CRYOGENIC INDUSTRIES

# FrostByte

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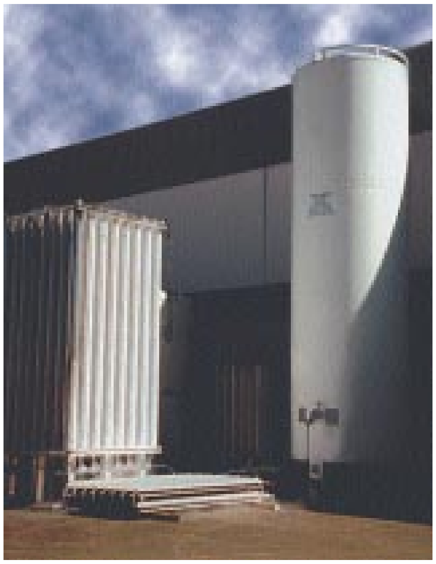
# Vaporizer ice build-up requires an analysis of switching issues for ambient air units

In recent years there has been a steady increase in the demand for ambient air natural draft cryogenic gas vaporizers for the continuous supply of gas for varied applications. Ambient air natural draft vaporizers utilize the heat contained in the ambient air to provide the energy required to vaporize the cryogens flowing through the units. They require no external power or additional fuel source and are easy to install. Once the liquid cryogen is connected, the vaporizer provides gas efficiently and reliably with virtually no maintenance requirements.

The high capacity of the Cryoquip units is achieved by designing each heat transfer element with eight fins measuring 203 mm (eight inches) tip to tip, coupled with Cryopquip's wide spaced extrusion design which allows for more ice formation. Each element has approximately 1.55 square meters of external heat exchanger surface per meter of length. Additionally, the vaporizer fin has a specially designed, patented* internal fin configuration that results in a very high forced convection heat transfer co-efficient, well in excess of those found in similar look-alike vaporizers.

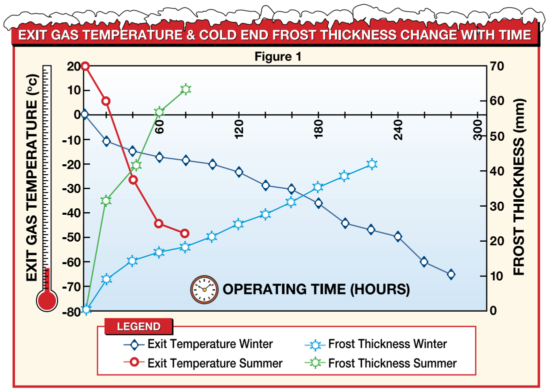
The limitation to the operation of this type of vaporizer is ice build-up. As the atmospheric heat is absorbed by the vaporizer, the water content of the air (humidity) freezes onto the surface of the fin elements and forms ice (frost). When the ice grows to the point where it touches the ice growth from an adjacent fin, the vaporizer becomes ineffective. The air flow through the unit carrying the much needed heat for the vaporization process is stopped by the ice formation. In order



*Providing the ice accumulation does not bridge the fin elements, the Cryoquip ambient air natural draft vaporizer will continue to function.*

to provide a continuous flow of vaporized gas at an acceptable exit temperature, a second unit has to be employed allowing the first unit time to defrost and shed its ice. Because Cryoquip's fin element is extruded to a high quality, very smooth surface finish, it promotes defrosting and rapid ice shedding and minimizes the time for defrosting. This in turn leads to the utilization of smaller units to meet flow requirements, which reduces system cost and improves efficiency.

However, regardless of the size of the units, in order to provide *continuous* gas flow, the vaporizer(s) will require defrosting at some point during operation. The length of time that elapses between the vaporizer being on-line and providing gas flow, and being off-line defrosting, is known as the "switching time" or "cycle




time." There is considerable debate over how long the switching cycle should be. Computer simulations suggest an optimum time lies between four and eight hours.

Because ambient air natural draft vaporizers' operation is affected by the ambient conditions, ice build-up during the winter is much less than during the summer, simply because of the lack of humidity in the winter months. (See Figure 1.) In the summer, although the ice build-up is much higher, the ambient temperature is

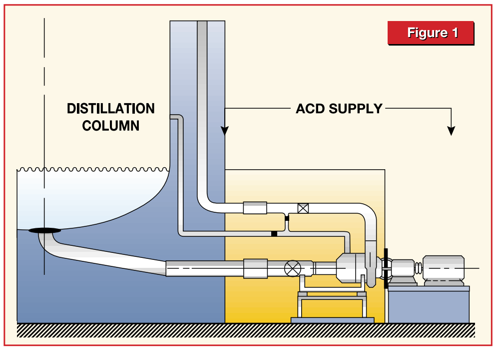
*Continued on page 7*

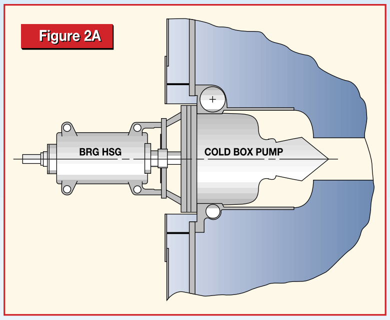
## Inside This Issue

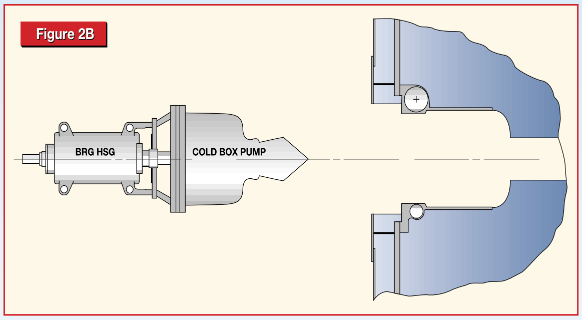
# ACD plans the next generation of cold box pumps

ACD, Inc. has supplied cryogenic pumps, turboexpanders, and compressors to the air separation industry for more than forty years. Currently, the company is prototyping a new cold box pump that will be reliable, safe, and have low operating costs.

The importance of compressors and expanders in the air separation process allows the manufacturing of these machines to be custom designed for each application. ACD's new process pump for cold box service will have many of the advanced features found in the turboexpanders and compressors. The reliability and safety features currently used in ACD's process pump will also be retained in the new design. These include dual labyrinth seals; dry nitrogen gas purge of the motor/bearings; intermediate/insulator housings to thermally insulate the bearings from the cold fluid product; and extinguishing bronze construction.




### *Design Features*

- The new cold box pumps will be able to connect to the cold box as an auxiliary. (See Figure 1.) The expansion joints, valves and piping can be supplied by ACD.
- The pump rotating assembly and all parts that could conceivably rub will be part of a cartridge assembly. A key feature of the new design is the ability to remove the cartridge assembly as a single unit. (See Figures 2A and 2B.) The cartridge assembly is a smaller package compared to that of the entire pump and this makes replacing pump components easier.
- The cartridge assembly is attached by a single joint. This means installation time will be less and because there are fewer joints, it will be a safer installation. The discharge, suction, vent, and purge lines are permanently welded as part of the cold box plumbing.
- The pump shaft is supported by oil lubricated bearings which are mounted in a separate bearing housing. (See Figures 2A and 2B.)
- The motor shaft is coupled to the pump shaft so the motor can be replaced without disturbing the bearing housing or the pump.

*The following design features are currently found on ACD's process pumps and will be retained in the new pump design:*

- Dual labyrinth seal. The dual labyrinth seal is a non-contacting seal. This seal provides long service life and is inherently safe. The primary buffer gas in the seal is the product gas itself and the secondary buffer gas is dry nitrogen gas.
- The bearings are separated from the cold product by a distance piece and insulator plate. A slinger is mounted after the insulator plate to assure no oxygen can enter the bearing housing.
- Continuous nitrogen gas purge of the motor and bearing housings.
- Bearing motor heaters for prolonged cool-down or stand-by modes.
- A control panel to monitor the buffer and purge gases.

### *Pump Efficiency*

In the past, pump efficiency has erroneously *not* been considered a major factor in cryogenic process pump selection. Experience has shown that ACD's current process pumps are reliable, safe, and have low initial cost. Process pumps are run continuously and in some cases, have the shaft energy removed by the process refrigeration. The operating cost of these pumps can be very high. ACD's new process pumps will have higher pump efficiencies and consequently lower operating costs. Air separation plant cold box pumps are prime examples of why pump efficiency *should* be given more consideration in pump selection.

A cold box pump has the pump input shaft energy removed by the process and therefore is more expensive to operate. The following example (See Figure 3.) demonstrates the effect pump efficiency has on operating cost. (Assumption: The cost of refrigeration is assumed to be the cost to produce liquid nitrogen and only the liquid nitrogen heat of vaporization is used to produce refrigeration.)

A typical 1,000 tpd liquid oxygen plant uses a centrifugal pump to transport liquid oxygen (specific gravity 1.14) to the

*Continued on page 3*

**Typical five (5) year cost to operate the pump is:**

**Figure 3**

$$\text{Power Cost (\$)} = \frac{\text{(kw (shaft)) (\$0.05/kw-h x 24 hr/day) (365 days/yr x 5 years)}}{\text{motor efficiency=92\%}} = \text{kw (shaft) x 2,380}$$

$$\text{Refrig. Cost (\$)} = \frac{\text{(kw (shaft))(3,413 BTU/kw-h)(.24 kw/\#}LN_2\text{)(\$0.05/kw-h x 24 hr/day)(365 days/yr x 5 years)}}{\text{85.6 BTU/\# }LN_2} = \text{kw (shaft) x 20,956}$$

**Note: The refrigeration cost (approximately 9 times that of power cost) is independent of pump flow, head and efficiency parameters, and specific gravity.**

**If the pump efficiency is 65%, then the kw (shaft) calculation would be:**

$$\text{kw (shaft)} = \frac{\text{gpm x head x specific gravity}}{5{,}303} \div \text{pump efficiency} = 39.29 \text{ kw}$$

| Total operating cost for five (5) years: | | |
|---|---|---|
| | Power | = $ 93,510 |
| | Refrigeration | = $823,361 |
| | Total Energy | = $916,871 |

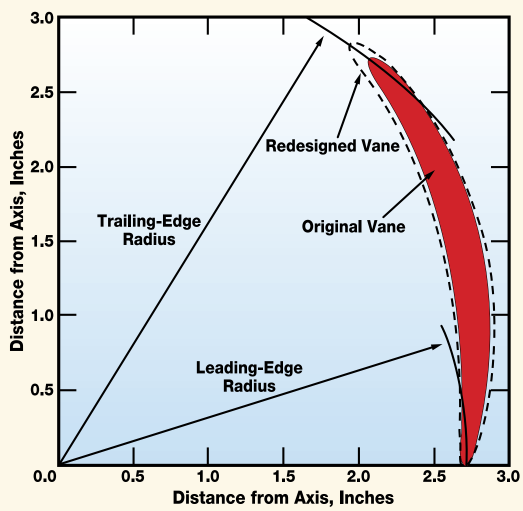
**If the pump efficiency could be increased to 80%, the total cost would be reduced to $744,989 with a $171,920 savings over five years. This is $23,337 saved per kw over a five year period. The amount of savings is substantial especially where refrigeration of pump input energy occurs.**

# A computer program redesigns radial diffusers in turbopumps

*The program for designing impeller blades has been adapted to the design of diffuser vanes*

A computer program for redesigning the vanes of a radial diffuser in a turbopump was written to satisfy new operating requirements, while not changing either the number of vanes or the radial locations of the leading and trailing edges of the vanes. (See Figure 1.) The new operating requirements include specified levels of performance in off-design operation.

Figure 1




*The leading and trailing edges of a redesigned diffuser vane were constrained, as an explicit condition of the redesign, to lie at the same radii as in the original design.*

The computer program is a modified, upgraded version of a program devised previously for designing blades of centrifugal pump impellers. By use of two coordinates called "G" and "H," the complex three-dimensional surface of a blade (in this case, a diffuser vane) can be described as though it were two-dimensional. The definitions of these coordinates are $G=\int dm$ and $H=\int rd\theta$, where $m$ denotes meridional length, $r$ denotes radial length, and $\theta$ denotes circumferential angle. The mean line of the blade is generated in the *G-H* plane with the inlet and discharge blade angle specified and the hub and shroud contours defined. The coordinates of the pressure and suction sides of the vane are computed from the mean line and a specified elliptical or other distribution of thickness along the mean line from the hub to the shroud.

The foregoing computation of the shape of the vane is performed by one of several subprograms that are executed sequentially in an iterative design-and-analysis procedure. The vane-shape-generating subprogram generates input data for use in computing distributions of pressure and velocity in a subprogram that analyzes the design. If the resulting blade loading and performance, as computed by the design-analyzing subprogram, are acceptable, the design is structurally analyzed. A design that satisfies both performance and structural requirements is passed to a final subprogram that generates a practical vane design for fabrication.

*This article was taken from the July 1996 issue of NASA Tech Briefs. The work was done by Kevin J. Lunde and Wei-Chung Chen of Rockwell International Corp. for Marshall Space Flight Center.*

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## *COLD BOX*

*Continued from page 2*

top of the second column (132 feet tall) at a rate of 900 gpm. The cost of the plant and power vary between locations, however, for this analysis, $ 0.05 per kw-h and .24 kw of power to produce one (1) pound of $LN_2$ are assumed.

ACD's new cold box process pumps will use advanced hydraulic design, machining, and materials of construction to achieve higher pump efficiencies by incorporating many of the advanced features now used in ACD's compressor and turboexpanders. The cartridge assembly design will make replacement easier and safer than that used currently. The new pumps will be more efficient and cost less to operate.

*For more information, contact Greg Fox at ACD, Inc.*

# Manager hired for sales and service center

Ed Huckstein was recently hired by Pittsburgh Cryogenic Services, Inc. as that company's Sales Manager. He will be responsible for increasing market penetration and awareness of Pittsburgh Cryogenic Services' sales and service capabilities to industrial gas welding distributors and major industrial gas suppliers.

Prior to his recent hire, he was a sales representative for BOC Gases. In this capacity, his efforts focused on the company's retail sales, bulk gas sales, on-site plant sales, and PSA plant sales. Large volume gain and significant increases in customer base were recognized while he was in this position.

Huckstein also worked for the Pulva Corporation in the chemical process industry in the industrial development of cryogenic grinding and testing. He earned a bachelor's degree in Business Administration from Grove City College, Grove City, PA, USA and a Master of Business Administration from Duquesne University, Pittsburgh, PA, USA.

Huckstein's office is located in the Pittsburgh Cryogenic Services headquarters; he can be e-mailed at edhuck@pulsenet.com.

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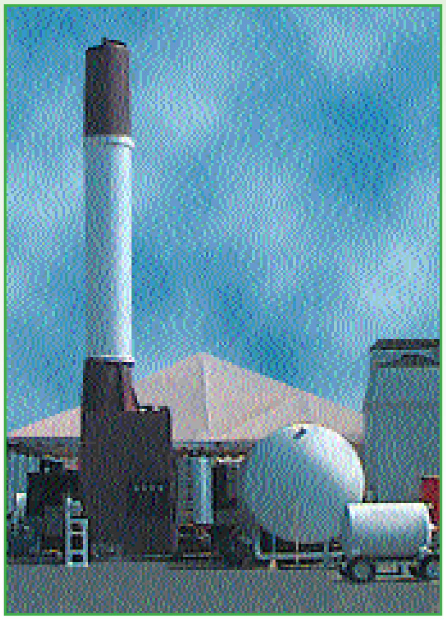
# Cosmodyne adds a new family of air separation plants to its portfolio

A new series of air separation plants is under development by Cosmodyne–the MAPLE Series. The MAPLE is a modular plant line with a capacity range of 8-16 tons per day of liquid nitrogen or liquid oxygen. The plant series is specifically designed for use in the more remote areas of the world where reliability, ease of maintenance, and portability are paramount.

Performance flexibility is fundamental to the design of this new plant series. The MAPLE can be configured to provide various production rate and purity requirements, within the the overall performance envelope. Both cost and delivery are comparable to that of standardized packaged plants because of the static fundamental design concept, which minimizes front end engineering and manufacturing lead time.

A typical MAPLE consists of four basic modules–the cold box, air purification module, feed air compressor, and an interconnecting piping and wiring kit. Both automatic and manual control systems are available. The modules are sized for shipment in standard ISO containers to minimize cost. This also eliminates the need for specialized transport and handling equipment in-country.



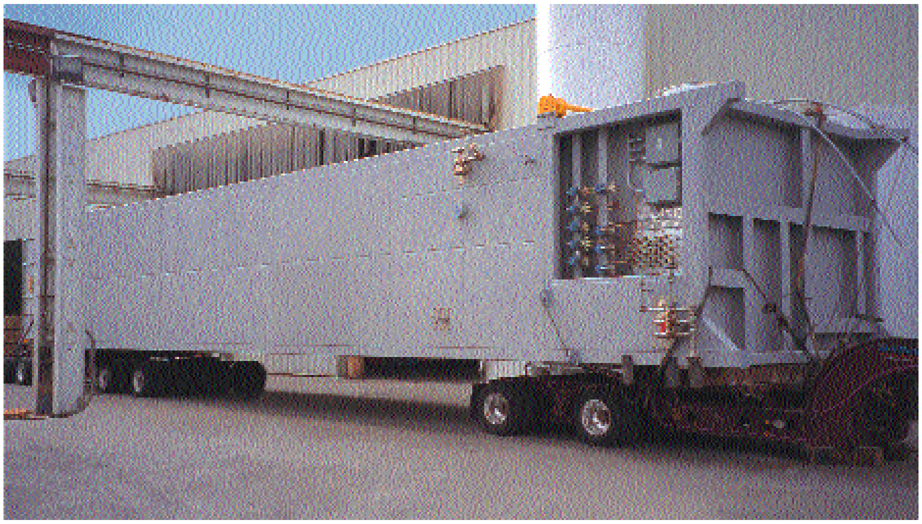
*Each MAPLE plant is fully assembled and tested at Cosmodyne headquarters.*

Following completion of manufacturing, each plant is fully assembled at Cosmodyne's headquarters where it undergoes thorough mechanical and electrical testing and complete performance specification evaluation. Customer training runs concurrent with this testing, allowing actual operating conditions to be used for education. This puts most of the pre-commissioning work at Cosmodyne's headquarters where it can be done most efficiently and cost-effectively. This also reduces on-site assembly and commissioning time to 10-15 days, depending on specific configuration. Overall installed cost and total time from order point to completion of on-site commissioning is substantially reduced.

*For more information, contact George Pappagelis at Cosmodyne, Inc.*

# Cryoquip fabricates a cold box for BOC Gases

A 160 ton/day oxygen gas generator cold box was fabricated by Cryoquip for BOC Gases.The cold box will be used in a gas plant for a steel mill in Texas USA. The cold box, jointly engineered by Cryoquip and BOC was fabricated in one piece, weighs 66 tons, and measures 66 feet long, 14 feet deep, and 10 feet wide. The box contains pre-manufactured plate fin heat exchangers and large valve array and distillation columns. After on-site installation, the cold box will be mounted vertically and insulated with perlite powder prior to start-up. Cryoquip is one of only a handful of skilled fabrication companies capable of the partial engineering and fabrication of such complex cryogenic assemblies.



## CryoAtlanta, Inc.

### A new service center increases global coverage

CryoAtlanta, Inc. has been added to the Cryogenic Industries group of companies in response to increasing cryogenic pump activity in the Southeastern USA. The company, located just one mile south of the Atlanta airport, is focusing its efforts on cryogenic centrifugal and reciprocating pump repair, service, and sales.

Customer service is the first priority for the company, according to General Manager Tom Farmer. To this end, a series of programs designed to aid cryogenic pump users is being created, including on-site support, an exchange program to facilitate pump repair, an extensive spare parts inventory for shipping efficiency, and pump training classes to educate users on installation and repair.

CryoAtlanta serves these states in the USA: Georgia, Virginia, S. Carolina, N. Carolina, Florida, Alabama, Tennessee, Mississippi, Arkansas, Louisiana, Oklahoma, and Texas.

Tom Farmer was hired as General Manager of CryoAtlanta because of his extensive experience as a service manager and broad technical knowledge. Prior to joining CryoAtlanta, he worked as a Service Manager for Siemens Industrial Automation directing the North American service center, field service, customer training, and parts inventory for gas analyzers.

Prior to that position he was Senior Instrument Technician for Air Products and Chemicals, Inc., Field Service Engineer for Xerox, Corp., and Flight Test Electronics Technician for Lockheed Georgia Co. Farmer was a Petty Officer 2nd Class in the US Navy, graduating from Navy "A" School in basic electronics. He also received an Electronics Technology degree from Marietta Area Technical School, GA, USA.

CryoAtlanta, Inc. is a member of Cryogenic Industries, an authorized ACD, Inc. sales and service center, and affiliated with Pittsburgh Cryogenic Services, Inc.

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# VAPORIZER

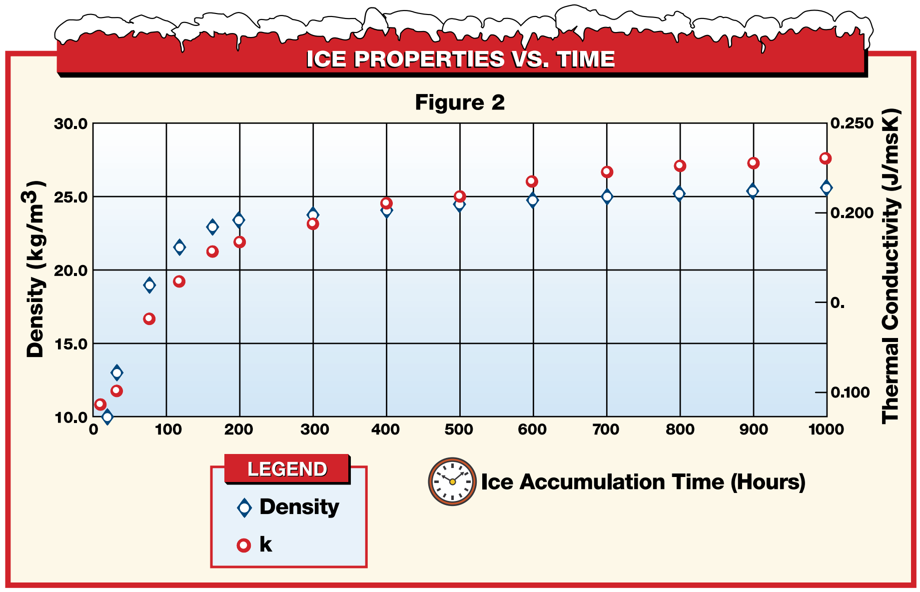
*Continued from page 1*

also a lot higher, leading to fast defrost and ice shedding. Also, ice build-up is not necessarily a negative. As the ice density increases with time so does the thermal conductivity, providing an adequate mechanism for heat transfer to supply the necessary energy for vaporization. (See Figure 2.) Providing the ice accumulation does not bridge the fin elements, the vaporizer will continue to function adequately.

There are many locations around the world where ambient vaporizers will operate continuously without any requirement for defrosting, eliminating the need for switching and for stand-by units. Where switching from one unit to another *is* required, there are a few things to consider. Switching can be done manually or automatically, rapidly (less than eight hours) or more slowly. Considering that the optimum time for efficient performance is approximately eight hours, manual switching is satisfactory. (Here, eight hours loosely equates to a working shift duration, after which the units can be switched and the stand-by unit brought on-line for the second working shift and so on.) Manual switching requires no power; uses simple cryogenic globe valves, is simple to install, requires little maintenance and is reliable.

Automatic switching, however, *does* require power (which to a certain extent defeats one of the primary advantages of the ambient vaporizer), and skilled installation. The more frequently the switching system operates, the higher the maintenance, the less reliable the switching becomes leading to the likelihood of interruption of the gas flow. In the case of a back-up system, which typically comes on-line during power failure, automatic switching would be inappropriate.

There seems little advantage to rapid switching (re: switching intervals of less than eight hours), and several drawbacks. First, rapid switching necessitates an automatic system. The initial vaporizer hardware may be slightly less expensive, but the total capital outlay is not; and there is no tolerance for error, for variable ambient conditions, or accommodation of future increased gas flow rate requirements. In cases where there is no risk in relying on the ambient conditions to provide quick defrosting to facilitate rapid

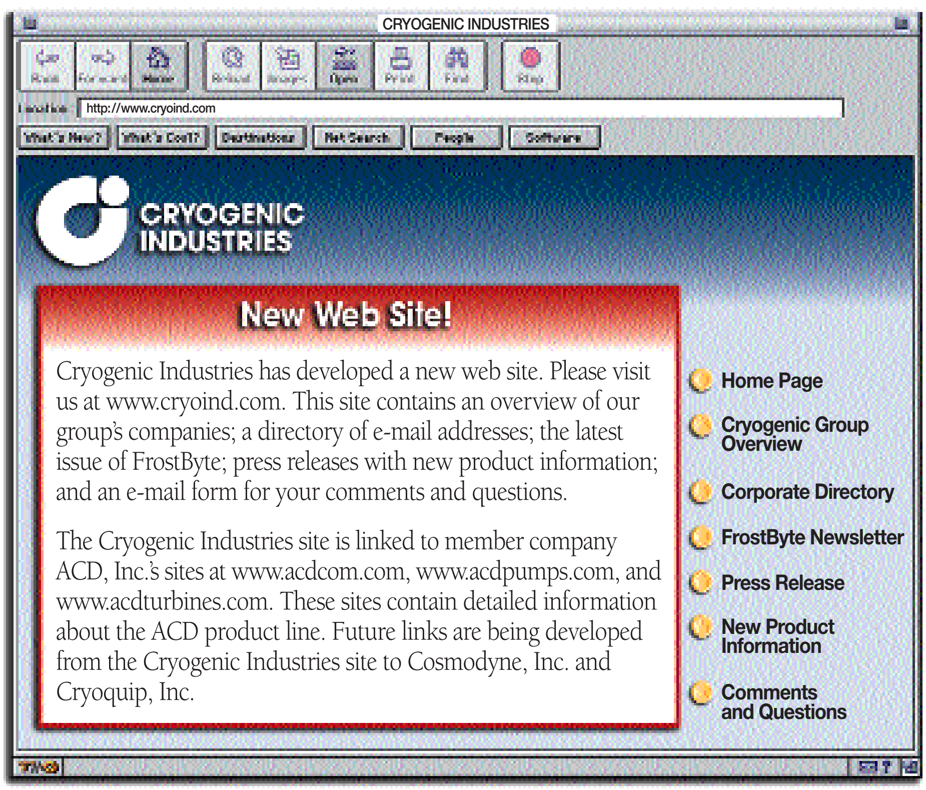



switching, a single, high efficiency heat transfer unit meets the process requirements with no risk and required maintenance, while giving maximum reliability.

For certain high volume flow rates required on a continuous basis, switching between units is unavoidable. Rapid switching though, especially in these cases, is not desirable. Long term manual switching offers the most reliable, flexible extension of the concept of the low cost, reliable and simple ambient air vaporizer. For convenience, automatic switching may be considered, but switching times should be between four and eight hours to ensure maximum system efficiency and avoid high maintenance costs, unreliability, inflexibility and system failure.

*For more information contact Bryan Smith at Cryoquip, Inc.*

*US patent #5251452



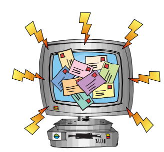
# Calendar of Events

| | |
|---|---|
| JAN 22-24 | SEMICON–KOREA '97, Seoul, Korea<br>Contact: Semicon USA +1 415-964-5111 |
| JAN 24-25 | 19th NATIONAL SEMINAR ON INDUSTRIAL GASES,<br>All India Industrial Gases Mfg's Association,<br>Hyderabad, India +91 40 3321422 |
| JAN 28-30 | 11th INTERSOCIETY CRYOGENIC SYMPOSIUM<br>Houston, TX, USA +1 713-621-8833 |
| FEB 24-26 | COMPRESSED GAS ASSOCIATION ANNUAL MEETING<br>Phoenix, AZ, USA +1 703-412-0900 |
| MAR (TBA) | NATIONAL $H_2$ ASSOCIATION ANNUAL MEETING<br>USA (City, TBA) +1 202-223-5547 |
| MAY 18-21 | AMERICAN GAS ASSOCIATION OPERATIONS<br>CONFERENCE & EXHIBIT<br>Nashville, TN, USA +1 410-997-0763 |
| JUL 28-AUG 1 | CRYOGENIC ENGINEERING CONFERENCE/INTERNATIONAL<br>CRYOGENIC MATERIALS CONFERENCE (CEC/ICMC)<br>Portland, OR, USA +1 503-292-2114 |
| OCT 28-31 | OIL & GASTECH '97<br>International Trade Fair Equipment for the Oil & Gas Industry,<br>Kiev, Ukraine +49 211 4560 739 |

## Quote

"The young do not know enough to be prudent, and therefore they attempt the impossible–and achieve it, generation after generation."
—Pearl S. Buck


## Member company utilizes electronic mail



Pittsburgh Cryogenic Services can now be reached via electronic mail. Use the following addresses to direct your message:

**pittcryo@pulsenet.com**

*Individual listings are as follows:*

**carl@pulsenet.com** (Carl Henningson)

**mousie@pulsenet.com** (Shawn Danna)

**edhuck@pulsenet.com** (Ed Huckstein)

**dianne@pulsenet.com** (Dianne Dorsek)

**donman@pulsenet.com** (Donald Manfredi)

*Note: There are no spaces between letters and symbols and the entire address is in lower case.*


**CRYOGENIC INDUSTRIES**
25720 Jefferson Avenue
Murrieta, CA 92562-9524 USA


BULK RATE
US POSTAGE
**PAID**
SANTA ANA, CA
PERMIT NO. 949

ADDRESS CORRECTION REQUESTED

Route to:

________________________

________________________

________________________

________________________

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