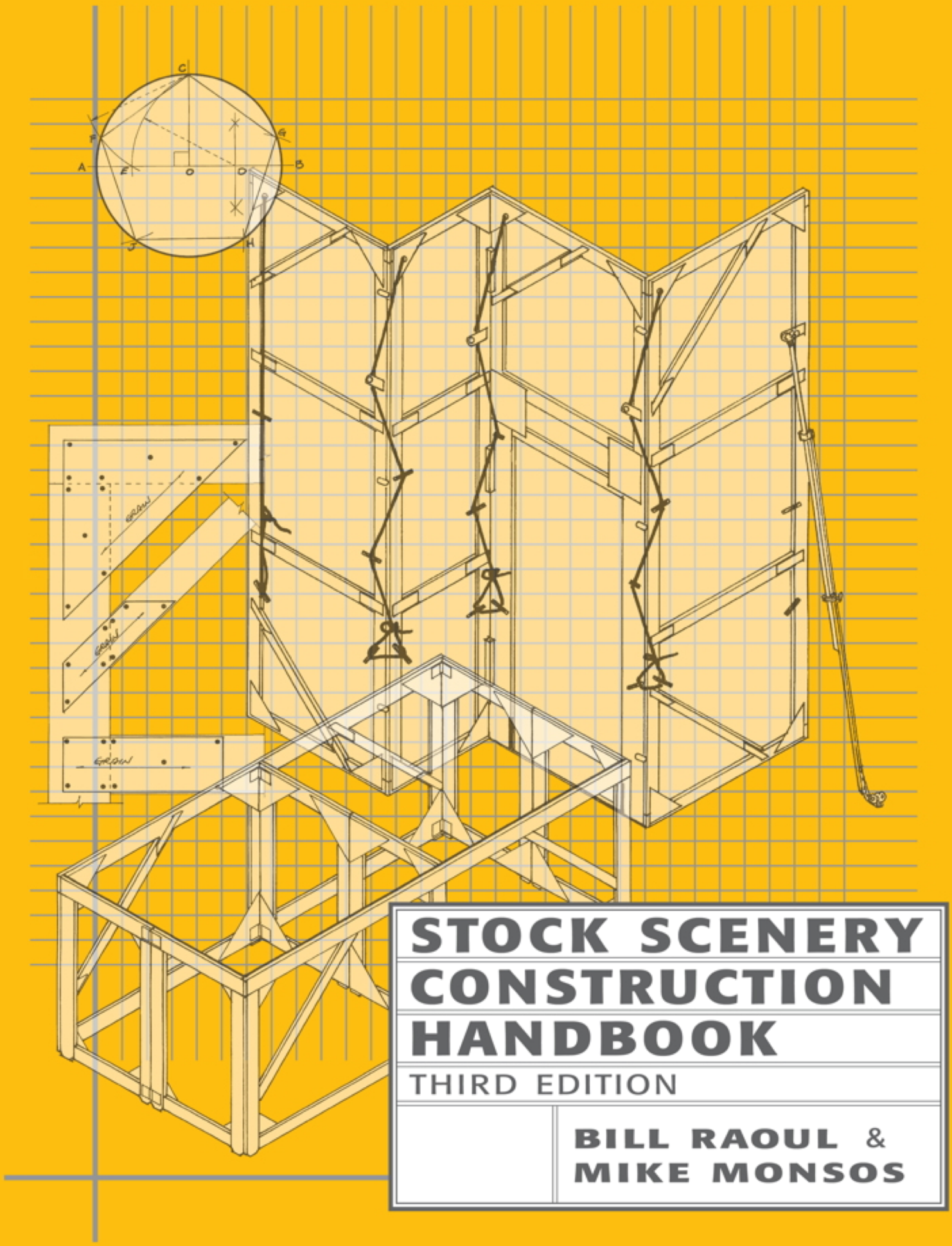

STOCK SCENERY CONSTRUCTION HANDBOOK

THIRD EDITION

BILL RAOUL &
MIKE MONSOS

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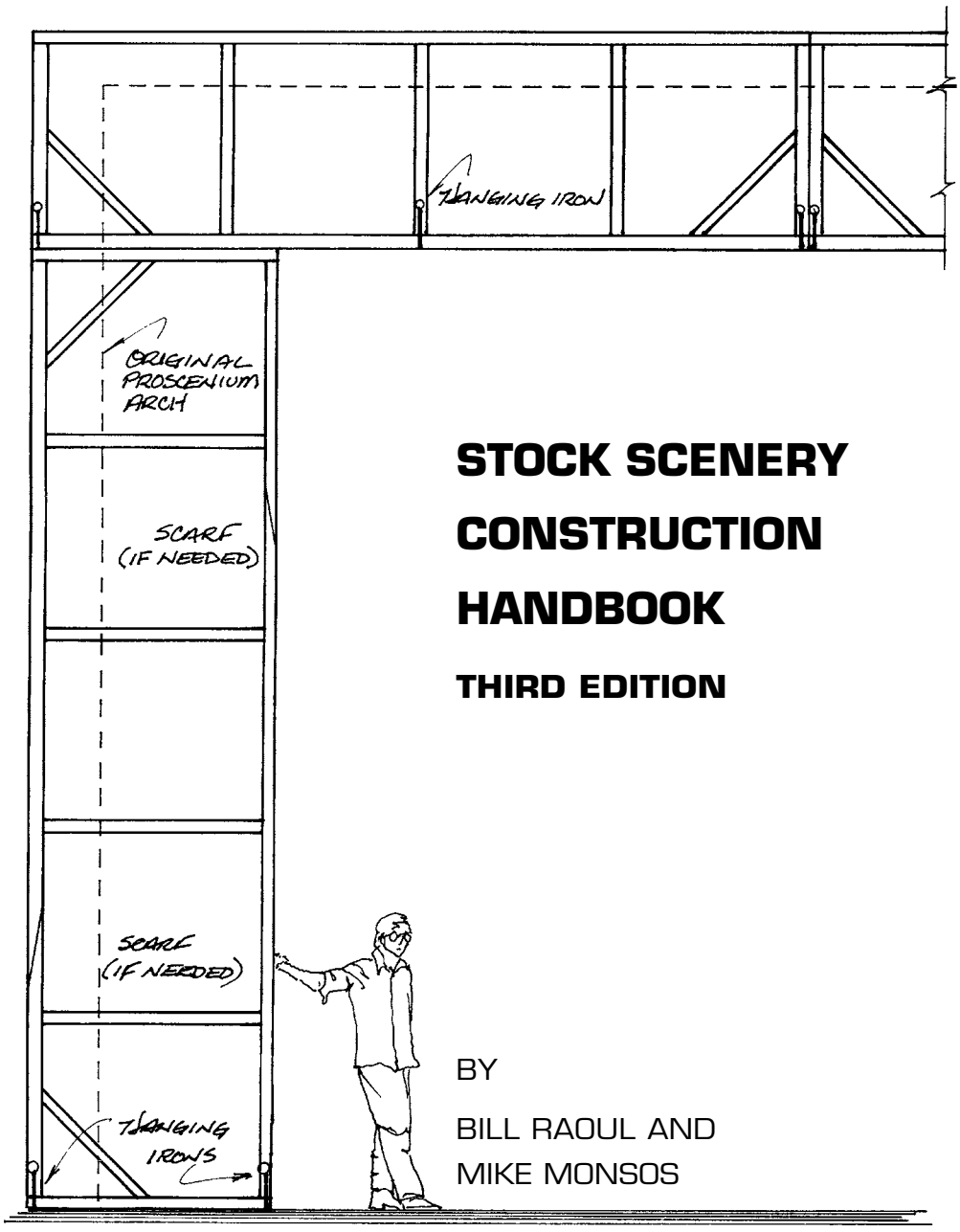

STOCK SCENERY CONSTRUCTION HANDBOOK

THIRD EDITION

BY

BILL RAOUL AND
MIKE MONSOS

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DRAWINGS

PREFACE

Bores can be divided into two classes: those who have their own particular subject, and those who don't need a subject.
—A.A. Milne

Scenery construction must certainly qualify as a subject, but I sincerely hope my digestion of it will not land me in either of Mr. Milne's classes. For more than thirty-five years I have found scenery construction fascinating, frustrating, and even baffling, but, at the same time, exciting and very satisfying. It is a subject in constant change, as is the rest of the theatre. I have also noticed that the more things change, the more they seem to stay the same. That, of course, has changed my thinking.

To some, the techniques and methods presented here will appear old-fashioned and outmoded. I can only counter with an acquiescent nod and hope if they ever need to get back to some of the basics, I don't bore them. There is nothing more instructive than observing the past, and if this handbook becomes something of a history of yesterday's techniques and methods, I have at least succeeded in preserving part of our theatrical heritage. But I truly believe it is more.

In this time of world waste, conspicuous consumption, and increasing shortages, we have a responsibility to conserve and reuse. Fortunately, our recycling plant is the theatre, and we all know it must reflect the times.

Before I bore you with my soapbox, let me say my thank yous to the hundreds of talented people who have been my co-workers. Their training methods, skills, and thoughts have been diligently collected and stored. Many of their wonderful ideas have metamorphosed to the point of nonrecognition, but, originally, I stole them nonetheless.

This book is now a fourth overhaul of what began as classroom handouts. They were gathered into a slim volume called *Flat Frame Construction*, which grew into a larger handbook, *Stock Scenery Construction,* which bears some youthful resemblance to the present tome.

Paul Carter, author of the invaluable *Backstage Handbook*, has my thanks for connecting me with publisher David Rodger, whose patience and help have been most appreciated. Stacia Graham, whose fleet fingers typed many a draft, deserves my grateful thanks. Carol Morris, whose red pen flowed around many an indefinite pronoun and dangling thought, certainly clarified many of the muddier passages. However, none of them knows, as I so gratefully do, how much we must all thank Tim Paul for his uncountable hours as proofreader, gentle suggester, and astute critic. The remaining errors must be his, but I will gladly assist him in correcting them if you will be so kind as to point them out.

My thanks ultimately go to my colleagues in the Department of Drama/Dance, and to those within the University of Montana who so graciously granted me the sabbatical leave which enabled me to rework this information.

SECOND EDITION NOTES

Second printings and second editions are both gratifying, but while the first is a mark of popularity, the later must admit the need for change. To the many people who have contacted me with kind comments, insightful suggestions, and reprimands for omissions, I am extremely grateful. Most users praised the limited scope of this handbook but had specific queries that I have tried to answer in the expanded sections on drops and hardwall scenery with related items. The number of questions specifically about paint and not the techniques of using it per se were surprising and prompted the new final chapter. To those who wanted a section on steel and metal construction I can only apologize for my lack of knowledge and urge them to seek those answers from a qualified source. However, my limited experience leads me to believe metal shops and woodshops need to be separate areas. The droppings on the floor and particulates and fumes in the air are not compatible. Metal is, however, an excellent scenic material and often perfectly answers the scenery demand of cost vs. weight vs. strength.

Again I must thank those same people who facilitated the first edition for their continued support…with the possible exception of the sabbatical committee…and if reception of this edition is as positive, who knows? They say: "Third's a charm!"

THIRD EDITION NOTES

Books are the quietest and most constant of friends; they are the most accessible and wisest of counselors, and the most patient of teachers.
—Charles William Eliot

Bill Raoul has been my friend, mentor, teacher, and critic for over thirty years now. So when he asked me if I would accept the task of creating the next edition of this gloriously useful book, I had to consider what this book meant to me personally. I learned to build scenery from this book. I have absorbed its thought process of evaluating the pros and cons of stock scenery. It taught me to appreciate the history of scenic carpentry and the methods of construction that have been passed down to us. It informs my understanding of why we make certain choices in the shop.

I decided that, yes, I did want to help keep this important book current so new generations of students can learn from it the way I had. And I want to honor the education I received at the University of Montana under Bill.

PART 1 • THE BASICS

AT HOME AND A BOARD

It is really beyond the intent of this handbook to go into great detail on setting up a shop and stocking it with the proper tools and materials. Each theatre situation will create a different set of demands, and available space will adapt differently to those demands. Perhaps it is beyond anybody's scope to describe an adequate scene shop or construction place. In truth, scenery can be built anywhere. It is also true that any shop space, no matter how large, is never spacious enough to do the job adequately.

Many theatre groups must build on the stage itself and clear away the shop for rehearsals and performances. Others are fortunate to have separate areas. However, both situations, as well as others, will benefit from careful planning. It is efficient to handle materials as little as possible. Therefore, if the supplies can load in one end and the finished work load out the other, a chain or path for the materials can be created. Each time a board or sheet of plywood must be picked up, turned 90 degrees or 180 degrees, not only is energy lost, but the spinning stock has the potential of interfering with other workers at other tools and jobs. Hollywood long ago exhausted the humor inherent in the situation. Unfortunately most work spaces must compromise this ideal, regardless of the sense of keeping the materials moving through the construction process in a smooth, direct, and efficient procedure.

It may also be necessary, if space allows, to provide separate work spaces for different methods of construction. The woodshop doesn't always mesh cleanly with the metal shop. If you have metal-working needs for your theatre, those usually require a different work area as well as the tools that can cut and shape steel. Worktables for wood construction aren't always compatible with worktables for steel, but in a pinch, and with clever planning and construction, the two worlds can peacefully co-exist. Not unlike sheep ranchers and cattlemen.

If scenery can be built anywhere, it can also be built with a wide assortment of tools, from the simplest saws and hammers to the most sophisticated pneumatic fastening tools and saws that automatically feed themselves. Fortunately, there are tools for almost any shop's budget in every area.

Tools can be divided into the following groups: measuring and marking tools, cut-

ting and shaping tools, and fastening tools. If you are unfamiliar with a tool, or tools in general, many excellent books are available which cover in detail how each should be safely and correctly used. A call to a high school shop teacher will possibly shake loose an old textbook or the use of one. Paul Carter's*Backstage Handbook* (Broadway Press) is a good reference for identifying tools and materials used in scene shops. Online tutorials are extremely beneficial, as well as the thousands of home improvement shows taking over television. Just be careful; yet another truism from the shops is that a little knowledge can be a very dangerous thing. Learn tools well enough to be comfortable and safe with them. Some tool dealers will give seminars, especially on products you buy from them, and especially if you specify the demonstration as a condition of the sale. Of course, power tools all come with booklets which explain their use. Hang onto these and have them readily accessible in your shop. The high turnover of workers in educational shops makes it imperative that tool information be easy to find. (Tool manuals are also tremendously helpful when that little part gets lost or broken and you are trying to describe what you need to a sales rep in Topeka, Kansas.)

Every tool is potentially dangerous, especially if handled improperly, too hurriedly, or in less than ideal conditions. Always have tools clean, sharp, and working properly. This, combined with the proper safety equipment and proper training, will help eliminate accidents. For some it is still necessary to count fingers before and after the day's work. It cannot be stressed enough: Always use the correct tool for the job and use the tool correctly.

It is also beneficial to be aware of situations that have a greater potential for accidents. Experience in the shops has informed us that the most dangerous moments occur when 1) a worker is a novice in the operation of a tool, 2) a worker is tired or distracted and, 3) an experienced worker drifts off into what we refer to as autopilot. This occurs when a cut is repeated so many times the carpenter stops paying attention. Managing a shop means much more than getting the scenery built and completed under budget. It also means being tuned into the workers and their habits and needs.

MEASURING AND MARKING TOOLS

As long as we are living in the last country on earth (except Myanmar and Liberia) to use the English method (versus the metric method) of measuring distances, we can drive the necessary miles to work and drag out our feet and inches in the shop. Available in many sizes, a flexible steel tape is the most common measuring tool for the shop. It should easily measure the longest scenery you normally plan to build. A 50′ or 100′ tape is most useful for measuring the stage.

A combination square or all-in-one square will greatly aid in many construction situations, in addition to doubling as a marking gauge. The all-faithful of the shop, the steel square or carpenter's square, with its 16″ tongue and 24″ body, is essential for most frame construction. Some of these squares come with a booklet explaining how to build

a house, lay out stairs, and chart rocket launches to the moon.

Dividers and trammels are useful. A good set of carpenter's trammel points will be most helpful if you plan to do much work with circles. However, these can be made, as shown in the Shop-Made Tools section in Part 7.

A level is useful. Be certain when purchasing to get one that is long enough to span a surface sufficient to get a correct measurement; usually a 4′ level will do. Unfortunately, experience and use are the best guides. Also, a snapline is needed. This can be made by applying chalk—available by the cake in different colors—to a good quality mason's line. Stick charcoal can also be used. A chalk reel or chalk line, a self-contained snap line that can be filled with powered chalk, is also a popular choice.

Lastly, an architect's scale is a must-have for any shop building its scenery from scale drawings. While designers will include measurements on a drafting, it is the rare draftsperson who had enough foresight to include every measurement the shop would ever need.

CUTTING AND SHAPING TOOLS

SAWS

Handsaws are over 100,000 years old, and you can often believe it after using a dull one. Like all saws, handsaws must be kept sharp. A dull saw is a dangerous saw. It will slip, skip, and stick, and throw material at you, or the materials will throw you into the blade. Neither is a pretty sight. All saws work because the teeth on the blade are set, each alternating in an opposite direction so the kerf or actual cut in the wood is wider than the blade holding the teeth.

Ripsaws, designed to cut along the length of a board, have flat teeth which are usually spaced farther apart than those on a crosscut blade. This allows the saw to chisel away the wood.

Crosscut saws, as the name implies, cut across the grain and have beveled teeth to shear through the wood. Both saws are becoming extinct, because the portable circular saw has become less expensive and can do the job both quickly and efficiently. It will also cut plywood and other panel boards. Circular saws are usually electric and can come with a cord or be battery operated and cordless. A wide choice of blades is available for circular saws.

A saber saw or portable jigsaw is another electric saw which has replaced the coping saw, keyhole saw, and even the metal hacksaw, depending on the style of blade used.

Even in large, nonportable or stationary saws, there is a wide variety of choices. The table saw (or bench saw or contractor's saw) is ideal for ripping lumber and panel materials, although it also cuts accurate dadoes, rabbets, and grooves. It is available in a number of sizes, depending upon the diameter of the circular blade.

For a tool that is up to the challenge of cutting large sheets of plywood perpendicular to the length, a panel saw can be a helpful tool. This tool uses a counterweighted

circular saw on guide rails to cut across sheets of plywood placed on a frame. The wood is stationary and the tool moves up and down, saving the operator from attempting to muscle a large sheet of MDF through a table saw. The panel saw, however, is difficult to line up accurately and, depending on the operator and quality and condition of the tool, doesn't always make perfectly square cuts. You have been warned.

The radial arm saw also uses a circular blade and is used primarily for crosscutting, but it is almost universally being replaced with motorized miter box saws, also called miter saws and chop saws. (Current vernacular usually associates chop saws with metal work and miter saws with wood, but you are free to establish whatever terminology your shop prefers.) While some shops may still have radial arm saws, they are rather restricted to cutting just right angle cuts because changing the angle is a tedious process and wreaks havoc on the fence. Carpenters everywhere cried out for ease in multiple-angle cuts, and the many generations of new and improved miter saws have answered that cry. Whether it is a miter saw or radial arm saw, the size of the tool is based upon the diameter of the blade. The advantages of the chop saw is that it can easily slide, tilt, and be set to cut both simple and compound angles, and almost all are portable.

A band saw has a continuous blade in an endless loop and has the greatest depth of cut of any stationary power saw. The band saw is the first choice of tool for many home shops because it can, in theory, provide almost any cut you need on most materials. However, while you can technically rip lumber on a band saw, it won't give the same quality result as a tool designed specifically for ripping, such as the table saw. And while the jigsaw can cut virtually any shape, the band saw should be the tool of choice for curvilinear shapes because the quality of the cut is vastly superior to the chewing action of the jigsaw. To some, the band saw may seem like a luxury as other tools can also accomplish similar results, but once your students begin using this tool, the jigsaws will grow lonely and dusty in their storage locker.

Most theatre work is done on a much less massive scale than the construction industry. Huge versions of power tools, common to some construction sites, are not only unnecessary from a use and cost standpoint, but also can dwarf those using them. Comparing the cost of the different diameters of blades will also be an eye-opener.

KNIVES

Most of the other cutting and shaping tools are hand tools, although a few have been motorized. Perhaps the most useful for scenery work is the utility knife. They are made with both fixed and retractable blades; it is advisable to get one with a textured handle to prevent wet or gluey hands from slipping on the grip. Blades are available in packages of five to one hundred. Never use a dull knife.

CHISELS

Chisels are for fine woodworking, are expensive, and difficult to keep sharp or properly honed. They also are excellent tools for opening paint cans, cutting through nails or

staples, and even chopping steel cable—all of which will instantly ruin them. Perhaps a cold chisel designed to cut metal is all a shop needs; it's an ideal tool to pry up misapplied fasteners and the like.

Purchasing a tool sharpening system, also called a honing station, to sharpen chisels correctly, and then actually using the station will help keep chisels effective for their real job. That and a well-placed sign that screams "Wood Only!" may slightly improve your chances of finding a sharp chisel when you need one.

PLANES

Handheld planes are perhaps more temperamental than chisels and certainly more costly. For most theatre work, the Surform rasp has replaced the plane and indeed will take the curse off a sharp corner, chamfer the edge of a plywood fastener, or remove a rough surface about as well as a fine plane, but without the excessive replacement cost. The small, handheld Surform plane and Surform shaver (which is pulled toward you and not pushed) are both very useful and have fairly inexpensive replacement blades.

Scenic carpenters, properties artisans, and furniture builders who need lumber at nonstandard dimensional sizes can find great value in wood planers. These electric tools can plane down the thickness of wood quickly and easily, and they come in sizes and price ranges that work in small shops and scenic studios. For those moments when the standard ¾″ will not satisfy your needs, surface planers can be so very helpful.

JOINTERS

Similar to surface planers but designed for truing up the edge of a board, jointers are available in handheld models or in heavier duty stationary form. This is also a tool that is used by more discerning carpenters, who need a professional finish or edge to their lumber.

SHEARS

Scissors, shears, and snips should be purchased as needed. It is practically hopeless to say that scissors are precision tools and should not be cutting anything but cloth. Shears are big scissors. Snips are designed to cut tin and other thin metal, which is normally done with the once usable pair of scissors.

FILES

Files and rasps are useful shaping tools, available in many lengths and shapes. The choice is multiplied by the desired coarseness and kinds of teeth desired. Generally speaking, files are finer and rasps are rougher; files are used on metal (and finger nails) and rasps on wood.

ROUTERS

To most people today, a router is the power tool which has replaced both the hand tool of the same name and the stationary shaper. It is used to form decorative edges and complicated joints. It can carve, incise, pierce, and even cut circles. It is an extremely useful

portable power tool. The bits can become expensive for theatre work because, like the shaper, jointer, and planer, one nick from an overlooked metal fastener or stray nail can ruin it. Also, the more expensive carbide-tipped bits are really necessary for shaping plywood and other panel boards. The popularity and widespread use of the router has had the manufacturers looking to improve the quality and range of profiles and shapes of the router bits. They now build routers with larger collets (the locking mechanism) to allow for larger bits. Most routers now come with the capability to use ¼″ and ½″ bits. Larger bits last longer and can have much more complex profile shapes, which also means you will feel the urge to buy lots and lots of profiles.

LATHES

The last cutting and shaping tool in this discussion is the lathe. This is a luxury tool for most shops and requires some special skills to operate properly. The turning tools it uses are also fairly expensive and must be kept sharp. You might say a shop has arrived when it has a lathe to make its own turnings.

FASTENING TOOLS

HAMMERS

Probably the most common fastening tool is the hammer. It is certainly the most neglected in quality when purchased. Cheap hammers will produce cheap work. Whether the handle is wood (easily replaceable), fiberglass (non-rusting and shock absorbing), or metal (nonbreakable), make sure the head is solidly attached to the handle. When you hold the hammer in your hand it should have good balance.

Large, heavy hammers are not made for theatre work. Scenery should be strong but light—so should the hammer. Remember that the force driving the nail is also exerted into the scenery and can knock apart what you're building. A 16-ounce hammer is plenty for any job. Some professional shops won't allow any hammer heavier than 13 ounces. It is not the weight of the hammer but the skill of the user which drives the nail.

The claw hammer has a curved claw behind the head for pulling nails easily. A straight claw is designed to pry apart previously nailed pieces. Both are useful. Ball-peen hammers with their specially tempered heads are designed for pounding metal, something which should never be done with a claw hammer, unless you want to ruin the hammer. Tack hammers, with their magnetic heads, are ideal for light fastening with not only tacks, but also brads and other small nails. Sledgehammers are often used to strike scenery which is going to feed the dumpster. They are rarely used to build it, not being known for inspiring craftsmanship.

Mallets are hammers with nonmetal heads. They should be used when striking another tool, like a chisel or even another hammer, or adjusting (through some friendly persuasion) a finished or polished surface without chipping or damaging it.

An exciting new addition to the hammer family is the dead blow hammer. This tool was designed to solve the annoying tendencies of hammers to bounce around once they strike a surface, as well as preventing the testosterone driven force that occurs when the hammer is being used to fine-tune a stubborn scenic element. The dead blow hammer is actually a mallet that has lead shot or sand inside a hollow section in the head of the tool. This transfers more energy to the object being struck and has the magical ability to not rebound back at the soon to be surprised operator.

While we're on the subject of hammers, the handiest little tool any shop can have is a nail set. It is designed to set the head of a nail below the surface of the board, but it is especially useful because of its cupped tip. Place the tip on a protruding end of a nail or staple, and you can drive out the offending fastener enough to reach the head or crown and remove it.

STAPLERS

Many shops have abandoned the hammer for electric or pneumatic staplers and nailers. The fasteners for these speedy and powerful tools, with their coated shafts, have much greater holding power than an ordinary nail and eliminate beating the scenery with a hammer. Certainly if labor and time are considerations, these powered fastening tools will quickly repay their investment. They do not, unfortunately, guarantee better work. There are many hand staplers on the market which are also worth investigating.

SCREWDRIVERS

Screwdrivers are available in many sizes and shapes, but they almost all have a handle, shank, and tip. The two most common tips in this country are the flat (or slotted) and the Phillips tip with its cross shape, although many other types of screw heads have been appearing in hardware stores, each with the idea of making a better mousetrap. Be sure to buy the size which fits the screw or bolt head you are using. It is not cheating to take along one of each when shopping for the drivers.

Ratchet screwdrivers will speed up work, but be wary of spiral ratchet screwdrivers (also called Yankees). Not only are they expensive, but they can be ruined quickly if not properly stored at all times, can easily slip and plunge through soft scenery, and have been known to eat the user's palm, removing a most painful pattern of flesh. It is embarrassing, but sounds like the Yankees my mama warned me about.

While there will always be a need for an assortment of hand screwdrivers, scene shops can no longer function without taking full advantage of one or more of the battery operated (cordless) screw guns. It appears everyone is making one nowadays, and they have become quite specialized. Hammer drill capabilities, multiple speed, work lights, and other features can make the choice very difficult. If budget is the biggest determining factor, try and think long term, as inexpensive models typically have a much shorter life span.

DRILLS

If the power drill threatens the screwdriver, its ancestors, the hand drill, the push drill, and the brace with its family of beautifully crafted bits, have joined the dinosaurs in the tar pits. Not only are many of the power drills cheaper, they are often much easier to use. The screw guns you purchased to keep your students and staff happy also double as drills, unless you bought the model that only functions as a powered screwdriver. The battery power in cordless drills is advancing so tremendously, you may never use a corded drill again. However, don't attempt to get very far drilling sturdy materials such as steel for very long without a corded drill. With all tools, you get what you pay for; drills are no exception. Buy good tools which are comfortable to the hand and have the power to do the job. Oversized hand tools are about as useless as undersized ones.

When buying drill bits, remember that wood bits can be used only in wood, but metal bits will do metal, wood, and plastics. The typical twist bit will work in virtually any material: wood, plastic, or metal. However, their life span can be drastically shortened when drilling heavy metal. Paddle or spade bits are designed to cut large holes in wood and should never be used in any other material. The quality of the hole is usually fairly low, but so is their price. For a higher quality large hole in wood, a Forstner bit is a much better choice and is best purchased in sets to save on the cost. Some drill bits can be sharpened, either by a professional or skilled worker, but generally they are simply discarded.

When a drill is mounted into a press, it becomes ideal for drilling perfectly placed holes. There are presses made for portable hand drills, but they are not as good as ones made with the drill permanently mounted. A drill press is particularly useful if you plan to do a lot of metal work. Always be certain to use a V-block (which you can make, see Drawing 7-2) with round stock.

GRIPPING TOOLS

Pliers and wrenches are the last of the fastening tools. Inasmuch as every trade has developed specialized types of wrenches and pliers, the market choice is exhausting. Basically, all have handles, a pivot (which slips or not), and jaws which grip or cut. Pliers and wrenches are available as some of the cheapest and worst-made tools on the market. Beware! Pliers are meant to grip. Those which also have cutting edges in the jaw are sometimes called side cutters or dikes. There are also end nippers, which are very useful in theatre work because they can grip a barely protruding nail or staple and rock it out of the wood. End nippers and side cutters seem to be logical choices when the task is cutting wire rope or aircraft cable. Avoid this temptation on all but the thinnest wire rope.

Vise-Grip brand and other locking pliers will lock onto an object and hold it. Many sizes and jaw designs are available. Open end and box wrenches are sometimes useful. They must be purchased to fit. The "adjustable open-end wrench" is a mouthful for a Crescent wrench (from the tool company of the same name). This has replaced most

single wrenches for theatre work, but there are times when the others may do a better job. Socket wrenches are often useful tools, though many theatres find a few properly sized nut drivers will often do the job.

There are, of course, many more tools and devices on the market. The best advice I can offer is go slowly and wait until demand dictates the purchase, then shop carefully with a reputable dealer. Never, ever, ever buy cheap and shoddy tools.

MATERIALS

The life expectancy of any piece of scenery, stock or not, is directly related to the quality of materials used, the care exercised in construction, proper use, and storage. Ideally, use only the best materials. Unfortunately, the cost makes that impossible except in a very few of the wealthiest theatres, and then there is the moral question of wasting beautiful wood which could be used elsewhere. We no longer live in a world of unlimited resources, in case you haven't been to a lumberyard lately. Flat frame scenery, more than other types, most clearly demonstrates the importance of a magic formula—cost vs. weight vs. strength. The order of importance changes in different situations, but if these three elements are carefully weighed when any scenery is considered, the end product will benefit.

LUMBER

Lumber is the most expensive and variable item in most scenery construction. It will vary in the piece itself, within the tree, with the locale in which the tree grew, and most greatly, of course, with different species.

The two basic types of trees are conifer (softwoods) and deciduous (hardwoods). The actual hardness of the wood is no gauge. Balsa wood, a hardwood, is certainly not as hard as the dense, brittle softwood, yellow pine. Hardwoods such as oak, elm, hickory, ash, and birch are used most often in furniture and are not well suited to scenery, even if they were readily available in long, workable lengths.

Of the softwoods, the white pines are the best scenery wood. Both Northern white pine and Idaho white pine are in high demand, but unfortunately, when available, are often very expensive. However, any wood which contains the better characteristics of these pines (good strength through long, straight grain, few knots, and light weight) can be substituted. There are many other regional white pines available. Beware of yellow pines because the wood is extremely hard and brittle. There are also redwood, cedar, fir, and spruce, but white pine is still by far the best. Study the costs of each plus its characteristics before buying. If a wood doesn't suit the cost vs. weight vs. strength formula, the scenery will suffer.

In order to buy lumber intelligently, you must know some of the vocabulary and methods of a lumberyard. All lumber is graded as to its type and use, in addition to quality. These grades, while standardized by lumber industry associations, do vary slightly because of interpretation, and it pays to know what each yard has in stock (see Table

1-1, The Grading of White Pine Lumber). Your local lumberyard will carry the grade of lumber most usually sought after in your region. It is often helpful and less expensive to ask the lumberyard if it can stock or order the grade your shop prefers.

Buying lumber today has certainly changed. In the past, the quality of wood was good enough to purchase it in bulk and leave on your own lumber racks for the season. Nowadays, lumber that is readily available will often warp after a very brief time. Left on a rack for a few weeks, it could begin to take on the shape of a canoe or the letter *S*. Learn how the wood in your region behaves and shop accordingly.

The Drawing 1-2 shows some of the many knots and blemishes found in lumber. Knots A, B, and C, if small and tight, will usually not affect the strength of a board, especially if they are contained within the edges. However, the next three, because they traverse the width of the stock, will probably weaken the board to the breaking point. Remember that a knot interrupts the grain, and therefore weakens the board.

Also shown in the drawing are six other common flaws. "Wane" occurs when the piece is milled leaving part of the outside of the tree. Sometimes bits of bark remain. The wane in pine stays mainly in the plane. "Split" is an aptly named and obvious flaw, but some lumberyards don't see it. The remainder are commonly grouped as "warps," each having its definite characteristics, although all are caused by uneven drying. "Cupping" is more pronounced in wider boards and, if they are to be ripped into narrower strips, may not affect construction. "Crooks," if not too severe, can be pulled out of most flat frame construction. A slight "bow" can usually be straightened and corrected in on-edge construction, common to hardwall units and platforms. The "twist" is difficult to remove, except to the lumberyard whence it came.

Lumber is either milled or rough, a term which refers to its finish. Milled lumber has been planed smooth. Rough lumber as it is delivered from the first cutting is indeed quite rough. It is in this form that it is given the nominal measurements by which it is computed, and these figures remain, even after the piece is milled. The dimensions, however, will change. An example of the dimension change is seen more clearly when it is understood that a 2×4, which rough is 2″×4″ (depending upon which side of the splinters one measures), becomes after milling about 1-½″×3-½″. A piece of 1×10 is similarly shaved down in the milling process to ¾″×9-¼″. The milled dimensions are subject to change, but seem only to get smaller over time.

BOARD MEASURE

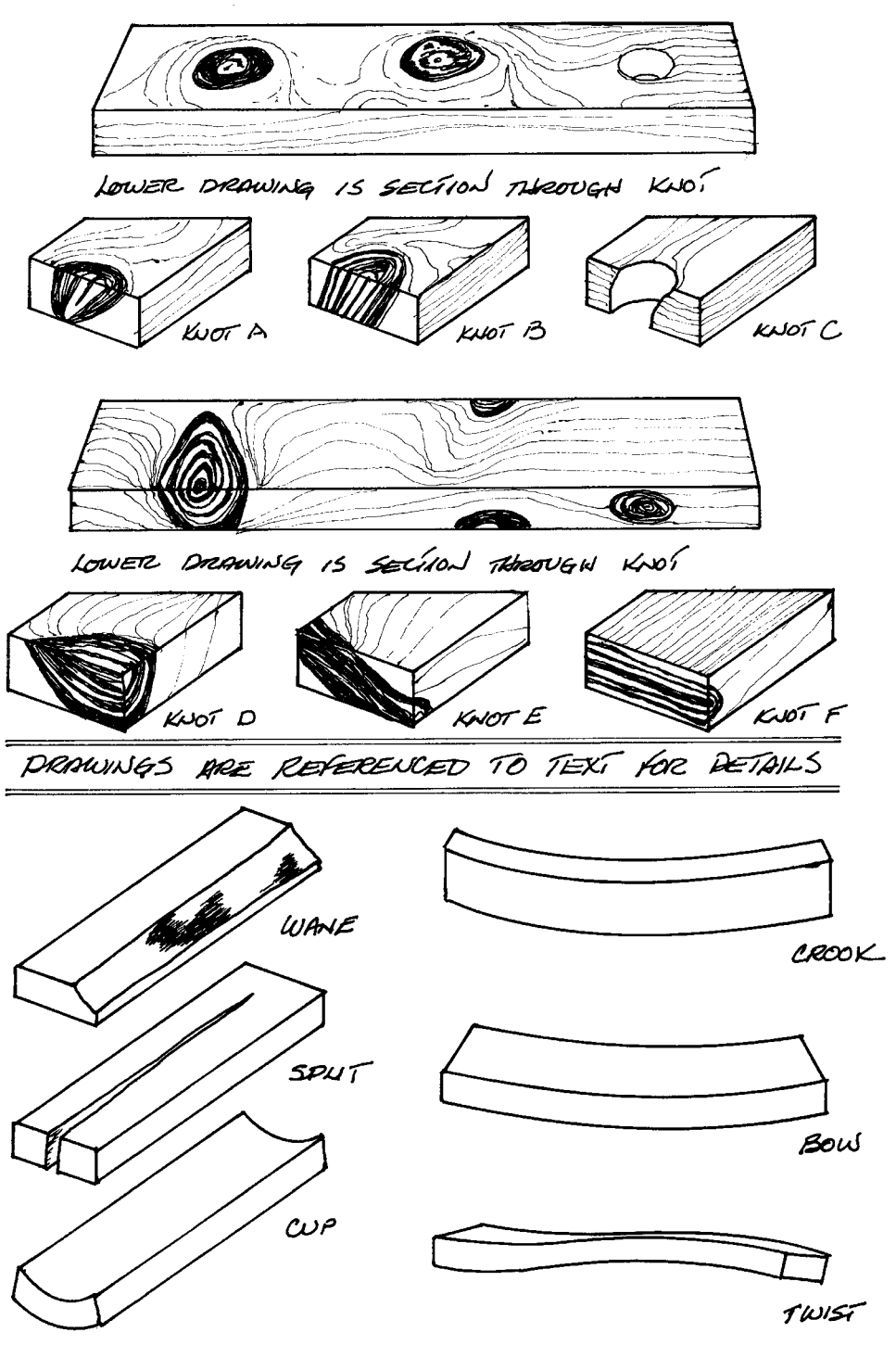
Lumber can be purchased by the piece (or stick), but it is most commonly sold either by lineal foot (running length) or by board foot (cubic volume) measure. Hardwood lumber is usually priced using board measure, with extra charges added for handling small orders, while all the dimensional lumber such as 1× and 2× (pronounced one-by and two-by) are generally sold by length.

The board foot is the most common method for measuring lumber. It represents a theoretical board which is 1″ thick, 12″ wide, and 12″ long, or 144 cubic inches. This

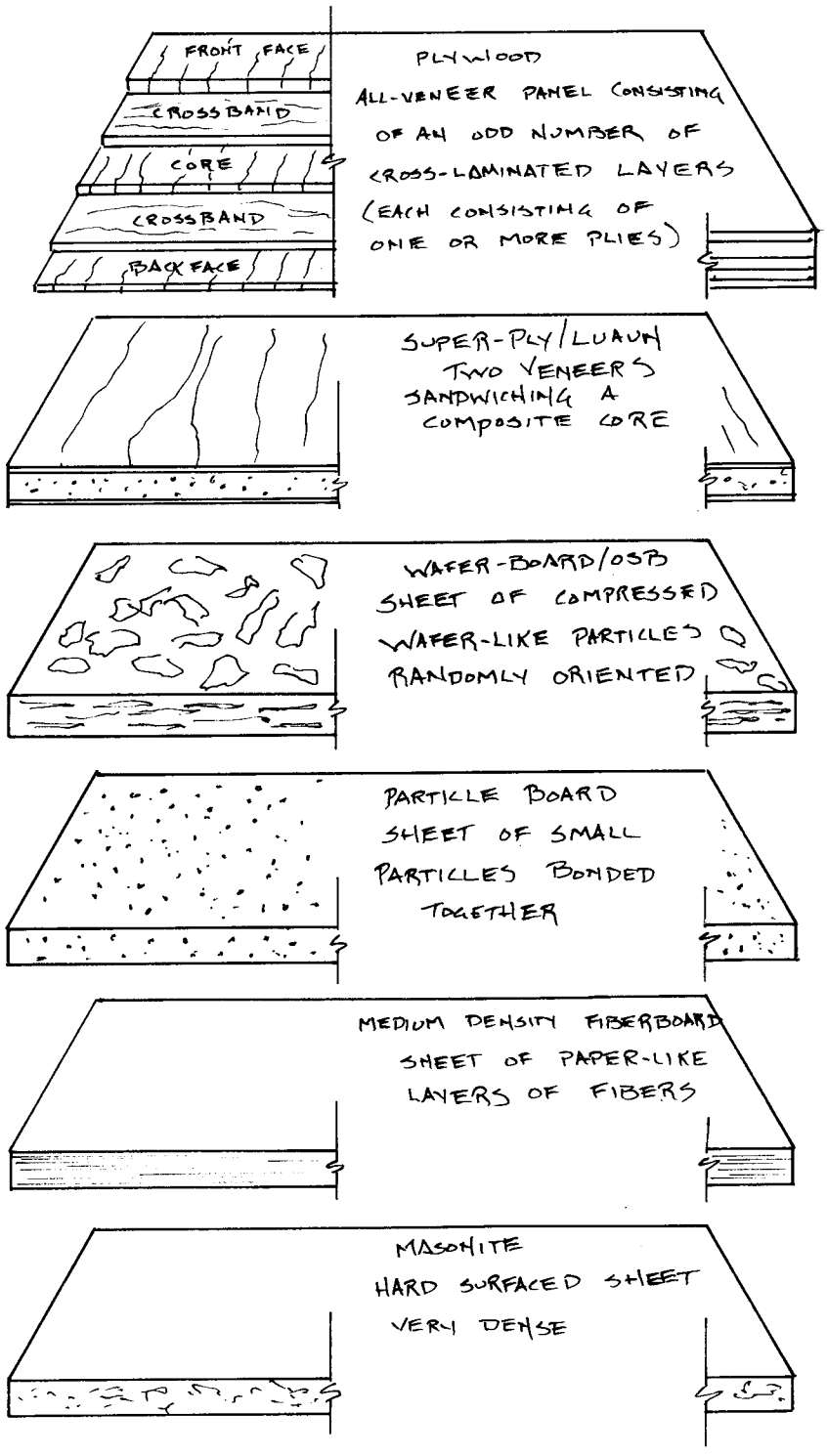
THE GRADING OF WHITE PINE LUMBER — TABLE 1-1

GRADE	CHARACTERISTICS
#1 & 2 CLEAR (B AND BETTER)	All the best wood falls into this grade. It must be at least 4″ wide. #1 & 2 clear can have slight blemishes (discolorations). It is far too good to use for theatre work.
C SELECT	This grade must also be 4″ wide or wider. It resembles #1 & 2 clear, but there are more blemishes. It is an ideal material for building scenery.
D SELECT	This grade must also be 4″ wide or wider. "D" select is a borderline grade, and can be considered as the highest grade of common lumber. It can be good on one side with serious defects on the other. It is also excellent for scenery construction.
#1 COMMON	This grade contains sound, tight knots, small pockets, stains, season checks, and equivalent characteristics. These are not considered defects in common grades but guides for grading. The more pronounced the defect, the lower the grade. #1 common is a very good lumber for building scenery.
#2 COMMON	This, of course, has larger and more pronounced defects. It is about as low as you can go and still build scenery, primarily because of the size and number of allowable knots.
#3 COMMON	This lumber is usually cut from a lower part of a log, and the defects are more pronounced. It is also usable for scenery construction if the pieces are carefully selected.
#4 COMMON	Bad.
#5 COMMON	This is the lowest recognized grade, and any defects are allowed as long as the piece will hold together long enough to be taken out of the lumberyard. There have been cases of #5 Common accidentally getting mixed in with higher grades. If this happens, a phone call to the lumberyard will often stop this defect.

KNOTS AND OTHER BLEMISHES DWG. 1-2



PANEL BOARDS DWG. 1-3



could be a 1×12 one foot long or a 1×6 two feet long or a 1×2 six feet long, etc.

For computing lumber, any board less than 1″ thick is figured at 1″. Any width is figured in even numbers, with the exception of 3″ and 5″. Partial amounts are computed as the next highest number. White pine is sawed to 3″, 4″, 5″, 6″, 8″, 10″, and 12″ widths. A 3″ board is figured as 3″, but 3½″ is figured as 4″ wide and 5¼″ is figured as 6″ wide.

To calculate board feet when all dimensions are in inches, use the following formula:

$$\frac{T'' \times W'' \times L''}{144}$$

If the length is in feet, use the following formula:

$$\frac{T'' \times W'' \times L''}{12}$$

(T = thickness, W = width, L = length)

Strip lumber, such as molding, full round, etc., is sold by the lineal foot. The important thing to remember in ordering lumber is that if you order either lineal or board measure, you will get a delivery of random lengths from the yard unless you specify the length or lengths necessary. For example, 650′ of 1×10 boards in 16′-0″ lengths would be 40.6 pieces, and you will received either 40 pieces, 41 pieces, or 40 plus a piece, and be charged accordingly.

If the length is important, be sure to specify. If you have computed the materials needed for construction, be sure to add 20 percent to the amount figured for waste. In an educational situation, 25 percent or even 30 percent should be added to make sure there will be sufficient material on hand to complete the job after the learning experience has taken place.

There are two schools of thought on ordering 1× stock for a shop. One is to order dimensioned lumber (1×3, 1×6, etc.) as needed and store each width. The other method is to order 1×10 and 1×12 only and rip the stock into narrower sticks as needed. There are advantages to each, provided that the lumber is used fairly quickly.

If you bulk order and store a stock of lumberyard pieces (1×3, 1×6, 1×8, etc.) in the shop, there is little time spent in selecting each as needed and little chance of varying width differences, assuming the mill is accurate. The edges are all planed smooth, and the quality of the wood is often quite good. A major disadvantage is the necessity of storing each width separately. This is partially avoided if you order only enough to complete a specific job, but that requires careful planning. Another problem can be the limitations a designer might encounter in the width sizes available, inasmuch as ordering anything other than what is commonly stocked at the yard is cost-prohibitive.

If you stock 1×10 and 1×12 and rip your own narrower pieces, you can build with any width called for by the designer at that moment and not have to order it from the

yard. By stocking wide lumber, you can take advantage of price breaks which come from large orders of single sizes. Another advantage is a more compact storage area. However, a table saw is necessary to rip the lumber. The fact that the ripped edges are not as smooth is usually of little importance, and they can be smoothed if need be.

Often a slightly lower grade of lumber may be ordered in the narrower widths. Wide widths have been known to have large knots which are structurally sound in the original board but, when ripped into narrower pieces, cause the lumber to break. This is often the deciding factor for ordering narrower stock. Check the lumberyard.

LUMBER STORAGE

Regardless of the size of lumber ordered, it must be stored evenly and with its own length and width to prevent warping. The most common method is to store it in horizontal racks with supports about every four feet. Do not mix lengths and widths on the same shelf, or warping will occur. The 1×10s and 1×12s can also be stored on end in vertical racks if there is little floor space and sufficient height. Try not to store stock narrower than 1×10 on end, because it tends to warp.

PLYWOOD

Plywood is one of the oldest manufactured wood products. The Egyptians and Greeks did veneer work, but it was not until the latter part of the nineteenth century that plywood became a commercial material for furniture. Perhaps the negative connotations of "veneer" (and perhaps the faulty glues) prevented widespread use. In 1905 the first commercial plywood plant opened in Portland, Oregon. The standardized 3′-0″×6′-0″ sheet was almost immediately replaced by the still common 4′-0″×8′-0″ panel. Plywood quickly became widely used in many industries and trades. The introduction of synthetic resin adhesives about 1935, which greatly shortened production time and increased strength, assured a permanent place for plywood in all the building trades.

Plywood manufacturing steps are basically the same for all types of ply. Plywood is made with an odd number of layers of wood, each consisting of one (or more) sheets of veneer. These veneers are stacked and glued together with the adjacent layers at right angles. Therefore, the two outside veneers have their grain running in the same direction, almost always parallel with the 8′-0″ length (see Drawing 1-3).

Plywood is most commonly manufactured from logs which are placed in a giant lathe and rotated against a long knife. This peels the wood off in a long, continuous sheet of veneer. The veneer is next cut to desired widths, dried, and graded. It is then spread with glue, and the plywood panel is laid up.

The freshly glued panel is put into a hydraulic press and subjected to intense heat and pressure, which cures the glue in minutes. From the press it is trimmed to size, finished with filler, and sanded to a predetermined grade.

A number of sheet goods are available that aren't true plywood, but they are often less expensive. These include lauan (often misspelled luan), door skins, and Superply.

Because these sheets typically have fewer plies and the interior wood is lower grade, they don't have the same bending characteristics as regular plywood. If the staff at the lumberyard can't tell the difference, look closely at the edge of the ply. You will be able to see the many layers of veneer in a true ply as opposed to surface veneers laminated to a core substance.

VENEER CLASSIFICATIONS

The grade classification refers to the outer veneers of the sheet of plywood. There is a face (or front) veneer and a back veneer. When a sheet of plywood is given two letters in its classification, the first refers to the front of the sheet and the second to the back.

Grade	Description
N and **A**	The highest grade with no knots and restricted patches. N is intended for natural finishes (staining, varnishing, etc.), and A is a good, smooth painting surface.
B	A solid surface. Small knots, patches, and round plugs are allowed.
C plugged	This is a C grade all dolled up. This high-drag of plywood is only cosmetic and designed for underlayment.
C	Small knots, knotholes, and patches. This is the lowest grade in exterior-type plywood.
D	Aaaah! Home again. Larger knots, knotholes, and some limited white pockets in sheeting grades are allowed. This is the most common back veneer grade for interior plywood.

INTERIOR / EXTERIOR

Plywood is available in interior and exterior types. The plywood varies little in appearance. The major differences are the water resistance of the glues used and that exterior plywood allows no veneer grade below C. However, in manufacturing, some mistakes slip by and are then relabeled "Interior plywood with exterior glue," or with some other telling, and quite catchy, little phrase.

AVAILABILITY

Plywood is available in many thicknesses in a standard 4′-0″ × 8′-0″ sheet. Both narrower and longer sheets are made and can sometimes be had through special order, although the cost is generally prohibitive. One exception is the 5′-0″ × 9′-0″ × ⅝″ thick plywood made for ping-pong tables. However, despite the enthusiasm of the Chinese for the game, this size is becoming rare. Isn't tradition a wonderful thing?

Thicknesses for plywood commonly stocked by most yards are ¼″, ⅜″, ½″, ⅝″,

¾″, ⅞″, 1″, and 1⅛″. Some other sizes are available but would probably need to be special ordered. After all, if they don't build houses with it, it is not common. It behooves one to seriously consider bribery or at least the cultivation of the person who runs the lumberyard. That can usually be done with complimentary tickets. If more is expected, check with a lawyer.

BENDING PLYWOOD

Plywood, especially in the thinner sheets, can be bent into curves. Narrower strips will bend more easily than full sheets and, as the following chart shows, strips cut across the grain will bend more easily than those cut parallel to the grain.

Minimum Radius for Bending Full Sheets of Plywood

Thickness	*Across Grain*	*Parallel to Grain*
¼″	2 ft.	5 ft.
⅜″	3 ft.	8 ft.
½″	6 ft.	12 ft.
⅝″	8 ft.	16 ft.
¾″	12 ft.	20 ft.

PLYWOOD STORAGE

Plywood will warp if not stored properly. It can be placed in vertical racks which do not allow it to lean and bend, or it can be stored flat, if space allows. Often there is room to incorporate a plywood storage area under a large worktable in the shop.

ORIENTED STRAND BOARD (OSB)

OSB, also called waferboard, is a manufactured wood panel developed in the 1970s that is now an accepted substitute for plywood in many home construction applications. For theatre use, however, OSB's surface texture can be a problem. OSB is composed of strands of wood oriented selectively to ensure a strong product. It doesn't have a smooth veneer surface like plywood. Homebuilders use OSB as an underlayment, so the quality of the finish is never an issue. But in theatre, our sheet stock material is usually seen by the audience. The cost savings of using OSB will never offset the evil glares from your designers and scenic artists. OSB, like its more worldly cousin, plywood, is a stock 4′×8′ and comes in a range of thicknesses including ¼″, ⅜″, 7⁄16″, 15⁄32″, ½″, 19⁄32″, ⅝″, 23⁄32″, and ¾″. Generally, the ¾″ thickness is used in flooring, so it comes standard with a manufactured tongue and groove along the 8′ edges, which adds more heartache for the shop.

HARDBOARD

Known to many as Masonite, the term hardboard is the generic name of this engineered wood product patented in 1924. Hardboard is a material that has limited use in theatre.

It is a dense material with a smooth finish on one side (usually) that looks like it could make your paint shop very happy. However, it is difficult to attach with staples or screws as the material is quite tough and fasteners don't penetrate enough to be flush with the surface. The 4 × 8 sheets also have a habit of buckling when used as a floor covering and are generally only available in ⅛″ and ¼″ thicknesses.

PARTICLE BOARD

In particle board, wood by-products such as sawdust and shavings are glued together under pressure. For the truly cash-strapped shops, particle board can be used instead of plywood. However, it is heavy, it chips and breaks easily, and it is manufactured with formaldehyde which can emit toxic gases.

MEDIUM DENSITY FIBERBOARD (MDF)

MDF is another attempt by the building industry to create a product that can accomplish what plywood does very well, but with a reduced cost. MDF is an engineered product much like OSB and hardboard that uses wood by-products bonded together under heat and pressure. It does have advantages over its predecessors in a few ways. It is a very good painting surface, being free of texture and blemishes, and it is a little stronger than particle board. The weight is concerning as a full sheet of ¾″ MDF weighs 96 pounds, with ¾″ plywood weighing in at 70 pounds.

As the goal is to find a competitive edge to replace plywood, MDF has created a characteristic that none of the other sheet stock materials has ever done. A sheet of MDF measures 49″ × 97″ as opposed to the standard 48″ × 96″, giving the ability for a shop to potentially save on materials. While plywood is a superior product, stronger and lighter, it will not yield two pieces 2′-0″ wide when cut in half, as the saw kerf steals ⅛″ away, never to return.

Approximate Weights of Sheet Products (4′-0″× 8′-0″)

	⅛″	¼″	⅜″	½″	⅝″	¾″
plywood*	13 lbs.	26 lbs.	35 lbs.	48 lbs.	58 lbs.	70 lbs.
hardboard**	19 lbs.	38 lbs.				
particle board***		24 lbs.	48 lbs.	62 lbs.	78 lbs.	94 lbs.
OSB		28 lbs.	38 lbs.	52 lbs.	68 lbs.	79 lbs.
MDF		33 lbs.	48 lbs.	80 lbs.	82 lbs.	96 lbs.

NOTES:

* Plywood weights will vary, depending on the type of wood used in veneers as well as on grade and type. Mahogany veneer (⅛″) is available in 4′-0″ × 8′-0″ sheets and 3′-0″ × 7″-0″ sheets (door skins). It is reasonably priced, but often must be a special order.

** Hardboard is available in many sheet sizes and thicknesses up to 12′-0″ long. Masonite is a common trade name for hardboard. It is available in untempered (easier to nail) and

tempered with an oil substance which makes it quite hard and brittle. The tempered sheet makes an excellent tap-dance surface when laminated over stock platforms. A rough screened surface is available on one side if ordered. This is a good texture for facings and floors.

*** Particle board varies greatly in weight, density, and strength, depending upon manufacturing techniques.

Approximate Weights of Dimensioned Lumber

	8′-0″	12′-0″	16′-0″
2×4	10 lbs.	16 lbs.	21 lbs.
1×4	4 lbs.	6 lbs.	8 lbs.
1×10	12 lbs.	18 lbs.	24 lbs.
1×12	14 lbs.	21 lbs.	28 lbs.

Note: weights will vary greatly depending on the amount of moisture in the wood (how well it has been dried). Typically, 2× stock is fir and 1× stock is white wood (white pine, spruce, hemlock, etc.).

JOINTS

When building scenery, you are essentially cutting materials to the right size and shape and then putting them back together into the desired form. Putting the wood back together requires some method of joinery in order to accomplish this task. The most important aspect of successful joinery is to provide the greatest amount of surface areas possible. The more area that is fastened together, the stronger the joint.

Some knowledge of the common wood joints used in scenery construction is helpful. Drawing 1-4 shows how basic they can be. All boards have narrow edges, a wider face (both front and back), and ends (so named because the ends of the wood's cellular structure are exposed). The edges and faces give good surfaces for holding nails, screws, and staples, but the ends have no real holding power.

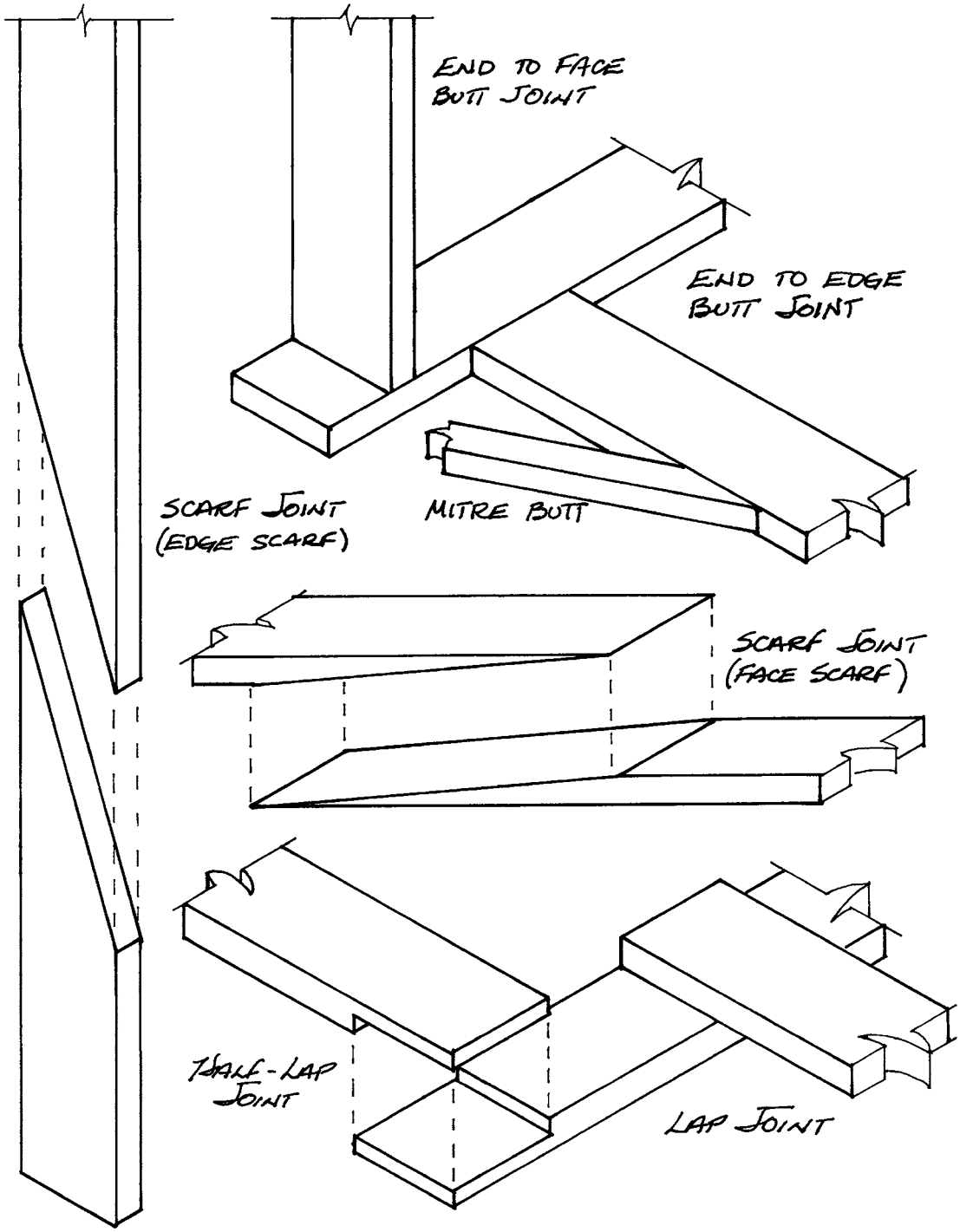
Two pieces of wood are butted together to make a butt joint. This is the most common joint in scenery construction and can be described in more detail by naming the parts of the boards which are touching.

A scarf joint is used to create a longer board than is on hand. As can be seen, the face scarf is stronger than the edge scarf because the surfaces to be glued together are greater. However, the edge scarf is faster and easier to make and often more accurate, which gives it some advantage. Until the board stretcher is perfected, the scarf joint is the best solution to create extra-long lengths.

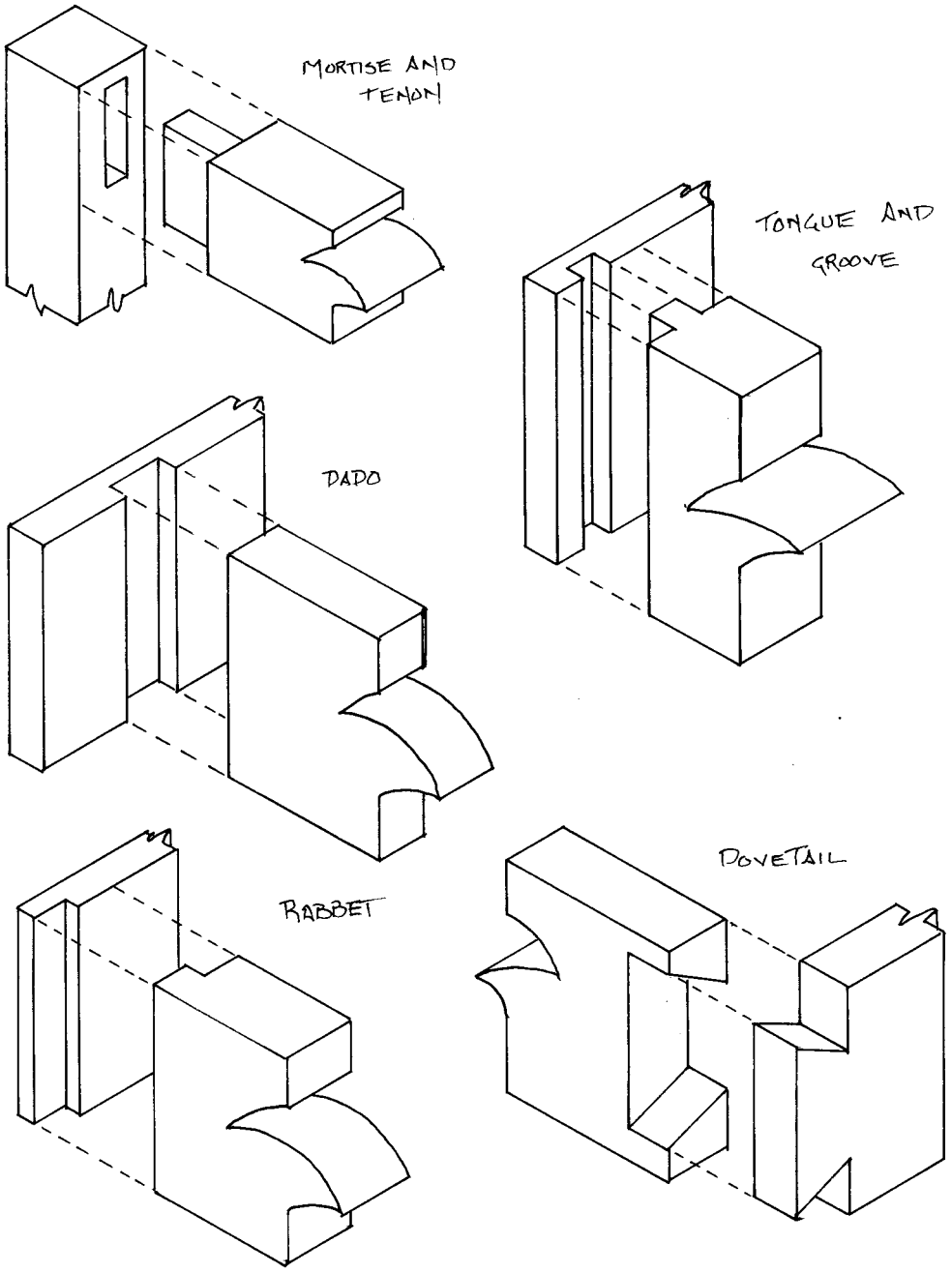
Lap joints are quick and, when properly attached, quite strong. The half-lap has the same good strength, with the added advantage of keeping the wood pieces in the same plane.

There are a number of less common joints used in scenery construction, but they are good to recognize and know as they often are used in the scene shop on properties

COMMON JOINTS IN SCENERY CONSTRUCTION DWG. 1-4



LESS COMMON JOINTS DWG. 1-5



and furniture construction. Drawing 1-5 illustrates these advanced joinery methods. While it is easy to dismiss advanced joinery in scenery construction because it increases construction time, it could prove beneficial in some circumstances (like touring shows or door slamming farces) to provide a stronger piece of scenery. The time spent on increased quality should result in less repair and rebuilding time. No matter the type of joint, be sure to make it a tight fit that is well glued.

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This book is all about the basics—flats, platforms, ramps, steps, curtains, drops, paint.

If you've never built scenery, this book will show you, in easy-to-follow steps, how to do it right the first time.

If you are an experienced builder, you will want to keep this book handy just in case you forget the answers to questions like:

- On an inside opening in a flat, what is the correct set back for plywood fasteners?
- Should fresh muslin always be used for a dutchman?
- What solvent will get dried paint out of a paint brush?

This third edition has been updated throughout by Mike Monsos, professor of Scenic Design/Technology at University of Montana, Missoula.

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