Report of the Mechanical Engineering Committee for the Japanese Antarctic Research Expedition.

Special Committee on Engineering for the Japanese Antarctic Research Expedition of Japan Society of Mechanical Engineers and Technical Members of the First, Second and Third JARE.*

南極地域観測機械関係報告

日本機械学会南極地域観測機械関係準備会

第 1, 2, 3 次南極地域観測隊機械担当隊員

要　旨

本報告には 1956 年から 1959 年に亘り実施された第 1, 2, 3 次南極観測隊のために, どのような機械類や機械部品が準備され, それらの南極における使用結果はどうであったかということについて述べてある. 本報告の対象とする観測年次は次のものである.

（1） **第1次予備観測並に越冬(1956年 11 月～1958 年 4 月)** 宗谷は基地予定点から 20 km の地点に接岸, 雪上車輸送によって用意した殆んどすべての物資の揚陸に成功, 昭和基地の建設, 西堀隊長以下 11 名の越冬を実施し得た. しかし, 機械類の一部は不幸にも揚陸後, 定着氷の流失と共に失なわれたが, その量は極めて僅であった.

（2） **第2次南極観測 (1957 年 10 月～1958 年 4 月)** 本観測を目標として, 新たに準備を行ない出発したが, 宗谷は堅氷にはばまれて接岸できず, 僅に空輸により越冬隊員を収容したのみにとどまり, 用意した物資は殆んどそのまま持ち帰られた.

（3） **第3次南極本観測 (1958 年 11 月～1959 年 4 月)** 第 2 次で持ち帰った機械類を再整備の上船積したが, 宗谷は基地附近への接岸困難のため, 雪上車輸送は実現できなかった. しかしヘリコプターによる補充物資や燃料の空輸を行ない, 14名の本観測隊員を昭和基地に越冬させた. 第 1 次に用意した設備機械類はそのまま直ちに本観測越冬のために役立った.

1956 年 2 月, 日本学術会議よりの依嘱により, 日本機械学会内に準備委員会が設けられた. そして学会委員, 第 1, 2, 3 次観測隊員中の機械担当隊員, 並に諸会社の協力によって機械関係の一切の企画, 準備が行なわれ, 製作, 試験を行なってそれぞれの性能を確認した上, 南極に携行された.

まず計画にあたっては次の諸点が考慮された.

（1） 1～2 年に亘り, 全くの補給なしに 10～15 名程度の越冬隊員の安全な生活のための機械設備を用意する.

（2） 船より基地までの輸送, 内地旅行に十分な雪上車, そり, 荷役機械類を用意する.

（3） 機械類は −30°～−40°C までの低温下に於ても, 十分その機能を発揮し得ることを目標とする.

（4） 最少の物資で最大の効果をあげ得るよう種類と量を最少限にとどめ, 互換性を計る.

（5） エネルギー資源としては, 最も安全で広い用途を有する軽油になるべく統一するように考慮し, 又その節約については特別に工夫した.

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* All members of the Special Committee on Engineering for JARE of Japan Society of Mechanical Engineers and Technical Members of the first, second and third JARE are printed at the end of this article. This article was written by Osamu HIRAO and Seiiti AWANO on behalf of the Special Committee on Engineering.

（6） 殆んどすべての機械類は国産品を使用することとした．それも時間の制限をうけたので，在来内地で使用されているものに最小限の改造を行なうにとどめたものが多い．

（7） 南極における使用を特別の目的として新たに設計，試作されたものもある．たとえば，そり，カブース，プラスチック・ボート，排熱利用造水装置並に温水器，発電用風車，熱風機，暖房機，燃料及び油脂類等がそれである．

1956 年の夏頃までは，南極プリンス・ハラルド附近の状況が殆んど不明であり，僅にノルウェー，米国で撮られた数葉の航空写真を基礎として判断するだけで，どのような自然状況に対応する機械類を作るべきかに悩まされた．しかし，第1次観測，特に予備観測越冬によって南極に関する大きな知識が得られ，これらは第2次以下の準備に対して直ちに反映されたが，残念ながら第 2, 3 次では宗谷の接岸不能のため，折角用意した機械類，燃料等も，これを昭和基地まで届けることに大きな困難を受けた．

しかし，第1次より第3次本観測越冬までの経験では，準備されたすべての機械類は大した困難もなしに，予期された性能を南極の厳寒の下においても十分に発揮していると認められる．

1. Preface

In September, 1955, Japan determined to join in the International Geophysical Year Antarctic Research Expedition. Then, the Science Council of Japan asked J. S. M. E. to organize the Mechanical Engineering Committee and to give assistance to this research enterprise.

In February, 1956, the Mechanical Engineering Committee was organized including the branches of Motor Vehicles, Heat and Thermodynamics, Air-conditioning and Loading-machines. This committee, teamed up closely by some members of the first and the second expeditions, and also by the manufacturers in Japan, began immediately to arrange the machines and mateirals such as snow-cars, cargosleighs, electric generators, air-conditioning system, boats, loading machines, bridges, fuel and oil, etc.

As the budget and the scale of the expedition were not decided until April or May, and as the ship for the expedition was expected to leave Tokyo on October 8 th 1957, or November 8 th 1956, only six months were left to arrange all of the requisites. Consequently, the committee had to be satisfied with altering, in most cases, the necessary parts of the existing machines in Japan.

2. The natural conditions of Antarctic Japanese Base

2. 1. Assumed conditions In the spring of 1956, the committee had hardly any knowledge of the geographical and meteorological conditions of the neighbourhood of the Prince Harald Coast, except those gained through the aerial photographs taken by the R. CHRISTENSEN Party of Norway in 1937.

But in September, 1956, when Dr. E. NISHIBORI, the subcommander of the first Japanese Expedition team went to America, he obtained some aerial photographs of this region taken by the American team in 1947.

Comparing these two sets of photographs the committee realized that the conditions of ice and open sea in this region are not the same every year. Although these photographs were a great help in 1956, the committee's limited knowledge of the Antarctic regions was yet insufficient to enable reading off all the details of the pictures such as "puddles". The committee assumed the condition near the Prince Harald Base as following five zones.

a) Pack-ice zone
b) Closed-ice zone
c) Fast-ice zone
d) Shelf-ice zone
e) Rock zone

The shelf-ice was considered to push the fast-ice zone making many cracks there, and on the contacting line of these two zones, steep cliffs of ice were considered to be formed. But, there were found some spots where easy slopes lay between these zones, and these spots were expected to be desirable points for landing. Another desirable point for landing was the spot where the fast-ice zone reached closely up to the rock zone.

The ship had to anchor near the fast-ice after she had pushed her way through pack-ice and closed-ice. The cargo had to be unloaded on the fast-ice and carried to the Base on the rock zone by snow-cars and sleighs.

At first, the distance between the anchoring point and the Base was expected to be less than 50~100 kms, but it was decided when Dr. E. NISHIBORI came back from his trip to Australia in September, 1956, that this distance must be shortened and kept within 20~30 kms for successful landing.

The minimum of the air temperature near the Base was assumed to be about $-60°C$, and the mean temperature throughout the year, $-35°C$, but in summer season, it was assumed to go up to between $0°C$ and $-15°C$.

2.2. **The Actual conditions near the Syowa Base** Soya, the 1 st Japanese JARE ship, arrived at the fast-ice zone of Prince Harald Bay on January 24 th, 1957, and left there in February the same year. Eleven members, including the commander, Dr. E. NISHIBORI, stayed one year on the newly-built Syowa Base. During this wintering period, they gained many valuable experiences. A summary of the record on the meteorological condition relating to the mechanical engineering field is shown below:

i) OUTDOOR AIR TEMPERATURE The air temperature measured at the Syowa Base from the end of January, 1957, to the beginning of February, 1958, is as follows.

Min. temperature $-36.0°C$ (August 31, September 1, 1957)

Max. temperature $+7.4°C$ (January 31, 1958)

During the period from the beginning of January to the middle of February, the minimum temperature was about $-15°C$, and the mean temperature throughout a day varied from $-5°C$ to $+5°C$. All of these temperature were recorded at sea level, and the temperture at an inland spot where the altitude was about 1000~2000 m, was assumed to be below $-40°C$. Even in this extraordinarily low temperature, all of the pieces of machinery used for the out-door trips had to be kept in good running condition without any damage.

ii) WIND VELOCITY The mean wind velocity throughout one hour recorded at the Syowa Base is follows:

Max. mean velocity (throughout one hour): 32.9 m/s (March 13 th, 1957)

Mean velocity (March, 1957 through December, 1957): 7.2 m/s.

Numbers of stormy days during this period:

Mean velocity during one hour > 10 m/s: 171 days

Mean velocity during one day > 15 m/s: 34 days

iii) HUMIDITY The minimum relative humidity recorded outdoors, was 34% (November 6 th, 1957), but the mean value of relative humidity during one month was almost 70～80% throughout all seasons. The air indoors was very dry. The slushy condition of the snow surface was scarcely observed through the year, except under the days of sunshine of December and January.

iv) FAST-ICE The surface of the snow-land which had not yet passed through the summer season, was very flat and little frozen, and in many cases, covered with a fast snow layer. This condition was most suitable for the operation of snow-cars and sleighs. But after the summer season, this snow-plain was changed into a fast-ice plain, and unevenness arose on the surface making very irregular snow drift which made transportation difficult.

v) PUDDLES The puddles caused most of the difficulties for transportation by snow-cars and sleighs over the sea-ice plain in summer. The puddles are the small pools made when sea-ice melts. They begin to be found at the end of November, developing remarkably after the middle of December towards the middle or the end of the following January, until they are perfectly frozen again at the end of February. The maximum depth of puddle was observed to extend to about 50～100 cm, but sometimes, it was found to be bottomless. The edge of the puddle was very steep and generally concaved, which occasionally prevented the nose of the snow-cars or sleighs that had fallen in it from running on to the far edge.

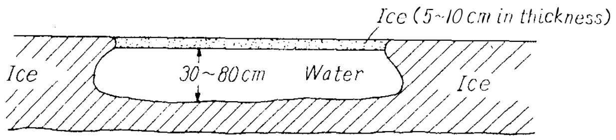


Fig. 1. An example of puddle on the surface of sea-ice.

vi) SASTRUGI From autumn to winter, the snow covering the sea-ice plain was beaten and hardened by the violent storms. Then blizzards came and shaved some parts into very irregular form. This uneven snow plain is generally called "Sastrugi". Sastrugies near the Syowa Base showed many snow edges arranged along the trade wind,

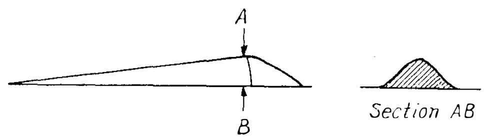


Fig. 2. Schematic profiles of sastrugi (1957).

(See Photo. 16-4 in the "Report of geomorphological and geological studies of the wintering team (1957-58) of the first Japanese Antarctic Research Expedition".)

and between them, the grooves of depth of about 30～80 cm were formed. The Sastrugi was very hard and not easily flattened by the weight of the snow-car, which was given a shock every time it passed over the edge.

vii) CRACK AND RIDGE Here and there on the sea-ice plain, cracks and ridges were formed. Their form and scale varied widely, affected by geographical features, tidal current, tide and glacier which had its origin in the innerland. But in most cases, they could be crossed over on snow cars and sleighs by patiently finding the spot where the ice packs compressed and pushed each other to make the cracks narrower.

viii) POLAR ICE AND CREVICE On the blue-ice covered, polar land slopes, many ripples were formed with wave lengths of 15～25 cm and heights of about 5～10 cm.

Gentle wave-like slopes continued and were formed with gradually rising elevation from sea-shore towards the innerland. In the first expedition, most parts of the blue-ice were found covered with snow, little bare places being left. On the convex parts of the slopes, many open crevices and hidden crevices were always found.

The sleigh was apt to side-slip and bump into the rear of the preceding snow-car when it traversed or descended a slope of blue-ice even when the inclination was less than 3～4 degrees. This forced the authors to prepare slip-prevention metallic edges and brakes for the sleighs although they were unnecessary for the sea-ice plain trip.

3. Snow-cars

3.1. Snow-cars for the first expedition It was planned, at first, to prepare five Japanese snow-cars and two American snow-cars for the transportation of the first JARE. But, as the expected landing course was shortened from 50～100 kms to 20～30 kms, this plan, too, was cut down to utilize only four Japanese snow-cars: "Ginrei" made by the Komatsu Manufacturing Co. after necessary alteration.

Two principal points were attentively observed in the planning of the snow-cars used in the Antarctic field. First of these points was that the car was to be used under very low temperatures of 0°C to −40°C, and the second was that all supply would be cut off in the polar field. The most important problems for the first reqirement were to keep the cold-starting of engines easy, and to prevent the cold-brittleness of carbon-steel under low temperature. For the second requirement, the minimum and necessary reserves had to be prepared to repair the engines in trouble, but at the same time, they could not sacrifice the activity of the party by over-loading.

For the engines under these special uses, the following characteristics were urgently demanded:

a) light weight and high performance
b) durability

c) reliability

d) fire-proofness

Particularly for safety against fire, Diesel engines were believed to be superior to gasoline engines. With these considerations, the authors adopted, for the main electric source of the Base, two sets of model DA 220, 100 V. A. C., 20 KVA, Diesel-electric generators manufactured by the Isuzu Automobile Co. A gasoline engine of one of four snow-cars was replaced by the same type Diesel engine with torque-converter to be the spare engine for the generator at the Base. Actually, in the winter of 1957, one of two generator-Diesel engines at the Base was replaced by an engine that had been mounted on the snow-car.

The numbers and kinds of snow-cars used for the first (1956~1958), second (1957~1958) and for the third (1958~1960) expeditions are listed in Table 1.

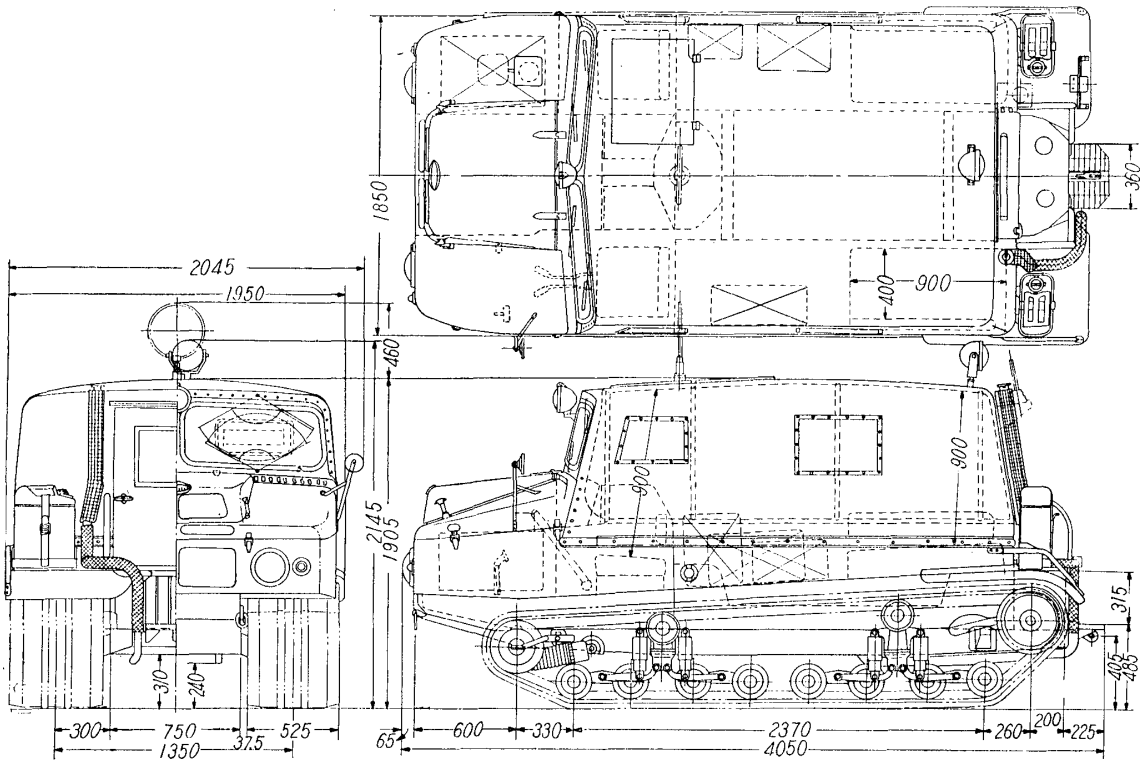


Fig. 3. "Ginrei" KC 20-3 S type snow-car made by Komatsu Manufacturing Co. (The first expedition, 1956/58).

Dimensions—

Total length:	about 4050 mm	Width of caterpillar track:	525 mm
Total width:	〃 1950 mm	Ground contact length:	2370 mm
Total height:	〃 1950 mm	Min. ground clearance:	235 mm
Mean tread:	〃 1350 mm		

Engine— Toyota F type gasoline engine Max. power: 105 HP at 3200 rpm.

Weights—

Weight of car empty:	2680 kg	Number in crew:	4 persons
Gross weight:	2900 kg		

Ground pressure—

Without crew:	0.112 kg/cm^2	With crew:	0.116 kg/cm^2

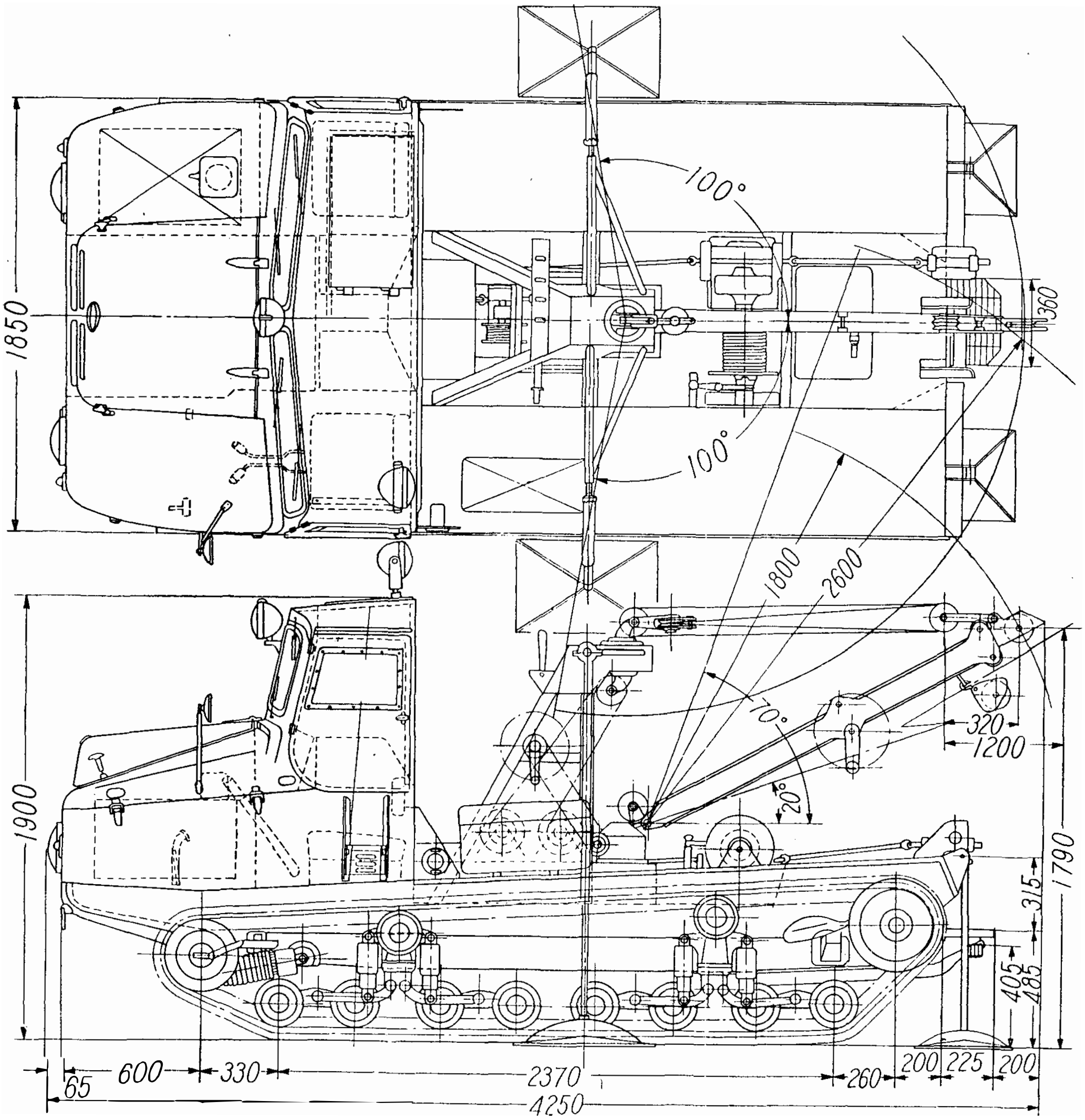


Fig. 4. KC 20-3 R type snow-wrecker made by the Komatsu Manufacturing Co. (The first expedition, 1956/58).

Dimensions—

Total length: about 4100 mm Width of caterpillar: 525 mm

Total width: 〃 1950 mm Ground contact length: 2370 mm

Total height: 〃 1900 mm Min. ground clearance: 235 mm

Mean tread: 〃 1350 mm

Engine— Toyota F type gasoline engine Max. power: 105HP at 3200 rpm.

Weights—

Weight of car without crews: 2770 kg Number in crew: 2

Total weight of car with crews: 2880 kg

Ground pressure—

Without crew: 0.111 kg/cm^2 With crew: 0.116 kg/cm^2

Crane—

Max. load: 460 kg Normal load: 330 kg

Winch—

Tractive force: 2000 kg

Table 1. Number of snow-cars prepared for the JARE.

	The 1 st exped. (1956/57)	The 2 nd exped. (1957/58)	The 3 rd exped. (1958/59)
Gasoline snow-car	2	2	2
Gasoline snow-wrecker	1	0	0
Diesel snow-car	1	5	3

As shown in this Table, the gasoline engines were gradually replaced by high-speed Diesel engines with torque-converters. The maximum speed of the Diesel snow-car was lower than that of the gasoline snow-car, but in the ease of steering and large torque at starting, the Diesel-car far excelled the other.

These merits were mainly brought about by the adoption of a torque-converter combined with selective-shifting type transmission gears, i. e. gears for two-speeds forward and single-speed reverse.

One of three gasoline cars was equipped with a crane, a winch and a power-take-off shaft. The winch mounted on the rear part of car was used effectively in many cases such as pulling up a sleigh from a puddle into which it had fallen.

The cabin was made to be warmed by hot air through the engine radiator. The rear part of the wagon was covered by a detachable canvas awning. The general features of the "Ginrei" are shown in Figs. 3, 4, Photo. 3.

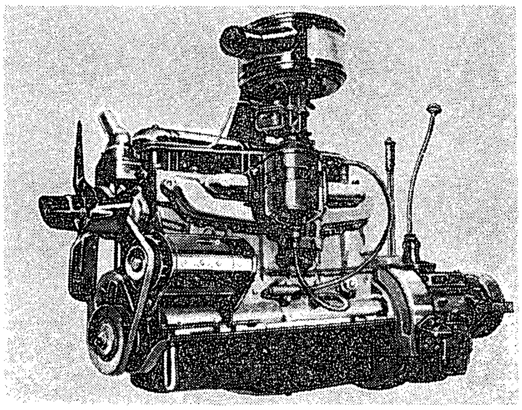


Fig. 5. Toyota F-type gasoline engine prepared for snow-car.

(4 cycle, 6 cylinders, liquid-cooled, bore: 90 mm, stroke: 101.6 mm, total piston displacement: 3878 cc, max. power: 105 IP at 3200 rpm, engine weight: 282kg, specific fuel consumption at full load: 232 gr/IP/h at 2000 rpm., manufactured by the Toyota Automobile Co.)

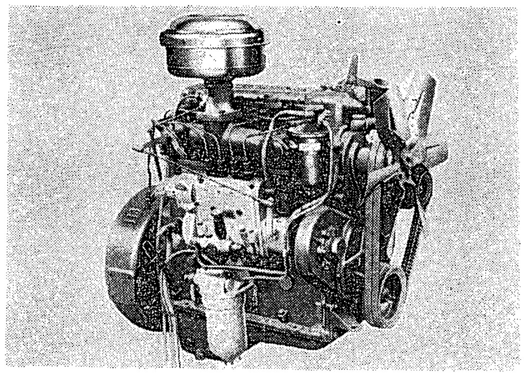


Fig. 6. Isuzu DA 220 type Diesel engine prepared for the snow-car and 20 KVA-electric-generator.

(4 cycle, 4 cylinders, liquid-cooled, bore: 100 mm, stroke: 130 mm, total piston displacement: 4084 cc, max. power: 80 IP/2600 rpm, 50IP/1400 rpm., min. specific fuel consumption at full load: 200 gr/IP/h at 1400 rpm., engine weight: 365 kg)

3. 2. Results of using the snow-cars in the first expedition 3. 2. 1. TROUBLE OCCURRING IN TRANSPORTATION FROM ANCHORING SPOT TO THE SYOWA BASE IN THE FIRST EXPEDITION

a) The snow-cars frequently fell into puddles, and their engines were immersed in the water which brought about the damaging of the electric insulation of the ignition system of the gasoline cars, while the lubricating oil in the crankcase, too, was contaminated by water.

b) Head-lights, radiator and other parts were damaged by collision with ice when the car fell into a puddle.

c) The prepared hook-joints connecting the sleigh to snow-car were deformed or broken. It was most effective to pull a sleigh by two, long, steel wire-ropes.

d) A starter motor was overheated by an imperfect action of the cut-off spring at low temperature.

e) A rubber oil pipe of a torque-converter was broken.

f) Some of the bolts of the caterpillar track and a nut of the caterpillar sprocket fell off.

g) Anti-freezing cooling fluid (water and ethylene-glycol mixture) froze when the ethylene glycol concentration was too weak.

h) Fuel filters and oil filters were choked by slices of ice which filled them to about one half level.

3.2.2. TROUBLES OCCURRING AT THE SYOWA BASE DURING THE FIRST WINTERING PERIOD

a) As the No. 3 snow-car had often fallen into puddles, and, as it was difficult to keep it in good order, its engine was quite dirty and had to be replaced by a new spare engine.

b) The piston pins of the engine of the No. 1 snow-car seized when it was very hard to start on one of the coldest days. Three of the pistons were replaced by new ones.

c) A leakage of oil was found in a receiver-cylinder of brake fluid, but was easily repaired by overhauling.

d) The fine slices of ice contained in the fuel choked the fuel supply and caused the engine to run irregularly.

This trouble was completely prevented by adding 250 cc of alcohol to 45 litres of fuel, at each fuel charge.

e) Slipping of a steering-clutch was observed.

f) The link-rod of a clutch-pedal was broken at its welded part.

g) A metallic oil-pipe for the brake system was broken by fatigue.

Fortunately, however, none of these troubles was fatal to the snow-cars for performing their tasks of transportation and inland travelling.

3.2.3. OTHER EXPERIENCES WITH THE SNOW-CARS IN THE FIRST EXPEDITION

Through one year from January, 1957 to February, 1958, the following results were obtained:

a) The four snow-cars were sufficient for their expected purposes and their records are shown in Table 2.

b) It was very advantageous to adopt the same Diesel engine for both the electric-generators and snow-cars.

c) The Diesel-car was better than the gasoline-car in the following points:

i) The fuel consumption of the Diesel-car (0.72 l/km) was less than that of the gasoline-car (0.93~1.15 l/km).

ii) The same gas-oil could be used for all of the cars, the electric-generators, and the room heating furnaces at the Base.

iii) Besides the easy and safe handling of gas-oil at the Base, it was more desirable than gasoline in its lower vapour pressure and lower inflamability for shipping over the equator from Japan to the Antarctic.

iv) As the Diesel-car did not have an electric ignition system, which was often affected by water, it withstood the puddle troubles better than the gasoline-car.

d) The engine must be water-proofed for resisting puddle troubles. The breather opening should be put on the upper part of the engine to prevent water flowing into it.

e) The positions of the engine radiator, exhaust pipe, and head-lights were too low for protection from damage by collision when the car fell into puddles. It was desirable to put more lights arranged on the roof of the car.

f) Power transmission by torque-converter showed its superiority to that of the gasoline engine without it in starting or running over the irregular snow-plain of the Antarctic.

g) The electric system had to be arranged as simple as possible, and still more reliability was desired.

Table 2. Operation record of snow-cars through the transportation period in the 1 st expedition (from January 24 th to February 15 th, 1957).

No. of snow-car	No. 1	No. 2	No. 3	No. 4
Type of snow-car	Gasoline car	Gasoline car	Gasoline car	Diesel car
Total running distance (km)	1530. 1	1709. 2	1668.2	1096.2
Total time for running (h)	181.10	238.04	245.29	162.11
Total fuel consumption (l)	1420	1770	1914	785
Fuel consumption (l/km)	0.93	1.03	1.15	0.72
Mean speed (km/h)	8.45	7.18	7.10	6.76
Total lubricating oil consumption (l)	45.0	46.6	51.4	29.0
Torque-converter oil consumption (l)	—	—	—	72.0*

* including the new charge for its overhaul.

h) Alarm devices for over-running of the engine and for extreme lowering of oil pressure were not always necessary.

i) The defroster for the front windshield glass was not perfect.

j) It was desirable that the captain in a snow-car could always watch forward by keeping his head or the upper half of his body up through an opening of the roof of the car. And some device was necessary to protect him from falling down in front of the car, which might run over him.

k) The steering-cabin was so narrow that it was difficult for the crews to jump out from the car in an emergency. Most of these inconveniences were eliminated for the cars newly prepared for the second expedition.

l) The winch installed on the rear part of the car was very convenient, and it was desirable to install them on all of the cars for the second expedition. The crane attached to one of the gasoline cars did not work well in the first expedition as its beam had been broken.

m) Joining-hooks of the snow-car and sleigh were damaged soon after the transportation began in the first expedition. These hooks, too, were improved in the second expedition.

n) The cover of thick canvas for the snow-car was very useful. As the car was always placed facing the wind when it rested on its way, the opening of the canvas cover had to be put on the rear side of the car.

o) The car radio was heard very usefully during the time of transportation and loading. But their effective audible range was so short that it was desirable to increase the range for use on long inland trips.

p) As the maximum number of members who rode on a car was about 4 or 5, the rear compartment might have been made narrower.

q) A powerful portable hot-air heater, such as the Hamann Nerson type, which was used successfully for preheating of aero-engines in the first expedition was desirable to be prepared for the snow-cars for the second expedition.

r) It was necessary to prepare spiked caterpillar track shoes for the trips inland.

s) It was necessary that at least one of the cars be always kept ready for starting all through the cold winter, a carhouse was urgently demanded for the second expedition. And, if possible, it was desirable that this carhouse be warmed by the warm air taken from the hot engine room.

3. 3. Snow-cars prepared for the second expedition On April 5 th, 1957, the committee decided to prepare eight Diesel snow-cars for the second expedition. But this plan was again changed at the end of May to prepare five Diesel type snow cars with torque-converters and winches, and two gasoline type snow-cars without them.

Figs. 7, 8 show the views of the new snow-cars, and in Table 3 the details of improvements are indicated, comparing the new type to the old type.

In the beginning of September, 1957, the seven snow-cars were completed. Each one of both Diesel and gasoline cars was cooled down to −40°C for tests in the low-temperature testing room of the Technical Institute of the Transportation Ministry at Mitaka, Tokyo. The cars were road tested over about 200 km from Kawasaki to Yumoto, Hakone. Durability and reliability were confirmed by this road test.

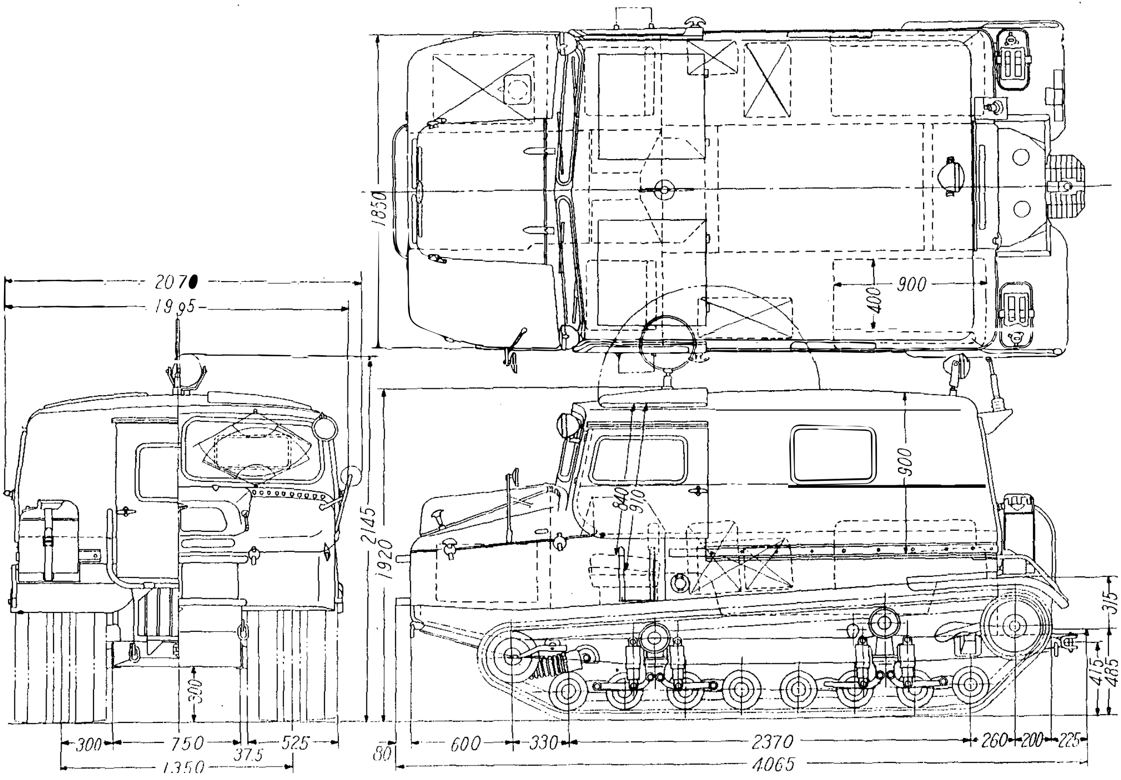


Fig. 7. New KC 20-3 S type "Ginrei" gasoline snow-car made by Komatsu Manufacturing Co. (The second expedition 1957/58).

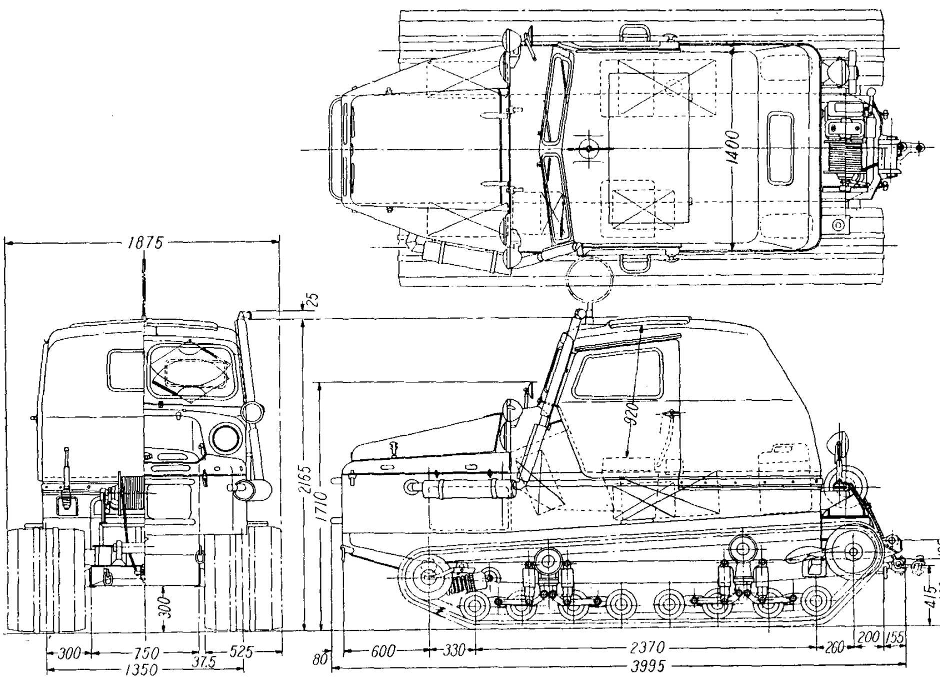


Fig. 8. New KD 20-2T type "Ginrei" Diesel snow-car with torque-converter made by Komatsu Manufacturing Co. (The second expedition, 1957/58).

Table 3. Improvements made in the snow-car prepared for the second expedition.

a) Diesel snow-car

Subject	Part	Purpose	Details of improvement	
			New car (The 2 nd exped.)	Old car (The lst exped.)
Wagon	Wagon	to prevent damage when car falls into puddle	The width of wagon was made narrower than the width between the outside edges of catapillars.	The width of wagon was the same as the outside width of catapillars.
		to make cabin space wider	Cabin was set behind the engine.	Cabin was set beside the engine.
		to separate the window and the bonnet	separation type	one body type
	Door	to make the getting in or out easier	doors provided on each side	A door was installed only on the rear side of the wagon.
	Opening in ceiling	to provide emergency exit for crew	broad opening over the heads of operater and chief	narrow opening over the head of the chief only
	Canvas	for better detectability	orange	O. D. colour
Engine	Oil level gauge hole	to protect engine from water flowing into crankcase	screw-plug type	plug type
	Port for oil filler tube	//	Port was held upward.	standard type
	Dynamo	to make it water-proof	water-proof type, 300 W	standard type, 350 W
Exhaust system	Exhaust pipe	to protect it from damage when the sleigh pushes the car	held upward on the left side and in front of cabin	lead to rear part of the wagon through space under the frame
Fuel system	Position of fuel tank	owing to redesign of cabin	under the steering seat	in the bonnet, on the right side of engine
Torque-converter	Oil-cooler	to protect it from vibration fatigue	air-cooled finned tube type	water-cooled type (bellow)
	Rubber hose	to protect it from thermal deterioration	the use of high-temperature resisting material and wire cover	
Speed changing gears	Gear ratio			
	1 st speed	to make the maximum speed higher	2.44	2.55
	2 nd speed		1.26	1.54
	reverse		1.86	1.58
	top over	to install power-take-off	power-take-off installed	cover attached
Guide ring	Auxiliary rim	to protect the catapillar plate from overloading	With it rime was provided.	without rim
Catapillar	Catapillar plate	to increase its strength	reinforced the hole and grouser	
Frame	Frame	to reinforce frame to ensure its action attaching a winch	with the section of reinforced D type	with the section of simple D type
	Hooks for pulling sleigh		D type	hook type

Subject	Part	Purpose	Details of improvement	
			New car (The 2 nd exped.)	Old car (The 1 st exped.)
	Bottom plate (leading edge)	to protect it from damage when the car fell down into puddle	Plate was thickened to 3.2 mm.	The thickness of plate was 0.8 mm.
Steering	Position of driver	as the cabin was re-designed	right side behind the engine	left side of engine
Instrument	Alarming (lamp-relay)	as it caused many troubles	It was not prepared.	It was prepared.
	Instruments	as the system was changed	12 V type	6 V type
Lamp	Headlamp	to protect it from damage when the car fell into puddle	It was set behind the bonnet.	It was set in front of the bonnet.
	Foglamp	as it was required	2	1
Winch	Winch	to pull up the car fallen into puddle	A winch was mounted on the rear part of snow-car.	It was not prepared except on a wrecker.
		to pull the sleigh from crack or puddle	2 hole type It was connected to hooks for pulling sleigh.	
Others	Fire extinguisher	to make the freezing point lower and to increase its capacity	CH_2, ClBr, 1/4 gallon	Ccl_4, 1/8 gallon

b) Gasoline snow-car

Subject	Part	Purpose	Details of improvement	
			New car (The 2 nd exped.)	Old car (The 1 st exped.)
Cabin	Door	to make it easy to get in and out	on each side of the operater and the chief as well as on the back	only on the rear side
	Opening in ceiling	to make it easy to get out from the car in emergency	two opening prepared over the heads of the operater and the chief	only one opening over the head of the chief
	Canvas	for better detectability	orange	O. D. colour
Engine	Oil-level gauge hole	to protect the engine from the water flowing into the crankcase	position of hole replaced higher	
	Hole for oil filler tube	〃	joined to the block by welding	joined to the block by insertion
Exhaust system	Exhaust pipe	to protect it from damage when the sleigh bumps into rear of the car	held out at the left side from inside of the frame	turned upward at the rear part through space under the frame
Guide ring	Auxiliary rim	(same as Diesel car)		
Catapillar	Catapillar plate	(same as Diesel car)		
Frame	Hooks for pulling sleigh	(same as Diesel car)		
	Bottom plate	(same as Diesel car)		

Subject	Part	Purpose	Details of improvement	
			New car (The 2 nd exped.)	Old car (The 1 st exped.)
	Engine support (front)	to protect it from shock when it falls down into puddle	Plate was thickened to 4.5 mm.	3.2 mm thick
Steering system	Starting lever	to protect the starting motor from over heating	pulling up system	pushing down
Instruments	Alarming (lamp-relay)	(same as Diesel car)		
	instruments	(same as Diesel car)		
Lamp	Headlamp	as it was damaged frequently	taken away	attached in front of the bonnet
	Foglamp	to augment the head lamp	attached on both side of the window	only at the center of the window
Others	Fire-extinguisher	(same as Diesel car)		

3.4. Results of actual use of new-type snow-cars in the second expedition (January~February, 1958) Unfortunately, the Soya could not anchor near the Syowa Base in the second expedition. Therefore, there was scarcely any transportation of cargo by snow-car. But on February 11, 1958, two gasoline snow-cars started from the Soya on a reconnaissance trip for finding a route for transportation across 120 km of ice field to the Syowa Base. Under the guidance of a helicopter, seven members operated these two trains of new-type car and sleigh and arrived at a point 34.6 km from the ship in 18 hours 17 minutes. But, as it was very difficult to find a good route, the men were obliged to abandon this trial and returned to the ship in 5 hours 8 minutes. The following results were obtained during this trip:

a) The seat space was still too narrow even after improvement.

b) The strength of the seats was not sufficient.

c) The door handle was to be improved.

d) It was desired that the electric source for the ice-drill be installed in the car.

e) Spiked-caterpillar track was necessary for climbing slopes of land-ice.

f) In general, the new type snow-car showed its superiority over the older type in reliability and convenience. As a Diesel-car was not used, sufficient data on it was not obtained.

4. Sleighs for transportation

4.1. Sleighs designed for the first expedition From the middle of April, 1957, the designing and manufacturing of the sleighs for the first expedition were begun, and in the beginning of May, each one of the following two types of sleighs was completed and tested in the mountains of Tateyama in the prefecture of Toyama.

a) All-plastic sleigh, glass fiber reinforced polyester sleigh designed and manufactured by the Honda Giken Kogyo Co.

b) Wooden sleigh (designed and manufactured by the Yokohama Yacht Co.)

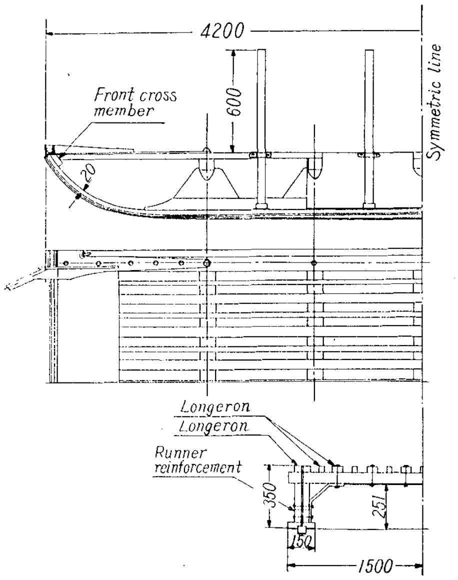


Fig. 9 (a). Wooden sleigh prepared for the first expedition (made by Yokohama Yacht Co. in 1956).

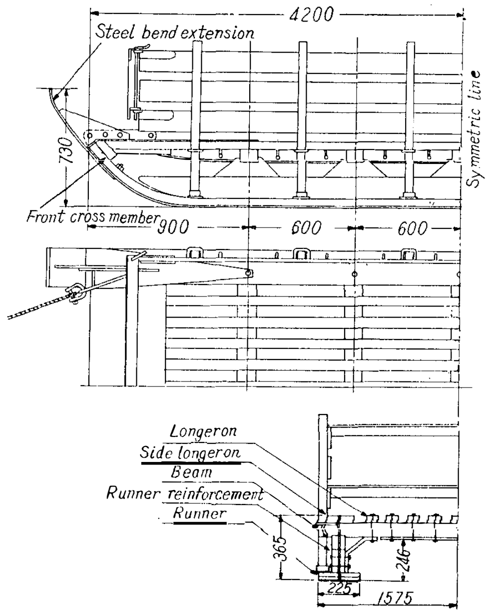


Fig. 9 (b). Improved wooden sleigh prepared for the second & third expeditions (made by Yokohama Yacht Co. in 1957).

The specifications and main features of these sleighs are shown in Table 4.

Table 4. Snow sleighs and snow boat.

Kind of sleigh / Items	Wooden sleighs prepared for testing	Wooden sleighs prepared for the 1st exped.	Wooden sleighs prepared for the 2nd and 3rd expeds.	All-plastic sleighs (caboose)	All-plastic sleighs (big snow boat)
Maker (year)	Yokohama Yacht (1956)	Yokohama Yacht (1956)	Yokohama Yacht (1957)	Honda Giken Kogyo (1956)	Honda Giken Kogyo (1957)
No. of sleighs	2	16	18	2	2
Total length (mm)	4200	4200	4200	4000	4000
Width (mm)	1500	1500	1575	1500	1596
Height of floor (mm)	350	350	365		(600)
Width of sliding plane (mm)	150×2	150×2	225×2	150×2	1200
Weight					
weight of chassis only (kg)	191 (173)	260 (230)	437		
total weight (kg)	208 (182)	313 (282)	628		250
Runner	2.1 mm, steel plate (a) (3 mm celluloide plate) (b)	4.5mm, steel plate (c) (stepped type) (d)	4.5 mm, steel plate (e)		1200×700 (f)
Pay load (kg)	2000	2000	2000		1500

(The form of runner is shown in Fig. 13)

The former was the first all-plastic-sleigh made in this country. It was afterward made into a new caboose style snow sled (cabin sleigh) as shown in Photo. 5, two of which were actually used in the Antarctic snow field.

As will be stated later, about 500 drums (100 metric tons) of gas-oil occupied the main part of the cargo, the total weight of which was 400 metric tons. All these drums had to be transported by sleighs pulled by snow-cars from the anchoring point to the Base. For this purpose, the dimensions of each sleigh were decided to be 4 m in length and 1.5 m in width; the pay load was 2 metric tons which can carry 10 drums.

The sleigh had to be designed to have sufficient strenth for the assumed loads as shown in Fig. 10, and to keep its torsional rigidity as low as possible, and its weight as light as possible.

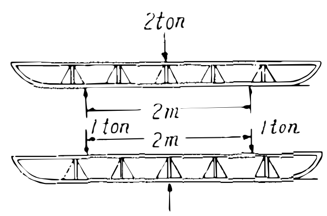


Fig. 10. Assumed load-distribution in the designing of sleighs.

When a snow-car pulling a loaded sleigh descended a slope, the sleigh occasionally skidded and clashed against the rear end of the snow-car. To eliminate this difficulty, a special brake was devised which could brake the sleigh automatically when the tractive force became zero or negative.

On May 22 and 23 of 1957, experiments on sleighs were conducted in Tateyama. The results were as follows:

a) Ascending, traversing and descending test, without and with loads of 1 ton and 2 tons, were carried out on slopes of 10°, 15°, 20°, and 25°.

The purposes of these experiments were, first, to determine to what degree of slope a snow-car pulling two sleighs loaded with 4 tons of cargo was able to go up and, secondly, to see whether or not side slip would occur in traversing a slope.

As shown in Fig. 11, in the all-plastic sleigh, anti-slipping pieces of a ⌐¬ form section of length 1000 mm × height 25 mm were attached to its sliding surfaces. To the wooden sleigh, anti-slipping pieces of smaller size were attached. As the result of experiments it was confirmed that these anti-slipping pieces were very effective for side-slip on slopes below 20°. But on a slope of 25°, a remarkable side-slip occurred, but no danger followed.

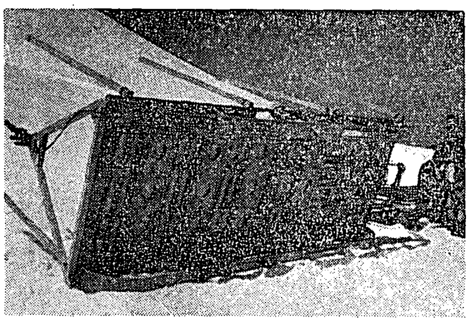


Fig. 11. Automatic brake and anti-side-slipping pieces (for the all-plastic sleigh prepared by Honda Giken Kogyo Co.).

b) Brake test

The brake test was conducted only for a plastic-sleigh, the first brake utilized solid friction, i. e., it braked the sleigh only when the sleigh pushed the snow-car forward with a force exceeding the solid friction resistance between the brake operating bar and the spring-loaded pads. In the experiment, when a snow-car and sleigh train descended a steep slope, the brake did not act in time, and the nose of the sleigh rammed against the rear part of the snow-car, pushing it sidewards and causing damage to the coupling of car and sleigh. Therefore, this brake was changed to another in which the use of solid-friction was not adopted.

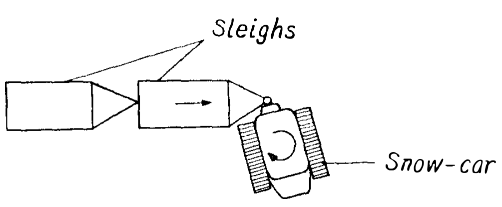


Fig. 12. The sleighs pushed the rear part of snow-car and turned it sideways and damaged its coupling joints.

c) Materials for runner sliding surfaces

For the sliding surface of a sleigh, three materials were compared, i.e., polyester, celluloid and steel plate. The sleighs with these sliding surfaces were left outdoors during one night on the snow. They were pulled by a snow-car, and the force necessary for starting was measured by a traction-force-meter. The measured force was greatest in the case of the sleigh with steel plates, and the coefficient of static friction was 1.3 at an air temperature of 0°C. The coefficient of static friction of polyester plates was 0.4, and that of celluloid plates came out still smaller but accurate values could not be measured.

As the results of starting tests after the sleighs had been kept outdoors for a time, the coefficients of static friction were 0.23, 0.20, and 0.10, respectively. The coefficients of friction in running condition were 0.13, 0.11, and 0.09, respectively. It was remarkable that the coefficient of static friction of steel plate, after it had been left outdoors for a long time, was very large, especially on the snow at low temperature. In this respect, the celluloid plates were the best of all, but it was considered to be easily broken or worn out when it ran over rock fields of the Antarctic. Therefore, the stepped type celluloid sliding surface as shown in the Fig. 13 (d) was utilized for half of the sliding plane of the runner, and the steel plate for the central part of the runner.

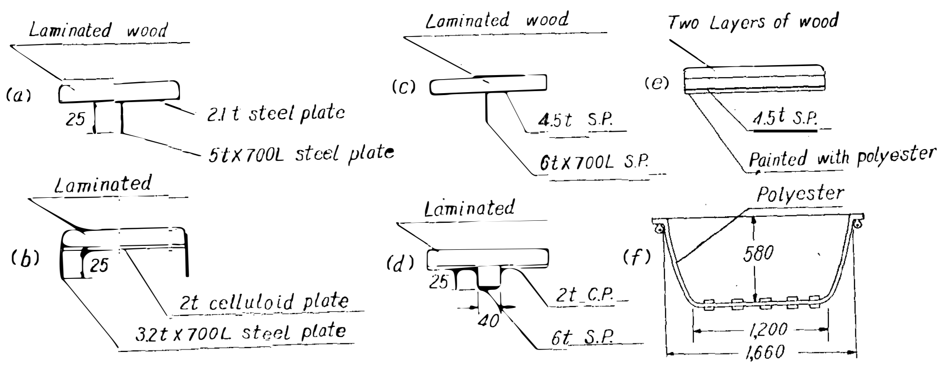


Fig. 13. Sliding plane of runner of snow sleighs (see Table 4).

d) Bending and torsional test

By means of a ditch 50 cm deep and 2 m long, bending and torsional loads of 2 metric tons were applied to the sleigh. The twisted angle between the leading and the trailing edge of the sleigh reached about 12°, but no damage was observed. On the other hand, it was understood that the gaps of wooden floor plates of the sleigh had to be made narrower than the breadth of man's foot, and the surface of the floor to be finished rough, so as to prevent slipping. As a result of these experiments, it was decided to use 8 wooden sleighs for transportation and 2 all-plastic cabooses for observation in the first expedition.

4. 2. **Results of practical use of the sleigh in the Antarctic snow field in the first expedition** As stated before, the puddles caused great difficulties to the sleighs, and damaged some of them. The results are summarized as follows:

a) In general the sleigh was somewhat weak; especially the front bend of the runner and the front cross-member were frequently broken when the sleigh fell down into a puddle. It was desirable to reinforce it to give more strength.

b) As to the sliding surface of the runner, the steel plate without joint was the best; the celluloid plate was soon stripped off. The steel plate with joint, too, was stripped off at the joint.

c) The anti-side-slipping piece of the runner was not necessary for transportation from the Soya to the Base, and, as it damaged the bridges built over the puddles, it was removed. But for the trips inland, where the sleighs had to go along sloping hills, the anti-side-slipping piece was found necessary.

d) It was the same also for the brakes. Although they were necessary for the inland trips, they, especially the automatic type brake, were not necessary for the transportation of the cargo.

e) As to the connecting joints between the snow-car and the sleigh, two long steel ropes of 16 mm, or at least of 14 mm in diameter, were the best. Shackles and eye-rings were both necessary.

f) The metal fittings for attaching the side panel supports to each side of the sleigh were found to be too weak.

The method of lashing cargo had to be improved; the side panels had to be prepared around the sleigh for the transportation of cargo of small size to prevent their falling off.

g) The hooks of the pintle-hook were frozen or became rusty.

4. 3. **Sleigh prepared for the second and third expeditions (1957/1958 and 1958/1959)** Although the sleighs prepared for the first expedition somehow completed the transportation of most of the cargoes of 400 tons from the Soya to the Syowa Base during January to February, 1957, they were somewhat weak and they did not have to be constructed so lightly. So improved sleighs of a new type were prepared for the second expedition by the Yokohama Yacht Co. The main features of the new type sleigh are shown in Figs. 9 b), 14, 15 and Table 4. The points of improvement are:

a) All parts of the sleigh were reinforced.

b) Steel extension bends were attached to each end of the sleigh, and by the aid of these bends, the sleigh could easily run over a puddle of about 50 cm depth without any aid. At the same time, these extensions acted as bumpers when the

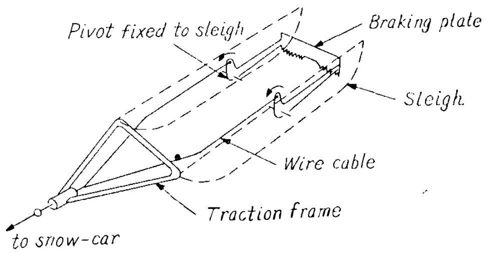


Fig. 14. (a) Principle of the automatic brake prepared for the wooden sleighs (manufactured by Yokohama Yacht Co.).

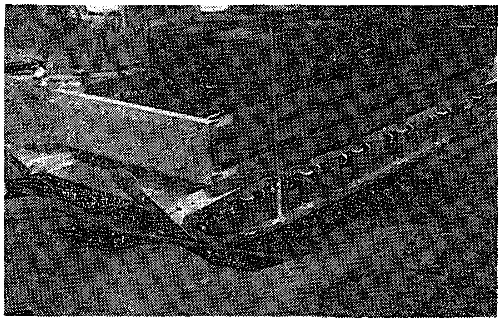


Fig. 15. Improved wooden sleigh with steel extension bends and hand-brakes (tested at Katsuta, Ibaraki on June 29, 1957).

sleigh collided against the pulling snow-car or other objects.

c) The connecting joint of snow-car and sleigh, the tow-ropes, the detachable wooden side-panels, the floors and other parts were improved or installed newly.

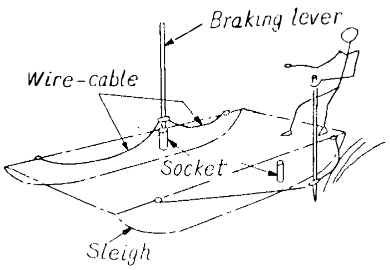


Fig. 16. Hand-brakes for sleigh.

d) As for the brake, only hand brakes, and no automatic ones, were prepared; they were of the same type as those used in the first expedition.

e) The weight of the sleigh was about 628 kg, about 3 times as heavy as that prepared for the first expedition.

This new type sleigh and the older type one were experimentally compared at Katsuta, in Ibaraki Prefecture on June 29, 1957. By this test on the soil ground, the new type sleigh was proved superior to the older one, and for the second and third expeditions, this new type was adopted.

4. 4. **Results of practical use of the new type sleigh in the second expedition (Feb. 9, 10, 1958)** As stated in the article on the snow-car, two of the sleighs ran 69.2 km on the hard field. The results were:

a) The new type sleigh was excellent.

b) It was desirable to attach chains some place on the runner to resist slipping.

5. Boats

5. 1. **Rubber boats prepared for the first expedition** As shown in article 1, knowledge of the field conditions in the Antarctic could not be obtained in 1956. Therefore, collapsible rubber boats and wooden landing stages for sailing across broad cracks were prepared. The rubber boat could be inflated in only a few minutes by a bellows type air compressor. The size of the boat was 2 m in beam and 6.18 m in length. Three boats joined side by side by ropes and wooden planks formed a ferryboat on which could be carried a snow-car or a sleigh. Two sets of this ferryboat were presented by the Mitsubishi Denki Co.

When a crack was narrow, the boats were floated in a line to form a floating bridge. The wooden landing stages were manufactured by the Delta Zōsen Co.

Besides these rubber boats for cracks, two rubber boats for reconnoitering the sea were prepared. This type of boat could carry four men and was propelled by a two-cycle, 15 hp. out-board gasoline engine which was prepared by the Kokusai Kyōtei Co.

5. 2. The results of practical use in the first expedition The rubber boats and their accessories were not used at all in the first expedition for their original purposes. But one of them was used for boating excursions in the beginning of 1958 at the Base. By this experience, it was learned that the part of rubber boat near the water line had to be protected from damage by the sharp edges of ice covering the open-sea.

The wooden landing stages made by the Delta Zōsen Co. were used for other purposes, e. g., to make bridges across the puddles, or to be used as material to build the Base. The same rubber boats were shipped for the second and third expeditions after being supplied with their wooden landing stages.

5. 3. The all-plastic boat prepared for the second and third expeditions Mr. M. MURAYAMA, the sub-commander of the second and third expedition teams, requested the preparation of a sort of boat-type sleigh which was used by the French team in the Antarctic and about which he learned in Paris in 1957. To satisfy this requirement, an all-plastic (polyester) big snow-boat

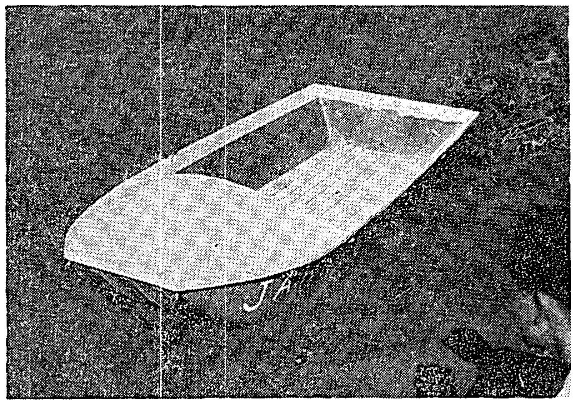


Fig. 17 (a). All-plastic snow-boat sleigh (prepared and presented by Honda Giken Kogyo Co., materials: glass fiber reinforced polyester).

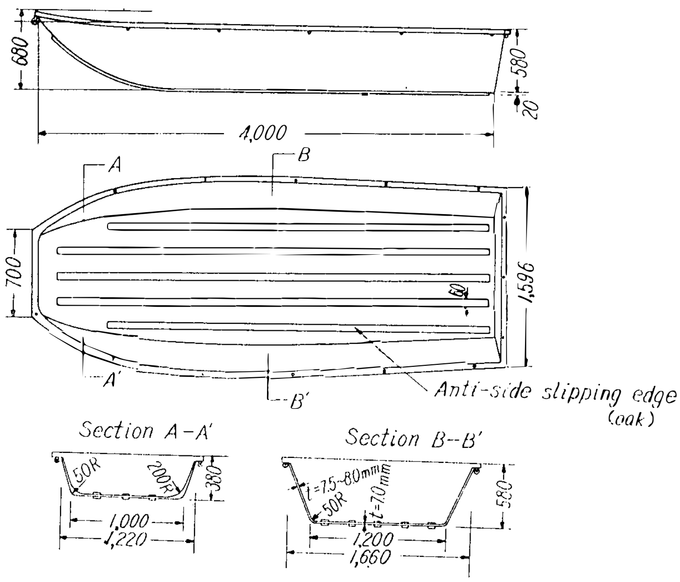


Fig. 17 (b). Outline of snow-boat sleigh.

reinforced by glass-fiber as shown in Fig. 17 (a), (b) was manufactured and presented by the Honda Giken Kogyo Co. The size of the boat was 1.596 m in beam 4.0 m in length and 0.6 m in depth; its weight was only 250 kg. It could be used as a boat as well as a sleigh.

6. Loading machines and tractors

6.1. Loading machines prepared for the first expedition (1956/1958) The loading machines were prepared to be used in the following cases;

a) Loading of cargo on and off the sleigh.
b) Passing a snow-car or sleigh across a crack or crevice.
c) Pulling a snow-car sleigh up steep slopes.
d) Hoisting up an engine or other equipment in the Base.

For these purposes, the following loading equipment were prepared as shown in Table I in the appendix.

a) A small type crane mounted on one of the snow-cars
b) A winch installed on the rear part of a snow-car
c) Steel tripods for lifting cargo
d) Steel pulleys
e) Chain-blocks
f) Lever-blocks
g) Shackles
h) Hooks
i) Ropes
j) Wooden landing stages

a) and b) were manufactured by the Komatsu Manufacturing Co., from d) to i) by the Kittō Manufacturing Co, and j) by the Delta Zōsen Co.

These pieces of equipment were tested in a low-temperature testing room down to $-40°C$ in the summer of 1956, and their reliability was assured.

Fig. 18. Steel tripod and chain-block lifting up a gasoline engine at the Syowa Base.

6.2. The results of practical use in the first expedition a) THE CRANE On account of some trouble in the machine it was not used at all, but it would have been useful in many ways, especially at the Base.

b) THE WINCH This was used very effectively for pulling up snow-cars from puddles and for other purposes.

c) STEEL TRIPODS These were very useful and necessary implements for the life at the Base.

d) CHAIN-BLOCKS, LEVER-BLOCKS These worked very effectively. The lever-block was useful for lashing cargoes to sleighs.

e) ROPES The steel wire-ropes prepared were 12 mm in diameter, so it was desirable to prepare ropes of 14~16 mm. A rope of 5~10 m length with loops on each end was very useful and convenient. Ropes of about 100 m length also had to be prepared.

f) KITO-CLIPS These were used very effectively.

g) WIRE-CLIPS, PULLEYS, TURN-BUCKLES, I-BEAM CHUCKERS, DRUM-LIFTS These were scarcely used.

h) STAY-ANCHOR PIPES AND ANGLES Their tips had to be heat treated and hardened for drilling easily into hard ice or snow.

6. 3. Loading machines and equipment for crossing over puddles prepared for the second and third expeditions (1957/1959) By the experience of the first expedition, it was realized that the equipment and loading machines prepared for the first expedition were very effective and suitable for use in the Antarctic, but they had to be increased in number.

a) CRANE It was not prepared.

b) WINCH It was installed on the rear part of each of the Diesel snow-cars.

c) CHAIN-BLOCKS, LEVER-BLOCKS, HOOKS, TRIPODS, ROPES AND KITO-CLIPS The same kind as used in the first expedition was prepared in each case by the Kito Manufacturing Co..

d) SPECIFIC METALLIC FITTINGS AND STEEL ROPES To simplify the work of lashing cargo, and to shorten the working hours, special metallic fittings were attached to the sleigh, and the steel ropes combined with lever-blocks were used to fix the cargo tightly to the sleigh.

e) ROLLER CONVEYER To carry the cargoes away as fast as possible when they were unloaded from the Soya on the fast-ice, roller conveyers were adopted. Thirty conveyers of 3 m length, of the NE-125 type of the Sanki-Kogyo Co., slightly improved, were prepared. Their features are shown in Figs. 19, 20. The weight of a roller conveyer was only 32 kg, being possible to be carried by one man.

f) TRACTOR AND TRAILER To transport the cargoes from the edge of the fast-ice to the Base on the rock zone, a Diesel-tractor was prepared for the second and third expeditions. As it was required to use the same type of Diesel engine as the Isuzu

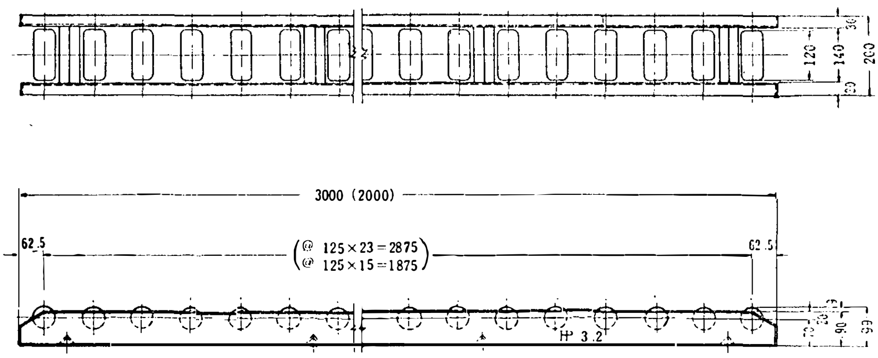


Fig. 19. NE-125 type roller conveyer.

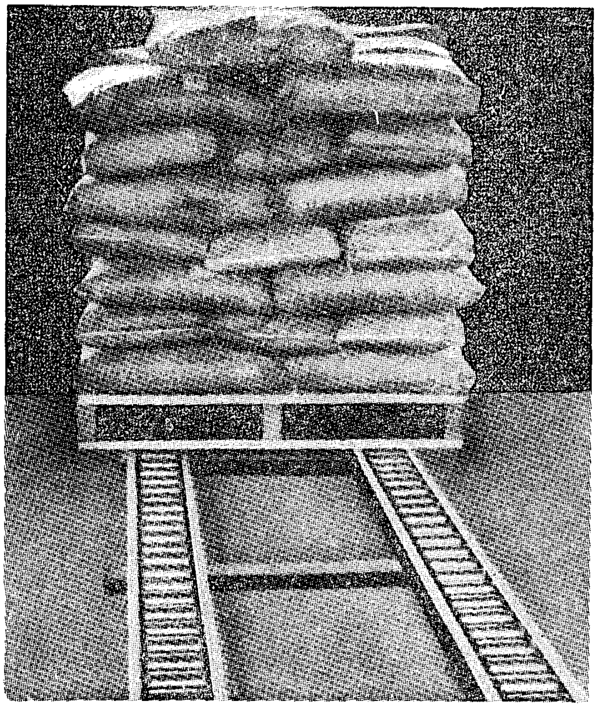


Fig. 20. Roller conveyer (prepared by Sanki-Kogyo Co.).

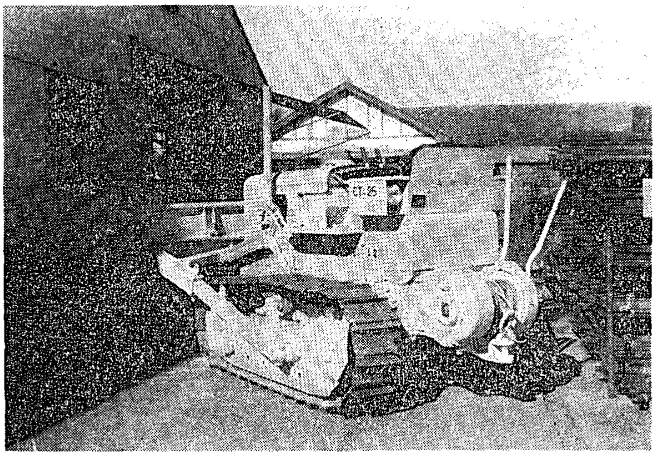


Fig. 21. Diesel-tractor CT-25 A type with angle-blades (prepared by Iwate Fuji Sangyo Co.).

Total length :	3350 mm	Total weight :	3350 kg
Total width :	2157 mm	Ground pressure :	0.35 kg/cm^2
Total height :	1515 mm		
Total weight :	3350 kg		

Performance——	speed (km/h)	tractive force (kg)
1 st speed :	3.16	3250
2 nd speed :	4.73	2200
3 rd speed :	10.40	990
Reverse :	4.20	2400

Engine—— Isuzu DA-220 type Diesel, 48 Ps at 1800 rpm.

Angle dozer——

Width of blade :	2157 mm
Height of blade :	600 mm
Hydraulic control type :	335 kg

DA-220 Diesel engine, the angle dozer Model CF-25 A of the Iwate Fuji Co. was adopted after necessary alteration. The engine was changed to Isuzu DA-220 from its original DA-78, and the forks for lift were prepared for attachment to the tractor in the place of the blade of the angle dozer if desired.

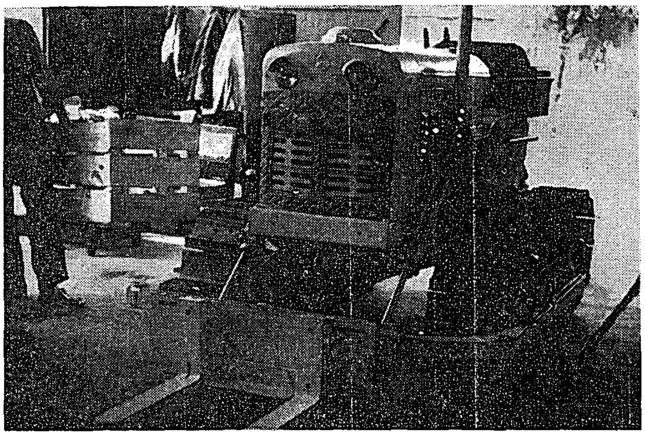


Fig. 22. Diesel tractor CT-25 A type with loader forks (capacity: 800 kg at 400 mm of lift. Made by Iwate Fuji Sangyo Co.).

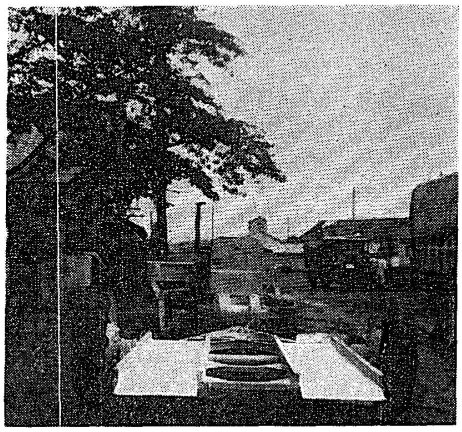


Fig. 23. Trailer (prepared by Fuji Sangyo Co.)

The semi-trailer, as shown in Figs. 23, 24 was prepared. On this, a sleigh loaded with cargo could be carried bodily as shown in Fig. 25.

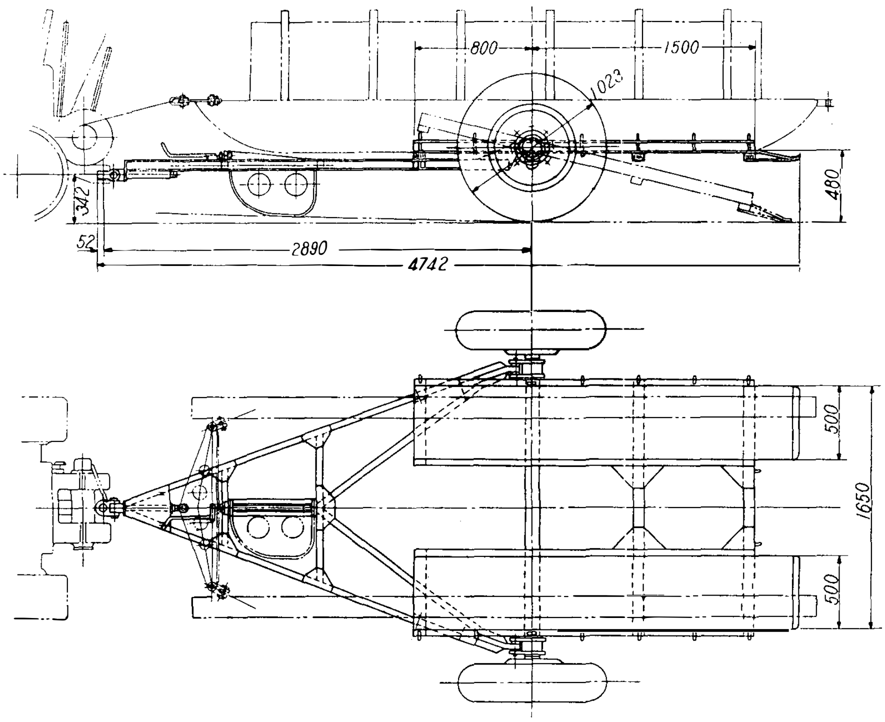
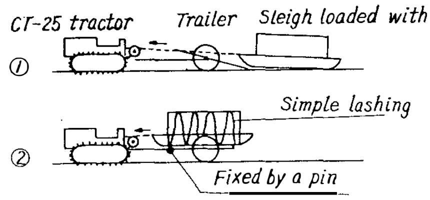
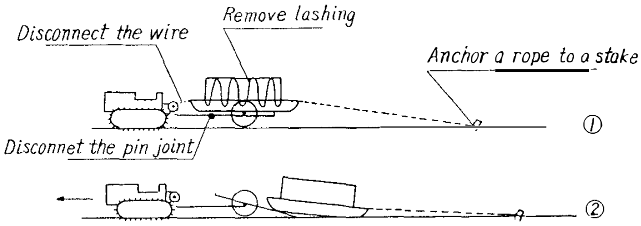


Fig. 24. Trailer for transporting a loaded sleigh on the rock zone.

After the tractor and the trailer had transported all of the sleighs with cargo on them from the shore to the base-hut on the rock, then they could be used as a fork-lift or as an angle dozer.



(a) Process of pulling-up the sleigh onto the trailer by winch.



(b) Process of unloading a sleigh from a trailer.

Fig. 25. Processes of loading and unloading trailer.

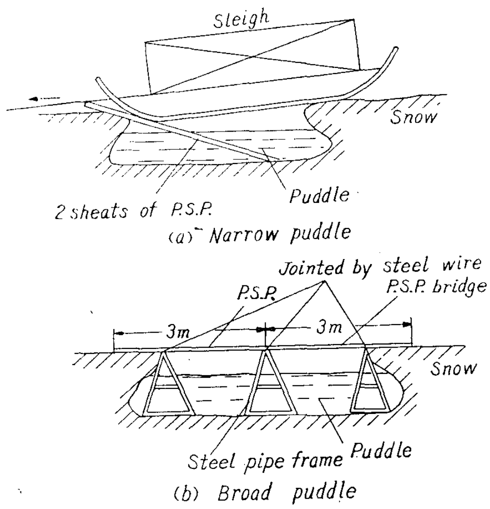


Fig. 26. P.S.P. to be used for puddle.

g) PUNCHED STEEL PLATE (P. S. P.) From the experiments at Katsuta in July, 1957, it was learned that P. S. P. of about 3 m in length was very effective for sliding the sleigh over a puddle safely. The P. S. P., set in a puddle as shown in Fig. 26, prevented the falling of the sleigh into the puddle. As shown in Fig. 26, the P. S. plates only, or the ones combined with simple legs of steel pipe, could be used as a steel plate bridge, which could be easily built up in short time. Therefore, 400 sheets of P. S. P. were prepared. On one hand, the civil engineering committee prepared the girder sets ready for building up a bridge, i.e., the 15 sets of 5 m span and the 4 sets of 10 m span

6. 4. The results of practical use in the second expedition a) The roller-conveyer was used very effectively. An increase in number to about 50 sets was desired.

b) Punched steel plates were very effective, for example, to prevent the slipping of the caterpillar tracks of a snow-car when it was pulling up another stalled snow-car from deep snow. P. S. P. was used as a bridge over the pressure ridge of an ice crack. Thus, four bridges of P. S. P. were built during a scouting trip of 346 km.

7. Electric generators

7. 1. Electric generators prepared for the first expedition As the main electric source in the Syowa Base, 2 sets of 20 KVA (100 V, 3ϕ, 50 cycle) Diesel electric generators were prepared. The engine was that of the Isuzu DA-220 type, high speed, 4-cycle, liquid cooled Diesel engine (manufactured by the Isuzu Automobile Co., Tokyo) and was coupled with an A. C. generator made by Meidensha, Tokyo (Fig. 27).

As half of the total electric power in the Syowa Base was consumed in the form

Photo. 1. The snow-car fallen in the puddle (Feb. 6, 1957).

Photo. 2. Snow-car with sleigh (the first expedition, Feb. 1957).

Photo. 3. Gasoline type snow-wrecker (prepared by the Komatsu Manufacturing Co. for the first expedition).

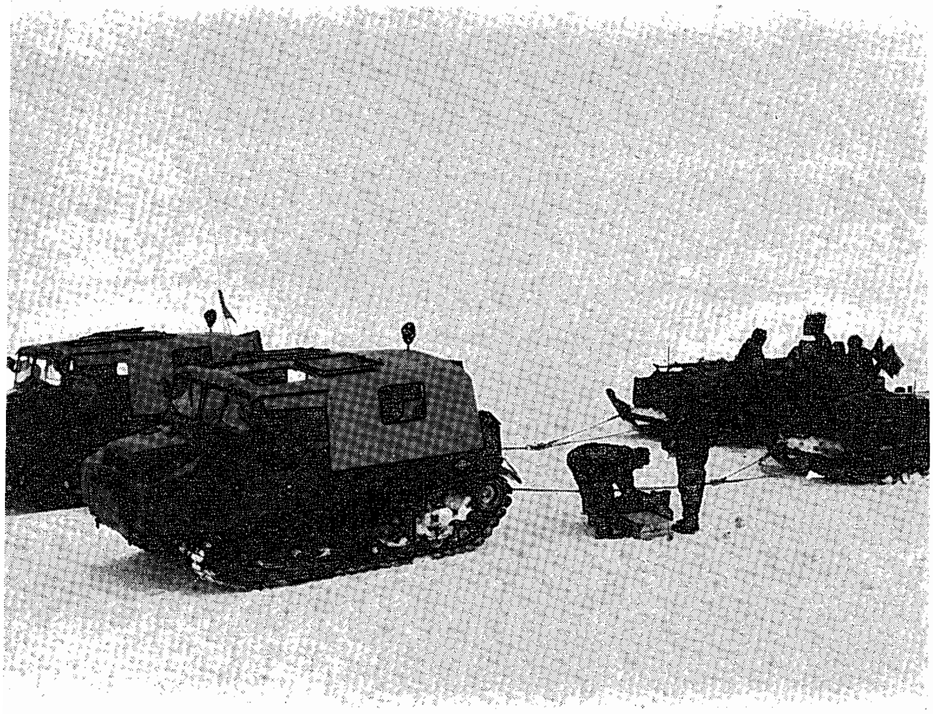


Photo. 4. New type (KC 20-3S) gasoline snow-cars and sleighs prepared for the second expedition.

Photo. 5. The all-plastic caboose in Antarctic field (prepared and presented by Honda Giken Kōgyō Co.). The upper half of its chimney was not attached in this photograph.

Photo. 6. Three rubber boats carrying a snow-car under testing at Tamagawa River, Tokyo, in the summer of 1956 (manufactured and presented by Mitsubishi Denki Co.).

Photo. 7. The collapsible rubber boat was used only for boating excursions in the Antarctic in 1958.

Total length : 6.180 m
Total beam : 1.680 m
Dia. of air-chamber : 0.560 m
Weight : 85 kg
Collapsed volume : 0.6×0.6×1.5 m

Photo. 8. P.S.P. used as a bridge over a crack in the second expedition (Feb. 1958).

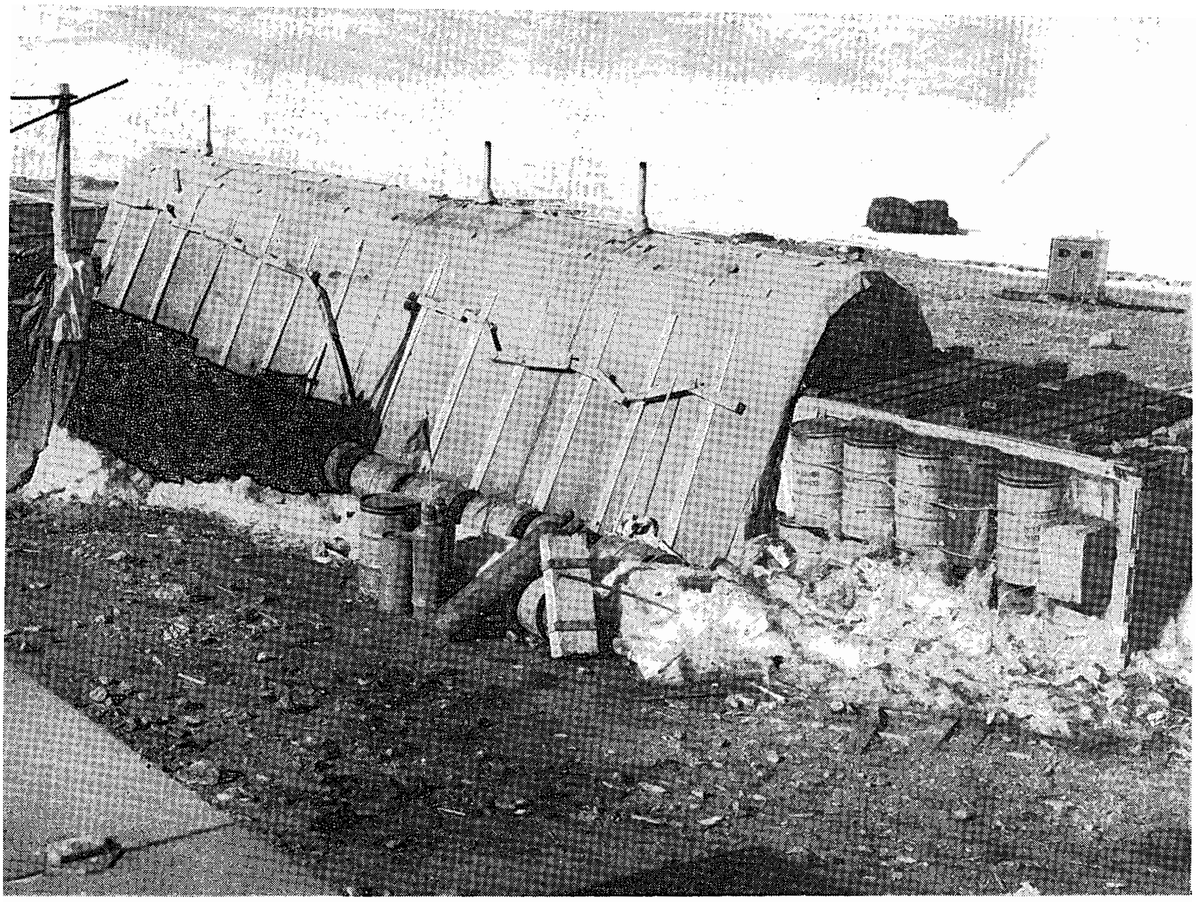


Photo. 9. Outside view of engine room at the Syowa Base.

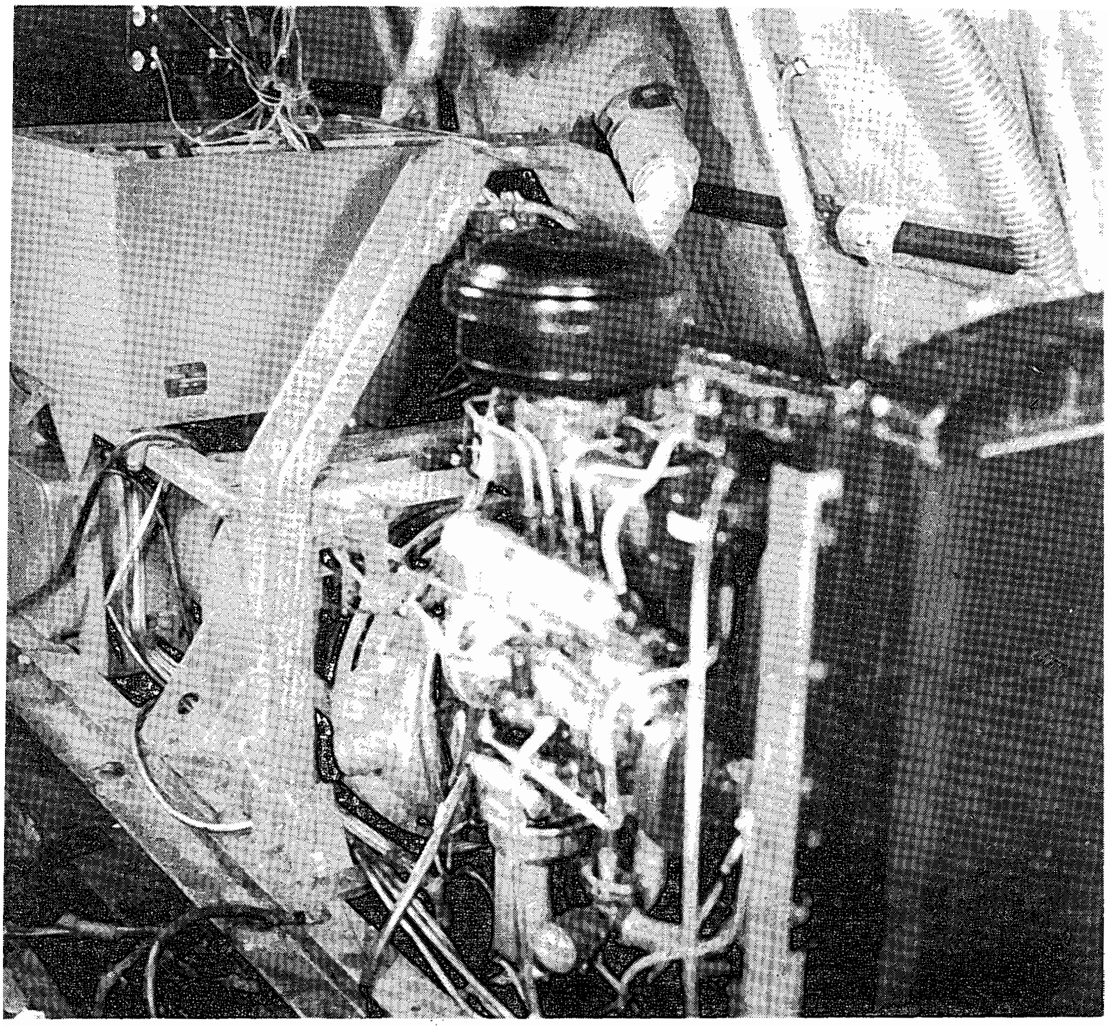
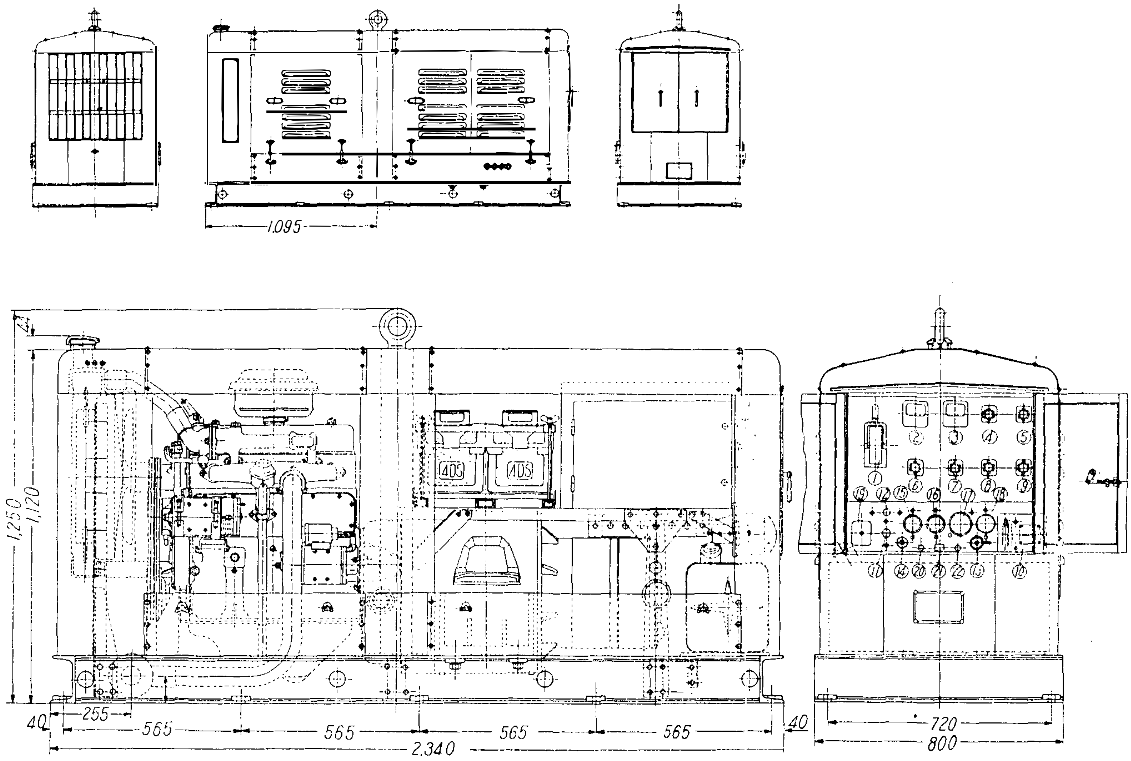


Photo. 10. Inside view of engine room and a 20 KVA Diesel electric generator.

of 200 V and 3-phase, and the other half at 100 V and single-phase, the choice of the kind of voltage and phase was a problem. At first, it was decided to adopt 10 V and 3-phase for the following reasons.



Engine:	Isuzu DA-220 Diesel engine
Piston Displacement:	4084 cc
Alternator:	Meidensha AF
Output:	20 KVA
Phase:	3
Cycle:	50 CPS
Voltage:	100 Volt
Current:	115 AMP
Revolution:	1,500 RPM

1	Main switch	12	Control resistance
2	Voltmeter	13	Fuel control button
3	Ammeter	14	Timing control button
4	Ammeter switch	15	Oil pressure gauge
5	Change over switch	16	Water thermometer
6	Alternator rheostat	17	Engine tachometer
7	Field switch	18	D. C. ammeter
8	Exciter rheostat	19	Fuse box
9	Resistor for A. V. R.	20	Panel lamp switch
10	Engine main switch	21	Alarm lamp
11	Starter button	22	Alarm switch

Fig. 27. 20 KVA Diesel electric generator as the main electric source of the Syowa Base (prepared by Isuzu Auto. Co. & Meidensha for the first expedition).

1) 100 V is safer with respect to electric shock and electric leakage.
2) Single-phase was more desirable than 3-phase from the point of view of

load balance between lines. Therefore, the combination of 100 V and single-phase was favoured, but this was changed to the combination of 100 V and 3-phase on the strong request of the radio team.

The engine room was separated from the other huts to protect the members from the engine noise and vibration. And as will be stated later, water making equipment and a bathtub were installed in the same engine room to use the exhaust energy of the Diesel engines of the electric generators. This Diesel engine could run continuously for about 3,000 hours without any overhaul, so power could be obtained for about 8 months, by running the 2 sets of the generators alternately, without overhauling. From this it was plain that one or two engines had to be overhauled in a year. As the spare engine, the one used as the prime-mover of a Diesel snow-car was prepared, and with it, a set of engine parts was prepared for replacement of damaged parts. For emergency use, a Yammar K-6 type, 3KVA Diesel electric generator (100 V, 3ϕ) was presented by the Yammar Diesel Co. (Fig. 28).

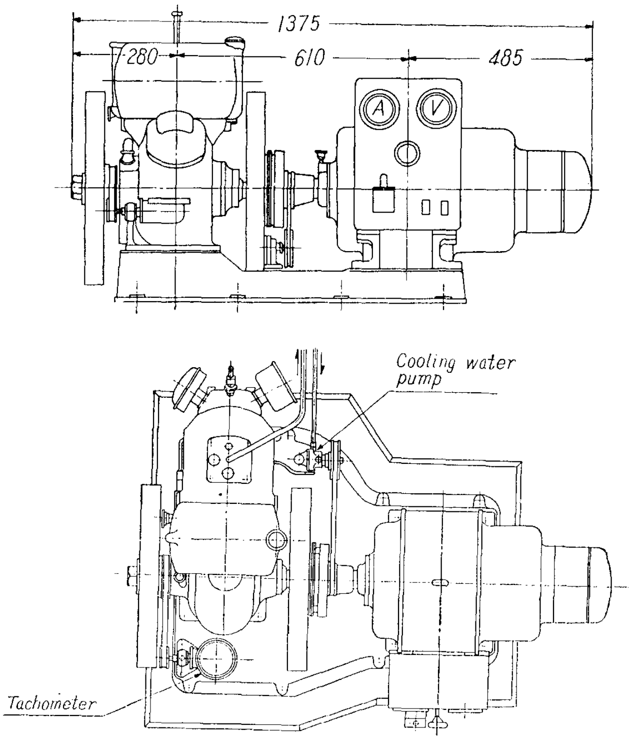


Fig. 28. Yammar K-6 type, 3 KVA Diesel electric generator (100 V, 3ϕ) (presented by Yammar Diesel Co.).

7.2. The results of practical use in the Syowa Base The 2 sets of 20 KVA, main Diesel electric generators ran alternately 16 hours in a day, and they kept stopped the remaining 8 hours at night to save fuel.

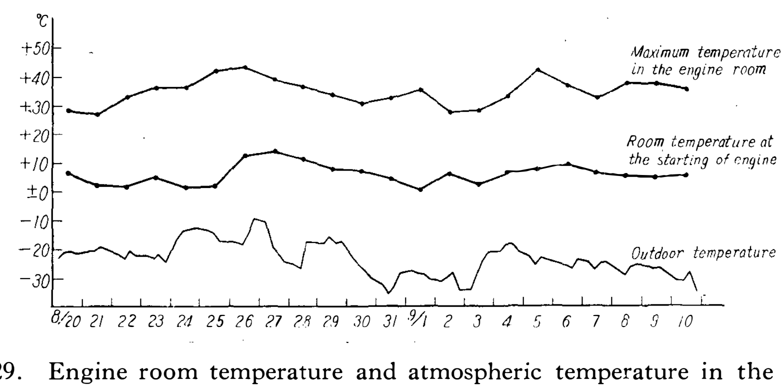
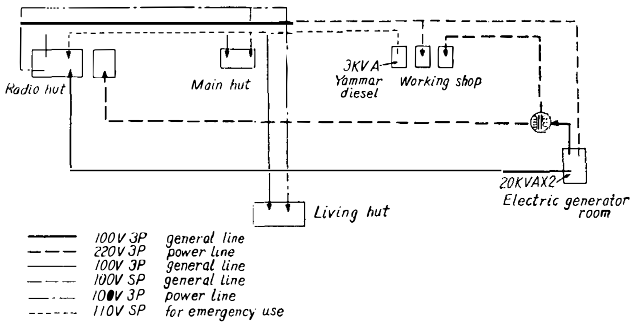


Fig. 29. Engine room temperature and atmospheric temperature in the winter at the Syowa Base (Aug. 20th to Oct. 10th, 1957).
Room temperature was measured at 1.2 m above floor.

When an engine was running, the engine room temperature was so high that it seldom went down below 0°C, even in the morning after the engine had been stopped for 8 hours (Fig. 29). Accordingly, the men did not experience any difficulty in the starting of the engine. The capacity of one generator was sufficient to keep the life of 11 members comfortable throughout one year at the Syowa Base. Except in the time of peak-load in the evening, 9KVA of electric power was supplied to the three 3 KVA electric room heaters to save on the total fuel consumption. These heaters were installed in the upper part of the oil-heater prepared for service as the warm-air heating furnace for the three living huts (Fig. 30).



1) This figure shows the electric feeding lines from the engine room to other huts.
2) Beside these main lines, many lines such as for telephone, fire-alarm equipment and etc., connected huts to each other.

Fig. 30. Electric supply lines at the Syowa Base. (July 5th, 1957).

Table 5. Total running time and fuel and oil consumption of Diesel electric generators (20 KVA × 2) through year at the Syowa Base.

Subjects	No. 1 Diesel electric generator	No. 2 Diesel electric generator
Total running time	2162 h 55 mns	3380 h 25 mns
Total sum of running time	5543 h 20 mns	
Total fuel consumption (l) Fuel consumption (l/h)	26968 (about 135 drums) 4.86	
Total lubricating oil consumption (l) Oil consumption (l/h)	440.5 (about 2.2 drums) 0.0795	

The readings of meters were recorded one hour after starting, before dinner, before supper and before switch off.

The records of the consumptions of fuel and oil and of running time are shown in Table 5.

Some experiences with the operation of the Diesel electric generators at the Base, and some troubles which occurred there are as follows:

a) To make the transportation and the installation of the electric generators easy, special wooden sleighs had been prepared for attachment to their bottom parts. The sleighs themselves functioned as very good foundations of the sets and were the best ones at the Base. This installation method kept other huts free from the engine vibration and noise.

b) In the early period, disconnection troubles frequently occurred in the voltage regulator. But these troubles were completely eliminated by removing the steel collars which had been left forgotten in the place where they had been inserted to prevent the permanent set of anti-vibration rubber pieces during transportation.

c) An incidence of seizing of main bearings and big-end bearings of the Diesel engine occurred.

This was caused by the breaking of the oil pipe leading from the engine to an alarm device, which was actuated by the lowering of the oil pressure. Unfortunately, at that moment, no one was present, and the alarm buzzer was not heard. This device had to be improved by combining with another device in which the engine was to be stopped automatically by cutting off its fuel when the oil pressure was lowered below 0.7 kg/cm^2.

d) The capacity of the original fuel tank was so small that a drum was substituted and connected to the fuel system of the engine by a vinyl pipe. The vinyl pipe tended to be hardened by the fuel and to break; so this had to be replaced by an anti-erosive synthetic rubber pipe.

e) Sticking of the plunger of the fuel-pump was caused by the infiltration of water into the fuel.

f) One of the cylinder head bolts of the No. 2 engine was broken after it had been operated 3200 hours, while two of them were elongated by excessive tightening.

g) The bakelite plate and rubber cover of the water-pump were replaced by spares when the water leaked through the packing.

h) The radiator was damaged and the cooling water leaked; so it was replaced by the one installed on the snow-car.

Generally the operating conditions and circumstances were kept good, so each engine was inspected for each 200 hours of running. The wear of all parts of the engine after 3,200 hours of running was slight as almost no dust was contained in the air. The 3 KVA Yammar Diesel electric generator prepared for emergency use was tested twice after every 2 hours of running.

This emergency generator was connected only to the lines which supplied the power necessary to meet the minimum requirements for daily life (Fig. 30).

7.3. Diesel electric generator prepared for the second and third expeditions In the first expedition, 2 sets of electric generators were installed at the Syowa Base and were operated alternately. In the second expedition, the necessary power was increased and this required the operation of 2 sets in parallel.

For this requirement, two new sets of the same type 20 KVA Diesel electric generators and the spares for the 2 sets left in the Syowa Base were prepared.

In the second expedition, the materials to build a new engine room adjoining the older one were prepared; it was planned to be the room in which to install the two new generators.

The control panel was placed on the generator unit in the older type, but those of the new type were separated from the generator set. The control panels for the 4 engine-generator sets, two of which were of the old type and remainder of the new type were concentrated into a box as shown in Fig. 31. This control box was expected to be placed between the two older engines and the two new type engines.

To simplify the connection system and to avoid errors in wiring the two new sets of generators were arranged to supply their power only to the huts which were to be prepared newly for the second expedition.

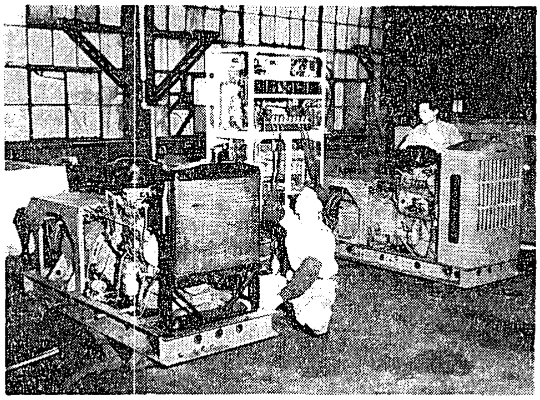


Fig. 31. Improved type 20 KVA (100 V, 3ϕ) electric generators and their control panel (prepared by Isuzu Auto. Co. and Meidensha).

8. Air-conditioning systems

8.1. Air-conditioning systems prepared for the first expedition i) MAIN WARM-AIR HEATING FURNACE The sub-committee for "Air-conditioning problem" at the Base was organized in May, 1957. After earnest discussions on this problem, it was decided to adopt a warm-air heating system for the prefabricated huts and to use as its heat-source the gas-oil which was to be used in the Diesel engines.

The three huts, i. e., main hut, living hut, and radio hut had the same size of (16′×28′×8′); accordingly their heating load, too, were nearly the same (3,000~7,000 kcal/hr). The pot-type warm-air heating furnace Model MHF-40D manufactured by the Minorikawa Manufacturing Co. was selected. These were specially designed for this purpose and had a maximum capacity of 40,000 Btu/hr (10,000 kcal/hr).

Table 6. Estimated heating load of a hut (by Prof. INOUE).

Outdoor air temp.	0°C	−30°C	−50°C
Heat-loss by transmission	800	2300	3400
Necessary heat to heat fresh air (kcal/h)	2200	4600	6400
Total heating-load (kcal/h)	3000	6900	9800

The quantity of fresh air was assumed to be 190 m^3/h.
Room temperature was assumed to be 15°C and relative humidity to be 50%.

The characteristics of this heater are shown in Figs. 32, 33. This furnace can heat room air of 25.5°C to about 69.5°C, blowing out hot air at the rate of 900 m^3/hr when the fuel is supplied at the rate of 0.965 l/hr. The total output is 8,069 kcal/hr and its efficiency is 81.4%. This furnace was originally designed

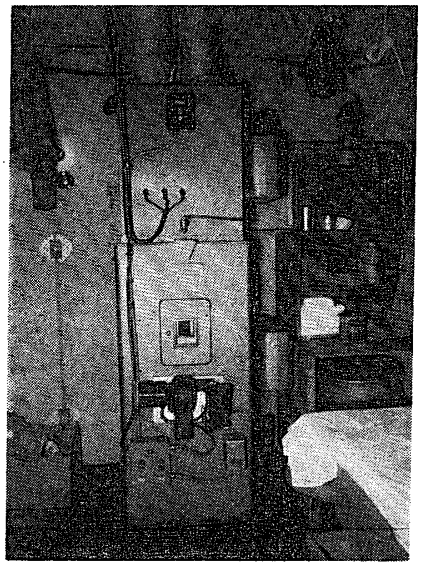


Fig. 32. Pot type warm-air heating furnace MHF-40D type set in a living-room of the Syowa Base (prepared by Minorikawa Factory).

to burn only the gas-oil in a pot, but a 3 KW (2,580 kcal/hr) electric space-heater was installed in the upper part of the furnace. Therefore, the heaters could be heated electrically also by utilizing the excessive electric power of the 20 KVA Diesel electric generator.

The loop system, warm air ducts and spherical type warm-air outlets were designed by Prof. U. INOUE and Mr. M. YANAGIMACHI. The air ducts could be assembled in a short time by joining short steel pipes with steel bands. They were installed through and supported by the circular holes formed in the beams supporting the roof.

To this furnace a fuel controller, an oil-tank, safety device and humidifyer were installed.

In August of 1957, the furnace was tested in Tokyo and operated continuously for 3,500 hours, during which its durability and performance were checked. Another test was carried out in a low-temperature testing room at -40°C. The furnace ignited easily even at that low temperature. In the first expedition, 4 heating furnaces of this type were carried to the Syowa Base.

ii) POT-TYPE OIL-STOVE

Just before the start of the team to the Antarctic the preparation of another type of oil-stove with a capacity of 20,000 Btu/hr (5,000 kcal/hr) was requested as the heater of the caboose (cabined sleigh). For this request three pot-type oil stoves without fan were manufactured by the Minorikawa Manufacturing Co. The characteristics of this stove are shown in Fig. 35 (a).

iii) AIR VENTILATOR AND CHIMNEY FOR HUTS AND FOR ENGINE-ROOM

For each of the three huts at the Syowa Base a small sirocco-fan type exhauster which was driven by an AC electric-motor (35 Watt single-phase) was installed. The flow of exhaust air was about 135 m^3/hr. This fan was installed near the ceiling of the room, and the fresh air flowed into the room through the circular space around the chimney of the furnace. The chimney was as is shown in Fig. 36. The fresh air was slightly warmed by the hot exhaust gas flowing out through the chimney.

The construction of this special chimney was effective in preventing the freezing of water vapour contained in the exhaust gases of furnace or engine.

iv) VENTILATOR WITH HEAT-EXCHANGER

A newly developed ventilator with heat-exchanger was presented by the Okamura Manufacturing Co., and this was to be installed in the pre-chamber of the engine

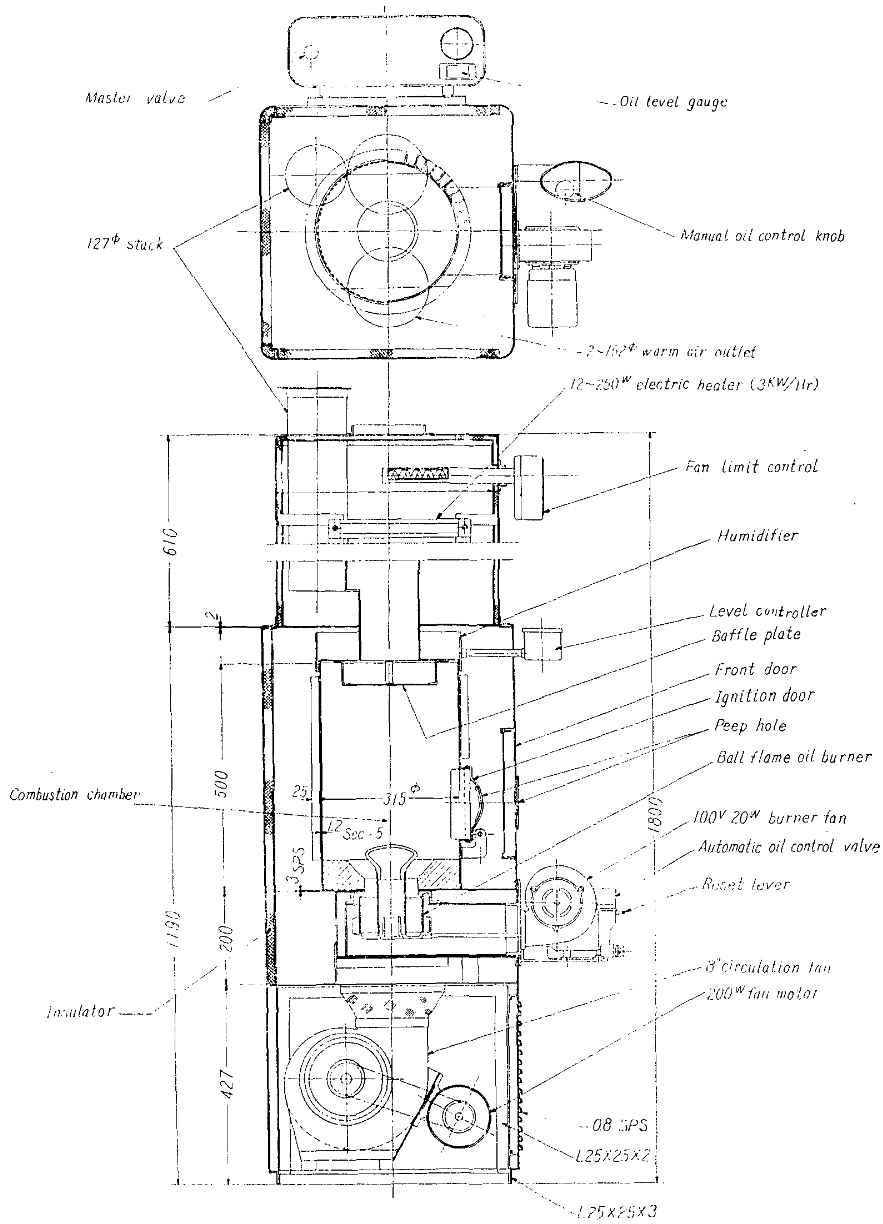
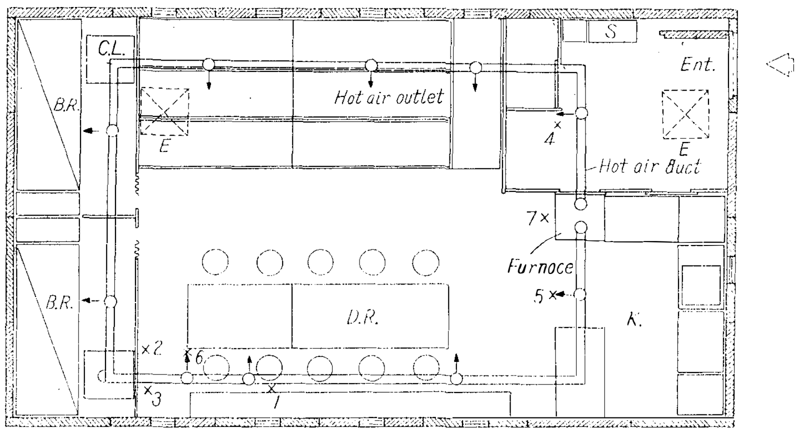


Fig. 33. Cross section view of warm-air heating furnace (prepared by Minorikawa Factory).

Maximum capacity:	40,000 Btu/h (10,000 kcal/h)
Fuel:	gas-oil
Hot air volume flow:	500 CF/M (850 m^3/h)
Static pressure:	3/8″ Aq. (9.5 mm H_2O)
Fan motor:	1/4 HP, 1 phase, 100 V
Burner motor:	20 W, 1 phase, 100 V
Space heater:	3 KW electric auxiliary heater

room. This ventilator consisted of two sets of small sirocco-fans and a special plate type heat-exchanger. The air temperature of the engine room was assumed to be fairly high. Therefore, the cool fresh air sucked in by a suction-fan could



Dining room
- 1 30 cm below the ceiling
- 2 1 m above the floor
- 3 on the floor

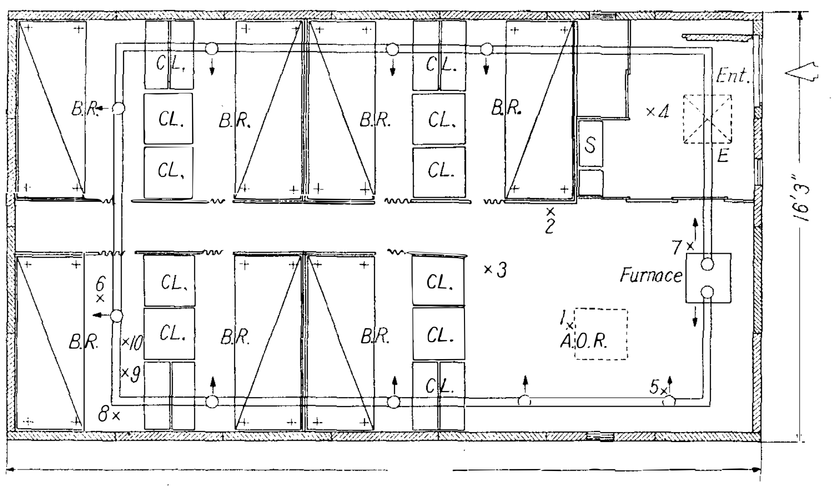
- 4 1 m above the floor of entrance
- 5 hot air outlet nearest to the furnace
- 6 hot air outlet most remote from the furnace
- 7 inlet air to the furnace

Ent. Entrance
B. R. Bed room
D. R. Dining room

CL. Closet
S Ski place
E Emergency exit
K Kitchen

External wall panel
Partition wall panel

Fig. 34 (a). Plan of main hut and its warm-air duct.



- 1 30cm below the ceiling
- 2 1 m above the floor
- 3 on the floor
- 4 1 m above the floor

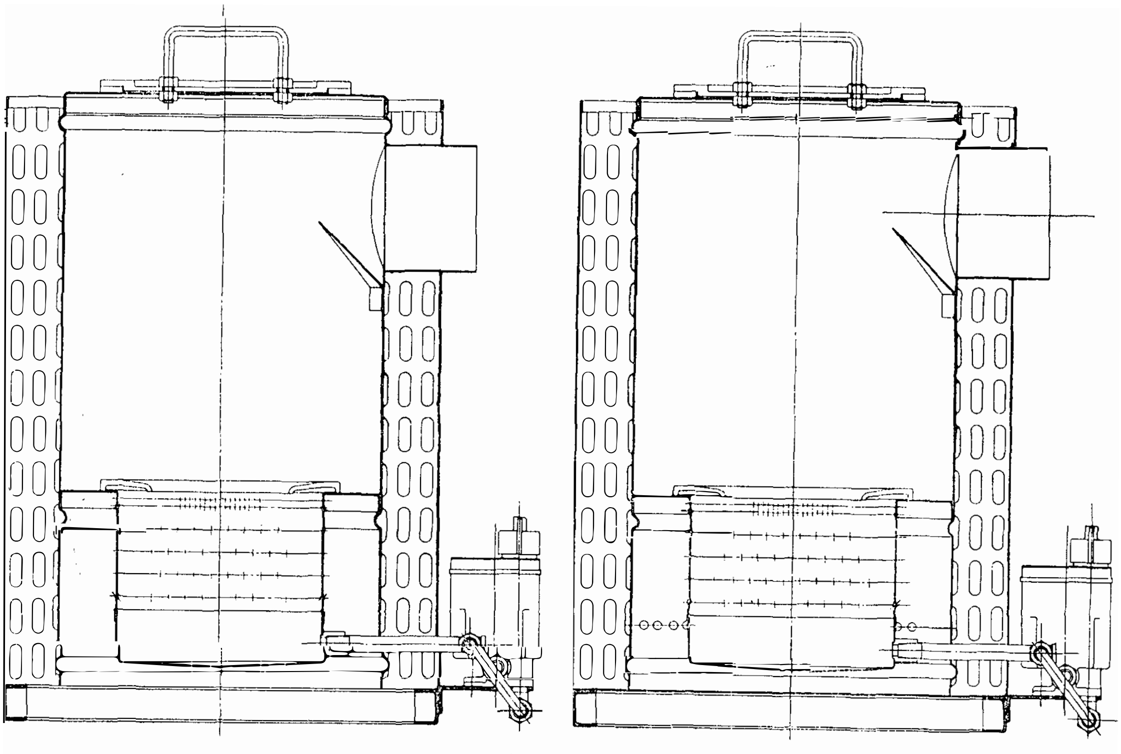
- 5 hot air outlet nearest to the furnace
- 6 hot air outlet most remote from the furnace
- 7 air inlet to furnace

- 8 30 cm below the ceiling
- 9 1 m above the floor
- 10 on the floor

Ent. Entrance
B. R. Bed room
A.O.R. Aurora observation room
CL. Closet
S Ski place
E Emergency exit

External wall panel
Partition wall panel

Fig. 34 (b). Plan of living hut (designed by Architecture Committee) and its warm-air duct (designed and prepared by Mr. M. YANAGIMACHI and Prof. U. INOUE).



(a) Before improvement (b) After improvement

Fig. 35. Oil-stove for caboose with capacity of 20,000 Btu/hr (prepared by Minorikawa Factory).

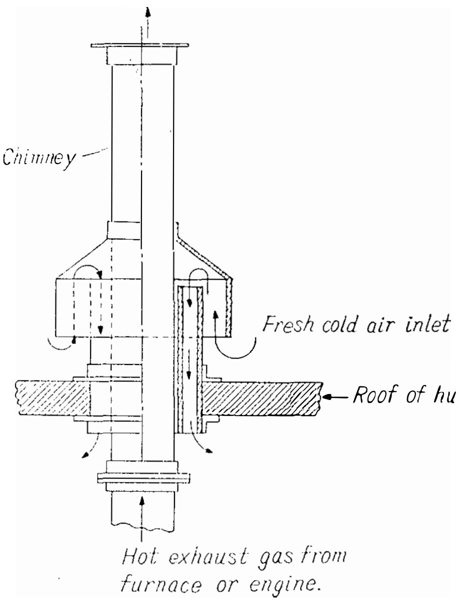


Fig. 36. Chimney

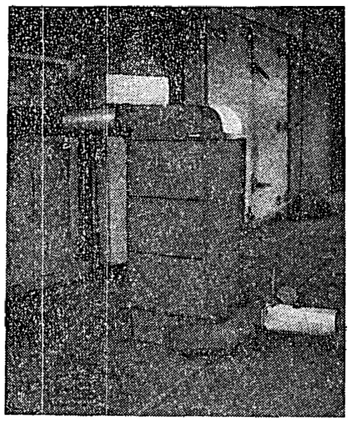


Fig. 37. Ventilator with heat-exchanger under test (prepared and presented by Okamura Manufacturing Co.).

be heated by the warm exhaust air while they were flowing through the heat exchanger. This ventilator was tested in the low-temperature testing room at $-40°C$ (Fig. 37); it was found that the temperature efficiency of the heat-exchanger was 81%, and its capacity about 160 m^3/hr.

This means that the sucked-in fresh air would be preheated up to $+10°C$ from $-40°C$ when the engine room temperature was $+22°C$. If this special ventilator was used in the living hut, the quantity of fuel necessary for heating the hut would be decreased to about 66~70% of the total. One set of this ventilator was carried by sleigh to a spot quite near to the Base, but to everyone's disappointment, it was lost with a drift-ice blown away by a violent blizzard before it was transported to the Base.

8. 2. **The results obtained by actual use at the Syowa Base** i) WARM-AIR HEATING FURNACE a) The warm-air heating system was very effective in keeping the life in the Syowa Base comfortable through the year.

Table 7. Fuel consumption of 40,000 Btu/h warm-air heating furnace.

Output	Fuel consumption	
kcal/h	kg/h	l/h
11,000	1.32	1.6
10,000	1.23	1.5
7,500	0.965	1.2
4,200	0.67	0.8

b) The temperature change through a day was measured by Dr. T. TATSUMI and is shown in Fig. 38. To save on the fuel consumption, the heating was completely shut off during sleeping hours, but the room temperature was always kept from going below +3°~−10°C. The distribution of temperature was as shown in Fig 38, which was not yet quite uniform throughout one room. This was a point left to be improved.

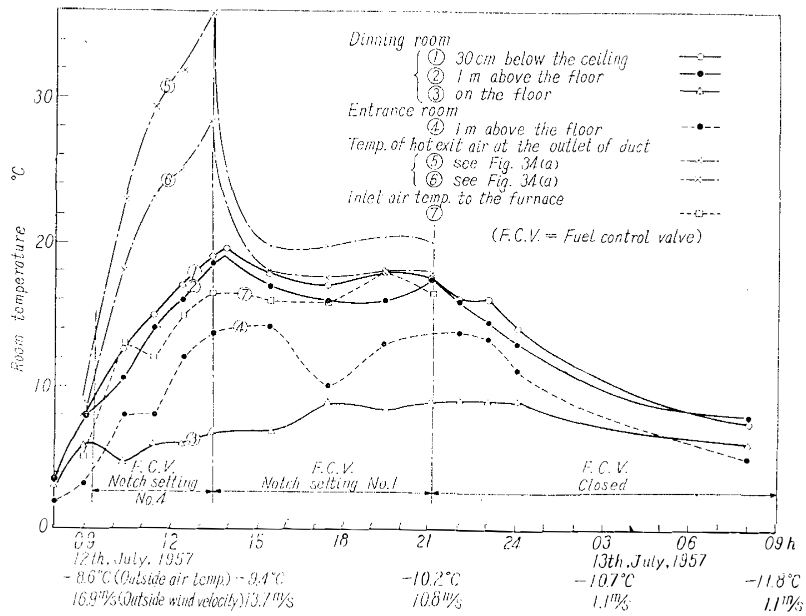


Fig. 38 (a). Temperature change in main hut (heated by oil only, thermostat 1.25 (about 18°C)). The index numbers in this figure correspond to the one shown in Fig. 34 (a).

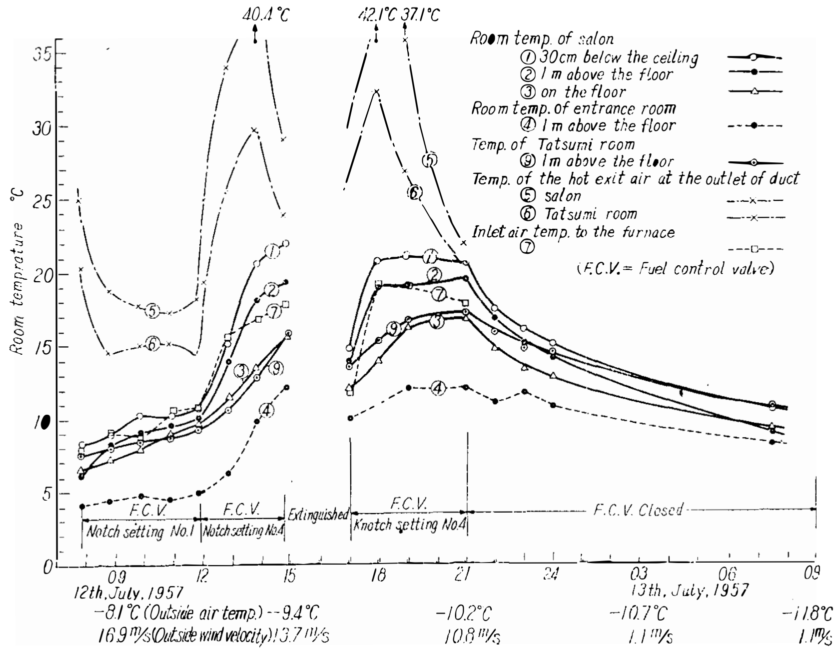


Fig. 38 (b). Temperature change in living hut (heated by oil only, thermostat 1.25 (18°C)).

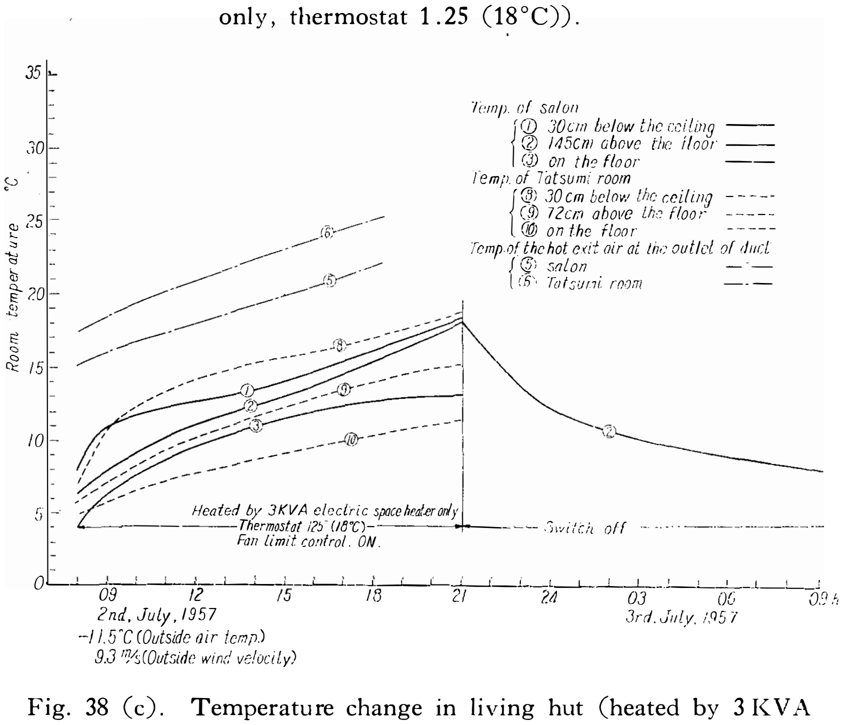


Fig. 38 (c). Temperature change in living hut (heated by 3 KVA electric space heater only, thermostat 1.25 (18°C)).

c) The total quantity of fuel of gas-oil consumed in the furnaces of three huts through a year was only 2,000 litres or 10 drums. This remarkably small fuel consumption resulted mainly owing to the adoption of 3 KVA electric heaters to the furnaces. In the living hut, especially, only 40 litres of fuel were consumed for the heating through one year. Thus the combined method of electrical and oil heating for the Antarctic Base showed its excellency on the economical side, also.

Table 8. Outdoor air temperature and wind velocity.

Date	Time (h)	Temperature (°C)	Wind velocity (m/s)
July 12th, 1957	03.00	− 7.1	16.1
	09.00	− 8.1	16.9
	15.00	− 9.4	13.7
	21.00	−10.2	10.8
〃 13th 〃	03.00	−10.7	1.1
	09.00	−11.8	1.1

d) The capacity of the fuel tank had to be increased.

e) A water-drain cock was desired at the bottom of the fuel tank to drain off the water mixed in the fuel.

f) The oil-pot was kept horizontal as much as possible, otherwise the flame would not be distributed uniformly in the furnace.

ii) POT-TYPE OIL STOVE

Unfortunately, at 0600 hours, on July 24, 1957, an accidental fire occurred in a caboose, and some instruments and valuable data were burnt with it. The fire originated from the 20,000 Btu/hr, pot-type oil-stove installed in the caboose. After one of the members had finished his observation through the night in this caboose, he extinguished the stove and swept the chimney immediately. At the moment when he replaced the chimney on the stove, a slight explosion occurred in the stove and the back-fired flame ignited fuel spilt on the floor. He immediately took a fire-extinguisher and operated it. But unfortunately, the fire-extinguisher did not work well. So he was confused and ran to a hut to take another extinguisher, and to call for help. When he returned with others to the caboose, the fire had already spread.

The sub-committee in Tokyo, having received the telegraph on this accident, immediately conducted an experiment with a stove of the same type to ascertain the cause of the fire. As the result, the cause was assumed to be the following:

a) Before this accident occurred, a blizzard had overturned the caboose and the automatic fuel-level-controlling device of the stove was made defective. Therefore, it was removed and the fuel was made to be supplied directly from the tank through a vinyl pipe. This brought an extraordinary high level of fuel in the pot. It overflowed onto the floor and at the same time caused incomplete combustion of fuel.

b) After the member had extinguished the stove, some hot spots still remained in the furnace. The fuel in the pot was evaporated and its vapour filled up the stove. This vapour was exploded at the moment when the chimney was replaced again and fresh air was admitted to make an explosive mixture in the stove.

c) As shown in Fig. 35 (a), the bottom of the stove was opened to supply the necessary air for combustion. The explosion flame spread downward against the floor through this opening.

d) Unfortunately, the stove was set directly on the combustible floor without any shielding material between.

e) The member was not familiar with the handling of the fire-extinguisher.

As the result of this experiment, the stove was improved as shown in Fig. 35 (b). The main points were:

a) The bottom of the stove was covered with a circular steel plate and many small circular holes were drilled on the circumferential side near the bottom through which the fresh air was admitted.

b) The vinyl pipe connecting the stove to its fuel tank was to be changed to a copper pipe.

c) A heat insulating board beneath the stove was indispensible.

d) The sweeping of the chimney had to be avoided just after the stove was extinguished.

It must be mentioned that a fire is the most disastrous of all accidents, especially in the Antarctic.

8. 3. Warm-air heating systems prepared for the second and third expeditions For the second and third expeditions, two sets of the same type warm-air heating furnace and four sets of exhaust fans as used in the first expedition were shipped, but the oil-stove and the ventilator with heat-exchanger were not prepared.

A new attempt to save fuel for the warm air heating furnace was planned and tested in Tokyo by Prof. S. AWANO. As will be stated later, hot water could be easily obtained by utilizing the exhaust-gas heat energy of the 40 hp Diesel engines coupled with 20 KVA electric generators.

A hornet's nest type heat-exchanger was placed in front of the suction side of warm-air heating furnace as shown in Fig. 39, and through it, hot-water which was pumped from the engine room was circulated to heat the room air flowing into the furnace. As the result of experiments, hot air of 42°C was obtained at a rate of 850 m^3/hr by utilizing the exhaust-heat of a 40 hp Diesel engine without any supply of heating fuel or electric energy. This means the recovery of the waste heat of about 22, 000 Btu/hr (5, 500 kcal/hr) which was equivalent to the heating load of a hut. If necessary, the electric heating could be combined with this heating system.

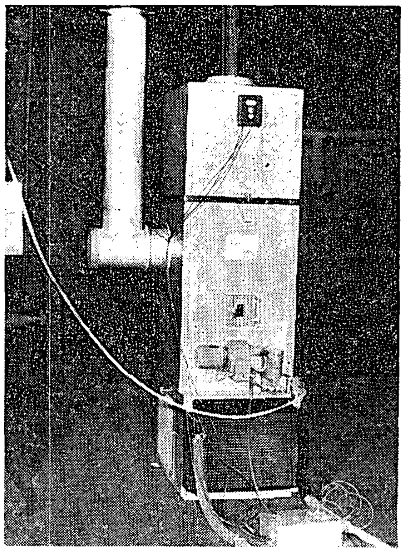


Fig. 39. New system for recovery of exhaust-gas heat of 40 HP Diesel engines driving 20 KVA electric generators (A heat-exchanger was placed at the inlet of room air to the warm-air heating furnace).

The most important problem for this system was to prepare a simple and well-insulated hot-water tube for conveying the hot water from the engine room to the hut. For this purpose, a synthetic reinforced rubber tube was prepared. This was insulated by molto-plane sheets (organic heat-insulating material made by the M. T. P. Co.) of 10 mm thickness and vinyl bands. If this system could be realized successfully at the Base, a hut would be kept at a comfortable temperature without using even a drop of heating fuel throughout a year.

9. Cold and hot water making equipment utilizing waste heat of Diesel engines

9.1. The equipment prepared for the first expedition To save gas-oil, an attempt was made to recover the waste heat of 2 sets of 40 hp Diesel engines coupled with 20 KVA electric generators, one of which ran continuously as the main electric source. Three kinds of water were needed at the Base:

a) Cold water for drinking

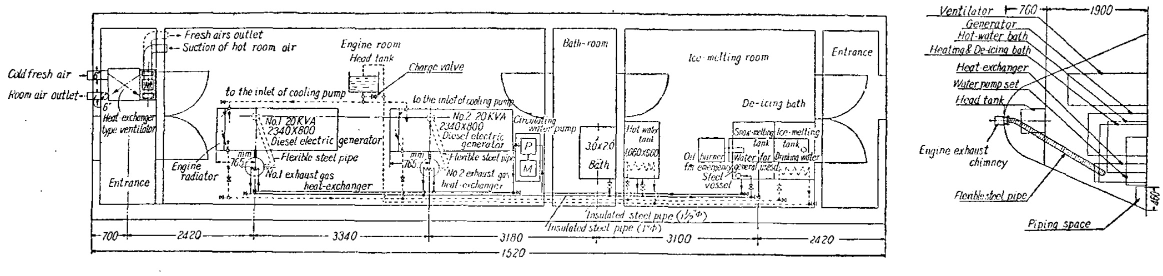
b) Cold water for other general uses

c) Hot-water for bath and washing

The minimum quantity of water necessary for the life at the Base was assumed to be about 20 litres a day per person. The following three systems were completed as the equipment ready for the first expedition. It was designed by Prof. S. AWANO and manufactured in the factory of the Engineering Department of the Nihon University.

a) The system for waste-heat recovery from engine exhaust-gases.

This consisted of a recirculating pump, exhaust-gas heat-exchanger, ice-melting tank to make the water for general uses, hot-water tank, bath tub and 1″ insulated steel piping. The heat carrier of this system was the melted water itself which circulated through an open circuit. By an experiment, it was found that heat of about 9,600 kcal/hr could be recovered from the exhaust gas energy.



—— Exhaust gas heat recovery system (1″ ϕ)
········ Cooling-water heat recovery system ($1^1/_2$″ ϕ)

Fig. 40. Engine room and cold and hot water making system utilizing waste heat of 40 HP Diesel engines (prepared in the factory of the Nihon Univ. for the first expedition).

b) The system for waste heat recovery from engine-cooling water.

This consisted of the engine water-pump, heating coil of the ice-melting tank to make drinking-water, heating coil of hot-water tank, bath tub, and $1\frac{1}{2}''\phi$ steel piping. The heat carrier for this system was the engine cooling liquid itself which circulated through a closed circuit and transferred heat of 22,400 kcal/hr from engine cooling water to ice or hot-water.

c) Directly heating system for emergency use.

This consisted of an oil-burner, heating tube set horizontally in the ice-melting tank, and chimney.

It was planned to use the system (a) or (b), and system (c) was added for emergency use only. If we had used both system (a) and (b), the available heat energy would have been 32,000 kcal/hr, which corresponds to a fuel consumption of 4.7l/hr. The components of the equipment were as follows:

i) ICE-MELTING TANK

As shown in Fig. 41, and aluminized steel vessel with the dimensions of length: 1560 mm × breadth: 1010 mm × height: 800 mm, was prepared for melting ice or snow block. This vessel was divided into two sections, one of which was for making drinking-water and the other for making general use water. The drinking-water section was to be heated by a coil laid on the bottom of the vessel, and the other section directly by pouring in hot water which had been heated by an exhaust gas heat-exchangers.

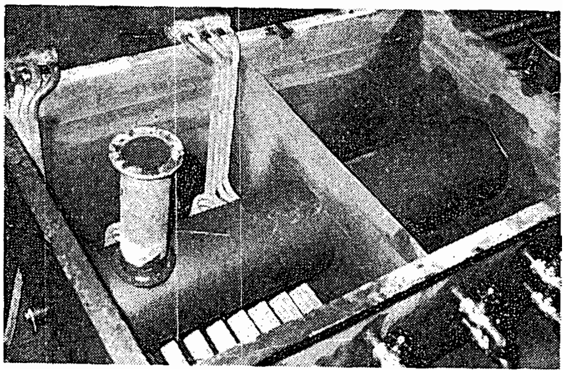


Fig. 41. Inside view of ice-melting tank (prepared in the factory of the Engrg. Dept. of the Nihon University and aluminized by the courtesy of Almer Kogyo Co.).

ii) HOT-WATER TANK

An aluminized steel tank, insulated by glass-wool, and whose dimensions were length: 910mm × breadth: 540mm × height: 800 mm, was prepared. Through the coils of the drinking water section of the ice-melting tank and of the hot-water tank, the engine cooling liquid (ethylene glycol and water mixture) was circulated and melted the ice or heated the water.

The water could be heated by the system (a) or (b) up to 40°~100°C from 0°C in the hot-water tank.

iii) BATH TUB

The bath tub was made by assembling wood boards together with several long bolts. The hot-water heated in the hot-water tank was transferred into this bath tub by a pump.

iv) HEAT-EXCHANGER FOR RECOVERING THE ENGINE EXHAUST-GAS HEAT

Fig. 42 shows the features of the heat-exchanger, which was a kind of shell and coil heat-exchanger. The cold water from the ice-melting tank first flowed into its jacket, and then into the double helical coils heated by the exhaust-gases of a Diesel engine. The exhaust-gas of 380°C was cooled down to about 52°C while the cold water was heated up and absorbed heat of 9, 600 kcal/hr from the exhaust-gas.

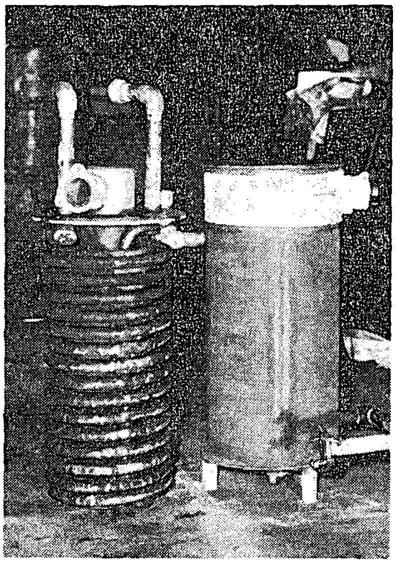


Fig. 42. Heat-exchanger for recovering the engine exhaust gas energy (not yet insulated and in the state of overhauled).

v) PUMP

A circulating centrifugal pump was driven by an electric motor of 1/4 hp; the capacity of the pump was 1, 670 l/hr. Above the pump-motor set, a head tank was installed.

vi) PIPING

The piping was one of the most important problems for this equipment. We adopted, for the first expedition, 1″ steel pipes for system (a), and 1-1/2″ steel pipes for system (b), all of which were cut into necessary lengths and threaded for joining and insulated with glass fibre.

9. 2. Results of experiences at the Syowa Base in the first expedition At the Syowa Base, unexpected pure water could be found in the ponds and puddles. So, this water was used during February to June. But, with the approach of winter, it became difficult to draw the water from the frozen ponds. The ice-melting plant utilizing the exhaust gas heat energy of the Diesel engines was installed. The ice-melting system assembled at the Syowa Base is shown in Fig. 43.

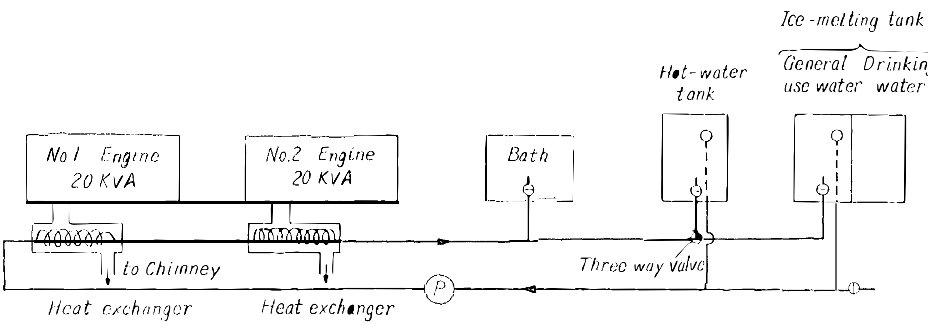


Fig. 43. Simplified water making system installed in the engine room of the Syowa Base.

Only the exhaust-gas heat system (a) was used, and the the other system for recovering the cooling heat energy of the engines was not assembled because of the following reasons.

a) Sufficient cold and hot water for the life of 11 members could be obtained by using only the exhaust-gas heat energy of a 40 hp Diesel engine.

b) It was thought best to avoid lowering of the temperature of the engine room. The cooling waste heat of the Diesel engines was dissipated from the radiator into the engine room air. Accordingly, the temperature of the engine room was kept at about 30°∼40°C (Fig. 29). Therefore, the ice-blocks put into the ice-melting tank were melted by the exhaust-gas heat energy and, at the same time, also by the heat transferred from the hot engine room.

c) The use of the cooling heat of a Diesel engine was apt to result in engine trouble caused by the loss of coolant if some part of the long pipe lines was broken unexpectedly.

d) As the coolant of the engine, a mixture of water and ethylene glycol was used. This mixture would be slightly injurious if it were drunk by mistake.

e) The outlet temperature of the coolant flowing out from the heating coil was near 0°C which would be an abnormally low cooling temperature for the engine.

Snow blocks put into one of the sections of an ice-melting tank was heated and melted directly by the hot-water circulated between this tank and the exhaust-gas heat exchanger by an electric pump. The cold water or hot water obtained by this system was sufficient for the general uses, bath, and washing.

The bath was prepared every other day. The pure ice-blocks which had been cut out from an iceberg were transported by snow-car and melted in the other section of the ice-melting tank by the heat transmitted through the steel partition and also by the heat from the air.

The difficulties experienced with this plant were as follows:

a) The water for general use and for the bath was stained by the rust from the heating-coil of the exhaust-gas heat-exchanger, which was made of steel pipes. The steel pipes and shells were aluminized by the Almer Eng. Co. except the inner surface of the steel pipes.

b) The pebbles contained in the snow blocks often damaged the blades of the circulating pump. Consequently, the intake point of the suction pipe had to be held up from the bottom of the ice-melting tank.

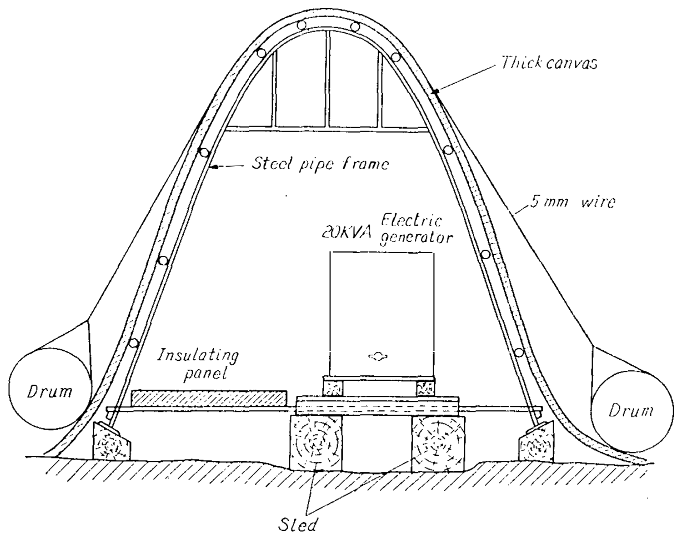


Fig. 44. Section of engine room.

c) The treatment of sewage was a problem. But this problem was solved by a sewerage system devised by a member of the team in which a small-size air compressor and a drum was used (Fig. 45).

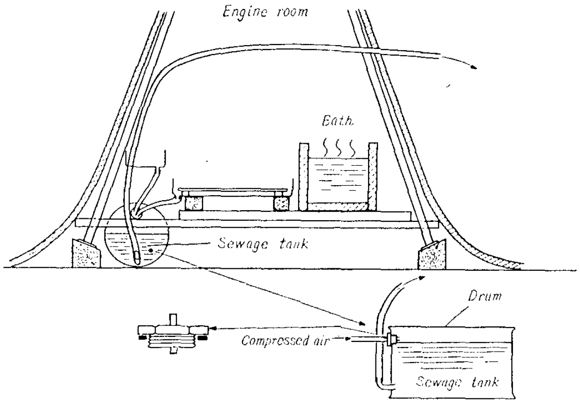


Fig. 45. Sewer system in the engine room at the Syowa Base.

9. 3. A new type water-making equipment prepared for the second and third expeditions An improved type of water-making system was designed by Prof. S. AWANO and prepared in the factory of the Nihon University. Fig. 46 shows the general view of this plant which was tested in September 27, 1957. To this new system shown in Fig. 46, the following improvements were added:

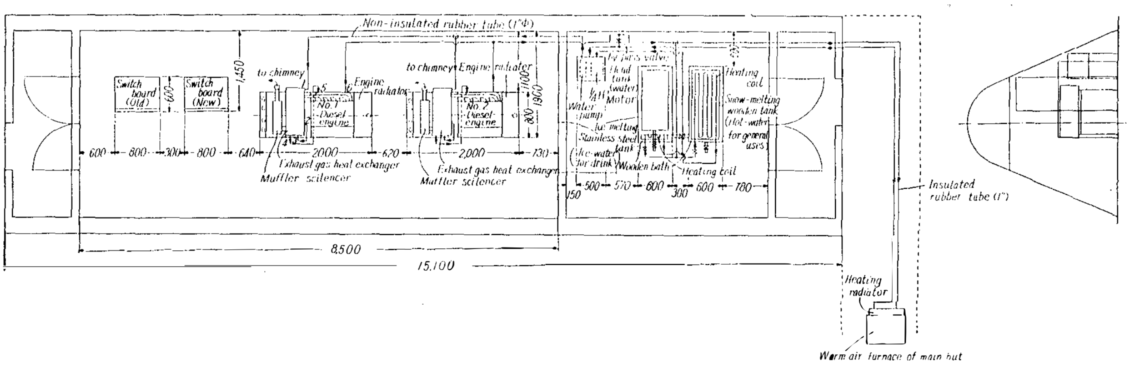


Fig. 46. General arrangement in new engine room and flow diagrams for ice-melting and hot-water heating systems utilizing the exhaust gas energy of Diesel engines (1957).

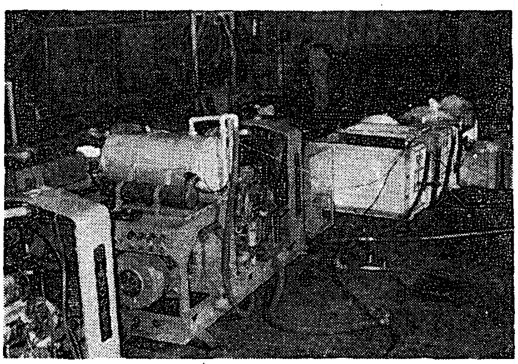


Fig. 47. Improved water-making system utilizing engine exhaust-gas heat energy (prepared by the Nihon University for the second expedition in 1957).

a) Only the exhaust-gas heat energy of the Diesel engine was utilized. The system was simplified and, accordingly, the weight and volume of the equipment were decreased considerably.

b) Reinforced synthetic rubber tubes of 1″ϕ, which were not insulated, were used for the pipe lines in place of steel pipes. This made the piping easy and shortened the time for installation.

c) The heat recovery circulating water system was changed to a closed system from an open one, i. e. the hot water heated by an exhaust-gas heat-exchanger was pumped to the heating coils of an ice-melting tank or of a hot-water tank and returned again to the head tank. The snow-block was melted by the heating coil indirectly. By this new system, the problems of the staining of water and of pebbles were solved.

The drinking water was produced by melting pure ice in a stainless steel tank placed in a wooden vessel and by heating by the hot water which had been heated by a heating coil set on the bottom of the tank.

d) The drinking water tank and the general-use-water tank were prepared independently as two vessels, each of which was made from Japanese cypress and could be disassembled into five panels and enveloped in a vinyl bag. This vinyl bag package was most effective in keeping the wooden panels from excessive drying or cracking through the long sea voyage. These wooden tanks were prepared at the Tomoe Co.

e) A water strainer of prefabricated type was prepared.

f) A heat-exchanger to absorb the exhaust-gas heat energy was newly designed to be placed on the engine generator set (Fig. 47).

g) A water-cooled type exhaust-manifold was adopted for the Isuzu 220 Diesel engine. The circulating water flowing out from the heat-exchanger was led to the jacket of the exhaust-manifold to be heated still more there, and then transferred to the heating-coils in the tanks. The total heat energy recovered by this heat-exchanger was about 58, 000~79, 000 Btu/hr (14, 500~19, 800 kcal/hr).

By this system, 230 kg of ice was melted in an hour at full-load running of a 20 KVA Diesel-electric generator, and the exhaust-gas temperature at the outlet of the heat-exchanger was measured to be about 39°~78°C.

h) When ice-melting was not needed, the hot water heated up to 70°~80°C by the exhaust gas heat-exchanger could be pumped to the nearest living hut in the Base through a rubber pipe insulated by molto-plane as stated before.

i) Four pure-water reservoirs were prepared for the second expedition.

A cotton-canvass reservoir was hung by hemp strings to a steel framework made of 1″ pipes and a polyethylene reservoir was inserted in it to prevent leakage of water through the texture.

The reservoir was filled with the pure water pumped up from a pond or puddle in summer by means of a water pump driven by a 2-cycle gasoline engine (made by the Tokyo Hatsudōki Co.). Another polyethylene covering covered the whole reservoir. On the top of the covering two holes were prepared, through one of which the hot exhaust air of 30°~40°C from the engine rooms was charged and warmed the water to prevent its freezing. Through the other hole, the water could be pumped out by an electrically driven pump.

The capacity of each reservoir was 15, 000 litres and the size, 4 m in diameter and 1. 5 m in height. Four reservoirs were to be installed in a line outdoors beside the old and new engine rooms. The water in the reservoirs would supply ample water for the life at the Base and for extinguishing fire.

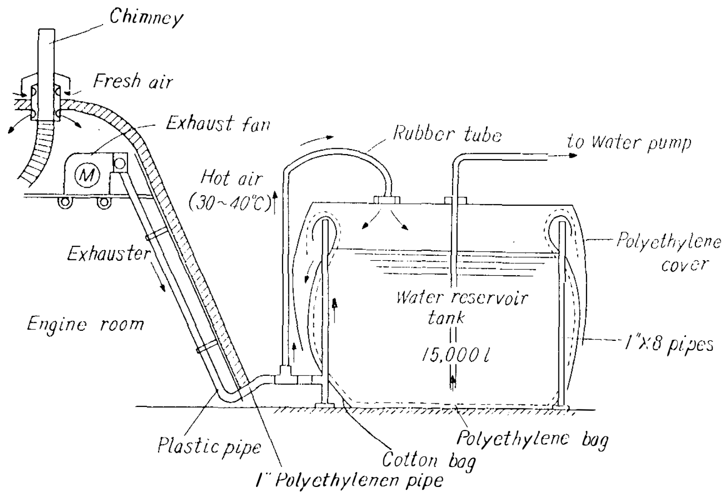


Fig. 48. Water reservoir tank.

If the water in the reservoirs were frozen in winter, then the labour of transporting the ice for melting from an iceberg would be saved.

All of these reservoirs were shipped for the second expedition, but, unfortunately, the team could not reach the Syowa Base. Accordingly, these plants were not used at all in practice. The same ice-melting plant was shipped again to the Antarctic in for the third expedition (1958/1959), but the water reservoirs were excluded to decrease the total volume to be transported by air from the Soya to the Base.

10. Fuels, oils, and other liquids

10. 1. Fuels prepared for the first expedition a) GAS-OIL The main heat source in the Syowa Base was to be supplied by the gas-oil, i. e., it was used as the fuel for the Diesel engines of the electric generators and the fuel for the room heaters. The fuel for the Diesel snow-car also was gas-oil.

A special gas-oil was made ready by the Nihon Petroleum Co. to satisfy the following three requirements.

i) Its solidifying temperature had to be below −40°C.

ii) Its cetane number had to be greater than 45.

iii) The same fuel had to be used for Diesel engines, for snow-cars, for electric-generator engines and for heating furnace.

b) GASOLINE

As the fuel for three gasoline snow-cars, and for several 4–cycle gasoline engines of small type, a special gasoline was prepared by the Nihon Petroleum Co. to satisfy the following requirements.

i) Its octane number had to be greater than 80.

ii) Tetra-ethyl-lead fluid had to be added by not more than 1 cc for 1 gal. of fuel to protect the engine from deposits.

iii) Easy starting had to be secured at low temperatures below $-40°C$.

iv) Its vapour pressure had to be kept as low as possible as the storage room temperature would rise when the ship went over the equatorial zone.

c) LUBRICATING OIL

A special kind of engine oil, SAE 10–30 class, multigrade motor oil, was prepared by the Nihon Petroleum Co. to satisfy the following requirements.

i) The same oil had to be used for the Diesel snow-cars, gasoline snow-cars, the Diesel engines for electric generators. Besides, it was to be used as the lubricating oil for several 4-cycle and 2-cycle engines.

ii) The solidifying temperature had to be below $-45°C$.

iii) An anti-oxidizing agent, anti-corrosion agent, purifying agent, anti-foaming agents, viscosity-index promoting agent, and an agent for lowering the solidifying temperature had to be contained in the motor oil.

d) TRANSMISSION OIL

A special transmission oil was prepared by the above company to satisfy the following requirements.

i) Viscosity corresponding to SAE–80 class.

ii) Good lubricating performance at low temperature under high load.

e) TORQUE-CONVERTER OIL

The oil had to have suitable viscosity even at low temperatures.

f) MIXED OIL FOR 2-CYCLE GASOLINE ENGINES

As the fuel for the 2-cycle gasoline engines for the boat, automatic sawing machine, and for boring machines, two kinds of mixed oils were prepared. In each, special oil was mixed with special gasoline with ratios of 15:1 and 12.5:1, respectively; the former was called (A) mixed-oil, the latter, (B) mixed oil.

g) FLUSHING OIL

Kerosene was prepared for washing and cleaning of the instruments and machines.

h) GREASE

A certain kind of grease was prepared for engines and snow-cars. It was a universal purpose grease composed of lithium soap and synthetic oil. The viscosity of the grease was required to be fit for use in extremely low temperatures.

i) BRAKE-FLUID AND ANTI-FREEZING COOLANT

Some precautions were necessary in the design of gasoline drums and their packaging to keep them safe from fire hazards in shipping and on board.

The gasoline vapour pressure was increased when the ship went across the equator. 45 litres of special gasoline were placed in a reinforced drum of 54 litre capacity, and a special sealing method used for chemicals was adopted. This drum was set in a wooden case and it was fastened by steel bands.

Other fuels and oils were placed in 200 litre drums, 18 litre cans and 4 litre cans to make their transportation easy. The total quantity prepared for the first, second, and third expeditions are tabulated in Table 9.

Table 9. Fuels and oils prepared for shipping on Soya (by Nihon Petroleum Co.).

Kinds of fuel or oil	The 1 st exped. (1956–58)	The 2 nd exped. (1957–58)	The 3 rd exped. (1958–60)
	l	l	l
Antarctic gasoline for cars	7155	184	184
〃 mixed gasoline A	1035	—	—
〃 mixed gasoline B	630	—	—
〃 crankcase oil	2908	6000	2600
〃 kerosene	844	—	—
〃 gas-oil	114580	186000	80200
〃 torque-converter oil	108	400	200
〃 gear oil	72	90	36
〃 grease	160 kg	272 kg	48 kg
〃 brake oil	36	90	72
〃 preston	144	600	618
〃 gasoline for aero-engine	1215	6460	2090
〃 crankcase oil for aero-engine	54	200	—
Ordinary gasoline (s)	—	15200	7000
Ordinary Kerosen	—	1000	216
Total	134941	216496	94264

10. 2. Results obtained in the first expedition As the temperature at the Syowa Base was warmer than assumed no trouble was experienced with the fuels and oils.

a) The gasoline was suitable for the use at low temperatures below −30°C. The special packaging of gasoline completely prevented leakage of fuel vapour or liquid. But in winter, some slices of ice became suspended in the fuel. This signifies the importance of the solubility of water in fuels.

b) The solidifying temperature of the gas-oil was −45°C, so a pre-warming room was built beside the engine room (Photo. 9). But, as the outdoor temperature did not go down below −36°C, the pre-warming of gas-oil was not necessary at all.

c) No troubles with lubricating oil were experienced for the engines of the snow-cars and of the electric-generators.

d) Although two kinds of mixed oil, (A) and (B), were prepared for the 2-cycle engines, the mixing could be done easily at the Base.

e) The small-size air compressor manufactured by the Hitachi Manufacturing Co., and "Daiya" type pump operated well in charging the fuel from the drum to the fuel tank.

10. 3. The fuels and oils prepared for the second and third expeditions The quantities of fuels and oils are shown in Table 9. The preparations were changed as follows:

a) The special gasoline with high volatility prepared for the first expedition was changed to ordinary gasoline which was contained in 200 litre drums.

b) Mixed-oil for 2-cycle gasoline engines was not prepared.

11. Refrigerating machine

11. 1. Refrigerating machine prepared for the first expedition A unit cooler was prepared. The refrigerating medium for this was F-12. The cooling capacity was 1600 kcal/hr and the motor output was 1 hp.

The refrigerated foods transported to the Base had to be stored in the storage-room and kept below $-15°C$ throughout the year. To save cargo, the materials for building the storage-room except a door were excluded. Instead, it was planned to excavate a snow room on the side of a snow hill and to make a storage room by putting a prepared insulated inlet door at the entrance (Fig. 49). A refrigerator was to be set outside the door. The refrigerator would produce cold air at 860 m^3/hr for cooling the box.

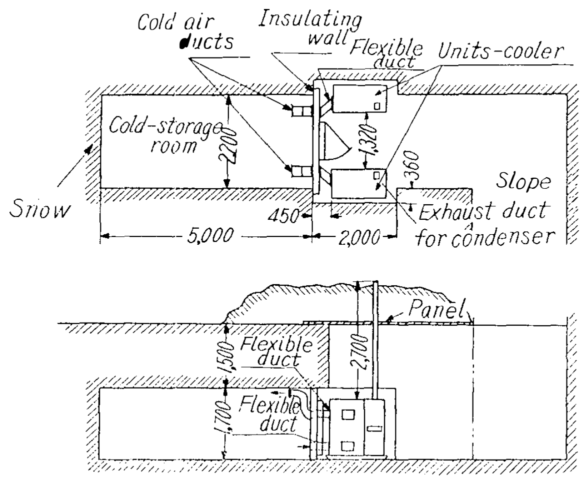


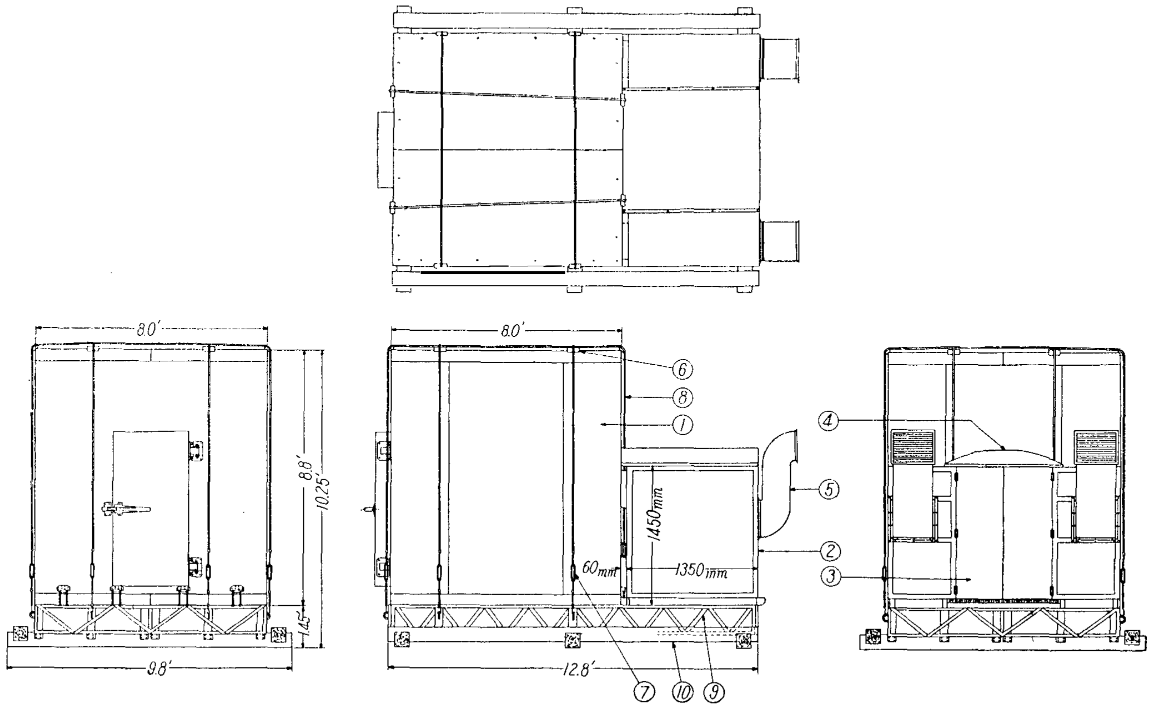
Fig. 49. Cold storage-room in the snow.

11. 2. Results obtained in the first expedition The expedition team could not find a suitable hillside to excavate the storage-room. So, they made a snow room under the snow field of the sea-ice near the Base, and the refrigerating machine was not set beside it. But after some time, they found that the storage-room was flooded with sea-water and some of the foods spoilt.

11. 3. Cold storage-room and unit-cooler prepared for the second and third expeditions With consideration of the failure in the first expedition, a knock-down storage-room, the inside dimensions of which were $7.2' \times 7.2' \times 8'$ height, and two sets of unit coolers with the capacity of 1600 kcal/hr and 1 hp motor each as shown in Fig. 50 were prepared. The inside temperature of the storage-room was to be kept below $-15°C$. This insulated storage-room and these unit-coolers were designed and prepared by the Nakano Refrigerating-Machine Manufacturing Co. under the leadership of Prof. J. NAGAOKA.

12. Wind-mill with electric generator

12. 1. Wind-mill with electric generator prepared for the first expedition To utilize wind energy in the Antarctic, a large wind-mill was designed, constructed and presented by the Honda Giken Kogyo Co. under the leadership of Prof. T. MORIYA, University of Tokyo. For testing, the mill was erected near Omaezaki light



No.	Nomenclature	QTY.
1	Cold storage-room	1
2	Unit cooler	2
3	Compressor compartment door	1
4	Compressor compartment roof	1
5	Condenser duct	2
6	Contact metal	8
7	Turn buckle	8
8	Wire	4
9	Foundation beam	1
10	Foundation bed member	1

Fig. 50 (a). Cold storage-room prepared for the second expedition (made by the Nakano Refrigerating-Machine Co.).

house in Shizuoka Prefecture, in the summer of 1957. The diameter of the three blades was 4,400m and the weight was kept to about 300 kg by using plastic materials. The measured mean capacity of this D.C. electric generator was about 1 KW. It was shipped and transported to a spot near the Base by sleigh, but unfortunately, it was lost with the ice in a blizzard before it was carried to the Base.

13. Other apparati and equipments

13. 1. Other apparati and equipments prepared for the first expedition

i) Battery and dry-charger

Batteries used as the electric source of the ignition systems of the gasoline snow-cars and those used for the starting of the engines were prepared by the Nihon Denchi Co. (type 4 DS and 2HS) and the Furukawa Denchi Co. (type

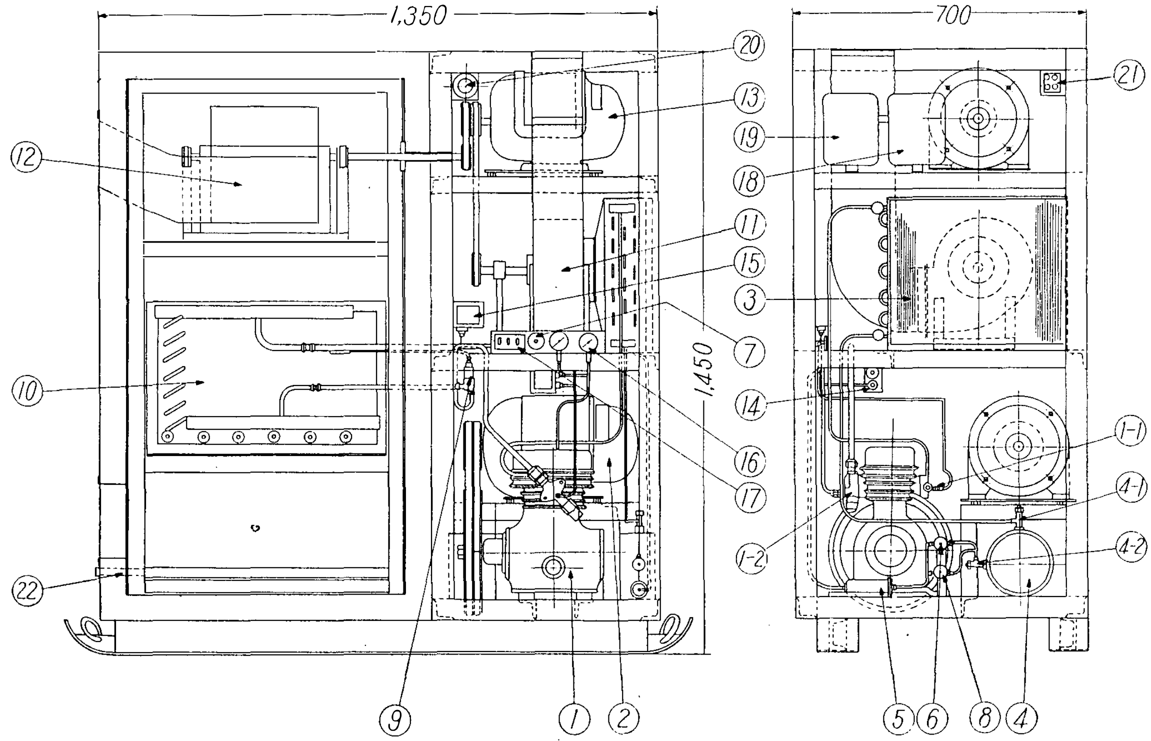


Fig. 50 (b). Unit cooler for food storage room
(made by the Nakano Refrigerating-Machine Co.).

1 NF-50 compressor
2 Motor, 1 hp
3 Air-cooled condenser
4 Receiver tank
5 Refrigerant dryer
6 Stop-valve before refrigerant dryer
7 Stop-valve before expansion valve
8 Refrigerant charging valve
9 Temperature type automatic expansion valve
10 Evaporater
11 Blower (1)
12 Blower (2)
13 Motor, $\frac{1}{2}$hp, for blower
14 Pressure switch
15 Temperature controller
16 Pressure gauge
17 Switch
18 Solenoid switch
19 Lamp (1)
20 Lamp (2)
21 Terminals for exterior wiring
22 Drain pipe
1-1 Compressor discharge control valve
1-2 Compressor intake control valve
4-1 Receiver tank inlet valve
4-2 Receiver tank outlet valve

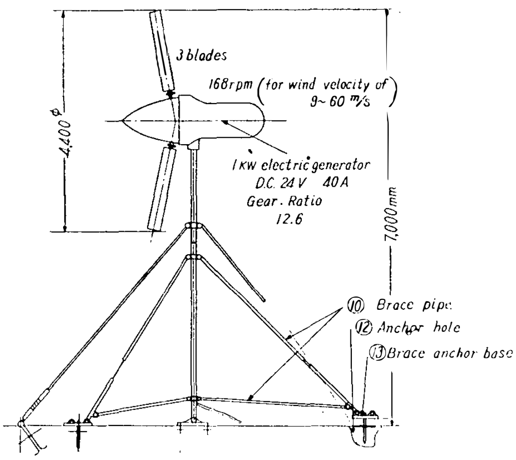


Fig. 51. Wind-mill for 1KW electric generator
(constructed & presented by Honda Giken Kogyo Co.).

4 HS and 4 DS.). All of them were of the dry-charging type as they had to be used in extremely low temperature after a long period of shipping.

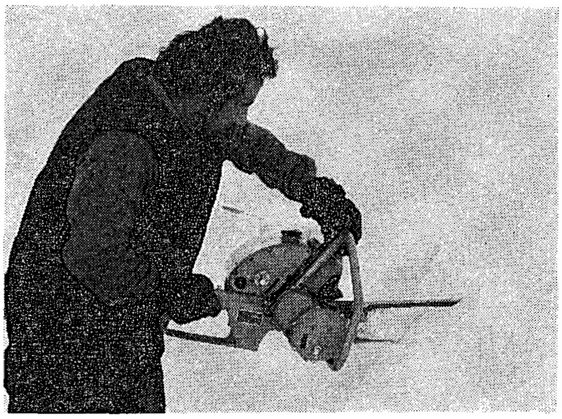


Fig. 52. Ice-saw driven by a small 2-cycle gasoline engine (prepared by the Fuji Heavy Industry Co.).

ii) POWERED ICE-SAW AND BORING MACHINES

An ice-saw driven by a 3.2 hp 2-cycle gasoline engine (made by the Fuji Heavy Industry Co.), a Pionjär boring machine driven by a 6 hp 2-cycle gasoline engine, a small boring machine driven by a 2-cycle gasoline engine (presented by the Tanaka Kogyo Co.), and a boring machine (made by the Tone Boring Co.) driven by a 4-cycle gasoline engine (made by the Fuji Heavy Ind. Co.) were prepared (Figs. 52, 53). All of these tools were tested in the low temperature testing room at Mitaka down to $-40°C$. There, a special lubricating-oil prepared by the Nihon Petroleum Co. was found necessary for easy starting of these engines.

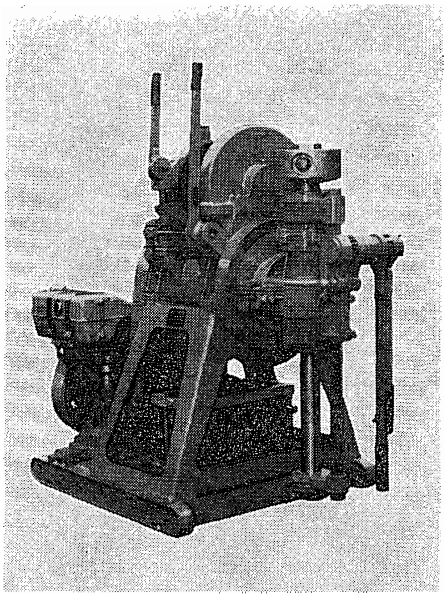


Fig. 53 (a). T-100 type boring machine (prepared by the Tone Boring Machine Co.) driven by a 4-cycle gasoline engine (prepared by the Fuji Heavy Industry Co.).

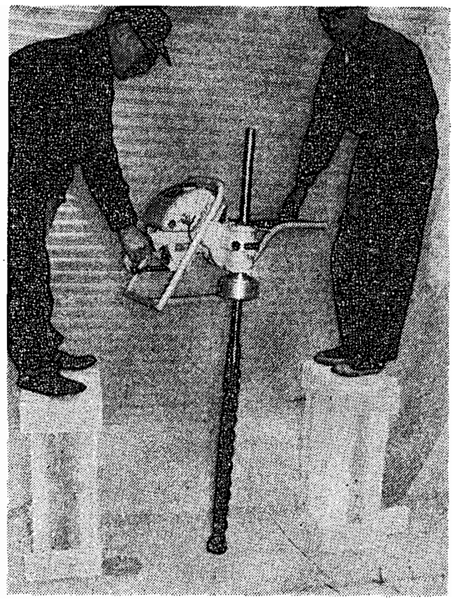
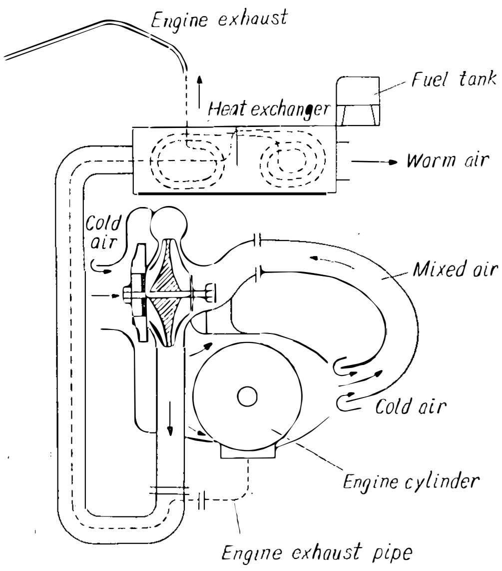


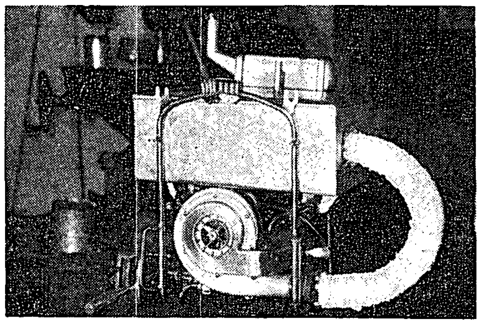
Fig. 53 (b). T-10 type tone boring machine.

iii) WARM-AIR HEATER UTILIZING ENGINE WASTE HEAT

A special warm-air heater utilizing the waste heat of a 2-cycle gasoline engine as shown in Fig. 54 was devised by Prof. S. AWANO. A special 50 cc, 2-cycle gasoline engine drove two fans, one of which was a small cooling fan and the other a large blower. The engine-cooling air blown by the small centrifugal fan was heated by the engine cylinder when it went through the engine cooling fins. This hot air was mixed with the cold fresh air after it was blown out of the fins, and sucked again into the large blower. The air delivered from the large blower was led to the exhaust gas heat exchanger which was set on the engine. As the exhaust port of the engine was opened soon after top dead center, the exhaust gas temperature was very high. The hot exhaust gas was blown through the helical heating coil of stainless steel pipe installed in the heat-exchanger, and heated the mixed warm air still more. When the engine was started, warm and dry air was immediately delivered from the outlet of a flexible steel tube at a rate of 45~110 m^3/hr and the temperature of the air went up to about (t_R+23) °C, where t_R is the room temperature. The available energy rate was 300~700 kcal/hr This would have been useful as a dryer or a portable air conditioner. But it was desired to elevate the outlet temperature still more. This heater was made in the factory of the Nihon University with the use of the engine presented by the Kyoritsu Nōki Co.



(a)



(b)

Fig. 54 (a), (b). Portable warm-air generator utilizing the exhaust-gas heat energy and cooling loss of a 2-cycle air-cooled gasoline engine.

iv) HAND OPERATED HOT-AIR-HEATER

Two types of a hand operated hot-air-heaters were designed by Prof. S. AWANO and made in the factory of the Nihon University (Fig. 55). They were used as hand dryers on the trips. Each was composed of three parts, i. e. a pressurised oil heater, a small hand-operated fan, and a finned tube type cylindrical heat exchanger. When the heater was ignited, and the handle was turned by hand, hot air was blown out from the flexible tube. The outlet temperature was about (t_R+88) °C and its available energy

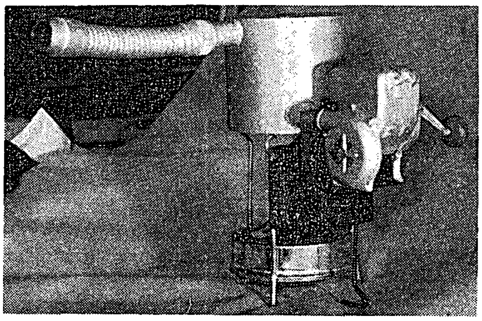


Fig. 55. Hand operated hot-air generator.

rate was 130 kcal/hr in the smaller type, and (t_R+105)°C and 160 kcal/hr in the larger type. The fans were presented by the kyoritsu Nōki Co..

Many other machines and tools such as a lathe and milling machine were prepared and transported to the Base.

The details of the mechanical equipment prepared for the life at the Base is shown in Tables in the Appendix.

13. 2. Results of actual use in the first expedition

i) BATTERIES AND DRY-CHARGER

No trouble arose at the Base during one year from February, 1957 to February, 1958.

ii) ICE-SAW AND BORING MACHINES

The ice-saw was very effective in cutting out ice blocks from icebergs; but the engine problems of easy starting were still left to be solved.

iii) PIONJÄR TYPE BORING MACHINE

Pionjär type boring machine did not operate well because of slight damage caused by inadequate packaging. Generally speaking, the soundness of packing was most important for the smooth operation of the engines and other machines when they were used in the Antarctic.

iv) THE WOODEN HANDLES OF HAMMERS

They were apt to be broken or slipped out because of the dry air of the Antarctic.

13. 3. Other machines prepared for the second and third expeditions i) 1KW, A. C. PORTABLE GENERATOR

An A.C. portable generator of 100V, single-phase, 1KW rating driven by a 2-cycle gasoline engine was prepared as the electric source of the electric boring machine which was mounted on a snow-car and used for measuring the thickness of ice.

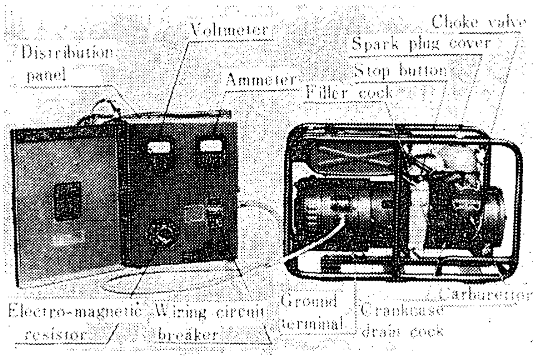


Fig. 56. Portable 1KW, A. C. 100V electric generator (prepared by Tokyo Engine Ltd. Co.).

Fig. 57. Webust type hot-air generator 100SN (prepared by the Mikuni Shoko Co.).

ii) WEBUST TYPE AIR-HEATER

An hot-air heater of the Webust type (prepared by the Mikuni Shoko Co.) was very useful for the pre-heating of the engines of snow-cars. The heater supplied a hot-air jet at a rate of 550m^3/hr, and also heat of 11,000 kcal/hr by the burning of gas-oil at a rate of 1.55 litres/hr.

Besides this heater, a Hamann Nerson type, large hot-air heater was used very effectively; it was very useful for the trips in the Antarctic field and in the inner high-lands.

iii) PINAZZA-TYPE BORING MACHINE

A pinazza-type boring machine was prepared in place of the pronjär type for the second expedition.

iv) WATER PUMP DRIVEN BY A 5 hp, 2-CYCLE GASOLINE ENGINE

As shown in Fig. 58, a portable water pump driven by a 5 hp gasoline engine was prepared by Tokyo Engine Co. to pump up the water of puddles or ponds into the water-reservoir.

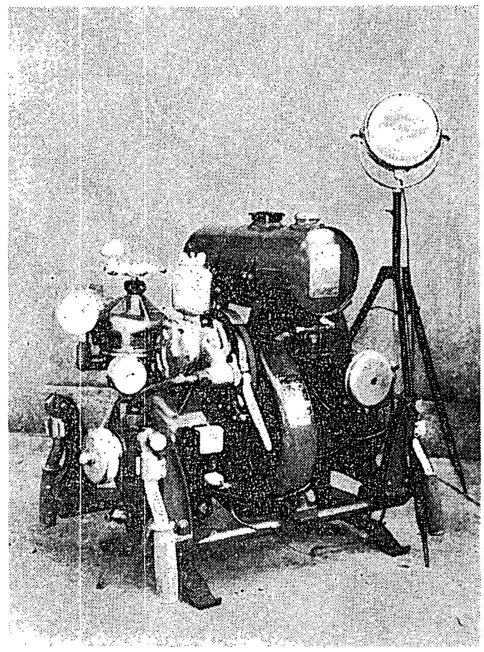


Fig. 58. Water pump driven by a 5hp, 2-cycle gasoline engine (prepared by the Tokyo Engine Co.).

14. Conclusion

In this report the authors have described the snow-cars, sleighs, electric-generators, heating system and some other mechanical equipment that were prepared for the first (1956/1958), the second (1957/1958), and the third (1958/1960) JARE.

Fortunately, in the first expedition, the Syowa Base was built on Ongul Island and most of the cargo, including the machines and fuels, was transported there and 11 members were able to gain precious experience with the comfortable but hard life at the Base through one year. However, in the second expedition, regrettable to say, the utmost which could be done was to visit the Base and take the remaining 11 members back from there without leaving any one of the new team or any one of the new machines which had been prepared for the expedition. But in the third expedition 59 tons of cargo and 14 members of the JARE were transported safely by two helicopters from the Soya to the Base.

As stated thus far, the authors had to devise and prepare many machines which were suitable for the life in the Antarctic, for transportation, and for the trips under many restrictions. The members of the team had to install the prepared machines at the Base and to use them most effectively. The success of these difficult tasks was to be obtained only by the cooperation of the designers, manufacturers, and the team members. This means that the new field of "Antarctic engineering" is being developed. So, consequently, if the work of the JARE is to be continued, an "Antarctic Research Institute" in which engineering problems as well as those on the natural phenomena in the Antarctic can be studied must be established in Japan.

1) **Members of Special Committee for JARE of Japan Society of Mechanical Engineers**

Masaaki KAWADA (Prof. of University of Tokyo, Engrg. Dept., Committee chairman)

Osamu HIRAO (Prof. of University of Tokyo, Institute of Industrial Science, Committee secretary)

Seiiti AWANO (Prof. of Nihon University, Engrg. Dept., Committee member)

Junkichi NAGAOKA (Prof. of Tokyo University of Fisheries, Committee member)

Yasuhei HIRAGURI (Hitachi Ltd. Co., Committee member)

Riichi MAEDA (Nissan Motor Ltd. Co., Committee member)

Masanosuke YANAGIMACHI (Yanagimachi Solar Energy Res. Institute, Committee member)

2) **Technical members of JARE**

Eisaburo NISHIBORI (Prof. of Kyoto University, Sub-commander of the First Exped. Team. Commander of the First Wintering Team)

Tatsuo TATSUMI (Asst. Prof. of University of Tokyo, Member of the First Exped. Wintering Team. Commander of the Fourth Exped. Team)

Masao OTSUKA (Isuzu Automobile Ltd. Co., Member of the First Exped. Wintering Team and of the Third Exped. Team)

Kenzo ARAGANE (Komatsu Manufacturing Co., Member of the First Exped. Team and of the Third Exped. Wintering Team)

Hachiro MARUYAMA (Azabu Automobile Ltd. Co., Member of the Second and Third Exped. Teams)

Masayoshi MURAYAMA (Prof. of Yokohama University, Member of the First Exped. Team and the sub-commander of the Second and Third Exped. Teams. Commander of the Third Exped. Wintering Team)

Sadanori MURAUCHI (National Science Museum, Member of the First and Second Exped. Teams and Third Exped. Wintering Team)

Takeo TAKEUCHI (Komatsu Manufacturing Ltd. Co., Member of the Second Exped. Team)

Shinpei ISHIWATA (Komatsu Manufacturing Ltd. Co., Member of the Second Exped. Team)

Ichiro KANEKO (Isuzu Automobile Co., Member of the Second Exped. Team)

Hitoshi TAKAHASHI (Meidensha Ltd. Co., Member of the Second Exped. Team)

Shunichi HONDA (Victor Automobile Ltd. Co., Member of the Second and Third Exped. Teams)

APPENDIX

Table I. LISTS OF MACHINES, TOOLS AND MATERIALS PREPARED FOR THE 1ST EXPEDITION.

(1) Snow-cars and forklift

Items	Numbers	Maker	Remarks
Gasoline snow-car	2	Komatsu Mfg. Co.	
Gasoline snow-car (wrecker)	1	〃	
Diesel snow-car	1	〃	with torque-converter Ref. Table I. 15 (a), (b).
Spare parts for snow-cars	1 set	〃	
Forklift	1	Toyo Unpansha	unused
Spare parts and tools for same	1 set	〃	

(2) Cargo-sleighs

Wooden cargo-sleighs	16	Yokohama Yocht Co.	18 sleighs were prepared, 2 sleighs were not shipped.
All-plastic caboose	2	Honda Giken Kogyo	One of them was burnt down at the Base.
Sleigh for small compressor	1	Yokohama Yocht Co.	

(3) Rubber boats and plates

Cargo rubber boat	6	Mitsubishi Denki Co.	
8 man rubber boat	2	〃	
5 man rubber boat	7	〃	
2 man rubber boat for air-plane	2	〃	
1 man rubber boat for air-plane	1	〃	
Cylinders and spare-parts	1 set	〃	
Girderages for rubber boat	2	Delta Zosen Co.	
2 cycle-gasoline engine for rubber boat	4	Kokusai Kyotei Co.	
Engine bed for same	4	Delta Zosen Co.	
Propeller	1	Kokusai Kyotei Co.	
Plugs	5	〃	
Tank-cap	2	〃	
Blade of water pump	2	〃	
Propeller pin	8	〃	
Astro-compass mount	2	Tamaya	
Oars	36	Delta Zosen Co.	

(4) Electric generators

20 KVA Diesel electric generator	2	Isuzu Automobile Co.	
Spare parts for same	1 set	〃	Ref. Table 2
3 KVA Diesel electric generator	1 set	Yammar Diesel Co.	
Spare parts for same	1 set	〃	
1 KVA wind-mill electric generator	1	Honda Giken Kogyo	blown out to sea, unused.

(5) Heating furnaces, water-making equipment and hot-air generators

Items	Numbers	Maker	Remarks
40000 Btu/h warm-air heating furnaces	4	Minorikawa Factory	
20000 Btu/h oil-stoves	3	〃	
Spare parts for heating furnaces	3	〃	Ref. Table I. (16).
1/4 HP single phase motor	3	Toshiba Shoji	for burning fan of heating furnace
1/4 HP exhaust fan	1	Minorikawa Factory	
Ice-melting equipment and hot-water making equipment	1 set	Factory of Engr. Dept. of Nihon Univ.	
ice-melting tank	1		Steel plates for tanks were presented by Niso Seiko Ltd. Co.
hot-water tank	1		
exhaust-gas heat-exchanger	2		
oil-burner	1		Steel tanks, heating coils, and exhaust-gas heat exchanger were aluminized by the courtesy of Nihon Almer Co.
circulating water pump	2 set		
heating coil	2		
head tank	1		
piping (insulated) 1″	1 set		
piping (insulated) $1^1/_2$″	1 set		
Warm-air generator	1 set	Factory of Nihon Univ.	A 2-cycle gasoline engine was presented by Kyoritsu Noki Co.
Hand-operated warm-air generator	10 set	presented by Factory of Nihon Univ.	Miset-fans were presented by Kyoritsu Noki Co.
Ventilator with heat exchanger	1 set	presented by Okamura Manuf. Co.	blown out to sea

(6) Boring machines

Pionjär boring machine	1	Rasa Shoji Co.	
Ice boring machine	1	Tanaka Kogyo Co.	blown out to sea
Tone T-100 type boring machine	1 set	Tone Boring Co.	Engine was prepared by Fuji Heavy Ind. Co.
Tone T-10 type boring machine	1 set	〃	
Spare parts for T-100 and T-10 type	1 set	〃	

(7) Loading machine and tools

Steel tripods	2	Kito Manuf. Co.	
Chain-block	2	〃	
Lever-block, 3 tons	3	〃	
〃 , 3/4 tons	4	〃	
I-beam chucker	4	〃	unused
Wire-clip, 12 mm	24	〃	
Pulley, 2 tons	20	〃	
Wire-rope			
12 mm×2 m endless	6	〃	12 mmφ wire was too weak.
12 mm×10 m single	20	〃	14-16 φmm wire was more suitable.
12 mm×2 m loops at both ends	20	〃	
12 mm×5 m 〃	10	〃	
Hooks to hang drum	4 set	〃	unused

Items	Numbers	Maker	Remarks
Manila-rope (20 mm × 30 m)	8	Kito Manuf. Co.	
Rope-clip (12 mm, V type)	40	〃	Number must be increased.
Turn-buckle (12 mm)	5	〃	
Shackle (12 mm)	13	〃	
Anchor (1″ SGP × 1 m)	20	〃	Tip was too weak.
〃 (6 × 50 × 50 × 1 m)	20	〃	〃
Chain-clip (for 3 ton lever-block)	4	〃	unused
Spare parts	1 set	〃	Ref. Table I, (17).

(8) Gas-welding equipment

Oxygen cylinder (700 *l*, dry gas)	8	Nihon Oxygen Co.	1 cyl. was used.
Acetylene cylinder (55 *l*, dry gas)	6	〃	〃
Welder, A–medium type	1	〃	
, A–1 type	1	〃	
Cutter, CB–small type	1	〃	
, CB–1 type	1	〃	
Oxygen regulator, 120 type	2	〃	
Acetylene regulator, 5 kg type	2	〃	
Brazing powder	1 kg	〃	
Welding rod, 2 mm	10 kg	〃	
, 3 mm	20 kg	〃	
Brass rod, 2 mm	5 kg	〃	
Oxygen hose, 20m ($^1/_4$″ × 3B)	2	〃	
Acetylene hose, 20 m ($^3/_8$″ × 2B)	2	〃	
Hose-clamp	10	〃	
Tools and spare parts	1 set	〃	

(9) Storage battery

Battery (40S, 12V, 150 AH)	20	Furukawa Electric Coal Co.	
Dilute H_2SO_4 (18 *l*)	20	〃	
Conc. H_2SO_4 (18 *l*)	2	〃	
H_2SO_4 bath	1	〃	
Battery tester	3		
Spare part and tools	3 sets		

(10) Cold-storage equipment

1HP unit-cooler	2	Nakano Refrig. Machine Co.	unused
Cold air ducts	1 set	〃	
Insulated door	1 set	〃	
F–12 refrigerant	20 kg	〃	

(11) Machine-tools

Lathe (4 ft)	1	Isuzu Automobile Co.	unused
Accessories for same	1 set	〃	

Items	Numbers	Maker	Remarks
Electric drill (1/2HP)	1	Hitachi Manuf. Co.	very useful
〃 (1/4HP)	2	〃	〃
Electric grinder	1	〃	〃
Electric grinder (hand type)	1	〃	〃
Small air compressor	1	〃	〃
Electric fan	4	〃	This was to be used for equalizing the room temperature distribution. unused.
Electric-heater	4	〃	used in dark room
Stand for electric-drill	1	Banzai Motor Co.	very useful
Breast type hand-drill	1	〃	〃
Hand-grinder	1	〃	unused
Gasoline blow-torch (1 *l*)	6	〃	very useful
G-20 type hand oil pump	6	〃	too many
SOP-2 type syphon pump	4	〃	very useful for fuel transfer
Wing pump	2	〃	Number must be increased.
Spray-gun	1	〃	unused as the paint was deteriorated.
Vise (8″ box type)	1	〃	Small bench type must be prepared too.
114R type pipe screw cutter	1	〃	
HS-3 screw jack (3 tons)	3	〃	very necessary
Tap-wrench (several sizes)	3	〃	
Die-wrench (〃)			
Tap-dies (〃)			One set 3×0.6～14×2.0 inch size must be prepared.
T-56 tube flaring cutter	1	〃	unused
L-50 valve lifter	1	〃	〃
Hack saw	3	〃	very useful
Saw-blade (10″)	12 dozens	〃	〃
Radio-pliers	3	〃	〃
Pliers (8″)	5	〃	〃
〃 (6″)	5	〃	〃
Nipper (6″)	3	〃	〃
Pliers (8″)	3	〃	〃
〃 (6″)	3	〃	〃
Metal shears (straight)	1	〃	〃
〃 (curved)	1	〃	〃
File (sets consisting of various kinds)			sets of 5 and 10 kinds useful
File handle	30	〃	too many
File for saws	12	〃	
Center punch, 5×3/8″	5		Punches of good quality must be selected.
Crosscut chisel	2		
Flat cold chisel, 3/4″	3		
〃 , 6/17″	2		

Items	Numbers	Maker	Remarks
Wire-brush	5		
Double-end wrench, BT-9	3		select good quality
Double-end wrench, BT-6	1		〃
Socket-wrench (mm size), 15	2 sets		〃
10	1 set		〃
Box wrench (mm), BT 61 (set of 6)	2 sets	Banzai Motors	〃
Adjustable wrench, 12″	2	〃	
〃 8″	2	〃	
〃 6″	2	〃	
Pipe wrench, 36″	1	〃	not necessary
〃 18″	1	〃	necessary
〃 8″	1	〃	necessary, Wrench bought in Cape Town was very easy to use.
〃 6″	1		(ditto)
Screwdriver (various kinds, flat and cross)			(ditto)
C-clamp vise, 8″	2		
〃 〃 5″	5		
〃 〃 3″	5		
Hand vise	1		
Oiler can	10		
Grease gun	3		
Drill bits (various kinds)			Small diameter bits were easily broken; therefore increase number of them.
Wire wheel (8″)	1	〃	
Grinder wheel (8″)	4	〃	
〃 (4″)	4	〃	
Dresser	4	〃	
Oil stone	5	〃	
Sandpaper (various kinds)			extremely fine, also necessary
Valve-seat lapping tool	5	〃	
〃 〃 rubber	5	〃	
Stud bolt extractor	1		
Reverse tap	1		select good quality
Pilot reamer set (set of 11)	1		
Work lamp	15		used for night illumination
Soldering iron, 300 W	2		
〃 150 W	2		
Hammer, 1 lb	5		
〃 1/2 lb	2		
〃 3 lb	1		
Sledge hammer, 10 lb	4		
Copper mallet, 2 lb	2		
Wood mallet (large)	2		
〃 (small)	3		

Items	Numbers	Maker	Remarks
Slide hammer puller	1		
"Super-clip" puller	1		
Piston ring compresser	1		
Motor siren	1		useful for signals within Base
Hand siren	1		
Tods and parts for clocks	1 set	Nakamura Tokeiten	
Funnel	10	Banzai Motors	

(12) Measuring tools and instruments

Folding scales	3	Banzai Motors	not enough
Steel scales	2		
Feeler gauge (mm)	1		
Calipers, inside and outside (set of 2)	1		
Compasses, 8″	1		
Sqare, $5\times3^1/_2$	2		
Height or surface gauge	1		
V block	2		
Micrometer calipers, 0～25 mm	1		
〃 25～50 mm	1		
〃 50～75 mm	1		
Thermometer (column), 0～100°C	10	Banzai Motors	not enough
〃 (〃), −40～+50°C	10	〃	〃
Compression gauge	1	〃	
Vacuum gauge	1	〃	
Battery hydrometer	10	〃	
Volt-ammeter	2	〃	Tester is better.
Frequency meter	2	Meidensha	
Measuring cup	10	Banzai Motors	

(13) Materials

Galvanized sheet steel (flat)	100	Nippon Kokan	for passageway roof
〃 (corrugated)	100	Kinoshita Shoten	〃
Aluminum sheets	4	Takada Aluminum	al. fittings very useful
Steel angle, 3×25×20 ft	68 kg	Kinoshita Shoten	
〃 3×40×5.5 m	101 〃	〃	
Round bar, 6 mmϕ×5.5 m	9 〃		
〃 8×5.5 m	15 〃		
〃 9× 〃	16 〃		
〃 13× 〃	29 〃		
〃 19× 〃	37 〃		
〃 25× 〃	42 〃		
〃 80×500 mm	20 〃		
〃 100×500 mm	31 〃		
Steel sheet, 0.6 mm×3 ft×6 ft	16 〃		

Items	Numbers	Maker	Remarks
Steel sheet, $1.0 \times 3\,\text{ft} \times 6\,\text{ft}$	26 kg		
〃 $2.3 \times 3\,\text{ft} \times 6\,\text{ft}$	30〃		
Steel plate, $4.5 \times 3\,\text{ft} \times 6\,\text{ft}$	59〃		drifted away
Thick plate, $10 \times 3\,\text{ft} \times 6\,\text{ft}$	131〃		
Steel pipe, $1^1/_2'' \times 18'$	43〃		
〃 $1'' \times 8'$	27〃		
〃 $^3/_4'' \times 18'$	46〃		
〃 $^1/_2'' \times 18'$	7〃		
Steel wire, No. 20	20〃	Kinoshita Shoten	
〃 No. 14	20〃	〃	
〃 No. 10	20〃	〃	
Copper tubing			
$6\,\text{mm}\phi \times 0.8\,\text{mm} \times 16'$	2 lengths	Furukawa Denko	
$8\,\text{mm}\phi \times 0.8\,\text{mm} \times 16'$	〃		
$10\,\text{mm}\phi \times 1.0\,\text{mm} \times 16'$	〃		
$12\,\text{mm}\phi \times 1.0\,\text{mm} \times 16'$	〃		
$18\,\text{mm}\phi \times 1.2\,\text{mm} \times 16'$	〃		
Piano wire, 3 kinds			
Wire rope (5 mm)	400 m		
Solder	10 kg	Banzai Motors	too much
Soldering paste	500 grams	〃	not enough
Insulation tape (black)	10 rolls	〃	must have good low-temperature performance
Vinyl tape	10 rolls	〃	
Asbestos yarn	10 kg	〃	
〃 tape	5 rolls	〃	
〃 sheet, 1 m × 1 m	3 sheets		
Rubber sheet, 1 m sq., $t=2$ mm	4 sheets		
Bakelite plate, $t=8$ mm	6		
Rubber hose, $1^1/_2''\phi$	40 m		
〃 $1''\phi$	40 m		
〃 $^3/_4''\phi$	40 m		
〃 $^1/_2''\phi$	40 m		
〃 $65\,\text{mm}\phi$	10 m		
Hose clamps (various sizes)			
Vinyl pipe, $6\,\text{mm}\phi$	20 m		must be oil-proof, cold-proof, and heat-proof
〃 $8\,\text{mm}\phi$	20 m		
〃 $10\,\text{mm}\phi$	20 m		
〃 $12\,\text{mm}\phi$	20 m		
〃 $18\,\text{mm}\phi$	20 m		
Polyethylene thick sheet (yard width)	200 m		very useful
"Super sheet packing", 1 m sq., $t=2$ mm	2		
Waste (rag), 150 lb			
Red lead, 1 lb	1		
Hermetic paste, 1 lb	1		

Items	Numbers	Maker	Remarks
Lapping compound, (fine) 1 lb	1		
(medium) 1 lb	1		
Grease nipple (various kinds)			
Vee belt, 120	3		
Electric bulb, 12 V., 20 W	100		
Wiring material (various kinds)		Okabe Shoten	
Bolts, nut, washers		Takayama Shoten	
Electric wire, 4 mm (enameled)	100 m		
Terminals for wiring	100		
〃 battery			

(14) Tools for unpacking and transportation

Crowbar with nail-extracting slots	10		
Nail extractor	3		
Crowbar, 1500 mm	10		
Lever pole (oak), 2000 mm	6		
Roller (oak), 1500×100 ϕmm	6		
Saw (large)	2		
Wood-working tools (sets)	3		
Axe	2		
Drum can carrier	1		
Drum can tilter	1		
Winch (1 ton)	1		
Two-wheel truck (pipe construction)	1		

(15) Supplies for snow-cars

(a) Engine supplies (Toyota Motor Co., Ltd.)

(Note: Symbol * indicates items used.)

Part No.	Item description	Quantity
	Engine (Model F 105)	1*
F 11371	Gasket, valve rocker arm cover	3
F 11213	Gasket, cylinder head	7*
F 12231	Gasket, valve lifter cover	3
F 12302	Oil retainer, complete, timing gear cover	3
1161	Gasket, oil pan, front and rear	4*
1160	Gasket, LH, oil pan	2*
1159	Gasket, RH, 〃	2*
12103	Screw, oil pan	3*
F 13111	Piston	3*
F 13411	Compression ring, piston	12*
F 13511	Oil ring, piston	12*
F 13711	Shim, connecting rod	12
14142	Bolt, flywheel	6
B X11795	Shim, crankshaft front bearing	3

Part No.	Item description	Quantity
B X11796	Shim, crankshaft 2nd and 3rd bearing	6
B X11797	Shim, 〃 rear 〃	3
B X11773	Oil stopper, 〃 〃	2
F 14512	In take valve	6
F 14522	Exhaust valve	6
F 14532	Valve spring	12
1547	Stem guide, intake valve	6
1548	〃 , exhaust valve	6
14552	Seat, valve spring	6
F 14551	Cap, 〃	6
F 14591	Oil seal, valve stem	6
1562	Retainer, valve stop ring	6
1552	Cap stopper, valve spring	12
1554	Push rod	6
1538	Screw, valve adjusting	6
1054	Rocker shaft, valve	2
18164	Rubber, water pump shaft	3
B Q16311	Fan belt	10*
B Q29500A	Ignition coil assembly	3*
B J R18201	Distributor ignition cord, complete	1*
B J R18296	Resistor, coil	3*
S A18295	Resistor, spark plug	6*
B J R27337	Condenser, complete	3*
F 27600	Spark plug	24*
5502	Gasket, spark plug	24*
B Q27000	Generator assembly	1*
	Bearing for generator	1
B Q27700	Voltage regulator assembly	3*
B Q28000	Starter motor assembly	2*
	Cap, distributor rotor	3*
54337	Condenser, complete	8*
54317	Breaker arm, complete	8*
54327	Contact point, complete	8*
F 23213	Packing, exhaust pipe	4
F 25400	Fuel pump assembly	2*
A-FX 25500	Carburetor assembly	1*
F 18312	Packing, carburetor	2*
1759	Sleeve	10
1676	〃	4
2344	〃	12
BXSST1001	Engine adjusting kit	3*
BXSST1002	Guide pine, cylinder head	1*
BXSST1003	Valve guide tool	1*
BXSST1022	Pulley puller, crankshaft	1*
BXSST1061	Screw driver, carburetor	2*
FA60 SST1072	Clutch guide tool	1*

(b) Chassis supplies (Komatsu Seisakusho)

Part No.		Item description	Quantity
KC20	H 700b	Caterpillar assembly	3*
〃	B 155a	Strainer	2*
〃	B 156a	Drain plug, oil	1
〃	B 701a	Radiator assembly	1*
〃	B 733	Hose radiator	4*
〃	B 735	〃	4*
PG20	T 324	Clamp	20
KC20	B 832	Rubber hose	2*
〃	B2832	〃	2*
〃	D 224	Snap ring (14.8 d)	6
HD50	33225	Spring (Forkshaft)	3
KC20	D 312	Snap ring (47.5d)	1
〃	D 323	(95d)	1
〃	D 324	(97d)	1
〃	D 413	Gear, main 1st & 2nd speed	1
〃	D 415	Needle bearing	3
〃	D 513	Counter gear, 2nd & 3rd	1
〃	D 516	Snap ring (76.5 d)	1
〃	D 614	〃 (33 d)	1
〃	D 453	Shim	10
〃	D 653	〃	20
KD20	D 412	Gear, main, speed reduction	1
〃	D 513	Gear, secondary, 〃	1
KC20	E 170	Needle bearing	6*
KC20	E 191	Snap ring	8*
〃	F 312a	Drive shaft	2
〃	F 319a	Feather key	6
〃	F 313	Cap nut	2
〃	F 314a	Lock washer	3
〃	G 311	Coil spring (large)	4
〃	G 312a	〃 (small)	4
〃	G 353	Snap ring (17.5 d)	20
〃	G 461a	Adjusting bolt	2
〃	H 401a	Track roller	20
〃	H 501a	Track carrier roller	4
〃	J 501	Hand brake band assembly	1*
〃	K 201	Release bearing	6*
〃	J 535	Adjusting plate	60
〃	K 241a	Return spring	10*
〃	K 296	Cup	6
〃	K 333	Clutch spring	6
〃	K 343	Pin	3
〃	K 362	Stud bolt	12
〃	K 363	Nut	3
〃	K 501a	Brake band assembly	2*

Part No.		Item description	Quantity
KC20	K 541 b	Return spring	10
〃	L 121	Spindle	2
〃	L 331	Restraining rod	2
〃	L 333	Fork joint	2
〃	M 111 a	Equalizer spring	10
〃	M 112 a	Auxiliary spring	5
〃	M 411	Track roller arm (A)	2
〃	M 412	〃 (B)	2
〃	M 421	Arm shaft (A)	2
〃	M 431 a	〃 (B)	2
〃	M 451 a	Spring support shaft	2
〃	N 686	Piston cup	4*
〃	N 721	Brake hose assembly	4
GD30	N 738	Nipple	5
〃	N 751	Packing	10*
〃	N 752	〃	10
KC20	Q2161	Wiper	2
〃	Q2161	〃	2
〃	Q 169	Blade (Scraper type)	6
〃	Q2108	Defroster, electric heating type	1
〃	Q 171	"Noise filter" (50A)	6
〃	Q 172	〃 (10A)	3
〃	Q2191	Electric bulb (A 12 V, 40/40 W)	12*
〃	Q2192	〃 (A 12 V, 40 W)	12*
KC50	Q 194	〃 (A 12 V, 10 W)	20*
KC20	Q2198	〃 (A 12 V, 15 W)	30*
〃	Q 199	Fuse box	1
〃	Q2211	Speedometer	1*
〃	Q2212	Tachometer	1
〃	Q2213	Ammeter	3
〃	Q2214	Oil pressure gage	3
〃	Q2215	Water temperature gage	3
D30	E 92	Resistance	2
KC20	Q2223	Tachometer unit	1
〃	Q2224	Oil pressure gage unit	2
〃	Q2225	Water temperature gage unit	2
〃	Q 231	Flexible shaft, speedometer	2*
〃	Q2232	〃 tachometer	2
〃	Q2251	Relay, lamp	2
〃	Q2261	Buzzer	2
KC50	Q 156	Relay, horn	4
〃	Q 311	Terminal, positive	2*
〃	Q 812	〃 , negative	2*
HD50	65591	Connector	20*
〃	65592	Spherical joint for connector	40*
GD30	Q 115	Cord connector	5*

Part No.		Item description	Quantity
GD10	E 326	Terminal	20
GD30	Q 825	Terminal, ring	20
〃	Q 851	〃	20
〃	Q 849	〃	10
〃	Q 853	〃	10
KC20	Q 841	〃	2
KD20	Q 161	Wiper	1
〃	Q 191	Electric bulb (24～32 V, 50/50 c.p.)	4
〃	Q 192	〃 (24 V, 45 W)	4
〃	Q 194	〃 (A 24 V, 15 W)	7
〃	Q 198	〃 (24 V, 1 c.p.)	13
〃	Q 229	Temperature gauge, oil	1
〃	Q 214	Pressure gauge, oil	1
〃	Q 226	Resistance for meter	1
〃	Q 223	Tachometer unit	1
〃	Q 251	Relay, lamp	1
〃	Q 261	Buzzer	1
〃	Q 827	Terminal block	1
HD50	65319	Relay, horn	3
KC20	Q 813	Terminal lug, tubular	2
〃	R 341 a	Rim frame	2
〃	R 342 a	Glass	4*
〃	R 346	Sponge rubber	1*
〃	R2792	〃	1*
〃	R2793	Tapping screw	50
〃	R2794	Rivet	20
〃	R 745	Hook	50*
〃	R 746	Twist hook	50*
〃	R 997	Round-head screw (cross-recessed)	50*
〃	R 998	〃 (〃)	150*
〃	R 999	〃 (〃)	100*
〃	80304	Roller bearing, conic	10
KC20	D 213	Oil seal	4
〃	G 422	〃	4
〃	H 454	〃	20
610S	2011	〃	4
〃	4012	〃	4
〃	4512	〃	8
〃	5012	〃	2
〃	5812	〃	4
〃	7513	〃	4
		Hexagonal bolt (various kinds)	*
		Stud 〃	*
		Flat-head screw 〃	*
		Castle nut 〃	*
		Spring washer 〃	*

Part No.		Item description	Quantity
		Lock washer, toothed (various kinds)	*
		Cotter pin 〃	*
		Rivet, hollow	
		Tapered plugs (various kinds)	*
		Grease niple 〃	*
KC20	Y2291	Hook type spanner	1
〃	Y2292	〃	1
〃	Y2293	Steering clutch assembly	1
〃	Y2294	Plate for steering clutch	1
〃	R2741	Window (A)	10*
〃	R2742	〃	8*
〃	Y2900	Shipboard stowing equipment (1 set)	1*
〃	YA 270	Caterpillar connecting tool	2
〃	YA 280	Master pin pulley	1

(16) Spare parts for warm-air furnaces

Items	Quantity	Items	Quantity
Motor, 1/4 hp., single-phase, Toshiba	3*	Outer ring for oil burner	16
Spare parts for above	1 set	Top brick 〃	16
Motor, 1/4 hp., 3-phase, Kurita	1	Spreader 〃	8
Motor for burner, 20-watt	1	Electric heater	24
Oil control valve, complete	1	Pilot lamp	4
Spare parts for above	1 set	Bearing for blower	4
Fan limit control	1	Glass for inspection hole	4
Room thermostat	1	Mica 〃	8*
Magnetic switch	1	Asbestor sheet packing for combustion chamber door	4*
Burner ring for oil burner	4	Vee belt	4
Inner ring 〃	226		

Note: Symbol * indicates items used.

(17) Spare parts and tools for cargo-handling equipment

Brake plate, for 1/2 ton chain block	6	Pawl spring, for 3 ton lever block	6
〃 , 〃 3/4 〃 lever block	6	Ratchet wheel, 〃 1/2 〃 chain block	3
〃 , 〃 3 〃 〃	6	〃 , 〃 3/4 〃 lever block	3
Pawl, 〃 1/2 〃 chain block	3	〃 , 〃 3 〃 〃	3
〃 , 〃 3/4 〃 lever block	6	1/2 inch box spanner	3
〃 , 〃 3 〃 〃	6	3/8〃, 5/16〃, box spanner	3
Pawl spring, 〃 1/2 〃 chain block	3	Cotter pin extractor	3
〃 , 〃 3/4 〃 lever block	6		

Table II. THE PROPERTIES OF FUELS AND OILS PREPARED FOR THE 1ST EXPEDITION

(1) Antarctic gasoline

Items	Quantity	Items	Quantity
Specific gravity, 15/4°C	0.6780	Fractional distillation °C	
Corrosiveness test (copper sheet)	0	Initial boiling point	29
Sulfur content, %	0.003	10%	42
Octane rating (motor method)	80.3	50%	59
Vapour pressure, psi. at 100°F	12.8	90%	94
Tetra-ethyl lead, cc/gal.	0.3	97%	128
Existent gum content, mg/100 cc	0.3	End point	140
Induction period, hrs.	16 or more	Total distillate	99.0

(2) Ordinary gasoline

Specific gravity, 15/4°C	0.721	Tetra-ethyl lead, cc/gal.	1.3
Reaction	neutral	Induction period, hrs.	8 or more
Sulfur content, %	0.01	Fractional distillation °C	
Doctor test	satisfactory	10%	53
Gum, mg/100 cc	1	50%	100
Octane rating (motor method)	83.3	90%	165
Corrosiveness test (copper sheet)	0	97%	188
Vapour pressure, kg/cm^2	0.59	Total distillate	98

(3) Antarctic gas-oil

Specific gravity, 15/4°C	0.8580	Sulfur content, %	0.155
Reaction	neutral	Diesel index	47.9
Flash point, °C	87	Residual carbon, %	trace
Viscosity, at 30°C	33.5	Aniline point, °C	61.3
Fractional distillation, °C, 95%	30.6	Colour (union)	1(−)
Pour point, °C	−55.0	Corrosiveness test (copper sheet)	0

(4) Antarctic aviation gasoline 91L

Specific gravity, 15/4°C	0.7156	Oxidation stability, 100°C × 5 hr.	
Reaction	neutral	Potential gum, mg/100 cc	0.4
Corrosiveness test (copper sheet)	0	Lead precipitation, 〃	0.4
Sulfur content, %	0.004	Colouring	blue
Aniline point, °C	52.2	Solubility in water (test), cc	0
Aniline specific gravity constant	8.341	Fractional distillation °C	
Freezing point °C	−60 or lower	Initial boiling point	49
Octane rating (motor method)	91.3	10%	65
Vapour pressure, kg/cm^2	0.45	50%	80
Tetra-ethyl lead, cc/gal.	2.8	90%	100
Existent gum content, mg/100 cc	0.2	97%	112
		End point	133
		Total distillate	99.0

(5) Kerosene

Items	Quantity	Items	Quantity
Specific gravity, 15/4°C	0.801	Colouring (saybolt)	30 or more
Reaction	neutral	Smoking point, mm	30
Flash point, °C	74	Fractional distillation °C	
Sulfur content, %	0.01	Initial boiling point	200
Doctor test	satisfactory	10%	212
Corrosiveness test (copper sheet)	0	95%	255
Lighting test	satisfactory	End point	275

(6) Antarctic engine oil

Specific gravity	0.870	Viscosity index	146.7
Flash point, °C	218	Colouring	$1^1/_2{}^{(-)}$
Pour point, °C	−37.5 or less	Stability test, 170°C×24 hrs.	satisfactory
Viscosity (saybolt universal seconds)		Neutralization number, KOH, mg/gm	1.09
at 0°F	10.888	Saponification number, KOH, mg/gm	1.46
at 100°F	24.3	Residual carbon, %	0.81
at 210°F	57.9		

(7) Antarctic gear oil

Specific gravity, 15/4°C	0.9277	Viscosity index	135
Flash point, °C	164	Pour point, °C	−42.5
Viscosity (saybolt universal) at 210°F	63.59	4-Ball test, kg/cm²	12.5

(8) Antarctic torque-converter fluid

Specific gravity, 15/4°C	0.8870	Viscosity index	182.8
Flash point, °C	161	Pour point, °C	−55.0
Viscosity (centistoke) at 100°F	18.09	4-Ball test, kg/cm²	5.5
at 210°F	4.56		

(9) Aviation engine oil

Specific gravity, 15/4°C	0.8767	at 100°F	530
Flash point, °C	238	at 210°F	67
Colouring (ASTM)	$4^1/_2{}^{(-)}$	Viscosity index	103
Pour point, °C	−17.5	Residual carbon, %	0.14
Viscosity (saybolt universal)		Neutralization number, KOH%, mg/gm	0.01

(10) Antarctic brake fluid

Viscosity, Centistoke at 130°F	4.48	Erosiveness test, mg/cm²	
at −40°F	870	Copper	0.18
Cold test (−40°F×6 days)	satisfactory	Brass	0.19
Boiling point, °F	267	Tin	0
Flash point, °F	130	Aluminum	0
PH value	8.9	Cast iron	0
Rubber swelling	0.0022	PH value after erosiveness test	6.3

(11) Antarctic anti-freeze fluid

Items	Quantity	Items	Quantity
Specific gravity, 15/4°C	1.032	Tin plate	0.05
Colouring	blue	Solder	0.04
Coagulation point, °C	−75	Brass	0.03
Water content, %	30	Copper	0.05
Corrosiveness test (95°C×150 hrs.), mg/cm^2		Aluminum	0.07
		Additive	contains

(12) Antarctic grease

Dropping point, °F	356	Leakage test, %	0.5
Consistency, U.W.	242	Oil separation, %	0.8
〃 , W	280	Corrosiveness test (copper sheet)	0
Evaporation loss, %	0.88	Mineral oil content, %	71.0