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BV 307

AN AEROMAGNETIC SURVEY
IN THE
ARENDAL REGION NORWAY
FOR
DET KONGELIGE DEPARTEMENT FOR
INDUSTRI OG HANDVERK

INTERPRETATION REPORT

OCTOBER 1958

HUNTING GEOPHYSICS LTD.
4, ALBEMARLE STREET
LONDON W.1.

WIDERØE FLYVESELSKAP A/S
AUGUSTAGT 19
OSLO.

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F. The Vinten 35mm camera and intervalometer

I. INTRODUCTION

1. General Information

(i) The aeromagnetic survey described below was carried out in the Arendal Area of Norway on behalf of Det Kongelige Departement for Industri og Handverk. It was carried out jointly by Wideroe Flyveselskap A/S and Hunting Geophysics Ltd.

(ii) The survey operational time extended between the 28th September, 1958, and the 9th October, 1958.

The expedition personnel consisted of:-

- 2 Pilots (Wideroe Flyveselskap A/S)
- 2 Navigators (Wideroe Flyveselskap A/S and Hunting Geophysics Ltd.)
- 1 Licensed Aircraft Engineer (Wideroe Flyveselskap A/S)
- 1 Electronic Engineer (Hunting Geophysics Ltd.)

2. Purpose of the Survey

(i) To compare the magnetic pattern obtained over the area with the known geology.

(ii) To examine magnetic anomalies in relation to the known mineral deposits.

(iii) To derive additional information about geological trends and to investigate the probability of existence of unknown mineral deposits.

3. Area Surveyed

(i) The area was centred approximately on the town of Arendal, latitude $58^{\circ}27\frac{1}{2}'N$ longitude $8^{\circ}45\frac{1}{2}'E$, being rectangular in shape and having approximate dimensions 30 kms x 16 kms.

(ii) The actual contract line miles/kms flown were 698 and 1,123 respectively.

II. METHODS AND INSTRUMENTS EMPLOYED ON THE SURVEY

A. The Airborne Magnetometer

(i) Method

In the aeromagnetic method employed on this survey, variations in the total magnetic field were measured. As the instrument does not measure the absolute value of the field, the observations are related to an arbitrary datum.

(ii) Instrument (Plates 6B, 6C, 6D)

The installation consisted of Gulf Research and Development Company magnetometer MKIII. The detecting part of the instrument was installed in the bird which was towed behind the aircraft.

/This instrument

This instrument was of fluxgate type. The measuring fluxgate was maintained in the direction of the total magnetic field through the action of the servo motors operated by two orienting fluxgates.

The effect of the ambient magnetic field on the measuring fluxgate is compensated and the voltage changes across the recording potentiometer due to the changing compensating current, are recorded continuously in terms of magnetic units on the recorder chart of a Leeds and Northrup Recorder.

(iii) Record (Plate 3)

The speed of the record was 6" per minute and the full scale deflection was set to be 1,200 gammas. The value of the step change (an automatic reset procedure operating when the magnetic field variations exceed the range of the full scale) was 1,000 gammas.

(iv) Calibration

The instrument was calibrated by Gulf Research and Development Corporation using a Helmholtz Coil.

(v) Tests

(a) Lag Test

Lag (or delay of the response considered in relation to the ground position of the aircraft) is due to the delay in the electronic circuitry of the equipment and the difference in the position of the 35mm positioning camera and the detector head.

A test was flown and the lag was found to be 0.75 seconds which is equivalent to 0.075 inches on the record at a speed of 6 inches per minute.

The offset of the recording pen from the camera fiducial pen ranged from 0.225 to 0.25 inches and was added to the aforementioned lag.

(b) Heading Test

The effect of the aircraft's magnetic field on the recorded variations of the magnetic field, depends on the heading of the aircraft. Compensation can be made for a part of this effect. A heading test is carried out in order to check the compensation of the aircraft and to assess the uncompensated residual effect. The results of the heading test flown on this survey, at an altitude of 500 feet above ground level, shows the maximum change peak to peak to be 2 gammas.

B. Ancillary Equipment

1. 35mm Positioning Camera

(1) Method and Instrument (Plate 6F)

A Vinten positioning camera was mounted in the aircraft with its optical axis vertical for level flight of the aircraft. Exposures were made automatically at 1 second interval. The speed of the shutter was 1/250 of a second, and the aperture was varied manually according to the light intensity.

The camera exposures were related to the magnetic record by a system of fiducial marks. The exposure counter was also photographed and the photograph number appears in the corner of each photo-frame.

(ii) Film (Plate 5)

The film used was Kodak Plus X. It was processed by the Survey Team and by George Humphries and Company of London.

(iii) Tests

The functioning of the camera was tested by taking a series of exposures in flight and developing the film prior to the commencement of the survey. Similar tests were also carried out during the survey.

2. Radio Altimeter (Plates 4 and 6E)

Apart from the barometric altimeter which is a standard instrument carried in the aircraft, a radio altimeter of the A.P.N.1 type was also carried. The full scale range was 0-800 feet and the speed of the record, on which variations of altitude of the aircraft above the ground were recorded continuously, was 6 inches per minute.

III. FLYING OPERATIONS

1. Aircraft

The aircraft was a Lockheed 12, registration letters LN-BFS, belonging to Widerøe Flyveselskap.

The aircraft was equipped with normal radio equipment.

2. Base

The aircraft was based at Kjevik Airport, Kristiansand. The airfield was 60 millimetres from the survey area. The crew were accommodated at the Astoria Hotel, Kristiansand, which is approximately 14 kilometres from Kjevik Airport.

3. Maps, Photographic Cover and Photo Mosaics

(i) Maps

(a) 1/50,000 scale maps were used for navigation and flight planning.

(b) A 100,000 scale map was also used for flight planning. This map was enlarged to 1/25,000 but this enlargement was not used operationally.

(ii) Photographic Cover

(a) Photographic prints were supplied by Widerøe Flyveselskap at the commencement of the survey. These prints were at three different scales ranging from 1/15,000 to 1/20,000 and only partially covered the area. Stick down mosaics were compiled, but were not used operationally.

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(b) Additional photographic cover was found as the survey proceeded and the complete set of contact prints were used in the final reduction.

(iii) Photo Mosaics

Semi controlled mosaics at a scale of 1/25,000 (approx.) were constructed and mounted on Pagra for final presentation.

4. Navigational Method

The navigation of the survey area was accomplished by map reading using the 1/50,000 maps mentioned above.

5. Flying and Navigational Problems Encountered

(i) Aircraft Serviceability and Maintenance

No delays were experienced due to unserviceability of the aircraft.

(ii) Weather

Seven days were lost because of inclement weather caused by low stratus.

(iii) Navigational Problems

Owing to maps which were a little inaccurate, tracking was found to be difficult in certain areas where detail was sparse.

6. Flight Pattern (Plates 1 and 2)

(i) Flight Line Spacing and Direction

The planned flight line spacing was $\frac{1}{2}$ km and the true direction 310°/130°.

The pattern achieved is as shown on the final map.

(ii) Flying Height

The planned nominal flying height was 150 metres (500 feet) above ground level.

(iii) Re-flying (see Plate 1)

A certain amount of re-flying was carried out due to navigational errors and instrument defects.

(iv) Supplementary Flying

The flight lines were extended from the main coast line to smaller islands in areas of interest.

7. Airborne Procedure

(i) Warming Up of Instruments

All instruments were switched on and kept running for at least half an hour before recording began to ensure their proper and steady functioning.

(ii) Annotation of Records

During the survey the records were annotated for reduction and plotting purposes.

The following annotations were made:-

- (a) Start and end of line giving number and direction
- (b) Step numbers
- (c) Camera fiducial numbers
- (d) Instrument drift corrections/indications
- (e) Navigational fixes
- (f) Time checks
- (g) Other relative information

(iii) Daily Flight Reports

These reports give a detailed description of the sortie from an operational point of view and show the following information:-

- (a) Times of start and end of sortie
- (b) Instruments used and relevant details
- (c) Crew members and functions
- (d) 35mm photograph numbers
- (e) Times of start and finish of lines
- (f) Direction of lines flown
- (g) Changes of magazines, charts, etc.
- (h) Weather
- (i) Navigator's diagram showing the sortie's flying

IV. MAGNETIC CONTROL PROCEDURES

1. Control of Observation

The control of observations was achieved by terminating the ends of each line over common tie points, connecting the tie points by an independent tie line and flying another tie line across the northern ends of the lines.

This system of control made it possible:-

- (a) To establish a common reference datum for the whole survey.
- (b) To determine and adjust small errors caused by instrumental drift, diurnal magnetic variations, minor local magnetic disturbances.

2. Instrument Drift

Instrument drift was checked at intervals of approximately every 15 minutes. Standardisation adjustment was carried out when necessary.

3. External Check on Magnetic Disturbances

In order to detect any major magnetic disturbances which could have occurred, a vertical force magnetometer (Schmidt type and Askania manufacture) was set up at Kjevik Airport, Kristiansands.

V. FINAL REDUCTION OF DATA

1. Plotting of Flight Path

(i) This was achieved by identifying points from selected frames of 35mm film on photographs at scales of 1/15,000 to 1/20,000 (approx.). The points selected for identification were along the flight lines at an average distance of 750 metres, this distance being greater in areas where detail was sparse.

2. Transfer of Plotted Flight Path

The points plotted were transferred to astrafoil overlays to photo mosaics mounted on Pagra at a scale of 1/25,000 (approx.)

3. Relating Profiles to the Plotted Flight Path

All plotted and estimated points were marked on the record, using the photo-frame numbers and the corresponding fiducial marks, after allowance had been made for lag.

4. Datum Lining and Intercepting

(i) Recorded profiles were referred to a common datum based on tie points.

(ii) Intercepts were read from profiles at minima and maxima. Also at intervals of 20 gammas in areas of low magnetic gradient and at 100 gammas in areas of high magnetic gradient.

(iii) The intercepts were transferred to the overlays making due allowance for horizontal scale changes.

5. Contouring

Intercepts transferred to the overlays were contoured at intervals of 20 gammas in areas of low magnetic gradient and at 100 gammas in areas of high magnetic gradient.

6. Work Sheets

Copies of the magnetic contour work sheets on Accurene transparent material and working copy photo mosaics mounted on linen were given to the client's representatives.

VI. COMPILATION OF CONTOUR MAPS

1. Base Maps

The Base Maps are semi controlled photo mosaics at a scale of 1/25,000 (approx.) mounted on Pagra.

NOTE: Duplication and omission of topographic detail exists on the photo mosaics used as a basis for the presentation of the geophysical data. They have affected the anomaly pattern presented. This should be taken into account when a detailed study of anomaly position and shape is made.

2. Presentation

(i) The final maps are presented on transparent astrafoil and overlay the Pagra photo mosaics.

(ii) The topographical detail is taken from the base maps and presented in black.

(iii) Flight lines are shown in black and plotted 35mm points are shown at intervals along the lines.

(iv) The magnetic contours are shown in red.

VII. MISCELLANEOUS

1. Liaison with Client during Survey

Messrs. Aalstad (Geophysicist) and Borgan (Technician) were the client's representatives at Kristiansand and Hunting Geophysics laboratories, London, whilst the flying and data reduction was in progress.

2. Material Supplied to the Client

The following maps, mosaics, reports and records were supplied to the client:-

(i) Maps at 1/25,000 (approx.)

One copy of the following:-

- (a) Magnetic Contour Work Sheets on Accurene.
- (b) Final Magnetic Contour maps on transparent astrafoil.
- (c) Interpretation map.

(ii) Mosaics at 1/25,000 (approx.)

One copy of each of the following:-

- (a) Working copy mounted on linen
- (b) Final mosaic mounted on Pagra

(iii) Reports

Two copies of the Operational Report
Two copies of the Interpretation Report

(iv) Records

Airborne Geophysical Records consisting of:-

- (a) Airborne Magnetometer Record
- (b) Radio Altimeter Record
- (c) 35mm film
- (d) Daily Flight Reports

INDEX TO LINES FLOWN

AEROMAGNETIC SURVEY - ARENDAL AREA (NORWAY)

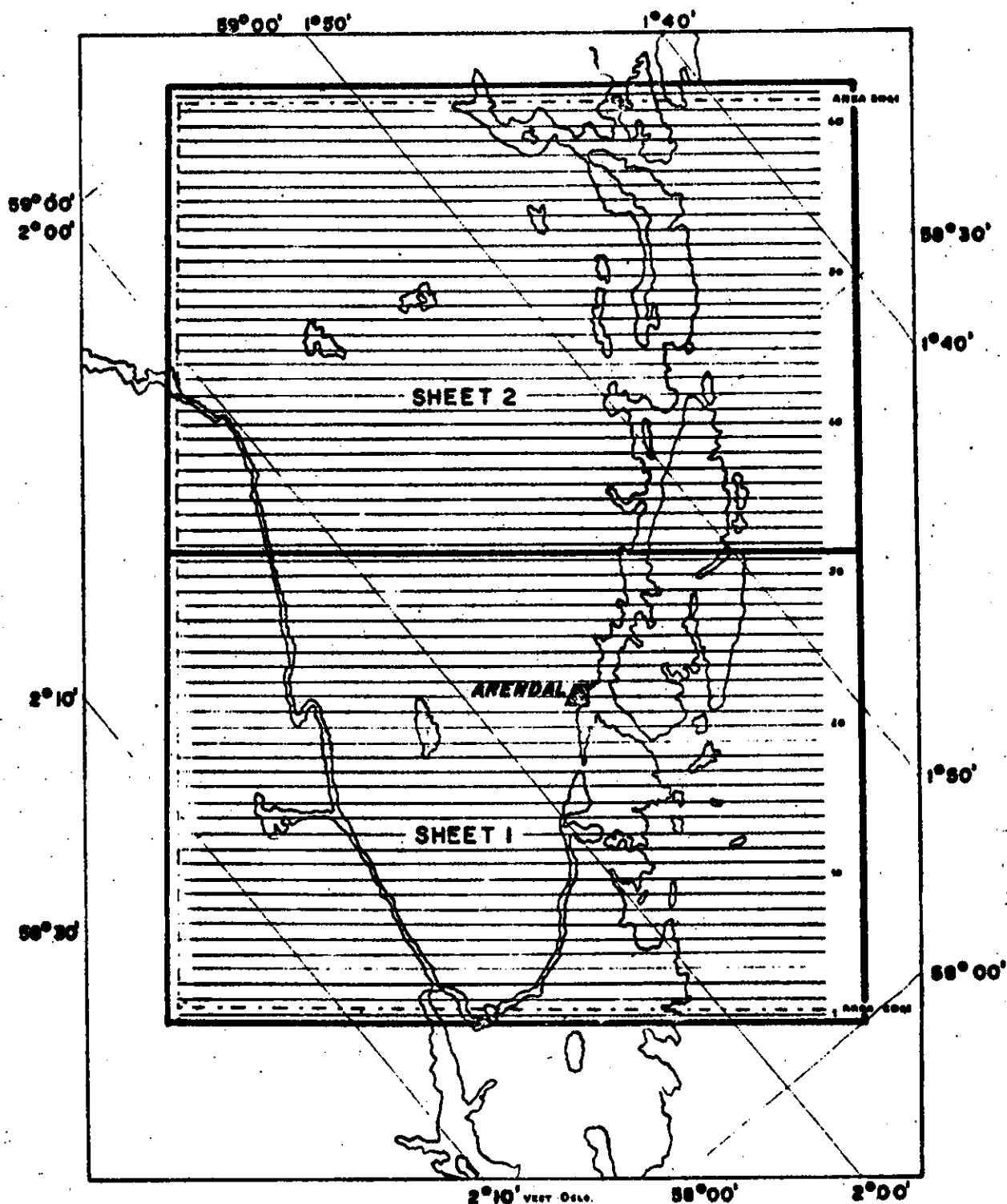
H.G.L. SURVEY NO: G170

No. of Flight Line	True direction of Flight Lines (in degrees)	Date Flown	Sortie No. (where applicable)	Remarks
1	129°	4/10/58		Reflown due to navigational error (part used in reduction)
1 RF	309°	8/10/58	2	
2	129°	4/10/58		
3	129°	4/10/58		
4	129°	4/10/58		
5	129°	4/10/58		
6	129°	7/10/58	1	
7	129°	7/10/58	1	Reflown due to navigational error (part used in reduction)
7 RF	129°	8/10/58	2	
8	129°	7/10/58	1	
9	129°	7/10/58	1	
10	129°	7/10/58	1	
11	129°	7/10/58	1	
12	129°	7/10/58	1	
13	129°	7/10/58	1	
14	129°	7/10/58	1	
15	129°	7/10/58	1	
16	309°	4/10/58		
17	309°	4/10/58		
18	309°	4/10/58		
19	309°	4/10/58		
20	309°	4/10/58		
21	309°	7/10/58	1	
22	309°	7/10/58	1	
23	309°	7/10/58	1	
23 RF	309°	7/10/58	1	Reflown due to navigational error (part used in reduction)
24	309°	7/10/58	1	
25	309°	7/10/58	1	
25 RF	309°	7/10/58	1	Reflown due to instrument error

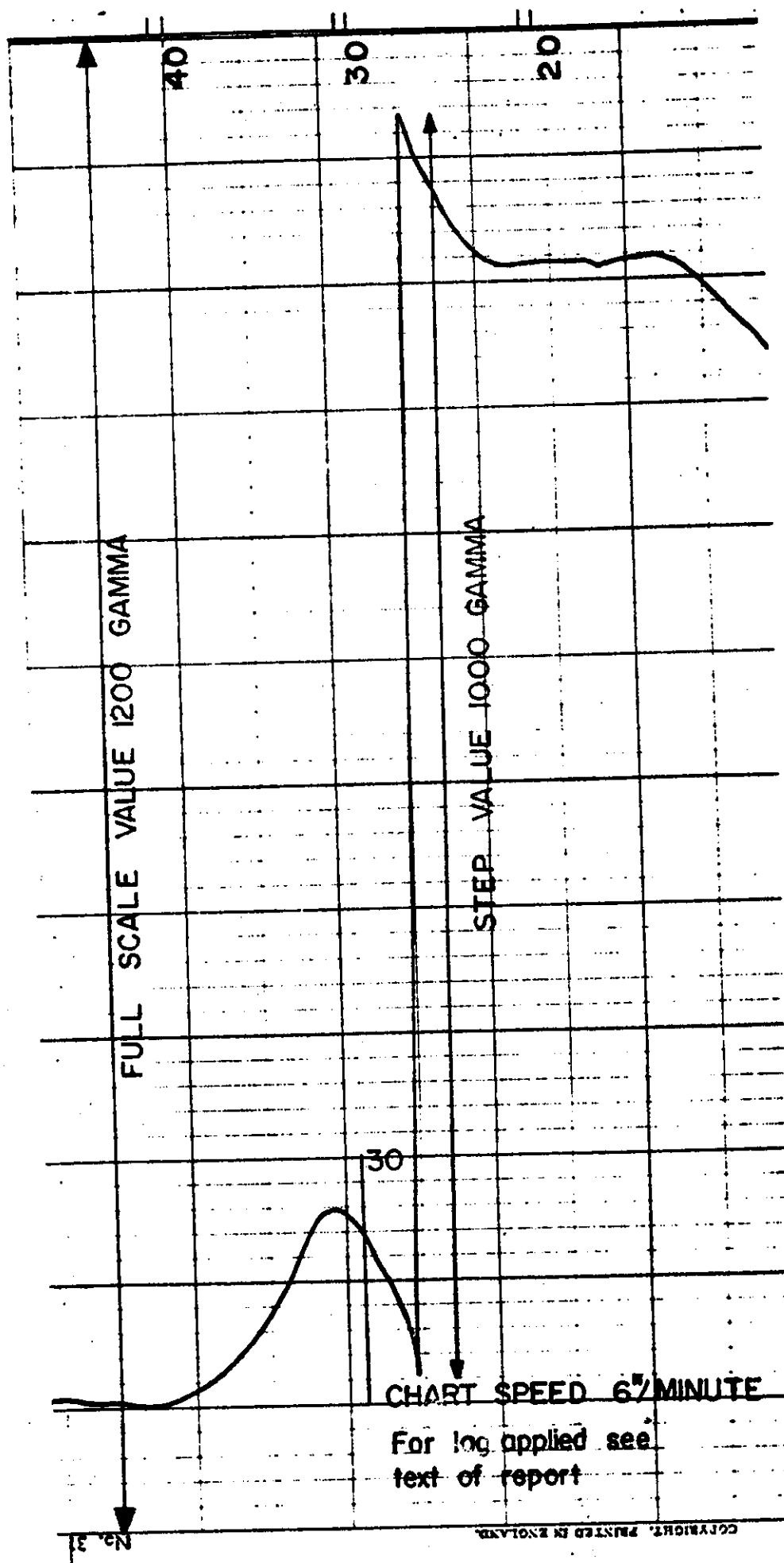
No. of Flight Line	True direction of Flight Lines (in degrees)	Date Flown	Sortie No. (where applicable)	Remarks
26	309°	7/10/58	1	Reflown due to navigational error (part used in reduction)
27	309°	7/10/58	1	
28	309°	7/10/58	1	
28 RF	309°	7/10/58	1	
29	309°	7/10/58	2	Reflown due to navigational error (part used in reduction)
30	309°	7/10/58	2	
31	309°	7/10/58	2	
32	309°	7/10/58	2	
32 RF	309°	7/10/58	2	Reflown due to navigational error (part used in reduction)
33	309°	7/10/58	2	
34	309°	7/10/58	2	
34 RF	309°	7/10/58	2	
35	309°	8/10/58	1	
36	309°	8/10/58	1	
37	309°	8/10/58	1	
38	309°	8/10/58	1	
39	309°	8/10/58	1	Reflown due to navigational error
40	129°	8/10/58	1	
41	129°	8/10/58	1	
41 RF	129°	8/10/58	1	
42	129°	8/10/58	1	
43	309°	8/10/58	2	
44	129°	8/10/58	2	
45	129°	7/10/58	2	
46	129°	7/10/58	2	
47	129°	7/10/58	2	
48	129°	7/10/58	2	
49	129°	7/10/58	2	
50	129°	7/10/58	2	
51	129°	7/10/58	2	
52	129°	7/10/58	2	
53	309°	8/10/58	2	
54	309°	8/10/58	2	
55	309°	8/10/58	2	
56	309°	8/10/58	2	

No. of Flight Line	True direction of Flight Lines (in degrees)	Date Flown	Sortie No. (where applicable)	Remarks
57	309°	8/10/58	2	
58	129°	8/10/58	2	
59	129°	8/10/58	2	
60	129°	8/10/58	2	
61	129°	8/10/58	2	
62	129°	8/10/58	2	
<u>No. of Tie Line</u>				
1	220°	8/10/58	2	

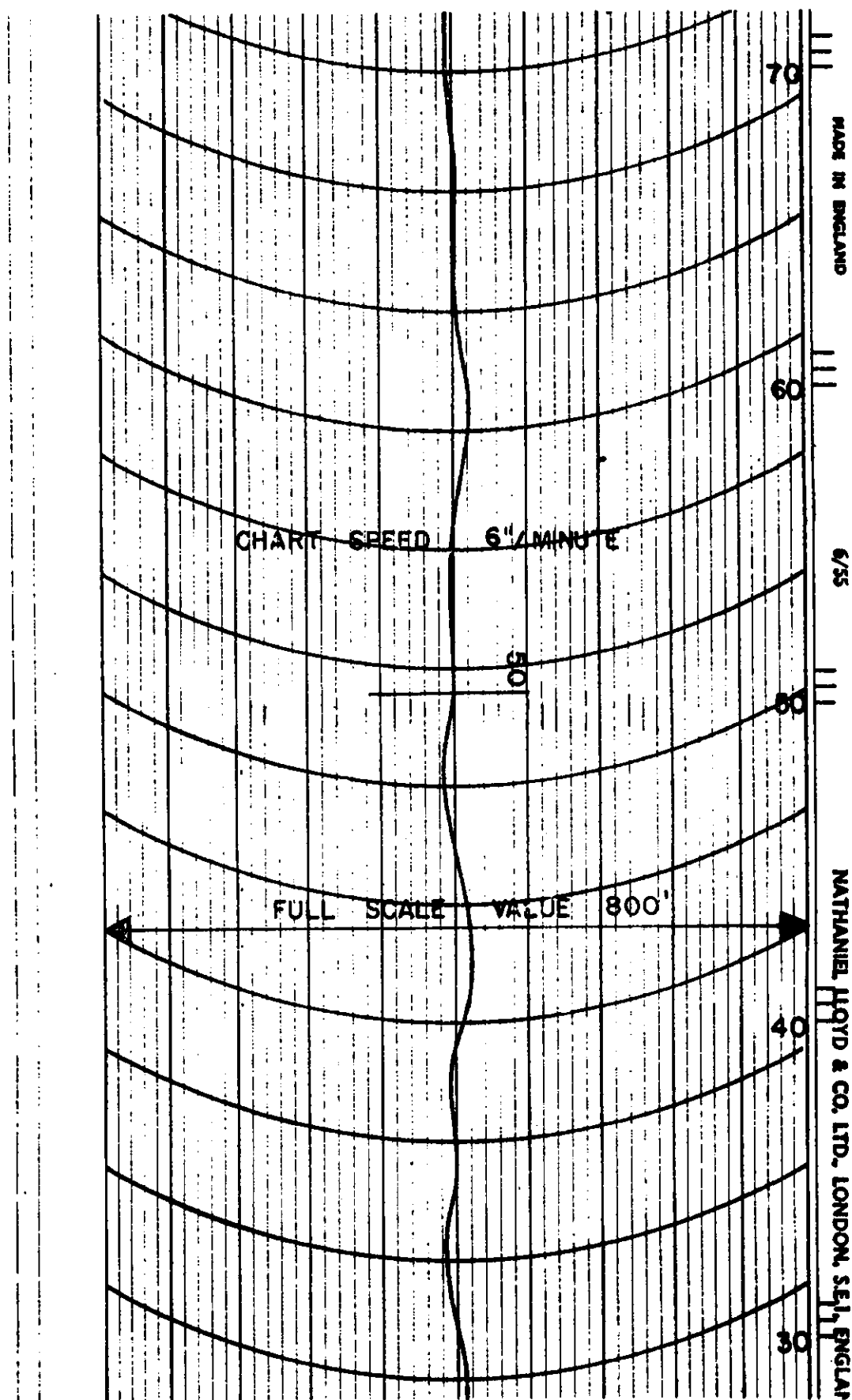
LOCATION MAP, SHOWING FLIGHT LINES AND SHEET LAYOUT.



SPECIMEN GULF MK III MAGNETOMETER RECORD



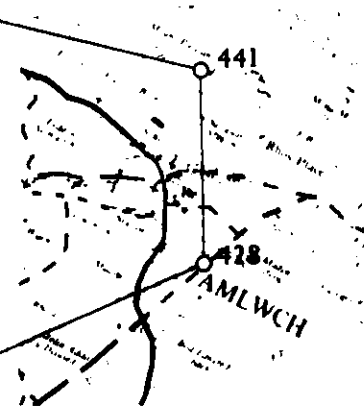
SPECIMEN APN1 RADIO ALTIMETER RECORD



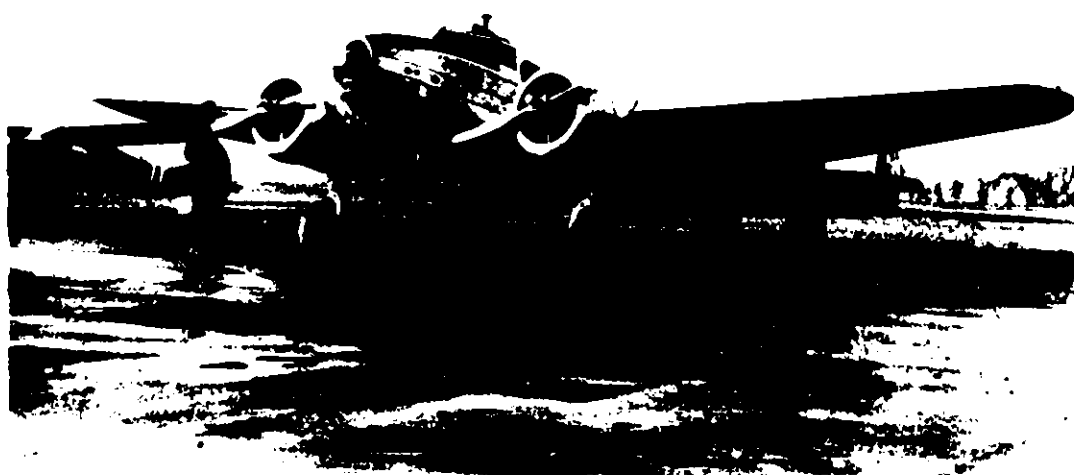
IDENTIFICATION
OF
FLIGHT PATH



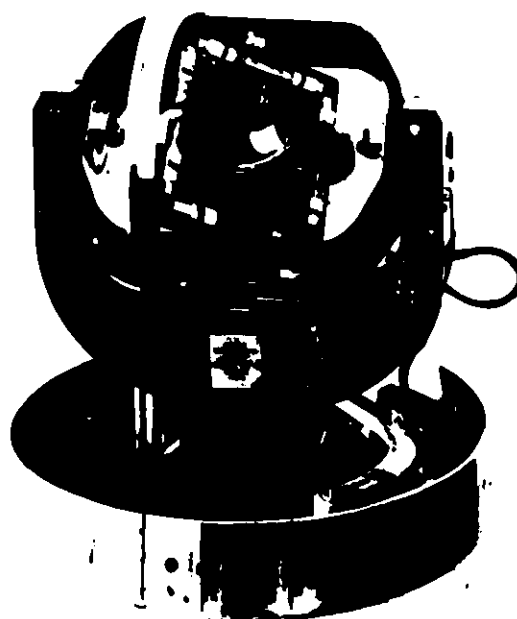
AERIAL PHOTOGRAPH
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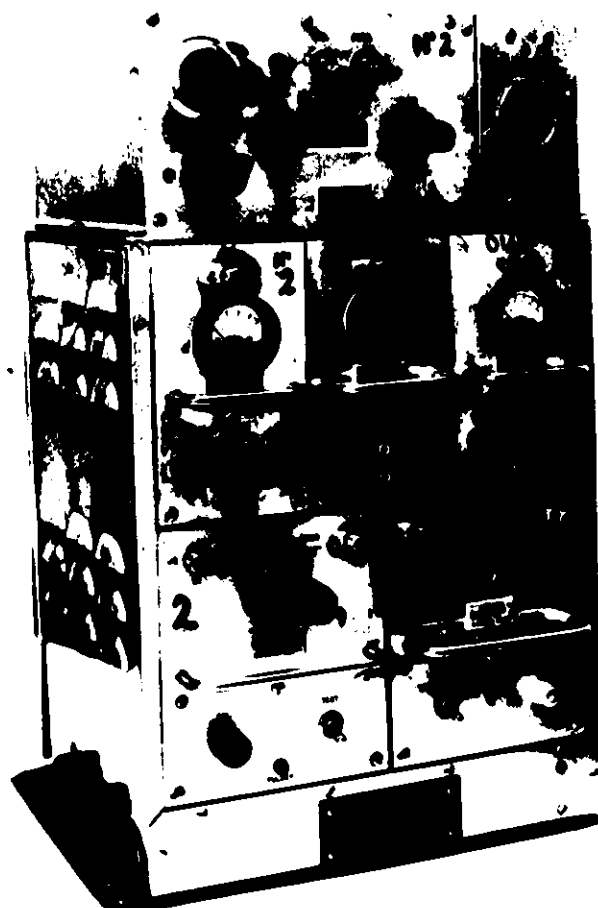
TOPOGRAPHICAL MAP
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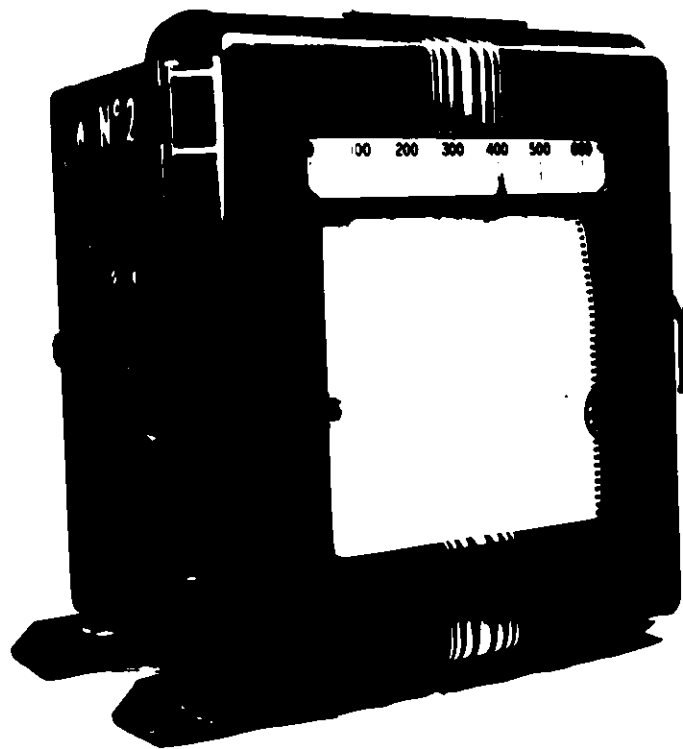
Lockheed 12



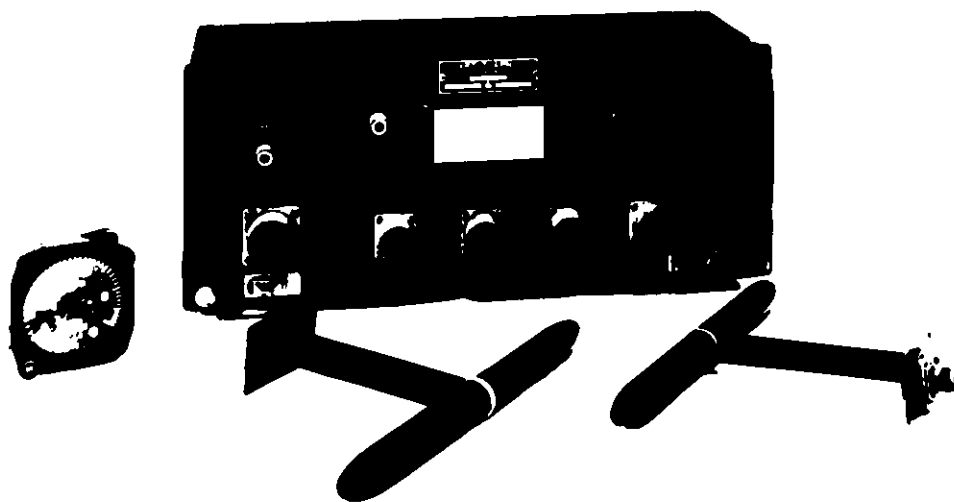
Gulf Mk III magnetometer detector head



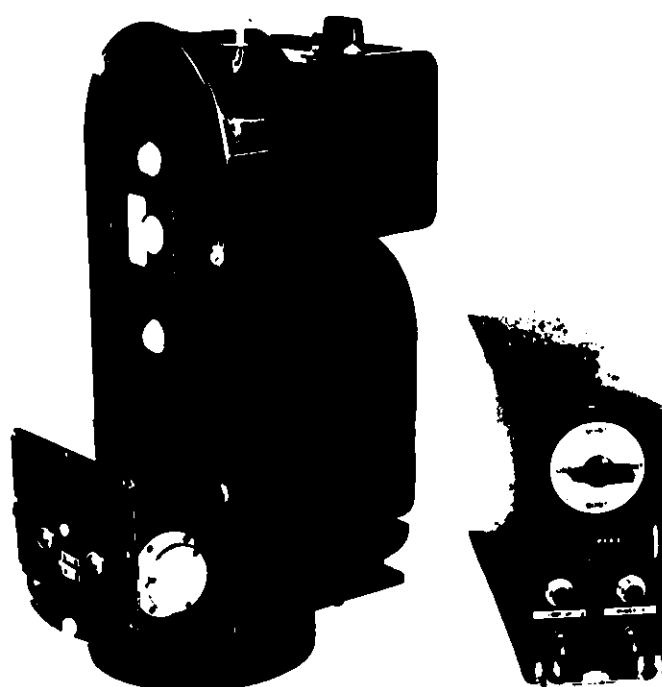
Gulf Mk III Magnetometer console



Leeds Northrup recorder for the Gulf magnetometer



The APN. I. Radio Altimeter showing transmitter/receiver unit,
antenna and pilots indicator



The Vinten 35mm camera and intervalometer