 K ne sont pratiquement plus accessibles (ancien aéroport provisoire). Elles ont été remplacées par la station dont la description est indiquée ci-dessous.

Par ailleurs, il faut noter le signe "x" aéroport et non le signe "*" port.

A) AEROPORT de BRUXELLES-MELSBROËK

Définition : Hall de transit. Devant la grande verrière ayant vue sur le tarmac. Banquette en marbre blanc longeant la verrière. Sur la 5ème plaque de marbre à partir de la gauche lorsqu'on regarde vers le tarmac. Un repère en aluminium, en forme de pastille, est scellé dans le mur de la banquette à l'aplomb de la station, marqué Gravimétrie - 31/4/4 = 21604 52 S.

Cette station se trouve dans l'enceinte douanière ; on peut donc y faire des mesures au cours d'une simple escale.

La différence de pesanteur entre cette station "nouvelle" et l'ancienne station (cave chaufferie) de l'ancien aéroport est : de la nouvelle à l'ancienne station + 5,36 mGal.

B) STATION EXTERIEURE à l'OBSERVATOIRE ROYAL de BELGIQUE (UCCLE)

Emplacement : Jardin intérieur de l'Observatoire ; porte y donnant accès à l'extrémité du grand couloir central de l'Observatoire (l'autre extrémité de ce couloir est l'entrée principale de l'Observatoire).

Trottoir en brique rouge devant cette porte ; la station est sur le bord de ce trottoir à l'aplomb du battant de droite (lorsqu'on entre) de la porte.

On peut faire des mesures en cette station lorsque le gravimètre est utilisé dans la voiture qui le transporte.

Le numéro de cette station est : 31/7/1/a = 21604 42 B.

Le numéro de la station dans la cave gravimétrique de l'Observatoire est : 31/7/1 = 21604 42 A.

La différence de pesanteur est : de 31/7/1a à 31/7/1 = + 0,75 mGal.

C) RESUME des DIFFERENCES de PESANTEUR

- Aéroport Bruxelles-Melsbroek "nouvelle station" 21604 52 S		
	+ 5,36 mGal	
- Ancienne station Aéroport (cave chaufferie) 21604 52 K		
	- 29,43 mGal	
- Observatoire Royal 31/7/1 (cave gravimétrique) 21604 42 A		
	- 0,75 mGal	
- Observatoire Royal 31/7/1/a (station extérieure) 21604 42 B		
- Institut Géographique Militaire 216 04 C		

L. JONES
Institut Géographique Militaire
BRUXELLES

DENMARK

Additional information concerning stations of Norway, Denmark and Greenland.

Geographical positions of the following stations :

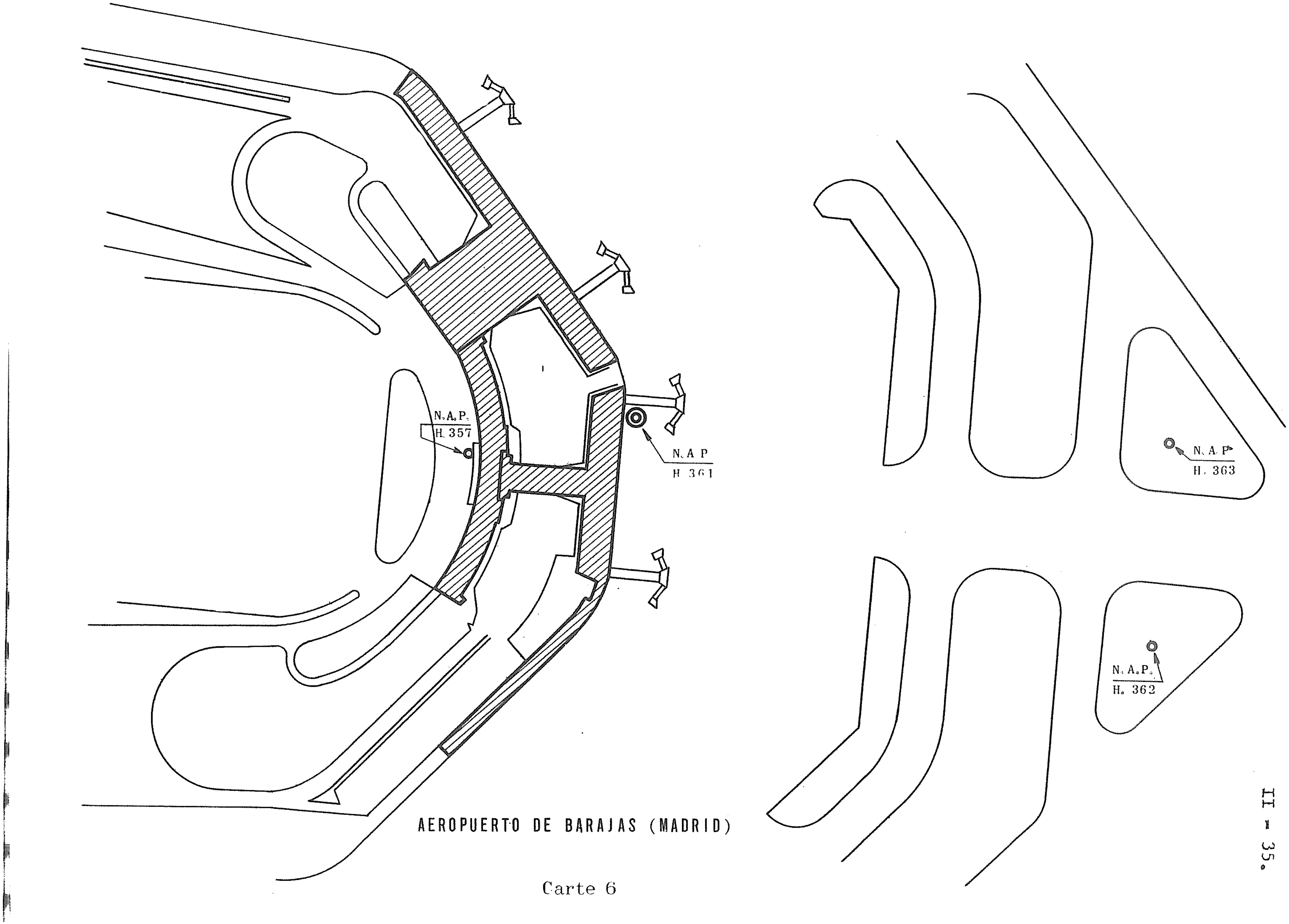
- Larvik pier	(Norway)	φ= 59°02' λ= 10°02'	21590 00 P
- Frederikshavn pier Navy base	(Denmark)	φ= 57°28' λ= 10°32'	21570 23 P
- Grønnedal pier	(Greenland)	φ= 61°14' λ= 48°07'	22118 10 P

Inst. Geod. - COPENHAGEN -

ESPAGNE

Station de BARAJAS, Aéroport de Madrid 14503 23

Les bâtiments anciens de l'Aéroport de Barajas ont été totalement rénovés ; les anciennes stations J, K (14503 23) indiquées dans le Bull. Inf. n°15, p.31, ont disparu. De nouveaux emplacements ont été choisis, voir carte n°6 page suivante.



AEROPUERTO DE BARAJAS (MADRID)

Carte 6

La station de référence C.N.A.P. (calvo nivelacion alta precision) n°361 a été reliée par 5 rattachements gravimétriques à la station de l'Institut Géographique ; la précision de la différence gravimétrique est de l'ordre de 0,008 mGal.

Les autres stations sont secondaires ; elles n'ont été reliées que par un aller et retour.

14503 23 O	- N.A.P. H. 357 (1)	entrada principal del Aeropuerto	= 979,99614
"	P	N.A.P. H. 361	junto a la central de Correos	= 979,99833
		N.A.P. H. 363	en dos zonas verdes a los lados	= 980,00007
		N.A.P. H. 362	de la pista principal	= 980,00017

J. RUIZ LOPEZ
Instituto Geografico y Catastral
MADRID

(1) La station 14503 N (Whalen) est différente.
(Entrée à droite du bâtiment pour départs nationaux)

FRANCE

MACQUARIE Island	ANARE Camp
AUCKLAND Island	Port Ross
KERGUELEN Iles	Port aux Français
" "	Port Jeanne d'Arc

"Les stations australes étant si peu nombreuses et les rattachements des mesures en mer si importants, il y aurait intérêt à ajouter ces stations à la liste. G.ROUILLON m'a informé que ses plus récentes mesures aux Kerguelen confirmaient au milligal mes résultats plutôt anciens maintenant, il en avait été de même avec mes stations de Terre Adélie, auxquels les Iles Maquaries et Auckland sont directement liées".

P. STAHL

Les stations principales dans les Kerguelen et Crozet occupées récemment par G.ROUILLON ont été indiquées dans l'additif ci-après (p.II - 51) ; elles sont décrites dans :

G.ROUILLON & F.HELLY. - "Terres Australes et Antarctiques françaises, Campagne d'été 1962-63. Mesures de gravité dans les Iles Kerguelen et Crozet". Comité National français pour les Recherches Antarctiques, 1967. (sous presse).

PORTUGAL

Les deux stations indiquées p.5 dans le Bull. Inf. n°15

- DOCA DA ALFANDEGA 10989 40 P
- DOCA DA MARINHA 10989 40 M

sont voisines. Elles ne sont éloignées l'une de l'autre que de quelques mètres. On les a établies à l'occasion des passages à Lisboa de deux navires océanographiques, un hollandais, l'autre anglais, dont les gravimétristes sont venus réellement à la station fondamentale portugaise à l'Instituto Geográfico e Cadastral, avec leurs appareils pour transporter à bord la valeur de g. Et selon que le navire était accosté à l'extérieur ou à l'intérieur du bassin, on a, par commodité, choisi un emplacement, sur la même digue, le plus proche du navire. On utilisera le même nom pour ces deux stations : DOCA DA MARINHA.

J.M. MARTINS
Instituto Geográfico e Cadastral
LISBOA

SUISSE

Renseignements complémentaires sur les stations suisses.
Voir Bull. Inf. n°15

p.61	18066 10 J	GENEVE	Suisse	x	Cointrin	Kneissl
p.62	18066 20	S. CERGUE	Suisse		Maison Com.	S.G.K.
p.64	18068 05	LOCARNO	Suisse	x	Aéroclub	S.G.K.109
	18068 33	BUTZENKEHR	Suisse		Rocher, rte	S.G.K. 85

Cette station terminant la ligne d'étalonnage nationale a été omise.

p.65 18069 La situation des anciens points pendulaires n'est plus intéressante. Les points actuels importants sont :

	18069 10	ROVEREDO	Suisse	Eglise	
	18069 21	MESOCCO	Suisse	Eglise	
	18069 31	SPLÜGEN	Suisse	Maison n°11	
	18069 53	LANDQUART	Suisse	Maison n°211	S.G.K. 76
p.66	18077 15	REIDEN	Suisse	Eglise	S.G.K. 43
	18078 01	LUZERN	Suisse	Eglise	S.G.K. 7

W. FISCHER
Schweizerische Geodaetische Kommission
ZURICH

Remarques générales concernant le "code number"

a) Rectificatif au Bulletin d'Information n°15
   p.1 : les 6 et 7ème chiffres correspondent aux dizaines de minutes (et non pas aux dixièmes de degré) ;
   p.XIV : MILANO, lire 18058 et 59

b) On notera que les 6 et 7ème chiffres qui différentient les stations par carreau de 10' x 10', ne sont pas utilisés dans le classement international du Groupe Spécial d'Etudes n°5.

En conséquence, la différentiation alphabétique qui avait été utilisée pour certaines stations françaises, a été modifiée pour éviter toute ambiguité dans un classement par degré carré qui ne tient compte que des 5 premiers chiffres.
(voir pages suivantes : 1er Additif).

c) On notera de plus que le code utilisé par le B.G.I. est le code correspondant aux coordonnées géographiques des emplacements :

Ex. :	M'BOUR-DAKAR	A	14°23'5 N - 16°57'7 W.	03846 25
	M'BOUR-DAKAR	C	14°40'4 N - 17°25'8 W.	03847 42

Par contre, le Groupe Spécial d'Etudes n°5 utilise pour tous les "excenters" d'une même station, le "code number" correspondant à la station principale ; les divers emplacements sont différentiés seulement par une lettre A,B,J...

De ce fait, le "code number" des excenters ne correspond pas, dans certains cas, à celui provenant des coordonnées géographiques. Dans l'exemple mentionné ci-dessus, on aura :

M'BOUR-DAKAR C 03846 (au lieu de 03847)

Les divergences entre les 2 nombres seront signalées dans les nouvelles listes (voir pages suivantes).

d) Enfin, dans quelques cas, toutefois assez rares, on a constaté un désaccord entre les lettres utilisées dans de récentes publications et celles antérieurement mentionnées par le B.G.I. dans le Bulletin d'Information n°15 :
   même signe alphabétique pour 2 emplacements différents
   ou signe alphabétique différent pour le même emplacement.

Ces divergences sont aussi indiquées dans les listes ci-après.

REPERTOIRE des STATIONS GRAVIMETRIQUES

(Schémathèque B.G.I.)

ADDITIF et RECTIFICATIF n°1

La liste suivante comprend les rectificatifs indiqués précédemment ainsi que tous les schémas reçus au B.G.I. depuis la parution du Bulletin d'Information n°15, même si des emplacements identiques ont déjà été mentionnés.

Les informations complémentaires concernant les stations déjà "listées", ont été soulignées.

Les nouveaux emplacements ont été indiqués par le signe ∓ .

Les schémas mentionnés ci-après sont extraits des publications suivantes :

A) BOLLO R. & M.DIDOSKI. - "Rapport sur la détermination de bases gravimétriques portuaires".
Bureau Recherches Géologiques et Minières - Serv. Hydro. de la Marine
DS.65, A.24, 1965. (BRGM)

B) 1381st GEODETIC SURVEY SQUADRON. - "American secondary calibration line, descriptions and excenter corrections". (GSS)

C) WHALEN C.T. - "The Euro-African secondary calibration line survey 1965".
Phase Report n°4, APCS OPLAN 503, USAF, 1381st GSS, 1966. (Wh.C)

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001 50... 038 36

00150 31 A	ACCRA	Ghana		Univ.Geol. bldg	Wh. C
±00150 31 C(a)	"	"		Geol. Surv. Dept	Wh. C
00150 31 J	"	"	x	Health Office	Wh. C
±00150 31 K	"	"	x	Departure ent. (street side)	Wh. C
00150 41 L(b)	AYIMENSAH-ACCRA	Ghana		Water tank	Wh. C
00150 51 M(b)	ABURI-ACCRA	Ghana		Girls School	Wh. C
±00260 12 K	MONROVIA	Liberia	x	New term.(st.side)	Wh. C
±00260 12 J	"	"	x	KLM term.	Wh. C
±00260 14 B	"	"		Temple of Justice	Wh. C
±00260 14 C	"	"		Camp Ramrod	Wh. C
00293 33 J	CONAKRY	Guinée	x	Restaurant	Wh. C
±00293 34 B	"	"		Ministry Justice	Wh. C
±00655 21 J	PARAMARIBO	Surinam	x	Zandery Airp.	Wh. C
±00668 31 J	GEORGETOWN	British Guinea	x	Atkinson Field	GSS
±00668 40 B	"	" "		Geol. Surv.Dept.	GSS
00844 30 A	BOGOTA	Columbia		Inst. Geog. Mil.	GSS
00889 53 A	PANAMA	Panama	x	Bldg 1019	GSS
00889 53 M	"	"	x	Howard AFB	GSS
±00889 53 S	"	"	x	Albrook AFB, Hg 1	GSS
±03609 22 B	LIBREVILLE	Gabon		Main Post Off.	Wh. C
±03609 22 J	"	"	x	Airp. term.	Wh. C
±03649 04 B	DOUALA	Cameroun		Main Post Off.	Wh. C
03649 04 J	"	"	x	Salle d'attente	Wh. C
±03663 22 B	LAGOS	Nigeria		U.S. Embassy	Wh. C
03663 31 J	"	"	x	Ikeja Airp (old)	Wh. C
±03663 31 K	"	"	x	Ikeja Airp. term	Wh. C
±03836 23 B	BATHURST	Gambie		Adonis Hotel	Wh. C
±03836 24 J	"	"	x	Yundum Airp.	Wh. C

(a) C au lieu de B (Publ. Whalen), car 00150 31 B = Univ. Phys. Dept. (Davis 2, Bull.Inf. n°15, p.6).

(b) Désignées respectivement par ACCRA L et M dans publ. Whalen.

038 46... 081 41

03846 25 A	M'BOUR-DAKAR	Sénégal		Centre Geophys. (int.)	Wh. C
03846 25 B	" "	"		" " (Ver.)	Wh. C
±03847 41 F (a)	RUFISQUE	Sénégal		Gare	ORSTOM 115
±03847 42 C (a)	M'BOUR-DAKAR	Sénégal		Main Post Off.	Wh. C
±03847 42 Q (a)	" "	"	x	VIP Lounge	Wh. C
03847 42 J (a)	" "	"	x	Ent. luggage	Wh. C
±03847 42 R (a)	" "	"	x	Control Tower	Wh. C
±03885 05 J	NOUAKCHOTT	Mauritanie	x	Transit Lounge	Wh. C
±04301 32 J	PORT of SPAIN	Trinidad	x	New Piarco Int.A	GSS
04301 43 M (b)	CHAGUARAMAS	Trinidad	*	Pier n°1	GSS
±04341 00 B	S. LUCIA	Lucia Isl.		Government bldg	GSS
±04341 00 J	"	"	x	Airport Tower	GSS
±04371 04 J	ANTIGUA	Antigua	x	Coolidge Airp.	Wh.C-GSS
±04371 05 B	"	"		Post Office	GSS
±04374 44 J	S. CROIX	Virgin Isl.	x	Alex.Ham. Airp.	GSS
04386 20 J	SAN JUAN	Puerto Rico	x	Main lobby	GSS
±04387 30 J	RAMEY	Puerto Rico	x	Ramey AFB "OPS"	GSS
±04387 30 K	"	" "	x	to 6m. from J	GSS
±04476 54 J	KINGSTON	Jamaïca	x	New Airp.term.	GSS
±04476 54 K	"	"	x	Old Airp.	GSS
±04482 32 J	PORT au PRINCE	Haïti	x	Bowen Field (old)	GSS
±04482 32 K	" "	"	x	New Airp. 1965	GSS
±04495 50 K	GUANTANAMO	Cuba	x	McCalla Field	GSS
±04495 51 J	"	"	x	Leeward Pt Field	GSS
07407 50 J	PORT ETIENNE	Mauritanie	x	Airp. term. (in)	Wh. C
07475 52 J (c)	LAS PALMAS	Iles Canaries	x	Gando Aerop.	Wh. C
±07485 02 B	" "	" "		"Timanfaya"	Wh. C
08141 34 A	KEY WEST	U.S.A.		Nav. St. bldg 91	GSS
±08141 34 J	" "	"	x	Bronze Statue	GSS

(a) dans publ. Whalen : 03846 (voir remarque p.38).

(b) Station mise à PORT of SPAIN (Publ. GSS).

(c) dans publ. Whalen : 07485 (voir remarque p.38).

081 41... 109 37

08141 34 M	KEY WEST	U.S.A.	*	Pier n°4	GSS
08141 34 N	" "	"	*	"Mole" pier	GSS
±08141 34 O	" "	"	x	Boca Chica	GSS
±08150 22 O	MIAMI	U.S.A.	x	Homest.AFB,gate 7	GSS
±08150 22 P	"	"	x	" ",N.ent.	GSS
±08150 22 Q	"	"		Post Office	GSS
08150 41 A	"	"		Bio. Labo. Off.	GSS
08150 41 B	"	"		" ",dormitory	GSS
08150 41 J	"	"		Post Office	GSS
±08150 41 L	"	"	x	Old Eastern Airl.	GSS
" N	"	"	x	New terminal	GSS
±08160 10 F	POMPANO BEACH	U.S.A.		Post Office	GSS
08160 10 N (a)	" "	"	x	Municipal Airp.	GSS
±08160 40 A	WEST PALM BEACH	U.S.A.		Post Office	GSS
08160 40 J	" " "	"	x	Term. gate 2	GSS
±08170 32 B	VERO BEACH	U.S.A.		City Hall	GSS
08170 32 J	" "	"	x	E.Airl.,wait.room	GSS
±08170 32 K	" "	"	x	New Airp. 1965	GSS
±08180 13 J	COCOA	U.S.A.	x	Patrick Base CPS	Wh. C
08181 22 L (b)	ORLANDO	U.S.A.	x	McCoy AFB,bldg 421	GSS
±08181 22 M	"	"	x	" ",Mail Box	Wh.C-GSS
08181 31 K	"	"	x	Bldg 2090 (AFB)	Wh.C-GSS
08181 32 J	ORLANDO (I)	"	x	Herndon Airp.	Wh.C-GSS
±08191 10 B	DAYTONA BEACH	"		Junior College	GSS
08191 10 J	" "	"	x	Muni. A., gate 2	GSS
±08191 52 F	S. AUGUSTINE	"		Post Office	GSS
08191 52 O	"	"	x	Hall, USAF	GSS
10909 23 J	AGADIR	Maroc	x	Pav. escale	Wh. C
10909 23 L (c)	"	"		Pont Oued Tildi	Wh. C
10937 33 A (d)	CASABLANCA	Maroc		Trav. Publ.(ext.)	Wh. C

(a) au lieu de : Z (Bull. Inf. n°15, p.19).

(b) au lieu de 08181 31 (Bull. Inf. n°15, p.19).

(c) dans publ. Whalen : 10909 K

(d) dans publ. Whalen : 10937 B

109 37... 117 14

10937 34 J	CASABLANCA	Maroc	x	Salle d'attente	Wh. C orst 12
±10955 44 B	TANGER	Maroc		Rembrandt Hl	Wh. C
±10955 45 J	"	"	x	Main entrance	Wh. C orst 18
10955 45 K	"	"	x	Bar	Wh. C
±10965 02 M	GIBRALTAR	Gibraltar	*	South môle (AB)	Un.Camb;Mor.
10989 40 A	LISBOA	Portugal		I.G.C.	Wh. C
10989 40 K	"	"	x	St. basse	Wh. C
10989 40 L	"	"	x	St. haute	Wh. C
10989 40 M,P	"	"	*	Doca da Marinha	p.II- 37.
±11524 24 J (a)	S.GEORGE'S	Bermuda	x	Kindley AFB	GSS
11629 45 A (b)	CHARLESTON	U.S.A.		Citadel Univ.	GSS
±11649 14 B	FLORENCE	U.S.A.		Post Office	GSS
11649 14 J	"	"	x	Wire barrier	GSS
±11658 54 B	RALEIGH	"		Main Post Off.	GSS
11658 54 J	RALEIGH-DURHAM	"	x	Passenger ent.	GSS
±11677 32 B	RICHMOND	U.S.A.		State Capitol bldg	GSS
11677 32 J	"	"	x	Municipal Airp.	GSS
11687 50 A	WASHINGTON	U.S.A.		Com.bldg, room	GSS-Wh.C
11687 50 C	"	"		" ",car base	GSS
11687 50 D	"	"		Carn.Inst.Geoph.	GSS
11687 50 L	"	"	x	N.Airp., term.	GSS-Wh.C
11687 50 P	"	"	x	Bolling AFB	GSS
11687 52 R	"	"	x	Dulles Airp.	GSS
11701 23 J	JACKSONVILLE	U.S.A.	x	Waiting room	GSS
±11701 23 K	"	"	x	Gate 7	GSS
±11701 23 L	"	"		Bay St.Rail.term	GSS
11711 02 J (c)	S. SIMONS	U.S.A.	x	Sidewalk	GSS
±11711 12 K	BRUNSWICK	U.S.A.	x	Glynco Nav. St.	GSS
±11714 30 J	ALBANY	U.S.A.	x	Turner AFB	GSS

(a) désignée par BERMUDA Isl. (publ. GSS).
(b) voir aussi 11720.
(c) désignée par BRUNSWICK J (publ. GSS).

117 20... 145 91

11720 24 J	BEAUFORT	U.S.A.	x	Marine Air St.	GSS
11720 50 J (a)	CHARLESTON	U.S.A.	x	Municipal Airp.	GSS
‡11720 50 L	"	"	x	AFB (1) MATS	GSS
‡ " M			x	" (2)	"
‡11721 00 B	SAVANNAH	U.S.A.		Chatham Cty Hse	GSS
11721 00 J	"	"	x	Travis. Field	GSS
14323 51 A,K	TRIPOLI	Libye	x	Wheelus (T-101)	Wh. C
14323 30 L	"	"	x	Idris, lobby	Wh. C
‡14492 33 K	PALMA (Mallorca)	Baléares		Centr. train St.	Wh. C
‡14492 34 J	" "	"	x	San Juan Airp.	Wh. C.
‡14503 22 M	MADRID	Espagne	x	Torrejon AFB	Wh. C
14503 23 K	MADRID-BARAJAS	"	x	Old Airp. Salle d'attente	Wh. C
‡14503 23 N	" "	"	x	New Airp. Nat. Dep.	Wh. C
‡14503 23 O	" "	"	x	" , ent. princ.	p.II - 36.
‡14503 23 P	"	"	x	" , correos	p.II - 36.
14503 24 A	MADRID	"		Obs. Astr., sol	Wh. C
14503 24 B	"	"		" " pilier	Wh. C
14503 24 C	"	"		Inst. Geo. Cad.	Wh. C
‡14531 22 B	BAYONNE	France	*	près ponton 2	BRGM 1509 B
‡14540 53 C	BORDEAUX	France	*	Quai douane	BRGM 1439 C
‡14540 53 D	"	"	*	Quai Quinconces	BRGM 1439 D
‡14541 30 D	ARCACHON	France	*	Port de pêche	BRGM 1511
‡14551 30 B	LE VERDON	France	*	Port Bloc	BRGM 1513 B
‡14573 42 B	LORIENT	France	*	Quai Pétroliers	BRGM 1032 B
‡14582 30 B	S. MALO	France	*	Quai	BRGM 999 B
14584 22 N	BREST	France	*	"Le Port", quai	BRGM VII
‡14584 23 L	"	"	*	Pt Militaire (b.19)	BRGM I
14584 23 M	"	"		Porte Caffarelli	BRGM B
‡14591 33 B	CHERBOURG	France	*	Arsenal (Poste 12)	BRGM 1122 B
‡14591 33 D	"	"	*	Digue Homet	BRGM 1122 D

(a) dans publ. GSS : 11629 J (voir remarque p. 38).

151 48... 180 29

‡15148 44 B	BANGOR	U.S.A.		Penobscot Cty Hse	GSS
15148 44 J	"	"	x	"Dow AFB"	GSS
‡15167 55 B	CARIBOU	U.S.A.		Post Office	GSS
15167 55 J (a)	"	"	x	Base Operations	GSS
15204 03 J	PRINCETON	U.S.A.	x	McGuire AFB lounge	GSS-Wh.C
15204 03 K	"	"	x	" ,term. ent.	GSS
15204 23 A	"	"		Univ.,boiler room	GSS-Wh.C
15204 40 L	"	"	x	Newark Airp.term	GSS
‡15212 15 B	NEW HAVEN	U.S.A.		Yale University	GSS
15212 15 J	" "	"	x	Tweed N.Heaven	GSS
‡15221 21 B	BOSTON	"		MIT Inst. Labo.	GSS
15221 21 J (b)	"	"	x	Hanscom AFB 1721	GSS
15230 31 J	PORTLAND	U.S.A.	x	Waiting room	GSS
‡15230 31 B	"	"		Congress St.	GSS
15253 24 N	MONTREAL	Canada	x	Dorval Airp.	GSS
15255 24 A	OTTAWA	Canada		Dom. Obs. bldg	GSS
15255 24 E	"	"		Geoph.Labo.bldg	GSS
‡15282 31 J	ROBERVAL	Canada	x	Nordair hangar	GSS
15282 31 K	"	"		Post Office	GSS
‡15282 31 L	"	"	*	Lake S.Jean,pier	GSS
15282 31 M	"	"		,, Dept Land-For.	GSS
15514 14 A	CHEYENNE	U.S.A.		Recr.Hall, pend.	Wh. C
15514 04 K	"	"	x	New terminal	Wh. C
18012 10 J	BARCELONA	Espagne	x	Gate 3, in	Wh. C
‡18012 10 L	"	"	x	Campsa bldg	Wh. C
18022 45 F	PERPIGNAN	France		Gare	CGG
‡18022 45 J	"	"		Hotel Delseny	Wh. C
18022 51 C	COUIZA	France		Eglise	Coron-CGG
‡18023 30 B	PORT-VENDRES	France	*	Quai Douane	BRGM 1503 B
‡18023 30 C	" "	"	*	Quai P. Forgas	BRGM 1503 C
18029 02 G	GHISONACIA	Corse		Gare	Lejay

(a) désignée par LORING A.F.B. (Bull. Inf. n°15, p.33).
(b) désignée par HANSCOM (Bull. Inf. n°15, p.36).

180 30... 180 68

18030 00 B (a)	BAGNERES de BIG.	France		Obs.,nouv. cave	Wh. C
18030 05 G	S. MARTORY	France		Gare	Martin 121
18030 10 H	TARBES	France		Gare	Martin 117
±18030 10 L	"	"		Place de Verdun	Wh. C
18031 32 A	TOULOUSE	France		Obs. Astr.pilier	Wh. C
18031 32 B	"	"		" ",labo ph.	Wh. C
18031 32 J	TOULOUSE-BLA.	"	x	Salle d'attente	Wh. C
18034 53 R	REMOULINS	France		Gare	Lejay CGG
18035 05 P	TOULON	France	*	Arsenal	BRGM
18037 42 P	VINTIMILLE	France-Italie		Frontière, pont	Inghilleri
18037 42 C	MONACO	Monaco		Gare	BRGM
18040 13 J (b)	AGEN	France		Eg. S. Hilaire	Wh. C
±18040 13 K	"	"		Gare	Wh. C
18042 23 C	RODEZ	France		Cathédrale	Martin 98
18042 52 G	AURILLAC	France		Eg. S. Géraud	Martin 88
18050 21 J	MONTIGNAC	France		Villa Bagatelle	Wh. C
18053 00 C	S. FLOUR	France		Cathédrale	Martin 87
18054 30 G	MONTBRISON	France		Gare	BRGM 669
18056 00 D	BOURG d'OISANS	France		Gare	Coron
18056 50 G	ANNECY	France		Gare	Martin 236
18060 32 J (c)	POITIERS	France		Palais de Justice	Wh. C
±18060 32 K	"	"		Gare	Wh. C
18061 15 G	GUERET	France		Gare	BRGM 698
18063 01 G	GANNAT	France		Eg. Ste Croix	Martin 59
18064 51 G	AUTUN	France		Gare	BRGM 490
18065 31 D	LOUHANS	France		Gare	Martin 222
18065 43 G	LONS-le-SAUNIER	France		Gare	BRGM
18066 10 J	GENEVE	Suisse	x	Cointrin	p.II - 37.
18066 20	S. CERGUE	Suisse		Maison Com.	p.II - 37.
18068 05 J	LOCARNO	Suisse	x	Aeroclub	p.II - 37.

(a) dans publ. Whalen : 18030 A.
(b) au lieu de E (Bull. Inf. n°15, p.58).
(c) au lieu de C (Bull. Inf. n°15, p.61).

<u>180 68... 215 70</u>

‡18068 33	BUTZENKEHR	Suisse		Rocher, route	p.II-37 (SGK
18069 10	ROVEREDO	Suisse		Eglise	p.II - 37.
18069 21	MESOCCO	Suisse		Eglise	p.II - 37.
18069 31	SPLÜGEN	Suisse		Maison n°11	p.II - 37.
18069 53	LANDQUART	Suisse		Maison n°211	p.II-37 (SGK
18070 35 J	CHATEAU-RENAULT	France		Gare,côté voie	Wh.C - Gantar
‡18070 35 K	" "	"		" , dépôt	Wh.C
18070 35 <u>L</u>	" "	"		" salle d'atten.	Martin-Rouillo
‡18075 15 B	BESANÇON	France		Observatoire	Goudey
18077 15	REIDEN	Suisse		Eglise	SGK <u>43</u>
18078 01	LUZERN	Suisse		Eglise	SKG <u>7</u>
18082 41 A	PARIS-SEVRES	France		B.I.P.M.	Wh. C
18082 42 O	PARIS-ORLY	"	x	1st floor (4-34)	Wh. C
18082 52 K	PARIS-LE BOURGET	"	x	Douane	Wh. C
18082 52 J	" "	"	x	Hall, U.T.A.	Wh. C
‡18090 20 B	LE HAVRE	France	*	Bitte 214	BRGM 1618 B
‡18090 20 C	"	"	*	Bitte 261	BRGM 1618 C
‡18091 50 B	DIEPPE	France	*	Quai des Indes	BRGM 1619 B
18110 22 N	LONDON-TEDDING.	G.Br.		Term. 1 (9)	Wh. C
18110 22 J	" "	"		" 1 (12)	Wh. C
18110 22 O	" "	"		" 3 (teleph)	Wh. C
18110 22 A	TEDDINGTON	G.Br.		NPL, room 11	Wh. C
18153 50 A	EDINBURGH	G.Br.	x	R.Obs.(clock room)	Wh. C
‡18153 52 O	"	"	x	Turnhouse Airp.	Wh. C
18154 33 K(a)	PRESTWICK	G.Br.	x	MATS, term.	Wh. C
18154 51 B	Glasgow	Eng B		University	[illegible]
18154 52 N(a)	GLASGOW	G.Br.	x	Renfrew Airp.	Wh. C
‡18746 44 <u>J,K</u>	SCHEFFERVILLE	Canada	x	Knob Labe Airp.	GSS
‡18746 44 L	"	"		Labrador Min.C°	GSS
‡18788 02 J	FORT CHIMO	Canada	x	Nordair term.	GSS
‡18788 02 K	" "	"		R.C.M.P. House	GSS
21570 <u>23 P</u>	FREDERIKSHAVN	Denmark	*	Pier	p.II - 34.

(a) dans publ. GSS : 181 <u>53</u> (voir remarque p.38).

215 90... 221 18

21590 00 P	LARVIK	Norway	*	Pier	p.II - 34.
±21601 43 B	BOULOGNE	France	*	Quai Al.Huguet	BRGM 1621 B
±21601 43 C	"	"	*	Quai J. Voisin	" " C
±21601 55 B	CALAIS	France	*	P. Devot	BRGM 1622 B
±21604 42 B	BRUXELLES-UCCLE	Belgique		Obs.Royal, out	p.II - 33.
±21604 52 S(a)	" "	"	x	Hall, transit	p.II - 33.
21608 03 A	FRANKFURT	Allemagne		I.A.G., cave	Wh. C
21608 03 O	"	"	x	Waiting room B	Wh. C
±21612 02 B	DUNKERQUE	France	*	Quai	BRGM 1623 B
21629 24 A	HANNOVER	Allemagne		Tech. Hochsch.	Wh. C
21629 24 M	"	"	x	Langenhagen, control area	Wh. C
±21716 34 P	TVAERA	Faroe Islands	*	Pier	Saxov
±21726 04 C	TORSHAVN	Faroe Islands	*	Sch.navigation	Saxov II
±21726 04 D	"	" "		King's monument	Saxov III
±21726 04 F	"	" "		Fortress-light	Saxov IV
±21726 04 P	"	" "	*	Harbor, quay	Saxov I
±21726 13 P	KLAKSVIG	Faroe Islands	*	Harbor-mastersHse	Saxov
21932 53 K(b)	KEFLAVIK	Islande	x	Bldg S - 782	Wh. C
±21941 02 O(c)	KOLVIDARHOLL	Islande		Hveradalir	Saxov
21941 05 A	REYKJAVIK	Islande		Université	Wh. C
21941 05 B	"	"		Skolavarda	Wh. C
±21941 05 C	"	"		Catholic Church	Saxov II
21941 05 D	"	"		City Hl, vest	Saxov VII
21941 05 L	"	"	x	Main entrance	Wh. C
±21941 05 J(d)	"	"	*	Aegisgardur	Saxov VI-EPF-Wh.C
±21941 05 P	"	"	*	Geirsgata	Saxov IV-Schleus.
±21941 05 Q(d)	"	"	*	Faxagardur	Saxov V-Wooll.
22118 10 P	GRØNNEDAL	Groenland		Pier, Arsuk Fjd	p.II - 34.

(a) 21604 52 J et K ne sont plus accessibles.
(b) dans publ. Whalen : 21941 (voir remarque p.38).
(c) au lieu de C (Bull. Inf.n°15, p.5).
(d) la station "Long Pier" de Woollard n'est pas la station "Aegisgardur".
(voir Saxov - Boll. Geof., n°33, Trieste, 1967).

223 38... 295 22

∓22338 43 J	FROBISHER BAY	Canada	x	D.O.T. Hangar	GSS
∓22338 43 K	" "	"	x	Federal Bldg	GSS
∓22581 41 J	HALL BEACH	Canada	x	Lower Camp	GSS
∓22581 41 K	" "	"	x	Upper Camp	GSS
25093 51 L	ALTA	Norway	*	33m.Esso Pier	Sømod-Wh.
25093 51 M	"	"	x	Seaplane Pier	Whalen
∓25968 34 J	THULE	Greenland	x	Hangar 7	GSS
∓25968 34 K	"	"	x	Hangar 9	GSS
∓26244 45 J	RESOLUTE BAY	Canada	x	Bldg 10	GSS
∓26244 45 K	" "	"	x	Bldg 28	GSS
∓26244 45 L	" "	"	x	Pass.term, out	GSS
∓26195 54 J (a)	EUREKA	Canada	x	Bldg 15	GSS
∓26195 54 K	"	"	x	Bldg (1965)	GSS
∓29522 32 J	ALERT	Canada	x	Windsock	GSS
∓29522 32 K	" (Camp)	"		D.O.T., bldg 2	GSS
∓29522 32 L	" "	"		" , bldg 14	GSS
∓29522 32 M	" "	"		Dept. Defense	GSS

(a) voir 29605 (Bull. Inf. n°15, p.86).

Fin Hémisphère Nord

326 74... 401 23

‡32674 52 J	ASCENSION	Ascension Isl.	x	Auxiliary Airf.	Wh. C
‡32838 43 J	FORTALEZA	Brésil	x	New Pinto Martins	GSS
‡32838 43 K	"	"	x	Old term. bldg	GSS
‡32884 05 J	RECIFE	Brésil	x	Guararapes Airp.	GSS-Wh.C
‡32884 05 K	"	"	x	" MATS	GSS-Wh.C
‡32884 05 L	"	"	x	" st. ent.	GSS
32918 22 A	BELEM	Brésil		SNAPP Water fil.	GSS
‡32918 22 K	"	"	x	Val Caes, term.	GSS
32918 22 L	"	"	x	" " , out	GSS
32918 22 N	"	"	*	end City pier	GSS
32918 22 O	"	"	*	Ballard 109	GSS
35716 15 A	NAIROBI	Kenya		Field Surv. Headq.	Wh. C
35716 15 Q	"	"	x	Embakasi, ent.	Wh. C
35945 12 K	LEOPOLDVILLE	Congo	x	Guest Hse Sabena	Wh. C
35945 21 A	LEOPOLD.-BINZA	"		Serv. Meteo. cave	ORSTOM 216 Wh. C
35945 22 L,M	LEOPOLDVILLE	"	x	N'Djili Airp.	Wh. C
‡35983 41 B	LUANDA	Angola		Main Post Off.	Wh. C
‡35983 51 J	"	"	x	Pdt. Crav. Lopes	Wh. C
‡36428 52 J	SALVADOR	Brésil	x	Dois Julho Airp.	GSS
‡36438 03 B (a)	"	"		Post Office	GSS
‡36479 30 B	CARAVELAS	Brésil		Post Office	GSS
‡36479 31 J	"	"	x	Term. bldg	GSS
‡39525 44 B	NOVA LISBOA	Angola		New Post Off.	Wh. C
‡39525 54 J	" "	"	x	Term. bldg	Wh. C
‡39543 53 B	SA DA BANDEIRA	Angola		Republic Square	Wh. C
‡39543 53 J	" " "	"	x	near Cont. Tower	Wh. C
‡40100 11 J	VICTORIA	Brésil	x	Goiabeiras Airp.	GSS
‡40100 21 B	"	"		S. Antonio Ch.	GSS
‡40111 41 B	CAMPOS	Brésil		(down.) Post Off.	GSS
‡40111 41 J	"	"	x	Bonsucesso Airp.	GSS
40123 41 K	RIO de JANEIRO	Brésil	x	Galeao Airp.	GSS

(a) dans publ. GSS : 36428 B (voir remarque p.38).

401 23... 525 48

40123 51 A	RIO de JANEIRO	Brésil		Obs. Nacional	GSS
40123 51 L	" "	"	x	Santos Dumont A.	GSS
±40136 22 J	SAO PAULO	Brésil	x	Cumbica Air Base	GSS
±40178 33 A	FLORIANOPOLIS	Brésil		Post Office	GSS
±40178 43 J	"	"	x	Hercilio Luz A.	GSS
±40257 13 B	ASUNCION (down)	Paraguay		Dir.Gal.Turismo	GSS
±40257 13 J	ASUNCION	"	x	Pdt Stroessmer A.	GSS
±43801 01 B	PORTO ALEGRE	Brésil		Post Office	GSS
±43801 01 J	" "	"	x	Salgado Filho A.	GSS
±43812 41 B	PELOTAS	Brésil		Govern. Bldg	GSS
±43812 42 J	"	"	x	Airp. term.bldg	GSS
43848 33 A	BUENOS AIRES	Argentina		Inst.Geo. Mil.	GSS
43848 43 K	" "	"	x	Ezeiza Airp.	GSS
±49790 21 J	Pt AUX FRANCAIS	Iles Kerguelen		Old pavillon	Stahl (TA 4)
±49790 21 M(a)	" "	"	±	Quai, hangar	Rouillon (K 2)
±49899 34 F	Pt JEANNE D'ARC	"		entre réservoirs	Stahl (TA 3) Rouillon
±49960 01 F	Ile AUX COCHONS	Iles Crozet		Cap Verdoyant	Rouillon
±49961 25 C	Ile de la POSSESSION	Iles Crozet		St. météo.	Rouillon (C 1)
±52406 31 C	PORT ROSS	Auckland Isl.		Grand pilier	Stahl
±52548 35 C	MACQUARIE Isl.	Macquarie Isl.		ANARE Camp	Stahl

(a) Cette station remplace la station J qui n'est plus accessible.