NEW NONELECTRIC EXPLOSIVE INITIATION SYSTEMS

by

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INTRODUCTION

In blasting, an initiation system transmits energy from the shotfirer's location to the charge in the blasthole. Until recently, the blaster could choose from three basic initiation systems (figure 1): (1) the total electric system where electric blasting caps in each charge are joined into circuits and connected to an electric power supply by connecting wire and a lead line; (2) cap and fuse, where blasting caps are crimped onto a fuse which burns at 40 seconds per foot and ignited separately, in a bunch, or by means of an igniter cord connecting the fuses; and (3) detonating cord systems, where explosive cords, usually containing from 25 to 50 grains of explosive per foot, extend from each hole and are connected by a detonating cord trunkline. The trunkline, in turn, is initiated by an electric blasting cap or fuse cap. A fourth system, which is a variation of system 3, is an in-hole assembly consisting of a blasting cap connected to a low-energy (4 grains/ft) detonating cord downline, which in turn is connected to the detonating cord trunkline. Recent inventions will give the blaster two additional choices. One called Hercudet[1], uses an explosive gas mixture inside a network of small plastic tubing. The other, called Nonel, consists of a tough plastic tube with a thin coating of explosive (0.1 grain/ft) on the inside surface.

[1]Reference to trade names does not imply endorsement by the Bureau of Mines.

INITIATION SYSTEMS

1 Total Electric

2 Cap and Fuse

3 Detonating Cord

3a Low-Energy Detonating Cord

4 Gas Detonation

5 Shock Tube

FIGURE 1. - Initiation Systems.

CURRENTLY USED SYSTEMS

An explosive initiation system should be safe and reliable. Good blast design also demands dependable, reasonably accurate delay systems. The following is a brief evaluation of the three currently used initiation systems.

Total Electric Initiation

Electric blasting is widely used in both surface and underground mining. When used properly, the system is both safe and reliable. Advantages of electric blasting include a variety of accurate delays, both millisecond and half-second (figure 2). The ability to check the system after hooking it up and before firing is an important feature. When the system is activated, the lead wires will neither initiate nor disrupt the charge in the blasthole. Airblast is minimized because no explosive is exposed at the surface. With electrical blasting, the shotfirer controls the precise time of detonation. He may decide not to fire the shot, because of a potential safety hazard, at any time before the instant of initiation. The primary disadvantage of electric blasting systems is the potential for accidental initiation caused by external electrical sources. This can be a concern when blasting in conductive ground, where very large electrical equipment is used, where sudden electrical storms are prevalent, where static electricity is present, or in the vicinity of transmitters of high levels of radiofrequency energy. The possibility of broken leg wires can be a problem in deep vertical blastholes. However, special rugged systems are available to alleviate this problem.

Fuse Blasting

By most standards, fuse blasting is the least desirable of the available alternatives. The main advantages that can be claimed for

ELECTRICAL INITIATION

Advantages:

Accurate delays

Can be checked

No charge disruption

No air blast

Disadvantages:

Electrical hazards

Somewhat fragile

FIGURE 2. - Electrical Initiation.

the system are a slight cost saving, the lack of a need for a special firing mechanism, elimination of the electrical hazard, and lack of charge disruption (figure 3). By using varying lengths of fuses or sequential initiation with igniter cord, slow delays can be obtained, but the timing is inaccurate. Airblast is minimized and the fuse does not affect the charge in the borehole. The disadvantage of fuse blasting is in the area of safety. Like any system, fuse blasting is safe when all proper procedures are followed and nothing goes wrong. However, it has more potentially hazardous situations than the other initiation systems. First, the shotfirer must be in the blast area to energize the circuit. Records show several cases where, for some reason, the shotfirer has been blasted by a fuse round. Either he did not leave the area quickly enough or he returned too soon. Fuse blasting is the only system which requires a waiting period between energizing the circuit and the actual firing of the blast. During this period, security in the area must be maintained, which is difficult in certain physical situations. In all other systems, the shotfirer assumes a controlling location, firing when security has been assured, and detonation is completed within a few seconds or less.

Detonating Cord Initiation

Detonating cord is the most widely used system in large surface operations. This is primarily because the system is rugged and will function under severe conditions (figure 4). It also eliminates electrical hazards because the cap is introduced immediately before firing and it incorporates an accurate millisecond-delay series. Because detonating cord systems are usually initiated electrically, the time of initiation is precisely controlled. Because the delay elements are placed on the surface between blastholes, cutoffs created by movement of the

FUSE BLASTING

Advantages:

No airblast

No charge disruption

No electrical hazard

Blasting machine not required

Disadvantages:

Inaccurate delays

Shotfirer in dangerous position

Imprecise time of blast

Security is difficult

Visual checking only

FIGURE 3. - Fuse Blasting

DETONATING CORD INITIATION

Advantages:

- Rugged
- No electrical hazard
- Accurate delays

Disadvantages:

- Cutoff possibility
- Airblast
- Charge disruption
- Delay caps on surface
- Visual checking only

FIGURE 4. - Detonating Cord Initiation.

rock mass can occur unless the delay patterns and intervals are well thought out. The trunkline of high explosive on the surface creates significant airblast, which is becoming an increasingly serious problem as more mines and quarries become surrounded by residential areas. This problem can be alleviated by covering the trunkline with dirt, although this is costly, time consuming, and not always completely successful. A high-energy detonating cord downline can disrupt a column charge of blasting agent or, in some cases, cause marginal initiation. The severity of this problem depends on the type of blasting agent and the borehole diameter, and has not been accurately quantified. The presence of millisecond connecting caps on the surface is a potential premature detonation hazard.

The Primadet system, a variation of detonating cord blasting, employs a low-energy downline; this minimizes charge disruption, although the low-energy cord will initiate cap-sensitive explosives. The cap in the Primadet assembly contains the delay element, thus eliminating the need for surface-applied delays. Surface delays may be employed where delays both within and between blastholes are required. Primadets are available with both millisecond and half-second delays. The assembly is placed in the blasthole, similar to an electric cap, and is connected to a standard detonating cord trunkline. To reduce noise, a low-noise 4/54 trunkline can be used. This is a 4-grain cord with 50-grain sections spliced in where the downlines are to be connected. Primadets are useful underground where stray electrical currents are a problem, and in small-hole blasting where a standard downline will disrupt the charge.

RECENTLY DEVELOPED SYSTEMS

Both the Hercudet and Nonel systems are nonelectric. Both use a low-energy explosion within a hollow plastic tube to transmit energy from the shotfirer's location to the charge in the blasthole. They are available with both millisecond and half-second in-the-hole delay initiators. Because of the low energy levels involved, neither system will initiate a cap-sensitive explosive or disrupt a column of blasting agent. As with most low-energy systems, neither product is self-initiating; a Nonel line will not initiate another Nonel line, nor will Hercudet propagate from one line to another. Although these systems will alleviate some of the problems associated with current systems, it is not anticipated that they will replace current systems in all, or even most, situations. However, on jobs where none of the existing systems are totally suitable, they will provide two alternatives. Neither Hercudet nor Nonel is permitted in underground coal mines.

The Hercudet System

Development of the Hercudet system is complete and it is being used in commercial operations under the close supervision of the manufacturer. Instead of leg wires, each cap contains two small plastic tubes in lengths made to order (figure 5). A slip-on connector is used to seal the ends of the tubes and connect one cap to the next. Additional lengths of tubing connect the circuit to the firing console (figure 6). The console in turn is connected to a gas supply module equipped with a pressurized bottle of inert gas for console operation and circuit purging and bottles of fuel and oxiding gas. A totalizing counter which indicates the volume of fuel-oxidizer mix introduced into the system, and a firing button are located on the console. After the hookup has been completed, an inert gas, usually air, is fed through the circuit to check for plugged tubes or broken connections. When continuity has been assured, a metered mixture of fuel and oxidizer gases is fed into the circuit. After introducing a predetermined volume of fuel-oxidizer mixture, the blaster may fire when ready. The gas mixture is initiated by a spark, and the reaction travels through the circuit at a rate of

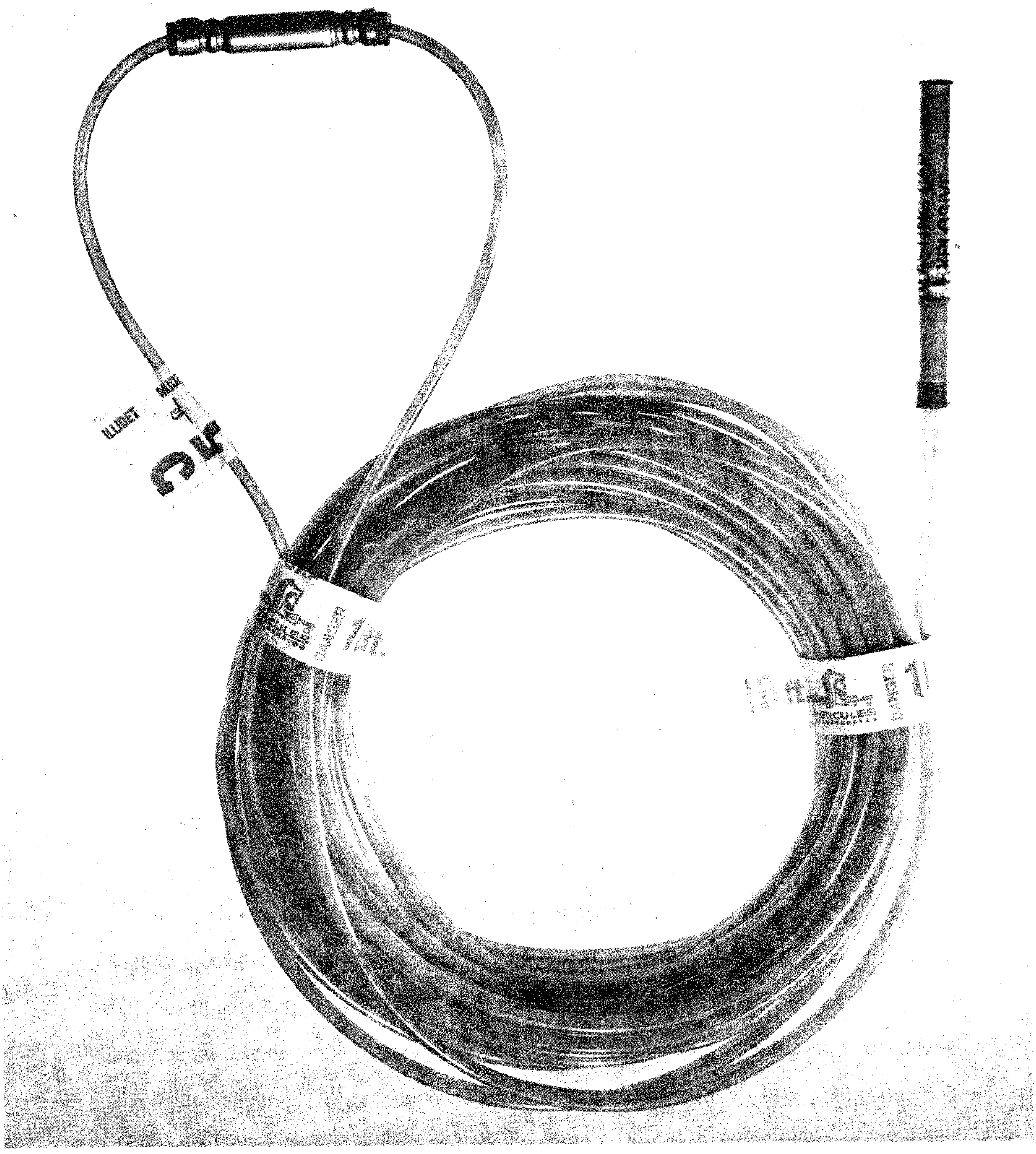

FIGURE 5. - Hercudet Detonator.

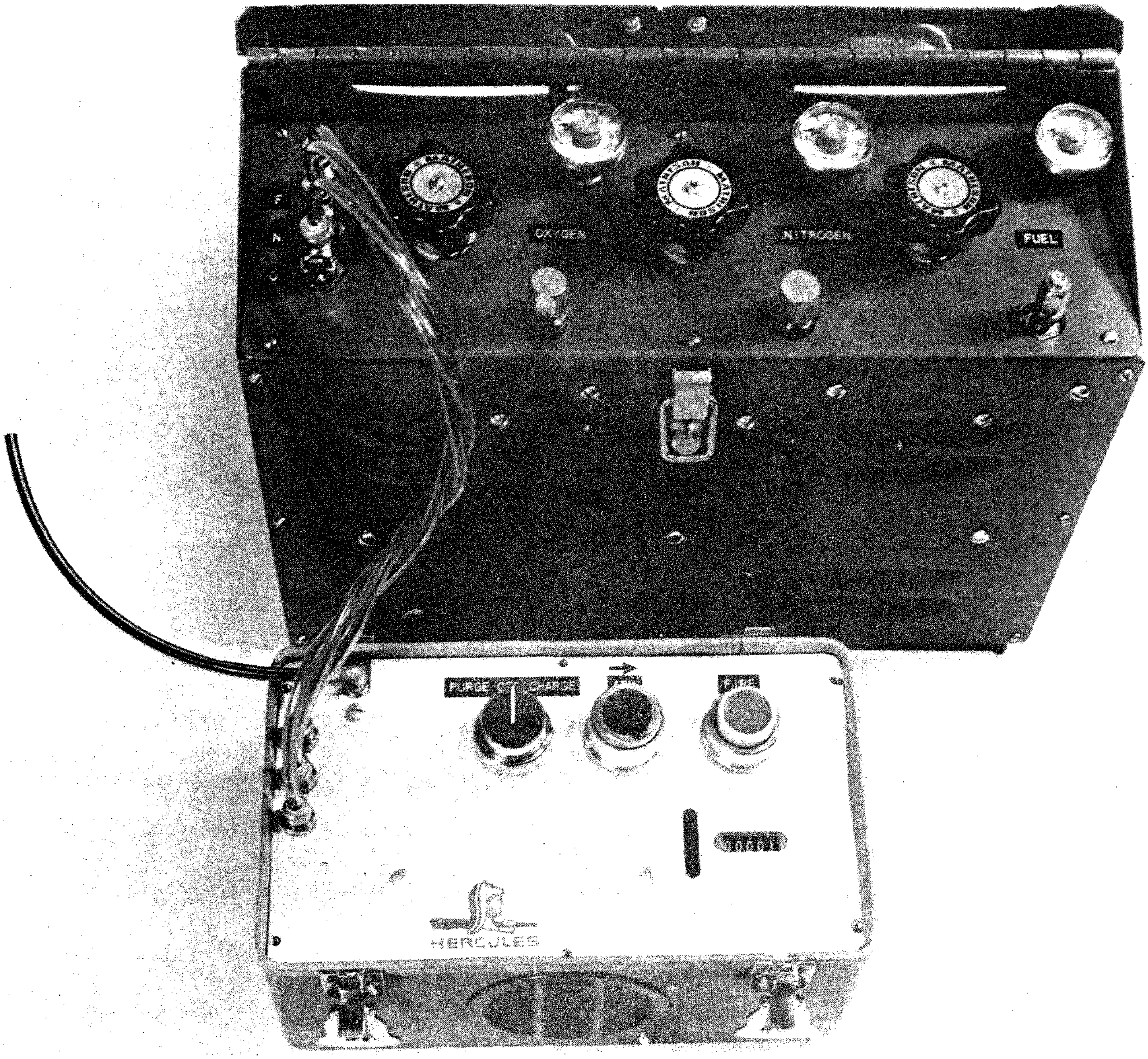

FIGURE 6. - Firing Console and Gas Supply.

10,000 ft/sec to detonate the caps in the boreholes. The system can be used on the surface or underground.

Advantages of the gas initiation system include the ability to check the circuit before firing and its inert condition until the explosive gas is introduced, just prior to initiation (figure 7). Electrical hazards are eliminated, the trunkline system is virtually noiseless, and the low energy downline will not disrupt the column charge. It incorporates accurate series of millisecond and half-second delays. Because it is a new concept in blasting, a certain amount of reeducation of the blasting crew will be required. Also, the equipment is quite specialized and will be available from only one manufacturer. Care must be exercised to assure that water and dirt do not enter the tubing after the heat-sealed end of the tubing is cut off and before the connectors are attached.

The manufacturer recommends that no more than 500 feet of tubing be used in a single series. This limits the number of detonators per series. However, a virtually unlimited number of series may be hooked in parallel.

The Nonel System

The Nonel system, the name of which is derived from the first five letters of the word "nonelectric," is a Swedish development that has been licensed for manufacture in the United States. The system is currently undergoing field trials in this country and is not yet available on the general market. As used in Sweden, the system employs a trunkline of low-energy (0.1-grain/ft) Nonel tube, connecting caps at the collar of each borehole, and a downline of Nonel tubing (figure 8). At the end of the downline is a millisecond- or half-second-delay blasting cap. The tube is a tough, hollow plastic, lined with a fine coating of explosive. When initiated, the explosive is dispersed in the tube, and a detonation, analogous to a dust explosion in a coal mine, propagates at 6,000 ft/sec.

HERCUDET SYSTEM

Advantages:

- Can be checked
- Inert until ready
- No electrical hazard
- No airblast
- No charge disruption
- Accurate delay

Disadvantages

- Crew training required
- Possible system contamination

FIGURE 7. - Hercudet System.

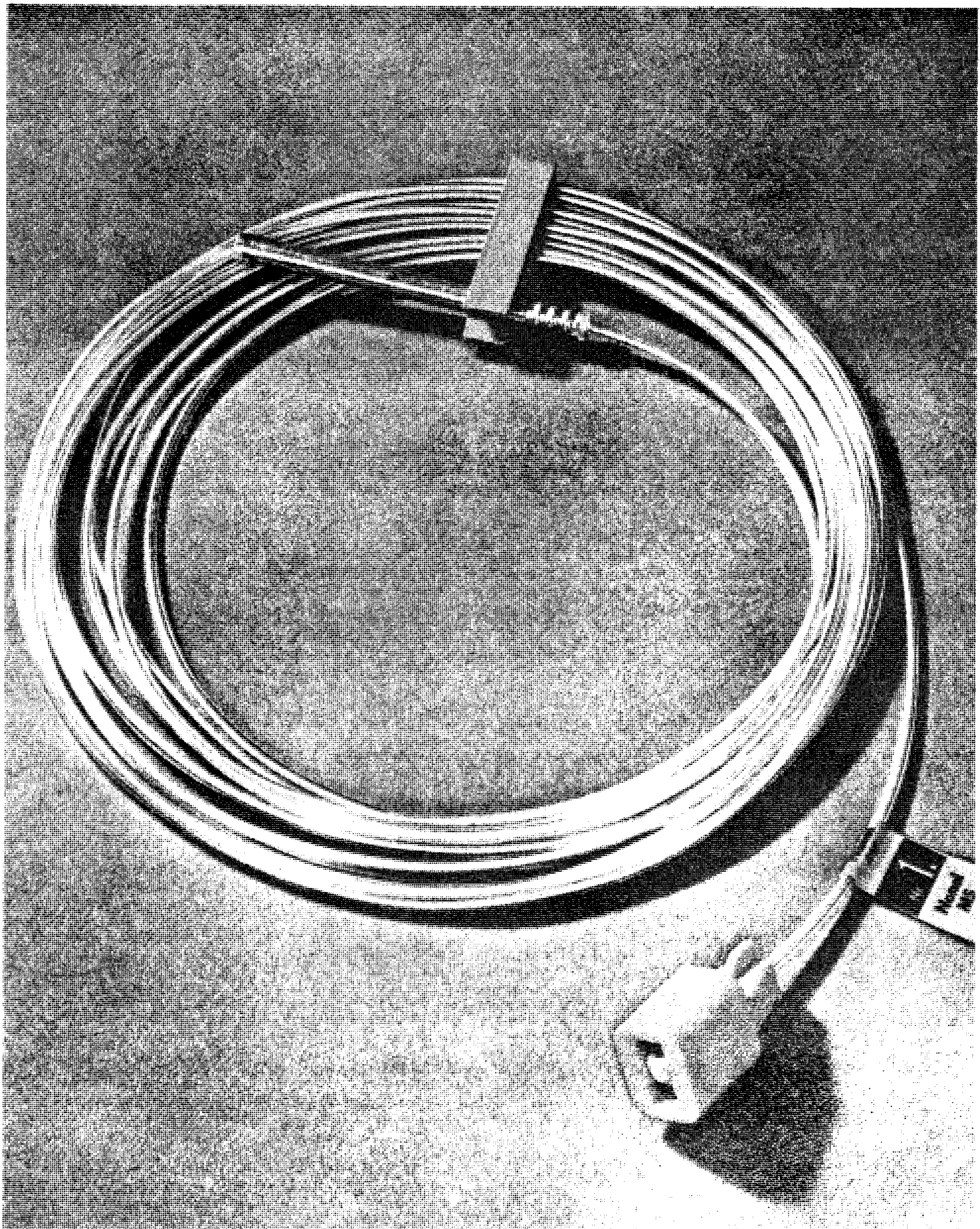

FIGURE 8. - Swedish Nonel Assembly.

The Nonel system is virtually noiseless and will not disrupt the column charge in the blasthole (figure 9). It incorporates an accurate series of millisecond and half-second delays. It is similar to current detonating cord systems in that it is rugged and hookup is simple. Electrical hazards are minimized although it must be realized that lightning and electrostatic charges are potential hazards with any initiation system. Disadvantages of the system include the potential hazard of the connecting caps on the ground surface and the fact that the circuit must be checked visually. Like Hercudet, the Nonel system will be available from only one manufacturer.

Ensign-Bickford, the U.S. licensee for the Nonel system, dislikes the use of a cap at the collar of each blasthole. Therefore, they are using standard 18- or 25-grain/ft trunklines to which the downhole Nonel assemblies are tied. In doing this, they get rid of the connecting caps on the surface but lose the noiseless feature of the system. Research is underway to develop a suitable noiseless trunkline system. For underground blasting, the Nonel assembly is tied directly to the trunkline. For surface work, the basic Nonel assembly is a 15-inch length of tube crimped to a delay cap. This assembly is tied to a 7.5-grain/ft cord, which in turn is lowered into the blasthole. The delay will function with a cap-sensitive primer if the 7.5-grain/ft cord does not contact the primer. The end of the 7.5-grain/ft downline is tied to a 25-grain/ft trunkline. Delays between and within holes can be used. With Nonel, as with all low-energy detonating cord systems, connections and knots must be carefully made because the low propagating energy increases the chance of misfires.

SWEDISH NONEL SYSTEM

Advantages:

- No airblast
- No charge disruption
- Accurate delays
- Rugged
- No electrical hazard

Disadvantages:

- Connecting caps on surface
- Visual checking only

FIGURE 9. - Swedish Nonel System.

SUMMARY

The number of initiation systems from which the blaster can choose has recently been increased from three to five. This report has described the systems and compared them by pointing out advantages and disadvantages of each. No system is the best answer to all situations. Each will find a place in the blasting industry. The two new developments will increase competition and flexibility, both of which normally work to the mine operator's advantage.

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January 14, 15, 16, 1976

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