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Technical Report

BYRD STATION SNOW TUNNELS — MAINTENANCE EQUIPMENT AND TECHNIQUES

June 1965

U. S. NAVAL CIVIL ENGINEERING LABORATORY

Port Hueneme, California

BYRD STATION SNOW TUNNELS—MAINTENANCE EQUIPMENT AND TECHNIQUES

Y-F015-11-01-080

Type B

by

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ABSTRACT

To prevent excessive snow-tunnel closure, equipment and techniques were developed to score and trim the snow-tunnel walls at Byrd Station, Antarctica. The equipment includes a chain saw and guide for scoring the snow to a controlled depth, hand tools for chipping the scored snow from the walls, a gasoline-fired snow melter for melting the waste snow, and a pump and hoses for transferring the water to the station sewer line. This equipment was tested at Byrd Station in January 1965 and found to be suitable for clearing walls with up to 7 inches of closure. Less frequent clearing would be possible if side-cutting equipment were used to remove the snow.

INTRODUCTION

Measurements taken in the undersnow camp at Byrd Station, Antarctica, indicate that tunnel walls are closing in due to plastic flow of the snow. Although the rate is slow, maintenance will be required to prevent excessive closure. Any closure restricts passage, as the clearances between the tunnel walls and the buildings are only 2 to 4 feet. It is important that a method be developed for removing the snow from the walls before the closure becomes critical and the space is too restricted for access.

In addition to shaving the snow from the walls, the snow must be removed from the tunnels for disposal. The size of the undersnow complex and the relative inaccessibility of certain tunnels make removal extremely difficult. After the snow is removed from the tunnel complex, it must be spread so that it will not influence drift.

This report presents the development of equipment for scoring the snow on the tunnel walls for removal and disposal. Field tests of prototype equipment were conducted at Byrd Station during Deep Freeze 65.

BACKGROUND

Byrd Station is located in Antarctica at approximately long. 120° W and lat. 80° S on snow and ice 8,000 feet thick. The undersnow complex (Figure 1) was built during FY 61 and FY 62 to replace the IGY surface station of the same name. The design was patterned after Camp Century, Greenland, with improvements suggested by construction and operation of Camp Century. Deep trenches were cut with Peter Snow Millers. These trenches were roofed with metal arches which were covered with snow to form tunnels. Prefabricated buildings to house the scientific and support activities were erected in the tunnels.

The difficulties experienced in maintaining proper clearances in the tunnels at Camp Century[1] prompted an investigation of wall-tunnel closure rates at Byrd Station immediately after construction. Measurements taken by U. S. Army Cold Regions Research and Evaluation Laboratory[2] show that the closure rate during the first year ranged from 1-1/4 to 5 inches, with an average of about 2 inches.

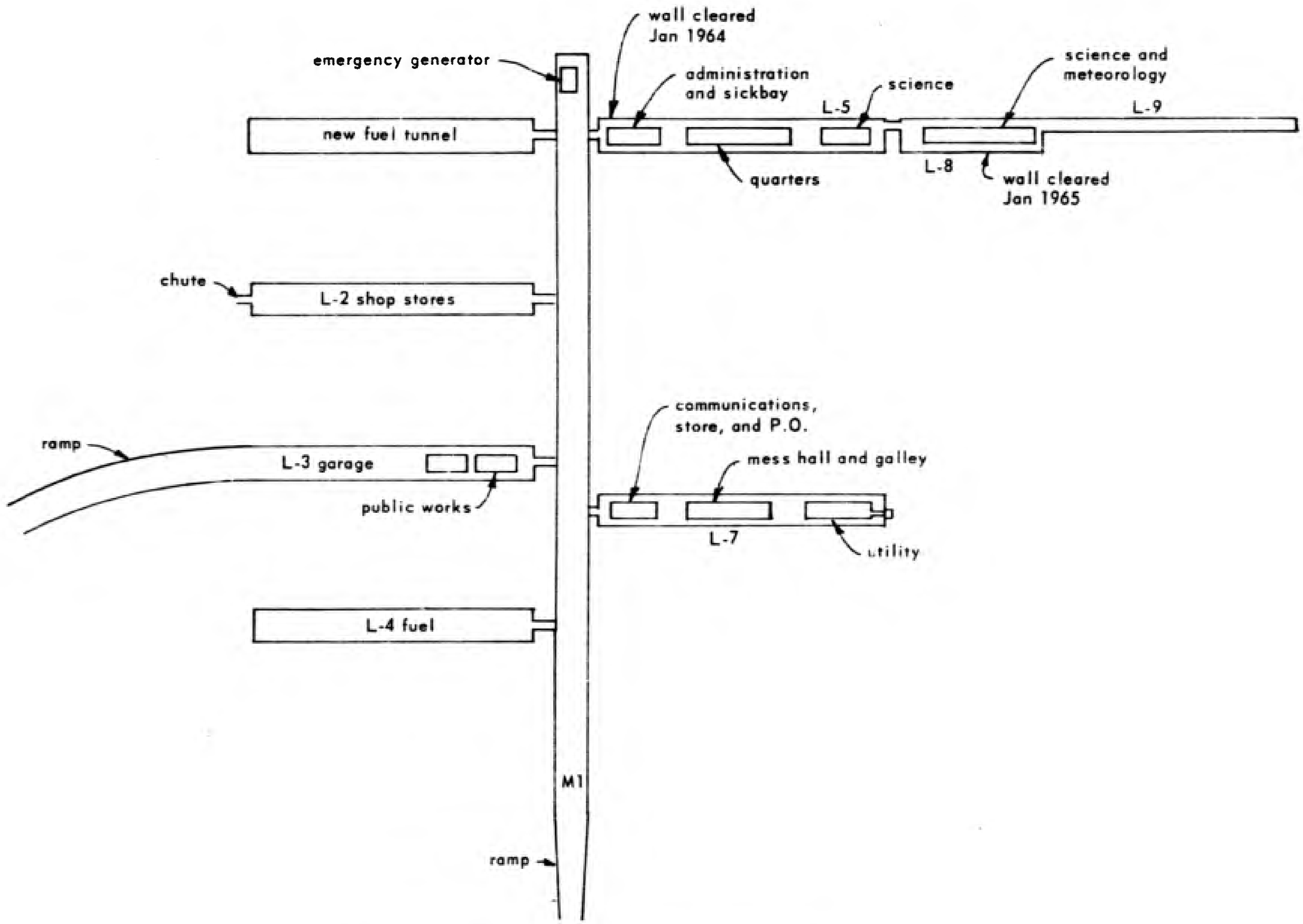

Figure 1. Layout of Byrd Station showing test locations.

During Deep Freeze 64, studies were made by NCEL at Byrd Station to determine an approach for developing snow-tunnel wall-trimming equipment.[3] A chain saw was mounted on a wooden frame which could be placed a controlled distance from the tunnel wall. The chain saw was operated vertically in this fixed plane to score the snow to the depth to which it should be removed (Figure 2). The snow was chipped from the wall to the depth of the scoring cuts using a square-ended shovel (Figure 3). Waste snow was loaded onto banana sleds for manhauling to the main tunnel, where it was reloaded onto a large sled and towed by a tractor to the surface.

CONCEPT

Based on the Deep Freeze 64 studies, a wall-clearing system entailing trimming of the walls by scoring at frequent intervals was selected as the most appropriate method for the existing conditions in the tunnels and the anticipated manpower available for this work. The equipment was to be easily operated by a small crew, and lightweight for manhauling in the tunnel complex. The principle of scoring the walls with a chain saw was to be retained, but a wider guide frame of aluminum was envisioned to lighten the weight of the frame and minimize frequency of relocation. Removing the snow from the tunnel complex and spreading it on the surface was to be eliminated by melting the snow and disposing of it in the station sewer system, thus reducing the manpower requirement.

CRITERIA

Criteria established for the wall-clearing system were as follows:

1. A lightweight chain-saw guide frame of sufficient width to minimize relocation of the frame.

2. Both vertical and horizontal movement of the chain saw.

3. A manhauled, skid-mounted snow melter with 100-gph capacity.

4. An oil- or gas-fired heat source for the melter.

5. Minimum heat escaping from the melter.

6. A discharge system for the snow melter, including 100 feet of hose.

7. A purging system for the hose to prevent freezing.

8. All components as lightweight as possible for easy movement within the tunnel complex.

9. Easy operation by unskilled personnel.
10. Operable in confined spaces.

DESCRIPTION

The basic components of the wall-clearing system include a chain-saw guide frame for scoring the walls; hand tools for chipping and scaling the snow; and a heating unit, melting tank, and hose line for melting and disposing of the waste snow in the Byrd Station sewer system. All of these items can be manhauled. The guide frame weighs 104 pounds, the heating unit weighs 500 pounds, and the melting tank weighs 485 pounds.

Shop-fabricated items for the wall-clearing system are detailed in Y&D Drawings Nos. 993773 through 993777, and procurement information for commercial items is listed in Appendix A. Packaged weight, shipping volume, and 1964 cost of the components are given in Table I.

Table I. Packaged Weight, Volume, and Cost of Wall-Clearing-Equipment Components

Component	Packaged Weight (lb)	Packaged Volume (ft^3)	Cost ($)
Chain saw, guide frame, and hand tools	300	27	1,330
Melter tank, hoses, and purging system	930	116	1,560
Heating unit	914	55	2,180
Total	2,144	198	5,070

Wall-Trimming Equipment

Guide Frame. The basic frame (Figure 4) is rectangular in shape, 11-1/2 feet high, 6-1/2 feet wide, and is made of 2-inch-diameter aluminum tubing with a 0.125-inch-thick wall. It consists of two side members and three cross members — one at the top and bottom of the side members and the third 3-1/2 feet up from the bottom. The center and top cross members have channels which support the rollers of the 4-way carriage and guide it during horizontal movement (Figure 5). The bottom member is a 2 x 6 tapered on the ends to serve as a skid. The top support arms, which are connected by a board that rests on the top of the tunnel wall, are adjustable from the ground by a bell-crank-and-rod linkage; the center support arms are adjusted individually by hand.

The 4-way carriage is also rectangular in shape and made of 2-inch-diameter aluminum tubing with a 0.125-inch-thick wall. The vertical members, or slide tubes, are 8 feet 4 inches long; the top and bottom connectors are 1 foot 2 inches long. The rollers bolt to the slide tubes near the two end connectors. Single-groove sheaves, to hold the rope for raising and lowering the chain saw on the slide tubes, are secured to the front of the carriage at the top right and lower right.

The saw mount consists of two 7-inch-long sleeves of thin-wall steel tubing, which fit over the carriage slide tubes and are connected horizontally by two pieces of 1-inch-square steel tubing. The two pieces to which the saw is attached are welded perpendicular to the horizontal connectors.

Chain Saw. The saw is an electric model with a 16-inch guide bar. The direct-drive motor operates on 110-volt 60-cycle AC. The motor develops 2 hp and has a cutting speed of 2,000 feet per minute. The overall dimensions are 29 inches long, 9-1/2 inches wide, and 5-1/2 inches high, with a weight of 17-1/2 pounds. The factors in selecting this saw were its small size, light weight and removable handle.

Hand Tool. A hand tool was used for removing the scored sections from the tunnel walls. The tool used was a scaler with a 5-foot-long, 1-1/4-inch-diameter wooden handle and an 8-inch-wide by 4-inch-long flat steel blade bent to about a 10-degree angle to the handle. The forward corners of the blade were bent outward slightly to prevent them from digging in. The leading edge of the hand tool was sharpened for more efficient use.

Snow-Disposal Equipment

The snow-disposal equipment (Figures 6 and 7), consisting of the snow-melter tank, heater, and liquid-disposal system, were assembled into two large units: a tank unit consisting of the melter tank, the water pump, and the air compressor; and a heater unit consisting of the heater only.

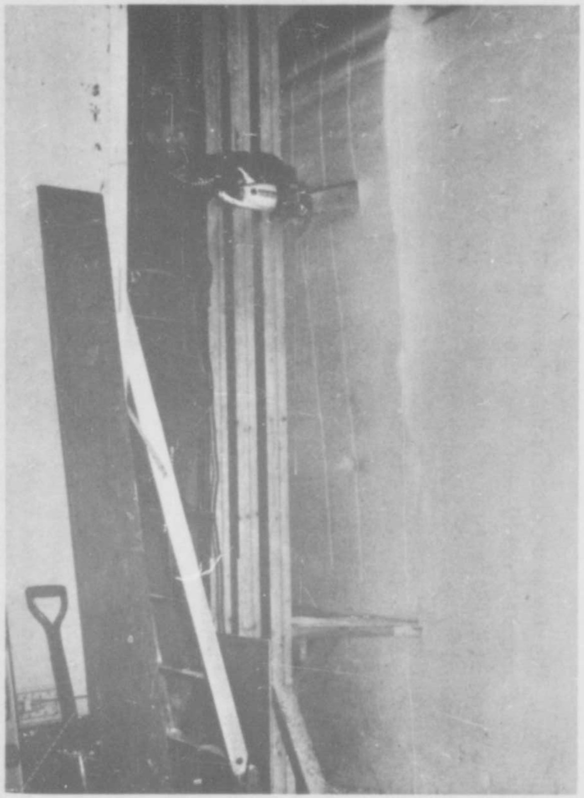

Figure 2. Wooden chain-saw guide frame used in Deep Freeze 64 studies.

Figure 3. Chipping closure snow from the tunnel walls with a square-ended shovel.

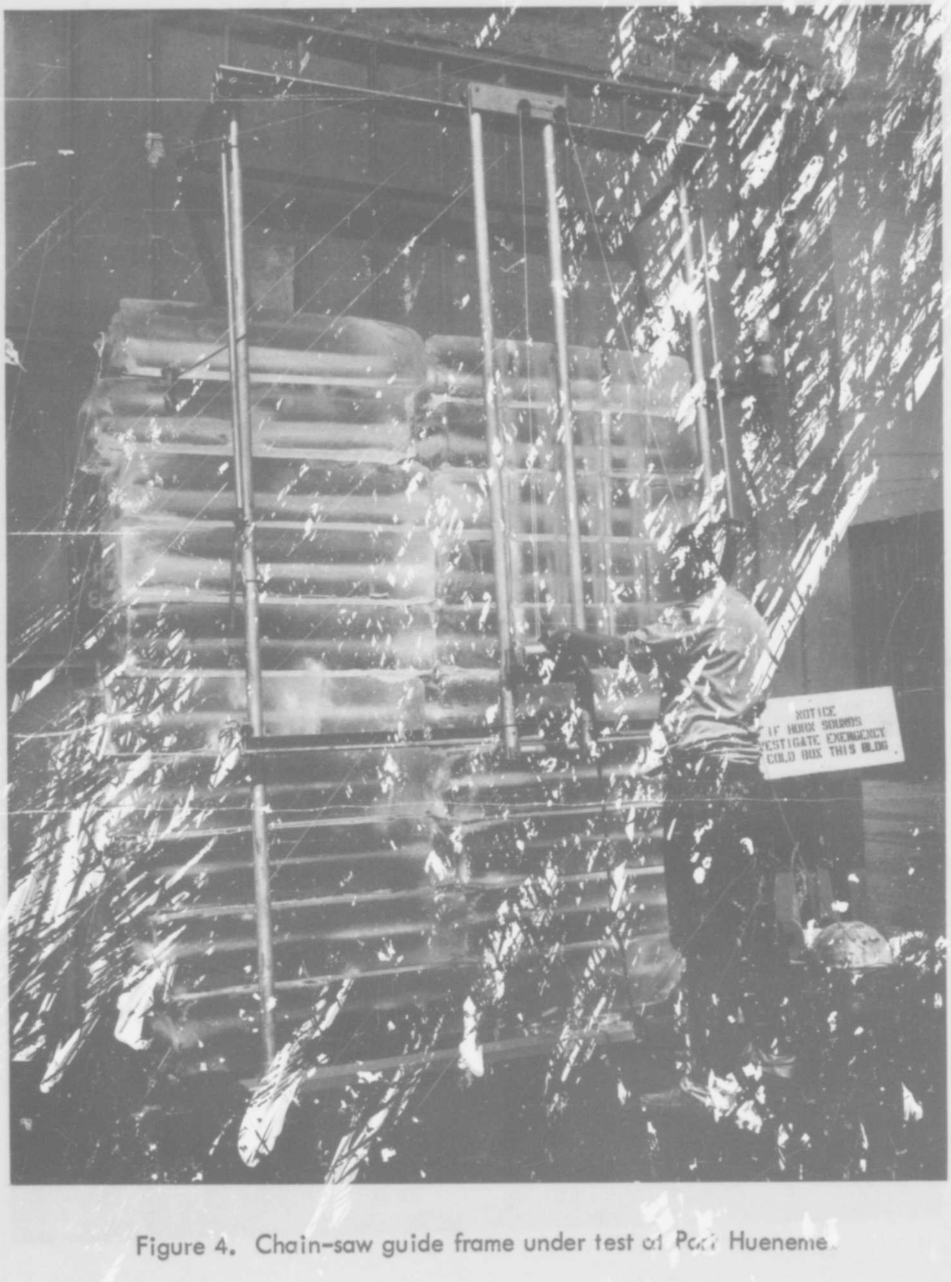

Figure 4. Chain-saw guide frame under test at Port Hueneme.

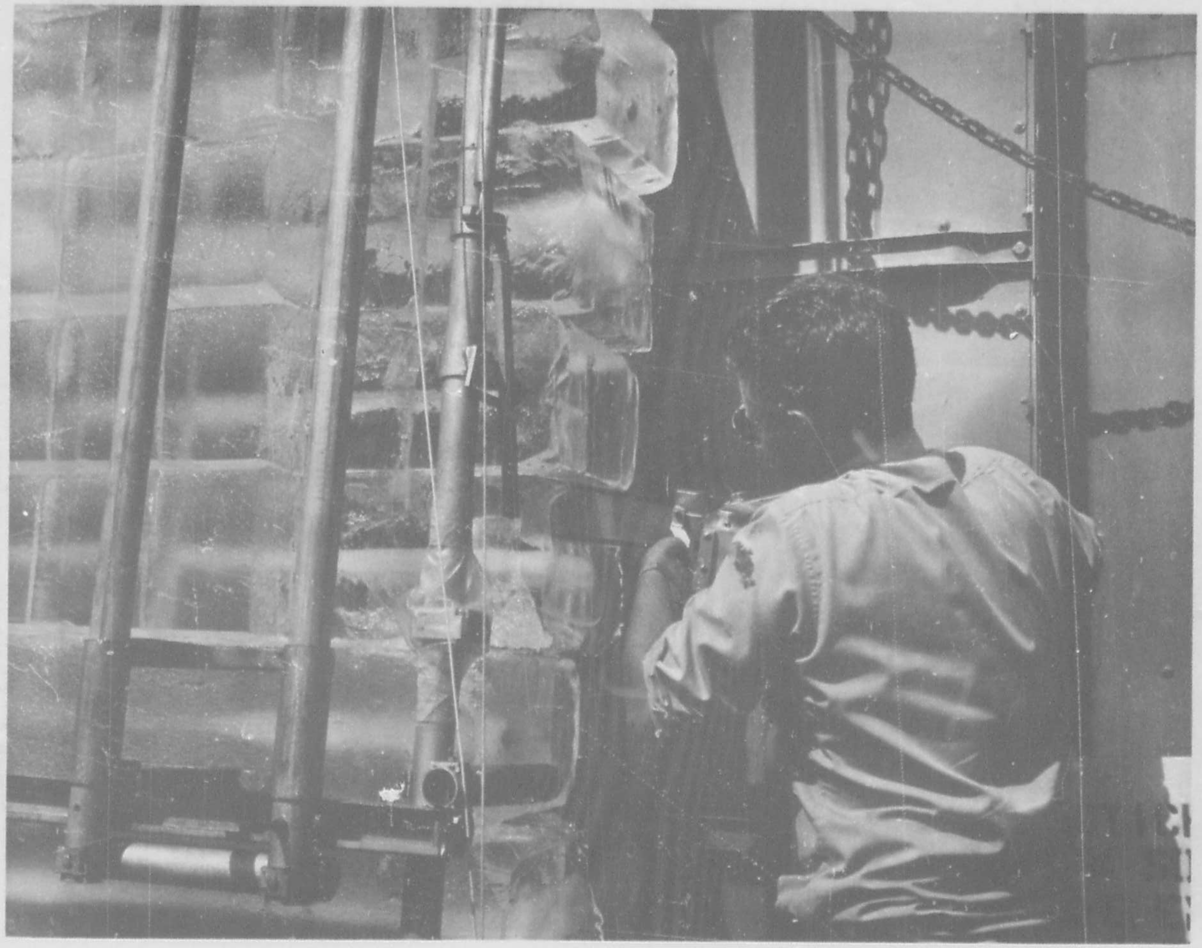

Figure 5. Movable carriage on guide frame.

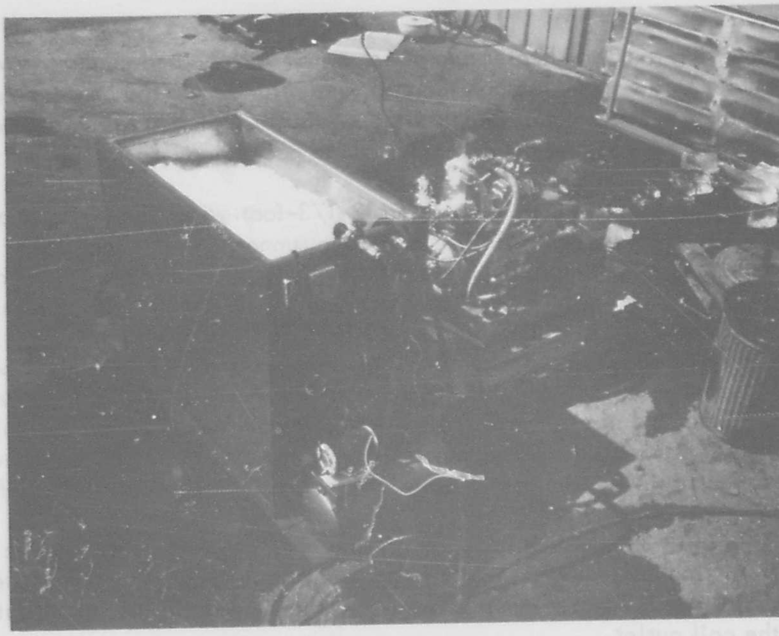

Figure 6. Snow-disposal equipment; note compressor and air tank.

Figure 7. Snow-disposal equipment; note hose for circulating heated coolant through melter coils.

The melting tank and heater operate as a unit with heated coolant flowing from the heater to the tank, through the coil, and returning to the heater through two 25-foot-long rubber hoses. Quick disconnects are attached to the tank and the hose ends for easy disassembly for moving and packaging.

Tank Unit. The skid is a 7-foot-long, 2-1/3-foot-wide plywood platform mounted on two 3- by 6-inch full-length wooden runners.

The tank is an open-top, double-wall-and-bottom, insulated container with the following dimensions: 4 feet long, 2 feet wide, and 3-1/2 feet high. The inner wall and bottom are 3/16-inch welded aluminum; the outer wall and bottom are 1/16-inch welded aluminum. Insulation between the walls and bottom is 2-inch rigid polyethylene foam cemented to the inside of the outer walls. A double heating coil resting in the bottom of the tank is made from 44 feet of 3/4-inch annealed copper tubing. Both ends of the coil are brazed into bulkhead fittings that extend through one end of the tank. One-inch quick-disconnect fittings are secured to the outboard end of the bulkhead fittings.

An aluminum 3/4-inch-thick mesh grating rests on stringers around the inside of the tank 5-3/4 inches above the tank bottom and 1 inch above the coil. A retaining ring to accomodate the water pump is welded to the top side of the grating at the end opposite the coil outlet.

The 1/3-hp electric water pump is submersible and is driven by 110-volt 60-cycle AC. It is 8-1/2 inches in diameter and 12 inches high. It has a 1-1/4-inch discharge pipe and a capacity of 50 gpm at 10-foot head, or 45 gpm at 20-foot head. The centrifugal impeller housing is on the bottom of the pump and is the base on which the pump rests. The discharge pipe rises from the top of the volute alongside the motor. The 1-1/4-inch outlet is bushed down, and a 32-1/2-inch-long, 3/4-inch pipe discharge riser is used. A 90-degree street ell, a 3/4-inch gate valve, and a 3/4-inch quick-disconnect nipple complete the end of the discharge pipe.

The pump rests inside the melter tank on top of the mesh grating at the opposite end of the tank from the coil outlet. The pump is turned so the discharge pipe is near the end wall and rises up and over the edge of the tank. The pump is held in place by securing the pipe to the tank at the top of the wall.

The air compressor is a lightweight diaphragm type with integral 110-volt 60-cycle AC shaded-pole motor. It has an air capacity of 1.2 cubic feet per minute at 20 pounds per square inch. The sealed ball bearings are lubricated with low-temperature grease, and the regular diaphragm is replaced with a diaphragm of special low-temperature material. The unit is mounted on top of the air tank which, in turn, is secured to the skid at the opposite end of the melter tank from the coil connections. Quarter-inch copper tubing runs from the compressor to the tank. A quarter-turn valve is installed between the tank and the compressor so the pressure will not leak back through the compressor.

The air tank is a 10-inch-diameter by 25-inch-long cylindrical tank of 1.2 cubic feet (9 gallons) capacity, with a working pressure of 150 psi. It is mounted on the skid at the opposite end of the melter tank from the coil-inlet connections. A 1/2-inch pipe discharge line runs from the air tank to the melter tank wall, then upward nearly to the top of the wall. A 1/2-inch globe valve, a 90-degree elbow, and a 3/4-inch quick-disconnect nipple complete the air line. A pressure gage is installed in the line just below the globe valve. The top of the discharge line is secured to the wall of the tank.

The drain hoses are 3/4-inch ID, single-ply, low-pressure, low-temperature, synthetic-rubber tubes with cotton-braid outer cover. (Cotton-braid-covered hose is much easier to handle in the extreme cold than rubber-covered.) They are made up in 25-foot lengths for ease of handling. Quick disconnects with low-temperature seals are clamped to each end to facilitate joining and separation.

Heating Unit. The heating unit is a 150,000-Btu, gasoline- or diesel-burning, recirculating-coolant heater mounted on a sled-tank equipped with a tow bar (Figure 8). It is 48 inches long, 24 inches wide, 34 inches high, and weighs 475 pounds dry. The fuel tank holds about 18 gallons, which is enough for 10 hours of operation at rated output.

The unit is powered by a 1-hp, single-phase, 60-cycle, 110-volt AC motor. This motor, which drives the coolant-circulating pump, the fuel-distribution pump, the combustion air blower, and the magneto, remains in continual operation after starting. The heating operation is also automatic after starting and maintains the coolant temperature between 145 and 180°F by cutting the burner in and out.

The heated coolant is circulated through the heater and melting tank at 7.2 gpm and a maximum pressure of 25 psi. The two pressure and return circulating hoses, between the heater and the tank, are 1-inch-ID, single-ply, cotton-braid-covered, neoprene hoses, 25 feet long. They have quick disconnects at the melter-tank end. The hoses can be connected together so the coolant can be recirculated through the heater.

The combustion chamber of the heater is cylindrical, with the burner at one end. The water jacket is a two-pass system with a thermostatic actuator that relieves the fuel pressure when the coolant reaches the upper temperature limit.

PERFORMANCE

A prototype of the wall-clearing system was functionally tested at Port Hueneme in September 1964 and field tested at Byrd Station in January 1965. Operating procedures used in the Byrd Station tests are given in Appendix B.

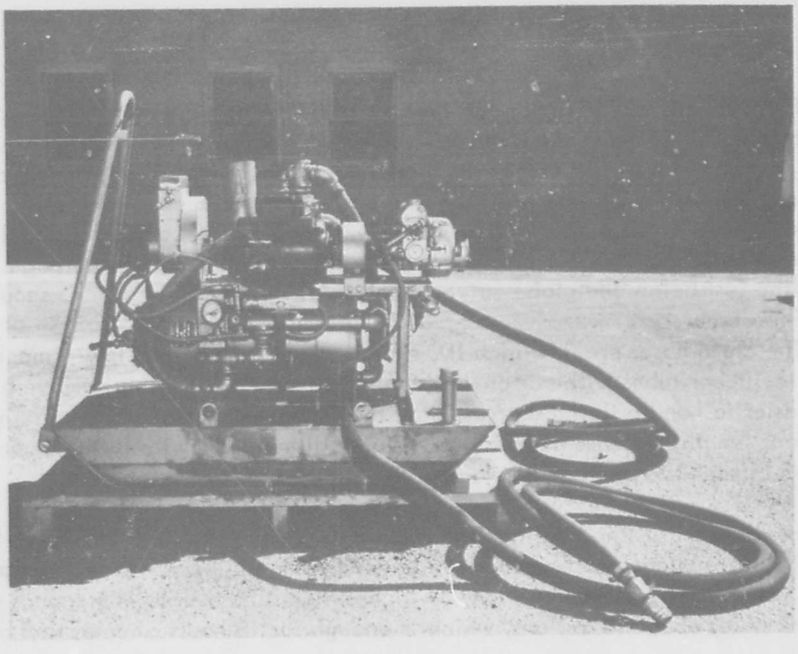

Figure 8. Heating unit for snow melter.

Based on the Deep Freeze 64 studies, the prototype snow-melter tank and the heating unit were designed for manhauling on skids over the snow floors in the Byrd Station tunnels; however, boardwalks had been installed during the interim between the studies in January 1964 and the January 1965 field tests. In order to facilitate relocation of equipment, an alternate wheel system has been added to the drawings of the melter tank. A heater unit mounted on wheels can be purchased as an alternate to the skid-mounted unit.

Functional Tests at Port Hueneme

Three-hundred-pound blocks of ice were stacked to a height of 11 feet to simulate a snow-tunnel wall. The chain-saw guide frame was placed against the stack of ice, and the chain saw was operated, scoring both vertically and horizontally to a controlled depth. The guide frame worked quite well, requiring only one modification. The tubes near the bottom of the frame, which space the frame the required distance from the wall, were made adjustable to accommodate irregularities in the tunnel walls.

The snow melter was tested by using crushed ice to simulate the snow removed from tunnel walls. The ice was melted at the rate of 110 gph, which is slightly faster than the requirement established in the criteria.

The disposal system for the melted snow was tested in a cold chamber at temperatures to -10°F. The compressor would not operate below 10°F, so new bearings with low-temperature grease were ordered. After this modification, there were no problems encountered in cold-chamber tests.

Field Tests at Byrd Station

An inspection of the tunnel complex was made to determine conditions that would limit operation of the equipment. The primary limiting condition was the clearance between the buildings and the tunnel walls. The smallest clearance was in tunnel L-8 behind the Science and Meteorology Building (Figure 1). The clearance near the base of the building where there was no closure was 28 inches. The maximum closure near the top of the wall was 5 inches, leaving a clearance at that point of only 23 inches (Figure 9). A sewer trench between the building and the tunnel wall further complicated any work in that location. This section of tunnel was selected for the wall-clearing tests as it presented the most difficult conditions and, therefore, should reveal any limitation of the equipment.

The aluminum chain-saw guide frame was easily moved to the test location and was assembled by three men in 45 minutes. The 104-pound frame could be moved to any point in the tunnel complex without being disassembled. It was easily carried by two men.

The chain saw was too long to operate in the 28-inch clearance, so the handle was removed. The chain saw with the handle was 29 inches long; without the handle, it was 22 inches long. After making this modification, the chain saw was operated without difficulty.

With the aluminum guide frame, a 5-foot-wide section could be scored without moving the frame. Scoring 5 lineal feet of wall vertically at 10-inch spacing was accomplished in 3 minutes. Movement of the frame to the next section required 2 minutes with two men. Time studies over larger sections proved this average, which is 60 lineal feet per hour.

Test sections were also scored horizontally so that square blocks could be chipped from the wall. The square blocks were easier to handle, but the horizontal scoring did not increase the speed of the chipping operation. In order to score horizontally, each section had to be chipped before the next section could be scored. When only vertical scoring was used, the scoring could advance at a rate independent of the chipping operation. Horizontal scoring was eliminated, because the time consumed was not gained in successive operations; operation was complicated, because the speed at which the scoring advanced became dependent on the chipping.

The scored walls were chipped and smoothed in one operation which advanced at the rate of 18 lineal feet per manhour. At this rate, chipping lagged behind scoring even when two men were chipping. This is a laborious task, and a worker cannot proceed at this rate for any extended period.

With the exception of difficulty in moving the skid-mounted 485-pound melter tank and 500-pound heating unit over the boardwalks, the snow melter was relatively trouble-free during the Byrd Station tests. There was no temperature increase noted in the tunnels due to its operation. Starting with a water charge of 14 inches in the melter tank, snow was melted at the rate of 106 gph. With a cross-sectional area of about 1-1/4 square feet, the snow removed from the wall was melted at the rate of 22 lineal feet per hour. This rate varies with the amount of snow being removed.

Water was pumped from the melter tank to a sewer cleanout through 50 feet of hose. Pumping a full tank of water to the sewer required 10 minutes.

SNOW-CLEARING RATES

Operation of the chain saw and guide frame requires two men. The rate of removal of the scored snow depends upon the number of men employed. In the field test, one man worked full time removing snow; a second man worked half time removing snow and half time filling the snow melter. With this distribution of labor, scoring advanced at twice the speed of removal and disposal. In order to balance this, the two-man team that is scoring the walls would have to spend one-fourth of their time assisting with removal and disposal. They could distribute their labor on a daily basis or complete the scoring of all the tunnel walls and then assist in removal and disposal. In either case, the average advance would be 200 lineal feet of tunnel wall per day. This rate includes allowance for warm-up breaks and minor difficulties that may arise. The estimated time required for a four-man crew to clear the walls in tunnels L-5, L-7, and L-8 is given in the following table. An additional allowance is made for movement of equipment and moving supplies stored behind the buildings.

1,600 lineal ft at 200 ft/day (days)	8
Moving equipment nine times at 2 hr each (days)	2
Moving supplies stored in tunnels (days)	7
Returning supplies to storage location (days)	7
TOTAL	24

The wall-trimming operation could be accelerated by using two additional men to remove and dispose of the snow. If the closure exceeds 2-1/2 inches, an additional snow melter is required, or two men have to work a night shift using the same melter. The average advance for the six-man crew would be 300 lineal feet per day. Time requirements for the six-man crew are given in the following table.

1,600 lineal ft at 300 ft/day (days)	5-1/2
Moving equipment nine times at 1-1/2 hr each (days) . . .	1-1/2
Moving supplies stored in tunnels (days)	4-1/2
Returning supplies to storage location (days)	4-1/2
TOTAL	16

Based on present knowledge of closure rate, one snow melter would keep up with the scoring if the walls were trimmed annually. Two melters would be required, or one would have to be used on a 24-hour basis, to keep up with the scoring if the walls were trimmed biennially.

Supplies stored in the tunnels are a major obstacle to maintenance of the walls (Figures 10 and 11). A better storage system would considerably reduce the manpower required for wall maintenance.

FREQUENCY OF CLEARING

Scoring the walls requires that the operator and equipment work in the limited space between the closure snow and the buildings. The maximum closure that can be cleared with this equipment is 7 inches. At the present rate of closure, the 7-inch maximum would be reached in some locations as frequently as every 2 years. Based on the clearing rates tabulated earlier, 96 mandays of labor over a 16- to 24-day period would be required for biennial clearing of the walls in the building tunnels.

Less frequent clearing would be possible if side-cutting equipment were developed for trimming the walls. Such equipment would operate flush with the wall and, as it progressed along the wall, would remove the snow ahead of the operator. Thus, closure snow up to 18 inches thick in the limited spaces between the buildings and tunnel walls could be removed in a single operation. Side cutting would permit the frequency of clearing to be extended up to 6-year intervals.

Less frequent clearing would result in economy of manpower, because the same manpower is required to remove the snow regardless of the amount of closure. Side cutting would further increase efficiency by eliminating the requirement of chipping and smoothing the walls.

The same disposal system could be used regardless of the approach to removing the snow from the walls; however, the method of loading the snow melter and the number of melter units required might vary with the removal system.

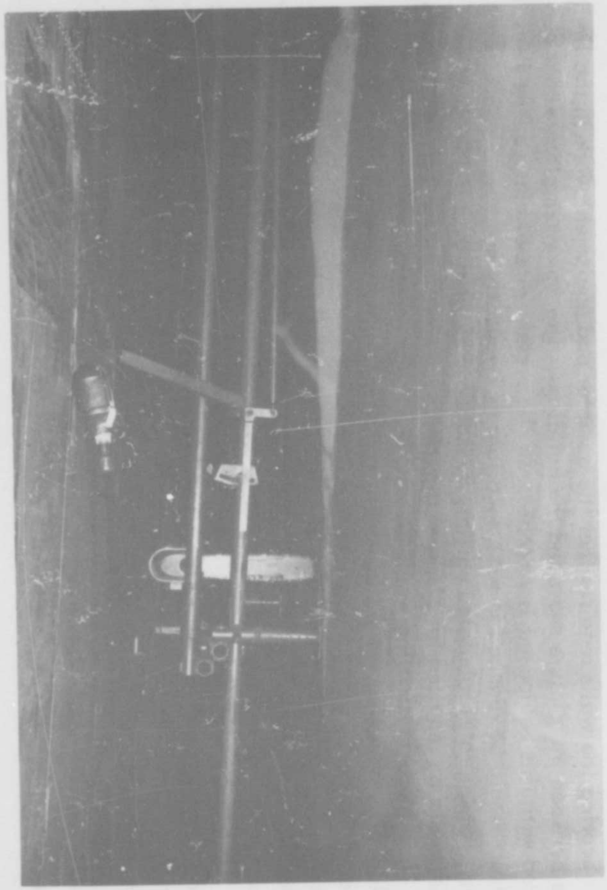

Figure 9. Scoring a wall in limited space; note configuration of closure snow.

Figure 10. Supplies stored between a building and the tunnel wall.

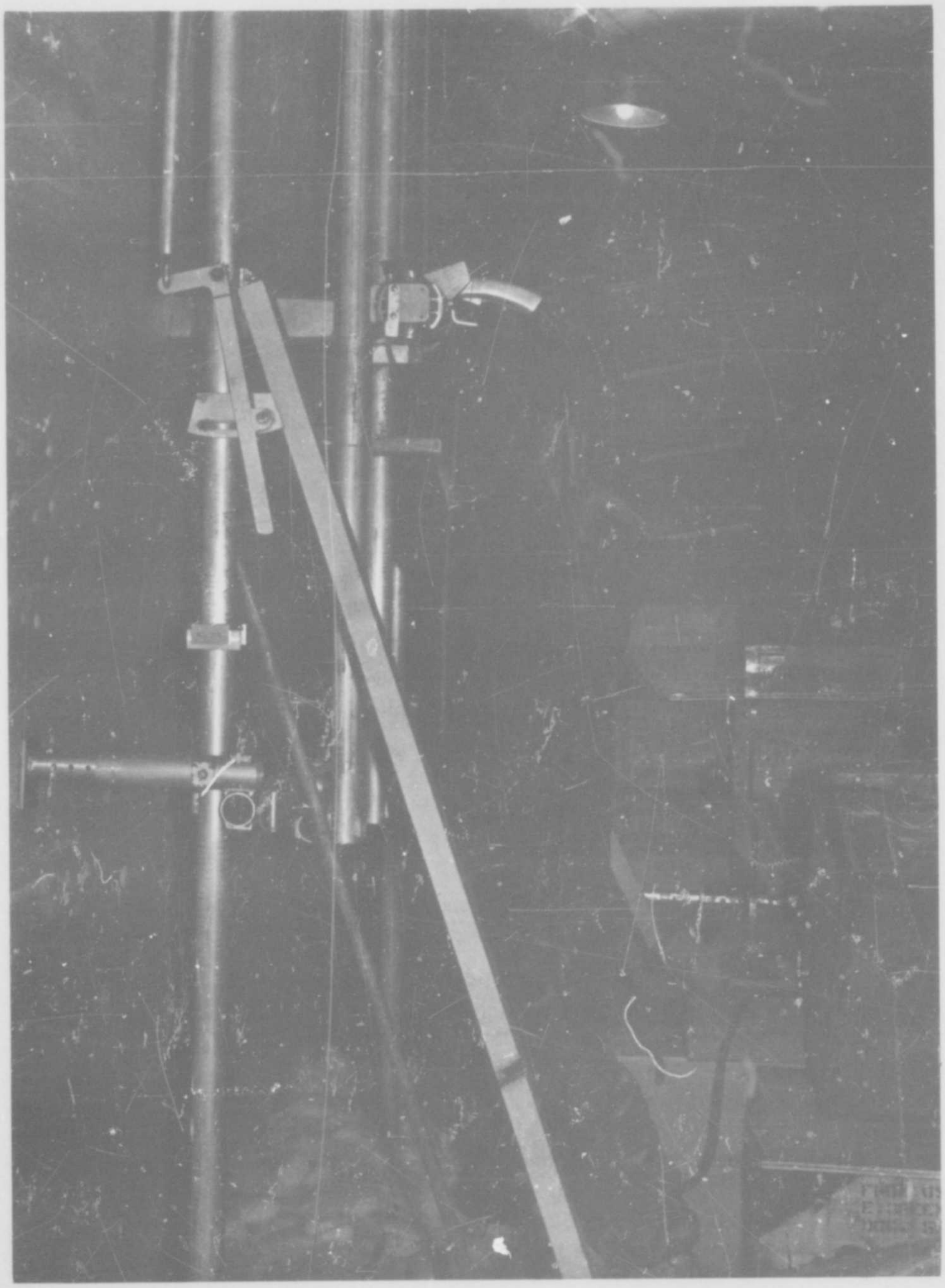

Figure 11. Supplies stored in the space at the end of a building.

FINDINGS

1. With scoring equipment for trimming the walls and a snow melter for disposing of waste snow in the tunnel sewage system, the following holds true:

   a. A maximum closure of 7 inches of snow can be removed from the tunnel by scoring, and based on available information on closure rates, biennial trimming is required.

   b. Tunnel walls can be cleared at a rate of 200 lineal feet per day by a 4-man team, and 300 lineal feet per day by a 6-man team.

   c. Clearing the walls in the occupied tunnels, L-5, L-7 and L-8, requires 96 mandays over a period of 16 to 24 days, depending on the crew size.

2. Analysis shows that side cutting rather than scoring would accomplish the following:

   a. It would permit closures up to 18 inches to form, and frequency of clearing could be extended up to 6 years.

   b. Side cutting would be suitable for use with the snow-melter disposal system, with variation in the number of melter units required and the method of melter loading.

   c. The need for chipping and smoothing would be eliminated.

CONCLUSIONS

1. Scoring equipment for trimming and a snow-melter disposal system are suitable for biennial clearing of the tunnel walls.

2. Frequency of clearing could be extended to 6-year intervals if side-cutting equipment were used for trimming.

ACKNOWLEDGMENTS

Dr. C. W. Terry is acknowledged for providing the basic concepts and Mr. R. W. Hansen is acknowledged for assistance in developing and testing the equipment described in this report. The Byrd Station personnel are also acknowledged for their assistance in the tests conducted at that Station in January 1965.

Appendix A

COMMERCIAL ITEMS USED IN SNOW-TUNNEL WALL-MAINTENANCE EQUIPMENT

Item	Supplier	Catalogue No.
Chain Saw	Milwaukee Electric Tool Company	Model #6200
Railroad (scaling tool)	California Hardware	RS-84
Heating Unit[1/]	Vapor Heating Corporation	Type 4915-ES
Water Pump	Sears, Roebuck and Company	42K2837K Model #259.4857
Air Compressor	Sears, Roebuck and Company	30K15041C Model #283.150410
Air Tank	Sears, Roebuck and Company	28K8965K
Hoses	Aeroquip Corporation	
Quick Disconnects	Snap-Tite Corporation	

1/ A wheel-mounted unit can be purchased by special order.

Appendix B

OPERATING PROCEDURES

The area of the tunnel floor which is to accommodate the base of the guide frame should be fairly level. The frame is set vertically against the wall with the inner edge of the wooden base 7-1/2 inches from the bottom of the wall. The guide supports holding the frame from the upper portion of the wall are adjusted so the leveling bubbles indicate that the frame is plumb vertically; then the middle support arms are adjusted, and the frame is braced in this position. The chain saw is positioned in the mount on the carriage, and vertical cuts are made in the wall 10 inches apart. The saw is removed, the adjusting guides on the frame are retracted, and the frame is slid forward to a new position.

Standing at the side of the first cut and starting at the bottom, the hand tool is jabbed into the scored snow, always trying to hold the blade so that it will remove the snow but not dig in excessively. When a quantity of snow has been removed, the snow melter can be operated, or the snow can be stockpiled and the melter operated later.

In the initial operation of the snow melter, warm water is introduced into the tank to cover the heating coils. (If no water is readily available, snow can be put into the tank and melted, but this is a time-consuming task.) The heater hoses are disconnected from the tank and hooked together; the heater is started, and the coolant (60% ethylene glycol and 40% water by volume) is recirculated through the heater to raise it to temperature. The hoses are then connected to the tank, and the heated coolant is circulated through the coil to raise the temperature of the water. Snow is piled into the tank until it is full. The temperature of the water at the grating level stays at about 50°F, while the top of the water in the snow remains at 32°F. (To accelerate melting, the warmer water can be mixed with the snow by putting the drain hose into the tank and agitating or circulating the water with the submersible pump.) The heater operates continually without cycling and melts sufficient snow to obtain approximately 110 gallons of water each hour. With snow of 0.5 density, about 25 cubic feet can be melted each hour.

When the water gets near the top of the tank, the drain hoses are connected to the pump discharge line, and the pump is started. With 100 feet of hose attached, a full tank can be pumped out in 10 minutes; with less hose, the time is reduced. At the completion of the pumping, the hose is disconnected from the pump discharge line and attached to the air discharge line. The air compressor is started and the build-up of air gradually forces the liquid out and drains the hose. If a sewer opening is available, it is better to fill the air tank and let a larger volume of air drain the hose.

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U. S. Naval Civil Engineering Laboratory
BYRD STATION SNOW TUNNELS—MAINTENANCE EQUIPMENT AND TECHNIQUES by G. E. Sherwood and S. E. Gifford
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To prevent excessive snow-tunnel closure, equipment and techniques were developed to score and trim the snow-tunnel walls at Byrd Station Antarctica. The equipment includes a chain saw and guide for scoring the snow to a controlled depth, hand tools for chipping the scored snow from the walls, a gasoline-fired snow melter for melting the waste snow, and a pump and hoses for transferring the water to the station sewer line. This equipment was tested at Byrd Station in January 1965 and found to be suitable for clearing walls with up to 7 inches of closure. Less frequent clearing would be possible if side-cutting equipment were used to remove the snow.

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BYRD STATION SNOW TUNNELS—MAINTENANCE EQUIPMENT AND TECHNIQUES by G. E. Sherwood and S. E. Gifford
TR-389 25 p. illus June 65 For Official Use Only

1. Polar snow tunnels—maintenance 2. Byrd Station I. Y-F015-11-01-080

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Port Hueneme, California

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9 Feb 1966

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