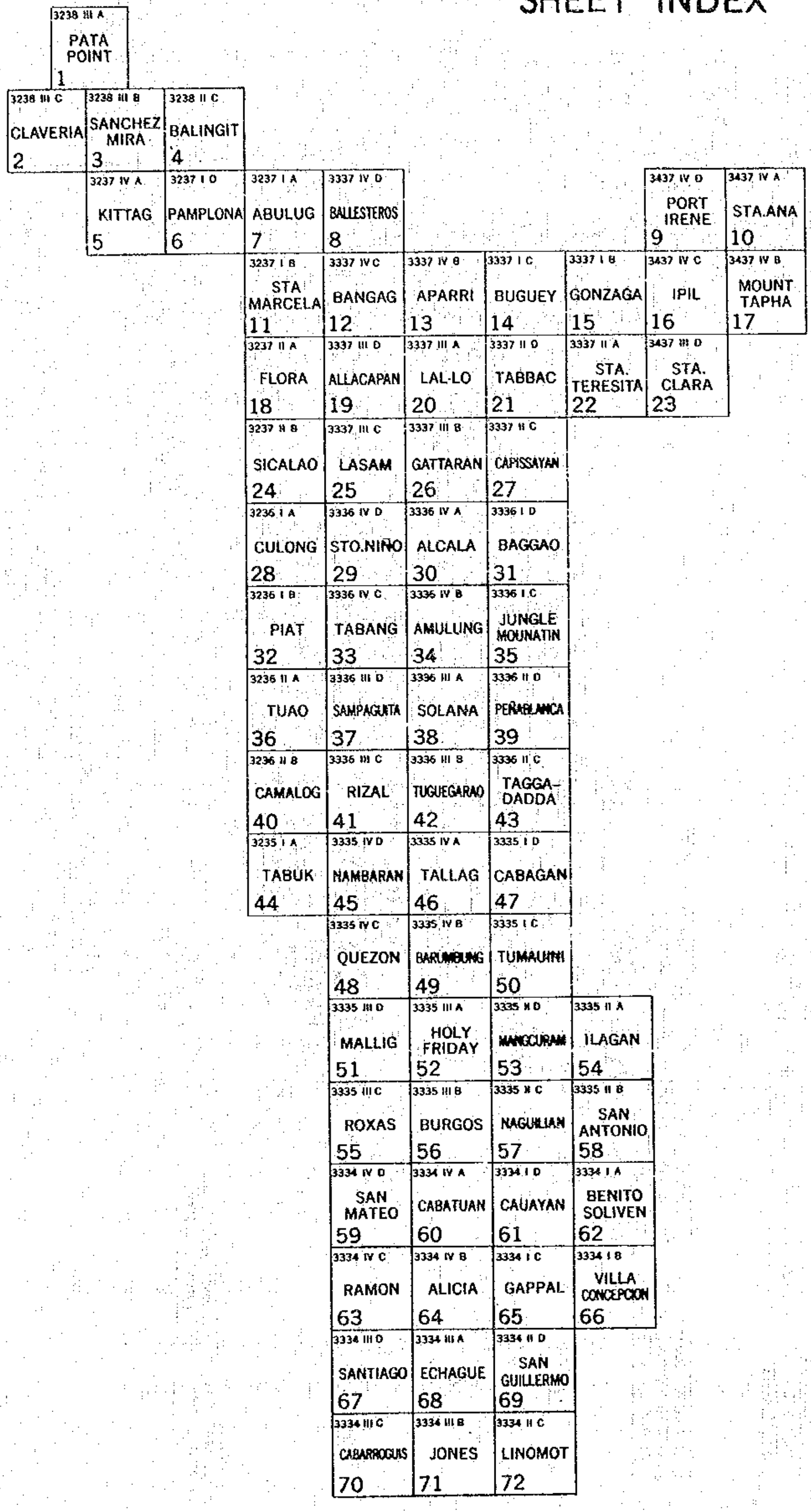
Table 2

CAGAYAN VALLEY TOPOGRAPHIC MAPPING SHEET INDEX



9) Marginal information and annotation plates

Common marginal information was imprinted on the polyester base and a required number of scribing sheets were duplicated on polyester base 500#.

Note: As for building symbols, photo setting types and symbols were stuck, while confirming proper positions based on the data.

10) Symbol plates

Vegetation symbols were printed, using mask plates and symbol negatives, on polyester bases by means of photographing.

11) Matching

Scribing and mask plates and polyester bases were matched sheet by sheet for each color. Final inspection was performed on the five-color surprint.

(3)-2 Quality Control and Proofchecking

1) After completion of operation, color printing compound positive plates were prepared and proofchecked through in-house inspection.

2) Stereocompilation manuscripts, field verification data and compound positive plates were presented of the Japan Surveyers Association for inspection. After proofreading, compound positive plates were again prepared for final approval.

3) The above-mentioned final surprints were presented to Commodore Antonio P. Ventura, Director of BCGS, for approval.

(3)-3 Details

1) Vegetation symbols

The symbol negatives offered by BCGS were used.

2) Screen density

For screen density, 10%, 20%, 30% and 50% of D120-45° and 20% of D120-75° were used.

3) Application in work

a. Point names of control points and bench marks are not shown.

b. When spot elevation and road overlap, road symbols are discontinued.

c. Road symbols within road marks are discontinued.

d. Building symbols are as a rule shown vertically above corresponding buildings, provided that if vertical presentation is not appropriate, they are shown on blank parts.

e. Contour line values are shown by up slope rules. They are so positioned that characters are not up-side down.

f. Annotations and symbols are not shown on the same place.

g. When it is not possible to show contour lines due to narrow index contour line intervals which are due to steep topography, contour lines may be omitted, provided that no index contour lines may be omitted.

(3)-4 Marginal information

1) UTM coordinates values are for every 2Km (even numbers). Grid reference ticks are shown inside neat lines for the length of 3mm.

2) Magnetic north values and true north values are shown on azimuthal charts for every five minutes and for every second respectively.

3) On location map, names of sheet and coastal lines are shown by black and the waters by blue.

4) Destination annotations are entered 5mm away from neat lines with arrow marks.

5) As for geographical coordinates values, figures are entered on the outer circumference every 2'30", and coordinates lines are shown by tick 5mm inside neat lines. On drawings, 10mm cross lines are shown on each cross.

6) Sheet names and numbers are as specified by BCGS.

7) On left top is shown the name of administration to which the majority of the area belongs.

(3)-5 Annotation

Although BCGS possesses photo-setting types of sans serif, it was agreed to photo-setting types which are close to the former. Conversion is as shown in the table. (Annex II)

(4) Printing of Topographic Maps

(4)-1 Outline

Using the scribed sheets, explained in above, developed through, plate making and printing were done.

(4)-2 Materials Used

For printing, map papers with minimum elasticity, excellent printing characteristics (reproducibility) and durability (stretching, humidity, tearing) were used with the approval of BCGS.

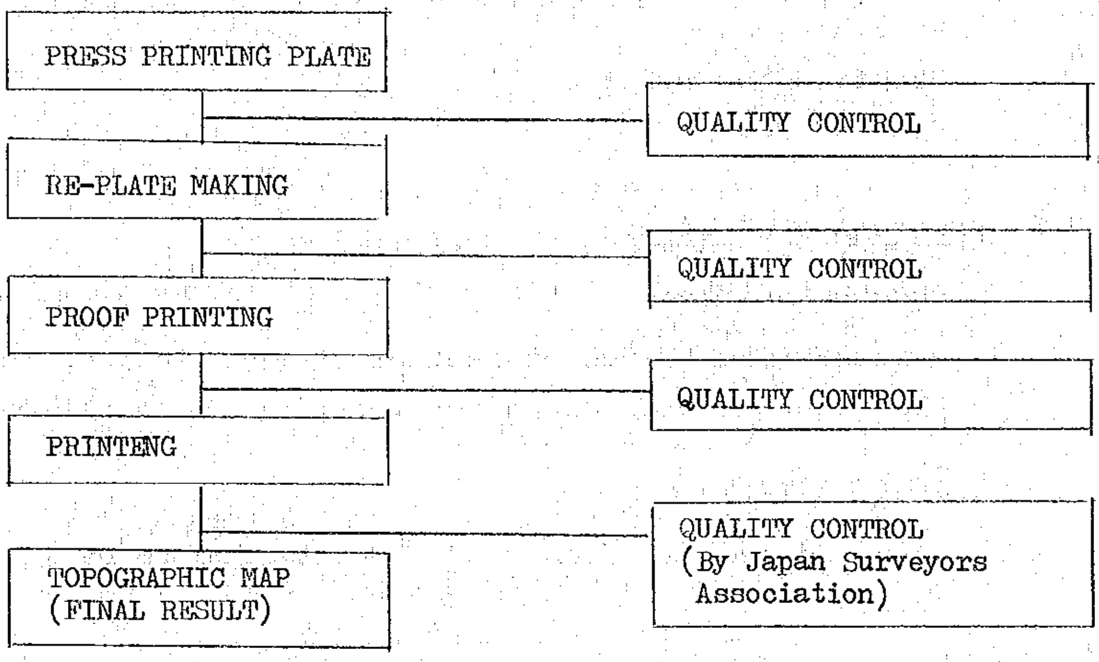
For printing ink, non-permiable inks with excellent tone and fade resisting were used.

(4)-3 Execution and Flow Chart

For plate making, scribing, negative and mask plates were used to develop printing plates (P.S.) for individual colors by means of photo-plate making.
Color tones were matched to the samples presented by BCGS for black, blue, green, brown and red.

Papers were B1 90Kg papers, and the finishing size was 59.6cm x 72.0cm as specified by BCGS. (Annex III) The total quantity was 72 plates, each 1,000 pieces.

WORK FLOW



(4)-4 Inspection and Proofreading

Proofreading prints were strictly inspected to compare with samples for tone, to find irrational entries and entries which may lead to misreading and any omission. They were presented for approval to Director Antonio P. Ventura of BCGS.

(4)-5 Inspection at Survey Engineering Center

All results were inspected at the Survey Engineering Center.

(5) Items Delivered

Scribing plate
Mask plate
Positive plate
Negative plate
Color printing compound positive plate
PS plate
Proofreading print
Printed chart

2-5 Progress of Project

o December, 1976:

Request from the government of the Philippines to the government of Japan for technical cooperation.

o June, 1977:

Detailed request from BCGS. The period to be five years.

o 1977:

The government of Japan inquired details via the Japanese Embassy in the Philippines.

o September, 1977:

BCGS replied to the inquiry.

o November, 1977:

Request for additional photographing of the Phil-Japan Friendship Highway from BCGS.

o January, 1978:

The Ministry of National Defense of the Philippines permitted to take out films of the Philippines.

- January 24, 1978 to March 9, 1978:

  Dispatched the JICA Preliminary Survey Mission. Agreed on the S/W joint memorandum.

- February 15, 1979 to May 18, 1979:

  First field reconaissance survey: Photographing, photograph processing.

- February 21, 1979:

  The Aerial Photographing Agreement was signed between International Construction Engineering Association and F.F. Cruz & Co., Inc.

- May 7, 1979:

  Photographing inspection completed.

- May 10, 1979:

  The Survey Mission requested to bring the photographs to Japan at an earliest time.

- November 29, 1979 to December 16, 1979:

  Preparation for the second field reconaissance survey.

- January 7, 1980 to May 28, 1980:

  Second field reconaissance survey: Control point survey, pricking operation.

- October 11, 1980 to December 13, 1980:

  Third year Work in Japan: Photograph processing.

- December 1, 1980 to April 21, 1981:

  Third year field reconaissance survey: levelling, field reconaissance survey, bench mark pricking.

- o June 1, 1981 to January 3, 1982, March 4, 1982 to March 30, 1982:

  Fourth year Work in Japan: Aerial triangulation, plotting, compilation, orthophotomap.

- o January 4, 1982 to March 4, 1982:

  Fourth year field reconaissance survey: Supplementary survey.

- o June 17, 1982 to February 28, 1983:

  Fifth year Work in Japan: Drawing, printing.

(Refer to Attached Table 3.)

Table 3

CAGAYAN VALLEY MAPPING PROJECT

Stage	1				2				3				4				5				
Fiscul Year	1978				1979				1980				1981				1982				
Work Items / Month	4	7	10	1	4	7	10	1	4	7	10	1	4	7	10	1	4	7	10	1	4
Aerial Photography				═	═																
Geodetic Control Survey								═	═												
Pricking								═	═		═	═									
Photo Processing											═										
Leveling												═									
Field Identification												═									
Aerial Triangulation													═	═							
Stereo Plotting														═	═						
Compilation														═	═						
Orthophoto Mapping														═							
Field Completion Survey																═					
Drafting																	═	═	═		
Map Printing																			═	═	
Delivery of Final Results																				═	
Remarks	═══ Duration of Work																				

3. ENGINEERING REPORT

The project to produce maps of the Cagayan Valley area in the Philippines which was started in 1978 was completed in 1982.

It was initially planned to work for four years. Due to delay in agreement between the two governments and also due to possible working seasons, the first year was spent to take photographs, and one year extension was inevitable.

There were various difficulties both in field survey and Work in Japan, but the project was successfully completed as a result of cooperative efforts by Japan and the Philippines. All objectives of the project have been achieved.

This section reports exclusively on engineering aspects related to a series of works on the mapping project. The report places emphasis on the flow of works and technological transfer so that it will be useful to Philippino engineers.

3-1 Aerial Photographing

3-1-1 Outline

Aerial photographing and photo processing were conducted as preparation to develop 1/25,000 topographic maps and 1/10,000 (four places in the area) of the Cagayan Valley area.

In accordance with the existing Philippine security regulations, the above-mentioned operations were performed by the private company in the Philippines. For photographing and photo processing, two Japanese engineers were sent to the Philippines for conducting and controlling the work by sub-contractor.

As for photo scaling, 1/30,000 scale was employed in view of that the Philippines plans to produce 1/10,000 orthophotomaps for studying various development plans, in addition to 1/25,000 topographical maps.

To meet the desire of the Philippines, photographing was done following the flight line passing the center of the 1/10,000 orthophotomap planned map sheet in PTM Projection.

As successful completion of the project was highly dependent on photographing operation, PIPER NAVAJO PA-31-T was assigned and CESSNA 310C was stationed as a standby at the Tuguegarao Airport so that operation could be carried out on sunny days.

3-1-2 Specifications

(i) Area Covered
About 15,000Km^2

(ii) Photograph scale
1/30,000

(iii) Number of courses
24 courses (including five trunk courses)

(iv) Total length of courses
3,538Km

(v) Aerial camera
ZEISS RMK-A 15/23

(vi) Photographing altitude
4,660m to 5,060m

(vii) Overlapping
Overlapping: 60%
Side-lapping: 27.5%

(viii) Camera tilting
Less than 5%
Less than 10% of drift angle

(ix) Allowable cloud density
Less than 5%, provided that there should be no cloud at principal points

(x) Course position
The north-to-south course should be on the center of photomaps.
A trunk course should be placed on the border of each block.

(xi) Local photo processing
Film development, preparation of contact photos

3-1-3 Equipment and Materials Used in Photographing

(1) Photographing airplane

Piper Navajo PA-31-T Registered number: RP-C1120
Cessna 310C Registration Number: RP-C932

(2) Aerial camera

Camera RMK-A 15/23 No.124259
Lens PLEOGON-A f = 152.85mm No.124311
Magazine FK 24/120
Filter B(yellow) No.124400

(3) Film

Kodak Double-X Aerographic 2405 76M length

3-1-4 <u>Photographing</u>

(1) Time of Photographing

January	February	March	April	May	June	July	August
——	——	——	——	- - -	- - -	- - -	- - -

Photographing

September	October	November	December
- - -	- - -	- - -	——

—— December - April dry season

--- May - November rain season

The best photographing season are considered for Dec. to April.

(i) The time of photographing was determined on the basis of the weather data obtained during the prior investigation for the project.

(ii) Photographing was carried out during such hours that no extensive halation would occur.

(2) Photographing Base

There are airports in Tuguegarao, Aparri and Cauayan within the project area, from which the Tuguegarao Airport was selected as a photographing base airport that it is located in the center of the area, it is easy to get supply of fuel and oxygen and it is convenient to transport films as there are daily flights from Manila.

(3) Execution of Photographing

The airplanes were transported to the Tuguegarao airport on March 9 to complete all photographing operations, including re-photographing, by May 5. Re-photographing was necessary mainly due to very poor visibility during the period from the early part of March to the early part of April and also due to secular changes of 1/50,000 topographical maps used in photographing plan.

As Tuguegarao has inland climatic conditions, the temperature went up as high as 38°C during daytime, and therefore every care was taken in keeping films.

(4) Photo Processing

(i) Negative Film

Pictured films were developed in Manila. As rewind development was employed for development, every care was taken to prevent scars and uneven development. In order to obtain optimum images, processing time was changed for individual film rolls.

(ii) Contact Photograph

After developing films, contact photos were produced for orientation inspection.

(5) Quality Control

(i) Preliminary Check

Photos for each course were uncontrolled-mosaiced to be fixed with staples. Photographing planned lines were written on them to measure discrepancies with the flight courses. At the same time, gradients were inspected, and whenever any discrepancy from the Technical Manual of Overseas Surveying of the Japan International Cooperation Agency was discovered, re-photographing was ordered.

(ii) Quality Control

Those photos which passed preliminary check were inspected in detail, in accordance with the Manual, as to overlap, side-lap, K, ω, ψ, etc. to produce an Quality Control Sheet.

(6) Film Annotation and Preparation of Index Maps

As a result of consultation with BCGS, the mode of annotation on films was determined as follows:

	Project Name	Course, Photo Number	Roll Number	Photographing Scale	Date of Photographing
Start	Cagayan Valley	C1-1	R-01	1/30,000	April 15, 1979

		C1-2	R-01		
		:	:		
End	Cagayan Valley	C1-12	R-01	1/30,000	April 15, 1979

Compilation numbers were assigned to those courses which passed photograph accuracy test, and annotations were made as stated above. As for the start and end of photographing, only project name, course number, photograph number and course number were assigned.

Index maps were arranged in the form of index map to be transferred to 1/250,000 topographic maps after completion of quality control.

(7) Results of Photographing
The number of photographs taken per course is as shown in Attached Table 4 and photographing index maps are as shown in Attached Map 1.

(i) Number of films
14 films

(ii) Photographs taken
About 4,100 photographs

(iii) Number of final photographs
1,461 photographs

3-2 Control Point Survey

3-2-1 Outline

Table 4

Description of Aerial Photography

Line No.	Roll No.	Photo No.	Quantity
C 1	13	092 ~ 117	26
C 2 A	12	070 ~ 102	33
B	13	122 ~ 135	14
C	05	127 ~ 150	24
D	14	061 ~ 072	12
C 3 A	11	192 ~ 199	8
B	10	054 ~ 083	30
C	11	224 ~ 258	35
D	13	068 ~ 076	9
E	10	116 ~ 123	8
C 4 A	04	183 ~ 237	55
B	10	165 ~ 185	21
C 5 A	09	062 ~ 074	13
B	11	049 ~ 065	17
C	04	109 ~ 159	51
C 6	04	009 ~ 084	76
C 7 A	11	166 ~ 188	23
B	03	207 ~ 227	21
C	11	138 ~ 159	22
D	13	041 ~ 061	21
C 8 A	11	094 ~ 110	17
B	03	103 ~ 127	25
C	13	010 ~ 039	30
D	13	258 ~ 277	20
S	09	028 ~ 030	3
C 9 A	05	199 ~ 243	45
C 9 B	03	033 ~ 046	14
C	12	249 ~ 274	26
C 10	06	139 ~ 216	78
C 11	12	161 ~ 241	81
S	01	018 ~ 025	8

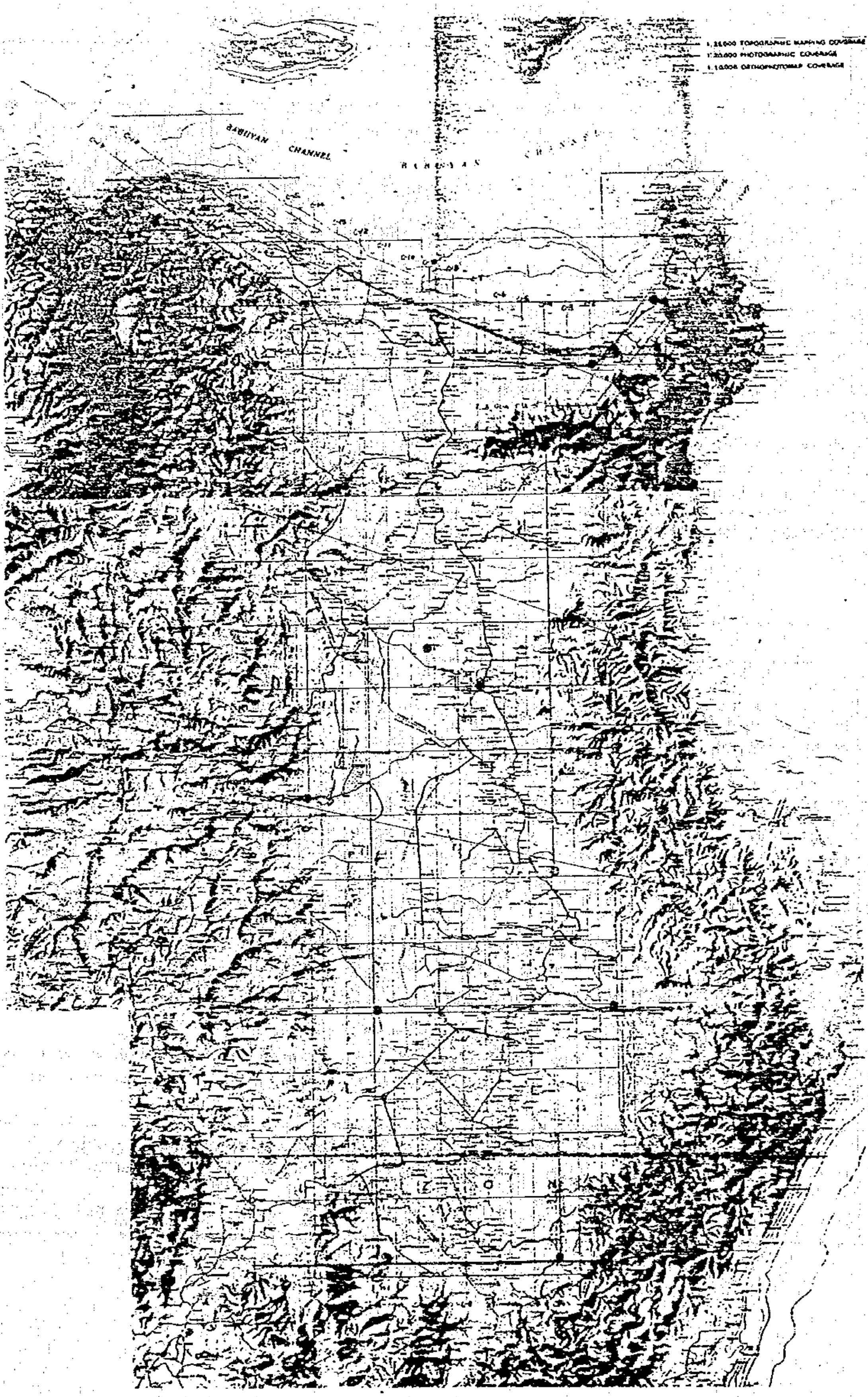
Line No.	Roll No.	Photo No.	Quantity
C 12 A	10	040 ~ 047	8
B	12	127 ~ 148	22
C	06	239 ~ 273	35
D	01	242 ~ 266	25
C 13 A	02	070 ~ 081	12
B	07	020 ~ 030	11
C	02	085 ~ 112	28
D	07	052 ~ 091	40
C 14 A	07	183 ~ 197	15
B	13	194 ~ 208	15
C	10	224 ~ 241	18
D	14	005 ~ 041	37
E	07	099 ~ 111	13
C 15 A	02	223 ~ 238	16
B	07	212 ~ 222	11
C	13	221 ~ 253	33
C 16 A	02	007 ~ 024	18
B	12	005 ~ 016	12
C 17 A	12	030 ~ 039	10
B	09	015 ~ 030	16
C 18	02	182 ~ 201	20
C 19	02	203 ~ 220	18

Line BC			
BC 1	04	240 ~ 273	34
BC 2 A	13	164 ~ 187	24
B	05	020 ~ 032	13
BC 3 A	07	259 ~ 277	19
B	08	047 ~ 064	18
BC 4	08	015 ~ 043	29
BC 5	08	069 ~ 093	25

Total: 1,461 pcs.

Photographic Flight Plan

Map 1



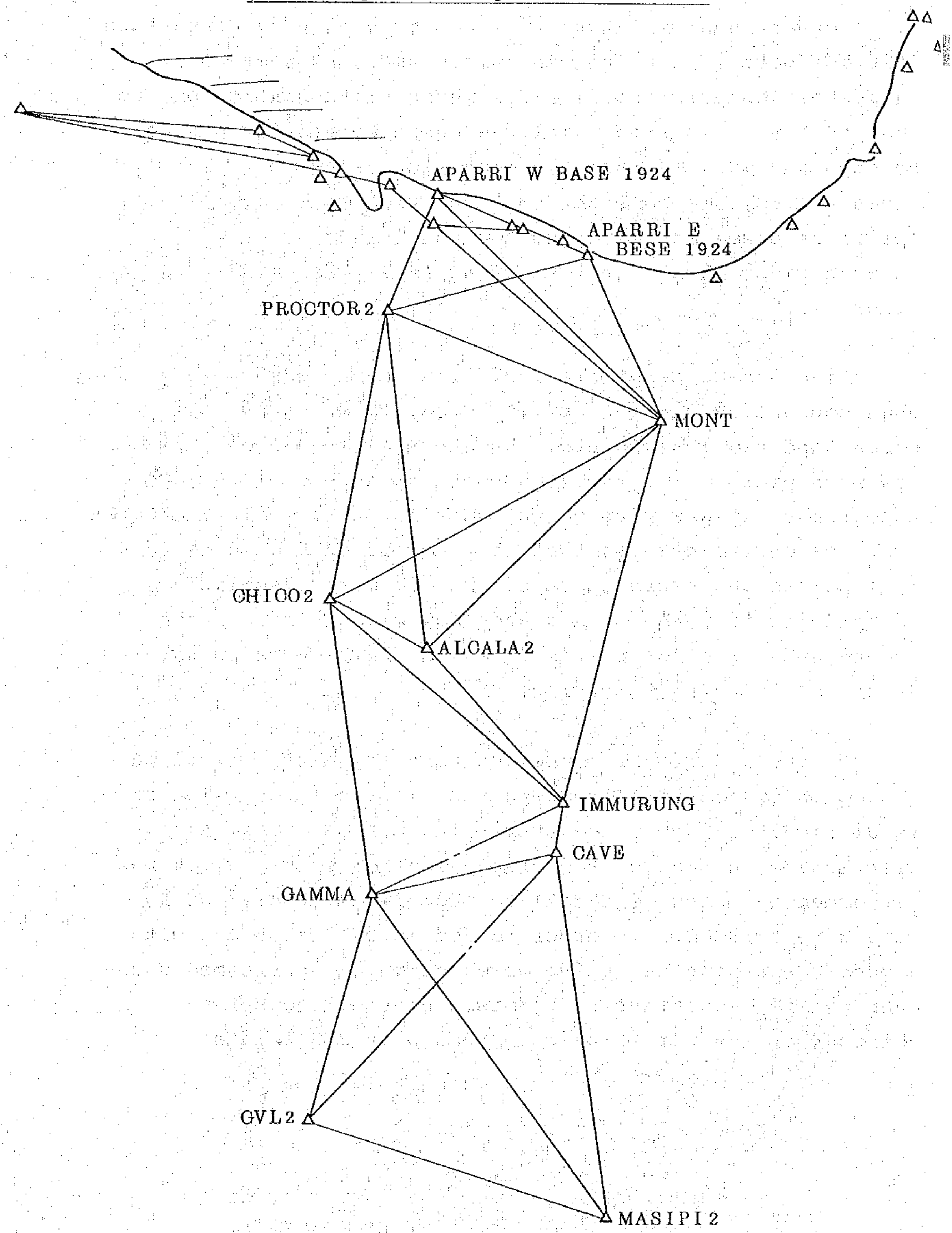
Conventional triangulation has been already done since 1926 for part of the Cagayan Valley area and there are tables of geodetic coordinate. These triangulation points seem to have been used mainly as basic points for marine survey, and many of them are installed along the coastal lines. Also, second order triangulation networks, with Aparri as base, are extended towards inland along the Cagayan River, but do not reach as far as Isabela (Attached Figure 1).

Five second order triangulation points were investigated when conducting the feasibility study to discover three normal and two lost points. As other existing points were not much useful from the standpoint of accessibility and topography, it was planned to install control point networks over the entire area so that they may be used also as control points in future surveys. Survey method applied by the precise traversing, and accuracy classification the second order control points based on the JICA Technical Manual of Overseas Surveying.

Of the area to be mapped, the narrow districts along the northern coastal lines and the districts for which it is difficult to apply the traversing method or triangulation method in view of topography control point survey was performed by means of satellite (Doppler method). Works were done by BCGS. In order to get mutual relations with geodetic coordinates, tying observation was performed whenever possible on traverse points and satellite survey points (hereinafter to be referred to as JMR points).

Figure 1

Index Map of Triangulation Station



3-2-2 Outline of Work

For use in following aerial triangulation, control points including existing triangulation points were field-surveyed with reference to topography, transportation and materials used at the time of feasibility study in order to distribute them with even density. The second order triangulation points were surveyed at an early stage as they were fulcrums for control points to be newly installed, but many of them had been either lost or not known and only three points (CHICO2, GAMMA, MASIPI2 (the name on the mark stone is CABABAN 1964) were usable. These points were distributed rather on the northern side from the middle of the area and azimuthal errors were expected to exert considerable impact. For azimuthal correction, therefore, single azimuthal angle observation was performed using the Polaris at the three points of Aparri, Tuguegarao and Cauayan.

As levelling routes were provided on the National Highway Routes 5 and 3, the three points of Aparri, Tuguegarao and Cauayan were selected, and observation for connection to the nearest control points was done so that bench installation points would not be unbalanced. These points were set as fulcrums for elevation calculation. Although there were some changes in the JMR points carried out by BCGS from the planned points due to topography and other reasons, they were carried out as planned. (Refer to Attached Figure 3 for relationship with geodetic control points.)
Although JMR No. 5 GAMMA is a second order triangulation point, no observation was done by JMR.

3-2-3 Specifications

1. Accuracy

A) Geodetic control point accuracy
Second order control point relative accuracy (1/25,000)

2. Amount of Works

i) Geodetic control point survey (traversing)
45 points

ii) JMR point tieing
4 points

iii) Geodetic control point (traverse point) pricking
45 points

iv) JMR point pricking
4 points

3. Monumentation of Control Points

In accordance with BCGS specifications.

4. Observation and Limitation of Horizontal Angle

Method of direction, three-pair times, 12-second double angle difference, less than 7-second difference of observation.

5. Observation and Limitation of Vertical Angle

Four-pair times by normal and reverse states of transit (simultaneous observation), less than 10-second difference in elevation constant.

6. Observation and Limitation of Distance

All modulation frequencies were read to make them a set, and two sets were measured. 1/75,000 difference between sets.

7. Differential Levelling from a Bench Mark to a Triangulation Station

Two-way observation, less than 10mm $\sqrt{S}$

8. Recording of Points

Attaching of regular routes, sketch and ground photos

9. Calculation

Field rough calculation

Closing error of direction angle:

$2.5\sqrt{N}$ seconds

N: Number of included angles

Coordinate closing error ratio:

1/75,000

Relative height closing error:

$3.0cm\sqrt{\Sigma S^2}$ S: in Km

Precise Computation

(1) Adjustment Computation (coordinates)

Single direction standard deviation	±2.5 seconds
Angle residual	4 seconds
Distance residual	1.0cm x S(Km)

(2) Adjustment Computation (elevation)

Single direction standard deviation	4 seconds
Residual	4 seconds

10. Pricking

Direct or eccentric pricking

Geodetic control points (traverse point)	45 points

JMR points	13 points

11. Unit of Figure

Angle (horizontal, vertical angles)	one hundredth of a second
Side length	one thousandth of a meter

12. Reference Ellipsoid

    Clerke 1866

13. Scale Factor

    0.99995

14. Coordinate at Point of Origin

    $N = 0^{m}.00$ $E = 500,000^{m}.00$

15. Coordinate System to be used

    Zone IV (121°30' - 124°30')

3-2-4 Equipment and Tools Used

1. Transit

    Wild T3
    Wild T2

2. Electro-Optical Distance Meter

    Geodimeter 600
    Geodimeter 6BL
    Hewllet Packard 3800B

3. Level

Auto level, 3-meter staff

4. Target

Signal lamp, heriotrope

5. Weather Measurement

Wide area aneroid barometer
Every other ventilation thermometer

6. Radio

Enny FB 1501 E(5W)

3-2-5 Point Distribution Plan

In view of the JMR point distribution plan to be carried out by BCGS, it was planned to distribute control points along roads as much as possible so that they could be conveniently used. In order to relate them to the existing triangulation points, three second order triangulation points confirmed through the prior investigation were incorporated into the traverse network.

3-2-6 Point Selection

In selecting points in accordance with the point distribution plan, the following points were taken into consideration:

i) That they will be safely kept and the ground is stable.

ii) That it is easy to bury and to observe.

iii) That places are easily recognizable as control points for aerial triangulation.

3-2-7 Monumenting

In accordance with the specifications consulted in advance as to buried control point monumenting, 40cm x 40cm x 70cm concrete blocks were used for principal points and 30cm x 30cm x 50cm concrete blocks for contact points. Steel bolts were used as metal marks. Refer to Attached Figure 2.

Some maintenance and management problems were initially predicted in monumenting, but no influences were experienced on following works as explanations given by the accompanying counterparts made the mayor, the Barangay captain and the residents understood.

3-2-8 Installation of Observation Tower

As a necessity to install towers for observation was pointed out at the time of the prior investigation, temporary scaffold materials for building construction were provided. The towers were specified to be 17-meter high, but their height could be adjusted as they were consisted of the same concrete blocks from top to down. (Refer to Attached Figure 3.) Installation points and tower heights are as follows:

No. 1 11.62m
No. 2 23.49m
No.37 8.41m
No.42 2.87m

Figure 2

Discription of Monument

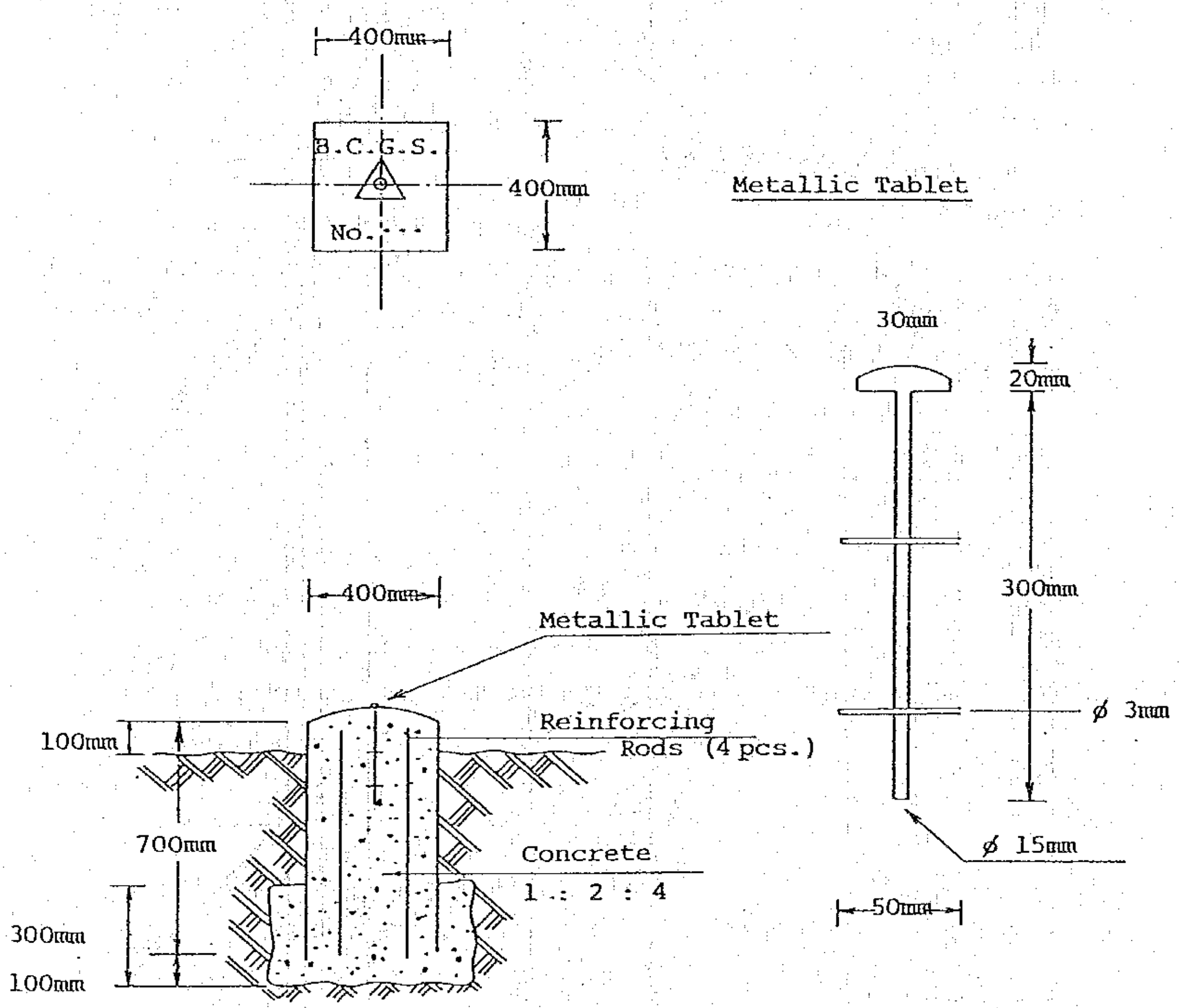
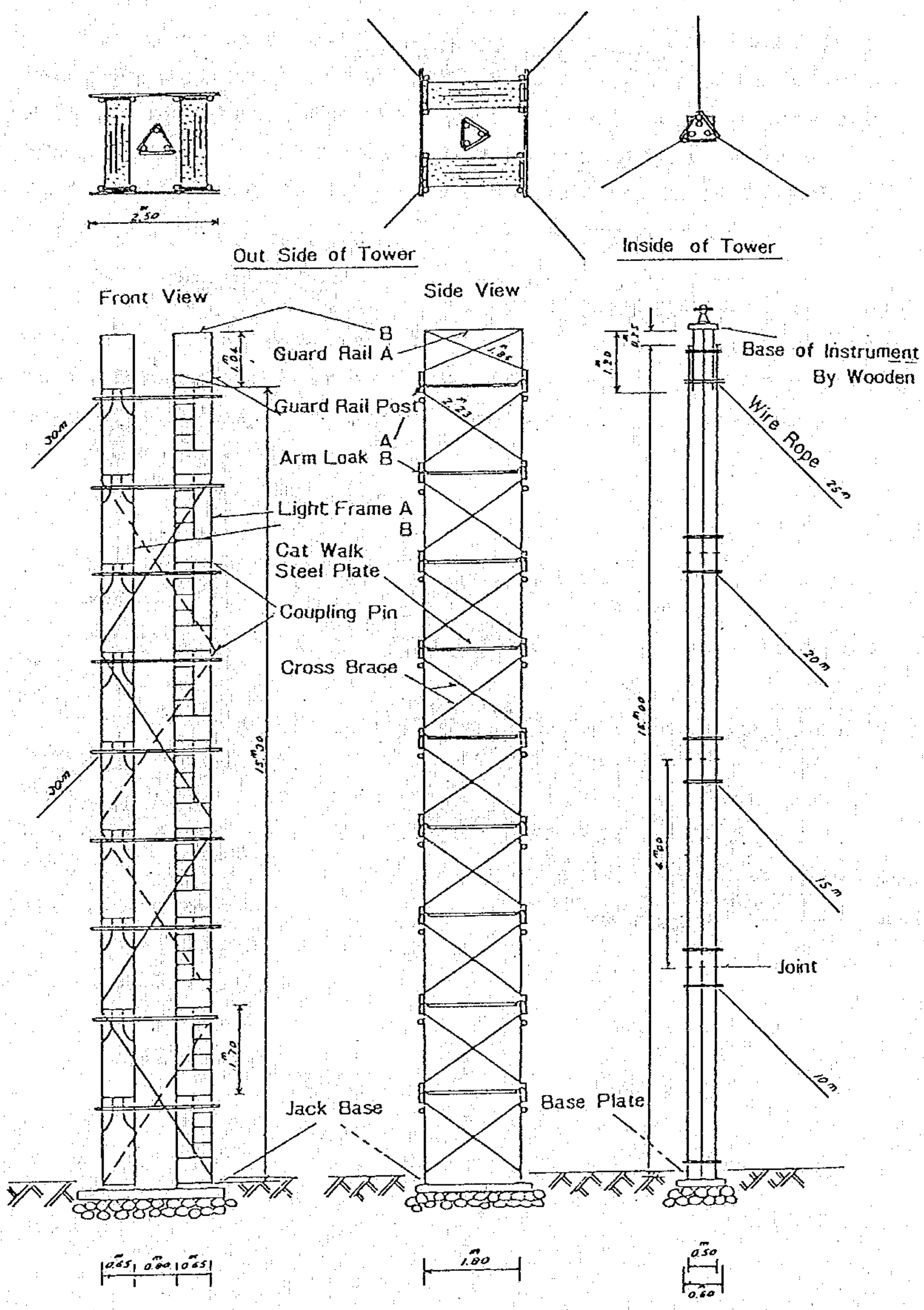


Figure 3

Tower For Observaition scale 1 : 100



3-2-9 Observation

Equipment were inspected and adjusted to start observation as follows, starting at the vicinity of Tuguegarao.

(1) Distance Measurement

Geodimeters were used as range finders. Two-set measurement was made for each side, and the difference between the sets was determined to be less than 1/75,000. When there was a reading exceeding the limit, measurement was repeated. Also, inspection measurement was made when the difference was large even if it was within the limit. Intervals between sets were established to be more than 30 minutes to improve accuracy. In long distance measurement, careful attention was paid to weather measurement as measurement error of temperature and atmospheric pressure would have effects upon accuracy. In order to avoid ground radiant heat, a thermometer was set more than 3 meters above the ground.

(2) Horizontal Angle Observation

Using Wild T3, three-pair (0°, 60°, 120°) observation was performed. For observation, the double angle difference was limited to less than 12 seconds and the observation difference to 7 seconds. If any of them exceeded the limit, re-measurement was performed. For long distance, heriotropes and signal lamps were used as pointing marks.

(3) Vertical Angle Observation

Two set observations were grouped as a set and four sets were simultaneously observed for vertical angle. Intervals between sets were established to be longer than 10 minutes and the difference between elevation constants to be 10 seconds. Observation was made during the period from 9 to 16 o'clock.

(4) Astronomic Azimuthal Angle Observation

In order to improve the accuracy of geodetic network adjustment, azimuthal angle observation was performed using the Polaris as to the three existing control points. Wild T3 was used to observe four set observations (0°, 45°, 90°, 135°). Observation was made at three points of No.2 (azimuth mark No.5), No.15 (azimuth mark JMR No.16 CAG 1972) and No.36 (azimuth mark No.36-1).

(5) Determination of Elevation for Geodetic Control Net

To determine the elevation of JICA Traversing Net, direct levelling from the first order bench marks as given data was performed. The elevation of geodetic control points Nos. 2, 3, 15 and 32 were thus precisely tied to the Philippine national datum to adjust whole geodetic control net.

The discrepancy of duplicate run are limited to:

$\pm 10 \text{ mm} \sqrt{S}$

3-2-10 Computation and Adustment

1. On-Field Rough Estimation

As the second order triangulation points (three points) whose planimetric position was known were observed, GAMMA was fixed to make calculation as to two routes of CHICO2 and MASIPI2 in order to investigate their relative accuracy and to study future ways of calculation. As a result of these operations, the following ratios of closing errors were obtained.

Starting Point	Closing Point	Through Point	Closing Error	ΣS	dS	Remarks
GAMMA	CHICO2	2	1/29,000	$37^{K}.8$	$1^{m}.28$	Distance between two points, 30K
GAMMA	MASIPI2	3	1/55,000	48.0	0.86	Distance between two points, 40K

These triangulation points are estimated to have been installed with Aparri as a base line in around 1924, but data are not available as to equipment used and method of observation. Calculation indicates that the ratio of closing error of the coordinates is less than the second order control point survey accuracy, 1/75,000, specified under the International Cooperation Agency Operation Rules, and is therefore outside the limit. All dSs show a long tendency to cause about 2m error between CHICO2 and MASIPI2. Judging that the error was not in proportion to the distance, but due to some factors other than the distance, one GAMMA was selected as it would invite confusion if three points were used as given data. The horizontal and vertical angles observed and the distance corrected for slope and projection were used to trial-calculate the accuracy of the traverse network. Setting a fulcrum at GAMMA, the coordinate and the angle of direction calculated from the network were used as given conditions for the neighboring networks for calculation to obtain Δx and Δy for each network, and the following equation was applied to calculate the ratio of closing error. (Attached Figure 4 - Control Point Network Chart)

$$\text{Ratio of Closing Error} = \frac{\sqrt{(\Delta x)^2 + (\Delta y)^2}}{S}$$

As for elevation, Nos. 2, 15 and 32 for which direct levelling was performed were given as conditions to calculate the ratio of closing error for relative height.

$$\text{Closing Error} = 3\text{cm}\ \sqrt{\Sigma S^2} \qquad S: \text{ in Km (one way distance)}$$

The calculation results showed that both coordinate and elevation were within the respective limit.
Refer to Attached Table of Traversing Accuracy
Astronomic azimuth were calculated with GAMMA as fulcrum to inspect if observation was proper.

2. Precise computation

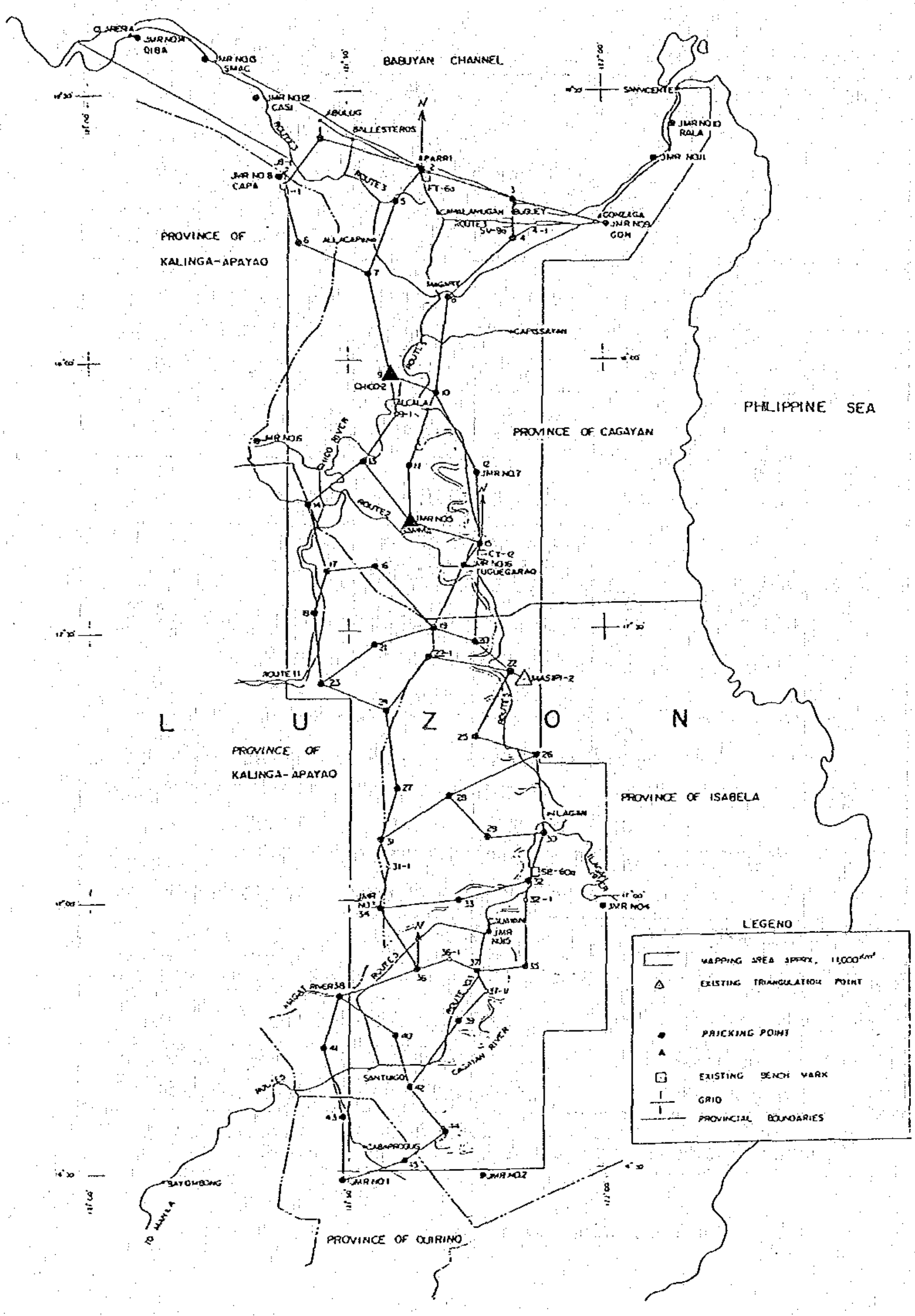
Coordinate rough calculation found that the relative accuracy of the three second order triangulation points was not so good, and thus

Figure 4

CAGAYAN VALLEY TOPOGRAPHIC MAPPING

SECOND STAGE SURVEY SCALE 1:1,000,000

Geodetic Control Net



TRAVERSING ACCURACY

No.	ΣS	dα	dx	dy	ds	dh
1	85.2 km	±6.12″ -3.26	m -0.064	m +0.242	1/340,000	±1.08 m -0.78
2	120.2	±7.07 -5.86	+0.505	+0.268	1/210-	±1.34 +0.96
3	49.1	±5.00 +3.30	+0.371	+0.126	1/125-	±0.79 -0.26
4	76.7	±6.12 +4.37	-0.007	-0.329	1/233-	±0.96 -0.20
5	75.8	±5.59 -1.27	+0.233	+0.211	1/241-	±1.02 +0.18
6	105.3	±7.07 +0.24	+0.248	-0.314	1/263-	±1.15 -0.07
7	76.1	±6.12 -1.17	+0.136	-0.344	1/313-	±0.95 -0.36
8	90.9	±6.61 +3.63	+0.479	+0.439	1/139-	±1.05 -0.14
9	125.0	±7.07 +1.68	+0.010	+0.147	1/850-	±1.34 +0.65
10	59.9	±5.00 +3.59	+0.206	+0.257	1/182-	±0.92 +0.17
11	96.3	±7.07 -0.08	+0.185	-0.269	1/295-	±1.06 -0.43
12	87.6	±7.07 +0.93	-0.285	+0.072	1/297-	±1.00 +0.66
13	86.0	±7.07 -2.11	-0.339	-0.376	1/169-	±0.98 +0.19
14	98.2	±7.07 -1.54	+0.402	+0.311	1/193-	±1.04 -0.26
15	48.5	±5.00 +3.50	+0.369	+0.026	1/131-	±0.79 +0.35

Remarks: Above: Torellance $d\alpha = 2.5\sqrt{N}$ sec

$dH = 3$ cm$\sqrt{\Sigma \ell^2}$

Bottom: Closing error

consultation was held between the two parties to reach a decision as follows:

(A) JMR No.5 (GAMMA) is assumed fixed and azimuth is determined by azimuth observation at Stations Nos. 2, 15 and 36.

(B) The coordinates of No.9 (CHICO2), MASIPI2 and JMR No.5 (GAMMA) and the three coordinates determined under (A) are adjusted by means of the least square method, and calculation with these conditions as given conditions.

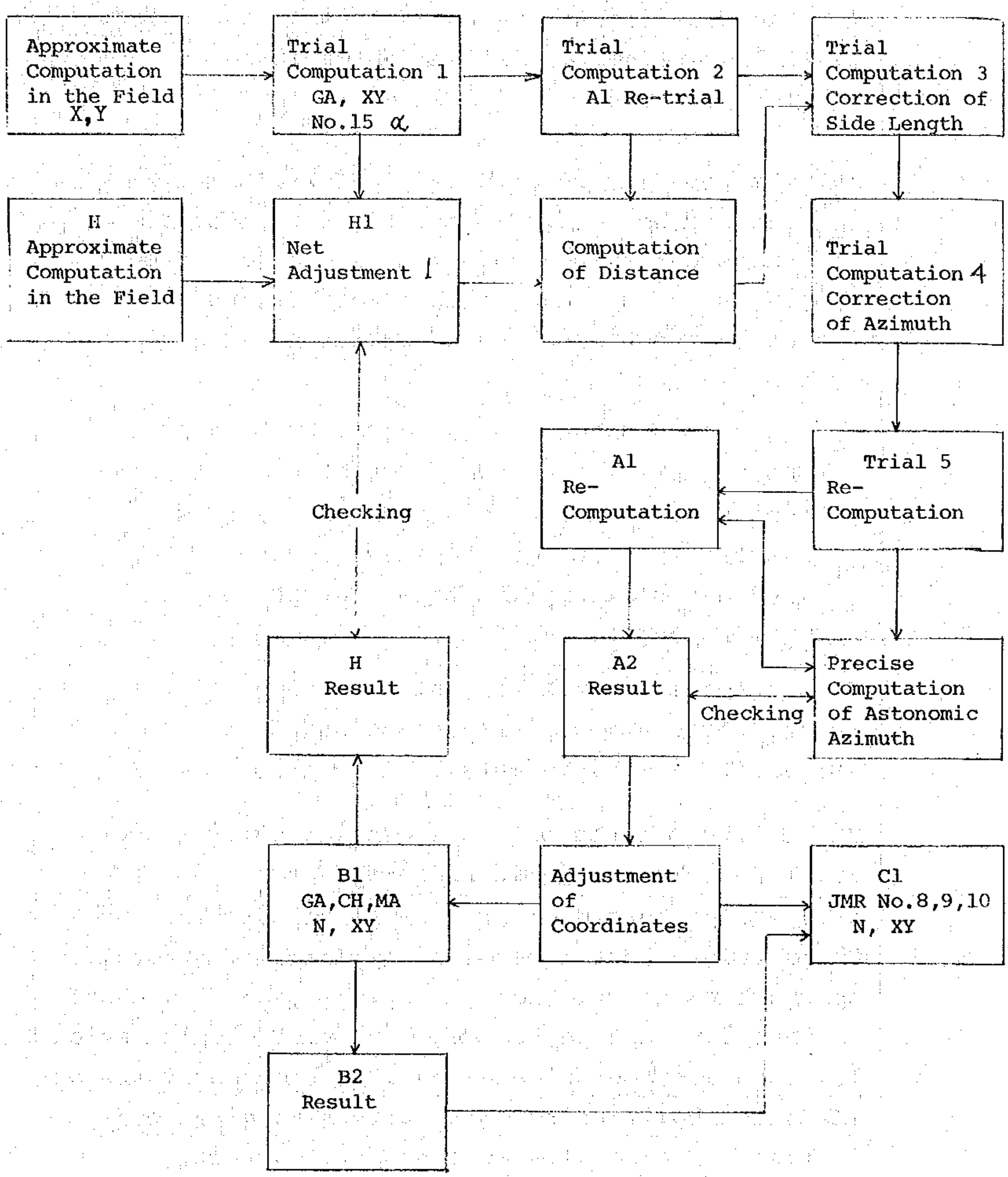
(C) The coordinates of JMR No.8 (CAPA), JMR No.9 (GON) and JMR No.16 (CAG) and the three coordinates determined under (A) are adjusted by means of the least square method, and calculation with these conditions as given conditions.

It was agreed to make adjustment calculation as to the three above-listed plans and to leave (B) as final achievements.

As, in the process of settlement, longitude and latitude for astronomic azimuth, a trial calculation was performed prior to full calculation and these values were determined by means of gradually approaching calculation. A calculation flow chart is as shown in Attached Table 5. Trial Calculation 1 was an average calculation with the coordinate of GAMMA and No.15 Astronomic azimuth as given conditions. The results were used to correct

Table 5

COMPUTATION WORK FLOW



GA : GAMMA

CH : CHICO 2

MA : MASIPI 2

elevation and distance and then to move to Trial Calculation 2. In the same manner, calculations were performed.

After determining results of (A), the coordinates of (B) and (C) were calculated.

Coordinate mean square errors found in the above-mentioned calculations are as shown below:

(A) = 1".43

(B) = 1".05

(C)1 = 1".03 (C)2 = 1.03

Provided that the given conditions of (C) are the results of the JMR point received in the second year. Then in August, 1980, new results including the newly installed points were received, but as the results of JMR No.16 (CAG) were not in the records, additional results were received in the third year and calculation was repeated to obtain the value of (C)2.

The results of JMR points are shown in Attached Table 6.

3-2-11 JMR Geodetic Control

The JMR points carried out by BCGS are as shown in Table 7.

Table 6

Comparison of Coordinates

点　　名	(B)	(C)2	JMR点	δ_1	δ_2	δ_3
ENAEF	m 1823 200.69	m 203.01	m 207.63	m − 2.32	m − 6.94	m − 4.62
	553 189.82	189.12	188.03	+ 0.70	+ 1.79	+ 1.09
BCGS №34	1878 544.70	547.06	547.50	− 2.36	− 2.80	− 0.44
	560 146.03	145.04	142.54	+ 0.99	+ 3.49	+ 2.50
BCGS №12	1967 794.90	797.32	798.55	− 2.42	− 3.65	− 1.23
	579 876.69	875.31	870.52	+ 1.38	+ 6.17	+ 4.79
CAPA	2027 942.25	944.49	943.05	− 2.24	− 0.80	+ 1.44
	538 881.39	879.70	878.49	+ 1.69	+ 2.90	+ 1.21
GON	2018 547.53	550.19	549.84	− 2.66	− 2.31	+ 0.35
	605 970.80	969.16	971.18	+ 1.64	− 0.38	− 2.02
CAG 1972	1948 762.10	764.51	766.30	− 2.41	− 4.20	− 1.79
	576 960.34	959.01	958.21	+ 1.33	+ 2.13	+ 0.80
BCGS №11	1969 259.98	262.33	284.22	− 2.35	−24.24	−21.89
	565 540.02	538.63	537.23	+ 1.39	+ 2.79	+ 1.40

3-2-12 Pricking

Pricking of 45 control points and 13 JMR points were eccentrically indicated at clear points on double-enlarged photos.

Table 7

TABLE OF JMR OBSERVATION STATIONS

STATION	OBSERVED RESULTS	TENTATIVE RESULTS	STATION IN COMPUTATION SHEET	REMARKS
EMAET	16° 29' 6,984"	"	JMR No. 1	Tied to Traverse Net
	121 29 53,367			
MABUR	16 28 46,928		JMR No. 2	
	121 44 32,260			
BCGS No.34	16 59 6,707		JMR No. 3	Used with Traverse Net
	121 33 53,144			
FIL 1980	16 58 58,027		JMR No. 4	
	121 59 16,859			
GABU	17 51 52,079		JMR No. 6	
	121 21 46,050			
BCGS No.12	17 47 27,774		JMR No. 7	Used with Traverse Net
	121 45 11,874			
CAPA	18 20 8,170	8,366	JMR No. 8	Tied to Traverse Net
	121 22 4,153	4,365		
GON	18 14 54,461	54,748	JMR No. 9	Tied to Traverse Net
	122 0 7,315	7,268		
PALA	18 28 2,450	2,450	JMR No.10	
	122 8 41,702	41,741		
PORT 1979	18 22 59,487		JMR No.11	
	122 6 7,324			
CASI	18 29 25,355	25,736	JMR No.12	
	121 19 21,318	21,608		
SMAC	18 32 58,639	58,651	JMR No.13	
	121 12 26,590	26,781		
DIBA 2	18 35 46,552	46,573	JMR No.14	Re-established in 1980
	121 5 26,776	26,749		
CAG 1972	17 37 9. 07	9,038	JMR No.16	Tied to Traverse Net
	121 43 30. 51	30,455		
BCGS No.11	17 48 17,805		JMR No.17	Tied to Traverse Net
	121 37 5,400			

For eccentric measurement, the given point method was employed. A plane table was set at a control point and both given point and eccentric point directions were observed to find their included angles. For distance measurement, electro-optical distance meters or esron tapes were used. Heights were obtained by means of triangulation levelling.

Two sets of measurement were performed to determine the coordinate and elevation of eccentric points.

3-3 Levelling

3-3-1 Outline

In the Cagayan Valley area, the first order levelling route installed by BCGS is provided over about 430Km along National Highway Routes 3 and 5, and observation was completed in 1979 over about 26Km between the Magapit Bridge and Bangaku. Using these bench marks as given point, levelling required for aerial triangulation and plotting was performed this time. As for areas where it was difficult to perform direct levelling due to topographic restrictions, it was determined to conduct indirect levelling.

The Cagayan Valley levelling network charts are as shown in attached Figures 5 and 6.

3-3-2 Outline of Work

Of the direct levelling routes, the routes between Enrile and Tabuk, Santa Maria and Quezon, and Marigue and

Figure 5

EXISTING LEVELLING NET

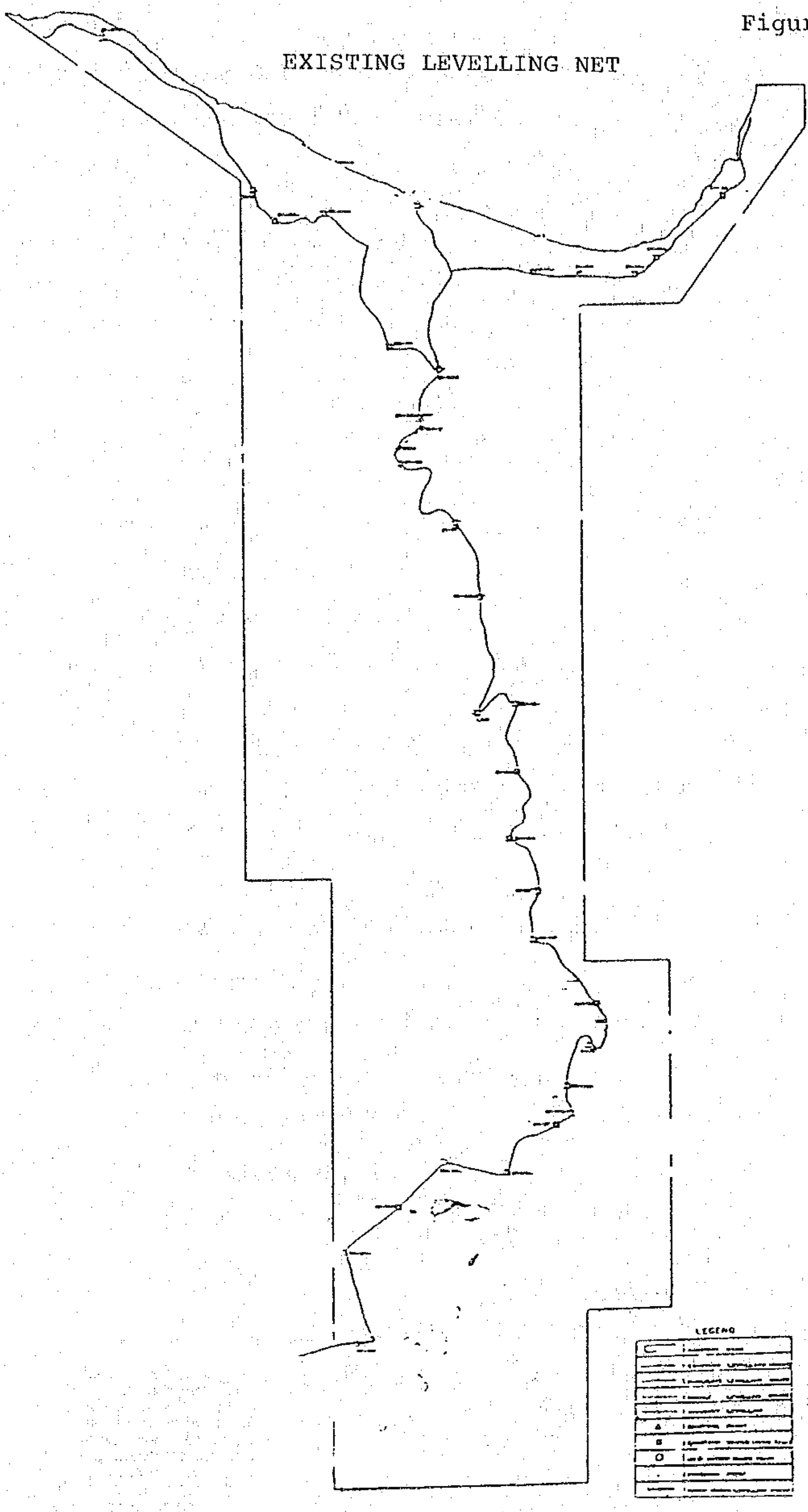
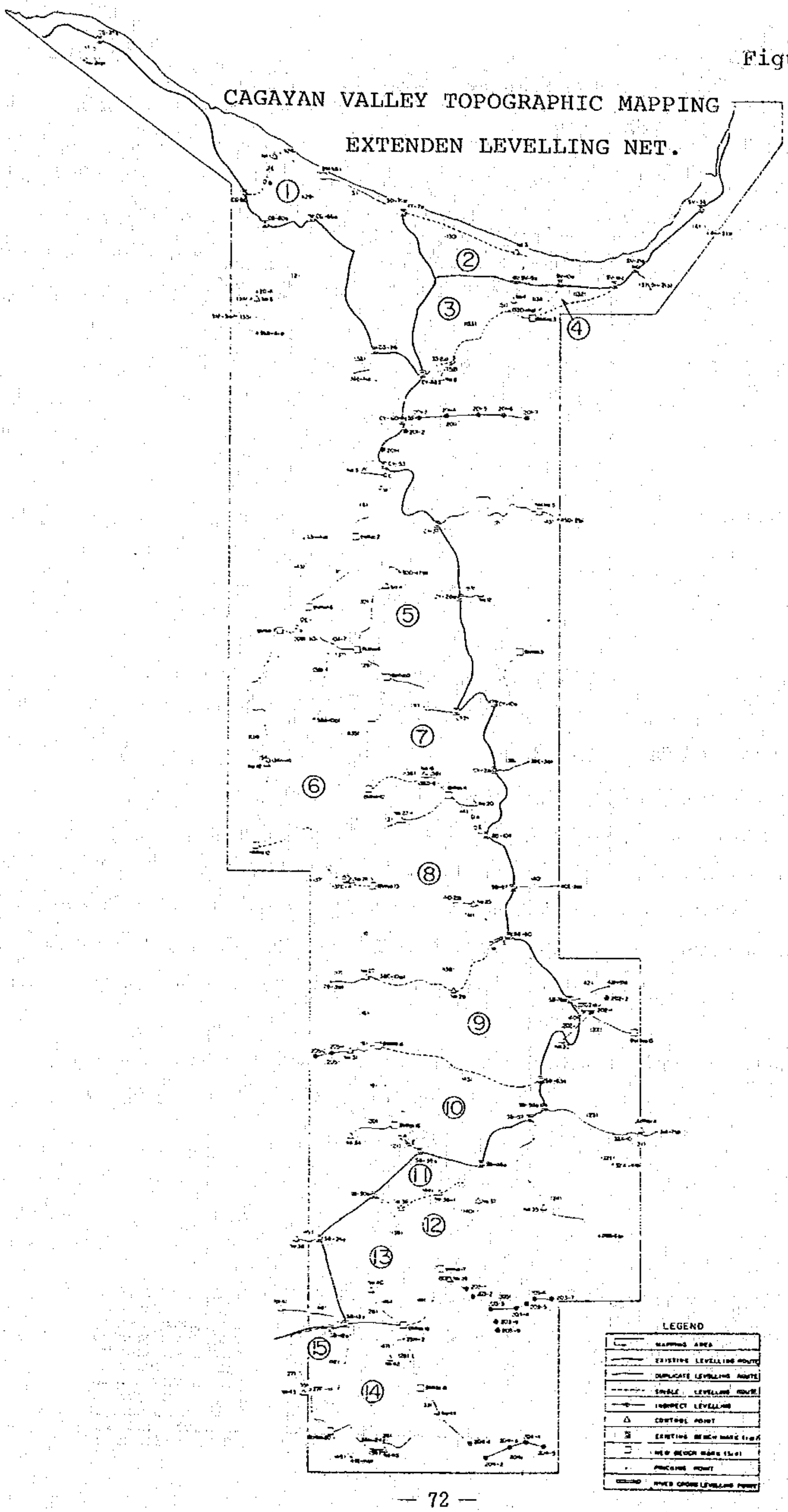


Figure 6

CAGAYAN VALLEY TOPOGRAPHIC MAPPING

EXTENDEN LEVELLING NET.



San Antonio had large relative height differences as they passed through hill tops, but other routes had relatively small relative height differences, and it was therefore possible to carry out works smoothly. As the newly installed control points, elevation was determined by means of indirect levelling, and it was planned to pass through these points as many as possible on the flat areas.

3-3-3 Specifications

1. Order

   Third order levelling

2. Amount of Operation

Direct levelling	460Km	(duplicate line)
	340Km	(single line)
Indirect levelling	80Km	
Over-river levelling	6	places
Burying	20	points

3. Given Points

   First order points installed by BCGS

4. Bench mark intervals

   One bench mark stone per 10Km as a rule

5. Length of Sight

   Less than 70m

6. Instrument Used

   Auto Level (direct levelling)

   Wild T2 (indirect levelling)

   Electro-optical distance meter (indirect levelling)

7. Indirect levelling

   Number of observation sets ...

4 sets (simultaneous observation)

Elevation constant difference ...
less than 10 seconds

8. Limitation

Clousure divergence... 10mm $\sqrt{S}$

Loop closing error ... 10mm $\sqrt{S}$

S: One way distance in Km

3-3-4 Equipment and Tools Used

1. Transit

   Wild T2

2. Electro-Optical Distance Meter

   Hewlet Packard (3808A)

3. Level

   Auto level 3-m staff (single graduation, double graduations)

4. Target

   Heriotrope, signal lamp

5. Radio

   Enny FB1501E Type (5W)

3-3-5 Selection of Levelling Routes

In view of control point distribution, aerial triangulation and levelling network supplement, levelling networks were divided as follows for selection.

1. Direct Levelling Routes

   (i) Duplicate line Observation Routes

Routes connecting existing first order bench marks and open routes due to difficulty to form a loop due to topographic conditions.

(ii) Single line Observation Route
Routes connecting existing first order bench marks and routes for which loop closing conditions are satisfied with the bench marks newly established under (i) as given points.

2. Indirect Levelling (triangulation) Routes

Routes for which it is difficult to perform direct levelling due to topographic restrictions.

3. River-Crossing Levelling

Points on direct levelling routes which cannot be observed with standard staff distance due to topographic conditions.

3-3-6 Point Selection, Monumenting

Townhalls, passage route marks, schools and passage route cross points were selected to bury new bench marks, taking into consideration future convenient utilization. In so doing, the following matters were confirmed.

a. That they will be securely kept and the ground is stable.

b. That it is easy to bury and to observe.

c. That they will not obstruct traffic.

Concrete blocks of 30cm x 30cm x 50cm were buried, and iron bolts were used as metal marks. (Refer to Attached Figure 7.) As burying records, point records showing place, owner or controller and route from the nearest city, town or village were prepared.

In burying marks, some maintenance and control problems were initially expected, but there were no influences on following operations as most of marks were buried on public-owned lands.

3-3-7 Observation

1. Direct Levelling

   i) Duplicate Run

   An auto level was used as level and a single graduation staff (3 meters) was used. The existing bench marks to be used were inspection-measured in relation to the neighboring points to confirm existing abnormalities. They were used as starting and closing points. During observation operation, the following points were always inspected.

   (A) Inspection and adjustment of circular level.

   (B) Inspection of collimation lines.

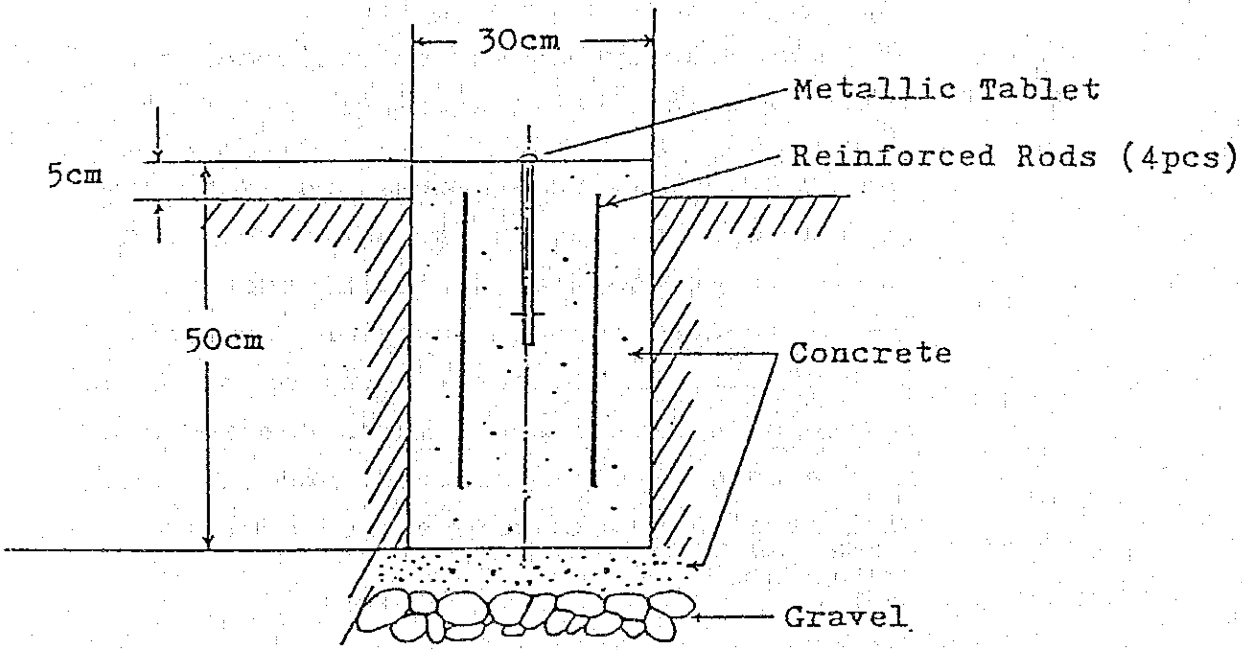
   (C) Inspection and adjustment of staff-attached level.

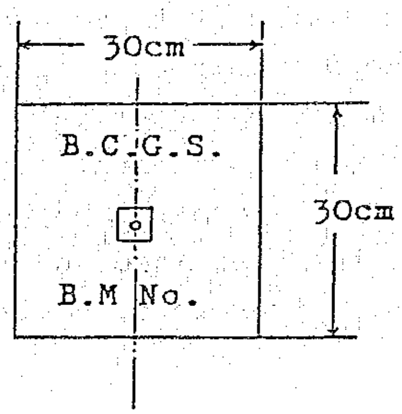
   As the average distance between newly established bench marks was 10Km, temporary points (fixed points) were established to inspect closure discrepancy.

Figure 7

BENCH MARK

Scale 1/10





ii) Single Run

An auto level was used as level and a double-graduation staff (3 meters) was used to observe 4 pointings and 4 readings. Inspection-measurement between given points and inspection of instruments were performed in accordance with i) above. As closure discrepancy could not be inspected due to one-way observation, the right-left discrepancy at each observation point was limited to less than 3 mm and the average of these discrepancy was established as a relative height between points.

In direct levelling as mentioned above, installation observation was performed as to 26 points on the flat areas in order to confirm control point elevation accuracy. As a result, there were a total of 30 points including 4 direct bench marks carried out in the second year operation, and relations with level networks were satisfactorily maintained.

2. Indirect Levelling

Indirect levelling was performed as to areas where it was difficult to conduct direct levelling due to topographic conditions. Elevation may be determined by observing vertical angle and distance. I f horizontal angle is observed and installed to a control point, a horizontal position may be determined and may be used as a control point. Therefore, horizontal angle observation was performed as to all routes, taking into consideration aerial triangulation. Observation points were pricked on contact photos.

i) Horizontal Angle Observation
Wild T2 was used to perform two set observations (0°, 90°). As observation limitations, 12-second double angle difference and 7-second observation difference were used. Signal lamps were used as targets.

ii) Vertical Angle Observation
Using Wild T2, four set observations were simultaneously done for each direction. Also, taking into consideration weather changes, more than five-minute intervals were taken between sets.

iii) Distance Measurement
Using Hewllet Packard 3808A, one set (four readings) of observation was done. In order to avoid heat reflextion from the ground, a thermometer was set two to three meters above the ground to measure temperature. An Aneroid Atmospheric Pressure Meter was used to measure atmospheric pressure.

3. River-Crossing Levelling
River-Crossing levelling was performed as to six places where there were no bridges and it was not possible to make observation at an ordinary staff distance (less than 70 meters).
In so doing, signal targets were constructed at

each over-river point to install a signal lamp. The maximum length between over-river points was 1,000 meters.

i) Vertical Angle Observation
Using Wild T2, two sets (each set consisting of ten pairs) of observation were simultaneously made. Each set was symmetrically divided with 13 o'clock in the center.

ii) Distance Measurement
Using Hewllet Packard 3808A, two sets, each set consisting of four readings, of measurement were done. An interval of more than 30 minutes was left between sets, and set-to-set discrepancy was limited to less than 35mm. Weather measurement was performed in accordance with 2-iii).

3-3-8 Computation

(1) Field
Using the observed values obtained through direct levelling (duplicate line routes, single line routes) and the calculated values obtained through over-river levelling, loop closure was investigated. For over-river levelling calculation, vertical angles and corrected distances were used to make calculation for each set, and the average obtained was made a relative height value. Using results of fulcrums obtained from BCGS, loop closure was

investigated to discover that all were within the limit of allowable error.
(Refer to Attached Table 8.)
For indirect levelling, vertical angles and corrected distances were used to make calculation separately for positive and negative directions to inspect their matching discrepancy. The refractive factor was set at 0.13.

(2) Precise Computation
Using a computer, bench mark results were computed for three blocks of Aparri, Tuguegarao and Cauayan. The elevation average mean square errors obtained from the network average are as follows.

Aparri Area	$\pm 5.65^{mm}$	(Loop Nos. 3 and 4)
Tuguegarao Area	± 4.88mm	(Loop Nos. 5, 6, 7, 8, 9, 10)
Cauayan Area	± 5.03mm	(Loop Nos. 11, 12, 13, 14, 15)

The elevation of the control points carried out in the second year operation was calculated with the three direct levelling points (Nos. 2, 15, 32) as given points. As twenty-six points installation observation was performed in the third year operation, the elevation was calculated again to improve accuracy with the above as given conditions. Elevations are compared as shown in Attached Table 9.

Table 8

CLOSURE TABLE OF LEVELLING LINKS

LINK No.	ROUTE LENGTH	TOLERANCE	CLOSURE	REMARKS
1.	km 29.8	mm ± 54	mm + 44	
2.	25.7	± 50	+ 15	
3.	28.0	± 52	+ 34	
4.	15.0	± 38	+ 12	
5.	65.6	± 80	+ 14	
6.	163.4	± 127	− 48	
7.	68.7	± 82	− 50	
8.	79.3	± 89	− 35	
9.	69.0	± 83	+ 13	
10.	52.1	± 72	+ 14	
11.	39.4	± 62	+ 13	
12.	58.4	± 76	− 40	
13.	38.1	± 61	− 25	
14.	71.7	± 84	+ 30	
15.	53.8	± 73	− 46	

Table 9-1

TABLE OF ELEVATION

Station No.	1980	1981	1981 - 1980	Remarks
	m	m	m	
No. 1	34.15	34.455(D.L.)	+ 0.30	(D.L.) : Station
No. 1 - 1	65.09	65.36	+ 0.27	connected with
No. 2	1.400			2nd Order National
No. 2E	12.590			Bench Mark by
No. 3	5.079	5.051(D.L.)	- 0.03	direct leveling.
No. 4	59.42	59.153(D.L.)	- 0.28	
No. 4 - 1	45.20	44.94	- 0.26	
No. 5	43.84	43.89	+ 0.05	
No. 6	77.63	77.862(D.L.)	+ 0.23	
No. 7	116.35	116.54	+ 0.19	
No. 8	104.82	103.415(D.L.)	- 1.40	
No. 9	178.30	178.69	+ 0.39	
No. 9 - 1	125.25	125.59	+ 0.34	
No. 10	207.08	207.17	+ 0.09	
No. 11	21.92	22.195(D.L.)	+ 0.28	
No. 12	74.18	74.268(D.L.)	+ 0.09	
No. 13	121.79	122.00	+ 0.21	
No. 14	118.82	118.94	+ 0.12	
No. 15	75.948			
No. 16	110.60	119.61	+ 0.01	
No. 17	323.99	323.98	- 0.01	
No. 18	135.45	135.370(D.L.)	- 0.08	
No. 19	181.37	181.456(D.L.)	+ 0.09	
No. 20	60.42	60.481(D.L.)	+ 0.06	
No. 21	402.74	402.73	- 0.01	
No. 22	92.04	92.00	- 0.04	
No. 22 - 1	128.94	128.674(D.L.)	- 0.27	

Tabel 9-2

Station No.	1981	1980	1981 - 1980	Remarks
	m	m	m	
No. 23	264.50	264.37	- 0.13	
No. 24	222.69	222.391(D.L.)	-0.30	
No. 25	30.96	30.848(D.L.)	- 0.11	
No. 26	146.02	145.92	-0.10	
No. 27	58.49	57.369(D.L.)	-1.12	
No. 28	122.55	122.028(D.L.)	-0.52	
No. 29	63.30	63.12	-0.18	
No. 30	116.56	116.73	+0.17	
No. 31	100.96	100.447(D.L.)	-0.51	
No. 31 - 1	91.33	90.82	-0.51	
No. 32	81.070			
No. 32 - 1	80.83	80.82	-0.01	
No. 33	48.00	47.77	-0.23	
No. 34	157.49	156.971(D.L.)	-0.52	
No. 35	97.66	97.511(D.L.)	-0.15	
No. 36	73.42	72.783(D.L.)	-0.64	
No. 36 - 1	65.05	64.386(D.L.)	-0.66	
No. 37	63.57	63.192(D.L.)	-0.38	
No. 37 - 1	75.84	75.45	-0.39	
No. 38	156.33	156.514(D.L.)	+0.18	
No. 39	66.38	65.922(D.L.)	-0.46	
No. 40	75.02	75.485(D.L.)	+0.46	
No. 41	115.65	115.093(D.L.)	-0.56	
No. 42	106.81	106.976(D.L.)	+0.17	
No. 43	180.34	180.598(D.L.)	+0.26	
No. 44	130.67	130.749(D.L.)	+0.08	
No. 45	153.88	153.088(D.L.)	+0.01	
JMR No. 16	42.10	42.12	-0.02	CAG 1972
JMR No. 1	424.37	424.50	-0.13	ENAEF
JMR No. 9	164.59	164.43	-0.16	GON

Table 9-3

Station No.	1981	1980	1981 - 1980	Remarks
MASHPI 2	$190^{m}.92$	$190^{m}.08$	$-0^{m}.04$	
JMR No. 5	193.24	193.43	- 0.19	GAMMA
JMR No. 4		114.265 (D.L.)		FIL 1980

3-3-9 Pricking

In order to use in following aerial triangulation and plotting operations, control points were pricked using existing first order bench marks, newly installed third order bench marks and indirect bench marks.

Pricking was done on 2 times enlarged photos, confirming positions relative to surrounding planimetric features. Those points which could not be clearly confirmed on photos such as roads and bridge tables were eccentrically indicated. Results of investigation of the existing bench marks are as shown below.

Total distance	Total points	Pricking points	Lost points	Lost rate	Remaining rate
457Km	340 P	308 P	32 P	9.4%	90.6%

3-4 Field Identification

3-4-1 Outline

Data required to compile 1/25,000 topographic maps and 1/10,000 orthophotomaps (about 300Km^2) of the area covered (about 11,000Km) were collected, and topography and planimetric features were surveyed for confirmation. Upon consultation between Japan and the Philippines, rules were made and operations were carried out in accordance with the rules thus made. Bordering, place naming and annotation were done by BCGS.

It was decided to directly indicate by color pen survey

results on the photos which were brought (uncontrolled mosaic photos, 1/25,000), and overlays were used as for place names, annotation and complex districts.
All survey matters were decided to be completed at the site, without leaving any questions. Data on isobathymetric lines, neat line divisions and map sheets required in following operations were received from BCGS.

3-4-2 Map Symbols Rules

Rules to apply BCGS 1/25,000 map symbols received during the second year were prepared in advance, and its English version "Manual of Guideline for Field Identification" was consulted with BCGS. On the basis of this English version, definition of symbols, uniform interpretation, limit of indication and methods of expression were discussed thoroughly for codification.

Incidentally, discussion was made at BCGS. It was decided to handle any question upon consultation with the counterpart if any occurred on the site.

3-4-3 Field Identification

(1) Preparation
On the basis of already surveyed maps (1/250,000, 1/50,000) and neat line divisions, uncontrolled mosaic photos were developed. On these sheets, the areas surveyed and ordering numbers were written, and photo-interpretation and preliminary photo-interpretation were performed.

After arriving at the site, confirmation was made as to "Manual of Guideline for Field Identification" and the area to be covered was divided into three blocks in view of characteristics to make discussion with the counterpart on such matters as additional preliminary photo-interpretation operation, development of interpretation keys and measures to deal with secular changes.

(2) Verification of Interpretation Keys
The survey area was divided into three blocks of Aparri, Tuguegarao and Cauayan. To achieve technological transfer, the counterpart and the local survey group made a joint field survey to understand planimetric features and land classification items on photos. Methods of expression were confirmed, and also interpretation keys were verified.

(3) Field Confirmation
Of those arranged on the basis of photo-interpretation keys, questionable ones and those which were not clear were re-confirmed on the site.

3-4-4 Collection of Data

It was decided that the counterpart would collect data at the time of confirmation of photo-interpretation keys and also at the time of on-site confirmation survey. The counterpart collected data concerning border, place name and annotation on the basis of the matters consulted and confirmed with the survey group.

3-4-5 Arrangement

Photo-interpretation keys were arranged, and matters incorporated thus were preliminarily arranged. Moreover, inspection was performed on the basis of 1/50,000 topographic maps, other data and field reconnaissance survey photos, and the secondary arrangement was made, paying attention to secular changes and matching.

The counterpart was guided to pay attention especially to annotation spelling, and technological transfer was effected as to the flow of operation and methods of operation.

All works related to arrangement were completed on the site.

3-5 Aerial Triangulation

3-5-1 Outline

Aerial triangulation was performed by means of the block adjustment of aerotriangulation method. The entire area was divided into five blocks, and framework courses were planned, by means of photographing operation, close to the border of each block in order to improve accuracy.

3-5-2 Division into Blocks

As for block division, the entire area was divided into five blocks, each consisting of about 300 models, taking into consideration distribution of control points. Those courses with a larger number of models were so divided at the positions of trunk courses, as a rule, that two to four models would overlap. Each block was so organized that there would be courses containing control points and trunk courses. (Refer to Attached Figure 8).

The names of blocks covering multiple blocks, the number of blocks forming each block, the number of models forming each block and the number of control points used are as shown below:

Block Name	Overlapping Course
1 - 2	C-9A
1 - 3	BC - 2A, C - 15C
2 - 3	BC - 2B
3 - 4	BC - 3A, BC - 3B, C - 13D
4 - 5	BC - 4

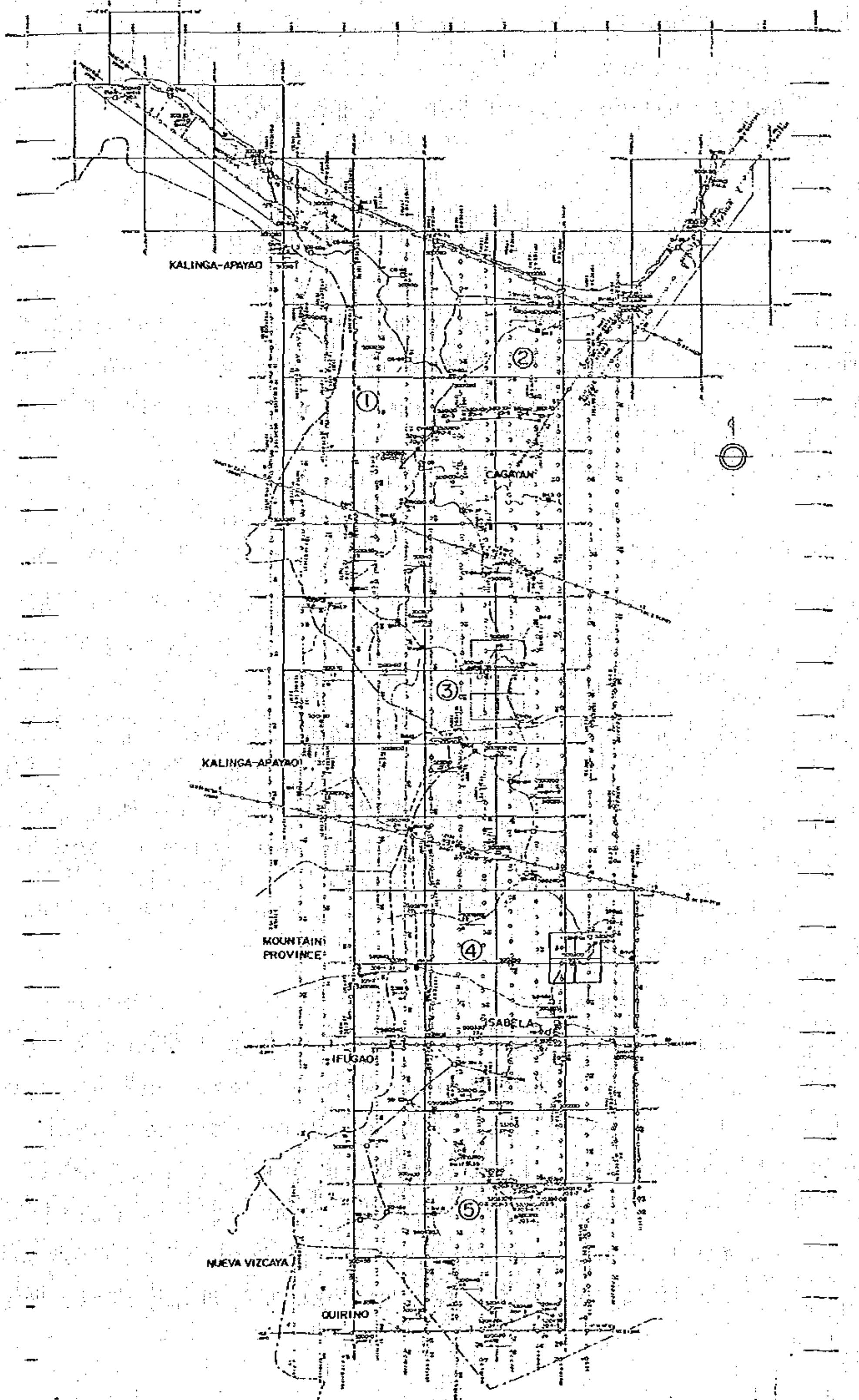
Block Name	Number of Course	Number of Model	Number of Control Point	
			Horizontal	Height
1	18	257	29	194
2	16	223	27	214
3	21	339	42	160
4	17	233	40	134
5	18	284	39	127

Figure 8

CAGAYAN VALLEY TOPOGRAPHIC MAPPING
Index Map for Block Adjustment

PLANNING ORGANIZATION : JAPAN INTERNATIONAL COOPERATION AGENCY, 1978~1982
EXECUTIVE ORGANIZATION : INTERNATIONAL ENGINEERING CONSULTANTS ASSOCIATION

MAP SCALE 1: ,000 MAPPING SCALE 1:25,000
PHOTO SCALE 1:30,000 ORTHO PHOTO SCALE 1:10,000



3-5-3 Major Equipment

(i) Model PUG II (Wild)
(ii) Stecometer (Carl Zeiss Jena)
(iii) Melcom-Cosmo-500 (Mitsubishi)

3-5-4 Point Selection and Point Transfer

Using point transfer devices, points were selected, each model being looked at stereoscopically. Then, points were pricket and marking was made on positive films.

(1) Pass Point

One pass point was selected as a rule close to the photo principal, and one pass point each at each end of a line roughly perpendicular to the principal basic line and passing through the part close to the principal.

A place where stereoscopic looking was sufficiently possible on three consecutive photos and which was flat was selected as a point selection position which was pricket and red-marked on positive films.

(2) Tie Point

More than one tie point were selected for each model at places where it was possible to perform measurement and where there was an overlapping with the neighboring course. Tie points were also used as pass points as a rule, and transferred. When it was difficult to transfer points, wing points were selected on both photos, and pricket. The points thus selected and pricket were blue-marked as tie points. "T" was written after each tie point.

(3) Transfer of Control Point
The positions pricked on the site were transferred to positive films from control point statements, using precision point transfer devices and making stereoscopic observation.

3-5-5 Measurement of Photo Coordinate

Using stereocomparators, fiducial marks, pass points, tie points and control points contained in each model were independently measured twice.

When the discrepancy was more than 0.02mm, another measurement was added to adopt an average of all measured values. When the fiducial mark residual was more than 0.03mm, the residual vertical parallax of mutual orientation was more than 0.03mm on positive films or when the pass point discrepancy between the neighboring models was more than 0.5% of the photographing height as to both planimetry and height, the model was re-measured.

3-5-6 Computation of Conversion to Geodetic Coordinates

Code numbers were assigned to control points, pass points and tie points as their data were entered into the computer. Photo coordinates were measured and adjustment computation was performed.
Taking into consideration distribution of control points

contained in each course, adjustment was performed for each block, separately for horizontal and vertical.
Code numbers are as follows:

Example:

a. Control Point

300010 ..... JMR1 main point

300011 ..... JMR1 eccentric point

400010 ..... bench mark

500010 ..... control point 1 main point

500011 ..... control point 1 eccentric point

b. Pass Point, Tie Point

```
21012 ...... 2A course, photo number 1, pass
|  | |        point number 2
|  | |
|  | |.... pass point number
|  |
|  |...... photo number
|
|........ course number ......... 2A course ..... 21
                               |... 2B course ..... 22
                               |... 2C course ..... 23
```

3-5-7 Adjustment and Accuracy

Between-course block adjustment calculation was performed separately for plane and elevation. The same weight was added to control points and tie points to repeat weight calculation in order to improve and secure accuracy.

This process was performed for each block to make

conversion to geodetic coordinates.
As adjustment calculation accuracy factors, the mean square error and maximum error of each block were all within the limits established as shown in the Table 10.

3-6 Plotting

3-6-1 Outline

Plotting operation was carried out separately for plane tables, contour lines and vegetation tables, taking into consideration that vegetation distribution was fine, topographic changes were big, etc.

3-6-2 Specifications

(i) Plotting Scale
1:25,000

(ii) Plotting Area
11,200Km^2

(iii) Contour Line
10-meter contour line, 50-meter index contour line, 5-meter half interval contour line, 2.5-meter quarter interval contour line.
Provided that both half and quarter interval lines are indicated in accordance with topographic conditions.

(iv) Plotter
Autograph A10, Stereoplotter A8, Metrograph, Planimat, Planicart.

Block Adjustment Accuracy

Black	Models	Control Point		Residuals of Control Points				Descripanicies of Tie Points	
				Horizontal		Vertical		Horizontal	Vertical
		H	V	R.M.S.E	Max.	R.M.S.E.	Max.	Maximum	Maximum
1	257	29	195	2.12	3.31	1.20	3.30	3.31	-3.41
2	223	27	214	2.28	3.25	1.17	3.28	3.33	3.35
3	339	42	160	2.23	3.41	1.42	3.35	3.24	3.34
4	233	30	134	2.06	3.29	1.16	-2.80	3.35	3.29
5	284	39	127	2.27	3.23	1.31	3.33	3.46	3.33

(v) Projection Method

UTM projection, 2.5' section, 1Km tick.

(vi) Neat Line

East-to-West 7.5' x South-to-North 7.5'.

(vii) Plotting Paper

Polyester base (#500)

(viii) Plotting

High speed automatic drawing device

3-6-3 Plotting of Control Points, etc.

Neat lines, section lines, longitudinal and latitudinal lines, control points, pass points and tie points were plotted. The maximum error was limited to less than 0.2mm on drawings. High speed automatic drawing devices were used for plotting. (Sheet Index is Shown in Figure 10.)

3-6-4 Orientation

(1) For relative orientation, six pass points were used. The residual vertical parallax was limited to less than 0.02mm on contact positive films.

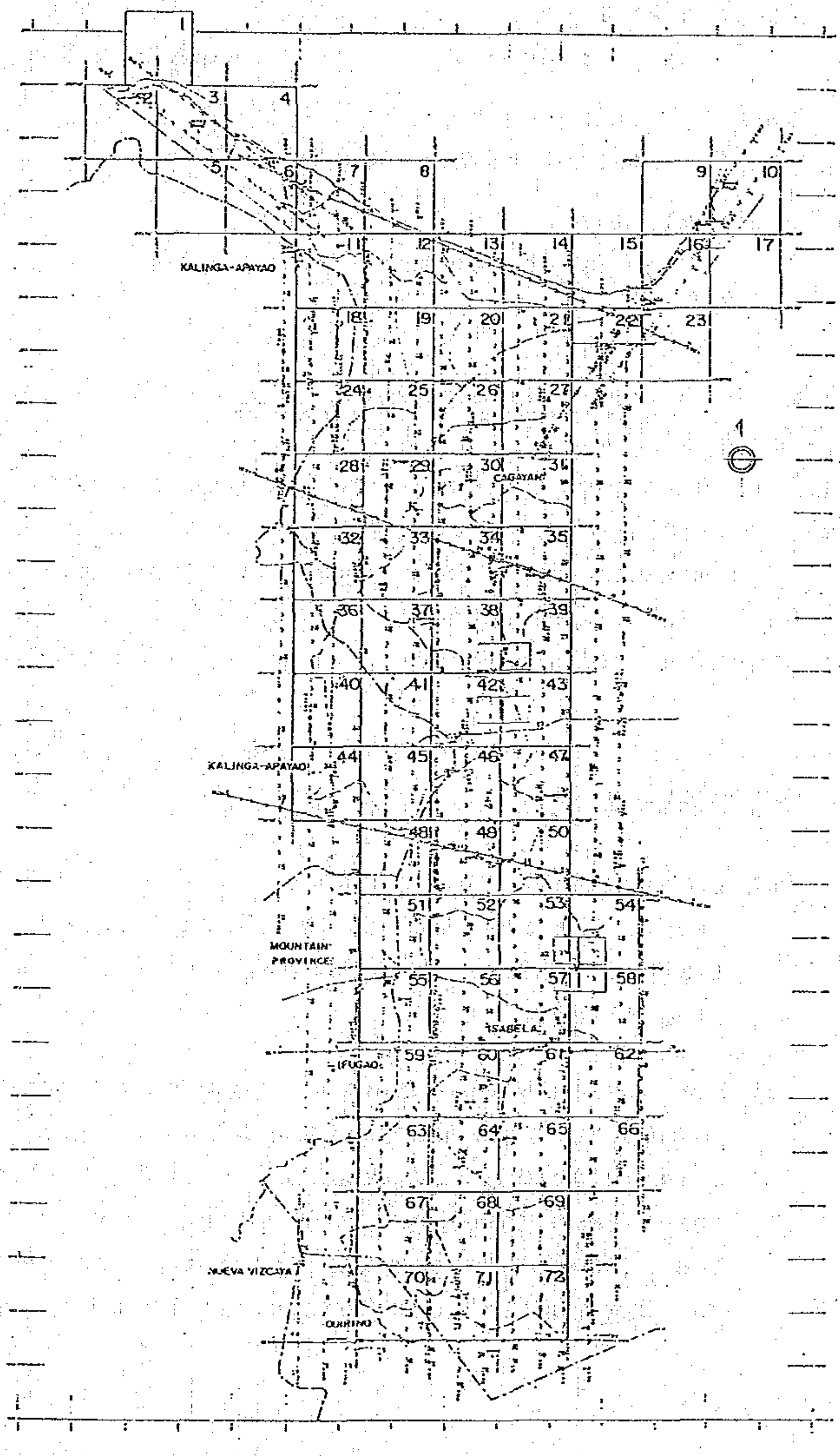
(2) For absolute orientation, results of pass points and tie points determined by aerial triangulation, and control points, pricking points and level pricking points were used. The allowable error for absolute orientation was limited to less than 0.5mm as to planimetry

Figure 10

CAGAYAN VALLEY TOPOGRAPHIC MAPPING

PLANNING ORGANIZATION : JAPAN INTERNATIONAL COOPERATION AGENCY, 1976~1982
EXECUTIVE ORGANIZATION : INTERNATIONAL ENGINEERING CONSULTANTS ASSOCIATION

MAP SCALE 1: ,000 MAPPING SCALE 1:25,000
PHOTO SCALE 1:30,000 ORTHO PHOTO SCALE 1:10,000



and 2.5m as to elevation. After completion of absolute orientation, results were recorded on plotting orientation recording sheets.

3-6-5 Detail Plotting

(1) Detail plotting was performed in the order of linear objects, buildings, vegetation, contour lines and elevation lines to avoid omission of drawing.

(2) It is desirable to follow the Map Symbol Specification as a rule for symbols to be used in plotting operation, but near symbols were used as the symbols were complex and some symbols were not determined.

(3) In plotting operation, field reconnaissance survey photos and other references were used. As for discrepancies between readings by operators and field reconnaissance survey data, marks were placed on field reconnaissance photos or comments were attached on them for confirmation in compilation and supplementary surveys.

(4) Detail plotting classification was as follows:

(i) Red .... roads

(ii) Blue ...... coastal lines, lake coastal lines, rivers, water ways

(iii) Black ..... buildings, contour lines (index contour lines), works, symbols, elevation points.

(iv) Green ..... vegetation delineation, swamp delineation

(v) Orange, Red .. contour lines, half interval contour lines, quarter interval contour lines of contour lines

(5) Each road was drawn by a single red line in the center of it, provided that two red lines were used when it was possible to indicate on scale.

(6) For plotting, the floating mark of stereo plotter was precisely placed to the object to prevent discrepancy due to elevation measurement error.

(7) As for plotting of buildings, every individual buildings were plotted as the rules of generalization for built-up area was not defined yet.
These were partly due to easiness of examination and judgement of dislocatiming and generalization from the cartographic view.

(8) Vegetation, cultivated land, non-cultivated land and swamp were plotted, photo-interpreting them by means of shape, color tone, design and shade and referring to results of field reconnaissance surveys.
As vegetation and land use in this area was very finely distributed, manuscripts were highly finely drawn.

(9) In drawing contour lines, special attention was paid so that unique topographic characteristics would not be lost. As for summits, depressed topography and mountain saddles, spot elevation was measured and ν mark was attached to prevent omission of contour lines.

(10) Spot elevations were measured twice to adopt the average value. Measurement was done in the unit of 0.5 meters.
Spot elevations were measured with the density of about 5-cm intervals on the map, including control points and bench marks.
Spot elevations positions were pricked on control point source maps, and plotting manuscripts, and measured values were recorded on control point source maps.
Elevation points were measured at the following positions:

(i) Major summits

(ii) Road major turning points, saddles to which road lead, and other major saddles.

(iii) Valley mouths, river meeting points, broad valley bottom parts, river basins.

(iv) Major slope changing points.

(v) Representative points.

(vi) Readable deepest parts in concaved areas.

(vii) Other points required to define topography.

3-6-6 Tying

As there were no existing maps of the same scale for the area covered, attention was paid only to tying of newly developed maps. Tie-strips of about 10cm inside the internal neat line were duplicated to inspect and adjust tying.

3-7 Compilation

3-7-1 Outline

Using stereo plotting manuscripts, control point source maps and field reconnaissance survey data, compilation was performed in accordance with the Map Symbols Specifications.

(1) The same drawing materials as used in plotting operation were used.

(2) Symbols, character sizes, methods of expression and color classification were determined in view of color density, uniformity and color reaction in photo processing operation, as results would be used as basic charts in the following drawing operation.

(3) Just like plotting operation, compilation was done map sheet by map sheet. Marginal information matters were indicated in accordance with BCGS data.

(4) Drawing of isobathymetric lines which could not be obtained in plotting operation was

performed in accordance with BCGS data.

3-7-2 Order of Drawing

The order of drawing in compilation operation was as follows as a rule:

(i) Control Points

Geodetic control points, bench marks.

(ii) Trunk Planimetric Features

Roads, river, water's edge lines.

(iii) Vegetation, Cultivated Lands

Vegetation, cultivated lands, swamps.

(v) Borders

Various borders.

(vi) Topography

Contour lines, deformed lands.

3-7-3 Planimetry

(1) Drawing lines were clearly indicated not to damage topographic planimetric features on stereo plotting manuscripts. Drawing line density was maintained constant at a somewhat dense level.

(2) Planimetry of various objects to be compiled were to be correctly indicated. It was decided, however, to make transfer within the extent of the Map Symbols Rules when such transfer was needed, by such means as symbolization.

3-7-4 Contour Lines, Vegetation Plate

As for contour lines and vegetation, compilation was performed carefully so that regional characteristics would not be lost.

3-7-5 Control Point Source Sheets

Arrangement was made on the basis of the control point source maps developed through plotting operation. In so doing, some elevation points were not adopted, and marked by the elimination mark(x). On the control point source maps were indicated point names and elevations.

3-7-6 Annotation Source Maps

Using polyester base #300 and in accordance with the source maps developed earlier on the site by BCGS, annotation source maps were developed in accordance with the Map Symbols Specification as to position of annotation, character size, strokes, character style and annotation characters.

Questionable matters found in the process of developing annotation source maps were to be confirmed in a supplementary survey.

3-7-7 Road Source Maps

Road source maps were developed in accordance with road control and width classifications, following the Map

Symbols Rules.

Merits of developing road source maps are as follows:

(i) Prevent errors due to mixing of matters written.

(ii) Easy to obtain and to inspect road information.

(iii) Easy to discover omission of indication, defective tying and error as it is possible to make color classification.

3-7-8 Isobathymetric Lines and Water Depth Values

Isobathymetric lines were indicated as follows:

(i) Isobathymetric lines were to be indicated down to the depth of 200 meters.

(ii) Intermediate coutour lines were to be written every 20 meters and index contour lines every 100 meters.

(iii) Only those water depth values indicated on source maps were to be written.

(iv) Blue color was to be used for color classification.
These were as in BCGS data, and only water parts were indicated. Taking into consideration blue indication (final maps), flat tables were used as in the case of water part indication.

3-7-9 Marginal Information

Those to be directly entered on compilation source maps and those to be entered on marginal information tables were separately indicated.

(1) Major items indicated on compilation source maps are as follows:

(i) Name of topographic map.
(ii) Number of topographic map.
(iii) Longitude, latitude and coordinate value.
(iv) Position map.
(v) Contact map example.

(2) Major items recorded on marginal information source tables are as follows:

(i) Name of topographic map.
(ii) Number of topographic map.
(iii) Explanation of drawing method.
(iv) Neat line dimension and index map.
(v) Aerial photos used.

3-7-10 Tying

Tying was done as follows:

(1) There was no tying between the area covered and the existing maps.

(2) As for the parts overlapping with the orthophotomaps developed this time, attention was paid to compatibility, though the scale differred.

(3) All drawing lines, road classifications and names of annotation source maps were to be

agreed on the neat lines between compilation manuscripts.

(4) It was determined to confirm supplementary survey and make consultation when tying was not achieved for some reasons.

3-7-11 Inspection

In compilation operation, the following items were mainly inspected.

(1) Compilation manuscript dimensions.

(2) Application of map symbols.

(3) Methods of expressing various matters to be expressed.

(4) Drawing lines.

(5) Arrangement of various source maps and contradiction with compilation manuscripts.

3-8 Supplementary Survey

3-8-1 Outline

Secular changes occurred after the field reconnaissance survey done in 1980 and questions occurred during compilation were investigated and accuracy was inspected. Also, to improve compiled draft maps, supplementary survey was performed. Preliminary photo-interpretation was done on the basis of compilation manuscripts prior to entering the site. Important points and questionable points were marked on maps to examine items to be surveyed and the order of survey. Incidentally, BCGS surveyed borders, place names and annotations. Also, BCGS requested to add marginal information items and to change titles, and the request was accepted. All of these were arranged on-site as final results.

3-8-2 Inspection Survey

From the standpoint of general accuracy in the area to be covered, places requiring inspection and districts with topographic restrictions were examined to check out districts to be inspected, and inspection survey was done as to plane and height. (Refer to Attached Figure 11.)

(1) Planimetry

It was determined to conduct inspection survey on four districts. Transits and range finders were installed at the existing control points to perform drawing inspection survey by means of distance and angle. Calculation results showed that all items were within the allowable limits. (Refer to Attached Tables 11.)

(2) Height

Just as planimetry inspection survey, four districts were selected. Levels or transits depending on topographic conditions were applied for inspection survey at bench marks and control points.

Calculation results indicated that all were within the allowable limits.

(Refer to Attached Tables 12.)

Figure 11

CAGAYAN VALLEY TOPOGRAPHIC MAPPING

LOCATION MAP
OF
FIELD VERIFICATION

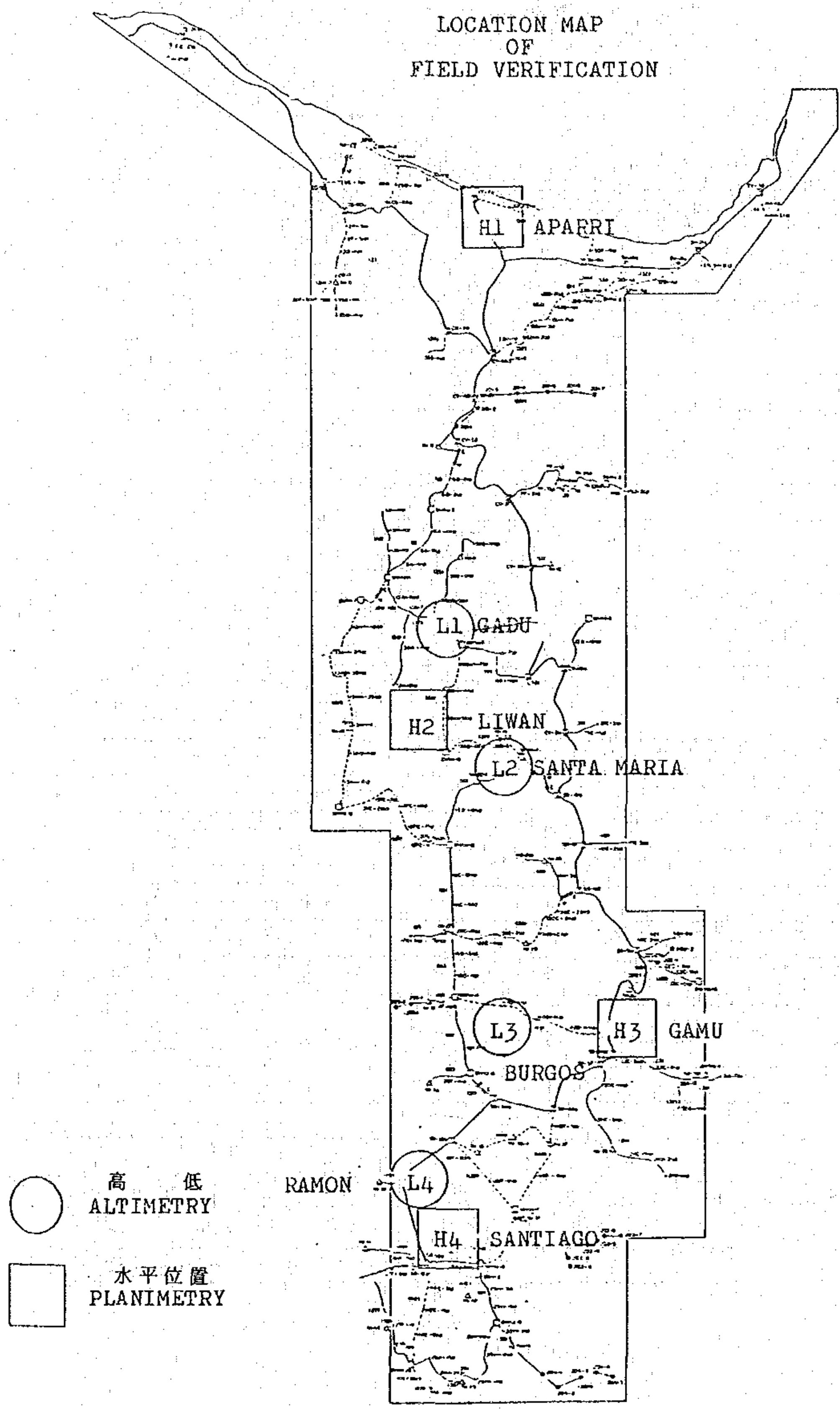


Table 11-1

FIELD CHECKING SHEET

AREA: H 1 PLANIMETRY.

No.	DISCREPANCY			REMARKS
	1/25,000 (mm)	GROUND (m)	D^2	
1.	0.1	2.5	6.25	
2.	0.0	0.0	0.00	
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

ACCURACY OF PLANIMETRY A CLASS	N - 1	D^2	$\sqrt{\frac{D^2}{N-1}}$ (m)	1/25,000 (m)
	1	6.25	2.5	0.1

FIELD CHECKING SHEET

Table 11-2

AREA: H 2 PLANIMETRY.

No.	DISCREPANCY			REMARKS
	1/25,000 (mm)	GROUND (m)	D^2	
1.	0.1	2.5	6.25	
2.	0.8	20.0	400.00	
3.	0.4	10.0	100.00	
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

ACCURACY OF PLANIMETRY A CLASS	N - 1	D^2	$\sqrt{\frac{D^2}{N-1}}$ (m)	1/25,000 (m)
	2	506.25	15.91	0.6

Table 11-3

FIELD CHECKING SHEET

AREA: H 3 PLANIMETRY.

No.	DISCREPANCY			REMARKS
	1/25,000 (mm)	GROUND (m)	D^2	
1.	0.1	2.5	6.25	
2.	0.5	12.5	156.25	
3.	0.2	5.0	25.00	
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

ACCURACY OF PLANIMETRY A CLASS	N - 1	D^2	$\sqrt{\frac{D^2}{N-1}}$ (m)	1/25,000 (m)
	2	182.50	9.68	0.4

Table 11-4

FIELD CHECKING SHEET

AREA: H 4 PLANIMETRY.

No.	DISCREPANCY			REMARKS
	1/25,000 (mm)	GROUND (m)	D^2	
1.	0.2	5.0	25.00	
2.	0.5	12.5	156.25	
3.	0.7	17.5	306.25	
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

ACCURACY OF PLANIMETRY A CLASS	N - 1	D^2	$\sqrt{\frac{D^2}{N-1}}$ (m)	1/25,000 (m)
	2	487.50	15.61	0.6

Table 12-1

FIELD CHECKING SHEET

AREA: L 1 ALTIMETRY

No.	DISCREPANCY				REMARKS
	1/25,000 (m)①	GROUND (m)②	①-②D (m)	D^2	
1.	58.	60.3	- 2.3	5.29	
2.	43.	45.5	- 2.5	6.25	
3.	36.	38.0	- 2.0	4.00	
4.	40.	42.9	- 2.9	8.41	
5.	46.	46.4	- 0.4	0.16	
6.	39.	41.3	- 2.3	5.29	
7.	38.	40.8	- 2.8	7.84	
8.	38.	38.3	- 0.3	0.09	
9.	29.	27.5	1.5	2.25	
10.	22.	25.3	- 3.3	10.89	
11.	67.	67.2	- 0.2	0.04	
12.	69.	69.3	- 0.3	0.09	
13.	51.	49.5	1.5	2.25	
14.	46.	45.5	0.5	0.25	
15.	40.	37.7	2.3	5.29	
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					

	N - 1	D^2	$\sqrt{\frac{D^2}{N-1}}$ (m)	1/25,000 (m)
	14	58.39	2.04	

Table 12-2

FIELD CHECKING SHEET

AREA: L 2 ALTIMETRY

No.	DISCREPANCY				REMARKS
	1/25,000 (m)①	GROUND (m)②	①-②D (m)	D^2	
1.	36.	35.9	0.1	0.01	
2.	36.	35.7	0.3	0.09	
3.	54.	51.6	2.4	5.76	
4.	56.	55.3	0.7	0.49	
5.	41.	40.2	0.8	0.64	
6.	62.	61.5	0.5	0.25	
7.	54.	53.5	0.5	0.25	
8.	54.	51.7	2.3	5.29	
9.	32.	29.2	2.8	7.84	
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					

N - 1	D^2	$\sqrt{\frac{D^2}{N-1}}$ (m)	1/25,000 (m)
8	20.62	1.60	

Table 12-3

FIELD CHECKING SHEET

AREA: L 3 ALTIMETRY

No.	DISCREPANCY				REMARKS
	1/25,000 (m) Q	GROUND (m) G	Q-G D (m)	D^2	
1.	48.	50.8	- 2.8	7.84	
2.	49.	50.2	- 1.2	1.44	
3.	49.	48.4	0.6	0.36	
4.	47.	48.5	- 1.5	2.25	
5.	50.	50.9	- 0.9	0.81	
6.	48.	47.8	0.2	0.04	
7.	49.	49.2	- 0.2	0.04	
8.	49.	50.3	- 1.3	1.69	
9.	52.	51.8	0.2	0.04	
10.	57.	57.5	- 0.5	0.25	
11.	62.	61.0	1.0	1.00	
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					

	N - 1	D^2	$\sqrt{\frac{D^2}{N-1}}$ (m)	1/25,000 (m)
	10	15.76	1.26	

Table 12-4

FIELD CHECKING SHEET

AREA: L 4 ALTIMETRY

No.	DISCREPANCY				REMARKS
	1/25,000 (m) ①	GROUND (m) ②	①-② D (m)	D^2	
1.	75.	74.3	0.7	0.49	
2.	73.	72.9	0.1	0.01	
3.	71.	70.8	0.2	0.04	
4.	69.	69.4	- 0.4	0.16	
5.	71.	70.9	0.1	0.01	
6.	72.	72.0	0.0	0.00	
7.	73.	73.1	- 0.1	0.01	
8.	74.	74.4	- 0.4	0.16	
9.	76.	75.3	0.7	0.49	
10.	78.	77.5	0.5	0.25	
11.	77.	77.0	0.0	0.00	
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					

	N - 1	D^2	$\sqrt{\frac{D^2}{N-1}}$ (m)	1/25,000 (m)
	10	1.62	0.40	