

Tracking a Unicorn

The frictionless counter-weight rigging system exists after all—for those willing to invest in and properly maintain a high-quality system, even one that's nearly three decades old

BY RICK BOYCHUK

Custom gallery brace (in red oxide primer) to allow an arbor to pass through. | Photo courtesy Rick Boychuk.

Whether renovating an old counterweight rigging system or planning to install a new one, consider the total cost of ownership over the price of the initial investment. A major factor in the total cost of ownership is how long it will last before needing maintenance or replacement. Thus, a focus on where the investment will do the most good and provide the most longevity can result in substantial savings over the long-term. Most importantly, this investment should be guided by a strong collaboration between consultant, owner, architect, manufacturer, installer, general contractor, and the users.

Although I have, for some time, suggested that a counterweight line set should operate with very little friction, I did not really expect it to be a reality. But I found the unicorn in January 2020 at the Imperial Theatre in St. John, New Brunswick, Canada. Shawn Lord, the technical director of The Imperial Theatre, engaged me to inspect the counterweight rigging system. He expected that their 27-year-old system, for which he had no record of inspections, would be “nearing the end of its usable life.” The inspection was the first step in planning for the system’s replacement. Instead, I realized I was inspecting one of the best counterweight rigging systems I have ever encountered. What was so special about this 27-year-old system?

First, the force needed to initiate movement of the line set was minimal. Second, the force needed to keep the line set running for the entire length of its travel was minimal. Third, when starting at either end of travel, the force required decreased until mid travel, after which

the line set wanted to run by itself.

It was like there was no friction in the line set for its entire length of travel. How can it be? If one must exert force to keep a line set running, then the system is encountering friction, a force that resists relative motion between two materials. What causes the friction in the system? Why is there so little in this one? Let’s explore.

There are a number of potential causes of friction in a counterweight line set: the block set, the arbor shoes, rope groove sizing, pitch diameter at the head block, and the rope lock. Other factors include surface roughness, adhesion, or imperfections in the system components. The arbor shoes could be rubbing on the guides. This could be the result of the guide wall out of plumb and being not true. It could also be a result of a misalignment of the head block with the guide wall.

Or, the block set can inflict friction into the lineset for any of a number of reasons. The fleet angles of the lift lines as they

From the author:

As I travel and visit theatres looking at their counterweight systems, I often ask the technical director if I can run one or two line sets, always empty ones. I run them from one end of travel to the other and back. When I first started asking to do this, I felt kind of awkward because I didn’t really know what I was looking for. Eventually, however, I began to notice differences among the systems. At first, I made mental notes about how the line sets operated, the level of friction or resistance, and how easy or difficult it was to move them. Eventually, I developed a detailed checklist with key benchmarks.

To date, I have run many line sets in many theatres. They were built by multiple manufacturers and installed by many vendors. The ages of the line sets have varied from brand new to one dating back 116 years. I’ve operated systems made by Wenger/JR Clancy, Thern, Knoxville Scenic, SECOA, Peter Albrecht, Sosman and Landis, Channon, United Stage Equipment, and many more. They have been American, Canadian, German, Italian, British, Spanish, French, and homemade. They all operated differently. Some were better than others. Eventually, I realized that I was on a quest to find the perfect system. That quest ended with the Imperial Theatre in St. John, New Brunswick, Canada.

roll off the grooves of the blocks could be excessive, therefore causing friction. The sheave grooves could not have proper angles to support the wire rope. What types of sheaves are used—steel, cast, Nylatron? What kind of bearings do the blocks have—ball, tapered, roller, plain? Are the bearings properly lubricated? If there are idler pulleys, what kind of bearings do they have? And, there are other causes, to be sure. All of those factors involving blocks can impact the friction in the line set. Or, the operating rope could be too taut causing friction as it passes through the rope lock. The rope lock could be worn and not adjusted properly to compensate for the wear. Are the operating ropes and their grooves in the sheaves sized properly for each other?

The Unicorn's Home

The Imperial opened in 1913 as part of the Keith chain of vaudeville/movie palaces. The original rigging was a hemp system. The Imperial, like many theatres of its vintage, spent most of the 20th century as a cinema. In the late 1980s, however, the community decided that it needed a performing arts center. The Imperial was the place that answered those needs. So in 1993, the front of house was renovated and the original stage house was replaced with a full fly tower equipped with 50 counterweight line sets.

Getting a superior system involves the consultant, the owner, the architect, the manufacturer, the installer, the general contractor and last, but not least, the user. Bob Brannigan of Robert Brannigan and Associates was rigging consultant. J.R. Clancy of Syracuse, New York, manufactured the rigging equipment. And, GC Stage of Montreal, Quebec, installed the rigging. These were three of the key partners whose skillful efforts brought the unicorn into existence.

On the day of my inspection, the core of Imperial Theatre's system was in perfect working order. By my estimation, the core of the system, which is the most costly element to replace, will remain serviceable for the foreseeable future with proper maintenance and inspection. After 27 years, most system cores have begun to fail, so questions to consider include: What is different about this one? And why does it operate so smoothly? What does it take to put in place a superior counterweight rigging system? Does

it cost more? If so, is it worth any extra cost? The Imperial Theatre system is a lesson for us all.

The Unicorn's Design Team

A major ingredient to getting a unicorn, is having a good rigging consultant, though not every theatre chooses to hire a rigging consultant at all. The manufacturers of rigging equipment are quite willing and capable of providing the information required and to specify their equipment. In fact, this is how much of the industry operated from the 1920s until the mid-1980s when theatre consultants became more common. Manufacturers still provide specifications today. And, to be sure, it is better to have a manufacturer specify a system than an architect who may not be well versed in counterweight rigging systems and may lack the industry-wide equipment familiarity of a consultant.

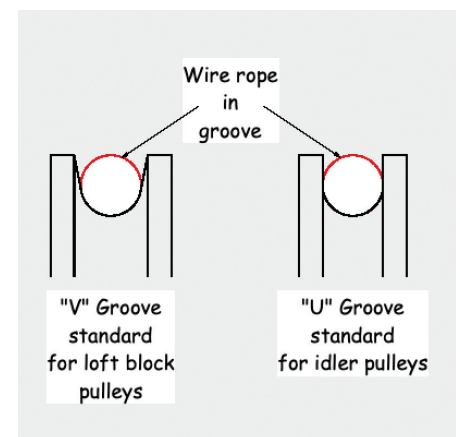
Robert Brannigan Associates was a busy theatre consultancy in the last portion of the 20th century. The system that exists today is evidence that he was very particular about this project. A number of small details speak to the longevity of this installation.

One detail in particular is the structural bracing installed for the fly galleries. A fly gallery is supported at one end by the proscenium wall and at the other end by the upstage wall. If the gallery is long enough, it may also be suspended from the roof steel. What results is a long gallery that tends to flex toward and/or away from the side wall. To prevent the flexing, the gallery is braced to the wall in a small number of places. Generally, each brace interferes with one line set, thus eliminating that line set. In this installation, there are three braces, which would have resulted in the loss of three line sets. But Brannigan had a special brace designed that allowed the arbor of the line set to pass through it, thereby allowing for three extra line sets.

The bracing, however, is a side issue. The relevant detail that reduces friction is the loft block set Brannigan selected. When counterweight systems were first used in North America, the practice was to mount the loft blocks on top of a walking grid. By the time the Imperial was rebuilt, the industry had moved away from grid-mounted loft blocks and had adopted blocks that are underhung from the overhead loft beams.

The easiest and least-expensive way to make this transition is to take a grid-mounted block and invert it to hang under the loft beams. However, the longer lift lines sag severely, so idler pulleys are added to prevent the sagging. The problem is that idler pulleys add friction to the line set. The extra fleeting of the lines required to maneuver them back and forth among the unaligned grooves of the load sheave and the idler pulleys adds friction. The fleeting between idler pulleys and the main sheave of the next block will be approximately 0.5°. The friction of this fleet angle is compounded by the fact that the grooves on the idlers are more "U" shaped, than "V" shaped. Often, individual idlers are used, which compounds the friction. Sometimes multi-groove idlers are used. Sometimes the idler bearings are a simple hole inserted onto a bolt. Sometimes idlers have ball bearings. Depending on these details, the idler pulleys will impart more or less friction. In all cases, the idlers impart friction. Over time, idler pulleys, which are one more thing that can go wrong, can rotate less easily to the point of freezing up completely.

However, Brannigan did not specify loft blocks with idlers. He specified multi-groove loft blocks. A multi-groove block set has a first block with a sheave with five grooves, the next block has one with four grooves, then one with three, and then two, and then one groove as you move away from the arbor (in a five lift set, for example). A benefit of a multi-groove block set is that the fleeting of the lift lines between one loft block and the



A simple drawing to show the difference between a V groove and a U groove on a sheave. See how the wire rope is in greater contact with the sides of the groove in the U groove. | Image courtesy of Rick Boychuk.

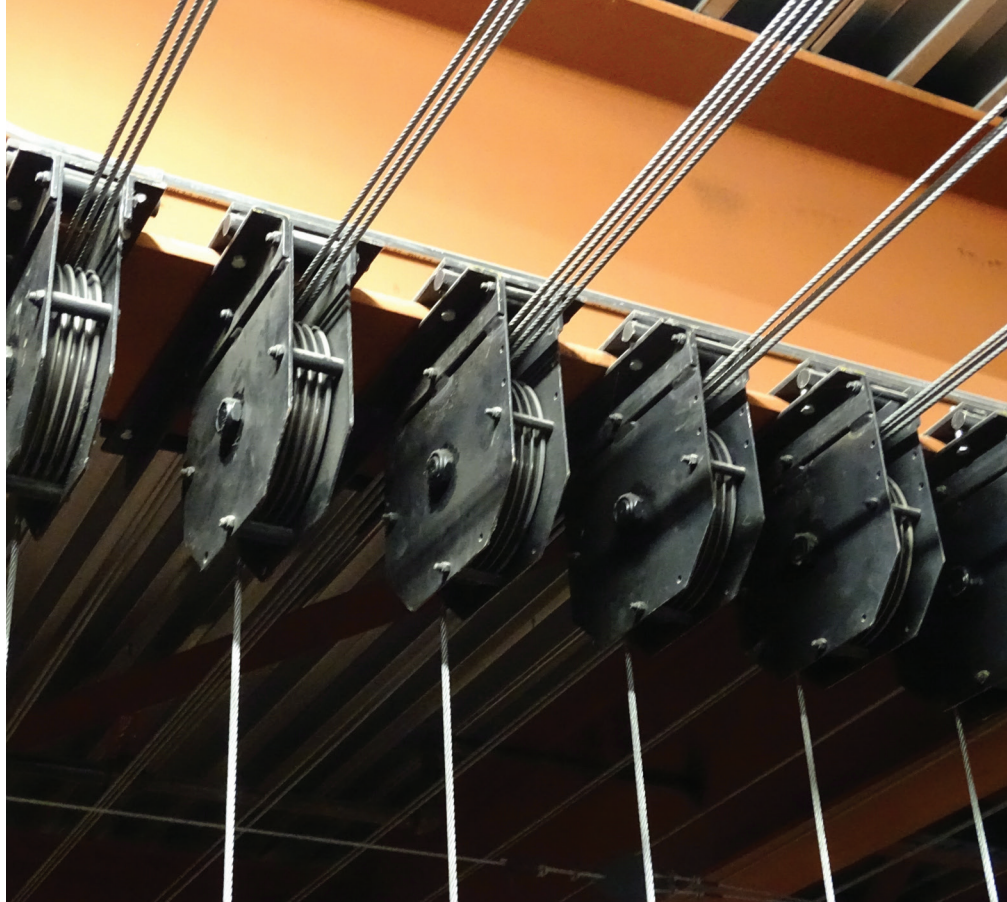
next is minimized. Depending on the specific approach to stringing the lines, the maximum fleet angle will be about 0.2°. Furthermore, a multi-groove sheave on a loft block has “V” grooves, which, at that small fleet angle, eliminates the friction of the wire rope against the sides of the groove. Another benefit is that the dropping line rotates the sheave and the passing lines simply ride in the groove of a sheave that is already turning. However, multi-groove block sets are more expensive than single groove block sets with idlers, and they were not the standard offering at the time. Brannigan had to specify them and had to ensure that they were bid and delivered.

Brannigan made some excellent decisions about what the system should be. And he followed through by seeing that it happened that way. I was told that he continued to come to the site even after the funds to pay for the expenses were depleted, showing his commitment to getting the project right.

At the time of the renovation, the board of directors was focused on the budget, had the responsibility for discerning between essential and non-essential spending, and did this well. The renovation of the Imperial had a false start because the first architect did not fit the project, envisioning a world-class facility with a budget that reflected this design. The owner was astute enough to recognize that a lot of that money was going into a showplace for the architect, but that the community did not need a showplace; the community needed a regional performing arts center. So that architect was released, and a local architectural firm was engaged. The first architect had brought in Bob Brannigan as the theatre consultant, who, having impressed the board, was asked to stay on.

Doug Kochell of MMC Architects of St. John was the lead architect for the project. MCC is no longer in business, but Kochell recently discussed the positive working relationship among the owner, architect, and consultant. Together they strove to create the best possible outcome for a city the size of St. John. Kochell said, in no uncertain terms, that they “trusted Bob (Brannigan).”

In the world of architects and consultants, legally, the consultants work for the architect unless they are hired by the owner directly. The architect pays the consultant’s fee. However, if the



The loft lines (with head block to the right and up) drop one line and pass the rest to the next loft block. | Photo courtesy Rick Boychuk.

consultant’s fee must come out of the architect’s fee, an architect may scrimp on the consultant. Sometimes an architect will not even engage a consultant, but instead will reach out to the manufacturer for specification guidance. Although not the worse situation, it is better to have the consultant, as an “interested third party,” to make decisions about a rigging system. But to do so, the architect must be able to carry the consultant fees over and above the architectural fees, as was done in the Imperial project.

The Unicorn’s Manufacturer and Installer

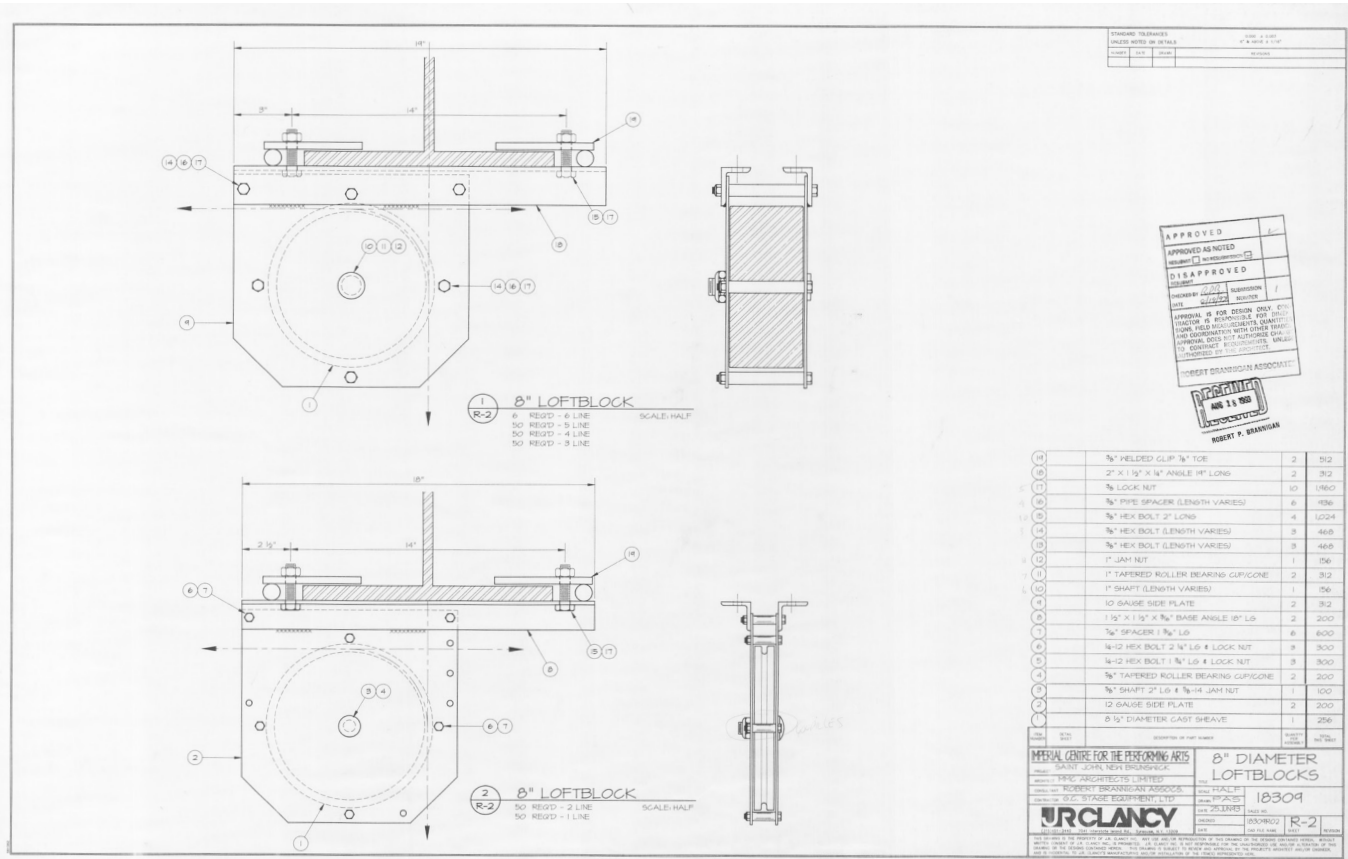
At the time of the Imperial project, J.R. Clancy had been in business for 112 years. At the time of this project, Clancy built single groove blocks with idlers as well as multi-groove block sets. Market forces are always at work and, unfortunately, when the market lowers prices, quality often suffers. The competitive markets demand a low price, resulting in many installations opting for idlers. The discerning markets demand higher quality, multi-groove headblocks.

The block sets for this installation were specified and delivered with tapered

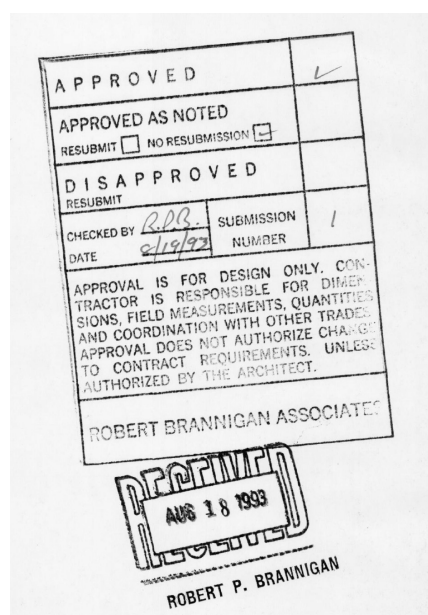
roller bearings. This is where the quality of the manufacturer and its quality control comes in. A tapered roller bearing requires a certain amount of attention when being assembled. The bearing must be lubricated with grease. There can’t be too much grease, nor can there be too little. It must be properly tightened and must be neither too tight nor too loose. The lubrication and tightening of the bearings happens in the factory during assembly. For the Imperial system to be operating as it does, with such little friction, the blocks will have been properly lubricated and tightened.

All of this is lost if the installer doesn’t pay attention to the installation. GC Stage, which was founded by Gary Tuzo in 1985, took extra care with this installation. Today, the company is run by his sons, Courtenay and Justin.

What are the indications of the extra care taken by GC Stage? A minor, but interesting detail, is that all of the nuts and bolts used for the Imperial were grade 5, even those holding together the guide wall. In 1993, common practice was to use grade 2 hardware. Did Brannigan require grade 5 bolts? Or, was grade 5 the instigation of the installer? The legend of



Construction drawing showing the multi-groove loft blocks. | Image courtesy of Rick Boychuk.



Detail of the Brannigan and Associates approval stamp on the submittal drawings by JR Clancy along with the initials of Robert Brannigan. | Image courtesy of Rick Boychuk.

the drawing from Clancy shows that the responsibility of the hardware was left up to the installer. GC Stage could have installed grade 2 fasteners, but instead chose the higher grade fastener.

A potential friction point in a system is the sliding of the arbor shoes on the rails of the guide wall. Guide walls must be true and plumb on two axes. If the guide wall is not true and plumb, it results in the wear marks on the guide rails where the arbor shoe slides along the guide. Another possible result is guides that are bent. This installation showed neither.

I have seen, on a small number of occasions, a curious alignment of the head blocks and the guide rails. In these installations, the head block is situated a bit further off stage by about 2-3 inches. The effect is to force the arbor toward the guide rails, with increased friction, as it rises to the top of travel.

At the Imperial, the installers from GC Stage installed a true and plumb guide wall. The alignment of the grooves of the head blocks and the loft blocks at the Imperial is true, as well. You can see this in your own system. Do the loft lines, where they connect to the arbor top, form an isosceles triangle or do they form a scalene triangle? Isosceles is the right

answer. And you thought that you would never use that trigonometry from high school!

One of the most remarkable features of the line sets is how well balanced they are at mid travel. In talking with the three successive technical directors and the current head flyman, Bob McNulty, I discovered that the practice of balancing the line sets at mid travel has been in effect since the delivery of the system. Gary Tuzo, who oversaw the installation, says that he taught the first crew to balance the line sets at mid travel—a practice maintained to this day. As a batten is raised from low to high trim, the wire rope lift lines are moved from the batten-side of the line set to the arbor-side. In a 6-lift line set with 60 feet of travel, the total amount of wire rope moved from one side to the other is 40 pounds (60 feet of travel x 6 lift lines x .11 pounds per foot = 40 pounds). If line sets are balanced at mid travel, the operator has only to deal with half of the 40 pounds of imbalance at each end of travel. So, when starting the batten, either at low or high trim, it was necessary to start only 20 pounds. And when stopping it, one must stop only 20 pounds.

Gary and Justin Tuzo indicate that

they do one more thing to ensure the easiest, most friction-free operation. At the point that the blocks are installed, and before the loft lines are strung, the installer spins every sheave by hand. Gary says that in his years of experience, between 10 and 20 percent of the sheaves did not spin freely. As an installer and, now, a manufacturer of blocks, the people at GC know that 100 percent of the sheaves may turn freely on the assembly bench. But then they are loaded into a truck to travel perhaps hundreds of miles, then off-loaded from the truck, hauled up 50 to 80 feet to the grid, carried to the installation point and then installed. All that time they are being bumped and bounced. Once installed, the travails of the blocks end. And the last step of spinning the sheave allows the installer the opportunity to make any adjustment necessary to free it.

Maintaining the Unicorn

A well-designed system, with the better components from a better manufacturer, and installed by a qualified installer, will result in a system that can be the best system ever for the first day. The system then becomes the property of the user.

Dan Mooney was the first technical director at the Imperial when the system was delivered in 1993. Mooney started his ownership by receiving a training session on the balancing of line sets at mid travel. The training was provided by the installer. And the users that followed Mooney, and trained by him, have maintained balanced line sets for the entire 27 years.

Then there is ongoing maintenance. According to standard accounting practices, 10 percent of the capital cost of whatever—in this case a rigging system—should be budgeted every year for operation, maintenance, repair, and replacement. In the military, the practice is to budget 20 percent for a minimum of 10 years in advance. The reason that the military uses this higher amount is that everything that the military owns is mission critical. I think we can agree that theatre technical systems, including rigging, are mission critical to our operation.

How much should the Imperial spend on operation, maintenance, repair, and replacement every year? The Imperial system, if replaced today, would cost at least \$500,000. Therefore, optimally, this

system should have \$100,000 budgeted annually for operation, maintenance, repair, and replacement. Of course, budgets are never so neat and clearly defined, but discussion with Shawn Lord suggests that the Imperial Theatre falls somewhere around the 20 percent range.

What are the extra costs of installing a superior rigging system, such as the one in the Imperial Theatre? There are two cost categories: components and installation time. A block set with multi-groove sheaves is about 10 percent more expensive than a block set with single groove sheaves and idlers. But the cost of loft blocks represents only about 25 percent of all of the components of a line set. All other components are the same price no matter what loft blocks are used. So a 10 percent increase for loft blocks, which represent 25 percent of the total of components, increases the cost of all components by 2.5 percent.

The second cost category is the installation. Some argue that there should be no extra cost to installing a system well. Although there is merit to that argument, for the purpose of this article, let's assume it does cost more. Most of the costs of installing a system well or poorly are the same. The cost of bidding the project is the same. The cost of transporting the components to the site is the same, as is the cost of removing the old system. In fact, the only difference in installation time is the extra time it might take to assure that the guide wall is true and plumb and the extra (albeit necessary) time that it might take to assure that the blocks are properly aligned. What might be the extra cost of aligning the blocks and the guide wall properly? It might be very little.

When I was first engaged by the Imperial, I was told that they needed to start to plan the replacement of the system. For a 27-year-old system, that seemed to be a reasonable presumption. By the time I left St. John, I was of the opinion that the system simply needed to have some of the normal wear items replaced, which was not a surprise. But the core of the system was in a very serviceable condition. It might have another 15 years left. Or, it could last for another 27 years. I expect that the system did cost more when initially installed, but a 40- to 60-year life expectancy, rather than 30 years, means that they will have saved money in the long run.

So what if they paid 2.5 percent more for components and, say, 10 percent more for installation? Admittedly, these figures are arbitrary, and only time will tell how long the system will last. But the figures permit a conceptual discussion to make a point. Let's assume that the building itself lasts for 120 years clocked from 1993. Let's also assume that any future replacement system is the same quality. The final assumption is that the replacement system will cost \$500,000 per installation (in today's money). If a rigging system lasts 30 years, the Imperial will need four systems in 120 years for a total cost of \$2 million. If the system lasts 40 years, the Imperial will need three systems for a total cost of \$1.5 million. If the system lasts for 60 years, as this one may, the Imperial will need two systems for a total cost of \$1 million. Therefore, by paying 12.5 percent more for the initial installation, the Imperial saves \$1 million. It seems the extra cost would be well worth the investment.

The counterweight rigging system at the Imperial is not really a unicorn. Every system can be like this, provided the team collaborates to design, install, and maintain a well-chosen system. However, as with anything else, we get what we pay for.



Rick Boychuk is a theatre technician and designer. He is also an inventor and owns the patent for the front-loading arbor and has a

patent pending for an arbor trap, which is designed to prevent runaway line sets. He has discovered that new innovations for counterweight rigging find their foundation in the history of the technology. Boychuk continues to explore the spread of the counterweight rigging system in the United States in anticipation of releasing a second volume of Nobody Looks Up: The History of the Counterweight Rigging System: 1500 to 1925, the only book ever written to document the history of the counterweight rigging system. See: www.gridwellinc.com and www.counterweightrigging.com