Report on the Operation of Mechanical Transport for the JARE South Pole Traverse 1968-69

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1. Introduction

This report summarizes the operation of mechanical transport of the Japanese Antarctic Research Expedition (JARE) South Pole Traverse in 1968-69. Detailed description is given on snow vehicles, sledges, fuel oil, lubricating oil, and relevant matters.

2. Snow Vehicles

Since 1963, research and development of new snow vehicle (KD60 series) have been carried out exclusively for the purpose of South Pole Traverse. Vehicles No. 1 to No. 3 manufactured during the developmental stage were successfully used for the traverse between Syowa Station and the Plateau Station during the period of November 1967 to January 1968. Subsequently vehicles No. 4 to No. 6 were used successfully for the traverse between Syowa Station and the South Pole which was conducted during the period of September 1968 to February 1969.

These snow vehicles were of two types; one is a personnel carrier type, allowing to accomodate men and to make observations in the cabin. Vehicles of this type constitute the main part of the traverse party. The other is a cargo type equipped with platform for carge loading in the rear. KD601, 602, 604, and 605 are personnel carrier type, while KD602 and 606 are cargo carrier type.

Photo 1 and Fig. 1 give a general view of KD604 or 605, and Photo 2 and Fig. 2 for KD606. Fig. 3 shows the performance characteristics of these snow vehicles on the snow.

All vehicles, cab-over full-track type, are constructed with semi-closed frames, equipped with a tractive hook at the front and a tractive pintle hook for cargo sledge at the rear. Power of the engine installed at the front is reduced through a clutch, transmission, and final drive before it drives the track with the sprocket

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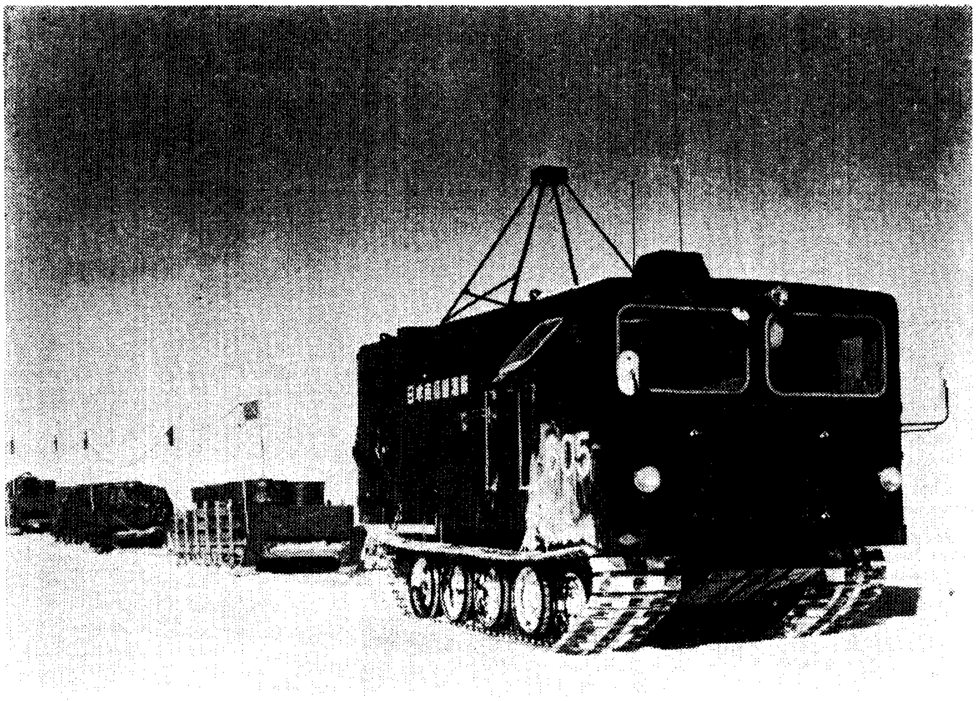

Photo 1. General view of KD605 (604).

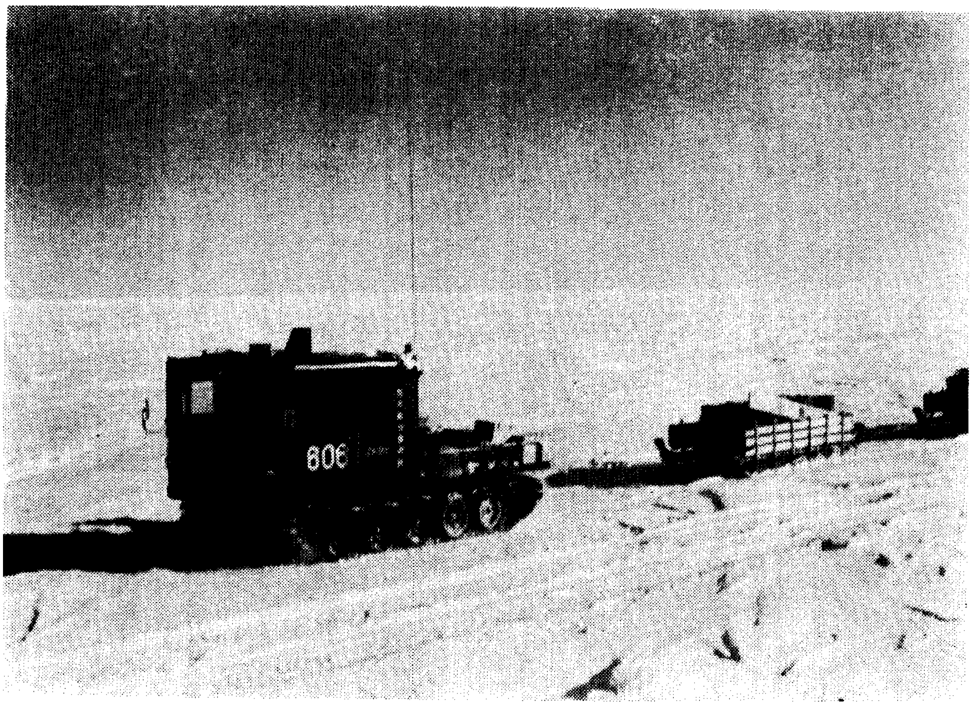

Photo 2. General view of KD606.

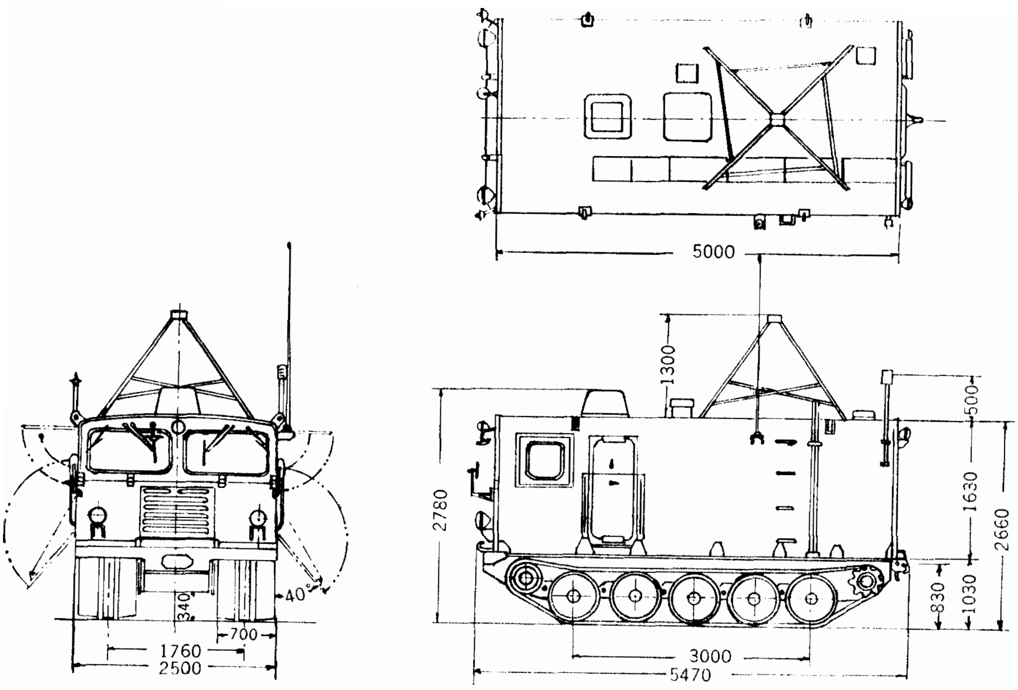

Fig. 1. General view of KD604 (605).

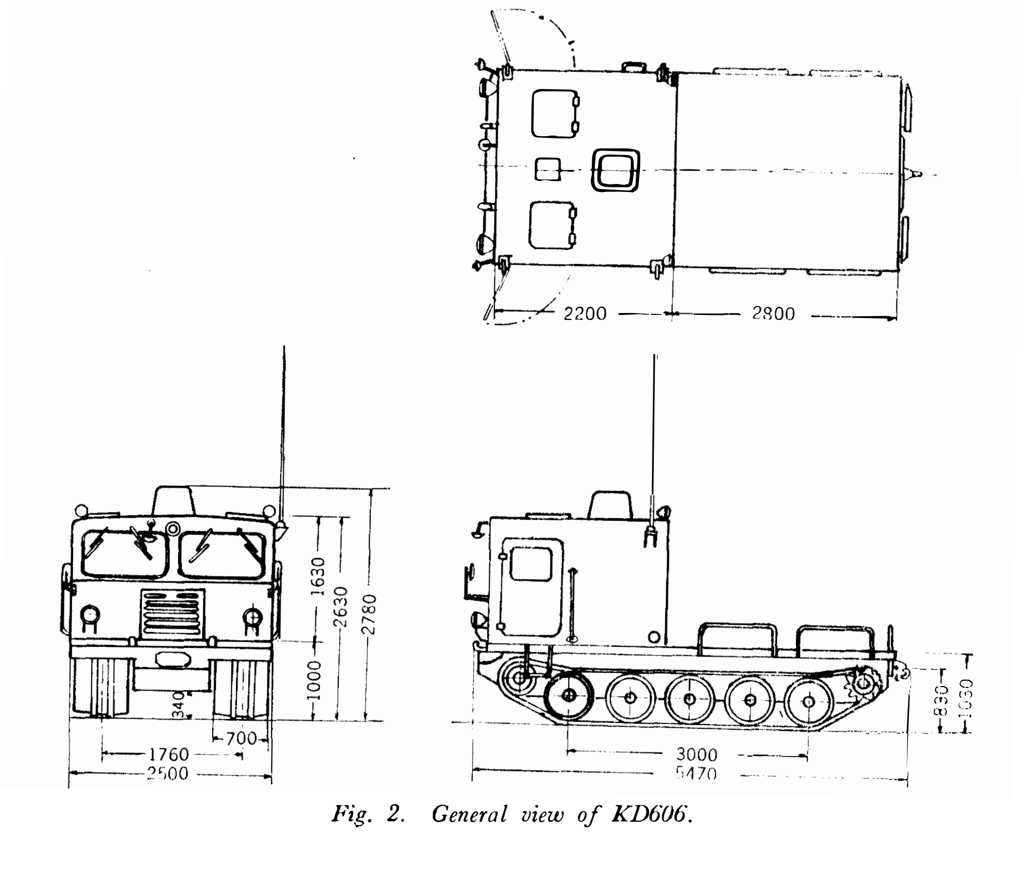

Fig. 2. General view of KD606.

Table 1. Specifications.

Type	KD604 (KD605)	KD606
Manufacturer	Komatsu Mfg. Co., Ltd.	
Overall length (mm)	5470	
Overall width (mm)	2500	
Overall height (mm)	2660	2630
Track width (mm)	700	
Ground contact length (mm)	3000	
Ground clearance (mm)	340	
Weight (kg)	7400	7100
Crew	4	2
Payload (kg)	500	800
Gross weight (kg)	7900	
Ground pressure (kg/m²)	0.19 (payload)	
Maximum speed range (km/h)	30 (paved way)	
	20 (on snow)	
	5–12 (antarctic terrain)	
Maximum pulling load (t)	15 (with sledges)	
Fuel consumption (*l*/km)	1.8–2.2 (traction of sledges)	
Climbing ability on snow slope (degree)	7 (traction of sledges)	
Minimum turning radius (m)	7	
Engine	Isuzu, DA640T.P.G.	
Horsepower rating (PS/rpm)		
Fuel set at high altitude	105/2400	
Fuel set at sea level	140/2400	
Number of cylinders	6	
Piston displacement (*l*)	6.373	
Transmission	5 forward and 1 reverse	
Differential	Double differential	
Driving system	Full-track	
Suspension	Torsion bar, independent suspension	
Frame	Semi-closed	
Body	Cab-over engine type with insulated construction	

at the rear. Steering is made by braking of the double differential drum with the band. Vehicle cabin has closed insulated construction and provided with a heater, a ventilator, an operating control system, a switch board for observation and for radio communication, a lighting system, and an engine compartment mounted on the frame. In addition to these, KD604 and 605 are provided with a navigation system, sleeping and living facilities, cooking facilities, and water-producing device (snow melter) and racks for installing observation and communication equipment.

2.1. *Engine*

There are several problems on the engines to be used for the Antarctic traverse such as starting at low temperature, equal lubrication on the mechanism of

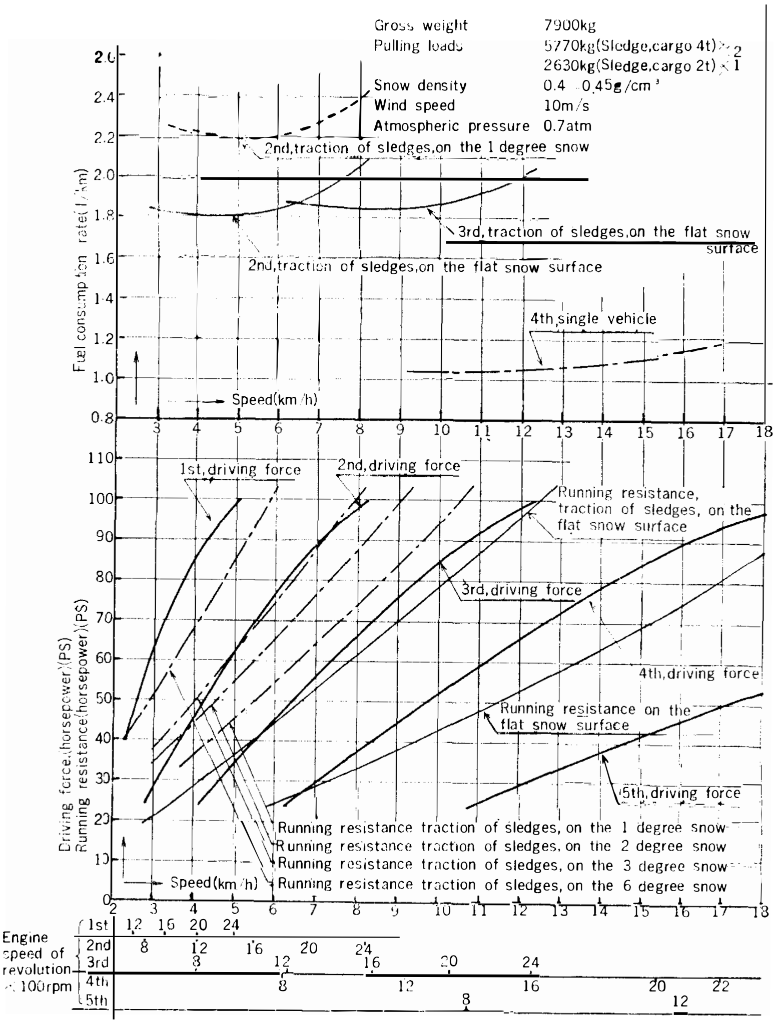

Fig. 3. Characteristics of the model KD60 (traverse vehicle) on the snow.

power and valve unit, and low-temperature brittleness of materials. Another problem is the lowering of output due to altitude.

Fig. 4. shows the effect of low temperatures on starting of the engine at 0.6 atm. A test was made on the effect of low temperature and low pressure on starting of the engine. This result showed that oil temperature caused more effect than others, higher suction temperature was favorable, and atmospheric pressure caused very little effect. For this reason, necessary measures were taken for heat insulation and preheating for installing the eingine.

For heat insulation, internal walls of the engine compartment and the power-line compartment were all insulated by the use of foamed polyurethane sheets; cooling air intake and exhaust outlet were tightly closed with heat-insulation plates, preventing intrusion of cold air and fine snow particles during camping or parking. Engine preheater is so designed that it can operate simultaneously

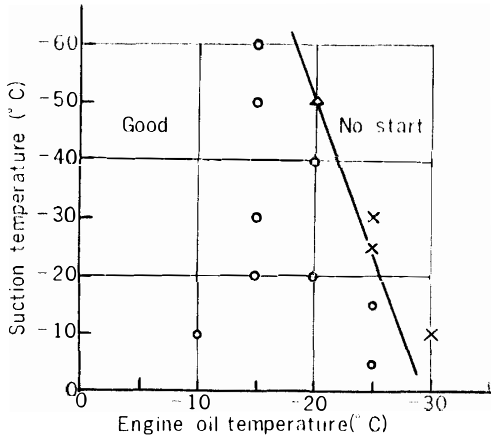

Fig. 4. Characteristics of low-temperature starting of the engine at 0.6 atm.
○ *Complete explosion*
△ *Imperfect explosion*
× *No explosion*
— *Boundary line of engine start*

Table 2. Specification of engine.

Model	Isuzu DA640T.P.G. diesel engine
Type	4-cycle, water cooled, overhead valve in line
Cylinder Nos.-Bore × stroke	6-102 × 135 mm
Piston displacement	6373 cc
Compression ratio	22 : 1
Type of combustion chamber	Pre-chamber
Governor speed, minimum/maximum	500 rpm/2400 rpm
Air cleaner	Dry type
Turbo-charger	Ai Research T0705
Overall, length × width × height	1156 × 698 × 1140 mm
Gross weight	605 kg
Output horsepower	
Fuel set at sea level	140 PS/2400 rpm
Fuel set at high altitude	105 PS/2400 rpm
Output torque	
Fuel set at sea level	43 m-kg/1800 rpm
Fuel set at high altitude	34 m-kg/1800 rpm

even while the cabin is being heated. It is a combustion burner type heater in which a method of direct heating of engine cylinder wall is employed; that is, heated water after heat-transferring with the engine cooling water (containing 55 to 60% antifreeze) comes through the pipe inside the cabin, goes around the water jacket and then circulates back to the preheater for heating. In addition, an electric heater of 250W was fixed to the engine oil pan. In order to solve

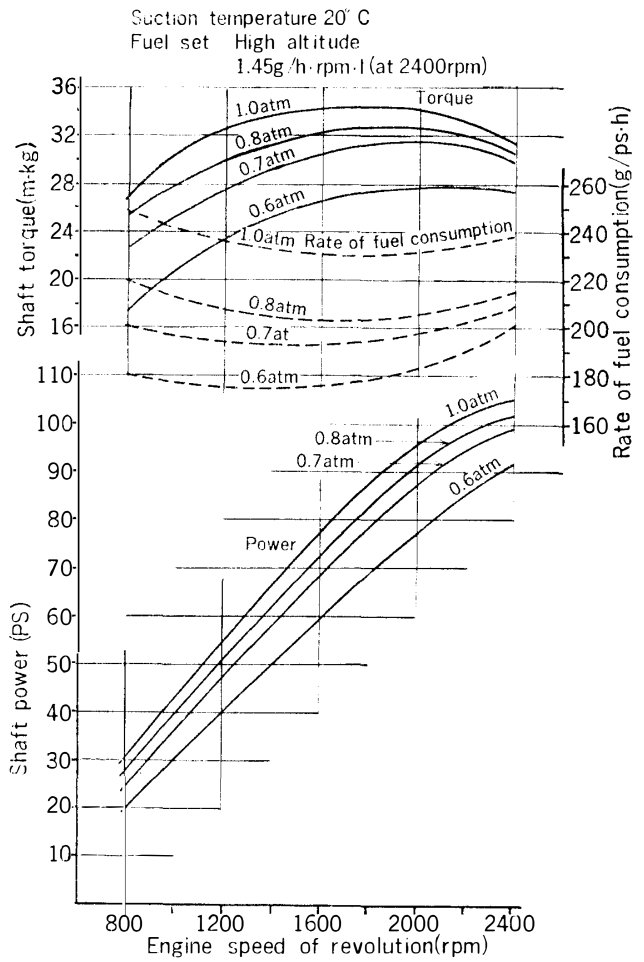

Fig. 5. Engine performance curve.

the problem of output lowering on the polar plateau, an exhaust turbo-charger was installed after consideration of its simplicity, reliability and other factors. The turbo-charger stabilizes the amount of fuel flow at 1.45g/h·rpm·l when the engine runs at 2000 rpm, thus the engine can be used at sea level as well as at high altitude when the air pressure of 0.7 atm and an altitude of 3000 metres are considered as a standard.

Fig. 5 shows the engine performance at sea level and at high altitude when the flow rate of fuel was set for high altitude.

2.2. Power transmission system

Speed change mechanism is composed of dry-type, single-plate clutch and manual gear shifting type synchromesh to provide five forward speeds and single reverse speed. The top speed is arranged for the need of a single vehicle drive for fuel economy, and mechanical speed change system is employed in order to secure safety as well as mechanical perfection. Power that is speed-changed by

Table 3. Typical example of power transmission system.

Clutch	Dry, single plate
Transmission	Synchromesh type
Speed ratio	1st 6.451
	2nd 3.900
	3rd 2.605
	4th 1.732
	Top 1.000
	Rev. 6.110
Parking brake	Dry single, hand lever type
Propeller shafts	Front and rear propeller shafts
Final drive	Final driven bevel gear
	Reduction ratio 4.86
Differentials	Double differentials
	Ratio 1.90
Steering brake	Wet-3 shoe

means of transmission is conveyed through a propeller shaft, reduced with final drive, steering-controlled through differential system and conveyed to axle shaft to drive track with a sprocket.

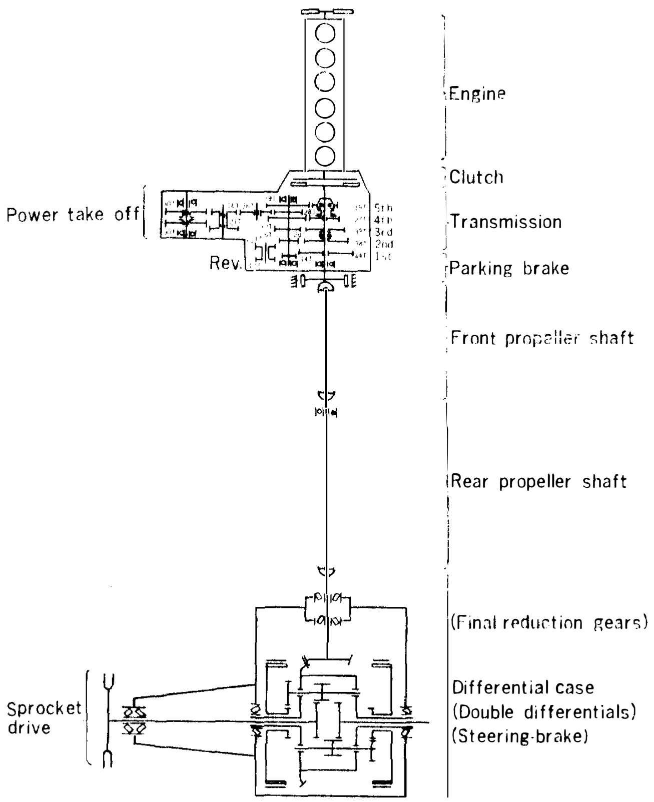

Fig. 6. The diagram of the transmission system.

As the whole power transmission system is installed in an enclosed compartment, it is sufficiently heated and not affected by low temperatures or penetration of cold air. Fig. 6 shows the motive system of the power transmission line.

2.3. Driving suspension system

Since this system is exposed to the air, strict examinations were made to select component materials. Taking into consideration such factors as harsh antarctic environment, reliability of the system, maintenance, and fuel economy, a type of full-track, rear drive, big road wheel, and independent suspension system has been adopted.

Table 4. Typical driving suspension system data.

Driving system	Full-track, rear drive
Sprocket	Semi-floating, center drive, tooth number 18, pitch 60 mm
Road wheel	Double wheel, aluminium disk, solid rubber tire, outside diam. 620 mm
Track	Track plate: channel section, high tensile steel, with rubber rail, two-line single-link chain, hard plate drive, center guide
	Track plate pitch = 120 mm, width = 700 mm, length = 110 mm
Track tension system	Compensator type
Suspension system	Torsion bar, independent suspension

Track plate is made by welding of homogeneous high tensile steel which has low temperature resistance, durability, and easy in workability. Its section is a channel type. Spike is fixed on every other track plate in order to increase to tractive force and a special plate is provided to prevent horizontal slide. Connection is made with two lines of chain links, and provided in the center is a guide to guide the road wheel. Drive is achieved with hard plates on both sides of the center guide. Rubber rail is fixed by baking to the rotating surface of the road wheel. Tension of the track is constantly maintained by compensating the front induction wheel axle and the first suspension arm. Five road wheels are provided on the right and left side each, rubber tire is fixed by baking to the outside circumference of the aluminium disk, and guide pan to guide the track is fixed to the inside. Suspension used here is a kind of torsion bar type independent suspension with five legs each on the right and left side. Springs are made of torsion bar of chromium-vanadium having a good low-temperature resistance, and a stopper is so designed that no metal contact will be made.

2.4. Frame and cabin

Frame is of upward-open box and made of steel plates for the use at low temperatures. Semi-single unit construction is adopted for body installation considering the sea ice condition at Syowa Station. Assuming various sea ice conditions around Syowa Station during unloading period from the icebreaker, chassis and cabin are designed to be separated and the chassis separated can move on the sea ice surface by its own power, or the whole unit can be dismantled

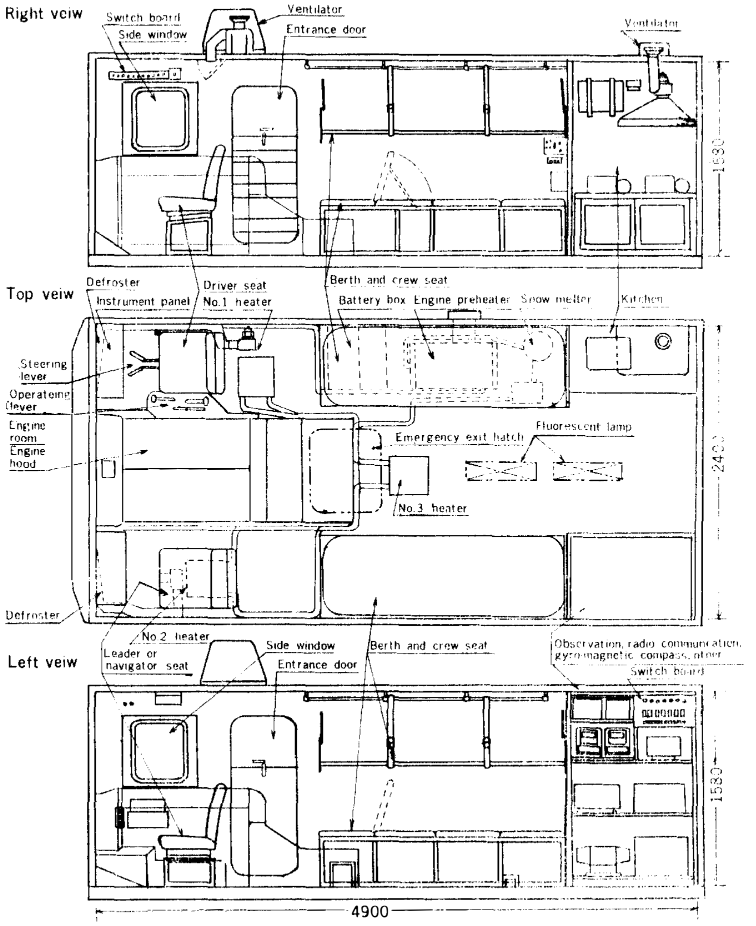

Fig. 7. Inside view of the cabin for KD604 (605).

into six parts units and transported by a helicopter. It was designed that the cabin should be light in weight, strong enough for either long use or dismantled for transportation, good heat insulation, suitable for living, driving, and observation activities in the small space. The cabin is of cab-over skeleton construction, and its skeletal structure, and outside and inside walls are covered with aluminium alloy plates. Insulation material (40-mm thick, hard foamed polyurethane) is packed between outside and inside walls, and the outside is painted black to absorb solar heat.

Fig. 7 shows the inside sketch of the cabin for KD604 or 605 and Fig. 8 for KD606.

2.4.1. Personnel carrier type snow vehicle (KD604 and 605)

Doors are provided on both sides towards the front portion and also at the rear; the front doors serve as the stepway for the crews when left open. Windows are of double-glass shielded type and provided at three positions—front,

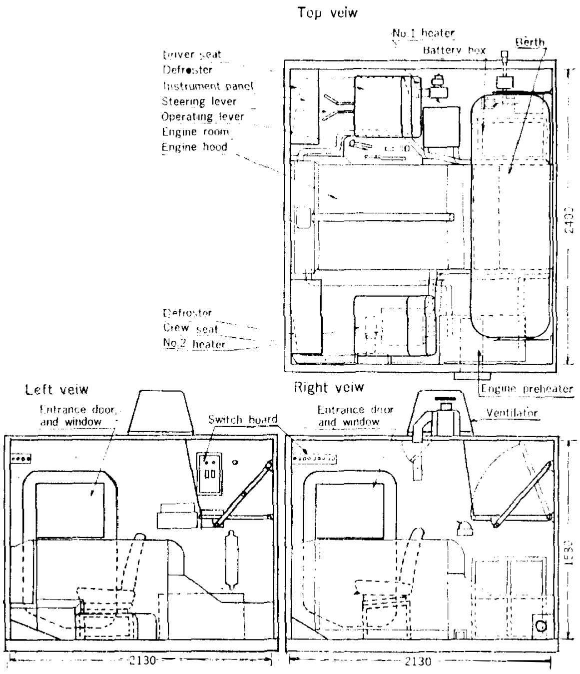

Fig. 8. Inside view of the cabin for KD606.

both sides towards the front, and rear; the front window glass is equipped with heated air type defrosting device which kept blowing of heated air 30°C to 40°C. In the roof over almost the center is an emergency exit hatch, from which a navigator can take a view in case of poor visibility. The space inside the cabin is allocated for various purposes; approximately 1.8 m of space in the front is allocated for driving and navigation, next space of about 2.1 m for living and sleeping, the last 1.1 m for scientific instruments, communication, cooking, and others. Located in the center of the front space is an engine compartment that can permit the crew to make inspection as well as maintenance from inside the cabin. Positioned at the right side of it is a driver's seat where operating control system, instrument panel, etc, are arranged. The left side is allocated for a navigator or leader seat where transceiver for vehicle-to-vehicle communication and folding table are set. In the center portion of the ceiling are a ventilator and two fluorescent lamps. Both right and left sides of the center space are occupied by berths of two beds each along the side walls, one above the other. Lower beds, however, are used for seats and space beneath the seats is utilized for storing batteries, engine preheater, snow melter, and others. Upper beds are suspension type and are to be put away the vehicle is moving. The right side of rear space is allocated for kitchen and is provided with a small-quantity food locker, a cooking table, two cooking oil stoves, a water tank of 30 l capacity, and a ventilator; a crew can prepare a meal sitting on a chair. The left side space is occupied by 3 or 4 racks, one above the other, which install obser-

Table 5. Details of frame and cabin.

Frame	Semi-closed type	
Body	Cab-over engine type, skeleton construction	
	KD604, 605	KD606
Cabin, length × width × height	5000 × 2500 × 1630 mm	1560 × 2500 × 1500 mm
Cabin volume	18.6 m^3	5.0 m^3
Crew	4	2
Cabin space per man	4.65 m^3/man	2.5 m^3/man
Front window	Fixed type, with defroster	
Side window	Open type, right: 1, left: 1	
Rear window	Fixed type: 2	
Entrance door	Hinged double door type	
Emergency exit hatch	Open type on the celler	
Driver seat	Reclining	
Crew set	Reclining	
Berth	Single bunk, 2 each on right and left	
Heater capacity	12000 kcal/h	
Ventilator capacity	250 m^3/h	
Lighting system	Head lamp, tail lamp, room lamp (fluorescent lamp, 10 W × 3), pilot lamp	
Instruments	Tachograph, revograph, ammeter, voltmeter, oil pressure gauge, fuel gauge, fuel flow-meter, water heat indicator, gyro-magnetic compass indicator	
Accessories	Wind shield wiper, back mirror, under mirror, combination tools, O.V.M.	
Traction system	Pintlehook (rear), hook (front)	

vation and radio communication equipments and power source.

Fig. 9 illustrates heater piping. As seen in this diagram, there are one 12000 kcal/h engine-preheater and three 4500 kcal/h heaters, two of the latter are equipped with a defroster of air blowing capacity of 250 m^3/h. When the vehicle is in motion, engine coolant is circulated and, when camping, circulating water is heated through the engine-preheater and is heat-transferred with heaters

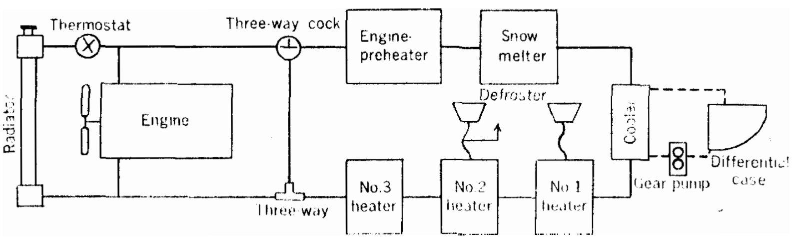

Fig. 9. The diagram of the heating-pipe lines.

before heating interior of the cabin. This heating system is capable of maintaining the cabin temperature at 10°C even at a low temperature of −60°C and blowing wind averaging 10 m/s. It is also capable of heating engine to start at low temperatures and of maintaining the engine temperature at a proper value. Furthermore it functions as the heat source of water-producing tank installed in the piping lines.

2.4.2. Cargo carrier type snow vehicle (KD606)

Front hinged type doors are on both sides of the cabin, and front window is the same as that of a personnel carrier type vehicle. Both right and left doors are provided with regulator type door windows. Rear window is made of shielded-type single glass. The center portion of the cabin is occupied by an engine compartment; on the right side is the driver's seat, operating control system, and instrument panel; on the left side is crew seat; the rear portion contains a bunk bed along the rear side wall; engine-preheater and batteries are stored under the bed. The heating and ventilating devices of this vehicle are almost the same as the personnel carrier type. Its rear platform with dimensions of 2.8×2.5 m can carry a load of 800 kg. In the early stage of the South Pole Traverse, a mechanical earth auger and its diesel engine were placed on this platform.

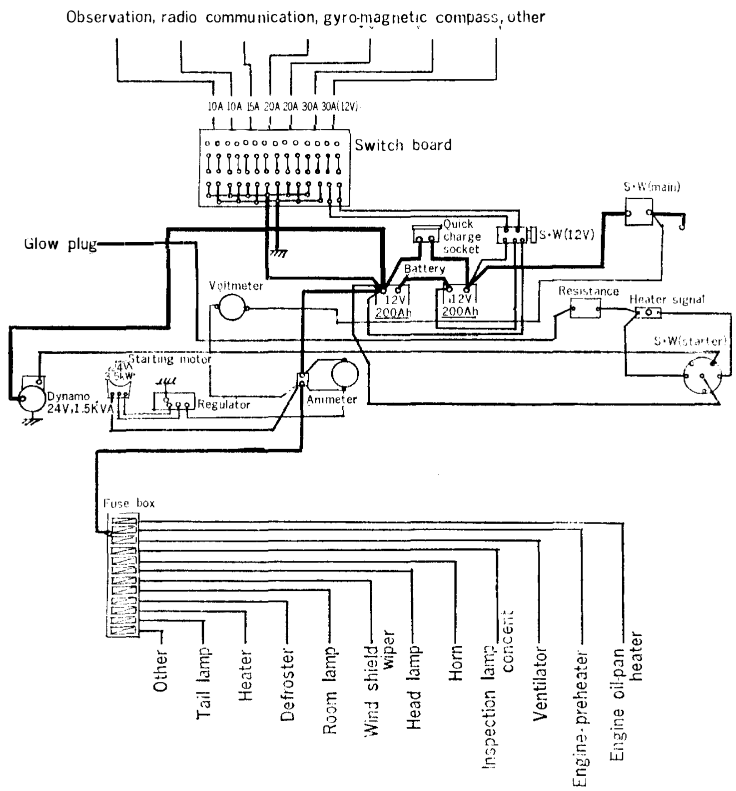

Fig. 10. The diagram of the electric wiring for KD605.

2.5. *Electric system*

Fig. 10 shows the diagram of electric wiring for KD605. As seen from this diagram, there are power source for operating control, lighting, and heating system and a switchboard for observation and radio communication, and gyro-magnetic compass. All the power needed is supplied from the electric generator and batteries installed in the vehicle. Measures have been taken to prevent electric noises occurred from various equipments.

Table 6. Summary of electric system.

Charging dynamo	AC, 1.5 kVA, with commutator
Voltage regulator	Fully transistorized
Starting motor	3.5 kW, 24 V, low-temperature resistant type
Batteries	12 V × 2, 200 Ah, low-temperature resistant type
Type of ground	Negative
Switchboard	
Observation	24 V × 30 A—1
Radio communication	24 V × 20 A—2
Gyro-magnetic compass	24 V × 15 A—1
Others	24 V × 10 A—1
	12 V × 30 A—1

2.6. *Gyro-magnetic compass system*

Fig. 11 shows the diagram of the gyro-magnetic compass system which was installed in KD604 and 605.

The system is consisted of a magnetic detector and a compensator, a compass indicator, a controller, a gyro, and an amplifier and an inverter.

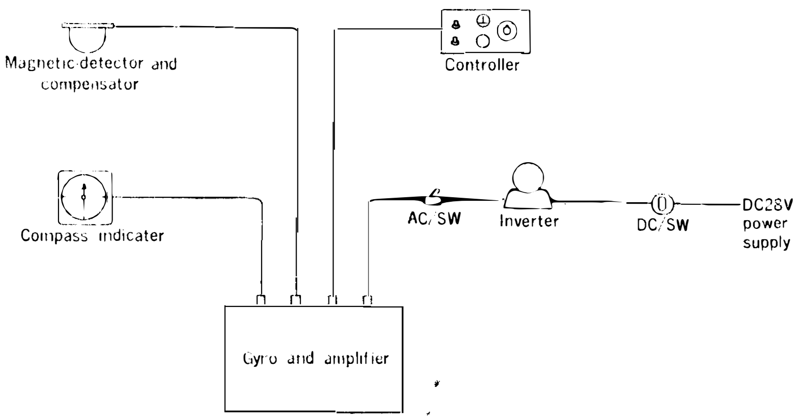

Fig. 11. The diagram of the gyro-magnetic compass system.

2.7. *Selection of materials*

When considering the snow vehicle to be operated at low temperature down to −60°C and the steel to be used for this vehicle, it is essential that cold

Table 7. Characteristics of gyro-magnetic compass.

Compass system accuracy	±1 degree
Free gyro drift rate	±3°/h
Slaving rate	1～2°/min
Power requirement	28 V DC
Power consumption	Start 280 W
	Run 200 W
Manufacturer	Tokyo Keiki Seizosho Co., Ltd.

notch-brittleness of steel, hardening and brittleness of rubber materials should be carefully examined. For this purpose, not only the materials which had been used for the snow vehicle but the ones for potential use were also tested before the final selection was made. Before testing the metal material, chosen as a standard was Tr 15 (transition temperature corresponding to absorption energy of 15 ft-l b) which corresponds to a given low level of absorption energy, among those showing ductility transition temperature. Thus, various kinds of steel were tested for their cold notch-brittleness at −60°C. In case of normalizing materials such as carbon steel and low alloy steel which are generally used for construction material, Tr 15 is found in normal temperature if they contain carbon in high percentage and at as low as −50°C if they contain a small percentage of carbon. However, even in case of the materials containing a high percentage of carbon, this brittleness can be reduced to some extent through proper heat treatment so that the transition temperature may be able to satisfy the required value of −60°C. Therefore, the material containing low percentage of carbon was used for parts provided that it could be given a heat treatment. The materials designated as SCM (JIS), SNC (JIS) and SNCM (JIS) are alloy steels and used for gear, shaft, axle, pin, link, and have favorable low-temperature characteristics but chromium and molybdenum, for example, tend to raise their transition temperature. For this reason, efforts were made to find a material not containing nickel to increase its toughness through a process of tempering at a slightly higher temperature. Cast steel was fairly improved in its cold notch effect through quenching and tempering, but it was difficult to obtain Tr 15 at −60°C. Consequently aluminium alloy had to be selected. Carbon steel plate, like cast steel, was unable to satisfy the requirement and, therefore, homogeneous high tensile steel and low temperature-use steel plate of aluminium-killed steel group were used.

In selecting the material for suspension spring, not only examining notch effect but also, by use of models, modulus of transverse elasticity, spring constant, impact stress were tested in order to learn low-temperature mechanical performance and design standard. After confirming the obtained results by these tests, spring steel containing chromium-vanadium phase was selected. High tensile steel for track plate was also tested, using the samples in actual size and applying the same method as for spring steel, and chromium-manganese group

"Wel Ten 80 C.P." was selected. In the case of snow vehicle, rubber-like material, by virture of shock absorption, had been largely used for power transmission mechanism and spring system. However, it hardens at low temperatures. As a result of testing, with both test pieces and actual objects, several kinds of grouping of natural rubber, low-temperature polybutadiene, it was learned that the variation point of spring constant varies greatly depending on the kind of grouping quantity; under the temperatures between −40°C and −60°C, it becomes rapidly high, that is, as high as 6 to 7 times of that under the normal temperature. Repeating allowable stress does not vary significantly between normal and low temperatures, but strain is allowed by only one-quarter of that of normal temperature. This means an extremely hard spring is to be made. For this reason, spring steel was used for springs and shock absorption materials. There is no substitute but rubbers for the following parts such as piston cup, V-belt, oil seal, mount rubber, V-packing, wind shield, O-ring, guide pan, tire, rail, hose, and other minor parts. Considering the way of use, therefore, silicon, butadiene, natural rubber, were used through a process of heating. Other materials such as insulating tape, cork, felt, fiber, cloth, polyurethane, were also used after their low-temperature characteristics were studied.

3. Fuel and Oil

Fuel and lubricating oil prepared for South Pole Traverse was produced by Nippon Oil Company. Their specifications are given in Table 8.

Table 8. Specification of fuel and lubricating oil.

1. Diesel gas oil	
Specific gravity 15/4°C	0.8465
Flash point (°C)	72
Viscosity (CS @ 30°C)	2.16
Pour point (°C)	−60
Distillation (°C 90%)	258
Carbon residue (10% bottom) (%)	0.02
Sulfur (%)	0.05
Corrosion test, Cu-strip	1 a
Reaction	Neutral
Cetane index	37.5
2. Engine oil	
Specific gravity 15/4°C	0.9194
Flash point (°C)	190
Pour point (°C)	−45
Viscosity: CS @ 37.8°C	57.73
〃 @ 98.9°C	9.54
〃 @ −17.8°C	1.76
Viscosity index	138.5

	Neutralization number (mg KOH/g)	1.67
	Carbon residue (%)	0.87
	Corrosion test, Cu-strip	Pass
3.	Gear oil	
	Specific gravity 15/4°C	0.9421
	Flash point (°C)	222
	Pour point (°C)	−35
	Viscosity, CS @ 37.8°C	142.8
	〃 @ 98.9°C	16.82
	Viscosity index	123.5
	Four-ball test (kg/cm²) 200 rpm	5.0
	(kg/cm²) 750 rpm	4.0
4.	Hydraulic oil	
	Specific gravity 15/4°C	0.861
	Flash point (°C)	92
	Pour point (°C)	−50 below
	Viscosity, CS @ 37.8°C	146
	〃 @ 98.9°C	5.16
	Viscosity index	223
	Total acid value (mg KOH/g)	0.04
	Corrosion test, Cu-strip	1 a
	Sludge test, 170°C×24 h	Pass
5.	Grease	
	Penetration, @ 25°C worked	293
	Dropping point (°C)	185
	Corrosion test, Cu-strip	Pass
	Water (%)	None
	Soap type	Li
6.	Kerosene	
	Specific gravity 15/4°C	0.7978
	Color, saybolt	+30
	Corrosion test, Cu-strip	1 a
	Distillation (°C)	
	Initial boiling point	164
	10%	177
	50%	192
	90%	219
	95%	227
	End point	245
	Flash point (°C)	47.5
	Sulfur (%)	0.001

Pour point (°C)	−60
Smoke point (mm)	27
7. Gasoline	
Specific gravity 15/4°C	0.6855
Corrosion, Cu-strip	1 a
Octane No. (motor method)	88.0
Distillation (°C)	
Initial boiling point	29
10% evaporated	38
50% evaporated	59.5
90% evaporated	144
End point	191
Gum, glass dish (mg/100 ml)	1
Induction period (min)	480
Alkyllead content (cc/l)	0.265
Vapor pressure (kg/cm^2)	0.975
Color	Standard red
Doctor test	Negative
8. Antifreeze	
Color	Blue, transparent
Hydrogen ion concentration(pH)	7.8
Boiling point (°C)	156
Freezing point (°C)	
25 v/v solution	−11.9
Specific gravity 15/4°C	1.122
Corrosion test, 70°C × 336 h	
mg/cm^2 Aluminium	−0.01
Cast iron	−0.01
Steel	−0.01
Brass	−0.03
Solder	−0.04
Copper	−0.01
Foaming test, cc @ 70°C	
50% solution	2

4. Sledge

Cargo type sledges are two types: one is of wooden for 2-ton payload, and the other made of steel for 4-ton payload. Cabooses with sledges are of two types; one is for 2-ton load and the other for 4-ton load. The large 4-ton sledge is drawn by either a steel draw-bar or wire rope and the 2-ton sledge is drawn by a wire rope. A train of several sledges can be formed connecting with wire ropes one after the other. Figs. 12, 13, 14, and 15 show general view of each type of sledges and Table 9 gives specification of these sledges and cabooses.

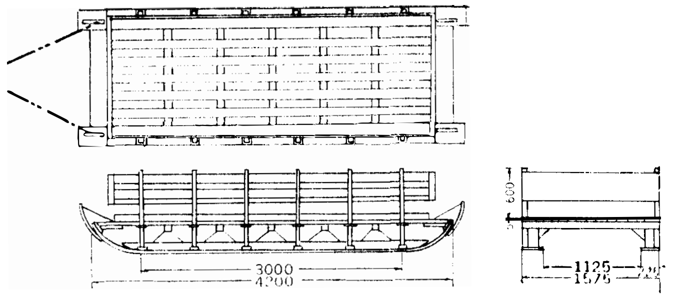

Fig. 12. 2-ton sledge.

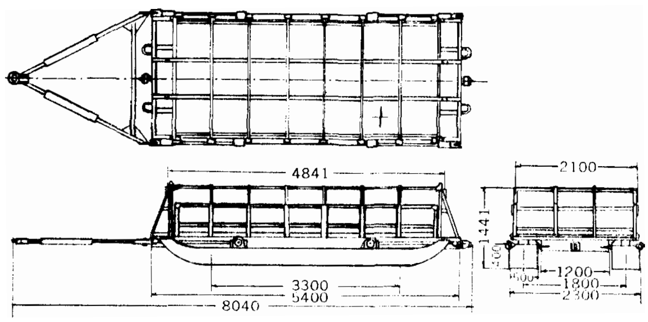

Fig. 13. 4-ton sledge.

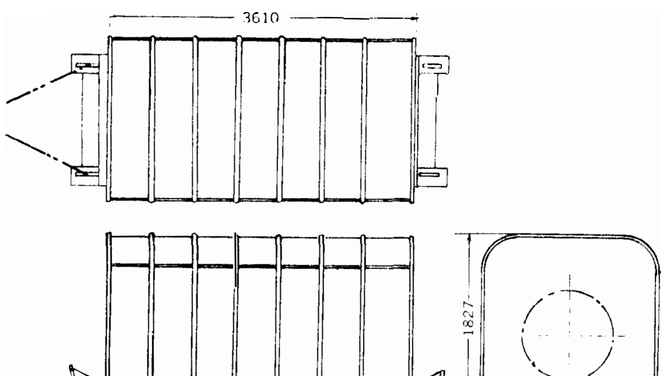

Fig. 14. 2-ton caboose.

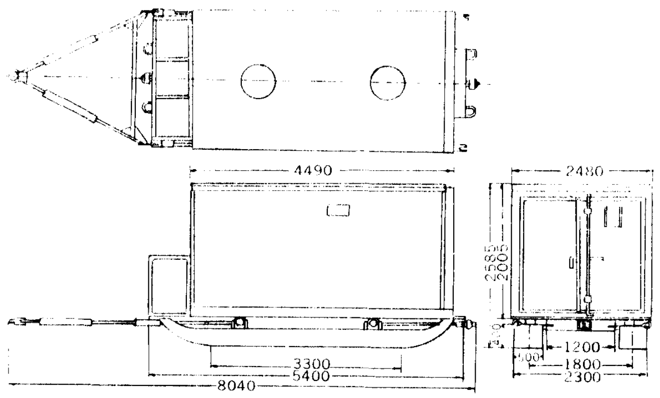

Fig. 15. 4-ton caboose.

Table 9. Specifications of sledges and cabooses.

1. Sledge, cargo, 2 t	
Manufacturer	Yokohama Yacht Co., Ltd.
Weight: net	628 kg, without wire rope
: payload	2 t or 12 drums of 200 *l* oil barrel (uncrated)
: gross	2.3 t, without wire rope
Loading height, empty	365 mm
Overall, length × width × height	4660 × 1575 × 955 mm
Body, inside dimension, length × width × height	3600 × 1395 × 600 mm
Ground clearance	246 mm
Length, ground contact	2400 mm
Width, runner	225 mm
2. Sledge, cargo, 4 t, model ST-40	
Manufacturer	Ôhara Iron Works Co., Ltd.
Weight: net	2.3 t with draw bar
: payload	4 t or 21 drums of 200 *l* oil barrel (uncrated)
: gross	6.5 t
Loading height, empty	610 mm
Overall, length × width × height	5400 × 2400 × 1441 mm (draw-bar removed)
Body, inside dimension, length × width × height	4600 × 2100 × 891 mm
Ground clearance	320 mm
Length, ground contact	3300 mm
Width, runner	500 mm
Length, draw bar	2500 mm
3. Sledge, caboose, medium	

Manufacturer	Yokohama Yacht Co., Ltd.
Weight: net	700 kg
: payload	1.6 t
: gross	2.3 t
: closed curtains	90 kg
Loading height, empty	365 mm
Overall, length × width × height	5690 × 2170 × 2200 mm
Cargo curtains, inside dimension, length × width × height	3570 × 2110 × 1827 mm
Ground clearance	246 mm
Length, ground contact	2400 mm
Width, runner	225 mm
4. Sledge, caboose, model BG14	
Manufacturer	Nippon Fruehauf Co., Ltd. Ôhara Iron Works Co., Ltd.
Weight: net	2.6 t with draw bar
: payload	3.0 t
: gross	5.6 t
: container	900 kg
Loading height, empty	500 mm
Overall, length × width × height	5400 × 2420 × 2505 mm
Container, inside dimension, length × width × height	4370 × 2340 × 1820 mm
Ground clearance	320 mm
Length, ground contact	3300 mm
Width, runner	500 mm
Length, draw bar	2500 mm
Body insulation	Fiber glass
Front and side wall	Smooth aluminium panel
Roof	One-piece aluminium roof sheet
Rear wall	Stainless steel rear and aluminium plymetal doors

5. Preparation for the South Pole Traverse at Syowa Station

5.1. JARE Traverse to Plateau Station, November 1967–January 1968

1) JARE 1967–68 conducted a trip to the Plateau Station, establishing the route for the Pole traverse and laying depots of fuels and equipment.

2) Vehicles used for this traverse were No. 1 to No. 3 of Model KD60, and one KC20. Specifications of these vehicles are given in Table 10.

The shape of KD60 used for JARE 1967–68 traverse is the same as that of new KD60 used for the South Pole Traverse, but these two are different in drive-suspension system, cabin interior layout, heating and water-producing device, and navigation system. The vehicle KC20 had been used for general

Table 10. Specification of snow vehicles.

Manufacturer	Komatsu Mfg. Co., Ltd.			
Model	KD601	KD602	KD603	KC20
Overall, length × width × height (mm)	5470 × 2500 × 2650	5470 × 2500 × 2600	5470 × 2500 × 2420	4050 × 2010 × 1905
Ground contact length (mm)		3000		2373
Ground clearance (mm)		340		240
Weight (kg)	8000	7050	6550	2650
Crew	4	4	2	5
Payload (kg)	500	500	1000	275
Gross weight (kg)	8500	7550	7550	2925
Ground pressure (kg/cm²)	0.21 (payload)	0.18 (payload)	0.18 (payload)	0.12 (payload)
Maximun speed range (km/h)	25 (paved road) 20 (on snow) 5–12 (antarctic terrain)			45 30 10–15 (antarctic terrain)
Maximum pulling load (t)	12 (with sledges)			5 (with sledges)
Fuel consumption (*l*/km)	1.8–2.5 (traction of sledges)			1.2–1.5 (traction of sledges)
Snow hill climbing ability (deg.)	7 (traction of sledges)			10 (traction of sledges)
Maximum turning radius (m)	7			Pivot turn
Engine	Isuzu, DA120 P.T.G. diesel engine			Toyota, F. gasoline engine
Horsepower rating (PS/rpm)				105/3200
: Fuel set at sea level	140/2400			—
: Fuel set at high altitude	105/2400			—
Number of cylinders	6			6
Piston displacement (*l*)	6,126			3,878
Transmission	5 forward and 1 reverse			4 forward and 1 reverse
Differential	Double differential			Clutch-brake
Drive system	Full-track			Full-track
Suspension	Torsion bar, independent suspension			Coiled spring, independent suspension
Frame	Semi-closed			Conventional type
Body	Cab-over engine type			Truck type

purpose in Japan and was partly modified for observation and cargo transportation in the Antarctic. When camping, canvas is used for covering to avoid the effect of wind and low temperature.

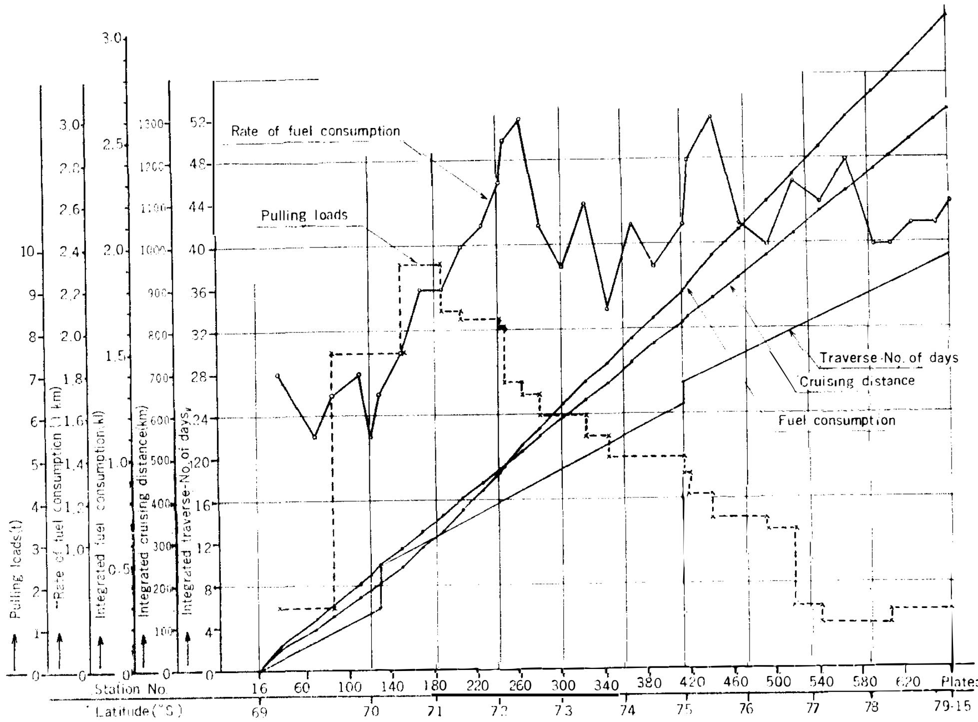

Fig. 16. Traverse record of KD602 in JARE 1967-68 (No. 1).

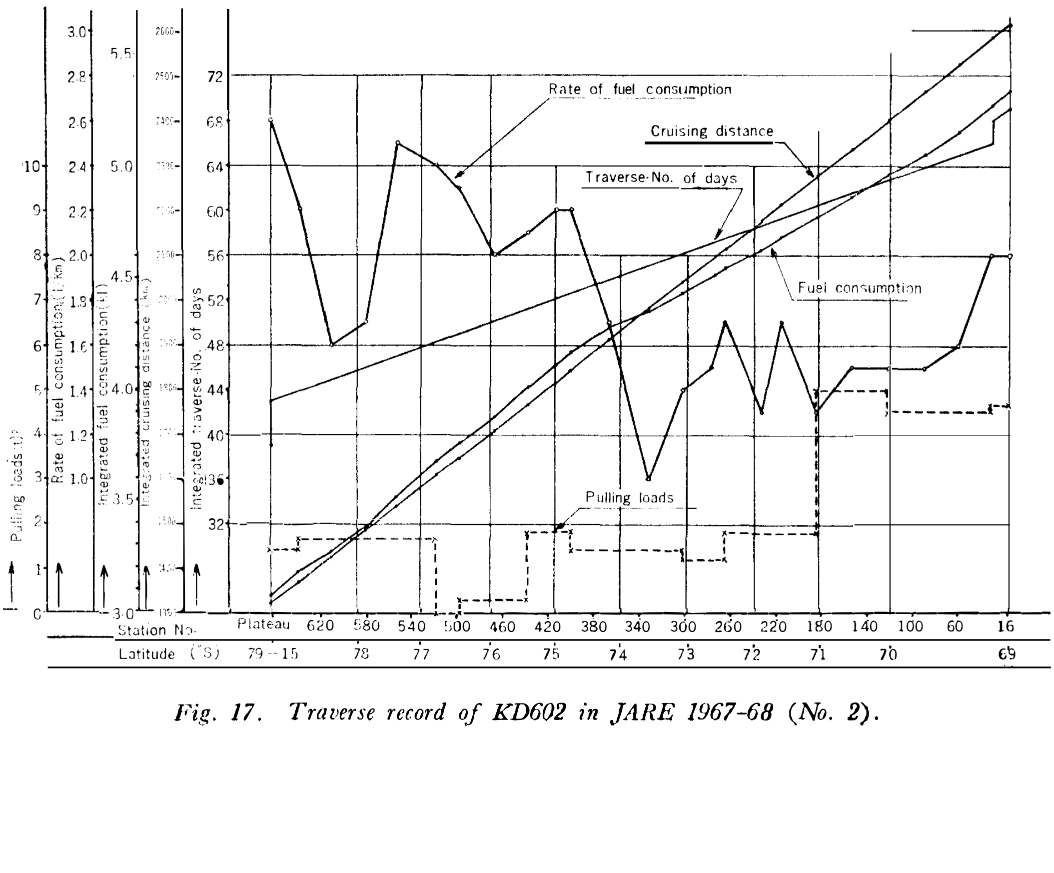

Fig. 17. Traverse record of KD602 in JARE 1967-68 (No. 2).

These 4 types of snow vehicles differ in their construction and mechanical function. Because of this difference the traverse party experienced some difficulties in the maintenance and operation of vehicles.

A total of 16 sledges were used for the traverse; 2 of 4-ton steel type, 2 of 3-ton wooden type, 9 of 2-ton wooden type, and 2 of 2-ton caboose, 1 lavatory caboose. These sledges were distributed to each vehicle and pulled with wire rope.

3) The traverse took a total of 69 days, from November 1967 to January 1968, that is, 12 days for rest in doing observations, vehicle inspection, and other works, and 57 days for movement, covering an average of 2,600 km per snow vehicle with an average speed of 46 km per driving day. The traverse record of KD602 is given in Figs. 16 and 17.

This traverse trip established depots of fuel/oil, machine parts, and sledges in preparation for the JARE South Pole Traverse as follows:

St. 70 Gasoline 400 *l*, kerosene 88 *l*

St. 122 Gasoline 200 *l*, diesel gas oil 5400 *l*, antifreeze (55%) 36 *l*, kerosene 22 *l*, 3-ton sledge cargo 1, 2-ton sledge cargo 1, machine parts, etc. 150 kg.

St. 184 Diesel gas oil 600 *l*, hydraulic oil 36 *l*.

St. 323 Diesel gas oil 400 *l*, gear oil 54 *l*, antifreeze (55%) 200 *l*, electrolyte

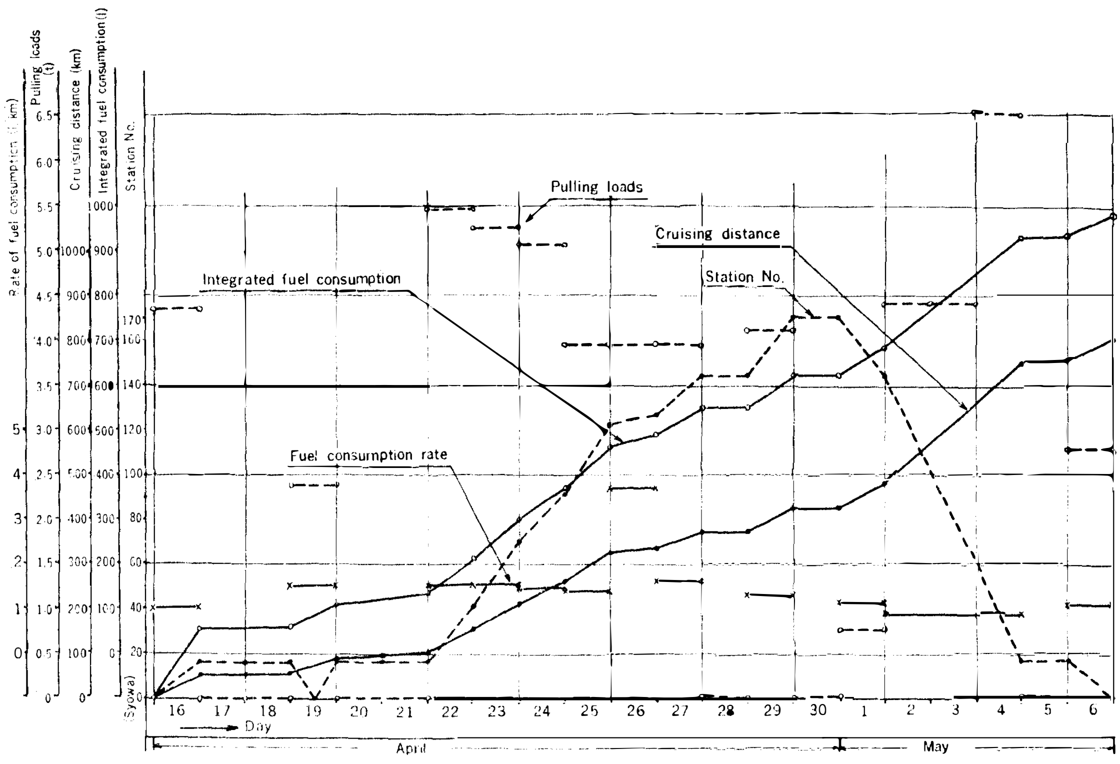

Fig. 18. Autumn traverse record of KC20 (No. 12).

18 *l*.
St. 414 Diesel gas oil 800 *l*.
St. 518 Engine oil 72 *l*, antifreeze (100%) 200 *l*.
St. 568 Diesel gas oil 1200 *l*, gear oil 40 *l*, kerosene 22 *l*, 2-ton sledge cargo 1, others 100 kg.

5.2. Autumn traverse, April-May, 1968 by JARE 1968-69

In preparation for the South Pole Traverse, establishment of fuel depots combining with acclimatization of members, 3 weeks of traverse between Syowa Station and St. 170 was conducted by 13 members with two KC20 vehicles (No. 12 and 13), four 2-ton sledges and one observation caboose. The traverse record of KC20 (No. 12) is given in Fig. 18. In this traverse a depot was established at St. 170, storing 2400 *l* of diesel gas oil, 200 *l* of engine oil, and 200 *l* of antifreeze.

5.3. Maintenance of snow vehicle and sledge

Three months of June, July, and August, 1968, were spent for completion of snow vehicles and sledges at Syowa Station. Model KD604, 605, and 606 new vehicles, only observation equipments and radio communication equipments were installed, except for adjustment, improving of inaccessible oiling/inspection parts, and installing of insulating plate radiator mask holder. Mechanical earth auger was fixed to the platform of KD606.

For better running, an extension was fixed to both the front and rear portion of the runners of 2-ton wooden sledges; as for the sledge to load ration pasteboard boxes, the crate was made for loads. In order to give the 4-ton caboose a function of laboratory and maintenance shop, following provisions were installed

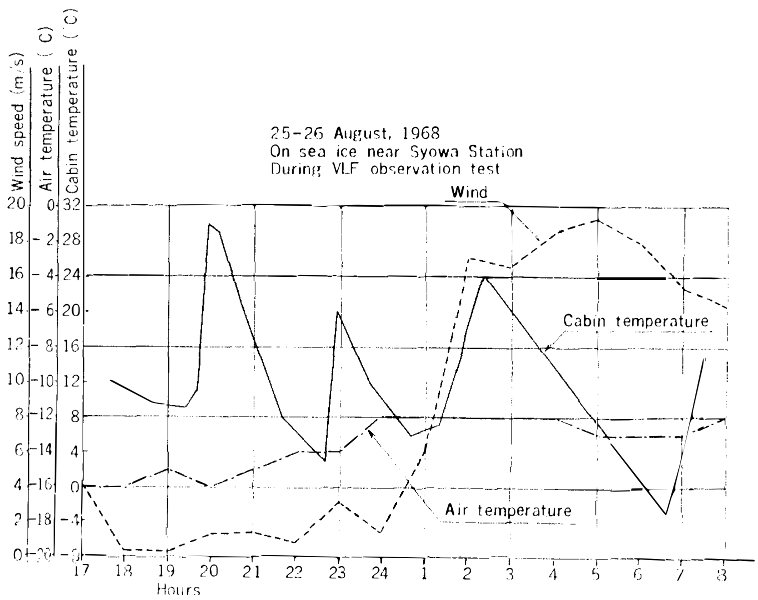

Fig. 19. Record of cabin temperature.

besides seismic recorder and ice radar; working table, welding machine, 1 KVA generator, DC heated air blower, heating device, and switchboard of AC 100V, and DC 24V and 12V.

In the middle of August, fully equipped vehicles and sledges were given a test drive to St. 22 during which depots were also established. Results of the test drive to St. 22 by KD605 showed that snow condition in that terrain was changeable and soft, and that an impact was necessary to move four sledges loaded with 14.8 tons. On the soft drift, slip was experienced and steering became impossible. When pulling three sledges with a load of 12.6 tons, an average second gear speed was 8 km/h. The test on the surface-hard snow gave a traction of about 5t, but the traction was reduced to less than 2.5 t when the hard snow surface was destroyed. The dynamic frictional resistance of the sledge were 1.8 to 2.[illegible] tons in the case of three sledges with a load of 12.6 tons. In this test drive, navigation by the gyro-magnetic compass was favorably carried out.

A check on the regulation of cabin temperature of KD605 was made in relation with automatic controle of the heating system. The result is shown in Fig. 19.

5.4. Planning of fuel consumption, vehicle maintenance, and pulling load

1) The quantity of lubricating oil, hydraulic oil, and others were estimated from the distances to be covered, and kerosene from period of time of consumption.

The plan for gasoline and lubricating oil was as follows:

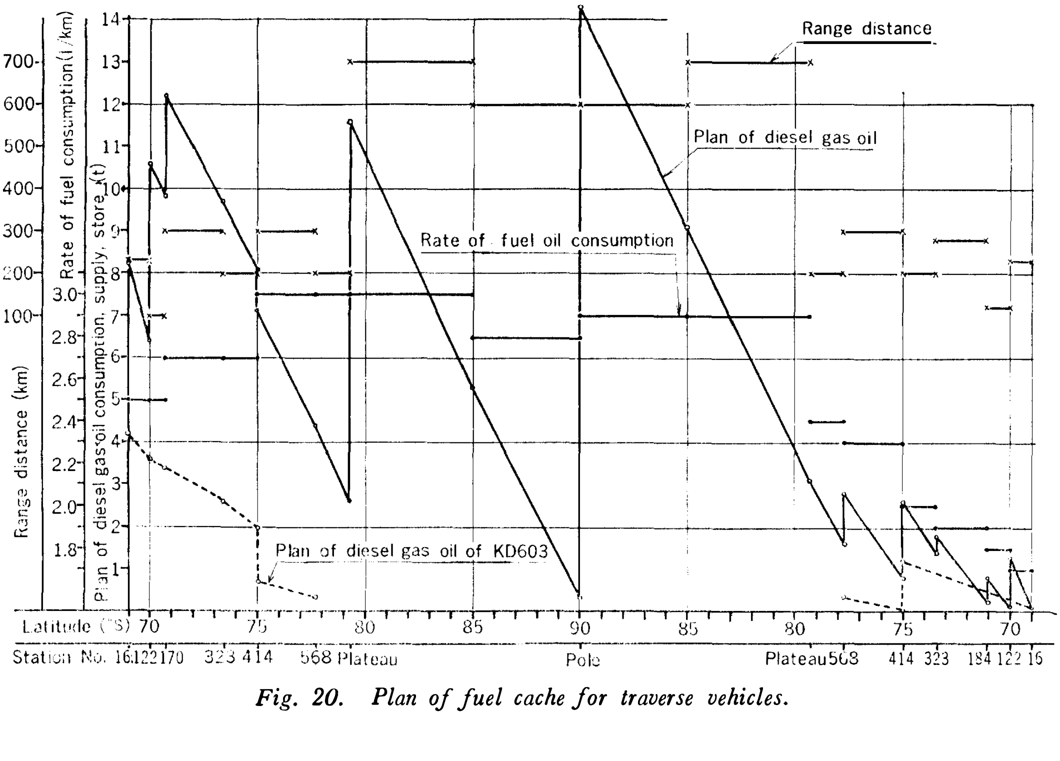

Fig. 20. Plan of fuel cache for traverse vehicles.

Gasoline	1.1 t
Engine oil	955 *l*
Hydraulic oil	270 *l*
Gear oil	463 *l*
Grease	92 kg
Kerosene	1.4 t
Antifreeze (55%)	1.2 t
Electrolyte	50 *l*

2) The prepared quantity of spare parts, and tools and wire rope was 3 tons in net weight and 3.7 tons in gross weight.

6. JARE South Pole Traverse, September 1968 - February 1969

6.1. Traverse in general

In the beginning of this traverse, from the starting point St. 16 to the neighborhood of 75°S, the surface snow was relatively hard. On the upward slope, however, the surface-creeping snow by the katabatic wind was intense, and snow heaps created by this wind, soft drift, and skavler were encountered in succession. This caused snow vehicles and sledges to go deep into the snow and the trip was a trying experience.

The high plateau area from 75°S to 80°S has an elevation of more than 3500 m and covered with soft snow, very light wind and low temperature down to −60°C. Tracks of vehicle sank as deep as 30 cm and the fuel consumption rate became as high as 4 *l*/km. More than 5-minute stop for observation caused

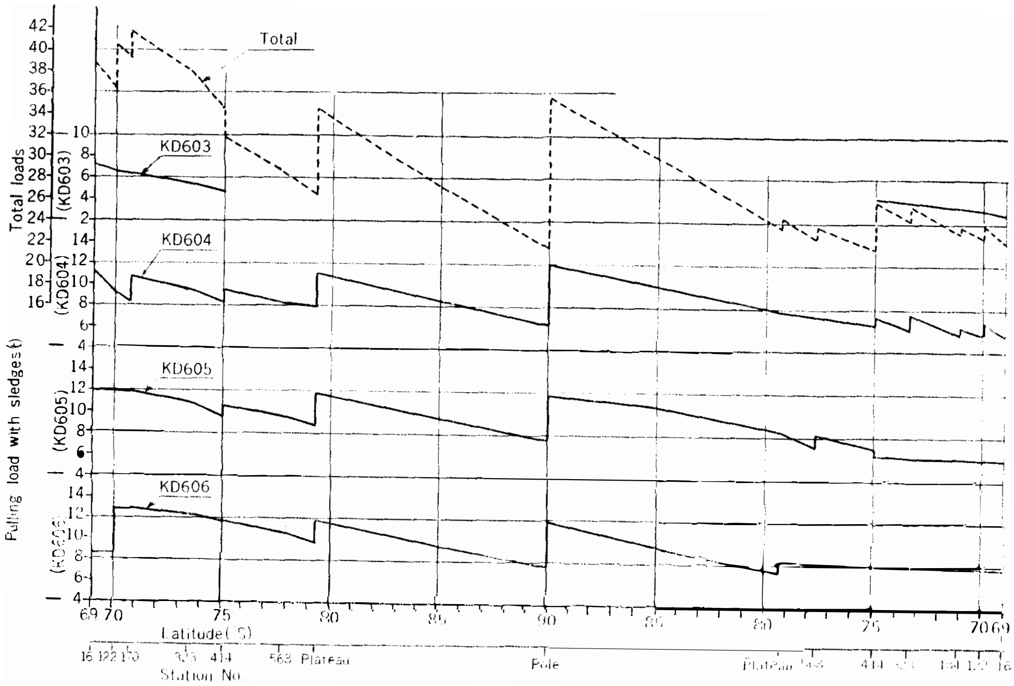

Fig. 21. Plan of pulling load with sledges.

the runners of sledge to stick to the snow and starting without help became impossible. This was because of the increase in friction resistance of sledge movement due to temperature. Traction force of the snow vehicles was reduced because of the increased resistance of soft snow. On the plateau higher than 3700 m in altitude, the exhaust gas turned dark due to thin air and increased resistance, resulting in apparent lowering of output accompanied by knocking sounds while the engine was driven at low or medium speed.

In the terrain south of 80°S (except in the soft snow area near the Pole), the air temperature was about −30°C and the snow condition was getting better. As the terrain was downward slope, all these conditions helped the party to have good progress.

In the return trip, the snow surface had crusted due to solar heat and wind. Smaller pulling load, downward slope, and higher air temperature in addition to the hard surface contributed to make a smooth progress.

6.2. Traverse record

1) The traverse of September 28, 1968 to February 15, 1969 was a long trip of 141 days in all. The traverse record is summarized in Table 11.

Fig. 22 shows the days spent and their percentage in month for cruising and camping for maintenance, bad weather rest, etc., for all vehicles. As seen from Table 11 and Fig. 22, days spent for maintenance during December and January reached as high as 16%. This high percentage can be attributed to the fact that vehicle maintenance in detail was carried out at the Pole and Plateau Stations. After all, days for maintenance reached 10% in the total days of traverse although those for repair work during cruising were not included. The fact that the days of cruising reached as high as 78% owes much to rather favorable weather condition and no vehicles stopped for repair for a long time.

2) Table 12 shows operation records of four vehicles at intervals of about

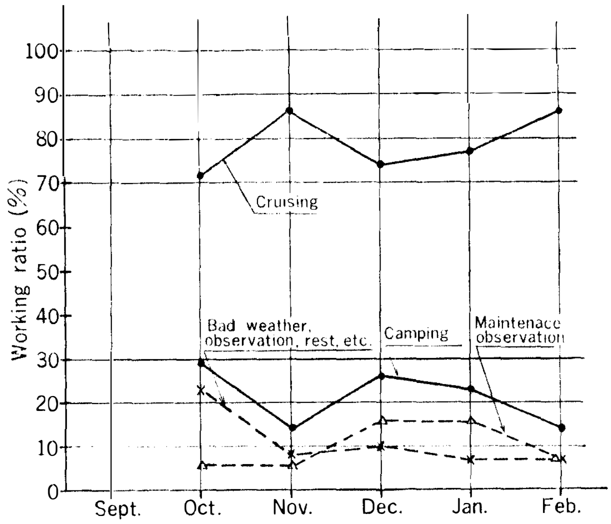

Fig. 22. Monthly working hour percentage.

Table 11. Monthly working day and ratio.

Month	Classification	KD604		KD605		KD606		KD603	
		Days	(%)	Days	(%)	Days	(%)	Days	(%)
Sept.	Cruising	3	100	3	100	3	100	3	100
	Camp (bad weather, observation, rest, etc.)	0	0	0	0	0	0	0	0
	Camp (vehicle maintenance, observation)	0	0	0	0	0	0	0	0
	Total	3	100	3	100	3	100	3	100
Oct.	Cruising	21	68	25	81	22	71	20	65
	Camp (bad weather, observation, rest, etc.)	8	26	4	13	7	23	9	29
	Camp (vehicle maintenance, observation)	2	6	2	6	2	6	2	6
	Total	31	100	31	100	31	100	31	100
Nov.	Cruising	26	86	26	86	26	86	2	67
	Camp (bad weather, observation, rest, etc.)	2	7	2	7	2	7	1	33
	Camp (vehicle maintenance, observation)	2	7	2	7	2	7	0	0
	Total	30	100	30	100	30	100	3	100
Dec.	Cruising	23	74	23	74	23	74		
	Camp (bad weather, observation, rest, etc.)	3	10	3	10	3	10		
	Camp (vehicle maintenance, observation)	5	16	5	16	5	16		
	Total	31	100	31	100	31	100		
Jan.	Cruising	24	78	24	78	24	78		
	Camp (bad weather, observation, rest, etc.)	2	6	2	6	2	6		
	Camp (vehicle maintenance, observation)	5	16	5	16	5	16		
	Total	31	100	31	100	31	100		
Feb.	Cruising	13	86	13	86	13	86		
	Camp (bad weather, observation, rest, etc.)	1	7	1	7	1	7		
	Camp (vehicle maintenance, observation)	1	7	1	7	1	7		
	Total	15	100	15	100	15	100		
Total	Cruising	110	78	114	81	111	79	25	68
	Camp (bad weather, observation, rest, etc.)	16	12	12	9	15	11	10	27
	Camp (vehicle maintenance, observation)	15	10	15	10	15	10	2	5
	Total	141	100	141	100	141	100	37	100

Total in all (KD604 KD605 KD606 KD603)	Cruising		Camp (bad weather, observation, rest, etc.)		Camp (vehicle maintenance, observation)		Total	
	Days	%	Days	%	Days	%	Days	%
	360	78	53	12	47	10	460	100

Table 12a. Operation record (KD604).

*Engine oil changed

l/km•t: Fuel consumption/Distance × pulling loads with sledges

Departure/Arrival	Date (month day)	Latitude (deg.-min.)	Station No.	Pulling loads with sledges (t)	Cruising time (min)			Cruising distance (km)			Fuel consumption								Oil consumption (l)					
											Diesel gas oil							Heater, kerosene or diesel gas oil (l)	Gasoline	Engine oil	Hydraulic oil	Gear oil	Grease (kg)	Antifreeze
											Driving			Other (l)	Total									
					Actual driving	Other	Total	Advancement	Other	Total	(l)	(l/km)	(l/km•t)		(l)	(l/km)	(l/km•t)							
D	9. 28	69-00	Syowa	6.0																				
A	10. 8	70-02	122	11.6			4147			252.1					656.9	2.61	0.23	D28	—	2	1	—	2.3	3
D	10. 9			11.7																				
A	10. 13	71-10	190	11.5			2460			152.2					367.2	2.41	0.21	D 9	—	2	—	—	—	2
D	10. 14			11.5																				
A	10. 16	72-04	244	11.2			2280			120.3					365.6	3.04	0.27	D 4	—	2	—	—	—	2
D	10. 17			11.2																				
A	10. 21	70-06	304	9.2			1830			129.7					315.7	2.43	0.24	D 5	8	*14	1	—	2.3	—
D	10. 22			9.2																				
A	10. 23	73-46	344	9.0			1530			87.1					227.4	2.61	0.29	D 4	—	2	—	—	—	—
D	10. 24			9.0																				
A	10. 26	75-00	414	8.6			1830			141.5					380.4	2.69	0.31	D 4	—	2	1	18	—	25
D	10. 27			8.5																				
A	10. 30	75-57	470	8.1			1920			119.6					388.3	3.25	0.39	D 3	—	3	—	—	—	—
D	10. 31			6.5																5				
A	11. 5	76-59	530	8.0			3010			159.1					527.4	3.31	0.45	K 6	8	*14	1	—	2.3	3
D	11. 6			8.0																				
A	11. 8	78-01	590	7.5			2645			144.8					534.8	3.69	0.47	K 4	—	2	—	—	—	3
D	11. 9			7.5																				
A	11. 12	79-14	Plateau	6.9			2840			158.9					565.7	3.56	0.50	K 3	—	2	1	—	—	1

Departure/Arrival	Date (month. day)	Latitude (deg.-min.)	Station No.	Pulling loads with sledges (t)	Cruising time (min)			Cruising distance (km)			Fuel consumption								Oil consumption (l)					
											Diesel gas oil													
											Driving			Other	Total			Heater, kerosene or diesel gas oil (l)						
					Actural driving	Other	Total	Advancement	Other	Total	(l)	(l/km)	(l/km·t)	(l)	(l)	(l/km)	(l/km·t)		Gasoline	Engine oil	Hydraulic oil	Gear oil	Grease (kg)	Antifreeze
D	11.13	79-14	Plateau	9.7																2				
A	11.17	80-01	687	9.4			1485			118.0					379.2	3.21	0.42	K 8	12	*14	—	30	2.3	1
D	11.18			9.4																				
A	11.20	81-01	717	9.0			1405			120.3					337.1	2.80	0.30	K 3	—	3	1	—	—	3
D	11.21			9.0																				
A	11.23	82-00	747	8.6			1565			120.3					333.5	2.77	0.32	K 4	—	1	—	—	2.3	—
D	11.24			8.6																				
A	11.26	83-00	777	8.2			1571			120.7					344.5	2.85	0.34	K 4	—	2	—	—	—	1
D	11.27			8.2																				
A	11.29	84-02	807	7.9			1546			120.8					318.6	2.64	0.31	K 2	—	1	—	—	—	1
D	11.30			7.9																2				
A	12. 2	85-03	837	7.6			1590			120.4					312.4	2.59	0.33	K 1	8	*14	1	—	2.3	—
D	12. 3			6.9																				
A	12. 6	86-05	867	6.6			1665			120.9					287.8	2.38	0.35	K 1	—	—	—	—	—	—
D	12. 7			6.6																				
A	12. 9	87-08	897	6.3			1740			121.2					247.0	2.04	0.31	K 1	—	3	—	—	2.3	—
D	12.10			6.1																				
A	12.12	88-08	927	5.8			1705			120.4					288.6	2.40	0.40	K 2	—	2	—	—	—	—
D	12.13			5.1																				
A	12.15	89-08	957	4.8			1715			120.4					301.4	2.50	0.50	K 1	—	3	—	—	2.3	—
D	12.16			4.8																				
A	12.19	90-00	Pole	4.5			1578			102.2					257.7	2.52	0.54	K 6	12	*14	4	30	—	10

Departure/Arrival	Date (month. day)	Latitude (deg.-min.)	Station No.	Pulling loads with sledges (t)	Cruising time (min)			Cruising distance (km)			Fuel consumption								Oil consumption (*l*)					
											Diesel gas oil													
											Driving			Other (*l*)	Total			Heater, kerosene or diesel gas oil (*l*)	Gasoline	Engine oil	Hydraulic oil	Gear oil	Grease (kg)	Antifreeze
					Actural driving	Other	Total	Advancement	Other	Total	(*l*)	(*l*/km)	(*l*/km·t)		(*l*)	(*l*/km)	(*l*/km·t)							
D	12. 20	90-00	Pole	7. 4																				
A	12. 28	88-08	927	7. 0			2528			228. 1					460. 9	2. 02	0. 28	K 3	—	5	—	18	2. 3	—
D	12. 29			7. 7																7				
A	1. 2	85-03	837	7. 5			3557			348. 0					736. 7	2. 12	0. 28	K 3	8	*14	—	—	2. 3	2
D	1. 3			8. 1																				
A	1. 7	82-48	771	7. 4			2634			264. 7					599. 6	2. 27	0. 29	K 2	—	4	2	—	2. 3	—
D	1. 8			7. 4																				
A	1. 11	80-43	708	6. 8			2767			240. 4					536. 8	2. 23	0. 31	K 3	—	3	3	—	—	2
D	1. 12			6. 8																4				
A	1. 14	79-14	Plat-eau	6. 5			2818			177. 0					468. 0	2. 64	0. 39	K 4	12	*14	4	30	2. 3	—
D	1. 15			7. 9																				
A	1. 22	78-01	590	7. 4			2396			164. 1					543. 1	3. 31	0. 43	K 2	—	6	4	—	—	5
D	1. 23			7. 4																11				
A	1. 30	75-00	414	6. 5			4513			391. 6					1049. 9	2. 68	0. 38	K 5	8	*14	5	—	2. 3	8
D	1. 31			7. 6																				
A	2. 4	73-02	300	7. 2			2216			226. 3					419. 6	1. 85	0. 25	K 4	—	5	—	—	—	—
D	2. 5			7. 2																				
A	2. 10	70-02	122	6. 7			4186			348. 7					562. 7	1. 61	0. 23	K 3	—	7	—	—	2. 3	20
D	2. 11			6. 7																				
A	2. 15	69-00	16	6. 5			1978			215. 9					335. 0	1. 55	0. 23	K 8	8	5	—	—	—	6
Total or average							71660 (1194h)			5376					13450	2. 50		D 57 K 83	84	98 *112	29	126	32. 2	98

Table 12b. Operation record (KD605).

*Engine oil changed

l/km·t: Fuel consumption/Distance × pulling loads with sledges

Departure/Arrival	Date (month. day)	Latitude (deg.-min.)	Station No.	Pulling loads with sledges (t)	Cruising time (min): Actual driving	Cruising time (min): Other	Cruising time (min): Total	Cruising distance (km): Advancement	Cruising distance (km): Other	Cruising distance (km): Total	Fuel consumption, Diesel gas oil, Driving: (l)	Driving: (l/km)	Driving: (l/km·t)	Other (l)	Total: (l)	Total: (l/km)	Total: (l/km·t)	Heater, kerosene or diesel gas oil (l)	Oil consumption (l): Gasoline	Engine oil	Hydraulic oil	Gear oil	Grease (kg)	Antifreeze
D	9. 24		Syowa	6. 0																				
A	9. 27	69-00	16	6. 0	269	93	362	39. 3	1. 3	40. 6	53. 3	1. 36	0. 23	20. 5	73. 8	1. 82	0. 30	D 6	—	—	—	—	—	1
D	9. 28			11. 3																2				
A	10. 8	70-02	122	11. 9	2730	4170	6900	216. 4	445. 9	662. 3	487. 8	2. 25	0. 19	367. 5	855. 3	1. 29	0. 11	D 7	4	*14	9	18	2. 3	2
D	10. 9			11. 9																				
A	10. 13	71-10	190	11. 2	1767	974	2741	140. 9	0. 5	141. 4	318. 2	2. 26	0. 20	20. 5	338. 7	2. 40	0. 21	D 2	—	—	—	—	—	12
D	10. 14			11. 2																				
A	10. 16	72-04	244	11. 0	1504	911	2415	129. 1	0. 4	129. 5	324. 2	2. 51	0. 23	6. 9	331. 1	2. 56	0. 23	D 1	—	2	—	—	—	—
D	10. 17			11. 0																1				
A	10. 21	73-06	304	8. 4	1633	732	2365	142. 8	0. 3	143. 1	349. 0	2. 44	0. 25	33. 2	382. 2	2. 67	0. 28	D 7	8	*14	—	—	2. 3	1
D	10. 22			8. 4																				
A	10. 23	73-46	344	8. 1	879	696	1575	86. 1	0	86. 1	218. 6	2. 54	0. 31	5. 1	223. 7	2. 60	0. 31	D 3	—	—	—	—	—	1
D	10. 24			8. 1																				
A	10. 26	75-00	414	7. 7	1427	727	2154	146. 6	0. 3	146. 9	383. 0	2. 61	0. 33	7. 5	390. 5	2. 67	0. 34	D 4	—	3	—	18	—	2
D	10. 27			6. 7																				
A	10. 30	75-57	470	7. 1	1181	673	1854	114. 2	1. 3	115. 5	266. 1	2. 33	0. 34	26. 7	292. 8	2. 54	0. 37	D 9	—	—	1	—	—	2
D	10. 31			7. 0																5				
A	11. 5	76-59	530	7. 8	1645	1535	3180	170. 5	4. 9	175. 4	514. 0	3. 01	0. 41	29. 3	543. 3	3. 10	0. 42	K 6	8	*14	1	—	2. 3	1
D	11. 6			7. 8																				
A	11. 8	78-01	590	7. 4	1953	824	2777	143. 4	0. 6	144. 0	454. 8	3. 17	0. 42	12. 1	466. 9	3. 24	0. 43	K3	—	6	—	—	—	1

Departure/Arrival	Date (month. day)	Latitude (deg.-min.)	Station No.	Pulling loads with sledges (t)	Cruising time (min)			Cruising distance (km)			Fuel consumption								Oil consumption (l)					
											Diesel gas oil							Heater, kerosene or diesel gas oil (l)	Gasoline	Engine oil	Hydraulic oil	Gear oil	Grease (kg)	Antifreeze
											Driving			Other (l)	Total									
					Actual driving	Other	Total	Advancement	Other	Total	(l)	(l/km)	(l/km·t)		(l)	(l/km)	(l/km·t)							
D	11. 9	78-01	590	7.4																				
A	11.12	79-14	Plateau	6.9	1878	1151	3029	154.9	2.4	157.3	449.3	2.90	0.40	13.5	462.8	2.94	0.41	K 4	—	4	—	—	—	1
D	11.13			9.7																1				
A	11.17	80-01	687	9.4	1238	581	1819	97.2	13.8	111.0	287.4	2.96	0.31	63.4	350.8	3.16	0.33	K 3	12	*14	—	27	2.3	1
D	11.18			9.4																				
A	11.20	81-01	717	9.1	1179	658	1837	118.8	0.2	119.0	278.3	2.34	0.25	9.3	287.6	2.42	0.26	K 3	—	2	—	-	—	—
D	11.21			9.1																				
A	11.23	82-00	747	8.8	1224	656	1880	119.1	0.3	119.4	280.6	2.36	0.26	1.27	293.3	2.46	0.27	K 5	—	1	—	—	2.3	2
D	11.24			8.6																				
A	11.26	83-00	777	8.4	1145	516	1661	118.5	0.1	118.6	281.0	2.37	0.28	6.6	287.6	2.43	0.29	K 2	—	4	—	—	—	—
D	11.27			8.4																				
A	11.29	84-02	807	8.0	1176	498	1674	118.9	0.2	119.1	258.2	2.17	0.26	6.5	264.7	2.22	0.27	K 2	—	2	—	—	—	—
D	11.30			8.0																2				
A	12. 2	85-03	837	7.8	1184	489	1673	118.1	0.2	118.3	260.8	2.21	0.28	10.3	271.1	2.29	0.29	K 2	8	*14	1	4	2.3	—
D	12. 3			7.4																				
A	12. 6	86-05	867	7.2	1233	466	1699	118.6	0.5	119.1	259.4	2.19	0.30	6.8	266.2	2.24	0.31	K 2	—	—	—	—	—	9
D	12. 7			7.2																				
A	12. 9	87-08	897	6.9	1227	473	1700	120.1	0.3	120.4	240.8	2.01	0.28	5.0	245.8	2.04	0.29	—	—	1	—	—	2.3	—
D	12.10			6.4																				
A	12.12	88-08	927	6.1	1237	495	1732	118.8	0.4	119.2	274.2	2.31	0.37	6.3	280.5	2.35	0.37	K 2	—	1	—	—	—	—
D	12.13			6.2																				
A	12.15	89-08	957	5.9	1254	500	1754	118.7	0.3	119.0	285.7	2.41	0.40	4.5	290.2	2.44	0.40	—	—	3	—	—	2.3	1

Departure/Arrival	Date (month. day)	Latitude (deg.-min.)	Station No.	Pulling loads with sledges (t)	Cruising time (min) Actual driving	Cruising time (min) Other	Cruising time (min) Total	Cruising distance (km) Advancement	Cruising distance (km) Other	Cruising distance (km) Total	Fuel consumption: Diesel gas oil, Driving (l)	Driving (l/km)	Driving (l/km·t)	Other (l)	Total (l)	Total (l/km)	Total (l/km·t)	Heater, kerosene or diesel gas oil (l)	Oil consumption (l): Gasoline	Engine oil	Hydraulic oil	Gear oil	Grease (kg)	Antifreeze
D	12. 16	89-08	957	5. 0																1				
A	12. 19	90-00	Pole	4. 7	723	674	1397	99. 5	0. 1	99. 6	221. 0	2. 22	0. 45	7. 0	228. 0	2. 29	0. 47	K 8	12	*14	2	30	—	4
D	12. 20			7. 4																				
A	12. 28	88-08	927	8. 0	1091	663	1754	211. 2	11. 6	222. 8	402. 5	1. 91	0. 25	28. 1	430. 6	1. 93	0. 25	K 2	—	3	—	—	2. 3	6
D	12. 29			8. 1																8				
A	1. 2	85-03	837	7. 3	2596	1366	3962	345. 6	0. 5	346. 1	638. 4	1. 85	0. 24	6. 3	644. 7	1. 86	0. 24	K 4	8	*14	4	—	2. 3	7
D	1. 3			8. 2																				
A	1. 7	82-48	771	7. 5	2008	863	2871	255. 6	3. 1	258. 7	466. 2	1. 82	0. 23	12. 7	478. 9	1. 85	0. 23	K 3	—	1	—	—	2. 3	1
D	1. 8			7. 5																				
A	1. 11	80-43	708	7. 0	1815	1096	2911	234. 3	0. 6	234. 9	412. 2	1. 76	0. 24	6. 2	418. 4	1. 78	0. 24	K 3	—	6	—	—	—	2
D	1. 12		Plat-	7. 0																2				
A	1. 14	79-14	eau	6. 9	1523	980	2503	167. 7	0. 6	168. 3	326. 6	1. 95	0. 28	3. 8	330. 4	1. 96	0. 28	K 4	12	*14	1	30	2. 3	1
D	1. 15			8. 1																				
A	1. 22	78-01	590	7. 6	1598	777	2375	152. 1	16. 7	168. 8	351. 9	2. 31	0. 29	53. 8	405. 7	2. 40	0. 30	K 3	—	5	4	—	—	8
D	1. 23			7. 6																6				
A	1. 30	75-00	414	7. 4	3688	1598	5286	369. 6	5. 1	374. 7	852. 2	2. 31	0. 31	22. 8	875. 0	2. 34	0. 31	K 6	8	*14	—	—	2. 3	17
D	1. 31			8. 1																				
A	2. 4	73-02	300	7. 4	1781	841	2622	221. 7	1. 8	223. 5	344. 1	1. 55	0. 20	14. 8	358. 9	1. 61	0. 21	K 5	—	5	—	—	—	8
D	2. 5			7. 4																				
A	2. 10	70-02	122	6. 8	2784	1757	4541	346. 0	5. 2	351. 2	491. 2	1. 42	0. 20	12. 5	503. 7	1. 43	0. 20	K 3	—	6	—	—	2. 3	8
D	2. 11			6. 8																				
A	2. 15	69-00	16	6. 6	1252	849	2101	216. 8	2. 6	219. 4	279. 3	1. 29	0. 19	11. 9	291. 2	1. 33	0. 20	K 6	8	3	—	—	—	8
Total or average					49822 (830h)	29282 (488h)	79104 (1318h)	5271	522	5793	11310	2. 15		854	12164	2. 10		D39 K81	88	86 *126	23	127	32. 2	107

Table 12c. Operation record (KD606).

*Engine oil changed

l/km·t: Fuel consumption/Distance × pulling loads with sledges

Ddparture/Arrival	Date (month. day)	Latitude (deg.-min.)	Station No.	Pulling loads with sledges (t)	Cruising time (min): Actual driving	Cruising time (min): Other	Cruising time (min): Total	Cruising distance (km): Advancement	Cruising distance (km): Other	Cruising distance (km): Total	Fuel consumption, Diesel gas oil, Driving: (l)	Driving: (l/km)	Driving: (l/km·t)	Other (l)	Total: (l)	Total: (l/km)	Total: (l/km·t)	Heater, kerosene or diesel gas oil (l)	Oil consumption (l): Gasoline	Engine oil	Hydraulic oil	Gear oil	Grease (kg)	Antifreeze
D	9. 24		Syowa	5. 0																				
A	9. 27	69-00	16	5. 0	360	30	390	41. 8	2. 0	43. 8	56. 4	1. 35	0. 27	11. 9	68. 3	1. 56	0. 31	6	—	—	—	—	—	2
D	9. 28			11. 4																				
A	10. 8	70-02	122	9. 4	3367	2086	5453	237. 1	6. 3	243. 4	546. 3	2. 30	0. 24	30. 9	577. 2	2. 37	0. 23	5	—	2	1	—	2. 3	3
D	10. 9			13. 0																				
A	10. 13	71-10	190	11. 1	2845	370	3215	164. 1	3. 2	167. 3	401. 6	2. 45	0. 20	29. 7	431. 3	2. 58	0. 21	2	—	2	1	—	—	—
D	10. 14			11. 1																				
A	10. 16	72-04	244	10. 8	2390	140	2530	150. 8	0. 3	151. 1	369. 2	2. 45	0. 22	6. 2	375. 4	2. 48	0. 23	3	—	3	—	—	—	—
D	10. 17			10. 8																1				
A	10. 21	73-06	304	9. 4	2713	385	3098	149. 7	1. 8	151. 5	355. 6	2. 38	0. 22	10. 0	365. 6	2. 41	0. 23	1	8	*14	4	—	2. 3	2
D	10. 22			9. 4																				
A	10. 23	73-46	344	9. 2	1130	440	1570	84. 6	0. 9	85. 5	195. 9	2. 32	0. 25	2. 0	197. 9	2. 32	0. 25	1	—	3	—	—	—	—
D	10. 24			9. 2																				
A	10. 26	75-00	414	8. 9	1980	110	2090	145. 5	4. 5	150. 0	347. 6	2. 39	0. 26	18. 2	365. 8	2. 44	0. 27	1	—	2	—	18	—	—
D	10. 27			7. 4																				
A	10. 30	75-57	470	7. 1	1665	275	1940	115. 4	9. 3	124. 7	291. 4	2. 53	0. 35	33. 2	324. 6	2. 60	0. 36	4	—	2	—	—	—	3
D	10. 31			7. 0																3				
A	11. 5	76-59	530	7. 5	2760	230	2990	152. 6	18. 6	171. 2	460. 2	3. 02	0. 41	59. 0	519. 2	3. 03	0. 42	5	8	*14	4	—	2. 3	5
D	11. 6			7. 5																				
A	11. 8	78-01	590	7. 0	2810	210	3020	159. 3	6. 2	165. 5	493. 4	3. 10	0. 43	61. 5	554. 9	3. 35	0. 46	1	—	4	—	—	—	—

Departure/Arrival	Date (month. day)	Latitude (deg.-min)	Station No	Pulling loads with sledges (t)	Cruising time (min)			Cruising distance (km)			Fuel consumption								Oil consumption (1)						
											Diesel gas oil							Heater, kerosene or diesel gas oil (l)	Gasoline	Engine oil	Hydraulic oil	Gear oil	Grease (kg)	Antifreeze
											Driving			Other (l)	Total									
					Actual driving	Other	Total	Advancement	Other	Total	(l)	(l/km)	(l/km·t)		(l)	(l/km)	(l/km·t)							
D	11.9	78-01	590	7.0																				
A	11.12	79-14	Plat-eau	6.4	2665	90	2755	161.6	12.1	173.7	513.8	3.18	0.47	44.5	558.3	3.21	0.48	2	—	5	1	—	—	5
D	11.13			9.4																2				
A	11.17	80-01	687	9.0	1215	555	1770	100.5	13.2	113.7	334.5	3.33	0.36	55.1	389.6	3.43	0.37	6	12	*14	—	30	2.3	10
D	11.18			9.0																				
A	11.20	81-01	717	8.7	1445	190	1635	120.0	1.8	121.8	315.4	2.63	0.30	5.2	320.6	2.63	0.30	4	—	2	—	—	—	—
D	11.21			8.7																				
A	11.23	82-00	747	8.4	1355	235	1590	124.7	1.0	125.7	315.6	2.53	0.29	2.6	318.2	2.53	0.29	4	—	3	—	—	2.3	4
D	11.24			8.3																				
A	11.26	83-00	777	8.0	1425	170	1595	118.9	0.6	119.5	301.9	2.54	0.31	3.3	305.2	2.55	0.31	3	—	2	—	—	—	4
D	11.27			8.0																				
A	11.29	84-02	807	7.7	1295	210	1505	119.2	0.6	119.8	265.1	2.22	0.28	16.7	281.8	2.35	0.30	3	—	—	—	—	—	4
D	11.30			7.7																3				
A	12.2	85-03	837	7.4	1335	230	1565	118.9	0.9	119.8	276.1	2.32	0.30	12.2	288.3	2.41	0.32	2	8	*14	1	—	2.3	4
D	12.3			6.6																				
A	12.6	86-05	867	6.4	1462	253	1715	119.0	0.5	119.5	260.2	2.19	0.34	6.1	266.3	2.23	0.34	2	—	1	—	—	—	—
D	12.7			6.4																				
A	12.9	87-08	897	6.1	1460	240	1700	120.4	0.5	120.9	236.2	1.96	0.31	1.6	237.8	1.97	0.31	1	—	2	—	—	2.3	4
D	12.10			5.8																				
A	12.12	88-08	927	5.5	1350	370	1720	119.8	0.5	120.3	274.6	2.29	0.40	3.3	277.9	2.31	0.41	2	—	—	—	—	—	4
D	12.13			4.3																				
A	12.15	89-08	957	4.0	1405	280	1685	118.0	0.1	118.1	271.2	2.30	0.55	2.5	273.7	2.32	0.55	1	—	4	—	—	2.3	4

Departure/Arrival	Date (month. day)	Latitude (deg.-min.)	Station No.	Pulling loads with sledges (t)	Cruising time (min): Actual driving	Cruising time (min): Other	Cruising time (min): Total	Cruising distance (km): Advancement	Cruising distance (km): Other	Cruising distance (km): Total	Fuel consumption, Diesel gas oil, Driving: (l)	Driving: (l/km)	Driving: (l/km·t)	Other (l)	Total: (l)	Total: (l/km)	Total: (l/km·t)	Heater, kerosene or diesel gas oil (l)	Oil consumption (l): Gasoline	Engine oil	Hydraulic oil	Gear oil	Grease (kg)	Antifreeze
D	12. 16	89–08	957	4. 0																2				
A	12. 19	90–00	Pole	3. 8	1425	75	1500	97. 7	3. 9	101. 6	212. 9	2. 18	0. 56	28. 4	241. 3	2. 38	0. 61	2	12	*14	1	30	—	5
D	12. 20			7. 4																				
A	12. 28	88–08	927	7. 0	2295	480	2775	216. 6	12. 0	228. 6	457. 1	2. 11	0. 29	32. 9	490. 0	2. 14	0. 30	1	—	4	—	—	2. 3	7
D	12. 29			7. 6																5				
A	1. 2	85–03	837	7. 5	3620	205	3825	348. 0	3. 0	351. 0	684. 3	1. 97	0. 26	17. 7	702. 0	2. 00	0. 26	6	8	*14	—	—	2. 3	4
D	1. 3			8. 2																				
A	1. 7	82–48	771	7. 6	2565	150	2715	263. 2	2. 7	265. 9	551. 3	2. 09	0. 26	9. 4	560. 7	2. 11	0. 27	1	—	4	1	—	2. 3	5
D	1. 8			7. 6																				
A	1. 11	80–43	708	7. 1	2750	0	2750	243. 4	11. 7	255. 1	477. 8	1. 96	0. 26	26. 4	504. 2	1. 98	0. 27	1	—	4	—	—	—	5
D	1. 12			7. 1																3				
A	1. 14	79–14	Plat-eau	6. 7	2175	150	2325	171. 5	3. 3	174. 8	382. 9	2. 23	0. 32	11. 8	394. 7	2. 26	0. 33	1	12	*14	4	30	2. 3	9
D	1. 15			6. 0																				
A	1. 22	78–01	590	5. 7	2185	270	2455	151. 8	18. 7	170. 5	352. 7	2. 32	0. 39	39. 4	392. 1	2. 30	0. 39	—	—	3	—	—	—	4
D	1. 23			5. 7																8				
A	1. 30	75–00	414	5. 5	4420	150	4570	365. 7	4. 8	370. 5	789. 4	2. 16	0. 39	16. 2	805. 6	2. 17	0. 39	5	8	*14	—	4	2. 3	23
D	1. 31			6. 3																				
A	2. 4	73–02	300	6. 3	2260	50	2310	223. 6	0	223. 6	361. 2	1. 62	0. 26	4. 6	365. 8	1. 64	0. 26	7	—	3	—	—	—	1
D	2. 5			6. 3																				
A	2. 10	70–02	122	3. 3	3960	200	4160	348. 7	0	348. 7	463. 9	1. 33	0. 21	0	463. 9	1. 33	0. 21	1	—	4	—	2	2. 3	1
D	2. 11			3. 3																				
A	2. 15	69–00	16	3. 3	1810	160	1970	216. 1	0	216. 1	331. 6	1. 53	0. 46	1. 2	332. 8	1. 54	0. 47	D 4	8	3	—	—	—	3
Total or average					67897 (1132h)	8989 (150h)	76886 (1282h)	5388	145	5533	11947	2. 22		604	12551	2. 27		K 87 DO	84	89 *112	18	114	32. 2	121

Table 12d. Operation record (KD603).

*Engine oil changed

l/km·t: Fuel consumption/Distance × pulling loads with sledges

Departure/Arrival	Date (month. day)	Latitude (deg.-min.)	Station No.	Pulling loads with sledges (t)	Cruising time (min): Actual driving	Cruising time (min): Other	Cruising time (min): Total	Cruising distance (km): Advancement	Cruising distance (km): Other	Cruising distance (km): Total	Fuel consumption, Diesel gas oil, Driving: (l)	Driving: (l/km)	Driving: (l/km·t)	Other (l)	Total: (l)	Total: (l/km)	Total: (l/km·t)	Heater, kerosene or diesel gas oil (l)	Oil consumption (l): Gasoline	Engine oil	Hydraulic oil	Gear oil	Grease (kg)	Antifreeze
D	9. 24		Syo-wa	4. 0																				
A	9. 27	69-00	16	4. 0			390			37. 8					62	1. 64	0. 41	3	—	—	—	—	—	2
D	9. 28			8. 4																				
A	10. 8	70-02	122	8. 0			2707			210. 6					380	1. 80	0. 22	3	—	20	—	—	—	1
D	10. 9			8. 2																				
A	10. 13	71-01	190	8. 0			2135			142. 1					250	1. 76	0. 22	2	—	5	1	—	2. 3	1
D	10. 14			8. 8																				
A	10. 16	72-04	244	8. 3			2248			111. 3					240	2. 16	0. 25	2	—	5	—	—	—	1
D	10. 17			7. 7																5				
A	10. 21	73-06	304	7. 6			1800			151. 1					270	1. 79	0. 23	2	8	*14	1	—	—	1
D	10. 22			8. 2																				
A	10. 23	73-46	344	8. 1			1494			81. 5					190	2. 34	0. 29	1	—	6	1	—	—	2
D	10. 24			8. 1																				
A	10. 26	75-00	414	7. 1			1895			138. 5					280	2. 02	0. 27	1	—	5	1	18	—	2
D	10. 27			5. 3																				
A	10. 30	75-57	470	5. 0			1880			120. 0					250	2. 08	0. 40	2	12	6	—	18	—	—
D	10. 31			5. 0																				
A	11. 3	76-27	499	4. 7			1170			54. 0					230	4. 26	0. 87	1	—	—	—	—	—	—
Total or average							15719 (262h)			1047					2152	2. 06		K17 DO	20	52 *14	4	36	2. 3	10

one degree in latitude. In this table, pulling loads include the weight of sledge on days of departure and arrival at each interval. The column "actual driving" indicates the hours of actual driving of vehicle, and "advancement" the distance actually covered from one station to other predetermined destination.

The total hours and total distance for each vehicle are listed below, including average speeds:

KD604	1194 h	5376 km	4.5 km/h
KD605	1318 h	5793 km	4.4 km/h
KD606	1287 h	5533 km	4.3 km/h
KD603	262 h	1047 km	4.0 km/h
Total or average speed for four vehicles	4061 h	17749 km	4.4 km/h

Examination of tachographs for KD605 indicated 488 hours (37% in total) for observation, communication, repair, and other stop, and 830 hours (63%) for actual cruising. The total distance of actual advancement in 830 hours was 5271 km which was equivalent to 91% of the total driving distance. The total distance made by preparatory driving, test driving, organization of sledges, cargo movement, etc., was 522 km (9%). Figures for other cruising time and distance of KD605 include 440 km and 60 hours from St. 102—Syowa Station and back for ambulance operation, which are extra figures compared with other vehicles. When these are subtracted, the actual stoppage time turns out to be 32% of its total driving hours and the total distance which had no connection with the actual advancement was 1.4% of its total driving distance.

The actual average speed calculated from tachographs of KD605 was 6.3 km/h, substracting hours for rest.

Fuel consumed and fuel consumption rate for each vehicle are as follows:

KD604	13452 *l*	2.50 *l*/km
KD605	12164 *l*	2.10 *l*/km
KD606	12546 *l*	2.27 *l*/km
KD603	2152 *l*	2.06 *l*/km
Total and average of four vehicles	40314 *l*	2.27 *l*/km

When checked from the records of actual driving of KD605 and 606 disregarding those not directly related to advancement such as for observation and other purposes, figures come out as follows:

KD605	11310 *l*	2.15 *l*/km
KD606	11949 *l*	2.22 *l*/km
Total and average of four vehicles	23257 *l*	2.18 *l*/km

For heater fuel, diesel gas oil was partly used until reaching the neighborhood of 76°S and kerosene thereafter. The total consumption of heater fuel and consumption per day for each vehicle are as follows:

KD604	Diesel gas oil Kerosene	57 *l* 83 *l*	0.99 *l*/day
KD605	Diesel gas oil Kerosene	39 *l* 81 *l*	0.85 *l*/day
KD606	Kerosene	87 *l*	0.62 *l*/day
KD603	Kerosene	17 *l*	0.46 *l*/day
Total for four vehicles per day	Diesel gas oil Kerosene	96 *l* 268 *l*	Average 0.79 *l*/day

In the above mentioned figures of daily rate of fuel consumption, 0.4 to 0.5 *l*/day are used to preheat the engine, and the rest was used for heating the cabin. For this reason, vehicles provided with living facilities such as KD604 and 605 consumed more fuel.

Lubrication and maintenance oil consumption: Quantity of oil consumed and changed (marked with an asterisk in the Table) for each vehicle is shown in Table 13.

Table 13. Lubricating and maintenance oil consumed and changed.

Vehicles	Gasoline (*l*)	Engine oil (*l*)	Hydraulic oil (*l*)	Gear oil (*l*)	Grease (kg)	Antifreeze (*l*)
KD604	84	98 *112	29	*126	*32.2	98
KD605	88	86 *126	23	*127	*32.2	107
KD606	84	89 *112	18	*114	*32.2	121
KD603	20	52 * 14	4	* 36	* 2.3	10
Total	276	325 *364	74	*403	*98.9	336

Average consumption rate calculated by disregarding the quantity for maintenance and oil change was as follows:

Engine oil—7.15 *l* for every 1 k*l* of fuel consumed.

Hydraulic oil—4.17 *l* for every 1000 km of cruising distance.

Antifreeze—18.9 *l* for every 1000 km of cruising distance.

Pulling load: A various kind of combination of sledges and loads was used during depot-setting, fuel supply, and relevant works. Table 14 gives the record of pulling loads, including sledge weight, while Fig. 23 shows the changes in pulling loads. At near 70°S the total traction weight reached 44.8 tons and snow vehicles KD604, 605, and 606 each carried a pulling load as heavy as 12 to 13 tons. As cruising continued, however, the weight was gradually reduced before arriving at 75°S, heavy 4-ton steel cargo sledges were left behind at Sts. 170, 240 and 414 and light 2-ton wooden cargo sledges were used for reorganization. Thus, a total weight of 27 tons were shared by four snow vehicles. At St. 499, however, KD603 was abandoned and a total of 23.9 tons (about 8 tons per vehicle) had to be pulled all the way over the watershed of the continent. After receiving supplies at the Plateau Station, the weight totaled 28.8 tons. In average of the entire traverse, the pulling load was 22 tons.

Table 14. Record of pulling loads of sledges. (Weight: gross)

Vehicle No.	St. 16 Departure Sledge No.	St. 16 Departure Weight (t)	St. 70, 78 Arrival Weight (t)	St. 70, 78 Departure Sledge No.	St. 70, 78 Departure Weight (t)	St. 122 Arrival Weight (t)	St. 122 Departure Sledge No.	St. 122 Departure Weight (t)	St. 170 Arrival Weight (t)	St. 170 Departure Sledge No.	St. 170 Departure Weight (t)	St. 270 Arrival Weight (t)	St. 270 Departure Sledge No.	St. 270 Departure Weight (t)
KD604	94	6.4	6.2	94	6.2	5.6	94	6.4	6.1	94	6.4	5.8	36	3.0
	29	2.0	2.0	29	2.0	2.0	29	2.0	2.0	29	2.1	2.1	29	2.6
	28	2.0	2.0	28	2.0	2.0	28	1.9	1.9	28	1.9	1.9	28	2.2
	0	1.0	1.0	32	2.0	2.0	2t cab.	1.4	1.4	2t cab.	1.3	1.3	2t cab.	1.6
(Total)		11.4	11.2		12.2	11.6		11.4	11.4		11.7	11.1		9.4
KD605	95	6.6	6.0	95	6.6	6.0	95	6.6	6.4	95	6.6	6.0	95	6.5
	23	2.3	2.3	23	2.3	2.3	23	2.3	2.3	23	2.3	2.3	122	2.0
	31	2.4	2.4	31	2.3	2.3	31	2.4	2.4	31	2.4	2.4		
				0	1.3	1.3	0	0.6	0.6					
(Total)		11.3	10.7		12.5	11.9		11.9	11.7		11.3	10.7		8.5
KD606	96	4.2	4.2	96	4.2	4.2	96	6.4	6.1	96	6.4	5.7	23	2.2
	4t cab.	3.7	3.7	4t cab.	3.7	3.7	4t cab.	3.7	3.7	122	1.4	1.4	31	2.3
	32	2.0	2.0	27	1.5	1.5	27	1.5	1.5	27	1.6	1.6	0	2.1
	27	1.5	1.5				122	1.4	1.4	0	1.8	1.8	27	3.0
(Total)		11.4	11.4		9.4	9.4		13.0	12.7		11.2	10.5		9.6
KD603	24	3.0	2.8	24	2.9	2.6	24	2.6	2.4	24	3.0	2.5	24	3.0
	25	3.0	3.0	25	3.0	3.0	25	3.0	3.0	25	3.0	3.0	25	3.0
	2t cab.	1.4	1.4	2t cab.	1.4	1.4	32	1.8	1.8	32	1.8	1.8	32	1.7
	36	1.0	1.0	36	1.0	1.0	36	0.8	0.8	36	1.0	1.0		
(Total)		8.4	8.2		8.3	8.0		8.2	8.0		8.8	8.3		7.7
Total in all		42.5	41.5		42.4	40.9		44.8	43.8		43.0	40.6		35.2

Vehicle No.	St. 414 Arrival Weight (t)	St. 414 Departure Sledge No.	St. 414 Departure Weight (t)	St. 470 Arrival Weight (t)	St. 470 Departure Sledge No.	St. 470 Departure Weight (t)	St. 509 Arrival Weight (t)	St. 509 Departure Sledge No.	St. 509 Departure Weight (t)	St. 663 (Plateau St.) Arrival Weight (t)	St. 663 (Plateau St.) Departure Sledge No.	St. 663 (Plateau St.) Departure Weight (t)	St. 747 Arrival Weight (t)	St. 747 Departure Sledge No.	St. 747 Departure Weight (t)
KD604	2.2	32	1.7	1.7	29	2.7	2.4	29	3.0	1.7	29	3.0	2.0	29	2.1
	2.6	29	3.0	2.6	28	2.1	2.1	28	2.3	2.3	28	2.2	2.2	28	2.1
	2.2	28	2.1	2.1	2t cab.	1.7	1.7	122	1.1	1.1	32	3.0	2.9	32	2.9
	1.6	2t cab.	1.7	1.7				2t cab.	1.8	1.8	2t cab.	1.5	1.5	2t cab.	1.5
(Total)	8.6		8.5	8.1		6.5	6.2		8.2	6.9		9.7	8.6		8.6
KD605	5.7	23	2.2	2.2	36	1.6	1.2	24	3.0	1.9	24	3.0	2.1	24	1.9
	2.0	36	1.6	1.6	23	2.1	2.1	23	2.1	2.1	23	2.1	2.1	23	2.1
		25	2.9	2.6	32	1.7	1.7	25	1.0	1.0	25	3.0	3.0	25	3.0
					0	1.7	1.7	36	1.9	1.9	36	1.6	1.6	36	1.6
(Total)	7.7		6.7	6.4		7.1	6.7		8.0	6.9		9.7	8.8		8.6
KD606	2.2	0	2.1	2.1	122	2.4	2.4	0	2.0	2.0	0	1.3	1.3	0	1.3
	2.3	31	2.3	2.3	31	2.1	2.1	31	2.0	2.0	31	2.1	2.1	31	2.0
	2.1	27	3.0	2.7	27	2.5	2.2	32	0.7	0.7	27	3.0	2.6	27	2.6
	2.3							27	3.0	1.7	568	3.0	2.4	568	2.4
(Total)	8.9		7.4	7.1		7.0	6.7		7.7	6.4		9.4	8.4		8.3
KD603	2.4	122	2.4	2.1	25	2.5	2.2								
	3.0	24	2.9	2.9	24	2.5	2.5								
	1.7														
(Total)	7.1		5.3	5.0		5.0	4.7								
Total in all	32.3		27.9	26.6		25.6	24.3		23.9	20.2		28.8	25.8		25.5

Vehicle No.	St. 837			St. 897			St. 927			St. 957			St. 982 (Pole)		
	Arrival	Departure		Arrival	Departure		Arrival	Departure		Arrival	Departure		Arrival	Departure	
	Weight (t)	Sledge No.	Weight (t)	Weight (t)	Sledge No.	Weight (t)	Weight (t)	Sledge No.	Weight (t)	Weight (t)	Sledge No.	Weight (t)	Weight (t)	Slegde No.	Weight (t)
KD604	2.1	29	3.0	2.6	29	2.5	2.2	29	1.6	1.3	29	1.3	1.0	29	3.0
	2.1	28	1.7	1.7	28	1.0	1.6	28	1.5	1.5	28	1.5	1.5	28	1.4
	1.9	32	0.8	0.6	32	0.6	0.6	32	0.6	0.6	32	0.6	0.6	32	1.6
	1.5	2t cab.	1.4	1.4	2t cab.	1.4	1.4	2t cab.	1.4	1.4	2t cab.	1.4	1.4	2t cab.	1.4
(Total)	7.6		6.9	6.3		6.1	5.8		5.1	4.8		4.8	4.5		7.4
KD605	1.1	24	1.0	0.6	24	0.6	0.6	24	0.6	0.6	24	0.6	0.6	24	1.1
	2.1	23	2.1	2.1	23	2.1	2.1	23	2.1	2.1	23	2.1	2.1	23	2.1
	3.0	25	3.0	2.9	25	2.5	2.2	25	2.3	2.0	25	1.1	0.8	25	3.0
	1.6	36	1.3	1.3	36	1.2	1.2	36	1.2	1.2	36	1.2	1.2	36	1.1
														M	0.1
(Total)	7.8		7.4	6.9		6.4	6.1		6.2	5.9		5.0	4.7		7.4
KD606	1.3	0	1.1	1.1	0	1.1	1.1	0	1.1	1.1	0	1.1	1.1	0	1.1
	2.0	31	1.5	1.5	31	1.6	1.6	31	1.5	1.5	31	1.5	1.5	31	1.5
	2.6	27	3.0	2.9	27	2.5	2.2	27	1.1	0.8	27	0.8	0.6	568	1.8
	1.5	568	1.0	0.6	568	0.6	0.6	568	0.6	0.6	568	0.6	0.6	27	3.0
(Total)	7.4		6.6	6.1		5.8	5.5		4.3	4.0		4.0	3.8		7.4
KD603															
(Total)															
Total in all	22.8		20.9	19.3		18.3	17.4		15.6	14.7		13.8	13.0		22.2

M: magnetometer

Vehicle No.	St. 947 Arrival	St. 947 Departure		St. 927 Arrival	St. 927 Departure		St. 888 Arrival	St. 888 Departure		St. 837 Arrival	St. 837 Departure		St. 663 (Plateau St.) Arrival	St. 663 (Plateau St.) Deperture	
	Weight (t)	Sledge No.	Weight (t)	Weight (t)	Sledge No.	Weight (t)	Weight (t)	Sledge No.	Weight (t)	Weight (t)	Sledge No.	Weight (t)	Weight (t)	Slegde No.	Weight (t)
KD604	2.7	29	2.9	2.8	29	2.8	2.5	29	3.0	2.6	29	3.0	1.4	29	2.6
	1.4	28	1.3	1.3	28	1.3	1.3	28	1.3	1.3	28	1.4	1.4	28	1.6
	1.6	32	1.6	1.6	32	2.3	2.3	32	2.3	2.3	32	2.4	2.4	568	2.3
	1.4	2t cab.	1.3	1.3	2t cab.	1.3	1.3	2t cab.	1.3	1.3	2t cab.	1.3	1.3	2t cab.	1.4
(Total)	7.1		7.1	7.0		7.7	7.4		7.9	7.5		8.1	6.5		7.9
KD605	0.9	24	1.9	1.8	24	1.9	1.8	24	1.7	1.7	24	1.9	1.9	23	2.1
	2.1	23	2.1	2.1	23	2.1	2.1	23	2.1	2.1	23	2.1	2·1	25	3.0
	2.9	25	2.9	2.9	25	2.9	2.7	25	2.7	2.3	25	2.9	1.6	24	1.8
	1.1	36	1.1	1.1	36	1.1	1.1	36	1.1	1.1	36	1.2	1.2	32	1.1
	0.1	M	0.1	0.1	M	0.1	0.1	M	0.1	0.1	M	0.1	0.1	M	0.1
(Total)	7.1		8.1	8.0		8.1	7.8		7.7	7.3		8.2	6.9		8.1
KD606	1.1	0	1.1	1.1	0	1.1	1.1	0	1.1	1.1	0	1.1	1.1	27	2.8
	1.5	31	1.3	1.3	31	1.3	1.3	31	1.4	1.4	31	2.1	2.1	31	2.1
	1.6	568	1.8	1.8	568	2.4	2.4	568	2.7	2.3	568	2.3	2.2	0	1. [illegible]
	2.9	27	2.9	2.8	27	2.8	2.5	27	2.7	2.7	27	2.7	1.3		
(Total)	7.1		7.1	7.0		7.6	7.3		7.9	7.5		8.2	6.7		7.4
KD603															
(Total)															
Total in all	21.3		22.3	22.0		23.4	22.5		23.5	22.3		24.5	20.1		22.0

M: magnetomerter

Vehicle No.	St. 470 Arrival Weight (t)	St. 470 Departure Sledge No.	St. 470 Departure Weight (t)	St. 414 Arrival Weight (t)	St. 414 Departure Sledge No.	St. 414 Departure Weight (t)	St. 170 Arrival Weight (t)	St. 170 Departure Sledge No.	St. 170 Departure Weight (t)	St. 16 Arrival Weight (t)	St. 16 Departure Sledge No.	St. 16 Departure Weight (t)
KD604	1.3	29	1.2	1.2	29	1.2	1.2	29	1.3	1.3		
	1.6	28	1.6	1.6	28	1.9	1.9	28	1.7	1.7		
	2.3	568	2.5	2.2	568	3.0	2.2	568	1.3	0.9		
	1.4	2t cab.	1.5	1.5	2t cab.	1.5	1.5	2t cab.	1.5	1.5		
								0	1.1	1.1		
(Total)	6.6		6.8	6.5		7.6	6.8		6.9	6.5		
KD605	2.1	23	2.1	2.1	23	2.1	2.1	23	2.1	2.1		
	1.7	25	2.6	2.3	25	3.0	1.6	24	1.8	1.4		
	1.8	24	1.8	1.8	24	1.8	1.8	31	1.9	1.9		
	1.1	32	1.1	1.1	32	1.1	1.1	32	1.1	1.1		
	0.1	M	0.1	0.1	M	0.1	0.1	M	0.1	0.1		
(Total)	6.8		7.7	7.4		8.1	6.7		7.0	6.6		
KD606	2.2	27	2.5	2.3	27	3.0	3.0	4t cab.	2.7	2.7		
	2.1	31	2.1	2.1	31	2.2	2.2	25	0.7	0.6		
	1.1	0	1.1	1.1	0	1.1	1.1					
(Total)	5.4		5.7	5.5		6.3	6.3		3.4	3.3		
KD603												
(Total)												
Total in all	18.8		20.2	19.4		22.0	19.8		17.3	16.4		

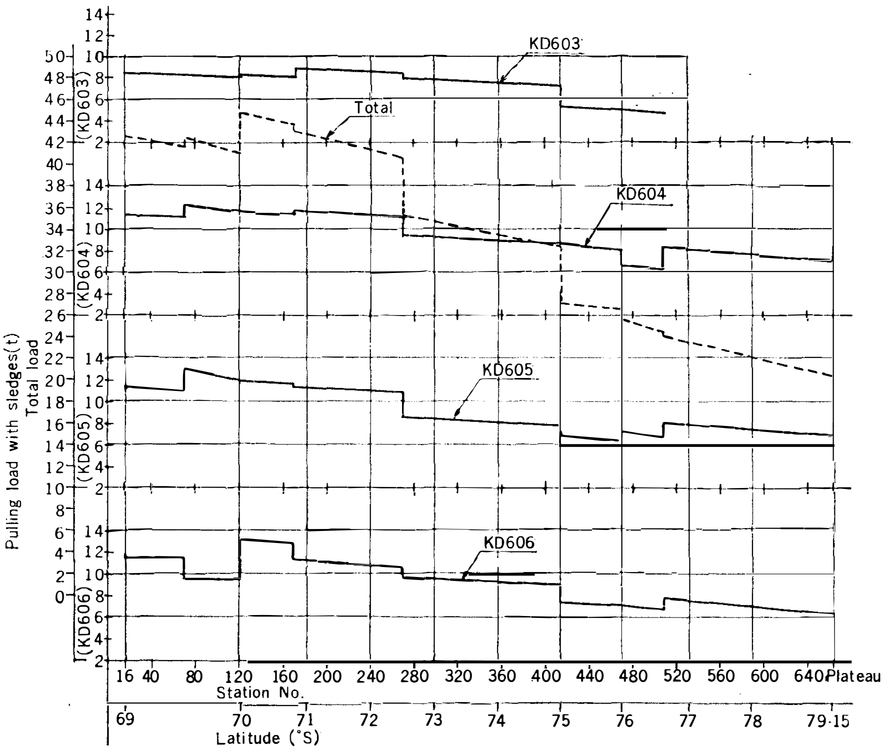

Fig. 23a. Record of pulling loads (St. 16–Plateau Station).

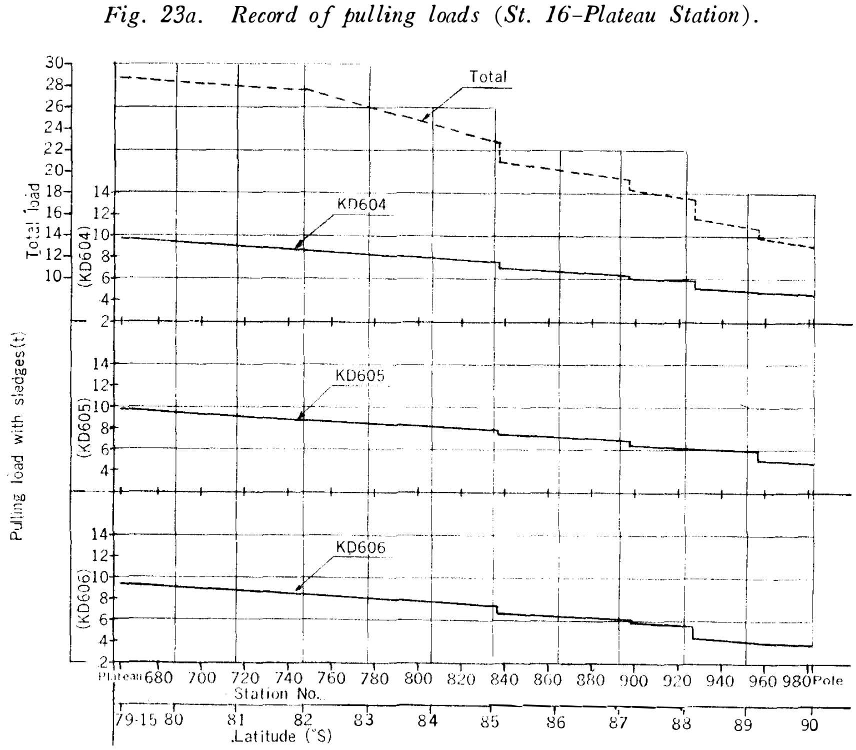

Fig. 23b. Record of pulling loads (Plateau Station–South Pole).

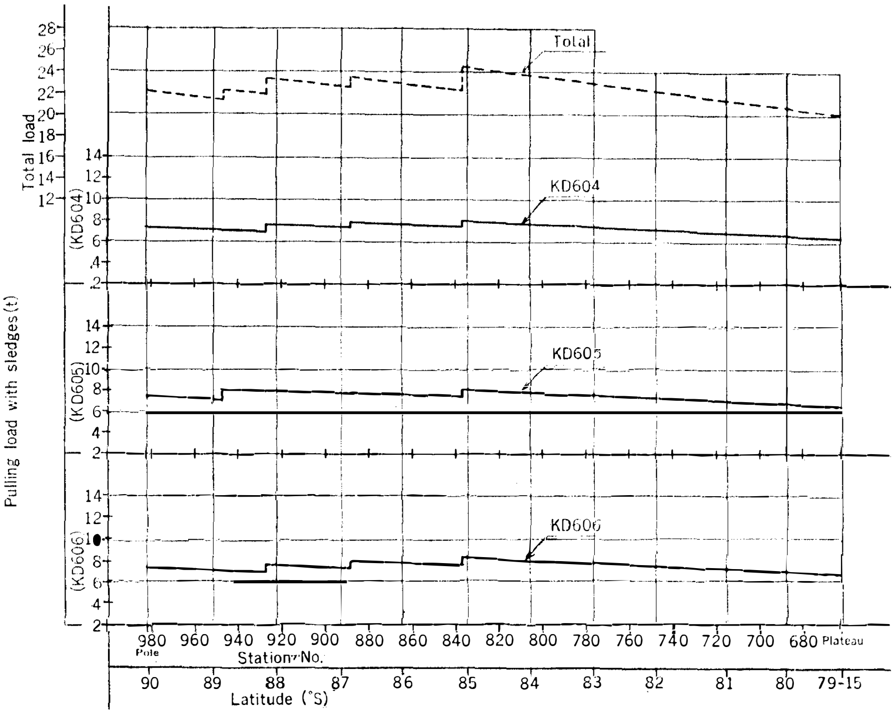

Fig. 23c. Record of pulling loads (South Pole-Plateau Station).

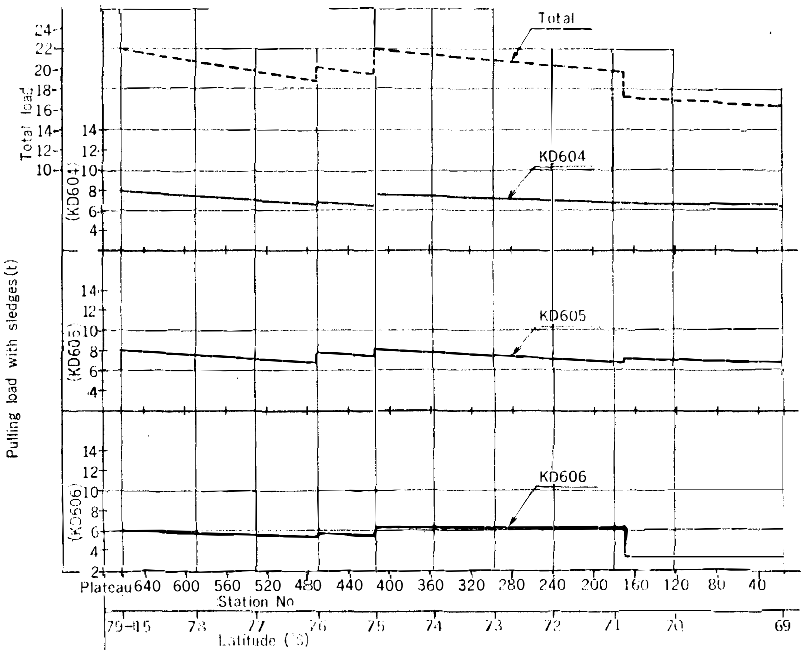

Fig. 23d. Record of pulling loads (Plateau Station-St. 16).

3) Result of cruising: Cruising distance, daily cruising hours and traverse period are shown in Fig. 24. Distance of net advancement per day averaged 48 km (average values for KD605 and 606) and actual total distance per day, including preparatory heating run, etc., averaged 50 km.

This means an extra of 2 km per day. As seen from Fig. 24, such tendency

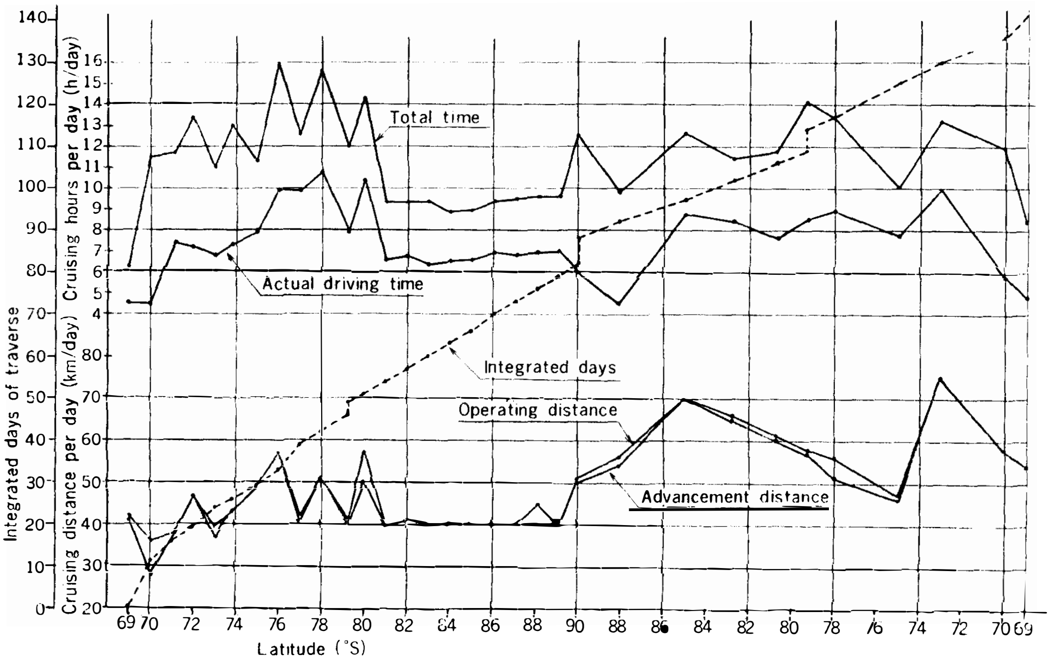

Fig. 24. Cruising distance and hours per day, and integrated days of traverse.

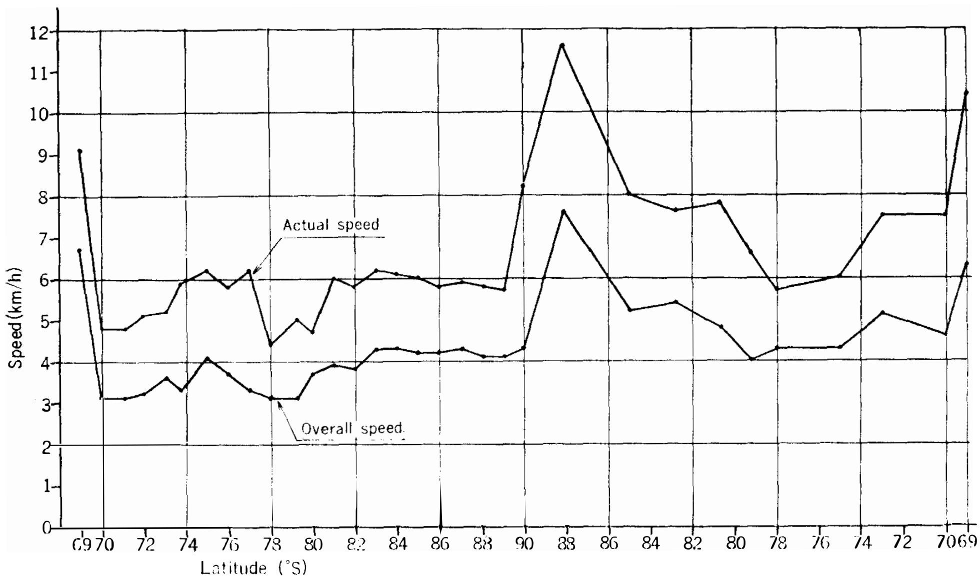

Fig. 25. Cruising speed of KD605.

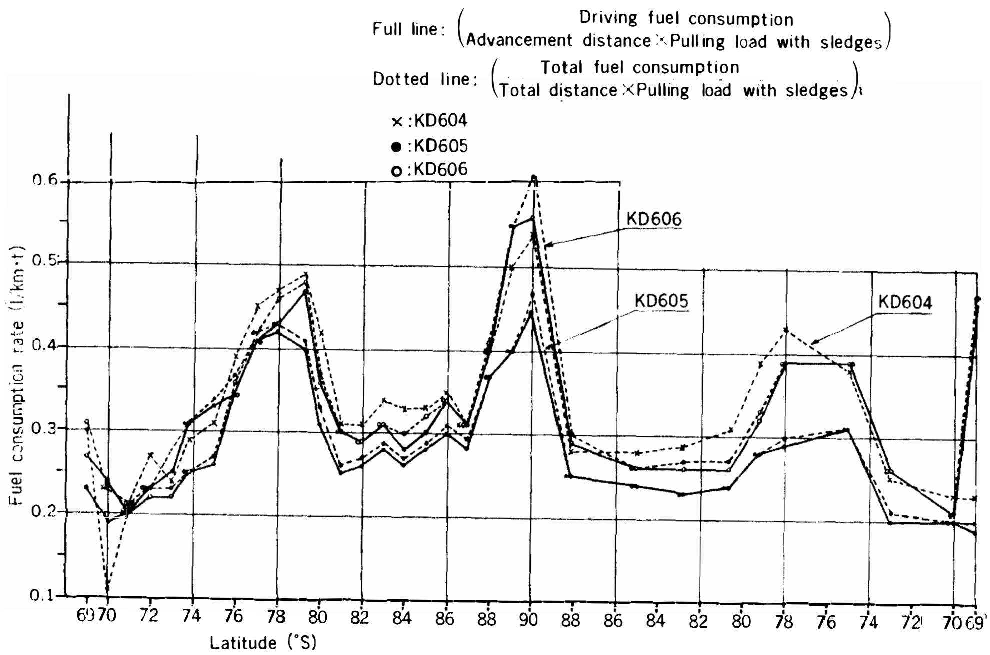

Fig. 26. Fuel consumption rate.

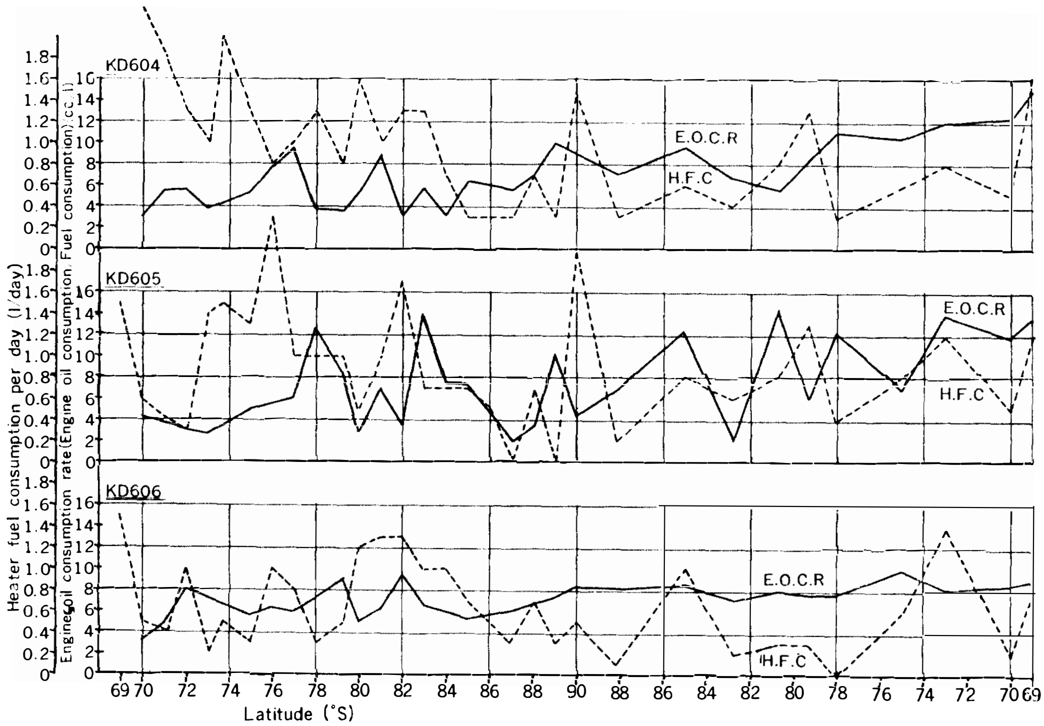

Fig. 27. Rate of engine oil consumption and daily rate of heater fuel consumption.
—— *Rate of engine oil consumption.*
------ *Heater fuel consumption per day.*

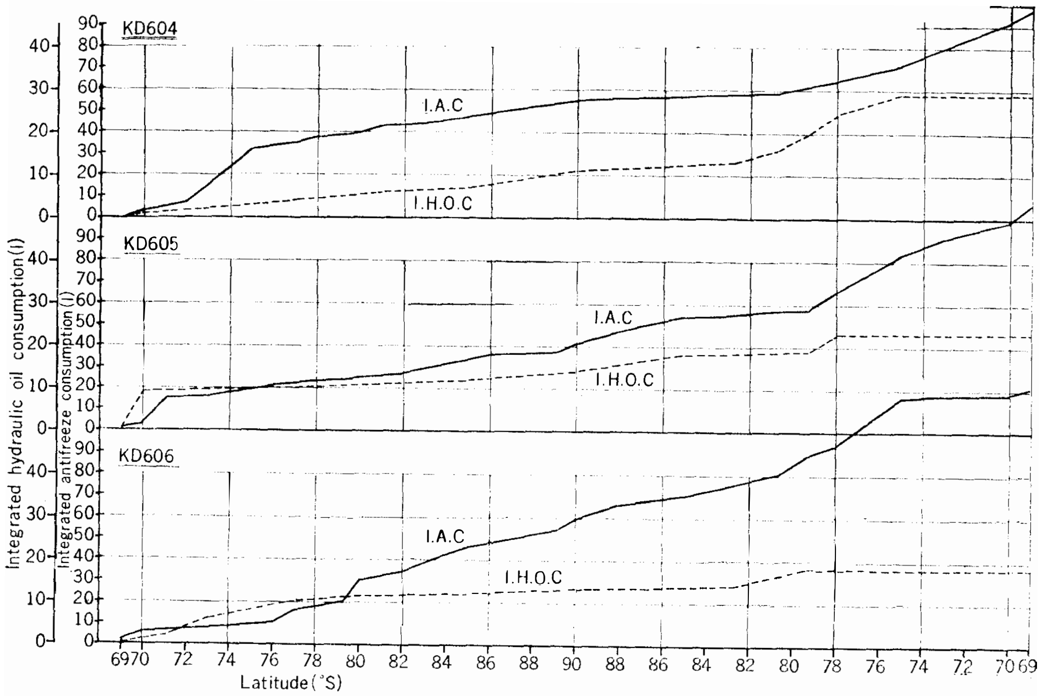

Fig. 28. Integrated antifreeze consumption and integrated hydraulic oil consumption.
—— *Integrated antifreeze consumption.*
------ *Integrated hydraulic oil consumption.*

is more pronounced at or around 70°S, 73°S, 80°S, and 88°S on the way to the South Pole. This is because cargo reloading, sledge reorganization, and other activities were carried out in those area; although a heating run of 200 to 300 m was required in most cases.

Daily run of the return trip was slightly longer because of increase in the distance for usual heating run.

Operating hours (KD605) per day averaged 11.4 hours and actual driving hours was 7.3 hours. This difference of 4.1 hours were for observation and lunch. It should be noted, however, that no extra hours were spent for lunch during the trip to the Plateau Station, recovering lost time during hard trip.

Fig. 25 shows both actual cruising speed and overall cruising speed of KD605. As seen in this figure, actual speed averaged 6.3 km/h and overall speed 4.4 km/h. The cruising speed between 70°S and 74°S, and between 77°S and 80°S in the going trip was lower than the average. This is because of difficult drive pulling heavy loads on soft skavler and many slopes between 70°S and 74°S. The soft snow terrain between 77°S and 80°S was also the place which gave lower average speed.

Fig. 26 shows fuel consumption rate of KD605 and 606 for their actual advancement and fuel consumption rate of KD604, 605, and 606 for their total driving. Consumption rate showed three maxima which correspond to soft

Table 15. Intervals (km) of lubricating oil change and engine maintenance parts replacement.

KD604					KD605					KD606					KD603				
G.R.	E.O.	G.O.D.	G.O.M.	E.M.	G.R.	E.O.	G.O.D.	G.O.M.	E.M.	G.R.	E.O.	G.O.D.	G.O.M.	E.M.	G.R.	E.O.	G.O.D.	G.O.M.	E.M.
439	663	964	1542	1542	455	455	455	2032	2032	319	650	991	1626	1626	350	737	876		
645	522	603	1255	1255	441	588	892	1249	1249	413	581	635	1261	1261					
101	382	1255	1300	1300	654	544	594	1265	1265	491	395	1261	1315	1315					
382	700	121			391	354	1249			403	715	1315							
339	555	1179			345	701	1265			456	546	1013							
603	606				356	548				359	614								
313	694				239	597				240	701								
258	552				309	668				306	536								
348					251	537				263									
264					346					351									
430					259					266									
237					409					435									
315					235					238									
480					302					298									
					481					477									

Note: E.O.: Engine oil; G.O.M.: Transmission gear oil
G.O.D.: Differential gear oil; G.R.: Grease
E.M.: Engine maintenance parts
Unit of interval: km

snow areas.

Fig. 27 shows the relative consumption of engine oil to that of fuel and also heater fuel consumption per day. Engine oil consumption increased in direct proportion to the fuel consumption. Heater fuel consumption increased because of stay at South Pole and the Plateau Station, otherwise it rather decreased in the inland zone and increased in the northern parts from 80°S. Engine oil consumption averaged 7.2 cc/*l* and heater fuel, 0.8 *l*/day.

Fig. 28 gives consumption of antifreeze and hydraulic oil.

6.3. Maintenance and repairs

1) Regular inspection was performed on daily basis and at intervals of 250, 500, 750, 2500, or 600 km according to prearranged procedures. The former was usually made after arrival at camp site. In the latter case, a more detailed inspection was made with greasing and change of engine oil.

Table 15 shows the driving distance intervals (km) for lubricating oil change and grease supply and engine maintenance parts replacement for each vehicle. Engine maintenance was performed mainly on replacement of element oil filter, element turbo-charger oil filter, element fuel filter, fuel injection nozzles, fan belts, and gear pump belt.

Grease was supplied to the each mechanism at same intervals. For exterior parts, such as in driving and suspension systems where sufficient oiling was difficult due to low temperature, intervals were shortened. Because of continuation of full load driving, intervals for engine oil and gear oil change were also shortened, and the oil was warmed in the cabin before being applied.

The trip from St. 16 to the Plateau Station was considerably behind schedule and the supply of grease and adjustment of track tension and steering control had to be made during the time allocated for observation. As the advancement turned out easy, however, it became possible to allocate half-day for maintenance hours every 3 days.

2) Vehicle stoppages that hampered operation occurred several times, which were in most cases recovered either during observation hours, camping, or regular maintenance hours.

Main replacement parts of engine system.

KD604	KD605	KD606	KD603
Injection pump Resistance coil Thermostat Oil filler cover packing	Turbo-charger Oil filler cover packing	Injection pump Water pump	Water pump Injection pump Thermostat

Main replacement parts of fuel system.

KD604	KD605	KD606
Fuel oil pump	—	Fuel oil pump

Main replacement parts of instruments and electric system.

KD604	KD605	KD606
Charging dynamo Charging regulator Battery 12V×2	Oil pressure gage Pipe, oil pressure gage Charging regulator Battery 12V×2	Fuel flowmeter Hose, fuel flowmeter Battery 12V×2

Main replacement parts of differentials and steering brake system.

KD604	KD605	KD606
Brake cylinder 3 Final driving gear Bearing, driving shaft 2 Oil seal, driving shaft 2	Brake cylinder	Brake cylinder 4 Return spring, brake cylinder 2

Main replacement parts of driving system.

KD604	KD605	KD606
Guide-pan, sprocket 14 Guide-pan, road wheel 10 Master pin, truck 6	Guide-pan, sprocket 7 Remer bolt, idler wheel shaft Bearing, idler wheel shaft Oil seal idler wheel shaft Master pin, track 8	Guide-pan, sprocket 10 Sprocket 2 Remer bolt, idler wheel shaft Guide-pan, road wheel 5 Master pin, track 6

Main replacement parts of steering brake and control system.

KD604	KD605	KD606
Master cylinder Rubber hose, height pressure 2 Steel pipe, height pressure Hydraulic oil pump	—	Master cylinder Flow-divider

Main replacement parts of heating system.

KD604	KD605	KD606
Thermostat	Thermostat	Thermo-relay
Clip, hose 4	Hose, 2 m	Relay
	Clip, hose	Clip, hose 4

Main replacement parts of others.

KD604	KD605	KD606
Pintlehook	Wind shield wiper	Radiator, engine
Radiator, heater		Differentials shiftining lever

Two reasons will be considered on the stops of vehicles which occurred at the beginning of the traverse up to about 75°S. One was malfunction of track guiding system because of riding over a rugged surface. The other was the trouble due to insufficient knowledge of drivers on operation, that is, absence of engine power and/or burning of charging regulator due to penetration of snow into the fuel line and other reasons.

During the period of middle to latter part of the traverse, troubles occurred in connection with overloading or durability, but it should be noted that there were only two cases when the repairs are needed.

Malfunction of steering control system was due to low temperature in most cases, and it apparently resulted from inadequate low-temperature performance of oil pressure-operating system, although this was overcome by heating to a favorable condition.

6.4. Effect of solar heat

Fig. 29 shows the relationship between solar heat and cabin temperature near 86°S (St. 867), while Fig. 19 gives the data of cabin temperature measured during the hours without solar heat effect and on the sea ice near Syowa Station.

Without using room heater, the cabin temperature was maintained at above +10°C at 86°S, although there was a difference of about 10°C between two cases when the direction of sunlight was normal to the side wall and when it was front-rear direction of the vehicle.

Due to the effect of air temperature and the wind, a cycle to 'heated' and 'cooled' state was repeated as shown in Fig. 19. Although this cycle involved the effect of opening and closing of door for observations, the cooling rate was 5.5°C/h on the average.

As mentioned before, the vehicle exterior was painted black and that insulating material used was of excellent quality, the temperature in the cabin and engine compartment was maintained favorably by fully absorbing the solar heat. By virtue of this, not only heating fuel was economized but also good effects were given to every portion of the vehicle.

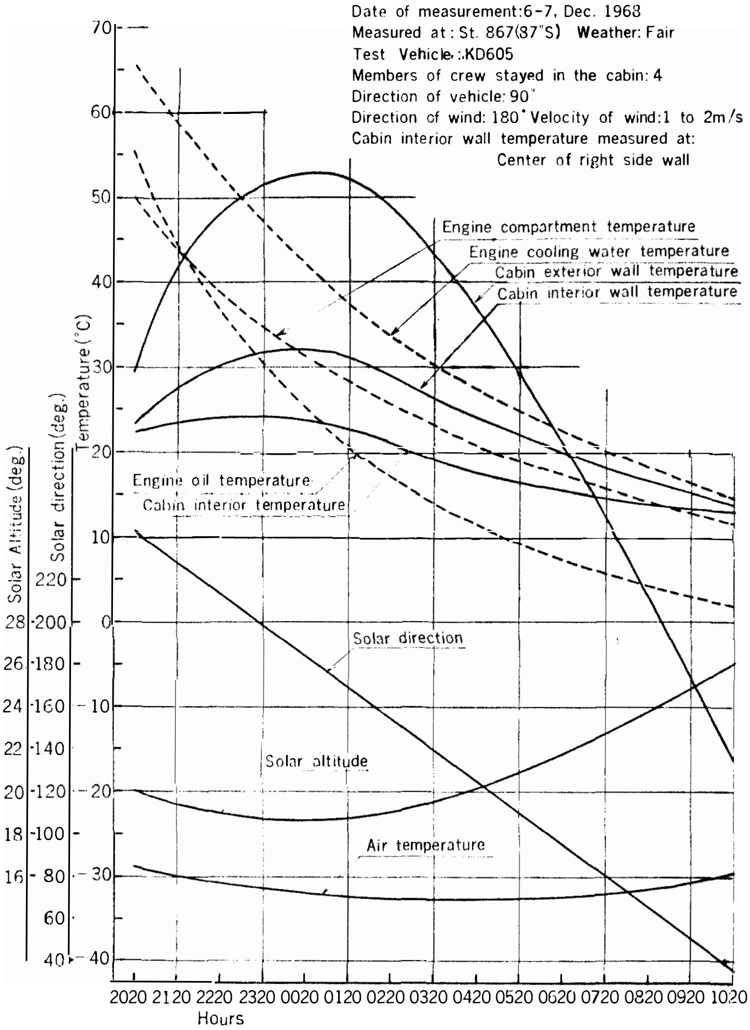

Fig. 29. Effect of solar heat.

6.5. *Traction of sledge*

One of the reasons for a hard trip experienced in the beginning of the traverse was the shape, size, and method of pulling the sledge. At first, one large 4-ton sledge and three 2-ton sledges were pulled by KD604 and 605, and one 4-ton sledge, one large caboose and two 2-ton sledges were pulled by KD606. However, these snow vehicles lost control of driving and steering on account of large 4-ton sledges being connected at the front, and were eventually forced to stop as the runners of the sledge tended to run into the snow surface, though snow vehicles themselves were able to pass over the skavler or drift. Before reaching 75°S, large sledges were all left at depots, and thereafter a train of four 2-ton sledges was pulled with a wire rope, which gave easy driving.

Runners did not slide well when the snow temperature dropped to around

−45°C, and this situation became rapidly worse when the temperature further dropped to around −53°C.

For connecting and pulling of sledges, wire rope was more flexible and therefore better than a steel draw-bar. Taking pulling loads and snow condition into consideration, distance between sledges was not kept the same but was made longer in the middle than at ends by approximately 1.5 times. A better result was obtained with this method.

6.6. Others

1) Navigation: Navigation was made by reading the indication of gyromagnetic compass and then confirming the positions by means of astronomical observations. Even at a high latitude, the compass gave an accurate magnetic direction. For future reference, it would be more convenient if a compass repeater was also provided near the left-side seat.

2) Operation: In addition to ordinary indicators for driving and maintaining engine, there were tachograph, revograph, battery voltmeter, and temperature indicators for engine cooling water, engine oil, transmission gear oil, differential gear oil, and the cabin. These indicators proved to be quite effective from the viewpoint of maintenance and operation, but a distance meter for navigational use had been very convenient.

During operation after sunset, tail lamp was effectively used in confirming if sledges were being pulled and also in making contact with the following vehicle.

3) Accommodation: A space of 7.44 m^2 was allocated for observation, communication and cooking. The space was quite small for the men since it also held beds, cooking table, and observation racks. It was possible, however, to accommondate 5 to 6 man in this limited space without over lapping many works at the same time.

4) Because of sufficient heating capacity and adequate means for temperature regulation, no difficulty was ever experienced in starting the engine.

Approximately 30 minutes of defrosting of the front window glass was made every morning prior to departure. During driving, no clouding occurred on the glass since heated air was constantly kept blowing.

Also during driving heated water of 70–85°C was produced through water-producing device by utilizing the engine cooling water as heat source. Thus the members were able to enjoy quite a pleasant journey such as drinking hot beverage even while driving. Moreover, cooking hours were shortened and fuel was economized.

5) Observation and communication racks were situated opposite to the cooking table and close to the rear door, so that they were subjected to frosting because of the opening and shutting of the door or cooking.

6) Troubles resulting from low temperature were malfunction of steering brake control and hydraulic oil leakage due to deformation and cracking of brake cylinder piston cup.

7. Conclusion

The JARE South Pole Traverse 1968-69 covering the distance of 5182 km was accomplished after overcoming many difficulties, such as hard driving over the soft snow and skavler-covered terrain while pulling heavy sledges and crossing over the continental plateau of 3800 m while being exposed to the intense cold of $-60°C$.

Even so, encountered with during this traverse were such problems as balancing among snow vehicles, sledges and cargos of fuel, etc., as well as fundamental specification of vehicles that can assure adaptability against various snow conditions. This signifies that a more comfortable traverse will be realized when these basic problems and various kinds of tasks associated with them are solved.