THE FRENCH "AVALANCHEUR"

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ABSTRACT

The use of military weapons in order to release avalanches has always been prohibited in France. Therefore, at the beginning of the seventies, people in charge of the avalanche release project at the ANENA decided to import an American avalauncher. It was modified and reinforced to remove several drawbacks and a more powerful projectile was designed which contained liquid explosive. As liquid leakages were noted and several misfires occured, a new, more reliable, projectile has been designed. It includes: a stabilizer (caliber: 83 mm.) with a 2-gram cap and the priming system, an aluminum tube (length: 1.8 m. - diameter: 40 mm.) which contains the self-neutralizing liquid explosive, and a watertight conical plastic head. This new generation projectile manufactured by the Ruggiéri Co. offers a working security of more than a 99%.

THE PLACE OF THE AVALAUNCHER AMONG THE DIFFERENT RELEASE METHODS

During the 1990 ISSW, we described the different avalanche release methods in use in France (Borrel, 1990). Since then the French snow professionals have slightly shifted from their original position, as the most recent methods have proved to be very effective.These changes are given below (Tables 1 and 2, next page).
First, in France, only soldiers are allowed to fire military artillery. In addition, the time needed to get the right troops at the right place is prohibitive.
Second, we note that there is a move from the use of proximity blasting methods to remote blasting techniques, to avoid sending blasting parties on hazardous slopes. It also saves time (i.e. money) and may save lifes too.
Third, two methods lose importance:
- the use of hand-charges armed with a fused cap and tossed down onto the release point,
- the use of the CATEX (bomb tram), mainly because of maintenance problems and their induced losses of time.

Meanwhile, the use of more recent methods such as helicopter bombing and the GAZEX system has increased. Both methods are very effective and save time, though, the helicopter cannot fly during bad weather.
Finally, the use rates of electric blasting and **avalauncher** have remained the same. Electric blasting is almost unknown among the ski resorts safety patrols and the use of the avalauncher remains uncommon. The early avalauncher had some drawbacks concerning the 1st-generation

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"arrow", giving it a bad reputation today, even though dramatic improvements in its performance were achieved with a new projectile.

Table 1. The snow professionals' choices in 1990

Blasting family	Blasting method	Use percentage[3]
Proximity Blasting	Hand charge (fused cap)	66
	Electric blasting	3
	Heli-bombing	6
	Total "Close" Blasting	**75**
Remote Blasting	CATEX	23
	Avalauncher	1
	GAZEX	1
	Total Remote Blasting	**25**

Table 2. The snow professionals' choices in 1994

Blasting family	Blasting method	Use percentage[3]
Proximity Blasting	Hand charge (fused cap)	63
	Electric blasting	3
	Heli-bombing	8
	Total "Close" Blasting	**74**
Remote Blasting	CATEX	19
	Avalauncher	2
	GAZEX	5
	Total Remote Blasting	**26**

In addition, some guns are not used because staff snow professionals may have forgotten how to use them.
Then, the new projectile has a slightly reduced range because of its increased weight, so that remote release points may be unreachable now.
Last, some ski resort managers are waiting for a lower arrow price, before they decide to use their avalaunchers anew.

HISTORICAL BACKGROUND

At the beginning of the seventies, with the goal of developing remote avalanche control methods, the Association pour l'Etude de la Neige et des Avalanches (ANENA), imported the American MK 16 avalauncher, used by the U.S. Forest Service, since 1950.

3. Percentage of the total weight of burst explosive (1 GAZEX shot ~ 8 kg. of dynamite).

Before these avalaunchers could prove to be an effective avalanche control method, several problems had to be resolved. The difficulty of importing the solid explosive payload used in the U.S. required that a French projectile be developed. This projectile preserved the ATWATER explosive system which was easy to use and reliable, but had poor ballistic performance.
Furthermore, the French standards on pressurized container supplies were not satisfied on the MK's vessel so we were unable to use either the MK 16, or the MK 18 that was purchased later, to improve our knowledge in the field.

TECHNICAL DATA

The French Cylindrical "Avalancheur" and the First Generation of "Arrow Projectile "

The first French cylindrical "Avalancheur" was an improved copy of the MK 16 with an improved barrel that used a single 4-meter fiberglass barrel to increase the range and the accuracy. The gas volume of the avalauncher was 32 liters and after our first firing tests we kept a 45° firing angle only. The tests of the launcher itself were successful. Our main objective, during this period, was to enable the avalauncher to deliver a 2-kg. or larger explosive charge within a range of 1500 meters with a consistent projectile trajectory. This task was accomplished, after overcoming many problems, at the end of the seventies, with the development of the first generation "Arrow Projectile".
The "Arrow Projectile" will be detailed into the second part of this paper.
The first generation was not sufficiently reliable. It had too many misfires (about 25%) and it contributed to a decline in "Avalancheur" development in France.
In the mid 1980's the ANENA and some partners, convinced that the avalauncher could provide a useful remote control device, initiated a new development effort.

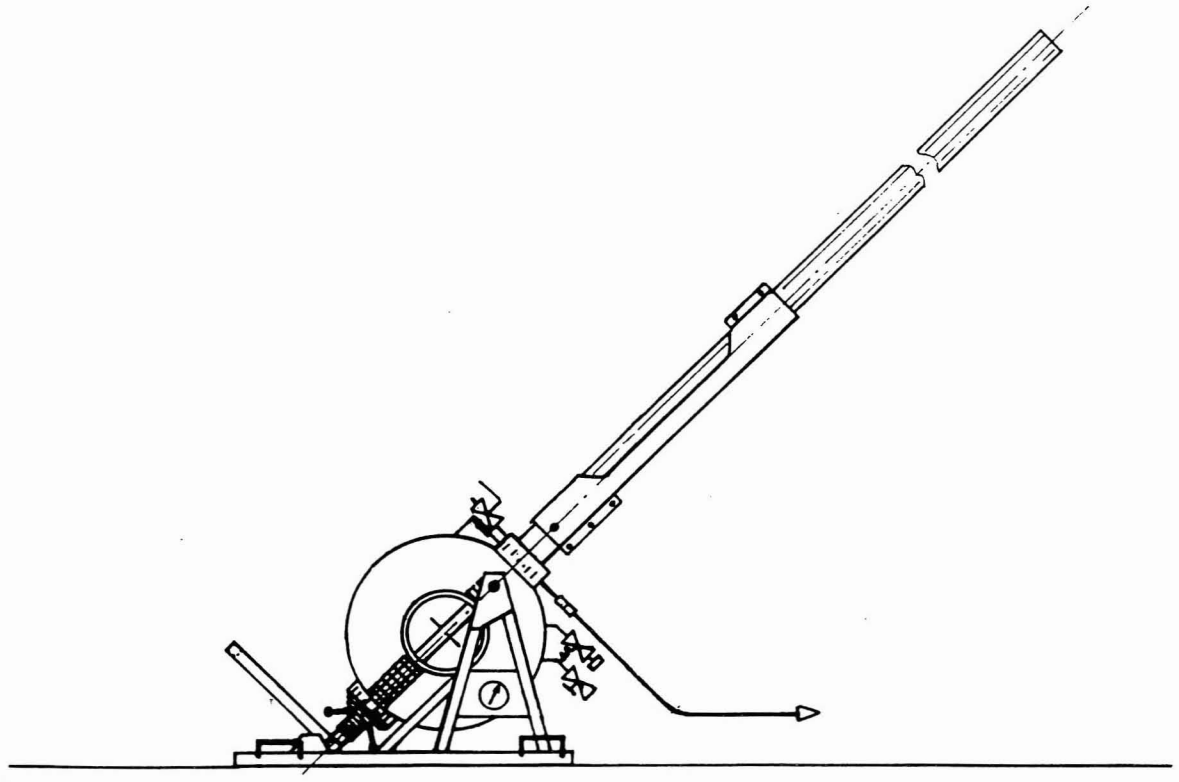

Figure 1. The spherical "AVALANCHEUR" in firing position.

The Spherical Breech-Loading" Avalancheur" (Figure 1)

Many improvements have been introduced to the apparatus, in an effort to match technology with our customers' requests to launch a 2.5-kilogram (equivalent TNT) explosive payload 2 kilometers horizontally or at 1 kilometer with 700 meters in elevation.
Mechanically, we preserved the simple and reliable MK technique, which is described below (Figure 2):

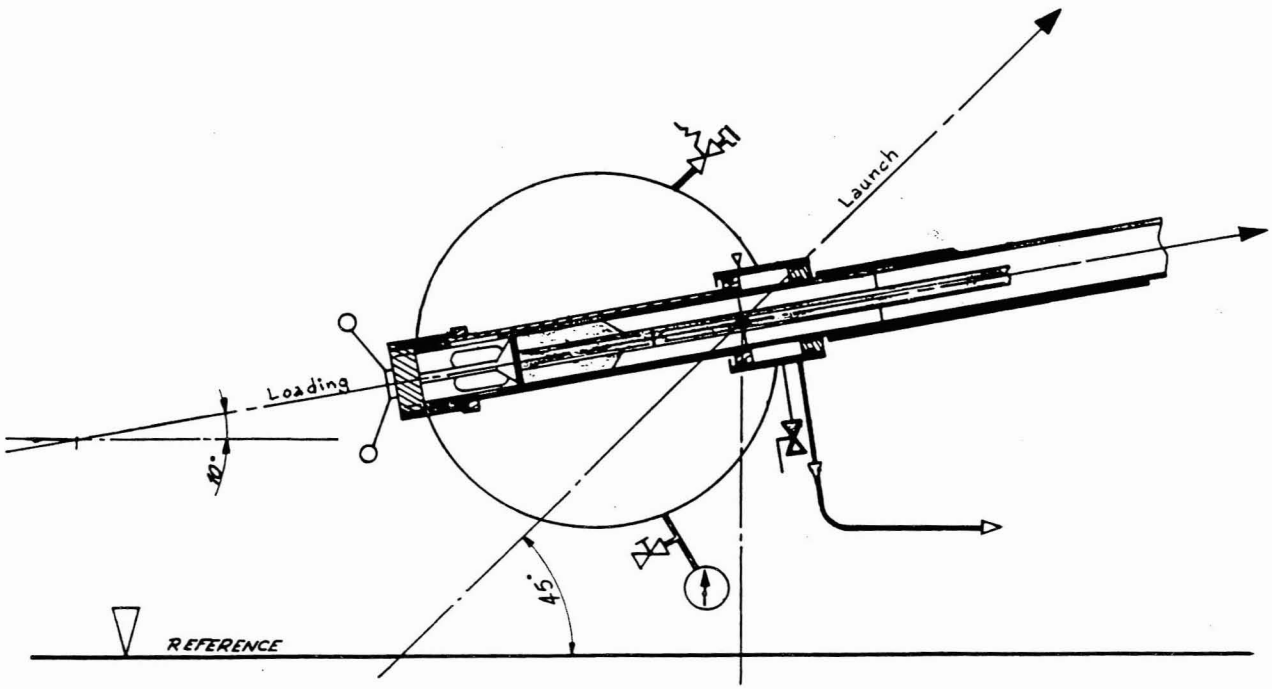

Figure 2. The spherical "AVALANCHEUR" in loading position.

When the main sphere (45 liters) and the fire chamber (1 liter) are simultaneously pressurized, a quick-release of the fire chamber pressure creates a forward motion of the piston, the propellant gas enters into the barrel and launches the projectile, previously introduced into the barrel.
The projectile is loaded through a removable breech-valve. The loading requires that the launcher be set up at a 10° angle (Figure 2). The elevating mechanism has only one firing angle: 45°.

The main advantages of the breech-loading are:
- safety: operators are more comfortable to proceed;
- accuracy: the single fiberglass barrel remains in place between the rounds, so, small errors due to misalignment of the barrel can be taken into account.

The pressure vessel frame includes: the gas supply inlet, the remote-controlled shooting box, the pressure gauge, the pressure control valve and the pressure disk.
The quick-release valve consists of a pneumatic valve monitored by the shooting box.
On both sides of the frame, an absorber device with mounted springs limits the recoil effect.
A base plate allows an operator to place the "Avalancheur" on any level surface of snow or other material.
The most common way to use the launcher in France is to bolt it to a rotating platform, with marks corresponding to each avalanche starting zone direction. This is necessary when the targets are invisible from the shooting area (e.g. bad weather conditions, night operation...).

Main Features of the "AVALANCHEUR"

Overall weight: 160 kg.
Dimensions: 1.0 x 0.8 x 0.7 m.
Fiberglass barrel length: 4.2 m. (6.0 m. when the new carbon graphite barrel becomes available)
Gas volume of the vessel: 45 l.
Maximum operating pressure: 30 bar.
Propellant gas: nitrogen in standard tall cylinder (50 liters, 200 bar).

Most Recent Improvements

We have recently been requested by some users to increase the range of the system.
We plan to lengthen the avalauncher's range by increasing the barrel length and increasing the operating pressure from 30 bar to 35 bar.
Initial successful tests have been conducted with a 6-meter long carbon graphite barrel. A longer barrel reduces payload rubbing, provides a significantly longer thrust duration and a better accuracy.
The difficulties associated with increasing the operating pressure are not associated with the launcher, but with the projectile. We have conducted successful tests at a 40 bar pressure and we expect to soon meet the requested specifications.
With these two modifications, we increased the performance by about 15%.
The pneumatic quick-release valve will be replaced by a two-way solenoid valve (TWSV) with an electric remote control to further improve the system.
This TWSV plays a prominent part in the "Avalancheur" practise and reliability.
First, it makes loading and launching operations easier by suppressing the remote shooting box and consequently, suppressing the low-pressure circuit.
Second, and this is the most important improvement, during the loading procedure and until the shot is decided, the main volume and the firing chamber are put at an **equal pressure** by the TWSV and by a steel 10-mm. in diameter pipe link.
In other words, it means that, even with a large leak in the fire chamber, an unexpected launch cannot occur at any time.

The Second Generation of Arrow Projectile

Many years of research and tests, carried out by different French organizations in charge of the development of the "Avalancheur" have demonstrated that:
- the angle of launch (45°) is an acceptable compromise for more than 90% of the avalanche release needs (France);
- the best trajectory and ballistics are obtained by a projectile with an arrow-shape and four stabilizing fins, where the ratio L (projectile length) to d (projectile diameter) is high enough to significantly reduce crosswind effects;
- the range of projectile speed: $100 < s < 200$ m/s. (depending on the vessel pressure) ensures a stable trajectory;
- the choice of a liquid explosive avoids the main problem encountered when a solid explosive is used in a long projectile: the burst of a charge with a diameter lower than the critical diameter of the explosive results in a detonation failure. Furthermore, the liquid explosive self-neutralizes after a given time. It means that in case of misfire, after something like 8 hours, the projectile becomes inert, **but for the ignition system.**

As we mentioned previously, the first generation of the arrow projectile (Figure 3), was not reliable enough for several reasons:

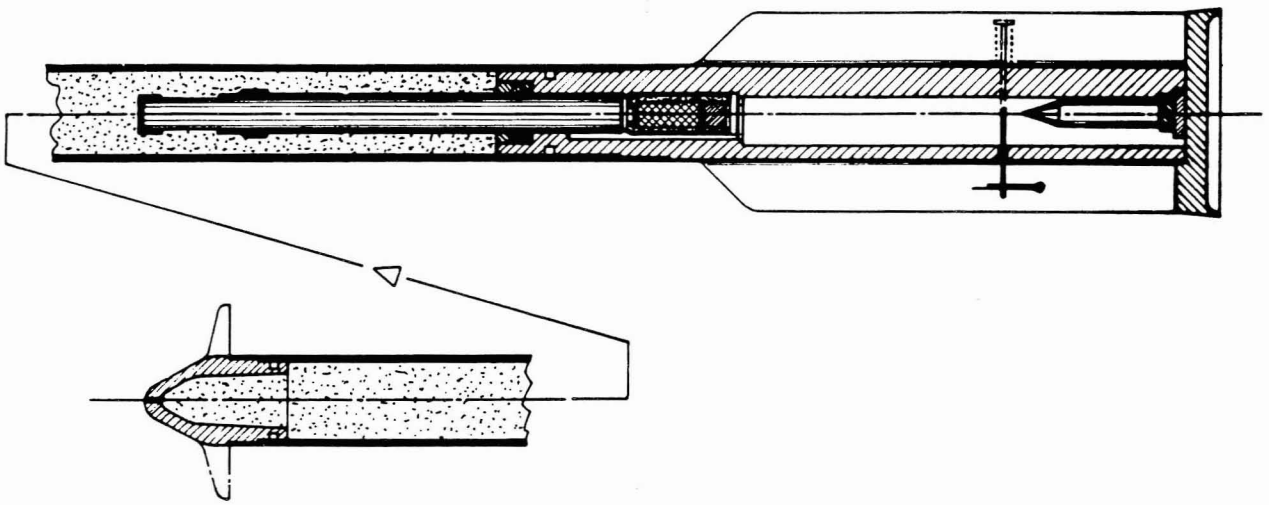

Figure 3. The first generation of arrow-projectile: stabilizer and ignition system

- the four-fin stabilizer was breakable in case of impact on rocky ground;
- the forward movement of the firing pin was 10-centimer long; therefore, in case of impact on rock,the four-fin stabilizer broke sometimes before the firing pin reached the cap and lead to a misfire;
- the ignition system was composed of a **1-g.** cap crimped around a **27-g.** piece of detonating cord in order to make the liquid explosive burst. In case of misfire, the ignition system with **28 g.** of explosive hidden into a dud remained an objectionable. and even unacceptable potential danger;
- last, the payload (less than 2 kilograms of explosive), was generally considered as not efficient enough in terms of avalanche release.

The second generation of the "arrow projectile", takes into account these miscellaneous malfunctions.

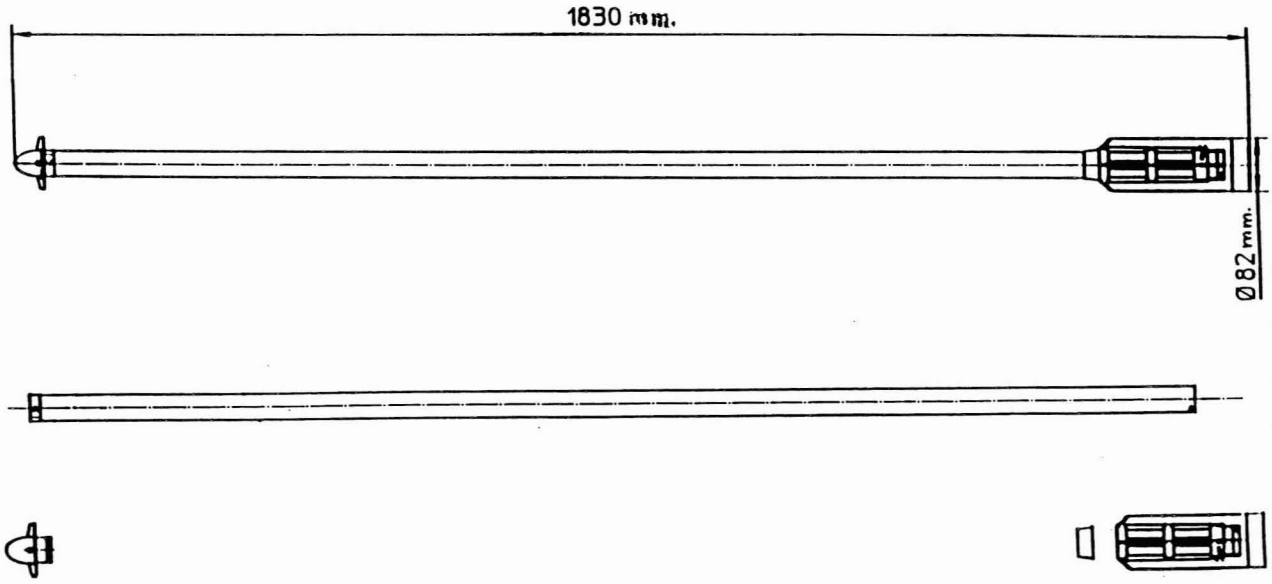

Figure 4. The second generation of arrow-projectile (M 92 SNOW ARROW): overall view.

The "Arrow Projectile" of the Second Generation: the "M 92 snow arrow" (Figure 4)

Main Characteristics

- Overall weight: 3.2 kg.
- Length: 1.80 m.; diameter: 40 mm.
- Gauge: 83 mm.
- Explosive payload: 2.2 kg. of liquid explosive (equivalent to 2.5 kg. of TNT).
- Range: 1800 m. horizontally, with about 500 m. in elevation.

Ignition System Characteristics (Figure 5)

- The four-fin stabilizer is shorter and more efficient;
- the forward course of the firing pin is reduced from **10 cm. to 1.5 cm.;**
- the ignition system itself is composed of a **2-g.** detonator only (instead of **28 g.** of explosive used previously), reducing the potential danger in case of misfire.

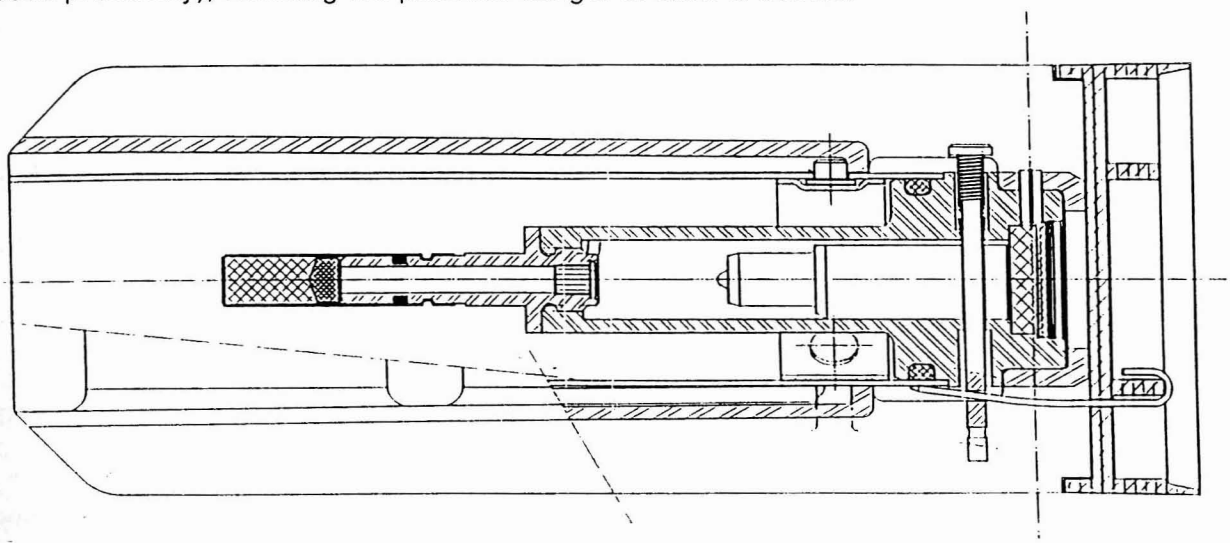

Figure 5. The M 92 SNOW ARROW: stabilizer and ignition system (courtesy of Ruggiéri).

We kept the safety devices such as the pullwire extending through the pressure cap, which stays in place and holds back the firing pin, until the projectile reaches a safe distance of about 30 meters away from the launcher.

Performance

The abacus (Figure 6) shows the typical trajectories of the M92 snow arrow, for the fixed angle of 45° and for a 4.2-meter fiberglass barrel.
With the M92 snow arrow, no untimely explosions have ever occured. Nevertheless, a few misfires have occurred, usually due to a liquid leakage, and led to an explosion of the ignition system only, without remaining danger.
During the 1993-94 winter season we noticed such failures on 1.3% of about 350 rounds).
No erratic flight has been observed for correct launches and the accuracy of the "Avalancheur" with the "M 92 snow arrow" is good: about 20 meters at the maximum range. The length of the fiberglass barrel and the arrow-shape of the projectile, among other aspects, are responsible for a large part of this accuracy.

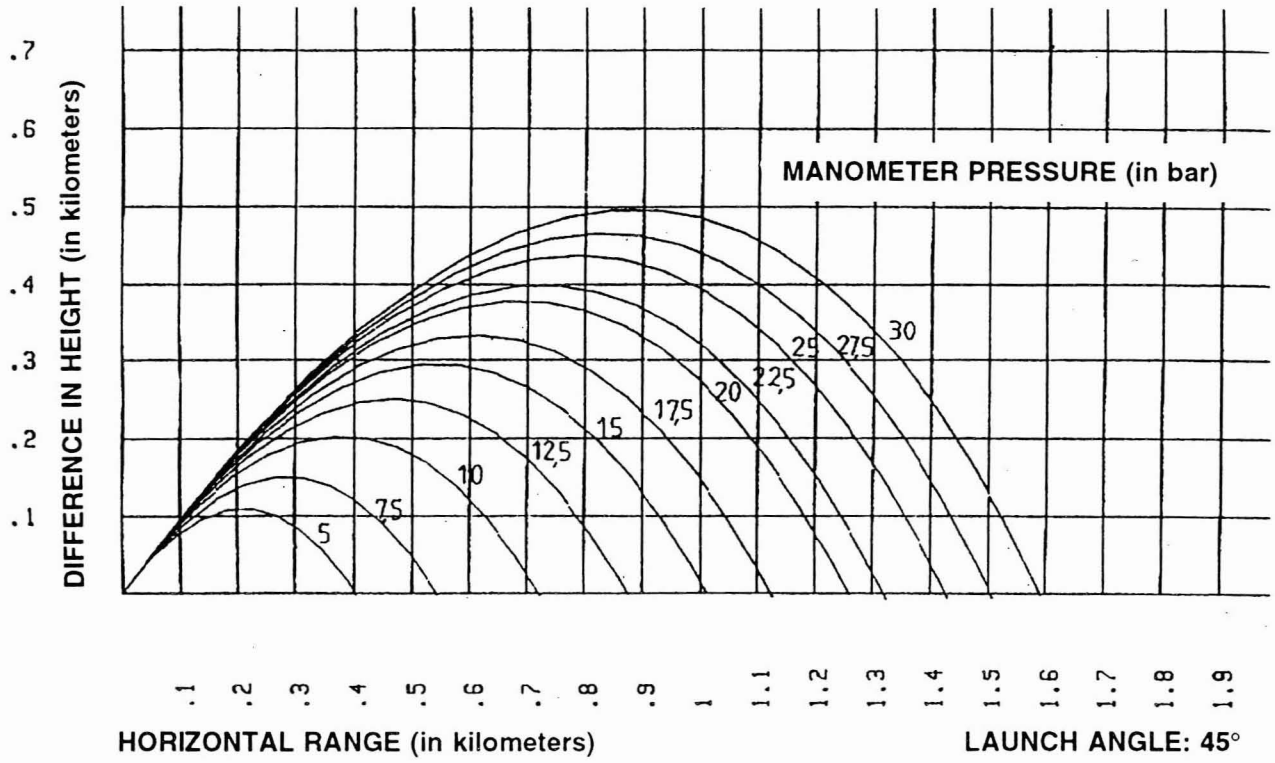

Figure 6. The "AVALANCHEUR" performance abacus with the M 92 SNOW ARROW.

The Liquid Explosive (Trade mark: NITROROC)

"NITROROC" liquid explosive, consists of two components (A and B) which are classified as non-hazardous materials for shipment anywhere and for any carriers. This is great advantage for users. Upon mixing the two components A and B, the combination produces a powerful explosive. The distinctive characteristic of the French "NITROROC" in comparison with "ASTROLITE", is its self-neutralizing ability after a few hours of life time. It may seem very attractive to use such an explosive, from a safety point of view. In fact, this neutralizing effect contributes to reduce the remaining danger due to the ignition system. Morever, the self-neutralizing ability adds a significant manufacturing cost to the price of the explosive.

Main Characteristics

"NITROROC" consists primarily of nitromethane and ammonium nitrate.
- Density: 1.12 (90% A component, 10% B component).
- Specific energy: 1250 cal/g. - TNT equivalent: 1.25.
- Detonation velocity: ~ 6000 m/s.
- Impact sensivity: 28 kg-cm.
- Temperature sensivity: ~ -15° C.

SAFETY REGULATIONS

The French "avalancheur", as well as the other means of avalanche release, are subjected to the French laws concerning the use of explosive materials. Its use is also kept under specific mountains and ski resorts regulations. In France, the customers and the users must receive

training from a qualified "Avalancheur" instructor. A certificate is issued by the ANENA, after a 2-day course and practice training session.

ECONOMICAL DATA

The cost of the gun sold by Ruggiéri[4], along with all the accessories, is approximately US$ 20,000. The cost of one arrow is US$ 200, of which about $ 50 are for the Nitroroc explosive.
Since the beginning of the eighties, about 50 guns have been sold. Some are not used anymore. This last winter, about 350 new "M 92 snow arrows" were fired. As they proved to be very effective, the seller expects a strong sales increase for the next winter season.

CONCLUSION

Our most recent generation of projectile (new improvements will be brought in the near future) has proven to be a very effective way to carry out remote blasting. The "avalancheur" is a very flexible device, despite its limited range. The use of a different liquid explosive would reduce the price of the arrow and make it more affordable. The French cylindrical avalauncher and its new projectile may offer a new solution to solve the ammunition problem faced by American avalanche control professionals (Abromeit, 1990 and 1993).

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