GEODETIC POSITIONS OF TORI SIMA BY THE ECHO-II

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Received 31 August 1967

Abstract

In July 1964 and in September 1965, observations for determining geodetic positions of Tori Sima by using the Echo satellites were carried out under cooperation with the Tokyo Astronomical Observatory and the Geographical Survey Institute.

During these two observing periods, 9 simultaneous observations were obtained, 5 for the Echo-I and 4 for the Echo-II. Due to the unfavourable observing conditions of Echo-I, longitude alone is evaluated employing observations of the Echo-II.

Result shows that the present charted position of Tori Sima should be shifted about 1500m westward. Comparison with astronomical positions suggests the order of the vertical deflection to be 13″ to the west.

1. Introduction

The position of Tori Sima on the current chart was determined through observations of the sun and polaris by 8-inch theodolite in 1913 by the then Hydrographic Department of the Imperial Navy. Unfortunately, this observing spot was destroyed by the eruption in 1939. In 1958 and 1959 the Hydrographic Office made astronomical surveying with the method of constant altitude of stars by a 3rd-class theodolite equipped with Talcott level. Results of these observations suggested that the charted position of Tori Sima should be shifted considerably towards west. Since 1962 the Hydrographic Office had developed a method of satellite triangulation and had made several experiments in laboratory and in field.

As a cooperation of the Tokyo Astronomical Observatory, the Geographical Survey Institute and the Hydrographic Office, the office sent observing teams to Tori Sima in July 1964 and in September 1965, to determine its geodetic position. Soon after the second observation, volcanic earthquakes occured continually, and all members of the Meteorological Observatory there had to evacuate from the island. Under the existing circumstances it seems to be difficult to repeat the satellite observation in near future. Accordingly, in this paper the results of observations obtained up to present are summarily reported.

2. Situation of Tori Sima

Tori Sima, lying about 600km south of Tokyo, is a volcanic islet with diameter of about 4km, and surrounded by precipitous cliffs on all sides. A meteorological observatory is situated on its western slope. Two poor wharves *A* and *B* are located at the foot of steep slope, just below the observatory. Load is carried to the wharves by a sampan from ship and therefrom to the observatory by a ropeway.

The present spot for satellite observations was constructed in a space in the northern corner of the observatory, and the spot has a good situation for observing satellite except that the eastern direction is obstructed for the altitude lower than 30°. Since the old datum point had destroyed by the eruption, the H. O.-observing team of 1958 established a new datum on the roof of the main building of the observatory.

The coordinates of the present observing spots were all linked to this datum.

3. Observations

For the simultaneous observation of satellites each network stations of the Tokyo Astronomical Observatory, the Geographical Survey Institute and the Hydrographic Office, as shown in Table 1, took part in the project as the reference points of the geodetic system of Japan. Coordinates of stations are computed on the International Ellipsoid with provisional corrections $\Delta L=+20''$ and $\Delta B=+10''$ to the geodetic datum of Japan. The position of Tori Sima is that of new datum point determined from the photoelectric observations of constant altitude of stars made in the first observing period.

During two observing periods, 9 simultaneous observations were obtained, among which 5 were made for the Echo-I and 4 for the Echo-II. Since the tracks of the Echo-I at that times were nearly parallel to the direction connecting the base stations, we can not expect good accuracy from those observations of the Echo-I.

TABLE 1. STATIONS

Station	L	B	h	Camera	f	Institute
	° ′ ″	° ′ ″	m		cm	
Mitaka	−139 32 8.31	+35 40 21.03	61	Baker-Nunn*	50	TAO
Simosato	−135 56 6.99	+33 34 34.38	56.5	Simple star camera*	60	HO
Kanozan	−139 57 7.67	+35 15 15.71	343.0	Parkin Elmer*	100	GSI
Kurasiki A	−133 45 58.65	+34 35 33.24	5.8	Parkin Elmer	100	TAO
Kurasiki B	〃	〃	〃	Simple star camera	50	TAO
Taniyama	−130 31 34.70	+31 31 45.27	17	Simple star camera	50	TAO
Sapporo	−141 21 0.7	+43 02 41.6	33	Simple star camera	50	TAO
Sirahama	−138 59 2.00	+34 42 56.16	160.0	Simple star camera	50	HO
Tori Sima	−140 17 21.3	+30 28 59.4	86	Parkin Elmer	100	HO

* with timing device

TABLE 2. NORMAL EQUATION FOR SATELLITE OBSERVATION

Date	UT2	Stations		Normal Equations				
		A	B	ΔB	ΔL	Δh	Δp	w
	h m s						m	
22 July, '64	12 41 5.302	Mi	Ta	−.1044	+.5908	+.7999	− 47.22	4.7
〃	〃	Mi	Ku	〃	〃	〃	− 37.96	3.5
23 July, '64	12 14 45.836	Mi	Ta	−.1175	+.7937	+.5967	−128.89	3.3
〃	〃	Mi	Ku	〃	〃	〃	−124.66	7.7
29 Sep., '65	18 27 51.124	Mi	Sim	−.1201	−.8763	+.4664	+133.69	12.1
〃	〃	Mi	Ku	〃	〃	〃	+132.46	54.1
〃	〃	Mi	Ta	〃	〃	〃	+131.93	54.1

TABLE 2. NORMAL EQUATION FOR SATELLITS OBSERVATION (continued)

Date	UT2	Stations		Normal Equations				
		A	B	ΔB	ΔL	Δh	Δp	w
4 Oct, '65	19 18 32.322	Mi	Sim	−.0757	−.5025	−.8612	+109.86	5.7
〃	〃	Mi	Ku	〃	〃	〃	+107.03	5.7
〃	〃	Mi	Ta	〃	〃	〃	+106.58	5.8
〃	19 18 34.699	Sim	Ta	−.0742	−.5020	−.8616	+ 75.33	5.3
〃	〃	Sim	Sir	〃	〃	〃	+115.29	1.1

4. Measurement of Photographic Plate and Reduction

Measurements of plates and films were made by a comparator of Carl Zeiss, Jena, of Tokyo Astronomical Observatory. Satellite positions on B. N. camera film were smoothed over all frames of the films which had been exposed during the passage of the satellite, employing the method proposed by one of the authors. Stars of magnitude between 8 and 9 were selected for comparison stars, and their apparent places were calculated with the AGK2 catalogue. The resultant accuracy of plates and film readings are within $\pm 2''$ for the smoothed position of the satellite.

The reduction of observations were performed by formulae developed by one of the authors basing on the simultaneous trail method suggested by Hirose (1963).

5. Results

In Table 2 the results of the reductions of the successful simultaneous observations are given. The first and second columns contain the observation times, the third column contains the base stations employed to the reductions, where notations *A* and *B* denote one equipped with timing device and the other without it, respectively.

The fourth column contains the coefficients of equations of the position plane; ΔB, ΔL and Δh denote corrections to the assumed longitude, latitude and elevation of the unknown stations, i.e. Tori Sima, and Δp denotes the distance between the assumed position and the position plane in unit of metre. The final column contains weights of the position planes derived from geometrical relation of the two base stations relative to the satellite track. For convenience, the new datum point are employed as the assumed position in the reductions.

Due to unfavourable observations of Echo-I, it is hardly possible to determine latitude of Tori Sima. The observations of Echo-II were made under favourable conditions for determing longitude, we can solve the normal equations of Table 2 for longitude by the method of least squares.

The results are given:

$$\Delta L = +139\overset{m}{.}5 \pm 5\overset{m}{.}5 \text{ (p.e.)}.$$

Therefore, the longitude of the observation's spot is

$$L = -140^\circ\ 17'\ 16''.1\ \pm 0''.2 \text{ (p.e.)}.$$

6. Comparison with Astronomical Surveying

In order to compare the geodetic positions derived from the present satellite triangulation with the astronomical positions, their coordinates are reduced to the coordinate of the new datum point described in the preceding section. Table 3 shows the results of the comparison. In this table, coordinates derived from satellite triangulation are converted to the geodetic system currently adopted in Japan from the system adopted in the reductions.

TABLE 3. COMPARISON WITH ASTRONOMICAL SURVEYING

Epoch	*L*	*B*	Observing Method
1913	−140° 18′ 15″	+30° 28′ 57″	8-inch Theodolite, transit
1958	17 22.2±2.0	29 6.4±2.7	3rd Theodolite, constant altitude
1959	17 25.8±0.6	28 57.3±0.3	〃 〃
1964	17 21.3±0.2	28 59.4±0.3	photoelectric astrolabe
1964 1965	17 34.5±0.2		satellite

Due to the missing of old datum point by eruption, it is imposible to compare accurately the recent observations with the charted value, but it seems that the charted position should be shifted about 1500m westwards. Discrepancy between the astronomical and the geodetic positions seems to suggest the order of the vertical deflection to be 13″ to the west.

In order to determine the precise latitude of Tori Sima, it is highly desirable that Japan launches an adequate satellite in the near future.

Acknowledgement

The authors would like to thank Professor H. Hirose, Director of the Tokyo Astronomical Observatory, for his valuable suggestions and putting the photographed plate at our disposal. They are also indebted to the staff of the Geographical Survey Institute for the coorperation of the simultaneous observation of satellites. Their thanks are also due to Dr. A. M. Sinzi, chief of the Astronomical Section, who planned this operation and has advised and encouraged them constantly. Finally, the authors also acknowlege the staff of the Meteorological Agency for their obliging help at Tori Sima.

(Astronomical Section)

References

Hirose, H. 1963, *Procedings of the First International Symposium on the use of artificial satellites for geodesy, Amsterdam*, p. 278.

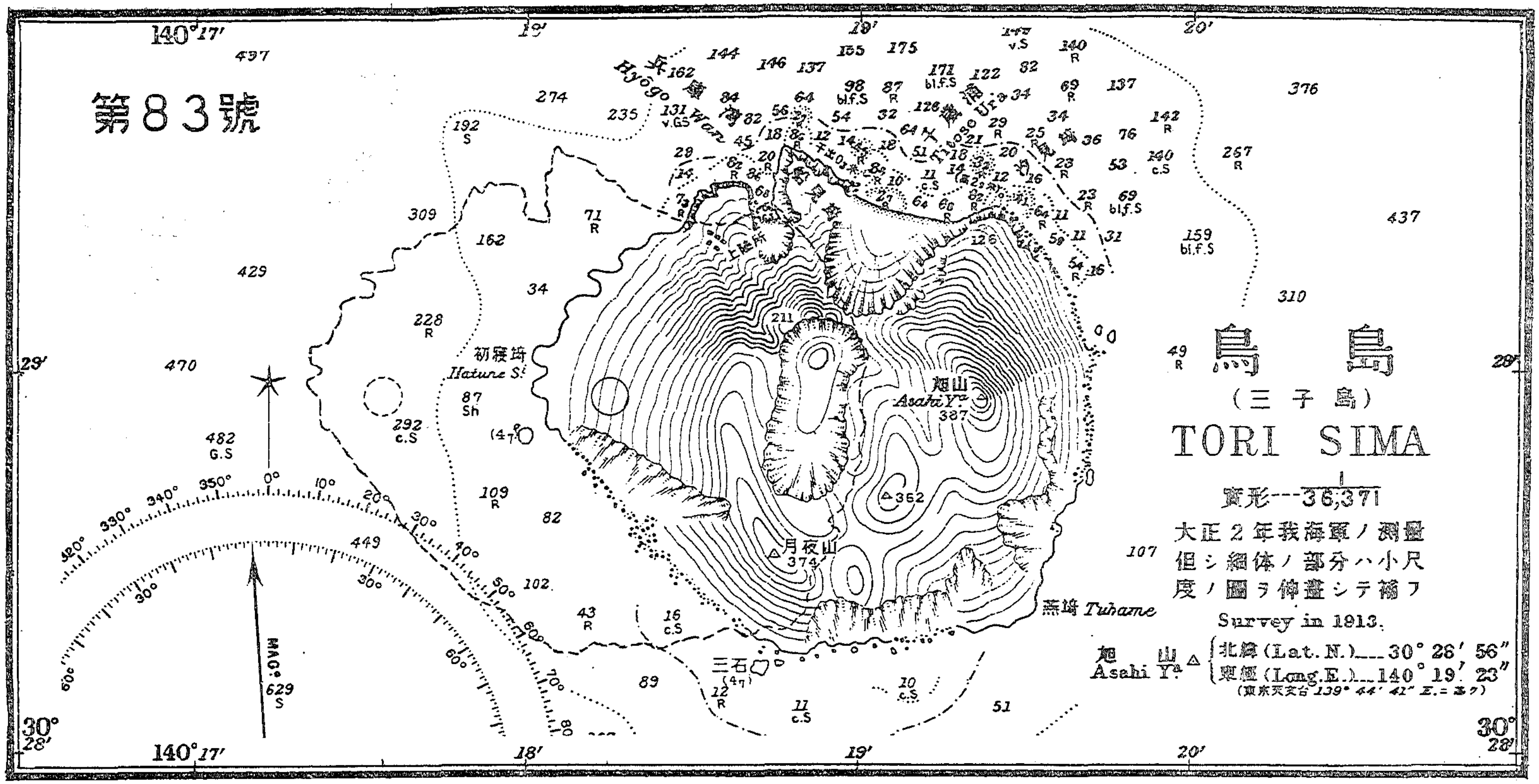

Fig. 1 Part of Chart No. 83, dashed-line contour shows location of the island by satellite.

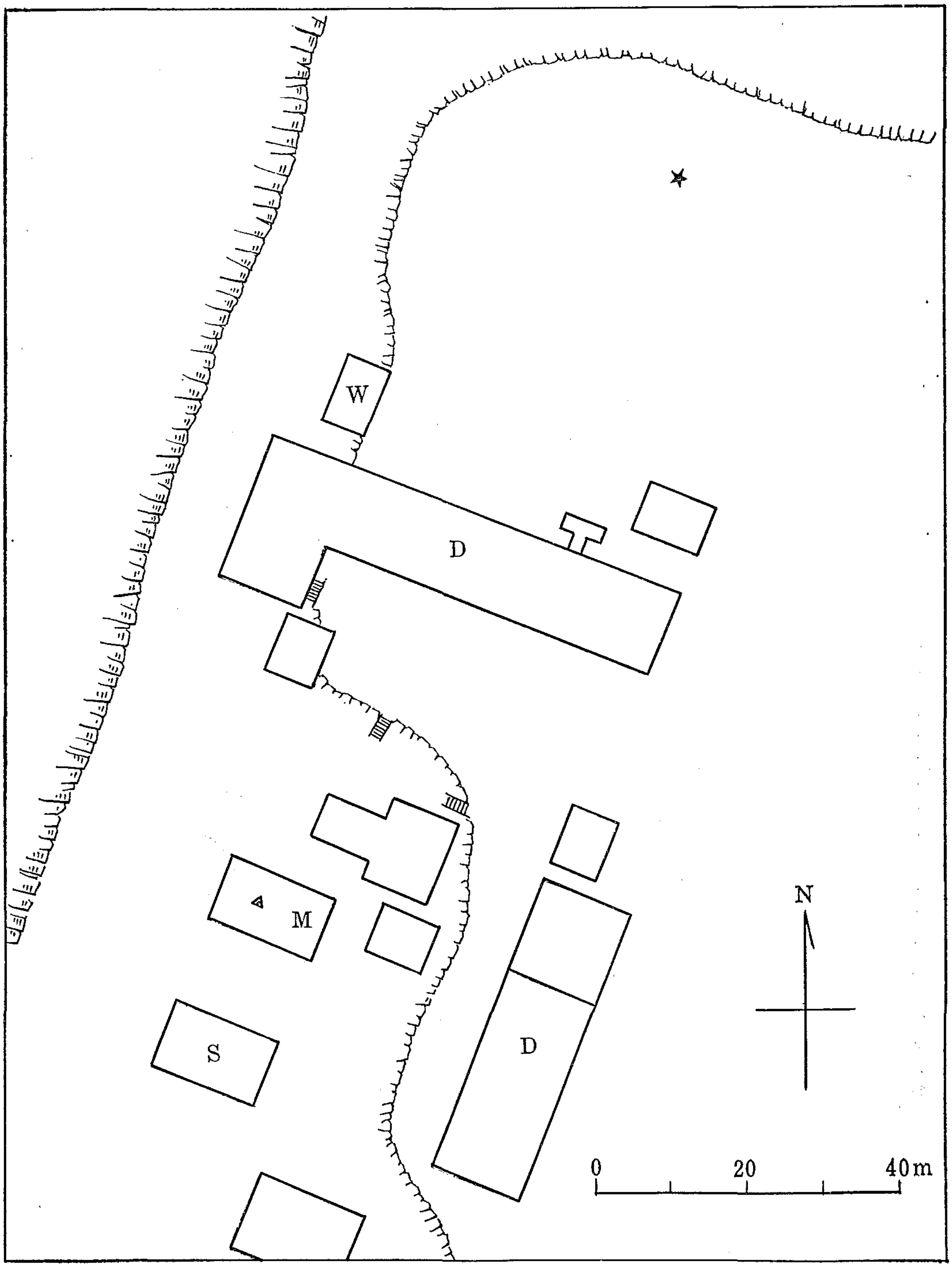

Fig. 2 Sketch plan of the meterological observatory,
D: Dormitory, M: Main building, S: Salon,
W: Water tank, △: New datum, ☆: Observing spot.

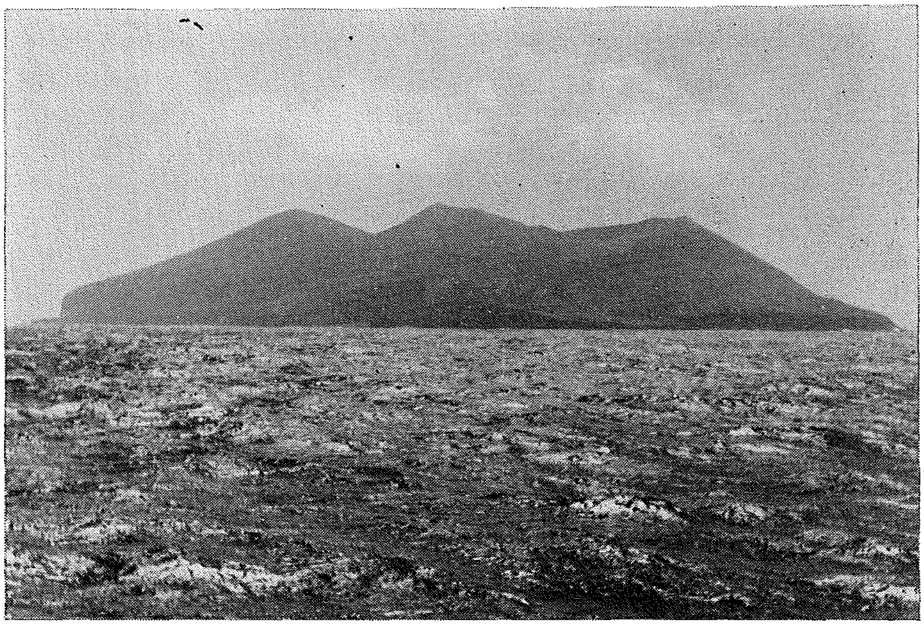

Fig. 3. Tori Sima viewed from north.

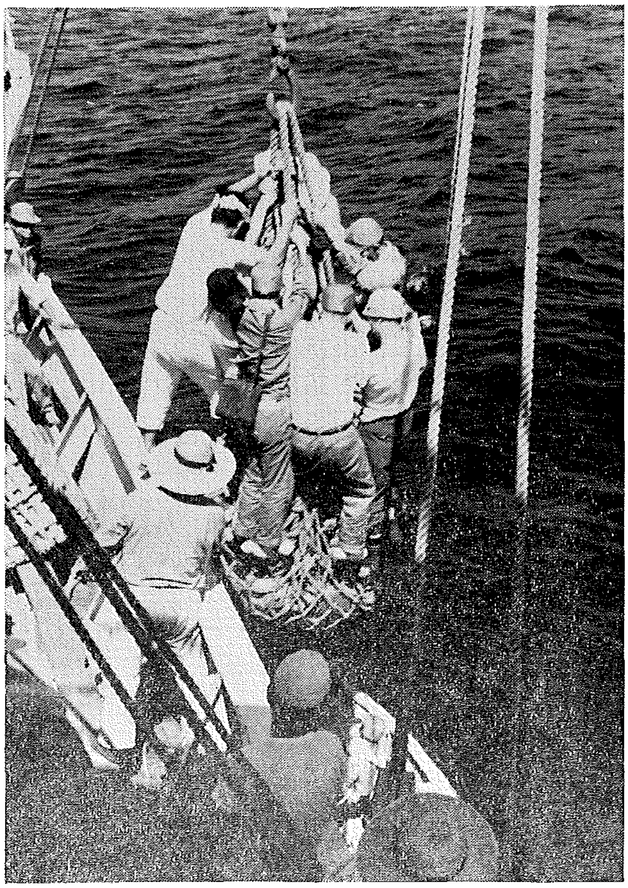

Fig. 4. Unloading the observing equipments.

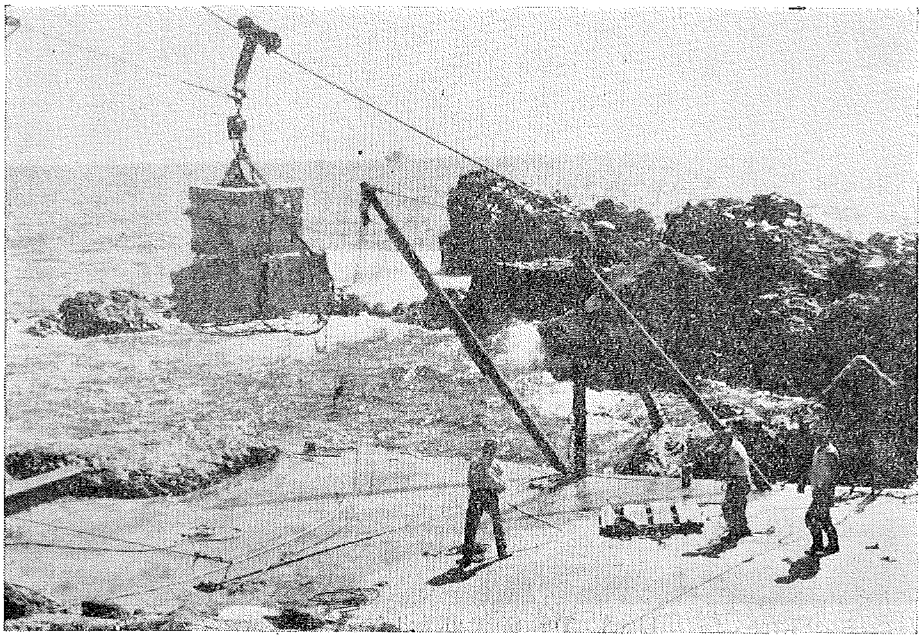

Fig. 5. Landing at wharf B.

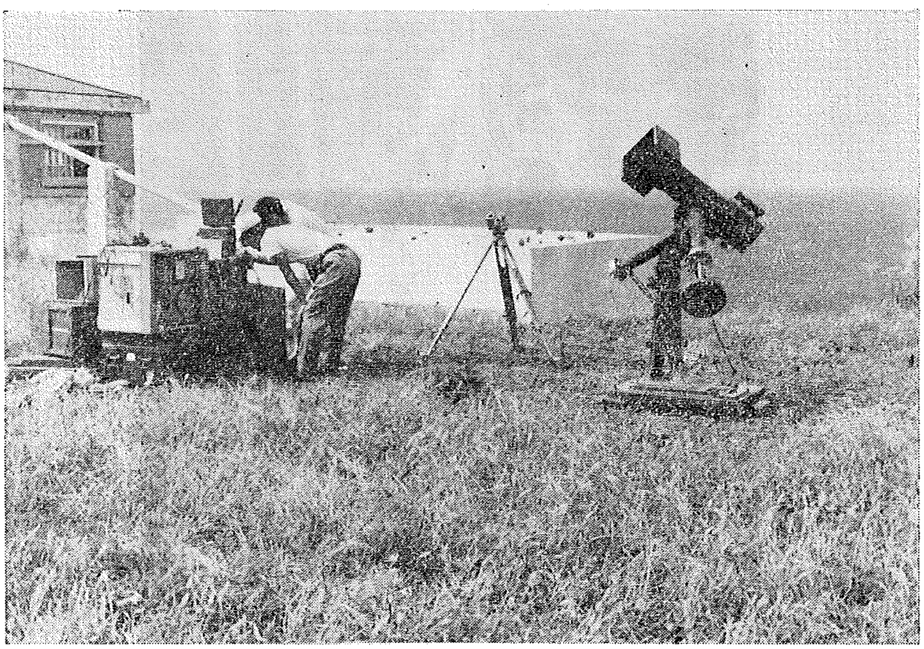

Fig. 6. Observing equipments for satellite.