Rigging is an entertainment business term with a variety of meanings. A definition of the widest possible latitude might say that rigging means to put something into a workable state. A shirt may be rigged with Velcro when a quick change happens too fast for buttons. Flats may be rigged with stiffeners when they are too floppy to stand on their own. Rigging for a rock show in an arena has its own specific meaning, which is using wire rope and shackles to hang chain motors. In the first part of this chapter, the term *rigging* will cover the equipment used in hanging scenery and lighting over the stage. Ropes, pulleys, arbors, and pipes are all a part of this equipment. The end of the chapter is a survey of how to rig chain motors in a theatre.

Chain motors have been used extensively in arena rigging for decades. They have become increasingly important in theatres in recent years.
TRADITIONAL RIGGING SYSTEMS

There are two main types of theatre rigging systems. The first and oldest type is known as the hemp system, and a second, newer type is known as a counterweight system. The word system is used to denote that there are many parts to each type and that these parts work together in concert to form a method of flying scenery. Some theatre buildings use various types of electric and/or hydraulic winches to fly scenery. Wire rope cable is wound/ unwound from a drum, something like a winch that you might find on the front of an off-road vehicle.

Thrust and arena theatres often use winches because their placement is more flexible. The winches can be picked up and moved to new locations if necessary. They are more adaptable to fit the different needs of a thrust theatre. Proscenium stages are rectangular, and the rigging is arranged so that all the pipes are parallel with the proscenium. Thrust theatres are irregularly shaped, and a rigging system made of winches that can be arranged in different ways is more useful. The problem with winches in general is that the precise control of automated equipment can be difficult to achieve. These machines have no ability to “feel” when something is going wrong. A good flyman can slip a batten past a crowd of others in a graceful way that a machine cannot possibly mimic. The flyman gets feedback from eyes, touch, and ears that a machine does not. This is an example of how the art of theatre sometimes wins out over the science of technology.

Chain motors have become very popular in recent years as scenery has become heavier and more complex. Most of the time motors are used for items that are dead hung, that is, ones not moving during the normal course of a performance. Chain motors are quite noisy when they operate. That is not so much a problem in the concert business, in which performances are very loud, but they are problematic in a quiet theatre.

Hemp system
The hemp system was developed in the mid-nineteenth century by stagehands who were recruited from the ranks of the merchant marine. As sailors, these stagehands were familiar with methods of using hemp rope to hoist heavy objects. As a result, many stagehand terms are derived from nautical sources. This will no doubt become obvious during this discussion of hemp rigging. On a sailing ship, the ropes and pulleys used to manipulate the sails are known collectively as “the rigging” of the ship. More about ropes and knots can be found in Chapter 4.

When studying the hemp system, it is helpful to imagine a practical rigging problem. For the purposes of the following example, imagine that a curtain needs to be hung across the stage, parallel with the plaster line, and that at some point in the evening’s entertainment this curtain will need to be flown up out of sight.

If the curtain is laid out on the stage floor or deck, it becomes immediately apparent that the first thing required for this rigging job is a horizontal pipe or batten to which the drapes may be tied. Also we will need some method of hoisting this batten up into the air and leaving it suspended. This can be accomplished by attaching hemp lines to the batten and pulling the lines upward toward the grid. At one time, battens were made from wood, but modern battens are made of steel pipe. When working on the stage, the terms batten and pipe are interchangeable.
Notice that in the curtain-hanging example, three stagehands are needed to haul the piece up into position, and tie it off at its designated trim. The word trim is used to indicate proper positioning of a flown piece. Setting a trim means to adjust a piece to its proper location and then mark that spot so that it can easily be found again. These stagehands have little choice but to tie off their lines and have them remain in one place.

A curtain that has been tied off in one position like this and just hangs there is said to be dead hung. In general practice, dead hanging is a last-resort situation, because it is a difficult and time-consuming procedure. It is hard to get all the lines tied off so the pipe is level and at the right height. At the beginning of our rigging example, we said that this drape would need to move on cue, so dead hanging would not be an appropriate solution to this rigging problem.

Other difficulties need to be addressed as well. First, it would be more efficient to use only one stagehand to run the curtain up and down rather than three. This would save on labor and also make sure that all lines are synchronized to move at the same time and speed. Second, it would be wise to find a method of balancing some of the weight of our load. A large curtain may weigh several hundred pounds—far too much for one flyman to handle without assistance. These concerns can be addressed by employing a system of pulleys and weights.
Actually, the word *pulley* is somewhat of a misnomer as it has been used here. Generally, a device with a *sheave* (the rotating part of a pulley) used to change the direction of rope travel is referred to as a pulley if it is free to swivel or travel and as a *block* if it is bolted to one spot and stationary. A device that has been bolted to the wood or steel of the grid where it is not allowed to move in any direction is therefore a block. Those particular blocks are known as *loft blocks*, because they are in the loft area of the flyhouse. Loft blocks change the direction of rope travel from vertical to horizontal, that is to say, from an upward motion (leading from batten to grid) to a cross-stage inclination (from the loft block to the side of the stage). When they reach the side of the stage, the three hemp lines are together in one group and are able to be handled by one person.

It would be much easier to work with the three lines if they were hanging down on the side of the stage rather than remaining horizontal. Pulling down on a rope is more ergonomically efficient, because gravity helps you do it. The change in direction is accomplished using the *head block*. Again,
this pulley is referred to as a block because it remains stationary. In our example, the head block has three sheaves, because there are three lines used to lift the batten. The block is constructed so that the three sheaves are side by side in the same housing but turn freely and independently.

Our hemp lines are now hanging downward in the direction of the pin rail. Better leverage is gained because it is physically much easier to pull down on a rope than it is to pull sideways. It is important to note at this point that when the ropes are pulled down, the batten will move upward. Conversely, when tension is released, gravity will cause the batten to move in a downward direction.

Our example has not yet addressed the problem of counteracting the weight on the batten, but this can be achieved by adding weight to the downward-hanging lift lines. In a hemp house, sandbags are used for this purpose. The easiest and most effective means of attaching sandbags to ropes is to use a clew that has been fastened to the lift lines themselves. An older method was to use a special rope and knot known as a sunday, but a clew is much easier to attach. A clew is little more than a clamp with individual channels in it for the various ropes.
A clew makes it possible to make small adjustments in the lengths of the different lift lines, and thus to adjust the trim of the batten so that it will hang level and parallel to the stage floor. If a proper trim is not reached, the pipe may be bowed or slanted, and the curtain will not hang straight. A hook at the bottom of the clew is used to attach sandbags. Remember that the weight of the bags should be slightly less than the weight of the load on the batten. This condition is referred to as batten-heavy. If the lineset is batten-heavy, its own weight will cause it to fly in (down) when the ropes are loosened. If the weight of the sandbags and the weight on the pipe are perfectly balanced, it will be necessary to push up on the rope to get the batten to fly in, which is a method reserved exclusively for magicians.

The final step in operating a hemp system is to secure the group of lines to the pin rail when the batten is not in use. The rail itself is a horizontal pipe, which runs up- and downstage. There are holes drilled through the rail from top to bottom that are used in conjunction with belaying pins. In nautical terms, “belay” means to stop, or hold fast. The hemp lift lines are wrapped in a figure-eight around the cleat and into a special knot that will come completely untied whenever the belaying pin is removed from the rail. This method of tying off makes it easier to deal with several ropes at once and to move a lineset in a hurry, and is the same as when tying off to a cleat on a ship.
There are a number of shortcomings associated with the hemp system of rigging. The largest of these is the difficulty of attaching sandbags to the line-sets. This is at best a cumbersome task, and when the weight to be added is over 200 or 300 pounds, the sheer size of the bags is a test of anyone’s strength and endurance. The largest bags used for electrics at the Lyric Theatre in Baltimore weigh 1,500 pounds! Also, since there are many such linesets arranged side by side, it becomes quite a trial to maneuver the bags past one another as several linesets are being simultaneously worked. On occasion, it is physically impossible, such as when several heavy loads are in close proximity to one another. In addition, there is the problem of the hemp lines stretching. Hemp rope tends to stretch when there is a load placed on it, and also when there is a change in humidity. Several different types of synthetic lines are available that are not affected by humidity, but they too have their own stretching/contracting quirks. Some become shorter and fatter over time—just the opposite of hemp.

The various ropes that make up a lineset are of differing lengths, because the opposite side of the stage is farther away. As the proportional amount of stretch is a function of the length of the rope, the far side of the batten will tend to droop as that line stretches excessively, and the problem will need to be adjusted using the clew. This can be a time-consuming chore, and it requires a great deal of skill to be done properly. It is also difficult to deal with tying off the individual hemp lines at the rail, and to keep the massive amount of line that ends up on the floor neat. Several years of apprenticeship is required to develop the necessary skills. As you will see, the invention of the counterweight system was a giant step forward.

Even so, it is good to understand how this early system of rigging worked, because stage-hands are often called upon to rig lines for temporary lifting jobs, and understanding the basic principles of hemp-style rigging will make such tasks much easier.

**Counterweight system**

The counterweight system of rigging works on the same basic principles as the hemp system, but with a number of important refinements. Aircraft cable, a very high-strength stranded steel cable, is used in the place of hemp for the lift lines. This product was originally developed for use in linking the control surfaces of early airplanes, hence the odd name.

Most installations are equipped with a 1/4” size cable generally rated at around 7,000 pounds breaking strength. This far exceeds the breaking strength of any reasonably sized hemp rope. Another
The advantage of aircraft cable is that the stretching factor is negligible, and steel is not affected in the least by changes in humidity. However, the very stiff cable is not at all suitable for tying off to a pin rail. It is important to realize that breaking strength is just that: the point at which the cable will break. Most riggers use a safety factor of four, meaning that the load placed on a rigging component should be only one-quarter of the breaking strength. Some components are marked with their breaking strength; others are marked with a working load limit.

Instead of tying off to a pin rail, the counterweight system uses an arbor that holds steel or lead weights rather than sandbags. The metal used in manufacturing counterweights is dense; these weights thus take up much less space than bags do. Aircraft cable lift lines are attached to the batten, then run upward through the loft blocks, across the grid to the head block, and down to the top of the arbor. A large diagram of that is at the end of the chapter.
Counterweights are added to the arbor to exactly balance out the weight of the batten and its load. The cable may be fastened to the pipe with a clove hitch and wire rope clamp, or it may have a trim chain that can be used to adjust the exact length of the cable.
CABLE CONNECTED TO A BATTEN
WITH A TRIM CHAIN
It is not necessary to leave the lineset batten-heavy, because there is a positive way to haul the arbor both up and down. This motion is accomplished by the use of a large diameter hemp line known as the *purchase* or *operating line*. A 1/4” line is standard, because the large size is easy to grip. Although I used the term “hemp” for the operating line, most modern systems use one of several types of synthetic materials. Although hemp is still in use in many places, it may eventually become a thing of the past, because synthetic fiber ropes are greatly superior.
The purchase line is attached to the top of the arbor and passes over the head block, down to a tension pulley, and back up to the bottom of the arbor, where it is again secured. Pulling down on the rope causes the arbor to move upward. As the arbor travels up, the batten travels down. Hence pulling down on the purchase line will cause the batten to also go down, and, in reverse, pulling up will move the batten upward.
As the purchase line is composed of either hemp or a synthetic such as nylon, it will tend to change length over a period of time. A bottom-tension pulley (remember that pulleys move) serves to keep the line taut at all times. It is set into special guides known as T-tracks that allow it to move downward by force of gravity, but cause it to jam rather than slide back up. The rear side of the arbor is guided by the same T-tracks that prevent the arbor from swaying from side to side as it travels up and down. Older systems use a cable-guiding device that is not nearly as effective, especially in a tall house.

In some theatres, a lack of wing space means that the floor space under the rail must remain unobstructed, so that scenery and actors may pass back and forth. This is made possible with a 2-to-1 or double-purchase counterweight system. In this case, the rail is located approximately halfway between the deck and the grid. With that ratio, if the same type of cable system were used as in the standard counterweight system just discussed, battens would move only halfway up and down. In a double-purchase system, cable length is increased by passing the aircraft cable lift lines around a pulley on top of the arbor, and then tying them off at the grid.
What this means is that for every foot the arbor rises, 2 feet of lift line will pass over the head block, and as a consequence, the batten will drop 2 feet. You can clearly see how the names “2-to-1” and “double-purchase” originated. One drawback of this system is that it also requires twice the amount of weight to be loaded into the arbor. If your scenery weighs 150 pounds, then 300 pounds must be loaded onto the arbor. When hanging a heavy load, these arbors tend to fill up in a hurry. Theatres with a double-purchase system may find it best to use heavier lead weights rather than the standard steel ones.

At this point it seems prudent to offer a word of caution. Flying scenery is dangerous. It involves lifting heavy objects over the heads of actors and stagehands. Accidents can and will result in serious injury. You should be very familiar with any type of rigging system you use and should never exceed the limits of your knowledge. If you are unsure of what you are about to do, stop and seek advice from someone with more experience.

Before discussing the operating procedures of a counterweight rigging system, it is wise to review the relationship between battens and arbors. Remember that when a batten has been flown all the way in (down) as far as it will go, its arbor will be all the way up. Actually, the arbor will stop when it reaches its barrier at the top of the T-track. When the batten is flown out, the arbor will be stopped by a similar barrier at the bottom of its travel, preventing it from colliding with the tension pulley. This barrier is usually a piece of angle iron with a rubber or wooden cushion bolted to it. This assembly is bolted at a 90-degree angle across all of the T-tracks. When an arbor is snug against the top barrier, it is physically unable to move any higher. If the arbor cannot move any higher, the batten cannot sink any lower; at least until the weight limit of the various component parts is reached. This limit should be several thousand pounds at least, depending upon the quality and construction of the system, but in any case, more than the largest amount of weight the arbor can hold.
When the batten is flown all the way in and the arbor is all the way out, snug against its barrier, it is safe to load any practical amount of scenery or lighting equipment onto the batten without fear of anything falling to the floor. Of course, this statement presupposes that you securely fasten that load to the batten and that your rigging system is in proper working order.

A word of warning! Be sure to completely lower the batten all the way in before adding a load to the pipe. If you stop a few inches short, and a large amount of weight is put on the pipe, it will suddenly slip down until the arbor reaches its full out position at the T-track barrier. This can be very dangerous for the stagehands who are loading the pipe!

Let us suppose for a moment that the load on the batten is 400 pounds. With no weights in the arbor of a single-purchase system you would need to pull down on the purchase line with a force of 400 pounds in order to haul the batten into the air. Clearly, it would be terribly unsafe to do this, if it were even possible. You would need to weigh at least 401 pounds yourself, or as a group. Then the batten would have a potential to fall, with the inertia gained from the distance involved and its 400 pounds of mass. That would be illogical, however, because the whole point of using a counterweight system is to allow the weights in the arbor to balance a load placed on the batten.

Counterweights are generally stored on the loading gallery. The loading gallery is positioned near the grid, where it is possible to reach the arbors when they are at their highest point of travel. Counterweights, which are often referred to as bricks because of their shape, are stacked in the arbor in an amount that matches the load on the batten, in our case 400 pounds. Bricks most commonly have rounded indentations at either end that are intended to fit around the upright bars found on an arbor. Bricks are tilted at an angle for placement into the arbor and then laid fat. These weights will not fall out of the arbor when they have been properly placed between the bars.
Most arbors have one or more fat pieces of metal connecting the two upright bars. These spreader plates slide up and down on the rods, and are intended to prevent the bars from warping out of shape from the weight of the bricks. Spreader plates should be distributed more or less evenly throughout the stack of weights in the arbor.

Counterweights are manufactured in a variety of different poundages, but the 20- and/or 25-pound weights seem to be the most popular. Theatres often have a small number of half-sized bricks so that a more exact balance can be reached than is possible with the standard types. Sometimes lead is used in place of steel in manufacturing the weights, with the advantage being that the same size lead brick weighs approximately twice as much. This can be very useful in theatres that have unusually short arbors that cannot hold very many weights, and especially in a double-purchase system.

Remember to load the batten first and the arbor second. This prevents creating a situation where a heavily weighted arbor can fall. If the arbor were to be loaded first, the only thing holding it up would be the rope lock on the rail. That is a completely unsafe procedure, as the rope lock can be expected to hold back only a few dozen pounds at best, and not nearly the 400 that were mentioned earlier. Remember that the batten is always loaded first because it has nowhere else to go. It has no potential for movement.
Conversely, when removing objects from a batten, the arbor should always be unloaded first to avoid the same unsafe situation from occurring in reverse. If the batten were to be unloaded before its corresponding arbor, the system would be very far out of balance, creating a dangerous situation. Again, the weight of the arbor would be held in check from falling only by the pressure of the rope lock on the purchase line. Under normal circumstances, linesets should be safe to load and unload even with the rope lock loosened.

**STEPS FOR SAFELY LOADING AND UNLOADING STAGE WEIGHTS**

When loading:
- Fly the pipe all the way in.
- Place the load on the pipe, taking care to properly secure it.
- Load the proper amount of stage weights into the arbor.
- Fly the lineset out to its proper trim.

When unloading:
- Fly the pipe in to its extreme bottom position.
- Unload the arbor.
- Remove the load from the batten.
ADVANCED TECHNIQUES

There are a number of added complexities to operating a stage counterweight rigging system. One of them is that the weight of the pipe itself must be balanced out by one or two weights in the arbor that need never be removed. This is often referred to as pipe weight. It is helpful to strap these weights down, or to paint them a safety color, or otherwise mark them in some way so that they are not accidentally removed. It is customary that when the loaders, as they are called, are finished unloading an arbor they yell down “pipe weight” so that the flyman on the rail below knows that it is safe to unload the pipe and can announce this to the stagehands on the deck.

Unless you are touring and have hung the same show a number of times, it is often difficult to know exactly how much weight should be loaded on a batten. There is a danger of greatly overloading the arbor so that it is vastly heavier than the pipe, thus creating a safety hazard. When an exact weight total is not known, it is best to load the arbor with the purchase line unlocked, slowly and until repeated testing shows that a proper balance has been achieved. If the same scenery or lights are to be hung again at some future date, make a note of the precise weight involved so that this time-consuming procedure can be eliminated. When you are unsure of the weight, load the arbor the safe way. It is very important not to greatly overload the arbor.

Unfortunately, scenery or drapes hung on a pipe may be too large to hang without at least some portion of the load resting on the floor. This will obviously affect your ability to judge the weight of the load by the process just described. In this event, it will be necessary to determine the weight by some other means (such as an educated guess) to within a hundred pounds or so of the actual amount. After the load has been secured to the batten, a bull line is used to safely get the piece into the air.

A bull line is a stout length of rope that is comfortably large enough to bear the weight of the load you are hanging. The larger the diameter of the line, the easier it will be for the stagehands to grip. The rope should be lengthy enough so that it reaches the floor even after it’s been doubled over the batten, and the pipe has been flown out far enough for the entire weight of the load to be resting on it. Do not tie it to the batten, but do tie both of the ends together so that the line will not accidentally slip off the pipe. If you tie the bull line to the batten you will be subsequently unable to remove it without a ladder or a Genie lift.
Stagehands take the place of the eventual load by keeping tension on the bull line as the batten is flown out. Make absolutely certain that the bull line rope is able to handle the strain and that the load is not too much for the stagehands to easily handle. If the load is not more than 100 pounds or so out of weight, you shouldn’t have too much trouble. After you’ve manhandled it all the way out, the arbor will have come in far enough to be fine-tuned from the rail. It is very important that a knowledgeable flyman be on hand when using a bull line.

On occasion, and especially with a double-purchase system, a need arises to hang a piece that is heavier than the amount of counterweight that can be fitted into one arbor. When this happens, it is possible to use a second lineset as a helper. This is known as marrying the two pipes. It is a good idea to keep a number of short chains and shackles on hand that may be used for this procedure. Make sure that the hardware in question has a capacity rating high enough to hold the weight involved. How can you know this? Suitable hardware has a rating. Shackles are the best connectors because they generally have a known working load limit or WLL stamped on their sides. Snap hooks and quick links generally do not. You do not need to use a safety factor when the WLL is known; it is OK to use the entire limit.
Use one marrying chain for each of the lift lines in your particular system. Fly in a pipe that is either just upstage or downstage from the one that is being loaded and wrap the chains around the two pipes so that they are tightly bound together. It is best to put the chains next to the lift lines. This will ensure that they are evenly spread out along the length of the pipe.

As a matter of physics, it really doesn’t matter how the weight is distributed between the two arbors with regard to their effect on the load. As a practical consequence though, it is easier to load and unload the arbors if a majority of the weight is in the primary arbor. This also places less of a load on the marrying hardware. If the piece must work, or move during the show, both linesets must be unlocked and moved together. It takes more physical strength to overcome the inertia of a heavy weight, but it is still possible for one person to fly the piece, because when one purchase line is pulled, the other will automatically follow as a slave.

The aircraft cable making up the lift lines has a certain weight itself. This weight can really add up in a large system. If the arbor and batten are visualized as opposite ends of a set of balance scales, the
The passage of the aircraft cable from one side of the scales to the other can be seen to make a measurable difference in the balance of the system. Therefore, when the batten is very far in, the lineset will seem a bit batten-heavy, and when it is all the way out, it may seem quite arbor-heavy. This is a natural occurrence and there is not much that can be done about it. In extremely tall and wide houses, a heavy cable running the opposite direction through the head block is sometimes used to account for the difference in the in/out weights.

There are times (such as those calling for a bull line) when loading and unloading weights will require that the system be very arbor-heavy for a short while. When this situation occurs, special steps can be taken to ensure that the lineset does not become a “runaway,” meaning that the arbor is falling and out of control.

One method is to tie the front and back parts of the purchase line together with a timber hitch or other suitable choking knot. The friction between the two ropes lashed together will keep them from slipping. It is imperative that the two ropes be very tightly bound.

Another method is to take a short length of pipe and twist the front and back portions of the purchase line together several times until there is enough friction created to prevent the line from slipping. If you wish to leave the lineset unattended for a moment, it is possible to jam one end of the
pipe between two of the T-track rails so that it will stay put. (Just make sure that it does.)

The last method is to create slack in the purchase line by pushing down on the front of the tension pulley. Not all systems work this way. If yours does, the pulley will become unjammed and jump up several inches, creating slack in the line. You can then twist the front and rear portions of the purchase line around one another and hold them together tightly with a gloved hand. This last method has the added advantage of allowing the flyman to slowly let the two lines slide through his or her hands while flying the piece out. For loads that are not too greatly out of balance, this technique can take the place of a bull line, but be careful, as it takes a great deal of experience to know the difference. Do not exceed your limitations, and, as they say, better safe than sorry.
Running a show from the rail involves the marking of trims (the limits a purchase line should move), the clear labeling of all linesets in use, making up a cue sheet, and establishing a means of communication from the stage manager. Flymen should exercise a great deal of caution when flying scenery. The inertia of a heavily laden batten can cause severe damage to scenery or props on the deck, as well as to humans. If it is not possible to see the stage while running a cue, it is best to have someone else watch for you. During work calls, a flyman should always announce a batten moving in or out. The most common way is to call “Pipe number so and so, coming in. Heads up!” Remember to speak loudly, from the diaphragm.

Although the term flyman is used here in an effort to respect tradition, the rail is by no means an exclusively male domain. There are many fine women flymen, and the term is not intended to exclude them. One of them is listed in the acknowledgments section of this book’s preface.

Trims may be marked in one of two basic ways, either with colored tape wrapped around the purchase line or with small pieces of yarn or ribbon that are worked between the strands of the same line. The ribbon is easier to see, and less likely to become dislodged from the purchase line, but it is somewhat more difficult to install and unkind to the rope. The yarn method will not work at all with a newer braided line such as Stage Set X. Whichever method is used, the basic concept is to take the batten to its desired trim, and mark the purchase line where it lines up with a stationary point on the rail. In this way, the pieces to be flown in can be stopped at a precise, predetermined point without hesitation.

The best practice is to mark the *in trim* with white tape so that the mark is even with the top of the rope lock when the low trim is reached. If the purchase line is white, use a dark color. As the scenery is flying in, the front part of the purchase line will be moving down. When you see the trim mark come into view, cover the mark with your hand and gently stop the momentum of the lineset as the mark reaches the top of the rope lock. It is important not to run past the mark, as the scenery may hit the deck with some force and make an unpleasant noise.

Running a soft piece past its trim and piling it up on the deck is known as *overhauling*. The error is particularly heinous if it extends to a point where the batten pipe shows to the audience. Should that occur, expect a stern reprimand from the stage manager. With a bit of experience, you should be able
to touch in the piece to the deck without making a sound. Slow way down as the trim mark approaches the lock, let it just touch the floor, and then give a small tug on the line to settle the piece against the floor snugly. If you are flying in a hard piece, snugging it against the deck will keep it from drifting back and forth during the scene. You should be able to tell a definite difference in the feel of the purchase line when the piece reaches the deck. With some of the weight on the floor, the arbor will seem heavier.

After the scenery has had its moment in the footlights, it must be flown up or out of view of the audience. It is best not to mark the out trim so that it matches up with the top of the rope lock, because you may confuse it with the in trim. Also, because the front section of the purchase line is moving upward when the piece flies out, a mark in that position would be coming from the wrong direction to be easily seen. The tape would be invisible until it suddenly popped up past the lock and had already passed its stopping point. It is far better to mark the high trims on the rear part of the rope. It will be passing downward as the scenery flies up. In this way, you can see the mark approach and more easily stop at the proper trim. With this method, both trim marks will be coming down toward you. Usually there is some horizontal framing member that is a part of the T-track system that can be used as a visual reference for the stopping point. If not, one can easily be established using marker or paint to create a line across the tracks themselves. Out trims are most often marked with red tape, but the color does not really matter as long as you are consistent with it. Avoid using the same color tape for both your ins and outs, because that will create confusion.

On occasion, you may need to mark an intermediate trim. That is a point for scenery to stop somewhere between the high/out and low/in trims. You should mark this trim at the rope lock as you would the low trim, but find some means of differentiating the two, such as by color or by size of the trim mark.

All linesets should be clearly marked by name. Often there is a card holder or marker board on which to write. I personally prefer to use white gaff tape and a black Sharpie marker. The tape is less likely to fall off at some crucial moment. Marking in the clearest possible manner can prevent some fairly embarrassing, though perhaps memorable, moments in the theatre. Clearly marking everything backstage that must be found in the dark is always a good idea. In some theatres, working pieces
(linesets that will move during the show) are marked with red tape above the name card so that they are easier for the flymen to spot. Some rails will go so far as to lash together the front and rear purchase lines of all the nonworking linesets so that they will not be grabbed by mistake.

Fly rail cue sheets should be made in a large enough format that several people can look at them at the same time. It is not at all unusual for three or four lines to move at the same time, meaning that the same number of flymen will need to review their cues, or pulls, all at once. Most often, each flyman is given a number to use as a reference when reading the cue sheet. Sometimes there is a change in personnel, and rather than changing the cue sheet, someone can tell the new person his or her number.

![Diagram of a rail cue system with labels]

### MARKING THE NAME OF A LINESET

The sheet should list the number of the rail cue, the numbers of the flymen involved, the name of the piece each will be pulling, its speed and direction, and the color of cue light on which the pull is to occur. Cue lights are double sets of small colored bulbs controlled by the stage manager. You may wish to use a red clothespin or some other small clamp to mark your place on the cue sheet. After a

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Use the clothespin to mark which cue is next.
cue is taken, the pin is moved down to the next reference. When the cue light comes on, and the hands gather to check their next pull, the red pin marks the appropriate spot.

The cue light coming on is a warning to get ready for the cue. When the light goes out, the cue should be taken immediately. This method allows any number of flymen to see the command at one time, and synchronizes their moves. Trying to run a headset to each person would involve far too many pesky wires and would unnecessarily burden the stage manager with too many verbal commands. Two bulbs are used on each circuit to guard against the inevitable burnout. When there are a series of cues going in a close time period, it is best to use a different color of light for each section of the cue in order to reduce confusion. Switches at the stage manager’s desk are used to control the cue lights, which are often used on the deck as well as the fly floor.

Running a fly cue involves knowing which lineset you are to use, the direction of travel (in or out), the speed, and the color of cue light. If a line is to be pulled down so that the scenery is to fly into the view of the audience, you should unlock the lineset when the cue light comes on and stand ready. Watch the light carefully until it goes out. On that command, pull down on the rope until the trim mark is seen. Cover the mark with your hand, slow down the line as the trim mark approaches the lock, and stop it gently in the right spot. Remove your hand, and after checking to see that you are indeed correct, replace the lock and ring.

Sometimes, when the exact positioning of a piece is critical and/or the flymen have proven themselves to be unreliable, a knuckle buster may be used. This is essentially a small clamp that may be attached to the purchase line at the low trim mark. It is too large to fit through the lock and is a certain means of assuring that the line cannot travel through the lock any farther than is intended. Even limited experience with a knuckle buster will well acquaint a novice flyman with the origins of its colorful name. They are really a last resort and should be avoided in most situations.
Flying a piece out to its high trim is essentially the same as flying one in, but there are several important differences. Some pieces of scenery are quite heavy, and as a result, the amount of inertia that must be overcome in order to begin moving the lineset can be rather large and difficult to handle. Bear in mind that it is much easier to pull down on a rope than to pull up. Notice that when a lineset is going out, the front portion of the purchase line (the one nearest you) is also going out, but the back line is going down. Hence, by grabbing the rear line and pulling down, the piece will actually fly up. Pull on the back line, at least until the pipe is up to speed. As the trim mark comes down into view, you can stop by using downward force on the front line at the appropriate point.

Another difference encountered in flying out lies in the position of the scenery just before the cue is taken. By definition, if a piece is to be flown out, then it must be in view of the audience. Often when a lock is pulled open, the lines will tend to creep a bit, and this might be seen by the audience—or even worse, by the stage manager. To avoid that, grasp both the front and back lines together before the lock is undone, and hold them together until the cue is taken. This will prevent the scenery from moving visibly.

Many small nuances make a really experienced flyman an expert in the field, and I’ve listed just the basic methods in this chapter. Other methods are just as good, but I have found the practices outlined here to be the most easily understood and universally practiced. Perhaps the best advice is to simply watch carefully at all times and pay attention to what is happening around you. There will be many occasions when lines will foul, wrong lines will be pulled, or pieces will move in the wrong direction. If you are watchful, these mistakes can be caught when they are still relatively minor and corrected.
PARTS OF A COUNTERWEIGHT SYSTEM

- Head Block
- Loft Area
- Loft Block
- Grid
- Lift Line
- Batten
- Loading Gallery
- Rail
- Purchase Line
- Stage Floor
- Tension Pulley
**RIGGING WITH CHAIN MOTORS**

This type of rigging is sometimes called *arena rigging*, because it was developed to set up lights and sound in multipurpose indoor arenas that are often used for things like ice shows and rock concerts. Wire rope similar to the aircraft cable in theatre rigging is used to suspend industrial-type *chain hoists* from the roof trusses. The chain hoists are then used to lift aluminum trusses, which have scenery and/or lights attached to them. The terms *chain hoist* and *chain motor* are interchangeable.

CM Lodestar motors are by far the most common, although there are a couple of other types. The initials CM stand for Columbus McKinnon, the company that makes them. Lodestar is their premier model. Insurance companies feel better about lifting heavy loads over thousands of people in an audience if you use the best equipment available. An *inverted* type of hoist is made for use in the entertainment field. Normally, in a factory setting, hoists are attached to the ceiling. The chain hangs down, and a hook at the end of it is used to lift heavy loads like a crane. In an arena, lifting the motor itself to the high ceiling is problematic, so the hoists are reconfigured to operate upside-down, with the hook in the air and the motor on the floor. When the hoist does its lifting, it lifts itself along with the load, which slightly de-rates the manufacturer’s load limit designation. But in general, these motors are designed to lift the full amount they are rated for, with a safety factor already considered.

The hoist has a sprocket inside of it that the chain runs through, and as the motor turns the sprocket the chain also moves. A very heavy-duty clutch inside the housing keeps the sprocket from slipping when the motor is turned off. The speed is not adjustable, but different motors are designed to run the chain at 16, 32, and 64 feet per minute. Sixteen feet per minute is standard; faster speeds are usually for some type of effect. Chain motors are rated by how much weight they can lift. The *one-ton* size is by far the most common, but *two-ton* and *half-ton* sizes are also available. Half-ton motors are physically smaller and also use a smaller-gauge chain, but the two-tons are the same exact size as the one-tons. The difference is made up by using a different sort of hook with a pulley in it. The chain is fed through the hook so that a 2-to-1 mechanical advantage is achieved. Columbus McKinnon makes...
many other types of hoists, but they aren’t commonly used in the entertainment industry.

No matter what the type, the chain runs through the motor and is fed back out. As the motor lifts a load, the chain is gathered into a chain bag attached to the side. There are several different types, and some are better at preventing the chain from falling out of the bag on its own or running. That happens when enough chain misfeeds and begins to pull all the rest of the chain out of the bag. The chains are heavy, and can cause serious damage when they run and hit some other part of the rigging.

Chains generally come in 60- or 80-foot lengths, meaning that the distance from the hook to the motor is about that long. Rigging the hook with wire rope from the ceiling increases the distance, so even if the ceiling of an arena is 85 feet tall, an 80-foot chain will probably still be long enough. Theatres are generally not that tall, and chain length is not usually an issue. Before rigging, stagehands must run the chain all the way out of the motor so that the hook to motor distance is at its maximum length. That is called running the chain out. The motors have a limiting device inside them that will prevent the chain from coming all the way out of the motor at the free end or from hitting the hook at the hook end. The motor will stop on its own when the limit is reached. It is considered good practice to run the motor back a bump after reaching its limit so as to protect the inner workings of the motor.
during transport. To bump a motor means to turn it on and off rapidly. Additionally, the term is used to describe moving just a bit. You may be asked to “go up a bump” when setting the trim of a piece of truss.

Two-, one-, and half-ton entertainment motors generally work from a 120VAC 60 Hz power supply, which is the common North American line voltage. Two connectors are located on the motor. One is for the input power, and the other is a lower-voltage control circuit. In order to operate the motor, you must connect it to a suitable power source and then use a control mechanism to switch it on and off. The most common type of controller is called a pickle, and has a rocker switch on it with three positions. A spring inside automatically selects the center or off position unless the operator intentionally presses another setting. As a safety precaution, when the operator lets go of the button, the switch automatically shuts off the motor. The two other switch positions are up and down. Movement up and down is achieved by having the motor run forward or backward so that the chain feeds either in or out. More complex switching mechanisms may run numerous motors all at the same time. Three position toggle switches on a central panel are used to select up/ off/ down for the various motors in the system, and a GO button engages them all at once. Like the pickle, the GO button is spring loaded so that releasing it turns everything off automatically. This arrangement is sometimes known as a dead-man switch.
Most of the time, in an arena, motors are used to hoist a system of trusses into the air. Scenery and lights are connected to the truss. That is a means of reducing the number of motors required. An aluminum box truss is the preferred type. A box truss is four-sided, and a delta truss is three-sided. Box trusses are more heavy-duty and easier to connect together at angles, so they are the most commonly used. Motors in a theatre are most often used to hang lighting trusses, lighting towers, and speaker clusters. These units are designed with motor hoisting in mind. But motors may also be used to hoist scenic units in place, and care should be taken to find a safe hookup location on the piece. Motors can be an excellent way to lift heavy scenery that must be assembled on top of some other unit, and can be thought of as a sort of impromptu crane.
Trusses are joined to the motors using *slings*, which are often called by the trade name *Spanset*. Spansets are made from a very strong synthetic material, and are formed into a loop, so that there is no discernible end. They come in many different sizes and load capacities. Typically, the Spanset is *choked* to the bottom horizontal member of the box truss, and then again around the top member. Choking means that one Spanset is used on each side of the truss, so that the ends of two loops are left at the top. These two loops are fitted into a shackle, and then into the hook that is on the motor itself. A video of how to do that is available on the Web site. Just to be clear, the other hook is the one at the end of the chain, which would actually be up in the air at this time. Frequently, the motor would already be connected to the overhead support structure, and would be floating in the air by the time the trusses are connected.
THEN CHOKE SPANSET ON THE TOP OF THE TRUSS
When the motor is activated, and the hoist pulls the truss upward, the Spansets pick the truss up from the bottom, a setup that is less likely to pull it apart under load. Rigging from the top of the truss is not allowed by the manufacturer, and the equipment is not rated for it.

Excess chain should be fed into the chain bag from the free end first, so that the part nearest the motor out-feed goes in last. This will help keep the chain from becoming fouled when it feeds back out of the bag, and perhaps avoid its running out entirely. The free end of the chain is generally semipermanently connected to the motor, but if not, you should at least tie it to the bag.

In an arena, steel cables are used to connect the motor’s chain to the roof’s support structure. In a theatre, the chains are often simply rigged to the grid itself using a pipe. This is especially true if the grid is the standard type constructed from heavy steel channels with spaces between them, forming a slotted floor.
If the chain is long enough to reach the grid all on its own, clip a Spanset through the hook on the chain and pull it up through a space in the grid at the desired location using a bowline. Slide a piece of schedule 40, 1.5” ID or larger pipe through the Spanset and set the rig down across the grid channels with the pipe at a 90-degree angle to them. The channels should be no more than 4” apart, so the pipe is spanning a very small distance. Use some small line to tie off the ends of the pipe to the channel steel so that it does not accidentally turn sideways and fall through the slot. That is really just a safety against its being kicked while rigging, because under load the pipe will be pressed very firmly against the grid. The tie line has no real load on it. The pipe should be about 36” in length, which is long enough so that you have room to tie it down, but not so long as to be unduly cumbersome on the grid. This method will work only in a theatre with an old-style, heavy-duty steel-channel grid. It would be very dangerous to try this on an expanded metal or cable style of grid, so don’t do that! If you are not sure, then rig your load from the loft block wells instead.

**USING ROPES TO RAISE THE RIGING**

The next chapter of this book discusses ropes and knot tying, and has a thorough description of how to tie the most important rigging knot, the bowline. A bowline is used to create a fixed loop in the end of the rope, and is very useful for raising and lowering the steel cables used to hang chain motors. Tie the bowline so that the line of the loop goes through the Spanset, or through the shackle of the rig, depending on the type of rig you are using. The bowline knot will be easy to untie after the rig is secure. A large-diameter, woven exterior nylon fiber rope is best for this work, because it is very supple and bends well, thus making the knots easier to tie. A larger rope is easier to grip, which is important when pulling up the heavy chain by hand.
If you do not have a standard grid with channel steel, you may be able to hang from the loft blocks. Wells are formed with much larger steel than the rest of the grid. Because they run up- and downstage, you can pick a spot that has the right up/down location. The wells must support the weight of the batten loads, plus the weight of the bricks in the arbor, so they are usually very strong. If the span of the opening is more than 10”, you may want to use a larger piece of pipe, perhaps 2” or 3” in diameter, but otherwise the method of hanging the motor from the well is pretty much the same as hanging from the grid.
When rigging from the steel-channel grid, correct placement is easy, because the channels fall every few inches left to right and the open slot runs up- and downstage, so the rig can go most anywhere. If you must rig from the wells, you can still locate the rig at any point up- and downstage (as long as you go between two loft blocks) but placement left and right can be a problem. If the well is not in the proper location left to right, you can use a bridle to adjust the rigging.

Bridles require the use of wire rope. In stagehand lingo, this wire rope is simply called steel. The most common diameter for the wire rope is 3/8”, because its load rating matches the load capacity of a one-ton motor. The end of the steel is made into a loop by passing it around a thimble. The resulting eye is used together with a shackle, in connecting pieces together. Steel comes in standard lengths of 2, 5, 10, 20, and 30 feet. They can be shackled together to form different sizes.

Shackles are used to connect the different parts of the rig together. When 3/8” steel cable is used, a
5/8” shackle is considered standard. Larger or smaller shackles might not properly fit through the eye of the steel. A shackle has three distinct parts: the *pin*, the *bell*, and the *hubs*. When connecting two pieces of steel, the eye of one rests on the bell, and the pin is inserted through the eye of the other. Never use a shackle when the load rests only on the two sides, because that tends to deform the bell and places stress on the pin threads.

Shackles can also connect three points in a Y shape by using the bell for two of them and the pin for the third. This type of configuration is used when forming the apex of a bridle.
Deck chain can be used to create a smaller length by using a specific number of the 4” links, in the same way that trim chains are used in standard theatrical rigging. Chains of this sort come from modern cargo ships, and are very heavy.

A simple rig that hangs straight down is called a dead hang, but when two pieces of steel are used in conjunction with the motor chain to form a Y shape, the result is known as a bridle. The parts of a bridle include the two legs, which are the two uppermost sections, and the downleg, which forms the upright, lower part of the Y. The downleg could be simply the motor chain, or it could be another piece of steel that connects to the chain. The intersection of the three parts of the Y is called the apex. A shackle forms the center of the apex and connects all the parts together.
An even bridle from two wells will make the rig hang dead center between the two points; this is formed by using the same length of steel on each leg. Uneven bridles are formed by using different lengths of steel rope on the two sides. If one of the legs is made up of a standard-length piece of steel, you can design a length for the other that will make the rig fall in the exact spot you wish to hang your load. A bit of geometry is involved—specifically, congruent triangles and the *Pythagorean Theorem* \(a^2 + b^2 = c^2\).

**A practical example**

Imagine that the wells in the theater are 15 feet apart. You would like to hang the rig so that it is 5 feet from one and 10 feet from the other. A diagram looks like this:

![Diagram of a bridle system with legs and apex points.

Arbitrarily select a reasonable length for one of the legs. Bear in mind that a bridle that hangs down more is easier to hang and puts less stress on the equipment. But a bridle that hangs down too far may place the apex so low that the motor will not be able to fly out far enough. For our example, let’s pick a 15-foot bridle leg. Now our diagram looks like this:
You know the dimensions of two sides of one right triangle, because the apex hangs 10 feet over from the well, and the angular hypotenuse distance is 15 feet. Solve the equation $a^2 + 10^2 = 15^2$ to determine the distance from the grid, down to the apex. The answer is $\sim11.18$ feet. So now our diagram looks like this:

Now the base and altitude of the second, congruent right triangle are known and the same formula can be used to determine the missing bridle leg length: $11.18^2 + 5^2 = c^2$. The answer is 12.25 feet, or 12’ 3”. Taking into consideration the standard parts available, this length can be made up from adding $10’ + 2’ +$ one 4” link from a deck chain. Shackles are used to connect the parts together.
In reality, there are a few more variables, such as the length of the Spanset used and the number of shackles used to connect the rigs. Because so many shackles are used to connect the previous example, the chain link could probably be left out. The standard tolerance for this type of rigging is usually 1 foot, and so close is close enough.

You may need to attach the two legs of the bridle to something other than a pipe on the grid. If you want to hook the bridle up to a steel beam instead, use a **basket** to make the connection. A basket is a loop made from a 5-foot (or 10-foot if necessary) piece of steel. You should make the loop using two shackles so that one holds both the thimble of the 5-foot steel, and the other is used to make the connection.
Tie your bowline through the bell of the connecting shackle, to the outside of the 5-foot steel. If you tie it between the steel and the hookup shackle, there is a tendency for the two of them to pinch in on the rope, making it difficult to remove.

Pull the basket up to the beam it will hang from, and wrap the 5-foot steel around the beam. Remove the pin from the shackle and use it to connect the free end of the steel.

**Parts of a Basket**

1. **5' Steel**
2. **Hookup Shackle**

Use the hookup shackle to attach the bridle.
TIE THE BOWLINE HERE

SO THAT IT DOESN'T GET PINCHED BETWEEN THE PARTS