

COMPLETELY REVISED AND UPDATED

Woodshop Dust Control



A Complete Guide to
Setting Up
Your Own System

SANDOR NAGYSZALANCZY

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The Taunton Press

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This updated edition is dedicated to Gregory Bateson, Dudley Burton, and James Pepper, three extraordinary men who were my professors and mentors back in the halcyon days at the University of California, Santa Cruz.

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Introduction

Up until just a few years ago, the primary means of dust collection in most woodshops was a simple broom and dustpan. But 21st-century woodworkers are much more aware of the impact of wood dust on their respiratory health. They are also aware of the fire danger that sawdust poses to their shops—and the homes that are often attached to them. Hence, woodshop dust control has become a hot topic, and the devices and strategies used to collect chips or filter dust now receive almost as much attention in the woodworking press as the latest and greatest machines, portable power tools, and shop gadgets.

Since *Woodshop Dust Control* was first published seven years ago, hardly a week goes by when I don't receive an e-mail query or telephone plea from a puzzled reader: Can I design a ductwork system using my computer? Should I replace the bags in my portable chip collector with advanced filter media? Are there affordable ways I can automatically control my central system? Is there some new way I can ground my plastic ductwork? Which disposable dust mask is best for me, according to the new guidelines of the National Institute for Occupational Safety and Health (NIOSH)? Can I make the power sanding of wood parts a cleaner task? Keeping up on the latest collection equipment and methods is essential to providing the best answers to such questions.

Fortunately, technology and product design have kept pace with the current trend to make dust collection as much a standard part of a woodshop as electricity and lighting. Lots of noteworthy innovations and improvements in dust equipment and accessories have come to market in the last seven years, including: better filters for dust and chip collectors, disposable bags for portable power tools, advanced electronic systems that make central collection systems easier to control, air-filtration devices that are more convenient to use, affordable downdraft tables to capture fine dust while sanding, and easier-to-use shop vacuums with better fine-particle filtration. One of the goals of the new and updated version of this book is to acquaint you with the complete range of dust-control devices and methods available to outfit your small (or not-so-small) woodworking shop.

Some things about dust control haven't changed since the earliest days of woodworking. Sawdust is still a woodshop nuisance: a messy by-product that's hard to avoid. Our machines churn out great heaps of chips and shavings that combust all too readily. They also throw a ton of fine wood dust into the air, which, as medical studies continue to reveal, can pose a significant health hazard. Do we really need more to convince us that capturing and controlling woodshop dust is an essential duty?

Probably the hardest part of dealing with dust is knowing which devices and methods to choose from among the extensive assortment of collection, filtration, and ventilation devices currently available. One class of devices, including shop vacuums and central collectors, is designed to capture dust at its source—at a woodworking machine, a sanding table, or a workstation where portable power tools are used. These devices provide the most direct and efficient means of dust control since the majority of chips and dust are captured and collected before they can escape. Airborne dust can be abated by several different secondary control methods, including ventilation and air filtration or by wearable protection devices such as disposable masks, replaceable-cartridge respirators, and powered air-purifying respirators.

Unfortunately, buying the right respirator to protect your lungs or picking a collector powerful enough to handle your shop's sawdust output isn't as straightforward as the process of buying a handplane or table saw. If you've browsed a woodworking supply catalog or website lately, you've likely been confronted by a confusing array of information about particle size, filtration efficiency, airflow and ductwork sizing, cubic-foot-per-minute (cfm) and static-pressure ratings, etc. This kind of technical data is usually more befuddling than helpful. A troubling result is that many woodworkers end up with equipment that provides only a poor or partial solution to their dust problems.

This updated version of my book presents all the latest information you'll need to choose and implement dust control in your shop with a minimum of head scratching. Everything you need to know is explained in layperson's terms that you don't need an engineering degree to understand. Better still, there are lots of suggestions for how to achieve your dust-control goals without breaking your bank account.

This book's chapters progress from simple and inexpensive dust-control measures, such as wearing a dust mask and ventilating the shop, to more complex and expensive means of capturing and filtering dust, from shop vacuums and portable collectors on up to full central collection systems. Because installing a complete central system is an extensive undertaking, the last four chapters are devoted to all the necessary steps, from choosing a collector and designing the ductwork, to hooking up machines, to fine tuning the system for best performance.

Whichever dust-control measures you choose, you'll end up with a shop that's a cleaner and healthier place to work. After you take the plunge, I'm sure you'll never let a little thing like sawdust get in the way of your enjoyment of woodworking again.

The Problem of Dust in the Woodshop

As a by-product of the woodworking process, sawdust occurs at practically every phase of a project: when dressing lumber (with handplanes or thickness planers and jointers), when cutting out and shaping parts (with power saws and handsaws, routers, shapers, and drills), and when smoothing parts (with stationary sanders, power finish sanders, and hand-sanding blocks). Different types of operations create different-size chips, from large shavings to fine dust. This assortment of wood debris presents a variety of problems for the woodworker, from a mere nuisance and a disposal hassle to a safety hazard that can pose a serious threat to respiratory health. In this chapter, I'll examine these problems thoroughly and then explore a variety of solutions in subsequent chapters.

Different Forms of Dust

It's important to differentiate the various kinds of dust created in the woodshop because each type of dust is best contained and controlled by a different set of strategies. Further, you'll need to consider the amount of different-size debris you create when selecting and sizing your dust-collection system's filtration. Let's start by looking at each kind of wood debris (see the photo on the facing page), how it's created, and what kinds of problems it presents. Sizes obviously aren't absolute—a single tool and operation can produce a wide range of sizes of dust particles and wood debris; I've separated them out here for the sake of discussion.



Different kinds of woodworking tools create different kinds of wood debris, including large shavings from a handplane, chips and sawdust generated by bladed and bitted tools, and fine wood powder created by sanding operations.

LARGE SHAVINGS

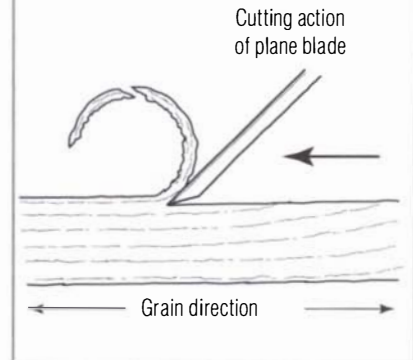
The largest shavings typically found in the woodshop are produced by powered cutterhead tools—including thickness planers, jointers, and shapers (fitted with long or large-diameter cutters)—and hand tools, such as chisels, carving and turning tools, and handplanes. These tools typically shear wood from the surface or edge of a board, removing fibers in long bundles, as shown in the drawing above.

Hand operations such as planing a surface with a well-tuned handplane can remove wide, continuous sheets of wood—not unlike unrolling a roll of paper towels. A power machine's rapidly spinning cutterhead produces shorter shavings since the blades travel through an arc, with each stroke removing a short shaving as it passes through its cut. Thickness planing or jointing long-grained softwoods (such as pine and hemlock) at slower feed rates produces longer, larger shavings, while planing short-grained hardwoods (such as mahogany and ebony) at higher feed rates produces shorter, smaller shavings and chips. Shaping operations with large cutters also produce large shavings and chips—and occasionally small chunks of wood torn from a shaped edge or surface as well.

Because of their size and volume, large shavings accumulate quickly and occupy a lot of space. If your shop is small and you don't get rid of large shavings regularly, you'll end up tripping over pulpy mountains that accumulate underfoot and make getting around the shop hazardous. Stationary machines with dust chutes or catch bins fill up so quickly that shavings clog the tool's cutterhead. The catch bin on my old Davis & Wells 6-in. jointer works fine during the occasional edge dressing but

Large Shavings

Large chips and shavings are created when bundles or sheets of fibers are sheared from surface or edge of wood.





Without dust collection, the large shavings generated by even a small thickness planer grow into mountains of debris that get underfoot and can create a fire hazard.

Central Collection Is Best

A powerful, well-designed central collection system provides the best means for successfully collecting shavings from woodworking machines. Shop vacuums with small-capacity canisters can quickly become overloaded, and long, stringy shavings easily clog the small-diameter (1-in.- to 1½-in.-dia.) hoses found on many models these days.

quickly gets stuffed after any significant amount of edge trimming—say, when preparing a gang of boards for gluing up into panels for cabinet doors.

It's astonishing how quickly you can generate an extra-large plastic trash bag's worth of shavings when thicknessing a stack of boards on a thickness planer (see the photo at left). The shavings seem to pile up faster than snow during a winter storm in Buffalo. A common problem when running a thickness planer without dust collection is shavings ending up on top of the board just ahead of the outfeed roller. The roller presses these shavings into the top surface of the board as it passes through the planer. You end up scraping shavings off the freshly planed surface or, worse, have a board with shallow depressions where shavings were embedded in the surface. This problem is particularly vexing when taking deep cuts on very hard woods; the thick chips can leave indentations nearly $\frac{1}{16}$ in. deep!

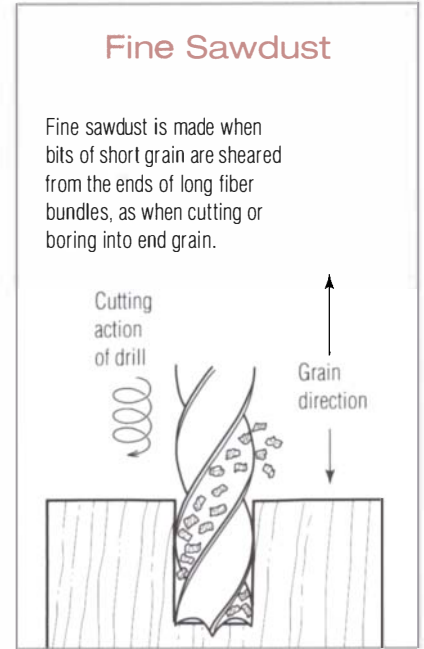
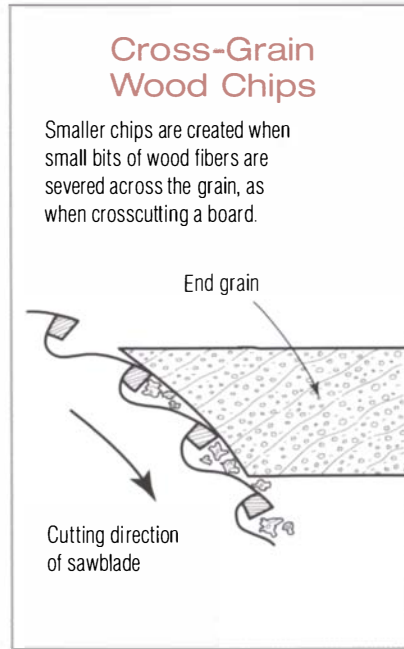
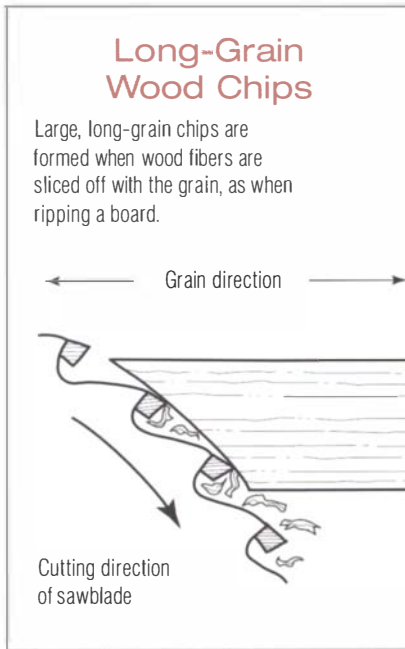
Large shavings also present significant problems when shaping with large cutters working with the grain of the wood, during tasks such as raising panels or shaping railings and large moldings. If the shavings aren't collected, they accumulate around the cutter and tend to obscure the operator's view of the cutterhead and workpiece, which is clearly dangerous since there's a natural tendency to sweep shavings out of the way with your hand.

Roughing out a bowl blank on a lathe also produces sizable shavings that can become a nuisance. With a properly sharpened tool taking a shear cut, continuous shavings stream off the edge of the tool like ribbon unwinding from a spool. When turning green wood, these long, fibrous shavings can obscure the edge of the tool and entangle the tool and/or the turner, posing a hazard as well as a nuisance.

Because of their relatively large size and weight, shavings are the most difficult of all wood waste to collect, even with a small central dust-collection system. It takes more energy to capture and transport large shavings through a vacuum hose or collection-system ductwork than to collect smaller chips and sawdust. The airflow from the vacuum/collector not only must have enough velocity (the speed of the collector's air suction) to capture shavings but also a high volume of airflow to handle the copious amounts of chips output by a thickness planer or shaper.

CHIPS AND SAWDUST

A wide range of cutting tools produces chips and sawdust, including power saws and handsaws, boring tools (such as drills and countersinks), and small- to medium-size shaper and router bits. Depending on the type of blade, bit, or cutter and a number of other variables, debris ranges in size from shredded cheese-size chips to fine-grained sawdust. Generally, cuts taken with the grain, as when ripping stock or dadoing on the table saw



(see the drawing above left), create large chips and coarse sawdust. Smaller chips and finer sawdust are produced by cuts taken across the grain, as when crosscutting, as shown in the drawing above center, or by cuts into end grain, as when cutting tenon cheeks on the table saw, plunge-cutting a mortise with a router, or boring dowel holes in a face-frame rail (see the drawing above right). Other factors that influence the coarseness or fineness of chips produced include:

- The design of the tool—the number of knives/teeth and their design, relief angles and gullet sizes, as well as the diameter of a cutter and its rim speed. Larger-diameter, faster-spinning blades and bits generally take more cuts per inch and hence produce finer chips. Rip blades with chisel-like low-angle teeth and large gullets produce longer shavings than cutoff blades with lots of high-angle, alternate-top bevel (ATB) teeth. Router bits or small shaper cutters with more flutes/knives produce finer shavings.
- The type of material and its strength and density. Cutting dense hardwood produces smaller chips than cutting softwood. Cutting plywood produces smaller chips since cutting in any direction penetrates layers both across and with the grain. Sawing or machining particleboard, hardboard (such as Masonite®), and fiberboard (such as MDF, or medium-density fiberboard) produces fine dust, part of which is dust from the adhesives used to manufacture these products.
- The condition of the blade or cutter, including sharpness, balance, and degree of runout. A dull sawblade makes finer dust than a sharp one, and a poorly balanced cutter or blade with lots of runout takes a slightly wider cut, thus producing slightly more sawdust.

Dust Collection Keeps Cutters Sharp

An important reason for sucking away sawdust during the cutting process is that it actually reduces the dulling of cutting edges and teeth. Chips that aren't evacuated bounce around and are recut many times before they're ejected. This repeated cutting causes more heat buildup, and it dulls teeth quicker since the teeth are doing more work than they need to.



It's astonishing how quickly sawdust and chips can accumulate under closed-base machines, such as this table saw. If not cleaned out regularly, chips can quickly foul a tool's works.

Although less bulky than large shavings, chips and sawdust can also pile up with surprising rapidity. Often-used machines, such as table saws, not connected to a dust-collection system quickly accumulate enough sawdust to clog the working parts to the point where you can't tilt or lower the blade easily (tilt stops for square and 45-degree cuts are thrown off as well). If you own a table saw with an enclosed base (such as a Delta® Unisaw® or a Powermatic® model 66 saw) that isn't connected to a collection system, you've undoubtedly had the occasion to open the trap door in the base and scoop out copious quantities of sawdust (see the photo below). Shaper and router tables also generate mountains of chips and sawdust, even when using relatively small bits and cutters.

Besides clogging a machine or power tool's internal works, accumulating sawdust can also ruin workpieces. Parts sometimes get cut too short or narrow when small chips keep the end of a board from bearing flush against an end stop or rip fence. When working freehand with a portable power tool such as a sabersaw, free-flying sawdust obscures the line of cut, often resulting in a miscut.

A simple but annoying aspect of woodshop sawdust is its tendency to stick to the bottom of your work shoes (it seems to have a special affinity for the tread pattern on sneakers). You end up tracking the sawdust around the shop and, if you work at or near home, into your house as well.

FINE WOOD POWDER

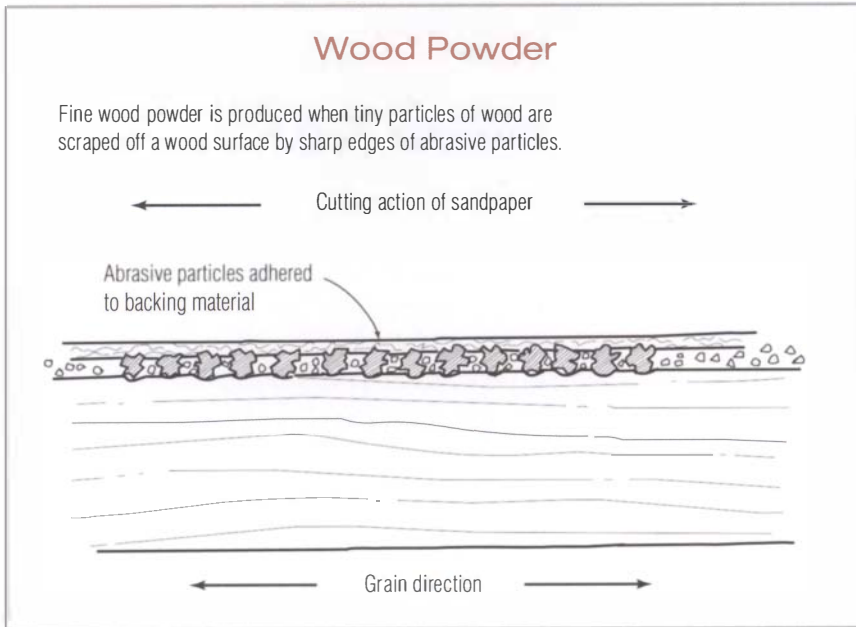
Although most wood-machining operations create small amounts of fine wood dust, powder is a primary product of sanding wood. Whether you deposit a thin layer of powder on the bench or create an ominous cloud of woody effluent is greatly influenced by your means of sanding. Random-orbit sanders (electric or pneumatic) are hard to beat for their ability to smooth a surface quickly and efficiently, but they're also champs at throwing out great billowing clouds of dust in every direction. Even if you simply sand by hand with a piece of sandpaper wrapped around a wood block, you still end up churning out a noticeable amount of very fine dust.

Fine wood dust is composed of particles that are really broken pieces of wood fiber abraded from the side, face, or end grain of a board (see the drawing on the facing page). Think of each particle as a tiny chip that's been scraped off by the abrasive particles on the surface of the sandpaper as it scours the wood. Finer-grit sandpaper is covered with finer abrasive particles and, hence, creates finer-size dust particles.

Sanding dust also creates problems for the sandpaper used to create it. Fine wood dust churned out by power-sanding machines—such as stationary belt, disk, or oscillating spindle sanders—tends to embed in the surface of the sandpaper where it clogs abrasive particles and decreases their efficiency. This problem is especially bad when sanding resinous woods, such as pine, and oily woods, like teak. As the clogging gets worse, more heat is generated during sanding, which causes glazing that shortens the life of



Power sanders—including belt, random-orbit, and orbital sanders—make quick work of smoothing rough surfaces but can create clouds of extra-fine wood powder, which wafts about the shop and becomes both a nuisance and a health hazard.



abrasive disks, drums, or belts or ruins them rapidly. Since a replacement belt for a wide-belt sander (such as a Timesaver®) can cost over \$100, clogging from fine sanding dust is a big problem indeed.



Sweeping the shop floor with a broom or blowing off benches and machinery with a compressed-air hose may be expedient, but it also sends tons of fine dust flying. For more breathable air, always clean up with a shop vacuum or hose connected to a central collection system.

Most other problems caused by sanding dust are the result of the particles' smallness. Very fine dust is measured in microns (abbreviated μm): One micron equals one thousandth of a millimeter. Larger particles, $100\mu\text{m}$ and bigger, tend to fall to the floor quickly. In contrast, wood powder is so fine that it's easily suspended in the air where it wafts around for a long time (a $5\mu\text{m}$ particle stays aloft for 30 min. or longer, depending on the amount of air movement in the shop). The lightness of the particles explains why you can run a power sander over a large panel, blow or brush the top clean, and then come back half an hour later and find that a thin layer of fine powder has recoated everything.

If you don't keep your shop's floors and benches tidy, just picking up a board or walking around can raise a dusty cloud. Even sweeping with a broom stirs the dust up like crazy. Fine dust also makes it difficult to do any kind of finishing in the same space that you make sawdust; particles continue to settle as the finish dries, and you end up with a nubby surface.

Fine dust easily floats under doorways and through ventilation ducts to infiltrate spaces adjacent to workshops, such as offices, finishing booths, or (if your shop is attached to your house) your living room. The dust also

clings tenaciously to your clothing and travels indoors whenever you run in for a refreshing beverage in the middle of a work session.

The good news is that capturing and collecting fine wood dust is easier than corralling larger chips and shavings. A typical shop vacuum's air volume and velocity is sufficient to collect fine dust from portable power tools. Dust created by hand-sanding can be mitigated by shop ventilation or with an air-filtration device (see chapter 4). Capturing dust from large power sanders, such as drum or stroke sanders, is a walk in the park for a central collection system, provided that the machine's dust hood is well designed (see p. 173).

The bad news is that uncaptured fine dust presents the most serious hazard to the woodworker: an assault on respiratory health. Ironically, it's the smaller dust particles— $10\mu\text{m}$ and less—that create the biggest respiratory problems, ranging from mildly annoying to life threatening, as we'll see in the next section.

Sawdust and Respiratory Health

Most woodworkers who have installed dust collection in their shops, be it a small shop vacuum or a large central collection system, rest easy thinking that they've got sawdust beat. But usually there's still an invisible culprit lurking in the shop: the wood powder with particles so small that it can pass right through the filters on some vacuums and the bag fabric used for inexpensive chip collectors. Like demon seeds ready to unleash contagion, these diminutive dust particles are so light that they can travel around on the air itself, held aloft by static electricity and circulating air currents. You can barely see the largest particles under ordinary lighting, but they're there, remaining airborne for hours after the last board has been sanded. What's more insidious is that the smallest particles are the most harmful to your lungs.

How small are the fine dust particles that can harm us? We can't see most of them: Individual particles smaller than $100\mu\text{m}$ (0.1mm) are invisible to the unaided eye. Particles between $10\mu\text{m}$ and $20\mu\text{m}$ tend to become trapped in the outer passages of your respiratory system (resulting in the grotty goo that you see on a clean hanky when you blow your nose after a sanding session). Minute wood-powder particles—particularly those between $0.3\mu\text{m}$ and $10\mu\text{m}$ —easily penetrate deep into the farthest reaches of your lungs, even into the tiny air sacs called alveoli. Really tiny particles (under $0.3\mu\text{m}$) are small enough to be expelled by exhalation.

HOW FINE DUST HURTS YOUR LUNGS

Because we breathe in a certain amount of dust in our everyday lives, our bodies have built-in protection mechanisms, as depicted in the drawing

Check for Dust in the Dark

To check for fine dust in your shop, shut the lights off some evening after a sanding session, and then shine a flashlight across the shop; the concentrated beam will reveal a swirling swarm of talcum powder-like dust. The phenomenon is known as the Tyndall effect; you've seen it in the movie theater when dust or smoke passes in front of the projection beam.



The Human Body's Respiratory Defenses against Dust

Nasal Hairs

Coarse hairs that trap larger dust particles that are inhaled

Cilia

Tiny, hairlike arms that work to sweep dust-laden mucus out of the lungs and air passages

Mucus Blanket

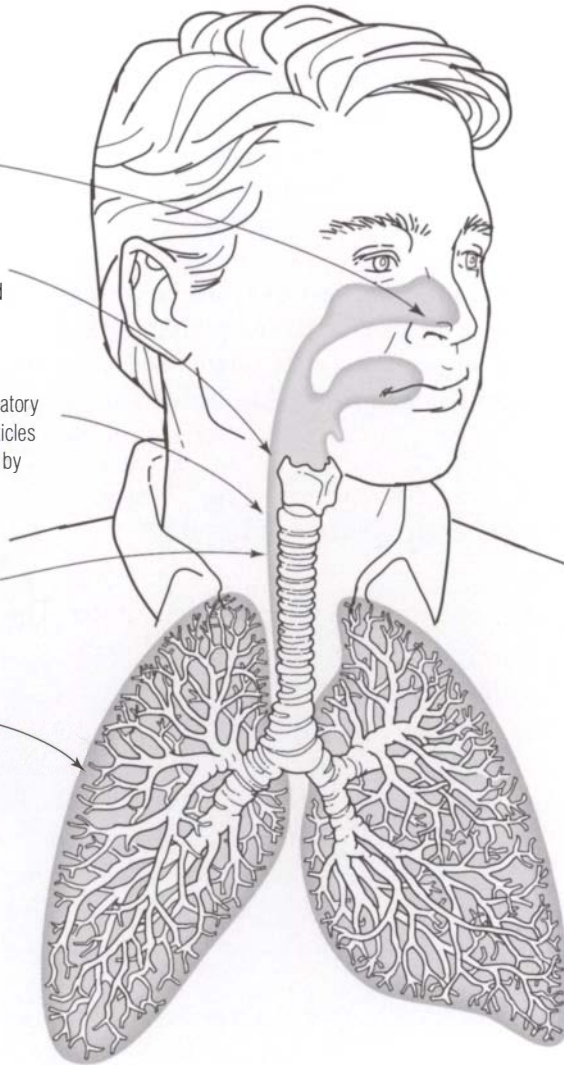
A sticky coating that lines entire respiratory system; catches microscopic dust particles like flypaper, so they can be discarded by the cilia

Cough Reflex

A protective natural reflex that helps to expel dust and mucus from the respiratory tract

Alveolar Macrophages

Special cells that travel around the alveoli, serving to clean out dust that interferes with the alveoli's function of oxygenating the blood and expelling carbon dioxide



above. These respiratory defenses include: nasal hairs, which snag large particles as you inhale; mucus, a sticky blanket that lines your respiratory tract and acts like flypaper to capture errant dust particles; and cilia, which are tiny hairs that line your respiratory tract. Like the tentacles of a sea anemone, the cilia work to transport dust particles trapped in the mucus (using a beating motion that takes place about 10 times each second) and move them toward the back of your throat where they can be swallowed or coughed up. The cough reflex is a protective reaction that works to expel the mucus and dust that builds up in the respiratory system. Finally, deep in your lungs, alveolar macrophages clean out dust that gets into your alveolar sacs.

Minute dust particles harm us by interfering with the lungs' functions in a variety of ways. As large quantities of dust particles become lodged in the lungs, they tend to foul the dust-ejection systems described in the previous paragraph. Copious amounts of dust clog the natural cleaning action of the lungs' cilia, which leads to irritation. As the cilia become more clogged, their effectiveness is reduced, so the lungs lose capacity to eject dust. Eventually, chronic exposure leads to permanent damage of the lungs' tissues, resulting in the buildup of scar tissue.

By restricting the absorption of oxygen into the blood, chronic exposure to fine dust can lead to shortness of breath and dizziness. The effects of dust can also weaken the body's natural defense mechanisms, making you more susceptible to bacterial or viral infection and illness. Long periods of exposure to fine wood powder can lead to conditions similar to cold and flu symptoms, including coughing, sneezing, bronchial inflammation, shortness of breath, and a runny nose as a result of increases in discharge of saliva and phlegm from the respiratory passages. The kind of lung problems that sometimes develop in woodworkers from chronic inhalation of wood dust are similar to those developed by longtime smokers: chronic bronchitis and emphysema.

Worse, chronic exposure to wood dust may even cause cancer: The National Institute for Occupational Safety and Health (NIOSH) considers both hardwood and softwood dust to be potentially carcinogenic to humans. Three types of cancers associated with wood-dust exposure are nasal and sinus cancer, Hodgkin's disease, and lung and other cancers. Woodworkers are about 1,000 times more likely to develop nose cancer than nonwoodworkers (although only one out of every 1,500 active woodworkers will ever have to deal with this horror). As with the respiratory problems described in the previous paragraph, nasal cancer tends to develop over many years, sometimes with decades between initial exposure and the outbreak of symptoms.

OTHER DANGERS CARRIED IN WOOD DUST

In addition to the harmful effects of the dust particles themselves, woodworkers may also be negatively affected by soluble chemical components carried in or along with wood dust. These chemicals include a whole gamut of resins and extractives, commonly found in (but not limited to) exotic species of hardwoods. Extractives serve a living tree by repelling insect attacks and retarding the decay of the tree's nonliving heartwood. Wood dust carrying extractives can exacerbate the effects of the fine dust particles themselves or cause allergic reactions in woodworkers who are sensitive to the extractives' chemical makeup (sometimes after only limited contact). These chemicals include natural classes of compounds with strange-sounding names, such as alkaloids, glycosides, saponins, and quinones. Wood species with extractives that are more prone to cause allergic reactions include redwood, mahogany, boxwood, western red cedar,

TOXIC WOODS

Type of Wood	Source of Problem	Reaction	Areas Affected
African blackwood	Wood	Irritant, sensitizer	Eyes, skin
Cedar, western red	Dust, leaves, bark	Sensitizer	Respiratory
Cocobolo	Dust, wood	Irritant, sensitizer	Eyes, skin, respiratory
Ebony	Dust, wood	Irritant, sensitizer	Eyes, skin, respiratory
Greenheart (Surinam)	Dust, wood	Sensitizer	Eyes, skin
Iroko	Dust, wood	Irritant, sensitizer, pneumonitis	Eyes, skin, respiratory
Mahogany (<i>Swietenia macrophylla</i>)	Dust, wood	Irritant	Eyes, skin
Mansonia	Dust, wood	Irritant, sensitizer	Eyes, skin
Maple, spalted (mold— <i>C. corticale</i>)	Dust	Sensitizer, pneumonitis	Respiratory
Obeche	Dust, wood	Irritant, sensitizer	Eyes, skin, respiratory
Oleander	Dust, wood, leaves, bark	Direct toxin, nausea	Heart
Olivewood	Dust, wood	Irritant, sensitizer	Eyes, skin, respiratory
Redwood	Dust	Irritant, sensitizer	Respiratory
Rosewood	Dust, wood	Irritant, sensitizer	Eyes, skin, respiratory
Satinwood	Dust, wood	Irritant	Eyes, skin, respiratory
Wenge	Dust, wood	Irritant, sensitizer	Eyes, skin, respiratory
Yew	Dust, wood	Direct toxin, nausea	Heart

yew, satinwood, teak, ebony, and wenge (see the chart above). Western red cedar is one of the most infamous of these species because it contains an allergen called plicatic acid that causes a condition commonly known as red-cedar asthma.

Another possible source of allergic reactions from wood dust are the spores of fungi that can be contained in the dust. Certain fungi cause decorative staining in woods, known as spalting (see the photo on the facing page). Dust from spalted wood has been suspected of causing idiopathic pulmonary fibrosis, a horrific disease that's treatable only by lung transplant and can result in death. Even a fungus occurring in the bark of a tree can cause allergic reactions or worse. A condition known as maple bark disease is ostensibly caused by the fungal spores found in maple bark, which are released when the wood is cut or when maple burls are turned on the lathe.

In addition to the potentially harmful effects from the natural compounds found in wood, there's also the danger of dust from the adhesives used in woodworking. These include glues used to manufacture wood-based materials, such as particleboard and plywood, and glues used to assemble projects. One of these adhesives—polyurethane glue—contains isocyanates, which cause severe reactions in some people. Working with



Decorative and exotic woods, such as the spalted olive turning (left) and the rosewood and spalted maple boards (center), can cause allergic reactions ranging from mild to serious. The sawdust created when cutting man-made sheet goods—such as particleboard, plywood, and melamine-coated particleboard (right)—includes not only wood particles but also glue and other potentially harmful substances.

recycled wood (from old houses and barns) can also present health problems. This wood may be coated with lead-based paints or treated with wood preservatives containing toxic substances, such as pentachlorophenol and copper naphthenate (known commercially as copper green). Pressure-treated lumber is also impregnated with these kinds of preservatives, including chromate copper arsenate (CCA). When you cut, plane, shape, or sand such wood, you create dust that can carry these substances into your lungs, where they are subsequently absorbed into your bloodstream.

Severe symptoms from exposure to both natural and manufactured chemicals in wood dust may include skin rashes, headaches, facial swelling, wheezing and coughing, and conjunctivitis (irritation of the eyes).

Ingestion can also be a factor because particles trapped in the mouth and nose usually end up getting swallowed, where toxins are absorbed by the digestive tract. Fine dust from tropical woods—such as Indonesian teak, cocobolo, and rengas (Borneo rosewood)—can cause irritation to the skin. Even touching these woods can cause acute skin rashes in some people.

Just as with the respiratory problems from fine dust particles themselves, what makes the breathing of other chemicals carried by wood dust such an insidious problem is that symptoms don't always manifest themselves quickly. Unless you exhibit an allergic reaction that suddenly alerts you to a wood dust-related health problem, symptoms might take years—or even decades—to appear. I read one story about a longtime woodworker

Meeting OSHA's Dust Standards

For an average small shop (say, a 24-ft.-sq. garage with 9-ft. ceilings, equal to approximately 147 cubic meters), the OSHA standard allows a maximum of 735mg (about 1/8 tsp.) of wood dust over an 8-hr. period. This means that in a single work day, the average amount of fine dust in a cubic foot of space should equal only a little more than one tenth of a milligram—about the weight of a flea!

who was commissioned to build a couple of dozen redwood cabinets. One afternoon, he was having difficulty breathing (his bronchial tubes became inflamed by the volatile oils in redwood dust, causing constriction in his air passageways). By the time he got home, his breathing was so labored that he had to go to the local emergency room, where a doctor diagnosed a condition known as occupational asthma. Treatment required him to take a bronchial-dilation medication, and because his air passageways were sensitized and prone to overreact to any kind of dust, he had to stay away from dusty environments (including his own woodshop) and continue taking medication for several years.

As with most serious health problems, it's always more difficult to overcome a problem once the body has experienced chronic damage. This is yet another good reason to evaluate your dust-control needs carefully so that you're not trading your future good health for the enjoyment (and income, if woodworking is your vocation) you get from your pastime—or your profession—of woodworking.

HOW MUCH DUST IS TOO MUCH?

How much wood dust can you breathe and still be safe? To protect people who work in the wood-products industry (as well as in dozens of other industries), the Occupational Safety and Health Administration (OSHA) has developed a set of guidelines for wood-dust and worker-respiratory safety. While the regulations imposed by OSHA are designed for wood-working businesses with one or more employees, the guidelines also provide hobbyists and weekend woodworkers with a good understanding of how little fine dust it takes (over time) to cause respiratory problems.

To meet current OSHA regulations (OSHA 29 CFR 1910.1000), the total amount of respirable dust particles (10µm or smaller) in a shop should average no more than 5mg (one gram equals 1,000 milligrams) per cubic meter of air over an 8-hr. period. This is referred to as a time-weighted average or TWA.

While this standard applies to most common hardwoods and softwoods, dust from “allergy-prone” woods, such as western red cedar, must be kept down below half that amount: a TWA of 2.5mg/cubic meter over an 8-hr. period. While these amounts are averages over time, OSHA also specifies a ceiling for dust concentration for exposures longer than 15 min. This ceiling, known as the short-term exposure limit (or STEL), is 10mg/cubic meter. For up-to-date information about the latest OSHA standards, check OSHA's website (www.osha.gov) or contact your state office.

While OSHA dust standards are highly regarded, they are not the strictest. The exposure limit recommended by NIOSH for all softwood and hardwood dusts (except western red cedar) is only 1mg/cubic meter for a 10-hr. workday and a 40-hr. workweek. In a garage-size shop, this translates to less than 150mg (1/8 tsp.) of dust for every 10 hr. of shop time. While these amounts may sound minuscule, daily exposure over many years clearly has no small impact on respiratory health.

EVALUATING DUST LEVELS IN YOUR SHOP

How can you tell if your shop has too much fine dust floating around in it? Unfortunately, you probably can't. To quantify accurately how much airborne fine dust there is in your shop requires a direct-sampling measurement. This is done by taking a sample of dusty shop air and then processing a predetermined volume through a special device that measures the amount of dust in it. You can hire an industrial-ventilation specialist to come to your shop, evaluate your dust problems, and recommend remedies for them. However, hiring a specialist is an expensive proposition, usually necessary only for professional businesses and one that most hobbyist and part-time woodworkers don't really need to undertake.

On a practical level, if you're power sanding without some form of collection and are spewing out great clouds of visible dust, you can bet that you're churning out unhealthy levels of invisible, respirable dust as well. Regardless of what tools you use, if you find yourself picking gobs of dust out of your nose at the end of an average day of woodworking, you've almost certainly been exposed to too much dust.

For most of us, the best way to ensure that the air quality in our shops is not deleterious to our health is to act preemptively: Control fine dust before its adverse effects become a problem. The means to put the kibosh on dust involves implementing control measures such as collecting at the source, using air-filtration devices, and wearing personal-protection devices such as respirators, all of which are discussed extensively in later chapters of this book. Controlling fine dust is especially important if you power-sand often and with gusto because no other kind of fine-dust production equals the output of a power sander.

Fire and Explosion Hazards

Beyond the risks of long-term exposure to wood dust, the greatest immediate hazard of having wood chips and dust around the shop is the risk of fire: Just think of what you typically use to touch off a blaze in your fireplace or barbecue—it's probably wood kindling. Any wood debris, from shavings to chips and powder, can be ignited with remarkably little effort. A tiny spark generated by a machine's on/off switch or from the process of grinding a sharp edge on a chisel (see the photo on p. 18) might be all it takes to turn your cozy shop into a deadly inferno.

Smoking in the shop is clearly a grave hazard; I heard one story (which fortunately didn't end tragically) of a boss who had his workers frantically shovel a mountain of planer shavings into the street after he'd accidentally dropped the glowing end of his cigar into the pile. Similarly, tossing an oil finish-impregnated or solvent-soaked rag on a sawdust-strewn floor or chip-filled waste is asking for trouble. Even if your shop is usually clean and tidy, it can't hurt to keep a fire extinguisher on hand to prevent a small fire from becoming an all-consuming blaze.



Grinding an edge on a tool, such as this bench chisel, generates a shower of sparks, which can quickly ignite any fine wood powder that has collected around the base of the grinder and cause a shop fire.

Although it might not seem obvious, fine wood dust can also pose as high a fire risk as chips and shavings (as well as an explosion hazard, as discussed later in the chapter). There are many documented cases of shop fires caused by a layer of fine dust atop overhead light fixtures, ignited by the heat of the lamps. With fluorescent lights, the heat of the ballast may be enough to cause a fire.

Believe it or not, chips and shavings from working unseasoned wood, such as from turning green wood, can also pose a fire hazard. Damp shavings left in a pile produce organic heat, like a compost pile, and can even generate enough heat to combust spontaneously. Just to be safe, remove damp shavings from the work area or keep them in a fire-safe container.

Cleanliness is the best way to prevent a fire in a workshop. Make sure to get out the shop vacuum every once in a while and clean off all light fixtures, electrical outlets, and piles of chips that have accumulated around benches and machine tools. (Even well-designed central collection systems aren't 100 percent efficient; some chips end up around the bases of the machines.)

To ensure fire safety prior to disposal, store dust and chips in metal or fire-resistant containers. A regular galvanized-metal trash can with a tight-fitting lid works just fine.

AVOIDING THE “BIG BANG”

It's ironic, but the same dust-collection system that helps keep sawdust off the floor to reduce the possibility of fire can be responsible for a rare yet devastating kind of danger: an explosion caused by the ignition of fine wood dust by a static-electric charge. When certain concentrations of fine wood dust are mixed with air (the lower explosive limits are 10g to 300g of dust per cubic meter of air), an errant spark can cause an explosion with tremendous force (see the photo at right). In a woodshop, the most common place where dust concentration can reach explosion potential is in the collection system itself: inside the ductwork, the blower, or, most often, the dust-filter bag or canister. If a spark from a static-electric charge ignites a cloud of fine dust, it can cause an explosion strong enough to blow the dust collector apart. But what's worse is that the burning dust and gases that are expelled by the shock wave can produce an additional source of combustion (especially if the shop is dusty), creating a chain of explosions that can level a large shop. Although such woodshop explosions are rare, I've read a few grisly accounts about woodworkers who were thrown through walls and were badly burned—enough to make it clear that it's worth taking every reasonable precaution to prevent explosions.

The best way to prevent a fine-dust explosion is to keep your shop clean, eliminate any open flames (such as from a furnace, water heater, or cigarette), choose a central collector with a nonsparking fan wheel, and make sure your dust system is properly grounded (see p. 160). Grounding allows most static charges to dissipate harmlessly, rather than building up and releasing in a sudden burst, which can trigger combustion.

Although it's probably not a big issue in most shops, be aware that working with aluminum can present a very serious danger, even if your wood-dust system is perfectly safe. Any reactive metal dust, such as from grinding or sanding aluminum, is much more susceptible to fire and explosion than regular wood dust.

For more information on protecting your shop from a disastrous conflagration, get a copy of The National Fire Protection Association's book, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities* (NFPA 664), available from the NFPA website (www.nfpa.org) or by calling the organization at (800) 344-3555.

Disposing of Sawdust

My friend Roger Heitzman, a custom furniture maker in Scotts Valley, California, used to say that he gauged the success of his woodworking business by the size of the pile of chips and shavings that accumulated behind his shop (he called it “Mount Sawdust”). Before going into a lot of detail in subsequent chapters about the various methods of collecting dust and chips, a word is in order about what to do with these generally unwanted woodshop by-products.



A small pinch of fine wood dust sifted over a blowtorch flame combusts with surprising volatility, demonstrating how readily fine dust in a collection system can burst into flames. (Please don't try this at home!)

Keep Shop Lights Fire Safe

You can help to prevent fires in a shop that has overhead lights by getting up on a ladder once every few months and vacuuming off the top surfaces of hanging fluorescent fixtures or the reflectors on incandescent lights. The wand or brush attachments that comes with most shop vacuums are great tools for this job.

Large cabinet- and furniture-manufacturing plants deal with the mountains of sawdust they generate by installing special equipment to turn their wood waste into a source of energy. These include furnaces that burn sawdust and chips directly, producing energy for powering plant equipment or for space heating. Another device called a “bricketer” compresses collected dust and fuses chips and shavings into little round briquettes that will be burned in a furnace. Unfortunately, such machines are big and expensive, making them highly impractical for all but the largest woodshops.

If you have a small shop in an urban area and don’t produce much more than a bag or two of sawdust a week, you can probably get away with disposing of sawdust with your regular household garbage. Many municipalities require you to put the sawdust in sealed bags before placing it in refuse cans. This practice keeps clouds of dust from rising when cans are emptied into collection trucks. Plastic trash bags (4 mil thick, lawn size) work well. If you’re against using plastic bags, you can fill regular paper grocery bags, and then seal them with masking tape.

Some sanitation districts also specify that refuse left for curbside pickup should not include construction debris. This shouldn’t be a problem unless you’re running a commercial woodshop at home and your sawdust and cutoffs outweigh the regular household garbage. If the city or county refuses to collect your debris, you might have to contract with a private disposal company. Alternatively, you might consider burning your wood debris, though strict air-quality standards in and around many suburban areas prohibit outdoor burning and incineration.

If you live outside a sanitation district, you’re probably already hauling your sawdust to the local landfill along with your other trash. To reduce the fire hazard, keep sawdust awaiting a trip to the dump in metal containers (stored away from buildings). If you must pile your sawdust, locate the piles well away from buildings and dry vegetation, and keep them covered.

Other creative ideas for getting rid of sawdust? If you have any friends who are into ceramics, it’s possible they’ll gladly haul away some of your sawdust to fire raku-style pottery. If there’s a large pet store, horse farm, or animal-feed and farm-supply store in your area, the owners might be happy to pick up your sawdust and shavings, depending on the wood species, to use for animal bedding (they might even pay you for it!).

USING SAWDUST FOR COMPOST AND MULCH

If you have sufficient acreage or a big yard and want to turn your woodshop-disposal problem into a garden soil-improvement program, then composting is the answer. When combined with plenty of wet, green, nitrogen-rich material, composted sawdust can improve soil structure, build up the humus content in soil, and even help fight plant diseases. The catch is that it takes some time and work to transform sawdust into useful compost; you can’t just shovel it into the garden because carbon-rich wood materials



To transform sawdust into soil-enriching humus, the author uses a commercially made plastic compost bin, located behind his home workshop. Here, he mixes fresh sawdust with grass clippings, green food waste, and other nitrogen-rich organic matter, which help the sawdust decompose into a rich garden fertilizer.

Spreading Composted Sawdust

When you're ready to mix compost into your garden, cover the soil with a 1-in.-deep layer; that's all the food a garden plant needs. To feed your lawn with compost, apply $\frac{1}{4}$ in. on top of your turf and water it well. Apply compost twice a year: once in the fall and again in the spring.

rob the soil of plant-feeding nitrogen. But if you mix the sawdust with green organic matter—such as grass clippings, garden debris, food waste, or barnyard animal manure (no dog or cat waste!)—and allow it to decompose, you'll create better fertilizer than you can buy. You can compost sawdust from just about any kind of wood species, although you might want to limit the quantity of dust from extractive-laden exotic species (rosewood, teak, etc.). And, of course, *never* compost sawdust from pressure-treated wood.

A compost bin, such as the commercially made model shown in the photo above, keeps materials contained and speeds up the composting process greatly. Mix three parts of green waste to each part of sawdust, and let it sit for a month or so. If the ratio of greens-to-sawdust is right, your pile should steam and begin to shrink down in size. Then, tear the pile apart and rebuild it, moving the outside material to the center and vice versa to speed the process along. The compost is ready to use when all components have broken down into a black/deep brown soil-like mixture.

Composting larger wood chips is possible, but it's tricky and takes forever. It's better to use them as mulch for pathways. Don't ever use wood chips or sawdust as a mulch right around living plants—the plants can starve to death as the wood absorbs the soil's nitrogen while decomposing.

Strategies for Controlling Dust

If the health hazards of breathing wood dust threaten to scare the enjoyment out of your woodworking, now is a good time to get serious about dust control in your shop. It should already be clear that collecting dust—in the form of shavings, chips, and sawdust—isn't enough to keep your shop completely clean; you must deal with the fine wood powder floating around the shop as well to keep the air safe to breathe. But this doesn't mean you have to wear a spacesuit in the shop to stay healthy during a lifetime of woodworking. There is a wide variety of filtration and collection methods to corral dust and keep your shop clean.

The best devices and strategies for dealing with dust depend on the size of your shop and the kind of woodworking you do. To help you gain a better perspective of your dust-control needs, I've compiled a quick overview of the major forms of collection and control in the first part of this chapter. The advantages and disadvantages of each are summarized in the chart on the facing page. In subsequent chapters, I'll delve deeper into each method of dust control and collection, presenting you with a more complete picture of how to choose the right equipment as well as how to install and/or use it in your shop.

Implementing complete and effective dust collection doesn't necessarily mean that you have to run right out and buy a lot of equipment. At the end of this chapter, there are some alternative strategies for reducing the production of dust in your shop as well as basic means of reducing your exposure to dust in the long run.

A SUMMARY OF METHODS OF DUST CONTROL AND COLLECTION

Method	Advantages	Disadvantages
Personal respiratory protection (disposable mask or reusable respirator; powered air-purifying respirator)	Disposable masks and respirators are inexpensive and readily available; can provide good respiratory protection in lieu of primary dust collection.	Disposables that don't seal well to face can compromise respiratory health; reusable cartridge-style respirators are uncomfortable to wear for long periods; powered-air respirators are expensive.
Shop ventilation	Easy, inexpensive way to exhaust fine dust-laden air from shop at minimal cost.	Limited protection from fine dust; most useful in temperate climate; unfiltered fan can pollute local environment.
Air-filtration device	Removes fine dust particles effectively without exhausting shop air; simple units can be shop-built; unobtrusive; easy to install in most shops.	Initially expensive to buy; some units are noisy; filters need occasional cleaning and replacement; doesn't totally replace primary collection.
Shop vacuum	Compact, portable, and relatively inexpensive; good for primary collection from portable power tools.	Limited effectiveness in collection from most stationary machines; limited chip-holding capacity; most units are noisy.
Portable collector	Less expensive and more versatile than installing a central collection system; can be used to collect from most stationary machines.	Not strong enough to use with long lengths of hose or ductwork; can be expensive; can take up room on the shop floor.
Central dust collector	Powerful; convenient way to collect from most stationary machines in the shop.	Expensive to buy; requires additional purchase and installation of ductwork; need space inside or outside shop for installation; some units are noisy.

Masks and Respirators

Although wearable personal-protection devices are the last line of defense against respirable wood dust (which is best collected at the source), their low cost and ease of use make them the first choice for many woodworkers. Respirators offer inexpensive protection for hobbyists, who need only occasional protection, or for small-shop woodworkers who don't have a dust-collection system in place.

Respirators worn around the nose and mouth prevent dust from entering your respiratory tract, which is especially important when generating fine dust during sanding (see the photo on p. 24). Disposable masks are a popular choice for daily shop duty because they are inexpensive and comfortable to wear. Reusable cartridge-style respirators accept a wide assortment of replaceable-filter elements, making them more versatile than disposables.

For woodworkers who find it difficult to wear respirators yet demand thorough protection against dust due to allergies or respiratory problems, powered air-purifying respirators (PAPRs) are a good choice. PAPRs—commonly known as air helmets or dust helmets—supply fresh, clean air to the wearer via a small filter and fan device. The positive airflow makes them effective even for bearded woodworkers, who usually don't get effective protection from other kinds of respirators.



A disposable face mask provides inexpensive respiratory protection from the long-term effects of fine dust, created in great quantities during jobs such as machine sanding.

Shop Ventilation

If you use a shop vacuum to collect chips in your small woodshop but still need to deal with small amounts of fine sanding dust, you can keep your shop and lungs cleaner by exhausting the dust-laden air outside the shop with a fan. All it takes to ventilate small garage-size shops is one or two inexpensive box-style household fans (see the photo on the facing page). A larger squirrel cage-style blower is needed for larger spaces (see the photo on p. 55). Fresh air enters the shop through an inlet port—an open window or door, or a cutout in a wall. Filters at the intake and/or exhaust openings keep incoming air clean and prevent exhausted air from polluting your yard or neighborhood. This kind of ventilation system not only reduces your exposure to fine wood dust but also exhausts vapors from water-based glues and finishes and other nonflammable vapors or mists.

Since simple shop ventilation means drawing in fresh air from the outside, it's a method that has real limitations: If your shop is subject to bitterly cold winters or horribly humid summers, it's expensive and uncomfortable to dump your heated (or air-conditioned) air outdoors. If you live in a harsh climate, use ventilation only during the more temperate seasons.

Air-Filtration Devices

While ventilation replaces dusty air with clean air from the outside, air-filtration systems (also called air cleaners) recirculate the air inside your shop, drawing in and trapping airborne wood dust before it settles on benchtops or gets inhaled. Designed to be suspended from the ceiling or a wall bracket, an air-filtration device (AFD) consists of a squirrel-cage fan and two or more filters housed inside a cabinet (see the top right photo on p. 26). The fan draws shop air through the filters, where the fine powder is collected. By circulating the air through the filters several times an hour, a significant part of the floating, invisible wood dust is removed, making the air in your shop cleaner, even after sanding.



A simple box fan perched on an open windowsill or in a doorway can provide enough ventilation to remove the lion's share of fine sanding dust generated in a small woodshop.

Passive Collection

You may choose to collect dust and chips from some tools and machines passively—that is, by using the bag, bin, or box that's built into the machine to collect dust from it. Portable power tools and benchtop tools, such as compound miter saws usually have built-in bags that at least make a dent in the collection. Jointers often have chip chutes built into their bases. Adding a box or bag under the chute provides a perfectly acceptable



The basic canvas dust bags that come standard with many portable benchtop power tools, such as the Bosch® 3912 compound miter saw shown here, do a pretty good job of abating the plume of chips thrown out during cutting.



Suspended from ceiling joists or mounted on a high shelf, an air-filtration device uses a fan and two or more filters to remove fine dust particles from the air, as the air circulates around the shop.



Adding this simple, snap-on canvas bag to the underside of a contractor's table saw prevents dust and chips from dropping through the saw's open base and collecting on the floor.

way of catching the large-size shavings produced by that machine. Table saws with enclosed bases will collect sawdust, and they can be cleaned out occasionally (see the photo on p. 8). You can add passive collection to a contractor's saw with an open base by fitting it with an aftermarket collection bag.

Portable Shop Vacuums

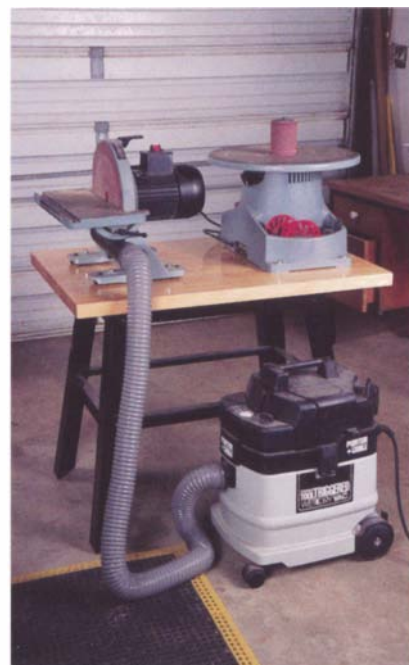
For flexibility in small-scale dust collection in a shop of any size, nothing beats a simple portable shop vacuum. Available in a wide range of sizes (both in terms of power and collection capacity), these versatile vacs can be temporarily connected to whichever small machine in the shop is currently in use (see the photo at right) or dedicated to collect dust and chips from just one or two machines. However, for most full-size woodworking machines, even a large unit might not be up to complete chip removal. Also, be prepared to empty the canister every few minutes unless you add an extra preseparator can to catch the bulk of the shavings ahead of the vacuum (see p. 105).

The greatest virtue of shop vacuums is their portability: They unhook readily and can be pulled around the shop for sucking up chips below the workbench or during your regular shop cleanup regimen. Shop vacuums also make great collectors for chips and dust generated by portable power tools. You can fit an electronic sensor switch to turn the vac on or off automatically along with the tool, or buy a model that comes with a sensor switch already built in.

Portable and Central Dust Collectors

Built essentially like a very large, powerful vacuum with ductwork connected to machines around the shop, a central dust-collection system provides the heavy artillery needed to keep a busy woodshop from overflowing with shavings and chips. A central collection system is a virtual necessity in shops that have the standard complement of full-size stationary machinery: thickness planer, table saw, jointer, shaper (and/or router table), cutoff saw, stationary belt and/or disk sander, etc. Unless you like to clean up around each tool every day, a central collector provides just about the only convenient way to stay one step ahead of the mountains of chips and sawdust you're likely to generate during an average day's work. All your dust and shavings end up in a bag or bin where they're convenient to dispose of.

The size of the central collection system you need depends on the size of your shop, the number of machines you want to connect, the volume of sawdust your shop generates, and the number of people operating machines at the same time. At the lower end of the scale are portable collectors with induction motor-powered blowers, such as the Delta 50-179



The versatile, portable shop vacuum is ideal for small-shop cleanup tasks and dust collection from tools and machines that don't generate tremendous amounts of chips, including portable power tools and benchtop machines.

Shop Vacuums Are Versatile Cleaning Machines

If you're sharing your workshop with the family automobile or your shop is tiny, you can't go wrong in buying a good shop vacuum. Even if your next shop will be as large as a dirigible factory, you'll still end up using your portable vac for all manner of shop cleanup. On the job site, it will help you tidy up after cabinet installations or trimwork (your client or spouse will thank you).



Portable collectors, such as the canister-top Delta 50-179 shown here, are a step up from shop vacuums, both in terms of power and chip-gathering capacity.



A central dust-collection system hooked up to all the machines in the woodshop conveys chips and sawdust to collection bags or canisters for convenient disposal.

shown in the photo at left. The limited power and capacity of these units is enough to handle a couple of the major sawdust-producing tools in a small workshop (table saw, thickness planer, shaper), as long as you keep all hoses short and collect from only one or two tools at a time. In a small hobby shop, a portable collector can be centrally mounted, with a system of ductwork and blast gates connecting a number of small machines to the unit.

Further up the ladder of power and performance for larger shops are full-blown (pardon the pun) central dust-collection systems, such as the collector shown above right. These systems feature large-capacity fans and permanently mounted rigid ductwork that serves all the machines in the shop (as well as inlets for floor sweeps, cleanup hoses, and possibly hose connections for portable power tools). Most central collection systems have large-capacity canisters or bags—for gathering and disposing of large shavings and sawdust—and sizable filter bags that thoroughly strain the finer dust out of the sucked-up air before exhausting it.

If you run a production cabinet shop or produce architectural millwork and do a lot of thickness planing, sawing, and shaping, you'll want to consider installing a collector with a cyclonic separator, or "cyclone" for short (see the photos on p. 104). For small and medium shops, these units are smaller versions of the cyclones found atop sawmills and large high-school woodshops. A cyclone separates out chips, shavings, and dust from the air

used to transport them to the collector. Debris is deposited in a large drum or bin where it's easy to empty; only the really fine dust makes it to the filters, so they aren't impacted by larger particles and they don't need to be cleaned as frequently.

Combining Dust-Control Measures

Ideally, a central collection system, portable collector, or shop vacuum captures dust and chips at their source—such as a machine, portable power tool, or work area—a practice known as primary collection. In reality, some dust always finds a way of escaping and ending up on the floor or, in the case of fine wood powder, in the air. Thus, even with the best systems, you'll need to capture and clean up this elusive shop dust. Vacuuming floors and benchtops will take care of chips and shavings, but fine airborne dust is better dealt with by some form of secondary collection, such as ventilation or air filtration. Although they don't capture fleeing dust, masks and respirators augment primary collection by preventing airborne particles from getting into your lungs.

The particular blend of primary and secondary collection and control strategies you choose and implement depends greatly on the scale and type of woodworking you do. If you're building miniature furniture in a closet-size shop, the amount of dust you create is probably minute as well; a dust mask might be the only form of dust control you need. A shop producing period-style furniture with traditional hand tools may only need a large push broom to sweep up shavings—more than adequate in that particular situation. At the other extreme, shops that do a lot of abrasive work—shaping parts using belt and disk sanders, grinders, and such—produce volumes of dust that require serious abatement measures, including a well-designed collection system and air-filtration devices. Persons with allergies or those who have experienced adverse reactions to wood dust are likely to need a respirator, in addition to other measures of dust collection/control implemented in their shops.

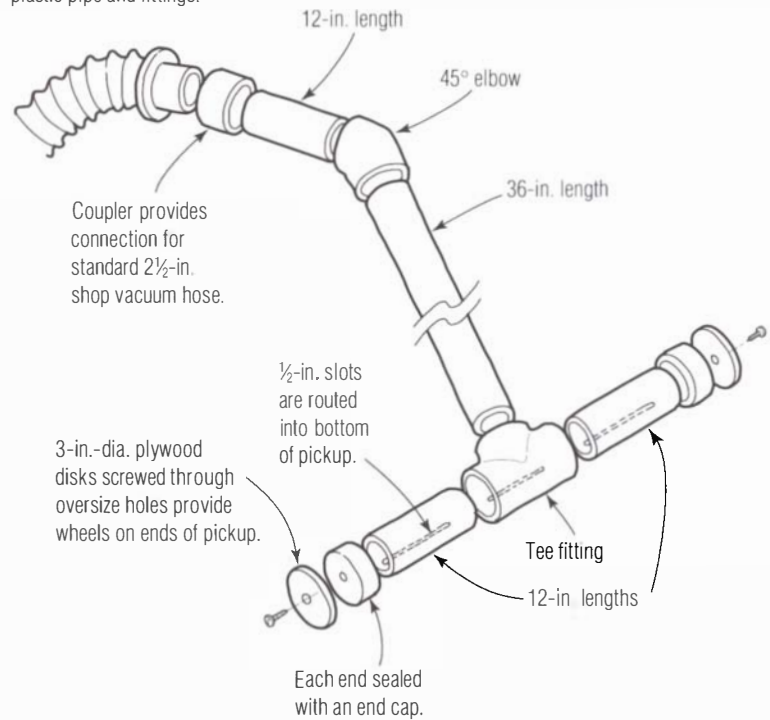
Shops where several people are working at one time will need different dust-control strategies than one-person operations. For example, central collection systems in multiple-worker shops—where several machines may be operating at once—are far more complicated to design than smaller systems that need serve only one machine at a time. The larger amounts of fine dust created by more frequent machine operations requires a high-volume air-filtration system or the extensive use of masks or respirators.

Alternative Means of Controlling Dust

For every problem you're likely to encounter in the woodshop, there's some handy device you can buy through a catalog or at the hardware store

Floor-Vacuuming Pickup

The pickup is made from regular 2-in. ABS plastic pipe and fittings.



that will solve it. But if dust is the problem, there are a few simple alternatives to going out and buying an expensive collection system. These include keeping the shop clean, generating less dust, and limiting your exposure to dust.

GOOD HOUSEKEEPING

Keeping the shop clean is the first and foremost way that you can control the accumulation of dust and debris in the woodshop. Not only is it harder to work efficiently in a space that's filled with sawdust and debris, but just walking around can raise a hazy cloud of fine dust that subsequently lights on tools and work in progress. If your shop adjoins your home, fine dust always seems to find its way inside your living space. Worse, a furnace in a basement shop can suck up fine dust and blow it all over the house. As we've seen, fine dust also pollutes the air with breathable fine powder that's deleterious to respiratory health.

When its time for your daily cleaning regimen, leave the broom in the closet. You'll surely churn up as much fine dust as the amount of shavings and sawdust you capture by whisking a broom around the floor. Cleaning

up floors is a job much better left to a portable shop vacuum or a hose connected to a central dust-collection system.

To save time cleaning up large floor spaces, build your own floor-vacuuming pickup from a few lengths of 2-in. ABS (acrylonitrile-butadiene-styrene) plastic pipe and a few pipe fittings (see the drawing on the facing page). A pair of shopmade wheels, cut from Masonite or plywood with a circle cutter or hole saw, helps the pickup glide easily along the floor. Slots sawn or routed into the bottom of the device allow dust pickup while preventing larger scraps from clogging the rig.

If you have large expanses of shop floor that need cleanup daily, it's worthwhile to invest in a specialized tool, such as the Shop-Vac® Shop Sweep® (see the photo below). Basically a powerful blower mounted atop a wide-mouth floor pickup, the Shop Sweep sucks up dust, fine chips, and debris with a vengeance, blowing it all into a large, 8-gal. capacity bag that has a rear zipper for easy emptying. Large wheels make the tool easy to maneuver around the floor and under benchtops and machine stands; it even has a kickstand, so it doesn't fall over backward when not in use.

For collecting large shavings (from handplaning, cutting dovetails, etc.), try using a small foxtail brush to sweep the shavings from benchtops and machine tables onto the floor where they can be vacuumed up. A snow shovel or a large plastic shovel, such as a grain scoop (available from feed and farm-supply stores), is a terrific tool for scooping up large quantities of shavings off the floor—and it raises far less dust than sweeping (see the photo on p. 32).



A specialized tool designed for cleaning up large shop floors, the Shop-Vac Shop Sweep uses a wide-mouth floor pickup and powerful blower to whisk chips and debris up and into a zippered fabric bag that's easy to empty.

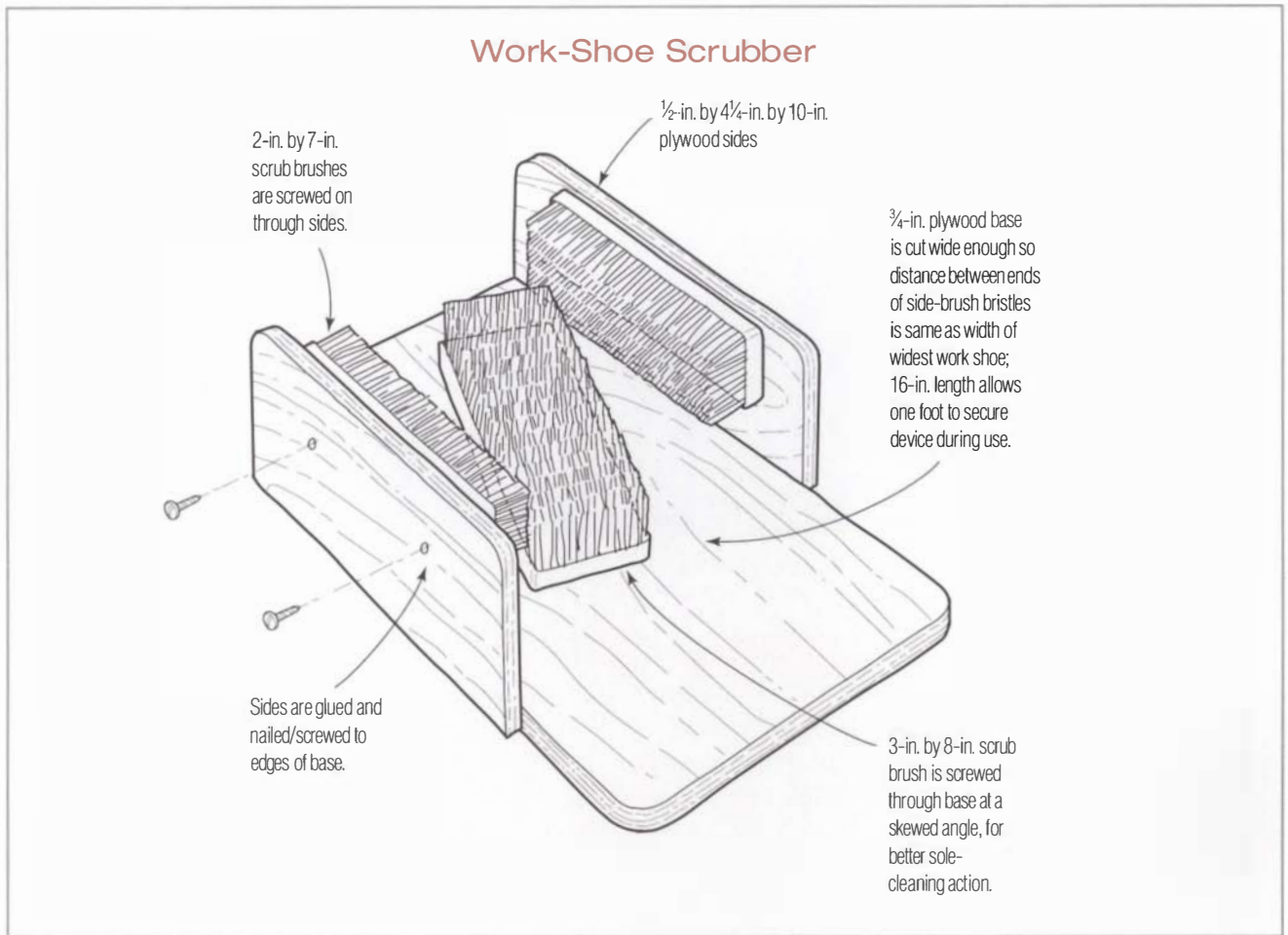
Coveralls Keep the House Clean

If your shop is at home and you often find yourself making trips inside the house, a good alternative to cleaning up before each jaunt is to wear coveralls in the shop. A quick peel and you're clean as a whistle—and no one can accuse you of depositing that thick film of dust on the family piano.



Rather than raising clouds of dust with a push broom, use a lightweight plastic grain scoop to shovel up mounds of shavings quickly and cleanly.

Since dust clings easily to hair, clothing, and the soles of shoes, you need to clean yourself off at the end of every work session to get rid of the dust before it ends up on your living-room couch. If you use a blow gun on a compressed-air line to accomplish this, make sure to blow off outside to avoid jet-propelling fine dust all over the shop. And wear a mask so you don't end up breathing all the dust you blow off. I prefer to give myself a quick cleaning at the end of the day with a vacuum hose fitted with a brush attachment. To extract the small chips trapped in my hair (they sometimes end up in my eyes when I remove my goggles), I run the

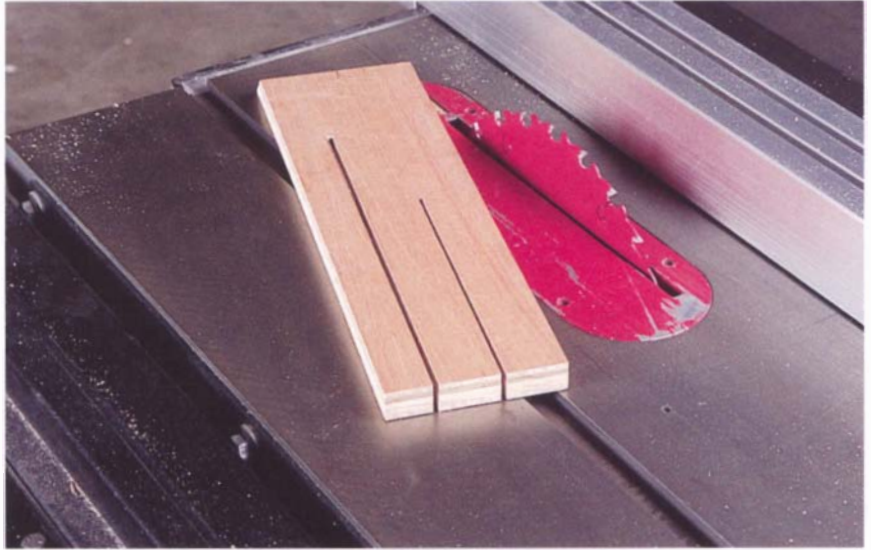


vacuum brush through my hair as well. It's actually kind of pleasant—like a vacuum scalp massage.

I had problems tracking in dust and chips on the bottoms of my shoes (especially when it rained), so I made my own work-shoe scrubber, modeling it after shoe-cleaning devices I've seen in trendy home-improvement catalogs. The device consists of three hardwood-backed stiff-bristle scrub brushes (from the housewares section of a department or hardware store) mounted to a plywood base, as shown in the drawing above. I keep my scrubber by the back door and take a second to brush each shoe through it before each trip into the house.

GENERATING LESS DUST

If you're attracted to the idea of simplifying your complex lifestyle, try this strategy in your shop before you go out and buy lots of new dust-control equipment: Generate less dust. Less dust in the air and on the shop floor means having less dust to collect and dispose of. Here are a couple of ways



You can cut a table saw's dust production by as much as 25 percent simply by mounting a thin-kerf sawblade. Adding a pair of stabilizer washers helps keep the blade running true during heavy cuts.

to reduce sawdust production without having to significantly change the way you work.

An easy way to pare down chip production is to fit your circular saws (table saw, circular saw, and cutoff saw) with thin-kerf blades. Modern blades, such as Freud®'s LU87 and LU88 and Forrest's excellent Woodworker II, are as smooth cutting as their standard-thickness counterparts. By reducing the kerf on a 10-in.-dia. blade to between 0.086 in. and 0.096 in. (as compared to 0.126 in.—about $\frac{1}{8}$ in.—for a standard blade), the amount of wood rendered as sawdust is reduced by up to 25 percent. If you plan to do any heavy ripping or precise crosscutting of thick hardwoods, it's a good idea to use these blades with a stabilizer—a precisely ground steel plate that bears against the sawblade on the saw arbor, reducing vibration and stiffening the body of the blade.

Because the thickness planer is the major chip producer in most shops, one way to reduce shavings is to purchase lumber already surfaced "S2S" (surfaced both sides). Also, many larger lumberyards are more than happy to custom-surface and dress lumber to your specifications for a price that is usually reasonable, considering the cost of buying a planer (and the drudgery of collecting and disposing of chips).

Here are some ideas for ways to reduce dust by working a little differently: On days when you've been grinding the gears on all the big machines in the shop and your ears are ringing, take a break from the power stuff and make a little sawdust the old-fashioned way. In many cases, you'll accomplish your task just as quickly and not owe the power company a cent for the job. For example, if you're handy with a handsaw, mallet, and chisel, it makes more sense to bang out those few odd tenons and mortises



A well-tuned cabinet scraper is a clean and quiet alternative to using a dust-churning power sander to smooth the surface of a wood panel, plank, or part.



The disposable paper bags on these portable power sanders do a better job of filtering out fine dust than most cloth bags. They also make it easier to dispose of the fine dust they collect.

by hand than to take the time to set up and adjust the fences and stops on the table saw and hollow-chisel mortiser. You'll be making big chips and shavings that are easy to brush off the bench and scoop up, generating very little fine dust in the bargain. The next time you need to clean up an area of torn grain on the face of a cabinet-door panel, don't reach for a belt sander; pull out a well-tuned cabinet scraper instead (see the top photo above). You might work up a sweat, but you won't kick up a cloud—and



One way to avoid eating dust inside the shop is to move operations to an outdoor driveway, deck, or patio. That's a good place to run portable tools that spit dust and/or chips in all directions, like belt sanders and routers.

you'll get the job done as well or better than that dust-spewing belted brute of a sander.

Another way to make less dust is to change the kinds of power tools or machines you use. Many of the newer power sanders feature built-in dust collection that's much more efficient than similar models of just a few years ago. For example, modern machines like the Bosch 3725DVS random-orbit sander and Metabo® Sr 358 half-sheet orbital sander (shown in the bottom photo on p. 35) use built-in fans to suck dust through their perforated sanding disks. These units also sport disposable paper dust bags, which trap more fine dust than cloth bags do. When full, paper bags are detached and disposed of—a much cleaner job than unzipping and emptying a cloth bag.

LIMITING YOUR EXPOSURE TO DUST

You can reduce the amount of time that you breathe dust in the shop by spending less time working in a shop that has a lot of airborne dust wafting around in it. If you're a full-time professional or happen to do a lot of power sanding, here are two strategies for limiting your exposure to fine wood dust.

First, set up your machine tools and power-sanding bench in a different room than your workbench, assembly, and glue-up areas. That way, you'll have a clean place to retreat to, where you don't have to keep wearing a respirator to keep from eating the cloud of dust you've just created. If your current shop is one big open space, you don't have to build a permanent wall to create separate machine and bench rooms: A floor-to-ceiling divider built by stretching sheets of thin (4-mil to 6-mil) clear polyethylene plastic over a lightweight framework of 1x2s can do the trick nicely. You can incorporate doors and pass-throughs wherever needed. By using clear plastic, light will travel from existing windows and light fixtures into your new, clean room.

Second, if you live in a temperate area, you might consider doing what I did before I set up a good dust-collection system in my shop: Set up your workbench outside the dusty confines of the shop whenever the weather permits (see the photo above). Working outside on a deck, patio, or driveway is especially desirable when power sanding or using a portable tool that spews tons of small chips, such as a router. You'll not only breathe more easily—unless you live in a smog zone, such as downtown L.A.—but you'll get a tan as well (just don't forget to wear sunscreen).

Respiratory- Protection Devices

If you are a weekend woodworker and don't have the time or budget to bother with other forms of dust collection or control, masks and respirators can provide a quick, inexpensive way to counter the short-term discomforts that come from breathing dust—as well as the long-term consequences that can rob you of good health. Even if you've outfitted your shop with complete central dust collection, no primary collection system is 100 percent efficient: Some fine dust particles still end up escaping and wafting about the shop. Ventilation and air-filtration devices (see chapter 4) take care of most of this free-roaming dust. But during periods of heavy sanding, you're still exposed to a certain amount of fine, respirable dust. The last line of defense against these lung-damaging particles is personal protection in the form of disposable masks, reusable respirators, or powered air-purifying respirators (dust helmets).

When chosen and worn correctly, most masks and respirators provide adequate respiratory protection to most individuals. But not all respirators work for all persons. The best device for you depends on a number of factors, including cost, desired level of comfort, work style, and (believe it or not) whether or not you have facial hair. The chart on p. 38 summarizes the advantages and disadvantages of each type of device. Note that the filters in wearable devices differ in the kinds of respiratory protection they provide. That is why you should acquaint yourself with the ratings and specifications for different types of disposable masks and filtering elements before buying and using them. In this chapter, we'll look at each type of device, arranged from least to most expensive, as well as explore different types of filtration devices appropriate for woodworkers.

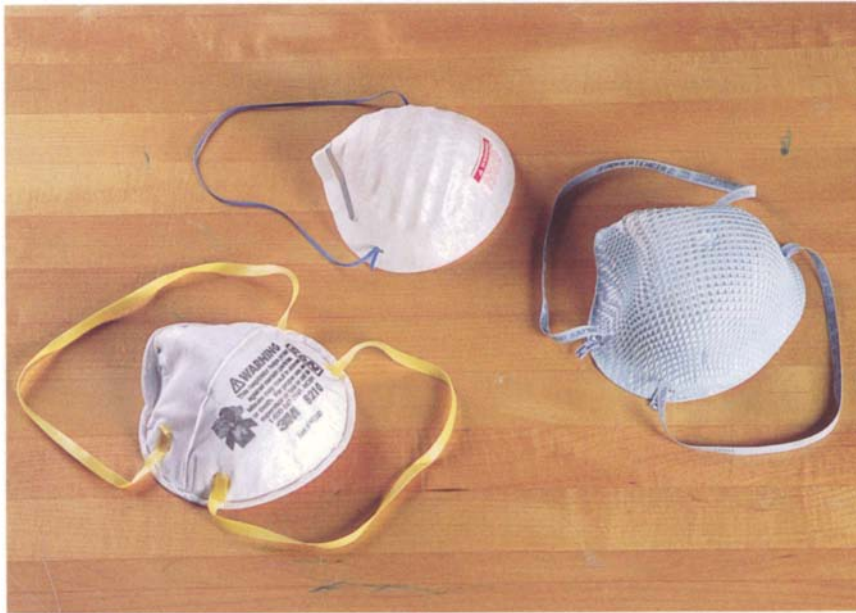
PERSONAL RESPIRATORY-PROTECTION DEVICES

Device	Advantages	Disadvantages
Disposable mask	Cheap; readily available; more comfortable for longer wear than reusable respirator; no need to maintain or clean.	Doesn't seal well on bearded faces; less effective than half-mask respirator; difficult to talk on phone.
Reusable respirator	Better face seal than most disposable masks; versatile (replaceable-cartridge respirator can be used for protection from dust or organic vapors).	Can be tiring to wear for extended periods; doesn't seal well on bearded faces; cartridge is expensive; facepiece should be cleaned after each use; must remove for conversation or to talk on phone.
Powered air-purifying respirator (dust helmet)	Combines eye, head, and respiratory protection in one device; provides a positive seal around the face for bearded woodworkers; eliminates fogging problems for eyeglass wearers.	Expensive (\$165 to \$450); cumbersome to wear, especially belt-pack models; difficult to converse; must be removed to talk on phone.

Disposable Masks

The easiest way to protect your lungs against fine wood dust is to wear a disposable mask (officially known as a “disposable respirator” or “filtering facepiece”). Readily available at hardware and paint stores, home centers, and even some drugstores, disposable masks provide the cheapest form of dust protection you can buy. They keep out dust by filtering the air you breathe through your nose or mouth (this arrangement is known as a half-mask, as compared to a full mask, which covers your nose, mouth, and eyes). The entire surface of a disposable mask is a filter made up of a matrix of nonwoven fibers that trap and retain dust particles. When the mask becomes dirty, you simply throw it away and fit a new one.

Several styles and models of disposable masks are safe and appropriate for use in most woodshops. One style that isn't appropriate is the so-called comfort mask. All too commonly used by thrifty or uninformed woodworkers, masks like the 3M® 8500 (shown center in the photo on the facing page) have one-layer shells, sport only a single strap, and are usually labeled “Warning: This mask will not protect your lungs.” They are recommended only for protection against “nuisance levels” of dust: the amount of dust you might be exposed to if you spent only about 15 min. in a dusty shop. The electronics and food-processing industries use comfort masks to prevent workers from contaminating the products they are processing. Their thin filter material doesn't offer enough protection for any kind of sustained woodworking operation.



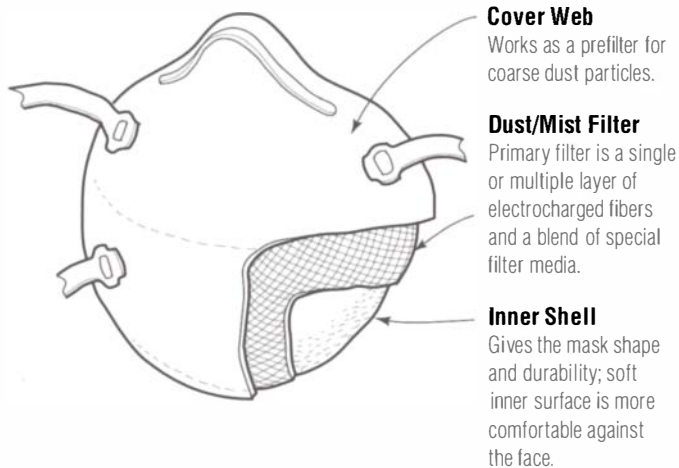
Buy Masks in Bulk

Woodworking dust masks are available at hardware stores, packaged a few at a time in shrink-wrap, but it's much cheaper to buy them in boxes of 10 or 20 from a mail-order supplier (see Sources of Supply on p. 195).

Distinguishing an inexpensive mask good only for “nuisance levels” of wood dust from one rated for more serious protection against particulates is as simple as counting straps: Disposable masks rated for protection against dust and mists have two straps, as opposed to the single strap on the comfort mask (center).

Disposable Dust/Mist Filtering Mask

Basic disposable masks are constructed in three layers:



The most basic mask recommended for woodworking has two straps and an adjustable nosepiece, both of which help to seal the mask to the wearer’s face comfortably and positively. Popular models include the 3M 8210 (shown at left in the photo above) and the Moldex® 1502 (at right).



The exhalation valve in the center of a disposable mask allows hot breath to be exhausted more readily, which makes the mask more comfortable to wear (especially in warm weather) and less likely to fog glasses or goggles.



Protect molded disposable masks against dirt by leaving them in the box or bag until use. You can protect masks currently in use from being crushed by storing them in a protective plastic case.

These masks are molded from three layers: a paperlike cover layer that pre-filters coarse particles (the Moldex features a molded outer shell to resist collapse in high heat and humidity), a center layer that's a blend of natural and/or synthetic fibers that are electrocharged so they will attract and trap small dust and mist particles, and an inner layer that's soft against the face (see the drawing on p. 39).

To keep masks clean, keep them in the plastic sleeve, bag, or box they came in until use. If you use a disposable more than once, you can prevent crushing between uses by storing the mask in an inexpensive plastic mask case (see Sources of Supply on p. 195), such as the one shown in the photo above right.

Alternative models of the basic two-strap disposable mask feature an exhalation valve in the center, such as the 3M 6979 (see the photo above left). This simple one-way valve closes during inhalation to prevent dust from being drawn in, allowing you to exhale more easily and making the mask less tiring to wear for extended periods. By allowing your moist breath to pass through easily, these masks prevent the buildup of moisture on the inside of the mask, which otherwise would feel clammy on your face. You'll especially appreciate this feature if you're working on a hot day. More important, the valve reduces the tendency for moisture to creep up under your eyeglasses or protective goggles and fog them up.

CLOTHLIKE DISPOSABLES

Another kind of disposable mask that's become popular among woodworkers in the past few years is a two-strap design made of a clothlike

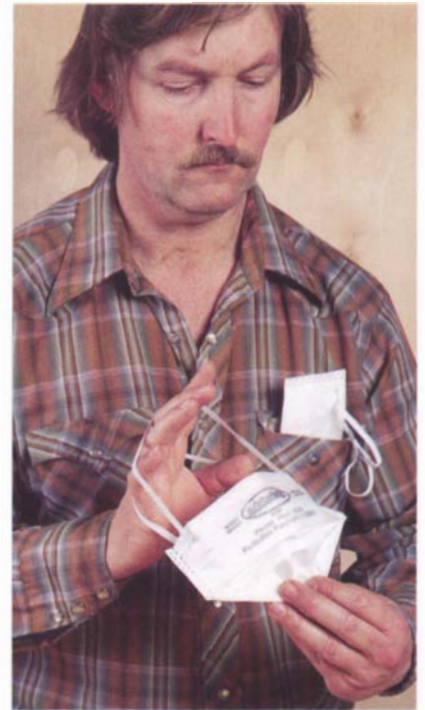
material. Models such as the AOSafety® Pleats Plus™ (see the photo below right) are more expensive than common molded disposables but offer several advantages: They are softer and more comfortable to wear than many molded disposables; they have low breathing resistance, making them less tiring to wear; and they easily fold flat, so they are less cumbersome if worn around the neck between uses. You can also keep a flat-folded cloth disposable in your shop apron or shirt pocket without compromising the mask's fit. This is a real advantage if you put on and take off your mask several times a day because molded disposable masks lose their ability to seal when they are crushed out of shape.

Reusable Respirators

An alternative to disposable masks are reusable respirators, such as the ones shown in the photo below left. These half-masks have two components: a disposable filter(s) or cartridge(s), which cleans the incoming air, and a reusable facepiece, which provides a mount for the filters, ensures an airtight seal around your face, and controls the airflow to and from the filters. You throw away only the filters after they are clogged with dust and reuse the facepiece indefinitely. In use, inhaled air is pulled through the filters mounted on the sides or front of the facepiece. Exhaled breath passes out of a simple flap-style one-way valve on the front of the facepiece. Another one-way valve fitted just behind each filter prevents moist air from passing back into the filter element, which could reduce its effective life.



The two types of reusable respirators shown here are the replaceable-filter facepiece (left), with a large, pleated paper filter element and bottom-mounted exhalation valve, and the replaceable-cartridge facepiece (right), with dual cartridges mounted on either side of a central exhalation valve.



Some woodworkers prefer the comfort and storability of clothlike flat-folding disposable dust masks. It's easier to don any type of two-strap mask by holding the straps back with one hand while you slide them over the back of your head.

When to Dispose of a Disposable

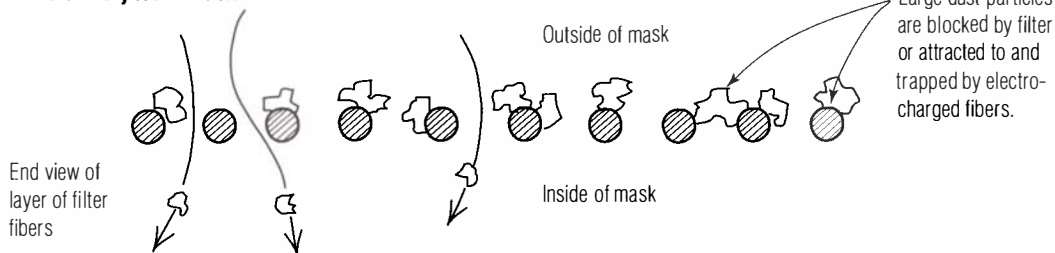
ONCE THE FIBERS OF ANY DISPOSABLE MASK (or filter cartridge) get clogged, it's time to throw it away and use a fresh one. How can you tell when a mask is used up? A layer of dust on the outside of the mask shows that many large, visible dust particles have been filtered out, but the filter may still be able to remove fine respirable particles. Ironically, the fine particle-filtering ability of a mask actually improves as the filter material fills up, as shown in the drawing below. This is true of all dust-filter media, including cartridge filters and filter-bag materials.

The most telling clue that a mask is spent is that breathing through it becomes more difficult because dust particles have clogged most of the small air passages remaining in the filter material. In a pinch, you can extend a mask's useful life a little by blowing or vacuuming it clean: The bigger wood dust particles are removed, but the fine particles that do the most to impede airflow stay trapped in the filter fibers.

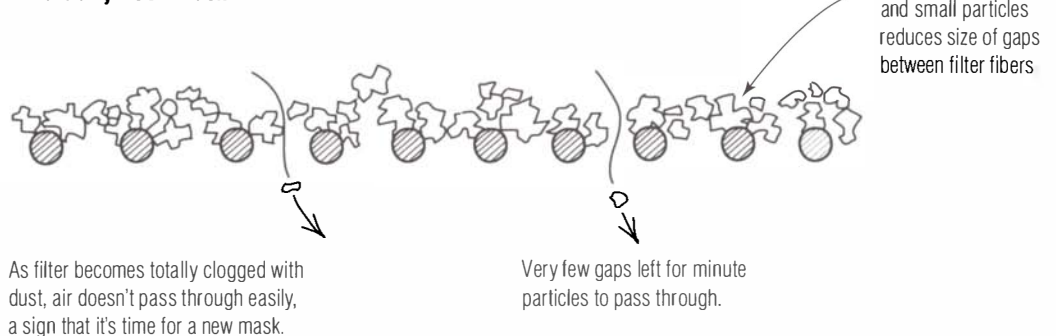
It's best to simply throw away inexpensive disposable masks after a full day of work or after a session of heavy sanding. Also dispose of any disposable that's been crushed or distorted or that has a broken or twisted nosepiece, as its ability to seal to your face has probably been compromised.

How a Disposable Mask's Filtration Improves with Use

A Relatively New Mask



A Partially Used Mask



Respirators designed primarily for woodworking have replaceable filter elements housed in a compartment, usually on the front of the facepiece. The filters in some respirators are pleated to enlarge the surface area of the filter and reduce breathing resistance (see the respirator at left in the bottom left photo on p. 41). Replaceable-cartridge respirators typically have a pair of disposable, screw-in cartridges mounted on either side of the mask (see the res-



Silicone Masks Are Best

While more expensive to buy, a silicone mask is softer and more comfortable to wear than a neoprene rubber mask. Silicone masks are also great for people who are allergic to rubber. The cushy material tends to mold more easily to the face, producing a better seal in the process.

The yoke or cradle-style top straps used on many respirators distribute the pressure of the strap evenly across the back of the head. This makes the mask more comfortable to wear for extended periods.

pirator at right in the same photo). Screw-in cartridges not only make it easy to replace filters but also allow you to change the kind of respiratory protection that the mask provides. There are literally dozens of different kinds of filters that are effective against dusts, mists, vapors, gases, chemicals, and various combinations of these materials (see pp. 45–47). The availability of different kinds of filters makes respirators versatile, since you use one facepiece with separate cartridges for dust and organic vapors, enabling you to use the respirator as both a dust mask and a spray-finishing mask.

The facepiece on most respirators is contour-molded from neoprene rubber or silicone. Some respirator models have a double sealing lip around their edge to achieve a better seal on sunken-cheeked or angular faces. Like disposable masks, reusable respirators don't seal well on bearded wearers (see p. 47). Twin adjustable straps attached to the body of the respirator make it easy for the wearer to achieve a tight yet comfortable fit. A yoke or cradle-style top strap, as shown in the photo above, does a particularly good job of pulling the mask up tightly to your face without putting undue pressure on the back of your head. This results in less pressure on the scalp and less fatigue during long periods of wear. However, some woodworkers find the added weight of the respirator and cartridge makes it less comfortable to wear than a disposable mask.

RESPIRATOR MAINTENANCE

When the filters or cartridges in a respirator are used up, simply remove them from the facepiece and replace them with fresh elements. A sure

sign that filter elements are spent is increased effort required to breathe through them. As with disposable masks, you can extend the useful life of a filter element or cartridge slightly by vacuuming its surface clean. Fitting a replaceable-cartridge respirator with inexpensive prefilters is cost-effective because throwing away dirty prefilters is much cheaper than replacing cartridges. The facepiece itself is reused many times, and most manufacturers offer replacement straps, valves, and other parts for their models so you can keep a well-maintained respirator in service for years.

Because condensed moisture from your breath collects inside the facepiece, you should wash it regularly with a mild detergent. First, remove the filter elements and straps. Then, take apart the intake and exhaust valves and wash them separately (see the photo below). Be careful with the thin, round rubber flaps that serve as intake valves; pull them from their mounting studs gently to avoid ripping them. After washing the facepiece, it's a good idea to sanitize it with a disinfectant. This extra step is mandatory if the respirator is shared with coworkers. You can buy solutions of commercial respirator disinfectant (typically quaternary ammonium; see Sources of Supply on p. 195), or you can make your own by mixing about 2 tbsp. of household bleach into 1 gal. of warm water. Soak the facepiece in this solution for 2 min. or 3 min., then towel it dry.

When reassembling a replaceable-cartridge respirator, press in the rubber gaskets that come with the mask before installing the cartridges. Once dry and fully assembled, store the respirator in a plastic bag to keep it clean until the next use. If you have organic-vapor cartridges (used when working with finishing materials; see p. 46), store them in a plastic bag as well: The activated charcoal in these cartridges continues to work—and wear out—even when the cartridges are not in use.



Washing a rubber or neoprene facepiece with a mild detergent between uses helps keep it sanitary, as well as ensuring that the valves work correctly and that the facepiece continues to seal effectively.

NIOSH MASK-CERTIFICATION NUMBERS

Filter Category:	N	R	P
Filter Efficiency			
95%	N95	R95	P95
99%	N99	R99	P99
99.97%	N100	R100	P100

Choosing the Right Filtration

Disposable masks and filter elements for reusable respirators are available in an extensive and confusing array. Fortunately, the government offers us help in the form of NIOSH certification numbers. The numbers ensure that the respirator has passed a rigorous testing program and is approved for protecting the wearer against the specified types of airborne contaminants.

NEW FILTER SPECIFICATIONS

For many years, the standard for dust-protection masks and replaceable-cartridge respirators in the woodshop was NIOSH specification number TC-21C (followed by a three-digit number that specified the particular model of respirator). In July 1995, NIOSH updated and modernized its regulations and certifications for these nonpowered particulate respirators. The new federal guideline, known as 42 CFR 84, provides nine new classes of filters: three levels of filter efficiency, each with three categories of resistance to filter degradation (see the chart above). The certification letter and number combination is stamped directly on the mask or filter element (see the photo on p. 46).

Despite the complex-looking lettering/numbering system, the good news is that all new disposable masks—N-, R-, or P-series—provide excellent protection against woodworking dusts and waterborne mists. N-series masks are the least expensive choice for regular woodshop applications. R-series masks filter oil particles (from lubricants, cutting fluids, etc.) in addition to filtering solids and waterborne aerosols. P-series masks also filter oil particles but are designed to be used for multiple work shifts, common in industrial situations. None of these series filter masks removes organic vapors (see the following section).

To recap, the new NIOSH N-, R-, and P-series certifications only apply to disposable masks and cartridges for reusable respirators; NIOSH has yet to revise its certifications for filters used in PAPRs. The certification for filters in those devices used for woodworking is still TC-21C. It's likely that standards for these filters will also be modernized in the next few years.

A Good Everyday Mask

An N95-rated mask (the mask most commonly available at hardware stores and home centers) stops 95 percent of respirable particles down to 0.3 μ m in diameter. That's good enough to eliminate serious risks for most people from exposure to the relatively modest dust concentrations found in a typical woodshop. The NIOSH rating is, of course, a general recommendation subject to different factors, such as the presence of air contaminants other than wood dust.



To make it easier to identify the type of respiratory protection provided by a disposable mask or replaceable-filter element, manufacturers print the rating number right on the nosepiece or strap or on the element itself. N95 is the most common number you'll find on store-bought masks and elements used to filter particulates, including wood dust.

ORGANIC-VAPOR CARTRIDGES

Another NIOSH specification number that you are likely to find on filter elements is TC-23C. Cartridges with this specification provide protection against organic vapors produced when solvents evaporate from glues, paints, and finishing materials (even the majority of water-based finishes contain low levels of solvents). Organic-vapor cartridges contain tiny granules of activated charcoal that actually absorb vapors as these gases pass through them. Most mask manufacturers color-code their filters, using black to indicate organic-vapor cartridges. Other color codes designate filters approved for protection against other gases and/or vapors, such as ammonia (green) and acid gases (yellow).

While a TC-23C filter is right for protection while painting or clear-finishing wood, you might be tempted to use it for dust protection in lieu of an N-, R-, or P-series dust/mist filter. Unfortunately, fine wood dust particles tend to pass through organic-vapor cartridges. In fact, you need to fit an appropriate N-, R-, or P-series prefilter over a TC-23C filter to protect yourself against mist droplets when you are spraying a solvent-based finish. Conversely, solvents evaporating from nitrocellulose lacquer or varnish will pass through a dust/mist filter. The bottom line is that you must select the right filter element (or elements) for the job at hand; your lungs depend on it!

If you're uncertain about what kind of mask or filters you (or your employees) need, do not hesitate to consult an industrial hygienist or other safety professional; try Lab Safety Supply™'s TECHline™ at

(800) 356-2501. These professionals are best equipped to help you evaluate your precise needs when it comes to respiratory-protection devices.

When purchasing replacement cartridges for your respirator, be aware that units with the same appearance may have different-size threads or bayonet-style mounting flanges that aren't compatible with your particular mask. In fact, most filters and cartridges aren't interchangeable among different brands (or, sometimes, even different models of the same brand), which means your best bet is to buy replacements from the same company from which you bought your mask.

Fitting a Mask Correctly

Regardless of the effectiveness of its filtering medium, a mask or respirator won't work effectively unless it's sealed tightly against your face. A poor seal simply lets dust-laden air sneak in past the filters where it's inhaled directly. Several factors can ruin a good mask-to-face seal, including high cheekbones, missing dentures, severe acne, facial scars, or facial hair. Beards, sideburns, and even a thick five-o'clock shadow easily thwart a good facial seal around any type of facial respirator. Some woodworkers have tried to get around this problem by covering their beards with a thick layer of petroleum jelly (such as Vaseline®), reasoning that the jelly will act as a viscous sealant around the edge of the mask. Unfortunately, this approach is not effective (and I can't imagine anyone working comfortably with their face coated with goo).

Molded disposable masks tend to be particularly bad at sealing to the face. I read one study (done by the Centers for Disease Control and



A foam inner seal around the nosepiece of a disposable mask helps prevent leaks around the wearer's nose, while providing a more comfortable fit.

Prevention) that said that it's possible for an incorrectly fitted disposable mask to leak around the edges and let in up to 20 percent unfiltered air. The bridge of the nose seems especially prone to fit problems. The adjustable nosepieces on some models do a better job of sealing than others. I especially like the ones with small foam cushions, such as 3M's 8715, shown in the photo on p. 47. A foam nosepiece also helps cure problems with nose pinching (making the mask more comfortable) and prevents expelled breath from fogging your glasses or safety goggles. One manufacturer, MSA Safety Works®, offers disposables with a patented self-adjusting foam face seal around the entire edge of the mask. While more expensive than regular molded disposables, MSA's Affinity® Ultra N95 respirators (available from Lab Safety Supply; see Sources of Supply on p. 195) are more comfortable and offer a more positive seal.

CHECKING THE FIT

How do you know if your mask fits you correctly? There are several ways of checking. With a reusable respirator, do the "negative-pressure-fit check" by removing the cartridges or filter elements and covering the intake ports of the facepiece with your flat palms (see the top photo on the facing page). Inhale lightly and hold your breath for 10 sec.; you should feel the mask suck in closer to your face. If the mask loses vacuum and moves away from your face before you exhale, the seal is probably compromised. Adjust the tightness and/or location of the straps and try again. If the test still fails with the straps tight, the exhalation valve might be leaking. The simple round flap inside the valve is inexpensive and easy to replace.

Next, try the "positive-pressure-fit check" by covering the mask's exhalation valve with your palm and blowing gently. The mask should retain pressure for at least 10 sec. If it doesn't, adjust the straps and try again. If this test fails, check the inhalation valves for leakage and replace them as necessary. If all the valves in the mask are in good shape and either or both tests fail, try tightening both straps and wiggling the mask so that it settles into a different position on your face. Don't tighten the straps to the point that the mask is cutting into your face, creating deep red welts (some facepieces really dig in around your nose!). If you have an older mask made of rubber, replace it with a newer model made of softer, more pliable silicone. Alternatively, try another size, brand, or model of respirator; subtle differences in size or manufacture can make one mask fit you better than another.

Qualitative fit testing The best assurance you can have that a reusable or disposable respirator fits properly is to perform a more formal, qualitative fit test (required by OSHA for testing respirator fit for woodshop employees). This procedure requires a special test kit (see Sources of Supply on p. 195), which includes a Tyvek® hood with a clear window, two types of testing solution, and a pair of squeeze-bulb atomizers (called nebulizers).

Choose the Right Mask Size

Although a typical medium-size mask fits about 90 percent of the population, well-stocked suppliers carry masks in small, medium, and large sizes. Some brands of disposable mask also come in more than one size. One brand might fit you better than another, so you might want to try out several models and brands before choosing a mask for everyday use.



The “negative-pressure-fit check”—performed by covering a respirator’s air intakes and inhaling for 10 sec.—can reveal leaks in the facepiece’s seal against your face, which compromises respiratory protection.

First, a sensitivity test solution is sprayed into the hood (fitted over the person’s head, sans mask) using the first nebulizer, to check whether the wearer can detect the sweet taste of the test solution. For the actual fit test, the person dons an N-, R-, or P-series mask or reusable respirator and a second, more concentrated test solution is sprayed into the hood with the second nebulizer (see the photo at right). The person is then asked to perform a series of tasks, including normal and deep breathing, head nodding, and talking—all intended to check how well the mask continues to seal to the face under working conditions.

If the wearer cannot detect the sweet taste of the test solution, the test is successful and good respirator fit has been demonstrated. If the test fails, it can be repeated after readjusting the respirator. Two failures indicate that it’s necessary to switch to another size, type, or brand of respirator.

WHEN DO YOU NEED TO WEAR A MASK?

Unless your shop has a central dust-collection system and air-filtration devices that are extremely efficient, you’ll probably still need to wear a mask or respirator during peak periods of dust production. Try to wear your respirator whenever you’re using machines that create fine dust (or dust and chips) and always when using tools that lack effective built-in dust collection, such as many older power sanders. Failure to wear your respirator during machining operations—or removing it when talking on the phone or drinking your morning coffee—can increase your daily exposure to dust by a surprising amount. I use a cordless phone in the shop so I can



A qualitative fit test is the best way to check that a respirator fits tightly to the wearer’s face and doesn’t let dusty air sneak in past the filters. The test requires the user to wear the respirator inside a hood where an aromatic test solution is blown inside with an atomizer. If the wearer detects the sweet taste of the solution, the respirator doesn’t fit properly.

take calls outside when I'm in the middle of dust-making activities. It's also best to avoid unnecessary conversations with coworkers in the woodshop since you're both likely to take off your respirators.

If you raise great clouds of fine dust in a shop that's not equipped with some form of secondary collection, such as ventilation or an air-filtration device, it's prudent to continue wearing your respirator after sanding is complete until you leave the shop. If this describes your situation, do your heaviest sanding at the end of the workday and clean up the settled dust before you begin work in the shop again the following day.

If you can't stand wearing a reusable respirator for long periods of time (and you don't want to install a collection system), try switching to a more comfortable disposable mask, such as one of the cloth-style models, or a molded mask with an exhalation valve (see p. 38).

Powered Air-Purifying Respirators

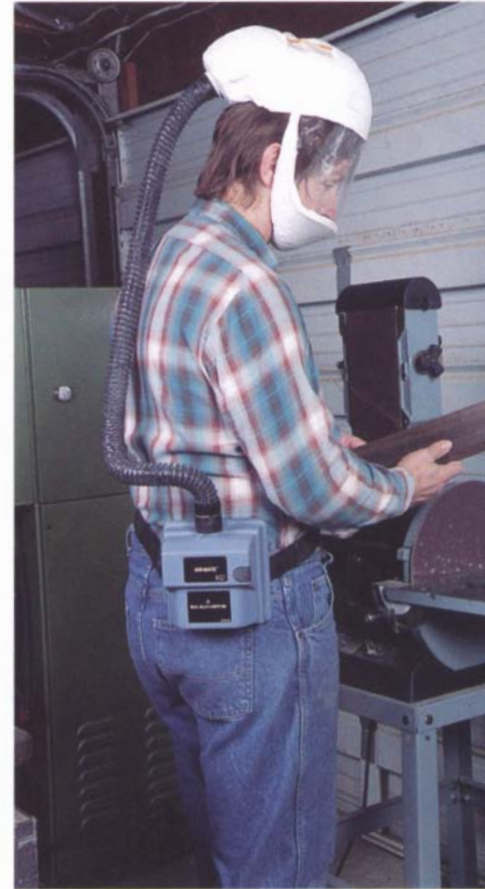
Powered air-purifying respirators are an interesting alternative to disposable masks and reusable respirators. These personal protection devices are known in the manufacturing industries as PAPRs for short; among woodworkers, they are more commonly referred to as air or dust helmets. Unlike half-masks that cover only the mouth and nose, PAPRs envelop and protect your entire face while they provide a steady stream of cool, clean, filtered air to breathe. Although expensive (\$165–\$450 plus), PAPRs provide a level of comfort and breathing protection that's difficult to achieve with standard masks and respirators.

A PAPR uses a plastic hard hat, lightweight crown, or fabric cap (see the photo at right on the facing page) to support a visor or clear shield that covers the entire face of the user. Helmeted PAPRs and visor-style models (see the photo at left on the facing page) have flip-up plastic face shields made from shatter-resistant plastic. An optional replaceable overlay—a clear piece of thin, flexible plastic that adheres to the outside of the face shield—prevents scratches that can quickly ruin the shield. An elastic-drawn, disposable seal (typically made of Tyvek fabric) fills the gap between the bottom of the helmet's shield and the wearer's face. A battery-powered fan provides a constant supply of air, and a system of pre-filters and filters cleans the air before it is fed to the wearer. Dust helmets aren't airtight, so you don't have to worry about suffocating if the fan suddenly quits. Although the visor and hood don't form a perfect seal around your face, the positive air pressure produced by the fan prevents dusty air from leaking in.

The arrangement of fan, battery, and filters varies from model to model. A few models, such as the 3M/Racal Airstream® AH5 and 3M's Airhat®, locate the fan and filter in the back of the helmet itself, with battery power supplied from a separate belt pack. Most PAPR models house the fan, filter, and battery in a separate belt-worn pack that con-



To get maximum protection from the dust of exotic woods, guitar maker Jeff Traugott uses a PAPR. Most PAPRs have a belt-worn filter and battery pack that blows air into a visored helmet or headpiece via a flexible hose.



If you don't need the protection of a helmet and impact-resistant face shield, choose a model with a soft fabric cap. The Tyvek material and thin, clear plastic shield are light, making the cap comfortable to wear.

nects to the helmet via a flexible hose. Designed for light or occasional use, the Racal Power Visor® houses fan, motor, filters, and batteries all in the crown of the unit itself (see the photo at left on p. 52). Although it isn't NIOSH TC-21C-rated, the Power Visor is more affordable and less cumbersome than a belt-pack PAPR and is still good for occasional use for protection from light "nuisance levels" of dust.

Regardless of which PAPR you choose, its battery pack has rechargeable nicads (nickel-cadmium batteries) in it. Depending on the model, these batteries typically last from 4 hr. to 12 hr. between charges. Like the batteries in cordless power tools, nicad battery packs for PAPRs have a "memory," which means you should use up most of the battery's capacity before recharging so that it won't lose its ability to take a full charge. New

Breathe Safely with a PAPR

PAPRs only filter the air; they do not supply fresh oxygen. You cannot work safely with a regular PAPR in an oxygen-depleted environment, such as in a solvent fume-filled finishing booth or in an enclosed garage with an unvented heater or running car engine.



To check a PAPR's filters, a bullet-shaped flow-test device is inserted into the end of the air hose. If the air pressure doesn't raise the device high enough (the orange line), it means the filters are clogged enough to need replacing.



Unlike heavier-duty PAPRs, the compact Power Visor doesn't have a belt pack and hose—all its components are conveniently located inside the visor's crown. It provides good respiratory protection during light sanding, as well as eye protection, with its integral face shield.

“smart chargers,” available for some models, can keep a battery charged and fresh for up to 30 days without diminishing its capacity.

The amount of airflow produced by the fan in a dust helmet varies by model but is typically either 6 cfm (cubic feet per minute) or 8 cfm. But, airflow diminishes as the filters become clogged. A simple pass/fail airflow meter (supplied with most PAPRs) lets you check the filters so you know when to replace them (as shown in the photo above). Vacuuming or blowing out the prefilters on some models can extend their useful life, but the main filters must be replaced when they're spent.

PROS AND CONS OF CHOOSING A PAPR

So why choose a powered air-purifying respirator when, for all the added expense, PAPRs don't provide any better fine dust-filtering performance than a well-fitted respirator? Many bearded woodworkers choose PAPRs because they can't get a good face-to-mask seal with regular dust masks or they can't comfortably wear prescription eyeglasses with a half-mask respirator. Another reason is that most PAPRs have plenty of room under their face shields for wearing eyeglasses (see the photo at right on p. 51). Other woodworkers prefer using PAPRs because they combine eye and respiratory protection in one device, and models with a hard hat provide head protection as well. Some models can be fitted with organic-vapor cartridges, so your expensive PAPR can do double duty in the finishing booth. Some PAPR models are equipped with extension hoses to draw fresh air from outside the spray booth, greatly extending their usefulness.

Because PAPRs provide a constant flow of fresh air, the face shield doesn't tend to fog up—a common complaint among woodworkers who wear regular safety glasses or goggles. Also, if you work in a cold shop, you can buy a helmet liner or wear a stocking cap to keep the top of your head warm. Others say that the positive air pressure makes it much less tiring to wear a PAPR compared to a regular respirator. And woodworkers who work in hot conditions enjoy the comfort of a continuous flow of fresh air streaming over their faces.

On the downside, dust helmets can be cumbersome to wear, especially models with large belt packs and protruding filters, which tend to bump into machines and benches as you navigate around the shop. Then there's the communication problem: Not all models feature a flip-up visor, requiring you to remove the helmet and hearing protectors before you can talk on the phone or even have a reasonably clear conversation. And you're likely to be assailed with nicknames like “aquarium head” and “space woodchuck” by your shop mates or, worse, scare the occasional unannounced shop visitor.

Some woodworkers complain that the noise from the constant whir of a PAPR's fan is annoying, especially in models that have the motor/fan mounted inside the helmet; many say that the sound is similar to the drone you hear on a plane in flight. Also, regular muff-style hearing protectors can't be worn with some helmets—although at least one unit, the Racal Air-Mate® 3, can be fitted with helmet-mounted earmuffs. An alternative is to wear special behind-the-ear muffs.

Shop Ventilation and Air Filtration

Because of the profusion of new abrasive portable power tools and machines, such as random-orbit sanders and stationary wide-belt sanders, the average woodworker today generates more fine dust than ever. Regardless of how big and powerful the dust-collection system in your shop may be, a certain amount of fine dust always escapes into the air. Once aloft, fine dust is easily respirable, and since dust can remain suspended for a long time, your exposure can continue for hours after you're done sanding. Dust that isn't breathed ends up all over your benches, tools, and floor in a fine film that once again becomes an airborne hazard each time you walk across the shop.

The best way to assure a clean shop and healthy breathing is to get the fine dust out of your shop's air. Two practical methods for abating airborne shop dust are ventilation and air filtration. Ventilation is the simple process of exhausting dust-laden shop air; air filtration uses fan-powered filter devices to remove the lion's share of fine dust from air circulating around the shop. Both are considered secondary air-cleaning methods; neither is a replacement for collecting dust at the source with some sort of shop vacuum or dust-collection system. However, both methods are economical and can dramatically improve the quality of the air in your shop—and your enjoyment of woodworking along with it.

Shop Ventilation

Probably the simplest way to reduce the amount of fine dust in your shop is to catch it while it's airborne and blow it outdoors. Shop ventilation works

by dilution, replacing dusty air with clean air from the outside. This low-tech method requires only a strong fan and a couple of open doors or windows, one as an intake outlet and one as an exhaust outlet. The idea is that the fan carries off airborne dust as it wafts around the shop and removes much of it before it has a chance to settle—or get breathed in. Fresh air enters the shop through an inlet located opposite the outlet, creating flow-through air movement.

Generally, you'd use shop ventilation only in conjunction with primary collection at the source, using a shop vacuum with portable power tools or a central dust-collection system to collect from stationary machines. But ventilation can serve as a primary means of capturing and expelling small amounts of fine dust—say, from hand-sanding or short



Cabinetmaker Cliff Friedlander uses a large squirrel-cage fan to exhaust fine sanding dust from his shop in temperate Santa Cruz, California. An open window across the shop allows fresh air to enter.



Roger Heitzman's clever shopmade ventilator, mounted in front of his shop's sliding door, uses a high-speed exhaust fan to blow dusty air out of the shop. The device swivels up and out of the way when not in use.

Get the Most from Your Fan

While a powerful fan moves a great volume of air, it has little power for capturing dust at its source. Therefore, move your dust source as close as possible to an exhaust fan used for shop ventilation. For example, to abate fine dust created during power sanding, set up a workstation next to a window or doorway and use a fan to suck the dusty air outdoors.

sessions of power sanding—albeit with limited effectiveness. Shop ventilation helps reduce the overspill from dust-spewing power tools, but tools should still be connected to dust collection whenever possible. For best protection, wear a respirator whenever you run power sanders.

FAN CAPACITY

The larger the air-moving capacity of the ventilation fan you use, the more dusty air that is exhausted. High-capacity fans (or blowers, as they're sometimes called) are rated for the volume of the air they remove, measured in cubic feet per minute (cfm). Santa Cruz woodworker Cliff Friedlander uses a large (2,500 cfm) squirrel-cage fan to exhaust fine dust from hardwood and MDF created during the process of building kitchen cabinets (see the photo on p. 55). You can buy a new squirrel-cage blower (see Sources of Supply on p. 195) or scavenge one from old air-conditioning equipment. Choose a fan that has enough cfm capacity to perform from six to eight air changes per hour, as described on p. 64. Another kind of high-volume fan useful for shop ventilation is a bladed exhaust fan, the kind used to move air through a spray booth. Furniture maker Roger Heitzman uses this kind of powerful fan, mounted in a special pivoting cabinet (see the photo at left), to draw fine dust from his shop. Just make sure that if you use this kind of high-volume fan—or any powerful fan—to ventilate a shop that contains a stove, water heater, or furnace, it's *imperative* to allow plenty of fresh air to replace the exhausted air. Otherwise, you'll create a downdraft that brings smoke and/or toxic fumes down the chimney or ventilation pipe and into the shop!

If you have a small (double garage-size) shop, you probably don't need a giant fan to get decent ventilation: A regular large box fan will do the trick. You can increase the efficiency of a box fan ventilation setup in two ways. One way is to tape cardboard baffles around the fan (see the photo at right on the facing page); the baffles help to direct the flow of air coming from the direction of the dust source and help the fan capture and carry away more particles. The other way to increase efficiency is to place a second fan behind your work area, to blow fresh air past you and aid the flow of dusty air toward the exhaust fan. Just about any fan will serve this function, but you'll get the best performance by using an air-circulation fan, as shown in the photo at left on the facing page. These compact fans are designed to move a good volume of air at high velocity (they are also useful inside the home to help spread cool or hot air from room to room). Just make sure to aim the fan so that its powerful blast won't blow fine dust off the bench or floor and around the shop.

FILTERING VENTILATED AIR

The relatively small amount of fine dust exhausted from your shop by a ventilation fan shouldn't pose a problem, as long as it's blown into an area large enough for it to disperse and settle harmlessly. But if your shop is



A household box fan with a furnace filter taped over its intake, set in an open doorway, provides an effective means of removing fine sanding dust from the shop. To improve ventilation performance, use a circulation-type fan to blow dusty air away from you and toward the box fan.

close to your home or a neighbor's house, you should do the environmentally friendly thing and filter most of the dust from the air leaving your shop. Fortunately, adding a filter isn't difficult or expensive. Simply mount a standard fiberglass-media furnace filter that's as big as the outer dimensions of your box fan (or inlet on your blower) to the intake side of the fan (I used tape to mount a filter to the box fan shown in the photo above right). You can buy these filters from your local hardware or building-supply store. The filter not only keeps dust particles from blowing outdoors but also helps keep the fan blades and motor from getting coated with dust.

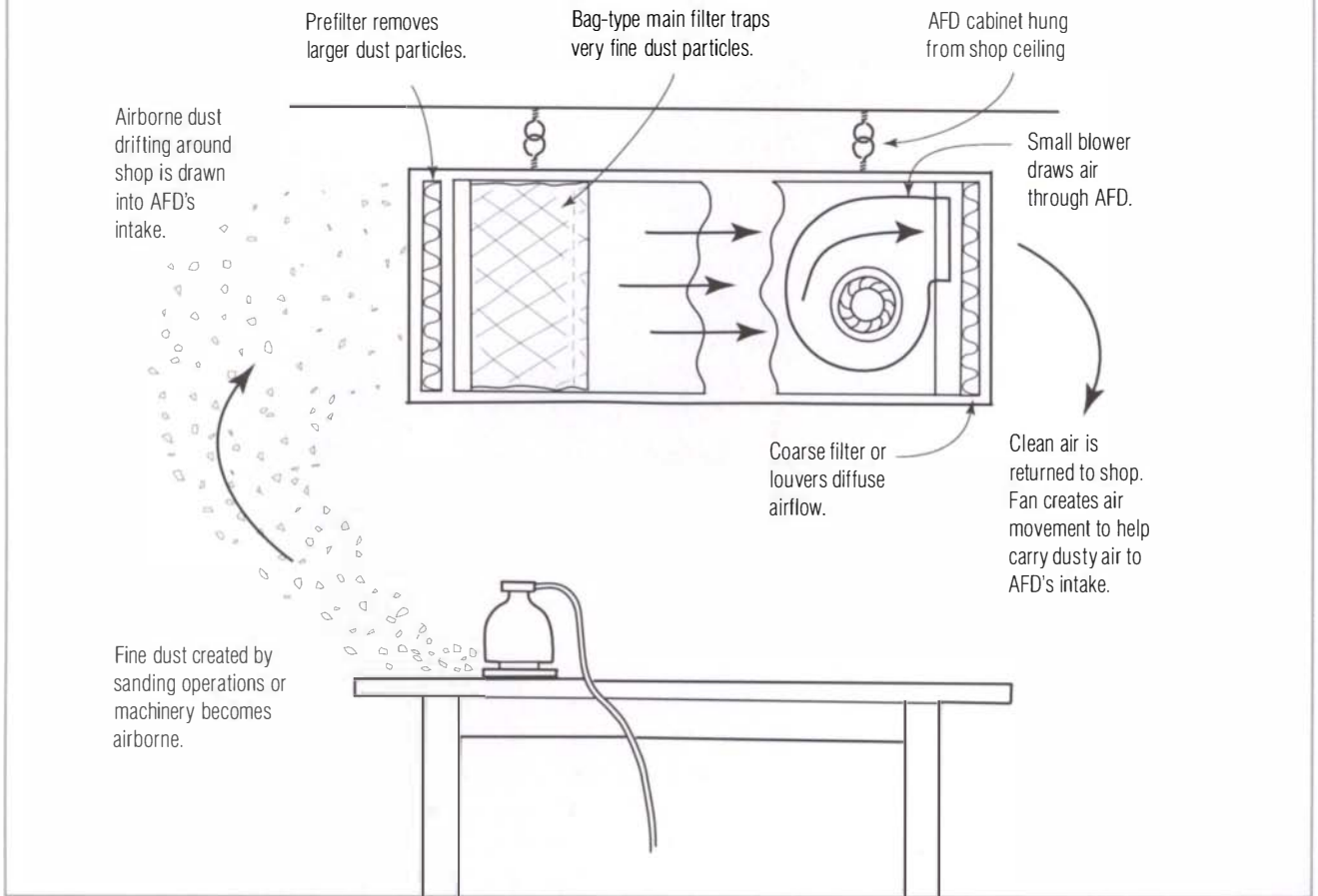
A fiberglass furnace filter, fitted over your shop's air inlet, keeps dust and airborne pollen from entering your shop. You can build a frame to hold the filter in place over the window or vent, or tape it in place. To extend the life of your ventilation filters, vacuum or blow them clean once in a while. Wear a respirator when you do, and replace the filters when they're heavily soiled or damaged.

Unfortunately, shop ventilation isn't a technique that's right for everyone. Unlike an air-filtration device (described in the next section), which circulates air inside a closed shop, simple ventilation displaces exhausted air with fresh air from outside. If you heat, cool, and/or dehumidify your shop air, blowing it outdoors is like throwing money out the window. (In some instances, you can cool a shop on a hot summer day by introducing fresh air from the shady side of your shop.) Generally, shop ventilation is a



To make shop ventilation more efficient when using a box fan, tape a three-sided cardboard baffle to the fan's frame. A furnace filter taped to the front of the fan traps dust and keeps the fan blades clean.

How an Air-Filtration Device Works



technique best suited to shops located in temperate climates or to be used during only the most temperate seasons of the year.

Air-Filtration Devices

Practically unheard of in small shops just a decade ago, air-filtration devices, also called powered air filters or air cleaners, have long been used in industrial facilities for cleaning all manner of particles out of the air. Air-filtration devices—I'll call them AFDs, for short—are compact devices designed to be installed near the ceiling, where they don't take up much room in a crowded shop. They operate by drawing dusty shop air through a series of filters and then returning clean air back into the shop, as illustrated in the drawing above. Because new air isn't introduced from outside, a heated shop stays warm and an air-conditioned shop stays cool. Ideally, an AFD exchanges all the air in the shop many times per hour, to keep free-floating dust in check.

Although the advertising for AFDs might tell you otherwise, air filtration is only intended to augment primary dust-collection systems, not replace them. Without a vacuum or central system to catch the lion's share of chips and dust at the source, most AFDs won't be able to keep up with dust production, and you'll end up breathing unacceptably high levels of fine dust before it's filtered out of the air. You're also likely to overwork the AFD by overloading its filters and thus diminish its air-moving capacity. But by using good primary collection, choosing the right air-filtration device, and locating it properly in your shop (both discussed later in this chapter), you'll effectively remove a great deal of the airborne dust that usually eludes capture. If you run a commercial shop, air filtration provides a great way to improve the quality of shop air, to meet OSHA regulations for maximum levels of dust permitted in the workplace.

AFD ANATOMY

An air-filtration device has three main components: a cabinet-style housing, a set of filters, and a fan. The cabinet, typically made from thin sheet metal, is sturdy enough to allow the unit to hang from ceiling joists or brackets. The cabinet also houses the AFD's filters and provides some means of removing them for replacement, as shown in the photo below. Air exhausted through the back of the cabinet is diffused by either a fiberglass-media filter or a louvered outlet (see the top photo on p. 60).

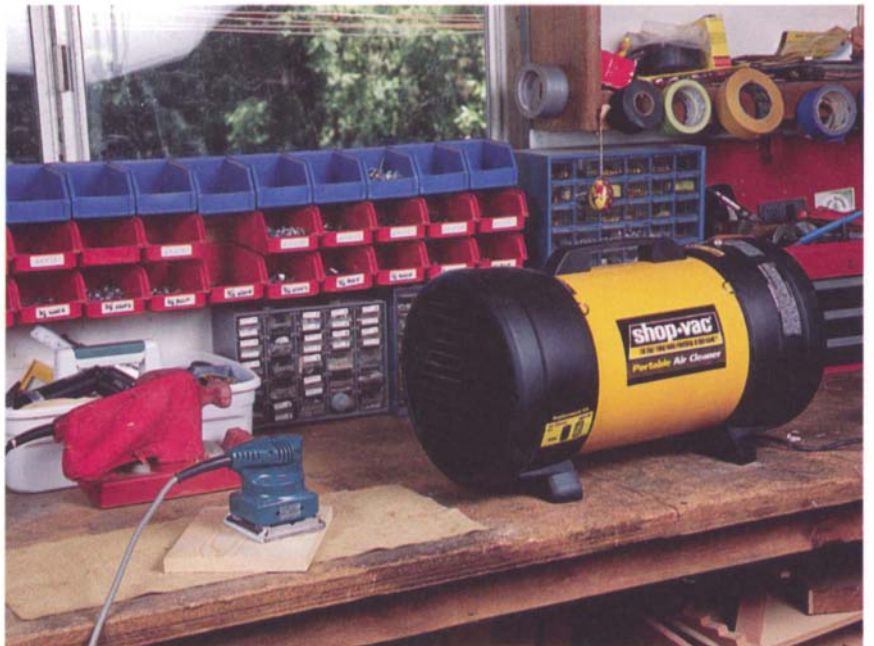
Most AFDs use squirrel-cage blower fans powered by a small electric motor between $\frac{1}{5}$ hp and $\frac{1}{4}$ hp. These motors are rated for continuous duty and designed to run all day, if need be. The fan and motor are largely shel-



To make cleaning and replacement easier, most air-filtration devices house their prefilters in a slide-in compartment on the front of the unit. The JDS Air-Tech 2000™ model 8-12 shown here also has a side door that allows easy access to the unit's bag-type main filter.



A few short lengths of colorful ribbon tied to the exhaust grill of an air-filtration device provide a simple way of gauging the airflow through the unit. When the ribbons sag and flutter less aggressively, it's a sign that airflow is restricted and the filters need cleaning or replacement.



Dust spewed from portable power tools that lack dust bags or hoses can be difficult to control. One solution when creating small amounts of dust, as with a $\frac{1}{4}$ -sheet orbital sander, is to work close to a benchtop air-filtration device, such as the Shop-Vac Portable Air Cleaner shown here.

tered from dust because they are mounted downstream of the unit's filters. Some units, such as the Penn State Industries AC930, Jet® AFS-1000, and JDS Air-Tech 2000 model 10-16, come with two- or three-speed motors that let you set the performance of the unit to suit the amount of dust in the air. This feature is useful if the amount of dust-raising work you do varies from light hand-sanding to running power-sanding machines, which churn up voluminous clouds of dust.

If you're a hobbyist who produces only small puffs of dust at a time—say, using small, powered abrasive tools that are hard to collect from, such as a Dremel® tool or die grinder—consider getting a benchtop AFD, such as the Penn State DC720 or Shop-Vac Portable Air Cleaner, shown in the bottom photo on the facing page. These compact units don't take up much space and store conveniently when not in use. Benchtop AFDs are also handy if you occasionally do a little hand-sanding on the living room coffee table while watching television. The Shop-Vac AFD also comes with straps for mounting it more permanently in the workshop.

TWO-STAGE FILTRATION

AFDs snag dust particles in either of two stages: first with a prefilter and then with a main filter. The prefilter is a regular spun-fiberglass, polyester-mesh, or pleated-fiber furnace filter. This first stage of filtration takes the brunt of the dust load, trapping the larger dust particles ahead of the more expensive main filter. The main filter's task is to capture the finer, lung-damaging fine dust; it should efficiently remove particles down to at least 3 μ m. Main filters are usually the bag type (one is shown in the photo on p. 59), although inexpensive AFDs are sometimes fitted with less expensive, extended-surface, pleated-style main filters. A bag filter's multiple-compartment design gives it lots of surface area relative to its height and width, thus allowing it to trap a lot of dust while keeping the filter's airflow resistance low. This lets the fan's motor work more easily and increases the volume of air moving through the AFD.

Filter efficiency How efficient is an AFD filter at trapping dust particles? All filters are rated for efficiency by detailed and complex testing procedures specified by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Filtration manufacturers employ independent testing laboratories to perform the ASHRAE tests to evaluate the efficiency of their filters and AFD units. The test most commonly employed is the dust-spot efficiency test, which gives a good indication of the amount of particulate matter a filter is able to capture. The test results are interpolated into an overall efficiency rating for that filter. Filters commonly used for AFD main filters have efficiency ratings of 45 percent, 65 percent, 85 percent, or 95 percent.

As with motor horsepower ratings, understanding how well any given filter performs is more complex than a single efficiency number can

The Right Filter Efficiency for an AFD

Air-filtration specialists recommend that woodworkers use an AFD with a filter efficiency of either 65 percent or 85 percent to abate respirable wood dust. If you are particularly sensitive to dust or prone to allergies, 95 percent filtration efficiency is recommended (some manufacturers offer a 95 percent main filter as an option). A 95 percent filter is efficient enough to cleanse the air of spores, mold, and dust-borne bacteria as well.

explain. Any filter's efficiency is different for different-size particles. For example, even a relatively low-efficiency 45 percent filter is capable of removing 90 percent of the particles that are 5 μ m and larger. By contrast, a 65 percent filter will remove 90 percent of the particles down to 1 μ m, and a 95 percent filter will scrub out an impressive 99 percent of particles down to 1 μ m from the air passing through it. Also remember that a filter's ability to trap small particles goes up as the filter becomes dirty, since the particles act as a sort of filter media themselves (see p. 42).

While even a 15 percent filter is 100 percent efficient at trapping particles the size of golf balls, it is a filter's ability to capture respirable dust (particles that are smaller than 10 μ m) that is of greatest interest to woodworkers. Manufacturers find it to their advantage to publish higher efficiency numbers when promoting their units, so be sure to check their claims carefully when evaluating an AFD's fine dust-filtering abilities.

It seems logical that the two filters in an AFD (the prefilter and the main filter) would work in tandem for better overall particle capture. However, the filtering efficiency is primarily a function of an AFD's main filter. The prefilter is primarily used for economy since it is cheaper to replace than the more costly main filter.

Optional filters If your shop produces lots of very fine dust—say, from running large stationary abrasive machines (stroke sanders, drum sanders, etc.) or from power carving with abrasives—you might opt to fit your AFD with an electrostatic prefilter. Although it is much more expensive than a regular furnace-type filter, you can wash an electrostatic filter and reuse it many times.

In spite of their name, electrostatic filters do not use electricity; rather, they are composed of electrostatically charged fibers contained in multiple layers. These layers have different ionic charges that attract dust particles in much the same way that balloons are attracted to a statically charged wool sweater. An electrostatic filter has a negative charge that neutralizes the charge in the dust so it falls out of the airstream and into the filter media. An electrostatic filter is also great for filtering out the smoke that's occasionally generated by overheated cutting tools. Despite their high efficiency, these filters must not be used in shops where large amounts of solvent-based finishes are applied (it's possible for dust particles to bridge the filter layers and trigger a spark that could cause a fire).

Some manufacturers offer an optional charcoal filter for their AFDs. Charcoal is a blessing if you occasionally work with odiferous materials, such as pungent woods, finishes, and adhesives. These optional filters will reduce most odors, as well as abate fumes and smoke. As with organic-vapor cartridges (see p. 46), the activated charcoal in these filters doesn't filter fine dust well. Therefore, you'll get the best performance by mounting a charcoal filter in place of the diffusion filter (found in most AFDs). Since the activated charcoal continues to work even when the filter is not in use, keep the filter in a sealed plastic bag between uses. However, don't

ever try to use a charcoal filter-fitted AFD—or any AFD—to filter the exhaust air from a spray-finishing booth if you use solvent-based finishes; the motors in these units are not explosion proof!

Filter cleaning and replacement Most prefilters and main filters can be vacuumed occasionally (on the side that faces away from the fan) to prolong their useful life (see the photo below). You can also clean a filter by blowing air through it from the exhaust side (the side of the filter that faces the fan). But work carefully to prevent the jet of high-pressure air from ripping holes in the delicate filter media.

All filters must be replaced once they're clogged to the point that the air flowing through them is restricted by about 50 percent. How can you tell when a filter is clogged to that degree? Expensive industrial AFDs keep tabs on airflow with a special pressure gauge (see pp. 112–113). A less accurate but inexpensive approach is to make your own airflow gauge (see the sidebar below). You can also do a quick filter check, hold the filter a few feet from a 75-watt or 100-watt lightbulb; replace the filter when it's hard to see light through it (the embedded dust particles reduce its translucence).

Don't be surprised by the cost of replacement filters for your AFD; ideally, you should check the price before buying a new unit. Prices can vary from about \$25, for a set of pre- and main filters for a small unit, to over \$100, for some of the larger industrial-duty AFDs. One way to save money is to buy replacements from your local heating, ventilating, and air-conditioning (HVAC) supply store. They're usually a lot cheaper than stock replacements from the manufacturer. Just make sure that the filters



To prolong an AFD prefilter's life, vacuum it clean when it has become coated with dust. The vacuum's brush tool allows thorough cleaning without damaging the filter.

A Simple Airflow Gauge

A practical, low-tech way of gauging an AFD's airflow is with a few pieces of ribbon tied to the exhaust end of the unit. When the filters are new, the ribbons fly straight out and flap vigorously in the rushing air (see the top photo on p. 60). Check the ribbons every once in a while, and replace the filters when the ribbons droop down or flap with about half of their original vigor.

FORMULA FOR SIZING AN AIR-FILTRATION DEVICE TO YOUR SHOP

Cubic-foot volume of shop (length x width x height [in feet])	X	Number of recommended air changes per hour (6 [hobby use] or 8 [full-time use])	=	Cubic feet per minute (cfm)
				air-movement capacity of air- filtration device
60				
(Division necessary to convert cubic feet per hour into cubic feet per minute ([cfm]))				

you buy are exactly the same type and size (frame dimensions and thickness) as the originals. More important, the new filters should be at least as good (ASHRAE-rated for the same degree of efficiency) as your AFD's stock filters. If you substitute cheaper filters—say, a pleated furnace filter for a bag-type main filter—you'll degrade the AFD's dust-capturing efficiency significantly. Conversely, you can improve the dust-grabbing performance of an AFD by replacing low-efficiency original filters with more expensive, higher-efficiency filters. When in doubt about filter substitutions, consult the manufacturer of your AFD for advice.

SIZING AN AFD FOR YOUR SHOP

To do the best job of filtering fine dust from your shop, you must choose an air-filtration device to suit the size of your shop. Like dust collectors, AFDs are sized by the amount of air that they move through them, measured in cubic feet per minute (cfm). The idea is to select an AFD large enough to make six to eight air changes per hour—the range recommended for typical woodshop conditions. This means moving the entire volume of air contained in the shop through the unit the specified number of times per hour. Why so often? First, the AFD needs to pick up any new dust that is created in the woodshop between air changes. Second, because AFD filters aren't 100 percent efficient, they don't catch all the particles flowing through them in one pass. Typically, air must pass through the filters several times before most fine particles are captured.

To figure out how large an AFD you'll need for your shop, start by performing a few calculations (summarized in the formula above). First, compute the total volume of your shop in cubic feet by multiplying its length, width, and height. If the shop's ceiling is taller than 12 ft., use 12 as the height. If the layout of the shop is L-shaped or divided into sections, compute the overall volume by adding up the volume of the individual sections. Next, multiply the total shop cubic footage by the number of air changes per hour the unit is to accomplish. If you're a hobbyist or weekend woodworker, multiply by 6; if you run a full-time business or production shop, multiply by 8. The result reflects the total volume of air that the AFD needs to move in an hour. But since AFDs are rated in cubic feet per minute, divide this number by 60 to get the correct cfm rating.

For example, a shop that's 20 ft. long by 16 ft. wide with a 9-ft. ceiling has a volume of 2,880 cu. ft. Multiplying that figure by 8 air changes an hour yields 23,040 cu. ft., which divided by 60 shows that you'd need an AFD that's rated for at least 384 cfm.

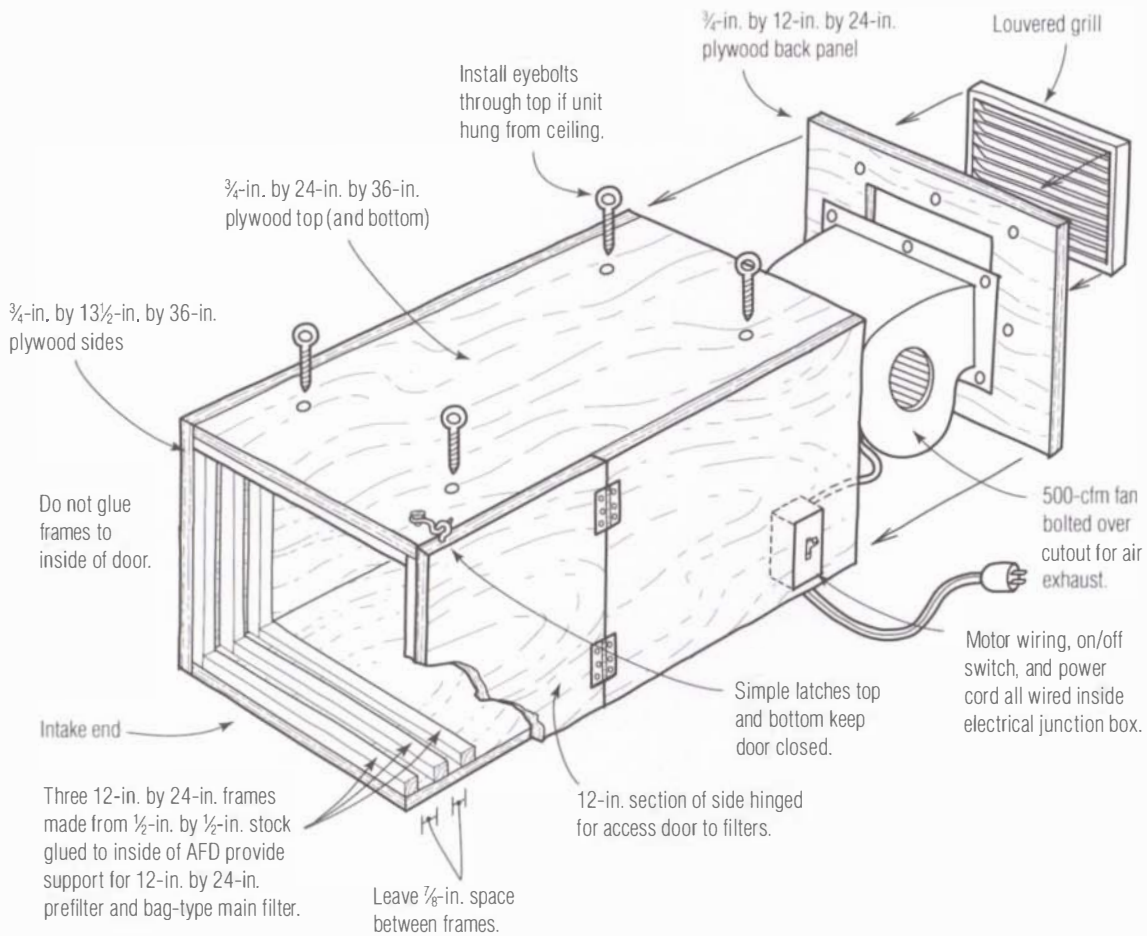
I use the phrase "at least" in this example because an AFD's cfm rating (as stated in the manufacturer's literature) typically indicates the amount of free air the unit moves: in other words, the quantity of air passing through a unit sans filters. A working unit draws air through two (or more) filters that restrict airflow, hence filtered cfm averages between 63 percent and 91 percent of free-air cfm. Furthermore, a dirty filter is more restrictive than a clean one, so the cfm performance of a well-used AFD is even lower. If you want to be sure that an air-filtration unit will fulfill your needs, select a model that offers 25 percent to 35 percent more free-air cfm than the actual airflow you need for your shop as calculated using the formula.

Two can be better than one If you have a large shop (say, over 7,500 cu. ft.), don't be surprised if your calculations reveal the need for a really big air-filtration device, one with a cfm of 1,000 or more. While there are quite a few AFDs on the market that can handle that kind of airflow, you'll get better performance by using two units instead of one. Industry experts often recommend using two or more small AFDs in large shops because it's easier to locate them closer to different sources of airborne dust—say, one near the workbench where hand-sanding is done and another near stationary sanding equipment. By mounting AFDs strategically, you can shorten the distance that dust-laden air travels before it's inducted. Better yet, multiple AFDs can be arranged to work together to increase air movement: The exhaust from one strategically placed unit will actually boost the intake of another unit, thus improving air circulation as well as dust capture (see the drawing on p. 69). Multiple units also yield better airflow in irregularly shaped shops, where it's more difficult to keep air circulating (see p. 70).

BUILDING YOUR OWN DEVICE

The basic design for an air-filtration device—a fan and some filters in a box—is so simple that many small-woodshop owners opt to save a little money and build their own units. More power to them. But while you can get away with mounting a scavenged attic-exhaust fan and a cheap furnace filter in an old orange crate, you'll get much better performance if you choose components carefully and follow a few basic guidelines. The drawing on p. 66 shows a simple AFD designed to handle light-to-moderate dust production in a small shop—say, up to the size of a two-car garage. If you're inventive and don't mind doing a little experimenting, you can modify these plans and build a larger unit to suit your needs.

Shop-Built Air-Filtration Device



The cabinet for the shopmade AFD is constructed from six pieces of 3/4-in. plywood, cut to the dimensions shown, and glued and screwed together. Three frames, made from 1/2-in. by 1/2-in. strips, create a pair of slots that house the unit's filters. A small hinged door on the side of the unit provides access to the filters for cleaning and replacement. The fan is mounted to the inside back of the cabinet over the rectangular cutout for the exhaust. A louvered grill (available from a hardware or home-supply store) fastened over the exhaust opening keeps debris and fingers out of the fan and allows you to direct the air exhaust to encourage air circulation. Eyebolts, fastened through the top of the cabinet, provide mounting anchors for hanging the unit from the ceiling (see p. 70).



You can save money by building your own air-filtration device. Furniture builder Roger Heitzman made this unit by mounting a squirrel-cage fan and a set of filters in a cabinet he crafted from plywood. The unit's hinged side makes filter replacement easy.



The heart of a shop-built air-filtration device is a small squirrel-cage fan, which is easier to mount before assembling the cabinet. The device uses a furnace-type fiberglass prefilter and a bag-type main filter (shown on the bench to the right).

To afford reasonably good filtration, the shopmade AFD has two filters, each 12 in. by 24 in. by 1 in. in size: a fiberglass-media furnace filter for the prefilter and a 90 percent to 95 percent efficiency bag-type filter as a main filter, which must be specially ordered (see Sources of Supply on p. 195).

Wiring a Shopmade AFD Timer

If you wire a shopmade AFD with a nonmetallic sheathed cable (such as Romex), make all connections inside an electrical junction box. If you opt to control your AFD from a timer switch (as described on p. 71), you can run a line for the fan directly to the timer, which will turn the unit on and off. If the AFD is within reach, you can install a single-pole, single-throw on/off switch (rated to handle the amperage and voltage of the fan's motor) in a junction box mounted on the side or bottom of the cabinet.

While just about any fan that's capable of moving 500 free-air cfm can be used as an air mover, a small squirrel-cage blower (W. W. Grainger item 4C445) is a good choice; a blower with a mounting flange on the outlet makes it easy to mount the unit to the cabinet. It's easier to bolt the fan to the plywood rear panel before assembling the cabinet, using lock washers to prevent fan vibration from loosening anything (see the bottom photo on p. 67). If you decide to use another size or type of fan, make sure that the cfm capacity of the fan suits your air-filtering needs, as outlined in the previous section.

INSTALLING AN AFD

An air-filtration device stands the best chance of removing the greatest percentage of dust from the air if most of the air in your shop is circulating through it. Unfortunately, most shops are square or rectangular, with corners where air is apt to stagnate and allow the dust to settle (only to become airborne again when disturbed). But judicious installation encourages good air circulation to and from an AFD and minimizes air-stagnation problems.

A couple of general rules about the placement of an air-filtration device apply to nearly all woodshops. First, locate the AFD between 8 ft. and 10 ft. off the floor (no lower than 6 ft.). If you have a shop with low ceilings (8 ft. or under), mount the unit to the ceiling or no lower than two-thirds up from the floor. If your shop has high ceilings, don't mount the unit higher than 10 ft. or 12 ft. up. Fine dust created at ground level doesn't circulate much above 12 ft., and higher mounting reduces filtering performance—as well as making access to the AFD for servicing more difficult and precarious.

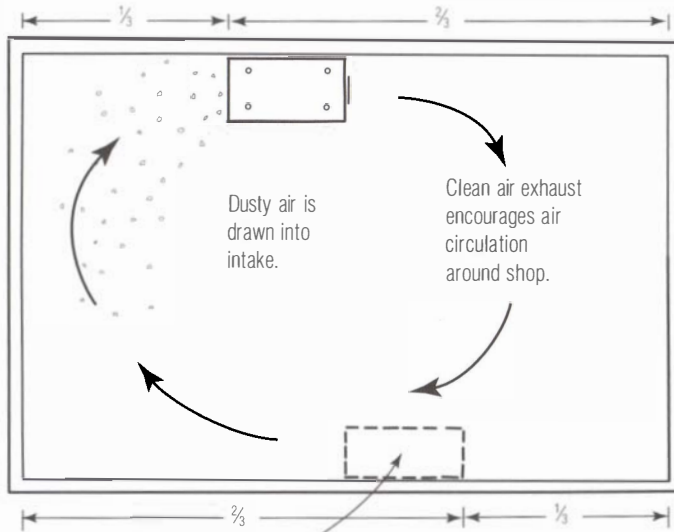
In a rectangular shop, locate the AFD along one of the longer walls, orienting the unit's intake (the end that draws in air) approximately one-third of the way from the end wall (see the drawing on the facing page). The suction produced by an AFD isn't strong enough by itself to pull dusty air from a great distance. This arrangement tends to enhance air movement toward the unit's intake by using the more powerful stream of air exhausted from the fan to create a circular airflow around the shop. Even if you can't position the unit ideally, locating it close to a wall creates better air circulation than hanging it in the middle of the shop.

If your AFD has adjustable exhaust louvers, set them where they will best encourage air circulation around the room. If your shop has forced-air heating or air-conditioning, make sure that the air exhaust from those units doesn't run counter to the flow of exhausted air from the AFD.

If you're not sure how well air is circulating to and from an AFD, check the airflow by observing how well smoke circulates around the shop. You can use a lit cigarette or a few sticks of incense, but you'll get a better supply of smoke from a smoke stick (available from Lab Safety Supply; see

Locating an Air-Filtration Device in a Rectangular Shop

Locate AFD on long wall, with intake one-third distance from short wall.



Dusty air is drawn into intake.

Clean air exhaust encourages air circulation around shop.

If second AFD is used, locate on opposite wall with intake one-third distance from short wall.



You can test to see how well shop air is circulating to and from an air-filtration device by lighting a smoke stick and observing the movement of smoke around the shop.

Sources of Supply on p. 195), as shown in the photo on p. 69. Turn on the AFD, hold the smoke source up to the exhaust end, and observe the movement of the smoke. It should continue moving around the shop and eventually move toward the AFD's intake. Also try holding the smoke source at the end of the shop nearest the AFD's intake. Smoke should move toward the unit, albeit slowly. If stationary-smoke haze reveals dead air zones, relocate the AFD, readjust its grill louvers, or use a circulation fan to bolster air movement, as described next.

If you're using only one AFD in your shop and are generating fine sanding dust in a location that's far from the unit, you can enhance the unit's dust-gathering performance by employing an air-circulation fan. Place the fan close to the dust source and point it in such a way as to blow the dusty air toward the AFD, just as you would to bolster shop ventilation (see the photo at left on p. 57). It's best to work in a spot where the fan is between you and the AFD. Avoid locating yourself between the fan and the AFD, as this draws dusty air toward you (where you're likely to breathe it in) rather than away from you.

AFDs in large and irregular shops In large rectangular shops, you can improve filtering capacity and air circulation by placing two air cleaners on opposite long walls; each unit needs to produce only half the overall cfm necessary (see p. 65). As with a single unit, locate the intake of each



Spring-loaded safety hooks and eyebolts provide a secure means of attaching an air-filtration device to the ceiling of your shop yet allow it to be taken down for convenient cleaning or servicing.

AFD one-third the distance to the short wall, as shown in the drawing on p. 69. Two or more AFDs also work better in extra-long and narrow shops (so-called “shotgun” shops), irregularly shaped spaces (with L-shaped or T-shaped layouts), and shops broken up by dividing partitions. The best air circulation in these situations is achieved by mounting AFDs in strategic locations—such as at corners where divided spaces meet—and using small circulation fans to encourage air movement through stagnant air zones.

Mounting an AFD Because the ideal location for an AFD in most shops is near a wall, the easiest way to mount a unit is to place it atop a shelf or on brackets fastened to a side wall. To deaden fan noise amplified by placement on a thin wood or metal shelf, set the AFD on rubber pads or furniture cups placed at the corners. Bolt or tie the unit down so it won’t vibrate or get knocked off accidentally.

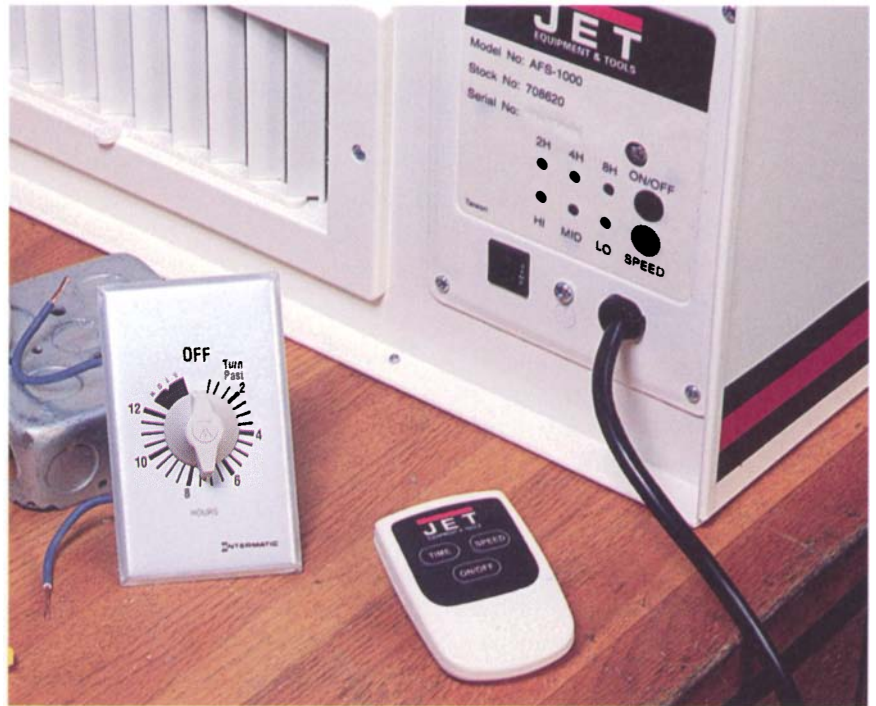
If you wish to hang an AFD from the ceiling, most units have holes in their cabinets for eyebolts. For safe mounting, drive heavy-duty eyescrews into ceiling joists, and hang the AFD’s eyebolts from the joists with spring-loaded safety hooks (see the photo on the facing page). Unlike open hooks, safety hooks must be manually snapped open before the unit can be taken down. Make sure the unit isn’t hanging low enough to smash into; the sharp-edged metal cabinets found on most units could render a nasty gash. Since most AFDs are fairly heavy (typically between 40 lb. and 85 lb.), place the unit on a stack of boxes during installation, rather than supporting it precariously while connecting the safety hooks. Your vertebrae will thank you for it.

WHEN TO RUN AN AFD

Air-filtration devices are so effective at collecting the fine dust that escapes primary collection, you’ll definitely notice a difference if you leave the AFD running during and after working; you won’t see that fine coating of dust all over your machine tables and benchtops. And if your shop is in your garage or basement, your family won’t be dusting the furniture nearly as often (it’s amazing how readily extra-fine dust particles penetrate fine cracks and under doors to travel around the house).

You should run an AFD whenever you are operating machinery for more than a few minutes and when you’re using portable power tools, such as routers and sabersaws. All these bladed and bitted tools generate fine dust along with larger chips. Always run your AFD during power sanding, which is the greatest source of fine dust in a woodshop. Even if your portable sander has built-in collection, most sanders spit out dust faster than a bag or shop vacuum can capture it.

If you sand close to the end of the workday, you’ll abate most of the floating dust by letting your AFD work overtime. Since it takes quite a bit of time for an air-filtration device to filter all the air in a shop thoroughly,



It can take many hours for an air-filtration device to capture all the fine dust wafting around the shop. An electric timer, either built into the air-filtration device itself or installed in the electrical box that provides power to the device, allows you to run the AFD for a specified number of hours after you leave the shop.

let the unit run for an hour or two after you've stopped working. To avoid the inconvenience of turning the unit off (or the cost of running it overnight), control it with a timer. You can buy a spring-wound timer with a capacity of up to 12 hr. (available from W. W. Grainger) and a hold feature, which allows you to turn the unit on manually for as long as you like. Mount the timer in an electrical box, just like a regular light switch, with the power line from the AFD connected directly to the timer. Locating the timer near your shop's front door makes it easy to remember to set it for timed operation when you're ready to call it a day.

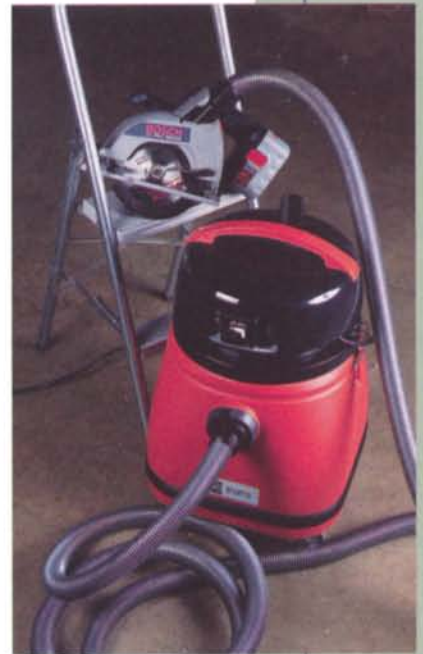
Portable Dust-Collection Devices

Small, portable vacuums are the poor man's dust collectors. They are relatively inexpensive, versatile, and don't take up much space in shops that must share valuable real estate with machinery and perhaps the family automobile. The smallest of the small, portable handheld units make quick work of dirty benchtops and perform double duty by cleaning up household spills or vacuuming sand from the trunk of your car. Canister-style shop vacuums are terrific for all kinds of shop pickup chores, from collecting dust from portable power tools and small stationary machines to sweeping floors without raising a cloud of fine dust, as a broom does. And, if you need more sawdust-sucking power, you can buy a larger portable collector that will handle some full-size jobs, like keeping a table saw's sawdust output under control.

In spite of the straightforward nature of these simple suction devices, there are more than a few tricks for getting the most out of them, including a slew of devices and methods for making them quieter to use and easier to empty, as well as for expanding their abilities and chip-holding capacity. Some of these devices are available commercially; others you can build yourself.

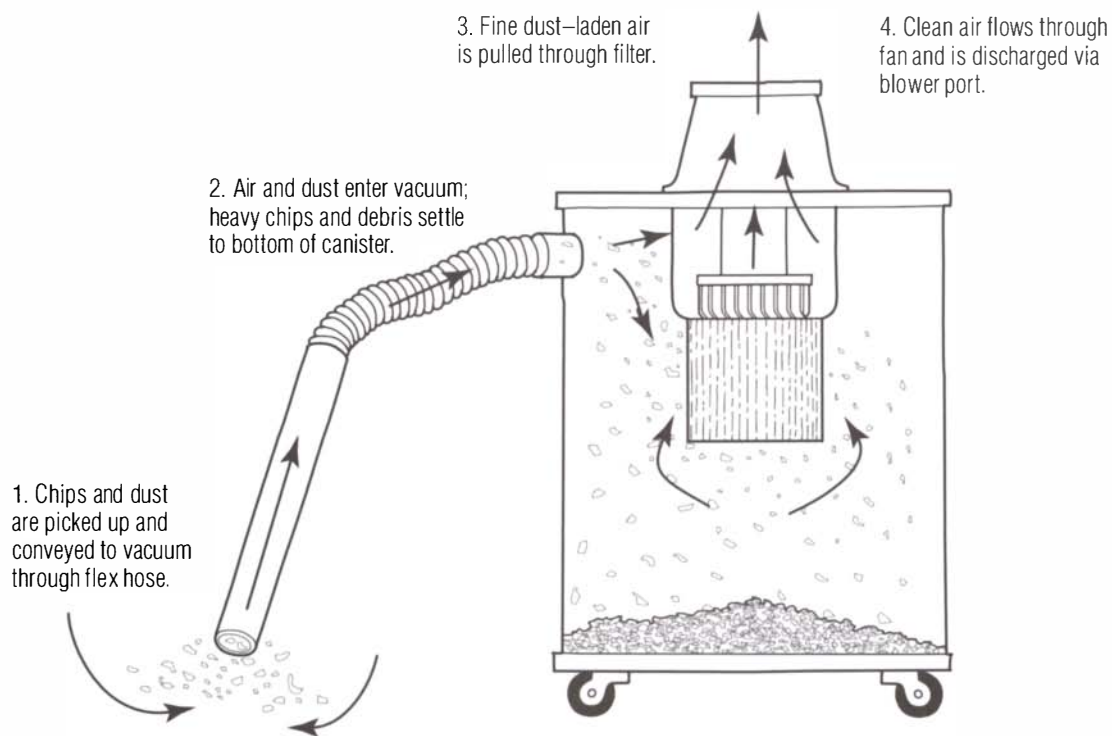
Shop Vacuums

Shop vacuums are much like their household counterparts but with a few important differences. A shop vacuum, often informally referred to as a "shop vac" (Shop-Vac is a trademarked brand name), has a larger



A canister-style shop vacuum is a champ at keeping a small shop clean—from collecting chips from portable power tools to cleaning up benchtops and floors.

Two-Stage Shop Vacuum



capacity and a more powerful motor than most canister-style household vacuum cleaners. More important for workshop cleanup, practically all shop vacuums work just like two-stage central dust collectors. “Two stage” means that large chips and shavings are deposited in the canister before the air passes through the filter, as shown in the drawing above. No debris passes through the vacuum’s fan, where a sucked-up chip or stray nail could wreak havoc. (See the discussion of single-stage vs. two-stage systems on p. 98.)

A shop vacuum’s light weight and compact size make it portable enough to excel at shop cleanup time. Most units come with wheels built into the bottom of their canister, or they have a cart or wheeled assembly mounted to the bottom or side of the unit. Portability is a big part of a shop vacuum’s usefulness, so if you plan to cart the unit around the shop a lot, check the size and quality of the wheels before you buy it. Cheap, hard plastic wheels on pressed-metal swivels can wear out quickly. If your shop floor has an irregular surface, these small-diameter wheels can jam into crevices or hang up on bumps and upset the canister. Some models, such as the Milwaukee® 8911 and the Bosch Airsweep™, have large rear

wheels and a pushcart handle, making them stable and easy to scoot around any floor.

As handy as shop vacuums are for shop cleanup and for collecting dust from portable power tools, they can't take the place of more powerful portable or central collectors, which produce the larger volume of air needed to collect chips and sawdust from shop machinery. While a shop vacuum produces an impressive amount of suction, thanks to a high-pressure airflow created by the high-rpm fan powered by its universal motor, the volume of air that's conveyed is low. (To understand better how air velocity and volume work together to carry dust and chips, see the sidebar on p. 95.) Low air volume, coupled with small-diameter hoses, means that shop vacuums are usually not up to handling the large quantities of chips and shavings produced by full-size woodworking machines. Also, shop vacuums typically create a tremendous amount of noise, although you can abate this by using methods discussed later in this chapter.

If your expectations are modest, you might be able to get away with using a shop vacuum to collect from a single small machine, such as a table saw, radial-arm saw, or router table. But a thickness planer is usually a different story. The heavy shavings take more suction to remove than most shop vacuums can generate. Even if the vacuum works reasonably well, its small canister will probably fill up after planing just a few boards. If your budget and space dictate that a shop vacuum is the only collector available, fit the planer with a good dust hood (see chapter 9), keep the hose short, and take light cuts to generate fewer chips.

POWER AND CAPACITY

As is the case with sports cars and power tools, the horsepower output of a shop vacuum is often much less than the figure advertised by the manufacturer or dealer. The confusion stems from the power-rating scale that's used to measure a vacuum's suction power. The "peak horsepower" figure that's often quoted represents the absolute maximum power a unit can produce, albeit, in some cases, for only a few seconds before the motor burns up.

A vacuum's motor-amp rating provides a slightly better gauge with which to compare different models: A shop vacuum with an 11-amp motor is undoubtedly stronger than one with a 6.5-amp motor. Unfortunately, for closer comparisons between units that have very similar-size motors, amp ratings don't tell you how efficiently the unit translates motor power into suction performance. Fan and air-system design, housing configuration, bearing quality, hose size, and filter type all conspire to make some vacuums perform better than others. These factors also affect qualities that are subjectively important to the user, such as the vacuum's noise output and service life.

The single best indicator of a vacuum's performance is the static pressure it's capable of generating. Static pressure, typically stated in "static

Collecting Small Parts

Sawdust-Only Diet for Shop Vacuums

One trick I use to suppress my vacuum's hunger is to stretch a small piece of ¼-in. wire mesh called "hardware cloth" (available at a good hardware-supply store) over the end of the hose (see the photo below). A rubber band or duct tape holds the wire mesh in place. You can use even finer mesh as needed—say, to prevent the accidental pickup of small screws or other hardware. It beats scrounging through a dusty canister searching for missing tools.



Stretching a piece of wire mesh over the end of a vacuum hose prevents it from accidentally sucking up small tools and hardware.

LEST YOU THINK YOUR SHOP VACUUM is only good for collecting sawdust, it can also provide a simple and foolproof solution to a common wood-working problem: cutting off small parts on a table saw or compound miter saw. For example, when cutting small blocks (like ABC blocks for a child), the "good" part is a small cutoff from a longer piece of stock. The problem is that these small parts are easily grabbed by the sawblade and chewed up or thrown violently across the shop. To remedy this, set up a shop vacuum to suck up these small parts as they're cut.

Start by cleaning out your shop vacuum so you won't have to pick the good parts out of a canister full of dust and debris. Remove the disposable bag, if need be. Then, temporarily clamp the vacuum hose with the open end near the point on the saw where each part will be sawn off (see the photo below). Now turn the vacuum on and take a trial cut. If parts aren't pulled away fast enough before the sawblade grabs them, try repositioning the end of the hose closer to the blade or fitting it with a smaller-diameter nozzle to increase the velocity of the airflow.

Not only does this technique make it safer to cut small parts such as wooden plugs, short dowels, and loose tenons, but it also virtually guarantees that you'll have fewer rejected parts (due to the sawblade's nipping). And all the small parts end up in the vacuum's tub, where they won't get lost and are easy to gather. Just don't try this trick with a single-stage dust collector (where all the air and debris pass through the blower en route to the filter bag); if you do, you'll hear some horrible noise as the parts are shredded as they hit the fan.



You can use a shop vacuum to suck up small workpieces, such as the short round slices shown here, before they are snagged by the blade and chewed up or thrown. Here, the vacuum hose connects to a Veritas® Magnetic Dust Chute, which adheres to the saw's cast-iron top.

inches of water lift,” is a measure of how high the vacuum draws water in a vertical tube against the force of gravity. Generally, the more inches of water a vacuum can draw, the better the sawdust-sucking performance it delivers. (This is only a test; not all vacs are designed to suck up water!) A top-performing shop vacuum may be capable of drawing more than 70 in. of water—at least half as much again as competing models with similar-size motors. While few manufacturers rate their units this way, you can compare test results for static pressure for more than a dozen popular shop vacuums in a product-test article in the April 1995 issue of *Wood* magazine.

Hose size Besides power ratings, another important factor that determines how well a shop vacuum picks up wood debris is hose diameter. The larger the hose, the greater the physical capacity the vacuum will have for picking up large chips, shavings, and even small cutoffs. For general shop cleanup or to collect chips from a jointer or table saw, you’ll want a vacuum with a 2½-in.-dia. hose. The 2½-in. hoses, which come standard on only about half of the models currently on the market, are fairly crush resistant, but they aren’t durable since they’re typically made of thin, easy-to-puncture vinyl wrapped around a spiral wire. If you need greater durability, you can fit your vacuum with an industrial flexible hose made of polyvinyl chloride (PVC) or polyester neoprene, as described on p. 158.

One downside of a 2½-in. hose is that its maw is big enough to suck things off benchtops and machine tables that you don’t want to dispose of, such as small parts, tools, and small pets. The large opening does, however, make them good for collecting cutoffs or small parts, as described in the sidebar on the facing page.

The smaller-diameter hoses—1 in., 1¼ in., and 1½ in.—that come standard on many shop vacuums (including the Porter-Cable® 7810, the Fein® model 9-55-13, and Festool® SR201 E-AS) generally create high air velocities, which make these units good for capturing small chips and fine sawdust. These smaller hoses are also more flexible and less cumbersome than 2½-in. hoses, so they’re great for collecting dust from belt sanders, routers, and other portable power tools (see p. 78). Don’t use them for collecting large debris, however, because small hoses clog easily. You can buy a larger-diameter hose as an optional accessory with some models. If not, you can jury-rig a 2½-in. hose to practically any shop vacuum, even if the maker doesn’t offer one.

One of the unpleasant side effects of having a plastic hose with dust moving through it at a high velocity in a dry environment is that it creates static electricity, which can result in some nasty shocks to the user. If your vacuum’s hose has an exposed wire helix inside, try running a ground wire from the spiraling wire to the motor housing or frame of the vacuum. (This remedy probably won’t work if the wire helix is sandwiched between layers of hose material.) If the vacuum’s motor isn’t grounded (it

Empty Your Shop Vacuum Less Often

You can increase the sawdust-holding capacity of most shop vacuums by substituting a large fiber or metal drum or trash can for the stock canister. If you can't find a can or drum that fits, cut an adapter ring from thin plywood. Apply a thick foam weather-strip gasket to both sides of the ring, to assure a tight seal between the vac head and the drum.

has a two-prong electrical plug), you'll need to fit a new three-wire electrical cord with a ground wire running from the motor frame to a three-prong plug.

Canister capacity As with horsepower ratings, manufacturers are apt to fudge a bit when it comes to the capacity of the canisters on their shop vacuums. Canister capacity is typically stated as "gross capacity" measured in gallons; actual capacity is usually less. For example, my aging Sears shop vacuum, rated to hold 16 gal., actually holds more like 14½ gal. once the pleated-paper filter element is in place.

Small-canister vacuums, in the 6-gal. to 10-gal. range, are compact enough to fit under a workbench and have adequate capacity for shop cleanup or for collecting small chips and fine dust from portable power tools. To collect chips and shavings from small stationary machines, I'd recommend a vacuum with at least a 12-gal. canister (preferably 16 gal.). If you'd prefer a really big shop vacuum, the Ryobi® IDV28 (shown in the photo on p. 86) and the Delta 49-255 feature 28-gal. canisters—large enough to contain the prodigious output of a small planer paring down a pile of rough boards. If your existing shop vacuum is powerful but lacks an adequate-size canister, you can expand its capacity by using a preseparator, as described on p. 105.

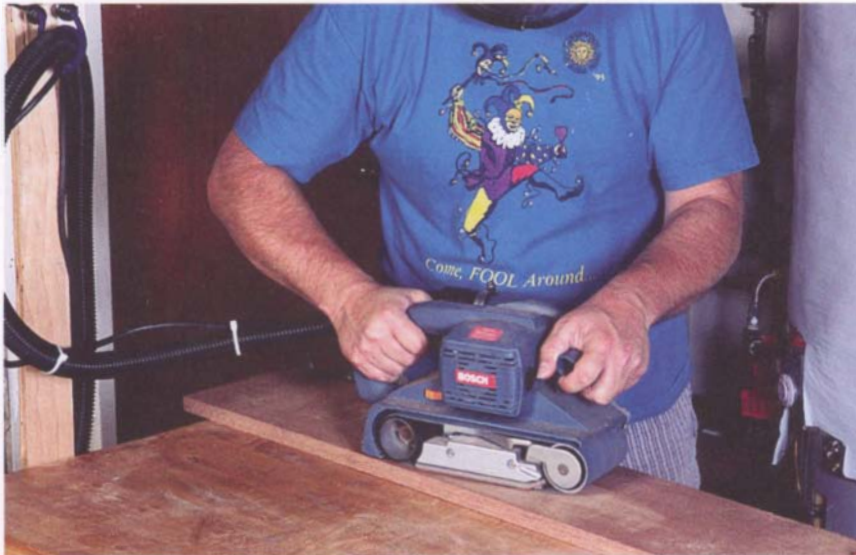
COLLECTING FROM PORTABLE POWER TOOLS

One of the best uses for shop vacuums is collecting small chips and fine dust from portable power tools, such as routers, sabersaws, belt sanders, and random-orbit sanders. Most modern portables feature built-in dust-collection ports. On power sanders, this port is often the mount for the tool's small dust-collection bag. You can usually remove the bag and plug a hose into the port. Some tools require an adapter to make this connection. If the hose doesn't attach snugly, you can usually hold it in place with a small flexible-hose clamp, as shown in the top photo on the facing page. Other portable power tools, such as routers and sabersaws, require special dust-collection adapters. You can also build custom hoods for portable tools and add dust collection directly to shop-built jigs and fixtures, as described on p. 188.

To make dragging around the vacuum hose while using a portable power tool less cumbersome, it's preferable to use a small-diameter flexible hose, somewhere between 1 in. and 1½ in. in diameter. If your unit came stock with a 2½-in. hose, you can probably get a smaller-diameter hose and fit it to your vacuum; if it isn't a standard accessory, a few wraps of duct tape or a connection fitting cobbled up from some PVC pipe should do the trick. When I connected a 1-in.-dia. hose to the 2½-in.-dia. port on my shop vacuum and switched it on, the motor whined and strained considerably. If this happens with your setup, I suggest adding extra ports to let air bleed into the hose—I simply drilled a few extra holes into my PVC con-



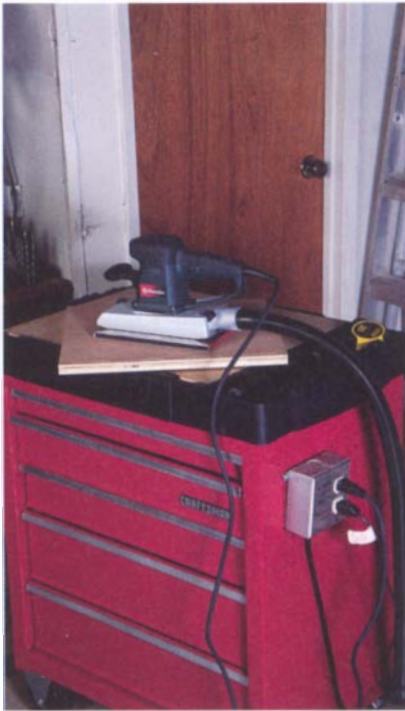
You can enhance the dust collection from a portable power tool with a built-in dust bag by connecting the tool's dust port to a shop vacuum. A small hose clamp holds the flexible hose in place.



Suspending the vacuum hose and electrical cord of a portable power tool with a bungee cord will keep them from fouling the tool. Attach the bungee to a ceiling joist above the bench or, as shown here, to a post clamped to the edge of the bench.

nector fitting, adding new ones until the straining motor quieted down to its normal dull scream.

At first, dragging the hose around makes the power tool feel terribly unwieldy. To ease the bulkiness of the hose, try suspending it with a bungee cord attached to the ceiling or a post near your bench or work



An electronic-switch accessory, such as The Automater, turns a shop vacuum on and off along with the power tool that's plugged into it. Plugging a power strip into the auto switch allows several tools to remain connected at once, so you don't have to replug a tool each time it's used.

Keep Multiple Tools Plugged In

If you often switch among several tools when working at your bench, you can plug them into an electrical power strip, then plug the power strip's cord into the tool receptacle on the automatic switch. If you plan to run multiple tools at the same time, just make sure their combined amperage doesn't exceed the limit of the auto switch.

area, as shown in the bottom photo on p. 79. Make sure to attach the bungee cord securely, so it won't spring back suddenly and cause injury; also, leave lots of slack in the hose so you won't suddenly reach the end of your tether as you come up to the end of a long board you're working on. If you can dedicate a hose to a single power tool, attach the tool's electrical cord to the hose with duct tape, wire, or plastic ties. Attaching the two together makes it less likely that either will snag or hang up as you work.

Automatic vacuum-control switches Another way to streamline the process of collecting dust from a portable power tool is to control the shop vacuum with an automatic switch. This special electronic switch detects the current of the power tool as it is turned on and switches the vacuum on at the same time. Most electronic switches have a built-in delay that waits a few seconds before cutting off power to the vacuum after the tool is switched off, thereby sucking out any dust or chips left in the hose. Some switch models even allow you to adjust the delay period.

You can buy an automatic switch as a plug-in accessory. The Automater line of switches comes as a small box that plugs directly into a 110-volt power source (see the photo at left). The box has two receptacles: one for the shop vacuum and one for the portable power tool. You can also buy units that will control a 220-volt induction motor, such as found on many portable and central dust-collection systems. Several shop vacuums currently on the market come with similar automatic switches built directly into them, including the Porter-Cable 7810, the Makita® 420, and the Fein 42989 (see the photo at right on the facing page). Regardless of the brand or model, any automatic switch has a maximum number of amps it will handle, both for the power tool and the vacuum. If you plan to run a power tool that's particularly power hungry, make sure to check the capacity of the switch before you buy it.

To circumvent the hassle of having to switch vacuum hoses when working with multiple portable power tools, you can make a wye adapter that connects two or more hoses to your vacuum at one time. I fashioned a very serviceable adapter (see the photo at left on the facing page) from several plastic pipe fittings. A sanitary wye creates the secondary connection; a slip-fit basin connector is just right for mounting a 1¼-in. hose on the wye. If your shop vacuum is reasonably powerful, you probably won't lose enough suction to require plugging the hose that's not currently in use. In fact, when using small-diameter hoses with a vacuum that has a 2½-in. port, connecting multiple free-flowing hoses seems to help; using only one small hose constricts the airflow too much.

VACUUM FILTERS

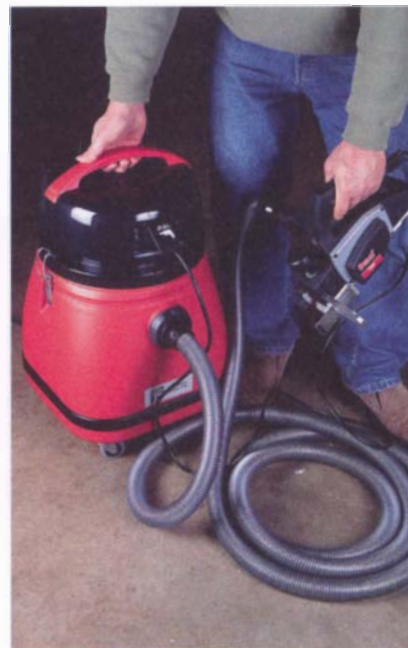
Portable shop vacuums employ any of an extensive array of filter materials, including pleated paper cartridges, foam or paper sleeves, cloth filters, tank liners, and disposable paper bags. Each individual type of filter has



Fitting a wye connector, made from plastic pipe fittings, to the intake on a shop vacuum allows the connection of two hoses, so that both tools served remain ready to run with dust collection.

particular advantages and disadvantages, as outlined in the chart on p. 83. To improve performance, many shop vacuums use two-stage filtration, using a prefilter, such as a cloth liner or a disposable bag (see the photo at right on p. 82), to screen out debris ahead of the main filter (foam sleeve, pleated paper, etc.). This prefilter keeps the main filter from clogging so it needs cleaning less often. An inexpensive prefilter also extends the life of the more expensive main filter. Several vacuum models, including the Fein 42989 (seen at left in the sidebar photo on p. 82), feature thick cloth filter media capable of trapping fine dust particles down to $1\mu\text{m}$ in size. Hence, these vacuums are a great choice for capturing fine dust from power sanders. Models with a disposable bag make emptying the canister a tidy task.

Unfortunately, the single filters found in most shop vacuums do a less-than-perfect job of removing respirable dust from the air passing through them. You can replace stock filters on some models with more efficient Gore® fabric filters, as described in the sidebar on p. 82). But, even if you use more efficient filters, it's not a bad idea to wear a dust mask, ventilate the shop, or use an air cleaner to protect your lungs from fine dust, especially during sanding operations. Alternatively, you can relocate your shop vacuum outside or move it to a room or closet adjacent to your shop. Make sure, however, that the room is ventilated; an airtight enclosure will prevent exhaust from the vacuum from exiting. You can run flexible hose (or PVC pipe) into the shop to connect to machines or portable power tools as long as you keep the runs relatively short—under 15 ft. for



Some shop vacuums, such as the Fein 42989 shown here, feature a built-in automatic switch. The portable power tool is plugged into a receptacle on the vacuum, and an electronic current-sensing switch turns the vacuum on and off in concert with the tool.

A Better Element for Your Shop Vacuum

You can improve the fine dust-filtering ability of your single-filter shop vacuum by replacing its standard foam or pleated paper cartridge with a CleanStream® replacement filter (see the filter at right in the photo below). The filter media of this special cartridge is made from Gore fabric, a fabric similar to the type that Gore-Tex® garments are crafted from. Gore fabric is able to strain out a greater percentage of fine, respirable particles, thus keeping your shop air cleaner and healthier to breathe.



The better the fine particle-capturing ability of the filter, the cleaner the air exhausted by a shop vacuum. The Fein vac (left) comes with a thick polyester felt cloth filter. CleanStream filters (right) replace less effective pleated filters found on many older shop vacuums.



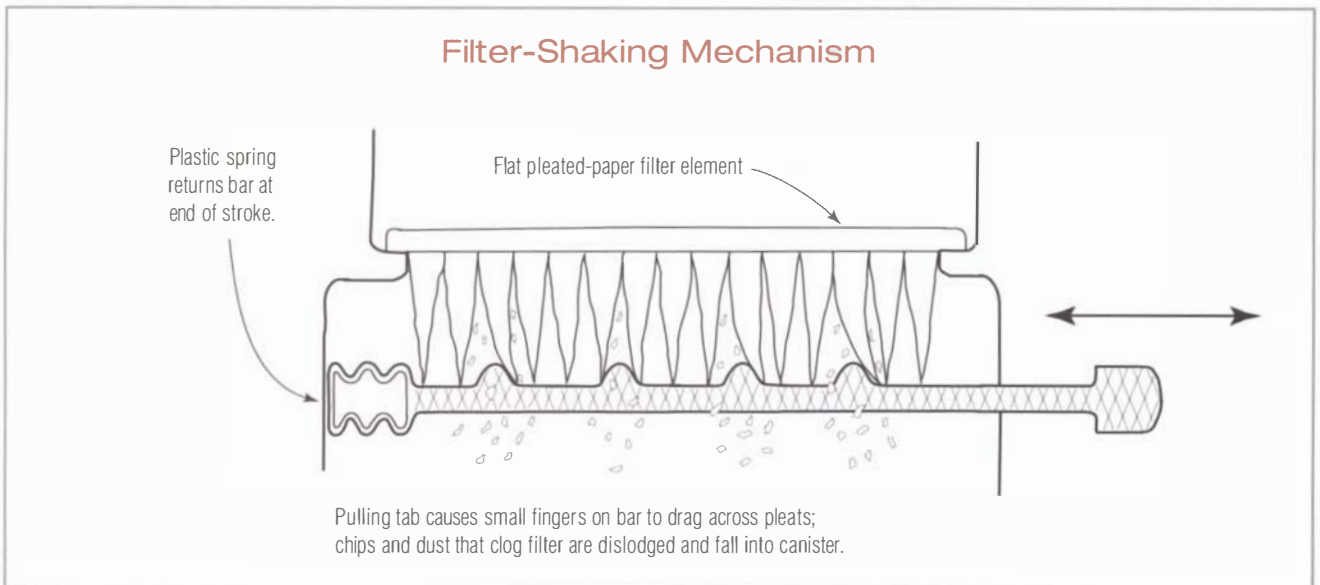
A paper dust bag used in this Porter-Cable 7810 makes dust and chip disposal easy. Additionally, the bag creates a sort of prefilter that helps the vac's main filter stay cleaner longer.

average-size vacuums. A bonus of removing the vacuum from the shop is the reduced noise. You can operate the unit remotely by running an extension cord and plugging it into a switched outlet in the main shop, by switching it on and off automatically (see p. 80) or by using an electronic remote control (see p. 169).

Keeping it clean Just as it becomes harder to breathe through a respirator when the filters are clogged, the suction performance of any shop vacuum diminishes as its filter becomes choked by dust and debris. Some vacuums, such as the Makita 420S, have built-in filter-shaking mechanisms to dislodge particles from their pleated filters to reduce clogging between major cleanings (see the drawing on the facing page). Disposable vacuum bags found on some vacuum models, including the Porter-Cable 7810 shown in the photo above, not only keep chips from prematurely

SHOP-VACUUM FILTER MATERIALS

Filter Media	Advantages	Disadvantages
Pleated paper cartridge filter (often used alone; sometimes with a prefilter)	Large surface area, for better flow-through; can be blown or washed out and reused. Excellent filtration when pleated filter combined with disposable bag.	Relatively expensive to replace; paper folds can be damaged by sharp-edged debris sucked into vacuum.
Foam sleeve (always used with a paper or cloth prefilter)	Inexpensive; easy to clean and replace; good for wet pickup.	Needs to be used with a paper sleeve or tank liner as prefilter.
Paper sleeve (often used as prefilter for foam sleeve)	Inexpensive; simple.	Paper can tear easily; installation can be tricky.
Cloth filter (usually used as prefilter)	Inexpensive; easy to install; good filtration when combined with foam sleeve.	Only fair filtering performance, even when used with foam- or paper-sleeve filter.
Cloth tank liner (used as prefilter)	Easy to install and clean; large filtering area less subject to clogging; good filtration when combined with foam or pleated filter.	Expensive to replace if badly torn.
Disposable filter bag (used in conjunction with another filter element)	Effective prefilter that extends life of main filter; convenient means of emptying debris from vacuum (especially good for disposal of fine dust).	Bag tends to be pricey (between \$3 and \$7 each); sharp-edged scraps can tear the bag; difficult to retrieve items accidentally sucked into vacuum.



clogging the main filter but make sawdust disposal a much easier and cleaner job.

You can make any vacuum's main filter element easier to clean—as well as protect it from damage—by pulling an old nylon stocking or a leg cut from nylon pantyhose over it (see the photo on p. 84). Queen-size



Pulling a nylon stocking over a pleated-paper filter prevents coarse chips and shavings from getting stuck in the deep pleats and clogging the filter, making it easier to clean.

pantyhose is fine for smaller-diameter (4-in.- to 7-in.-dia.) filters; for larger-diameter (7-in.- to 9-in.-dia.) filters, you'll need to buy extra-large or "full figure" pantyhose. If the fit is loose, use a big rubber band to hold the pantyhose in place. The fine nylon mesh of the pantyhose keeps chips from damaging or getting stuck in pleated-paper filters, which can be quite difficult and time-consuming to clean out. Remember to pull the stocking off before cleaning the filter.

Once a filter is clogged by fine dust, the simple way to restore its performance is to shake, blow, or vacuum off the dust (known as dust cake) that's built up on it. Thin, paper-sleeve prefilters can be gently shaken clean, but they should be changed once they get torn or really dirty. To avoid raising a ton of fine dust inside the shop, take your shop vacuum outside before removing the filter, and be sure to wear a respirator. Remove most of the sawdust buildup dry, using a brush to lightly clean between the corrugations on a pleated-paper filter. Work carefully and use a brush with bristles that aren't too stiff, as the paper is fairly easy to tear.

To clean out the really fine dust that embeds itself in the filter fibers, foam and most paper filters can be flushed out with water. Don't apply too much force—say, from a high-pressure garden hose—or you will tear the element. If you do get a small hole or tear in a paper or foam filter, wait for it to dry and then tape the hole with duct tape or glue on a small patch (use yellow glue for paper and silicone sealant for foam). Replace the filter if it's been damaged extensively or after a long period of heavy use. If you can't find a replacement for a cylindrical or flat pleated-paper element, check the stock at a local auto-supply store; you can often find an air filter that's a perfectly suitable substitute.

Some vacuums use disposable bags that make it easy to empty the canister. However, these disposables can be expensive to replace, costing up to \$10 each. Since the bag doesn't have to match the size and shape of the canister precisely, you can save money by substituting a cheaper disposable bag from a different make and model of vacuum (use duct tape to adapt the fit of the bag's intake hole to suit the vacuum). If you're using the vacuum to pick up only larger shavings and debris (not fine sawdust), leave the disposable bag out entirely to reduce the risk of the bag being torn, and let the vacuum's main filter do all the work.

ACCESSORIES

Most shop vacuums come with a whole gang of accessories, many of which are similar to the extras that come with standard household vacuums. These dust brushes, crevice tools, floor nozzles, and extension wands make the average cleanup chore easier. For example, extension wands make floor cleanup less backbreaking and can keep you off that rickety ladder when sucking up cobwebs and dusting on top of hanging fluorescent fixtures, where fine dust can be a real fire hazard. The crevice tool is a blessing for cleaning out small dust-packed spaces between the bench and wall or for retrieving a small tool or fastener that's rolled behind a cabinet. If your shop vacuum didn't come with all the accessories you need, you can probably buy them as optional items from the same company that made the vacuum. Alternatively, you can use accessories from other manufacturers, as long as they fit your hose. Another possibility is to make your own accessories from inexpensive PVC pipe and fittings, such as the floor sweeper shown in the drawing on p. 30.

CUTTING DOWN ON SHOP-VACUUM NOISE

Because most shop vacuums are powered by universal motors that operate at high speeds (typically upward of 10,000 rpm), they emit a surprisingly piercing, nerve-grating whine. Add to this the already bothersome roar of a power tool, and you get a cacophony on par with a heavy-metal rock concert. Such high noise levels make it nearly impossible to hear a ringing door buzzer or telephone.

Just as you would quiet down a noisy jalopy with a new muffler, you can quiet down your noisy shop vacuum the same way. A muffler specially designed for shop vacuums (see Sources of Supply on p. 195) connects to a vac's exhaust port (sometimes labeled "blower") to suppress the roar of the exiting air. A bracket and hose clamp are included with the muffler to allow mounting to the vacuum's canister. The muffler works best on vacuums that have their motors mounted inside the canister with the exhaust port on top, such as the Delta 49-255 or Ryobi IDV28 shown in the photo on p. 86. The vacuum must have an exhaust port. Vacuums with exposed motors mounted atop their canisters (such as most Sears models) aren't

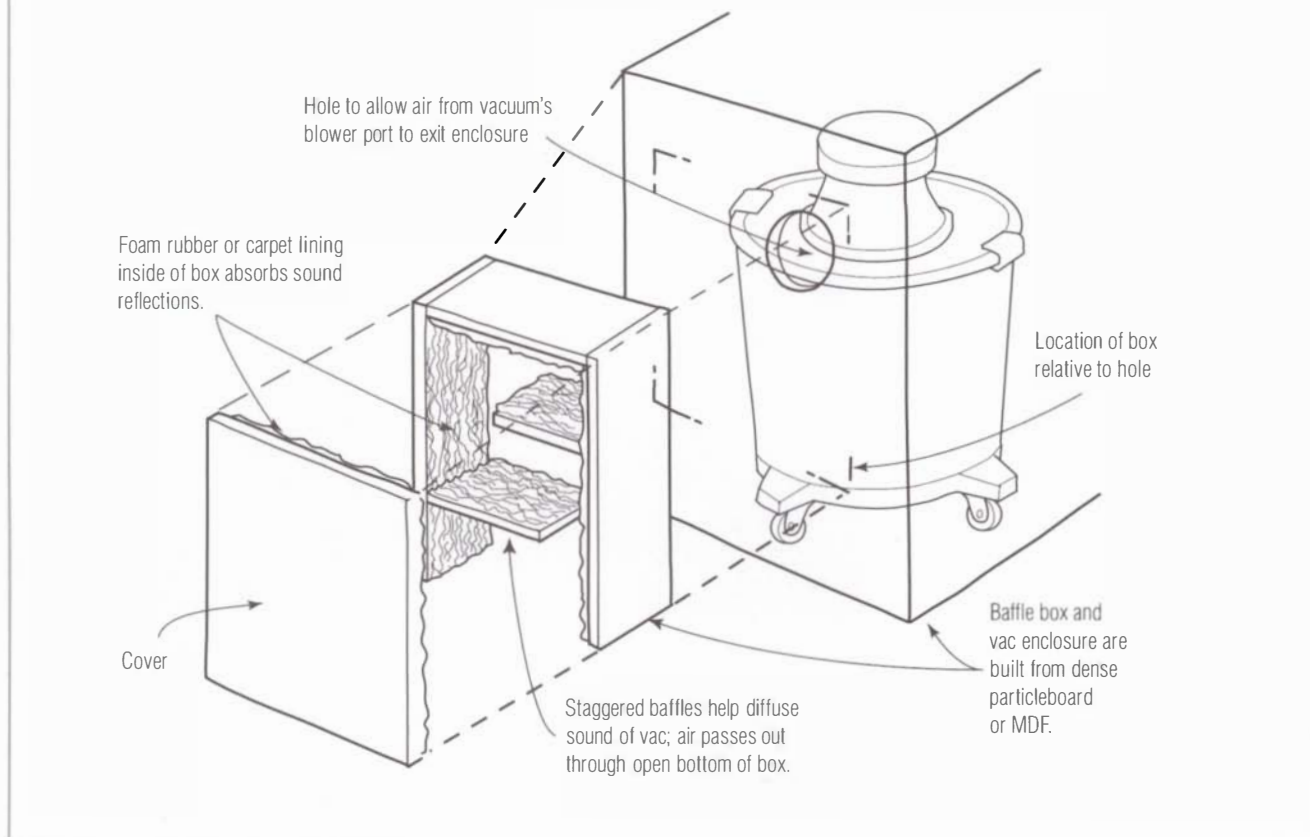


Quieting the nerve-grating racket produced by some canister-style shop vacuums can be done by adding a muffler. Here the compact plastic muffler is mounted to a Ryobi shop vacuum.

quieted much by the muffler; much of their noise emanates directly from the exposed motor housing.

Another way to reduce a shop vacuum's noise level is to relocate the unit to a closet or different room, as described on p. 80. If you keep your shop vacuum under your bench or machine tool, you can reduce its mighty roar to a whisper by covering it with a sound-deadening "doghouse" enclosure, such as the one shown in the photo at left on p. 88. An enclosure should completely cover the vacuum down to a solid floor (on a wood floor or shelf, put a couple of pieces of thick carpeting under the unit to keep motor noise from being conducted and amplified by the vibrating wood). A good enclosure should have a sound-reducing baffled air-exhaust cover (as shown in the drawing on the facing page) and a tight-fitting port for the vacuum hose. To contain a small unit, build a simple cover that fits

Baffled Exhaust Box for Shop-Vacuum Enclosure



over the unit like the domed lid on a serving dish. To keep larger-wheeled vacuums portable, build a door into one end of the enclosure, sealed when closed with weatherstripping (sort of a “vacuum garage”). To be most effective, any enclosure should be built from a dense material, such as particleboard or MDF. Thick weatherstripping around the bottom edge forms a good seal between the enclosure and the floor.

HANDHELD PORTABLES

Small handheld portable vacuums are the equivalent of handguns in the woodworker’s cleanup arsenal. Although they don’t have much in the way of sawdust-holding capacity, cordless handhelds, such as Black & Decker®’s Dustbuster®, are particularly handy tools that complement a regular shop vacuum at cleanup time. Not having a hose and electrical cord to contend with makes these units terrific for quick benchtop cleanups—for example, for sucking up small piles of carving shavings or for removing waste from mortises you’re chopping by hand (see the photo at right). For



Cordless portables, such as the 7.2-volt Black & Decker Dustbuster, are great for benchtop cleanup chores or for removing waste from joints cut by hand, such as these mortises.



Built of ¾-in. MDF, this “doghouse” cover reduces a shop vacuum’s wailing scream down to a muffled whisper. An electrical power strip (on the back of the cover) connects to this vacuum’s automatic power switch, allowing any power tool plugged into the strip to turn the vacuum on and off.



Using portable power tools at the job site is a much cleaner proposition if you connect the tool to a portable vacuum. The Makita 420S has straps that allow it to be worn like a backpack and has an automatic switch built in.

the best chip-collection power, pick a higher-voltage cordless, such as Black & Decker’s 7.2-volt Dustbuster, which offers stronger suction and longer running times than lower-voltage models (typically 3.6 volts). Keeping the handheld in its recharging station (located near the workbench, if possible) will keep it ever ready for use. Like most other nicad-powered cordless tools, you should occasionally allow the battery to drain most of the way before recharging it fully, to overcome the memory effect when constant topping off of the battery reduces its capacity to take a full charge.

One caveat when buying a handheld portable vacuum for the woodshop is to avoid the small-bagged models, such as Royal®’s Dirt Devil®. While these portables are great for household vacuuming chores, the big problem for shop use is that all debris must pass through the unit’s small fan before being blown into the collection bag (like a single-stage collector; see p. 98). If you suck up chips larger than lentils, they’ll bang around the fan until you switch the vacuum off, then they’ll fall out onto the floor. By contrast, most Dustbuster-style handhelds have a chamber and

filter ahead of the fan, so as long as the debris fits through the unit's intake opening, it will be collected without a hitch.

An interesting tool for woodworking cleanup tasks is the Makita 420S. This portable vacuum is small enough to be carried with one hand or worn as a backpack, allowing you to haul it around the shop or the job site with ease during cleanup (see the photo at right on the facing page). The unit includes a receptacle for plugging in a power tool and a built-in electronic switch that turns the vacuum on and off with the tool. By connecting a portable power tool's dust port to the vacuum's small-diameter flexible hose, you can do all kinds of trimming and finish work inside your home (or in a client's home) without making piles of sawdust.

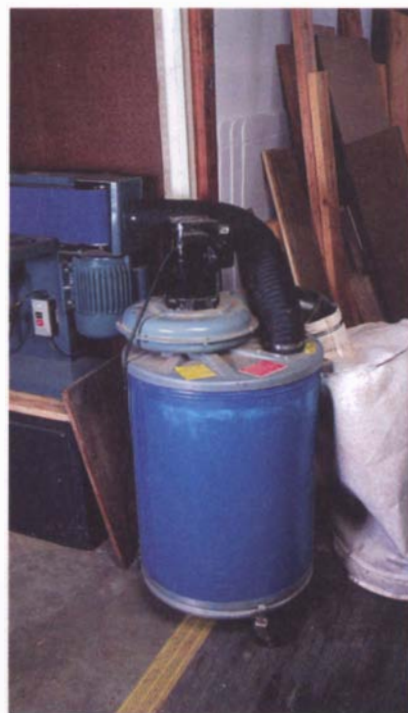
Portable Dust Collectors

The next step up from a shop vacuum is the portable dust collector. These devices are larger than a standard vacuum, both in terms of chip-holding capacity and in motor size and fan strength. Models like the barrel-top Delta 50-179 (shown in the photo at right below) sport durable ½-hp to 1-hp induction motors, as compared to the lighter-duty universal motors used in most shop vacuums. This power, coupled to a larger, stronger fan wheel (rather than the small plastic fans used in most shop vacuums), allows portable collectors to suck up a much larger volume of chips.

Many portable collectors are two-stage units: Chips flow into a collection drum or bin first, where large chips settle before fine dust goes on to be trapped by the filter bag (see the discussion of single- and dual-stage



The Delta 50-820 compact portable collector is easy to wheel around the shop to wherever it's needed. It takes only moments to connect the collector to a small machine, like this oscillating spindle sander.



Popular for their compact size and good collection strength, canister-style portable collectors, like the Delta 50-179, allow efficient chip collection from most machines without the cost of installing a central system.

Cut Down Dust-Collector Noise

Running a noisy portable collector in close proximity to a noisy machine can generate enough decibels to make the user feel sonically abused, even with earmuffs on. A couple of possible solutions are to build a removable sound-deadening enclosure for a portable collector similar to the one described for a shop vacuum (see p. 85) or to relocate the collector to a closet (see p. 80).

collectors on p. 98). But there are also single-stage portable collectors, such as the Delta 50-820 (shown in the photo at left on p. 89), the Makita 410, and the Penn State DC3. Like single-stage chip collectors, these smaller portables suck chips and sawdust directly through the fan and into a filter/collection bag. Single-stage units are compact, but they lack the power and air-moving capacity of full-size central dust-collector units, which are necessary for conveying dust through a ductwork system (see chapter 6).

There are at least two good reasons you may wish to buy a portable dust collector. First, portable collectors are less expensive than central units, both in terms of purchase price and installation. A single-stage model with a 1-hp motor costs less than a good cordless drill, and you need only buy a length or two of flexible hose to hook it up—there's no expensive ductwork to install. Second, their compact size and mobility make them nearly as portable as shop vacuums, but they're better able to handle the large volume needed to collect chips from full-size woodworking machines. Their portability makes these units flexible because they can be readily wheeled around the shop and hooked up only when and where they are needed. This is great for weekend warriors who work in a garage or space that's only a part-time woodworking shop. Many portable collectors are small enough to store under a workbench or in a closet when not in use.

On the downside, the chip-holding capacity of portables with small canisters leaves much to be desired. Also, single-stage units that lack a canister, such as the Delta 50-820 (see the photo at left on p. 89), can be difficult to empty since dust must be emptied directly from the filter bag. To increase chip-holding capacity and make sawdust easier to empty, try adding a dust preseparator ahead of the collector, as described on p. 105.

HOOKING UP A PORTABLE COLLECTOR

How you hook up a portable dust collector depends, as always, on how you work and which machines you wish to collect dust from. Most woodworkers I know keep a few feet of 4-in. flexible hose attached to the intake on the collector, which they connect to the dust ports on whichever machine is in use. If you have several machines to collect from, hose reconstructions will be faster and easier if you use quick-disconnect fittings, such as the ones shown in the photo at left on the facing page. These devices (available from Air Handling Systems; see Sources of Supply on p. 195) install on the ends of a flexible hose with hose clamps. Just a twist attaches or detaches the collector's hose to the machine or other dust source.

Because of its limited power and capacity (compared to larger central collectors), most woodworkers probably won't want to use a portable collector with more than one machine at a time. The exception would be



A portable collector is much handier to hook up when you add quick-disconnect fittings to the hose ends. The fittings allow you to switch the collector between machines with just a twist of the wrist.

hobbyists working with small benchtop machines that don't produce much dust, such as scrollsaws and oscillating spindle sanders. You can split collection using one or more wye fittings on your hoses; just keep your hose runs short. The longer the hose, the more the friction that's generated, which diminishes vacuum strength (see the discussion of static-pressure loss in the sidebar on p. 95). Also, using small-diameter hose or tubing can zap the dust-capture strength of most portable collectors. In my first attempt at installing a collector in my shop, I connected a ½-hp portable to a 12-in. planer via 3-in. PVC plastic drainpipe that was 15 ft. long; the only way the collector could keep up with chip production was if I set the planer to take an extremely light cut.

CONTROLLING CONNECTIONS WITH A SWITCHABLE MANIFOLD

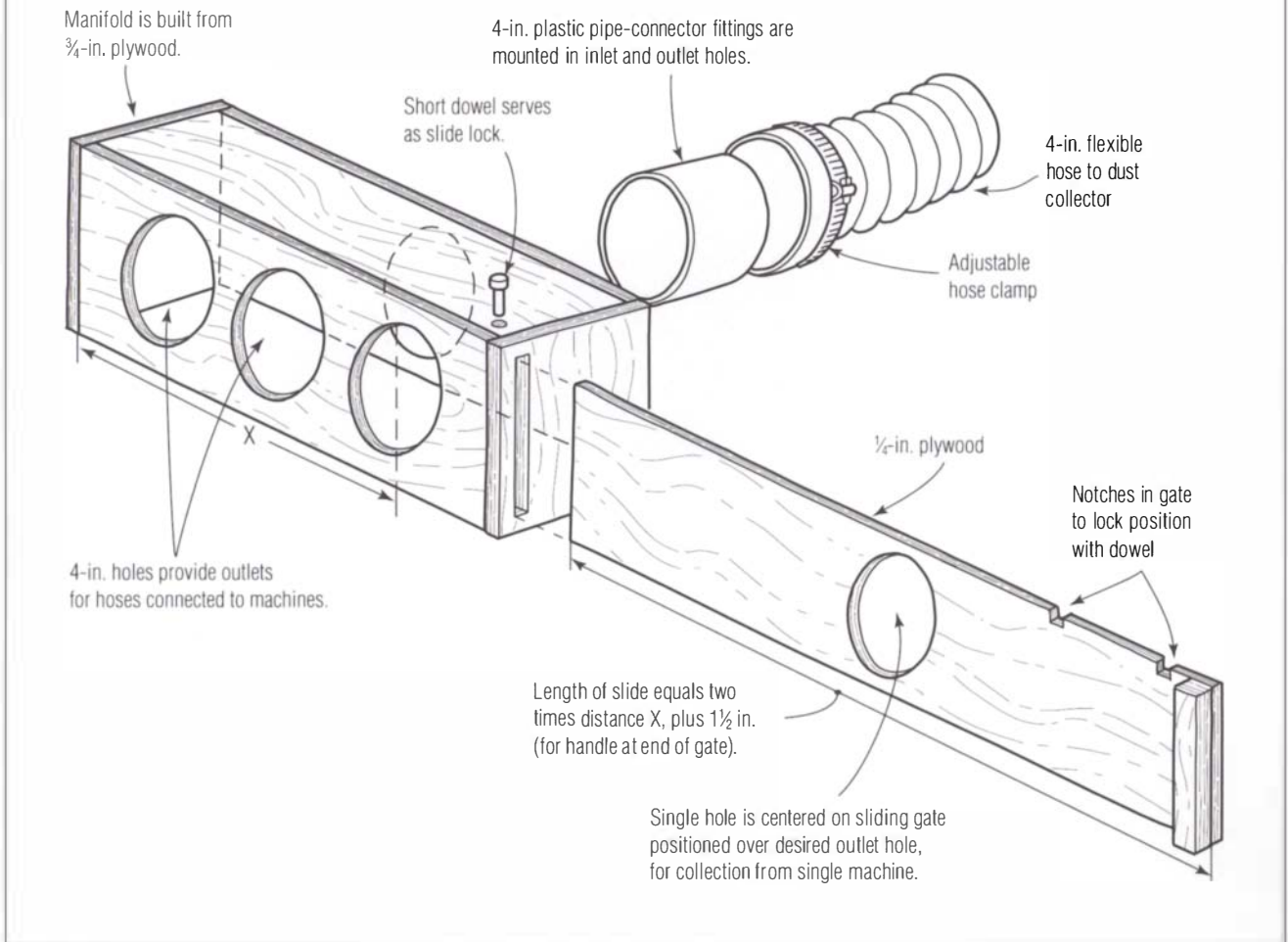
If you find yourself working between several full-size shop machines, say when ripping and dressing lumber using a table saw, jointer, and small planer, you might want to install a small duct and blast gate system, as shown in the top right photo. A less complex way to control collection to several machines is with a manifold—a device that directs the airflow from the portable collector to only one machine at a time, saving you the trouble of installing blast gates or having to switch hose connections each time.

A manifold consists of a box that provides connections for hoses coming from the collector and the machines, and a gate that directs



A centrally located portable collector provides a convenient means of collecting sawdust from several shop machines. Blast gates fitted on short lengths of flexible hose control collection from the table saw, band-saw, and drum sander, shown here.

Three-Outlet Dust-Collection Manifold



suction to only the chosen machine. A simple manifold that can serve multiple machines is shown in the drawing above. The box shown is built from $\frac{3}{4}$ -in. plywood and accepts hoses from three machines, although it could probably be adapted to work with four or five machines. A sliding gate made of $\frac{1}{2}$ -in. plywood controls the airflow, and a dowel locks the gate into position. Plastic pipe connectors, glued and screwed into holes in the box, provide mounts for flexible hoses connected to machines and the collector. Adjustable hose clamps attach the hoses and allow their removal for cleaning residual dust out of the manifold. A similar manifold, designed to suit your application, could also be used with a small central dust-collection system.

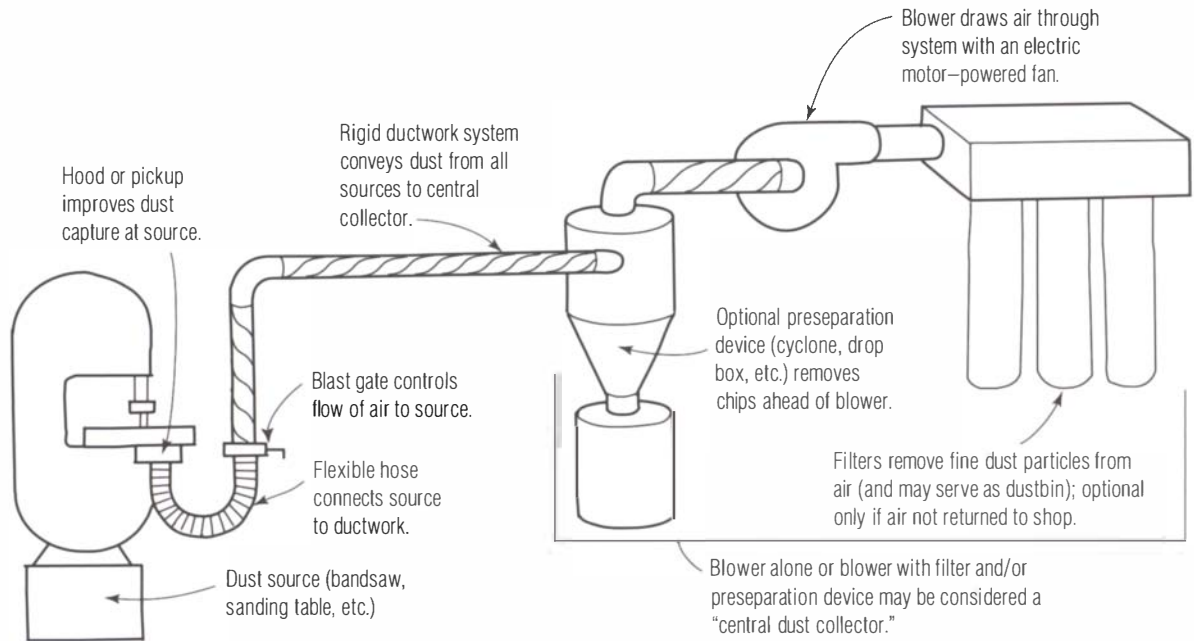
Central Dust Collectors

The best way to achieve the goal of a clean, dust-free work environment is to capture dust at the source, as it's created and before it escapes and ends up all over your shop. You can use a portable collector to capture sawdust at one or two machines or a shop vacuum to gather dust from portable power tools, but the best permanent solution for handling all the dust-producing machines in your shop is to install a central dust-collection system. Having all your machines connected to a central collection system is like having a cleaning service tidying up your shop: Every time you run a machine, the collector whisks chips and dust away, depositing them in a barrel, bin, or bag for neat and convenient disposal.

As shown in the drawing on p. 94, a central collection system uses a network of ducts to connect to all machines and dust sources in the shop. The ductwork transports dust and debris captured at the source back to the central collector. Collection begins with a hood or pickup at each machine that helps contain and capture sawdust. A flexible hose connects the machine to a blast gate, which opens or closes airflow to that machine. Air and dust then flow through rigid ductwork, consisting of branch ducts that feed from different locations in the shop into a main duct that goes directly to the central collector.

The anatomy of a central collection system may seem simple, but there's more to installing a complete system than just running ductwork made from that old surplus muffler pipe you have in the attic and hooking it up to a collector that you bought on sale at your local tool store. Air—the medium by which chips and dust are collected—has very specific char-

Anatomy of a Central Dust-Collection System



acteristics that must be harnessed correctly to achieve efficient, trouble-free collection (see the sidebar on the facing page). What's more, the central collector you choose to run your system must suit the size and capacity of the ductwork (see p. 101). You also have many choices to make about the configuration and features of your central collector. The type of collector you buy (or assemble from separate components) affects not only the performance of the system but the ease and safety of using it as well. Ideally, you should consider these factors carefully and choose a central collector unit before you buy and install ductwork and components for a complete central collection system. In this chapter we'll focus on the dust collector itself; in chapters 7, 8, and 9, we'll consider the design and installation of the entire system.

Central Dust Collector Basics

A central dust collector is like a big shop vacuum but with some important differences. A shop vacuum doesn't have the chip-collecting capacity or power of a central unit. It uses a small, high-rpm universal motor (the same kind used in most portable power tools) and a fan to draw sawdust through a small-diameter (1-in. to 2½-in. ID [inner diameter]) flexible

Air-Moving Basics

AIR IS THE MEDIUM THAT MAKES ALL DUST COLLECTION possible. The amount of air that flows through a system, how fast it flows, and how much friction it encounters during its journey are factors crucial to understanding how an efficient dust-collection system works. These factors enter into play when sizing and laying out ductwork (as discussed in chapter 7), as well as when choosing the right collector to suit your system (see p. 101).

Here are the basic principles of moving air that are important to understand when designing a central dust-collection system:

1. Air has volume, measured in cubic feet per minute (cfm). Generally, the larger the volume of air traveling through a pipe, the more dust and chips it can carry. Therefore, machines that produce a greater volume of chips (such as planers and shapers) require more air volume to capture and convey these chips to the collector. Dust collectors with bigger motors and fans generally move a larger volume of air. The larger the diameter of a duct, the more air and chips it can carry.
2. Moving air has speed or velocity, measured in feet per minute (fpm). The faster that air moves through ductwork, the better that larger shavings and chips will remain suspended in the airstream. Too slow an air speed and chips settle out and accumulate, eventually clogging the pipe. But too fast an air speed generates more friction than necessary and, hence, reduces the system's efficiency. The air velocity recommended for small-shop central collection systems is 3,500 fpm for the main duct and 4,000 fpm for branch ducts.
3. Moving air is subject to friction, measured as inches of static pressure (SP). Static-pressure loss is the energy lost as air and chips rub against the sides of the duct as they travel through it. Travel around corners and through transitions (such as where branches merge with the main duct) creates even greater static-pressure losses. The power of a central collector is rated in terms of the inches of static pressure that it can overcome.

hose that can easily clog with large shavings. In contrast, a central dust collector employs a powerful induction motor (as used in most stationary machines) and a special large-volume fan, called a blower, to convey chips and sawdust through larger-diameter (3-in. to 6-in. or more) ductwork.

A shop vacuum moves a small volume of relatively high-pressure air (between 45 in. and 80 in. of static pressure) through its small-diameter hose, whereas a central collector moves a large volume of low-pressure air (around 5 in. to 10 in. of static pressure in a typical small system), which is adequate for moving chips through larger-diameter hoses and ductwork (see the sidebar above). While a shop vacuum is certainly adequate for cleanup chores or collection from small tools, it just doesn't move the volume of air necessary to collect and convey the huge quantity of chips generated by full-size stationary machines.

CENTRAL DUST COLLECTOR ANATOMY

Most central dust collectors are made up of only a few basic components, as shown in the drawing on p. 94. At the heart of the system is the blower—the fan that creates the vacuum to entrain (capture in a stream of air) dust and chips and convey them through the ductwork to a dust bag or other collection device. Blowers designed for dust collection have paddle wheel–style fan blades (also called impellers), which revolve inside a metal housing that has an inlet port and an exhaust port. Most fan wheels are driven directly by a powerful induction motor. Better-quality collectors use TEFC (totally enclosed, fan-cooled) motors, which are sealed against dust for longer service lives. Some portable chip collectors (see chapter 5) also use this kind of blower and induction motor, but smaller units (1 hp to 2 hp) don't possess enough power or air-moving capacity to function effectively as blowers for central collection systems.

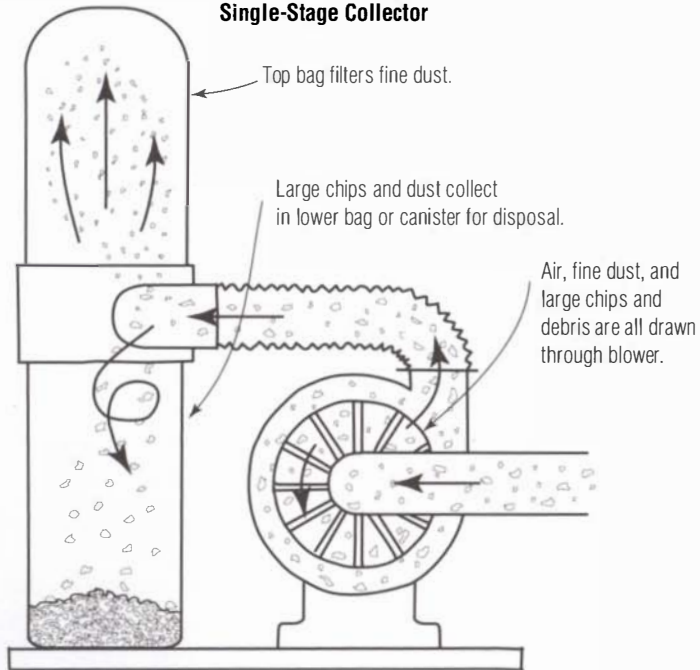
The blower's inlet may be connected directly to the ductwork that conveys sawdust from the machines or to a preseparation device, such as a cyclone, drop box, or canister. A preseparator removes debris and chips ahead of the blower for safety and better performance (see p. 102). The blower's exhaust is usually connected to one or more filter bags or an assembly called a filter-bag house to remove fine dust from the airstream before it passes through the filter media and back into the shop or outdoors (see p. 107).

You can purchase a central dust collector as a complete, ready-to-use unit, with all components hooked together and ready to go, or you can assemble your own collector from separate components. One advantage of building a customized collector is that you can mount components separately, to fit into narrow, odd-size, or cramped spaces. The most basic collector you can build consists of a blower alone connected directly to shop ductwork. The cost of simplicity is that this system must exhaust air outdoors so that you don't pump your shop full of sawdust. For a return-air system (see p. 126), you must add some form of filtration. And for even better system performance and longer filter life, it's desirable to add a pre-separation device ahead of the blower.

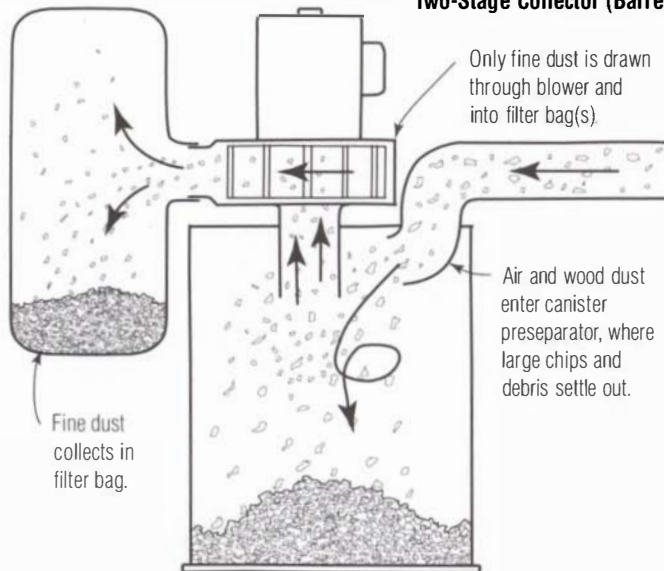
Ready-to-run central units are available in dozens of different models from home centers, woodworking mail-order catalogs, industrial dust-collection suppliers (see Sources of Supply on p. 195), or your local tool store. Central collectors come in different sizes and capacities (see the sidebar on pp. 100–101) and with different features. But the most important difference among models is whether or not they incorporate pre-separation, which determines if the unit is a single-stage or a two-stage collector.

Single-Stage vs. Two-Stage Dust Collectors

Single-Stage Collector



Two-Stage Collector (Barrel-Top Style)





Barrel-top collectors, such as this Delta 50-665, provide the safety and performance of two-stage collectors in a compact unit that can serve as a central collector for a small-shop system.

Shake or Empty Your Bags Often

Does the performance of your single-stage collector seem to wane the longer you use it? To keep it operating at its best, shake the collector bags lightly and often—to reduce dust-cake buildup on the inside bag surfaces—and empty chips from the lower bags when they're just one-quarter to one-third full. Better yet, install a preseparator ahead of your collector, as described on p. 102.

SINGLE-STAGE COLLECTORS

As shown in the drawing on p. 97, single-stage collectors (often referred to as “chip collectors”) draw air and sawdust directly through the blower, then expel them into a collection bag (or bags). In contrast, a two-stage system incorporates a preseparator, which removes chips and debris so that only finer dust and air pass through the blower and on to the filter bags.

The primary advantage of single-stage dust collectors, such as the one shown in the photo on the facing page, is that they are relatively simple and inexpensive to buy; they are the ubiquitous Asian-made collectors you see in most woodworking-supply catalogs. Smaller, 1-hp to 2-hp units use a pair of bags for chip collection and dust filtration. Larger collectors (2½ hp to 3 hp) use multiple pairs of bags to provide more chip-holding capacity and greater filtration area.

Unfortunately, single-stage units have several disadvantages for central collection. First, large chips, small wood cutoffs, and stray bits of “tramp” metal (small screws, nails, brads, etc.) come in direct contact with the fan as they are sucked through. This barrage of debris not only causes an alarming amount of noise, but it can also damage the blower impeller and housing or, at the very least, accelerate wear on these components, especially if the unit has a plastic fan wheel. A more serious problem is that bits of metal accidentally passing through the fan can create a spark that can trigger a powerful explosion and fire (see p. 19). Even in units with a nonsparking cast-aluminum or plastic fan wheel, sparks can occur when metal particles bounce off the inside of the sheet-metal blower housing. You can prevent this by adding a preseparator ahead of the blower, thus converting your single-stage collector into a two-stage unit, as described on p. 102.

Another shortcoming of single-stage collectors is that the filter bags found on most units lack the fine-filtering ability of industrially rated dust collectors. Single-stage filter bags are often made from materials not engineered for fine-particle filtration. Worse still, the lower bags are used as collection bins as well as filters. As these bags fill up, collection performance suffers since there is less surface area for air to escape through. This is why it's not recommended to replace your lower fabric bags with plastic bags, trash cans, or drums. Worst of all, increased pressure inside a full bag forces fine dust particles through the filter media and into the air (see p. 110).

TWO-STAGE COLLECTORS

A two-stage system is designed to eliminate the problem of impeller damage and sparking by drawing only fine dust particles through the blower. Larger chips and stray debris are taken out and deposited in a canister before they can reach the blower. The preseparation of chips and sawdust from the airstream is usually accomplished by a cyclone, drop box, or separation canister (see p. 102). In addition to making life easier for the blower (and less dangerous for woodworkers), a two-stage collector also sends far



Single-stage dust collectors offer affordable chip and sawdust collection in a ready-to-use package. A two-bag Jet DC-11001 ½-hp collector is shown here.

less sawdust to the filters, so they clog less readily and need cleaning or emptying less often. On the downside, two-stage collectors are generally more expensive than single-stage models. Also, units that incorporate large cyclones, such as the Delta 50-901 (see the photo at right on p. 104), or systems assembled from separate components take up more space than comparable-size single-stage systems.

Barrel-top collectors A two-stage unit that's very popular in small shops because of its compact design is the barrel-top collector; popular models include the Dust Boy, the Delta 50-182, the Delta 50-660, and the Delta 50-665 (the latter shown in the photo on the facing page). These collectors dump chips and shavings into a drum before sending finer dust on through the blower and into the filter bag. A flexible hose connects

Collector Power and Performance

BECAUSE ALL CENTRAL DUST COLLECTORS have blowers powered by electric motors, the obvious way to distinguish the size of various collectors is by the size of their motors—1 hp, 3 hp, and so on. But there are two figures that provide a far more important measure of a collector's capacity and strength than horsepower: the volume of air that a collector moves (in cfm) and the number of inches of static pressure (SP) for which it's rated. A collector with a higher cfm rating handles more dust output or collects from more machines simultaneously than one with a lower cfm rating. A collector with a higher SP rating will handle a larger, more convoluted system of ductwork than one with a lower rating.

Here's where it gets tricky: A collector's air-moving capacity (in cfm) changes depending upon the amount of air friction (SP loss) that the blower must overcome from the ductwork. (Imagine how much harder it would be to take a sip of soda through a 3-ft.-long straw than through a regular 8-in.-long straw.) When a collector is working harder, it moves a smaller volume

of air. Unfortunately, manufacturers usually print cfm ratings for their collectors that reflect the amount of air the collector moves when it's not connected to ductwork (operating at zero SP loss). This is known as "free-air cfm."

Static-pressure ratings can be similarly misleading because they usually represent the maximum power the collector generates when moving no air at all (at zero cfm). This is like the suction power you feel when you put your hand over the end of a running vacuum cleaner's hose.

Fan Performance Curves

The best way to make sure that a blower or dust collector you're considering buying will be powerful enough for your system is to ask the manufacturer or dealer for a fan performance curve, such as the one shown in the graph on the facing page. A test of actual collector performance, this graph plots the amount of air a collector's blower conveys under different work loads. A fan performance curve may reveal that a blower capable of moving 1,100 cfm at low

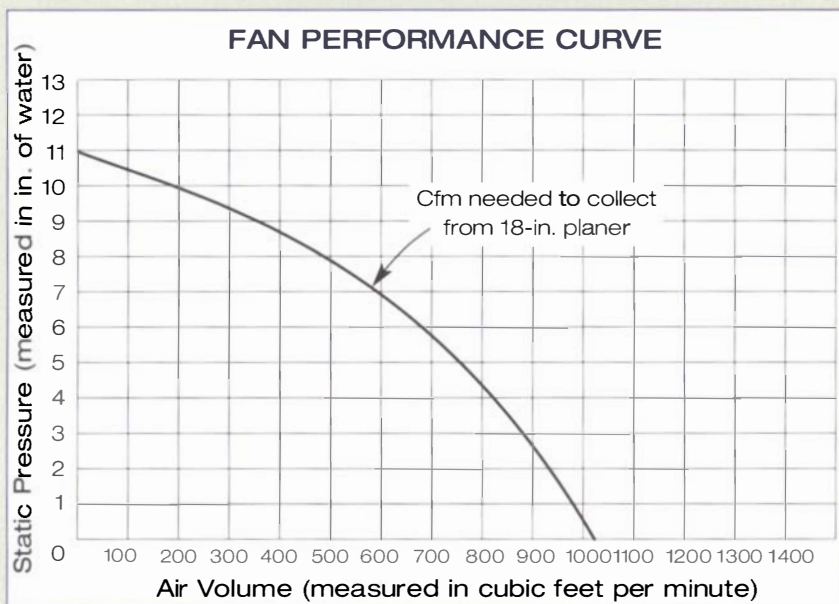
SP loss (say 2 in.) may deliver only 500 cfm when running a system with twice as much SP loss.

Once you know what your system's cfm requirements and SP losses are (as calculated on pp. 136-142), it's a simple matter to choose a collector by comparing these numbers to a collector's fan performance curve. For example, if the largest dust producer in your shop is an 18-in. thickness planer (which requires about 750 cfm), the graph shown here indicates the collector is powerful enough to handle that machine as long as the ductwork to that machine had 5 in. or less of SP loss.

Unfortunately, few manufacturers and dealers can readily supply you with a performance curve for their dust collectors, and there's no easy way to predict actual performance by extrapolating from the unit's free-air cfm rating. If you're willing to take the risk, you can simply buy a collector that you think will get the job done and see if it performs adequately when connected to your ductwork. In this case, it's prudent to select a unit that's at least 50 percent to

the unit to the shop's ductwork. Barrel-top units are compact because the blower and filter bag are mounted in a single unit. If the chip-holding capacity of the canister is too small for your needs, you can easily increase it by substituting a larger barrel or fiber drum. You can also make a large-capacity bin by building a plywood box with a round cutout on top. Make sure to use thick weatherstripping around the cutout so that the collector lid forms a tight seal with the bin.

One disadvantage of barrel collectors is that you have to lift off the heavy blower each time you need to empty the drum. You can get around this problem by lifting and suspending the top with a rope combined with a block and tackle (anchored to the ceiling above the collector), as shown in the photo on the facing page. A metal cleat screwed to the wall near the collector provides a place to secure the rope to hold up the top while you dump out the barrel.



75 percent more powerful than you think you'll need—just make sure before you buy it that the dealer will exchange the collector if it isn't right for you. If you already own an undersize collector, you might be able to coax better performance out of it, as discussed on p. 162.

If you'd rather play it safe, don't buy a dust collector from a dealer or manufacturer who can't supply

a performance curve graph for the unit. You might spend more time shopping, but you're more likely to end up with a collector that will run your dust-collection system effectively.

Choosing a Collector

Once you've decided on the type of collector system you want to install, you still have to pick a model that's right for your shop's ductwork system. How powerful a collector you need depends primarily on three factors:

1. How much sawdust your shop produces. The more (and the larger the size of) chips and dust a woodworking machine produces, the greater the volume of collection air needs to be to capture and convey them.
2. How far the ductwork must convey sawdust from the source (a machine, floor sweep, sanding table, etc.) to the central collector. The farther or more circuitous the distance traveled, the stronger the collector's blower must be to overcome the friction of the air passing through the ductwork.



To ease the task of lifting the heavy lid of a canister-style collector (with blower and motor attached), use a small block and tackle. To keep the lid suspended while chips are dumped, use a counterweight or tie the rope off to a cleat screwed to the wall.

3. The number of machines the collection system must handle simultaneously. Running several machines at once requires more air volume—and collector power—than running a single machine.

All these factors are determined by the design of your entire central system, which means you can't pick the right collector for your system until you've designed the ductwork, as described in chapter 7. The calculations necessary for designing the ductwork system will provide you with all the information you need to choose a central collector powerful enough to run your system efficiently (see the sidebar on pp. 100–101).

Preseparation of Sawdust

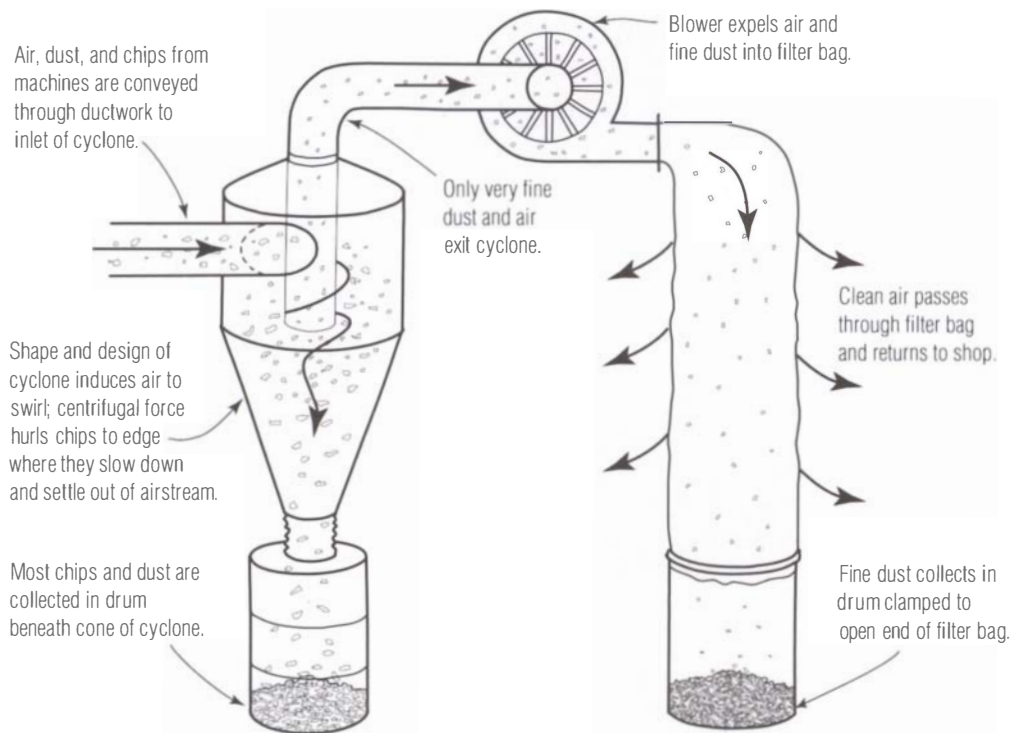
Most wood debris that's drawn into a central collection system contains elements that range in size from gum wrapper-size shavings to microscopic dust. A preseparation device removes all large shavings and chips, as well as the majority of sawdust, before the airstream passes through the collector's blower and into the filters. While commercially made two-stage collectors, by definition, incorporate some sort of preseparation, you can also add a preseparation device to a single-stage collector or to a central collection system assembled from separate components.

There are two practical methods for preseparation of wood chips. The simpler (though less efficient) way is to use a drop box or a dust preseparator canister, which creates a reduction in air velocity that causes heavier particles to fall out of the airstream. A more effective method is to use cyclonic preseparation, which swirls or slows down the airstream so that chips and particles drop out. Only the lightest, fine wood dust particles,



The dust-deflector ring inside the bag holder found on many single-stage collectors encourages large debris and coarse dust to swirl and settle to the bottom of the lower bag.

Cyclone Incorporated into a Central Dust-Collection System



which don't have much inertia, remain entrained in the stream of air. (Imagine a pea and a cannonball at the center of a spinning merry-go-round; the heavier cannonball will fly off the merry-go-round with far more force than the lighter pea.)

Many dust collectors incorporate some sort of cyclonic preseparation in their design. Barrel-top portable and central collectors employ a deflector just inside the intake that causes air to swirl and dust to settle (it's the first stage of their two-stage collection). Even some single-stage units have a spiral dust deflector inside the shroud that supports the collection bags (see the photo on the facing page). This deflector encourages larger chips to swirl and settle in the lower bag. But neither of these devices is as effective as a true cyclone.

CYCLONES

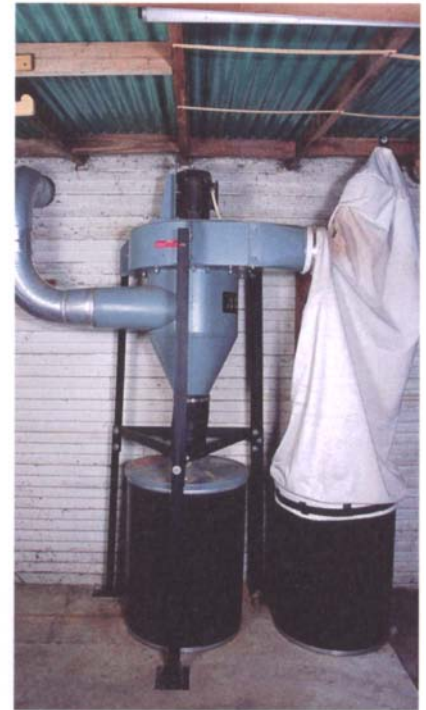
A cyclone is a sheet-metal cylindrical canister with a funnel-like bottom that looks like it's part of a whiskey still (see the drawing above). Air

Leave Cyclone Building to the Experts

You may have seen plans or magazine articles on building your own dust-collection cyclone, but I don't recommend this. Building and connecting the complex sheet-metal parts is a tricky project best left to an experienced sheet-metal worker. Besides, it's cheaper to buy a ready-made cyclone than assemble one from scratch.



A cyclone can be added to an existing single-stage system, to preseparate chips and sawdust before they enter the collector. This prevents damage to the fan as well as reducing wear and tear on filter bags.



You can buy a central collector with a built-in cyclone, such as the Delta 50-901 shown here. The cyclone is extremely efficient at preseparating chips and coarse dust, sending only fine dust through the blower and to the filters.

and debris coming from the shop's ductwork enter the upper part of the cyclone tangentially, creating a vortex. As the high-velocity airstream compresses against the wall of the cyclone, wood debris and coarse dust settle out and drop through an opening at the bottom of the funnel and into a barrel for easy disposal. Only air and very fine dust (typically $15\mu\text{m}$ and smaller) still entrained in the airstream exit the cyclone, passing up through a pipe that runs partway down the center and on to the blower. Cyclones are so efficient—removing up to 99 percent of the dust sent through them—that, in a non-air-return system, their exhaust can be discharged directly into the outside air. More often, the blower sends air on to the filters, for final removal of very fine, health-threatening particles before returning the clean air to the shop.

If you want to assemble your own collection system from scratch, you can buy a cyclone as a stand-alone unit and connect it to an existing blower and filter assembly (see the photo on p. 124). To add a cyclone to a single-stage collector, connect it between your shop's ductwork and the blower intake, as shown in the top left photo. Cyclones come in different sizes, each designed to handle a specific amount of airflow; you must buy the right-size cyclone to suit the capacity of your blower (see the sidebar

on pp. 100–101). Also, when designing your central collection system, you must remember to add an extra 1 in. to 2 in. of SP loss to your airflow calculations—the price that cyclones extract for their preseparation services.

To save you the trouble of sizing and mounting a cyclone and blower as separate components, some manufacturers offer dust collectors with integrated cyclones paired with blowers, such as the Torit® model 13, the Murphy-Rodgers MRC-7B3, and Delta’s 50-900 series of collectors. (The 3-hp Delta 50-901 is shown in the photo at right on the facing page.) These collectors are designed for medium and large shops and look like the big cyclones you see being used for dust collection at large cabinet factories and institutional woodshops. Because the blower and cyclone are carefully tailored to each other, it’s the surest way to get predictable performance in a cyclonic separation system. Most units have a top-mounted fan mated to a compact but efficient cyclone. A hose from the bottom of the cyclone drops chips and debris into a drum, while the air from the blower is sent to a large filter bag fitted over a second drum, for ease of emptying the finer dust.

DUST PRESEPARATOR LIDS AND CANISTERS

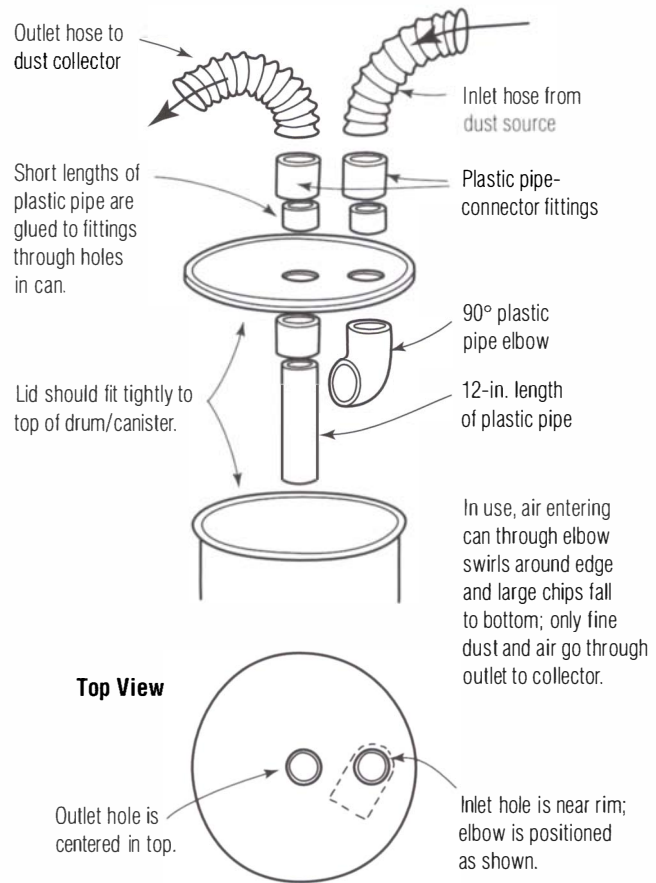
If you don’t want to buy a regular cyclone, you can still add the advantages of preseparation to your small central collector (or portable dust collector) by fitting a dust preseparator canister (the “poor man’s cyclone”). This device is compact, inexpensive, and easy to hook up to your present collector. A flexible hose brings incoming air and debris from the ductwork into the preseparator where the big stuff drops out. Cleaner air exits through a flexible hose that connects to the blower and filters.

Adding a dust preseparator canister not only transforms a single-stage collector into a two-stage system but also adds chip-holding capacity that many smaller central collectors and portables lack. The trade-off is that there is some loss of collection power due to the added energy it takes for air to travel through the canister. Also, a portable collector loses its portability when tethered to a preseparator. One solution is to permanently connect the preseparator can to the biggest chip-producing machine in your shop (probably the thickness planer or table saw). When needed, you can connect your portable collector to these machines via the preseparator can’s exhaust hose; the rest of the time, the unit remains portable, so you can use it wherever it’s needed.

It’s possible to get modest performance with a preseparator can hooked up to a shop vacuum, but you’ll need a powerful unit (with a motor rated at no less than 10 amps). I’ve used preseparator cans with standard 2½-in.-dia. shop-vacuum hoses (smaller hoses won’t work) with modest results when connected to a router table or 8-in. table saw; don’t expect thorough collection of chips from a planer or shaper.

Build one or buy one You can build your own preseparator canister using a 34-gal. fiber drum or a 55-gal. steel drum with a tight-fitting yet

Shop-Built Preseparator Canister



removable lid. A pair of 4-in.-dia. ABS or PVC fittings are installed into the lid of the canister, as shown in the drawing above. A PVC elbow installed in the top of the can provides an intake; turning the elbow as shown creates a rudimentary cyclonic action. A 4-in. connector fitting mounted into the top of the can provides an exhaust for the hose that connects to the blower.

If you don't care to build your own setup, you can buy a commercially made preseparator lid (see Sources of Supply on p. 195), as shown in the photo on the facing page. This molded-plastic device fits atop a regular 30-gal. steel trash can. It comes with ports sized to accept 4-in. hoses, but you can use special reducer fittings designed for inexpensive flexible hose—or cobble up connectors using regular PVC or ABS plumbing fittings—to adapt the ports to accept other-diameter hoses. You'll get slightly better performance if you run some wide, thin weatherstripping around the inside rim of the lid so that it seals better to the top of the can. The lid comes off

easily for emptying the can. Disposal is even neater if you line the can with a disposable plastic garbage bag.

DROP BOXES

In lieu of a preseparator canister, you can build a simple drop-box preseparator. A drop box, as shown in the drawing on p. 108, is essentially just a box with an intake, an exhaust, and an internal baffle. For best performance, the size of the box and the proportions of the box's width to baffle length should be calculated using the formula shown. While relatively crude and easy to construct, an airtight drop box is capable of removing up to 60 percent of wood particles from the air ahead of the system's blower and filters.

As in a regular cyclone, coarse dust and shavings drop out and fall to the bottom of the box. To make disposal neater and more convenient, build a chute into the drop box so that debris is deposited directly into a bin. Alternatively, you can build the box to fit atop one or more drums. I once saw a drop box installed in a second-story shop with a chute underneath that opened to deposit chips directly into the back of a pickup truck for easy disposal.

Collector Filtration

Unless you live in a temperate climate where you can simply run the exhaust from your central collector directly outdoors, adding a filter is the last step in creating a closed-air loop between the dusty air collected at your machines and the clean air that's returned to your shop. A good filter removes the very fine respirable dust from the airstream (preferably after most sawdust and chips have been removed by preseparation), transforming it into clean air that's perfectly healthy to breathe. To ensure optimal system performance, you must choose your filter system carefully, as well as match the amount of filtration to the size of your system.

There are lots of different filter media to choose from, either for replacement filter bags for an off-the-shelf system or for a custom filter assembly you build yourself. Also, there are several ways that you can increase the filter area and improve system performance without taking up too much shop space.

FABRIC FILTERS

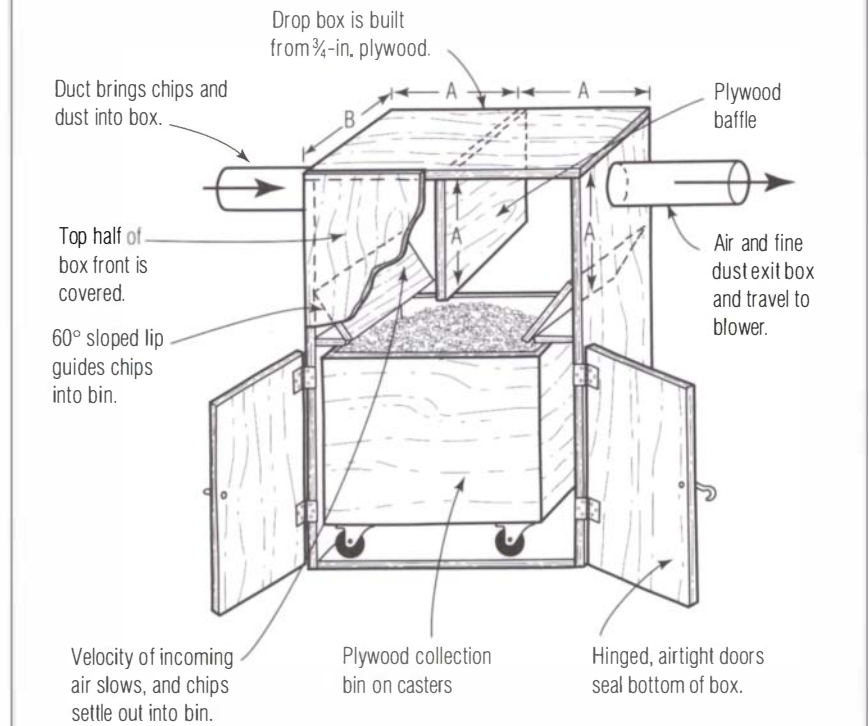
The most common way to filter dusty air is to pass it through fabric filter material. Fabric bags are standard on most small-shop collectors; on single-stage units, bags serve as collection bins as well as filters. Alternatively, filter-material tubes can be attached to a box called a plenum that distributes air to multiple filters, an arrangement commonly called a filter-bag house.

Among the dozens of fabric materials available for industrial dust and fume filtration, four are commonly used for woodshop filter bags and tubes:



A dust preseparator canister lid fits atop a standard galvanized trash can and adds capacity to a small collection system as well as preseparation ahead of the blower.

Drop-Box Chip Preseparator



Dimensions for A and B

$$\frac{\left(\frac{\text{cfm of blower}}{500} \right) \times 144}{A} = B$$

Example: for 800-cfm blower and 16-in.-deep box ($B = 16$)

$$\frac{\left(\frac{800}{500} \right) \times 144}{A} = 16 \qquad \frac{230.4}{A} = 16 \qquad A = \frac{230.4}{16} \qquad A = 14.4 \text{ in.}$$

cotton sateen, woven polyester, knitted polyester, and felted polyester (see the photo at left on the facing page). Each is discussed here, arranged in order of filtering efficiency:

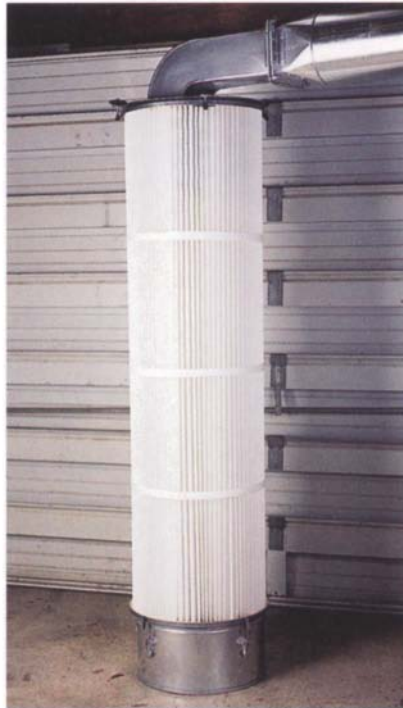
- **Cotton-sateen fabric**, or cotton duck, is a canvaslike material that was often used in years past for filter bags on some of the less expensive collectors. Cotton bags are inexpensive and work fine for collecting chips and sawdust, but they do a poor job of filtering fine dust. Particles smaller than $30\mu\text{m}$ are typically blown right through the weave (remember, particles smaller than $10\mu\text{m}$ tend to do the worst respiratory damage). For-

tunately, many manufacturers and tool dealers offer better-filtering polyester fabric bags as optional replacements for cotton bags.

- **Woven-polyester bags** have replaced cotton bags on many single-stage chip collectors as the price of cotton has gone up in recent years. Woven polyesters are slightly better at handling fine dust than cotton fabrics, but neither fabric is manufactured to industrial specifications for filtering wood dust. Woven polys are durable—a plus on two- or four-bag single-stage collectors, where the lower bags serve as dust bins as well as filters.
- **Knitted-polyester fabrics** are durable and very good at filtering out respirable dust particles. Knitted filter bags are thick woven and look something like giant tube socks. Sometimes, carbon fibers are incorporated in the weave to help dissipate static-electric charges. While good for handling a moderate volume of fine dust, knitted polys are not widely used for woodworking filter systems.
- **Felted-polyester filter fabrics** come in a wide range of weights and types that are designed and manufactured specifically to meet the filtration needs of the woodworking industry. The feltlike fabric is matted together from countless fine polyester fibers pressed into a thick material. While



Not all filter fabrics are equally effective at straining respirable dust from the air. Here are four popular fabrics for dust filtration, arranged from worst to best filtration (from top to bottom): cotton sateen, woven Dacron®, knitted polyester, and felted polyester.



Packing lots of fine-filtering into a compact package, a pleated filter does a great job of cleaning the air exhausted from a central dust-collection system. A single, tall pleated filter replaces several large filter bags and fits into a fraction of the space.

Use Special Fabric Dust Bags

If you want to fit filter bags or tubes to a new system or retrofit the bags that came with your collector, your best bet is to buy them from one of the many companies that sew filter bags for industry (see Sources of Supply on p. 195). These companies stock fabrics that are specially designed for dust collection. They offer many styles and sizes of bags or tubes and can usually make bags to suit custom applications.

more expensive than knitted polys, felted polyester fabrics really shine when it comes to fine-particle filtration. They are used almost exclusively in large industrial systems and are readily available for smaller systems as well. They're available as an option on some collectors. Filter bags or tubes sewn from a 12-oz. or 16-oz. felted fabric are a terrific choice, whether you're buying filters for a new central collector, upgrading an existing system, or building a bag house for a new system. Singed or glazed felted filter fabrics, which have been melted slightly on the inside surface by briefly exposing the fabric to a flame, release dust cake readily, making them a good choice for systems that handle lots of fine sanding dust.

PLEATED-CARTRIDGE FILTRATION

Cartridge filters have been used in lieu of dust bags in industrial dust-collection systems for many years. More recently, they've been developed specifically for smaller woodworking shops. Much like a pleated filter used in a shop vacuum, cartridge filters squeeze a lot of filter surface area into a small physical package, which makes them a good choice for cramped shops. The self-contained Oneida 1½-hp cartridge collector (shown in the photo on the facing page) incorporates an internal spun-bond polyester filter that cleans fine dust from the air discharged by the unit. Oneida also offers a large freestanding cartridge filter (see the photo at right on p. 109), which connects to an existing two-stage system (up to 3 hp) in place of the filter bags or bag house. Although more expensive than standard bags, pleated cartridges have excellent fine-dust filtering abilities and have a Teflon® nonstick coating inside that makes them easy to clean: Just blow with compressed air occasionally to dislodge fine dust cake.

DUST CAKE AND FILTER CLEANING

As counterintuitive as it sounds, the small-particle capture ability of the filter media in a good dust-collection system actually improves as the filters get dirtier. This is because the film of dust, or dust cake, that forms on the inside of a filter bag begins to act as a sort of filter itself: The accumulated particles block the passage of progressively finer and finer particles (see the drawing on p. 42). Unfortunately, in small collectors with a less-than-optimal amount of filter surface area, the chips and dust cake that accumulate inside the bags just make it more difficult for clean air to exit through the filter media. This restriction in airflow, known as filter blinding, creates more pressure inside the bag, which the blower must work harder to overcome. The end result is a drop in the overall performance of the dust-collection system. An unfortunate health consequence of higher bag pressure is that it tends to push fine dust particles right through the filter media and into the air (infiltration).

There are two ways to minimize system pressure losses and particle infiltration: One is to make sure you have enough filter area to handle the volume of air passing through your filters. The more surface area a filter has,



A cartridge filter made for central dust collection is much like a pleated filter used in a shop vacuum. Here, woodworker Matt Bays replaces the filter in his Oneida cyclone/blower, which uses the cartridge in lieu of filter bags.

the more minute passages it has for air to flow through it (see the sidebar on p. 112). The other way to minimize pressure losses and particle infiltration is to clean the filters regularly. In industrial dust-collection systems, filter bags or tubes are cleaned by means of special devices, such as shakers, pulse jets, and reverse air systems. In a small shop, the standard cleaning method is to grab a filter bag or tube and shake it gently. The secret is to remove the excess buildup yet leave a fine layer of the dust cake intact, so that the bag's extra-fine particle-filtering ability continues to work.

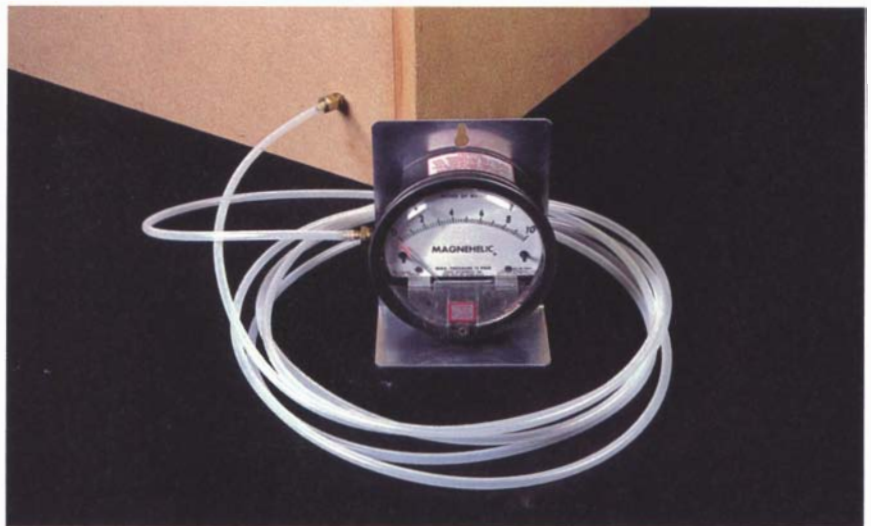
When do filters need cleaning? Generally, the more fine dust that is collected, the more often the filters in any collection system need atten-

How Much Filter Area Does Your System Need?

IT'S IMPORTANT FOR ANY DUST-COLLECTION SYSTEM to have an adequate amount of filter surface area to reduce air pressure caused by the natural buildup of dust cake as the filters get dirty. The amount of filter area, measured in square feet of fabric (cartridge filters are rated by their equivalent square-foot area), is always considered in respect to the system's air-handling capacity (in cfm) and stated as a ratio of "air to cloth." To calculate the air-to-cloth ratio, divide the cfm of the collection system by the number of square feet of filter area. For example, an 800-cfm system with 100 sq. ft. of filter has an 8:1 air-to-cloth ratio, or 8 cfm for every 1 sq. ft. of filter.

Note that the ratio changes depending on how much air is actually moving through the system. Your collection system may have a high air-handling capacity (say, 1,200 cfm), but if you use only one machine at a time, your air-to-cloth ratio should be based on the volume of air used by your largest dust source (say, a planer that uses 500 cfm).

What's the best air-to-cloth ratio for your system? A ratio of 10:1 is a good choice for an average system, and it's easy to calculate: Just take the system's cfm and discard the last digit. However, employing this ratio requires that two conditions be met. First, your filter bags should be made of 12-oz. or 16-oz. felted-filter fabric or other industry-rated medium (see p. 107). Second, large shavings and coarse sawdust must be removed ahead of the filters by preseparation (via a cyclone, drop box, etc.). Systems that must handle great amounts of very fine sawdust or sanding dust, such as from working MDF or solid-surface materials (e.g., Corian®), will do better to use a lower air-to-cloth ratio (more filter to cfm), such as 7:1, to handle the greater volume of fine particles. When in doubt, add more filters; they can only improve your system's performance and efficiency.



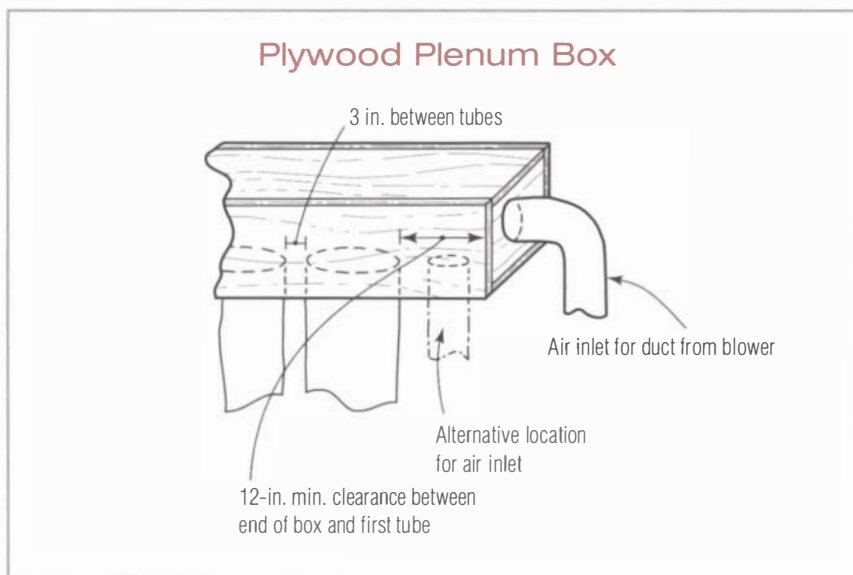
Running a small hose from a filter plenum to a Magnehelic gauge allows you to monitor pressure inside a filter-bag house. When the gauge shows that pressure is up, it's time to clean or replace the filters.

tion. Because they clog more quickly, you should empty the lower bags on single-stage systems when they're only one-third full and shake the dust buildup from both upper and lower bags. After a time, most filter materials clog to the point that they need replacement. When replacing pull-on bags, make sure the straps are tight: A loose strap may allow a bag to blow off, which will send a torrent of chips and dust all over the shop.

If your filter assembly is a large bag house (see the following section), a more reliable way to tell when your filters need attention is to use a static-pressure gauge, such as a Magnehelic® (see Sources of Supply on p. 195). A small-diameter flexible hose connects the gauge to the bag house, allowing the Magnehelic to measure the amount of pressure inside (see the photo on the facing page). As the filters clog, the pressure goes up. By marking the needle's position on the gauge dial when the filters are new, you'll know it's time to clean the filters when the gauge shows a 75 percent to 100 percent pressure increase. If pressure doesn't decrease significantly after filter cleaning, it's time to replace the filters.

FILTER-BAG HOUSES

Once you have calculated how much filter area your system needs (see the sidebar on the facing page), it's likely you'll want to increase the filter area your system has. An easy way of nearly doubling the amount of filtration in a single-stage collector is to remove its standard bags and retrofit over-size replacement bags (see the photo on p. 114). Oneida sells replacements that fit most single-stage collectors (see Sources of Supply on p. 195); they take up a lot more shop space than stock bags, but they're worth it. Cartridge filtration is another way to add lots of filter area in a small package (see p. 110).





Oversize replacement filter bags (left) help chip collectors perform better in two ways: Their thick, felted fabric traps fine, respirable dust, to keep the air cleaner, and their large size provides more surface area for clean air to escape through, thus improving the efficiency of the collector. The lower bag also provides more chip-holding capacity.

A better way to add more filtration in a compact space is to replace your system's one- or two-bag filter with a bag house. A bag house fitted with many small-diameter filter tubes or bags packs lots of filter surface area into a small physical space. The bags or tubes attach to an airtight box called a plenum, which receives air from the blower. A plenum box reduces the velocity of the dusty air entering it, eliminating particle infiltration due to high-speed air blowing directly against the inside of the bags. Also, a plenum box distributes the air to multiple filter bags, spreading dust cake more evenly and reducing filter clogging. The only shortcomings are that multiple filters are time-consuming to clean and costly to replace.

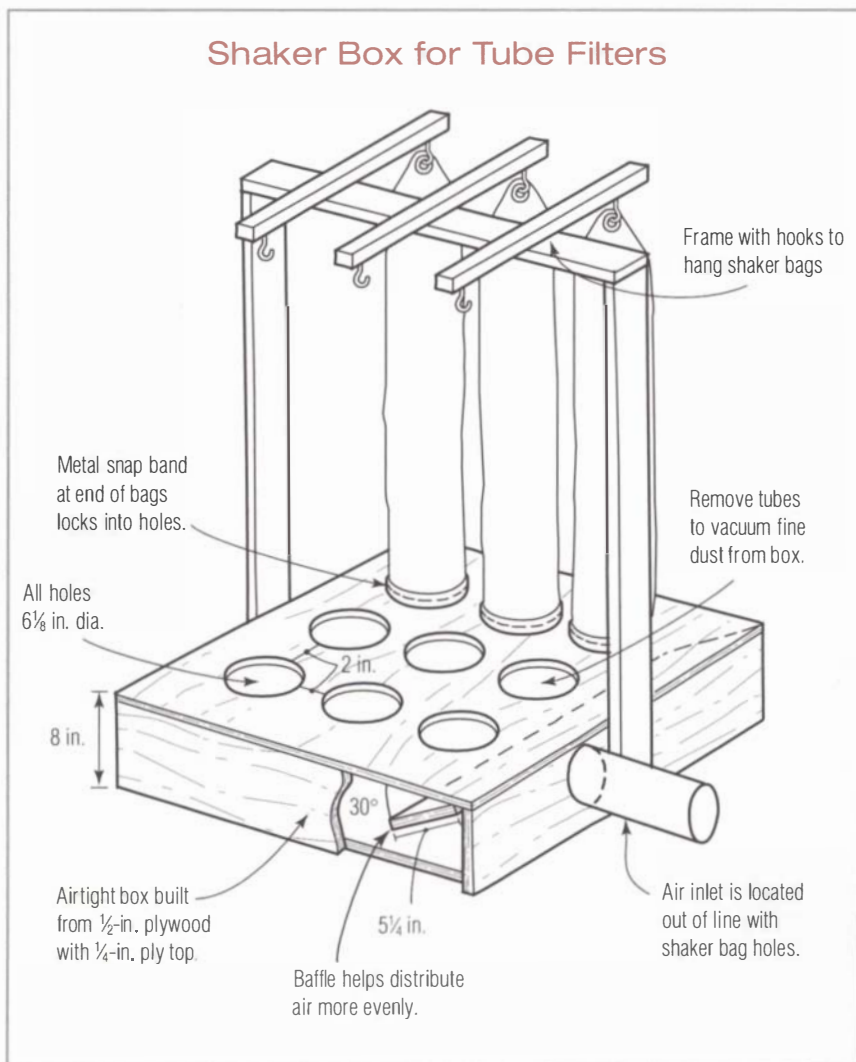


A plenum box provides mounting and air distribution for a series of tube filters. Made from plywood or purchased as a sheet-metal box or tube (as shown here), a plenum can be hung from the wall or ceiling.

Plenums and shaker boxes There are two popular plenum designs for bag houses that use filter tubes. A plenum box mounts to a ceiling or wall in the shop with filter tubes mounted below it. You can buy a rectangular or tubular sheet-metal plenum, such as the one shown in the photo above (see Sources of Supply on p. 195), or build a plywood plenum box yourself (see the drawing on p. 113). The filter tubes attach to metal flanges called thimble rings (available from Oneida). The open-bottom ends of the tubes fit over inexpensive 5-gal. plastic pails, which collect fine dust. Adjustable hose clamps secure the tubes to both the thimble rings and the pails. Unless massive amounts of sanding dust are collected, the pails only need emptying once in a while.



The small-diameter filter tubes that attach to a shaker box provide lots of surface area for clean air to escape through the filter fabric. The open end of each tube has a springy metal band inside, which locks into a hole to seal the bag to the plywood shaker box.



Another style of plenum commonly used for bag houses is the shaker box, such as the one shown in the drawing above. This device consists of a plywood box with two posts that rise up to support cross members from which tube filters are suspended by hooks through grommeted holes. You can also buy ready-made sheet-metal shaker boxes. Each small-diameter tube filter has one end sewn shut and a grommet for the hook from which it hangs. The open end of each tube has a springy metal band inside that snaps into a hole in the shaker box (see the photo above) for a dust-tight fit. The shaker box gets its name because dust shaken out of the tubes during periodic cleanings falls into the bottom of the box. You can clean the box by occasionally snapping out a few of the tubes and vacuuming them clean, or you can build a tight-fitting dust door or drawer into one end to allow easy disposal.

Designing a Central Collection System

A central collection system is a lot like the human circulatory system: A collector works like a heart to pump dust and chips through a series of ducts that branch out around the shop like veins and arteries. Smaller branch ducts from each machine (or group of machines) connect to a larger main duct that conveys all debris back to the collector. The sawdust is then filtered from the clean air, which is usually pumped back into the shop. But like a cardiac patient with arterial constriction, a poorly designed ductwork system won't convey dust effectively, and it can clog up entirely (in both the analogy and the example, this could result in a heart attack!).

This chapter will take you through all the steps required to design a central dust-collection system for a small- or medium-size shop, from laying out the ductwork to determining the right-size collector to run it. This book does not cover dust-collection systems for large commercial shops, which have more complicated needs.

If you've flipped through this chapter and seen all the math and calculations used for designing a central system you might think "Hey, is all this really necessary for a small-shop dust system?" For small-shop owners looking for an easier way to create a modest but effective small-shop system, I've included an easy out: a simple set of system guidelines on p. 118, which allows you to build a reasonably effective system without complicated calculations. Another alternative is to let someone else design your system for you; see the sidebar on p. 119. Whether you choose to follow my streamlined approach, adhere to the traditional calculation method, or get someone else to design the system for you, it's still a good idea to read

Simplified Central Collection for Small Shops

IF YOU'RE A HOBBYIST OR WEEKEND WOODWORKER looking for a basic central dust system that will keep the chips from piling up on the floor (and keep the lion's share of fine dust out of the air), then you can skip all the complicated math just by carefully following the plan of attack outlined in this section. The following seven steps will help you create a simple but effective collection system that will work in most small woodshops that are about the size of a two-car garage (or smaller) and have one person working on only one machine at a time.

To achieve success, keep in mind three caveats to this approach: The central collector should be located no more than 35 ft. from the farthest machine; collection should be from only one machine at a time (blast gates to other machines must be closed); and the biggest dust-producing machine on the system should put out no more dust than a 12-in. thickness planer or small shaper would produce.

Even if you decide to follow this abbreviated design process, you should still read through the sections on system design (branch- and main-duct sizing and pressure loss on pp. 135-146) because you'll glean many good suggestions for improving system performance and ease of use.

Seven Steps to a Good Small-Shop System

1. Choose a 1½-hp to 3-hp collector that delivers at least 600–800 actual cfm at around 5 in. or 6 in. of static pressure (see pp. 100–101). Mount the collector in a safe location that's reasonably close to the machines it will service (see p. 124).
2. Make sure that the collector has filters made from 12-oz. or 16-oz. felted-polyester filter fabric. The filter bags should be big enough so that there's 1 sq. ft. of fabric for every 10 cfm of air movement (see the sidebar on p. 112). If you're going to use a single-stage chip collector, you'll need to add oversized felted filter bags or a separate bag house (see p. 113).
3. Run a 6-in. main duct from your collector and use the table on pp. 136–137 to size each branch duct. Use rigid ductwork (preferably not plastic) for all main and branch ducts. All branches should join the main duct via 45-degree lateral tees.
4. All ducts should run as straight as possible to reduce static-pressure losses. A change in duct direction should be made with either a large-radius 90-degree elbow or with two 45-degree elbows (see p. 132).
5. Use only short (2½-ft. or less) lengths of flexible hose when connecting the machines to their branches, and fit a blast gate at each machine. Install efficient hoods and pickups on the machines that aid chip capture, but don't starve the system of air (see chapter 9).
6. Follow good practices for installing, grounding, and sealing the system, as described in chapter 8.
7. If the system doesn't work as well as you'd like or the collection at some machines is better than at others, read the section on tweaking your system, as well as the discussion of what to do if your collector is underpowered (p. 161).

Getting Help

IF JUST LOOKING AT ALL THE PAGES OF CALCULATIONS ahead makes you feel woozy or nauseous, fear not; there's help at hand. If you don't want to get in over your head or if you need help, talk to an air-handling expert at a company that sells dust-collection components (check the Sources of Supply on p. 195) or look under "Dust and Fume Collection" in the Yellow Pages®. Air-handling personnel are specialists at designing collection systems for all kinds of shops and factories, not just woodshops.

Better yet, why not let an expert design your system for you? If you are willing to commit to buying and installing a central collection system, dust-collection system suppliers such as Oneida (see Sources of Supply) are happy to do the dirty work for you. You can send them a rough drawing of your shop—showing the location of machines, where the central collector will be placed, where you want extra branches for vac hoses or sanding tables, etc.—and they'll do all the engineering for you, either free of charge or for a small fee. You'll receive an engineered system-layout drawing and a comprehensive materials list. If you have access to the Internet, Air Handling Systems (www.airhandlingsystems.com) has an interactive site that lets you lay out your shop and ductwork; the program then calculates your needs and generates a materials list.

through this entire chapter. The sections that follow will inform you of the design procedures and elements that are combined in a good central collection system. Examples included at the end of the chapter will give you an idea of how a few real-world woodshops handled the design process and the systems they ended up with. These are included not to provide you with set plans for a system (small changes can lead to big complications) but to show you the real systems that woodworkers installed using the design process described in this chapter.

The Design Process

In order to operate at peak efficiency—and make best use of the power of a central collector—the network of ducts and hoses that connects all shop machines and workstations must be properly designed. Proper design means that the sizes, lengths, twists, and turns of both the branch ducts and the main duct should be calculated and specified according to the established rules and formulas of air-handling systems.

However, anyone who has casually flipped through the pages of *Industrial Ventilation: A Manual of Recommended Practice* (the textbook, assembled by the American Conference of Governmental Industrial Hygienists, that is considered the technical bible on air-handling systems) might hazard a guess that brain surgery would be less complicated than

Permits and Approval

AN IMPORTANT ITEM TO CONSIDER WHEN INSTALLING a central collection system is the legal impact on your home or business. If a fire starts in your home shop, will your insurance be voided whether or not it started because of an unapproved central collection system? If you operate a medium-size business and install a fairly large collection system, you might run afoul of local building ordinances if you don't have a permit.

So, before you dive in, check with your local building department and fire marshal to see if you need a permit and to make sure the system that you plan to install meets local building and fire codes. In the case of home shops, you'll also want to check with your insurance company to find out how system installation might affect your policy.



Sizing pipe and specifying fittings are the first steps toward assembling an efficient central ductwork system. Shown here are the various components needed for a typical small-shop system: spiral pipes, elbows, taper tees, connectors, reducers, and blast gates.

designing a central collection system. Indeed, performing all the calculations necessary for a complex system can get far more involved than most pamphlets or magazine articles on dust collection would have you believe.

Fortunately, designing a simple dust-collection system doesn't have to be difficult and can be accomplished with a minimal amount of mathematical knowledge or background. By "simple," I mean a collection system where only one machine is used at a time or where only the machines on one branch of the system are used at a time. Larger, industrial systems are usually designed for running all or most machines at once and must be

designed for balanced airflows and specially stepped main lines—a complicated task well beyond the scope of this book. To make the process of designing a small-shop collection system easier, I've broken it down into seven steps:

- Step 1: Draw a layout of your shop showing the location of all the machines that will be hooked to the system (see the following section).
- Step 2: Decide on the location of the central collector (see p. 124).
- Step 3: Design a rough, general layout of the ductwork (see p. 127).
- Step 4: Work out the details of duct layout and connections (see p. 130).
- Step 5: Size pipe for all the branch ducts (see p. 135), then the main duct (see p. 135).
- Step 6: Calculate the static-pressure losses in the system (see p. 138).
- Step 7: Choose a central collector that suits the size and capacity of the system (see p. 141).

Once you've completed these design steps, it's important to consider any permits or approvals you need to obtain before you compile a final materials list and buy the necessary components (see the sidebar on the facing page). Then, you'll be ready to install and test your system, as described in chapter 8. Information on building hoods and dust pickups for connecting your ductwork to your machines is given in chapter 9.

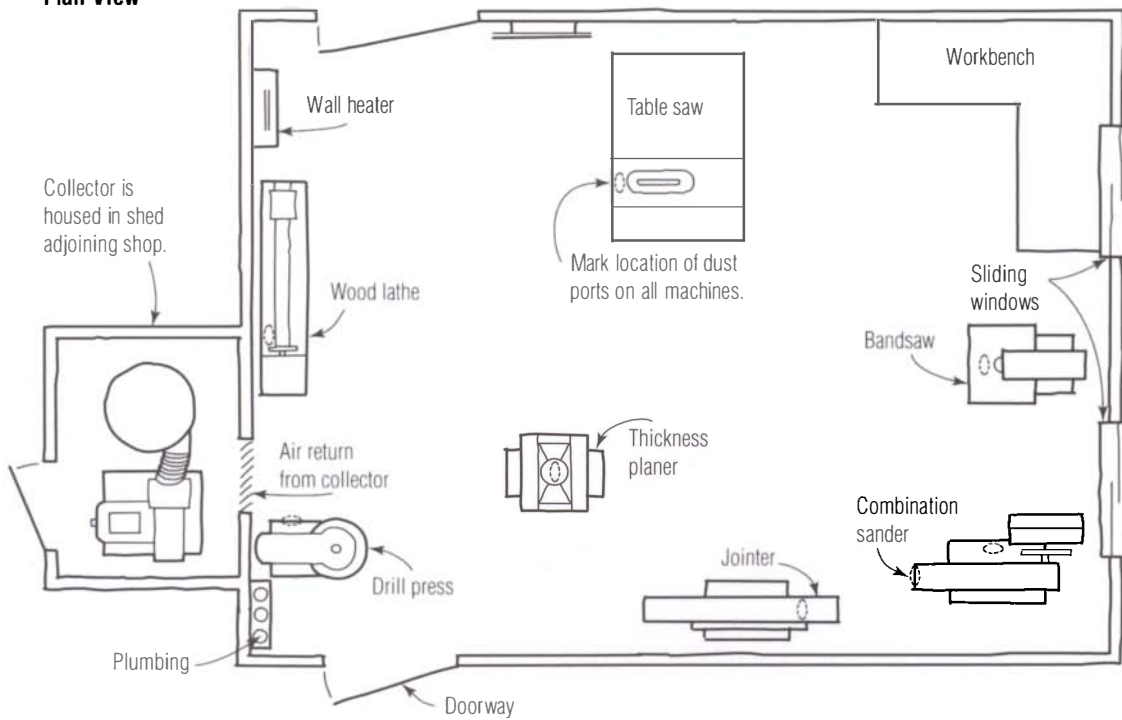
Step 1: Making Shop-Layout Drawings

Just as you would draw up plans before building a cabinet or a piece of furniture, you should make a drawing of the layout of your shop as the first step in designing your central collection system. This drawing should include:

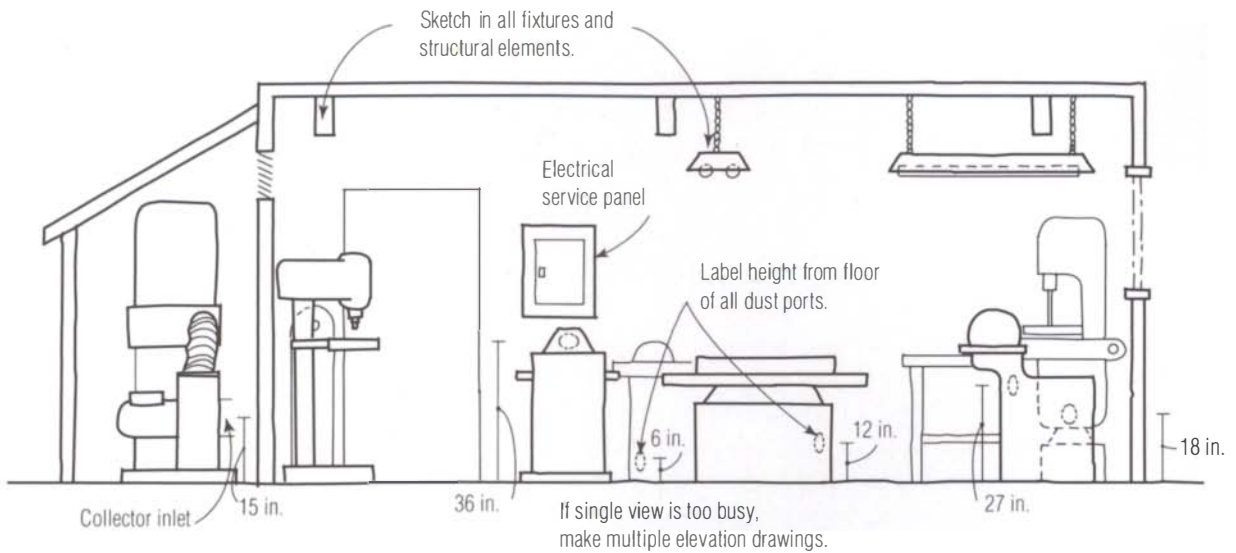
- A plan view (from overhead) and an elevation view (from the side) of your shop (see the drawing on p. 122). You may need to draw two or three elevations (north wall, west wall, etc.) for a less-cluttered view. Include any sheds or adjacent structures that will house ductwork or your collector. Make sure to include the location of all doors and windows, as well as permanent light fixtures.
- A sketch of all machines in your shop that will have ductwork running to them, as well as any machines that might interfere with duct runs. Include the position of the machine's dust port or proposed hood location. The machines don't have to look realistic; labeled boxes are usually good enough. Also note any locations where ductwork would interfere with the operation of machines—such as an area around a sliding table on a table saw, which must remain unobstructed.

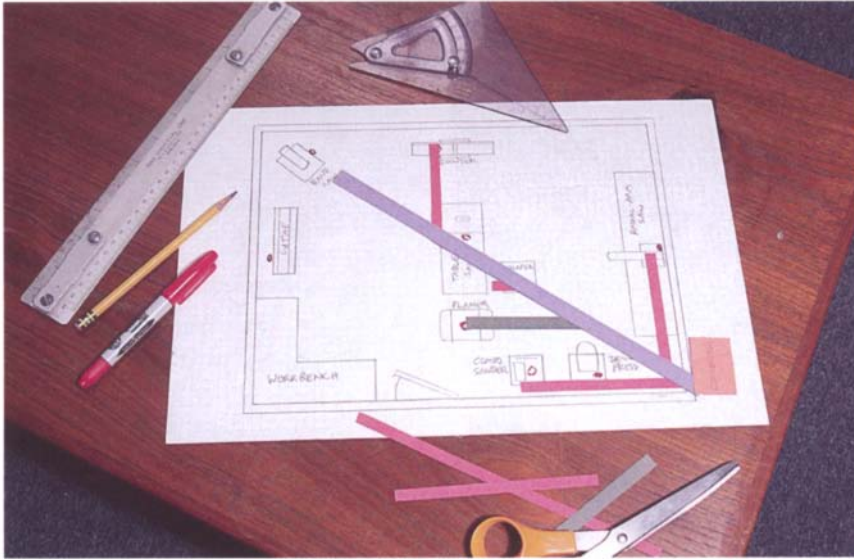
Shop-Layout Drawings

Plan View



Elevation View





Carefully planning your central dust-collection system's layout goes a long way toward preventing future problems and headaches. Colored paper-strip "ducts" laid on a scale drawing allow you to experiment with different arrangements and duct-routing schemes.

- The position and dimensions of any structural elements, such as beams, rafters, joists, posts, or soffits, as well as existing plumbing or electrical lines that might interfere with duct runs. If ductwork will be installed beneath the floor, include floor joists, ledgers, pipes, and heating ducts on your drawing, as relevant.

You can make your sketch or drawing on any kind of paper, or do the sketch on a computer using drawing or computer-aided design (CAD) software. I like to sketch on graph paper with a main grid of $\frac{1}{2}$ -in. squares and $\frac{1}{8}$ -in. subdivisions (commonly used for architectural drawings). Using a scale of $\frac{1}{2}$ in. equals 1 ft., you can usually draw an entire small shop on a single 11-in. by 14-in. sheet yet still sketch in all the relevant details without the need for a magnifying glass.

Producing an accurately rendered shop-layout drawing is the groundwork for developing a detailed plan for the location of your collector and the layout of the ductwork around the shop, as outlined in the next two sections. To avoid a lot of erasing during the design phase, I suggest you sketch your collector/ductwork ideas on sheets of inexpensive translucent tracing paper taped over your shop layout. That way, if an idea doesn't pan out, you can simply remove the tracing paper and discard it. Also, you can easily compare and contrast the relative merits of two different designs by alternately overlaying them (most CAD programs allow overlays as well). The tracing-paper method also makes it easier to revise the shop-layout drawing should you decide to move machines around to better suit the proposed collection system.

Step 2: Locating the Central Collector

Before you lay out your collection system's ductwork, it pays to consider carefully the location of the central collector. Your decision will likely affect both the performance of the system and the convenience of operating it. Choosing a spot that physically best accommodates your collector is no good if it requires a complicated layout and makes for poor collection from some or all of your machines. And locating a collector centrally (for optimal duct runs and best performance) is no advantage if its noise level keeps you from switching it on or if the collector is an obstruction that interferes with work. There are several factors to consider before deciding on a final location for the collector, including available space, proximity to machines, noise level, and the need to return clean air to the shop.

AVAILABLE SPACE

In most small shops it's hard to find room for a collector. Of course, space is a bigger issue if you're going to try to shoehorn a 3-hp single-stage col-



Separate components let you fit all the items needed for an effective central collection system into a relatively small space. Here, a blower is mounted on a shelf above and in close proximity to the cyclone and filter bags that connect to it.

lector (with its four large filter bags) into a one-and-a-half-car garage shop than if you're considering buying a compact barrel-top collector. Assembling a collector from separate components—blower, cyclone, and filter bags or bag house—lends a lot of flexibility because the various components can be located wherever they best fit the space available: under benchtops, in corners, or hung from the ceiling. (If you take this route, components should be mounted reasonably close to one another to keep static-pressure losses low; see p. 138.)

Another way to conserve valuable shop real estate is to locate your collector—all of it or part of it—in a space adjacent to your shop: a closet, a shed, or a space under a stairway. Just make sure to consider noise and air-return issues, as discussed in the following sections. Also keep in mind that, in cold climates, any metal components that are mounted outside (ductwork, cyclones, etc.) should be shielded from the elements and/or insulated against heat loss as warm shop air circulates through them.

PROXIMITY TO MACHINES

The farther a dust collector has to convey dust and chips through ductwork, the more power it requires. Therefore, for greatest system efficiency, it's best to keep duct runs as short as possible. This calls for some compromises when the ideal location for the collector doesn't coincide with the ideal location for the ductwork's main line. The issue will be more acute if you work in a really big shop, where the central collector may end up 65 ft. from the nearest machine it's going to serve or if you're trying to squeeze the best possible performance out of a small collector.

NOISE LEVEL

When you add up the whoosh of moving air and the whine of a motor and fan, central collectors can get pretty noisy. Noise can be a problem whether you locate the collector inside the shop (and must suffer with the accumulated din of machines and the collector) or outside (and have to deal with neighbors' complaints). You can quiet either an in-shop or outdoor unit by building an enclosure around it (see the photo at right). The enclosure will better attenuate noise if lined with soundboard or acoustical foam (see the vacuum enclosure on p. 87). If the enclosure is sealed, you must provide a way for air to return into the shop or escape outdoors. A louvered vent, such as used to ventilate a laundry room, can be installed over an opening for exhaust air. Ideally, the vent should be about 10 times as large as the cross-sectional area of the collector's intake duct.

EASE OF DISPOSING CHIPS

Locating all or part of your collection system outdoors or in an adjacent shed with good access not only saves valuable shop space, it also makes it easier to dispose of sawdust. When it comes time to empty dirty filter bags or collection bins, the clouds of dust you raise won't be inside the shop.



Building a movable enclosure can cut down on the noise created by a dust collector located inside the shop. The plywood box shown here has notches cut in the sides, to allow it to fit tightly against the wall, and is fitted with wheels for quick access to the collector.



For a “return air” system, ductwork feeds clean air back from the cyclone/blower (located in a separate shed or outbuilding) to the filter-bag house mounted inside the shop. A return-air system keeps heated, cooled, or dehumidified air circulating, instead of blowing it outdoors.



Mounting a central collector's blower and cyclone outdoors is perfectly acceptable for mild-climate shops that don't require heating or cooling. Chips may be deposited in bins or in a pile on the ground, as shown here, for easy disposal.

If you live in a warm, dry climate, you can probably get away with using a filterless collection system located outside your shop where it exhausts air directly outdoors. In the system shown in the photo above, the cyclone deposits chips directly into a pile on the ground.

RETURNING CLEAN AIR TO THE SHOP

If you live in an area with cold winters and/or hot summers, you'll want to return the clean air exhausted by the collector's filters back inside the shop. Otherwise, you'll need to heat (or cool and possibly dehumidify) the fresh air drawn in to replace the air that the collector has sucked out of your shop.

If you've chosen to save space by using separate collector components and locating the blower and/or cyclone in a separate outbuilding or outside, you can simply run a duct back into the shop and mount the filter-bag house inside. If you live in a cold or hot climate, you'll want to insulate any exposed ductwork and components (such as the cyclone), so that the air passing through them isn't cooled or heated excessively before it returns to the shop.

If you live in a temperate climate and have decided against an air-return system, it is imperative that you provide replacement air for the air removed from the shop by your collector. The replacement air can be supplied through a filtered vent or an open window. Air replacement is crucial if your shop has ventilation pipes for water heaters, furnaces, or stoves.

Fire Hazards

BECAUSE OF THE FIRE AND EXPLOSION HAZARDS associated with fine dust, never locate a collector near a source of sparks, such as a welding bench or grinding wheel, or near an open flame, such as from a water heater, stove, or furnace. Also, never store combustibles, such as rags and finishing materials, in the same area as the collector.

A forced downdraft caused by inadequate air replacement could bring smoke and/or toxic fumes into the shop when the dust-collection system is running.

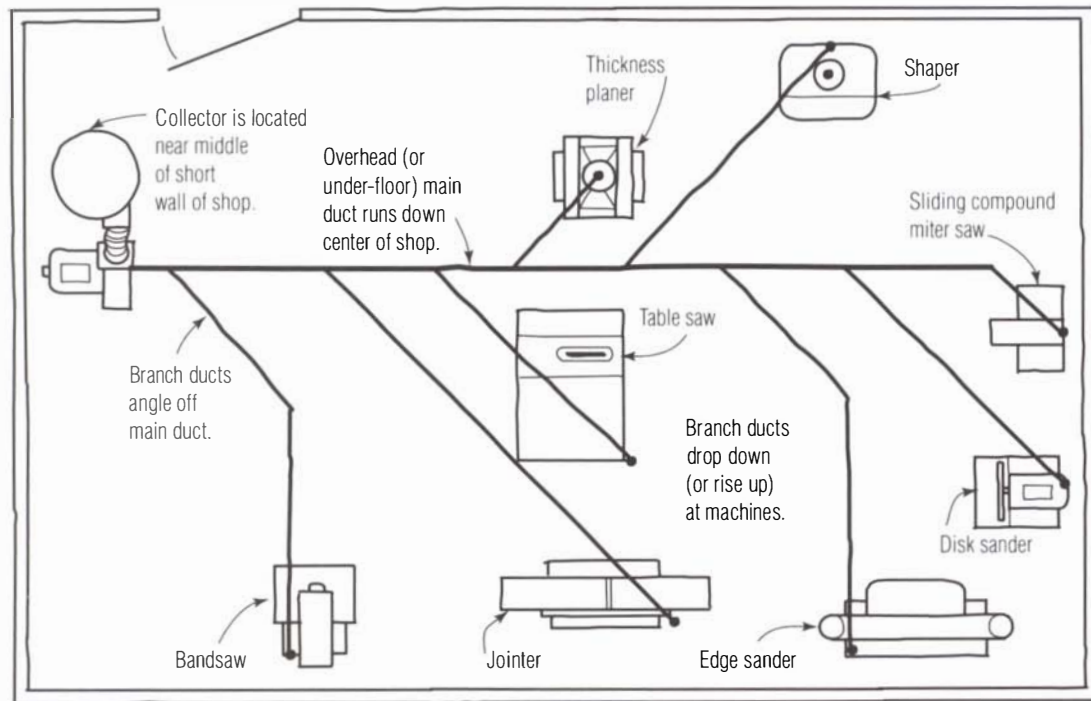
Step 3: Basic Layout of the Ductwork

Once you've got a pretty good idea of where you're going to put your collector, you're ready to lay out the ductwork to the machines. By now, you've probably decided on the height at which your ductwork will run; most woodworkers install their systems either above their machines, hanging ductwork from rafters or ceiling joists, or under the floor, suspending ductwork from floor joists. Hanging ductwork above machines is easy and convenient (you can even run ducts through attic spaces in shops with low ceilings), but branches that drop down to machines that are in the center floor area may get in the way. Under-floor installations solve this problem but are more time-consuming to install, unless you have a basement or large crawl space beneath the shop. It is also possible to install ductwork in a new cement-slab floor; consult your air-handling specialist for details.

Whether the collection system is in a small shop or a large factory, it is designed with two kinds of ducts: the *main* duct, a single large pipe that runs from the collector through the length of the shop, and the *branch* ducts, multiple smaller pipes that connect each machine to the main duct. The ductwork system resembles the branches of a tree, with branch pipes running diagonally or perpendicularly from the main line to the area of the machine. A vertical pipe then drops down (or comes up through the floor) to a convenient height for fitting a blast gate and a short (1½-ft. to 2½-ft.) length of flexible hose to connect the machine to the branch (see p. 155 and p. 158).

For now, you'll just be sketching in the proposed location of main and branch ducts as simple lines on both the plan and elevation drawings. To make things simpler when selecting fittings later, you'll want lines that represent a duct turning a corner to bend only at either 45 degrees or 90 degrees and lines depicting merging ducts to meet at 45 degrees (90 degrees only when absolutely necessary), with the angle pointing "downstream" (toward the collector; see the drawing on p. 128, for example). Try to make all your duct runs as short as possible: The longer the duct, the more energy it will take the collector to convey dust and chips from the machine. Also, try to make all your duct runs as straight as possi-

Central Main-Duct Layout



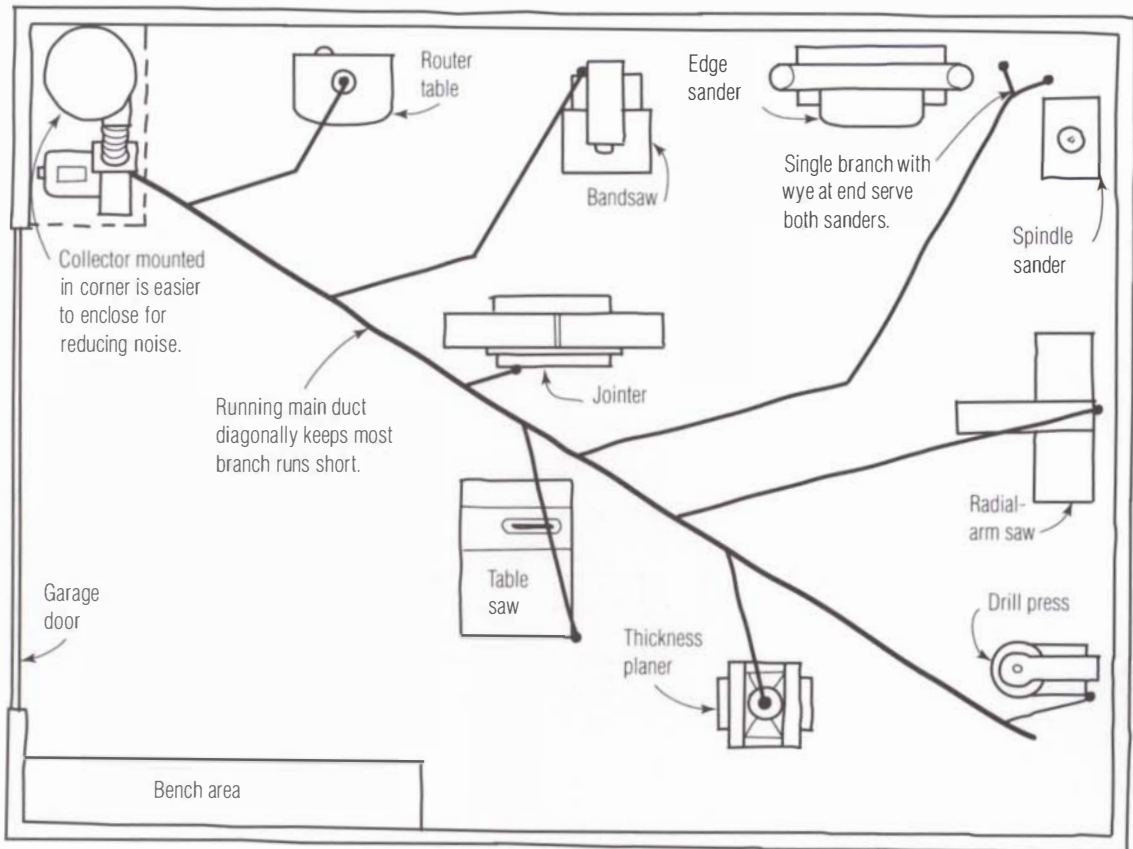
ble; every single twist and turn that the ductwork takes will require more collector energy.

The following scenarios are illustrated to give you some idea of different ductwork-layout strategies. Each has advantages that make it more suitable in some shop situations than in others.

Central main duct The drawing above shows one possible layout with the main line running directly across the center of the shop. This layout works best if most machines are grouped somewhere near the center of the shop (especially if they are in line), away from the walls, and there's room for a collector along the short wall or in an adjacent outbuilding. It provides for the shortest possible main line, with branch lines that drop (or rise) in the center of the shop or along walls as needed. But if your shop is wide and the machines are far apart, some of the branch lines in this scheme may end up being quite long. Depending on overhead (or under-floor) obstructions, you can run long branch lines diagonally (as for the branch to the jointer) or, by adding another 45-degree bend, run the branch perpendicular to the main (as for the bandsaw and edge sander).

Diagonal main duct The second layout, shown in the drawing on the facing page, has the main line running diagonally across the shop from

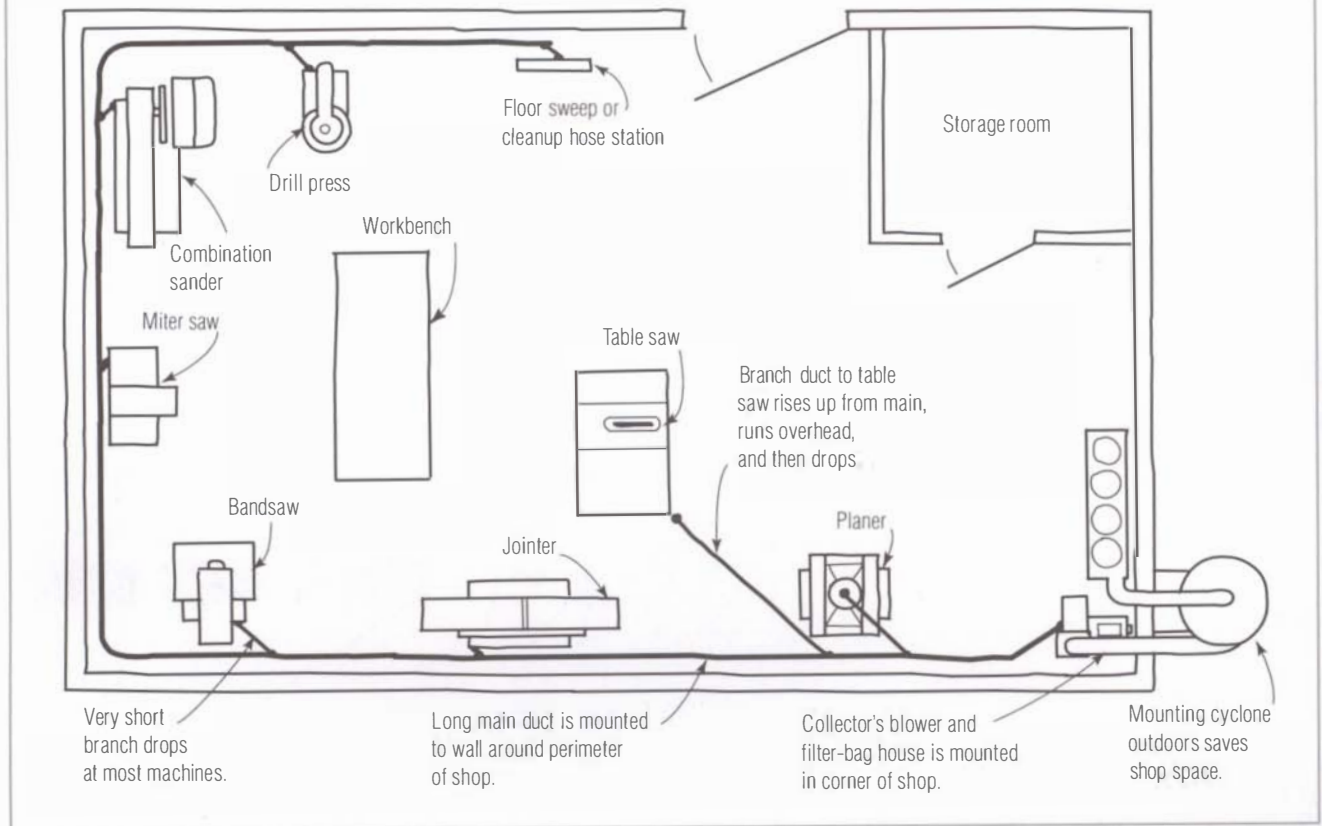
Diagonal Main-Duct Layout



corner to corner, with branch lines running off it diagonally. This arrangement locates the collector in the corner of the shop, where it's more out of the way and easier to enclose for sound attenuation (see p. 125). The branches from this diagonally running main line will be relatively short if most machines are grouped in the center of the shop or along two or three walls, as shown. In cases where two machines are grouped close together at some distance from the main duct (such as the edge sander and spindle sander in the drawing), it's possible to run a single branch duct to the tools, then split the branch duct to service both machines (see the discussion of wye branches on p. 132).

Perimeter main duct The main line in the drawing on p. 130 runs around the perimeter of the shop. This arrangement is best if most of the machines are located along the walls. It also allows you to hang the ductwork for the main line on the wall, rather than from the ceiling, which is preferable if your shop has no crawl space and low headroom. While

Perimeter Main-Duct Layout



the main line in this scenario is the longest of the three, it provides for the shortest branch lines to wall-hugging machines. On the downside, branches that serve center-floor machines (such as the table saw in the drawing) must reach up and overhead, and then down again—a long way to go with lots of efficiency-robbing twists and turns. An alternative is to move the machine closer to the wall and run the branch horizontally at main-line level, but you'll have to walk around it.

Step 4: Refining Duct Layout and Connections

Once you've finished the rough layout, it's time to add some detail to the simple duct-layout lines on your drawings by specifying many of the fittings that will be used to make bends and to connect branches to the main line. Considering the size of the fittings you use is especially important if your duct must pass through cramped quarters (around a corner, under a beam) because many fittings are bulky and take up quite a bit of room.

Additional Connections

WOODWORKING MACHINES AREN'T THE ONLY THINGS you can connect to a central dust-collection system. While planning the ductwork layout, you might also consider adding a few extra features to your system to make your shop easier to clean or to allow collection from portable power tools. Here are a few common additions:

Floor Sweeps

A floor sweep is basically a large rectangular hood mounted at floor level, with a flip-up door on the long side. Locate it in a convenient spot (see the drawing on the facing page) so you can sweep dust and small debris up to it and simply open the door to suck it away. Unless you buy a good-quality floor sweep (“good” meaning expensive) with a door that seals tightly, fit a blast gate to the branch to keep air losses down (see p. 155).

Vacuum-Hose Cleanup Station

If you'd rather avoid the clouds of fine dust that sweeping raises, you can add one or more vacuum-hose cleanup stations to your shop in lieu of floor sweeps. Each station consists of a length of flexible hose (2½ in. to 4 in. in diameter) connected to a branch duct and controlled by its own blast gate. A wye branch or lateral tee allows the hose station to share a branch duct with a machine (see the photo at right). Add a hook (or a tray or box) for hose storage to complete the station. A large-diameter (4-in.) hose makes it easy to vacuum dust and debris from benchtops or around machines. Just fit a piece of large-mesh nylon netting or steel-wire hardware cloth over the end of the hose to help you avoid accidentally sucking up small tools and parts. If you have lots of floor area to clean, you can construct a bigger version of the floor-vacuuming pickup (see p. 29) from 3-in.- or 4-in.-dia. plastic pipe.

Sanding Tables and Dust Hoods

You can also use the strong suction and high volume of air conveyed by a central collector to capture fine dust produced during sanding by hand or with portable power tools. Sanding tables and booths, portable dust hoods, and portable power tools themselves can be connected to a central system (see p. 188). You might want to include one or two extra stations, each with its own blast gate and flex hose, near workbenches for connecting such devices.



Adding a vacuum hose to your collection system makes shop cleanup quick and easy. This 2½-in. flexible hose, controlled by its own blast gate, connects via a lateral tee to ductwork servicing a stationary machine.

More important, the kind of fittings you choose has a major effect on how much friction the air and dust passing through the system encounter (see p. 138).

The general rule with turns and transitions in the ductwork is that the more gradual they are, the better. Changing directions suddenly takes more energy than changing directions gradually—think of how much more your car's tires squeal when you tear around a sharp curve than when you cruise around a gentle one at the same speed. When air and dust traveling through ductwork at high speed must round a sharp corner (or airstreams must merge at sharp angles), more friction is generated against the side of the pipe; hence, a more powerful collector must be used to convey it.

Large-radius elbows To turn ductwork corners gradually, special large-radius elbows are used. These elbows have a more gradual bend than standard HVAC (heating, ventilating, and air-conditioning) pipe elbows, as shown in the photo below left. Large-radius 90-degree and 45-degree elbows for dust collection typically have a radius that is one-and-one-half times the pipe's diameter. For example, a large-radius 4-in. elbow has a 6-in. radius (as measured on the elbow's centerline). For even more gradual bends, some suppliers make elbows with a radius two times the pipe diameter.

Wye branches and tees To merge the airflow between connecting ducts, special air-handling fittings are used, including wye branches, lateral tees, and tee-on-tapers (see the photo below right). Wye branches are used simply to merge two ducts into one—say, to connect a single branch duct to two machines. By installing blast gates on both legs of the wye, you can service two machines from the same branch, opening the gate to only one machine at a time. A wye is also handy for hooking up single machines with two hoods or ports (see the photo on the facing page).

Lateral tees (see the photo below right) are used to merge dust sources on a branch or branch ducts with the main duct (see the drawing on the facing page). They consist of a sleeve, with one or more connectors sticking out of the side for attaching the branch duct(s). The most commonly used fitting is a 45-degree lateral tee, such as a “4 on 6” with a 4-in. branch and a 6-in. main duct; 90-degree tees (also called bullhead tees) are available, but they tend to create high friction losses in the system. Branch lines that must run at a 90-degree angle from the main line are

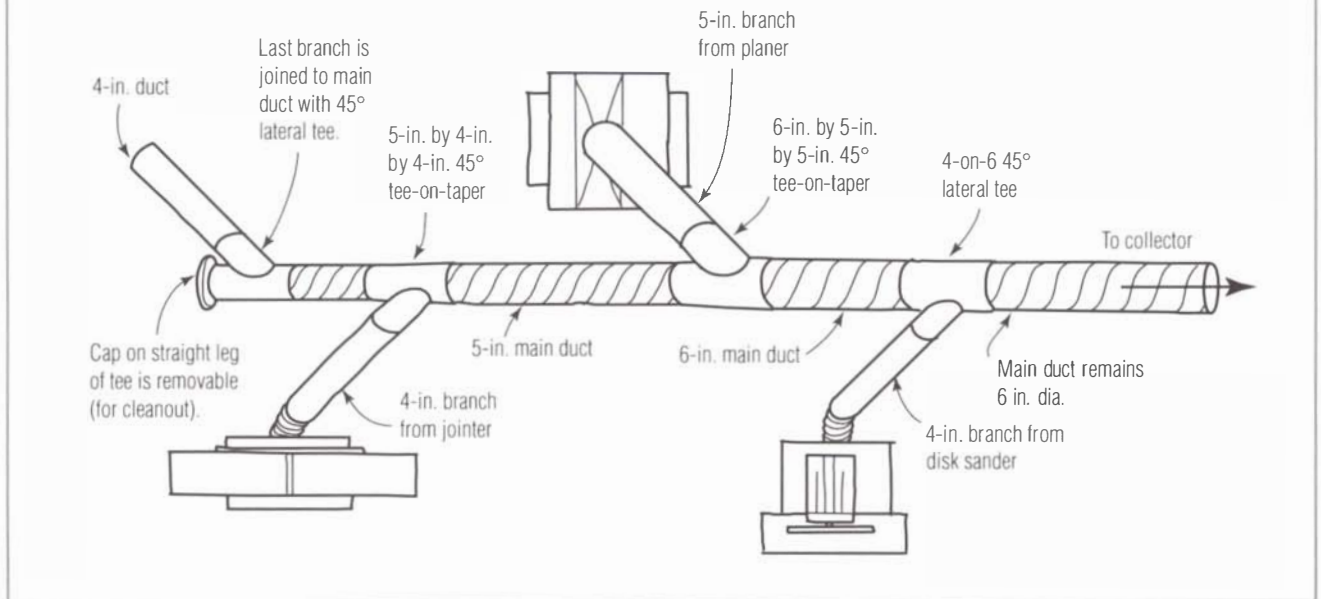


The large-radius elbow (right) allows air and dust to negotiate turns in the ductwork with less friction than a standard tight-radius HVAC pipe elbow (left), making for a more efficient collection system.



For efficient system performance, ducts should merge at a 45-degree angle whenever possible. A lateral tee (right) connects a branch to two ducts of the same diameter; a tee-on-taper (left) is used when the connecting ducts change diameter.

Stepping Up the Diameter of the Main Duct



best routed using a 45-degree lateral tee on the main duct and a 45-degree elbow on the branch. If you must run a perpendicular branch directly from the main duct, a special “boot tee” has an angled gusset that eases the transition of air flowing from the branch to the main duct, creating less friction than with a 90-degree bullhead tee. Many other special fittings are available (or can be custom welded) to suit all sorts of tricky installations.

In places where a branch duct joins a main branch that changes diameter, a tee-on-taper is called for (see the photo at right on the facing page). These fittings have one (or more) 45-degree connectors that join a tapered sleeve, such as a 6x5x4 with a main duct that reduces from 6 in. to 5 in. and a 4-in. branch. The larger end of the sleeve is oriented toward the collector. A tee-on-taper fitting is also useful for connecting machines with more than one pickup hood to a branch duct, such as a radial-arm saw with a rear hood and blade-guard pickup (see p. 180).

Whenever possible, the conventional way to orient a lateral tee or a tee-on-taper is to have the branch line split off horizontally from the main line (when viewed in elevation)—not directly downward. But on installations where the main line runs at the juncture of the wall and ceiling, it's more practical to orient lateral tees so that branches angle downward, as shown in the photo on p. 134. The only shortcoming of this arrangement is that chips may settle into unused branches that are closer to the collector—although any branches that accumulate dust are flushed out whenever they are brought into use.

The termination of the main line should connect to the last branch with a lateral tee. Installing an end cap on the straight portion of the fit-



Wye branches are handy fittings for connecting a single branch duct to two machines. Blast gates fitted on both legs of the wye allow you to open the gate to one machine at a time.



When ductwork is run along a wall, branches can be dropped down vertically to the machines below. This layout saves the room it takes to run branches horizontally and then drop them down to machines—the more conventional way of splitting off branch lines.

ting allows removal, in case you need to snake out a clogged main line. It's a good idea to terminate long branch lines this way, too. A lateral tee also allows the main line to be extended, should you add more machines in the future (see the sidebar on the facing page).

Mark out the location of each fitting on your drawing and figure approximate lengths for the straight pipe runs between fittings. Your next job is to figure out the diameter of pipe and the size(s) of fittings to use. Pipe-diameter choices will also determine which type of tee—lateral or tee-on-taper—you'll need to use at each location where ducts merge.

Step 5: Determining Correct Duct Diameters

Why be particular about the diameter of the pipes in your ductwork system? First, different machines produce different amounts of dust and chips: A thickness planer needs a greater volume of air to capture and transport its waste than a router table does. Second, air has to move at the right speed through the pipe. If it moves too slowly, chips will settle out before they reach the collector; too fast, and the air creates more friction against the sides of the pipe than necessary, which reduces collection efficiency. The correct pipe diameter will carry the right volume of air to meet the chip output of the machine, and carry it at a speed just fast enough to keep dust and chips entrained (carried in the airstream without settling out). When determining the diameter of the pipes for your ductwork system, start with the branch lines.

STEP 5A: SIZING THE BRANCH LINES

In most small-shop systems, only one machine is used at a time and, hence, only one branch duct will be drawing air at any time. The easiest approach to sizing branch ducts in such systems is to determine a pipe diameter that will meet the air-volume requirements of the machine(s) that the branch serves and carry that air at a high enough velocity. Relying on the experience of dust-collection experts, I've compiled the table on pp. 136–137, which lists the air-volume requirements in cubic feet per minute (cfm) for a wide assortment of woodworking machines. The chart also shows the correct branch-pipe diameter you should use to convey that air volume at approximately 4,000 feet per minute (fpm), which is the speed collection specialists recommend for air conveying dust and chips through branch-duct connections. (The optimal air speed is 4,000 fpm; actual air velocity in the final system is likely to range between 3,500 fpm and 4,500 fpm.) In cases where the machine might have more than one pickup hood—for example, a bandsaw with one hose from the wheel housing and the other from a hood beneath the table, as shown in the photo on p. 133—the table gives the correct branch-line size that will be split into two ducts, one to each hood. For branch ducts that will serve two machines with different cfm needs, pick the size needed to serve the machine with the highest cfm needs. In this case, the blast gates are used to control airflow to only one machine at a time. When in doubt about using, say, a 4-in. pipe or a 5-in. pipe for a branch, you're usually better off choosing the larger diameter. Write in all the required branch-line diameters on your sketch.

STEP 5B: SIZING THE MAIN DUCT

With all the branch ducts sized, it's time to size the main duct that will connect them all to the collector. Starting with the section farthest from the collector, the main duct is sized to convey the amount of air required

End Ducts with Lateral Tees

At the far end of your main line, connect the last branch via a lateral tee. Installing an end cap on the straight portion of the tee lets you remove the cap and snake out the main line should it become clogged (it's a good idea to terminate long branch lines this way, too). A lateral-tee termination also makes it easier to extend a duct, should you add more machines in the future.

STEP 5A: SIZING BRANCH DUCTS

Find the recommended branch-duct diameter for each machine on your system, and note its cfm requirements for Step 5B.

Machine/Dust Source	CFM Requirements	Recommended Duct Size (for 4,000-fpm air velocity)
Table saw or panel saw Up to 8-in. blade 10-in. to 16-in. blade Heavy-duty operation with dado or molding head Top pickup	350 cfm 350–500 cfm 650 cfm 100–200 cfm*	3 in. 4 in.–5 in. 6 in. 2 in.–3 in.
Radial-arm saw (rear-hood and blade-guard pickups) 10-in. or smaller blade 10-in. to 16-in. blade	350 cfm 550 cfm	4 in. 4 in.
Thickness planer (single head) 10 in. to 12 in. 15 in. to 20 in. 20 in. to 24 in.	500 cfm 600–800 cfm 1,000 cfm	5 in. 5 in.–6 in. 7 in.
Bandsaw (either single-top hood or dual pickup) 14-in. to 16-in. wheels 18-in. to 24-in. wheels Band resaw; blade 2 in. to 3 in. wide	400 cfm 550 cfm 550–750 cfm	4 in. 5 in. 5 in.–6 in.
Jointer Up to 8 in. wide 8 in. to 12 in. wide	350–400 cfm 550 cfm	4 in. 5 in.
Combination sander (6x48 belt, 9-in. disk)	600 cfm	5 in.
Disk sander (single or dual pickup) 12 in. 15 in. to 20 in.	350 cfm 550 cfm	4 in. 5 in.
Horizontal belt edge sander (single or dual pickup) 4 in. to 6 in. wide	550 cfm	5 in.
Vertical belt sander, up to 6 in. wide	400 cfm	4 in.–5 in.
Oscillating spindle sander, up to 50 sq. in. of abrasive	350 cfm	4 in.
Drum thickening sander (single drum) Up to 12-in. drum, 200-sq.-in. area 12-in. to 24-in. drum; 200- to 400-sq.-in. area 24-in. or larger drum; 400- to 700-sq.-in. area	400 cfm 550 cfm 650 cfm	4 in. 5 in. 6 in.
Drum thickening sander (dual drum) With single 5-in. or 6-in. dust port With dual 4-in. dust ports	800 cfm 700 cfm	6 in. 6 in.

STEP 5A: SIZING BRANCH DUCTS (continued)

Machine/Dust Source	CFM Requirements	Recommended Duct Size (for 4,000-fpm air velocity)
Wide-belt sander 12-in.- to 15-in.-wide belt 15-in.- to 24-in.-wide belt	500–800 cfm 800–1,200 cfm	5 in.–6 in. 6 in.–8 in.
Spindle shaper (single arbor) Up to ¼-hp motor ½-hp motor 3-hp motor	400 cfm** 550 cfm** 700 cfm**	4 in. 5 in. 6 in.
Router table or router-based joinery machine	200–350 cfm**	3 in.–4 in.
Drill press Small or large (also with mortising attachment)	350–400 cfm**	4 in.
Scrollsaw	200–350 cfm	3 in.–4 in.
Wood lathe Small Medium Large	400 cfm*** 550 cfm*** 650–750 cfm***	4 in. 5 in. 6 in.
Floor sweep	350–750 cfm	4 in.–6 in.
Cleanup hose 2½-in. vacuum-type hose 4-in. flexible hose	125 cfm 350 cfm	3 in. 4 in.
<p>* Add this cfm requirement to cfm needed for bottom-hood pickup. ** Chip production varies with type of cutter or bit used and rate of feed. *** Varies with type of tool used and method with which cut is accomplished.</p>		

by the largest machine on the farthest-away branch but at a slower velocity (3,500 fpm is recommended by experts as the optimal air velocity in the main duct). Because the air in the branch duct is traveling at 4,000 fpm, the size of the main duct is increased to convey it at a slower velocity. For example, as shown in the drawing on p. 133, a 6-in. jointer that requires 350 cfm and has a 4-in. branch duct will call for a 5-in. main duct. The table on p. 138 shows the correct main-duct diameters to handle different cfm requirements.

As you travel up the main duct to each branch, you increase the size of the main duct only if it must handle a higher volume of air from the branch. Referring again to the example in the drawing on p. 133, the next branch duct serves a 500-cfm thickness planer, and therefore the main duct must jump up to a 6-in.-dia. pipe. While you can use a simple reducer fitting to make the transition from 5 in. to 6 in., it's more efficient to use a 45-degree tee-on-taper, as shown in the photo at right on p. 132. Note that even though the next branch in the example connects a smaller machine (a 350-cfm, 12-in. disk sander) to the system, the diameter of the main duct does not decrease. It remains at the largest diameter necessary to serve the planer (the largest machine on the system) all the way until it

STEP 5B: SIZING MAIN DUCT

Find the recommended diameter of the main duct serving a branch with the largest cfm requirements noted in Step 5A.

Largest CFM Requirement	Main-Duct Diameter (for 3,500-fpm air velocity)
Up to 300 cfm	4 in.
Up to 475 cfm	5 in.
Up to 675 cfm	6 in.
Up to 925 cfm	7 in.
Up to 1,200 cfm	8 in.

reaches the central collector. On your shop-layout drawing, write in the diameter of the main duct along its entire length, noting the size of any reducers or 45-degree tee-on-taper fittings that you'll need along the way.

As you go through and size the main duct for your own system, it might be worthwhile to consider making a few changes in your shop layout. If your biggest machine, say a planer, is currently on the branch farthest from the collector, you would have to run your entire main duct in 6-in. pipe. However, if you move that machine to a closer branch, you could run smaller-diameter pipe for most of your main duct, only running the heavier and more expensive 6-in. pipe from the closest branch to the collector.

Step 6: Calculating Static-Pressure Losses

Once the ductwork is laid out and sized, the final step in designing an efficient central dust-collection system is to calculate the amount of resistance that air and dust traveling through the ductwork will encounter (measured as static-pressure loss; see the sidebar on p. 95). This information is then used to determine how powerful a collector you'll need to buy. If the collector isn't powerful enough to overcome the static-pressure (SP) losses inherent in the system, it won't perform up to expectations: The volume and velocity of the air moving through the ductwork will be inadequate, resulting in poor chip capture and chips settling inside ducts and possibly clogging them (see the photo on the facing page).

Calculating the SP loss in a small, one-machine-at-a-time system is based on developing a worst-case scenario: Under what circumstances will the collector have to work hardest? The answer is: when it is conveying dust and chips from the branch with the greatest resistance (with the highest SP loss), which is usually the longest, smallest-diameter branch with the most bends. Calculate the total amount of SP loss in the suspected worst branch by adding up the resistance in every single pipe, hose, and fitting in that branch and the main duct between the machine and



Why are careful engineering of duct sizes and the blower strength of your central collection system important? Because sloppy system design may create poor airflow, which can allow chips to settle inside ducts and clog them.

the collector. When in doubt about which is the worst branch, do the calculation for all suspected branches. Follow along with the example shown in the drawing on p. 140, as we go through each step of the computation in the following paragraphs.

STEP 6A: STRAIGHT-PIPE PRESSURE LOSSES

Static-pressure loss varies for air traveling through different diameters of pipe: the smaller the diameter, the higher the static pressure per foot of length. SP loss also varies for air traveling at different velocities: the higher the speed, the higher the loss. Therefore, we must add up SP losses for each diameter of branch duct and main duct separately. Starting with the branch duct, first add up all lengths of straight pipe. Multiply the total number of feet by the inches of SP loss per foot listed in the table on p. 141 for the corresponding duct diameter. Next, figure the SP loss in the main duct by multiplying the number of feet for each diameter with its corresponding factor in the table. Using the same table, look up factors for different diameters of flexible hose used in the branch (to hook up the machine) and the main duct (if you're using flexible hose to connect the collector to the system), and add in these lengths.

STEP 6B: PRESSURE LOSSES IN FITTINGS

Static-pressure loss is also different in the various types and diameters of fittings used in a ductwork system. The table on p. 142 shows a number of common pipe fittings (in different diameters) and their SP losses, stated as an equivalent number of feet of straight pipe. Add up the equivalent num-

Calculating Static-Pressure Loss

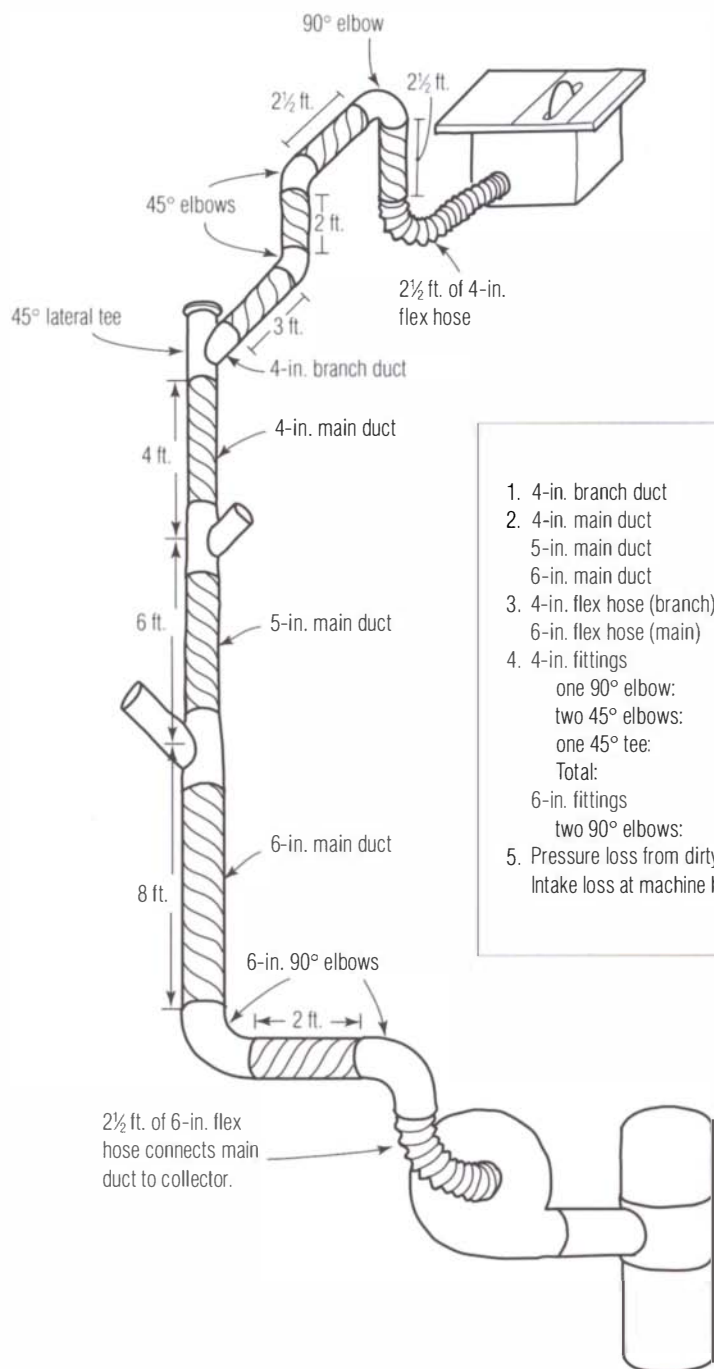


Figure static-pressure losses for your system's longest and/or most circuitous branch, from the machine back to the collector.

	Inches of SP loss
1. 4-in. branch duct	10 ft. x 0.070 = 0.70 in.
2. 4-in. main duct	4 ft. x 0.055 = 0.22 in.
5-in. main duct	6 ft. x 0.042 = 0.25 in.
6-in. main duct	10 ft. x 0.035 = 0.35 in.
3. 4-in. flex hose (branch)	2 1/2 ft. x 0.210 = 0.53 in.
6-in. flex hose (main)	2 1/2 ft. x 0.105 = 0.26 in.
4. 4-in. fittings	
one 90° elbow:	6 ft.
two 45° elbows:	6 ft.
one 45° tee:	5 ft.
Total:	17 ft. x 0.070 = 1.19 in.
6-in. fittings	
two 90° elbows:	24 ft. x 0.035 = 0.84 in.
5. Pressure loss from dirty filters	= 1.00 in.
Intake loss at machine hood	= 2.00 in.
Total SP loss	= 7.34 in.

Use charts on pp. 141–142 to determine losses for ducts and fittings.

STEP 6A: CALCULATING STATIC-PRESSURE LOSS

Add up lengths of branches, main ducts, and flexible hose of various diameters, and multiply each total by the static-pressure loss factors in the columns below.

Diameter of Duct	Inches of Static-Pressure Loss per Foot of Rigid Pipe		Inches of Static-Pressure Loss per Foot of Flexible Hose	
	For branch ducts (@ 4,000 fpm)	For main ducts (@ 3,500 fpm)	For branch ducts (@ 4,000 fpm)	For main ducts (@ 3,500 fpm)
3 in.	0.100	0.075	0.300	0.225
4 in.	0.070	0.055	0.210	0.165
5 in.	0.055	0.042	0.165	0.126
6 in.	0.045	0.035	0.135	0.105
7 in.	0.038	0.026	0.114	0.078
8 in.	0.030	0.022	0.090	0.066

ber of feet for elbows and tees, separately for each diameter of main duct and branch duct. Then, add each diameter's equivalent number of feet together and multiply by the SP factor (from the table above).

Next, you need to factor in additional SP losses caused by dirty filters and energy lost as the air and chips enter the hood or pickup at the machine. There are ways to calculate these losses accurately, but for small-shop purposes, it's less complicated simply to assign average losses: 1 in. of SP for dirty filters and 2 in. of SP for entry losses. Don't add the SP loss for filters if the system doesn't have them and is exhausting directly outdoors. If your blower, cyclone, and bag house are mounted in different locations (for example, as shown in the drawing on p. 130), you must also calculate and add the SP loss for every foot of pipe and fitting between these components. If your system uses a cyclone, drop box, or preseparator canister, add another 1 in. to 2 in. of SP loss as well.

The final step is to add up all the SP losses for the entire system; in our example, they amount to about $7\frac{1}{2}$ in. This is the amount of static pressure that our central collector must be capable of generating if it's going to collect dust efficiently from the worst branch. If it can do that, then it will surely handle collection from the shorter and/or straighter branches with ease.

Step 7: Selecting the Right Collector for Your System

Designing the ductwork for your system yields two figures that you'll need to choose the right-size collector. The first figure is the volume of air (measured in cfm) that the collector must be capable of moving to convey sawdust from the most air-hungry machine on your system, as discussed on p. 135. If your system will collect from two or more machines at a time,

STEP 6B: CALCULATING STATIC-PRESSURE LOSS OF FITTINGS

Add up fittings of various types and diameters to find out equivalent feet.

Then, use the table in Step 6A to find the actual static-pressure loss.

Diameter of Pipe Fitting	90° 1.5 x Radius Elbow	90° 2 x Radius Elbow	45° 1.5 x Radius Elbow	30° Lateral Tee or Wye Branch	45° Fitting Tee or Wye Branch*
	Equivalent number of feet of straight pipe				
3 in.	5 ft.	3 ft.	2.5 ft.	2 ft.	3 ft.
4 in.	6 ft.	4 ft.	3.0 ft.	3 ft.	5 ft.
5 in.	9 ft.	6 ft.	4.5 ft.	4 ft.	6 ft.
6 in.	12 ft.	7 ft.	6.0 ft.	5 ft.	7 ft.
7 in.	13 ft.	9 ft.	6.5 ft.	6 ft.	9 ft.
8 in.	15 ft.	10 ft.	7.5 ft.	7 ft.	11 ft.

**With lateral tees, use only for computing static-pressure loss of branch.*

this volume must equal the combined cfm of the machines. The second figure is the number of inches of static-pressure loss in the system (as calculated in the previous section) that the collector must be capable of overcoming to move the needed volume of air. Comparing these numbers to the performance curve of the collector you're considering purchasing will ensure that the unit will have adequate volume and power to run your system (see the sidebar on pp. 100–101).

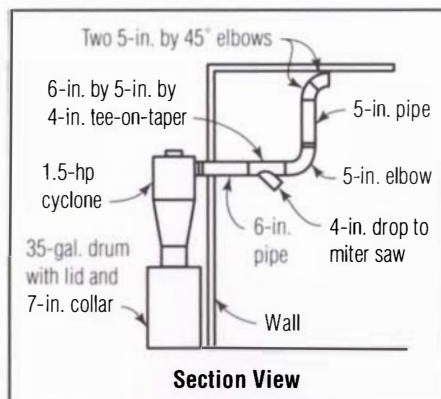
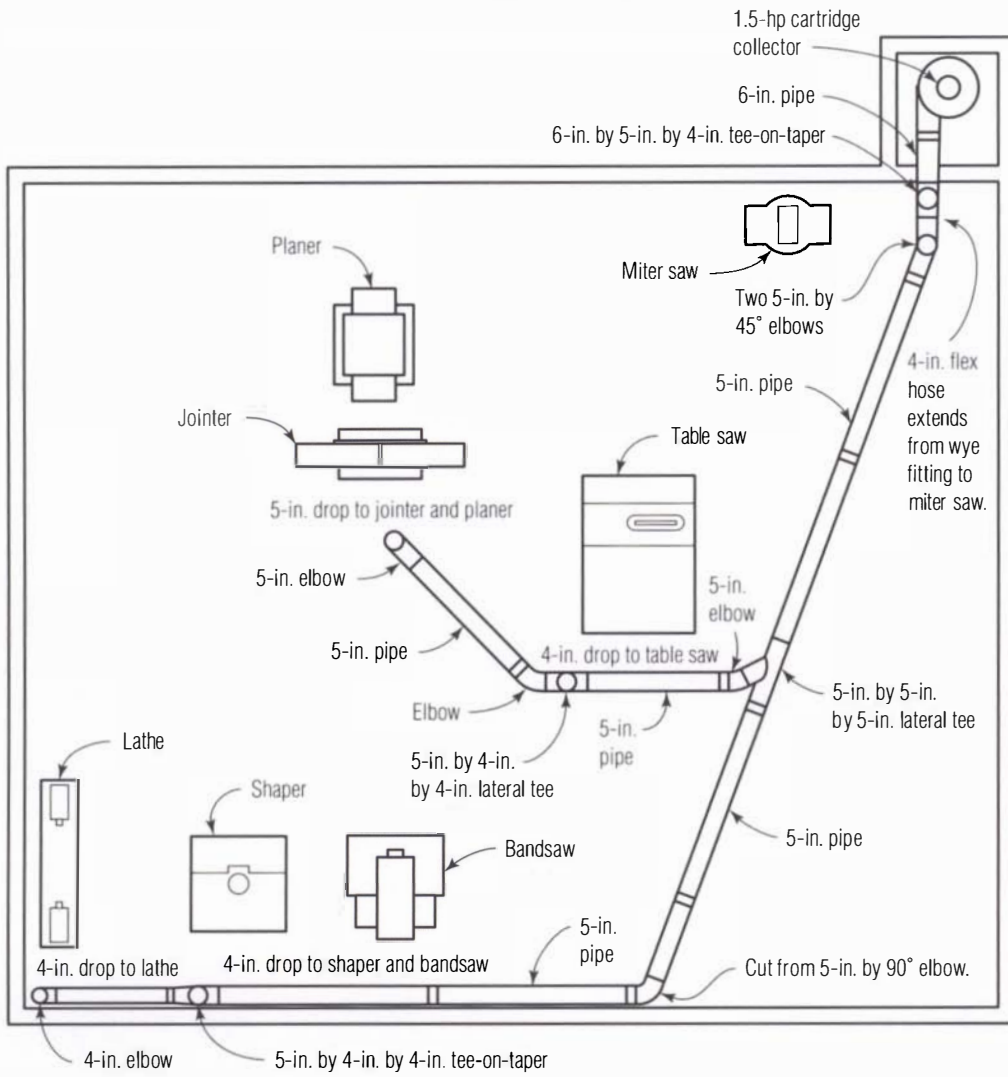
Good Examples: Three Real-Shop Collection Systems

Theory and formulas are great, but it's always better to see how they come together in the real world. In this section, I've included examples of collection systems designed for a small, medium, and fairly large woodshop. These aren't meant to provide you with exact plans but rather to show you how collector size, type and location, ductwork configuration, and pipe sizes and fittings vary for different-size shops. Each example includes a plan-view drawing that shows the relative layout of machines, ductwork, and central collector, as well as the cyclone and filters where applicable. Relevant pipe sizes and transition fittings are labeled, and all 90-degree elbows are large radius (see the photo at left on p. 132).

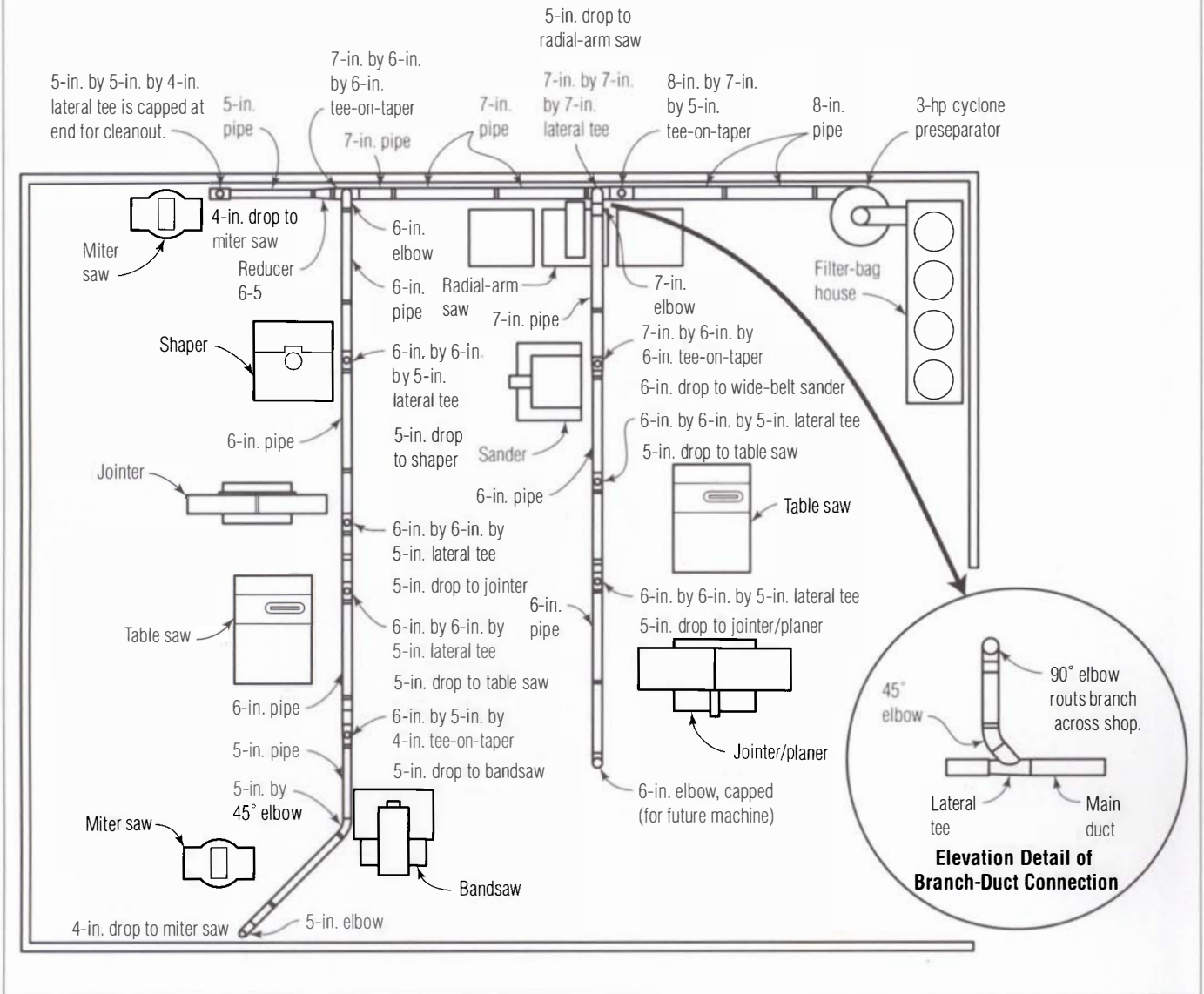
EXAMPLE 1: HOME-GARAGE WORKSHOP

Located in a typical two-car garage, this shop has a simple duct arrangement that provides dust collection to a complement of standard wood-working machines, including a table saw, jointer, planer, miter saw, band-saw, router table, and lathe (see the drawing on the facing page). A 1½-hp cartridge collector combines the blower, cyclone, and filters into a single, compact central unit that's mounted in a small shed adjoining the garage, to save space as well as cut down on noise. The collector's limited power

Home-Garage Workshop



Professional Woodshop

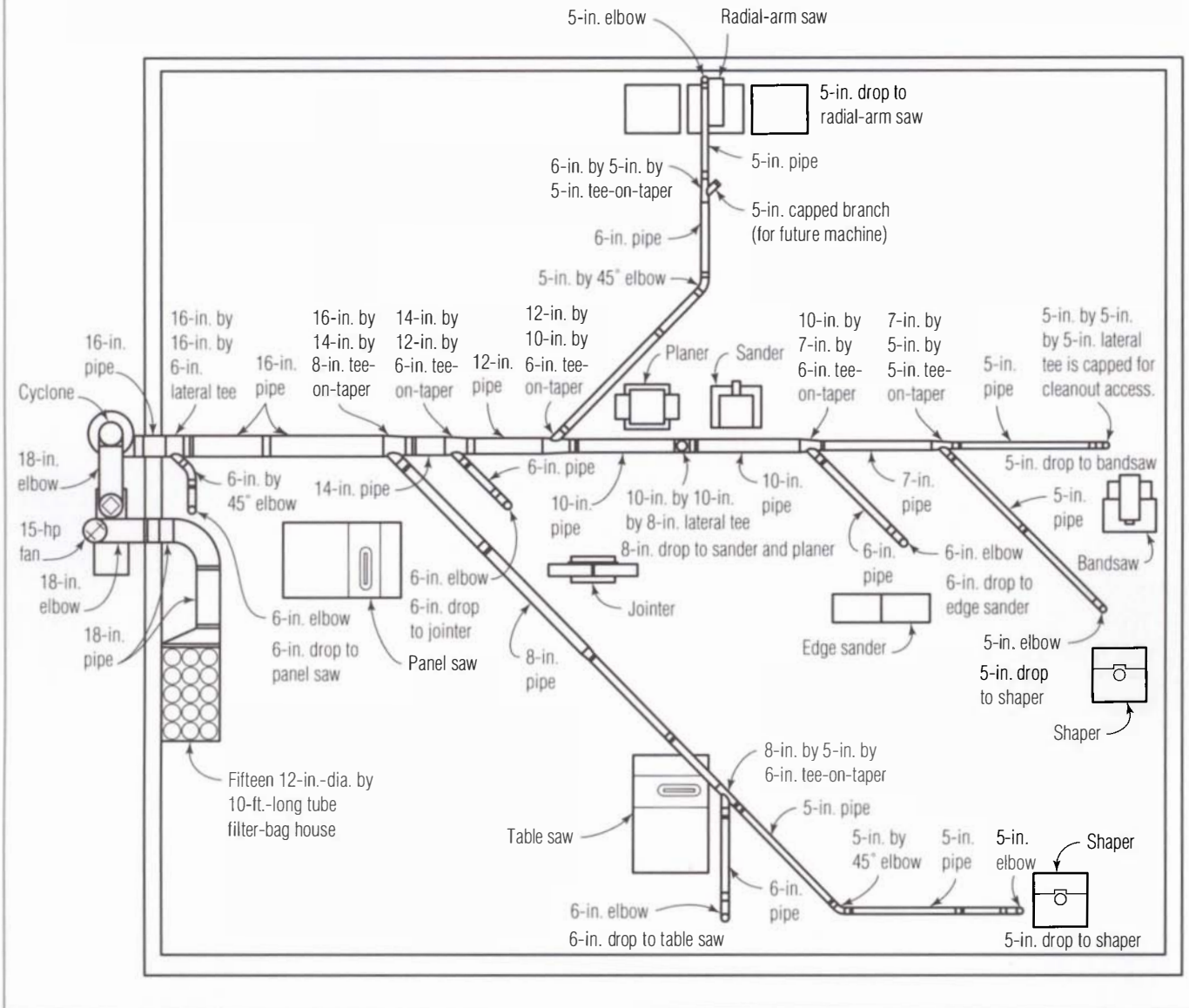


means that only one or two blast gates may remain open at a time—not a problem in this one-person shop. The 6-in. main duct comes through the outside wall less than 6 ft. above the floor, then transitions to a 5-in. pipe that jogs up and travels across the shop at ceiling height. The main and branch ducts are laid out diagonally to shorten the distance to the machines.

EXAMPLE 2: PROFESSIONAL WOODSHOP

This 30-ft. by 40-ft. shop, manned by one or two woodworkers building custom furniture and cabinets, has a collection system with an interest-

Production Cabinet Shop



ing layout (see the drawing on the facing page). Its main duct runs at midheight along one of the shop's long walls. Two lateral-tee fittings connect a pair of branch ducts to the main line. These branches rise to ceiling height before traversing the shop (see the elevation detail in the drawing). Numerous ducts drop from each branch to service a bevy of machines, most located in the middle of the shop. One 6-in. drop at the end of a branch is capped, ready to service a future machine once it's added to the shop. A 3-hp cyclonic collector (mounted inside the shop) runs the system, providing enough static pressure to run one, two, or

three machines with their blast gates open at the same time. Filtration for this return-air system is provided by a plenum with four filter bags (see p. 113).

EXAMPLE 3: PRODUCTION CABINET SHOP

This big, 58-ft. by 70-ft. shop houses a production shop where multiple employees build kitchen cabinets and custom furniture (see the drawing on p. 145). A large cyclone and 15-hp blower provide enough static pressure to allow the bulk of the commonly used machines on the system (table saw, jointer, planer, radial-arm saw, shaper) to be operated at the same time. The main duct extends down the center of the shop, close to the 12-ft. ceiling, with several relatively long branch ducts extending to machines all over the shop. A cleanout tee is provided at the end of the main duct. To meet codes for fire safety, the blower and cyclone are located outside the shop, while the large filter-bag house is mounted inside to return clean air to the shop.

Installing a Central Collection System

Once you've designed the layout of your ductwork system and compiled a list of all the various pipes and fittings you'll need, it's time to put theory into practice and assemble and install the ductwork and hook it up to your central collector. Installing ductwork is probably the cleanest kind of plumbing you'll ever do. But first, you have to decide what kind of pipe to use, and then go about cutting, fitting, and hanging it. After the blast gates and flexible hoses are chosen and connected, you'll be ready to test the system—and make changes if collection isn't up to snuff. To make your collection system easy to turn on and off, you may wish to set up a system of switches around the shop or install a remote or automatic switching device.

Before you dive in, check with your local building department and fire marshal to see if you need a permit and to make sure the system that you plan to install meets local building and fire codes. You'll also want to check with your insurance company to find out how a central dust system might affect your policy.

Ducting Materials

There are only three practical choices for ducting materials for woodshop dust-collection systems: plastic pipe, spiral metal pipe, or snap-lock metal pipe. Choosing among them can be a very important decision—one that affects the ease of installation, the cost of the system, and the safety of operating it.



Couplings offer a quick and easy way to connect lengths of spiral pipe. A male coupling is used because straight pipe usually has female ends.

PLASTIC PIPE

The single biggest issue in small-shop dust collection involves the use of plastic pipe as ducting material. Drain and sewage pipe made from PVC or ABS plastic is inexpensive, readily available (though not in all fittings), easy to work with, and easy to install; it's also already in use in innumerable small woodshops. But plastic pipe can be a problematic choice. Static electricity created by air and dust moving at high velocity through plastic duct produces annoying shocks and can suddenly discharge and spark a fire or even a powerful explosion (see p. 17). Admittedly, the chance for this kind of disaster to occur is very low—most explosions have occurred in systems operating in low-humidity climates that are collecting a large volume of very fine sanding dust. Despite the rarity of disasters, I've read enough accounts of plastic-pipe static combustion to make me reluctant to condone the use of plastic ductwork, even for small collection systems. Losing a shop, your home—or your life—to a fire is just too high a price to pay for saving time and money.

METAL PIPE

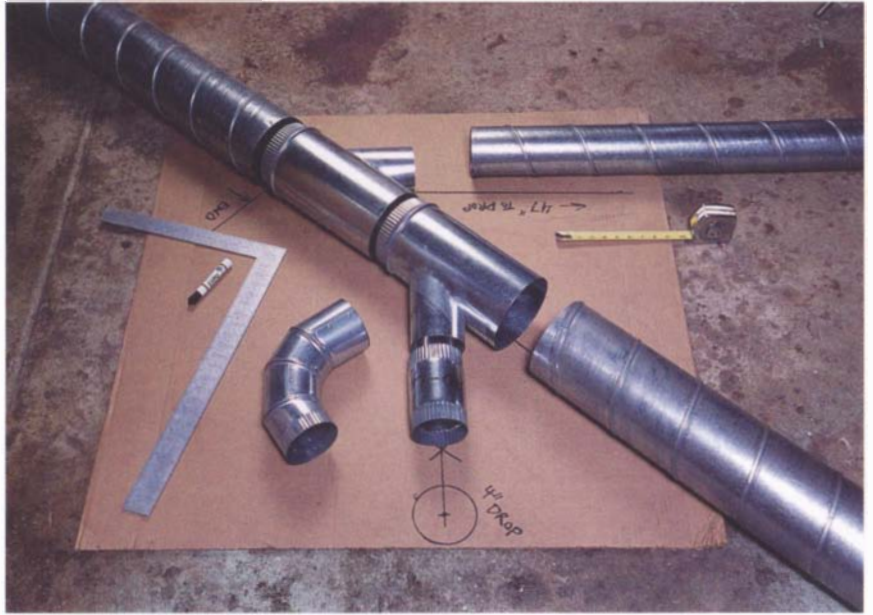
Static electricity also occurs in metal pipe—and explosions are not impossible—but the difference is that grounded metal pipe readily dissipates the charge. This fact, coupled with the strength and simplicity of metal ductwork, makes it the best choice for dust-collection ducting. Galvanized sheet-metal pipe is strong and light and not that difficult to install—if you're handy with a pair of tin snips (or a hacksaw) and a pop riveter.



More affordable than heavier spiral metal duct, 24-ga. or 26-ga. HVAC pipe (*do not use* 28-ga. or 30-ga. stovepipe!) is often available at hardware and home-supply stores. The pipe is cut to length with tin snips before the center seam is snap-locked into place.

Spiral pipe Among several types of metal pipe appropriate for collection-system ductwork, heavy-duty spiral pipe, typically made from 22-ga. galvanized steel, is de rigueur for industrial systems and production shops. While it's strong and durable, spiral pipe is also expensive, especially when you purchase heavy-duty welded fittings. Industrial-ductwork suppliers offer a tremendous range of fittings, including large-radius elbows, lateral tees, and tee-on-tapers (see the photo at right on p. 132), so you can choose the right fitting for any layout design. Couplings offer a quick and easy way of creating long lengths of spiral pipe, as shown in the photo on the facing page. Spiral pipe comes in standard diameters from 3 in. to 16 in. or more in 1-in. increments, allowing you to size your ductwork to your system's requirements.

Snap-lock HVAC pipe Although it's not as strong as spiral pipe, 24-ga. or 26-ga. snap-lock HVAC pipe (see the photo above) is a good choice for most small-shop installations. It is significantly less expensive than spiral pipe, and its lighter weight makes it easier to hang on overhead installations. Lengths of pipe (it comes in 3-ft. lengths) and fittings are joined by sliding together crimped ends, so you don't need to buy special couplings. On the downside, special dust-system fittings for HVAC pipe, such as large-radius elbows and 45-degree lateral tees (desirable for efficient airflow) are hard to find at your local building-supply store. Worse, some stores sell lighter 30-ga. HVAC components, which are too thin for dust collection; even 26 ga. is too thin for 5-in.-dia. pipe and larger. If you run the blower with all blast gates closed, you can accidentally suck thin pipe



The main duct should be assembled on the ground and then lifted into place. Working on top of scrap cardboard allows you to mark out the position of angled branches, making it easier to determine the length of pipes that join fittings.

flat, ruining your system (believe me, this *really can happen!*). It's best to mail-order 24-ga. and 26-ga. pipe and special fittings from one of the sources listed in the Sources of Supply on p. 195.

Cutting and Installing Pipe

Once you have all the pipes and fittings you need, you're ready to begin installing the ductwork. It's usually best to install the dust collector first, bolting down components as necessary, then assemble and connect the main duct, working out from the collector, and finally run the branch lines to the machines.

Start by assembling the main line on the ground or benchtop, mating straight pipe with fittings that will split off the branch lines. It's easier to lay out angled branch-line runs by setting the partially assembled ductwork atop a piece of cardboard and then drawing in a plan view of where the branch lines will drop or rise vertically (see the photo above). You can then calculate the position of angled lateral tees or tee-on-tapers on the main line to produce correct branch-line placement. Cut any sections of pipe to length as needed, as described on the facing page.

Once the main line is assembled, raise it into place with the aid of a friend and/or a block and tackle, as shown in the photo on the facing page. If the main line is particularly long or bends in the middle, it may be wiser to assemble and hang it in two steps. If you're installing ductwork



Setting up the ductwork for a central collection system starts with the installation of the main duct. A safe way to raise a heavy preassembled duct overhead is by using a rope with a block-and-tackle set.

below a floor with a cramped crawl space, you may have to assemble it in place, piece by piece. With the main line in place and level, fit pipe hangers—first at both ends, then at least every 10 ft. along the duct (as described in the sidebar on p. 152)—to keep the duct from sagging. Now cut and fit each branch duct in a similar fashion, building it on the ground first, then hanging it in place. Secure each branch line with a hanger or strap as necessary.

CUTTING PIPE TO LENGTH

Straight sections of HVAC pipe are easy to cut to length using a pair of tin snips; just make sure to wear gloves. Mark and cut the uncrimped end before the pipe is snapped together (see the photo on p. 149). The crimped end slips into the uncrimped end of the previous pipe, with the crimps always pointing “downstream” (back toward the collector). If the crimped end must be cut off, as occasionally necessary to make connections, you can rerimp the cut end with a special crimping tool, as shown in the top photo on p. 153. This tool is available from stores that sell heating pipe and from Woodworker’s Supply (see Sources of Supply on p. 195). Before cutting the pipe, be sure to leave enough extra length for the new crimp.

Spiral pipe can be cut with a hacksaw, but it is quicker and neater to use a powered miter saw fitted with a special metal-cutting abrasive blade (available at hardware stores). After measuring and marking the pipe length, draw the line of cut around the pipe with a permanent marker

Hanging Pipe

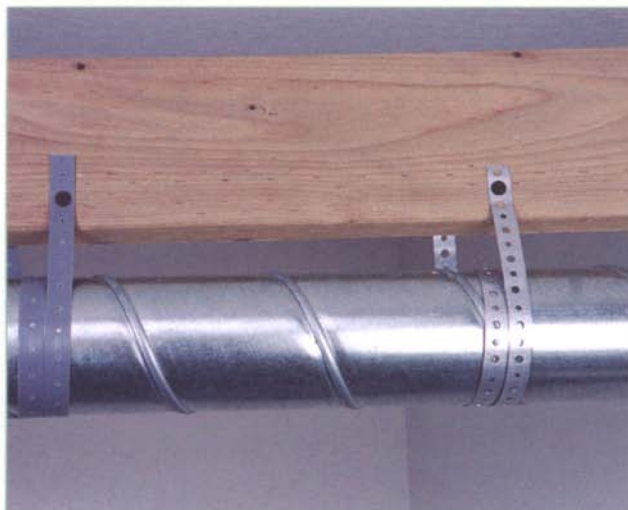
INSTALLATIONS WITH DUCTWORK THAT RUNS horizontally require pipe hangers to secure ducts in place. There are several different ways to hang ductwork, depending on your budget and the kind of walls you have in your shop.

If your shop has exposed stud walls and rafters or ceiling joists, it's easy to secure horizontal ducts using inexpensive plumber's pipe strap. Available at plumbing- or hardware-supply stores, pipe strap comes in metal or plastic and looks like tape with holes in it. Use washer-head screws (or screws with washers) to secure the strapping to structural members. Screws allow you to remove the straps for maintenance or revisions to your ductwork.

To mount a section of pipe, run a U-shaped length of strap around the pipe to hold it flush against a framing member or surface. To hang a duct from rafters or joists, wrap the strapping around it, crossing the straps as they're run up to the rafter or joist

as shown in the photo below left. Add several reinforcing straps on long runs of hanging pipe, to keep the pipe from swaying from side to side. For large main ducts, you might want to use heavy-duty hangers that bolt together, available from ductwork suppliers.

A good method for installing ductwork in shops with smooth (paneled or drywalled) surfaces is to attach thin wood strips to the walls or ceiling and secure the pipe to these strips. Attach furring strips exactly where each duct will run, with nails or screws driven into studs or joists. Then, attach the ducts to the strips with self-locking nylon tie straps (see the photo below right). Thread the ties through shallow cross-grain grooves cut into the inside of each strip before it is attached. Alternatively, you can shim the strips out from the wall a little, to allow the ties to be put on wherever you wish. If you use this method to hang heavy, large-diameter metal pipe, use pipe strap.



Plumber's pipe strap, either metal (right) or plastic (left), can be used to hold ductwork flush against a wall or ceiling, or to hang a duct from a rafter or ceiling joist.



A convenient way to install ductwork atop a paneled or dry-walled surface is to use 1x2 strips nailed or screwed along the path of the duct. The duct mounts atop the strips, which are grooved to allow fastening with self-locking plastic ties.

pen, using a flexible magnetic strip as a ruler (the strip sticks to the pipe, which makes marking easier). To start a cut, lower the sawblade into the pipe, then rotate the pipe through the cut, following the marked line. Always rotate the pipe toward you to prevent the saw from catching and flinging the pipe. Clean up each cut end by deburring the inside and outside edges with a half-round file, wearing gloves to protect your hands



Metal HVAC pipe that has been cut to length must have its male end crimped before assembly. A special tool crimps one small section at a time as you work all the way around the pipe.

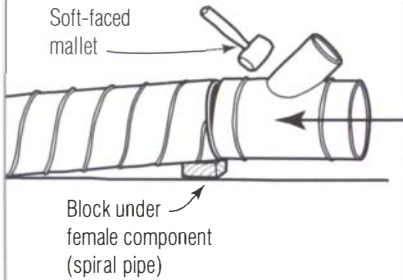


Fitted with a bonded-abrasive metal-cutting blade, a powered miter saw is a terrific tool for cutting spiral ductwork. You can cut ducts up to 6 in. dia. on a 10-in.-bladed saw by taking several cuts, rotating the duct between cuts.

against sharp edges. Spiral-pipe parts are designed to fit together tightly, so it's often necessary to drive connections home. Working on the floor or on a benchtop, place a small wood block under the female component and slip the end of the male component into it, as shown in the drawing on p. 154. Tap the top part of the male end near its lip with a mallet and push until the parts engage fully.

Assembling a Spiral-Pipe Joint

To engage parts, tap lip of male component (lateral tee) while pushing in.



Pop rivets provide a strong and fast way to join metal ductwork and fittings together. Each rivet is inserted through a small hole drilled through the pipe and set into place using a special pop-riveting tool, which pulls the core out of the rivet to set it.



To function at top efficiency, all joints between ductwork pipes and components should be sealed. Caulk is great for permanent installations, while duct tape is easier to use and allows for easy disassembly and future changes.

FASTENING AND SEALING DUCTWORK

On permanent installations, lengths of pipe and fittings should be fastened together with pop rivets (see the top photo above), which are quick and easy to install and leave only a small nub on the inside of the pipe. Steel rivets are stronger than aluminum rivets. Short sheet-metal screws are also

fine for small-shop systems. You can back out screws or drill out pop rivets if you change your mind or need to rearrange your ductwork later.

It's important to take the time to seal all pipe connections, as an unsealed system can lose 10 percent to 15 percent of its efficiency from leaks between fittings. Start by wiping any oil or other contaminants from the metal pipe using a rag dampened with naphtha or mineral spirits. For permanent installations, you'll want to caulk all joints with special high-velocity duct sealant, an inexpensive water-based material carried by HVAC suppliers (check your local Yellow Pages). If you can't get the special sealant, you might try silicone caulk; I've used it successfully as a substitute.

Seal each branch down to the blast gate, and seal all seams on snap-lock HVAC pipes and adjustable elbows (if used). Make sure that pipe connections between the fan, cyclone, and filter-bag house are also well sealed. It's easier to seal the main duct and branch-duct subassemblies on the ground before installation. Seal hard-to-reach connections by wrapping the seam with duct tape. On under-floor systems, run a heavy bead of caulk around the base of each duct where it comes through the wall or floor. This will keep out drafts, moisture—and bugs, too! If you plan to disassemble your ductwork in the future (either for reconfiguration or when you move), you can get by simply wrapping all pipe seams with duct tape.

BLAST GATES

Once all the ductwork is in place, cap the end of each branch duct with a blast gate to control the airflow to the machine on that branch. In small shops, blast gates allow a small collector to draw air from only one machine at a time. In large shops and industrial systems where many or all shop machines are run full-time, blast gates are used to adjust the airflow at individual machines. A blast gate is also useful for balancing the flow of air between two machines connected to the same blast gate or two collection pickups on a single machine (see p. 175).

A blast gate is a simple valve with a sliding door that runs in a slot in its body. Sliding the door all the way in or out turns collection off or on to that machine; sliding the door partway open lets some air into the system, for airflow balancing. Blast gates are made in both plastic and metal versions; plastic gates are cheaper, but metal gates are more durable. Metal gates come in three different styles, as shown in the photo on p. 156. The full gate is the most common style. It mounts between the ends of two pipes (or a pipe and a flex hose). You can mount a half-gate in the middle of a rigid duct by cutting a semicircle slot in the duct and pop riveting the gate in place. Half-gates provide a convenient way to add gates to existing ductwork, though they don't seal as well as full gates. A self-cleaning gate is a good choice for ducts that convey fine dust from

Blast Gates Join Hoses to Ductwork

Since most machines connect to dust-collection branch lines via flexible hoses, blast gates provide a natural transition: The rigid duct attaches to one side of the gate, the hose to the other (the thumbscrew that locks the gate should point toward the hose side). Use pop rivets or sheet-metal screws to join the gate to rigid ductwork, and use adjustable hose clamps to attach the flexible hose.



Blast gates provide a convenient way to turn collection on or off at each machine or dust source. Three styles commonly used are (left to right): a self-cleaning gate, a half-gate (shown mounted to a length of duct), and a standard full gate.

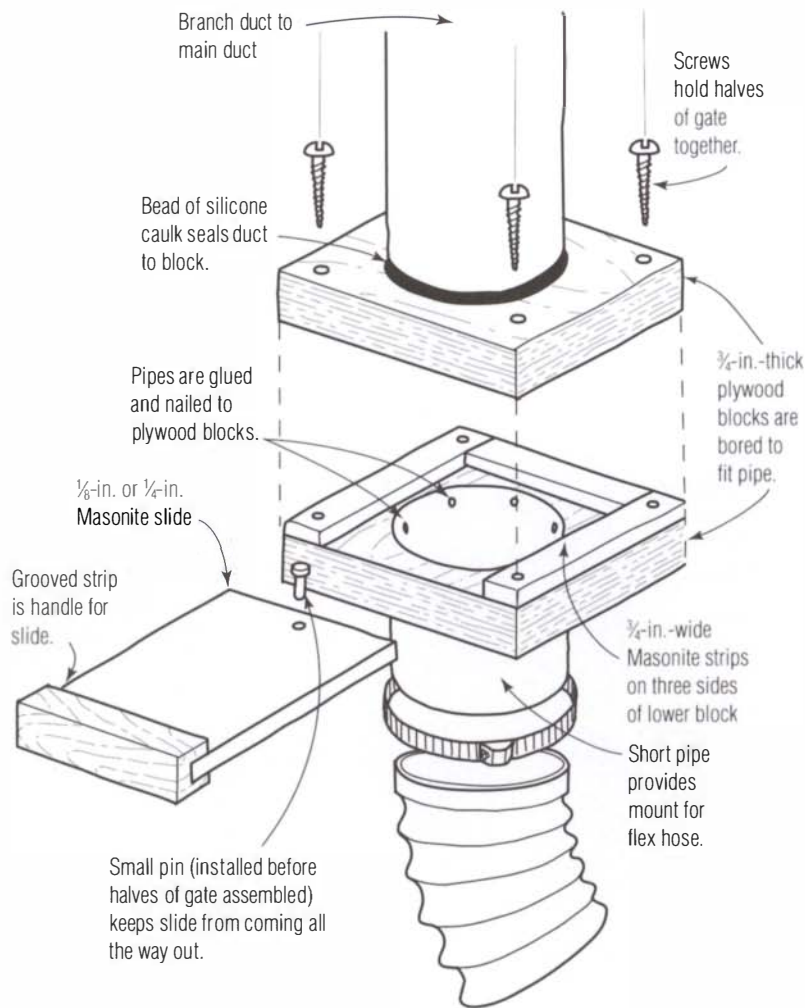
power-sanding machines. The fine, moist sanding dust can stick into the slot on a normal blast gate and, over time, make it difficult to operate. The sliding blade on a self-cleaning gate can be pushed all the way through the rear edge of the casting, to clean accumulated debris from the slot.

Because blast gates are opened and closed often, it's best to locate them in an easy-to-reach spot near where you stand when operating the machine; it's no fun to have to bend down to open a gate every time you want to run a tool. Ductwork near the blast gate should be anchored securely to a wall, machine base, or other solid object, so the gate can be operated without deflecting the duct.

Shop-built gates You can stretch a shoestring budget by building your own blast gates, like the one shown in the drawing on the facing page. Built from plywood, Masonite, and hardwood, the gate is screwed together with the Masonite slide in place (a small brad pin in the front edge keeps the slide from pulling all the way out). To save the trouble of having to open gates and switch on the collector separately, you can install a switch directly on your shop-built blast gate connected to a low-voltage relay that turns on the collector (see p. 168).

Automatic blast gates Once only available for large commercial dust systems, one company now makes a high-quality automatic blast-gate system that's practical even for small woodshops. The Ecogate® system uses solenoid-operated gates, which automatically open and close when-

Basic Shop-Built Blast Gate



ever the machine is turned on or off (see the photos on p. 158); the system “senses” machine vibration via a small contact pickup that sends a signal that operates the gate. The wiring from the gates and pickups also automatically switches the central collector on and off (how convenient!). The extensive Ecogate system allows gates to be manually operated and can work with any collector (110 volt, 220 volt, or three phase).



If you're tired of manually opening gates and turning your central collector on and off, you'll love the Ecogate system. It features solenoid-operated blast gates (see the inset photo) that automatically open and close whenever a machine is operated. Wires from each gate send signals to a central control box (upper center), which turns the dust collector on and off.

FLEXIBLE-HOSE CONNECTIONS

The final link between branch duct and machine is a flexible hose connected between the blast gate and the dust port or hood on the machine. A flexible hose allows you to move the machine around a little—say, to pull it away from the wall for adjustment—or to connect a hood that's

mounted to an adjustable part of the machine, such as a blade guard with a built-in dust port mounted over a table saw (see the shopmade hood in the drawing on p. 179). Flexible hose is essential for connecting a collection system to a tool that moves, such as the head of a radial-arm saw. You can also use hose to connect the main line to your central collector if it's in a location that's difficult to connect using rigid ductwork.

There are several types of flexible hose, and, as with most things in life, you get what you pay for. The inexpensive flexible hose that's sold by many woodworking-supply catalogs is light duty, with thin plastic coverings that are easy to tear and don't hold up well to abrasion. Wood chips and debris can actually wear through a hose over time. The heavier-duty, more expensive types of flex hose are better for serious woodworking. These come with a number of different materials covering their steel-wire helix. Neoprene and thermoplastic rubber are both durable and among the more popular flex-hose materials. Polyethylene and PVC hoses, which come in clear material, are other affordable choices.

You can also buy specialty hoses for unusual conditions. Elastomer-urethane hose, though more than twice as expensive as rubber hose, offers excellent abrasion resistance and is considerably lighter than rubber or neoprene hose. For hoses that will be dragged across the floor, you'll get longer service life from hose with an external wear strip (see the photo at left on p. 28). Crushproof flex hose is a must for applications where the hose may get stepped on. For hoses that require maximum flexibility (such as on panel saws and CNC [Computer Numerical Control] routers), Hypalon® hose is a good choice. Air Handling Systems offers a nice 2½-in.-dia. PVC hose kit for a cleanup station (see the sidebar on p. 119).

Most flexible hose can be cut to length easily, using a razor knife to cut the material covering and a pair of diagonal cutters to slice through the wire helix. Once the wire is cut, bend the exposed bare wire back into the end of the hose. This prepares the hose for grounding the ductwork to the tool, as discussed in the following section (it also prevents nasty puncture wounds!). Since the corrugated inside surface of flexible hose typically creates three times the air friction of smooth-walled pipe, it's a good idea to keep flex-hose runs short—under 3 ft. to 4 ft. if possible—to reduce static-pressure losses in your dust system.

Grounding the Ductwork

Proper grounding of the ductwork to stationary woodworking machines and to the central collector is necessary to discharge any static charge that may build up and cause nasty shocks, fires, or worse. Just as important, metal pipe should be properly grounded to prevent electrocution, in case a motor cord shorts out or frays. Plastic-pipe systems should also be grounded, as described in the sidebar on p. 160.

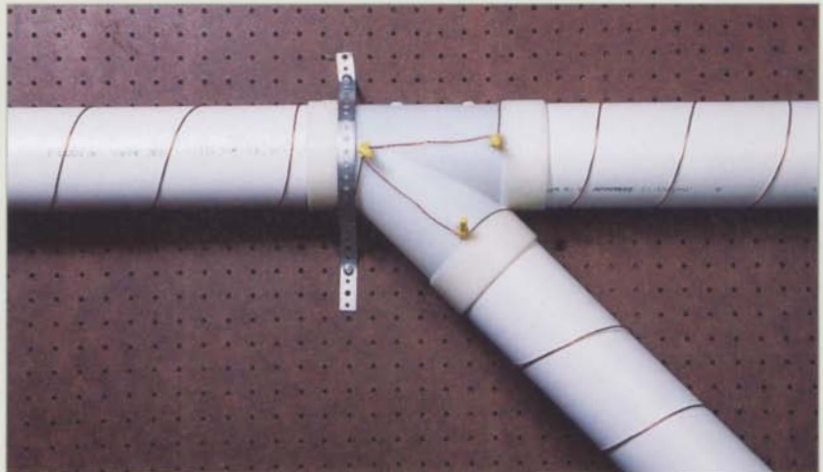
Grounding a Plastic-Pipe System

IF YOU HAVE PLASTIC-PIPE DUST-COLLECTION DUCTWORK in your shop, your best hedge against static-electricity problems is to ground the pipe thoroughly. You can do this by running a bare copper wire down the inside of each branch duct—as well as the main line—from the machine all the way back to the collector. Stranded wire has much better flexibility than solid wire; 14-ga. bare copper antenna wire (available at Radio Shack) is a good choice.

It's easier to install ground wiring before you install your plastic-pipe system, by running wiring through each section of straight pipe separately. Thread the wires through small holes drilled near both ends of the pipe, and stretch the wire tight. Leave the protruding wires long enough so that the ends can be twisted together and secured with insulated wire nuts after the pipe sections are joined or connected to fittings, as shown in the photo below.

To ground plastic ductwork that's already installed, tie one end of the grounding wire to a tennis ball and try sucking it from the farthest branch back to the collector. For single-stage collectors, wrap some heavy mesh over the inlet to keep the ball from going into the fan.

To discharge static charges that build up on the outside of the pipe, wrap an additional wire tightly around the outside of each pipe as shown in the photo. Splice the ends to the inside wire at all fittings and to the ground at the machines and the collector. Seal all holes in the pipe with a dab of silicone caulk.



To prevent annoying and possibly dangerous static-electricity problems in plastic-pipe ductwork, run grounded bare copper wires through the inside of each pipe, wrapping the outside with bare wire as well. Use wire nuts to connect separate lengths.

One of the great advantages of installing sheet-metal ductwork is that it conducts charges directly to the ground, as long as the machines and collector are grounded. Not all machines or collectors that have a ground lug on their electrical plug are properly grounded; electric ground

at the motor may be insulated from the machine frame. Check ground by doing a continuity test using an electrical multimeter or continuity tester between the ground bar of your shop's breaker box (with the power switched off) and the frame of each machine, as well as the central collector. If the test doesn't show continuity, add a wire between the electrical ground wire and the machine's (or collector's) frame or sheet-metal housing. If there's still a problem, check the circuitry inside the breaker box to make sure all ground connections are in order; better yet, hire a licensed electrician to do it.

Testing and Tuning the System

No matter how accurate your design calculations (see chapter 7), the only way to judge a collection system is to fire it up and see how well it performs. But don't run your collector before your ductwork system is completely installed; running an unrestricted blower can quickly overwork the motor and even burn it out. For your first test, open up all blast gates, connect an ammeter (available from Radio Shack) to the power wires feeding the blower, and flip the switch. The amperage read by the meter shouldn't exceed the motor's nameplate-rated amperage. If the amps drawn exceed the maximum, the motor could burn out if you happen to leave all or most of your blast gates open. Close blast gates until amperage drops to a safe level. Note that the number and sizes of blast gates now open are allowing the maximum safe amount of air into your system. Next, test each branch of the system by making sawdust at each machine. Watch for stray chips and plumes of dust thrown by the machine; these are signs that you may not have enough air moving through the branch serving the machine (see chapter 9).

CALCULATING AIR VELOCITY AND VOLUME

You can troubleshoot poor collection performance by measuring the air traveling through the duct with a special tool called a manometer. As you'll recall, static pressure is measured in inches of water, and a basic manometer is nothing more than a U-shaped tube filled with water attached to an inch scale (see the photo on p. 162). Static-pressure measurements are taken by connecting rubber hoses from the manometer to a Pitot tube; the tube is inserted into an 1/8-in. hole drilled into the ductwork, which you seal afterward. Whenever possible, locate this hole at least 10 pipe diameters from the nearest transition (elbow, lateral tee, etc.). Insert the end of the Pitot tube into the hole far enough for the tip to be centered in the duct and pointing upstream (away from the collector), and move the tube around until you get the highest reading on the manometer's scale. Take the measurement in a warm (70°F) shop; if this is not possible, you can convert your measurements using the conversion scale that comes with the Pitot tube (see Sources of Supply, p. 195).

Make Sure Your System Is Grounded

Nonconductive components—such as plastic or shop-built blast gates, flexible hose, and plastic fittings in a machine's hood—break continuity between metal ductwork and electrical ground. To restore the connection, run a short bridge wire between the machine or collector and the branch duct. When using flex hose, scrape off the rubber or plastic covering and use the wire helix to carry the ground connection between the blast gate and the machine.



A tube-style manometer and Pitot tube can be used to check static pressure, air velocity, and air volume moving through a duct. With the Pitot tube inserted into the duct through a small hole, fluid is displaced in the manometer tube, giving a reading as inches of pressure on the scale.

By connecting a single hose from the 90-degree leg of the Pitot tube to a single leg of the manometer, you can read static pressure directly; just add up the number of inches both above and below the zero mark on the scale. By connecting both tubes from the Pitot tube to both legs of the manometer, you can measure the velocity pressure inside the duct, and use this measurement to determine air velocity (how fast the air is traveling through the duct, in fpm) and air volume (how much air is flowing through the duct, in cfm). To determine air velocity, add together the number of inches above and below zero, then multiply the square root of this sum by 4,005. (It's normal for the actual air velocity to range anywhere from 3,500 fpm to 4,500 fpm in branch ducts and 3,000 fpm to 4,000 fpm in a main duct.) To compute the air volume, multiply the air velocity by the square-foot area of the duct (the square-foot area equals the duct radius, in fractions of a foot, squared and multiplied by pi, or 3.1416). For example, for a velocity-pressure reading of 0.9 in. in a 4-in. branch duct, you'd multiply the square root of 0.9 (which is 0.9486) by 4,005, yielding an air velocity of 3,799.14 fpm. To find the air volume, multiply 3,799.14 by 0.087 (the square-foot area of a 4-in. duct), to get 330.5 cfm.

IMPROVING COLLECTION

If the air velocity and volume are fairly close to your design calculations yet chips still aren't being collected efficiently, try redesigning the hood of the tool to contain and capture chips better (see chapter 9). If air velocity and volume are lower than expected, first try disconnecting the hood from the branch to make sure that the hood itself isn't constricting the flow of air at the machine; redesign the hood as necessary. If collection remains poor, you have several options for improving collection.

One option is to move the heaviest sawdust-producing machine (typically a planer, drum sander, or large spindle shaper) to a branch that's closer to your central collector or relocate the collector so that it's closer to the machines and dust sources. Reducing the amount of ductwork between collector and machine reduces static-pressure losses—hence improving collector performance. Collection also improves if ducts are reconfigured to run straighter, since every twist and turn adds SP losses. Another option is to remove the machine with the poorest collection performance (probably the thickness planer) from the system, and use a small dedicated collector to serve that machine separately.

A third, admittedly not welcome, option is to increase the size of the central collector running the system. Boosting collector size doesn't mean mounting a bigger motor on your existing blower housing. Since the motor would turn at the same rate, the fan would move the same amount of air as before, not improving things much. (On large belt-driven industrial systems, blower output may be adjusted by changing fan speed with different-size pulleys. This adjustment isn't possible with a direct-drive blower since most induction motors run at a fixed speed.)



Improve the performance of your single-stage collector by retrofitting a few components. A larger, cast-aluminum fan wheel and oversize collection bags work to help the collector move a larger volume of air with less resistance.

It's also possible to squeeze higher performance out of your current collector. Here are two upgrades you can do:

- Because many chip collectors come stocked with undersize filters, you can achieve modest performance gains by fitting larger dust bags or adding a separate filter-bag house (see p. 113).
- Performance of most Asian-made single-stage collectors can be boosted by retrofitting the blower's inlet plate and fan wheel, as shown in the photo above. A larger inlet plate lets the blower convey a larger volume of air, just like a bigger carburetor on an car engine. Replacing the 10-in. fan wheel found in many blowers with a 12-in. aluminum wheel that has more paddle surface area also improves the air-moving capacity of the collector. (Inlet plates and fan wheels are available from Oneida; see Sources of Supply on p. 195). One warning: Never run a retrofitted collector that's not connected to ductwork because a totally unrestricted blower works harder and can burn out its motor (see p. 161).

FUTURE CHANGES

You can always make future changes to central collection ductwork—it just takes more or less trouble, depending on the way you've laid out and installed your system. If you've planned ahead, your system has the capacity for adding on extra branches to serve new machines. The easiest kind of change is adding on to the end of the main duct, extending it and adding branches as needed. You can also add new branches without much fuss by using an ingenious fitting called a 45-degree lateral saddle-tap tee (see Sources of Supply on p. 195). This tee can be pop-riveted



Adding new branches along the length of the main line is easily accomplished by cutting a hole into the main and then pop riveting a lateral saddle-tap tee fitting over the hole.

to the outside of an existing duct over a hole cut into the duct (see the photo above).

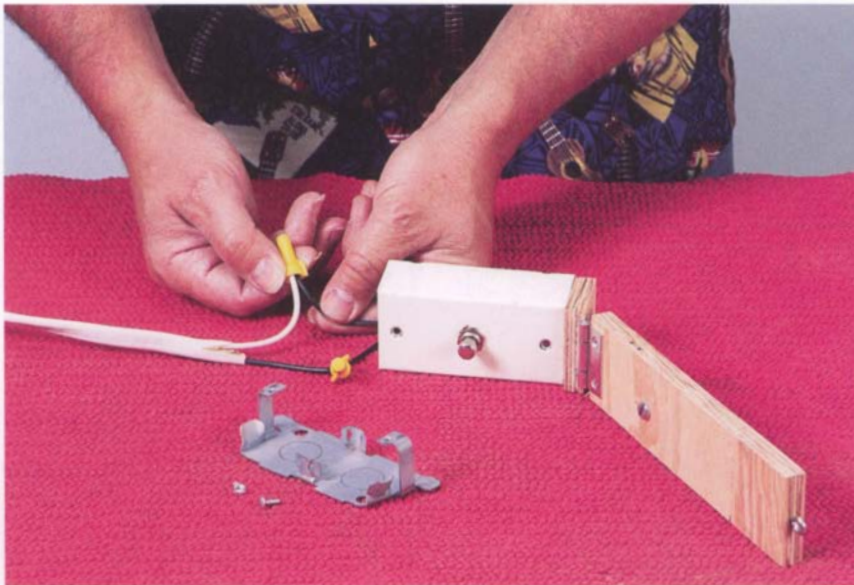
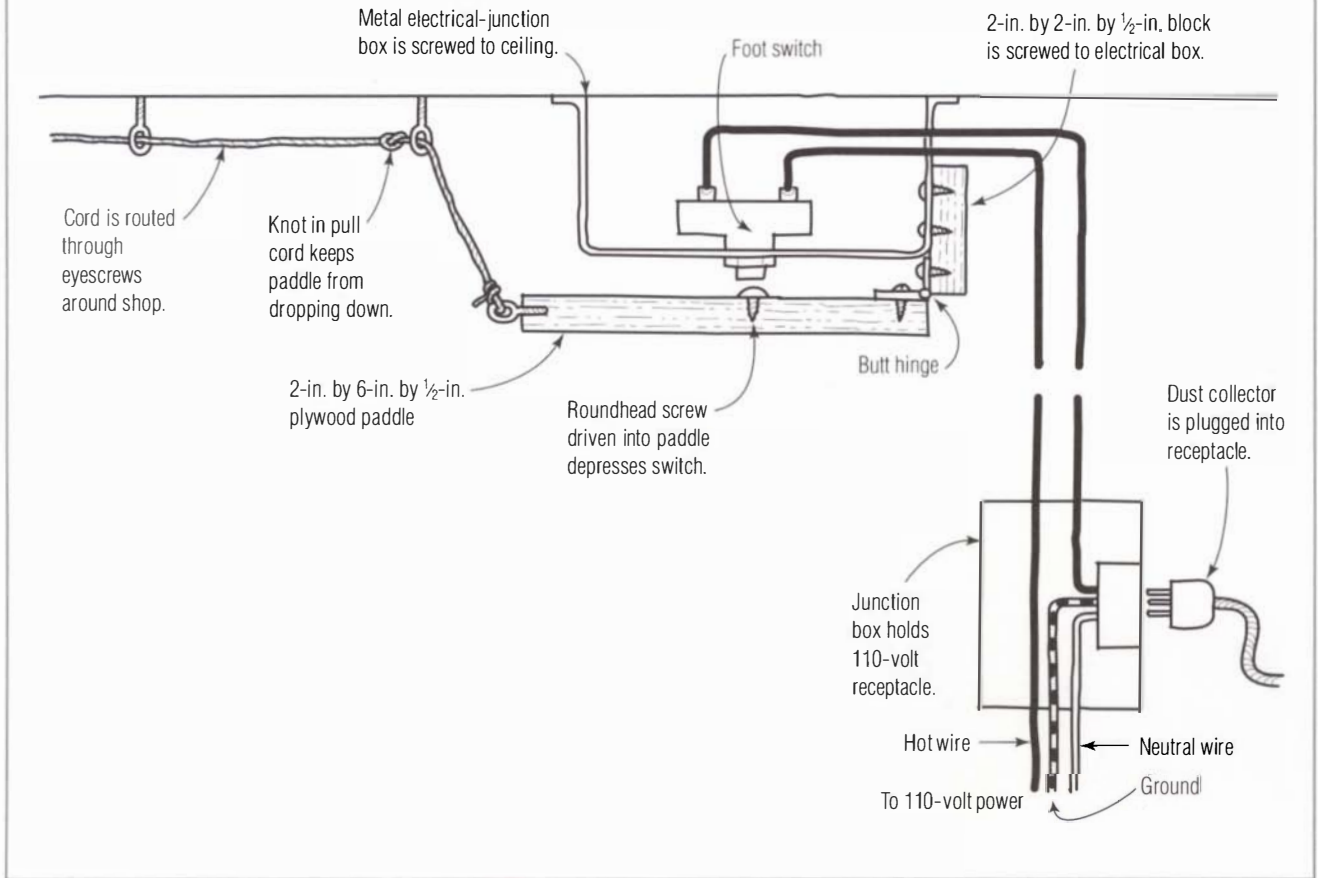
Switching the Dust Collector On and Off

Once you have your system up and running, you can leave it on all the time, but you'll save lots of electricity (and keep your shop quieter) by switching it off whenever it's not needed. The key is to make the collector as easy as possible to switch on and off. Access is the main issue here because you're less likely to use your collector if its switch is located across the shop from where you're working. There are at least half a dozen different switching methods that offer user convenience, including the simple mechanical pull cord and standard electrical switches as well as a bevy of remote-control and automatic electronic switching devices. The best method for you will depend on the size of your shop, the number of people that work in it, and the size of your budget.

PULL CORD AND PADDLE SWITCH

One of the lowest-tech remote switches I've seen is based on the old-fashioned pull cords found in city buses and trolleys, where pulling a cord strung the length of the passenger compartment rang a bell or a buzzer to alert the driver that your stop was coming up. Employed in the shop, a pull cord activates a remote paddle switch (see the drawing on the facing page) wired to the collector's motor, allowing you to turn the motor on or off from nearly anywhere in the shop.

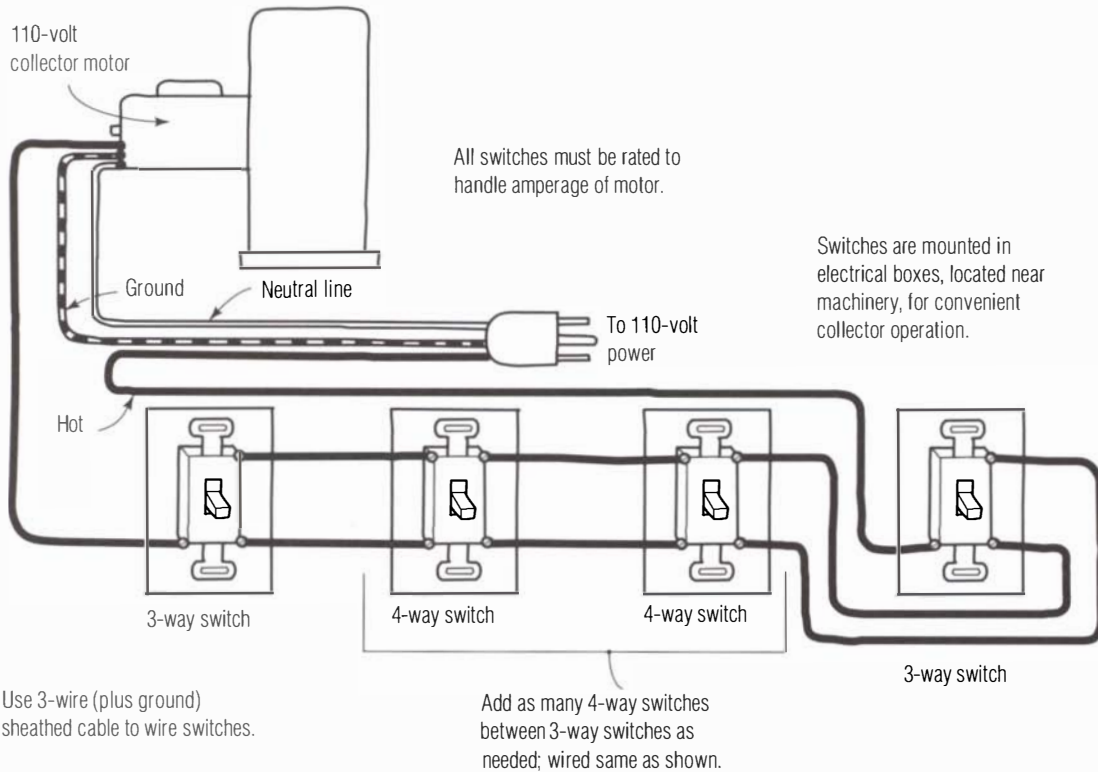
Pull-Cord and Paddle-Switch Dust-Collector Control



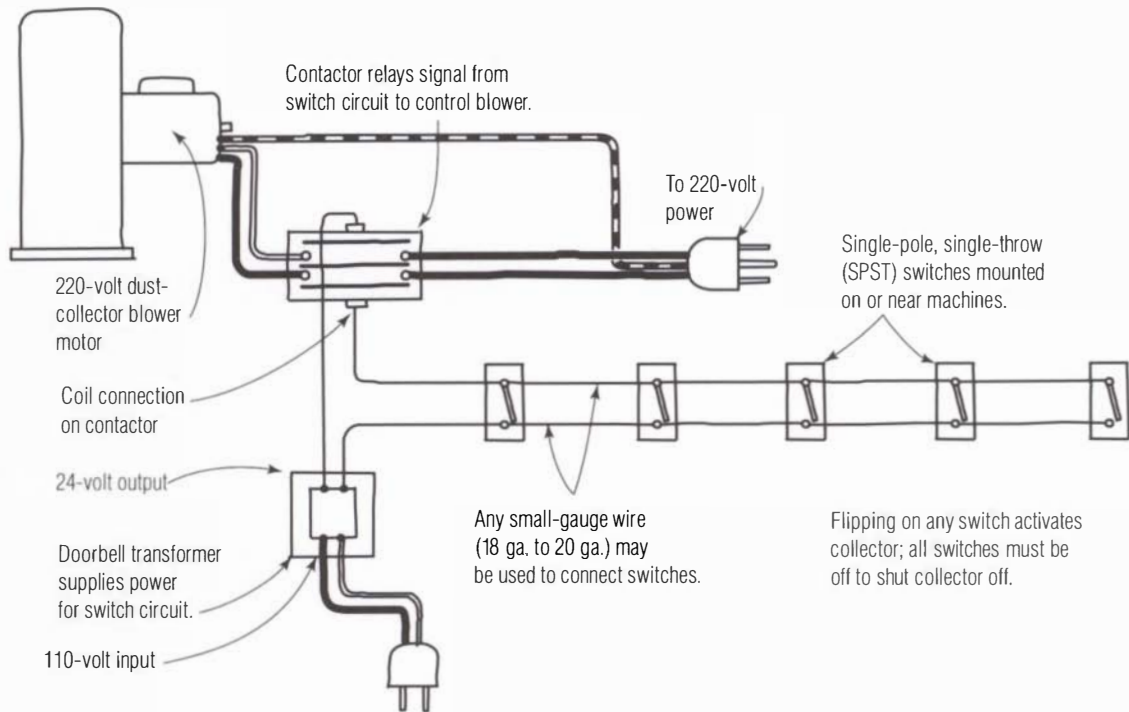
A low-tech method for turning a collector on or off from anywhere in the shop is to build a paddle switch. Pulling on a cord routed around the shop presses the switch's hinged lever arm against an on/off switch, which is wired to control the collector.

Here's how the pull-cord system works: A cord is routed around the shop, threaded through a series of closed eyescrews driven into walls, ceilings, and/or machine bases as necessary. Any strong cord, such as cotton or nylon mason's cord, will do. Several cords can be connected to the cord that reaches the switch, so there's no limit to the number of machines the pull cord will control. The end of the cord farthest from the collector is anchored by a screw or tied to an eyescrew. The other end of the cord is attached to a plywood paddle hinged to one end of a metal electrical junction box (see the photo on p. 165), to give the pull action of the cord enough leverage to trigger the switch. The box houses a heavy-duty foot switch—the kind that pushes once for on, once for off. Pulling on the cord once turns the collector on; pulling again turns it off. If your collector has a 110-volt, 1-hp or 1½-hp motor, the switch can be wired to control the motor directly. For higher-horsepower and 220-volt motors, use the foot switch to control a relay (see p. 168).

Wiring Electrical Switches for Controlling Central Collector



Low-Voltage Relay Wiring



WIRING MULTIPLE ELECTRICAL SWITCHES

Another way to control your central collector from several different locations in the shop is to wire a series of three-way and four-way 110-volt electrical switches, as shown in the drawing on the facing page. For a 110-volt collector, the circuit is wired to control the current directly to the motor. For a 220-volt collector, the circuit operates a relay that connects or disconnects power to the motor. The circuit is wired just as it would be to control a light—say, in a stairwell in your home—from several locations. Any switch will turn the collector on or off. So, for example, you can activate the collector from a switch near the table saw, then turn it off from a switch near the planer. You can wire practically any number of four-way switches in between the three-way switches at either end, as shown in the drawing.

While basic switch control of the collector is simple and thoroughly dependable, running sheathed cable is time-consuming and system components are expensive: A single four-way switch can cost \$10 or more, and most switches are rated to handle only up to a 1-hp motor.

LOW-VOLTAGE RELAY CIRCUIT

A popular—as well as cheaper and safer—version of the multiple-switch circuitry discussed in the previous section is to use a low-voltage transformer and wiring to relay the on/off signal to the collector's blower. In this system, a heavy-duty relay, called a contactor, is controlled by a series of low-voltage switches mounted around the shop, as shown in the drawing on p. 167. Turning any switch on or off completes or interrupts the circuit to an electromagnet in the contactor, engaging the electrical contact point(s) that switch the blower motor on or off. A single-contact contactor is used to control a 110-volt motor; a two-contact unit (shown) is required for a 220-volt motor.

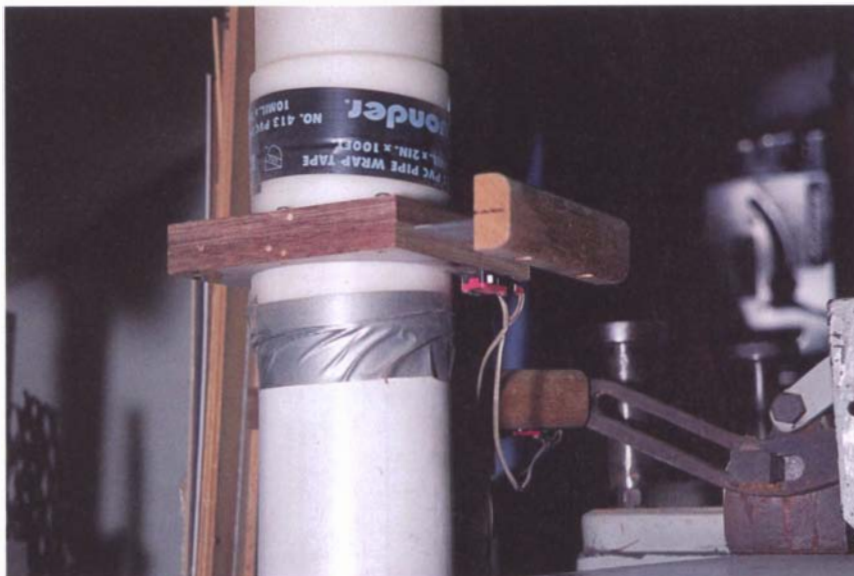
Choose a contactor with a 24-volt AC coil and use a 24-volt household doorbell transformer to power it (available at most hardware stores or from Grainger, #3A356). Because there's virtually no electrical-shock or fire hazard from low-voltage AC, relay-switch wiring is done with inexpensive 18-ga. lamp cord or 20-ga. speaker wire. The wire is run around the shop and held in place with staples. For switches, use any kind of basic single-pole, single-throw (SPST) switch: a regular household light switch or an SPST toggle switch (such as Radio Shack #275-602). Mount switches in surface-mounted electrical boxes or plastic electronic project boxes (available from Radio Shack). For greatest convenience, locate the switches close to each machine's starter switch.

The downside of a relay system is that while any switch will turn the system on, you must use the same switch to turn the collector off again. This gets confusing if you're working with two or three machines at a time. To reduce confusion—and make switching on the collector easier—some woodworkers incorporate low-voltage switches directly into their system's blast gates.

SWITCHES BUILT INTO BLAST GATES

As long as you have to open and close blast gates when you turn on machines anyway, the gates might as well do double duty. You can build relay-controlling switches into commercial or shop-built blast gates, as shown in the photo on the facing page. A low-voltage microswitch (available from Radio Shack, #275-017) is screwed to the frame of each blast gate. The handle of the gate bears against the head of the switch: Push the gate all the way closed, and the switch is off; pull the gate open, and the switch turns the collector on. The switches are wired just as they are shown in the relay-circuit drawing on p. 167.

As with a regular low-voltage relay system, you must turn the collector off by closing the same blast gate you opened in the first place. You can open other gates and use other machines in the process, but all gates must be closed to switch the collector off. Wire separate toggle switches for machines or accessories that don't have their own blast gates.



A low-voltage relay system is easier to use if you build switches directly into blast gates. The handle of the sliding gate presses against a microswitch screwed to the gate's frame, turning the collector on or off whenever the gate is opened or closed.

Keep Your Remote Control Handy

To keep your dust collector's remote control handy, try clipping it to your shop apron or work coveralls. If you don't wear special work duds, attach your remote to the end of the pull chain on a janitor's key reel (which hooks on a belt or waistband). Using a reel also helps prevent the remote from being dropped, which can destroy the remote in a single tumble.

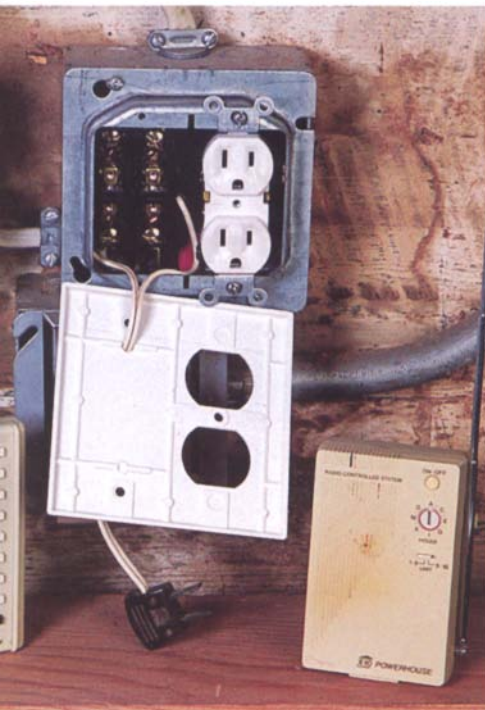
WIRELESS REMOTE CONTROL

To save the trouble of installing wiring, try a collector control that uses wireless remote-control technology. Simple systems such as the X-10 (from Radio Shack) or the Long Ranger (see Sources of Supply on p. 195) use a battery-powered radio-frequency remote sender to transmit a signal to a receiver module. The module, designed to plug into a wall receptacle, has a relay in it that switches electricity on or off to the blower motor. Most remotes have enough range for use in the biggest shops and, unlike infrared television remote controls, don't require you to point the remote at the receiver module to activate it.

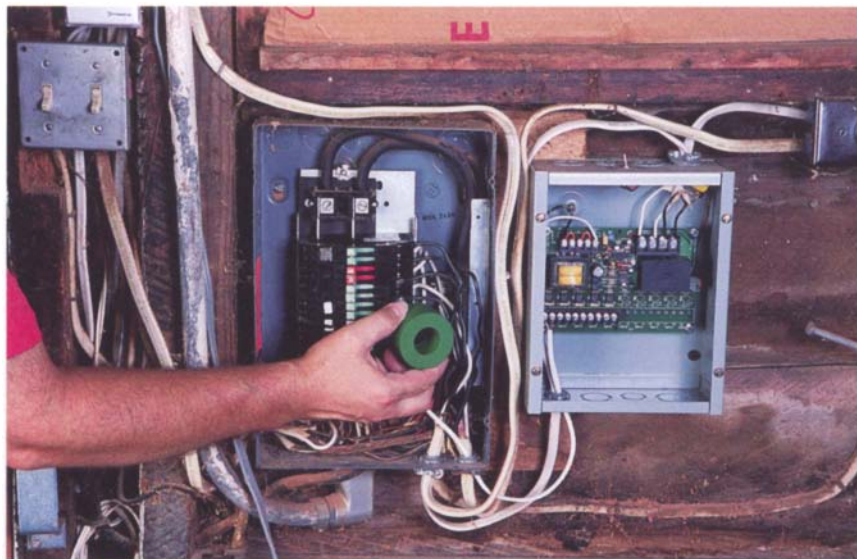
Inexpensive remote-control systems, like the X-10, have modules that only control 110-volt motors up to 15 amps. To control 220-volt blowers, use a 220-volt module, such as the Long Ranger, or rig a 110-volt remote-control module to switch the coil of a contactor, as shown in the photo at left on p. 170. The contactor must have a 110-volt coil and two contacts to connect or disconnect power to both hot leads to the 220-volt motor.

AUTOMATIC DUST-COLLECTOR CONTROL SWITCHES

What could be slicker than switching your central collector on and off automatically? Like the smaller-capacity models designed to work with portable power tools and shop vacuums (see p. 78), automatic control switches sense current from machines connected to them. When the machine is turned on or off, the automatic switch operates the dust col-



Controlling a central collector with an electronic remote control allows you to turn the collector on and off from anywhere in the shop. To control a collector with a 220-volt motor, the X-10 transmitter (left) sends a signal to a 110-volt receiver (right) which controls a 220-volt contactor relay, wired inside the electrical box (center).



The Dougherty automatic dust-collector switch uses a small pickup (the green “doughnut”) that can sense current flowing through circuit wires routed through it. When a shop machine is switched on, the sensor sends a signal to the main unit (housed in the box to the right of the breaker box), which automatically turns the dust collector on.

lector as well. You don’t have to remember to switch the collector on and off; just turn on the machine (and open a blast gate, as necessary) and you’re in business.

There are several different brands of automatic control switches on the market, which differ in the way they connect to your shop’s wiring. The Dougherty automatic switch, shown in the photo above right, uses a special sensor that mounts inside your shop’s breaker box. A hot wire from each circuit that powers machines served by dust collection is simply routed through the coil of the sensor; it is not direct-wired to the auto switch itself. The sensor detects current when a machine is switched on or off and sends a signal to the unit’s main circuit board and contactor, which are both housed in a metal box mounted near the breaker box. The Ecogate automatic-blast gate system (discussed on p. 156) uses sensors mounted on shop machines to open and close blast gates and turn the collector on and off in concert with the machine.

Even if you use an electronic switching system as the primary control for dust collection, it’s a good idea to install a simple backup system (such as regular electrical switches, described on p. 167). Simpler switching schemes are less complex—and therefore less subject to failure—than electronic devices and will keep your collector up and running if the gremlins glitch your high-tech controller.

Collection Hoods and Other Devices

Just because you've installed a perfectly designed ductwork system hooked up to a gargantuan dust collector, there's no guarantee that your shop will stay clean—you've got to get the sawdust into the system in the first place. To capture the maximum amount of dust at the source, you need a good collection hood that directs chips into the ductwork and provides ample airflow so chips won't settle on the way to the collector. Woodworking machines with well-engineered ports and hoods are easy to connect to a collection system; other sources of woodshop sawdust aren't as easy to handle. Older machines and portable power tools, such as orbital sanders and routers, often don't have built-in collection ports or, if they do, they are poorly designed or too small for good collection performance. Even hand operations, such as shaping a chair's arms with a rasp or smoothing a panel with a sanding block, can raise a significant amount of dust that's difficult to capture.

But there are solutions for all these situations: Well-designed custom hoods ensure efficient collection from stationary machinery; shop-built devices capture dust from portable power tools that lack built-in collection; and sanding tables, booths, and hoods arrest fine dust generated by hand-sanding before it escapes into the air. The time taken to implement these solutions is but a fraction of the time it takes to install your central dust-collection system. When you consider how much better your system will operate with them, it's certainly time well spent.

AIR VOLUME RELATIVE TO HOSE/DUCT DIAMETER

Hose/Duct Diameter	Cfm at 4,000 fpm
1½ in.	50 cfm
2 in.	85 cfm
2½ in.	135 cfm
3 in.	195 cfm
4 in.	350 cfm
5 in.	545 cfm
6 in.	785 cfm
7 in.	1,070 cfm
8 in.	1,400 cfm

Use Duct Reducers Close to the Source

One way to increase the diameter of a machine's undersized dust port is to fit a reducer as close to the tool as possible; the reducer steps down the size of the hose or duct to suit the port. A reducer is better than running a smaller-diameter branch duct to the tool, which results in lower airflow and much higher friction losses.



An angle-ring fitting pop-riveted over a hole cut into a flat metal surface, such as the lower blade enclosure on this bandsaw, provides a dust-collection port and a sturdy attachment for a flexible hose.

Hoods for Stationary Machines

Many stationary machines already have built-in dust-collection ports (sometimes called outlet collars); all you have to do is attach a flexible hose from your branch duct, and you're in business. Unfortunately, the ports on most light-duty and home-shop machines only accept 2½-in.-dia. vacuum hoses. These small ports severely limit the air volume that's needed for effective collection from these tools (see the chart on the facing page). To improve performance, it's best to adapt such ports to accept a 3-in. or 4-in. hose. If the port is in a sheet-metal panel or housing, you can use a nibbler tool (available from a hardware store or electronics supply house) to enlarge the opening. A flange-type pipe fitting (called an angle ring or starter ring) can be screwed or pop-riveted in place (see the photo on the facing page).

Newer machines that don't come with built-in dust ports often have optional hoods that you can buy from the manufacturer (for example, the hood on the DeWalt® portable planer shown below). However, if you have an older machine, you'll have to design and build a custom hood. In many cases you don't need to start completely from scratch: There are many different sheet-metal HVAC components and heating-pipe fittings—such as vent-stack roof flashing, reducers, tapers, and transition fittings (rectangular-to-round)—that can be adapted, with a little trimming and bending, to serve as dust-collection hoods on a wide variety of



Hooking a portable thickness planer to a central dust-collection system is as easy as mounting a dust hood, available as a standard or optional accessory on all popular models, including the DeWalt DW733 shown here.

woodworking machines. Even plastic sewer-pipe fittings can be used in making custom hoods—just be sure to run a bridge wire to ground the machine to the branch duct that’s serving it (see p. 159).

MAKING A CUSTOM HOOD

Machines with unenclosed bases (such as older table saws) and machines that have working parts that require clearance or access for adjustment (such as bandsaws) can be hard to fit using standard hoods and fittings. In such cases, you must build a custom hood from scratch, using thin sheet metal, aluminum, or plywood. But before you start building, it’s a good idea to make a trial hood from corrugated cardboard or foam-core board (available from art-supply stores), fastened together with cloth-backed tape (see the photo at left). The tape lets you disassemble components and recut them as necessary. You can also use tape to secure the hood to the end of a flexible hose for testing.

To optimize airflow into the collection system, a hood should enclose the area around the cutting tool and direct the flow of chips into the system and keep them from escaping. But be careful not to overdo it. It’s a common mistake to make a custom-built hood so airtight that it starves the air flowing into the ductwork; you can’t convey chips when you’ve cut your airflow significantly. The idea is to let air enter the hood at locations that best encourage the capture of chips and dust. For example, in the drawing on the facing page, allowing air to enter the front edge of the hood (past the infeed roller and cutterhead) encourages airflow to capture chips thrown up by the cutterhead and move them toward the hood’s outlet. If you suspect that a hood is constricting airflow, try trimming its opening to let in more air (you can check the airflow before and after using a manometer; see p. 161).

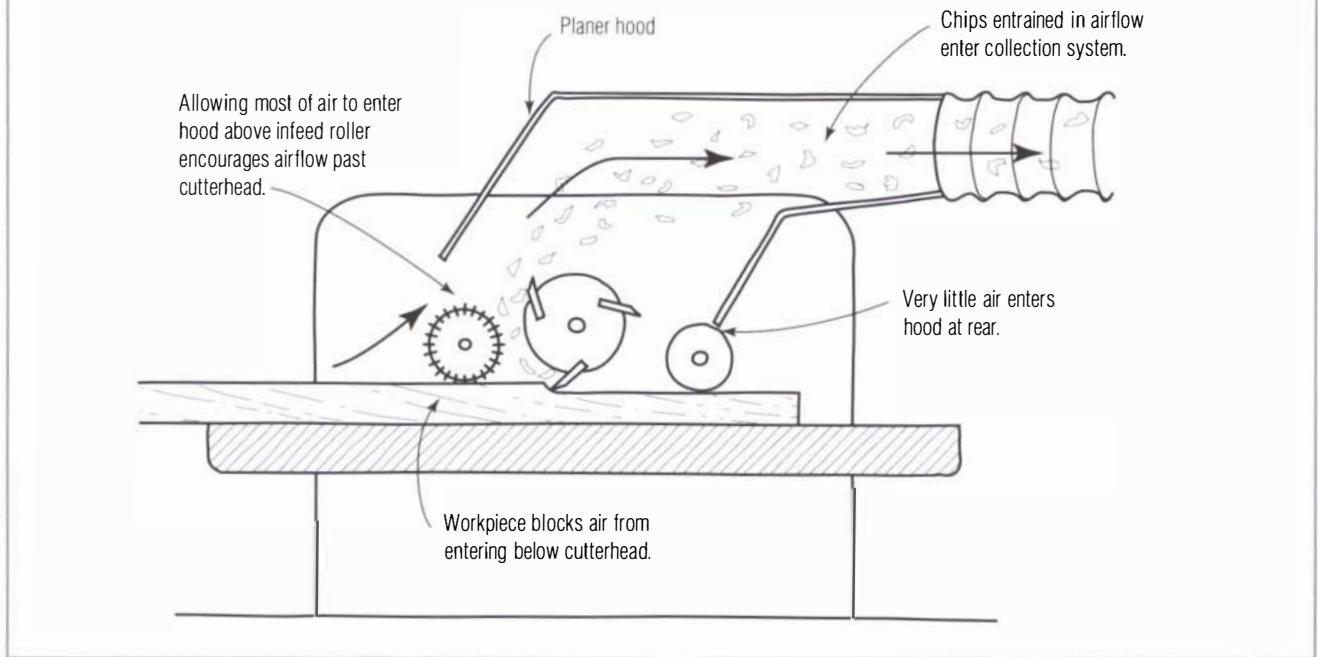
Larger chips and shavings produced by planers and spindle shapers take a tremendous amount of airflow to capture. These large wood bits weigh enough to develop a surprising amount of momentum—you already know this if you’ve been hit in the face by chips hurled by a whirring cutter. Unless the chips are thrown directly into the hood, it’s very difficult for even the most powerful stream of air to capture them. Therefore, take advantage of the propellant force with which chips are hurled. Carefully observe their propelled direction and try to design and position your hood to deflect or direct chips so they travel with the flow of air into the collection system.

Building the hood When you’ve come up with a hood design that seems to work well, you can use the cardboard or foam-core hood for light-duty work or use the pieces as a pattern to make a heavier-duty hood from sheet metal, Masonite, or thin plywood. Because it’s easy to work with, I like to use aluminum roof flashing (available from a hardware or building-supply store) and pop-rivet the parts together (see the discussion of pop riveting on p. 154). An easy way to add a round port for connecting a duct



A venturi-box hood, mounted behind a compound miter saw, speeds airflow and thus improves the capture of sawdust hurled by the sawblade. Made from corrugated cardboard and tape, the hood has a mouth wide enough to catch chips even when the saw is set for a miter cut.

Hood for Thickness Planer



or flex hose is to use an angle ring or a universal mounting strip (also called a catcher strip; see Sources of Supply on p. 195). A sheet-metal catcher strip has a 4-in., 5-in., or 6-in.-dia. round outlet to attach a flex hose. Alternatively, you can take just about any round sheet-metal fitting (such as an elbow or a connector) and make it into a flex-hose connector by making short ($\frac{1}{2}$ -in. to $\frac{3}{4}$ -in.) slits into the end about $\frac{1}{4}$ in. apart, and then bending out the strips to form a flange. Slip the fitting through a hole in your custom hood, and screw or pop-rivet the flange strips to the hood. Use silicone caulk or duct tape to seal up any gaps that leak air.

On tools that require access to cutterheads, blades, or bits for changeovers or adjustments (planers, bandsaws, shapers), it's best to make the hood easily detachable. On machines where the hood is mounted out of the way, you can attach it permanently with pop rivets or silicone caulk (see the photo on p. 181).

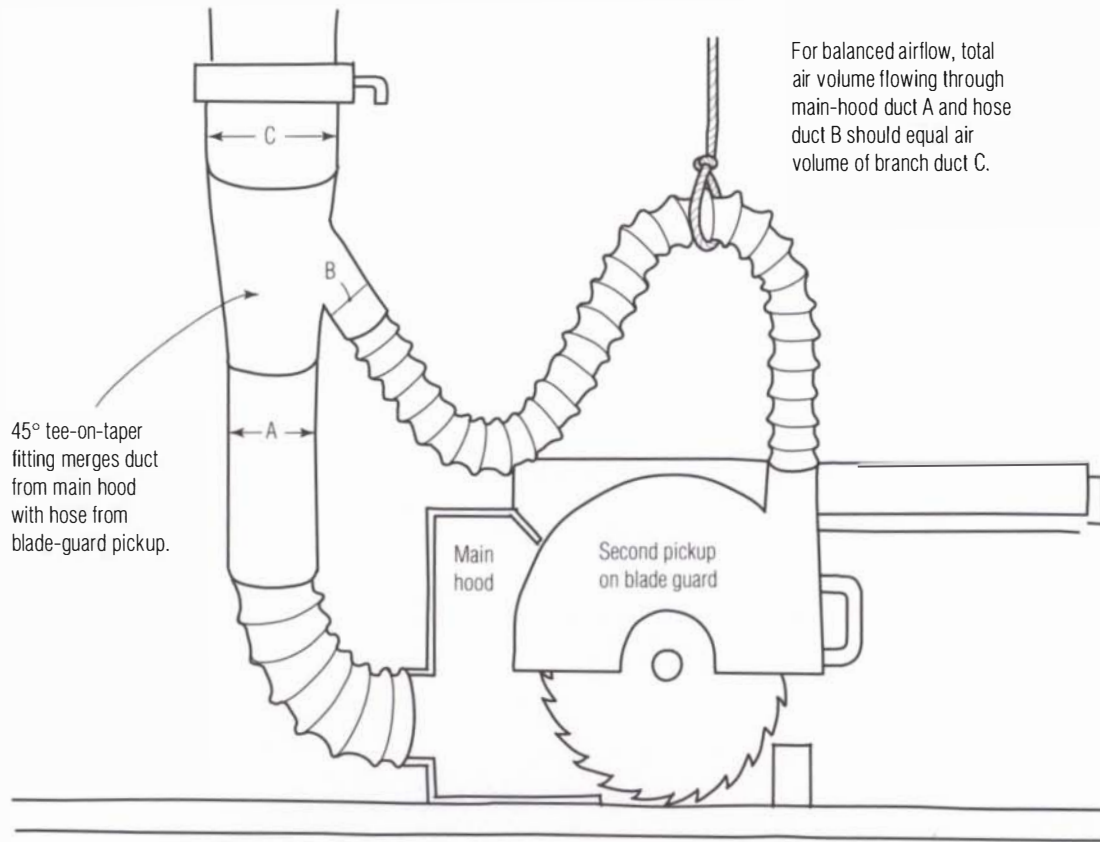
ADDING A SECOND PICKUP

With many machines, dust collection from a single port or hood just isn't enough to capture and convey all the dust and chips the tool produces. Machines such as stroke sanders and multiple-drum thicknessing sanders need additional ports or hoods simply because dust must be picked up at different locations on the machine. Other machines, such as radial-arm saws, bandsaws, and table saws, may benefit from a second pickup at the blade housing or above the table to enhance collection performance.

Testing a New Dust Hood

Before testing a new dust hood, clean up the area around the machine. Start the collector, take a few cuts, and see how much dust ends up on the machine or the floor; this should give you a pretty good idea of how well your hood is performing. Always make sure that the hood isn't mounted too close to any moving blades, bits, etc., and that it doesn't interfere with adjustments, such as blade tilt and elevation.

Balancing Airflow on Machines with Two Dust Pickups



The trick to connecting more than one pickup to the branch duct that serves a machine is to balance the airflow from the two sources. If you don't, you'll end up with one pickup getting the lion's share of the airflow and the other pickup doing practically nothing. The volume of air coming from both pickups should be equal to (or slightly less than) the volume of air traveling through the branch duct (see the table on p. 172). For example, a radial-arm saw with a 4-in. duct conveying 350 cfm from the main hood and a 2½-in. hose adding about 135 cfm from the blade-guard pickup needs a 5-in. branch duct that delivers 545 cfm at 4,000 fpm. The hose from the second pickup should join the branch at a 45-degree tee-on-taper, as shown in the drawing above. Note that small-diameter hoses (under 2½ in.) only draw 50 cfm to 135 cfm at best. Therefore, in situations where an existing branch duct is not large enough to serve two pickups, it's wise to eliminate the second pickup and concentrate collection at the main hood. Large stroke sanders with two hoods (one at each end roller) should connect to the branch duct with twin hoses fed from a wye branch. Fitting

blast gates on both legs of the wye allows you to regulate the airflow at each pickup, so you can balance them for best performance.

HOODS FOR COMMON WOODSHOP MACHINES

In the next few pages, I offer some design suggestions for dust-collection hoods to serve many of the machines commonly found in a woodshop.

Table saws Most large table saws (Delta Unisaw, Powermatic 66, etc.) have an enclosed base with a built-in 4-in. or 5-in. dust port and cleanout door. Connecting collection to one of these ports will do a fair job of removing sawdust, provided that the system moves an adequate volume of air (350 cfm to 500 cfm is recommended). On open-based saws, such as most contractor-type saws, no dust hookup is provided and you must make a custom hood. Many woodworkers choose simply to enclose the base of such saws by mounting panels of sheet metal, Masonite, or thin plywood to the sides and bottom of the saw and installing a port on the underside. The difficulty with this arrangement is preventing dust from escaping at the back of the saw, where the motor assembly protrudes.

A better hood for a contractor's saw is one that partially surrounds the blade so that sawdust is captured as close to the source as possible. This arrangement not only reduces the amount of chips that is recut by

Reducing Chips Thrown Up by a Table Saw

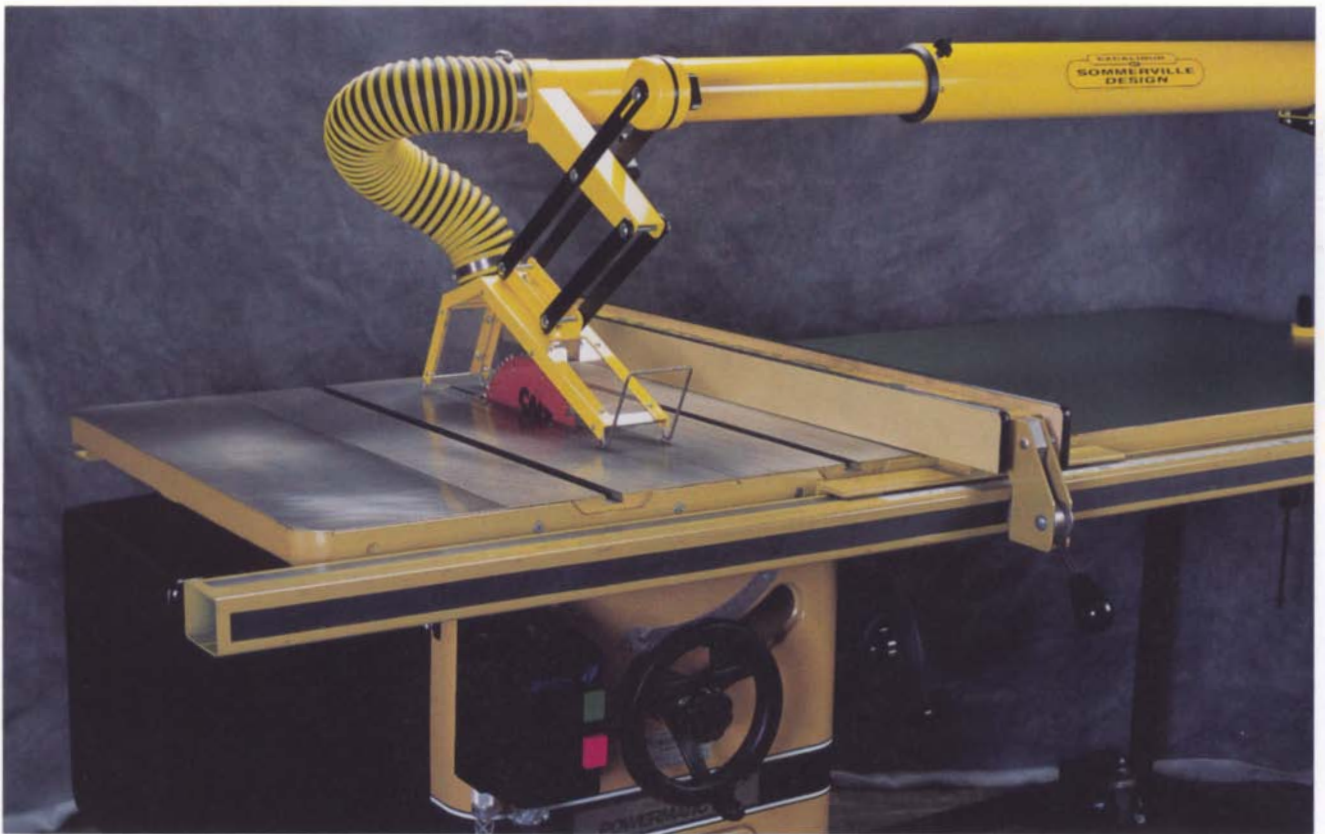
An easy way to reduce the plume of chips thrown up by a table saw's blade is to fit the saw with a zero-clearance throat plate—a wood or plastic plate that's slotted by raising the spinning sawblade up through it. To seal up just the back end of the throat-plate slot (where the majority of dust is thrown up), cover the underside of the slot with duct tape.



A shop-built sheet-metal hood fastened to a table saw's trunnion assembly provides effective dust capture on a contractor's-style saw that doesn't have an enclosed base. The hood tilts with the blade as you tilt it for bevel cuts.

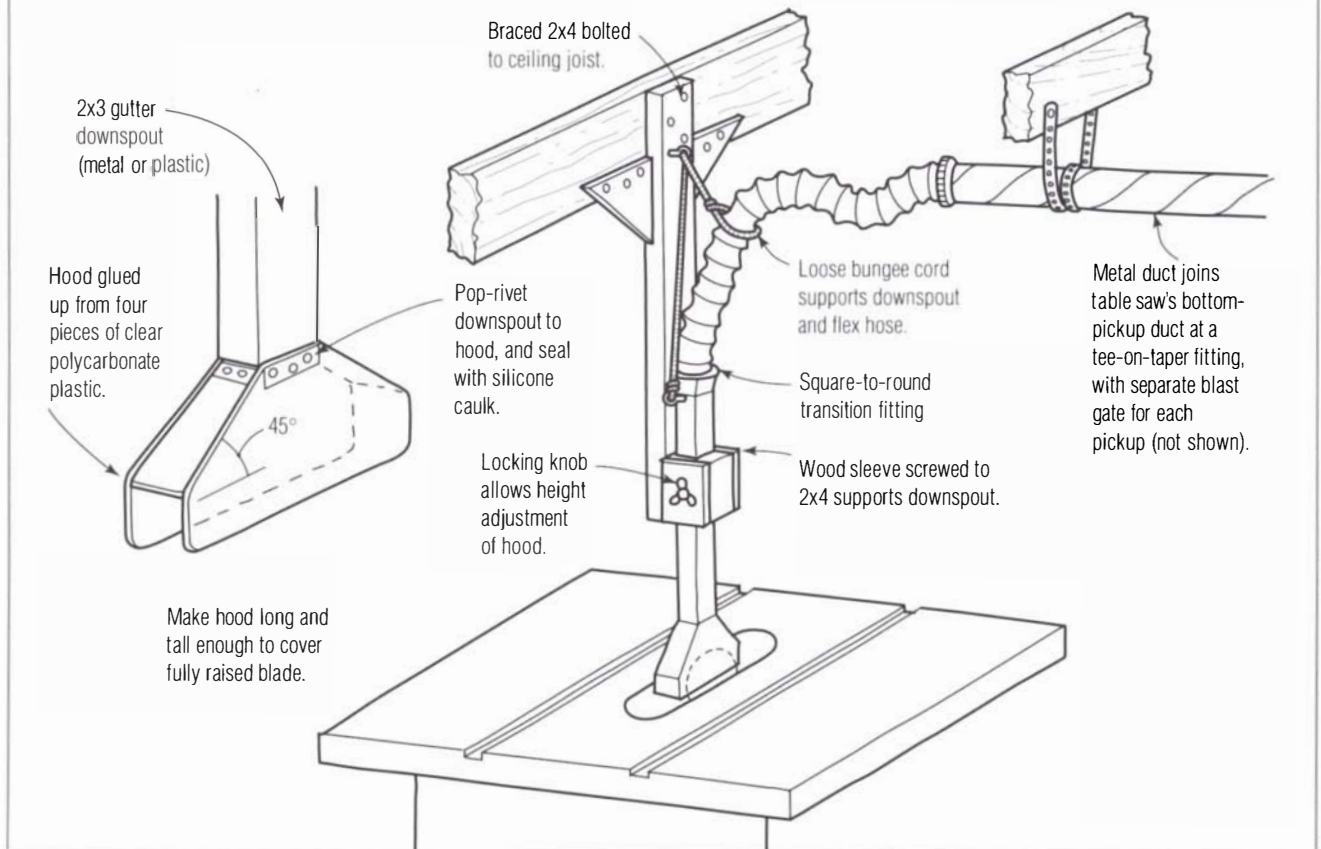
the blade (thus dulling teeth more quickly) but also captures dust before it can clog the saw's adjustment mechanisms. The challenge is to shroud the blade without interfering with the blade-raising and blade-tilting mechanisms. I built the sheet-metal hood, shown in the photo on p. 177, for my Delta 10-in. benchtop saw and attached it to the existing chip deflector at the front of the blade, so it moves with the trunnion. The bottom of the hood has a 4-in. angle-ring fitting, which connects to a flexible hose. A curved slot on the right side of the hood provides clearance for the saw arbor as the blade is raised and lowered. The width of the guard allows clearance for blade changes and the use of a dado set or molding head.

When a saw's chip collection is poor (especially during heavy cuts, as when using a dado blade), many woodworkers will seal up as many points of air entry on the hood or saw cabinet as possible, using a close-fitting throat plate and even covering up the curved bevel-tilt slot on the front with masking tape. Unfortunately, sealing up the saw this way restricts airflow to the point that collection almost ceases. To avoid air starvation, leave an air gap between the hood and the table. On my hood, I left a slit



Double your pleasure with an overarm-style blade guard, like the Excalibur system shown here. Besides providing crucial protection from that ravenous sawblade, the guard catches chips thrown up by the blade and sucks them away via a 4-in. pipe that connects to a dust collector.

Top-Pickup Hood for Table Saw



open at the front left of the blade to allow air to enter the hood and help stream chips into the ductwork.

Even with a pretty strong airflow through the lower hood, a table-saw blade is likely to spew a plume of dust out the top of the table. A good way to capture this dust is to install a top dust pickup, though this won't work if you use a power feeder. Some aftermarket guards, such as the Excalibur® Overarm Bladecover, shown in the photo on the facing page, come with a built-in pickup hose. You can also build your own combination blade guard/top pickup, as shown in the drawing above. It uses a short length of rectangular gutter downspout connected to a length of 2½-in. or 3-in. flex hose. The ceiling-mounted guard/top pickup raises or lowers to adjust to the thickness of the work. It also removes easily to allow cutting of tenons or finger joints. The top pickup should have its own blast gate so you can balance airflow with the lower pickup or shut it off when you use the saw without the guard. As discussed on p. 175, the ducts from the top pickup and bottom hood should converge at a 45-degree tee-on-taper for better airflow to both pickups.



Fitting each machine on a central collection system with a well-designed dust hood is the first step to efficient capture of chips and sawdust. A jointer's built-in chip chute provides an effective hood when enclosed and fitted with a port for attaching a flexible hose.

Crosscut saws Many portable powered miter saws already have a built-in port for a dust bag, but these ports (typically 1¼ in. dia.) are more suitable for collection by a shop vacuum than a central collection system. To get better dust collection from these machines, you can add a boxlike hood directly behind the saw's line of cut, where the majority of chips are thrown during cutting. A sheet-metal or thin-plywood hood, with side shrouds that extend to just behind the fence, is effective. To improve the chip-capture strength for this application, try building a venturi-box hood, such as the one shown in the photo on p. 174. The pinched waist of this box creates the venturi effect, increasing the speed of air at the constriction and the effectiveness of the hood to suck in chips thrown off by the saw.

To take advantage of the dust-ported blade guard found on most radial-arm saws, run a small-diameter flexible hose from the port to a 45-degree tee-on-taper that's connected to the main hood behind the saw. This dual-pickup setup improves collection when the sawblade is all the way out at the end of a cut (farthest from the main hood) and when the arm is adjusted left or right for a miter cut.

Jointers The jointer is one of the easier machines to fit with dust collection. Closed-base jointers usually have a built-in chip chute that can be enclosed and fitted with a simple rectangular-to-round HVAC hood (pop-riveted directly over the end of the chute opening). Most other jointers

I've seen have an opening directly under the cutterhead, which makes it easy to mount a hood to pull chips from underneath (see the photo on the facing page). A rectangular-to-round hood (which should be as wide as the opening below the cutterhead) can be screwed to the underside of the jointer's body casting or over a cutout in the jointer base.

When a hood is sealed too tightly against the base of the jointer, the collection system's high-speed airflow passes directly through the whirring cutterhead; it can sound as though you have an F-16 taxiing through your



A sheet-metal hood surrounding a thickness planer's cutterhead is a must for clean planing operations. Unless they're whisked away by dust collection, chips are pressed into freshly planed wood surfaces by the machine's outfeed roller.

shop! To reduce the noise level, simply remount the hood to draw air in from the sides of the cutterhead, or add slots or holes in the hood to reduce the whizzing air without adversely affecting good chip collection.

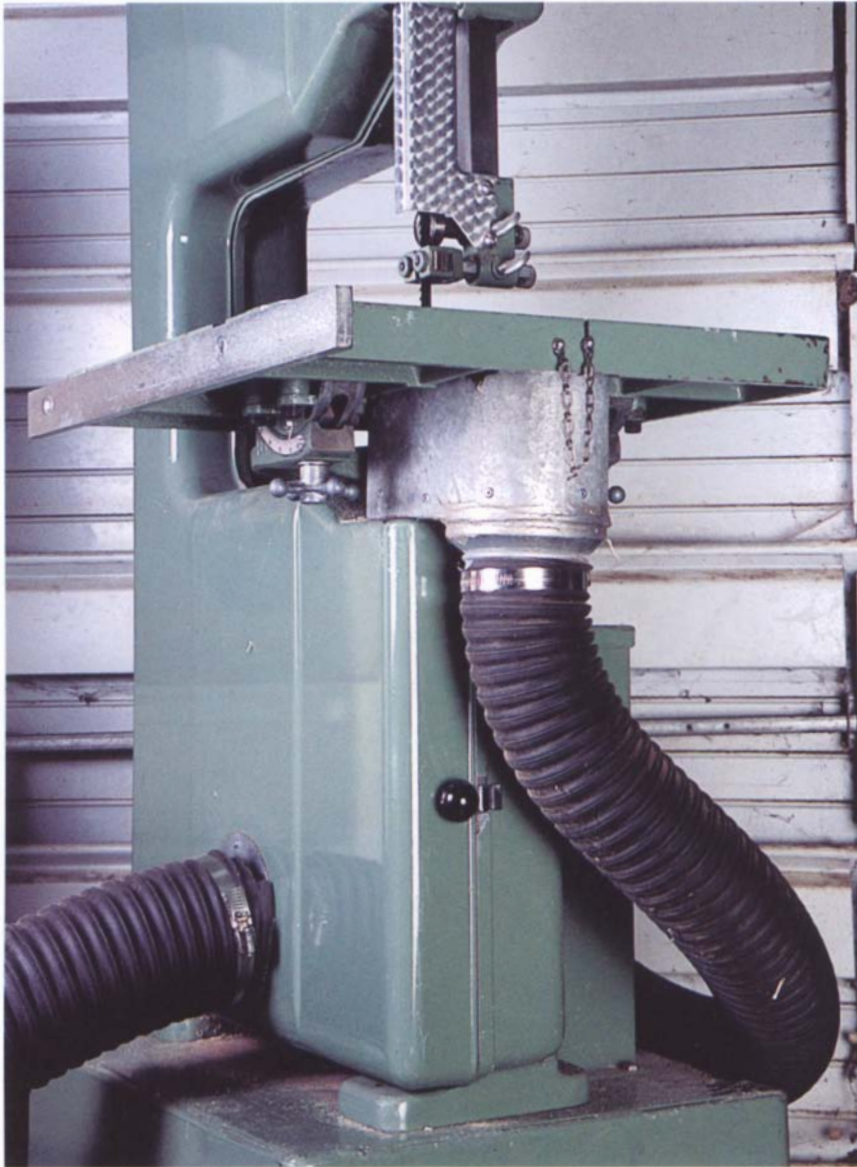
Thickness planers Many of the newer small planers come with a dust port either built into the housing or on a separate hood offered as an optional bolt-on accessory. Unfortunately, the dust hoods on some small (10-in. and 12-in.) planers have undersized ports, clearly designed to be connected to a shop vacuum, not a central collection system. For better performance, I suggest you enlarge these ports (if possible) to handle at least a 4-in.-dia. hose, although this may prove to be more of a hassle than simply constructing a new hood.

An effective hood can be adapted from an existing HVAC hood or built from scratch from sheet metal or plywood. One important consideration is to make the hood easy to remove in order to facilitate quick blade inspections and changes (see the photo on p. 181).

Because the planer produces a considerable volume of large-size chips and shavings, which require lots of air to capture and convey, it's especially important to make sure that you don't starve the hood of air. Don't bother sealing up the underside of the planer; wide boards sent through the planer usually do this anyway. When in doubt, check the air velocity and volume with a manometer (as described on p. 161). If you need to cut extra air-entry slots to increase airflow through the hood, locate them opposite the hose port to encourage chip movement away from the cutterhead (see p. 174).

Bandsaws The ideal location for the main dust pickup on a bandsaw is directly below the point where the blade passes through the table. Unfortunately, the blade guides, table trunnions, and wheel housings can get in the way of putting a hood there. Also, you need to make the hood removable so that you can adjust the guides or tilt the table without a lot of fuss. I built a small hood for my 15-in. General® bandsaw by cutting and bending a standard galvanized-steel gutter endcap to fit the gap between the table and wheel housing. A 3-in. flex hose fastens over the fitting's downspout (see the photo on the facing page). The rear-facing side of the hood is open, so air flows past the blade for better sawdust removal.

If you use wide, skip-toothed blades with deep gullets (popular for resawing), you're likely to get an accumulation of dust and chips in the saw's lower wheel housing. Adding a second pickup in the form of a dust port in the lower part of the sealed wheel housing should take care of the problem. Many saws have thin sheet-metal doors, which are easy to cut a hole into using a drill and a hand nibbling tool; you can then pop-rivet an angle ring over the hole (as shown in the photo on p. 172). Connecting this port to a tee-on-taper via a flexible hose allows the door to be opened without fuss.



Improving Collection at a Bandsaw

To increase airflow into a bandsaw hood mounted at the lower guide assembly, try drilling half a dozen or so ¼-in. holes through the small throat-plate insert that fits into the table around the blade. The added airflow actually aids capture and entrainment of dust and small chips.

Enclosing the area directly under the blade is the most effective way to capture dust from a bandsaw. This hood, made by modifying a metal rain-gutter fitting, removes quickly for saw adjustments and blade changes.

Stationary sanders Hood designs and setups for stationary sanders are as varied as the sanders themselves. Drum and wide-belt thicknessing sanders usually come with built-in ports, because thorough dust removal is necessary for these machines to operate without their abrasives clogging and burning the wood. Some machines, such as single- and dual-drum sanders, often come with two equal-size dust ports for more thorough collection along their wide drums. For best performance, run two flexible

Stripper Jets for Belt Sanders



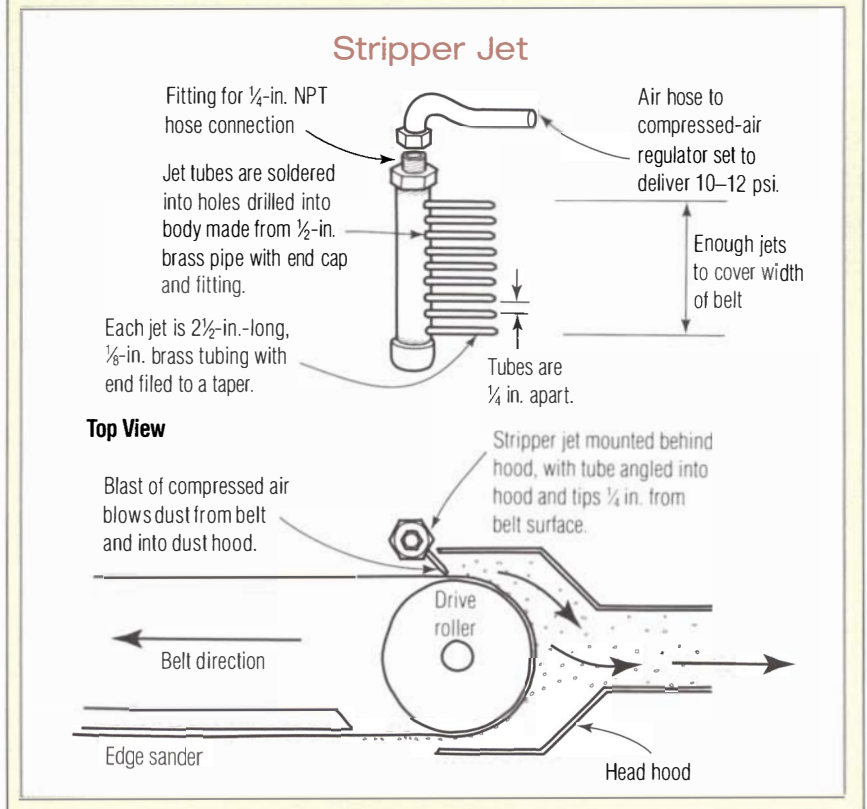
A dust nozzle mounted on a freestanding base is efficient and versatile for collecting fine dust from arbor-mounted wheels and drums.

ONE OF THE DIFFICULTIES IN CAPTURING fine dust from a sanding belt is that the dust doesn't always release readily from the abrasive; static electricity can charge wood particles and temporarily bond them to the belt. The result is excessive loading of the abrasive, which can burn the wood and reduce the life of the belt. An effective way to get dust off the abrasive is to employ a "push-pull" system: A jet of air blows particles off (the push) so that the collection system can suck them up (the pull).

A stripper jet, such as the one shown in the drawing below, consists of a series of thin tubes spanning the width of the belt, which blow jets of compressed

air against the surface of the moving belt. The tubes are mounted on a head, which is placed just outside the sander's main hood, with the tubes angled to blow air against the direction of the belt and toward the hood.

While few such heads are in use in small shops (industrial stripper jets are expensive), a simple jet isn't difficult to make, and the technique is definitely worth experimenting with. You can also try using compressed air to improve dust and chip collection from bit-tinged and bladed machines, such as the shaper, router table, and table saw. Aim the blast of air where it will blow dust away from the blade or cutter, in the direction of the dust-collection hood.



hoses to these ports from a wye fitting on the end of the branch duct. For balanced pickup, make both hoses the same length or crush the leg of the wye feeding the shorter hose to restrict its airflow slightly to match the higher-friction loss in the longer hose.

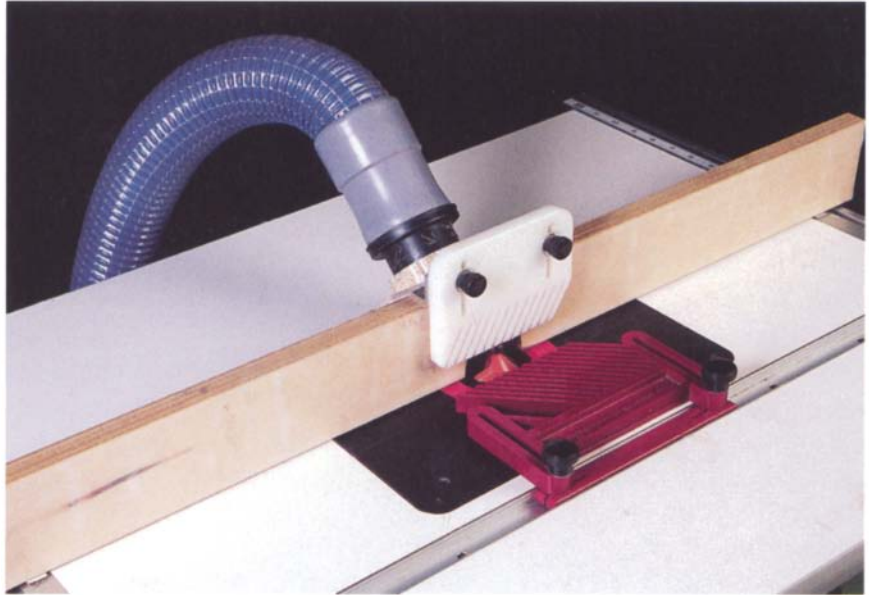
Disk sanders and combination belt/disk sanders also usually come with built-in ports, although on less expensive benchtop units these ports are designed for dust collection with a shop vacuum. If you decide to add a different or additional hood to these machines, locate the port nearest the point where dust is thrown by the sander. Arbor-mounted flap-sanding wheels, grinding wheels, or pneumatic sanding drums can be enclosed by a hood. Alternatively, for working flexibility, a dust nozzle attached to a separate stand can be positioned close to the wheel or drum to catch the dust as it's thrown off (see the photo on the facing page).

Horizontal-belt sanders typically come with a single, ported hood at the “head,” covering the drive roller. Large horizontal-belt and stroke sanders often have a second hood at the “tail” end, covering the idler roller, since dust is more likely to be thrown from the belt as it passes around a roller. If your sander doesn't have a tail hood, you'll catch more dust by adding a second pickup at the idler (nonpowered) roller. Size the duct fittings and hoses to direct 75 percent of the air to the head and 25 percent to the tail pickup. Alternatively, you can also use a stripper jet (see the sidebar on the facing page) to blow dust off the idler roller and into the hood.

Shapers and router tables Because of the wide range of cutters they handle—from small veining bits to gigantic raised-panel cutters—shapers and router tables are two of the most difficult machines from which to collect sawdust effectively. Most stock shaper and router-table fences incorporate a hood and/or dust port on the back side of the fence, directly behind the cutterhead. But a single rear-mounted hood won't do a good job of catching large chips that are thrown radially by a large cutter. Adding a second pickup is usually not practical because it will interfere with lumber handling and prevent mounting a power feeder.

One way to improve large-chip capture is to deflect chips so that they can be sucked in at the fence hood. The trick is not to seal off the flow of air around the cutter/workpiece, which starves the system of air and reduces collection efficiency. One way to do this is to mount featherboards around the cutter opening in the fence (see the photo on p. 186). Air flows between the fingers, while the featherboard also serves to hold the workpiece down during the cut—and to keep your fingers out of harm's way. If featherboards won't work, use a chip deflector made from an old wallpaper brush or a cheap, wide paintbrush, mounted so that it will cover the largest gap between the workpiece, the cutter, and the fence.

Wood lathes As with other dust-collection situations, the best way to deal with shavings and dust created on a wood lathe is to pick them up as



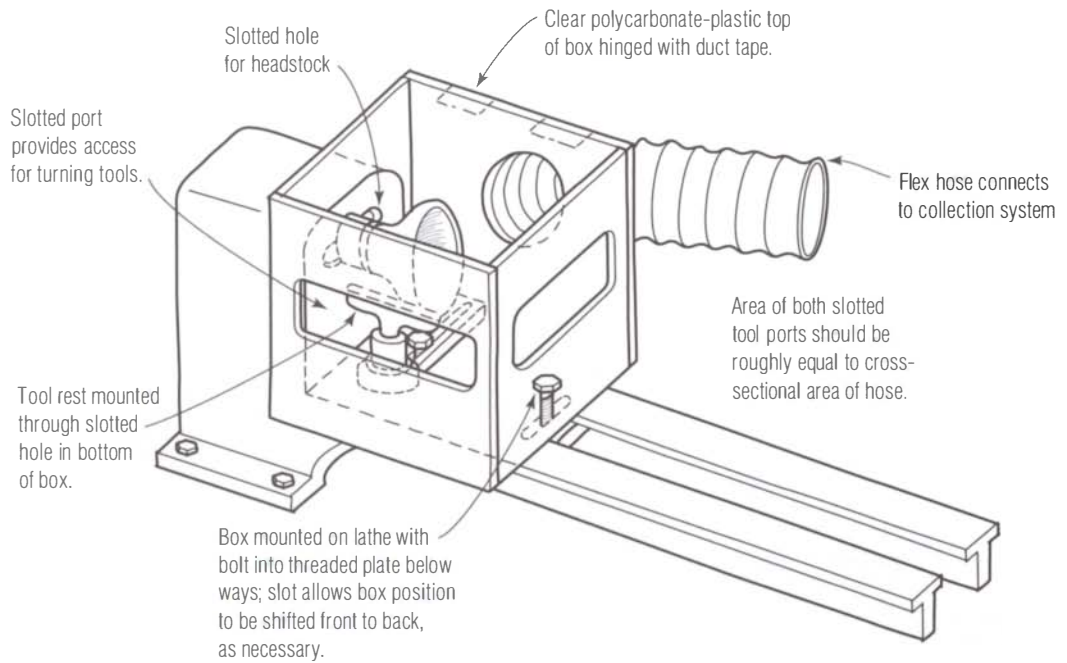
Plastic featherboards attached to a router table not only guide the workpiece and keep fingers clear of the spinning bit but also help deflect chips into the dust-port opening behind the fence.

close as possible to the point where they are first created. Some woodworkers accomplish this simply by clamping a flex hose (connected to a portable collector or a central system) to the lathe close to the workpiece. This is especially effective if you position the hose opening to point directly where chips/dust are thrown off the turning. For more complete collection, try mounting an enclosing dust hood to your lathe, such as the plastic aftermarket hood shown in the photo on the facing page. It's important to use a dust hood if you turn toxic materials—such as asbestos-laden soapstone or fossilized ivory—or woods that can cause allergic reactions, such as rosewood and spalted maple.

Alternatively, you can build your own dust hood, such as the one shown in the drawing on the facing page. This hood completely encloses a small bowl or other turning chucked in the lathe. Built from plywood like a five-sided box, the hood is mounted to the lathe bed beneath the tool-rest post. It has a slotted hole for the chuck and two slotted ports that provide access for turning tools. A clear polycarbonate plastic top provides a good view of the work and is hinged for access to the work and for tool-rest adjustments. A flexible hose connects at the rear of the hood and draws air through the slotted turning-tool ports, which are sized roughly to exceed the cross-sectional area of the hose.

Drill presses Because such a wide variety of bits and setups are used with a drill press (or a vertical mill-drill), in most cases it's best not to create a permanent hood for this tool. The most versatile arrangement is a flexible hose with a small nozzle or magnetic hood (see the Veritas mag-

Dust Box for Lathe



Made from impact-resistant plastic, an aftermarket hood clamps or screws to the lathe's ways to capture chips and shavings as they come off the turning tool.



With its interlocked links, Loc-Line plastic hose easily twists into position, then stays put. Accessory nozzles snap on the end of this novel hose to adapt it for collection at a drill press, oscillating spindle sander, or router table.

netic hood in the photo on p. 76, which may be positioned wherever required for a particular operation). By making the hose easily detachable from the hood, you can use the hose to clean up around the drill press after the job is done. Another versatile arrangement is to clamp a Loc-Line® vacuum hose to your drill press's column or table (see the photo at left). This hard 2½-in. plastic hose consists of a series of interlocked links that can be twisted into position to keep the hose exactly where it's needed. Accessory nozzles snap on the end of the Loc-Line to adapt it for any collection situation.

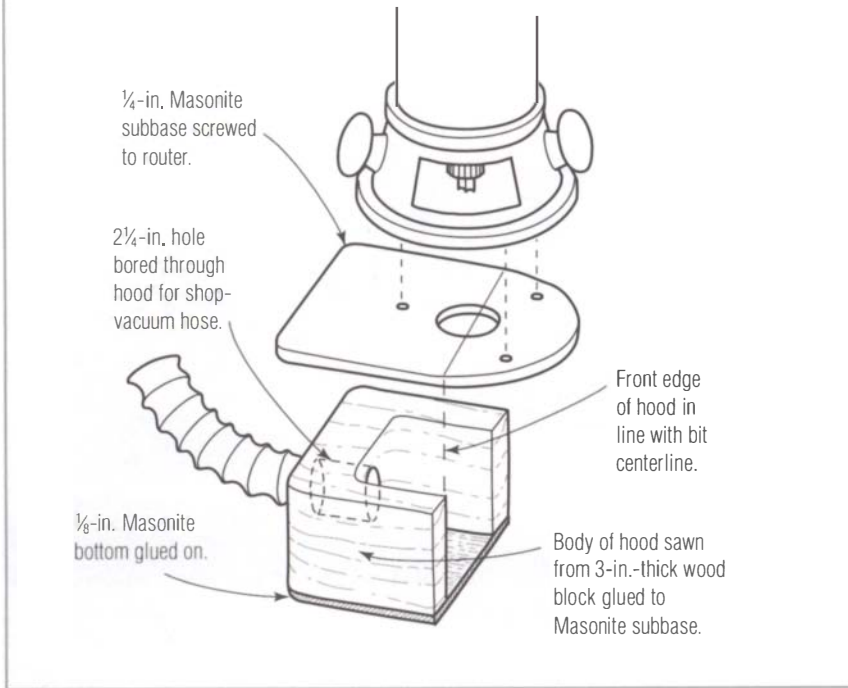
Capturing Sawdust from Portable Tools

As with stationary machines, the best means of collection from portable power tools that have built-in dust collection (such as belt sanders and plate joiners) is to remove their dust bags and use a hose to connect them to primary collection. But because the ports on these tools are so small—typically between ¼ in. dia. and 1¼ in. dia.—connecting them to a central



To tame a router's prodigious chip output, use an under base-mounted hood during edge routing. This Porter-Cable accessory hood connects to a small-diameter hose from a shop vacuum.

Dust Hood for Router



collection system is inefficient: A typical central system doesn't develop enough air velocity for effective collection through such a small hose. It's easier and better to collect dust from portable tools using a regular shop vacuum (see p. 78).

Collecting sawdust from tools that lack built-in collection ports—such as most routers, laminate trimmers, and electric drills—is always a problem. With its high speed and large bits that hurl chips in every direction, the router is particularly troublesome. You can improve capture of a router's chip output during edge routing by mounting a special dust-collection hood to its baseplate, such as the Porter-Cable accessory shown in the photo at right on the facing page. You can make your own custom subbase with built-in collection hood and hose port, as shown in the drawing above. The hood is sawn from a single block of 3-in.-thick wood with a 2 1/4-in. hole bored into it. Then it's glued and screwed to a 1/4-in. Masonite subbase plate. A piece of 1/8-in. Masonite covers the bottom of the hood. A standard 2 1/2-in. shop-vacuum hose connects the hood to your portable vacuum or a portable collector fitted with a reducer at the intake.

Rotary tools such as right-angle grinders and die grinders don't lend themselves to fitted custom hoods—the hoods tend to get in the way. But you can catch most of the chips these tools produce by using either a portable dust nozzle or a flanged hood. A portable nozzle, such as the one shown in the photo on p. 184, mounts on a stand that allows adjustment



Dust and chips created by freehand sanding or grinding operations can be captured if you work close to a flanged hood. The hood here was made from a sheet-metal roof jack joined to 4-in. flexible hose.

for height and position. A portable flanged hood, such as the one shown in the photo above, is useful atop a workbench, set on the floor, or on the workpiece itself. To get the best chip capture from either device, position the workpiece as close as possible to the air intake, and orient the tool so that the dust and chips thrown off the blade or abrasive travels toward the air intake.

ADDING DUST COLLECTION TO JIGS

Often you'll get better dust-collection performance by building a hood directly into a jig or fixture used with a machine or portable power tool. For example, I have a biscuit-joinery jig that I use on a router table that has a small housing directly behind the kerf-cutting bit (see the photo on the facing page). The housing provides a place to mount a flexible hose and attach a clear Lexan® chip deflector, both for safety and for better dust capture. For more ideas on adding dust collection to jigs, see my book *Woodshop Jigs & Fixtures* (The Taunton Press, 1994).

Capturing Fine Sanding Dust

Very fine wood dust particles generated during sanding operations are much easier to capture than sawdust and larger chips. They're easier to capture because they're so light and it takes less air velocity to entrain



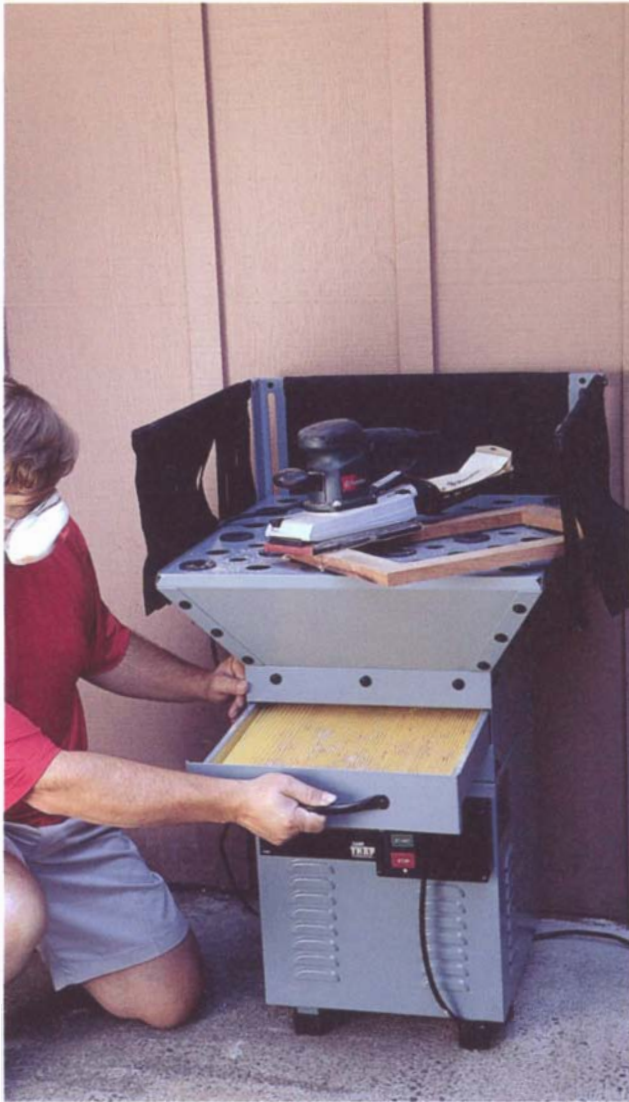
For optimal dust control when using a shop-built jig or fixture, incorporate a hood directly into your setup. The author's router-table biscuit-joinery jig, shown here, has a small dust hood and guard mounted behind the bit. A crevice tool connected to a shop vac slips into the hood.

them. You can take advantage of this fact to collect a great amount of the sanding dust created by portable power tools that lack or have poor built-in dust collection or to capture the dust created by hand-sanding. The high volume of air generated by even a small central collection system is enough to collect sanding dust near its source by using a sanding table or portable dust hood.

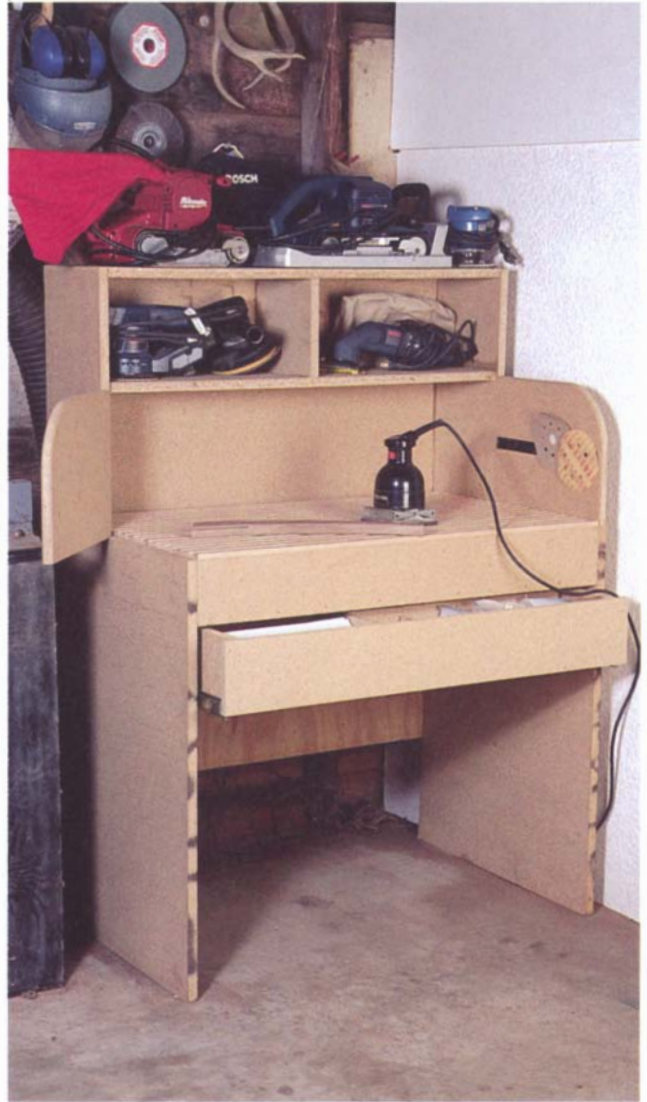
DOWNDRAFT SANDING TABLE

Essentially a hollow box with a slotted or perforated top connected to a source of vacuum, a downdraft sanding table pulls dust down and away from parts that are sanded on top of it. Large commercial sanding tables are available that connect to a central collection system or have their own built-in fans and filters. A compact, inexpensive unit, such as Delta's model 50-880 downdraft sanding table, shown in the photo at left on p. 192, is completely self contained. An induction motor drives a fan that draws dusty air down through the table's perforated top, then passes it through filters before returning clean air to the shop.

You can build your own sanding table, such as the one shown in the drawing on p. 193. As proportioned here, the slat-topped table operates optimally with 750 cfm of air, but you can make the top any size, as long as you maintain at least 200 cfm of air per square foot of table area. You can use the sanding table on a benchtop or mount it to its own stand.

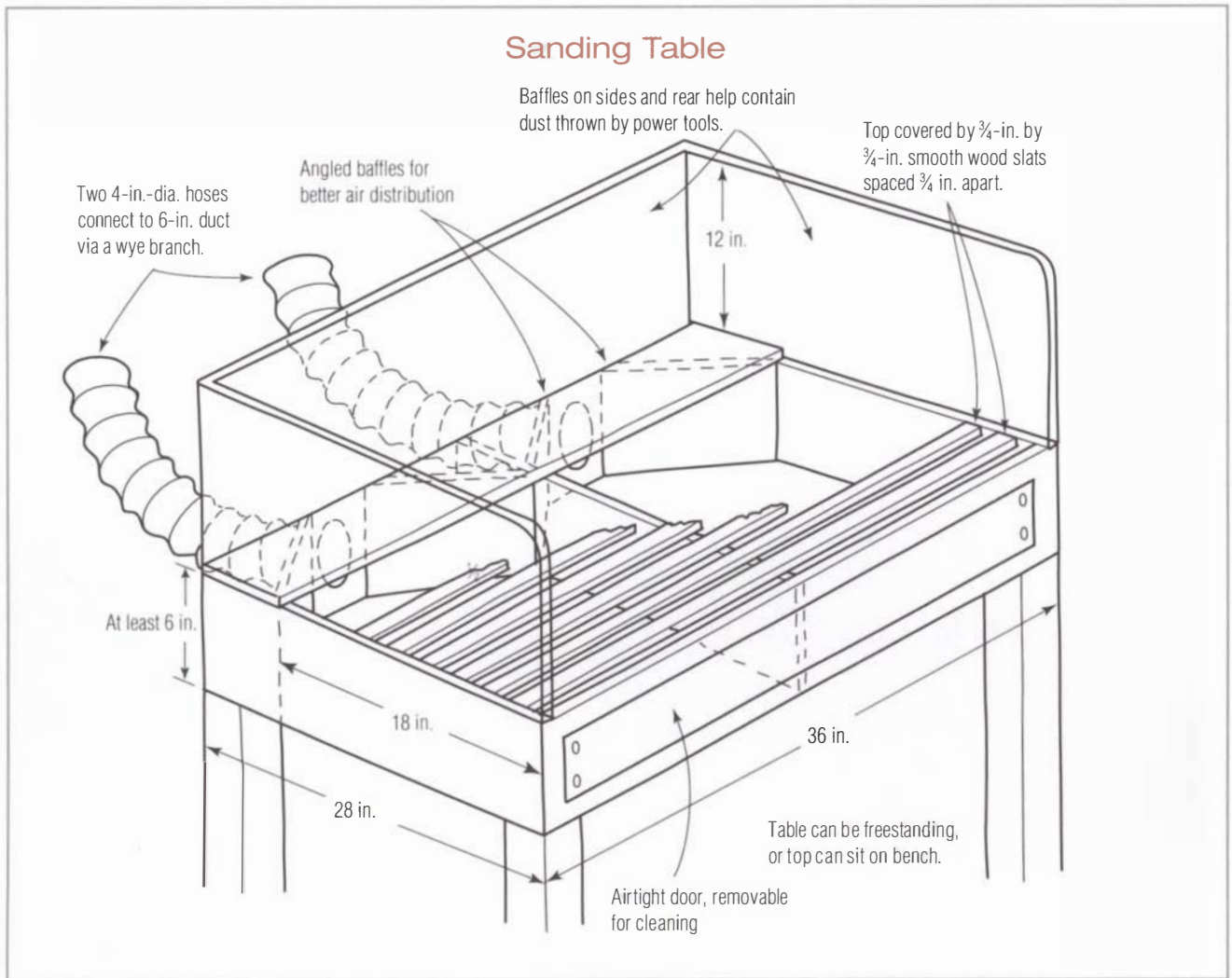


Delta's downdraft sanding table has its own built-in fan that pulls dust away from hand- or power-sanding activities and sits atop the unit's perforated sheet-metal top. A pleated filter mounted inside a drawer makes it easy to empty captured dust and keep the filter clean.



Power sanding becomes a less dusty affair when you sand atop a sanding table connected to a central collection system. Built from particleboard and maple strips (for the sanding-table grate), this "sanding center" features tool cubbies and a sandpaper storage drawer.

Baffles on three sides of the table not only help to contain dust thrown out by portable power tools, such as random-orbit sanders and belt sanders, but also help contain the flow of air to keep fine particles from escaping. Covering any unused portions of the top can also improve collection. By adding larger baffles and a top, you can create a small sanding booth, like the one shown in the photo above right, that increases the speed of the airflow coming into the open front, to contain and capture dust even more efficiently.



Sanding tables are terrific for sanding small parts because air flowing around the parts pulls dust down and away from you. They don't do so well, though, when you are sanding large flat boards or panels. Dust tends to stay on the horizontal surface because the air flowing into the table mainly draws in dust nearest the edges of the surface. Sanding tables are also limited in that you can't sand large assembled casework or furniture on top of them. In these cases, it's better to use a sander with built-in collection (see p. 78) or use a portable flanged hood.

PORTABLE FLANGED HOODS

A quick and versatile way to bring fine-dust collection to a benchtop or other work area is with a portable hood: Any kind of round or rectangular sheet-metal or plywood hood will work, as long as it's connected to at least a 4-in.-dia. hose. A flange that's at least 2 in. wide around the outside

edge reduces the air drawn from behind the duct, thus reducing entry loss (the energy it takes for air to enter an opening) and increasing pickup efficiency. You can buy a ready-made flanged hood or make one yourself: I made the hood shown in the photo on p. 190 from a 4-in. roof jack (used for flashing a vent pipe that comes through a roof) that I cut, bent, and pop-riveted to shape.

The most important thing when using a portable flanged hood is to set it as close as possible to the source of dust. The farther that dust particles are from the intake, the less likely they'll be captured. Air velocity decreases in proportion to the square of the distance to the hood opening. In practical terms, this means that maintaining a capture velocity of 200 fpm (the minimum air speed for catching fine dust) when sanding a workpiece 2 ft. from the hood intake requires 16 times the cfm that it takes at only 6 in.! On the benchtop, place the hood directly in front of where you're working. If you're using a belt sander or rotary grinder, position the hood in the path of dust thrown by the tool. When sanding a freestanding carcass or furniture piece, attach the hood to a stand (as with the dust nozzle, discussed on p. 183) and position it as close as possible to the area you're sanding. Remember, the more effort you take to capture dust as it is created, the less dust will end up in the air and in your lungs.

Sources of Supply

The following source listings are intended to help you locate many special and hard-to-find items used for dust control and collection that are discussed throughout the book. I've also included addresses and phone numbers for numerous mail-order suppliers, dealers, and manufacturers of dust-control and dust-collection machinery and components. These listings are by no means complete. They were compiled in Fall 2001 and are subject to change.

ITEMS CITED IN THE TEXT

Air-filtration devices (AFDs)

Aercology (manufacturer), Air Cleaning Specialists (manufacturer), Airflow Systems (manufacturer), Delta Machinery, Grizzly Industrial, Inc., Hartville Tool, JDS (manufacturer), Klingspor, Lee Valley, Penn State Industries, Ridgid, Rockler, Tool Crib, Shop-Vac, Woodcraft, Woodworker's Supply

Air helmets/dust helmets:

See **Powered air-purifying respirators**

Angle ring (starter ring)

Air Handling Systems

Automated blast gate system

Ecogate, Oneida Air Systems, Penn State Industries

Central dust collectors, blowers, and cyclones

Blue Tornado Cyclones, Cincinnati Fan & Ventilator, Delta Machinery, Dust Boy, Grizzly Industrial, Inc., Jet Equipment and Tools, Klingspor, Lobo Power Tools, Makita USA, Murphy-Rodgers, Oneida Air Systems, Penn State Industries, Powermatic, Rees-Memphis, Ridgid, Rockler, Seco (KUFO), Shopsmith, Sunhill Machinery, Torit Division (Donaldson Co.), Transpower, Trend-lines (Reliant), Wilke Machinery (Bridgewood), Woodcraft, Woodmaster Tools, Woodstock (Shop Fox), Woodworker's Supply (Woodtek)

CleanStream vacuum filters (replacement)

Hartville Tool, Klingspor, Lee Valley, Rockler

Contactors (relays for remote collector switching)

W. W. Grainger

Crimping tool (for ductwork)

Woodworker's Supply

Ductwork, pipe fittings, and accessories

Air Handling Systems, Arrowsmith & Lang-Borne, Grizzly Industrial, Inc., Klingspor, Lee Valley, Murphy-Rodgers, Oneida Air Systems, Penn State Industries, Rockler, Tool Crib, Woodworker's Supply

Dust-collection nozzle on stand

Grizzly Industrial, Inc., Klingspor, Penn State Industries, Tool Crib, Woodcraft, Woodworker's Supply

Dust masks, respirators, and air helmets

Airware America, Lab Safety Supply, 3M (manufacturer), Woodcraft

Dust preseparator-canister lid

Grizzly Industrial, Inc., Hartville Tool, Lee Valley, Penn State Industries, Rockler, Tool Crib, Woodcraft, Woodworker's Supply

Electronic dust-collector/shop-vacuum switches

Doughty Electronic Systems, Ecogate, Oneida Air Systems, Penn State Industries, Radio Shack (contact your local store), Tool Crib, Woodcraft, Woodworker's Supply

Fan wheel (cast aluminum, replacement)

Oneida Air Systems

Filter fabric (media, sewn bags)

Oneida Air Systems, P & S Filtration, Penn State Industries, Snow Filtration

Filter bags (replacement, for single-stage collectors)

Grizzly Industrial, Inc., Oneida Air Systems, Penn State, Woodworker's Supply

Filters (replacement, for AFDs)

W. W. Grainger

Flexible hose

Air Handling Systems, Dayco (manufacturer), Grizzly Industrial, Inc., Hartville Tool, iHOZs.com, Oneida Air Systems, Penn State Industries, Tool Crib, Woodcraft, Woodworker's Supply

Grain scoop

Lab Safety Supply

Grounding wire kit (for plastic pipe ductwork)

Grizzly Industrial, Inc., Hartville Tool, Lee Valley, Penn State Industries, Woodcraft

HVAC pipe and fittings

Arrowsmith & Lang-Borne, Oneida Air Systems, Woodworker's Supply

Lateral saddle-tap tee fitting

Air Handling Systems, Murphy-Rodgers

Lathe dust hood

Hartville Tool, Penn State Industries, Woodcraft

Loc-Line Vacuum Hose

Penn State Industries, Rockler, Woodcraft

Magnehelic gauges, manometers, and Pitot tubes

Oneida Air Systems, W. W. Grainger

Magnetic dust chute

Veritas

Mask case

Lab Safety Supply

Oversize filter bags, fan, and inlet plate

Oneida

Plenum box and shaker box (sheet metal)

Oneida Air Systems

Powered air-purifying respirators

Airware America, Craft Supplies USA, Lab Safety Supply, Woodcraft

Quick-disconnect fittings (for portable collectors)

Air Handling Systems, Rockler, Tool Crib

Remote-control dust-collector switches

Grizzly Industrial, Inc., Hartville Tool, Lee Valley, Oneida Air Systems, Penn State Industries, Radio Shack (contact your local store), Tool Crib, Woodcraft

Respirator test kit; disinfectant

Lab Safety Supply

Sanding tables (downdraft)

Delta Machinery, Grizzly Industrial, Inc., Hartville Tool, Penn State Industries, Tool Crib

Shop-vacuum muffler

Hartville Tool

Shop vacuums and accessories

Bosch Power Tools, Delta Machinery, Eureka, Fein Power Tools, Festool, Grizzly Industrial, Inc., Jet Equipment and Tools, Klingspor, Makita USA, Milwaukee Electric Tool, Porter-Cable, Ridgid, Royal Dirt Devil, Ryobi America, Sears (contact your local store), Shop-Vac, Tool Crib, Wap Cleaning Systems

Smoke stick

Lab Safety Supply

Squirrel-cage blowers

W. W. Grainger

Table-saw passive-collection bag

Rockler, Tool Crib

Table-saw top-guard collector

Excalibur, Penn State Industries

Timers (for AFDs)

Total Shop (manufacturer), W. W. Grainger

Universal hoods and mounting strips (catcher strip)

Grizzly Industrial, Inc., Murphy-Rodgers, Woodworker's Supply

SUPPLIERS AND MANUFACTURERS**Aercology (manufacturer)**

Donaldson Co., Inc.
P.O. Box 1299
Minneapolis, MN 55440
(888) 338-3878
www.aercology.com

Air Cleaning Specialists, Inc. (manufacturer)

826 Horan Dr.
Fenton, MO 63026
(636) 349-4400
www.aircleaningspecialists.com

Airflow Systems, Inc. (manufacturer)

11221 Pagemill Rd.
Dallas, TX 75243
(800) 818-6185
www.airflowsystems.com

Air Handling Systems

5 Lunar Dr.
Woodbridge, CT 06525
(800) 367-3828
www.airhand.com

Airware America

20219 240th St.
Elbow Lake, MN 56531
(800) 328-1792
www.airwareamerica.com

Arrowsmith & Lang-Borne

P.O. Box 126
Lumberport, WV 26386
(800) 544-4283

Blue Tornado Cyclones

P.O. Box 156
Buckner, KY 40010
(800) 292-0157
www.bluetornadocyclones.com

Bosch Power Tools

4300 W. Fulton
Chicago, IL 60612
(877) 267-2499
www.boschtools.com

Cincinnati Fan

7697 Snider Rd.
Mason, OH 45040
(513) 573-0600
www.cincinnati-fan.com

Craft Supplies USA

1287 E. 1120 South
Provo, UT 84606
(800) 551-8876
www.craftusa.com

Dayco (manufacturer)

P.O. Box 3015
Miamisburg, OH 45343
(937) 226-7000
www.dayco.com

Delta Machinery

4825 Hwy. 45 North
Jackson, TN 38305
(800) 223-7278
www.deltawoodworking.com

Doughty Electronics

23 Arnold Dr.
Texarkana, AR 71854
(870) 772-5849
home1.gte.net/res05944

Dust Boy Inc.

10002 N. Hogan Rd.
Aurora, IN 47001
(800) 232-3878
www.dustboy.com

Eagle America

P.O. Box 1099
Chardon, OH 44024
(800) 872-2511
www.eagle-america.com

Ecogate, Inc.

1821 Tyburn St.
Glendale, CA 91204
(888) 326-4283
www.ecogate.com

Eureka

2003 108th St., Ste. 301
Dallas, TX 75050
(800) 282-2886 (customer service)
www.eurekaco.com

Fein Power Tools

1030 Alcon St.
Pittsburgh, PA 15220
(800) 441-9878
www.feinus.com

Festool

Tooltechnic Systems, LLC
140 S. Los Carneros Way
Goleta, CA 93117
(888) 337-8600
www.festool.com

Grizzly Industrial, Inc.

P.O. Box 2069
Bellingham, WA 98227
(800) 523-4777
www.grizzlyindustrial.com

Hartville Tool

13163 Market Ave. North
Hartville, OH 44632
(800) 345-2396
www.hartvilletool.com

iHOZs.com

65 Aurora Industrial Pkwy.
P.O. Box 219
Aurora, OH 44202
(330) 562-6101
www.ihozs.com

JDS (manufacturer)

108 Leventis Dr.
Columbia, SC 29209
(800) 480-7269
www.thejdscompany.com

Jet Equipment and Tools/**Powermatic**

WMH Tool Group
P.O. Box 1937
Auburn, WA 98071
(800) 274-6848
www.jettools.com

Klingspor's Woodworking Shop

P.O. Box 5069
Hickory, NC 28603
(800) 228-000
www.woodworkingshop.com

Lab Safety Supply

P.O. Box 1368
Janesville, WI 53546
(800) 356-0783
(800) 356-2501 (safety/technical
information)
www.labsafety.com

Lee Valley Tools Ltd.

P.O. Box 1780
Ogdensburg, NY 13669
(800) 871-8735
www.leevalley.com

Lobo Machinery Corp.

9034 Bermudez St.
Pico Rivera, CA 90660
(562) 949-3747
www.lobomachine.com

Makita USA

14930 Northam St.
La Mirada, CA 90638
(800) 462-5482
www.makitatools.com

Milwaukee Electric Tool Corp.

13135 W. Lisbon Rd.
Brookfield, WI 53005
(262) 781-3600
www.heavydutytool.com

Murphy-Rodgers, Inc.

2301 Belgrave Ave.
Huntington Park, CA 90255
(323) 587-4118
www.murphy-rodgers.com

Oneida Air Systems

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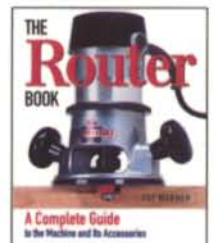
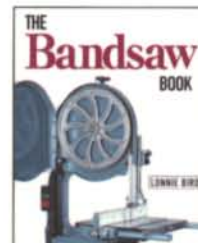
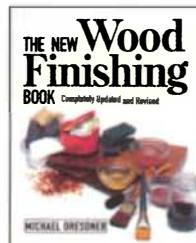


Sandor Nagyszalanczy, of Bonny Doon, California, is a professional furniture maker, designer, and tool expert. A former senior editor of *Fine Woodworking* magazine and West Coast editor of *American Woodworker*, he has written many other books, including: *Power Tools*, *The Art of Fine Tools*, *Setting Up Shop*, *Woodshop Jigs & Fixtures*, *Fixing and Avoiding Woodworking Mistakes*, and *The Wood Sanding Book*.

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