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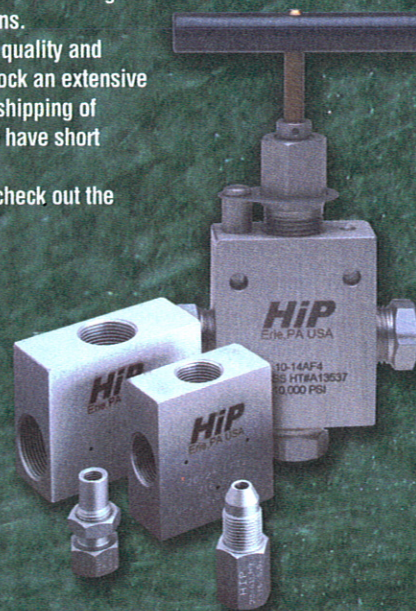
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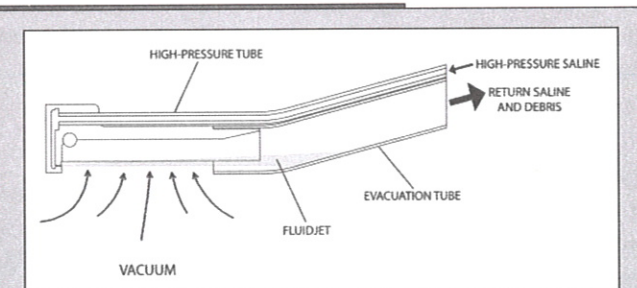
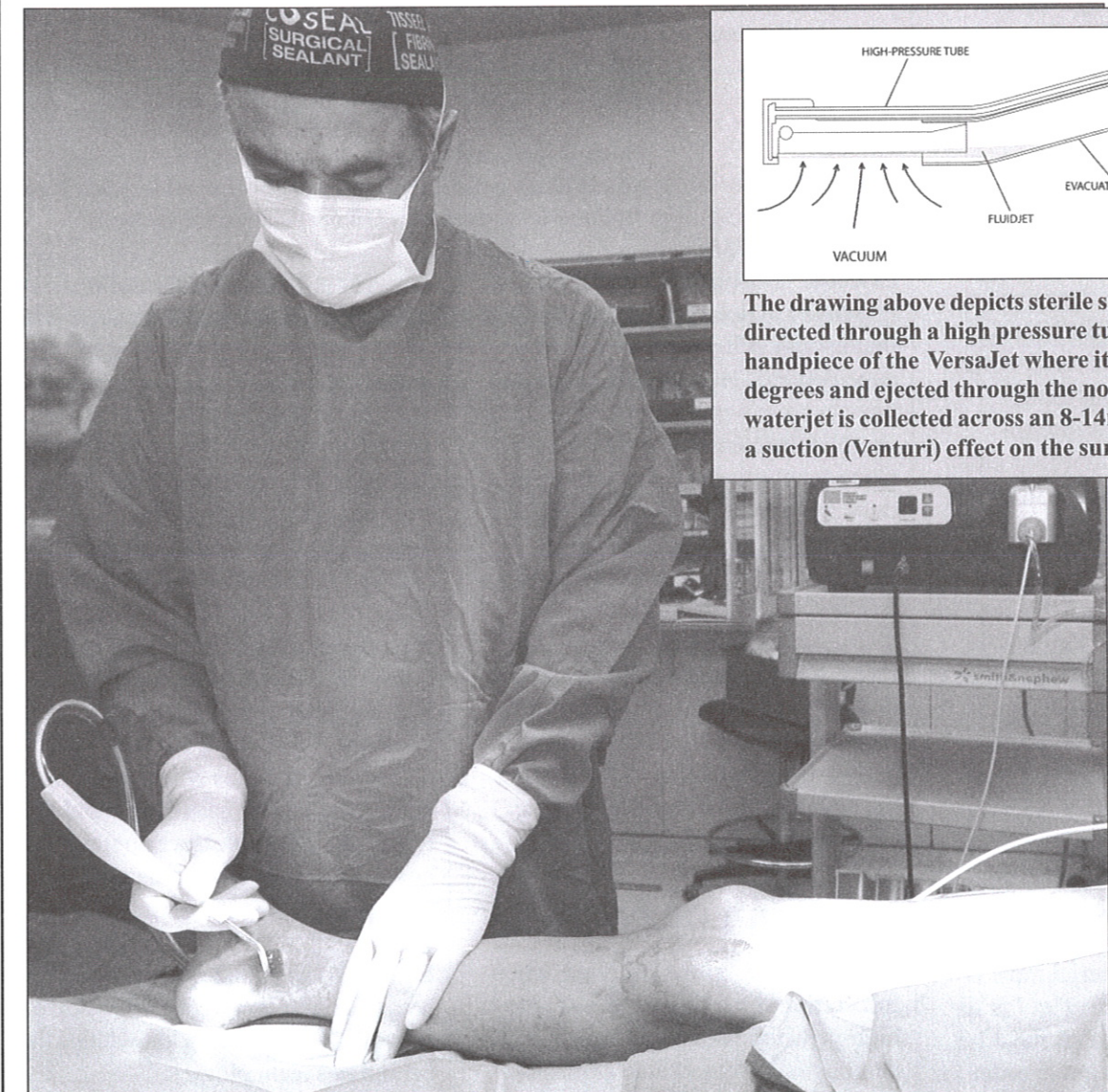
Jet News

DECEMBER 2005

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for the benefit of its
members*

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Waterjet Debridement Of Wounds



The drawing above depicts sterile saline being directed through a high pressure tube into the handpiece of the VersaJet where it is redirected 180 degrees and ejected through the nozzle. The waterjet is collected across an 8-14mm gap creating a suction (Venturi) effect on the surrounding tissue.

Acute and chronic wounds are major medical problems. Preparing a wound bed is an essential feature of their treatment. Wound bed preparation requires the removal of unhealthy and necrotic tissue as well as foreign bodies. A paper, "Medical Applications of the High Powered Parallel Waterjet," starting on page 2 describes an improved surgical debridement instrument (VersaJet™, Smith and Nephew, Hull, UK) using fluidjet technology and evaluates its applications in clinical medicine. This paper received the "Best Applications Paper" award at the 2005 WJTA American Waterjet Conference. The photo above depicts Dr. Ramazi O. Datiashvili, one of the authors of the paper, preparing a wound with VersaJet.

Medical Applications Of The High Powered Parallel Waterjet

By: Mark S. Granick, M.D.*; Ramazi O. Datiashvili, M.D.*; Parham A. Ganchi, M.D.*, Ph.D.; and Donald C. Freeman Jr., Ph.D.**
 *Division of Plastic Surgery, Department of Surgery, New Jersey Medical School-UMDNJ, Newark, New Jersey. **Board of Directors, HydroCision, Inc., Andover, Massachusetts

INTRODUCTION

Skin is the tissue that envelops the body and protects the internal environment. When the skin is disrupted a physiologic wound healing mechanism is immediately triggered. Initially bleeding is controlled and a clot is formed. An *inflammatory phase* then ensues during which inflammatory cells migrate into the wound to digest debris and set up for the next phase. During the *proliferative phase* new protein is elaborated and a scar is formed. The scar then undergoes a variety of changes during the post healing *maturation phase*. When a wound consists of a laceration the edges can be opposed and the wound healing process is optimal. In situations that develop from burns, large acute wounds, or from various disease processes, wounds can develop and fail to heal properly. This condition is referred to as a chronic wound.

During the past decade, the treatment of chronic wounds became focused on wound bed preparation. Essentially, this process consists of manipulating a wound to bring it into a physiologic state that is compatible with healing. This process has been codified with the acronym *TIME*. The *T* refers to *tissue necrosis*. All unhealthy tissue including tissue with inadequate blood supply, severely damaged tissue, and dead tissue must be removed from the wound. All foreign material must be cleared from the wound. The *I* is for *infection*. Bacterial burden must be below 100,000 bacteria/gm in order for a wound to heal. The *M* stands for *moisture balance*. Wounds heal best in a moist environment. Desiccation inhibits the healing process. Finally, the *E* means *edge*. The advanced edge of the tissue at the wound

perimeter must now be primed for healing. Healing can be facilitated by means of appropriate dressings, application of advanced technological wound coverage systems, or by surgery.

Effective debridement is the key to advancing through the *TIME* cascade. Various means can be employed to debride wounds, but this manuscript will focus on surgical debridement. Historically, surgeons have cut away unhealthy tissue using sharp instruments. Lasers, ultrasound, electrocautery, and radiofrequency devices have been employed but all have major drawbacks. The VersaJet® is a high powered parallel oriented fluidjet debridement instrument which was developed by HydroCision (Andover, MA) and brought into clinical use by Smith and Nephew (Hull, UK). This study will review the mechanics of the device, the developmental hurdles, and the clinical applications.

MAIN BODY OF PAPER

Water, an incompressible fluid, when forced through a tiny orifice at very high-pressure forms a jet that demonstrates remarkable abilities to cut materials. In industry, pressures of up to 100,000 psi are routinely employed. Nozzle orifices of only 0.1-0.5mm in diameter are used to generate these powerful jets. With properly designed nozzles the waterjet



The VersaJet in use in an Operating Room. An abdominal wound is being debrided in preparation for a skin graft. Note the VersaJet console on a OR cart behind the surgeon.

is highly collimated and can cut through a wide range of material with clean, smooth cut surfaces, with no thermal damage to the material. This technique is used industrially to cut soft materials such as candy, chicken, and fish. It is also used to cut harder materials like textiles and circuit boards and very dense materials such as concrete and glass, particularly if abrasives are added to the fluid. The performance features related to the industrial use of this technology are high throughput (cutting speed), avoidance of thermal damage, safety (especially in mines where electrical equipment can be hazardous) and high reliability. High-pressure pumps, hoses, valves, etc. are a natural extension of the same components used in hydraulic heavy machinery. Except for specialized areas like nozzle design, a considerable body of supporting engineering knowledge lies behind this technology.

Despite its success in numerous industrial applications, one must ask if there is any basis for utility of this technology in surgical applications.

(continued on page 4)

Upcoming Events

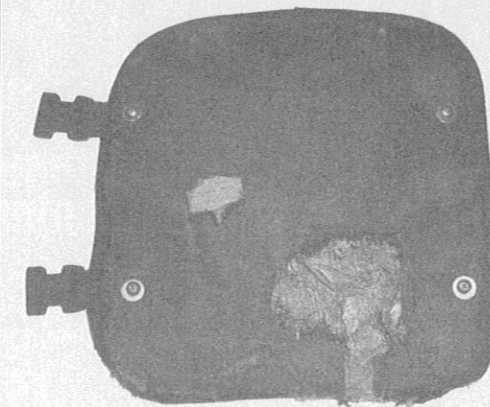
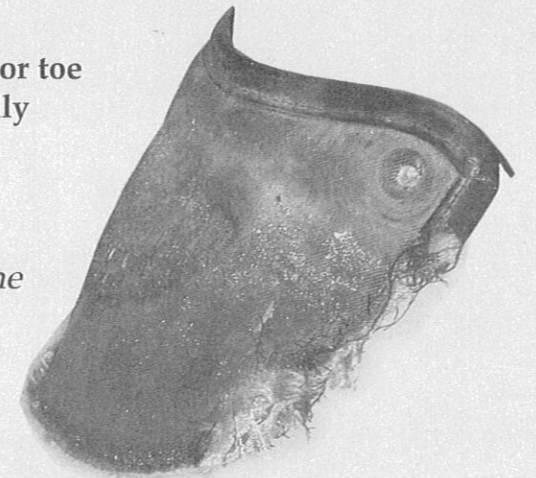
- **World of Concrete**, January 16-20, 2006, Las Vegas Convention Center, Las Vegas, Nevada. For more information, visit www.worldofconcrete.com or call (972) 536-6370.
- **PACE 2006 – The Paint and Coatings Expo**, January 25-February 3, 2006, Tampa Convention Center, Tampa, Florida. For more information, visit www.pace2006.com or call (302) 998-6560 or fax (302) 234-4608.
- **21st International Marble and Granite Fair: Vitoria Stone Fair 2006**, February 14-17, 2006, Carapina's Pavilion, Vitória, Espírito Santo, Brazil. Displays include over 500 commercial varieties of ornamental stone and the latest technology in machinery, tools and accessories. For more information, visit www.milanezmilaneze.com.br or email: milaneze@milanezmilaneze.com.br or call +55 27 3337 6855 or Fax: +55 27 3337 4011
- **Pumper & Cleaner Environmental Expo International**, February 15-18, 2006, Gaylord Opryland Resort & Convention Center, Nashville, Tennessee. Visit www.pumpershow.com or email: questions@pumpershow.com or call toll free (800) 257-7222.
- **Marmomacc International Exhibition of Marble, Stone and Technology**, October 5-8, 2006, Verona, Italy. Visit www.marmomacc.com for more information.

TurtleSkin Saves Water Jet Operators From Serious Injuries

TurtleSkin WaterArmor toe component accidentally swiped at 20,000 psi.

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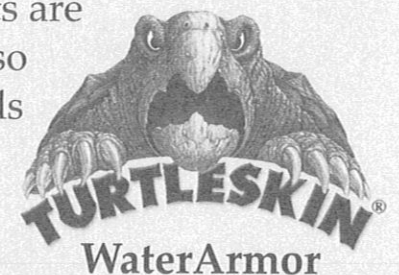
"I was unaware of the hit, until end of the day inspection of equipment."



TurtleSkin WaterArmor shin component accidentally swiped at 36,000 psi.

Supervisor's Comment:
 "Now I'll be able to order parts and not incur the extra costs of equipment that I do not need."

TurtleSkin WaterArmor has been proven to offer superior protection to high-pressure water jet operators at 40,000 psi or 2800 bar. It has saved numerous operators from injuries, as illustrated above. These TurtleSkin suits are made of individual panels, so only the damaged panel needs to be replaced, rather than buying an entire new suit.



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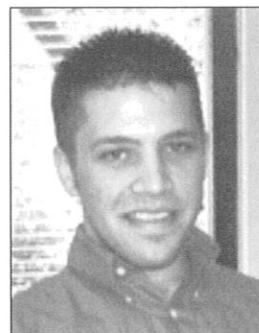
News From SPIR STAR Ltd.

SPIR STAR Ltd. has attained the recognition of certification for the **ISO 9001:2000** standard, which is the internationally recognized commercial standard for quality management. This certification is the culmination of years of hard work, consistent top-quality products, and great teamwork from the SPIR STAR staff, which is reflected by the outstanding customer service provided to valued customers. The management and employees of SPIR STAR are committed to continuous improvement of products and processes. SPIR STAR consistently strives to provide clients with the best pricing on quality products along with outstanding service.

SPIR STAR Ltd. has also announced the promotion of **Jacob**

Noack to sales representative. Jacob joined the SPIR STAR team in 2000, started out in the shop and rapidly advanced to an assembly technician. With Jacob's extensive knowledge of our product line, he was promoted to sales representative in August 2005.

As a sales representative, his primary duty is to uphold the high level of customer service that SPIR STAR customers have come to appreciate. "My ultimate goal is not only to be completely knowledgeable of our



Jacob Noack

product, but also to constantly look for ways to improve our high level of customer service," says Jacob.

For more information, visit www.spirstar.com, phone: (713) 856-8989, fax: (713) 856-8999, or write: 11983 FM 529, Houston, TX 77041.

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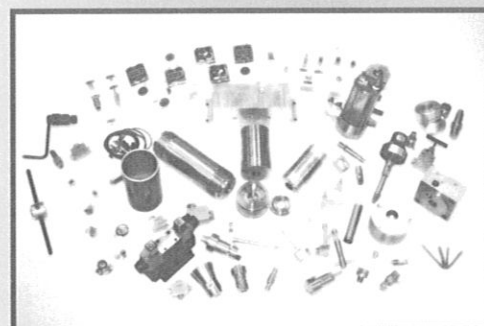
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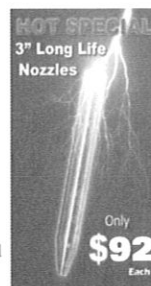


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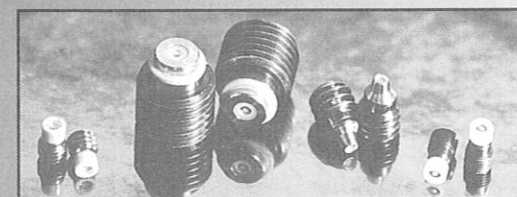
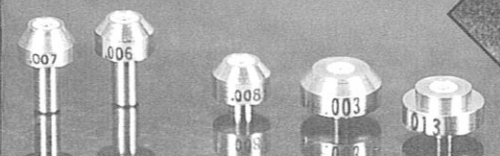


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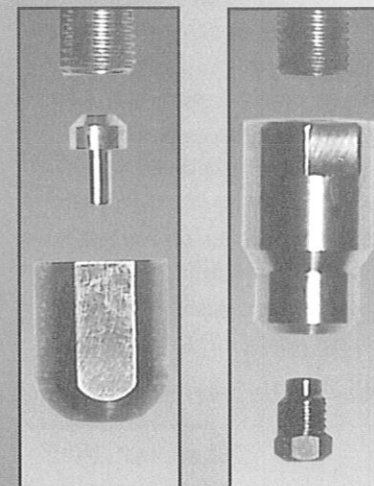
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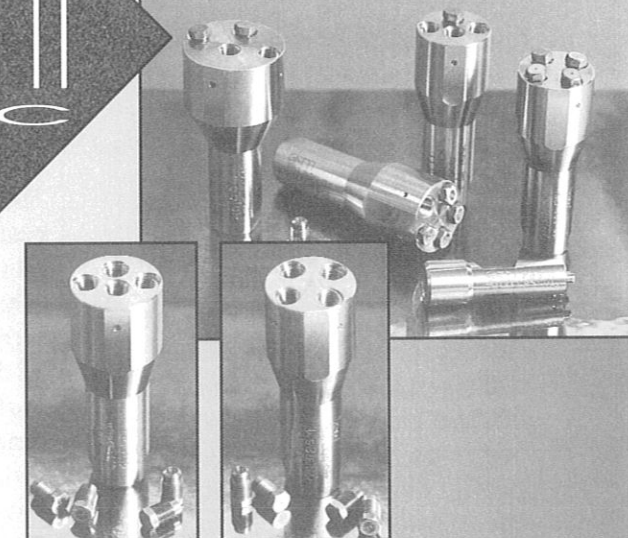
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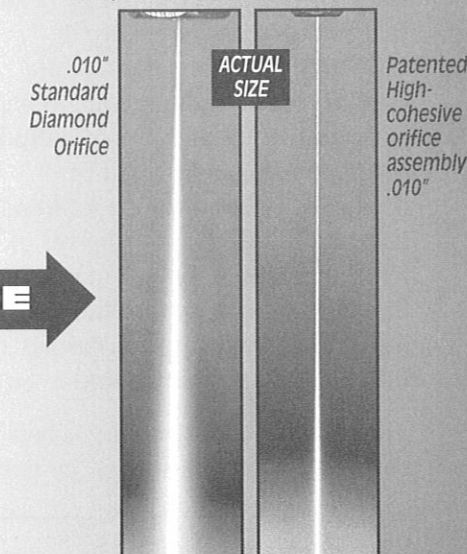
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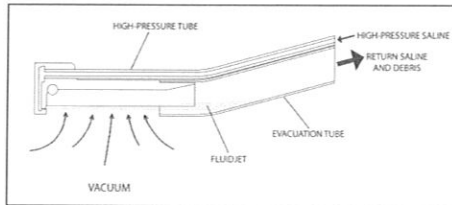
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After all, the scalpel (enhanced, in some cases, with heat or with ultrasonic vibrations) is a well-established cutting device—both simple and inexpensive. Furthermore, low-pressure “jets” of fluid (exemplified by the simple “squeeze bottle”, but sometimes enhanced by automation, as in pulsed lavage devices) have proven adequate for many medical applications, such as in wound cleaning. Why, therefore, introduce a complicated high-pressure technology into such a demanding field as surgery?

The fact that fluidjets can cut tissues ranging in hardness from fat to fascia cleanly and rapidly without any thermal effects is highly desirable, but not sufficiently beneficial *per se* to justify abandoning the scalpel. A phenomenological description of fluidjet cutting of biological tissue in air forms the theoretical basis for the effectiveness of the VersaJet. Visualize a homogeneous material such as a plastic. Obviously, a jet of fluid at low power (governed by the pressure forcing the jet through a tiny orifice) will merely bounce off the surface of the material. As the pressure is increased, the jet will reach a power level that exceeds the cohesive force between the molecules of the material, such that the material will begin to erode and a hole will be started. The power in the jet beam will be dissipated as energy is converted into momentum of the ablated particles of material, as well as in separating the particles initially. In addition, some energy will be dissipated by recoil of the jet from the bottom of the hole. The power of the jet beam must be sufficient to exceed the “ablative energy threshold” of these dissipational modes through the full thickness of the material to be cut.

The jet beam cutting ability is best characterized by its energy per unit



Sterile saline is directed through a high pressure tube into the handpiece of the VersaJet where it is redirected 180 degrees and ejected through the nozzle. The waterjet is collected across an 8-14mm gap creating a suction (Venturi) effect on the surrounding tissue. (Also pictured on the cover.)

area, where the kinetic energy is $1/2mv^2$, with m as the mass of the fluid/unit time and v as the velocity of the beam. As this formula implies, a higher velocity of the jet is more important than a high mass. Therefore, a very small diameter beam, traveling at a high velocity, is more effective than a larger diameter beam traveling at a lower velocity. It is therefore desirable to maintain the jet diameter as small as possible. Further, it is important to maintain the beam as coherent as possible, i.e., to avoid divergence of the jet beam as it travels away from the nozzle. Of equal importance is the ability to achieve very high jet velocities by generating high pressures (up to 15,000 psi) to force the jet beam through the nozzle. Simply stated, device designs that achieve a small diameter, highly coherent, high-velocity jet result in the ability to cut thicker materials. The maximum thickness will be proportional to the pressure behind the jet of fluid.

Other methods of cutting involve very different mechanisms. If the material is brittle, a mechanical method such as a blade can cut by cracking the material. Thermal methods, such as a laser, can cut by melting, or by spalling, or by a combination of both. In any case, the energy in the cutting method, translated into force per unit area, is the critical parameter.

Fluidjets can develop substantial energy (capability of doing work). If one assumes a jet orifice cross sectional area of 100 mm², a jet pressurized to 10,000 psi will then contain 4.7 megawatts of power, assuming that the nozzle is frictionless. Since, as noted above, it is desirable to minimize the diameter of the jet, most effective devices utilize nozzle areas much smaller than 100 mm², with about 0.01 mm² being typical. In this configuration (still assuming a frictionless nozzle) the power at 10,000 psi will be approximately 600 watts, or about 0.8 horsepower. If there is insufficient energy in the jet beam to cut through even softer tissue, it will lose its directional momentum and be deflected randomly into the surrounding tissue. This emphasizes the importance of having sufficient energy in the beam to penetrate the tissue completely before losing enough directional momentum for the cutting phenomenon to take place. Given sufficient energy in the jet beam, it is more likely to cut through the tissue and continue on its way. In general, jet pressures in the range of 10,000-15,000 psi are required to remove wound related soft tissue.

There are two attributes of waterjet devices that represent potential advantages over other incisional modalities. These are:

Tissue Differentiation: A conventional scalpel, in the hands of a skilled surgeon, can “differentiate” certain tissues, e.g., can resect fatty tissue away from stromal, or muscular tissue. However, the surgeon is using the scalpel to dissect through tissue planes and if these planes are not actually planar, but are topographically irregular, he is unlikely to achieve an exact separation. A great advantage therefore accrues to a device that can be pre-set to precisely remove layers

(continued on page 5)

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Dr. Rolf Koesters
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Fax: [352]311911

Shanghai Dalong-WOMA High Pressure

Dan Zhou
40 Guang Xin Village
#2 Guang Xin road
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Corporate Individual

Mike Lake

Onyx Industrial Services, Inc.
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William Dennison

National Industrial Maintenance
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Fax: (219)397-9316

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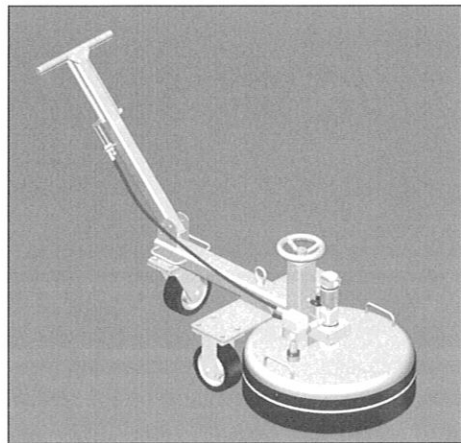
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For more information or to check availability, visit www.stoneagetools.com or contact StoneAge, Inc., 54 Girard Street, Durango, CO 81303, phone: (970) 259-2869, fax: (970) 259-2868, email: customerservice@stoneagetools.com.

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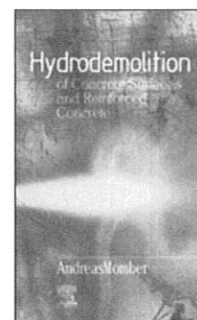
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Comprehensive Text On Hydrodemolition

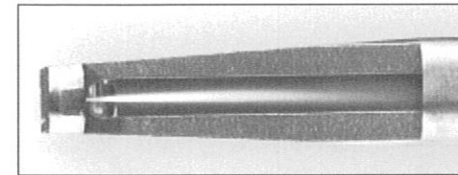
The publisher of World Pumps, Elsevier Ltd., has announced the availability of *Hydrodemolition of Concrete Surfaces and Reinforced Concrete* by Andreas Momber. The 278-page, hardcover book is a unique and comprehensive text dealing with the fundamentals of the hydro-demolition process. Coverage includes equipment, processes, surface quality aspects, demolition with abrasive waterjets, pulsed liquid jets, alternative applications and safety aspects.

Andreas Momber, a well-known expert in waterjet and abrasive waterjet cutting technology is a faculty member of GeoResources and Materials Technology, Aachen University, Germany.

For more information or to order online, visit www.worldpumps.com/bookstore.



Medical Applications Of The High Powered Parallel Waterjet, from page 4

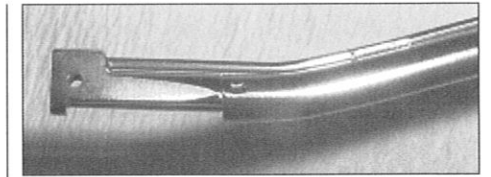


Side view of the tip of the handpiece.

of soft tissue to an exact level, even in surgical sites which are inhomogeneous, difficult to access, and/or difficult to visualize. Fluidjet devices can be "tuned" by proper nozzle design and operating parameters to do just this. In fact, the earliest fluidjet devices were indicated for use in dissecting away soft, parenchymal tissue in the liver and for dissecting tumors in the brain. More advanced technology, coupled with the use of higher fluid pressures, provides the potential for exquisite control of precision tissue excision, a capability which is particularly useful in wound debridement.

Ablation: A major disadvantage of the early, lower-pressure fluidjet devices for liver and kidney dissection was the fact that the fluidjet tended to disperse the tissue removed at the site. As a result various means of incorporating an external vacuum had to be utilized in an attempt to retrieve the dispersed tissue. Obviously, failure to accomplish this completely could represent some hazard, depending on the nature and area of dispersion of the resected tissue. In addition, great care must be taken to avoid inadvertently directing the waterjet against uninvolved contiguous areas.

A major advance ensued from the recognition that waterjets form the basis of the very old technology of "eductor pumps". Such pumps have been used in mines for centuries to pump out slurries of coal, for example. By the addition of a "collector" device, designed according to very specific



The waterjet is seen emerging from the nozzle and being captured in the eductor port.

criteria, it is possible to capture the fluidjet itself, while concomitantly creating a vacuum at the point of capture. When properly designed, this configuration results in intense cavitation at the collection point, so not only is the excised tissue drawn into the collector, but it is macerated almost to the cellular level and driven out of the collector tube without need for any external vacuum connection. When operated in a gaseous environment a flow of gas is drawn into the collector, by means of the

(continued on page 7)

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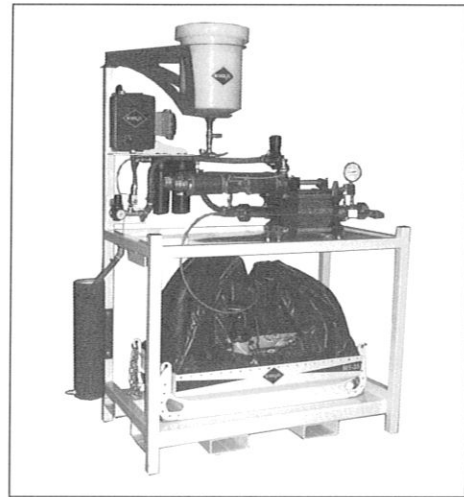
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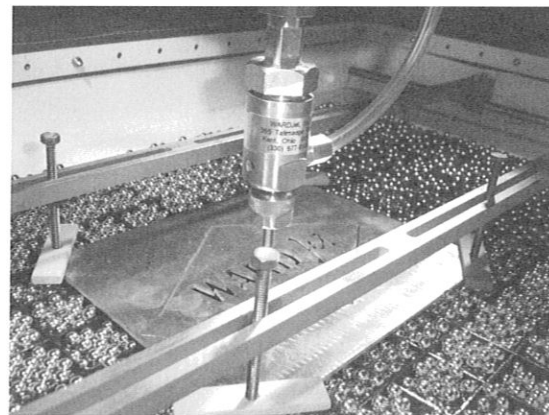
Use A CNC Mill As A Waterjet – Multi-Task With This Waterjet Cutting System

WARDJet, Inc. has introduced its new M-Series of waterjets, which enable you to use your CNC mill, laser, wood router, robotic arm, oxy-fuel or plasma cutter as a waterjet, and drive the intensifier off compressed air in your shop. Now you can adapt the machinery you own into a multi-tasking system by bringing waterjet cutting into your facility at a low price.



M-Series Cart

Retrofitting a CNC mill, or other CNC system, and then trying to cut with a waterjet on it would be like throwing buckets of sand and water all over your most treasured machine. The M-Series addresses and remedies this. A 'tent' specifically designed and built to contain all the abrasive and water inside the tank makes it possible to keep all M-Series waterjets



M-Series Cutting

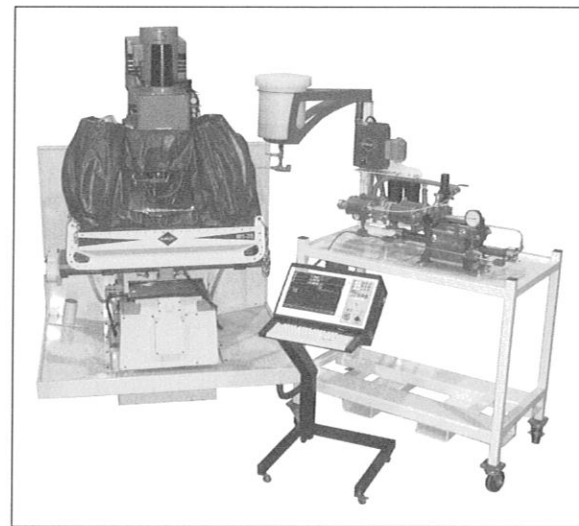
compact and self-contained. A self-flushing system removes the water, abrasive and any kerf material from inside the tank for disposal.

The 30-inch depth of water typically used in a large waterjet tank to dissipate the excess energy of the waterjet stream is replaced with a bed of ball bearings. Tanks come with either a 3.5-inch, 5-inch or 8-inch-deep layer of balls to match your cutting needs. Different size tanks are also available for different size CNC machines. 'Hooking into' outputs used to operate the mill, or whatever system you are going to use your M-Series with, activates the

waterjet cutting head and abrasive feed system. Because the M-Series waterjets are stand-alone units, there is no need to learn any new controller or programming. The same programming used to run your existing machine can be used to operate the waterjet motion.

For more information contact Julie Kaiser, WARDJet, Inc., 365 Tallmadge Rd., Kent, OH 44240, phone: 330-677-9100,

fax: 330-677-9121, sales@wardjet.com. Videos of the patent pending M-Series system and other informational videos can be viewed at www.wardjet.com.



M-Series Mill and Cart

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Jetstream® Introduces Universal Safety Warning Decal Kit

Jetstream is pleased to introduce a Safety Warning Decal Kit that can be installed on any waterblast unit in the industry, regardless of make or model.

Jetstream's new safety decal set includes 28 decals to place on all areas where heightened awareness to safety is needed. These Warning labels are designed for maximum operator visibility and contain pictograms and symbols that are recognized worldwide. They also include printed warnings in language developed by experts in the field of hazard warning. These generic labels can be used by existing Jetstream customers, as well as any competitor.

"We developed these decal kits to improve hazard notification throughout

the industry," said Ron Schmidt, general manager and vice president of Jetstream. "In doing so, we hope to increase awareness of hazards and how to prevent them, simplify training of new operators that industry personnel must undertake, satisfy our legal duty to warn of hazards, and elevate the warnings available in the industry. Our goal is to have all waterblast suppliers adopt these warnings and incorporate them on their equipment so they become an industry standard."

Key warning areas include towing, tire, belt guard burst hazard and fuel, just to name a few. Also included in the set is a general information label highlighting the inherent danger in using high-pressure water with a

checklist to be followed before turning on the pump.

All decal sets are accompanied with a Warning Label Installation and Location Guide. Call a Jetstream Solutions Provider today at (800) 231-8192 for your Safety Warning Decal Kit. Visit Jetstream online at www.waterblast.com.



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Orthopedic surgeons have found the VersaJet to be a quick and effective way of debriding infected prostheses. When a patient who has a total joint prosthesis becomes infected, the prosthesis is generally removed and a spacer impregnated with antibiotics is placed in the joint space for a period of months prior to replacing the prosthesis. With the VersaJet, the infected prosthesis can be removed, the wound completely cleaned and a new prosthesis inserted in one sitting. That saves multiple operations and months of disability for the patient. The VersaJet is used to remove osteomyelitic bone and metallosis from worn out prostheses.

CONCLUSION

The VersaJet, a high-powered parallel cutting water jet, was developed for the purpose of wound debridement. The process of development required solutions to many challenging technical problems. The result however is a device with remarkable accuracy and precision. As we gain more experience with this new approach to surgery, more applications for this device will undoubtedly develop. There are many potential applications that can be realized as well by adapting the instrumentation to different surgical environments. The VersaJet has empowered the surgeon to achieve better outcomes for patients while saving scarce economic resources for the hospitals at the same time. It has led to a paradigm shift in surgical thinking.

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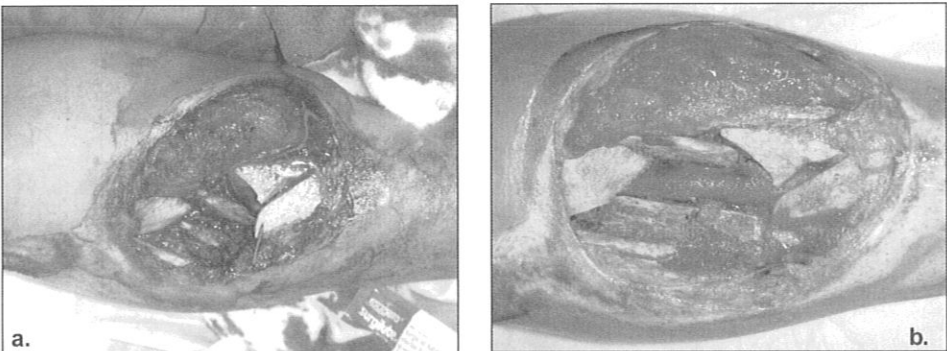
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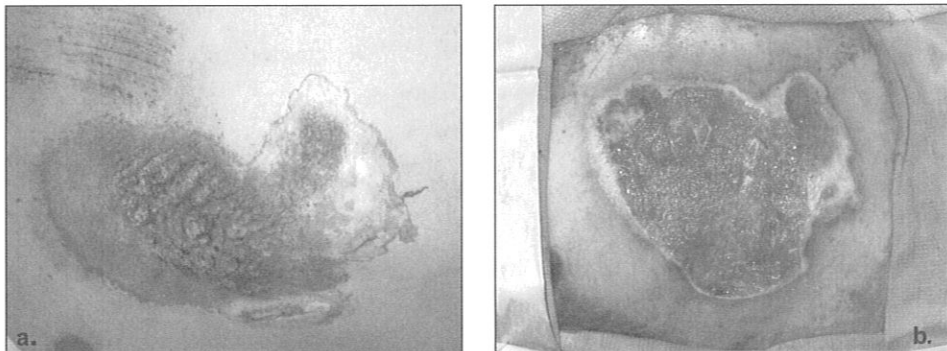
The three photographs below left depict wounds sustained when a person was dragged during a motor vehicle accident. The three photographs below right show that VersaJet can be used to remove the “road dirt.” “Road dirt” consists of soil and grit that is ground into the tissues when an injured person is dragged against the ground.



View of a thigh wound before (a) and after (b) serial debridements with VersaJet.



View of a lower leg wound before (a) and after (b) serial debridements with VersaJet.



View of a chest wound before (a) and after (b) debridement with VersaJet.

Venturi effect, along with the excised tissue or other debris. This phenomenon, which effectively removes the material cut by the fluidjet, allows the use of such devices not only for cutting, but also for “ablation”, or “sculpting” of tissue surfaces. An important further advantage of the collector configuration is that the jet is fully controlled, i.e., its action is constrained to the region between the jet nozzle and the collector, so the danger of impinging on uninvolved contiguous areas is greatly minimized. Furthermore, bacteria and wound contaminants will likely be removed along with the ablated tissues. By designing an appropriately contoured handle, the cutting edge of the fluidjet can effectively reach relatively inaccessible areas of a wound.

The above principal advantages of advanced fluidjet technology are very synergistic. These advantages, in addition to the inherent speed, precision and non-thermal nature of this technology, justify a potential place as a versatile, general-purpose modality in the surgical armamentarium. Nevertheless, a number of technical challenges needed to be surmounted before that potential could be realized.

The operating parameters of greatest importance for surgical applications are quite different from those for industrial applications. First, it is essential that the working fluid be sterile, since it is exposed to the site of surgery. All surgical procedures are performed under sterile conditions. This is a substantial hurdle, since power must be transmitted to the working fluid without the transmission of bacterial or viral contamination. This immediately gives rise to the question of re-sterilization of those components that carry the working fluid. Realizing that most fluidjet surgical devices will incorporate very

small diameter tubes and very fine nozzles leads to the conclusion that re-sterilization of such devices is extremely difficult to validate. In particular, the need for sterilization is compounded by the need for absolute cleanliness, since a single residual particle (even though sterile) can clog

a jet orifice. Consequently, that part of the system which carries the sterile working fluid is a pre-sterilized, single-use, device. This strategy, of course, imposes the need for low manufacturing costs, consistent with

(continued on page 8)

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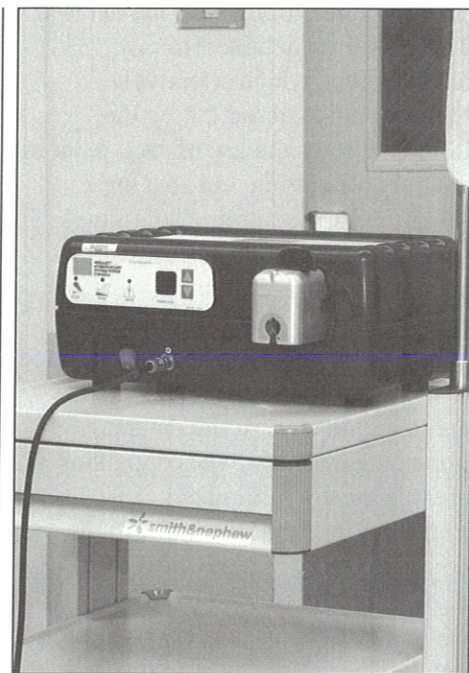
Medical Applications Of The High Powered Parallel Waterjet, from page 7

those for disposable devices, but does alleviate the need for the long useful lifetimes that would be required for reusable devices. For example, if the device is disposable, there is no need for the expensive sapphire nozzles used in industry to provide months of useful life.

A second technical hurdle is the need to reduce the size of a complete fluidjet system from the typical floor-mounted or truck-mounted industrial system to a size which allows mounting in typical operating room "towers" or on typical instrumentation carts. This hurdle is mitigated by the fact that the pressures required for surgical applications are not as high as typically used in industry. Generally, pressures from several thousand psi to 15,000 psi are sufficient for wound debridement as opposed to the 50,000

to 100,000 psi range used for industrial applications. Similarly, it is essential to reduce the size of the "working end" of the system to millimeter dimensions; a realm unheard of in industry.

Finally, it is obviously necessary to ensure that the stringent safety requirements consistent with operating room use are incorporated into the fluidjet system. This includes meeting well-prescribed electrical safety regulations, but also involves overcoming any hazard from fluids under high pressure, as well as from the spread of infective contamination from spray generated by the device. Other considerations, such as noise and ease of use, which are exacerbated in the often frenetic Operating Room environment are essential.



VersaJet Console

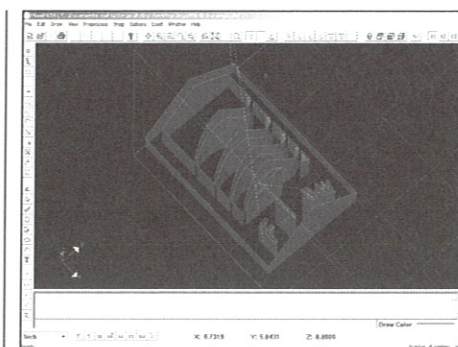
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Flow's New Software Adjusts For Cut Speed And Material Thickness

Flow International Corporation, a developer and manufacturer of ultrahigh-pressure (UHP) waterjet technology equipment used for cutting, cleaning (surface preparation) and food safety applications, has launched FlowMaster 6.0, Flow's innovative Windows®-based waterjet control system.

FlowMaster software is now easier to use and more powerful than ever before. The system's new features give operators the ability to:

- Improve cycle time performance up to 35%
- Program and cut parts of varying thicknesses with programmable Z-axis capability
- View and path parts in full 3D for easy design



- Optimize cut speed for part corners to reduce cycle time.
- Improve edge quality through the ability to control cut speed to reduce marks on parts
- Save time through automatic calculations – there's no need to stop and manually calculate and adjust the settings.
- Reduce the number of operational steps and increase output

- Enhanced file support including dxf for AutoCAD 2004

"Waterjet software is evolving to help solve the challenges faced by manufacturers," said Robert Peterson, waterjet market manager, Flow International. "With Flow's innovative software, waterjet operators are no longer restricted to cutting only on the XY plane, and can easily design and cut parts never imagined on a waterjet with varying height and thickness. In addition, FlowMaster 6.0 will help customers lower cost per inch on projects through the software's ability to improve cut speed and thickness."

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tissue and remove only the unwanted matter. There is minimal collateral damage, no thermal injury, and less bleeding. In spite of the less extensive nature of VersaJet debridement, patient outcomes are improved and it takes significantly fewer debridements to prepare the wound bed.

There are numerous recognized applications for the waterjet in surgery (1-8). The VersaJet has FDA approval as a wound debridement instrument.

It is effective in removing granulation tissue, fibrinous debris, or frank necrosis in all wound types, including fasciitis wounds. In very severe and extensive wounds near important anatomical structures, the VersaJet is capable of delicately and precisely removing tissue to an almost microscopic level so as not to injure the aforementioned structures. In combination with a negative pressure wound therapy system, a healthy wound can often be achieved in cases

that were not possible with scalpel debridement. This is also true in patients with loss of abdominal domain. We have found that the VersaJet can clean off exposed viscera in cases of open abdomens. This allows more rapid closure with less risk of fistula. The VersaJet is much more accurate and rapid than scalpel surgery in debriding necrotic muscle in compartment syndrome.

In burn wounds, VersaJet is not useful for the removal of dry eschar, which is too dense for it to cut. However, in chemical burns, friction burns, scald burns, and more superficial flame burns, it is a fast, less bloody, and very effective debridement tool. At this writing

the VersaJet does not have FDA approval for burn debridement in the United States, but has been used extensively for this purpose in the United Kingdom. The VersaJet is exceptionally useful in cleaning up acute traumatic wounds. Patients who have crush injuries, electrical burns, compartment syndromes, gunshot wounds and open comminuted fractures are traditionally treated with serial debridements and wound irrigations in the operating room prior to any attempt at closure. The VersaJet enables the surgeon to more accurately clean the wound so that the number of debridement sessions required to get to a properly prepared wound bed is significantly reduced.

The VersaJet is extremely useful for the removal of particulate foreign bodies such as "road dirt". Road dirt consists of soil and grit that is ground into the tissues when an injured person is dragged against the ground. Unless road dirt is removed from the wound early after the injury it gets incorporated into the healing skin and forms a traumatic tattoo. At that point it is almost impossible to get rid of it other than by directly excising it. The VersaJet readily and completely removes this material from an acute wound leaving a healthy wound bed. Similarly the VersaJet facilitates removal of silicone gel following implant rupture.

The VersaJet is useful for defatting flaps and skin grafts. When a full thickness skin graft is required, a piece of skin is cut away from one area of the body, all of the underlying fat is removed and it is then placed elsewhere on the body. The waterjet is a quick effective way to remove the excess fat from the underside of the graft.

(continued on page 14)

The VersaJet has resolved these hurdles. The overall system consists of a reusable power and control console for pressurizing normal saline (a biologically compatible isotonic fluid) up to 15,000 psi. The pressure required for the particular wound is adjusted on the console. The console, in addition to meeting international regulatory requirements for electrical and mechanical safety, has a low noise level, minimal operator interaction, and a size commensurate with "tower" mounting in the operating room. Handpieces are disposable, including the entire sterile fluid path from saline bag, through the integral "pump cartridge" to the high-pressure nozzle via high-pressure flexible tubing. The pump cartridge was designed to be easily inserted into a receptacle in the console and incorporates a sterile barrier, so that contamination from the non-sterile console is avoided. A foot pedal operates the handpiece that comes with either an 8 or 14mm working area.

Considerable innovation was required to meet these overall system objectives. For example, the cost requirements imposed by disposability of the sterile fluid path resulted in a unique pump cartridge design that is simple, while allowing ease of use. Special high-pressure tubing was required, so as to allow safe containment of the pressure, while still allowing high flexibility for ease of use. Obviously, the design of the handpieces needed to meet stringent cost requirements, while also meeting the weight and size requirements consistent with a hand held surgical device. Finally, the design of the fluidjet nozzle (.005inch diameter) and the jet collector was found to be critical in order to achieve optimal

cutting, ablating and tissue removal characteristics in an air environment. For centuries the debridement of wounds has been the hallmark of surgery. In the preanesthetic era amputation was the preferred method of debriding an extremity wound. The standard of operative management evolved into a radical excision of wounds. Extensive surgery of that nature widely removes all necrosis and debris, but at the same time sacrifices a large amount of healthy collateral tissue. In burn surgery it was recognized that tangential excision of burn wounds led to earlier wound closure and less scarring. Tangential excision consists of slicing through thin layers of dense burned skin until

punctate bleeding is seen. At this level, the advancing edge of the wound is present and skin grafting is possible. VersaJet debridement affords the same type of precision and control over wound surgery. The hand piece sculpts tissue in an orientation parallel to the direction of the water jet. Consequently, the device debrides tissue when the waterjet moves parallel to the wound surface with no pressure exerted on the wound itself. By removing necrosis and debris from within the wound and working towards the healing edge of the wound, surgeons employing the VersaJet can readily identify the edge of healthy

(continued on page 12)



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The WJTA Safety Committee hereby solicits comments regarding improvements to the publication, *Recommended Practices for the Use of Manually Operated High Pressure Waterjetting Equipment*. While *Recommended Practices* is reviewed periodically at the biennial conferences of the WaterJet Technology Association, your comments and suggestions for improving the publication are invited and welcome anytime.

Please address your comments and suggestions to: Safety Committee, c/o WJTA, 906 Olive Street, Suite 1200, St. Louis, MO 63101-14134, fax: (314)241-1449, e-mail: wjta@wjta.org, web site: www.wjta.org.

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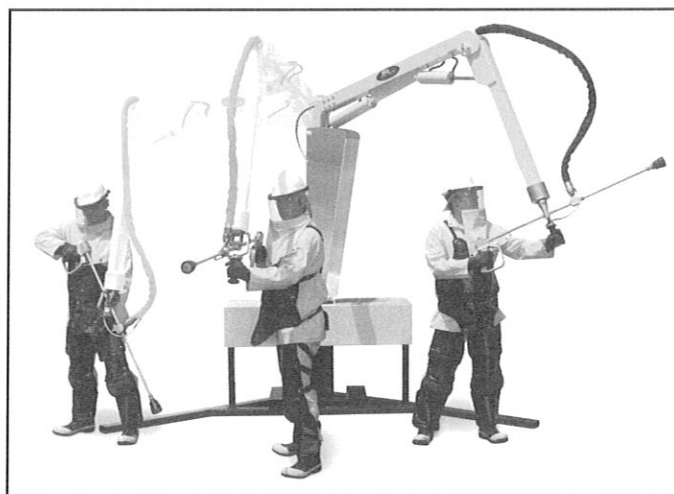
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Jetstream's Pneumatic "Arm" Absorbs Backthrust And Weight Of Waterjet Gear

Jetstream, a leading supplier of high-pressure waterblast equipment, has introduced Max ArmStrong. This innovative power-assist pneumatic "arm" is designed to alleviate the operator fatigue common to waterblasting work.



Max ArmStrong represents a technological breakthrough in waterblasting: a device that supports the weight and thrust of waterblasting guns, alleviating the extreme duress of hand-held blasting. Max ArmStrong counteracts these forces, using an intuitively operated control stick that allows the gun to be maneuvered simply by moving the stick in the desired direction.

The waterblast operator often works under adverse conditions, contending with extreme noise, water spray, reduced visibility and unsure footing. In this environment, the operator must deal with these difficult elements while trying to keep a high-pressure jet on target. These challenges lead to operator fatigue, reduced job performance and productivity, and in some cases, musculoskeletal injury.

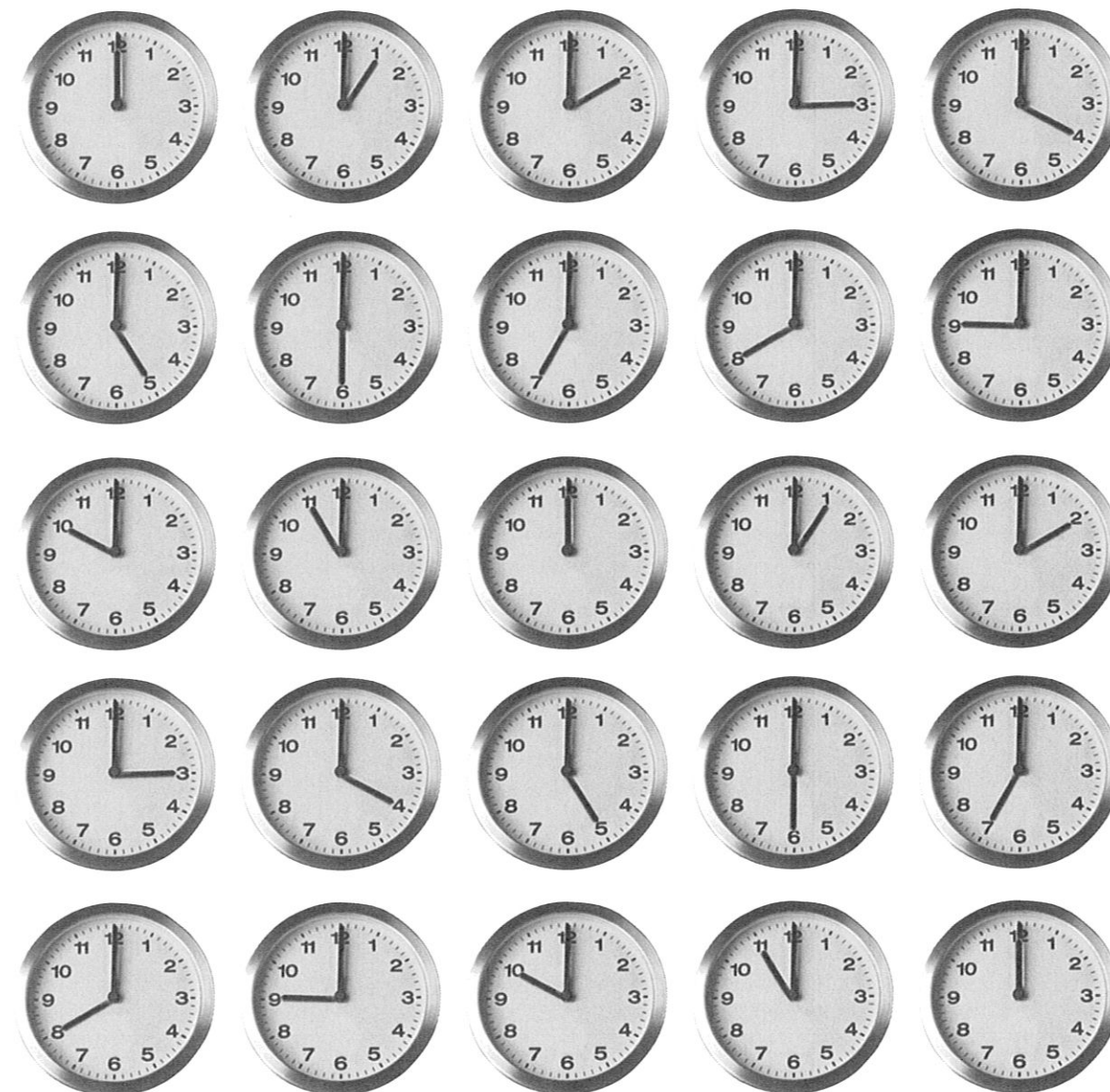
Waterblasting is very labor-intensive and extremely fatiguing to the operator. As a result, contractors face high turnover rates and increased employee costs related to maintaining a strong, competent workforce. With the Max ArmStrong technology, which alleviates the physical stress of conventional waterblasting,

contractors can boost profitability, improve worker safety and increase customer satisfaction.

The device operates on a low-volume, pneumatic control system that eliminates the need for electronics. This simplified design increases reliability, safety and speed of setup. It adapts to any nozzle, flow and pressure selected, and allows a wide range of motion: up, down, side-to-side and rotation.

Jetstream also produces waterblasters up to 40,000 psi, along with parts and accessories for Jetstream and competitive equipment. Product offerings include skid- and trailer-mounted units, pumps, control guns, valves, hoses, replacement parts and nozzles.

Jetstream is a subsidiary of Federal Signal Corporation's (NYSE:FSS) Environmental Products Group, which includes Elgin Sweeper, Vactor Manufacturing, Guzzler Manufacturing, and Leach Company. For more information, call 1-800-231-8192 or visit Jetstream online at www.waterblast.com.



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