RESEARCH AND DEVELOPMENT OF AVALANCHE CONTROL METHODS IN BANFF NATIONAL PARK

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Introduction

The primary method for controlling avalanches in Banff National Park is helicopter bombing. In 1970, we began investigating methods of controlling avalanches which would supplement helicopter bombing and provide capability to control avalanches under all winter conditions of the alpine environment. The National Research Council (NRC) and Parks Canada approached the Defense Research Establishment, Suffield, (DRES) for advice and guidance. DRES was in the process of developing a radio remote control system and a keen interest was expressed in attempting to apply this system for the control of avalanches. The following specifications were set:

1. The device must be reliable under all winter weather conditions.
2. The explosive charge must be activated remotely by a coded radio signal.
3. The charge must be activated independently of other such devices.
4. The device must be safe to handle and transport.
5. The device must be animal-proof.
6. The non-recoverable cost must not exceed more than $250.00 per explosive charge.

Receiver Explosive Model

In 1972, DRES designed a remote receiver system (Fig. 1), and incorporated it into an explosive package which could be fired by coded radio signal from a remote location. Since the receiver electronics would be destroyed in the blast, electronic quality was kept to a minimum. These units were installed at Rogers Pass and Banff and tested from 1972-74. They successfully released avalanches, but the receiver-decoder electronics were inadequate, and costs were not within the prescribed parameters.

The experience gained during the experiments with the radio-receiver-explosive package indicated that high-quality electronic hardware would be required to make the remote detonation concept reliable. The Electronic Engineering Division of DRES designed and developed a system similar to the public paging system (i.e., a beeper triggered by a receiver when two correct audio tones are received). Since a two-tone system was not considered safe enough for explosive work, a system which required 16 correct pulses (binary bits) was designed and built.

Signal Transmitting Unit

A portable signal transmitting unit (Encoder) (Fig. 2) was built with an enclosed rechargeable power supply that could be used in a fixed location, a vehicle, or could be transported in a packsack. The channel number of the receiver to be addressed is entered on the manual keyboard of the encoder. This number is visually displayed so that an accuracy check can be made. If a wrong number is entered, it can be cancelled by an erase button and the correct number re-entered. When ready to fire, one button is held to energize the radio transmitter and a second button is operated to transmit the selected channel code. The presence of a radio frequency signal is detected by the powerup circuit in the receiver at the remote site. As a power-saving feature, the receiver cycles through on-off periods and it is necessary to hold the radio receiver energizer on for a minimum of one second. By pushing the firing button, the encoder transmits a code in the form of audio frequency tone pulses which are superimposed on the carrier frequency.

Avalanche Zone Electronic Hardware

The radio receiver, decoder, individual channel number selector cards, output firing circuit and safety circuit form another compact unit placed near the explosive units in the avalanche starting zone (Fig. 3).

Once the receiver detects the correct radio frequency, the rest of the circuits are powered. The decoder reads the incoming pulses and registers the information into a shift register. This register checks against its own register and, if a match has occurred, the enabling signal is sent to the firing circuit activating the electrical detonator and the explosive charge.

The present system utilizes one main radio receiver and six decoder channels (one channel per explosive charge). The number of decoder channels could be increased, but six was chosen because it fulfilled our particular requirements.

Safety Aspects

1. The radio frequency used is authorized for use only by Parks Canada for this specific purpose.

2. The identification codes for each explosive package are set each year by DRES and Parks Canada technicians.

3. Sixteen correct pulses or "bits" of information are required to activate an explosive charge. There are 65,536 possible combinations before one might trigger a charge if a tone pulse generator were used on this frequency.

4. If the battery voltage drops to a point where reliable operation of the receiver and decoder cannot be guaranteed, the safety circuit will not allow the firing circuit to function.

5. A safety box allows trained personnel to short the detonators while placing the explosive charges. If a need should develop during the winter to repair or replace electronic components, this can be done safely by again shorting the detonators.

Hardwire Installation

In 1974, we placed a small building to house the above electronic hardware on a mountain ridge and laid wire enclosed in P.V.C. pipe to six explosive charge positions in an adjacent avalanche starting zone (Fig. 4). This installation has been used since 1974 and has proved to be a reliable system of controlling avalanches during storm periods. Following is a summary of our experience with hardwire installation:

1. To avoid damage to adjacent lines a minimum spacing of 5 m should be maintained.

2. Wiring was enclosed in 1½" PVC pipe which withstood abrasion animal attack and has remained in excellent shape.

3. Time and expense should not be spared on the original installation. Lines should be securely placed and buried, if possible.

4. Each season the explosion only destroys about 0.5 m of line. By adding 0.5 m of flexible line each season to the buried hardwire lines, the original installation lasts indefinitely.

5. Placing explosives on the ground results in very little damage on rock or shale slopes. On vegetation-covered slopes, damage may result unless precautions are taken.

Research and Development of a Remote Launcher

For added versatility, lower costs, and more convenient installation, it was decided to investigate the feasibility of incorporating the existing electronics into a remotely operated launching mechanism which would be located adjacent to the avalanche starting zone. An experimental bank of six launchers was built in the DRES laboratories and tested during the winter of 1975-76 to control avalanches on the Sunshine road. The system successfully released avalanches.

Each launch tube (Fig. 5) is a simple mechanical device based on the principle of the Spigot Mortar. Upon receipt of a correct signal, the firing circuit activates the expelling charge which is installed between the projectile (explosives head) and the launcher base expelling the explosive head past a safety shorting switch which allows initiation of a four-second delay detonator in the explosive head. Should a failure occur in the expelling charge, the shorting switch would prevent initiation of the delay-det and the explosive would not fire. The system may be serviced and explosives replenished during the winter -- operations that are not feasible on a pre-planted charge system.

Problems occurred with the exposed wiring and the mechanical interrupt device, and refinement was required. Experiments were carried out this past winter investigating methods to overcome occasional malfunction of the mechanical safety interrupt and to place all essential wiring undercover.

At present, a unit which incorporates the expelling charge and detonator into a single package is being evaluated on the DRES proving grounds. We are hopeful this unit will solve the reliability problems of the launcher system.

Conclusion

To supplement helicopter bombing of starting zones, and to provide capability for explosive control during all weather conditions, Banff National Park is utilizing detonation systems that are remotely controlled. Electronic packages which incorporate tamper-proof codes have been developed to detonate explosives pre-planted in avalanche starting zones. This equipment has been used successfully to release avalanches for the past three winters.

A remote launcher which includes the above electronics is under development. Initial experiments are encouraging.

ACKNOWLEDGEMENTS

The support, expertise, and skill of members of Defense Research Establishment Suffield is responsible for the success of the project. Particularly Mr. F. Ross, Mr. J. Michel and Mr. D. Weiler, Electronic Engineering Section, Mr. J. Anderson, Military Engineering for his work on the initial design, and the explosive expertise of Mr. R. Klymchuk, Field Operations Section. The National Research Council, Mr. P. Schaerer, initiated this project in 1970 and has been kind enough to support it technically and financially. The project would not have progressed without the support and expertise of the Wardens of Banff National Park, Parks Canada.

APPENDIX: Cost Structure[1]

Encoder (signal transmitting unit)	$3,000.00
Installation Cost per Avalanche Site (Hardwire Style)	
6 - Channel Receiver - Decoder*	$1,500.00
Safety - Metering Box	350.00
Building	500.00
Wiring	50.00
PVC Pipe	150.00
Explosives	50.00
Labour 80 man hours required	800.00
APPROXIMATE TOTAL COST (not including helicopter installation time)	$3,400.00
Annual Cost	
Explosives	$ 50.00
Labour eight man hours	80.00
Routine Maintenance	100.00
TOTAL ANNUAL COST	$ 230.00
Annual cost per explosive charge approximately	$ 40.00
Estimated costs of the launch system would be similar	

[1]Costs are based on 1976 pricing

Discussion

EIGENMANN: What is the carrier frequency in your remote controls?

EVERTS: It operates at the VHF band of approximately 160 MHZ.

NOREM: Can you remotely detonate explosives 24 hours around the clock? We have a similar system, but we are allowed to operate only one hour each day.

EVERTS: We have no restrictions which depend on time or weather.

FITZGERALD: How many times can you fire your pre-planted charges?

LAIDLAW: We use one decoder for each avalanche path. Each decoder is capable of firing 2000 separate signals, but we are presently coupled to only six explosive charges in a given path.

SALWAY: Does your remote launcher have to be maintained against icing and other winter problems?

EVERTS: As in any research project, we have had our share of equipment problems, although we have not yet had a malfunction due to icing.

LAIDLAW: I would like to add that we used the Spigot Mortar principle because of its excellent mechanical characteristics in a severe environment.

ANDERSON: Can you control several paths with one launcher?

LAIDLAW: We could adjust firing angles to align with two or more separate paths, provided they are within the launcher range. The present range is 60 m, but this can be increased.

FREER: Do explosive regulations restrict open storage of explosives at a mountain site?

LAIDLAW: We are presently consulting with the Department of Energy, Mines, and Resources on this problem.

ANHORN: You have received newspaper publicity for your launcher. Do you take precautions to prohibit tourists from inspecting your site?

EVERTS: The site is extremely difficult to access without a helicopter (helicopter skiing is prohibited in National Parks). The area is well posted with warning signs, and the system is removed in April.

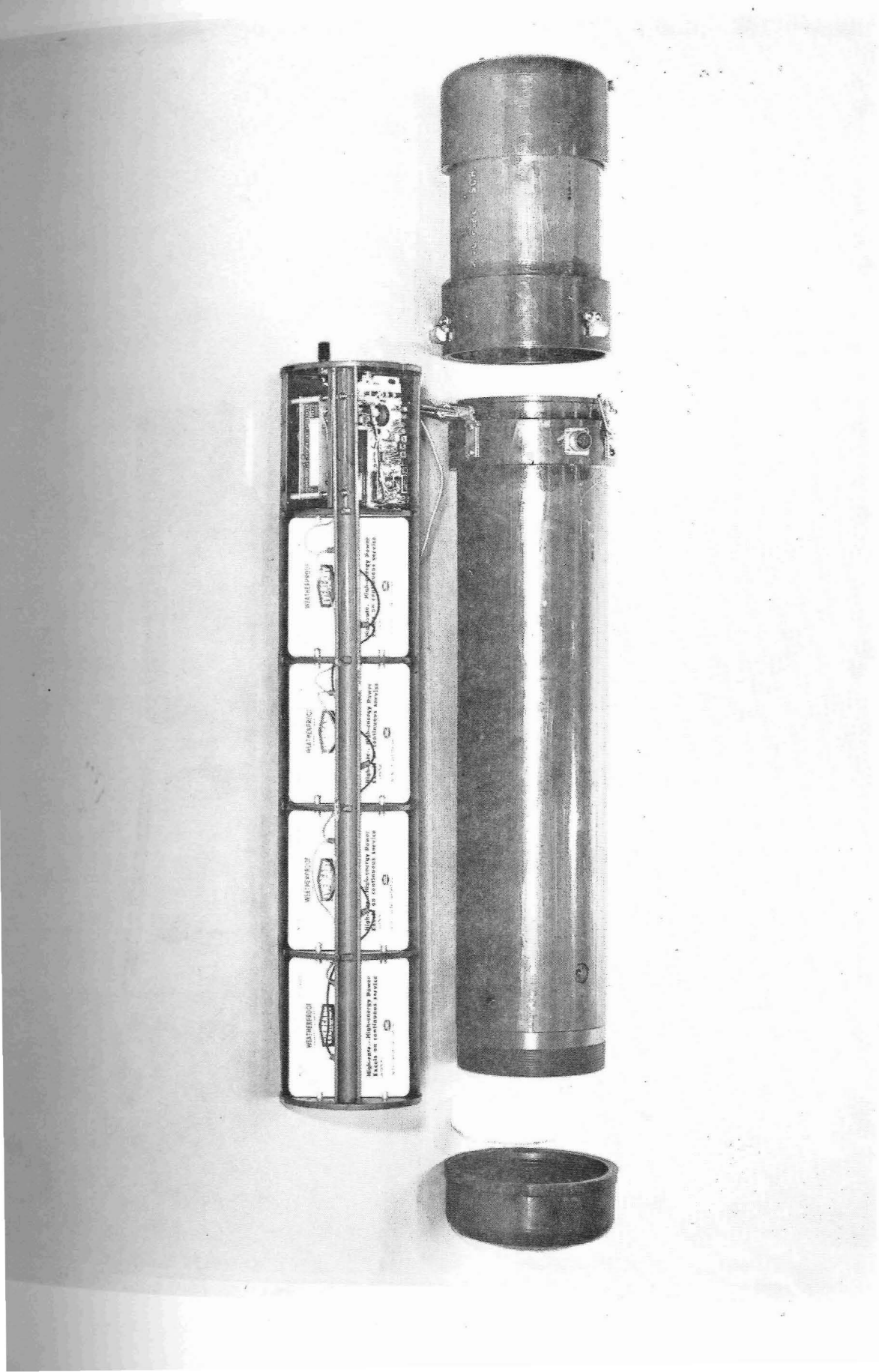

FIGURE 1 ELECTRONIC AND EXPLOSIVE ASSEMBLY PRE-PLANTED IN AVALANCHE STARTING ZONES

FIGURE 2 TRANSMITTER AND ENCODER

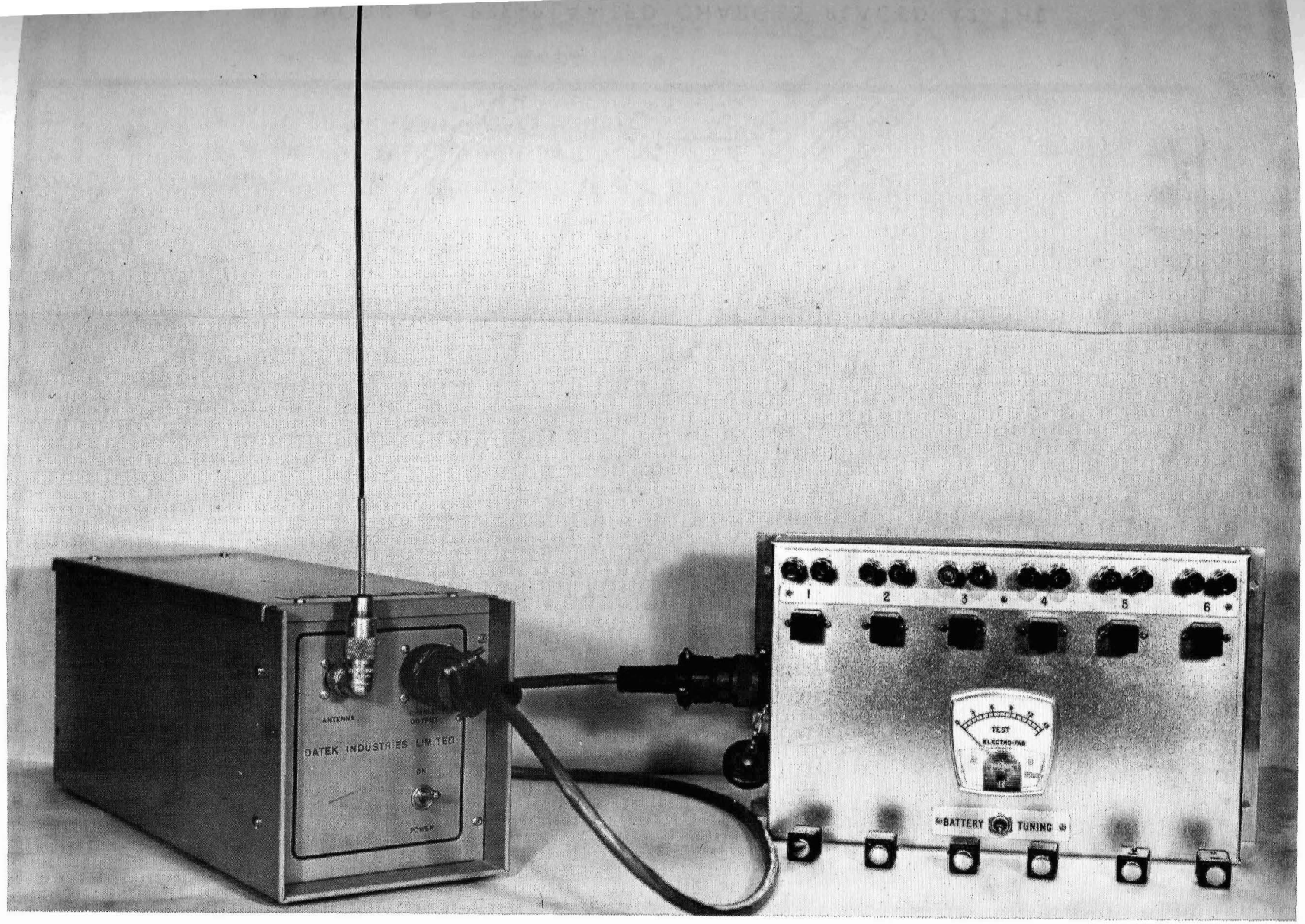

FIGURE 3 ELECTRONIC EQUIPMENT LOCATED NEAR AVALANCHE STARTING ZONES

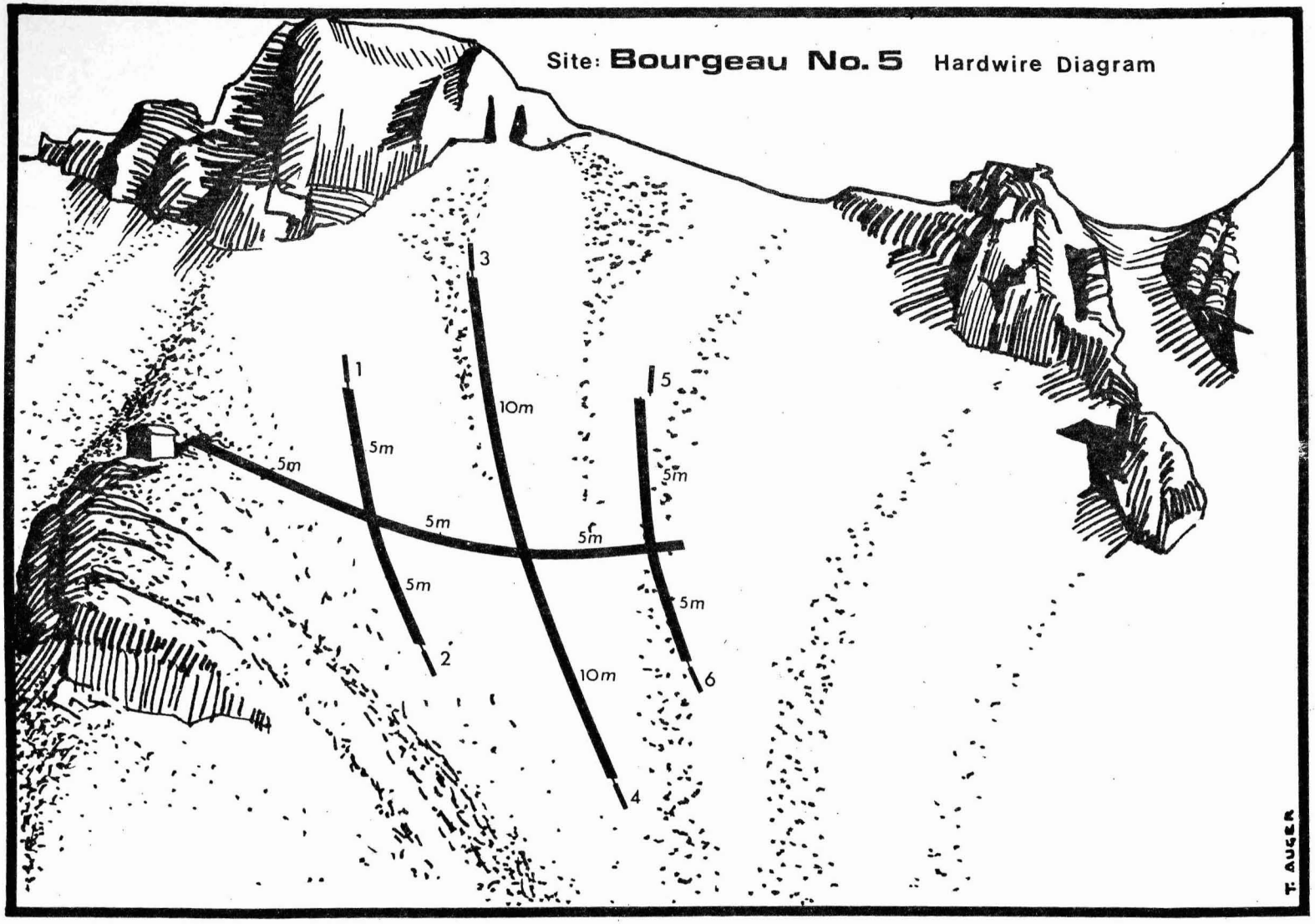

FIGURE 4 NETWORK OF PRE-PLANTED CHARGES PLACED AT THE "BOURGEAU NO. 5" STARTING ZONE

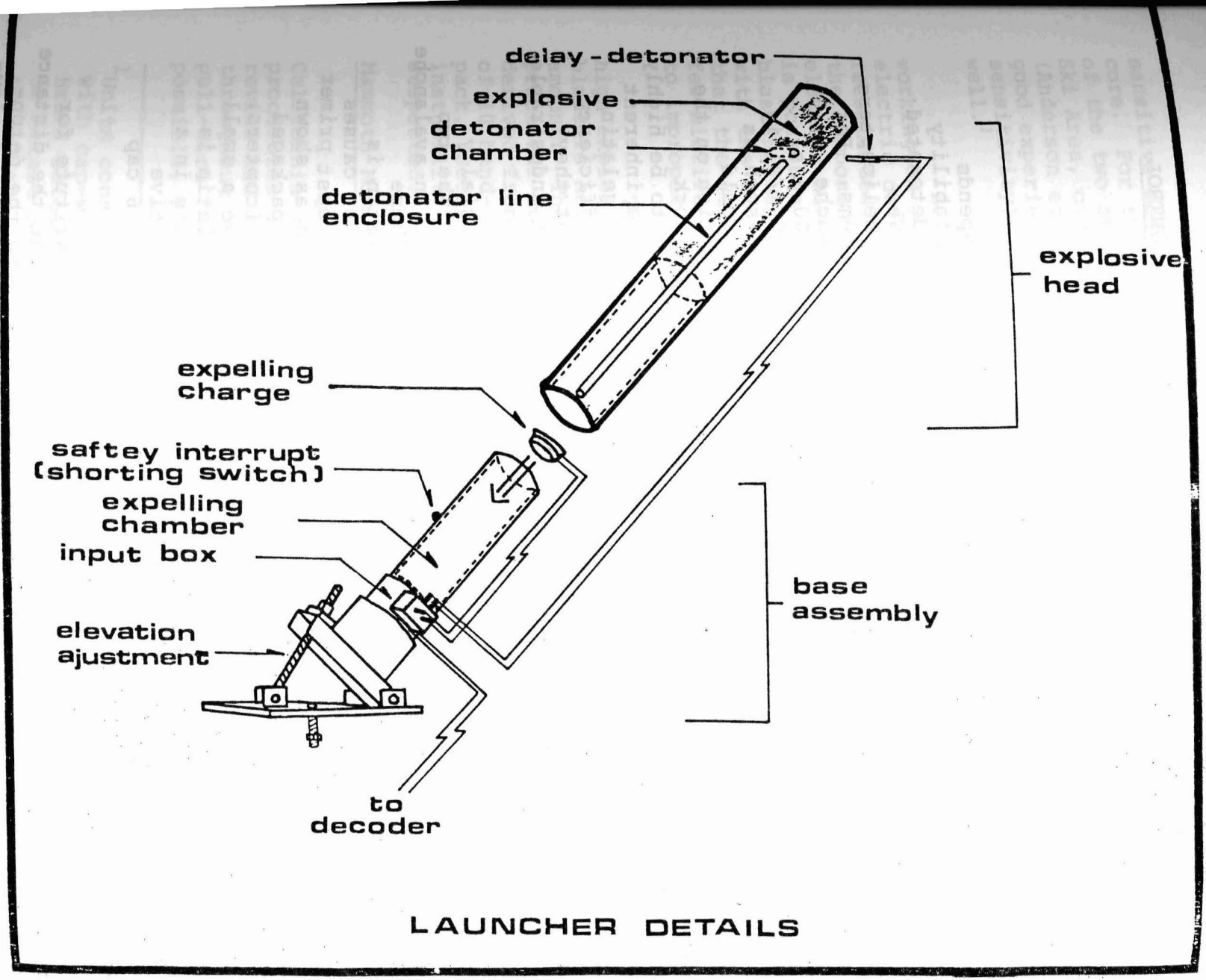

FIGURE 5 SCHEMATIC OF REMOTELY OPERATED LAUNCHER (UNDER DEVELOPMENT)