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Improvements In A Multi-use Waterjet Tool For Humanitarian Demining

R.D. Fossey, D.A. Summers, J.G. Blaine, G. Galecki, S. Dorle
University of Missouri-Rolla, Rolla, Missouri, U.S.A.



In-situ cutting of anti-tank mine

ABSTRACT

Safe removal of landmines depends on two separate elements: identification, and neutralization. A multi-disciplinary team from the University of Missouri-Rolla is working on a waterjet tool that can accomplish both elements in a single device. Simplicity and ruggedness are the key components to this dependable, useable device.

Identification is accomplished with removal of cover via a "soil sucker" for visual confirmation, and an abrasive jet is used for rapid in-situ neutralization. The design concepts are discussed and the prototypical device described. Preliminary results of field tests are reported.

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1. INTRODUCTION

Decades of wars and insurrections around the world have left a legacy of landmines to cause the daily maiming or killing of innocents. Many recent efforts at mine clearance have developed into large, sophisticated, and costly systems, as opposed to the traditional method of identification via hand digging and neutralization via blowing. While the recent systemic approach becomes too expensive for deployment on a large scale in all needy areas, it also requires a team of experts for implementation. The traditional method, on the other hand, is quite inexpensive and requires relatively few sophisticated tools. It is, however, potentially deadly.

2. BACKGROUND

The University of Missouri-Rolla began researching the interaction of energetics and high pressure waterjets in 1982 to demilitarize surplus air to air missile warheads. More recently UMR's High Pressure Waterjet Lab began using abrasive entrained waterjets to cut fuses and tracers from 40mm antipersonnel rounds. Even more recently UMR teamed with the U.S. Army and civilian agencies to apply this knowledge to demining strategies; first militarily, then humanitarian.

3. CONCEPT

Initial research was performed to use medium pressure water (10,000 psi) on a robot to perform the two necessary functions. The robot, called the "Pointman" (Figure 1) used the flow to power the soil

sucker (Figure 2) and uncover a targeted mine. Following identification of the mine and analysis of the fusing, an abrasive slurry jet (ASJ) was used from the same water source to slice through the mine at the fuse (Figure 3), a point that would render the mine inert for all practical purposes. With the fuse destroyed, the mine could be safely removed to a remote location where it could be treated.

In trials for the U.S. Army, several types of live fuses were safely neutralized in this manner. Inert landmines were also cut in-situ after location and identification (Figure 4).

The effectiveness of this system was somewhat reduced when costs and logistics were reviewed. The 10,000 psi pump is expensive and requires a vehicle and/or a trailer by itself. The water container necessitated another vehicle and a trailer was needed for the robot. Many thousands of dollars were required for mine neutralization along with a convoy of vehicles. This expense would greatly reduce the possibility of having such a system available in the remote areas where it is needed. Concurrently, the very sophistication of the system created another drawback whenever maintenance was needed. A specialist (or crew of specialists) would be needed for repair. What is needed is a smaller, simpler, more rugged tool that can accomplish the same objectives and do it in a safe manner with the operator remote from the landmine.

(continued on page 6)



Figure 1. Pointman Robot.

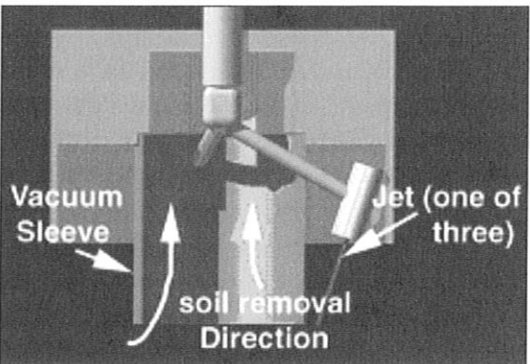


Figure 2. Design of Soil Sucker.

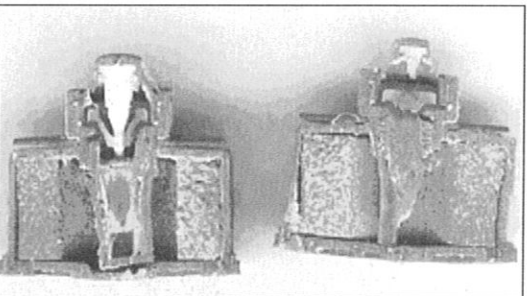


Figure 3. Sectioned Anti-Personnel Mine



Figure 4. In-situ cutting of Anti-tank Mine.
(Also pictured on the cover.)

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August 2004

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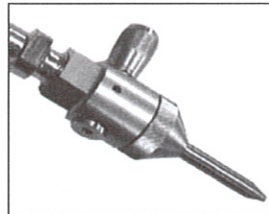
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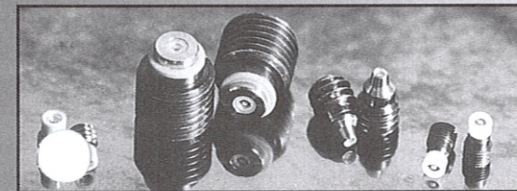
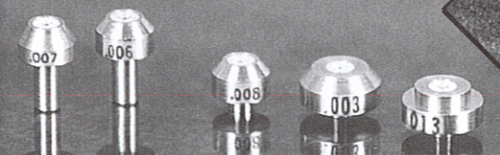
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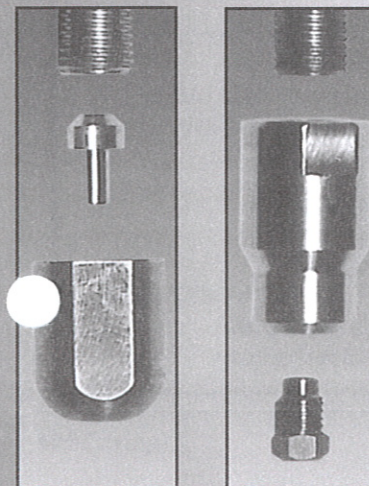
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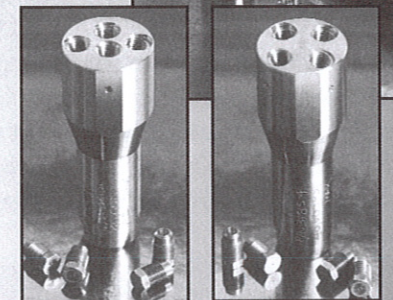
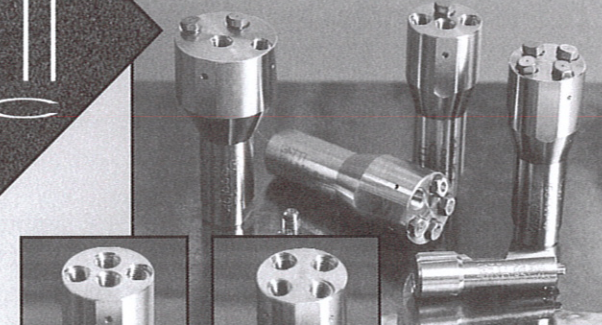
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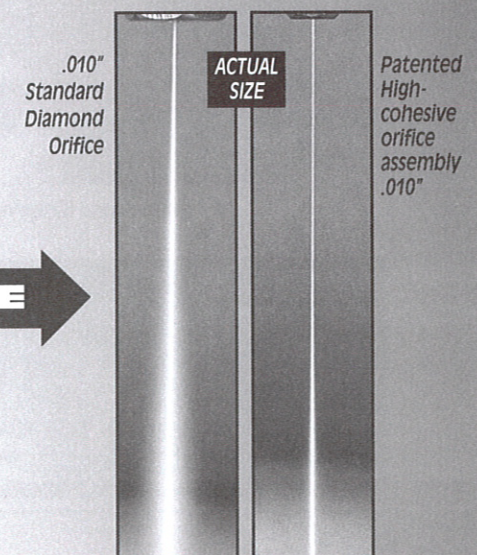
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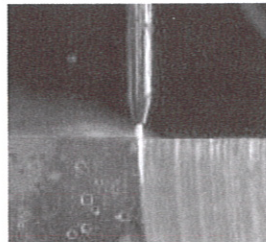
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The company's President John Wolgamott serves as Chairman of the Board of the WJTA. StoneAge conducts basic research studies that are frequently reported at the organization's biennial American Waterjet Conferences. Leading through research and development is a key strategy at StoneAge. Their mission is to lead the world in design, manufacturing, and service of premium quality waterjet tools.



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Waterjets For Selective Portioning Of Food

There are more than 150 waterjet machines in operation cutting chicken into portions. (Figure 1) These automated waterjet food portioning systems, which also cut beef, pork and fish, use vertical waterjet cutting (sometimes in conjunction with horizontal blade cutting) to optimize the use of randomly shaped three-dimensional pieces of meat.

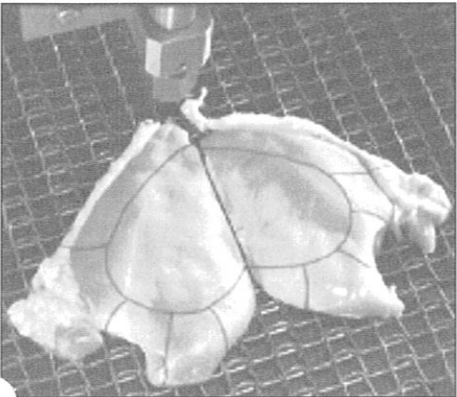


Figure 1.
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FMC FoodTech Inc., located in Sandusky, Ohio, produces such automated production portioning systems. (Table 1)

These automated production portioning systems work in the following way (Figure 2).

1. The meat is loaded onto the portioner infeed belt.
2. Each individual piece of meat is scanned with cameras to locate fat and to determine shape, thickness and weight.
3. DSI software optimizes a trim strategy for each piece of meat based on specifications and product values previously entered.

4. The computer controls the position of the high-pressure waterjets to hygienically and safely execute the cuts.
5. The computer-controlled waterjet cutting heads move both parallel and perpendicular to the direction of product flow.

Software programs automate fat trimming (Figure 3 on page 12), and

program cutting strategies to match product shape and weight requirements. Five different software routines can be run simultaneously to maximize the yield for each piece of incoming product.

DSI recommends 0.005-inch-diameter diamond orifices operating at 50-55 kpsi for most food portioning applications. Expected diamond

(continued on page 12)

DSI Model	512	624	SP12
Number of Cutters	2	4	2
Number of Lanes	1	2	1
Pieces per minute (typical range)	25 - 70	58 - 84	26
Capacity (kg/hr)	680 - 1430	1575 - 2275	11360
Factory Footprint (ft x ft)	1.8 x 6.4	3 x 10	3 x 11
Lane width (inches)	35.6	35.6 x 2	66
Capacity (lb/hr)	1500 - 3150	3460 - 5000	25000
Factory Footprint (ft x ft)	6 x 21	10 x 33	10 x 36
Lane width (inches)	12	14 * 2	26
Typical applicatin boneless product fillets less than 75 mm (3 inches) thick)	ham, fish, beef, poultry	poultry fish	pork belly

Table 1.
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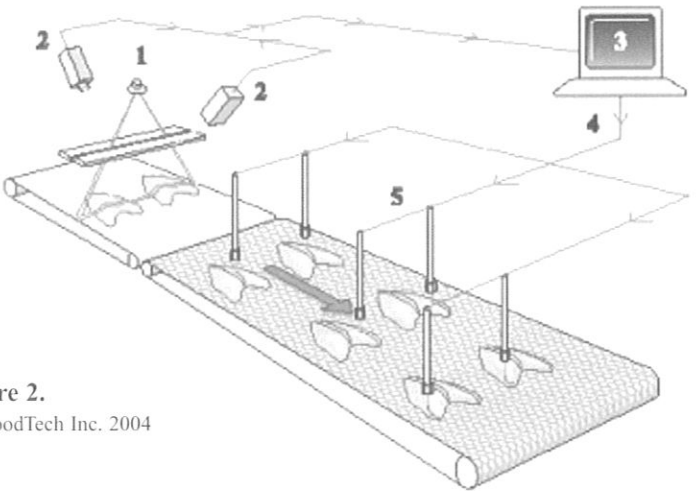


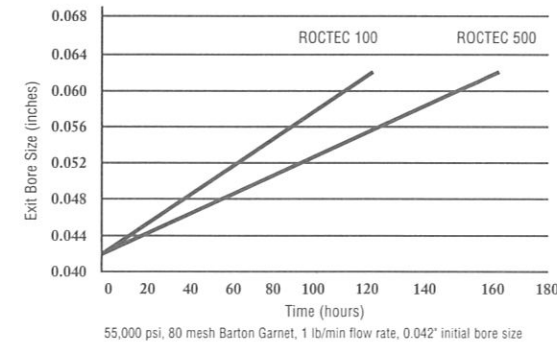
Figure 2.
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4. APPROACH

The increased efficiency of an ASJ allowed researchers at UMR to cut metal at a lower pressure than before. Enough lower that a commercial pressure washer could be obtained for considerably less money than the cost of a 10,000 psi Pump (Figure 5). The pressure washer develops a pressure of 3,500 psi, which, when applied to an efficient ASJ, is sufficient for cutting the relatively thin steel sheeting used for landmine casings at an acceptable rate. The reduced pressure requirements allow for a drastic reduction not only in expense, but in size and weight as well.

The elimination of most of the robotics can further reduce cost and

weight for a system, and with the reduction in weight, a person can carry the tools required for identification and neutralization from the delivery vehicle to the potential mine site. The operator can then move out of harms way during the actual operations to maintain safety.

5. COMPONENT PARTS

The identification tool is a lighter weight version of the soil sucker (Figure 6). It uses three jets converging below the vacuum sleeve. The jets rotate as the soil sucker translates across the ground digging a

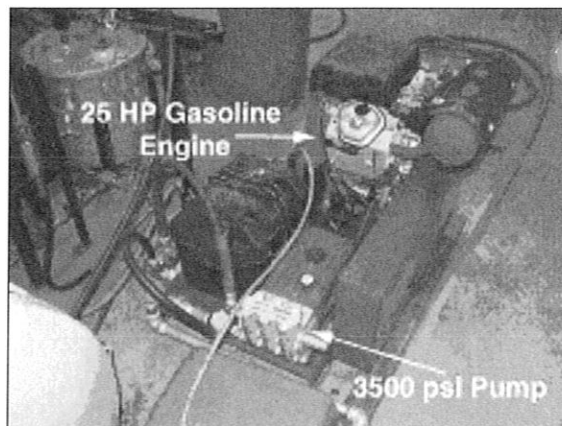


Figure 5. Pressure Washer Pump

trench with the water as the soil is removed via the vacuum. Rotation is powered by a small 12vdc motor,

(continued on page 7)

New Spin-Nozzle® Gets Back In Action In Five Minutes

NLB Corp.'s latest Spin-Nozzle®, the Viper 24™, has two significant advantages over previous self-rotating waterjet heads – it operates at pressures from 5,000 to 24,000 psi (350 to 1,680 bar) and practically eliminates downtime. While older heads must be returned to the factory for repairs, the Viper 24™ can be repaired in the field in just five minutes and go right back to work.



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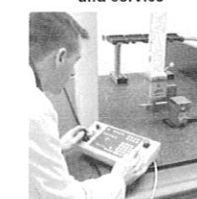
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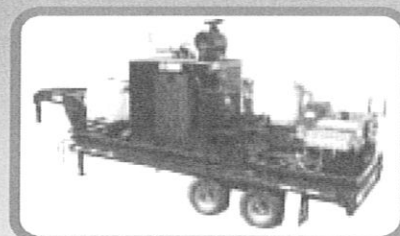


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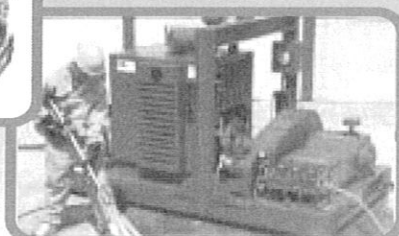
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International Manufacturing Technology Show (IMTS) 2004 – The New Manufacturing Age, McCormick Place, Chicago, IL, visit www.imts.com, or contact IMTS, 7901 Westpark Drive, McLean, VA 22102-4206, phone: 800-828-7469

October 26-28, 2004

FABTECH International, International Exposition (I-X) Center, Cleveland, Ohio, visit: www.sme.org/fabtech, call toll free 800-733-4763, or contact: Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, phone: 313-271-1500; fax: 313-425-3400.

October 31-November 2, 2004

CETA PowerClean 2004, Hyatt Regency and Albuquerque Convention Center, Albuquerque, NM, visit www.ceta.org, call toll free 800-441-0111, or contact the Cleaning Equipment Trade Association, 7691 Central Avenue NE, Suite 201, Fridley, MN 55432-3541, phone: 763-786-9200, fax: 763-786-7775.

BURNY® Phantom and 10 LCD Plus

BURNY®/Cleveland Motion Controls is pleased to announce the introduction of the BURNY Phantom numerical control and the BURNY 10 LCD Plus numerical control.

The Phantom PC based control has a 10-inch TFT LCD touch screen, 1 GHz processor and Windows® XP Embedded operating system. Programming functions allow the customer to automatically nest parts for maximum material utilization. Burny's superior motion engine provides excellent cutting accuracy and repeatability throughout its full range of motion using a variety of cutting tools. The BURNY Phantom is capable of directing waterjet, oxy-fuel, plasma, router, and many other cutting tools. The control has true multitasking capability and provides maximum productivity and functionality. The Phantom features an integrated operator's console, which contains full process control functions for oxy-fuel, plasma and markers. In addition, the integrated console houses 250-watt drive amplifiers. It is available on new cutting machines or as a retrofit to existing cutting systems.

The BURNY 10 LCD Plus PC based control is the next step in shape cutting motion control. Based upon the successful BURNY 10 LCD platform, the Plus integrates a larger 15-inch touch screen, 2 GHz Intel® processor, and Windows® XP Embedded operating system. The control can be interfaced to DC, AC or digital drive systems using Sercos protocol. Burny's superior motion engine combined with the high



accuracy of Sercos compliant drives, provide for the most accurate and repeatable motion available. The BURNY 10 LCD Plus is capable of directing waterjet, oxy-fuel, plasma, router, and many other cutting tools. The Plus is available on new cutting machines or as a retrofit to existing cutting systems.

Contact BURNY to learn more: BURNY Worldwide Headquarters, 7550 Hub Parkway, Cleveland, OH 44125, Phone: 216-524-8800 or 800-321-8072, Email: info@burny.com, Web: www.burny.com.

Improvements In A Multi-use Waterjet Tool For Humanitarian Demining, from pg. 6

which can be run from the battery of the support vehicle. Weight of the entire assembly is on the order of 12 kilograms, which can easily be hand carried to the suspected mine area where it is set up and run from a remote distance.

Upon identification of the mine, the second component, the neutralization tool (Figure 7), replaces the soil sucker. The neutralization tool consists of a tripod mounted mini-lance that is driven in either horizontal or vertical direction as needed by a 12 vdc motor for each axis. The operator positions the tripod and lance in the required position for the given mine and retires to the support vehicle where he activates the pump, slurry mixer, and cutting translation motor dictated by the fuse position in the mine. The neutralization tool weighs about the same as the identification tool.

The pump system consists of a 3500 psi commercial pressure washer pump powered by a gasoline engine, a pair of slurry pressure reservoirs, a water supply tank, and a slurry mixing vessel (Figure 8). All components are skid mounted and fit easily in a commercial pickup truck bed (Figure 9). Connections from the pump system to the tools are via lightweight pressure washer hoses, and electrical power for the motors can be transmitted through 18 gauge wires with control switches at the pump.

All components have been designed and fabricated to be as simple and trouble free as

(continued on page 10)

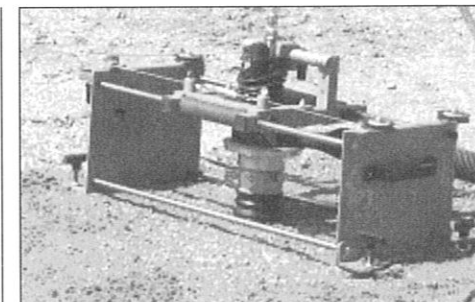


Figure 6. Early Identification Tool.

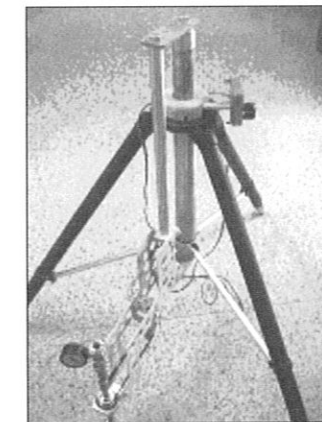


Figure 7. Two Axis Neutralization Tool.



Figure 8. Pump and Slurry System



Figure 9. Entire System being Deployed.

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Hydrodemolition In Plymouth, Devon, United Kingdom

A Conjet Robot 322 hydrodemolition machine, has been playing a key role in the UK removing concrete at a major redevelopment project in the centre of Plymouth, Devon. The Robot 322 on hire from Doornbos Rental UK in Southampton, is being used to accurately cut out the concrete from the reinforced deck and heavily reinforced cantilevered finger beams of a viaduct carrying a major road above a bus station, shops and café.

Main contractor Mowlem Civil Engineering is using Doornbos Rental UK's Conjet Robot 322 to remove concrete from the City's Exeter Street Viaduct to expose reinforcement in preparation for tying in additional reinforcement and casting on a short extension to make a wider deck. The hydrodemolition, which was specified by Plymouth City Council, is part of Mowlem's approximate £4M enabling works contract to divert all the utilities and services for the vast Drake's Circus Redevelopment Project for client P & O Developments.

"My concern was to leave as much of the original structure as intact as possible to connect and add the crossover and suggested the hydrodemolition technique, as I have used the method before," says Plymouth City Council senior bridge engineer Hrach Agobiani. "Hydrodemolition provides a clean exposure of existing reinforcement to tie additional reinforcement onto and recast with fresh concrete in order to get an integral monolithic structure. The client's consulting engineer Clark Nicholls and Marcel went along with my suggestion. They made it a contract requirement instead of breaking the concrete out manually with breakers, which would have caused damaged to the surrounding concrete from vibration. The hydrodemolition technique was

adopted as it leaves a very good uneven textured finish, which gives a very strong bond for the new concrete we have to cast on."

Mowlem initially planned the less efficient method of waterjetting with hand held lances, but the company investigated alternative robotic hydrodemolition methods and opted for the safer and more environmentally acceptable Conjet 322 Robot from Doornbos.

Using the specified hydrodemolition method Mowlem had originally planned to take out all the concrete from a 30m long, 900mm wide section of the 500mm thick deck, plus an adjacent and parallel 100mm deep 1.4m wide swath of concrete of the same length. The reinforced deck, built in the 1960s, proved to be exceptionally strong and allowed Mowlem to modify and reduce the amount of healthy concrete needed to be removed by the Conjet 322 Robot. "We started on the hydrodemolition to the original plan, but found the concrete was much stronger than expected," says Mowlem section agent Cris Peck. "We were able to reduce the amount and only take out a



Contractor Mowlem is using Doornbos Rental UK's Conjet Robot 322 in Plymouth to remove concrete from the viaduct deck and finger beams to expose the reinforcing ready for casting on an extension to the deck.

150mm deep strip and a parallel and adjacent 100mm thick section. This proved adequate to allow us to tie in the required additional steel reinforcement and extend the width of the deck with a C40 concrete mix."

For more information, contact: Lars-Göran Nilsson, Conjet AB, PO Box 507, S-136 25 Haninge, Sweden. Tel: [46](8)5565-2240, Fax: [46](8) 5565-2260, email: conjet@conjet.se, internet: www.conjet.com OR Stephen Toms, National Hydro Inc. 5643 Warner Road, Fowlerville, MI 48836 USA. Tel: (1)517-223-0915, Fax: (1)517-223-9525, email: toms@ismi.net

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Effective September 18, 2004, WJTA will be relocating to a new office at the following address:

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Waterjets For Selective Portioning Of Food, from pg. 5

orifice life is 700-1000 hours of operation. Diamond orifices are more expensive than sapphire nozzles; however, they last 7-8 times longer. These diamond orifices are advantageous when used in production lines where maximum uptime is critical.

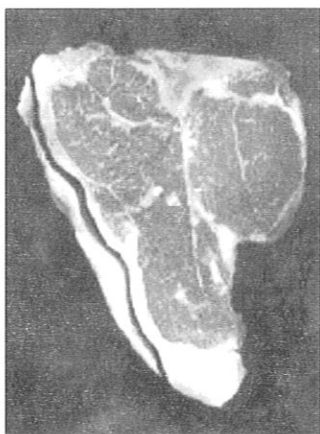


Figure 3. Automated Fat Trimming

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These DSI systems cut meat (Figure 4) to shape and weight with belt speeds as high as 80 feet per minute (24 meters per minute). The system can cut nearly any shape that can be drawn and new shapes can be loaded and run in seconds. These systems can process boneless pieces up to 3 inches thick.

Among the advantages of these automated portioning systems are:

1. Food safety is enhanced because human contact with the product is minimized.
2. Personnel safety is enhanced. There are fewer repetitive motion injuries and knife injuries.
3. Typical portioner installations generate a savings of 7-14

people per shift compared to hand cutting.

4. Cut quality and accuracy are consistent.
5. Fewer knives to sharpen.
6. Clean up is faster.
7. More capacity in less space.

For more information, contact: FMC Food Tech Inc., 1622 First Street, Sandusky, Ohio 44870, telephone: (419) 626-0304, fax: (419) 626-9560, web: www.fmcfoodtech.com, email: stein.info@fmcti.com.

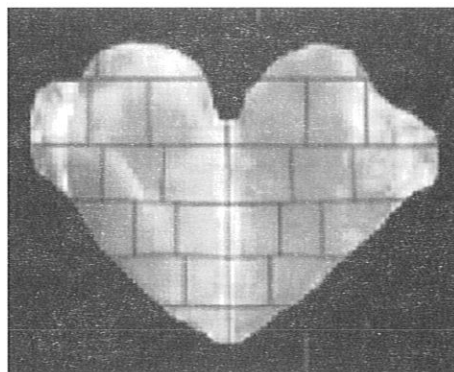
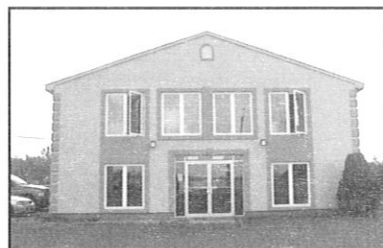


Figure 4.

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VLN Moves To New Headquarters

VLN Advanced Technologies, Inc., has relocated to a new building at 1166 Rainbow Street, Ottawa, Ontario K1J 6X7, Canada. The new building includes research and development and manufacturing facilities and office space.



VLN designed and manufactures the patented forced pulsed waterjet machine that operates at low pressures and is economical, compact, and easy to maintain. The forced pulsed waterjet machines can be used as conventional water blasters and for many applications.

For more information, visit www.vln-tech.com or contact: William Bloom, director of business development, telephone: (613) 223-3980, fax: (613) 747-0107, email: wbloom@vln-tech.com.



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Water Screen

Mirage Water Works of Anaheim, California, has developed a water screen for high-resolution projection and display of images. This device combines a nozzle system and a recirculating water collection system to create a water screen. Water (200-300 gpm) is recycled via a deep-well style pump and a 2-inch-diameter hose from a ground level trough to a perforated box through which the water drops under little or no pressure through several rows of small holes in the bottom surface of the box or "nozzle," thereby creating an array of droplets.

The rows of holes are staggered so that there are no gaps between the rows of falling water droplets. Pressure is kept to a minimum in the "nozzle" to avoid spray, which is deleterious in indoor applications. The weight of the nozzle and hoses plus the weight of the water is about 140 to 150 pounds per 10-foot nozzle section.

How it works

As a water droplet is hit with coherent light it will scatter light. Water does not provide much back-scattered light, which is what constitutes a front projection image. It provides mostly front scattered light, so that the water screen uses rear projection. It is the light scattering forward by the droplets that creates the image plane and not the light that passes through each droplet, otherwise the image would appear upside down and backward.

The Mirage water screens have 1,700 falling jets per 10-foot section of screen. A virtual image is reconstituted by the light after it interacts with hundreds of thousands of point source droplets. The projected surface gives the illusion that the image is floating in midair. Because this system is often used to project images in the immediate vicinity of people, the system is capable of shutting off 200-300 gpm in a tenth of a second with out a single drop. This is done by instantly applying a vacuum, which holds the residual water in a plenum.

Applications

One application of the Mirage water screen is at corporate functions where executives wish to make a dramatic entrance. A 30-foot water curtain can be created by linking three 10-foot nozzle sections together, each with its own pump supplying water. When operated together the water appears to fall as a single uniform curtain. One nozzle, however, can be shut off independently revealing a product or person behind while the water continues to fall on either side.

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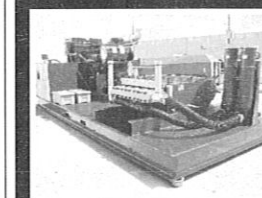
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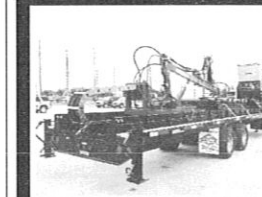
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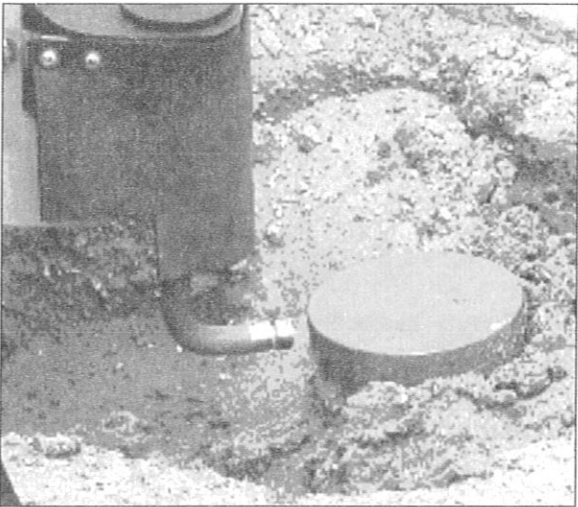


Figure 10. Early Neutralization Tool.

possible. Replacement parts can be, in many cases, fabricated from local

materials or obtained fairly rapidly from commercial ventures.

6. INITIAL TRIAL RESULTS

Trials of the concept have been successfully carried out at UMR using waterjet pressures of 3,000 to 3,500 psi. Identification of inert mines has been accomplished in a variety of soils with the soil sucker

clearing out overburden allowing the operator to see both mine type and

orientation. The neutralization tool (Figure 10) then used the 3,500 psi ASJ to slice through the mine at a predetermined zone.

Secondary field trials were conducted at an east coast military reservation which is set up for mine detection and neutralization. With observation from military and civilian agencies, a slightly modified system was tested on actual mines during which location, identification, and neutralization phases were satisfactorily completed (Figures 11, 12, 13, 14).

(continued on page 11)

7. CONCLUSIONS AND RECOMMENDATIONS

Field trials of the UMR developed demining system showed promise in the area of humanitarian de-mining. The ability of a single system to locate, identify, and neutralize landmines has increasing importance in many third-world countries, especially a system that is affordable and robust enough to reliably operate for a prolonged period of time.

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Figure 11. Field Trial of Early Identification Tool.



Figure 12. Modified Mine Identification Tool with Exposed Mine.



Figure 13. Uncovered Anti-Personnel Mine.



Figure 14. Neutralization Tool Slicing Mine After Identification

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