General Statement: JARE South Pole Traverse 1968–69

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1. The Beginning

The idea for an overland traverse from Syowa Station to the South Pole, crossing the Antarctic Continent, came to me at the end of 1961 while I was on my way back to Syowa from explorations in the Yamato Mountains. As is well known, the Antarctic Continent is divided into East and West Antarctica by two great indentations, the Ross Sea on the Pacific side and the Weddell Sea on the Atlantic side. East Antarctica, whose coastline curves out into the Indian Ocean, features a vast, white expanse of plateau ice of great height and thickness, literally forming a "White Continent". Because of traditional difficulties in approach and supply, it had for a long time been entirely unexplored. My thoughts were that a South Pole traverse, crossing East Antarctica, would be worthy of being called the last geographic-scientific exploration left on the face of this earth.

Japan established Syowa Station in February 1957 on Ongul Island, located at 69°00′ S and 39°35′ E, to prepare for Antarctic research during the International Geophysical Year (July 1957–December 1958). Subsequently, Japan has sent six expeditions to the Antarctic.

Prompted by the international science activity during the International Geophysical Year, an Antarctic Treaty was concluded by the various nations concerned, aimed at furthering the scientific research of the Antarctica through international and peaceful cooperation. Japan was one of the original signatories of this treaty, which took effect in June 1961. However, the Japanese Antarctic activity at Syowa had to be temporarily discontinued because of the superannuation of the icebreaker SÔYA and the lack of sufficient helicopter crews for necessary air transportation. The Syowa Station was closed in February 1962.

The necessity for a long-range and continuous Antarctic survey and scientific research program was keenly felt, and a call for the reopening of Antarctic activity was strongly voiced in Japan. Japanese scientists made representations to their Government on the great importance and necessity for continuing scientific study in the Antarctic on a permanent basis, especially in the routine observation of aeronomy and meteorology, and in reseach projects on glaciology and biology. It was emphasized that Japanese Antarctic research had to be reopened in a region

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of the world in which scientists of so many countries were working in close cooperation and harmony in accordance with the object of the Antarctic Treaty, thus promoting the establishment of a firm foundation for the continuation and development of cooperation in the Antarctic on a basis of freedom of scientific investigation.

In response to this demand, the Japanese Government finally decided to reopen Antarctic activity on a permanent basis beginning with a target year set at 1965, and initiated preparations by designating the Defence Agency to take charge of transportation. The budget for building a new icebreaker, and for vehicles for an overland traverse toward the South Pole passeed the Diet in December 1963.

Thus Japanese Antarctic enthusiasts won their long battle to ensure the re-activation of the base on the Prince Olav Coast which had been evacuated in February 1962. The second stage of Japanese Antarctic activities aimed at determining the characteristic features of the location. One of the features of Syowa is that it is located directly below the auroral zone. Aurora australis is said to be caused by terrestrial and cosmic electrical discharges, and it is in this zone, centering on the geomagnetic pole, that the electric discharges are strongest and most frequent. The routine observations and duties of the wintering team were to engage in the studies and measurements at the station of aurora, air-glow, geomagnetism, ionosphere, natural earthquakes, and tides, while high level scientific research was to be conducted on the auroral spectrum, natural intensity, auroral radio noise emission, geomagnetic pulsations, ionospheric absorption, thermal processes in the upper atmosphere, and biology. Emphasis in the research work was to be placed on the study of upper atmospheric physics and biology, in line with the International Quiet Sun Year (IQSY) and the International Biological Program (IBP), respectively. Additionally, Syowa Station, which has gradually been completed as a permanent station, was to launch rockets into the aurora to probe its secrets and their relationship with solar activities.

As mentioned earlier, the largest and highest ice plateau in the Antarctic lies immediately to the south of Syowa Station. The straight-line distance between Syowa and the South Pole is 2,300 km, but it is 3,000 km by over-snow vehicle. The eastern part of the Antarctic Continent is still relatively unexplored. The United States as well as the Soviet Union have initiated ambitious surveys of this area in recent years, but one of the biggest adventures remaining was perhaps the overland traverse between Syowa and the South Pole. The basic emphasis for an inland survey would be the investigation of the geomagnetic meridian which passes through Syowa, and the research in earth sciences, meteorology, and physiology, conducted between appropriate points on the geomagnetic meridian and the South Pole.

2. Decision for a South Pole Traverse

A scientific exploratory journey to the South Pole would be significant but hazardous accomplishment. The decision by the National Antarctic Committee of the Science Council of Japan for a South Pole Traverse accelerated the planning. The survey inland from Syowa to the South Pole would be aimed similar to the local surveys, starting from a point to be manned as future inland station. The Japanese Expedition earnestly wished to accomplish this overland traverse in two summer traverses.

The first summer traverse was to investigate the area up to 75° S and to put in fuel depots for the second traverse party. The scientific objectives included the determination of the surface and subglacial rock topography, observations of the geomagnetic field, and studies of the physical properties of the ice sheet. VLF emission (a natural radio wave, very low frequency), weather observations, and the collection of snow samples for glaciological and geochemical studies were also included in the program.

The South Pole Traverse plan was made possible as a result of the development of a snow vehicle for this purpose. The performance to be required for the vehicle was based on the conditions the traverse party expected to encounter during their trip from Syowa to the Pole. That included resistance against cold as low as −60°C, a capacity to reach sufficient altitude to cross the watershed of the East Antarctic Continent, presumed to be 4,000 m above sea level, and a traveling capacity to drive over Antarctic plateau ice, where soft snow and hard sastrugi alternate, for a combined total of 6,000 km to and from the South Pole. The snow vehicles were to be equipped with meteorological observation instruments, a seismograph, a radio echo sounder, VLF emission receiver, a gyrosyn-compass for navigation, radio transmitters and the like. Each vehicle was to contain four berths plus a kitchen and snow melter, and was to be capable of continuous operation for a five-month period. On the other hand, because of restrictions placed by their transportation aboard the icebreaker FUJI, and the required capacity to drive over sea-ice or crevassed areas, it was decided that the total weight of the vehicle should be held below 8 metric tons. Thus evolved the snow vehicle "KD60" designed for the South Pole Traverse. Following a field test in Japan of KD60 vehicle No. 1, the KD601 was sent to Syowa on the occasion of the reopening of the base, and KD602 and KD603 were sent there along with JARE 1967-68, the expedition scheduled to carry out the first step of the South Pole Traverse.

The task of the South Pole Traverse itself was entrusted to the JARE 1968-69 wintering party, which would be able to operate the vehicles and develop countermeasures against the adverse conditions expected to be encountered. The following abilities and plans were recognized by the JARE Headquarters as countermeasures:

(1) Inland traverse experiences as described in Table 1.

(2) The required performance of the vehicles had been tested and proven to some extent by JARE 1966-67. Three traverse engineers were to participate in the traverse party as irreplaceable men; the vehicle's designer, a specialist in the engines installed, and an experienced mechanic.

Table 1. Japanese overland expeditions.

Party (Leader)	Season	Route	Method	Distance (km)	Days	Research subjects
JARE 1957–58 (NISHIBORI)	Summer	Botnnuten Peak.	Dog sledge	435	27	Geology, glaciology, meteorology
	Summer	Prince Olav Coast	Dog sledge	355	16	Sea ice, geology, meteorology
JARE 1959–60 (MURAYAMA)	Autumn	Mizuho Plateau	*KC20×2	250	20	Seismology, geography, meteorology
	Summer	(ANARE Mts.)	KC20×2	735	35	Glaciology, geography, meteorology
	Summer	Shirase Glacier	Man hauling	328	19	Geography
JARE 1960–61 (TORII)	Autumn	Shirase Glacier	KC20×1 **KD20×1	466	26	Glaciology, geography, meteorology
	Summer	(Fuel cache)	KD20×2	426	18	Geography
	Summer	Yamato Mts.	KD20×2	1,200	45	Glaciology, geography, meteorology
JARE 1961–62 (MURAYAMA)	Autumn	(Fuel cache)	KD20×3	610	35	Geography, glaciology, biology, meteorology
	Summer	Prince Harald Coast	KC20×1 KD20×1	665	17	Geography, meteorology
	Summer	75°S–Yamato Mts.	KD20×3	2,100	77	Glaciology, geography, meteorology
JARE 1967–68 (TORII)	Summer	Prince Olav Coast—Molodezhnaya Station	KC20×2 KD20×1	726	17	Geography, sea ice, meteorology,
	Summer	Plateau Station (proposed)	KD60×3 KC20×1	2,600	70	Glaciology, geography, geochemistry, meteorology

* 2.5 t, Gasoline

** 3.0 t, Diesel

(3) An experienced geodesist and geographer was to participate in the party and was to be able to work as a navigator during the inland trip. The traverse party was to be equipped with two C10 gyrosyn-compasses and a C4 as reserve, and with a navigation system for straight steering.

(4) The traverse party is to be equipped with two 100W KWM2A transceiver, a 50W SSB transceiver, and a 15W GRC-9 as reserve. An experienced professional operator was to be included who could also work as an electronics specialist for the radio echo sounder and the beacon, etc., as well as maintaining usual radio contact between the traverse party and Antarctic stations.

(5) A fuel re-supply arranged at the Amundsen-Scott South Pole Station.

(6) Provisions sufficient for six months.

(7) A surgeon to provide medical care for the traverse party.

(8) The provision of urgent countermeasures for any emergencies.

(9) Nine Antarctic-experienced men, *i.e.*, five who have wintered-over, and four with Antarctic traverse experience, out of the twelve members, and all to be acclimatized in coldness up to -50°C and in altitudes up to 3,000 m above sea level during a scheduled preliminary trip.

The proposed initial route to the South Pole was scheduled to follow 52° E, but while the JARE 1968-69 traverse to the South Pole was being preceded by the JARE 1967-68 traverse, it was considered that the southward advance route should be changed to 45° E via Plateau Station, in order to avoid overlapping with the route surveyed by the 1966-67 U.S.S.R. party. On the other hand, JARE 1967-68, which had been entrusted to survey up to 75° S and there to establish a 3-ton fuel cache, wanted to proceed along a route further westward to evade a crevassed zone located around 45° E and 70° S. It was ultimately decided that the basic southward advance route would be 43° E via Plateau Station, which was expected to be activated by the United States by the end of January, 1969.

The proposed scientific program included the following subjects: Measurement of elevation every 4 km; measurement of gravity and emission of the radio echo-sounder every 8 km; measurement of geomagnetism every 24 km; VLF emissions hourly at 50 minutes past; astronomical observations for position at noon, daily; ice pit work every 50 km; seismic shooting every 100 km; and occasional medical studies.

3. JARE 1967-68 Traverse to the Plateau Station

The JARE 1968-69 wintering team, with its target set on a South Pole traverse, came to Syowa Station at the beginning of 1968. Three KD60 over-snow vehicles and five large sledges were landed on the edge of the Antarctic Continent. This was the first time in the history of JARE that the relief ship had reached the actual Antarctic coast. At this time, the inland party of four scientists and five logistics men in five vehicles successfully returned from the Plateau Station, completing their mission as a forerunner to the South Pole Traverse party. The JARE 1967-68 party, led by Dr. T. Torii, had started their trip on November

5 with three KD60 and two KC20 vehicles, pulling 17 sledges. Their aim was a preliminary survey for the South Pole Traverse scheduled for JARE during the 1968–69 season. Five days out, the JARE 1967–68 traverse reached a previously placed depot, 234 km from the base. Four loaded sledges were dug out and added to the sledge train, which moved at approximately 4 km/h. On November 29, 681 km from Syowa, the party was at approximately 74° S, and at an altitude of 3,000 m above sea level. The day temperature there was −28°C, and the night reading was −42°C. On November 30, the team reached 75° S and 42°50′E, and there the team rested three days before moving on towards the Plateau Station, which was finally reached on December 14. After fuel resupply, the JARE 1967–68 party set out on the return trip, following their previous route, and completed successfully their mission of an inland survey, having carried out the observation of meteorology, glaciology, geomagnetism, and geochemistry. VLF emission observation was not made because of a trouble in machinery. On the other hand, the following fuel caches were established en route between Syowa and Plateau Stations; approximately 6,000 l of fuel at around 70° S, 600 l at 71° S, 400 l at 73° S, 800 l at 75° S and 1,200 l at 77° S, respectively.

In all, the JARE 1967–68 traverse party covered a total distance of 2,611 km in 71 days.

4. Preparation by JARE 1968–69

The moment of JARE 1967–68 handed over the control at Syowa to JARE 1968–69 on February 20, 1968, careful and ambitious preparations for the pole trip itself were started. The greatest objective of JARE 1968–69 was naturally to reach the Pole, but continuation of observations in the field of upper atmospheric physics, and meteorological studies at Syowa were also included in the expedition's mission.

A 3-week preliminary trip was carried out to provide a preparatory survey, to test the scientific and logistic instruments in the field, to establish fuel caches, and to acclimatize traverse members to the coldness and height of the ice plateau. This trip turned out to be a difficult trek because of the use of KC20 vehicles which were not equipped with various countermeasures to withstand a coldness below approximately −30°C. Nevertheless, the objectives were accomplished. The fuel and equipment cached by the previous traverse party were excavated from a deep drift by rigorous efforts in severe coldness and with heavily drifting snow, at an altitude of nearly 3,000 m. Through this trip, all the members became experienced in traverse operations and seemed to be full of self-confidence to undertake the impending hazardous traverse to the Pole.

The three months of June, July, and August were required to put the vehicles in good working order and to install the scientific instruments. For the KD606, pit work required an earth auger to be fixed to its platform. Additionally, a 4-ton caboose was provided with a radio echo sounder, a working table, a welding machine, a generator, a heated air blower, a heating device,

Table 2. Fuel program.

Syowa to South Pole

	Section	Syowa Station	70°00′S	71°00′S	73°30′S	75°00′S	77°30′S	Plateau Station	85°00′S	Pole Station
	Vehicles	← 603, 604, 605, 606			→	← 604, 605, 606			→	
	Weight of load (t)	39.8	41.3	42.9	39.4	31.8	28.6	34.5	26.2	
	Distance (km)	230	100	300	200	300	200	700	600	
	Expected consumption (*l*/km)	2.5	2.5	2.7	2.7	3.0	3.0	3.0	2.8	
FUEL	Balance carried (t)	—	10.0	13.2	12.3	7.1	4.4	2.6	5.3	
	Supply	12.4	4.2*	2.4*	—	—	—	9.0**	—	
	Balance as of starting point	12.4	14.2	15.6	12.3	7.1	4.4	11.6	5.3	
	Cache for return	—	—	—	1.0	—	—	—	—	
	Consumption	2.4	1.0	3.3	2.2	2.7	1.8	6.3	5.0	
	Balance	10.0	13.2	13.2	10.1	4.4	2.6	5.3	0.3	

South Pole to Syowa

	Section	Pole Station	85°00′S	Plateau Station	77°30′S	75°00′S	73°30′S	71°00′S	70°00′S	Syowa Station
	Vehicles	← 604, 605, 606		→	← 603, 604, 605, 606				→	
	Weight of load (t)	35.6	29.9	24.6	22.7	25.5	23.1	22.6	22.4	
	Distance (km)	600	700	200	300	200	300	100	230	
	Expected consumption (*l*/km)	2.9	2.9	2.4	2.3	2.0	1.9	1.8	1.7	
FUEL	Balance carried (t)	0.3	9.1	3.1	1.6	0.8	2.4	0.8	1.7	
	Supply	14.0**	—	—	1.2*	3.1*	0.4*	0.6*	1.2*	
	Balance as of starting point	14.3	9.1	3.1	2.8	3.9	2.8	1.4	1.7	
	Consumption	5.2	6.0	1.5	2.0	1.5	2.0	0.9	1.7	
	Balance	9.1	3.1	1.6	0.8	2.4	0.8	0.5	0.0	

* Cached previously by the JARE 1967-68 and JARE 1968-69.
** Fuel supply by the United States Navy.

a steam bath, and a switchboard for AC 100V and DC 24V and 12V.

The 4-ton caboose, made of metal, is a new contrivance which was developed for the traverse party. It was to provide them with facilities as an observation room and workshop. Like the three other 4-ton steel sledges, the caboose was put together by the members themselves.

It is no exaggeration to say that the success or failure of the traverse would depend mainly on the efficiency of these vehicles and sledges. After completion of vehicle and sledge assembling, a test drive was carried out to confirm data under actual driving conditions, at full scale, for the actual terrain of the survey. Subsequently, a table of estimated fuel supply and consumption (see Table 2) was drawn up on the basis of the data obtained, based on the distance to be covered, snow conditions, elevation, and pulling load.

5. Time Schedule for the Traverse

By mid-September everything was finally ready in the formation of the traverse train as described in Table 3. The proposed plan was to reach the South Pole in 90 days, covering approximately 2,600 km, and then to return to Syowa in 60 days, along the same route, a total of 150 days for the period ending mid-February, 1969, when the icebreaker FUJI would have to depart to steam northward.

According to this schedule, the traverse party would be expected to encounter the winter low pressure conditions when it reached the ice plateau at an elevation of 3,000 m, in the area south of 73° S, and be at the highest point en route, around 77° S to 78° S too early in the season to enjoy the effect of solar heat absorption. I had paid careful attention to the movements of the winter weather and low pressure areas in the inland areas, but the weather report from the Plateau Station said that it was still below −75°C at the mid-September period.

In addition to the information obtained at Syowa, temperature data for the Plateau Station for the previous two years were supplied by the Department of Polar Research, National Science Museum, Tokyo. In accordance with the monthly mean average temperatures at the Plateau Station, we could operate in the December to February period because our vehicles would withstand temperatures as low as −60°C. Moreover, the Plateau Station is accessible even in the end of November, provided operations temporarily ceased when the temperature fell below −60°C. Although we had to expect worse conditions at around 78° S, because of higher elevation and an earlier season, before reaching the Plateau Station, a sudden rise in temperature in November and a relatively large difference between day and night temperatures might be expected. Therefore, the traverse was scheduled to arrive at Plateau Station not earlier than November 10, before which the weather conditions were too severe for traverse activitities. Under these conditions we would move while temperature rises, excepting the time of crossing meridians when it is below −60°C. Success or failure of the traverse would depend heavily upon how we can make the best use of the brief span of Antarctic summer during the trip. It was finally decided that the traverse party was to leave Syowa on September 28, 1968.

6. The Journey Begins

Everything was finally ready, and the JARE South Pole Traverse party, in four KD60 vehicles, set out from Syowa to the South Pole. The party consisted of Masayoshi MURAYAMA, leader; Tsuneo ETO, seismology, radio echo sounding; Yasoichi ENDO, glaciology; Kenzo FUJIWARA, geomorphology; Masayuki HOSOYA, engineer; Seiichi KAKINUMA, geodesy, geomagnetism, VLF emission; Iwao KAWASAKI, logistitics; Akio KOBAYASHI, medical doctor; Nobukazu NISHIBE, radio operator; Kitoshi TSUCHIYA, engineer; Riichi YAMAMOTO, engineer; Keizo YANAI, gravity, geodesy.

On September 28, 1968, the No. 604 vehicle left Syowa to St. 16 in the wake of the advance party, vehicle Nos. 603, 605 and 606, all of which had left four days earlier to load fuel at a rendezvous point. When ready to go, the four KD60 vehicles would be hauling, in all, three 4-ton sledges, ten 2-ton sledges, one 4-ton caboose, and one 2-ton caboose. The total load was approximately 45 t including the sledge weight, and was composed of 24 t of fuel and 3 t of food.

The traverse advanced in two sections. The first section consisted of No. 604 as the lead vehicle, and No. 603. At a stop every 4 km, these two vehicles, keeping a constant distance of 4 km between each other, simultaneously measured the elevation through radio contact, that is, using the interval method for elevation measurement. Meteorological observations were conducted by No. 604 at 0600Z, 1200Z, and 1800Z. Measurements were made of stakes placed by JARE 1967-68 en route towards the Plateau Station during the previous season, and

Table 3. Formation.

	1st Section		2nd Section	
Vehicle No.	604	603	605	606
Members	MURAYAMA TSUCHIYA FUJIWARA NISHIBE	KOBAYASHI KAWASAKI	ENDO YANAI KAKINUMA HOSOYA	YAMAMOTO ETO
Tasks	Navigation Elevation Meteorolology Topography Radio	Elevation Snow accumulation	Geomagnetism Gravity VLF emission Snow & ice, radio echo sounding Position	Drilling Pit work Seismic sounding
Sledge No. (load)	94 (fuel) 29 (observation) 28 (food) 122 (fuel)	31 (fuel) 24 (fuel) 2-ton caboose 36 (empty)	95 (fuel, VLF antena) 23 (machine) 25 (fuel) 27 (observation)	4-ton caboose 96 (fuel) 23 (food)

were to be placed by JARE 1968-69 between the Plateau Station and the South Pole to study snow accumulation. At 0900Z radio contact was routinely made between the traverse party and Syowa. Meteorological data were transmitted to Mawson Station daily, and the daily traverse report for JARE Headquarters, Tokyo, was transmitted to Syowa for relay.

6.1. *Radio code from traverse party to Syowa*

The code consists of nine groups composed of five figures when the party is moving, and six groups when the party has stopped because of bad weather, observations, or vehicle maintenance.

a) When the party is moving: 1st group of figures shows month, date, and time sent. The 2nd and 3rd are latitude and longitude, respectively; the 4th, true heading and distance covered from the starting camp to the present location; the 5th, the starting camp number and starting time; the 6th, an optional camp number and its distance from Syowa; and the 8th are its position by latitude and longitude. The 9th gives a meteorological report at the time of radio contact, as follows: 1st digit shows weather (0 means fine, 1 clear, 2 cloudy, 3 clear with drifting snow, 4 drifting snow, 5 blizzard, 6 snow, 7 mist), 2nd and 3rd, and 4th and 5th digits show wind speed and temperature, respectively.

Sample: 00112 73×45 46×15 18050 20063 20730 73×20 46×15 31545

The interpretation would be: October 1st, 1200; Position: 73°45′S and 46°15′E; heading 180° true, and 50 km covered from Camp 20; starting time was 0630; distance from Syowa to Camp 20 is 730 km. The position of Camp 20 is 73°20′S and 46°15′E. Present weather is clear with drifting snow, wind speed is 15 m/s, and the temperature is −45°C.

b) When the party is at standstill: 1st group shows date and time sent; the 2nd (CHINX) is a code for "standstill"; the 3rd, number of camp and distance from Syowa; 4th and 5th, position of the said camp; and the 6th is the meteorological report, the same as in (a).

Sample: 20112 CHINX 60730 73×20 46×15 53530

The interpretation would be: February 1st 1200 sent. Staying at Camp 60, 730 km from Syowa. Position of Camp 60 is 73°20′S and 46°15′E. Present weather is blizzard, wind speed 35 m/s, and the temperature is −30°C.

6.2. *Radio code from Syowa to traverse party*

The code consists of 11 groups. The 1st group shows date and time sent, the 2nd, 3rd, and 4th, the synoptical code for the weather at Syowa, the 5th, commencing with "1", is the weather forecast, the 6th and 7th groups, commencing with "2" and "3", respectively, are reports about station facilities; the 8th, commencing with "4", is a report about station observations; the 9th, commencing with "5", is radio traffic information at the station; and 10th and 11th give the position of the relief ship.

Sample: xxxxx Nddff VVwwW PPPTT 1xxxx 2xxxx 3xxxx 4xxxx 5xxxx xx–xx xx–xx.

Upon arrival at an overnight stop, generally after convering a distance of approximately 50 km, a glaciological pit was dug in which hardness and density of various layers were measured and a description made of the snow structure to a depth of 2 m.

The second section consisted of vehicle Nos. 605 and 606. Every 8 km the section stopped to measure the gravity with the LaCoste gravity meter. Every 24 km a stop was made to measure the three vector components of the magnetic field. Total magnetic intensity was measured with a proton magnetometer. Every 50-minute after the hour, a 5-minute stop was made for the observation of VLF emission. A one-hour stop centered on noon was made for astronomical observations. Every 100 km, the traverse party stopped to make seismic measurements. It had been scheduled to make a radio echo sounding to measure the ice thickness, but unfortunately we had to give this up because of a mishap in the middle.

7. The Traverse Party Encounters Difficulties

As expected, the traverse party encountered many difficulties when it entered the ice cap area in early October, a period when the Antarctic summer had not yet come to the inland. The progress was slow because of the heavy load while straining up the upward slope area near the coast, additionally hampered by rough weather in the beginning of October. On October 3, only five days after the party had left Syowa, an unexpected accident occurred. While working in strong drifting snow, Yasoichi ENDO, our glaciologist, had his left arm become entangled in the earth auger installed on vehicle No. 606 for the purpose of glaciological drilling. The arm bone was broken, a serious injury which would take three months to heal completely. There was nothing to do but to send him back to Syowa. Therefore, the number of the traverse party members dwindled to eleven only just after leaving Syowa. The party, somewhat restricted by the accident, nevertheless made a determined push against the soft snow and hard sastrugi. At about 72°S the party entered an area of very soft snow which seriously impeded the progress of the vehicles. There were alternate hollows and knolls, and the deep soft snow and extremely hard ribs both presented a defiant barrier against out advance. One of the reasons for trouble in our progress at this point was the shape and size of the 4-ton sledge, and the method applied for pulling the sledge. One vehicle was hauling one 4-ton sledge and three 2-ton sledges in that order. However, the vehicles were forced to a stop many times as a runner of the 4-ton sledge, at the head of the train, would tend to run into the soft snow surface, though the vehicles themselves were able to pass over it. The vehicles then lost steering and driving control, mainly because of the large 4-ton sledge being connected to the vehicle by a triangular draw-bar. Owing to the repeated strong shocks given the sledges when they were pulled out from the soft snow and the highly uneven sastrugi, all of the 4-ton sledges and the caboose were eventually damaged, a crack appering in the body of the sledge and the part which joints the sledge to the vehicle being torn off. There was nothing to do but to leave these damaged sledges behind. Before reaching 75°S, they were all left behind, and the vehicles were hauling the remaining train of four 2-ton sledges by wire rope, which provided smoother driving because of its flexibility in comparison with the rigid draw-bars.

According to the report made by the earlier U.S.S.R. traverse (Vostok-Pole of Inaccessibility-Molodezhnaya, 1964) (KAPITSA, 1965), the method of advancing the train in two sections was highly successful. They found that 6 or 8 hours after the passage of the first tractor, the tracks become two or three times harder than the surrounding snow surface and the following tractor's advance became easier. As previously mentioned, the JARE traverse also advanced in two-sections, with an interval of 2 or 3 hours, but this interval proved not only to be too short to have the tracks become harder than the surrounding snow surface, but also we found the ruts made by the first vehicle were quickly filled up by drifting snow, or the tracks were covered entirely by drifting barkhans, especially in the area from the upward slope as far as 78°S.

The party proceeded southward along 43°E. Forty days later we passed 76°S. From the starting point to the vicinity of 75°S, the surface was relatively hard, with the snow density rarely reaching 0.4 g/cm^3. After passing 75°S, however the drifting snow was heavy, caused by the downward wind, and barkhans and sastrugi created by the drifting snow were successively encountered. Therefore, we were plagued with a softer-than-expected snow surface, in addition to the uneven surface. One of the KD60's, No. 603, developed trouble in its turbocharger, and we were forced to abandon it at 76°30′S. Equipment such as the crevasse-bridging units, which appeared to be unneeded for the remainder of the trip to the South Pole, was left behind. The load of the abandoned vehicle was transferred to other vehicles and sleds.

The progress had also been slow when the party climbed to the East Antarctic continental watershed, more than 3,700 m above sea level, and through soft snow in severe cold, −60°C. When the temperature was −50°C or lower, instrument lines and wires froze so hard they broke like sticks or dead branches. The scientists concerned slept hugging their crystal watches or altimeters to their chests in order to prevent them from going out of order through freezing. When we carried out observations we had to make them very quickly so that the insturments would not lose their validity. The ruts made by the vehicles was as deep as 30 cm into the snow, and the fuel consumption rate became as high as 4 l/km. More than a 5-minute stop for observations caused the runners of the sledges to stick to the snow surface and starting became impossible without dividing loads. This was because the sledge's friction during movement increased as the temperature decreased. The vehicles' traction force was decreased by the increased snow-pressure resistance from the soft snow.

On the other hand, the runners did not slide well when the snow surface temperature fell to −45°C, or as the atmospheric temperature went down.

When the temperature dropped further, to around $-53°C$, this condition became rapidly worse. As the surface of the snow had not been warmed by the sun for many months in the extreme cold, the low temperature hampered the smooth progress of the sledges.

At the high altitudes, more than 3,700 m above sea level, the color of the engine's exhaust gas turned black because of the air shortage and the increased resistance, resulting in a lower power output accompanied by knocking sounds while driving at low and medium speeds.

The 3,717 m high watershed, reached in mid-November, was named Fuji Divide (tentative) because its height approximately coincided with that of Mount Fuji. After crossing the East Antarctic continental watershed between 77° and 78°S, the prevailing winds were found to have changed from east to north. Consequently, the lead vehicles suffered from reduced or no visibility ahead, due to this tail wind blowing the dense, black exhaust gas forward of the vehicle while in the extremely cold atmosphere of $-50°C$. As a countermeasure for this trouble, the Herman Nelson preheater duct was put on the exhaust pipe located on the left side wall, in order to guide the gas to the top of the vehicle, but the duct burnt out in a moment, and there was no other remedy except for putting in a chimney provided by the Plateau Station.

8. Plateau Station

The party finally reached the Plateau Station, located at 79°14′S, and 40°30′E. The JARE party was greeted with cheers and handshaking by all the personnel at the Plateau Station. The party was officially welcomed by Lieutenant Jerry JOHNSON, the officer-in-charge of the station, and by Mr. George Rubin de la BORBOLLA, the station scientific leader. The Plateau Station is explained as follows in "Antarctic", Vol. 5, No. 4:

"For three years from 1966 the United States has operated a station at a remote spot on the south polar plateau. Situated at 79°14′S, 40°30′E the station has sat atop approximately two miles of ice at an altitude above sea level of nearly 12,000 feet. Because temperatures during the winter months averages below $-70°F$, no aircraft operations were possible from mid-February to mid-November, leaving the eight-man complement completely isolated, except for radio communications, for eight months each year. Located about 700 miles form the South Pole in the direction of South Africa, Plateau Station had been sustained by LC-130F Hercules aircraft which flew from McMurdo, 1,400 miles away, frequently staging through Amundsen-Scott South Pole Station. The isolated site was chosen to fill a gap in scientific coverage. Programmes were conducted in meteorology, micrometeorology, upper atmosphere physics, and geophysics.

"Built during the 1965–66 operating season, the main station consisted of four prefabricated vans, each measuring 36 by 8 1/2 feet. Between the vans was flooring for another 8 1/2 feet, with a total station weight of 23,000 lb. The space was roofed to give a central living area of approximately 25 by 72 feet. A fifth van and 16-by-32-foot Jamesway hut were set up about 1,000 feet from the main building to be used in case of emergency. The construction crew had lived in two Jamesways, which were left on the site. These, with two others added later, provided recreation and storage space.

"Two 55 kW generators were installed in the main building, each sufficient to power the station. The emergency hut housed a third generator. Heat was derived from the warmed engine coolant of the diesel generators by means of heat exchanger system. The exhaust heat from the same engines was used to melt snow for water. Other amenities included an electric kitchen, washing machine, cloth dryer, a shower, and flush toilets. The United States Navy has manned the station with a physician, a mechanic, an electric technician, and a cook to support the programme of scientific investigation carried out to four civilian scientists under the auspices of the United States Antarctic Research Programme.

"The station was ideally located for studies in meteorology. No significantly different weather conditions existed for hundreds of miles around, and the remarkable phenomena of air stratification and temperature inversion could be studied in clarity not seen elsewhere on Earth. At 79°S the Antarctic night and day are each four months long, separated by two two-monthly periods during which the sun rises and sets. These long periods of light and dark, combined with the vast expanse of snow, provided an opportunity for basic studies in heat radiation. Routine weather measurements revealed one of the hardest environments known to man: temperatures varied from −1.3°F to −123.1°F, with the mean annual temperature being approximately −70°F."

After the JARE party received an additional 10 tons of fuel, repaired the vehicles, and even had a chance for a rest, the traverse party started from the Plateau Station on November 10, 1968. The station was scheduled to close in January 1969. Plateau Station is situated roughly at midway of the course between Syowa and the South Pole. It was very fortunate for the traverse party that the Plateau Station, an ideal relay station, would still be operating at the time of their proposed return.

By coincidence, at the time we arrived at the Plateau Station, a sign of summer, sunshine, began to appear in inland Antarctica. With the re-emergence of the sun over Antarctica, the low pressure section of stratosphere which stays over the South Pole during the winter time, becomes split and moves to the central part of the East Antarctic Continent, gradually losing its strength, and is finally replaced by the high pressure section which appears over the Vostok Station, U.S.S.R., to bring summer to Antarctica. It was just as we had expected, the arrival of the JARE 1968–69 party at the Plateau Station coincided with the arrival of summer.

9. Plateau Station to the South Pole

The 1,300-km traverse route from the Plateau Station to the South Pole is a long ice field with a succession of mild undulations. The surface of the snow now became better, and the party could make better progress with each rise of the snow surface temperature as the summer progressed. With the high pressure over the South Pole at the time, the weather was fine, with only a very weak wind, so that measurements and observations could proceed very smoothly.

The snow surface up to the area of 82°S was the same as in the vicinity of the Plateau Station, very flat but small-size sastrugi was distributed uniformly. Thereafter, downward slope towards south-west was conspicuous when the traverse party was proceeding to the vicinity of Pole of Inaccessibility. Undulation in the snow surface which seems to be characteristic of inland plateau began in the area of 83°S, but from a general view, there was a very flat terrain with the waving of 5 to 10 m wave-height in 3 km wave-length in the direction of NNW to SSE.

Although it was mid-summer in the remotest area on the polar ice cap atop approximately 2,500 m thick of ice at an altitude of 3,500 m above sea level, the temperature was still around −40°C. However, the black-painted vehicle received the benefit of sunshine to the utmost. Although the sun was not so high, the outer walls of the vehicle, exposed to direct sunshine, when there was no wind, had a temperature as high as 53°C, while the atmospheric temperature was −33°C at midnight. This caused the temperature of inner walls of the vehicle to rise higher than 32°C. Owing to the unexpectedly high temperature, members of the traverse party sometimes found it difficult to sleep at night. The temperature in the cabin and engine compartment was maintained favorably as black color was selected for vehicle's exterior painting so as to fully absorb solar heat and the insulating material used was of excellent quality. This maintenance of warmth meant that not only heating fuel was economized, but also good results were brought to every portion of the vehicles.

The vehicle, which started at six o'clock every morning, was parked in a position heading about 80 degrees to the east from the south, so that the sun which does not set in the Antarctic summer moved from the south to the east keeping warm the battery, which was installed on the right side of the vehicle, preventing cooling of the engine, and keeping the temperatures of water and oil at 25° and 15°C, respectively. There was no need for preheating the engine.

From the information given by previous traverse in the vicinity of the Pole, unfavorably soft snow was to be expected for a distance of 200 km from the Pole. In the terrain of 80°S, the temperature rose to even −30°C decreasing the friction of sledge movement. When the traverse party was proceeding in the area between 85°S and 87°S, we even experienced a hallucination of voyage in the dead calm of the Indian Ocean. In addition, the downward slope towards the Pole helped the party to continue smooth and trouble-free advance with low fuel consumption. But this situation changed from a point 87°S. No wind or radiation crusts were found on the snow surface from this area and the undulations were more ramarkable. The surface waved in approximately 20 km of wave-length and with 20 or 25 m of wave-height. The fuel comsumption rose suddenly from the point of 87°S to the Pole as was in the area of around 79°S in spite of the fact that the load had been reduced to only five or six tons for each vehicle. The fuel consumption rate did not exceed 0.5 l/km taking load into account, in contrast to the fact that the highest fuel consumption recorded at 79°S exceeded 0.5 l/km × ton. It is a very interesting coincidental fact that the hardness of snow surfaces were around 1.5 kg/cm^2 in the area of 87°S compared to less than 1.4 kg/cm^2 in the area of 79°S where the party encountered difficulties because the vehicles' tractional force was decreased by the increased snow-pressure resistance from the soft snow.

10. South Pole

On the 83rd day after leaving Syowa, the traverse party arrived at the South Pole. It was not the no man's land that SCOTT or AMUNDSEN saw. Lieutenant D. L. DAVIDSON who was at the Pole to cover JARE South Pole Traverse reported in USN news release as follows:

"On December 19, 1968, the U. S. Navy was privileged to host a historic event at the South Pole. At precisely 2 p.m. three black tracked vehicles made their way over the gleaming white horizon and stopped in line within yards of the Geographic South Pole.

"This entourage of vehicles, each towing sleds carrying more than 10 tons of supplies had just completed a 1,500 mile trek across Antarctic wasteland from Japan's Syowa Station. The Japanese traverse party of 11 Japanese scientific researchers was greeted with cheers, handshaking and backslapping by U. S. Navy men and a handful of Japanese scientists and correspondents flown to the Pole by the Navy. The traverse leader, Mr. Masayoshi MURAYAMA, and his men were welcomed by Lieutenant Jay BOWMAN, the officer in charge of the station, and by Commander James KEITH, Deputy Chief of Staff (Operation) for Commander, U. S. Naval Support Force Antarctica.

"A brief ceremony was held at the Pole under the fluttering of flags of Japan and U.S.A. The arrival marked the end of the first half traverse for the hardy Ninth Japanese Antarctic Research Expedition (JARE 1968-69). After several day's layover at the Pole they will begin their return to Syowa. During their time at the South Pole Station they will make repairs to their vehicles, load onto their sleds neccessary fuel and other supplies which were flown in for them by the Navy, and take some time to rest for their coming journey.

"JARE 1968-69 is scheduled to remain at Pole Station through Christmas before returning to Syowa via the Plateau Station. The traverse is now due to arrive at the Plateau Station before that station is deactivated at the end of January.

"This traverse is in the long tradition of Antarctic exploration. Norwegian Roald AMUNDSEN and four companions were the first men to reach the Pole on December 14, 1911, using dog sledge team. Englishman Robert Falcon SCOTT arrived about a month later on foot with four companions. His entire party died on their return from the Pole.

"Not until 1956 did another man set foot at the South Pole. On October

31 of that year Rear Admiral G. J. DUFEK, first commander of the Navy's Operation DEEP FREEZE, landed at the Pole with his crew in an LC-47 aircraft. The station was established later that year and has been occupied continuously ever since.

"In a gesture of international friendship the Japanese prepared for members of the station a meal of sukiyaki, a favorite dish in Japan, which was enjoyed by all. Camaraderie and friendship were evident throughout the stay of the Japanese despite a minor language barrier.

"An estimated 5,000 men from many nations have now reached the South Pole. Almost all of them have come by Operation DEEP FREEZE aircraft. Very few have distinction of having made an overland traverse to this last frontier on Earth.

"Christmas, at the South Pole Station, can be a lonely time. The men stationed here begin their tour of duty on October and remain at the station for a complete year. This particular Christmas at the Pole, though, was unlike any other in the 12 years' history of the station. This year the festivities were shared by 11 Japanese friends of JARE 1968-69.

"The Japanese lent an air of international friendship and cooperation unprecedented in the history of Christmas at the bottom of the world. About 11 o'clock of Christmas morning, all had gathered in the station's lounge. To begin the day, Christmas greetings were exchanged between Lieutenant B. J. BOWMAN and Mr. MURAYAMA.

"Gifts were exchanged on both sides to the delight of all concerned. A large package was given by members of the expedition to the station. On the wrappings, done in Japanese style, were the words "Best wishes for a Merry Christmas and a Happy New Year from the Japanese Antarctic Research Expedition". In return a package to the Japanese said "Merry Christmas from the men of South Pole Station to the Men of the JARE 1968-69 traverse party. Congratulations on your important success. Best wishes for a safe and speedy raturn home.

"Gifts to the Americans included wool socks, tea, toothpaste, razor blades, and a hand-made apron lettered in Japanese for the station cook. The box for the Japanese contained 12 bottles of blended whisky to help ease the extreme cold of their long return to Syowa Station. In addition, various gifts, souveniers and momentos has been exchanged both ways throughout the visit. Following this international exchange, eggnog was served and the remainder of the morning was spent in quiet conversation and in the opening of the gifts from home.

"Early in the afternoon, just prior to the departure of the Japanese from the Pole, a splendid meal was served in the galley. The meal was truly in the tradition of a Christmas feast. All of those present joined in demolishing two whole roasted pigs, several turkeys, shrimp cocktail, soup, asparagus, corn, giblets, gravy and turkey stuffing, a variety of salads, eggnog, hot rolls, pumpkin and mince meat pies, ice cream and cookies."

Instead of the "disappointment" felt by SCOTT, we had the pleasure of being welcomed and tasting fresh vegetables and enjoying splendid Christmas at the Pole. Instead of the "despair" experienced by SCOTT, we felt relieved as we received spare parts of snow vehicles transported by air from Japan to insure safety of the return trip to Syowa. What a change the South Pole has undergone!

11. The Return Journey

It was on the afternoon of Christmas Day that the traverse party departed for Syowa after obtaining vehicle maintenance and fuel supply.

On our way to the Plateau Station, the track of the coming path remained clearly on the surface of the snow, and we were able to follow it easily. In the area north of 88°S, however, the rut in the loose granular snow was generally filled with snow, but its outline was about 40% visible.

In general, smooth surface with rather hard snow, lighter pulling load, less upward slopes, and higher temperature combined to ensure trouble-free progress. The travel went satisfactorily and observations conducted at a faster pace than was scheduled.

On January 3, 1969, the traverse party was excited by the initial radio conversation with Dr. Kou KUSUNOKI, leader of JARE 1969-70 and Captain Shigeo MATSUSHIMA aboard the icebreaker FUJI which was approaching Syowa Station ahead of her schedule. But the Captain seemed to be worrying about the progress of the traverse party which was still far away from shore—a distance of more than 2,000 km. In fact, the traverse party had again encountered heavy drifting snow and had found previous tracks filled up entirely with snow in the vicinity of 85°S. Though soft snow and heavy sastrugi forced fuel consumption to rise again, we were not concerened about our fuel possession because there was surplus fuel and caches made by us were en route to the Plateau Station.

North of 85°S, there were many smooth areas in the waves with small size drift, or barkhands like a tongue in the direction of wind which we were informed by an aircraft that flew over this terrain previously. While returning towards the Plateau Station, the old rut to around 83°S in the region from north of 85°S was completely filled with snow. We found how snow was transported by weak wind as drifting snow and how it filled the rut. Dr. A. DRALKIN, U.S.S.R., who observed snow cover in his traverse between the Geomagnetic South Pole to the Geographic South Pole, stated that the relief of the snow surface, in the central region of Antarctica, is formed chiefly under the influence of weak winds, low air temperatures and intense solar radiation, and his observations showed that even weak drifting snow fills the caterpillar ruts of the car rather rapidly regardless of their depth, especially on a loose and granular snow surface. Snow transport in the central region of the continent is localized, since it is due to wind velocity, the character of the predominant snow relief, the general synoptic situation and other factors (DRALKIN, 1962).

Sublimation on the snow surface was distinguished in the terrain north of

81°S. Accordingly, the density of snow decreased to around 1.7 kg/cm^2 from the average density of 2.5 kg/cm^2 in the region between 86°S and 82°S. Soft snow surface caused by sublimation resulted in increasing fuel consumption rate which was between 0.26 and 0.29 l/km×ton from the rate of 0.24 l/km×ton in the region between 86°S and 82°S. The sublimation decreased in the visinity of the Plateau Station, because wind velocity increased in the region of the Plateau Station located on the southern slope of watershed of East Antarctic Continent, compared to the ice cap of the central region of the Continent.

It was fortunate that serious mechanical failures were very few. But several hours' delays were encountered en route for the repairing of such mechanical damages as leak in break cylinder, breakage of starter, and troubles in piping for heating.

On January 14, 1969, the traverse party arrived at the Plateau Station which was in the process of evacuation to be finished by the end of January. We spent several days at the Plateau Station taking in fuel supply and additional mechanical maintenance. There were signs of coming Antarctic autumn in inland—the temperature went down to −40°C again, but we were surprised to find by telephone call from Syowa that it had recorded the highest temperature of 9.5°C since its establishment. The distance exceeded 4,000 km from Syowa to South Pole and back.

We reached the Fuji Divide again. Wind was weak at this watershed, which is believed to be the source of the wind descending the Antarctic slope to the coast. Because of the weak wind and extremely low temperature, it was covered with soft snow and there was heavy sublimation due to summer sunshine. The vehicles had to go through deep snow and the trip was difficult, but the party now had light load to carry.

Snow conditions and traction-load affect not only the fuel consumption rate, but also the cruising speed. There were noteworthy stages in the South Pole Traverse in connection with fuel consumption. During the outward trip towards South Pole, the first one was in the region between 75°S and 79°S characterized by soft snow, high elevation, extremely low temperature in the period of early spring, and upward slope to the Antaractic inland terrain. The fuel consumption rate which had decreased from 80°S, suddenly increased again from 87°S in the approaches to South Pole. This was due to loose, granular snow in the vicinity of the Pole. In the return trip, however, in this same region from the Pole, fuel consumption decreased very much, particularly from 89°S, because the snow conditions had improved by the heat effect of the sun, also from surface was hard but relatively flat wind crust, although there was rather heavy load of refueling at the Pole and upward slope. The third stage came in the region between 80°S and 75°S, but fuel consumption showed a relatively low value as the effect of compression was remarkable in the old tracks as well as the sudden rise in temperature at the time.

Four months had passed since leaving Syowa but all the members were fit. There was variety in food, enough to keep the members healthy. Each was

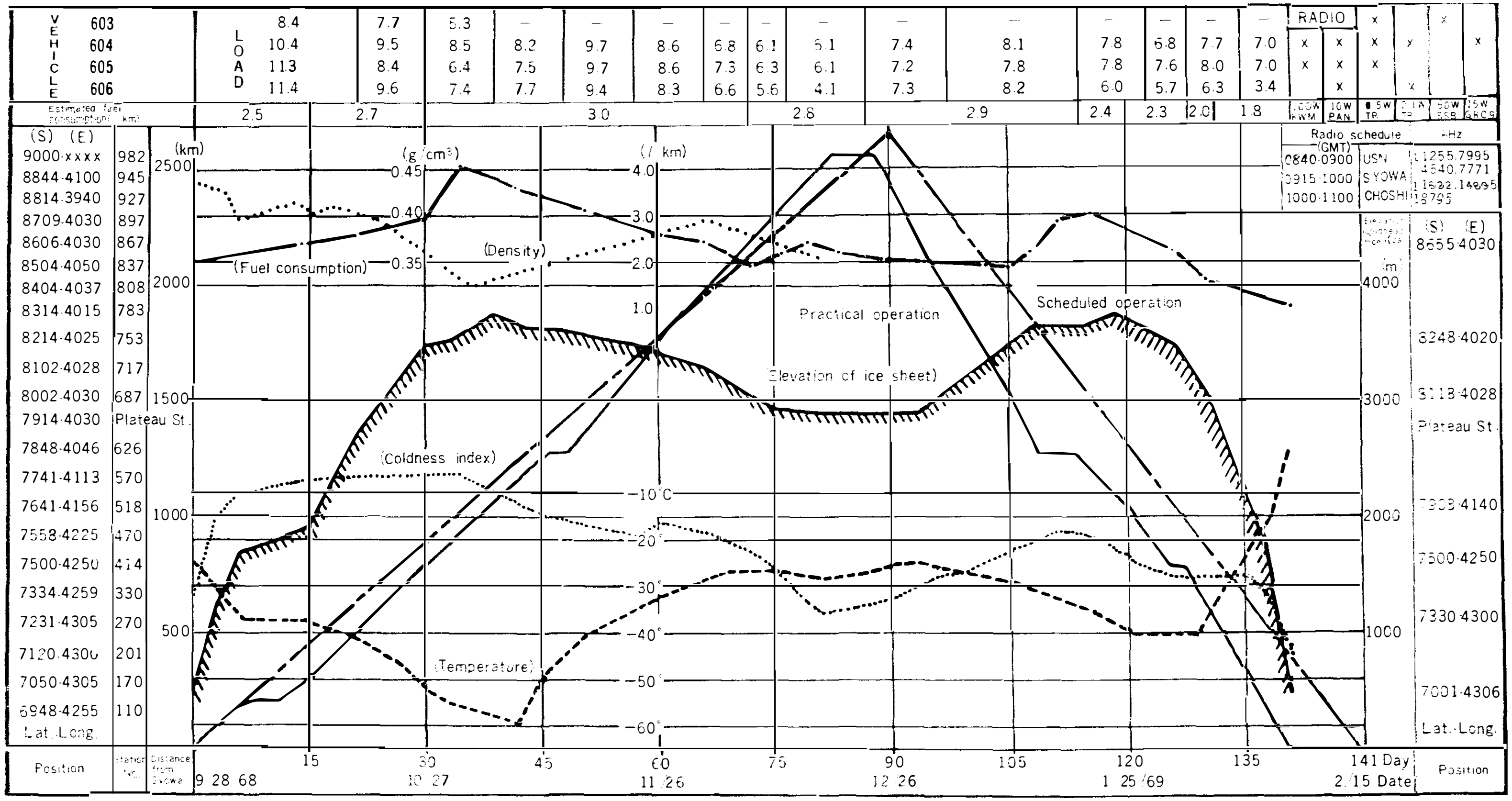

Fig. 2. Operational performances.

supposed to consume over 4,000 calories per day in order to keep in top physical shape. They all ate very well but since the energy spent far exceeded what we could obtain from our meals, all of us lost an average of about 5% in weight during this trip. Also, since we constantly had to engage in hard physical labor in the severe cold of $-50°C$ or lower at a high altitude of more than 3,000m for a period of some 18 hours a day, our blood pressure rose on the average about 10%. Since the number of our red blood corpuscles also increased, it took us almost a full month to become accustomed to breathing difficulties. In addition, we could barely manage to get more than three or four hours of sleep a night on an average as we had to cope with difficulties encountered in the watershed during our outward trip to the Plateau Station.

North of 75°S, the snow conditions suddenly changed. Soft snow caused by sublimation was replaced by a hard crust surface with sastrugi effected by strong eastery prevailing wind in the region influenced by ocean climate, which was remarkable from around 74°S. In the region of between 74°S and 72°S, the vehicles bumped and rolled considerably because of hard sastrugi covering. Observation showed that the hardness of snow surface suddenly rose to 4.5 kg/cm^2 in the north of 75°S, from 2.4 kg/cm^2 or less in the terrain at around 76°S. Average hardness of snow surface between 74°S and 70°S recorded 11.0 kg/cm^2.

On February 15, 1969, a helicopter came out from the icebreaker FUJI to give an advance welcome to the traverse party. On the 141st day after leaving the Syowa, the party completed the return trip from the South Pole, covering a distance of 5,182 km, averaging 36 km per day. The eleven members of the party stood again at their starting point. The scheduled scientific exploration of the area between the Syowa and the South Pole had been carried out almost completely, making a new record of Antarctic inland trip in terms of distance and period. The Plateau Station was so ideally located midway between the Syowa and the South Pole, and the Amundsen-Scott South Pole Station served effectively as a fuel supply station.

On the other hand, the South Pole Traverse was made possible as a result of the development of the snow vehicle for this purpose. Its performance met our expectations in the long trek over the Antarctic plateau. The detail is described by Masayuki HOSOYA, who designed KD60 and was in charge of the vehicle during this trek as mechanic engineer. A fact worthy of note is that the number of actual driving days was 110, and the operating hours per day averaged 11.4 h including net driving of 7.5 h in the period of 110 days.

So far, it has been a very difficult trek. In addition to factors such as ENDO's serious injury, the high altitude of more than 3,700 m above sea level, and the extremely low temperature of $-60°C$, the trek has also been hampered by soft snow and sastrugi. The Pole traverse vehicles were designed to move about efficiently on ice rather than on soft snow. Consequently, the vehicles got struck, and we had to abandon the power earth auger, metal made 4-ton sledges, and the bridging units. We were a little schocked to find the metal made sledges break down, but we had spare wooden ones for we had expected a disaster like this. Thus, we were able to squeeze through the crisis. We knew that it would be too difficult to keep the vehicles in low gear constantly at full capacity or to operate the vehicles for long hours without a break, but we simply could not do anything else, and as a result, the turbocharger of the vehicle No. 603 became overburdened and broke down, and we had to abandoned it altogether.

However, none of the members of the party felt, or at least showed, anxiety or irritation, for all of us were determined to carry out the project we had planned by ourselves, and this determination kept our vehicles moving towards the final goal.

It took more than 50 years for Japan to reach the South Pole over the snow of the Antarctic Continent. The writer wishes to extend his heartfelt gratitude for the cooperation in the project extended by the people of Japan and it was equally fortunate that the party not only reached the South Pole but attained scheduled results in its observations and investigations of the Antarctic terrain along the way, thanks to the kind cooperation and support given by the United States stations, and the kindness rendered to us during the journey by the Australian, British, New Zealand, and Soviet stations. Special gratitude is reserved for Mr. Michita SAKATA, Minister of Education and Chief of the Promoting Headquarters of the Japanese Antarctic Research Expedition, Dr. Seiji KAYA, Dr. Masasi MIYADI, Dr. Tekesi NAGATA, and Dr. Eizaburo NISHIBORI, and members of JARE Headquarters. Special appreciation is extended to Dr. Thomas O. JONES and Mr. Henry S. FRANCIS, Jr., N.S.F., who gave valuable suggestion for this project, and Mr. William H. LITTLEWOOD, assistant Scientific Attaché, U. S. Embassy, Tokyo, who furnished effective assistance during the Pole trek.

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