Short Papers and Notes

MOTOR TOBOGGAN SLED TRAINS IN ANTARCTICA

Introduction

A University of Minnesota expedition spent 88 days doing geological field work in the Ellsworth Mountains in the interior of western Antarctica during the summer of 1962-3. Sled trains pulled by a fleet of five new Polaris motor toboggans were used for transportation. The trains were used at altitudes up to 2000 m. on soft fresh snow, hard 4-foot sastrugi, and smooth blue ice. Each toboggan travelled between 1100 and 1400 miles and the total distance for the fleet was about 6200 trail miles. In addition, during the summer of 1961-2 a smaller expedition spent a little over 2 months in the Ellsworth Mountains using two Eliason motor toboggans and sleds, each machine recording about 750 trail miles.

The two operations added significantly to the experience with these vehicles in antarctic field work. For each machine records were kept of fuel consumption, performance, and mechanical troubles. These details and some of rigging and operating the sled trains, mainly in 1962-3, are summarized here for the guidance of future polar field parties using similar equipment.

The motor toboggans

The motor toboggans used in 1962-3 were Polaris K-95 Rangers, manufactured by Polaris Industries, Roseau, Minn., U.S.A. As adapted for antarctic use, each weighs about 650 lbs., is 10 ft. long, 3 ft. wide, and 3 ft. high without windshield. The toboggan will seat two people normally but only one if ridden side-saddle. It is equipped with a Kohler single cylinder 4-cycle 9.6 h.p. air-cooled engine, automatic clutch and transmission and a gearbox providing forward and reverse speeds and neutral. Drive is by endless track with channel cleats into which hard-rubber lugs are inserted; the traction surface is 1120 in.^{2}. Steering is by two frontal steel skis controlled by a conventional steering wheel. A winch mounted on the rear of the main skis permits lifting the track unit off the snow surface. Windshields are available from the manufacturer and are recommended by us for prolonged field trips. The stated towing capacity is 1000 lbs.

Maintenance and operation. The Polaris toboggans required only routine maintenance and proved to be durable and reliable on the trail. Dependable, efficient operation required the following daily schedule: (1) check oil in engine and gearbox, and (2) lubricate drive chain and steering arm. Every 25 running hours (roughly 200 mi.) the engine oil was changed, the entire machine was inspected for worn parts, loose screws and bolts, and tension and alignment of track. Every 100 operating hours (roughly 800 mi.) the gearbox oil was changed, spark plugs were cleaned and adjusted, and the breaker points were checked and reset.

Blowing and drifting snow complicates the operation of the machine. During a storm the toboggan may become buried and the front completely filled with snow; the tank housing and the engine may also be packed tightly with snow, and several hours may be required to free the machine. Snow may melt and refreeze inside the blower housing and jam the engine. These difficulties can be prevented or minimized by parking the toboggan facing into the wind and covering the engine with a tarpaulin.

The motor must never be left idling with the drive in forward gear. The toboggan could start off or, if attached to a heavy load, burn out the clutch.

The manufacturer recommends that the toboggan not be run continuously under maximum load. It was necessary on occasion, however, to drive the trains steadily at full throttle for long periods to take advantage of good weather, and the machines proved equal to these demands. One toboggan train, for instance, was driven for 26 hrs. fully loaded with only brief stops without developing any mechanical trouble.

Starting the engine. The engine is started by a rope starter; all normally started easily, even when cold, usually on the first or second pull. Although the manufacturer recommends preheating the engine in very cold weather, it was possible to start the motor cold in temperatures as low as — 20°F. Preheating was used only once when snow had melted and frozen again in the blower housing. When an engine did not start after some 10 pulls the spark plug was removed and a little gasoline poured directly into the cylinder. Another method is to spray a small amount of ether into the air intake, but care must taken not to cause damage through an overdose.

No attempt should be made to start the engine unless the area around the flywheel is free of snow. On two toboggans starter pulley casings were broken by efforts to start them despite a jammed (probably frozen) flywheel. A broken starter pulley can be repaired by (1) bending the circular sheet metal plate in front of the flywheel into a sleeve and using a short pipe as a crank, or (2) bolting the grooved rim to a plywood disc and this to the sheet metal plate.

Performance. Mechanical faults developed by the five toboggans were as follows: (1) Numerous rubber bearings at the front mounting of the power unit wore out; a set lasted an average of about 400 mi. (2) Two starter pulleys broke. (3) Three copper oil drain pipes fell off. (4) Three winch units were badly bent (by pushing the toboggan when stuck) and two winch cables broke. (5) Two carburettors failed temporarily, probably from water freezing in the needle valve. (6) One track cleat broke and several were bent. (7) The nuts sheared off one generator. (8) Three windshields became badly cracked or broken. (9) Steering was very difficult before the rudders on the front skis were sawed off. (10) One intake valve stuck.

These failures are mentioned to point out the problems field parties must be prepared to handle and are not intended as criticism of the Polaris toboggan. Although driven over thousands of miles of generally hard and rough surfaces the machines developed only minor and infrequent mechanical troubles. Based on our experiences the manufacturer has made a number of modifications to overcome these problems.

Fuel consumption. Operating at full throttle the toboggan consumes just under 1 gallon of gasoline per hour. Since the fuel consumption is essentially constant regardless of the conditions, the mileage per gallon is a function of the speed possible. Pulling a fully loaded train of two sleds and two men (total about 2000 lbs.) a toboggan can average 5 or 6 mi./h. over a fair surface. Rough sastrugi lower the average speed. It is difficult to pull this load in soft snow and double hauling may be necessary on upgrades.

On trips of a few days' duration lighter loads of about 1000 lbs. were towed and an average speed of about 9 mi./h. could be maintained on firm snow with moderate sastrugi. This load can generally be moved up moderate slopes or through soft snow but at a lower average speed. Daily visits to outcrops from trail camps involve loads of about 500 lbs. per toboggan for a two-man party on one train. The average speed under these conditions on a normal surface is 12 to 14 mi./h.

Capabilities. The toboggans can easily tow the loads claimed by the manufacturer and many miles were travelled with trains weighing about 2000 lbs. excluding the toboggan weight. In one instance a 2400-lb. train of three sleds was pulled a distance of 40 miles, 12 of them up a grade of 1.5 per cent, at an average speed of nearly 4 mi./h. In another, a 3500-lb. train of five sleds was towed 20 miles, mainly slightly down hill, by a single toboggan at an average speed of 3 mi./h.

Unloaded toboggans can climb a 16°-slope on a good surface and are very useful for reaching rock exposures. When descending such slopes a toboggan in gear and throttled down will about hold its speed or accelerate slightly. Should the machine jump out of gear it will accelerate rapidly to unsafe speeds; it is thus advisable to hold it in gear manually on steep slopes.

Travel on bare blue ice is very difficult and should be avoided if at all possible. An empty toboggan has trouble crossing level glare ice and cannot travel up hill on it. Rubber cleats on the drive track seemed to make little difference here. Deep soft snow also slows down travel. The track tends to spin and dig into the snow with a heavy load. When the speed starts to drop, digging-in can often be avoided if all passengers jump off to lighten the load. After a toboggan has stalled it can usually be backed out of the hole, but care must be taken not to run over the tow rope. If backing is impossible, the track must be lifted with the winch and the toboggan shifted by hand to a new spot. It may be necessary to unhitch and circle back after the toboggan has been freed. Slack should be provided in the tow ropes between the sleds when starting a heavy train.

The great towing capacity of the Polaris toboggan makes it possible for three- or four-man parties using two machines to travel hundreds of miles for periods of several weeks away from base camp. A three-man party with two trains travelled 660 miles in 30 days without support; a total load of about 4000 lbs., including all food and fuel for the trip, was carried on the two trains. For comments on the Eliason toboggan see ref. 1.

Sleds

The sled used most in the trains was the Nansen-type Grasshopper sled manufactured by Kolbjörn and Co., Oslo, Norway; it is hereafter referred to as the Nansen sled. It is 13 ft. long, a little over 2 ft. wide and 1 ft. high and weighs about 90 lbs. fitted with a canvas tank. It is built of hardwood lashed with rawhide, has bakelite-surfaced ski-like runners and either end can be front. The effective cargo-carrying length is 8 ft. and the capacity about 1000 lbs., which can be a very bulky load when consisting of trail gear and supplies.

A few times Akhio (banana) sleds were used to supplement the Nansen sleds. These are designed for limited man-hauling or general station use. The large Akhio measures 87 by 24 in. and has a capacity of 200 lbs.; the smaller is 47 by 23 in. with a 100-lb. capacity.

Low toboggan-type sleds with solid bar connections were used in the 1961-2 season. They were 10 ft. long 2.5 ft. wide and fitted with canvas tanks.

Performance. The Nansen sleds performed in general very well. They are strong, slide very easily and are flexible enough to be pulled over very rough sastrugi. On two sleds a runner broke just in front of the first bridge pillar but both were kept in use by turning them end for end. The major problem was loosening of some of the rawhide lashings, relashing with strong twine was effective. The Nansen has a fairly high centre of gravity when fully loaded but these sleds rarely upset. The Akhio sleds were less satisfactory in the trains because of their greater friction and their tendency to tip over in sastrugi. Low toboggan-type sleds have the advantage of a low centre of gravity and are easy to load but the type used in 1961-2 was heavy and pulled harder than the Nansen.

Accessories. Custom-made heavyweight cardboard boxes measuring 24 by 30 in. by 18 in. high were inserted in the canvas tanks on the Nansen sleds and proved very useful. Long items such as tents, skis, and shovels were lashed on top of these boxes. On the rear sled of each train plastic foam mattresses were tied across the boxes for the comfort of passengers. A convenient lashing method is shown in Fig. 1; this permits easy access to any part of the

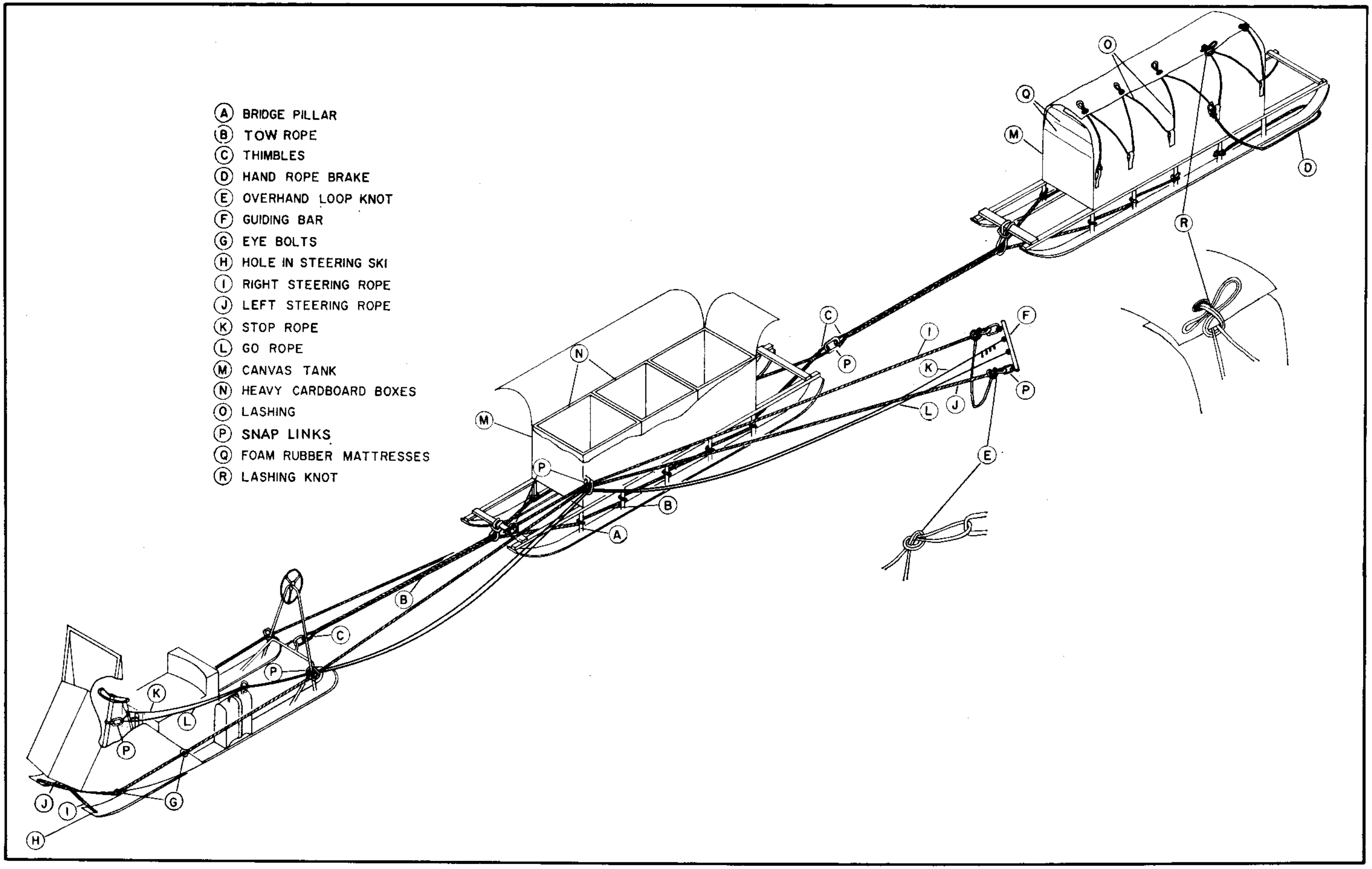

Fig. 1. Sketch of motor toboggan sled train.

load on the trail. Most passengers found it possible to nap in sleeping bags atop the sleds during long trips.

Gasoline for the toboggans was carried in 45-gallon rubber seal drums and in plastic or metal 5-gallon jerrycans. The seal drums (bladders) were mounted cross ways on the front of the sled inside the tank and fitted with spigots for easy filling of jerrycans on the trail.

Sled connections. The sleds were towed with half-inch nylon rope in the manner shown in Fig. 1. Thimbles (C) are tied into the end loops of the ropes and snap links (karabiners) (P) are used to connect toboggan and sleds. The advantage of the long tow rope over a solid bar with ball and socket joint are: (1) The toboggan can make a running start if necessary with a heavily loaded train. (2) The strain in the sled is not localized if the tow rope is looped around several bridge pillars. (3) The greater length of the train provides an extra margin of safety for passengers on the rear sled should the toboggan fall into a crevasse. The chief disadvantage is the poorer control of the train so that the sleds must be braked continuously on down-grades to keep them from overrunning the toboggan.

Braking. Ropes or ice axes were used for braking. Generally a half-inch or thicker manila rope was used. On moderate slopes a handbrake was rigged as shown in Fig. 1 at (D). By pulling upward the rope is forced under the runner. For steeper slopes the train was stopped and a permanent brake installed by wrapping a rope one or more times around each runner and tying it to bridge pillars. This was adequate to hold the sleds on the steepest snow slope down which it was considered safe to drive a toboggan (approximately 15°).

Occasionally ice axes were used for slowing the train by pushing the shaft end of the axe into the snow in front of a bridge pillar. The axe can also be tied to the last crossbar of a sled and operated as a lever, or it can be applied by a passenger sitting or lying on the sled. If ice axes are to be used constantly as brakes, spares should be carried to allow for breakages.

Steering the train

Three methods for steering the sled trains were used: (1) Direct steering from the seat of the toboggan. (2) Remote steering while skiing alongside. (3) Remote steering from the back sled.

Direct steering of the toboggan gives the best control over the train and, if the legs are kept inside the cab, is the warmest method. It is, however, advisable to sit crossways on the seat to prevent being trapped in the cab should the toboggan fall into a crevasse. This method was used mainly on previously travelled trails and other relatively safe areas, or in negotiating steep grades where firm control of the train is possible only in this manner.

Remote steering from skis was done with a rigging slightly modified from that used by Swithinbank[1] and described by Mogensen[2]. The method was employed early in the season and a total of about 400 miles was covered in this way. Steering from skis was eventually abandoned because: (1) The control is rather poor. (2) The method is very tiring. (3) Skiing over hard, high sastrugi is difficult and dangerous. (4) The train may get away from the driver during a fall. (5) It is very difficult to control the train on slopes steeper than 3°.

Remote steering from the last sled is a comfortable and relatively safe method and most of the trail travel was accomplished this way. The driver has good control over both steering and speed of the toboggan. Its chief disadvantage is the loss of control when the back sled is allowed to overtake the toboggan on a downgrade.

Rigging a two-sled train for remote steering from the last sled. (See Fig. 1). Make a guide bar (F) about 18 in. long and 1 in. in diameter with four evenly spaced eye bolts, two of which are at the ends of the bar. Lay a doubled three-eighth-inch nylon rope along the left side of the train with the loop just behind the centre of the rear sled and the ends extending about 6 ft. in front of the toboggan. Pass one loose end through a snap link on the lower front left corner of the canvas tank on the front sled, through another snap link tied to the left side of the winch, through the eye bolts (G) on the left side of the the toboggan near the front and then across the front of the toboggan. Tie the rope into a hole drilled into the front of the right ski. Pass the other loose end also through the snap link at the front left corner of the tank on the front sled, through a snap link tied to the centre of the front crossbar of the sled, through a snap link tied to the right side of the winch, along the right side of the toboggan, through the eye bolts on the right front, across the front of the toboggan and tie to the left ski. Take the loop end of the rope, determine the proper length and tie overhand loop knots (E) on each side. Fasten each loop to an outside eye bolt on the guide bar with a snap link.

Tie the end of a three-sixteenth-inch nylon cord, the "stop" rope (K), to the throttle and pass the other end backward through a snap link at the top of the jerrycan on the left runner of the toboggan and through the snap links used for the left steering rope. Tie the end to the right centre eye on the guide bar. Tie a similar rope, the "go" rope (L), to the throttle and pass it forward through a snap link tied to the steering column and then backward through the set of snap links used for the "stop" and left steering ropes. Tie this rope to the left centre eye on the guide bar. The throttle ropes should have a little slack to prevent interference with the steering ropes. It is worthwhile to tie a small flag to the "stop" rope for identification and a few knots near its end for a better grip.

The engine is started, shifted into forward gear at low throttle and left idling. The driver takes his place near the front of the rear sled and starts the toboggan moving by a steady pull at the "go" rope. The length of the steering ropes can be adjusted by retying the overhand loop knots to obtain maximum efficiency and comfort.

Summary

Motor toboggan sled trains have established their value for antarctic trail work. The capital outlay and maintenance costs are low compared with other vehicles and the trains can be operated in relative safety and reasonable comfort. Very few mechanical troubles are encountered during the first season of use providing the toboggans receive proper care. The toboggans are large enough to move all trail and survival equipment and supplies needed by geological or surveying parties but are small enough to be manhandled into and out of aircraft when desirable. One toboggan can pull at least 2000 lbs. over normal snow surfaces and approximately 6 ton-miles of payload moving is obtained for each gallon of gasoline consumed. An average of 50 mi. per day can be travelled under good conditions. Working from a base camp trail parties can cover an area with a radius of at least 200 mi.

DONALD E. SOHOLT*
CAMPBELL CRADDOCK*

[1]Swithinbank, C. 1962. Motor sledges in the Antarctic. Polar Record, No. 72:265-9.
[2]Mogensen, P. 1962. Remote control of motor toboggan trains. Arctic Institute of North America. 10 pages, mimeogr.

* School of Earth Sciences, University of Minnesota.

ECONOMIC DEVELOPMENT OF THE SIBERIAN NORTH

Soviet scientists regard all territory to the north of the Trans-Siberian Railway as the Siberian North. The region treated in this paper is that lying between the eastern slopes of the North Ural and Polar Ural in the west and the Yenesey-Lena divide in the east. It has an area of more than 3 million $km.^2$ (1,150,000 $mi.^2$), which is one-seventh of the whole territory of the U.S.S.R., but its population represents only 1.2