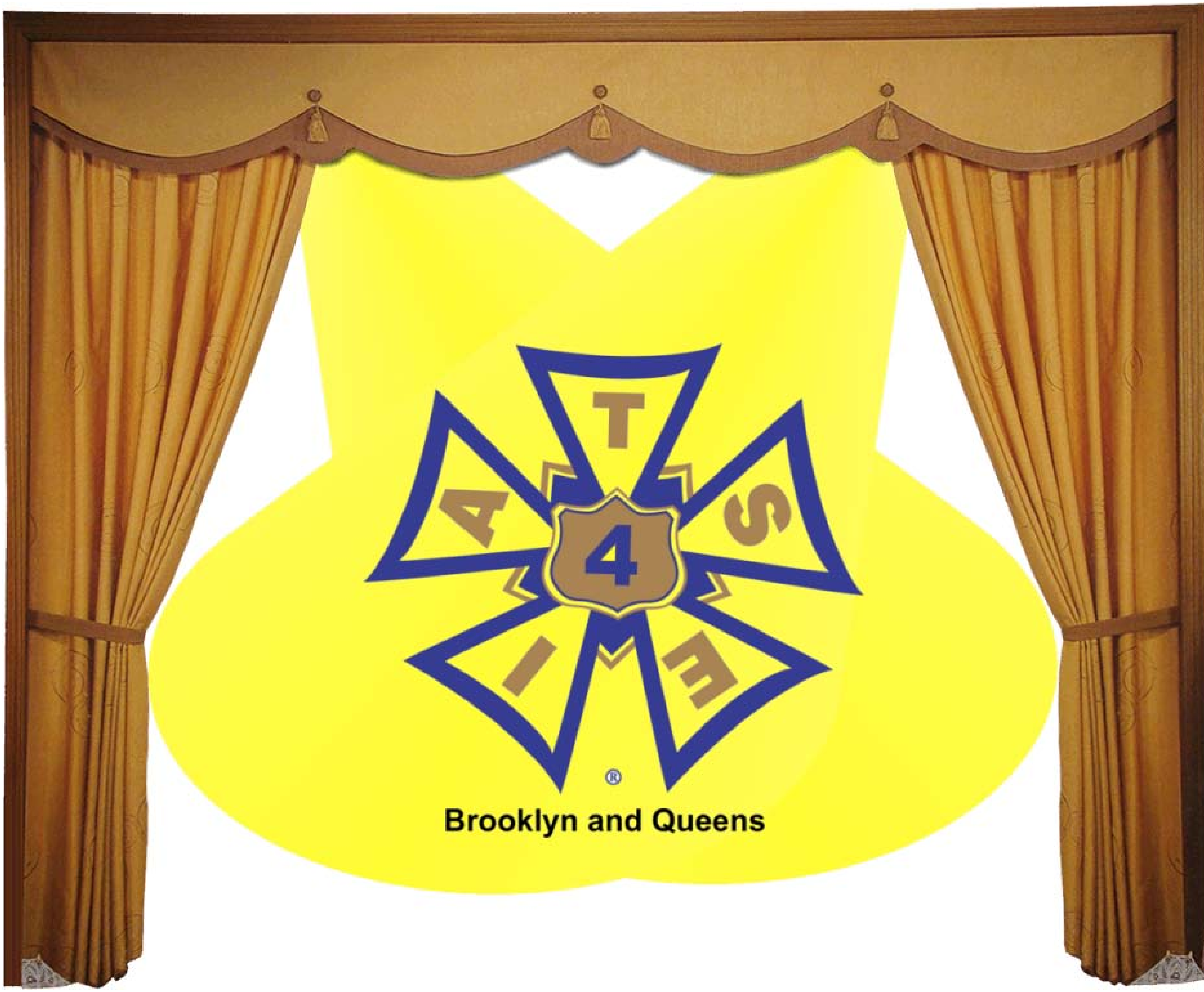

Theatrical Carpentry Handbook

2011

Contents

THEATER SPACES

Theater: a space where a performance takes place, a large machine in the form of a building specialized for presenting performances.

Stage types:

Proscenium stage:

A proscenium Stage is what we usually think of as a "theater". Its primary feature is the Proscenium, a "*picture frame*" placed around the front of the playing area of an end stage.

The frame is the Proscenium; the wings are spaces on either side, extending off stage. Scenery surrounds the acting area on all sides except the side towards the audience, who watch the play through the frame opening. "Backstage" is any space around the acting area out of sight of the audience.

Stage directions are given from the viewpoint of an actor center stage facing the audience. Stage Left is the actors left, Stage Right to the actors right. Downstage is towards the audience. Upstage is towards the back wall of the stage. The ***Plaster Line*** (PL) is a line running from the back of one side of the proscenium arch to the other side of the proscenium arch. The Center Line (CL) runs upstage/downstage half way between prosceniums and perpendicular to the Plaster Line.

Everything downstage of the Plaster line is called Front of House (FOH). Occasionally it is also called "Ante-proscenium" which means before the proscenium. Anything the audience can see on the stage is on-stage". Anything on the stage but out of the audience view is "off-stage" or "backstage". The floor is called the "deck".

The part of the stage in front of the Proscenium is the "Apron", or sometimes the "Thrust". The audience seating is the "Auditorium" or the "House".

Thrust Stage:

A stage surrounded by audience on three (3) sides. The fourth (4th) side serves as the background. In a typical modern arrangement: the stage is often a square or rectangle playing area, usually raised, surrounded by raked seating.

THEATER SPACES

End Stage:
A Thrust stage extended wall to wall, like a thrust stage with audience on just one side, the front.

"Backstage" is behind the background wall. There is no real wingspace to the sides, although there may be entrances there. An example of a modern End Stage is a music hall, where the background wall surround the playing space on three (3) sides. Like a Thrust stage the scenery is primarily in the background.

Arena Stage:
A central stage surrounded by audience on all sides. The stage are is often raised to improve sight lines.

Flexible Stage:
Sometimes called a "Black Box" theater, they are often big empty boxes painted black inside. Stage and seating not fixed. Instead, each can be altered to suit the needs of the play or the whim of the director.

Sports Arena:
Sport arenas often serve as venues for Music Concerts. In form they resemble very large arena stages, but with a rectangular floorplan. When used for concert, a temporary stage is up as an end stage on one end of the floor, and the rest of the floor and the stands become the audience. Arenas have their own terminology. The stage is usually set up at the loading dock end of the building for ease of setup. Opposite the stage is the Front of House (FOH), sometimes called "Sound World", as the mixing consoles are located here. Standard stage directions are usually used (Stage Right, Stage Left, Downstage, Upstage, etc.). The Monitor mixer often go SL and lighting dimmers go SR in Dimmer Beach. Seating is located on the main floor between the Stage and FOH, and also in the bleachers. Audience entrances from the "concourse" (lobby areas) into the seating bowl are called VOMs short for Vomitories, the old Roman name for such entrances.

FLY SYSTEMS

A fly system, flying system, or theatrical rigging system is a system of lines (e.g. ropes), blocks (pulleys), counterweights and related devices within a theater that enable a stage crew to quickly, quietly and safely fly (hoist) components such as curtains, lights, scenery, stage effects and, sometimes, people (e.g. Peter Pan). Systems are typically designed to fly components between clear view of the audience and out of view, into the large opening, fly loft above the stage.

Fly systems are often used in conjunction with other theater systems, such as Scenery wagons, stage lifts, and stage turntables, to physically manipulate the scenery.

theatrical rigging is most prevalent in proscenium theaters with stage houses designed specifically to handle the significant dead and live loads associated with a fly system. Building, occupational safety, and fire codes limit the types and quantity of rigging permitted in a theater based on stage configuration, Theatrical rigging standards are developed and maintained by organizations such as USITT and ESTA.

The Line Set:

The line set is the fundamental machine of a typical fly system.

The function of a typical line set is to fly (raise and lower) a slender beam (typically a steel pipe) known as a batten by hoisting it with lift lines (typically synthetic rope or steel cable). By hanging scenery, lighting, or other equipment to a batten, they in turn may also be flown. A batten is said to be "flying in" when it is being lowered towards the stage, and "flying out" when it is being raised into the "fly space". Battens may be just a few feet in length or may extend from one wing (side) of the stage to the other. A batten is suspended from above by at least two (2) lift lines, but long battens may require six (6) or more lift lines.

Line Set functions:

Line sets are typically general purpose in function, meaning they can perform any number of functions which vary depending upon the requirements of a particular theater production. For example, a general purpose line set can usually be quickly transformed into a drapery or scenery line set, but converting a general purpose line set into a electrical line set is more involved.

When a line set has a predetermined, relatively permanent function it is known as a "dedicated line set".

FLY SYSTEMS

Drapery and track line set:

Line sets often suspend theater drapes and stage curtains such as "travelers", "teaser, (a.k.a. borders), legs, cycs, scrims and tabs , as well as associated tracks , in order to mask the stage and provide backdrops. Line sets are sometimes dedicated to particular draperies, such as the main (grand) curtain and main border (valance) that mask the proscenium opening, but drapery locations can often vary.

Scenery line set:

In many stage productions, theatrical scenery is mounted to line sets in order to be flown in and out so as to quickly change set pieces during the course of a performance. For example, painted soft and hard flats (e.g. muslin drops) are used to depict settings. Also, three dimensional sets (e.g. box sets) may be flown.

Electrical line set:

Electrical line sets commonly called "electrics" are used to suspend and control lighting instruments and in many cases microphones and special effects equipment as well. Electrics may be temporarily "wired" with drop boxes (electrical boxes with outlets) or multicable "fanouts" dropped from the grid or draped from a fly gallery, or permanently wired with "connector strips" (specialized electrical raceway).

There are normally at least three (3) electrical line sets provided above the stage, with one just upstage of the proscenium wall, one mid-stage, and one just downstage of the cyc. Additional electrics are typically desirable.

Fire Safety curtain:

A permanently installed "fire curtain" line set, though not used for productions, it is a typical element of a theatrical rigging system installation. Building and fire codes typically require that either a fire curtain or "water deluge" system be installed to separate an audience from the stage in the event of a fire.

FLY SYSTEMS

Fly System Types

Fly systems are broadly categorized as "manual" or "automated" (motorized). Manual fly systems are more specifically categorized as "hemp" (a.k.a. rope line) or "counterweight" systems.

Hemp Rigging System:

A hemp fly system, so named for the manila hemp rope that was once common in theatrical rigging, it is both the oldest and simplest type of fly system. Hemp systems are also known as "rope line" systems or simply as "rope" systems.

Stage rigging techniques draw largely from ship rigging. That origin is most obvious with hemp rigging, which uses closely related technology and terminology. To this day , the stage is referred to as a "deck" in the manner of a ship's deck. Other expressions that overlap the nautical and theatrical rigging words include: batten, belay, block, bo'sun, cleat, crew, clew, hitch, lanyard, pinrail, purchase, trapeze and trim.

In a typical hemp system line set, the lift lines and hand (operating) lines are one in the same. The lift lines run from the batten up to "loft blocks", across the stage to a "head block" and back down to a "pin rail", where the lines are tied off, "belayed" with "belaying pins". A "trim clamp" (a.k.a. knuckle buster) is used to attach the sand bags to the lift lines to balance the load placed on the batten. The sandbags are usually filled to weigh a few pounds less than the load, making the line set batten-heavy (load-heavy) so it will fly in under its own weight when the lift lines are let out.

Another hand line, known as a "jack line" may be used to lift the sandbags if they are heavier than the batten load. The jack line, which runs up to a loft block and back down to the trim clamp, is tied off to a belaying pin adjacent to the one used for the line sets lift line, either at the same or secondary, pin rail.

Pulling on the hand lines of a hemp set flies a line set out. Pulling on the jack line flies a line set in.

Hemp systems can be easily configured for spot rigging, where lift lines must be frequently relocated. They are much less expensive and easier to install than counterweight fly systems, though somewhat more difficult to operate.

FLY SYSTEMS

Counterweight Rigging System:

Developed in the first half of the 20th century, counterweight rigging systems are the most common fly systems in performing arts facilities today.

In a typical counterweight fly system, an " arbor" (carriage) is employed to balance the weight of the batten and attached loads to be flown above the stage. The arbor, which carries a variable number of metal "counterweights" moves up and down vertical tracks alongside an offstage wall. In some lower capacity fly systems, cable guide wires are used instead of tracks to guide the arbors and limit their horizontal play during vertical travel.

The top of the arbor is permanently suspended by several wire rope "lift lines" made of galvanized steel aircraft cable. The lift lines run from the top of the arbor up to the top of the fly tower, around the "head block", across the stage to evenly spaced "loft blocks", then down terminating at the batten, a load-bearing pipe that spans much of the width of the stage.

If the loft blocks are mounted to the "grid deck", at the "loft block wells", the system is called a "grid mount", or "upright" counterweight rigging system. If the loft blocks are mounted to roof beams, the system is called an "under-hung" counterweight rigging system. Under-hung systems have the advantage of maintaining a clear grid deck surface for spot rigging and facilitating crew movement across the grid.

The arbor's vertical position is controlled by the means of a rope known as the "operating line", "hand line", or "purchase line":. The operating line forms a loop by running from the bottom of the arbor down to and around the "tension block", through the "rope lock" , up and over the "head block" and back down (alongside the lift lines), where it terminates at the top of the arbor. The head and tension blocks are located above and below the full extent of the arbor's travel (movement), respectively, thereby enabling an operator to pull the operating line up or down to move the arbor. When the arbor is raised via the operating line, the lift lines slacken, which causes the batten to lower under its own weight (and the weight of its load if any). Conversely, when the arbor is lowered, the lift lines increase in tension, which in turn causes the batten to rise.

The combined weight of the arbor and its counterweights initially matches that of the batten, so that when the batten is not being raised or lowered, it will tend to remain motionless at any arbitrary elevation above the stage. As more weight is added to the batten (in the form of curtains, scenery, lighting equipment, and rigging hardware), the system is rebalanced by adding more counterweights to the arbor. When the system is properly balanced, an unassisted operator ("flyman") can lift the batten and its arbitrarily heavy load from the stage, completely above the proscenium and out of view from the house, sometimes to heights in excess of seventy (70) feet.

Double Purchase Counterweight Systems:

"Double purchase counterweight systems" are sometimes used where the vertical travel of the counterweight arbor would be inadequate due to limited fly space or limited off-stage space at the stage deck. In systems of this type, the operating and lift lines are "double purchased" so that the batten can travel twice the distance of the arbor. In other words, for every foot of arbor travel, the batten travels two (2) feet. Often times this means the arbors remain well clear of the stage deck below, leaving the otherwise occupied wing space usable for the cast and crew.

In a conventional counterweight system the operating and lift lines terminate at the top of the arbor after passing over the head block. In a double purchase system, however, after passing over the head block the operating and lift lines pass through another block mounted to the top of the arbor before rising back up and terminating below the head block. In addition, the opposite end of a double-purchase operating line terminates at the "fly gallery", off stage wall, or stage deck, instead of the underside of the arbor, after passing through a block mounted at the underside of the arbor. The additional blocks result in the arbor moving at half (1/2) the rate of the lift and operating lines.

In order to compensate for the reduced arbor travel, the loaded arbors must weigh twice as much as the batten load, resulting in arbors that are twice as long. The additional mass on the arbor increases inertia and the additional blocks increase friction, resulting in line sets that are more difficult to operate. In addition, double-purchase lines sets are also more expensive to install and maintain. For those reasons, double-purchase line sets are generally avoided, or limited to a few sets within a counterweight system, unless space issues preclude the use of a (space for arbor travel.

Automated Rigging Systems:

Electrical hoists (also referred to as winches) can facilitate coordination with cues, move extremely heavy line-sets, and significantly limit the population of the fly crew. Despite those potential benefits, most hoists can fly line sets at only a fraction of the speed that an experienced flyman can achieve manually.

There are two (2) general categories of motorized fly systems, "motor assist" and "dead-haul".

"***Motor -assist***" systems closely resemble standard counterweight fly systems described above, however a drum winch, typically mounted behind the locking rail below the arbor, is used to drive a steel cable purchase line. The purchase line is still terminated at the top and bottom of the arbor, but a rope lock is not used on the motor-assist line set.

Weight on the arbor helps balance the batten load so that the hoist motor size can remain relatively small. It is often feasible to retrofit a standard counterweight line set to become a motor-assist set.

"***Dead-haul***" systems fly the entire load placed on a line set without the assistance of counterweight. Therefore dead-haul motor sizes are relatively large.

Hoist (winch) motors are either "fixed speed" or "variable speed". Fixed speed motors are used at heavy-load and/or slow-speed line sets (e.g. electrics and orchestra shell line sets). Variable speed motors are used at line sets requiring dynamic motion that may be viewed by the audience (e.g. drapery and scenery line sets). scenery hoists commonly allow travel at rate of hundreds of feet per second.

Digital control systems incorporating computers or programmable logic controllers (PLCs) have become commonplace as well, bringing their advantage of high accuracy, safety, and repeatability to fly systems.

Fly Systems Components:

Battens:

Battens are linear members, typically steel pipe, to which live loads may be attached for flying. Loads mounted to battens include lights, curtains and scenery so they may "travel" vertically, be raised up into fly space (flown out) or lowered near to the stage floor (flown in) by its associated line set. Battens usually stretch the width of the stage, parallel with the proscenium wall, and are maintained level (parallel to the stage deck) regardless of elevation. When a batten is flown all the way out (close to the grid) it is at "high trim". When it is flown all the way in (usually about 4' off of the stage deck) it is at "low trim".

Loads are attached to the batten in various ways. Most lighting fixtures, for example, utilize a C-clamp to rigidly secure the light onto the batten, in conjunction with a safety cable that is looped around the batten to prevent the light from falling should the C-clamp connection fail. Non traveling curtains (e.g. borders) often employ cloth ties, similar to shoe laces, that are tied onto the batten.

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Battens are suspended by evenly spaced lift lines, with "pick points" generally nine (9') to twelve (12') feet on center. The unsupported cantilevered ends of a batten, beyond the last lift line pick points, are generally no longer than three (3') feet unless a "bridle" is used to effectively limit the cantilever.

Standard Pipe Batten:

Battens were originally made from wood, but have been replaced by steel pipe. In the United States they are typically fabricated from twenty-one (21') foot sections of 1 1/2" nominal diameter, schedule 40, steel pipe that are spliced together (with internal pipe sleeves and bolts) to provide a continuous member that stretches the width of the stage. Standard pipe battens are typically designed to support fifteen (15) to thirty (30) pounds of live load per foot of pipe.

Truss Batten:

Truss battens, sometimes referred to as a double batten, use a pipe over pipe arrangement (often twelve (12") inch center to center), with vertical struts welded between the upper pipe and lower pipes to provide rigidity. Truss battens generally permit greater loads than a single-pipe batten and may not require as many lift lines due to improved ability to span between lift lines. Truss battens are typically designed to support twenty five (25) to fifty (50) pounds of live load per foot.

Electric Batten:

An electric batten, a.k.a. "lighting batten", may be a single pipe or truss batten. Electric battens typically incorporate steel straps that are used as brackets for the support of electrical equipment such as "connector strips" (raceways). The same straps supporting electrical equipment may also connect the two (2) pipe arrangement of a truss batten. The center-to-center spacing of electric truss pipe (often from 1'-6" to 2'-6") is typically greater than for a standard truss batten to allow for the proper mounting and focusing of lighting instruments. It is typical for an electric batten to support thousands of pounds of live load.

FLY SYSTEMS

Lines:

Lines are the ropes, cables (wire ropes) and proof coil chains that enable a fly system to function. Steel bands are a relatively new type of line used in "steel band hoists".

It is standard practice for overhead rigging lines and hardware to be rated with at least a eight (8) times safety factor to help ensure the protection of the cast and crew. In other words, a line intended to support 100 pounds should have a safe working load of at least 800 pounds.

Lift lines:

carry and transfer the loads of a fly system to the fly system infrastructure. The lift lines for manual rigging run from the batten up to loft blocks, across the stage to a head block, and down to the counterweight balancing the load on a line set. When running horizontally, between loft blocks and head block, lift lines typically follow a transverse path (side to side) across the stage.

Operating lines:

also known as "hand lines" or "purchase lines" are what the crew uses to manipulate manual fly systems. Operating lines are connected to sandbags (in a hemp system) or the top and bottom of arbors (in a counterweight system). Operating lines are typically 5/8" or 3/4" in diameter.

Lift and operating lines were commonly made of manila hemp. The rope was often simply referred to as "manila". Use of manila had a number of issues. Splinters of fiber could get into hands and eyes. Humidity and temperature changes could significantly affect the length of the rope. Over time the rope slowly rots. Synthetic rope can reduce or eliminate these issues, while providing greater strength by volume. Over time polyester rope became more than manila in hemp systems and for use as the operating lines in counterweight systems.

The lift lines of a counterweight rigging system are typically a specific type of steel wire rope known as galvanized aircraft cable (GAC). Oil free 1/4" diameter, 7 x 19 strand, GAC is the most common counterweight system lift line. It has a minimum cable breaking strength of approximately seven thousand (7,000) pounds.

Line Control:

Load bearing lines must be safely tied off, locked, terminated and/or connected to other rigging components to ensure line control and the safety of a fly system. Various methods are employed.

FLY SYSTEMS

Belaying pins:
are used to "belay", temporarily tie off, the ropes lines of a hemp system . Each belaying pin serves as a anchor to which the loose end of a rope may be quickly secured. A standardized method is used to tie off the rope so that it is subjected from friction from itself as well as from the pin rail, thus ensuring a secure connection that is unlikely to fail. Belaying pins are typically made of hickory wood or steel.

Knots:
such as the "clove hitch" and "half hitch" are used for rope line terminations. For example hitches are used to terminate hemp lift lines at battens and operating lines at counterweight arbors.

Rope locks:
are cam-actuated devices through which a counterweight system operating line passes. The adjustable cam or "dog", inside the rope lock constricts and releases the operating line as the flyman lowers and raises a hand lever. Rope locks are mounted in series to the locking rail. A single rope lock can typically secure a static unbalanced load to fifty (50) pounds. Rope locks are not intended to slow a running line.

Swage:
(compression or nicopress) fittings or "cable clips" are used to terminate counterweight system lift lines, after the cable has been looped around a "thimble". Cable clips terminations maintain less load capacity than swage fittings, typically require three clips, and are greatly reduced in load capacity if the installer happened to "saddle a dead horse". Both swage and cable clip terminations permanently crimp (deform) the wire rope.

Trim chains, shackles, turnbuckles, and pipe clamps:
typically connect the lift lines of a line set to the batten they . Those connections facilitate minor adjustments to "trim", the effective length of a lift line. By trimming the lift lines, loads are more evenly distributed to them. Turnbuckles are moused (secured against free rotation) to prevent the jaws from slowly unscrewing over time due to vibrations incurred during normal use.

FLY SYSTEMS

Blocks:

A "block" is a pulley used to support and direct lift and operating lines. A block consists of a grooved wheel, known as a "sheave" (pronounced "shiv"), steel side plates, spacers, shaft, flange bearings, mounting angles and clips, etc. Blocks are sized based on anticipated live loads, operating speeds, line type and other factors. Sheaves were traditionally fabricated of cast iron, but steel and nylon sheaves are now common.

Blocks are either "upright", when mounted atop a support structure, or "under-hung", when mounted to the underside of a support structure.

The side plates of blocks preferably fully cover the profile of (fully enclose) the sheaves to lend the block greater stability and limit the sheave's (and crew's) potential damage from foreign objects. Nevertheless, blocks are available with exposed sheaves.

Loft Block:

A "Loft block" is an overhead block that supports a single lift line. A loft block supports and redirects a lift line from the batten to the head block of a line set. Under-hung loft blocks typically mount to "loft block beams" (fly loft roof beams). Upright loft blocks typically mount to "loft block wells" (grid-level structural channels). A "spot block" is a readily moveable loft block for mounting anywhere on the grid deck for support rigging.

The diameter of a loft block sheave for galvanized aircraft cable is typically at least 32 times the diameter of the cable. For example 8" loft blocks are typically used with 1/4" GAC, but 12" blocks may be used to facilitate flying heavier line sets (e.g. electrics).

Loft blocks may be equipped with "idler pulleys" or "sag bars" to limit the sag of horizontally running lift lines on under-hung systems.

In under-hung counterweight systems that use "upright head blocks" the series of loft blocks immediately following the head blocks are typically multi-line loft blocks instead of single-line to account for built-in vertical misalignment between head blocks and loft blocks.

Head Blocks:

are overhead multi-line blocks used for the lift lines and operating lines. Head blocks support and redirect all the lift lines from loft blocks to sand bags (of a hemp set), counterweight arbor (of a counterweight set) or hoist (or an automated line set).

FLY SYSTEMS

Rope line (hemp) head blocks are typically upright blocks that mount the "rope line head block well" channels at the grid level.

In a counterweight rigging system the head block sheave is grooved for both the steel cable lift lines and an operating line, with the groove for the operating line provided at the middle of the multi-grooved sheave, between the lift lines. Counterweight head blocks mount atop or at the underside of the head block beam, depending on the beam's vertical position.

The diameter of a head block sheave used for galvanized aircraft cable is typically at least 48 times the diameter of the cable. For example 12" head blocks are typically used with 1/4" GAC, but 16" blocks may be used to facilitate flying heavier line sets (e.g. electrics).

Mule Blocks:
Lift lines sometimes require diversion to avoid obstacles, support non-linear loads and battens, deal with excessive "fleet angles", or be reoriented from the typical transverse path across the stage (e.g. for tab and light ladder line sets). "Mule blocks" are single or multi-line blocks able to divert the path of those lines. Mule blocks may be permanently installed as part of counterweight rigging systems, or used for spot rigging, where they are often equipped with swivel-pivots to divert lines across a large range of angles.

Tension Blocks:
are single-sheave blocks located at the lower end of the arbor guide track, beneath the arbor. The operating line is reeved through the tension block from the bottom of the arbor through the rope lock. Tension blocks typically ride vertically along the arbor guide system track, instead of being fixed, to allow for variation in the length of the operating line.

FLY SYSTEMS

Counterweights:

Counterweights are one of more sandbags (in hemp systems) or metal bricks (in counterweight systems) used to balance the line set loads. The term "counterweight" is commonly used to refer specifically to metal counterweight bricks.

Metal counterweights are made of lead, pig iron, or flame-cut steel. Flame cut steel bricks are most common. In any particular fly system all weights typically share a common, standardized footprint that matches the system's arbors and corresponds with line set spacing. Counterweight systems are most often designed to used either 4 or 6-inch (150 mm) wide weights. Weights vary in thickness, typically in half-inch increments ranging from 1/2 to 2 inches (51 mm), with each thickness corresponding to a different mass. 1" thick weights are most common. Counterweights are sometimes known as "bricks" or simply "steel". Often a rigging worker will be asked to load a number of inches of steel, which correlates to a specific mass. Weights are usually loaded from the loading bridge, but can also be loaded from the fly gallery or stage deck in some circumstances.

When viewed from the top, metal counterweight is basically rectangular, typically with 45-degree angle chamfers cut at two opposing corners. A slot is cut into each end of the weight so as to enable the weight to straddle, and be laterally secured by, the arbor rods. In order to facilitate removal of weights with angle cuts, it is customary to stack the weights in alternating orientations so that the square corners of any weight will be aligned with the angled corners of adjacent weights. This simplifies removal because the protruding square corners of the topmost weight effectively serve as "handles" that can be easily gripped, even with gloved hands.

It is customary to apply paint (typically yellow) or colored tape to the weights that counterbalance the batten (pipe) to indicate that they should not be removed from the arbor. As an additional precaution, they may be strapped in with steel strapping. When a dedicated line set carries a permanent load (e.g. main drape, orchestra cloud, etc) the counterweight balancing the additional load may be treated in a similar fashion.

FLY SYSTEMS

Arbors:

A "counterweight arbor" is a sturdy mechanical assembly that serves as a carriage for counterweights. In its simplest form, an arbor consists of two horizontal steel plates, a "top plate" and "bottom plate", tied together by two vertical steel "connecting rods ". Counterweights are stacked as required on the arbor's bottom plate to balance the line set load, with the weights held in place by connecting rods.

A flat "tie bar" at the rear of the arbor also connects the top and bottom plates. "Guide shoes" at the top and bottom of the tie bar guide the arbor along tracks mounted to the side stage wall. UHMWPE pads on the guide shoes limit friction between guide shoe and track as the arbor travels.

"Spreader plates" are thin steel plates with holes through which the arbor connecting rods pass. Spreader plates are lowered onto the counterweights in a distributed fashion as the counterweight stack is being built. Typically one spreader plate is placed on top of every two feet of counterweights and spreader plates and secured in a place with a thumbscrew.

Spreader plates serve to maintain consistent spacing between the arbor rods to ensure reliable containment of the counterweights under normal operating conditions. Also, in the event of a "runaway" (loss of control of an unbalanced lineset), the spreader plates will prevent the arbor rods from bending outward, and thus releasing the counterweights upon arbor impact at the end of its travel.

In order to avoid unreasonably tall counterweight stacks at high capacity line sets, arbors may employ more than one counterweight stack. Such arbors use multiple-width top and bottom plates with a tie bar and pair of connecting rods provided at each counterweight stack.

Counterweight rigging systems use either "tracked" or "wire-guided" arbor guide systems. The tracks or wire guides limit lateral movement of the arbors during arbor travel. Wire-guided systems have lower capacities and are not in common use.

In addition to guiding the arbors, a tracked counterweight system is provided with "bump stops" at arbor high and low trim that establish the limits of an arbor's travel.

A tracked guide system is sometimes referred to as a T-bar wall, as the tracks are commonly made of steel T-sections. Aluminum arbor guide tracks are a relatively recent alternative, often using a J profile, instead of a T profile, to facilitate system installation.

FLY SYSTEMS

Hoists:

Hoists of various types are used in manual automated rigging systems. The terms hoist and winch are often used interchangeably in theater jargon. Hoists are generally assumed to be motorized unless "manual" is used as a descriptor.

"Manual hoists", or "hand winches", are typically composed of a drum, gear box, and crank (operating handle). A worm gear is commonly used to provide mechanical advantage as the crank is turned, which coils a single line around a smooth or helically-grooved drum. The drum line is connected to the lift lines with a "clew", triangular plate with holes used for line terminations. From the clew, the lift lines run over a head block and loft blocks down to a batten. The clew may be wire guided to limit lateral play. Drill operated hand winches permit the handle to be removed so that an electric drill may operate the hoist.

Drum hoists:

are typically composed of an electric brake motor and multi-line helically-grooved drum. Helical drums are preferable to smooth drums for cable longevity and the precise and repeatable control of travel.

Drum hoists are used for motor-assist, engaging an operating line, and dead-haul, engaging the lift lines, applications.

A dead-haul drum hoist uses the single drum to support all the lift lines running from the head block of a line set. The lift lines neatly wrap and unwrap in a side-by-side arrangement on the drum as it is spun by the motor.

As a lift line coils and uncoils from the drum of a drum hoist, its fleet angle (angle of a line between drum and sheave) changes. Excessive fleet angles (e.g. greater than 1 1/2 or 2 degrees) cause unpredictable line behavior and can damage lines, blocks, and drums. As a result, fleet angles limit how close a dead-haul drum hoist can be mounted to the head block (usually about 10 feet).

A" moving drum hoist" is a variation on the traditional drum hoist. Moving drum hoists effectively eliminate the fleet angle between drum and block by shifting the drum along its axis as it spins. The amount of shift per drum revolution is equal to the pitch of the drum's helical groove. With the fleet angle problem resolved, moving drum hoists can combine drum and head block into a single, relatively compact, unit for mounting to fly loft structure, with a corresponding reduction of installation cost.

FLY SYSTEMS

Line shaft hoist:

are typically composed of an electric brake motor, line shaft (drive shaft) and evenly spaced single-line drums aligned above the batten pick points. By placing an individual drum over each pick point, line shaft sets have the advantage, over drum sets, of eliminating the need for blocks. To avoid lateral drift of the batten as the lift lines pay out of the grooved drums, the helical groove orientation on the drums of the line shaft may be alternated between drums to balance competing fleet angles. However the elimination of drift may be compromised by limited batten travel.

"Yo-yo, or pile-up hoists" are typically line shaft hoists that use yo-yo type devices instead of drums. Yo-yo hoists are typically used where lighter loads are imposed (e.g. for operating an Austrian puff curtain). Because yo-yos lines pile-up (coil), the velocity and travel of the lines are relatively hard to accurately control.

Point hoists:

also known as "spot line winches", control a single lift line and are commonly used for automated spot rigging or flying rigs. A point hoist may operate in solitude, or in unison with other point hoists to comprise a line set.

Point hoists using wire rope (GAC) are common, and steel band point hoists are also used. operate at relatively high speeds. Wire rope spot line winches may pay out to the side, for use with a loft block, so that only the block need be spotted above the pick point (instead of the entire winch).

Chain hoists:

more commonly referred to as "chain motors", are the most common form of point hoist, especially with touring musical shows (e.g. rock-and-roll shows), but are relatively slow. Chain motors can be mounted at the grid to hoist a load from above, or mounted at the load to "climb" towards the grid.

FLY SYSTEMS

Infrastructure:

"Fly system infrastructure" consists of the relatively permanent load-bearing and load-transferring structures of a stage house. The infrastructure, generally fabricated of structural steel members, is sized by a structural engineer during the design of a new theatre, or theatre renovation. Rigging system infrastructure ultimately limits a fly system's capacity.

Fly loft:

fly tower or fly space, is the large volume above the stage into which line set battens are flown, along with whatever load they may be carrying. In a full size fly space, the tower is preferably at least 2.5 times as tall as the proscenium, to allow a full-height set piece to be stored completely out of view of the audience while providing adequate travel distance for standard (single-purchase) counterweight arbors.

Grid deck:

gridiron deck, or grid", is a permeable working surface present at the top of many fly lofts that is used to support and provide access to many of a rigging system's components. Though originally constructed of wood, down-facing three-inch steel channels with three-inch gaps became the prevalent grid decking in the 20th century. Today, large-opening heavy-duty steel bar grating is most common in new theatres. The grid deck surface is usually rated to support live loads as well as all anticipated dead-hung equipment and hemp and motorized (e.g. chain hoist) spot rigging. Its permeability facilitates the mounting of equipment and the passing of lift lines and electrical cables. Spot rigging is not feasible without a grid.

The grid deck allows access to the "head block beam" and "loft block beams" of counterweight systems. Spanning from the proscenium wall to the upstage wall, these beams support the dead and live loads of a fly system. As per their names, counterweight system head blocks and loft blocks may be directly mounted to these beams. The head block beam is situated directly above the loading gallery. The loft block beams are spaced to match the "pick points" of the lift lines suspending the battens. The loft block beams may also be used to suspend the grid deck support structure.

A grid deck is indispensable in professional and touring theatres, and desirable in all theatres with a fly tower, providing invaluable access and flexibility to fly systems. However, due to height limitations, not all fly towers are equipped with a grid. Transverse catwalks are sometimes provided as compensation for the lack of a grid. San Francisco's War Memorial Opera House, not burdened by height limitations, has two grid decks.

Rope line (hemp) head block well:
channels sit atop the grid deck and are used for mounting hemp system head blocks. They are situated above the pinrail(s) below.

Loft block wells:
are ten inch gaps between pairs of face-to-face steel channels flush with the grid deck that occur beneath each loft block beam. The loft blocks of a hemp, or grid-mount counterweight, rigging system can mount to the loft block well channels. The loft block wells may also act as clear openings through which the lift lines of under-hung counterweight, or automated, systems may pass.

Loading bridge:
Specific to a stage house using a counterweight system, the "loading bridge", or "loading gallery", is a catwalk vertically positioned below the headlock beam, and above the fly gallery. The loading bridge is used to add or remove counterweights from arbors. The floor of the loading bridge is also typically used as a storage area for uncommitted counterweights that are available for loading onto counterweight arbors. Stage houses with especially tall fly towers, or double-purchase systems, may have two loading bridges, one stacked over the other to facilitate the loading of relatively tall arbors.

Fly gallery:
A "fly gallery" is a catwalk running from the proscenium wall to upstage wall to which a pinrail and/or locking rail may be mounted used by the fly crew to operate the fly system. The fly gallery elevation is typically at about proscenium height, providing a good view of the stage and fly loft. Fly galleries may be provided stage left and right, or at just one side. Where provided at both sides of the stage they may be connected by a cross-over catwalk at the upstage wall. It is possible to load arbors (add or remove counterweights) at the fly gallery, but standard practice is to load arbors at the loading bridge.

FLY SYSTEMS

Pin rail:

A "pin rail", originally a wood beam, is typically a large-diameter round steel tube with vertical through-holes that accept belaying pins used in a hemp rigging system. Depending on the pin rail design, the pins may be removable or permanently fixed to the rail. Pin rails are typically installed permanently at the onstage edge of the fly gallery(ies), extending from the proscenium wall to upstage wall, sometimes in a stacked (rail over rail) arrangement. Mobile pin rails may also be used and are bolted down to the stage deck where needed.

Locking rail:

A "locking rail" is typically a steel angle or rectangular tube to which the rope locks of a counterweight system are mounted. Locking rails are located on the stage deck and/or fly gallery and typically extend from the proscenium wall to the upstage wall.

A stage-level locking rail may be provided with an engaging bar for a portable capstan winch.

Arbor pit:

"Arbor pits", where provided, are troughs at the stage edge that provide additional vertical travel to a counterweight system's arbors. Providing a counterweight arbor pit can help compensate for height limitations of a fly tower. The trough depth typically ranges from 2 to 10 feet. Shallower pits may be accessible only from above at the stage deck. Deeper pits are sometimes accessible from a trap room or orchestra pit.

Operation:

Because fly systems involve large amounts of weight, and particularly because the weight is usually suspended above people, there are a number of precautions taken to ensure safety and prevent injuries. Communication, inspection, and loading procedure are a key to the safe operation of a fly system.

Except for during performances and some rehearsals, a standard practice in theatre is for the flyman to always call(shout) out a warning before moving a lineset so as to alert personnel (e.g., rehearsing performers and technicians) who are on the stage. People on stage typically acknowledge the operator's warning by yelling out a confirmation that the warning was heard.

A "runaway" is a moving lineset that cannot be safely controlled by its operator. Runaways can occur when the weight on the arbor is not equal to the weight of the batten and its load. Linesets are often intentionally unbalanced to facilitate quick flying in one direction and, in such cases, runaways are more likely to occur.

When loading a batten, or arbor in a counterweight system, it is imperative to control the balance of a set. The line set should be balanced before loading begins, then the batten flown in, the set added, and then the counterweight added from the loading bridge. The specific order is important because it keeps the set from being unbalanced in a position where it could run away. When it is batten-heavy (after the set is added, but before the counterweights) the arbor does not have anywhere to run away to as it is already at its grid stop (the upper end of the track). In cases where the set is too tall for the batten to be all the way in, it should be kept as far down as possible. It is always best to add the load in pieces as small as practical and counterweight them one at a time so the system can never get too out of balance. Improper loading procedure is a common cause of accidents in many theaters.

SOFTGOODS

Curtains: a cloth that fills the stage opening. Generally opaque, usually in a dark or subdued colors, made from heavy cloth. The best are made from velour, as this fabric is best at light absorption and has the lowest reflection. Curtains are usually hung with fullness, or pleating. Pleating may be sewn in, or created by hanging a long curtain on a shorter pipe, with the fullness tied in. Fifty percent (50%) fullness is common, meaning the curtain when stretched is half again as long as when tied on the batten.

Legs:
narrow curtains used as masking at sides of stage to hide wings.

Tormentors:
furthest downstage legs, the "torms". Used to reduce the size of the proscenium opening. Often hard , with a frame and hard substance beneath a velour covering.

Borders:
short curtains used to mask the top of the stage, to mask the fly loft.

Teaser:
furthest downstage border also used to reshape proscenium opening. Teaser is sometimes called the grand drape or the "Valence".

Portal:
a border and legs combined into a single piece with a large opening

Velour:
best cloth for curtains, a dull finished knapped fabric, really a form of velvet. Best at light and sound absorption and blocking, but also the heaviest and most expensive fabric for curtains.

SOFTGOODS

Duvetine:
lighter, cheaper substitute, a heavy fabric with brushed rather than woven knap. Looks almost like velour and weighs less, but doesn't work as well.

Corduroy: another substitute for velour, also cheaper and lighter weight; works well if it has a thin "wale". However the "wale" gives it a definite directionality.

Construction of Curtains:

Guillotine Curtain:
flies straight up and down. One of the most common curtain riggings.

Travelers or draw curtains:
split in the middle into two (2) panels and pulled open and shut on tracks, generally with a endless operating line. Usually operated by hand, but may be run with a winch, especially with remote control systems.

Braille curtain, or Austrian drape:
a curtain raised from the bottom using vertical parallel lift lines.

Tab or Tableau curtains:
also known as Venetian drapes: rigged similarly to braille curtains, but can be raised in various configurations because each lift line can be individually adjusted.

Contour or profile curtains:
also known as Venetian drapes: rigged similarly to braille curtains, but can be raised in various configurations because each lift line can be individually adjusted.

SOFTGOODS

Fullness:

Curtains, borders, legs may all be hung stretched flat, or may be hung with fullness.

Fullness is a gathering of the material of the soft goods to make it thicker and make it disappear in light even more.

Looks more attractive and finished than when hung flat.

Fullness is expressed in percentage of fabric folded back on itself, or how much longer material is than pipe length it takes up. Therefore: a curtain half again as long as the pipe it is hung on with the excess distributed as gathers or pleats, has 50% fullness. If it is twice the length of its batten, it has 100% fullness.

Fullness can be sewn in using any desired pleating system.

Gather

Z-fold

Box

Sewn fullness is easier to put up, only need to stretch the top out and tie to batten. Also, works well with traveller system; top can be pulled flat by the carriers but the fullness will stay evenly distributed. However, if fullness is sewn in, can't hang piece without fullness.

An alternative: use tied fullness. In this system, curtains are sewn flat but made longer than pipe. Piece is tied on with gathers.

Tied in fullness will not work well with travellers, as the carriers pull the fullness out as they extend. You CAN tie a sort of pinched pleat in by tying two grommets to each carrier, but that is all, and it doesn't work as well as a sewn fullness.

Other Softgoods

Scrims:

curtain made of an open weave fabric becomes transparent when lit from behind, but which appears opaque when lit from the front.

SOFTGOODS

Usually woven in one piece to avoid seams. Most scrims are of sharks tooth scrim, good compromise between transparency and opacity. Where almost complete transparency is desired there is bobbinets scrim.

Cycloramas or cycs:
large scrims used for simulating sky. Rigged far upstage, often on curved pipes to wrap around back of the scene. Usually hung with a Bounce, a white canvas curtain just upstage of the scrim cyc. The cyc gives effect of distance and the bounce gives opacity.

Transparency:
scrims "painted" with dyes to create a drop that is opaque and visible when front lit but which disappears to reveal a scene behind when back lit.

Drops, or backdrops:
large pieces of canvas which are painted to be scenery. To look natural as possible, must be stretched to get rid of wrinkles. Simplest way to do this is to sew a long tube called a pipe pocket into the bottom edge of the drop and insert a water pipe for weight. Wooden battens sandwiching the drop, or chain in a chain pocket are also used.

Full drop:
a solid piece of canvas, usually as large as the stage picture.

Cut drop:
a drop with holes cut into it for scenic effect. Often used for foliage drops, with leaf shapes cut into the edge and through the drop. Cut drop are often made using netting to hold the irregular edges and shapes of the cuttings in position.

Roll drop:
a method of rigging full drops in a theatre without a fly loft. The drop is tied to the batten above. The bottom is fastened to a round tube 4 to 6 inches in diameter. The ends of the tube sticks out beyond both ends of the drop by several feet. Ropes are wrapped around each end of the tube in opposite direction from the curtain wrap. When the ropes are pulled up, they upwrap

from the tube and cause the drop to wrap around the tube. When the drop is let in, the ropes wrap up around the tube as the curtain unwraps. The tubes were once made of wooden strips, but today are usually plastic or aluminum tubing. Cardboard rug cores also work for smaller drops.

Tripped drops:

Another method of flying out a long drop in a short fly house. Lift lines are attached to the bottom pipe (or to a pipe in a special pocket one-third of the way up the drop) and are raised to lift the bottom of the drop out of sight.

SCENE SHOP

Flat Assembly:

Stock lumber is almost never the size it claims to be.

For instance, wooden flat frames are typically built of either 1x3 or 1x4. Those numbers are supposed to be the cross sectional measure of the board. However, the actual true measure of a 1x3 is 3/4"x 2 1/2". It used to be 3/4"x 2 3/4". The actual measure of a 1x4 is 3/4x 3 1/2",a 2x4 is 1 1/2"x 3 1/2", and a 2x6 is 1 1/2"x5 1/2".

The nominal dimensions are meant to express the rough-cut measurement of the lumber before it is planed to a smooth finish.

The main thing to remember is that when you are cutting parts you must make sure that you deduct the actual rather than the nominal size of the lumber you are using.

The standard theatrical unit has long been the flat. This is an open frame covered with a lightweight material. Traditionally, frames were wood and were covered with painted fabric to represent wall. More recently, frames have been made of metal tubing and coverings have been thin plywood.

The standard flat, also referred to as a "theatre" or "Broadway" flat, is a wooden framework made of 1x3 or 1x4 pine. The frame pieces are laid flat to the surface of the unit, and assembled using butt joints held together with cornerblocks and keystones (pre-cut 1/4 ply gussets). The covering is canvas or muslin, glues to the frame. Cornerblocks: made of 1/4" fir plywood. These are the mechanical fasteners that hold the frame together. Cornerblocks are generally right triangles 10"x10". The surface grain should be across the joint at perpendicular or diagonal, NOT parallel to it.

Keystones are either rectangular or "keystone" shaped. The keystone shape is slightly stronger but takes longer to make. The keystone would be about 3 1/2"x 7"x2 1/2". The rectangular strap would be about 2 1/2 to 3"x7".

Cornerblocks and keystones are secured using an 11 nail/screw pattern for cornerblocks, and a seven to 10 nail/screw pattern depending on fastener and usage.

Once the standard fastener was the clout nail, a soft iron nail that clinched itself when nailed into a metal plate. Now standard fasteners are either pneumatic staples and glue, or since the advent of battery drills, 3/4" screws. Screws are quick and allow easy disassembly. Staples by themselves are not strong enough, but with glue are very fast and permanent.

After the glue is dry, trim the excess and size the flat with size water or a coat of paint to tighten the cover.

Hollywood or TV flat:

The frame boards are set on edge rather than flat, and may be made of 1x stock, or occasionally of 5/4 stock for rough duty. 1x3 and 1x4 is common, but 1x2 is generally sufficient if of good quality, and helps reduce the weight of the units, as well as significantly reducing required storage space. Instead of canvas, the frame is covered with 1/8" or 1/4" plywood, usually luaun. Luan is much weaker than fir, but it is lighter and the surface is much smoother.

Construction is simpler than a Broadway flat. The frame is simply nailed together like a box, and the surface nailed, stapled or screwed on. it doesn't need cornerblocks, as the cover will stabilize it. Each style has its advantages and disadvantages.

Broadway flats, when covered with canvas, are much lighter than a similar size Hollywood. One person can handle a flat. They are also somewhat cheaper in materials too, as canvas is cheaper per square foot than plywood. Canvas also gives a very good painting surface without obvious grain to fight. Since they only take about an inch to store, you can store a number in a fairly thin space Broadway flats are easy to assemble into corners, as they can be nailed, screwed or lashed.

Canvas flats are less rigid, so they require stiffeners and bracing to support walls of them, and the canvas can flap if the flat is bumped or a door in the wall is slammed. They take longer to build, and are fussier to construct. It is easy to get them out of square.

Hollywoods are easier to get square, somewhat easier to build, and don't flop in the breeze. They are easy to join together, can be clamped or screwed together. They are easy to paint, as you can use a roller instead of a brush.

corners are more difficult; you may have to use hinges on inside corners, or even build fillers on some outside corners. You have to pay some attention to the seams in the plywood, which otherwise show every 4x8 feet.

Metal flats:

The other technique for flat construction uses structural metal tubing, usually 1"x1" welded into metal frames, basically substituting metal for wood in standard flat construction. Steel is heavier but easier to work with . Aluminum is lighter, but needs inert gas welding for fabrication. Metal frame flats may be fabric covered, with muslin or other covering fastened to thin plywood strips glued and screwed to the frame, or may be hard covered with plywood like Hollywood flats. Metal flats are far more durable than wood flats, take less room to store than

Hollywood, but are more difficult to construct, requiring an entirely different set of skills and tools.

Platforms:

Platforms, parallels, stairways and ramps are necessary whenever a variation in floor levels is required.

Platforms are the most common units for adjusting elevations. There are two types, the rigid platform, which is usually just called a platform, and the parallel, which is a platform with a removable top and a folding frame.

The tops of platforms are, naturally, usually made of plywood. 3/4" is the usual thickness, but 5/8" is sometimes preferred for a small weight savings. A theatre should stick to one or the other, though, so that platforms with the same length legs will be the same height. Because plywood come in standard 4x8 ft., platforms are usually made in 4x8 units, or in some even division thereof.

Rigid platforms are usually made with frames of tubular metal, or of lumber. Each material has advantages and disadvantages. 2x4s are very commonly used. The wood is readily available, cheap and can be assembled with a variety of fasteners. The finished platform is 4 1/4" thick. Construction grade lumber is sufficient, although #2 is better. As disadvantages, 2x4 platforms must almost always be legged when used. The lowest level difference usually used is 6 inches, so even the bottom step of a stack of platforms needs legs to come up to six inches. 2x4 platforms must also be faced with 1/4 ply to give a smooth face, even on the bottom level.

1x6 platforms are another alternative,. 1x6 weighs about a quarter less tha 2x4, but is almost identical in strength. It does not have to be legged or faced when used for a 6" ride. When legged, it offers a longer diagonal for the bolts. On the minus side, 1x6 costs more, and you need to use a better quality board than for 2x4, adding further to the expense. #2 is the minimum, and Select is better. Each platform unit takes more space to store being thicker. 1x6 also splits easier, so more care must be taken with choice and placement of fasteners when assembling. This greater chance of splitting tends to negate the longer bolt diagonal of legs, so you need as much bracing as 2x4 platforms.

Strongest are platforms with tubular steel or aluminum for the frame. They require a qualified welder to build properly, but are most durable, esp. for a road tour. They are more difficult to leg.

Legging platforms:

The greatest advantage of stock platforms over plywood platforms or parallels is the ability to vary their heights easily by legging. There are three common methods for wooden platforms.

Simple bolted leg: A leg, usually of 2x4, is cut to the desired height minus the thickness of the platform lid. It is then placed inside the platform corner and two bolt holes are drilled through with holes placed diagonal to each other. The best bolt for this is the 3/8" Carriage bolt, usually about 1/2" longer than the platform and leg thickness combined.

This system is simple and direct, and reasonably strong. However, the weigh is carried only on the bolt holes, and if there are not enough legs or too much weight, the platform frame may split or the bolts might shift, causing the weight to be borne against the lid. This can cause the lid to pop.

Compression or step legs: For these, legs of the same thickness as the sides are cut to the height desired minus the overall thickness of the platform lid and sides. Then a bolt plate of 1x stock is laminated to the leg with screws and/or glue. This plate extends past the leg to the thickness of the platform frame minus about 1/4" or so. The extension plate can be the full length of the leg for a little extra strength, or can be applied to the top foot and a half or so of a long leg to save material. Compression legs are stronger than simple legs; the weight of platform bears directly onto leg in compression, rather than by the bolt holes in sheer, so much more wood bears the weight. The sides won't split and the lid never carries the load. Since the bolts are not load bearing, they can be smaller, 1/4" rather than 3/8". Often flathead bolts are used rather than carriage bolts, so even the slight bump of a carriage bolt head is avoided.

Trestles are another useful system, especially where large raise decks will be used. Also called "Knee walls", these are built like stud walls of a house, with top and bottom plates and vertical "stud" legs on two to four foot centers. The stud frame overall is the height of the deck minus the thickness of the platforms. The trestles are set in place and platforms are set on top of and secured to the top plates of the trestles. Trestles are placed on two to four foot centers, and may run under several platform units. Essentially it is a decking system rather than individually legged platforms fastened together.

Trestles may be built a stock and stored for future use. Trestles are a little slower to build, and bulky to store, but allow extremely fast assembly of large decks one the trestles are built. Trestles are very common as legs for metal framed platforms.

SCENE SHOP

Parallels:

An alternative to the rigid platform is the parallel. This consists of a series of trestles built flat like Broadway flats, and hinged together to make a folding platform frame. The frames are hinged together so they can fold up with the lid removed, but be held rigidly open when the lid is in place. Parallels come in two flavors, standard and continental.

The "standard parallel" is made with full-length side frames, and one-piece end and center frames. The frames are hinged together so that the frame folds like a big parallelogram.

Standard parallels can be almost any size so long as the ends and sides are parallel. It can be square, rectilinear, or even a skewed parallelogram. It requires fewer parts than an equivalent continental parallel. A folded standard parallel when folded is the combined length of one long side and one short end.

The other flavor of parallel is the "continental parallel". The ends and center frames are made of two identical individual frames, each half the size of the overall width. Combined, two of these equal one end or middle gate of the American style. The biggest advantage of continental parallels is that the frame when folded is the same length as the opened platform.

There are more restrictions on the size of continental parallels. The ends cannot be longer than 1/2 the length of the sides. Otherwise, the frames when folded run into each other and the frame cannot fold completely.

A word about platform lids. The tops of platforms and parallels are usually made of 3/4 plywood. CDX is usually sufficient, although occasionally AC or BC may be used instead if appearance matters. You can get away with 5/8" plywood for a small weight reduction, but don't go any lower, or the platform will be bouncy.

Also, when legging platforms, your legs should probably be no more than 4 ft. apart if possible. A platform may be supported just at the corners, but it will be bouncy; also if the load becomes too great, or there is dancing in it (synchronized dynamic loading), or if the side board has a knot in the middle it can break. Placing the legs four feet apart will cure those problems.

SCENE SHOP

Stairs and Stairways:

Many sets call for multiple levels, which call for stairways.

Stairs consist of several parts. The "tread" is the part that you walk on. The "carriages" are the sides of the staircase that support the treads. "Risers" are the boards that close in the front of each tread. "Stringers" are similar to carriages, but support the center of the treads. Carriages come in two forms. The "open carriage" is often used on stage and look like a stairway from the side. The rise and tread surfaces are cut into the carriage boards, and the treads and risers are fastened to the cut surfaces. It is important to remember that the carriage is only as strong as the part of the board that is left uncut. For this reason it is common to use 12" nom. lumber for carriages as this leaves the maximum board left after the steps are cut out.

The other type of carriage is the "closed carriage". The whole width of the board is left after the stairs are built. Treads are supported either by dadoing grooves into the carriages (the system used form finer stairs in houses), or they may be attached to wooden or metal cleats nailed to the carriages. Be careful not to use drywall screw to attach cleats. They break in shear, and may fail when someone runs down the stairs. In houses, cleated closed carriages may be found in basement stairways. In theatre they are common for escape stairs which are used to get off a set backstage.

Open carriage stairs may be made with lumber, which will have to be supported somehow but which take less space in storage, or they may be built with plywood sides which are self supporting, but which take a lot more room to store.

There are two general ways to describe stairs according to their support: independent and dependent.

"Independent stairs" are stairs that hold themselves up. If they are plywood stairs, the sides go all the way to the ground and also close in the space under the stairs. If they are board sided stairs, they can be legged like a platform with standard legs. The stairway would need to be closed underneath separately. Independent stairs put no stress on the platform they are beside, but they are bulky to move and store.

"Dependent stairs" need the unit they are against to hold them up. This can be done by bolting the stairs to the platform or platform legs, or using a support board that is nailed to the adjacent platform, to which the stairs are hooked. Dependent stairs are not self-supporting but take less room to store.

The legs on stairs can also be made to fold if a single bolt is used or if a flat type frame is used to hold the top of the staircase up. Be sure to use solid bracing to support the legs so they don't collapse.

Laying out Stairs:

Carriages should be laid out using a consistent rise to run ratio to prevent tripping. There are several "rules of thumb" which will help determine a proper ratio to make stairs comfortable to use. An easy one is the Rule of 17:

When measured in inches: Tread + Rise approximately = 17

For example: for an 8" riser, use a 9" tread, because, 8" + 9" = 17"

If stairs are more than about two feet wide, you will need to support the stairs somehow or they will sag in the middle under weight. The usual method is to use a middle stringer, Attoucak stringer looks basically like an open carriage, even on closed carriage stairs. There are other methods but this one works well.

Joints:

There are a number of types of wood joints. Some lend themselves to theatre use, some do not.

"Boards" have Faces (the wide side), Edges and Ends. Joints can be made on all these surfaces, but ht joints are not all equal. The strength of a joint will depend on the surface area of the joint. Faces have more surface then edges, and are therefore stronger; edges likewise have more surface than ends.

By far the most common in theatre construction are butt joints and lap joints.

Butt joint:
formed when a square cut end is placed against the side of another board. Used for construction most scenery, and are held together with fasteners and gusset plates. In theatre, the gussets are corner blocks and keystones.

SCENE SHOP

Lap joints:
when two boards overlap.

The strength of lap joints depends on how much of the joint actually overlaps.

Half laps:
half of each board is cut away before lapping.

Has most of the strength of the lap joint, but makes a finished joint only as thick as the stock.

Miter joint:
made when two complimentary angle are joined. For 90 degree angle, the complimentary angles are 45 degrees.

Scarf joints:
are complimentary tapered like two wedges fitted together ; when jointed it creates a board similar to a whole board.

Dado and rabbet joints:
are similar. A groove is cut into a board face forming a dado. A groove cut on the edge form a rabbet. They are strong, but rather putzy to make, and so are used mostly to build shelves, etc. that need the strength.

Mortise and tenon joint:
strongest of all shop made joints. A socket is cut in one side, and a tongue to fit it in the other. Somewhat tedious and time-consuming to construct, but very strong and stable. It used to be used for toggle rail shoes on flats, but those have been mostly replaced by cornerblocks and keystones.

Dowel joints:
simpler replacement for mortise and tenon. Not as strong but are much easier to make. They are commonly used for building furniture.

Spline Joint:
Is a variation of the dowel joint using a strip of wood glued into grooves cut in both boards. Splines are a good way to reinforce miter joints.

Biscuit joint:
Is another variation using wooden wafers instead of dowels.

Dovetail joint:
a joint usually found only in very fine cabinetry or furniture. Perhaps the strongest wood joint available, as the wood is locked into place without depending only on mechanical fasteners or glue. rarely worth the bother of making in theatre, but might be useful where high strength is needed. a prime example is when building drawers in a permanent prop.

Fasteners:

A variety of Fasteners are used in theatre construction, but these days screw have replaced most other fasteners. The best are drywall screws and the similar utility and deck screws. These are pointed with sharp threads and heads that self sink themselves in soft materials like pine and fir, although they may break off or strip out in harder materials. Most drywall screw use Phillips head screws because they work well in electric drills. Battery powered drills are most convenient for this. Some shops use square socket (Robertson) screws because they give even better torque than Phillips heads. Screws are sized by number and length, from #2 up to #12, and by the inch fraction diameter above that. The rule of thumb as to appropriate length is to use a screw at least twice as long as the top layer of material you are fastening down.

Very heavy screws with hex heads are called lag screws. They are used where extra strength and holding power is needed, and have a hex head so they can be turned in with a wrench.

SCENE SHOP

Nails used to be the standard fastener but are much less common because of screws. Nails are usually measured by the penny. A nail penny for common nails was once about the weight of a penny coin, so that a 2 penny nail weighed about the same as 2 pennies, a 10 penny nail weighed about 10 pennies, etc. A more useful way to look at it is that a 6d nail is about 2" long, and for each penny above or below that add or subtract 1/4". A 4d nail is 1 1/2", a 10d nail is 3", etc.

Nails come in different weights.

Common nails:
for general construction, with a fairly heavy shaft and a reasonably large head. Suitable for building frames with 2x stock but may split thinner wood unless a pilot hole is drilled first.

Box nails:
thinner nail with a slightly smaller head. Doesn't split thin wood as easily , but because they are thinner they don't hold as well.

Sinker or coated nails:
are coated with a rosin based glue. Holds as well or better than common nails, while resisting splitting like box nails. Because they are thinner, they do bend easier than common nails.

Finishing or casing nails:
are have small but slightly different head for finishing work. The heads are inset below the wood surface to be inconspicuous. They will pull through the wood easily, though.

Duplex nails:
also called scaffolding nail or hollywood , is like common nail, but has one head on top of another. When pounded in to the first head, the second head is exposed for pulling nail out easily. Has mostly been replaced by drywall screws.

SCENE SHOP

Staples:
come in lightweight wire for lightweight materials like fabric, and heavier wire for wood, plywood, etc. and with narrow crown or wide crown. These latter, need heavy, usually pneumatic staplers to drive. Staples do not hold very well, so they are usually used with glue to hold wood together until the glue dries.

Where screws will not hold well enough, bolts are used.

Bolts:
are threaded to take a nut as a fastener, and are usually stronger than screws. Bolts come with flat heads, round heads, pan heads, square heads, and hex heads, among others. The most common in the theatre is the carriage bolt, originally meant for building horse-drawn carriages. They have a domed head to avoid catching on things and a square or knurled collar which sinks into the wood so the bolt won't turn. On the other end are the threads for the nut. To keep from having the nut pull into the wood, you need to put a washer between the wood and the nut.

The basic difference between a bolt and a screw are you turn the NUT to tighten a bolt but you turn the SCREW to tighten a screw.

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THEATRICAL STAGE EMPLOYES, LOCAL NO.4, IATSE
2917 Glenwood Rd
Brooklyn, NY 11210
Phone (718) 252-8777 Fax (718) 421-5605

Officers

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