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TECHNICAL PROGRESS SURVEY - BYRD STATION, ANTARCTICA

BY

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TECHNICAL PROGRESS SURVEY - BYRD STATION, ANTARCTICA

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ABSTRACT

A technical survey was conducted at Byrd Station, Antarctica, in December 1965. The purpose of the survey was to obtain information on current construction problems and design adequacy in the undersnow camp.

The survey showed the camp to be in generally good condition with most systems functioning well. Areas in greatest need of improvement include summer tunnel cooling, control of surface air entry and circulation, increased water production and improved maintenance on systems for surface venting of combustion gases and noxious fumes.

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INTRODUCTION

Compilation and analysis of cold weather engineering and construction methods is an important factor in the advancement of polar construction technology. To obtain current information on construction problems and design adequacy, periodic surveys are conducted at selected temporary and permanent stations in both north and south polar regions.

This technical note presents the results of an engineering survey conducted at Byrd Station, Antarctica, in December 1965. Information is included on the snow tunnels, passageways and related facilities as well as camp buildings and equipment.

BACKGROUND

Byrd Station, Antarctica, is an undersnow camp designed by the U. S. Naval Facilities Engineering Command, and constructed by Navy Seabees during the antarctic summers of 1960-61 and 1961-62. The station consists of a network of tunnels containing prefabricated buildings and other equipment. While most facilities are in the tunnels, some small buildings are elevated above the surface. A few scientific facilities which require freedom from electromagnetic disturbance are located a mile or more from the station without subsurface communication. The general layout of the tunnel complex is shown in Figure 1.

The tunnels were constructed by excavating trenches in the snow, placing timber sills on the abutments and roofing the trenches with corrugated steel arches. Snow was backfilled to the peak of the arch to provide a smooth undisturbed surface to drifting snow. Entrance to and from the surface was by vehicle ramps at the end of the tunnels M-1 and L-3 or by vertical escape shafts from the lateral tunnels.

Population of the camp averages 50 to 60 persons in the summer and is reduced to half that from February to October while the station is isolated by the antarctic winter. Civilian scientists performing studies supported by the National Science Foundation make up about half of the camp occupants. The remainder are enlisted Navy personnel and officers responsible for camp operation and maintenance. The officer in charge is normally a Navy CEC officer and is generally the only engineer among military personnel.

Maintenance, modification and additions to the facilities and equipment in the undersnow camp are particularly difficult because of the severity of the environment and the short construction season. Other contributing factors are the annual change in station personnel and the remoteness of the station, making material procurement difficult.

TUNNELS AND RELATED INSTALLATIONS

The location of buildings and equipment in subsurface snow tunnels has resulted in problems not normally encountered in surface construction. These problems include plastic deformation of snow tunnel walls and connecting passageways, surface venting of waste heat and exhaust gases, and surface and passageway closures for airflow and snowdrift control.

Deformation

Deformation of the tunnels and passageways results from plastic flow in the snow and a general settlement due to continual increase in the overburden. Measurements of the tunnel deformation were made in 1961, 1962 and 1963 by CRREL personnel[1] and continued by station personnel in 1965 and 1966 after a 1-year lapse. Results of the later measurements are forwarded directly to the Naval Facilities Engineering Command.

Tunnels. Early measurements in 1966 showed a continued downward movement in the tunnel arches amounting to approximately 9 inches during the preceding 12 months. This amount is in keeping with preceding measurements.

Visual inspection shows an inward movement of the tunnel walls and the arch footings. This movement has produced a general buckling of the steel arches at the crown (Figures 2 and 3). While undesirable, this does not appear to be a serious structural weakness. The steel arch in tunnel L-3 is badly deformed over the maintenance shops as a result of the structural fire in that area, and appears to contribute little to the support of the overlying snow. A similar condition exists at the vehicle entrance ramp in the same tunnel. The increasing weight of snow overhang caused by drift at the entrance has resulted in failure of several feet of arch (Figures 4 and 5).

Loss of space around buildings due to inward movement of tunnel walls was corrected with extensive sidewall trimming performed by DF-65 winter-over personnel. A crew of four reportedly spent about 2 weeks trimming the walls where required. Chain saws and the NCEL trimming frame and snow-melting disposal system[2] were used in this work. Tunnels with low internal heat load have never been trimmed. At present all tunnel sidewalls are in good condition (Figure 6) and should not require additional work for several years.

Differential settlement of tunnel floors which caused building doors to stick during DF 64[3] was not a current problem. All buildings appear level, with no serious deflection even where sewer trenches are undesirably close to building foundations.[1]

Passageways. Snow deformation in the 5- by 7-foot passageways connecting the main and lateral tunnels has twisted the passageway door casing, and the doors no longer close. This is convenient for persons living in the camp, but has several undesirable effects. These are:

1. Lateral tunnels, including those used for bulk fuel storage, cannot be isolated for fire safety.

2. Carbon monoxide and other engine exhaust gases from vehicles in tunnel L-3 are carried throughout the camp.

3. The camp cannot be compartmented for control of air circulation and improved temperature regulation.

To correct this condition, passageway doors are required which are compatible with the slowly but continually deforming snow. This might be accomplished by:

1. A door casing of sufficient rigidity and strength to withstand the hydraulic pressures of the plastically deforming snow

2. A deformable diaphragm between the passage walls and door casing to absorb differential movement

3. A door system fitting against the face of the passageway bulkhead rather than set into the passage

Ventilation

The principal ventilation requirement in the undersnow camp is for temperature control and the disposition of heat lost from buildings and from other sources. Since the rate of snow deformation is dependent on its temperature, a minimum tunnel air temperature is desired. In designing Byrd Station, 0°F was selected as the objective tunnel temperature. This has not been attained in tunnels with high internal heat loads. A detailed summer ventilation survey being published as a separate report* showed that average tunnel temperatures were 5 to 6°F lower than

* Technical Report R-(MS-27): Tunnel ventilation and heat load survey - Byrd Station, Antarctica, by C. R. Hoffman. Port Hueneme, Calif., (Manuscript in preparation).

during a similar survey conducted in 1963, but were still as much as 18°F higher than the desired 0°F. This lowering of tunnel temperature was partially attributed to the reduced circulation of warm surface air by closing of the vehicle ramp at the end of tunnel M-1. Drifting snow covered the surface opening during the winter and reopening was not planned.

Little reduction in tunnel temperatures can be expected until the entrance and free circulation of warm surface air through the camp is eliminated. Doors at the tunnel passageways are required as well as sealing of snow bulkheads. Openings several times larger than needed now exist around utility lines penetrating these bulkheads (Figure 7).

Surface Air Entrance. The principal surface air entrances are the vehicle ramp in tunnel L-3 and vertical escape hatch in tunnel L-9 which, based on the accumulation of snow at the bottom, stands open most of the year. No simple yet practical solution is visualized for closure of the vehicle ramp. An elevator closing flush with the surface and capable of lifting the largest piece of equipment might be used, but would require major design and construction effort. Such a system, however, should alleviate snowdrift problems in the present ramp and reduce snow accumulation over the tunnels.

The vertical escape hatch in tunnel L-9 is used extensively by scientists going to and from the surface. Opening and closing the escape hatch with each use is inconvenient and somewhat dangerous while hanging on the vertical ladder. Entrance of warm surface air might be eliminated with installation of a self-closing door at the bottom of the escape shaft.

Tunnel Air Exhaust. Exhaust fans located at the top of the steel arches are used to vent warm air from tunnels containing heated buildings. Ducts from these fans carry the air to the surface and terminate in a weather hood. Because of the continual accumulation of snow, periodic upward extension of the ducts is required. This was accomplished during January 1966 using materials available at Byrd Station and McMurdo. Previous material shortage has resulted in some reductions in duct diameter. This, and lengthening of the duct, increases pressure drop and reduces the volume of air vented from the tunnels.

BUILDINGS AND EQUIPMENT

The location of buildings and equipment below the surface presents problems in disposal of combustion gases and noxious fumes. Disposal of waste heat from generator sets and its use in producing water by snow melting has also not been without difficulty.

Vent Stack

Exhaust gases from oil-burning furnaces and diesel generator sets are vented directly to the surface in individual stacks penetrating the roof arches. These stacks require frequent attention because of condensed vapors which produce rapid corrosion of the metal. Insulating the stacks reduces heat loss to the tunnels and maintains higher gas temperatures, thereby reducing condensation. Deformation of tunnel arches has produced misalignment between the vent stack and the arch-to-surface opening. This results in buckling and leaks in the vent stacks.

Furnace. At the time of the survey, nearly all furnace vent stacks were in poor condition, showing effects of corrosion and buckling. Stack replacement and insulation were scheduled pending receipt of the required materials. Annual maintenance of the stacks will probably be needed because of the severe operating conditions.

Generator. Arch deformation produced serious misalignment and loss of insulation on the heavy generator exhaust stacks. This, in turn, produced abnormally high temperatures in the exhaust pipe surface duct, and melting of the surrounding snow occurred. This condition was first observed when water leaked through the steel tunnel arch, forming icicles over the generator building and a large cascade of ice on the north tunnel wall. Arch deformation and misalignment is also believed to have caused earlier breakage of generator engine exhaust manifolds.

Repairs to the generator exhaust system were in progress in December. Exhaust pipes were realigned and insulated with magnesia insulation in a workmanlike manner.

Range Hood

Cooking fumes and odors from the galley range are vented directly into tunnel L-7 through an exhaust hood and jury-rig fan. The stainless steel hood is of adequate size, but has an outlet duct through the roof only 8 inches in diameter. A duct fan, 18 inches in diameter, is tacked to the roof over the hood opening. Grease filters were not available for the hood, but were being procured. Airflow from the hood could not be measured precisely, but was between 300 and 400 cfm. This volume is far below normal recommended values. The cook felt that operation of the hood was better than many shipboard systems with which he was familiar, but wanted grease filters to simplify cleaning.

The exhaust hood outlet should be reworked for venting directly to the surface to reduce the heat load in the tunnel. When this is done, a change in fan and hood outlet size would undoubtedly be required.

Engine Cooling

The diesel engine generator sets providing electric power are cooled by pushing room air from the generator building through the radiators into a large waste heat plenum. The plenum is vented to the surface through a large insulated steel duct. Make-up air from the surface entered the generator building through a second steel duct and discharged to the room at the rear of the generators.

This system apparently operated satisfactorily until water began leaking through the tunnel arch on the south wall behind the generator building. The water appeared to be the result of melting around the waste heat duct which was carrying air at 170°F and was not related to melting at the generator exhaust stacks. Entry of water through the arch, which created a considerable quantity of ice, was stopped by tempering the air in the waste heat plenum and duct with cold surface air. This was accomplished by closing the surface-air make-up duct as it entered the generator building and providing an opening to the waste heat plenum. A fan mounted in this opening pulled cool air from the surface and discharged it into the waste heat plenum, thereby diluting the warm radiator air. This reduced the temperature in the duct to about 80°F when the surface temperature was +2°F, and no further melting occurred.

The modification of the surface-air duct requires the use of tunnel air for make-up in the generator building. In most instances, existent building openings provided adequate air entry. If required, special ports cut through the building wall behind the generators can be opened.

Snow Melting

Water at Byrd Station is produced by melting snow in a 1,000-gallon rectangular tank. Waste heat from the diesel engine generators is used for this purpose with engine cooling water circulated through heat exchanger coils in the bottom of the melter tank. Snow from the surface is pushed by bulldozer into a vertical culvert pipe about 8 feet in diameter and drops to a height about 15 feet above the tunnel floor. From this point, snow is loaded by hand into a mechanical conveyor which discharges directly into the melter tank.

Water Production. With a camp population of about 50 persons, the water consumption is 800 to 1,000 gallons per day, or 16 to 20 gallons per man per day. This includes laundry, showers and minimum-water flush toilets. To produce this amount of water, four men load the melter four times a day on a rotational schedule which includes all camp occupants except short-term visitors. To prevent interference with normal work, the melter is loaded at 6 A.M., noon, 6 P.M. and midnight.

Use of water is definitely restricted; showers and laundry are permitted only once a week, and urine collection barrels are used outside the buildings rather than using a water-flushing toilet as a urinal.

The existing snow melter and waste heat system has sufficient capacity to produce at least twice the current amount, but is not being utilized because of the time-consuming labor required in filling with snow. A study should be performed to determine the most suitable method for increasing water production.

Waste Heat System. The waste-engine-heat snow-melting system was performing satisfactorily for DF-66 personnel. Inspection of the system by the engine manufacturers' representative in the early summer reaffired the suitability of their original system design. This resulted in addition of a 1/4-inch vent line from the highest point in the circulating system to the surge tank. Omission of this vent line in the original installation was believed to have caused vapor locking of the system and the resulting cracked engine heads reported in previous years' operations. A check of cylinder head breakage indicated that four units had been damaged since construction of the camp. With two cylinder heads on each generator engine, only two incidences could account for the total breakage.

SKIWAY

Aircraft operations at Byrd Station are restricted to ski-equipped aircraft. A skiway is prepared for use in early October and maintained until close of the season in mid-February. Preparation consists principally of leveling small drifts and smoothing the sastrugi. An improvised drag was used for this purpose in early operations. Because of its success at other locations, a 40-foot mechanically operated snowplane was procured for Byrd Station in DF 65. The unit received some use in that year, but had not been used in DF 66. Information relayed to DF-66 personnel indicated that the manually controlled machine was difficult to operate since it must be stopped for blade adjustment. Also, it required two operators to plane the runway, while only the tractor operator is required in dragging. Figure 8 shows the snowplane in the equipment line in December 1965. The plane is in good condition, but requires repair of a rear ski and diagonal tie-rods. Also, the draw pin plate at the outer end of the drawbar is missing.

Maintenance of the skiway is not performed on a rectangular schedule but rather as ground inspection and pilot complaints indicate a need.

REQUIREMENT SUMMARY

The DF-66 Byrd Station survey showed the present condition of the undersnow camp to be generally good, with the utilities being the principal area in need of improvement. These requirements include:

1. Improved summer tunnel cooling

2. Control of surface air entry and cross circulation between tunnels

3. Increased water production with reduced manpower

4. Improved surface venting of combustion gases and noxious fumes

5. Closure of fuel tunnel passageways for improved fire safety

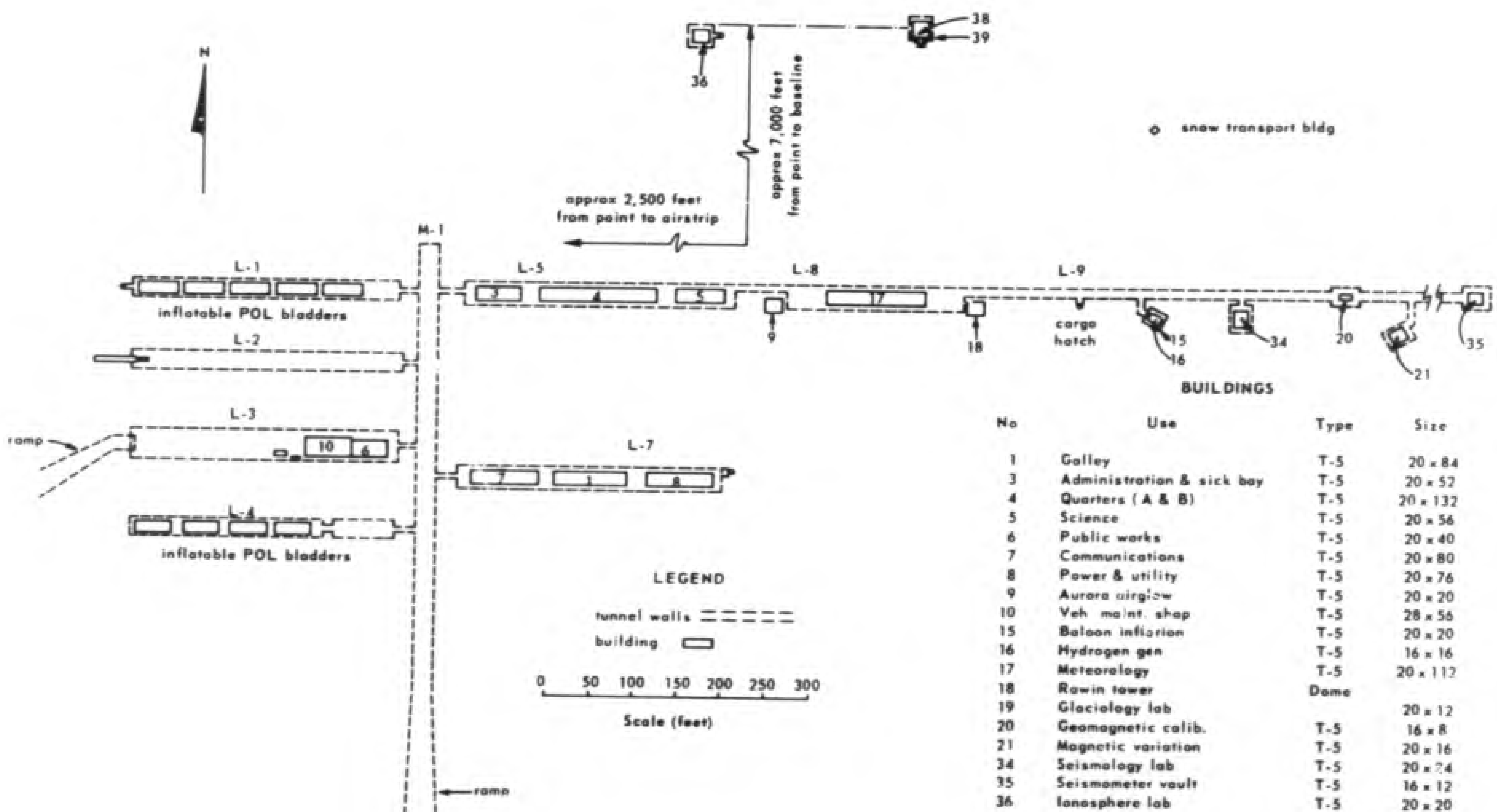
Shortness of the construction season and long lead time required for material procurement also requires the anticipation and careful, thorough planning of maintenance operations.

REFERENCES

1. U. S. Army Cold Regions Research and Engineering Laboratory. Technical Report 138: Undersnow structures, Byrd Station, Antarctica, by Malcolm Mellor and George Hendrickson. Hanover, N. H., 1965.

2. U. S. Naval Civil Engineering Laboratory. Technical Report R-389: Byrd Station snow tunnels - Maintenance equipment and techniques, by G. E. Sherwood and S. E. Gifford. Port Hueneme, Calif., June 1965.

3. _____. Technical Report R-438: Technical data compiled from operational reports on Deep Freeze 61 through 65, by J. P. Cosenza. Port Hueneme, Calif., April 1966.



BUILDINGS

No	Use	Type	Size
1	Galley	T-5	20 x 84
3	Administration & sick bay	T-5	20 x 52
4	Quarters (A & B)	T-5	20 x 132
5	Science	T-5	20 x 56
6	Public works	T-5	20 x 40
7	Communications	T-5	20 x 80
8	Power & utility	T-5	20 x 76
9	Aurora airglow	T-5	20 x 20
10	Veh maint. shop	T-5	28 x 56
15	Baloon inflation	T-5	20 x 20
16	Hydrogen gen	T-5	16 x 16
17	Meteorology	T-5	20 x 112
18	Rawin tower	Dome	
19	Glaciology lab		20 x 12
20	Geomagnetic calib.	T-5	16 x 8
21	Magnetic variation	T-5	20 x 16
34	Seismology lab	T-5	20 x 24
35	Seismometer vault	T-5	16 x 12
36	Ionosphere lab	T-5	20 x 20
37	VLF (whistler)		15 x 10
38	Radio noise lab	T-5	20 x 20
39	Gen. noise lab	T-5	16 x 16

Figure 1. Plot plan, Byrd Station, Antarctica, conditions as of DF-65.

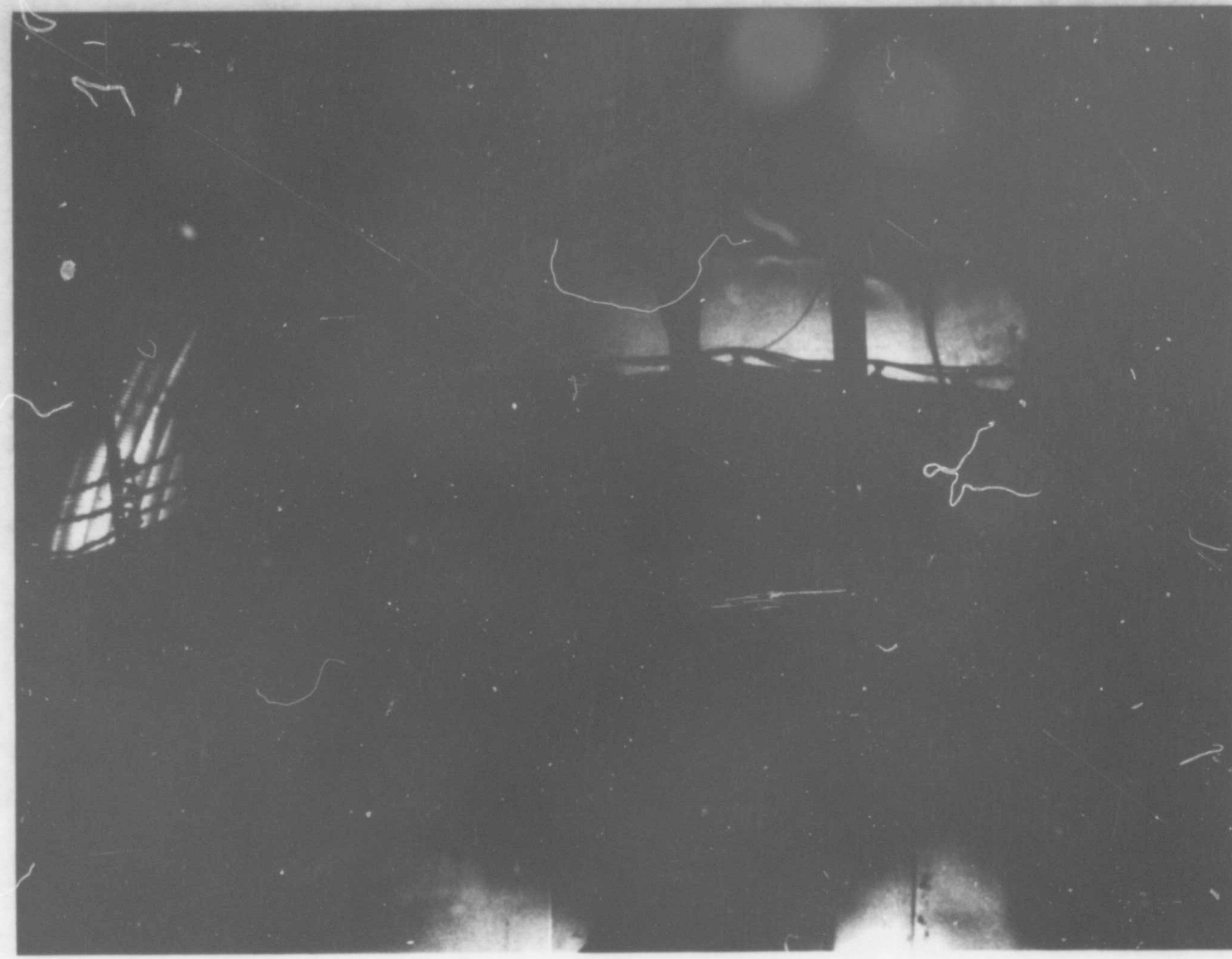


Figure 2. Tunnel L-5 showing steel arch over administration building looking east.

Figure 3. Tunnel L-3 looking east at maintenance buildings.

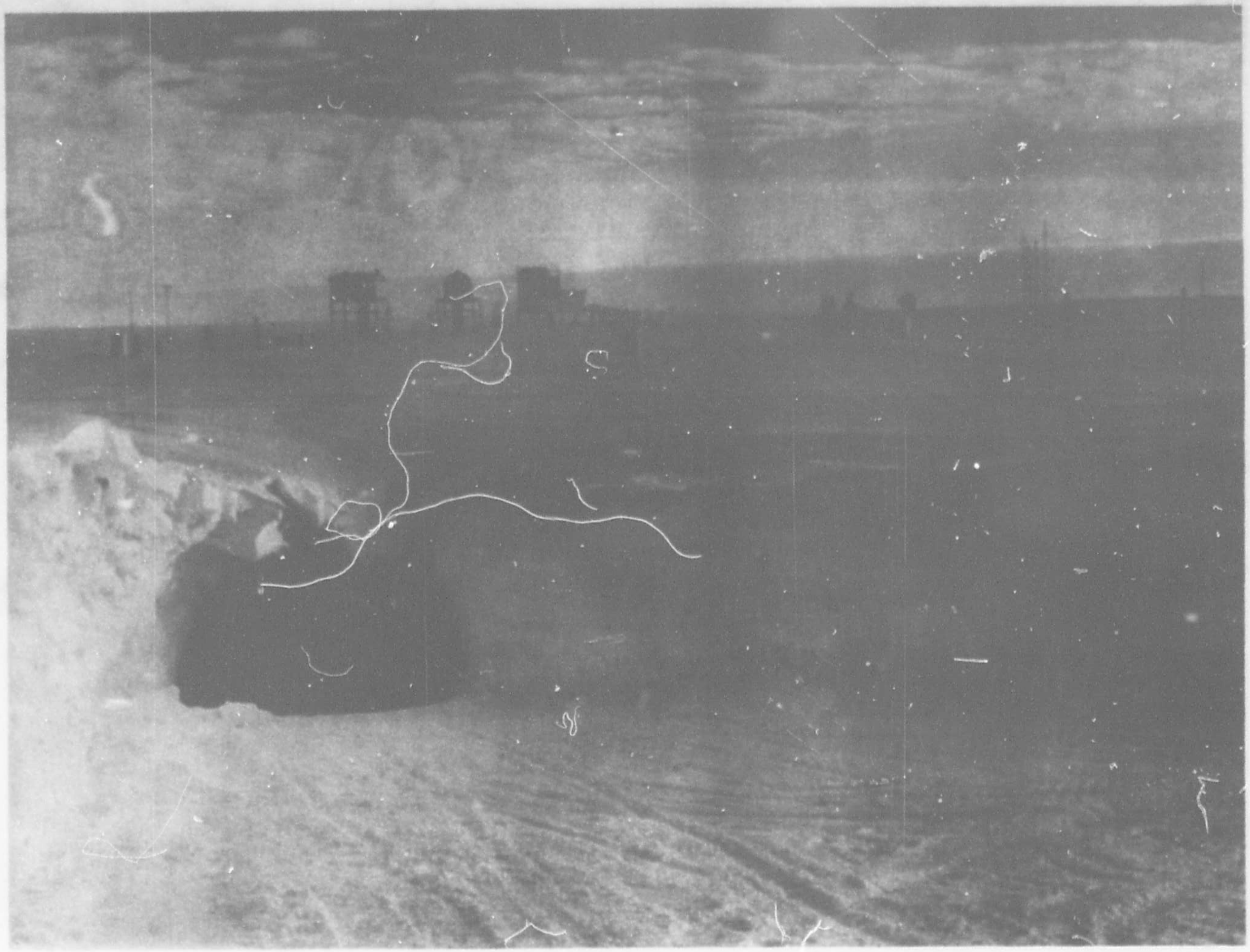


Figure 4. Entrance ramp to tunnel L-3 as seen from surface.

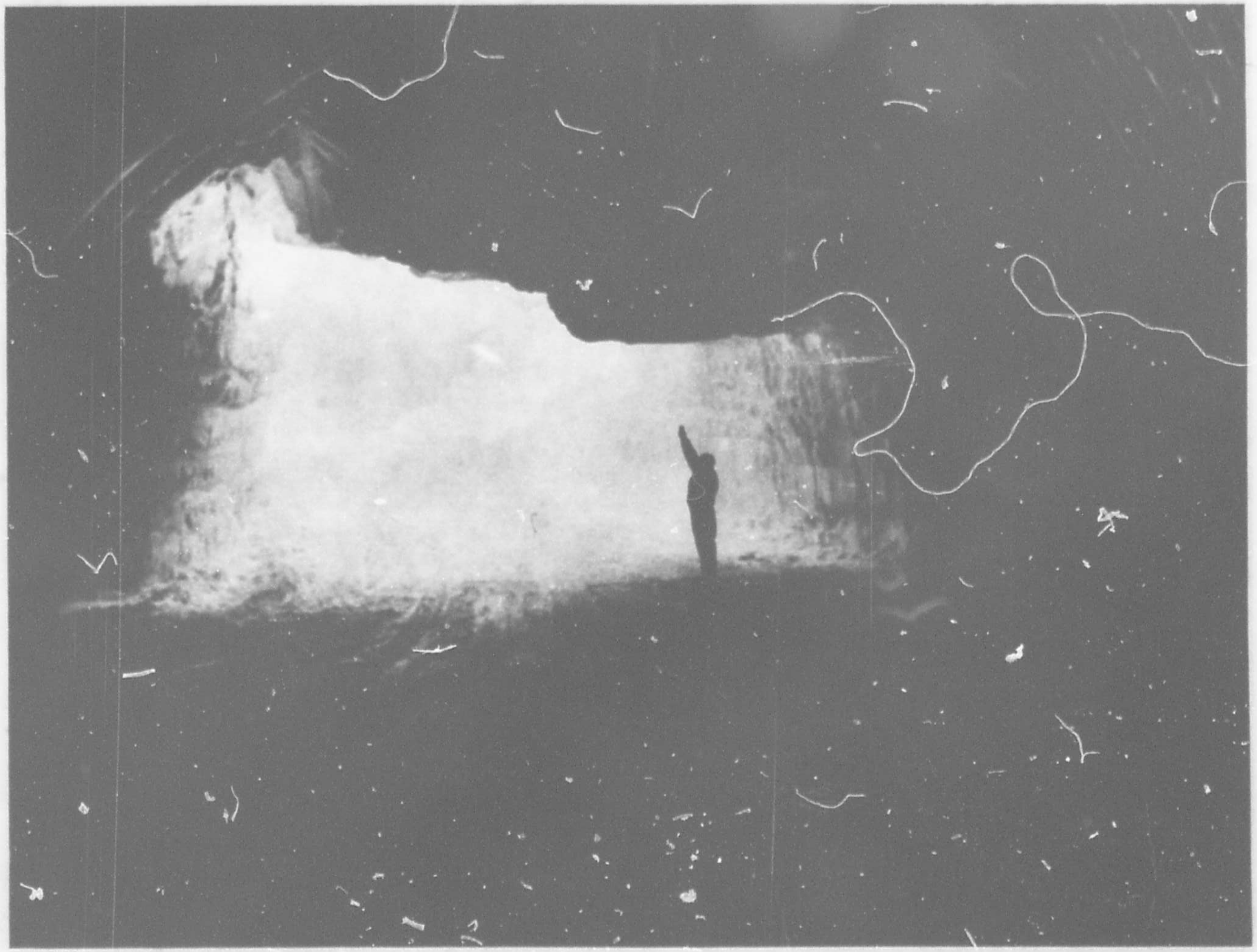


Figure 5. Surface-ramp entrance as seen from tunnel L-3.

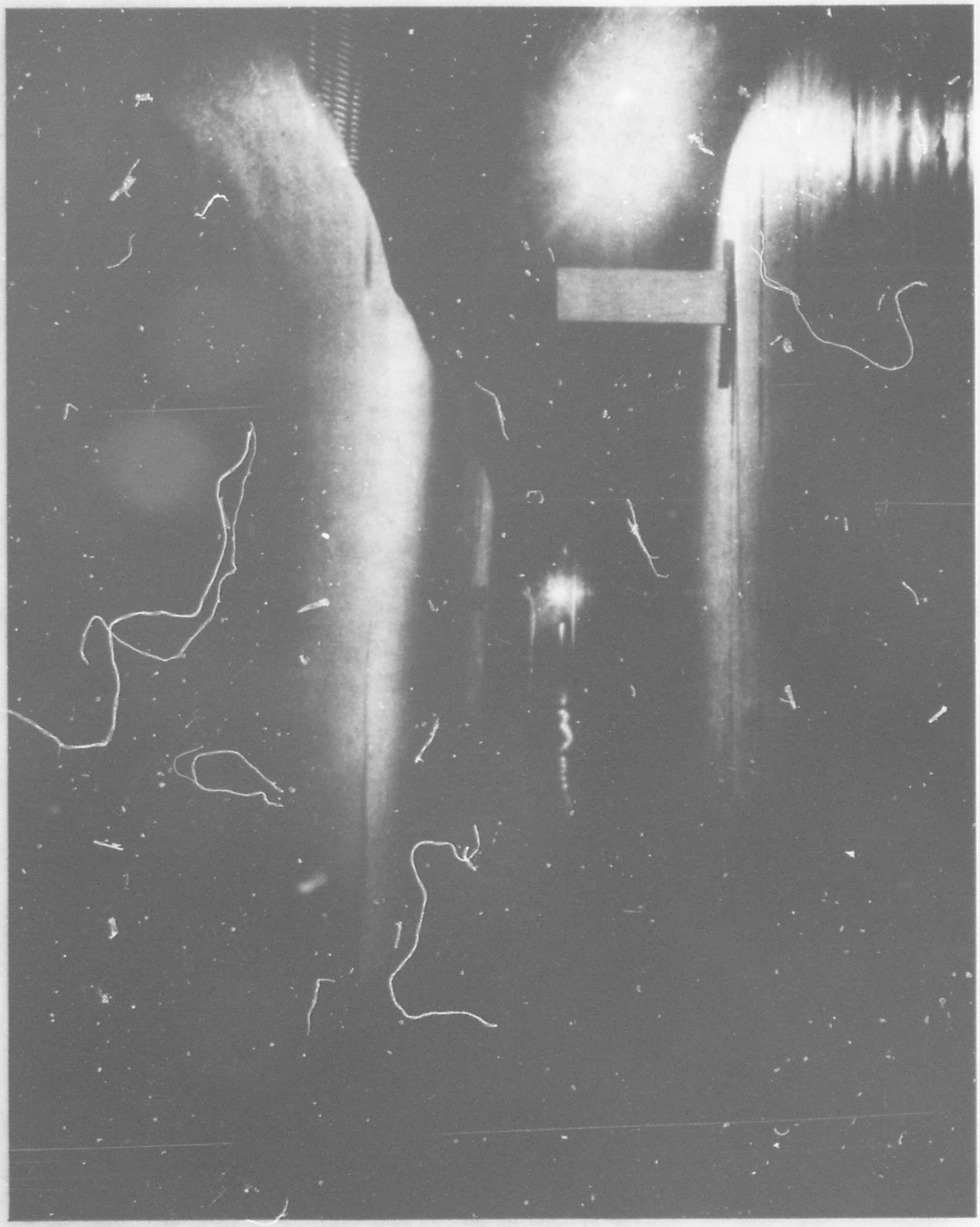


Figure 6. Walkway on north side of quarters building in tunnel L-5. Snow walls trimmed 12 months previous.

Figure 7. Passageway from tunnel M-1 to L-5 showing door and bulkhead opening around overhead water line.

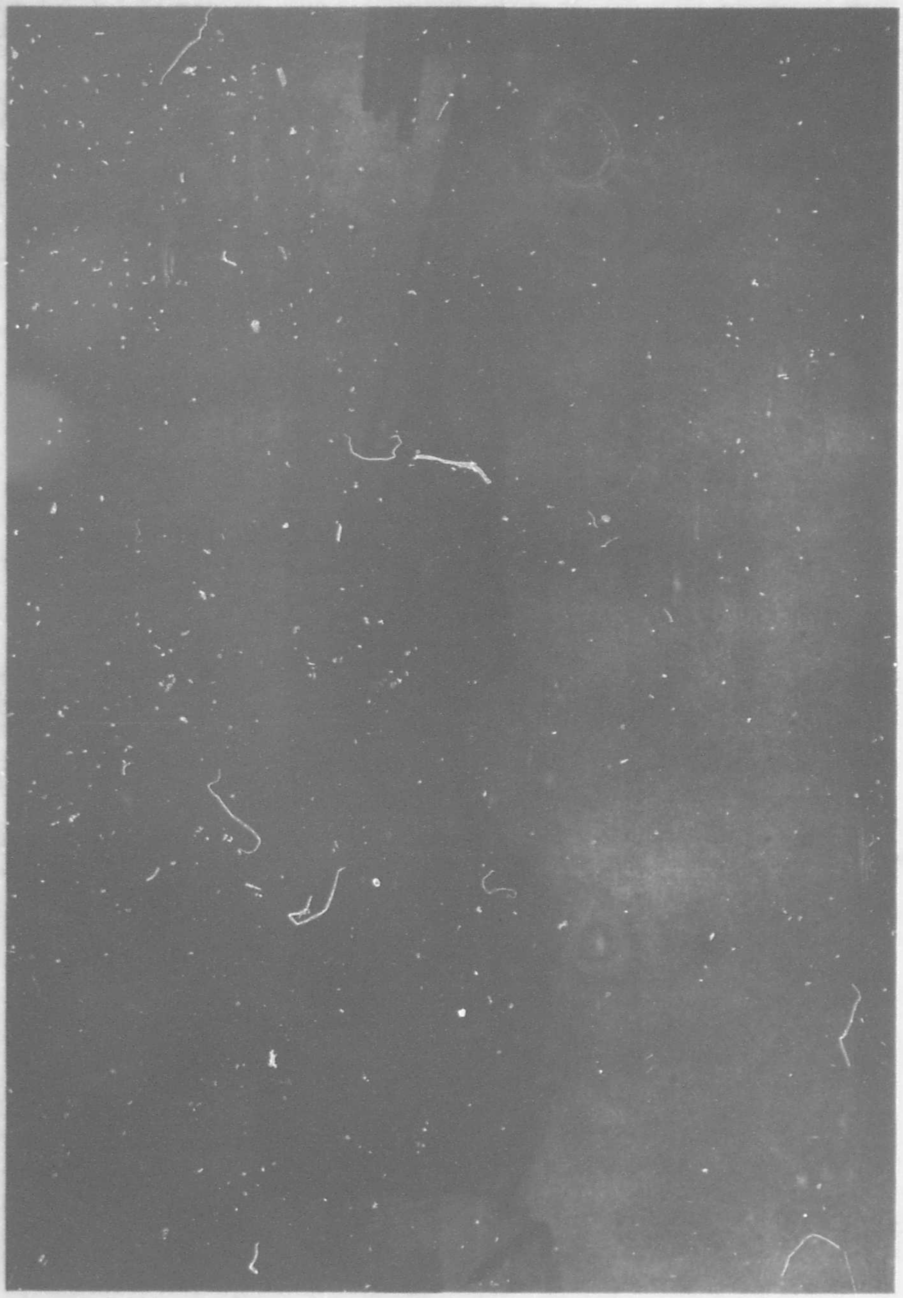


Figure 8. Manually operated snowplane at Byrd Station, January 1966.