PORT AND OCEAN ENGINEERING UNDER ARCTIC CONDITIONS
TECHNICAL UNIVERSITY OF NORWAY

THE COLLECTION OF OCEANOGRAPHIC DATA FROM THE SEA ICE SURFACE IN WINTER

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Equipment purchased for use from the sea ice surface in winter must usually be modified to contend with extremely low temperatures (down to -55° C.) and extremely variable rates of heat loss including thermal shock, as these problems are not normally considered in commercial design. Solution may be attempted by adapting the equipment to work in the natural environment or by providing a protective enclosure for the device. Sometimes in-house development of a new design is required. Generally speaking mechanical and electrical gear may be made to work in the cold, but at present most electronic equipment, particularly that associated with precision measurement, requires some protection. Typically the Arctic investigator enters the field with environmentally-proven apparatus from some military or space programme placed next to a device requiring a thermostatically-controlled enclosure. Essential equipment (e.g. life support, communications, navigation, etc.) must be made to work in the cold; ideally every component should have a low temperature operational capability. The system to be described has been designed for use on ice in enclosed waters where protection may be needed against ice failure beneath the equipment, but there is no possibility of large scale ice movement transporting the equipment into hazardous regions.

Figure 1 shows the two tracked vehicles which form the basis of our Arctic Research Units together with an oceanographic sled. A sled for supplies behind the second vehicle would complete the picture. The units are intended for far-reaching oceanographic surveys and have been used at distances up to 100 miles away from a central base. In operation, a hole is put through the ice sheet using a drilling rig (not shown in photograph) which operates off the hydraulic winch motor at the front of the vehicle. The vehicle then moves forward dragging the oceanographic sled until a hole in the sled deck is aligned with the hole in the ice sheet. Instruments are lowered by a special winch within the sled superstructure and data is automatically recorded on five-figure logging equipment in

Fig. (1) Arctic Research Units offshore near base on Greely Fiord, Ellesmere Island (80° 30' N., 79°, 30' W.).

the vehicle. These Arctic Research Units have been built up by the Frozen Sea Research Group onto an engine-power transmission-track and frame assembly supplied by the manufacturer (Thiokol). The bodies are formed from two fibreglass skins kept two inches apart by a fibreglass "top hat" section and filled with polyurethane foam insulation. The roof of the vehicle is easily detached and the walls can hinge down at a line just below the windows. The roof may then be replaced and the collapsed vehicle driven onto aircraft of the C130 (Hercules) type with the driver's body protruding in part through an escape hatch in the dropped roof. The fibreglass bodies are immensely strong and all apertures are sealed so that the vehicle will float. All repairs except those to the actual track assembly may be carried out from inside. The engine, transmission, hydraulics, etc., lie in a duct beneath floor level and air drawn downwards into the engine radiator from an opening just below the front windows heats the whole power train before being expelled at roof level at the rear after passing a snow-melting tank. Two such vehicles (with sleds) form an operational unit; they are respectively a mobile laboratory and living quarters. Attachment point at 20-inch centres cover the interior walls so that the fittings within the vehicles may be changed with ease. The instrument vehicle contains a radar system and a gyro compass for navigation purposes; the radar aerial mounted on a tripod above the vehicle roof may be seen in Figure 1. In poor visibility navigation is normally accomplished by setting a course on the radar screen to avoid rough ice and then steering from a gyro repeater in front of the driver. The vehicles have been extensively instrumented to report on their operational condition to the crew. A fire alarm sensor encircles the engine block and a built-in extinguisher can flood the power-train duct with heavy vapour. A multiplicity of engine heating systems

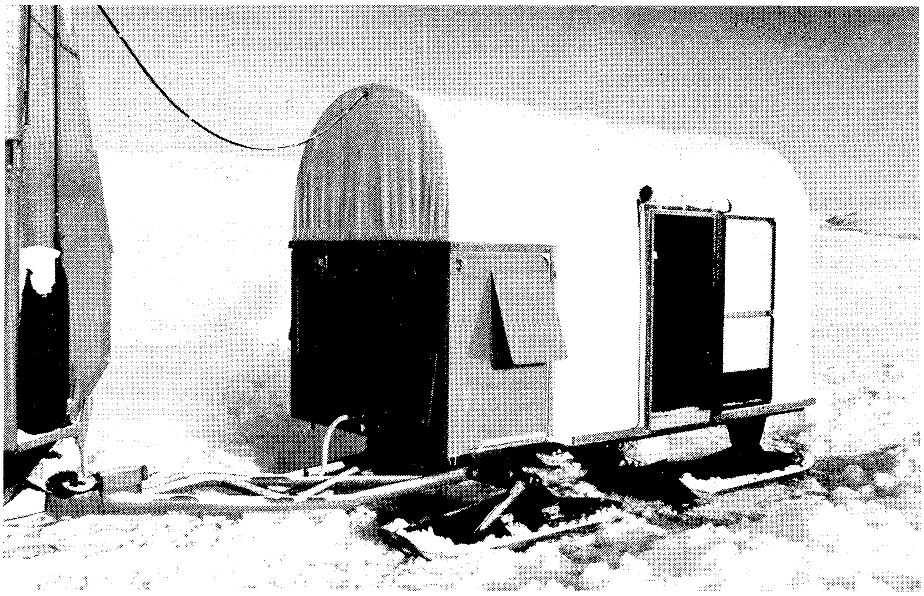

Fig. (2) Oceanographic sled in position behind vehicle showing generator box with inspection hatch open. Note deep shield over air intake louvres.

include a built-in pulse-jet engine heat exchanger (Eberspacher).

Vehicles and sled are designed as one engineering system; either may be used as a primary power source. In the front of the oceanographic sled (Figure 2) is a box of our design containing a 5 kW. air-cooled motor generator set (Onan) which determines its own environment by thermostatically-controlled louvres operating off the cooling air exhaust temperature. This generator box will operate satisfactorily under all conditions of temperature and wind. Waste heat is either dumped outside or enters the "covered wagon" part of the sled superstructure and escapes through the hole in the deck. Thus instruments may be lowered into the hole in the ice sheet surrounded by a warm air blast that is enhanced by provision of a canvas duct for air escape which hangs downward from the periphery of the hole in the sled deck. The top of the generator box forms a warm workshop bench complete with vise, etc. and the generator is used to supply heat and power to both vehicles when parked at night or on station. Figure 3 shows the oceanographic winch mounted in the sled about to lower an _in situ_ CTD instrument into the sea. Signals are transmitted up the cable to a gold-plated slip-ring assembly (noise less than 1 microvolt) and the information transmitted forward to the instrument vehicle by the cable shown at roof level in Figure 2. The winch is driven by 1 horse-power electric motor and has a maximum winching-in-speed of about 1 meter a second when the 1,000 meters of cable are all out. Figure 4 is a view of the interior of the instrument vehicle wherein data available as either a DC voltage or frequency may be recorded on both printed and punched paper tape to an overall accuracy of $\pm$ 2 parts in 10^5. Extensive trials

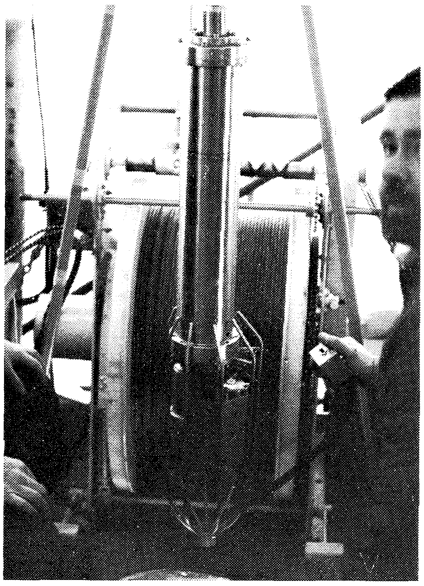

Fig. (3) Winch and in situ CTD equipment in rear of oceanographic sled. Sensor is lowered into ocean through warm air blast.

Fig. (4) Data logging equipment in laboratory vehicle. View from rear of vehicle looking forward.

and some modification have resulted in reliable performance of this equipment under these conditions of vibration and temperature cycling. A high speed point plotter working off an analog output of the digital printer enables three figures of the data to be plotted for immediate visual checking.

The C.T.D. is built by Guildline Instruments under license from the National Research Council, Ottawa. Their Arctic model has a maximum diameter of 4 1/8" which enables operation through minimum sized holes in the ice sheet. Five years of modifications based on user experience relayed back to N.R.C. combined with their active development programme have resulted in a reliable piece of equipment with one outstanding characteristic - - stability. Generally there is little difficulty in reproducing one's measurements to within the manufacturer's stated resolution. We have undertaken calibration procedures in the field allowing full use of this resolution in terms of accuracy of results ($\pm$ 0.01°/oo salinity $\pm$ 0.003° C. temperature).

Each vehicle carried 35 gallons of fuel and the Onan generator tank has 40 gallon capacity. 100 gallons more are carried in the oceanographic sled in tanks beneath seating benches around the canvas walls and 200 gallons further on the supply sled (not shown). The supply sled also carried two large aluminum boxes (60 cubic feet each) with hinged doors sealed with silicone rubber strips

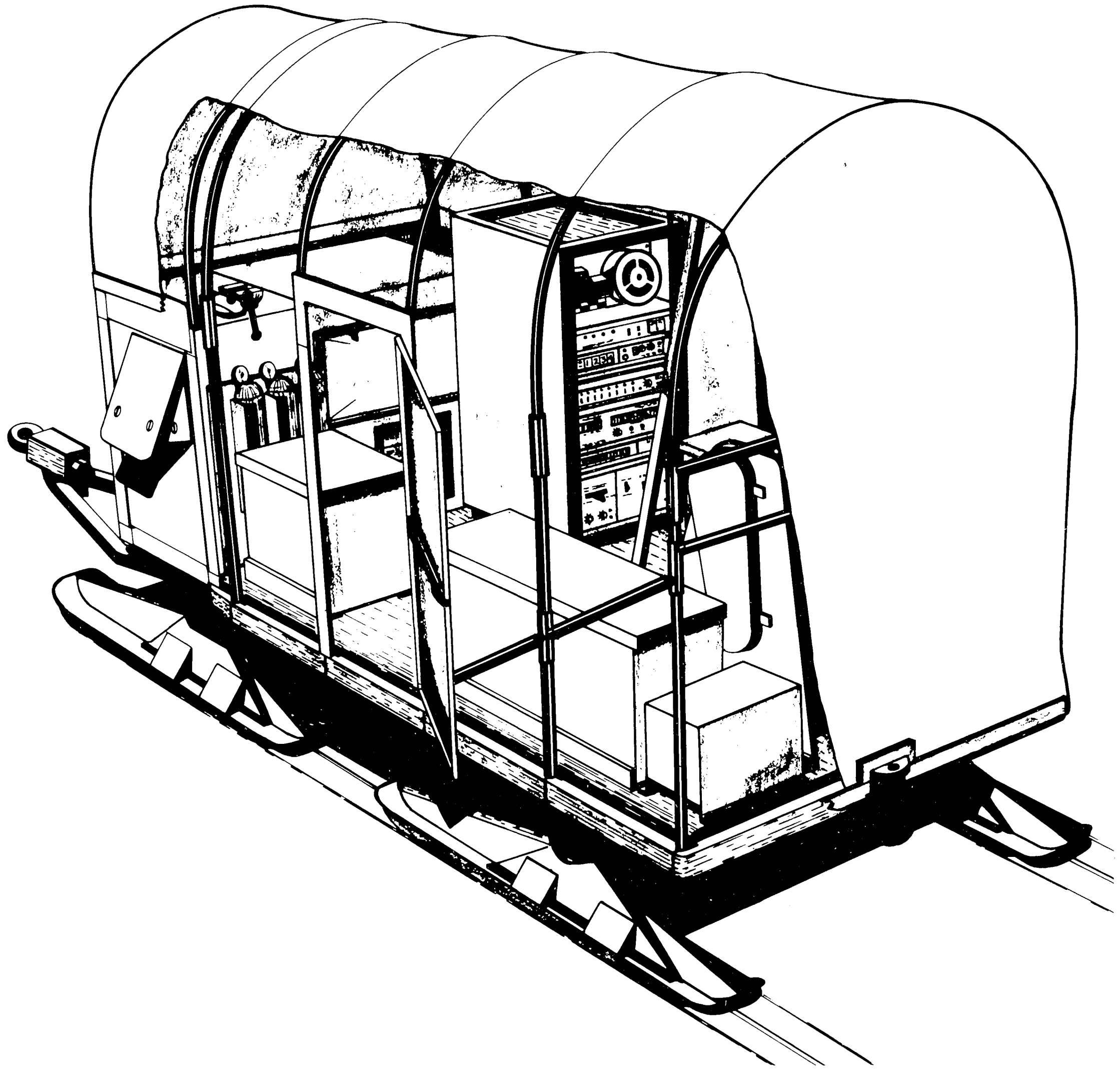

Fig. (5) Self-contained version of oceanographic sled for use in the vicinity of a base.

and held closed by over centre clips. These respectively carry "clean" and "unclean" stores; they also provide floatation for the sled. Under normal operating conditions, it is found that about 35 gallons of gasoline are required over 24 hours to run the entire train thus giving the system an endurance of about 10 days. A second sled can be towed behind each vehicle but although this has been done, it is felt that it is inadvisable over long periods due to the increased probability of track failure. Each vehicle consumes one gallon of fuel for about three miles movement.

The Arctic Research Unit has now seen operation over three years. Defects have proven to be minor and easily rectifiable. Some design changes would be made as the result of experience but, in principle, the concept has worked very well. Accommodation is for a maximum of four persons although three have normally been used. It is important to realize that the units are complex and sensitive pieces of machinery for the use of skilled operators. Extensive spares and accessories are carried so that most repairs including welding can be done in the field and the operators' skills should reflect the variety of tasks from scientific through electronic to mechanical that may be required of them.

The system as described is self-contained and may be flown in and deployed from any place where a plane may land. If oceanographic data is required in the vicinity of a fixed base where accommodation for personnel and vehicles are available, the sled only is required. Figure 5 shows such a sled complete with workshop table, winch, data logging equipment and storage. The principle of operation is the same as before, instruments being lowered into the sea through a warm air blast emerging from a hole in the sled deck. A six-inch diameter hole in the ice sheet can be made by hand using a heavy electric drill operating off the Onan generator. The datalogger is placed on shock mounts six inches above the sled deck in order to remove the electronics from the extreme temperature gradient often found at floor level in such enclosures. One of these "near base" oceanographic data collection systems is presently in operation. During summer months it has been mounted on a large cedar raft. When the ice is thick enough it will be towed off the raft. In this way a seasonal picture of oceanographic conditions may be obtained including details of the freeze-up period, which are of critical importance in determining the year's cycle of events.

From Figure 5 it is easy to visualize the sled when winch, datalogger, oceanographic bottles and storage boxes have been removed. There remains a general purpose warm workshop with continuous air change which will provide a protected environment for any activity under all weather conditions together with a source of electric power. The entire system including the vehicles with their quickly changeable interior fittings is adaptable to a wide variety of technical and/or scientific purposes limited only by range, endurance and payload (1,500 lb. per vehicle, 3,000 lb. per sled).