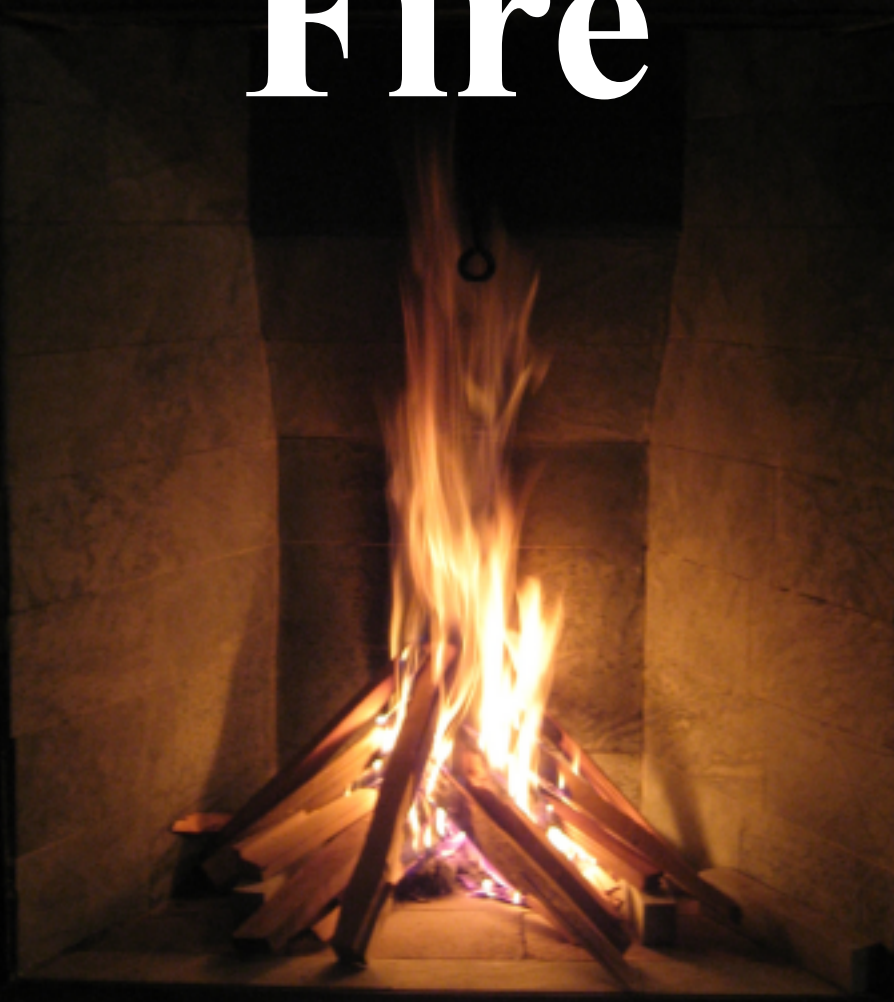
The Art of Fire



E.K. Wisner

Contents:

The Art of Fire
by E K Wisner

Introduction:

This book is intended as a very basic introduction to the ancient art of burning stuff. It might be useful to a family moving to the country, or extending their camping skills. A scouting troup might get a great deal of pleasure from the techniques in this book. Owners who rent any ski cabin or building with a fireplace may find this book very useful to leave on the mantle (perhaps with a bookmark noting the damper position on your particular fireplace). And of course it could make good outhouse reading for those aspiring to an elegant primitive lifestyle.

A book can give you ideas, but it can't start a fire by itself. (This one's too small for spontaneous combustion.) You have the full and awesome responsibility for your actions. Fire is dangerous. Please take care.

Our goal is to offer solid, general information for folks who are re-discovering fire as adults. Children raised around fire can develop solid skills with supervision from about age 6 or 7, but may not be able to handle full responsibility for a fire until they have many years' experience (age 12-25 depending on the person). Brain development for sound decision-making continues well into adult life, building on past experience. Keep elders handy for backup.

Those with long-standing fire skills may enjoy the way we've highlighted common skills and connected them with historic practices. We hope this book may be useful to you in sharing your skills with others. Feel free to make notes in the margins.

The material for this book has been collected over many years of personal experience, and some of it handed down over many generations. Many thanks to our parents, mentors, and colleagues, including:
- Scouts, Navy, fire crews, OMSI, Hampshire College, OSU, Cob Cottage Co;
- Personal mentors and colleagues Ianto Evans, Herb Bernstein, Deanne Bednar, Caleb Larson, Kiko Denzer, Dale, Jaimie, Thaddeus, numerous students, clients, and workshop participants;
- books by Vrest Orton, Ianto Evans, and David Lyle among others;
- online resources such as www.woodheat.org, www.permies.com, and www.chimneysweeponline.com.

Thank you for reading. Warmly yours,
Erica K Wisner Tonasket, WA 2012

I:Preparations

The first duty of the fire-keeper is preparing the fire's home.

EARTH: The hearthstone

The hearth is a fire-safe area. Your first job is to clear away anything that could burn by accident, creating a safe hearth.

How large a hearth do you need?

Indoor fireplaces have a space for the fire, plus 18” of heatproof hearth to catch popping sparks and embers.

A good bare-earth firepit might be six feet across, or bigger, and 50 feet or more from nearby structures. Clear away everything that might burn - grass, roots, topsoil. A big flat space lets people share the fire without tripping in the dark.

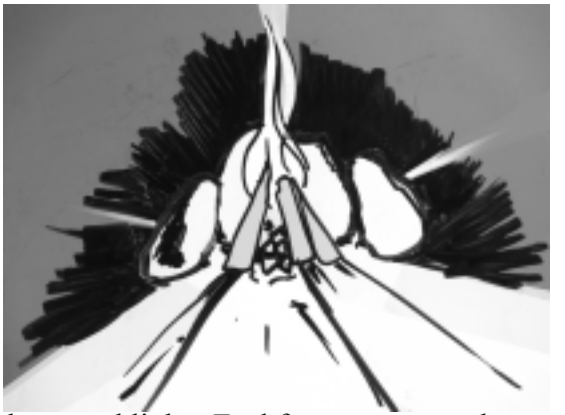
The earliest hearths were often simple flat pits. A pirate kitchen might be a big sand-pan, or portable iron brasier. Deep beds of dry dirt, sand, or ash insulate the fire, keeping the embers hot and the surroundings cool.

In early permanent dwellings, a 'fire back' or flat stone shelters the embers and draws smoke up like a chimney. Over time, firebacks evolved into full masonry fireplaces, ovens, and kilns.

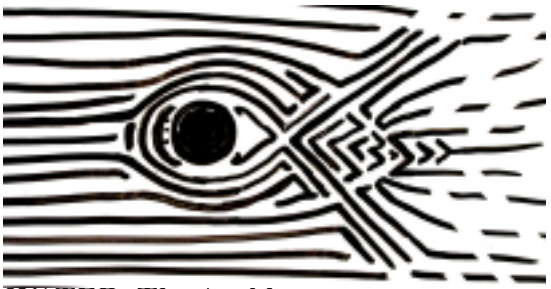
DANGERS: Boiling Oil! Asphalt, tarmac, and oiled roads are not fire-safe. Tar fires are nasty and hard to put out.

Wildfire! Respect 'burn bans' and fire season warnings. Clear away loose fuel near homes and firepits.

Steam explosions! Avoid wet rocks, slate, shale, closed water canteens, and unpierced potatoes.



Fire Rings: Rings are tidy, but they block air, heat, and light. Feel free to arrange the stones to suit your needs. They can reflect heat toward friends and food, and help control fuel, cookpots, smoke, and air flow. Experiment and see what works for you.



WATER: **The Antidote**

Be ready to put out a fire several times bigger than you plan to make. (You never *plan* to make trouble, right?)

Fire extinguishers, and someone ready to use them, are required at all times around an open fire.

Water and CO_2 are common fire extinguishers. If you happen to know that these are exhaust products of most natural fires, you suddenly see many options for fire extinguishers everywhere.

Placing a lid over a fire, or a jar over a candle, 'drowns' the fire in its own exhaust. A damp blanket or stone can smother a fire. A shovel and bucket can beat out a fire, smother it in several ways, carry water, or simply remove hot ash and debris.

Baking soda can smother surface fires, especially grease fires. Oil and grease float on water, so water can spread the fire. Boiling steam spits hot oil everywhere. **Use dry extinguishers for oil fires, and around electricity.**

As a splash of water hits a fire, that familiar 'hissing' sound is water expanding 1700 times its original volume, into steam. The water cools the fire, the expanding steam pushes away the air and airborne fuels, and the evaporation robs even more heat. (This heat is later deposited when the steam condenses - sometimes with scalding effects.)

Even boiling steam is "cold" to a fire. Water boils at 212° F, but clean flames are over 1200° F.

This explains why damp fuel burns so poorly. Green plant matter, wet wood, and sometimes natural gas and alcohol fuels, all contain dissolved moisture. If they burn at all, they make a damp and dirty exhaust. Keep water away from fuel.

Minutes matter when a fire is spreading. **Don't fret.** Grab anything handy, and get it under control.

Better yet, prepare ahead, so it doesn't happen again.

IRON: The tools

When I say 'fireplace tools' most people think of pokers and tongs. Yet you can do most of their jobs with a stick.

A good ax or hatchet is hard to replace. A stout knife does in a pinch.

We've already mentioned the many uses for buckets and shovels.

Indoor fireplaces usually include a broom to tidy up debris. Some folks like tongs, bellows or air pipe, and screens or doors. Various pots, pans, kettles, and utensils may also live near the hearth.

Out in the wood lot, you may see mauls, splitters, saws and chainsaws. These are not needed if you burn small fuels or buy your firewood already cut.

TOOL CARE AND SAFETY:

Bad habits are accidents waiting to happen. Good habits are priceless.

Keep hearth tools handy in a stand or fireproof spot: they get hot. Keep outdoor tools oiled and dry.

Treat all cutting tools with respect: people are softer than wood. Keep sharp edges sharp. A dull tool takes more force. Sharp tools work better, faster, easier, and safer.

Keep work areas clear. Consider your 'blood circle,' the entire area the blade could reach by accident. Stop if anyone enters this area.

Watch for 'lines of force': Where does the tool usually go? Where could it fly if I slip, or if it breaks?

Keep body parts and breakables clear of these lines of force. Wear appropriate clothing that fits, including stout shoes or boots. Consider gloves, eye protection, and finger-substitutes: a good chopping block, clamps or prop sticks.

Don't do heavy work when you're tired or distracted. There is no glory in pushing a routine chore to the point where it becomes dangerous. The first 'close call' means it's time for a break, re-think, or rest.

Practice a little bit each day. Choose good mentors - never go into the woods with anyone you don't trust.

The best tool for the job is the one that fits you.

Axes:

Chopping wood is great exercise, and most ax injuries are preventable. But they are serious enough to be worth avoiding.

Loose ax heads are like zombies: they move in straight lines and want to eat your brains.

Replace cracked or broken handles. Never soak loose handles in water or motor oil. Repeated swelling and shrinking crushes fibers and makes the problem worse. Linseed oil works well to preserve tool handles. It even swells slightly as it hardens.

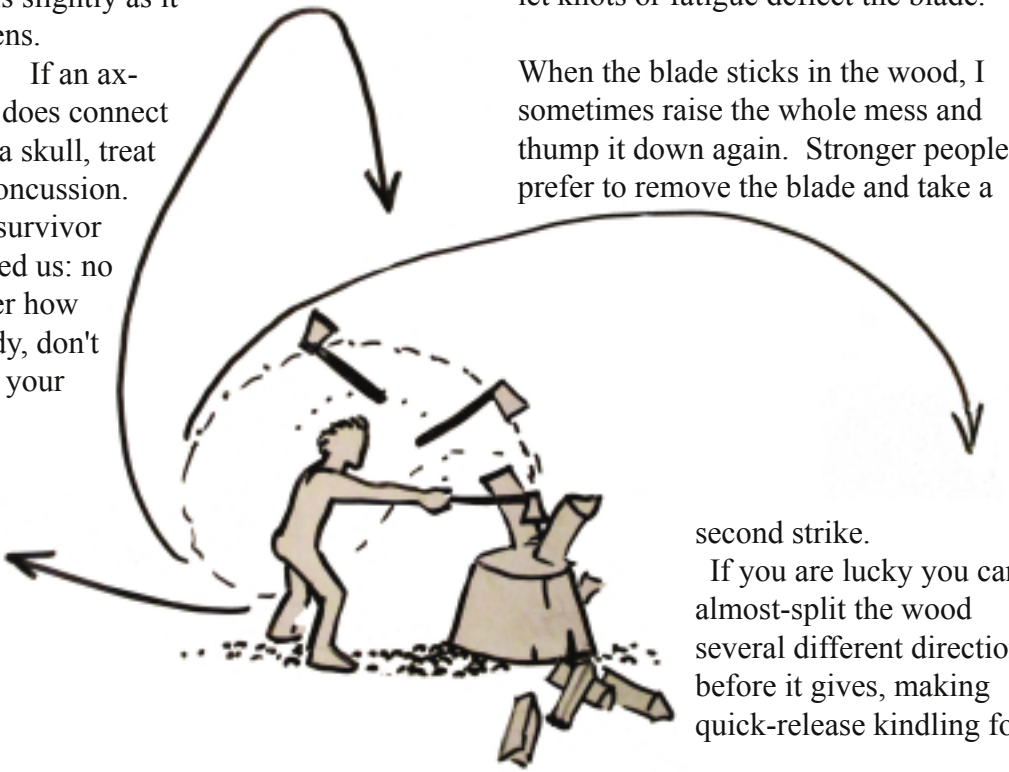
If an ax-head does connect with a skull, treat for concussion. One survivor warned us: no matter how bloody, don't blow your nose.

Set up a good, steady chopping block at a convenient height. (Clean wood - no gravel or nails. Masonry hearths are generally not designed for chopping wood; they can crack or chip.)

Set your firewood upright. Aim for a point near the middle of the wood. (Set the ax head where you want to strike, and adjust your position so it's easy.) Strike downward; let gravity help. Your arms end up horizontal, in line with the handle.

Guide the follow-through. Don't let knots or fatigue deflect the blade.

When the blade sticks in the wood, I sometimes raise the whole mess and thump it down again. Stronger people prefer to remove the blade and take a second strike.



If you are lucky you can almost-split the wood several different directions before it gives, making quick-release kindling for

later.
Keep refining your technique - your toes are worth it. Many people use skills from other hobbies. Consider the martial artists trick of 'relieving' a blow. Instead of crunching all your force downward, envision a down-then-away strike that just touches the block. Some people find it helps to lay a finger or thumb straight along the handle, for aim.

Try striking along a check (crack), or along the growth rings.

Firewood bouncing away is a good thing. Don't let it distract you from controlling the ax.

Try different tools, and see what works for you. If axes and hatchets make you nervous, we've had good results with a heavy cane-knife, froe, or splitting ring (kinda like an apple-corer). These can be tapped down into the firewood without any fingers nearby.

The safest tool may be no tool at all. Accidental gashes from a big nasty tool are all the more embarrassing when you could have snapped the target stick with bare hands.

Most North American forests are currently overloaded with small fuels. Brittle dead branches, or even weed-straw bundles, make good kindling if well dried. It's hard to justify the cost and risk of felling live trees when deadwood is abundant.

If you do need a chainsaw, choose one you can start and handle easily. A 16" bar works faster and safer for most people than a 40-inch logger's bar. Your local dealer can show you how to use and care for your saw.

Avoid surprises, and don't rush. Felling trees is an advanced art; start with downed logs. Consider the chain itself as a major line of force. Where might it the saw or chain go if it breaks?

Stand in the safest place possible. Avoid cutting near dirt, rocks, or metal (damages the chain). Plan ahead to avoid rolling logs onto yourself, or pinching the saw blade in sagging wood.

Cut square, and to fit your stove.

A decent woodshed is essential. Dry storage can be very basic, and save tons of fuel per year.

If you need a temporary woodshed, or chopping space, you can stretch a large tarp over poles to make a rainfly. Ventilation is key; a woodpile wrapped entirely in plastic will never fully dry.

Build your main woodshed big enough for a couple of years' supply.

Minimum seasoning times vary by climate and type of wood. Standing dead pine, stacked in a drylands summer, might be ready to burn in three months. But willow stored in a damp climate can send out leafy shoots many years later. Check with local foresters or the university extension service for local info. Buy ahead, or harvest ahead.

Room to swing an ax is a definite plus. Consider tool storage space. Overhangs should prevent ice or water from dripping inside. Sides should protect from blown rain, but allow ventilation.

Racks or poles hold wood off the damp ground, with air flow underneath. A center divider can keep seasoned wood accessible while loading fresh wood in to dry.

If wood does become damp, especially the end grain, the drying time effectively starts over. It's only slightly faster than the original curing time. Keep end grain exposed to air flow for the fastest drying time.

In mild climates, most people build their woodsheds a little distance from the house, to reduce the chance of termites or carpenter ants moving indoors. In severe climates, a covered walkway may be important.

In areas with misty or humid winters, many people keep a few days' supply of firewood indoors. Heating the air lowers its relative humidity, helping to dry the wood faster than outdoors.

Take a look at neighbors' sheds, and see what seems to work best in your area. Do what works for you and your family.

II: Makings

The second duty of the fire-keeper is attending the fire's needs.

WOOD: The Fuel

Plants harvest sunlight, air, and water, and store the energy in solid form. We eat the 'good bits' and use wastes for fuel. Straw, dung, peat, even bone and fat can burn, but wood is our most common heating and cooking fuel.

All fuels must be dry. Dry fuel makes fire easier, cleaner, and safer.

Dry fuel saves effort. Not only is dry wood lighter to lift and easier to split, you don't need as much of it. Heating with dry, seasoned wood takes half the fuel compared with damp or green wood.

Dry fuel burns without smoke. Even pitchy wood can burn clean if dry and seasoned. Green wood doesn't exactly burn - it leaks sap, steam, and smoke as it slowly smolders.

Unpredictable fires are dangerous. Punky rotten wood can hold a coal even when the outside feels cool to the touch. Damp wood burns cool, and the unburned smoke condenses as creosote inside the cool chimney. Chimney fires suck.

It is amazing how many people know about dry wood, yet don't keep it.

If you ask your Kamp Host how dry is their bundled firewood, and they say 'It hasn't rained in over a week,' the wood is not dry.

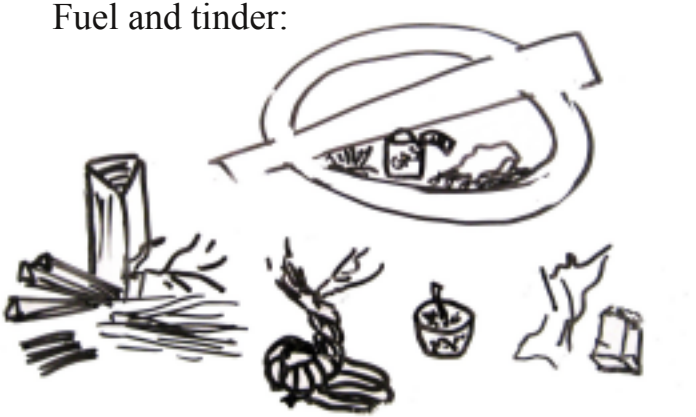
If you see mushrooms, white rot, ice, greenery, or anything slimy growing from/on the wood, it's not dry.

Wood 'seasoning' under a tarp can rot before it dries. Ground damp and sap moisture steam up, condense inside the tarp, and trickle back down into small pools. Rain and snowmelt percolate through any holes. If you must use a tarp, hang it up like a rainfly with good air flow, draining away from the wood.

When buying seasoned wood, look for well-ventilated stacks or piles, protected from weather by wide eaves or lofty rainflies. Buy well ahead.

In forests, the driest wood is 'standing dead,' up off the ground: brittle twigs under evergreen's skirts, dry limbs that snap when broken.

Fuel and tinder:



The main difference between tinder, kindling, and firewood is the surface area by weight. More surface area burns faster; bigger chunks burn longer and slower.

Tinder should be dryer than bone, finer than hair, and prepared with delicate care. It serves as the first fuel, and may also help protect and insulate the spark until the fire catches.

The traditional fire-keeper collects scraps of tinder from any daily activities. This might be scraps of birchbark or shredded cedar; trimmings from natural rope, thread, or cloth; planer-curls of fir and pine; cardboard and butter wrappers. There's something intensely satisfying about feeding the fire little mementos of your day.

Oils and fats hold a lot of energy. "Fatwood" is pitch-streaked wood that can hold a flame like a candle for lighting other tinder. Greased paper, wax-and-sawdust firelighters, and even oily tortilla chips give fires a similar boost.

DANGER: Explosives: Never squirt volatiles into the fire after it 'failed' to start, even official lighter fluid. The fire could easily track back up the oily stream and explode your container. Using gasoline or any other explosive fuels, at any stage, will get you institutionalized or dead.

The modern reader will most likely use paper scraps for tinder. Look for rough brown paper or newsprint. Bright printing paper contains clay, an inert mineral that dampens young fires and produces huge drifts of ash.

Plastic windows and varnished, painted, or glued materials are too rich and noxious for starting fires. Our preferred tinder is brown paper bags from the grocery store, or any waxed or greasy paper.

Good kindling has spunk. Dry twigs snap; dry cordwood splits with a crack and bounce. Kindling's job is to catch before the tinder burns up. Finely split cordwood of any kind works fine. Bundles of very dry twigs can work if the bark

is resinous (cherry, hemlock, spruce; I've even used ivy and bramble canes).

Play with your firewood – try whittling it; compare different locally available woods; save out some of last season's firewood to compare with the new load. The better you appreciate the wood, the better fires you can make, and the greater you will feel the sacrifice if burning poor, wet, or exceptionally valuable wood.

Good firewood is dry and dense. Dense hardwoods hold more fuel per stick, but all wood is about the same per pound. Resin or pitch can make fuel richer, sometimes too rich to manage. Soft 'punk' or rotten wood may feel dry, but actually contain a lot of moisture. Lumber may contain weird salts that can damage chimneys. Plywood, chip-board, and other wood/sawdust products should not be burned unless they are designed for the purpose.

If your firewood is actually dry - under 20% moisture - the fuel value is pretty consistent with the weight. Weigh a few pieces, force-dry in a warm oven, then weigh again to find the moisture content of your wood.

HEAT: The Spark

It takes heat to break down the fuel; once started, a fire produces more than enough heat to keep itself going.

There are many ways to start fires. Friction fire methods use easily-found materials like wood and cord: bow drill, fire piston, bamboo fire slide. Travelers might carry special fire starter materials: flint and steel, magnifying glasses, magnesium, matches. Modern materials work too: clear plastic can hold a water lens. Batteries can make a spark or red-hot wire.

One of the oldest methods of starting a fire is from a live coal. This is

great practice for any traditional method, since most of them only generate a tiny ember or spark. Get your tinder ready, then scratch the ashes for a hearth coal, or borrow a live ember from another campfire. There's nothing quite like holding a tiny ember in a nest of tinder, blowing it into life.

Many people religiously keep coals alive at all times; ancient calendars include annual re-lighting of new fires. Nomadic people might carry embers from camp to camp in fire-mushrooms, fire-horns, portable clay pots. Try it sometime. Keep a coal alive overnight in your firepit, in any weather, using only materials at hand.

Whatever your preferred method of starting a fire, practice and perfect it.

Can you build reliable one-match fires? How will you waterproof your survival matches? Try nail polish, wax, containers - test and compare the results.

Do you refuel your own lighters? Ever catch a spark from the lighter after the fuel is exhausted? Keep your spare lighter dry and handy.

Fire is a survival essential. Even with plenty of shelter, water, and food, fire lets me purify food and water; keep gear dry; drive away pests; signal for help; or live comfortably alone. If you depend on modern tools for your fire, make sure to keep them with you.

AIR: The Flow

All fires require air, as animals do, to survive. (Both animals and fire take in carbohydrates and oxygen, and produce energy, carbon dioxide, and water.)

A healthy flame circulates its own air by convection. Cool air enters near the bottom of the fire, mixes with fuel gases, burns, and rises up and away on the buoyant current of warmed air.

Fresh air is about 21% oxygen. It's mostly nitrogen; other gases add up to only 1%. It's important to maintain good fresh-air supplies for people, animals, and fire, or the oxygen can become depleted. Fires burn poorly in thin mountain air.

Pure oxygen makes fires burn with incredible intensity. Avoid fire around supplemental oxygen, and chemical oxidizers like chlorine.

In a perfect fire all the products are completely consumed, and warmed air carries off the spent fumes with less odor than a healthy animal's breath.

In an imperfect fire, stinging blue smoke soon obscures the surroundings. A very sick fire may produce yellow or even black smoke. All smoke is unburned fuel; all smoke is noxious to breathe.

'Airtight' stoves deliberately deprive fires of air, slowing the burn. These are now illegal in many areas because of their incredibly dirty smoke.

Too much air can cool a fire until it blows out, or fan flames into wildfire.

FIRE TRIANGLE:

The interaction between **air, heat, and fuel** is what makes fires work. These are called the 'Fire Triangle.' Remove any one, and the fire dies.

III: Forms

The shape of the fire fits its purpose.

GRID FIRE:
A big punch of heat is delivered by a grid of sticks, laid slightly apart for air (about half the sticks' width).

The first way I learned to build a grid fire is to work up from smaller to larger pieces. Fire burns up, right?

'Rails' make room for tinder on the bottom. Kindling crosses the rails, bigger wood goes higher up.

This layout is quick and reliable. A grid of 1" sticks quickly burns down to coals for campfire cooking.

But this grid is not clean. The larger logs smolder before they burn. Smoke from the log-ends escapes the flames. And of course, the logs fall down as the kindling burns away.

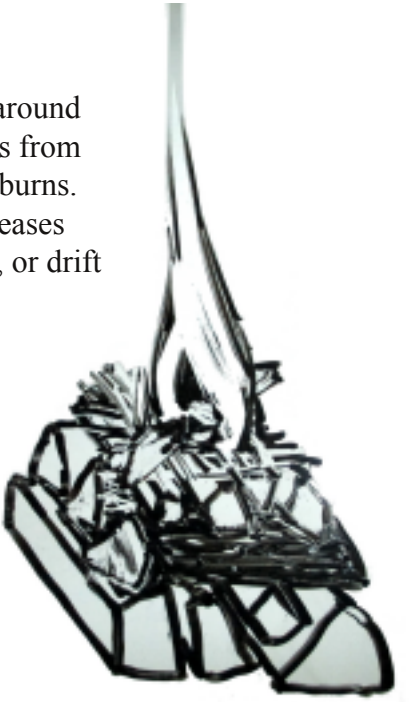
CANDLE or UPSIDE-DOWN FIRE:

Look at a candle flame. See the space around the wick? This is where melted wax evaporates from the wick as a flammable gas. This gas is what burns.

The same is true of wood: hot wood releases volatile gases. These gases can burn as flames, or drift away as smoke.

Smoke is wasted fuel: unburned wood gas, partially burned tar, soot, and exhaust gases.

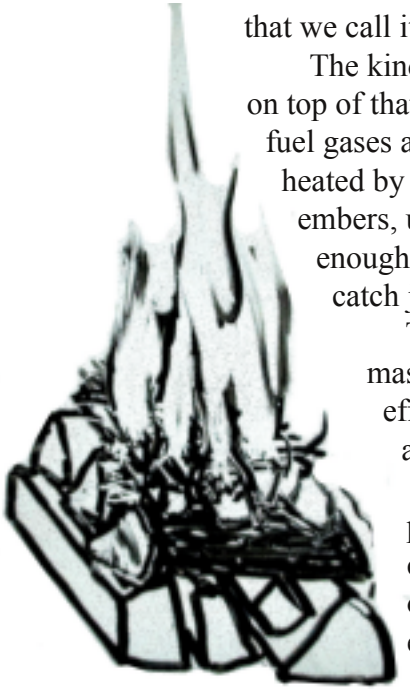
For a smokeless fire, we need a flame at the top of the fire to catch all this rising, smoky fuel.



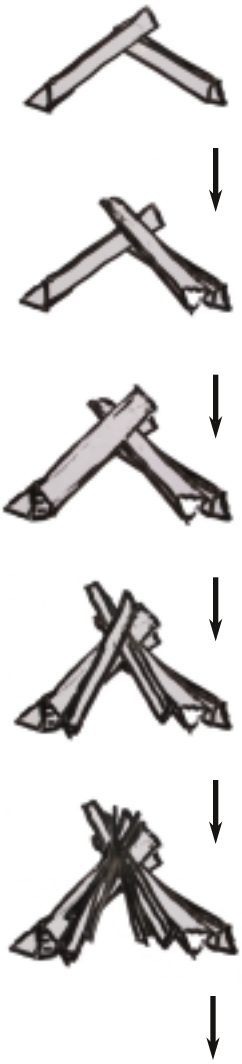
This is so counter-intuitive for most people, that we call it the "UPSIDE-DOWN FIRE."

The kindling goes on top, and the tinder on top of that. A bright flame burns up the fuel gases as they rise. The wood below is heated by radiant heat and falling embers, until the whole stack is hot enough to burn. It really does catch just fine: Gravity works.

This is the fire used in masonry heaters, to burn efficiently with less soot and creosote.



It works pretty well for campfires too, but in open air some smoke still escape from the log ends.



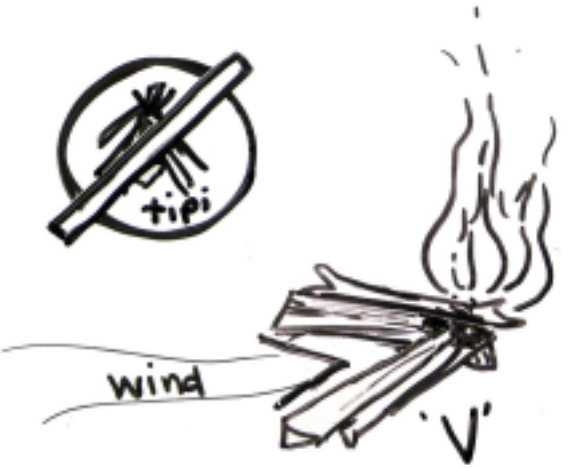
V-FIRE:
For focused, clean fire, my current favorite layout resembles a split-rail fence corner.

With your back to the wind, lay the sticks with their tips crossing (like drumsticks).

The crossed tips make a tall corner to protect and focus the flame. Light the fire in this corner.

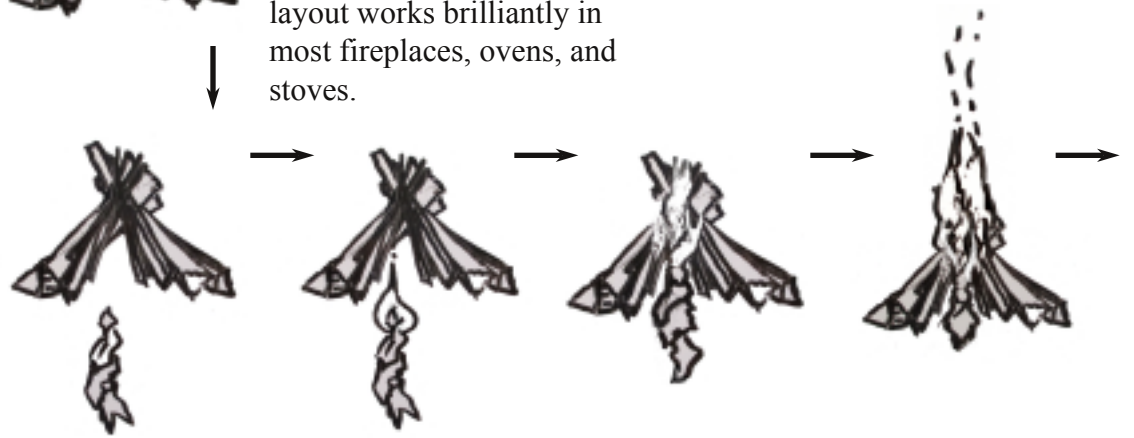
More wood can be added the same way, on each side. Push unburned ends into the flame as the tips burn. In a big fire circle, long logs can be burned frugally this way by heating only the tips.

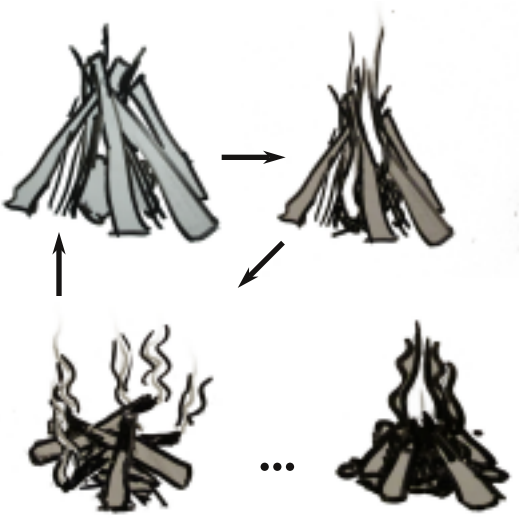
The V or split-rail layout works brilliantly in most fireplaces, ovens, and stoves.



I've shown the V-fire layout in detail, one stick at a time, because it's easy to confuse a simpler drawing with the 'Tipi Fire'.

The V-fire may be the original tipi fire. Certainly the V-fire has been used in tipis. And it's easy to confuse the two based on brief illustrations.





'TIPI' TROUBLE:

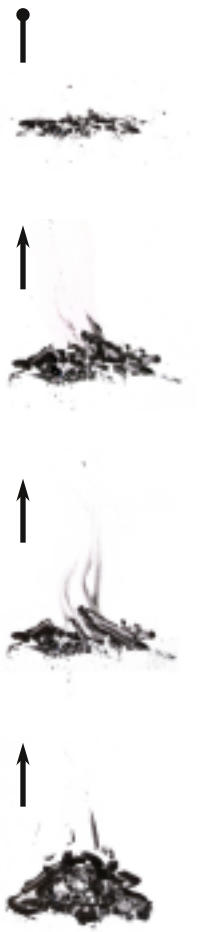
There's a popular idea that you can start a campfire by balancing sticks together in the shape of a tipi. This shows up in Scouting manuals and comics.

Vertical sticks do burn cleaner - the smoke from the log-ends stays right near the flame. A half-tipi against a fireplace wall, log, or rock works great. But anyone who's tried to balance sticks against each other, on end, in a campfire circle, knows it's not easy.

After lighting tinder under the carefully-balanced sticks, the fire burns until one of the sticks shifts from the heat. All the sticks fall down crosswise, the hot tips in different places, and the fire self-dowses.

The whole thing has to be started over again several times with much scorching of fingers and replacing of kindling.

The most practical use of this layout may be to keep the Scouts busy while the leaders handle other duties. Starting a tipi fire, including the arguments and false starts, can buy the leader an hour or more of near-privacy.



UPRIGHT 'WOOD STOVE'

With well-cut firewood that stands straight, you can build a "wood stove" or fireplace entirely from wood.

Do wooden fireplaces sound dangerous? They should. These fires get intensely hot, so use a big, level, outdoor firepit with plenty of water handy.

Choose three split logs the same height. Set them facing inward, in a tight circle with one opening. Light a small V-fire in the center using kindling. Feed more sticks in through the opening if needed, until the faces of the logs catch on fire.

To move the logs after they are burning, use heavy welding gloves. Pitchy wood can become an inferno.

This fire often wins friendly contests, boiling a liter of water in about 6 minutes.

LIGHT

Firelight is beautiful, but not as bright as modern lighting. It takes over 180 candles to equal a 100-watt lightbulb.

Reflectors and white walls can nearly double the light from a few candles. Lantern-shades shield the eyes from direct glare.

Big logs don't put out much light, so add pine-cones or twigs for a brighter show.

SMOKE:

Smoke is unburned fuel. It's also toxic. Smokeless fire is both safer and more efficient.

However, there are times you may want smoke: for signals, curing food, for camoflage scent, or for producing sooty stains and inks.

Insect-Repellent: Blood-sucking insects often follow carbon dioxide and heat. We can't help making these traces every time we breathe. But they shy away from smoke: a mosquito can't last long in a forest fire.

There's no need to burn a smoky fire or citronella all night; a brief 'smoke bath' or smoke-scented lotion can give several hours' protection.

Smoked foods are an art. You can find recipes online for hot-smoking, cold-smoking, jerking, curing, and drying. Green twigs or chips are chosen for flavor: hickory, alder, mesquite, applewood, and other fruit and nut woods. Pitchy wood has a nasty flavor.

Clean, non-treated wood is essential when cooking. Fumes from paint, varnish, or orchard spray can taint the food.

Like many arts, smoking food comes with rich private traditions. Local favorites may be closely guarded.

If you want to learn someone's secrets, use your best manners. Offer gifts, compliments, skill swaps, or plain chore labor. Respect their right to set terms, and to say 'no.'

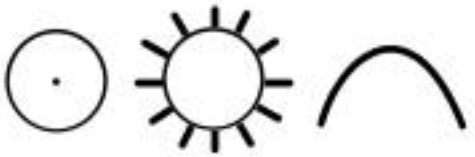
IV: Functions

The fire's surroundings help it do its job.

HEAT TRANSFER:

Fire serves many purposes, but the main goal is usually to heat something. Watch for heat transfer through conduction, radiation, and convection.

Conduction is heat moving through solid stuff by contact - like warm bath-water, or the hot handle of a skillet. Conduction is efficient and invisible. Watch for direct contact, dense materials, and shapes that fit the task or body.



Radiation is heat moving like light. Rays go straight until they hit something. Solid objects make cooler shadows. Hot and warm things re-radiate heat. Watch for round shapes that focus, shed, or reflect radiation evenly, and for directional reflectors.

Convection is how heat rises in warm air or fluids. It is least efficient, but easy to use. Watch for chimneys, funnels, dome traps, and ducts that rise or fall. Cool air flows down like water; warmer air rises up.

CAVE HEARTHS:

While primitive methods may not be safe or wise, we can learn a lot from how early people survived. A trained mind can find comfort with deceptively simple tools and materials.

Early masonry homes have been called ovens that people lived inside. One simple trick from cave-dwelling days was the practice of sweeping aside the embers

from daily cooking fires to sleep directly on the hearth stone at night, like bread rising in an oven.

FIRE BERM: An earthen wall or berm can reflect the heat of a fire toward people or tents nearby. If you can see the light, the heat can reach you too. (Note: heat also reaches the flammable tent material.)

SMOKE HOLES:
The more windproof and weatherproof the house, the more important it becomes to let the smoke escape.

Thatched stone or earthen cottages have thick walls that soak up and store the fire's heat. Most allow the smoke out through either the loose thatch itself, or through a hole in the roof.

TIPI FIRE / KIVA FIRE:

If one hole is good, two holes - one for smoke and one for incoming air - is even better.

Tipis (cone-shaped tents) are natural chimneys. The door opening serves as a natural air intake.

Tipis are primarily a warm-weather tent or travel shelter. Sometimes an under-floor air inlet and liner are used for cool weather camping. Historically, many tribes used tipis for summer only, and returned to earth-bermed or earth-sealed winter houses for winter.

A special air channel was traditionally built into **kivas**, a sunken earthen room from American Southwest

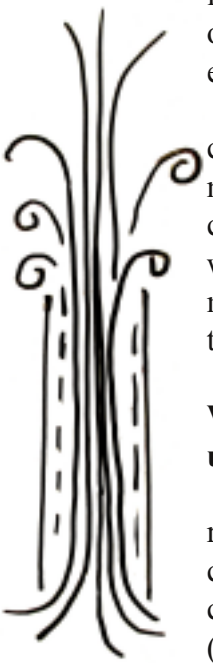
architecture. These rooms were accessed through a single opening in the top that served as both door and smoke-hole. Fresh air from a second shaft helps to keep the fire burning sweetly.

Note that the air shaft is well away from the fire, and lower than the roof hole. It will not accidentally start drawing backwards.

Note that a modern, synthetic yurt, with a vented skylight and a short side-wall chimney for its woodstove, looks a bit like this picture, too. Except the occupants expect the smoke to flow the opposite direction. Which do you think works better?

A **proper yurt** from the snowy high steppes of Mongolia traditionally has a framed-in smoke hole located at the top of the structure.

Any warm structure will draw air upward by natural convection. Hot air rises, generally seeking the highest point just as water seeks its own level.



CHIMNEYS:

A good chimney is hot, vertical, sealed, and taller than competing structures.

Vertical or near-vertical chimneys provide strong draft. There is no reason for a horizontal chimney to draw at all. Angles of about 45 degrees or steeper draw OK. Vertical draws best.

Warm chimneys work better than smoke-holes because room air doesn't disturb or mix with the upward-flowing hot smoky air. A *cold* chimney can channel cold air downward just as quickly, especially in a warm house.

If wind or shade chill the chimney, or the house has negative pressure, a chimney can easily reverse flow. A cold chimney flue next to a warm one may suck smoke back into the house.

Exposed chimneys must be insulated to above the ridgeline. Since insulated sections are costly, stuck-on-the-side chimneys become expensive quickly.

We prefer build chimneys centrally inside the house, exiting near the roof peak. More of the chimney's valuable heat is shared with the home; the chimney works more reliably in odd weather; and the proper materials may cost less.

Why do we willingly sacrifice heat up the chimney?

Breathing clean, safe air is the first reason. Combustion exhaust contains less oxygen and more carbon dioxide. Carbon monoxide (CO) is formed in low-temperature fires: it's an invisible gas that can displace vital oxygen in the bloodstream.

When starving peasants or Detroit squatters resort to burning indoor fires without a chimney, they are choosing a slow poison. Smoke exposure causes familiar symptoms like irritated eyes, nose, throat, and lungs. CO poisoning, excess CO_2, and depleted oxygen may cause symptoms too subtle to notice: lethargy, weakness, headaches, irritibility, and finally fainting. Entire families can pass out and die in their sleep.

Chimneys draft even if they are just warm, but we want them hot - above 350° F - for another reason.

Smoke contains unburned fuel.

This fuel can condense on the sides of a cool chimney, making a sticky, flammable mess we call 'creosote.' If the chimney is hot enough, there tends to be less creosote in the first place (because the heat is coming from a good hot fire below), and the remaining creosote stays evaporated and doesn't coat the chimney. A nice hot chimney, weirdly enough, helps prevent chimney fires.

Properly sized chimneys waste less heat, and experience fewer smoke and creosote problems. Creosote buildup can also be prevented by burning clean fires with little or no smoke.

Hot chimneys can help reduce the smoke from fires, on many scales.

CHARCOAL-CHIMNEY:

A steel can with a handle makes a great starter chimney for barbecue coals. Light a kindling fire at the base of the coffee can. Add clean fuel. Let the fire burn until the coals are hot enough. With tongs or an oven mit, lift the can off, and spread the coals out for grilling.

DIRT CHIMNEYS:

Boiling water may be the most common cooking task in the world. A short, hot chimney can make this task quick, efficient, and nearly smokeless.

FOX STOVE / DAKOTA FIREPIT:

The fox stove, badger stove, or tunnel stove is found on at least five continents. Examples dated to 5,000 years ago have been reported from India/Pakistan.

Why a 'fox' stove? An existing burrow offers a good slope and taper for the air feed. After digging straight down to meet the horizontal burrow, we pile the dirt around the hole to create a short chimney. The pot goes atop this chimney, on small stones with air gaps between.

The Dakota firepit is a North American tunnel-stove variation, sometimes shown without the chimney. Why would someone move dirt further to make the fire less effective? Readers, please enlighten me.

Tunnel stoves are nearly invisible,

nearly smokeless, cook effectively with little fuel, and are easily dowsed and hidden. Wickedly effective for traversing enemy territory, especially where flat plains make any light or smoke visible for miles.

The main weaknesses are flooding or damp, and a few rare soil types that are unsuitably loose or flammable.

JUG STOVE / TERMITE TEA STOVE

I am told that among the Masai, there is a tradition of making tea whenever and wherever a pair of warrior-herdsmen happen to meet. This courtesy shares clean water in a thirsty land, and allows time to establish mutual respect.

The 'jug stove,' or Masai tea-stove, can be dug into a termite mound or convenient hillside. The jug-shaped hollow holds fuel and fire, and the teapot sits (on rocks if needed) above the bottleneck chimney. The dry earth insulates so well that it takes only a few twigs to boil water.

Imitations dug into frozen piles of fill dirt may need more fuel.

ROCKET STOVES

Our 'tea stump' has a jug-shaped fire chamber inside, carved from refractory insulation and lined with harder materials. A wide range of insulated 'chimney cookers' are being advocated as an alternative to smoky open hearths.

Displaced people seem to default to an open hearth with three bricks propping the pot over the flames. Similar baseline conditions are reported on every continent, wherever people don't know any better or have lost access to their accustomed kitchens. A dry hearth with three bricks would be an air quality improvement over the common North American campfire circles full of damp charcoal.

Problems from cooking over an open hearth include

-inefficient use of fuel,
-toddlers falling into the fire while mother is cooking,
- and in indoor settings, cooks suffering from smoke inhalation equivalent to a 400-pack-a-day cigarette habit.

Scrap metal projects: a ROCKET COOKSTOVE (left) or POCKET ROCKET (right).
Narrow channels concentrate heat from a small load of fuel. Hot fuel and air mix, producing a clean hot fire.
Metals conduct more heat than they reflect, so insulation is key to concentrating the heat.

Clean fire starts around 1200 F, and wood fire can get well over 2000 F with good insulation. So we need inert, high-temperature minerals. Dry wood ash insulates pretty well if you have a container for it; so does dry dirt.

Super-insulative adobe can be made by mixing clay slurry with sawdust or charcoal dust. The dust burns out leaving a foamy ceramic. These 'Vernacular insulative ceramics' can work wonders: Rocket cookstoves lined with VIC in one Uganda experiment used about half the fuel compared with an open hearth.

THE GOOD STOVE: This two-burner adobe stove was made and decorated by its owner, a villager in rural India. The thick bricks protect toddlers from stumbling into the fire. The second burner allows cooking a full meal at once. Local culinary arts can be a bigger acceptance factor than efficiency.

Image courtesy Dr. N. Sai Bhaskar Reddy, http://goodstove.com

BRICK STOVES, OVENS, and FIREPLACES:

Speaking of traditional cuisine, you can't have bread without an oven.

Brick or clay are easy to work with, and hold heat beautifully for even baking. The dense masonry does take huge amounts of heat to warm up. A central bakery is more efficient than hobby ovens, since long, daily baking cycles take full advantage of stored heat.

EARTH OVEN

A traditional earthen oven can be built over a sand mold or wicker frame.

Every village from Italy to China has its own special oven shape to suit the local cuisine. Some are durable: built on stout foundations with a good roof, made with carefully chosen aggregates, clays, and decorative plasters or mosaics.

Others are re-built with straw and mud every year, the charred remains broken up into the fields. This 'careless' process can improve clay-heavy soils with porous drainage material and nutrients.

MASONRY HEATERS:

Masonry can also store heat for homes and people. Quick, hot daytime fires charge up the masonry thermal battery, which releases steady warmth all night and takes days to fully cool.

Roman hypocausts, 'Turkish' baths, Chinese Kang stoves, Russian fireplaces, Finnish and Swedish contraflow heaters, German kachelhofen (tile ovens/stoves) and steinoven (earlier stone-ovens or stone-stoves), Afghani clay stoves, Korean ondol... many names for civilized comfort.

Most masonry heaters include a floor, bench, or bed for directly enjoying the gentle warmth. Modern column

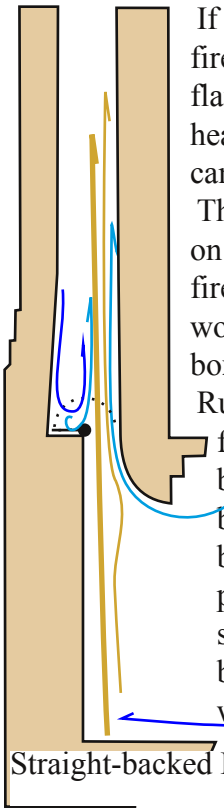
fireplaces and novelty tile stoves from Versailles are notable exceptions. Perhaps owners of luxury apartments can afford more fuel?

RUMFORD FIREPLACE: Fireplaces are far more common than masonry heaters, despite their lower efficiency. They're simple to build and operate, and give great entertainment watching the flames. But open fireplaces with big chimneys can draw a lot of heat out of the house.

If you want an elegant fireplace that offers showy flames *and* puts out more heat than it sucks up, you can't beat a Rumford.

There are many variations on the 'authentic' Rumford fireplace. They all seem to work better than the deep-box alternatives.

Rumford preferred his fireplace with a 'straight back and a rounded breast,' insulative, and brightly whitewashed or plastered. To make the smooth curved throat, behind the lintel, his workmen used plaster.



Straight-backed Rumford

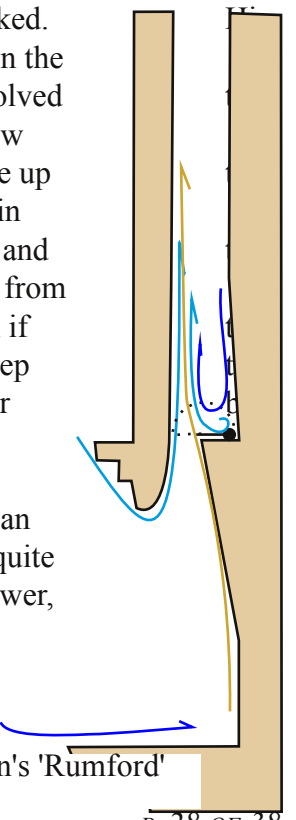
Some 'Rumford' masons prefer to introduce a slight inward slant to the back, to gather smoke along the surface.

We now know that all colors of masonry re-radiate heat about equally well, so white vs. colored is optional. Of course, white does reflect more light.

The key to the Rumford's heating efficiency is that it is shallow and tall, with angled walls that reflect heat outward, and a narrow throat that doesn't draw too much room air.

Prior to Rumford, shallow fireplaces often smoked. intuitive insistence on the curve of the throat solved problem: laminar flow smoothly rolls smoke up chimney behind a thin 'curtain' of room air, and smoke shelf keeps it from returning back down if chimney is cold. Keep smoke shelf clean for results.

An existing, oversized fireplace can often be remodeled quite cheaply into a shallower, better-performing Rumford.



Vrest Orton's 'Rumford'

Ox-Cooker
(non-heating)
Fireplace

Square walls reflect most of the heat inward. This works for an oven or cooking fire, especially if you don't want the kitchen too hot in summer.
But in winter, all that heat still goes straight up the chimney. So does a lot of the smoke - unburned fuel from the edges of the fire, that gets cooled by excess air.

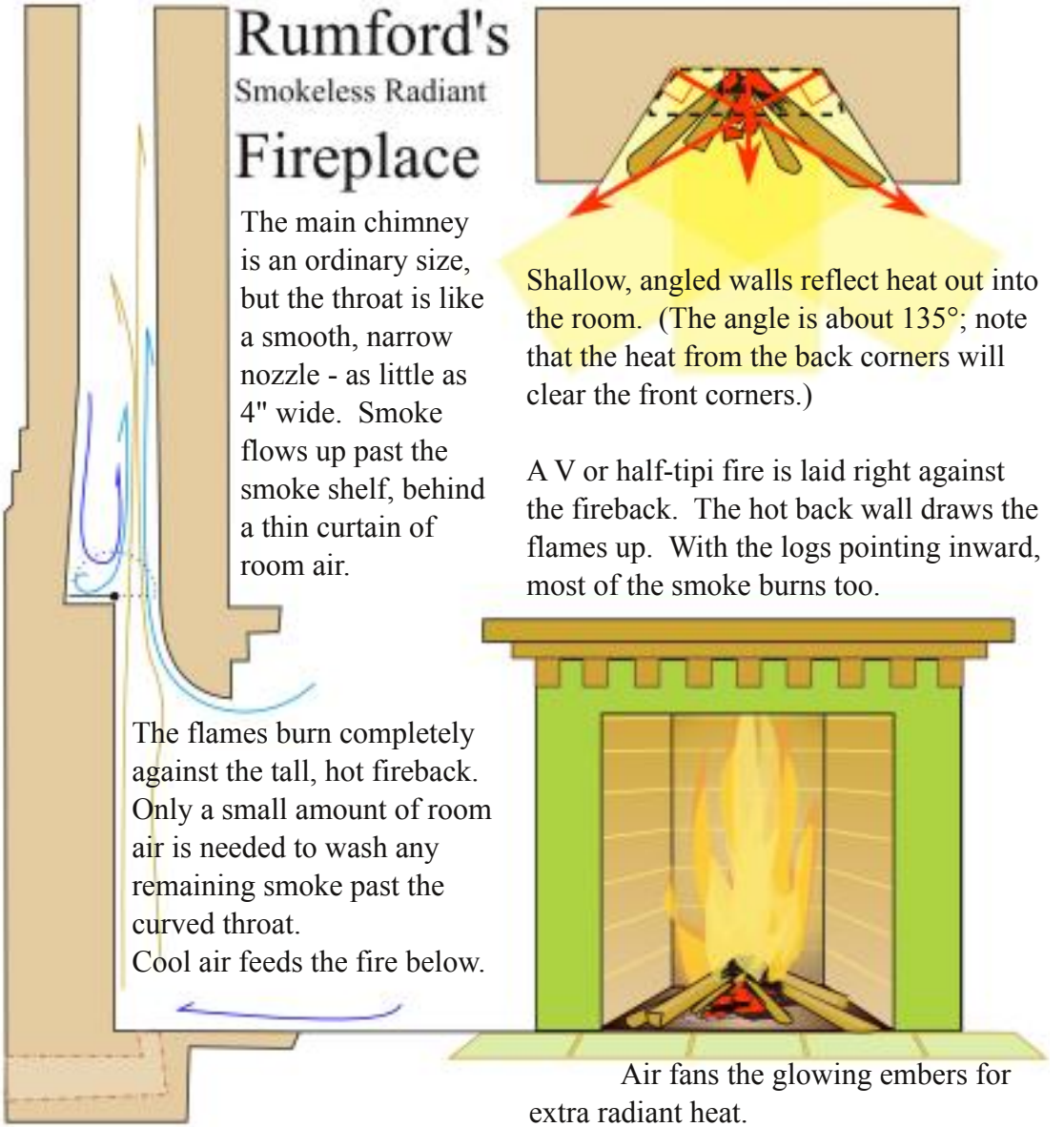
A poor fireplace will smoke. This leads to deeper fireplaces with lower lintels to trap the smoke under the chimney.

A big, turbulent chimney draws huge volumes of air through the house. Cold air flows in along the floor.

Deep box fireplaces are essentially an outdoor firepit that you tend from indoors. Even though a glass door blocks most of the radiant heat, it will also cut the heat loss due to excess draft.

Because the deep overhang makes it hard to see the flames, some fireplaces have a raised hearth. But raised hearths block radiant heat from reaching the floor. Cold drafts of replacement air pool below the hearth level. Feet stay cold unless propped directly on the hearth.

Rumford's
Smokeless Radiant
Fireplace



The main chimney is an ordinary size, but the throat is like a smooth, narrow nozzle - as little as 4" wide. Smoke flows up past the smoke shelf, behind a thin curtain of room air.

The flames burn completely against the tall, hot fireback. Only a small amount of room air is needed to wash any remaining smoke past the curved throat.
Cool air feeds the fire below.

The shallow Rumford fireplace draws minimal air for its needs, and heats best when wide open. Glass and screens block radiant heat, so we only use them if we need to leave the fire unattended.

Shallow, angled walls reflect heat out into the room. (The angle is about 135°; note that the heat from the back corners will clear the front corners.)

A V or half-tipi fire is laid right against the fireback. The hot back wall draws the flames up. With the logs pointing inward, most of the smoke burns too.

Air fans the glowing embers for extra radiant heat.

A flush hearth (at floor level) puts the radiant heat where it's most wanted: down low. Warm floors help counteract convective drafts, and keep toes warm too.

WOOD BURNING STOVES:

Wood stoves are the most popular wood heat option in North America today. They are lightweight and affordable, lab-tested for air quality and safety, and can be installed with basic clearances in almost any structure.

Since Americans on average live only 5 years in each home, low cost and portability are big selling points. So are flame-viewing windows, flat cook-tops, and built-in air controls.

You can use almost any fire layout in a box woodstove. Some stoves have both front and side loading options, or may be burned open, like a fireplace.

Every model is slightly different. Your home, chimney, wood choices, and weather also affect performance.

To get the most out of a woodstove, it helps to play prairie dog. **Any stove is burning at its most efficient when there is no visible smoke.** Early steam engineers calibrated their engines by mounting a mirror so they could watch for smoke from the controls.

Without a periscope, your simplest option is to build a fire, then go outside and look at the chimney. Adjust the damper, go check again. When there is no visible smoke outside, come back in and listen to the fire for a while. Make notes. Check again in 30 minutes, or an hour. Over time, you will learn to achieve your longest smokeless burn, and to hear and interpret the fire's subtle updates.

This no-smoke training method can even help you clean up the performance of older or antique stoves, and avoid chimney fires.

Some local air quality laws are starting to limit visible smoke to 20 minutes. This is a reasonable response to smoke pollution, especially compared with arbitrary rules like 'only one wood burning appliance per property / per acre,' or banning new installations while allowing the use of existing (older, smokier) stoves.

Why do people burn smoky stoves? Many operators don't know better; but a few deliberately smolder fuel for overnight heat.

A responsive stove is quick to heat up, quick to cool down. For overnight heating, we want a steady, stable, mild temperature.

How do you get fire to stand still, or burn in slow motion?

Don't be tempted to repeat the dirty trick we learned from the old 'Airtight' stoves: cutting off the air to 'bank' the coals. This makes loads of black smoke, and causes chimney fires.

Efficient fire is smokeless fire. Air-starved fires waste fuel, coating chimneys and lungs with flammable creosote. This can cause chimney fires, rattling and explosive flashbacks, asthma and black lung, CO poisoning, and recurring maintenance nightmares. And it makes regulators gnash their teeth and think up more laws.
Can you sleep peacefully through all this?

Modern woodstoves are designed to prevent this type of unsafe operation. They supply adequate air for clean combustion even at their slowest tested burn rates. Chimney temperatures remain above 350 F for safe draft, preventing creosote deposits. Even the smallest versions can offer a 6- to 8-hour 'long burn' operating by the book.

The problem is when an operator who likes 'the airtight level of control', he or she can work around the clean air design with thick beds of ash, unauthorized chimney dampers, or even a steamy pile of green wood. Back to the dark ages of creosote, smoke and smog.

CLEAN overnight heat takes thinking outside the box.

Remember how one of the selling points is the building doesn't matter? Well, it does. Everything counts.

Heavy materials store heat. Once that lightweight stove is in place, back it up with brick. Firebrick liners or soapstone tiles can store a couple hours' heat, extending that 6-8 hour burn into 8-10 hours of heat. A masonry hearth, concrete floor, or even loose rocks on the stove can store heat.

Give the stove a central place of honor. Radiant heat is line-of-sight, so place the stove near where you like to sit and keep an eye on the fire. Heated air rises, so upstairs bedrooms stay toasty. Distant rooms may need their own heat.

Energy audits can help pinpoint major heat loss areas, and suggest where to add insulation, storm windows, drapes or gap-sealing.

With R-60 insulation around both you and your water pipes, you could practically heat with a candle. Build a clean fire at your convenience, and sleep soundly.

V: Spirit and Practice: Fire in the Soul

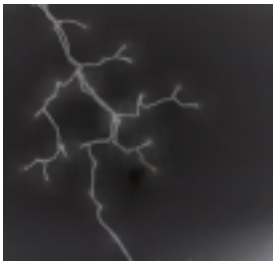
Physical, practical fire is captivating enough.

Fire also connects us with ancient human cultural and spiritual traditions. Careful tending of fire is a sacred trust.

Fire keepers maintain living traditions like sauna, hangi, luau, meditation or prayer with incense, fire-dancing and fire-walking, sweat lodges, candle-lit vigils, annual bonfires. Fire keeping is also the unsung dedication of those who rise first every morning to warm the food and house, and put the embers safely to bed before sleep.

Fire's symbolic meanings often reflect its practical roles. Some of the oldest references offer important reminders.

Stories about how humans learned to make fire often involve angry gods, theft, or terrible storms. Lightning strikes are unpredictable, with a reputation for



striking the tallest or proudest individual. Lightning is more powerful than kings: the wrath of God, celestial war-hammers, mad science, uncanny power beyond mortal control. Wildfires and volcanoes represent Hell, torment, punishment.

Fire is pain, death, and fear. It is power like a god's. Animals panic at it. Even plants and insects show aversion to smoke.

The most horrible wars, sacrifices, and tortures involve fire precisely because it causes extreme pain and devastation. Only humans have deliberately courted fire despite its terrible dangers.

How can this terrible thing also represent warmth, love, and peace?

Once the ember is tamed, keeping it alive calls for steadfast care and devotion. Kitchen fires show a mother's care. A light in the window welcomes the traveler home. Yule logs bring summer's bright cheer to the dark of winter. In fairy tales and literature, a hearth without a fire suggests something very wrong at home.

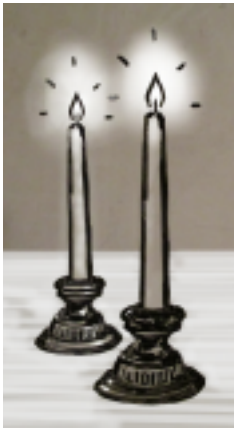
A temple or church can be a 'larger home' for the community, a refuge and a central hearth. Eternal flames: reassurance that you could always borrow a light? Sometimes in India, sacred groves are opened as an emergency supply of fuel and fodder when drought devastates ordinary sources.

Fire also asserts power and defiance. Balefires, bonfires, and pyrotechnics mark special events, seasonal festivals, coming-of-age, marriage, mourning, and celebration. Modern fireworks are big, bright, defiant bouquets of sparks. Like many festival gestures, they show off the wealth and power of some local elite organizer, by inviting everyone to join the celebration.

A steady, bright flame like the sun can comfort babies and germinate seeds. When the sun hides, we sit by the fire to swap stories, share inspiration, write, and teach.

When the temple is gone, Hannukah and Sabbath candles show steadfast faith.

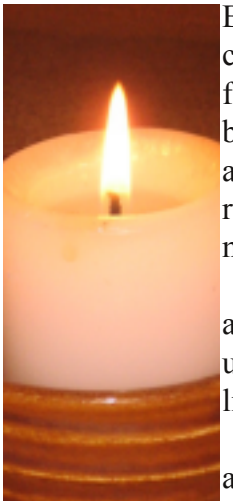
An Irish teen may call it superstitious nonsense to carry fire after dark on Samhain yet light his pipe for the evening walk home.



Candles are a luxurious, reliable flame that bridge the gap between honoring tradition and modern convenience.

Candlelit

dinners are romantic; 'carrying a torch' is a lover's burden. Unity candles celebrate the joining of two families at a wedding. A Christening candle welcomes a new soul into a church community, and serves as a memento of that reciprocal commitment.



Candles and pyres commemorate the soul's passing away from the body. Candles or incense at the shrine honor the departed.

Candles become part of the most unlikely traditions: pinned to the green branches of a Christmas tree, floating untended down rivers during a moonlit festival.

Incense and fragrant smoke sanctify prayer and meditation. Scents evoke memory very strongly. Scented smoke can create a unique association that helps people slip back into the same contemplative state. Smoke can also drive away pests, helping to minimize disease transmission in crowded gatherings. Smoky fires were used in early Irish housekeeping to fumigate vermin out of thatch. Where fleas and mosquitoes carry deadly plagues, smoke can 'purify' in a literal as well as spiritual sense.

Fire purifies and transforms many things. Cooking makes 'stuff' into food. Boiled over a fire, water becomes clean, pure, and safe. Burned in a fire, the contagious rags of sickness become harmless ashes. Fire can also purge unwanted things: rubbish, noxious weeds, bad memories.

Fire also transforms materials for art, agriculture, and industry, giving us the power to change our lifestyles and surroundings.

Cooks, smiths, potters, brewers and distillers, textile workers and tanners, welders and glassblowers, even painters use fire. Fire smelts ore, shapes metal, makes engines and dynamos roar.

"Inner fires" keep an artist or inventor working passionately; outer fires bring these inventions into reality.

Any art can serve both peace and war. Fire changes swords into plowshares, or hardens sticks into spears.

In wartime, fire serves as weapon, message, tool, and symbol of hate. Torches, signal lights, and bale-fires blaze out warnings. Blacksmiths forge weapons and armor. Greek fire, fire-arms, and rockets hurl devastation among enemies. 'Friendly fire' haunts armies. Burning bridges, boats, cottages, or capitol buildings declares ruthless resolve.

Fire's destructive power associates it with passions: love and hate. Even

before it causes pain, warmth brings blood to the skin. The flush mimics passionate emotions. And fire's powerful potential for both good and ill makes an apt metaphor for strong feelings.

Some people get very personal with fire: marking themselves with body art, or making a walk or leap through fire as a rite of passage.

Staring into the flames has a strange power for soothing grief and easing emotional transitions.

In the wake of fire comes peace. It's a paradoxical peace: as accessible to the warrior as to the priest, to the dancing girl as to the grandmother. This peace does not imply absence of pain or violence, does not require being sated or loved. It concerns the inner self: an inward rightness, truth, or acceptance that outer troubles can't touch.

Gazing into the embers, watching for 'fire fish' in the flickering flames, offers a timeless connection with something metaphysical, beautiful, something beyond the ordinary.

Tongues of flame, pillars of fire, halos of light, a face or garments that shine with radiance, fires that burn without consuming: glowing 'glories' mark miraculous moments and divine revelation.

Strangely colored or smoky fires, on the other hand, feed superstitions about unholy powers. Eerie flickering swamp-lights deceive travelers. Aurora dance madly in the snowbound Arctic night. St. Elmo's fire (electrical phosphorescence) crawls across ship's rigging and sailor's skins, an uncanny distraction in stormy seas. Even the local trash-burning grounds of Tophet are woven into warnings of torment for wicked or faithless souls.

Fire in short represents both holy and unholy, love and hate, peace and war. Is there any common meaning here?

All these are parts of our human effort to find meaning - and to define what we expect from ourselves and each other. A human trying to understand the meaning of fire is something like a fish knowing water.

Fire is an ancient, unique part of human experience. No other creatures on Earth use fire. Signs of cooking help archaeologists define early human sites, as distinct from animal or wildfire sign.

Mastery of fire allows people to live in every climate; protect our food, water, and comforts; control other creatures, even be flexible about day and night. We don't owe our current

worldwide dominance to thumbs, tools, language, clever brains, or upright walking; many other creatures share these specialties. Our willingness to use fire makes our physical limitations irrelevant. It brings us terrible power, and terrifying responsibility over life and death.

This ancient relationship with fire touches our deepest fears and securities. Practicing with fire may trigger intense emotional and spiritual experiences.

Many terrible cults have arisen from worshiping fire, rather than accepting responsibility for it. Don't mistake the part for the whole.

People are complicated. Fire reflects that complexity in a controllable form. Fire is a powerful tool for processing emotions, practicing skills, and satisfying instinctive cravings.

Don't let this tool become a substitute for existing relationships or responsibilities. A pleasure becomes addiction when it interferes with your health, family, or duties.

None of this is new. Don't imagine you are the first person to struggle with a particular challenge or goal. Seek experienced mentors, and guidance from older traditions. Those who already survived the journey can guide you around many pitfalls.

Fire offers both good and evil. Please use your powers for good.

Sometimes people 'catch the fire bug', and rush out to save the world by burning things. Cookstoves, biochar, space rockets, book burning. It's easy to rationalize that because you feel powerfully compelled, the action itself is right, good, or important.

There's a time and place for all things. Mind the context: Good for what? For whom? In what season? Against what excess? A fire that's good for biscuits is bad for fingers. Fire earns its place by serving a specific purpose.

Your desire to learn about fire is a valid purpose. The price is that you become responsible to do no harm, and manage the consequences.

If you want to justify your work by service to others, make sure you accept feedback about their specific needs.

Fire is never stagnant: it is change made visible. Working with fire teaches us to be adaptable, alert, and always learning.

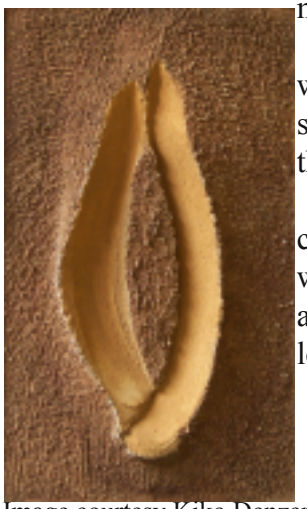


Image courtesy Kiko Denzer, www.handprintpress.com

A well-made fire is alive. There is a world of difference between a fire which is a pile of burning logs, and a fire which is made by someone who really understands fire. He places each log exactly to make the air between the logs just right. He doesn't stir the logs with a poker, but while they are burning, grasps each one, and places it again, perhaps only an inch from where it was before. The logs are so exactly placed that they form channels for the draft. Waves of liquid yellow flame run up the logs when the draft blows. The fire, watched, burns so intensely and so steadily, that when it dies, finally, it burns to nothing; when the last glow dies, there is nothing but a little dust left in the fireplace.

- Christopher Alexander, *The Timeless Way of Building*