

The Tube & Pipe Journal[®]

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January/February 2017

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Official Publication of
The Tube & Pipe Association, Intl.[®]
www.tubepipejournal.net
www.tpatube.org

Automated cutting machine turns notion of conventional work flow on its head

By Eric Lundin

In the business world, buzzwords come and buzzwords go, and most of them are about as forgettable as the latest slang used by the current crop of teenagers. A favorite from the 1990s, one that wasn't just overused but consistently misused, was *paradigm shift*. At that time, any small change in a procedure or a process was labeled as a paradigm shift, but a paradigm is a model, and changing an entire model is always a monumental undertaking. A new model usually is difficult to understand and normally faces substantial resistance. When a new model is finally accepted, it lays waste to whatever came before it. Changing automobile production from build-in-place to the assembly line was a paradigm shift.

Boston-based J.C. Cannistraro LLC tore up an old paradigm and replaced it with a modern one when the company realized that its sales force was in danger of outpacing its ability to deliver. A mechanical contractor that works hand-in-glove with developers and construction companies to provide plumbing, fire protection, heating, ventilation, air conditioning, and sheet metal systems, and service for those systems, Cannistraro does a lot of manual work with hand tools. This was fine when the company was small, but it's not small anymore. On a typical day it has 800 employees on the job, roughly 200 at Cannistraro corporate office and 600 in the field, working in essentially every sort of building: commercial, institutional, healthcare, mission-critical, and multifamily high-rise residential.

When a company has 800 employees doing all manner of manual tasks, it has a strong interest in efficiency gains. Shaving just a bit of time from just one often-repeated task can add up quickly, contributing to the company's profitability and, more importantly, the company's ability to adhere to its many construction schedules.

Operations Manager of Cannistraro's Plumbing Group Joe Mierzejewski



Mechanical contractor's plumbing team adopts one-piece flow system

looked for new tools and processes that would shave time from two of the more routine and monotonous tasks—cutting pipe and adding branch connections—and cracked a paradigm wide open.

Boomtown

Urban renewal. Downtown redevelopment. Gentrification. It goes by many names, but it's all about the same. Leafy, bucolic suburbs once drew people away from gritty, decaying downtowns. Rediscovered and revitalized, city centers have bounced back and now are attracting residents who yearn for a vibrant, dynamic urban lifestyle.

In the case of Boston, the city center has been making a comeback for some time. The demand for housing is substantial, and the city has been going full-tilt to keep up. In 2014 the city unveiled its development plan, titled Boston 2030, which details its strategy to complete 53,000 new housing units by 2030. This isn't a new trend.

"About 20,000 new housing units have been built over the last six or seven years," Mierzejewski said. Current apartment lease rates and condominium prices illustrate how, despite the construction boom, supply hasn't kept up with demand. Prices have climbed toward the stratosphere. In the Seaport district, an upscale studio apartment that measures a whopping 600 square feet leases for \$4,500 per month. The budget-conscious can find one for \$2,900 per month.

Buying a place is much worse.

"Condos can sell for upwards of \$1,000 per square foot," Mierzejewski said.

This is part of a cycle. Downtowns were once crowded with employers and residents. As manufacturers realized that they'd be much more efficient working on a single level, they scrambled for

the relatively cheap land in the suburbs and workers followed, their mobility assisted by the automobile. Many cities succumbed to urban blight, but the pendulum has been swinging the other direction for some time now. Businesses are coming back—well, many never left—and more people are looking for housing downtown.

While Boston has been booming, Cannistraro has been growing and seeking ways to work more efficiently.

"Boston is seeing a construction revival unlike any other in its long history," Mierzejewski said. Every company has to deal with a finite supply of workers, space, and time, but Cannistraro's fast growth meant that it faced these constraints in extremes. The company's executive team sensed that this was an opportunity to do things differently. The company staff knew it couldn't continue to expand in the traditional way, by buying more equipment and hiring more workers. Even if more skilled workers had been available, the company would soon run out of space.

Although the company isn't a manufacturer, its staff was familiar with concepts such as lean manufacturing and continuous improvement, and is always vigilant for opportunities to do things in a better way.

Is This a Pipe Shop?

Cannistraro's new model for running its plumbing operation wasn't a single, momentous flash of insight. It was an incremental undertaking, a process that changed little by little over several years. It entails the difference between working in the shop and working at the job site. The differences are great.

On one hand, the shop is a closely controlled environment. The tools and machines at hand, the shop layout, the inventory storage locations—

nearly everything is consistent and predictable from one day to the next. Moving material from place to place goes smoothly, and the work gets done in a scheduled and orderly fashion. On the other hand, the field entails risks, many of which are beyond the company's control. Loading the material onto trucks, transporting it to the job site, unloading it into carts, and wheeling the carts to the work area are activities that come with risk of damage or loss. Furthermore, working at the job site is inherently less efficient than working in the shop. Tools, supplies, and workers often are spread too far apart or crammed into too small an area; an inventory cart might get delivered to the wrong floor; a job might go faster or slower than expected; and any one of 100 other things might hold up a job. As projects grow in complexity, disorder can creep in.

If Cannistraro employees could do more work in the low-risk, efficient shop environment, preparing assemblies rather than components, they would do less work in the high-risk, not-so-efficient job site environment. Also, loading, transporting, unloading, and installing an assembly of four pieces, for example, is safer and much more streamlined than working with four separate items.

Mierzejewski envisioned a change in tasks. Workers at the site would do relatively less component fabrication and do relatively more prefabricated assembly installation.

To plumb a bathroom in an addition on a house, the plumber doesn't need to do much in the way of prep work. The plumber shows up with tools and supplies, has a five-minute chat with the homeowner, and gets to work. In a mechanical contracting shop the size of Cannistraro, the planning phase



Figure 1

An operator loads a 4-in. OD length of copper pipe into the cutting machine's automatic feed table (top) and sets the cutting head for a change in tube diameter (bottom). After these two preparation steps, the subsequent steps in Cannistraro's updated cutting and branching process are automated.

for installing a plumbing system in a condominium can take the better part of a year. In doing so, the company relies heavily on building information modeling (BIM) software.

"We model everything in 3-D," Mierzejewski said. "We know every dimension of every length of pipe that is going to go into that building before the first shovel hits the dirt." The company has 50 employees working

full-time on modeling for fabrication; of those, 15 are dedicated to plumbing.

"On an average residential floor, we install around 3,000 lengths of small-bore piping," Mierzejewski said. To prepare the pipes for installation, a machine operator has two folders: one stuffed with part drawings and another full of labels. He takes out one drawing and two labels—two identical labels, one for each pipe end—measures the

pipe length with a tape measure, cuts the pipe by hand, and applies the labels. After the operator fills a cart, it goes to another station where another worker uses a machine to drill holes and pull tees, making branches so the pipes are ready to be connected to other pipes.

These are labor-intensive and repetitious tasks.

For many years the company increased the amount of work it did in the shop, doing more to make assemblies that either were ready, or close to ready, for installation in the field. The problem was speed. Even in the shop, the combination of cutting and collaring was a slow, cumbersome process. During an extensive equipment search, Mierzejewski discovered that [T-Drill](#), which made the branching machines, also made cutting machines.

This is a Manufacturing Shop

Cannistraro had their eyes on a high-speed, chipless cutting machine (see [Figure 1](#)). They envisioned a process by which pipe would feed from a preloaded rack into the machine; the machine would cut the pipe to length with minimal operator input, relying almost entirely on CSV files. The cutting system would print labels with QR codes and additional data, derived from the same CSV files, and apply the labels to the pipe before they exited the machine (see [Figure 2](#)). A diverter table would convey the cut tubes to their programmed bin locations. The operator then would scan the cut tube's QR code with a hand scanner at the branching machine. The machine would access the branching program for that part and make branches in the appropriate locations.

The only drawback: T-Drill didn't offer anything quite like that. At the time that Mierzejewski called to discuss his idea, T-Drill had done some work in building [custom machines](#) for large manufacturing firms and had experience in developing systems for material handling, workcells, and



Figure 2

The TCC-50 rack loader is a standard T-Drill machine (left). The machine builder also provided a custom-made printing cell that generates and applies labels to every part the cell cuts (right). Short parts receive one label near the center of the part. Long parts receive two labels, one at each end.



Figure 3

The PC-based operator interface provides a graphical representation of the programmed cut lengths. The machine is equipped with an Ethernet connection for two-way communication with the company's network.

transfer systems, but the company had never been approached by a mechanical contractor about anything like this.

The initial inquiry was met with some skepticism. The folks at T-Drill

didn't understand why a mechanical contractor's pipe shop—granted, it's a big pipe shop, but it's a pipe shop nonetheless—had any interest in a machine designed for a manufacturer,

and it sure didn't have much interest in building a system of this sort. The software alone was unfamiliar territory. A standard T-Drill machine is designed to process up to four cut lengths thousands of times; a typical part run for Cannistraro is the opposite, entailing thousands of unique parts. Only a few out of 1,000 are duplicates.

Eventually the T-Drill staff agreed to discuss customizing the [TCC-50 RL](#), a chipless cutting system that handles outside diameters from ¼ to 2 in. in materials such as aluminum, copper, steel, and stainless steel. The suffix refers to a rack loader, meaning that the machine was designed to cut pipe from straight lengths, but it did have the ability to feed pipe from coils. The company's [S-54](#) tube branching system, equipped with an automatic feed table, was a likely candidate for the tee forming application.

The idea of combining these machines to make a workcell had two main drawbacks. First, the S-54 is not equipped for automatic programming. Setting the radial and linear position of each branch is a manual process done through the operator interface. Second, the TCC-50 didn't have any capabilities as far as receiving data inputs or labeling pipe, much less printing labels on the spot (see [Figure 3](#)). To achieve this with practically no operator input, T-Drill would have to start with a blank sheet of paper because, well, that's all it had.

And, there was one more thing. For any pipes over 10 ft. long, Cannistraro wanted two labels, one at each end. On any pipe less than 10 ft. long, the contractor wanted a single label in the center.

Actually, there were quite a few more things. Over the next 15 months or so, Mierzejewski and his team contacted T-Drill frequently to discuss new ideas to improve the concept.

Press START

Working up an entire system and the software to support it was a long, arduous challenge, and the engineering staff encountered some difficulties here

and there, right up to the end when the initial runoff didn't go as planned. Still, the staff came through with a fully functional workcell that delivers. In a typical eight-week period, the workcell processes 45,000 linear feet of pipe to make 16,000 components. Compared to the previous method, it's about six times as fast. A worker made one item every two minutes; the machine makes three items per minute. It also sorts the parts into the appropriate bins.

The machine performs intricate processes at a dazzling speed, but that's not the end of the story. Gone are the folders stuffed with drawings and labels. Gone is the batch processing. Gone is the dreaded prospect of a highly skilled plumber spending hours on a mundane task.

Parts for plumbing assemblies flow through the shop now. Shortly after pipe data starts flowing from the CAD system to the cutting-and-

collaring machine's controller, parts start flowing from the modified S-54. Other changes have worked their way through Cannistraro, too.

"According to many recent building contracts, the amount of material in wheeled carts on the job site cannot exceed three days of inventory," Mierzejewski said. Using a flow system rather than a batch system is a big benefit in this regard. It helps Cannistraro manage the inventory it keeps at its pipe shop, which aids in managing the inventories at the job sites, which assists in contract compliance.

The timing couldn't be better. The company has plans to move to a new 157,000-sq.-ft. multitrade facility on the Boston waterfront in 2017. New ideas that streamline processes and make better use of resources are necessary now more than ever.

This innovation also helped the company win an industry award, the

Plumbing-Heating-Cooling Contractors Association® Delta Plumbing Contractor of the Year for 2016. Furthermore, it brought about a fundamental change in the way the pipe shop views itself and its processes.

"This shop used to think like a mechanical contractor, then it thought like a fabricator, and now it thinks like a manufacturer," Mierzejewski said.

That's a paradigm shift. 

Eric Lundin can be reached at ericl@thefabricator.com.

J.C. Cannistraro LLC, 80 Rosedale Road, Watertown, MA 02471, 617-926-0092, www.cannistraro.com

T-Drill Industries Inc., 1740 Corporate Drive, Norcross, GA 30093, 770-925-0520, sales@t-drill.com, www.t-drill.com

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