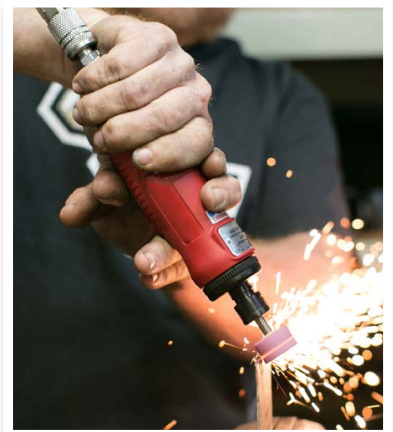
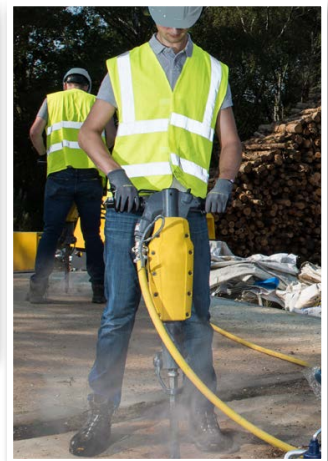


Air Tools and Air Tool Safety

Chapter 5



AIR TOOLS AND AIR TOOL SAFETY

Air tools are designed to provide increased productivity, long service life, and safe operation. But, as with any type of tool or machine, these advantages can be realized only through proper application, proper maintenance, and user training.

Application

Air tools should be selected by a person who is familiar with air tools and their proper application. Air tool selection must take into account the particular factors in a given job that will affect air tool and operator performance. Some factors to be considered are the workstation design, the operator-tool-task relationship, and the environment in which the user will perform the task.

The workstation should be carefully designed so that the workpiece is held securely, so that there is sufficient light and ventilation, and so that means are provided for safely holding or suspending the tool. The workstation should also be arranged for operator convenience and comfort.

Maintenance

Air tools must undergo periodic inspection and routine maintenance to ensure that they are operating properly. Tool maintenance and repairs should be performed by authorized, trained, and competent personnel.

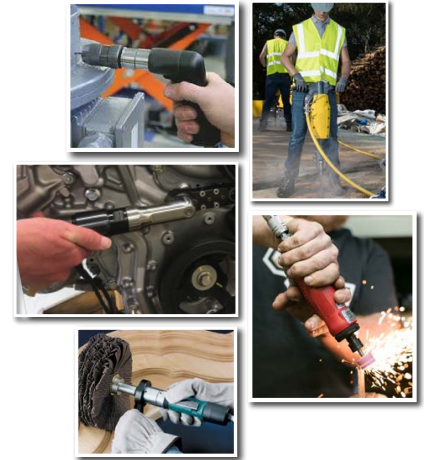
Premature failure and poor performance of air tools can often be attributed to the following:

1. water or foreign materials such as rust or pipe scale in the air supply lines
2. inadequate or improper lubrication
3. worn parts
4. incorrect air pressure and air flow

Training

Air tools should be operated only by qualified personnel who have been trained in their proper operation and safe use. Employers must ensure that their employees read and understand the tool manufacturer's operating and safety instructions.

Users must always wear protective equipment and clothing. Impact resistant eye protection must be worn while operating or working near air tools. Additional information on eye protection may be found in the Federal OSHA Regulations, 29 CFR, Section 1910.133, *Eye and Face Protection*, and ANSI Z87.1, *Occupational and Educational Eye and Face Protection*. Hearing protection should be provided in high noise areas (above 85 dBA). The proximity of additional tools, reflective surfaces, process noises, and resonant structures can substantially contribute to the sound level experienced by users. Proper hearing conservation measures, including annual audiograms and training in the use and fit of hearing protection devices may be necessary. Additional information on hearing protection may be found in the Federal OSHA Regulations, 29 CFR, Section 1910.95, *Occupational Noise Exposure*, and the American National Standards Institute, ANSI S12.6, *Hearing Protectors*.



Gloves and other protective clothing should be worn as required, unless they create a greater hazard. Improperly fitted gloves may restrict blood flow to the fingers and can substantially reduce grip strength. Loose fitting clothing should not be worn around air tools which rotate during their use. Avoid inhaling dusts or mists resulting from the use of any air tool. Wear an approved respirator or mask if the ventilation is inadequate. Respirators should be selected, fitted, used and maintained in accordance with Occupational Safety and Health Administration and other applicable regulations.

Cumulative trauma disorders make up a large percentage of occupational injuries and affect a wide and diverse sector of society. Users of air tools should be made aware of the symptoms of the most frequently occurring cumulative trauma disorders such as carpal tunnel syndrome, tendonitis, tenosynovitis, De Quervain's Disease, low back pain, and vibration-induced Raynaud's Syndrome.

In the industries that use portable air tools the employer is responsible for the job design and content, operator training, work methods, work pace, work environment, proper tool application, and other workplace factors. Personal factors such as inexperience or aggressive work methods, activities outside the workplace and pre-existing conditions such as arthritic inflammations, circulatory disorders or neuropathies, and hereditary wrist size may contribute to painful repetitive motion disorders of the shoulders, arms, wrists, hands and fingers. To avoid these disorders, users should be trained to:

- use a minimum hand grip force consistent with proper control and safe operation
- keep the wrists as straight as possible
- avoid repetitive movements of the hands and wrists
- notify their employer if any symptoms of wrist pain, hand tingling or numbness, or other disorder of the shoulders, arms, wrists, or fingers occurs

Some users of portable air tools may be susceptible to disorders of the hands and arms when exposed to extended vibration. Although the exact causes of these disorders are not well known, certain non-occupational factors such as age, physical condition, clogged arteries, injury to the hands, smoking, medications, and circulatory problems are thought to increase the risk. It is uncertain what vibration exposures are required to cause the disorder, including the vibration intensity, the frequency spectrum associated with the intensity, the daily exposure level, and total exposure. Also, factors such as ambient temperature, grip force, and intermittence of exposure may play a part in experiencing the disorder. To avoid the disorder, users should be trained to:

- use a minimum hand grip force consistent with proper control and safe operation
- keep the body and hands warm and dry
- avoid continuous vibration exposure by using rest intervals free from vibration
- avoid anything that inhibits blood circulation such as tobacco, cold temperatures, and certain drugs

Additional specific guidelines on the safe operation of portable tools are available from the American National Standards Institute publication B186.1, *Safety Code for Portable Air Tools*, and should be followed closely.

Additional specific guidelines on the safe use of grinding wheels, available from the same institute, can be found in American National Standards Institute publication B7.1, *Safety Requirements for Use, Care, and Protection of Abrasive Wheels*. These guidelines should be carefully implemented wherever abrasive wheels are being used.

AIR TOOLS

To manufacture the many products used in today's world, industry must receive raw materials, process those materials into parts, assemble the parts into a finished product, and package that product for shipment. The nature of the product, its size, the quantity to be manufactured, and the tolerances specified are a few of the many considerations that affect the selection of tooling to perform these operations. This chapter is designed to help identify the advantages of using air tools in their many applications and to familiarize the reader with the diversified types of air tools available today.

AIR TOOLS FOR INDUSTRY

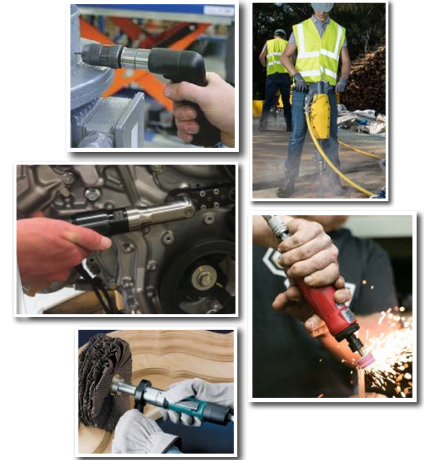
Air tools have gained widespread acceptance in industry because of their many inherent advantages. Air motors provide compact, lightweight, smooth-running power sources for air tools. They cannot be harmed by overloading, unlimited reversals, or continuous stalling. Also, they are explosion and shock resistant. Air motors start and stop almost instantly and provide infinitely variable control of torque and speed within their capacity range. Air and hydraulic motors share the advantages of high torque per pound of weight and safe operation in hazardous environments. Air motors also have certain advantages over hydraulic motors. First, air tools do not require return lines, but rather exhaust into the atmosphere. There is no heat buildup when air motors are stalled for a considerable length of time. In addition, low-pressure lines of 60 to 125 psig (4.1 to 8.6 bar) are less expensive than high-pressure hydraulic lines of 1500 to 3000 psig (103.5 to 207 bar). Leaks in air systems do not present the safety and housekeeping problems associated with hydraulic leaks. Air motors are unique in their ability to operate at any speed within their range for indefinite periods of time. Even continuous stalling has no ill effects on the motor, since there is no heat buildup and no danger of overloading. All these features contribute to the long service life associated with air tools. In addition, simplicity of construction makes the repair of air tools comparatively easy.

PRODUCTIVITY THROUGH AIR TOOLS

The use of air tools contributes directly to increased productivity. Even though the cost of compressed air is greater than that of electricity, economics favors air tools because of their weight advantage and longer service life. Laboratory experiments have shown that for every additional pound of hand-held weight there is a productivity loss of up to 7 percent.

Compact Size

One advantage of air tools over comparable electric tools is size. Air tools may be as little as one-half the physical size of the equivalent electric or cordless counterparts, as seen in Fig. 5.1. This smaller physical size generally makes them easier to handle than the corresponding electric tools and sometimes allows them to be used in confined spaces where electric tools will not fit.



Light Weight

Air tools are lighter than comparable electric or cordless models, often weighing as little as half as much as the corresponding electric or cordless tools. This lighter weight allows the tool to be handled more easily, reduces operator fatigue, and ultimately increases worker productivity.

Operating Pressures

Air power tools typically are rated at 90 psig (6.2 bar). They may operate at other pressures with varying consequences. Lower pressures result in decreased power to weight ratios negatively impacting production. Higher pressures may result in increased performance with a corresponding decrease in durability, reducing tool life and increasing service and repair costs. The quality of the work piece may also be affected by varying air pressure due to the proportional relationship between torque and supply pressure at the tool inlet. Similarly, paint spray may be too sparse or too dense if the supply pressure at the gun fluctuates significantly. Close control of the air supply pressure to air tools can improve quality control and, if done properly, can improve the energy requirement of the compressed air system.



Figure 5.1: An air tool may be as little as half the physical size of the corresponding electric or cordless tools, as shown in the comparison above of two hand-held, quarter-inch drills.

Speed, Torque, and Power

Torques and speeds of air tools can be matched to the specific needs of an application. Standard air tools are available in a wide range of speeds, in excess of 100,000 rpm and torques of up to 50,000 ft-lb (67,800 N-m).

The performance characteristics of an air motor can be expressed using torque and power curves like those in Fig. 5.2. These curves show the relationship among speed, torque, and horsepower for a given air motor operating at a given air pressure. The power curve shows that the horsepower of a motor with no governor increases to a maximum point as the speed increases and then decreases to zero as the speed continues to increase. This maximum horsepower of the nongoverned air motor is normally reached at roughly half the free speed, that is, the speed at which the tool runs when load is applied.

As a load is applied to such a nongoverned air motor, the speed decreases and the torque and horsepower increase to a level where they match the load. As the load is increased, the horsepower produced by the motor continues to increase until the motor slows to roughly half of free speed. At this point, the motor has reached peak horsepower and will run at greatest efficiency. If the load is increased beyond this point, the torque will continue to increase to the stall point, but the horsepower will decrease. As the curve in Fig. 5.2 shows, an air tool will slow down to match the torque and horsepower requirements of the load, a factor that

should be considered when selecting an air tool for a given application. This differs considerably from most AC electric motors, which tend to maintain a constant speed by consuming more energy. Non-governed air tools use less air at peak horsepower than at free speed.

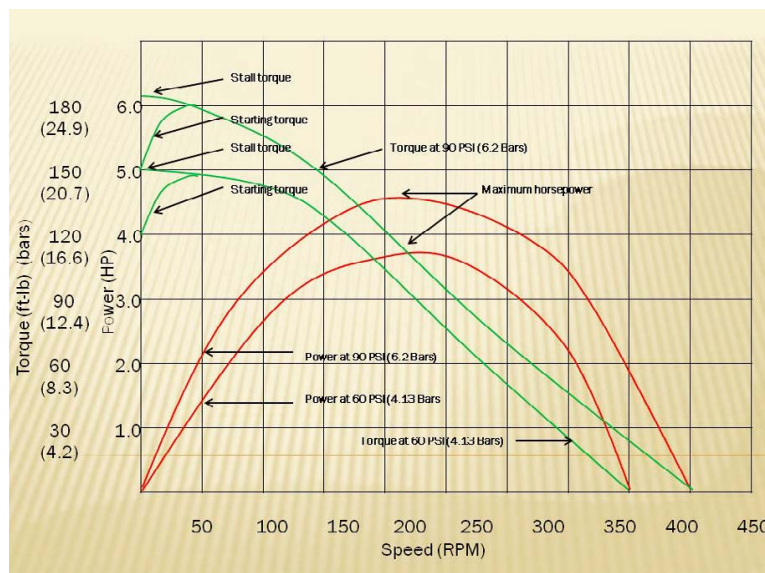


Figure 5.2: Torque and power curves for a typical air motor. Characteristics are similar to those of a series-wound DC motor; torque is maximum at zero speed, zero at free speed.

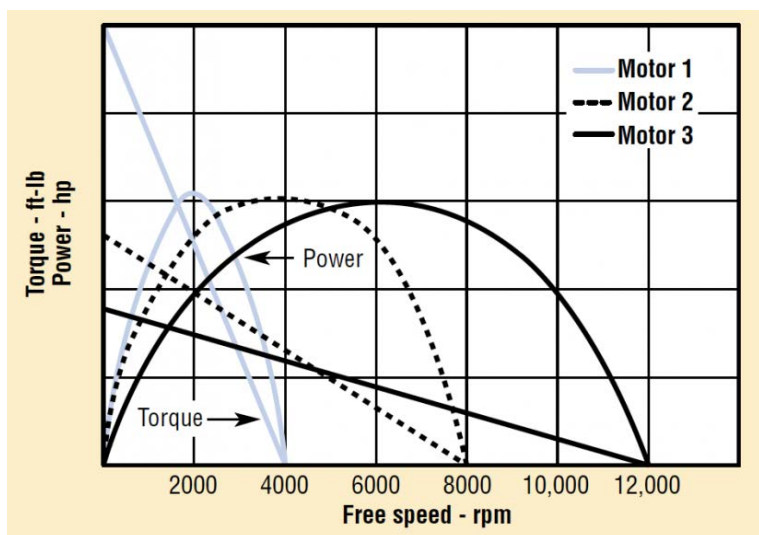
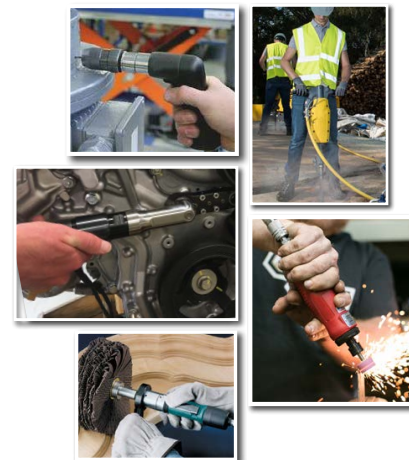


Figure 5.3: Torque and power curves for three motors having the same power rating. The motor with top speed of 12,000 rpm is much more susceptible to speed drop-off since its torque curve slope is shallow.

The major consideration in selecting an air motor for an application is the range of speed and torque required to satisfy the operating conditions. Different motors producing the same maximum power can have substantial variation in speed as a result of load change (Fig. 5.3). A 10 percent load variation will produce a speed variation of 435 rpm for a 3.1-hp (2.3-kW) motor with a 3200-rpm free speed. The speed of a motor of the same horsepower, but having a free speed of 2800 rpm, will vary only 360 rpm under the same load change. The steeper the torque curve, the less the speed variation will be with changes in load. Changes in basic free speed may be achieved through gearing.



Gearing

The nominal free speed of most air motors is higher than is suitable for many applications. To provide lower speeds and higher torque output, air tool manufacturers regularly incorporate reduction gears in a tool or air motor as an integral part of the unit (Fig. 5.4). By using different reduction ratios, it is possible to achieve a wide range of speeds. Whenever the speed of a motor is reduced by gearing, its torque is increased by the speed ratio and, at the same time, the torque curve slope increases. Increasing the torque curve slope decreases the effect of load change on speed. Geared units should be specified when minimum speed change is desired with a varying load. Many standard air motors can also be coupled to commercial gear boxes to provide low output speeds. The power and thrust required to drill certain metals are given in Table 5.1.

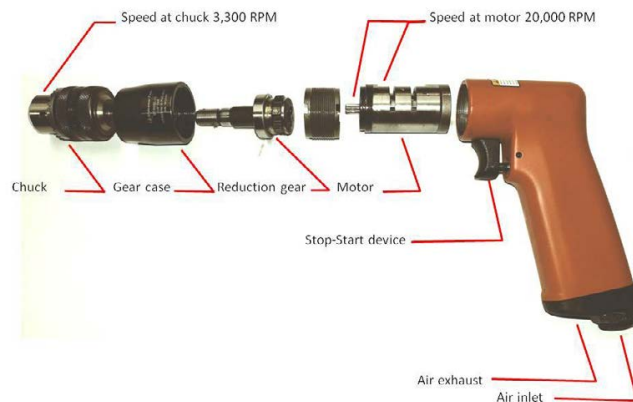


Figure 5.4: Reduction gears in an air tool provide for a lower speed at the output spindle than at the motor, with virtually no reduction in power.

Governors

Another way to modify speed is through the use of a governor. An air tool governor regulates the free speed to a predetermined limit and will keep the motor speed essentially constant through its normal working range as load is applied. This device counteracts an ungoverned air motor's tendency to lose speed as load is applied. Some manufacturers also furnish safety overspeed controls that can shut off the motor at a predetermined maximum speed. Another type of governor is a motor controller that regulates the air flow through the end plate into the motor to control the speed and power of the tool, and the motor controllers eliminate the need for additional overspeed shutoff devices. Speed-regulation devices to reduce available speed and power can be built into a motor or attached externally.

Durability

An air tool has some performance characteristics that an electric or cordless tool cannot match. An air tool can reach full speed in one-half revolution, and an air motor can stop very quickly after the valve is released. Also, in applications requiring greater control at start-up, an air tool offers variable control as standard so that no special valving is required. An electric tool or cordless, on the other hand, requires complex electrical circuits to achieve variable speed. Building variable speeds into an electric motor results in higher costs and creates a potential for heat problems, whereas very slow speeds with an air tool can be achieved by simple and inexpensive means without overheating. This quality in an air tool makes it ideally suited for driving screws where an operator sometimes needs to start a fastener slowly and then drive it full speed.

TABLE 5.1: Drill Horsepower and Thrust

	Drill Size	1/16	3/32	1/8	3/16	1/4	5/16	3/8	7/16	1/2
Brass	R.P.M.	4000	4000	4000	3000	2200	1800	1500	1300	1100
	Feed "/Rev.	.0004	.0005	.0008	.0012	.0017	.0021	.0025	.003	.0035
	H.P.	.010	.012	.022	.047	0.10	0.15	0.20	0.25	0.30
	Thrust (Lbs)	3	6	10	20	35	50	70	90	100
Aluminum	R.P.M.	4000	4000	4000	4000	3000	2500	2000	1700	1500
	Feed "/Rev.	.0005	.0007	.001	.0015	.0020	.0025	.0030	.0035	.0040
	H.P.	.010	.020	.040	.080	.140	.220	.300	.375	.450
	Thrust (Lbs)	2	3	6	12	20	40	60	80	100
Castiron	R.P.M.	4000	2850	2100	1400	1000	850	700	600	525
	Feed "/Rev.	.005	.0007	.0010	.0015	.002	.0022	.0027	.0030	.0035
	H.P.	.01	.02	.035	.060	.100	.125	.175	.210	.250
	Thrust (Lbs)	6	12	30	45	90	100	140	180	225
B112 Mild Steel	R.P.M.	3600	2400	1800	1200	900	750	600	525	450
	Feed "/Rev.	.0005	.0007	.001	.0015	.0022	.0027	.0032	.0037	.0045
	H.P.	.015	.025	.040	.075	.125	.175	.250	.300	.365
	Thrust (Lbs)	8	12	25	50	85	130	175	250	310
1045 Steel	R.P.M.	3600	2400	1800	1200	900	750	600	525	450
	Feed "/Rev.	.0005	.0007	.0010	.0015	.0022	.0027	.0032	.0037	.0045
	H.P.	.03	.02	.09	.15	.22	.25	.40	.60	.65
	Thrust (Lbs)	12	20	25	75	140	200	280	350	450

An air tool offers durability not found in an electric or cordless tool. An air tool will never bum out. If an air motor experiences an overload, it simply stops, and it can remain in a continuous stall indefinitely. In fact, when an air motor is running, the air flowing through it keeps it cool. If an electric tool is subjected to a sustained stall, burnout can result. Furthermore, if an electric tool is overloaded, it will heat up, and there will be a loss of speed and power.

An air tool can be switched from forward to reverse instantaneously without damage. Switching an electric or cordless motor in this way will cause an overload that may damage the unit.

Serviceability

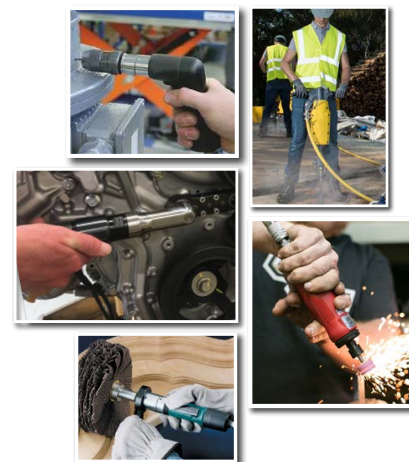
Not only is an air tool more durable than an electric or cordless tool, but it is easier to service as well. An air tool usually has fewer parts than the corresponding electric tool, and its simple construction makes it easier to repair.

Remote Control

Pneumatic tools can be remotely controlled using simple, commercially available air valves.

Pilferage

Because air tools use compressed air, which is not readily available in most homes as electricity and cordless are, theft is not as great a problem.



BASIC AIR MOTORS

Five basic categories of air motors will be discussed in this section:

1. Rotary vane
2. Axial piston
3. Radial piston
4. Turbine
5. Percussion

Rotary Vane Air Motors

Rotary vane air motors are the most common air motors used in industry today. They operate using blades that fit into radial slots in a rotor, as seen in Fig. 5.5. This rotor is mounted eccentrically inside a cylinder.

The rotary motion is a result of air pressure exerted against the exposed area of the blades. Thus, the force produced is transmitted through the rotor gearing to the output shaft or is transmitted directly, if no gears are used. The air is then discharged when it reaches the exhaust port (Fig. 5.6).

Rotary vane motors are essentially high-speed units that deliver a high ratio of power to weight. They are produced as either reversible or single-direction models. Single-direction motors are available with clockwise or counterclockwise rotation.

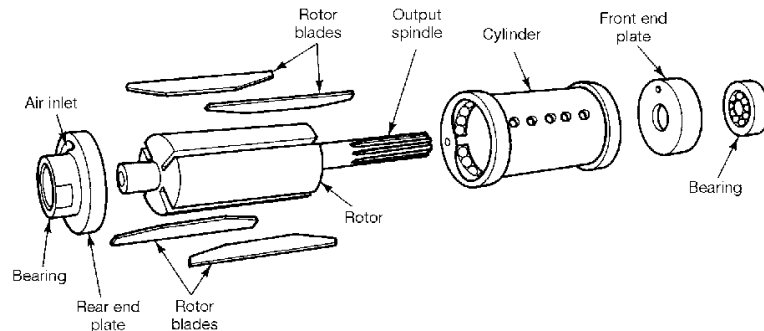


Figure 5.5: Parts which make up a typical, rotary vane air motor.

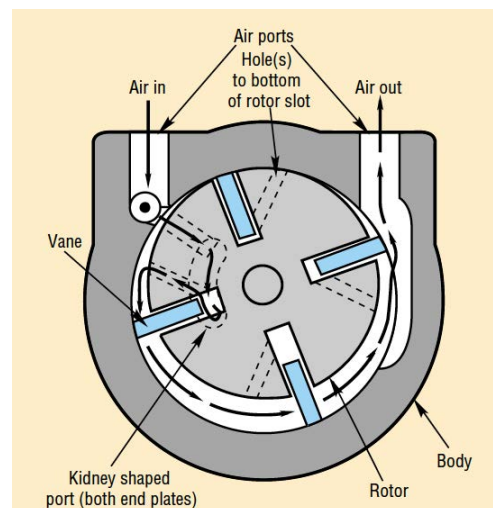


Figure 5.6: Single direction air motor.

Reversible motors are available in either balanced or unbalanced construction. Balanced motors produce equal power in either direction, whereas unbalanced motors produce more power in one direction than the other. Hoists are generally operated by unbalanced motors because more power is required to raise a load than lower it.

Some air tools that incorporate rotary vane air motors are portable grinders, sanders, drills, tappers, screwdrivers, nutsetters, impact wrenches, electrode dressers, routers, rotary shears, saws, hoists, power motors, and fixtured, self-feed drills.

Axial Piston Air Motors

In the axial-piston-type motor, the pistons and piston rods move parallel to the center line of the spindle. Their axial movement converts a reciprocating movement into a rotary one through a wobble plate to turn the output spindle. Despite their relatively small size, axial piston motors develop high speed and power. They are typically used in power motors and air hoists.

Radial Piston Air Motors

This type of motor (Fig. 5.7) is similar to a radial aircraft engine, except that it is powered by air instead of fuel. It is available with four, five, or six cylinders. Output torque is developed by pressure on the piston within each cylinder. It is inherently a low-speed power source, operating at free speeds of 3500 rpm or slower. It can carry heavy loads at all speeds and is particularly adaptable to operations requiring slow speed, high starting torque, and smooth starting characteristics.



Figure 5.7: A typical radial-piston air motor.

Turbine Air Motors

Turbine motors (Fig. 5.8) are the fastest of all air motors. They can be made to deliver speeds up to 300,000 rpm at comparatively low torques. Their high speed is achieved by expanding air to high velocities through carefully machined slots in the rotor or stator.

Turbine motors have long been used in portable die grinders, where their ultrahigh speed enables them to perform fine finishing on production tools and dies. In recent years, they have gained increasing use in power motors. One manufacturer has incorporated a turbine motor in a self-feed drilling unit where its speed is utilized for drilling holes in hard synthetics.

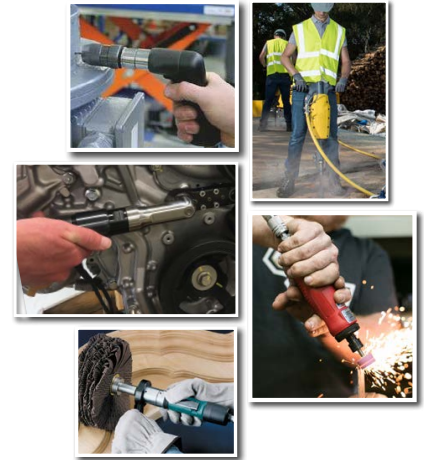




Figure 5.8: Movement of air through a two-stage turbine motor.

Percussion Air Motors

The percussion motor consists of valves, a cylinder, and a single piston (Fig. 5.9). By means of precise valve timing, the piston is given a reciprocating motion that can be used to deliver a powerful blow to an inserted or integral attachment on a tool.

Percussion motors are used where material must be broken up rapidly, chipped away, or impacted. Typical applications include breaking pavement, cleaning scale or sand from castings, removing rust, tamping sand in the foundry, and driving rivets or taper pins.

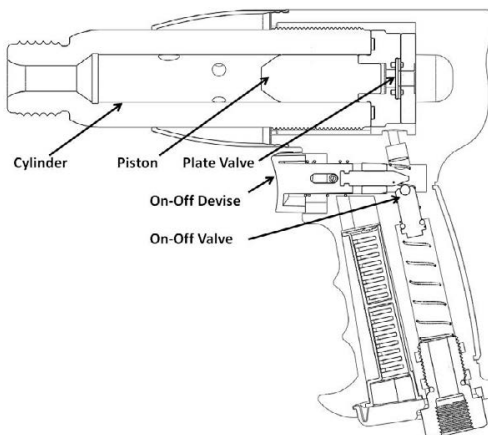


Figure 5.9: Sectional view of a percussion-type air motor.

Power Motor Application

Air-powered motors have been utilized in countless applications. For instance, they have been used in car washes to oscillate water nozzles and to power whitewall tire cleaners. Air-powered motors are very popular for operating paint-mixing propellers (Fig. 5.10) or driving conveyor belts. Grinding wheels have been mounted to air motors for grinding rock bits, and air motors provide the critical speed control necessary in moving parts for quality plating operations. The advantages and versatility of air-powered motors make them ideally suited for nearly any application where rotary motion is required.

Additional applications are as follows:

- Opening and closing large valves
- Powering bridges on overhead cranes
- Natural gas valve turning applications
- Operation of core drills
- Actuation of clamping devices
- Operation of holding and positioning devices
- Powering steel and plastic strapping machines
- Mixing liquids and chemicals
- Powering fuel hose take-up reels



Figure 5.10: Paint mixer powered by a rotary-vane air motor.

DRILLS

The air drill (Fig. 5.11) is one of the most commonly recognized portable power tools. Despite the continuing development of automatic production processes, there are still many applications where only portable air drills can be used. This fact accounts for their widespread industrial use.

The operator can start the drill gradually, making it possible to be sure that the drill bit is properly located. Then the tool is brought to full speed to complete the operation.

In industry, air drills are generally preferred to electric and cordless drills because of their lighter weight, their ability to stall repeatedly without motor burnout, and their freedom from the hazard of electric shock.

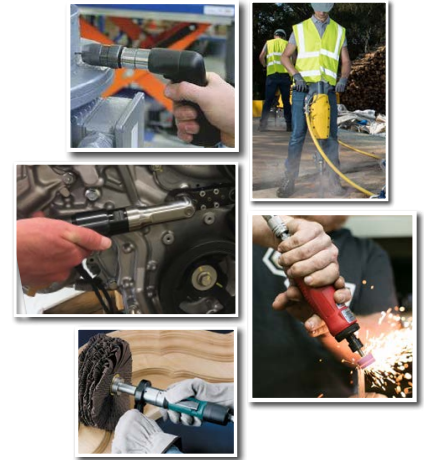




Figure 5.11: A portable air drill is used for drilling holes.

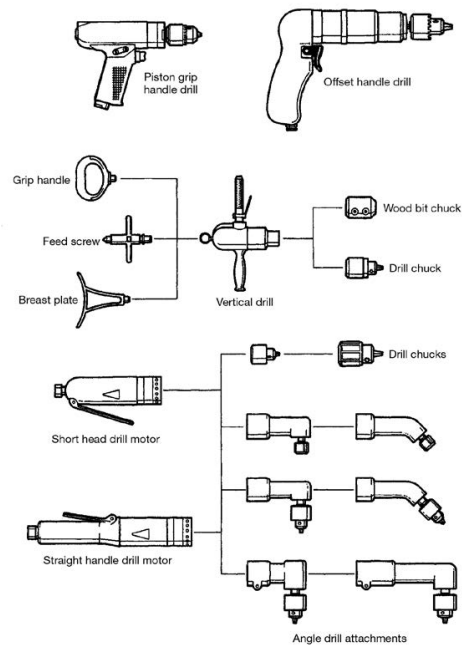


Figure 5.12: Various portable air drill combinations and attachments.

Drills are furnished in a variety of configurations, as shown in Fig. 5.12, to meet differing job requirements:

1. Pistol grip: the handle is set forward from the rear of the motor housing.
2. Offset handle: the handle is set near the extreme rear of the motor housing. The terms pistol grip and offset handle are often used interchangeably.
3. Spade handle: the handle is D-shaped with the trigger inside, and the drill is also equipped with a side handle.
4. Straight handle: the handle is in line with or part of the motor housing. This type of drill is used where vertical motion is required and has either a lever or button throttle.
5. Forty-five or 90 degree angle drills: these drills are used wherever work configurations or narrow space becomes a problem. Most drills in this category are light enough for manual use, although larger models can weigh from 60 to 80 lb (27 to 36 kg).

Speed Range

Available speeds range from a few hundred rpm to approximately 19,000 rpm. The important factor is not so much the turning speed as the cutting speed in surface feet per minute. This cutting speed is determined by the diameter of the drill bit, the rotating speed, and the hardness of the material being drilled.

Weight

Weights range from less than 1 lb (0.45 kg) for small collet-type drills to 80 lb (36 kg) for heavy-duty, right-angle drills. The most popular sizes are the 1/4- and 3/8-in. drills weighing from 2 to 2 1/2 lb (1.0 kg). Larger sizes are only a small percentage of the drills in current use.

Rotation

Most drills are right-hand, single-rotation models, but they can be furnished with reversible motors. Special chuck-retaining methods must be used with such models. Reversible models are used for tapping and for drilling in materials in which the drill bit tends to grab or become stuck when breaking through.

Capacity

The capacity of the drill is usually determined by the size of the chuck. The chuck size and the power are normally matched. Cutting-tool retainers range in size from 1/16- to 3/16-in. (1.6- to 5.0-mm) collets and 1/4- to 1/2-in. (6.3- to 12.7-mm) chucks. However, portable drills, both reversible and nonreversible, are available with the capacity for drilling, tapping, and reaming holes up to 2 in. (51 mm) in diameter.

Selection

For economical operation, a drill must produce a clean hole in the shortest possible time without undue effort by the operator. Selection of the drill is determined by the material to be penetrated and the size of the hole. To drill a 1/4-in. (6-mm) hole in soft materials such as wood or aluminum, a small, high-speed drill is ideal. But in hard metals, the small drill will stall repeatedly and its high speed will burn up the bit. A tool with more power and slower speed is required for the harder metals.

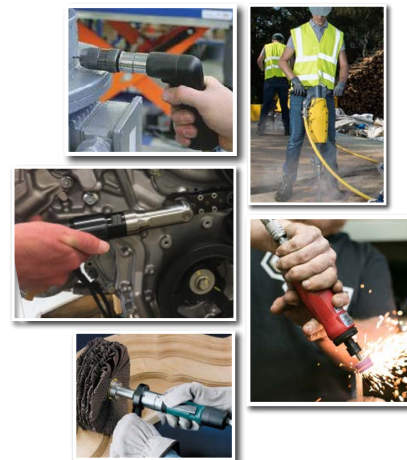


Table 5.2: Recommended Drills Speeds For Drilling In Various Materials

			Recommended Cutting Speed Range							
			1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2
Material		S.F.M.	.062	.125	.187	.250	.312	.375	.437	.500
Steel Alloy	300-400 Brinell	20-30	1250 1800	600 900	400 600	300 450	250 350	200 300	175 250	150 225
Stainless Steel		30-40	1800 2500	900 1200	600 800	450 600	350 500	300 400	250 350	225 300
Cast Iron, Hard		30-40	1800 2500	900 1200	600 800	450 600	350 500	300 400	250 350	225 300
Steel Forgings		40-50	2500 3100	1200 1500	800 1000	600 750	500 600	400 500	350 425	300 400
Steel, Tool	Annealed .90-1.20 Carbon	50-60	3100 3700	1500 1800	1000 1200	750 900	600 700	500 600	425 525	400 450
Steel, .40-.50 Carbon		70-80	4300 5000	2100 2500	1400 1600	1050 1200	850 1000	700 800	600 700	525 600
Cast Iron, Med. Hard		70-100	4300 6000	2100 3000	1400 2000	1000 1500	850 1200	700 1000	600 900	500 800
Bronze, High Tensile Strength		70-150	4300 9000	2100 4500	1400 3000	1000 2300	850 1800	700 1530	600 1300	500 1200
Malleable Iron		80-90	5000 5500	2500 2800	1600 1800	1200 1400	950 1100	800 900	700 800	600 700
Steel, Mild	.20-.30 Carbon	80-110	5000 6700	2500 3400	1600 2300	1200 1700	950 1350	800 1150	700 1000	600 850
Cast Iron, Soft		100-150	6000 9000	3000 4500	2000 3000	1500 2300	1200 1800	1000 1530	900 1300	800 1200
Plastic		100-150	6000 9000	3000 4500	2000 3000	1500 2300	1200 1800	1000 1550	900 1300	800 1200
Aluminum		200-300	12000 18000	6000 9000	4000 6000	3000 4500	2400 3700	2000 3000	1700 2600	1500 2300
Brass & Bronze		200-300	12000 18000	6000 9000	4000 6000	3000 4500	2400 3700	2000 3000	1700 2600	1800 2300
Magnesium		250-400	15500 25000	7500 12000	5000 8200	3800 6100	3000 4900	2500 4000	2200 3500	1900 3000
Fiber Glass		300-400	18000 25000	9000 12000	6000 8200	4600 6100	3700 4900	3000 4000	2600 3500	2300 3000
Wood		300-400	18000 25000	9000 12000	6000 8200	4600 6100	3700 4900	3000 4000	2600 3500	2300 3000

TABLE 5.3: Spindle Speeds (rpm) to Result in a Given Surface Speed

Drill Bit Diameter (in.)	Surface Feet per Minute (SFM)											
	30	40	50	60	70	80	90	100	110	200	300	400
1/8	917	1222	1528	1834	2139	2445	2750	3056	3662	6111	9168	12224
3/16	611	815	1019	1222	1426	1630	1833	2037	2241	4074	6111	8148
1/4	458	611	764	917	1070	1222	1375	1528	1681	3056	4584	6111
5/16	367	489	611	733	856	978	1100	1222	1345	2445	3666	4888
3/8	306	407	509	611	713	815	917	1019	1120	2037	3056	4074
7/16	262	349	437	524	611	698	786	873	960	1746	2619	3492
1/2	229	306	382	458	535	611	688	764	840	1528	2292	3056

As an aid in selecting a suitable speed, Table 5.2 lists the suggested surface speeds for high-speed steel drill bits in various materials. If there is a choice between tools of the same speed but different sizes, final selection is based on performance for a lighter weight tool or one with more power to maintain speed under load. Table 5.3 is included for convenience.

Drills with governor control of speeds are available so that maximum surface speed can be maintained under load.

TAPPING TOOLS

A portable tapping tool is sometimes the most practical means of producing threads in a predrilled hole. Portable tappers are low-speed tools, available in either reversible drills with a tapping chuck or single-direction drills with a special push-pull tapping attachment (Fig. 5.13).



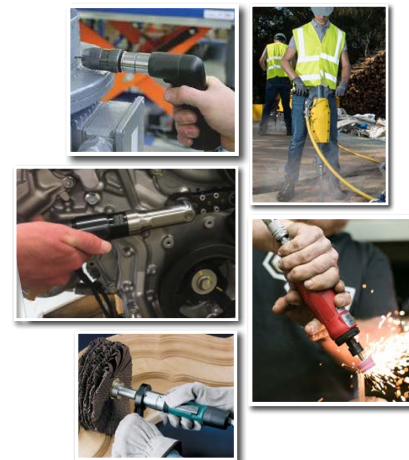
Figure 5.13: Portable compressed air tapping tool.

ASSEMBLY TOOLS

Air tools used for assembly applications are popular for high output and cost reduction. The controllable speed and torque of an air motor, its ability to tolerate repeated stalling without harm, its instant starting capability, and its high power per pound make it ideally suited to assembly work. Air tools perform many assembly operations that would be nearly impossible with tools powered by other means; many of these applications will be discussed in later paragraphs in this section.

Screwdrivers and Nutsetters

The basic difference between a screwdriver and a nutsetter is in the output spindle. Screwdrivers generally have female spindles (Fig. 5.15) in 1/4- or 5/16-in. (6- or 8-mm) hex size to hold commercially available screwdriver bits. They may also have a nonrotating finder to help locate the bit on the screw head. Bits and finders are made in a wide variety of sizes and lengths to fit any standard screw head configuration. Nutsetters usually have male square-drive spindles (Fig. 5.14) to which sockets can be attached, although they may also be equipped with integral sockets or with larger hexagonal chucks to receive hex-shank nutsetting attachments. Screw-drivers and nutsetters will drive fasteners in a range of sizes



from number 0 screws through 1/2-in. (12-mm) bolts. They weigh from 1/2 to 5 lb (0.25 to 2.3 kg). Power output varies from 1/8 to 1 hp (0.09 to 0.75 kW), with output speeds of 250 to 5000 rpm. The range of tools, attachments, and optional equipment makes it possible for off-the-shelf purchase of the correct tool for almost any application.

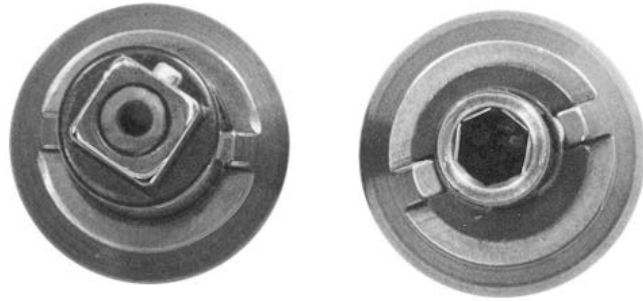


Figure 5.14: Output spindle of a nutsetter (left) and screwdriver (right).

Screwdrivers and nutsetters are classified by handle style, type of clutch, mode of throttle operation, type of drive, and torque capacity. Many models are furnished with a choice of single-direction or reversible motors, those with reversible motors being more popular.

Offset-handle or pistol-grip tools (Fig. 5.15) are normally used for horizontal work or where considerable torque reaction is transmitted to the operator. These tools can be actuated by either a trigger or by operator pressure against the fastener. Straight-handle tools are usually used vertically where reaction torque is low. They are normally balance suspended, as shown in Fig. 5.16. Lever, button, or push-start options are available on straight tools.



Figure 5.15: Pistol-grip screwdriver used in construction equipment assembly.



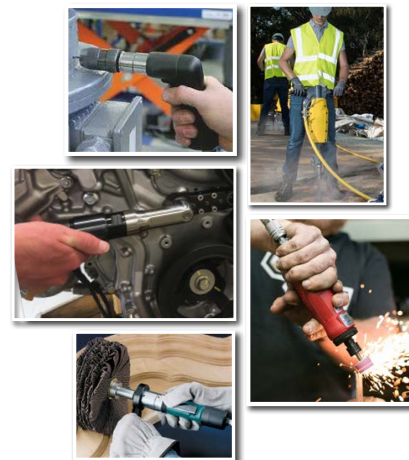
Figure 5.16: A balancer-suspended, straight style air screwdriver.

Screwdrivers may be driven directly or be fitted with one of several types of clutches. Torque repeatability is the factor that most often determines the type of clutch to be used. The more sophisticated the clutch, the less skill is required from the operator to achieve the desired torque.

Direct-drive tools are the simplest type, but their use is usually limited to the application of sheet-metal and wood screws where torque control is not critical and recessed head screws are used. They are typically utilized in stall-type applications.

Clutches for screwdrivers fall into three categories: positive, cushion, or shutoff. The positive clutch is the simplest and least expensive. It is a jaw-type, spring-loaded device that remains disengaged until the bit is pushed into the fastener head. When torque builds up in the fastener, the clutch acts as a ratchet, signaling that the fastener has reached the desired torque so that the operator will shut the tool off. This clutch is best suited to driving wood screws. The cushion clutch, also referred to as an adjustable clutch or adjustable ratcheting clutch, is usually composed of two stages. One is similar to the positive clutch described previously, except that the jaw faces are perpendicular and do not tend to disengage under torque. This allows the bit to be applied to and removed from the fastener with the motor running, since the bit remains stationary until axial pressure is applied to the fastener. The other part of the clutch consists of a spring-loaded pair of jaws with sloping faces or balls in detents. Torque setting is controlled by spring preload and is not affected by operator pressure. When fastener torque reaches the desired value, the second clutch ratchets. The selection of motor size and proper clutch adjustment for the particular fastener being driven present further torque buildup once the clutch begins ratcheting.

Shutoff and kickout-type clutches offer the best torque control and usually require less maintenance than other types. These clutches have a spring-loaded jaw or detented rolling element to control torque, but they either disengage, rotate freely, or shut off the tool when set torque is reached. Because they do not ratchet when the preset torque is reached, they generally offer the best torque control. For work in close clearances, a variety of attachments is made for



screwdriving and nutsetting. These attachments may be positioned with the driving spindle at 45 or 90 degrees to the tool for many have a flat extended spur gear train with the driving spindle at 90, 75, or 60 degrees to the tool, or parallel to the tool. Plain angle tools may be equipped for fastening with a square drive or with integral flush sockets.

Extended tools have either a square drive or an integral socket. Angle tools are available with clutches or as stall-type models. On work requiring higher torque, angle tools are frequently used to reduce operator effort even when no clearance problems exist.

Screwdrivers can be adapted to certain applications by adding a hopper that feeds the screws automatically into position under the driver bit.

Angle Nutsetters

An angle nutsetter, also referred to as an angle nut runner or angle wrench, is an air tool with straight, in-line motor housing and the output spindle arranged to drive at right angles to the axis of the housing (Fig. 5.17). While particularly suitable for applications in which space is limited, they are widely used for bolt and nut tightening. The right-angle configuration of the tool gives the operator a lever to make it easier to absorb the torque reaction.



Figure 5.17: A balancer-suspended right angle nutsetter being used on construction equipment.

Angle nutsetters are available with motors ranging from about 1/2 to 1 3/4 hp (3/8 to 1 1/3 kW) and are generally used for fasteners ranging in size from 1/4 to 3/4 in. (6 to 19 mm). Normally, a square drive output spindle is furnished for driving hex sockets, but integral flush sockets and other optional spindles are available. These tools are geared, and most models are offered in various speeds and torque output combinations. Many are available in reversible models.

Both stall-type and torque-control angle nutsetters are offered and provide accuracy and reliability. Stall-type tools are run until the fastener stops turning and the motor stalls. At a certain air pressure, a given-size air motor and set of gearing will always stall at the same torque. Adjustment of torque output is made by controlling the air pressure with an air-line pressure regulator. However, much of the effectiveness of this method depends on the technique of the operator, who must hold the tool firmly until the tool stalls, not ease off on the throttle or ratchet the tool.

Torque-control-type tools (Fig. 5.18) are probably the most common today because they are more accurate, and they eliminate most of the operator influence. A built-in control device shuts the motor off at a preset torque. This device can be an air shutoff valve that senses motor pressure, a mechanically disengaging clutch, a speed-sensing governor, or combinations of such devices. Adjustment of torque output is made either at the tool or with an air-line pressure regulator, depending on the design. Torque control is more precise with this type of tool, and sustained torque reaction to the operator is minimized. Both torque-control and stall-angle nutsetters can be provided with extensions to lengthen the lever arm or with reaction bars to further minimize or eliminate torque reaction (Fig. 5.19).

Nutsetters coupled with electronic torque-monitoring equipment are gaining wider acceptance. To be compatible with such systems, special angle nutsetters are available with built-in electronic options. These include torque transducers and angle encoders.



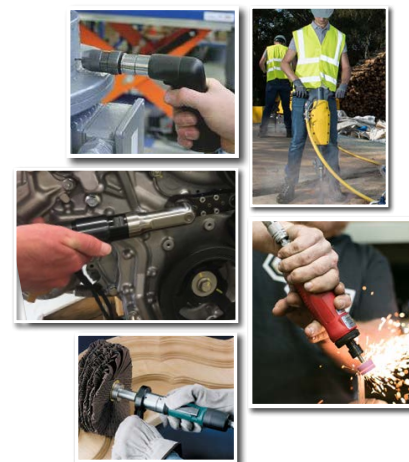
Figure 5.18: An angle nutsetter being used for automobile engine assembly.



Figure 5.19: A crow-foot nutsetter is used where limited access to threaded fasteners precludes the use of other tool types.

Ratchet Wrenches

Ratchet wrenches are limited-access, production-assembly tools that are now used throughout industry for applications where access to the fastener is so limited that conventional power tools cannot be used (Fig. 5.20). By means of a unique and compact ratcheting mechanism, these tools transmit their power to a drive socket



in the small end of the attachment. Such attachments are available with widths as small as 9/16 in. (14 mm) and thicknesses as small as 5/16 in. (8 mm).

Some ratchet wrenches may be used in reverse when they are turned over so that the socket runs in the opposite direction. Some even have a reversing mechanism in the valving section. Ratchet wrenches are obtainable as stall-type tools or with the shutoff valve options found in angle nutsetters.



Figure 5.20: A ratchet-type air wrench used where limited access space precludes the use of other types.

Impact Wrenches

The rapid acceleration of an air motor and its insensitivity to stall make it an ideal power source for an impact wrench (Fig. 5.21). Air impact wrenches weighing only 2 1/2 lb (1.1 kg) can tighten bolts to a torque of 100 ft-lb (135 N-m). Other models provide torque as high as 80,000 ft-lb (108,000 N-m). Wrenches used for tightening high-tensile-strength bolts in steel structures to torques of 3000 ft-lb (4070 N-m) weigh less than 34 lb (15.5 kg) and are easily handled by one operator.



Figure 5.21: An impact wrench generates very high torque in a relatively small tool.

Such wrenches give fast, free-speed rundown before impacting. An impact wrench consists of a rotary vane air motor and a special clutch mechanism through which energy from the motor is converted to a series of rapid, high-intensity rotary blows. These are transmitted from the wrench spindle to the fastener through a socket or other attachment.

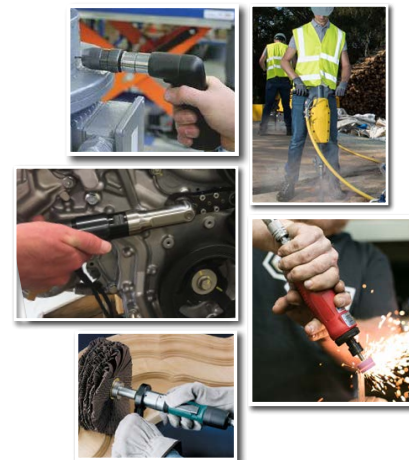
Chapter 5

Because of the nature of the impact mechanism, impact wrenches transmit little or no torque reaction to the operator. An operator can hold a heavy wrench on a fastener with one hand while tightening the fastener to as much as 3000 ft-lb (4070 N-m).

Impact wrenches are available in sizes to handle bolts as small as 1/4 in. (6 mm) in diameter or as large as 12 in. (300 mm) in diameter. Straight handles with lever or button throttles are furnished in sizes from 1/4- to 1/2-in. square drive. Pistol-grip or closed-type handles are furnished on sizes from 1/3- to 1 3/4-in. square drive. Larger tools with square drives as large as 3 1/2 in. are generally furnished in a straight configuration with a throttle handle on one side and a dead handle on the other side.

Impact wrenches are also available with 45- and 90-degree angle heads for applications with limited access. Considerable power is lost in the use of angle head attachments, or universal joints with impact wrenches. For safe operation, only attachments designed and manufactured for use with impact wrenches should be used with them. These attachments, such as sockets, universal joints, and adapters, are usually finished in black rather than the bright surface normally found on hand tool sockets. Hand tool sockets can shatter if used on impact tools. All modern impact wrenches are reversible and are used for disassembly as well as assembly. Most models provide a choice for square drive shanks and hex, quick-change chucks. Larger sizes have spline drives for heavy-duty application.

Sockets and attachments are retained on the driver or shank of the tool in several ways. Smaller impact wrenches with square drives up to 1/2 in. usually have pin or ball retainers mounted in the driver. Larger tools with square drives 3/4 in. and larger usually have a hole through the driver. Until recently, accepted practice was to retain the attachment on the driver with a through pin and keep the pin in place with an O-ring that fits into a groove around the attachment. An alternate retaining method now available consists of a one-piece flexible plastic ring and a pin that fits into the holes on the attachment and driver and into the groove around the attachment.



Torques and bolt diameter capacities are approximate only and depend on a variety of factors, such as the following:

1. Condition and lubrication of the threads
2. Air pressure
3. Duration of impacting
4. Type of material being fastened (i.e. metal to metal or metal to a resilient gasket material)
5. Condition of sockets or attachments and how well they fit the tool and the fastener head

Variations in any of these factors can significantly affect the torque obtained in any particular case.

Some manufacturers rate impact wrenches by bolt diameter capacity, while others rate them according to torque ranges and working torques. In the square drive, the size on impact wrenches corresponds approximately to the bolt capacity. However, because of the many variables involved in impact wrench applications, it is advisable to try a tool under actual operating conditions to ensure success on a particular tool. Most tool manufacturers provide various types of built-in tightening controls on their impact wrenches. Some include actual torque-responsive devices that monitor the bolt resistance at each blow and automatically shut off the air supply when resistance reaches a predetermined level. Others have built-in timers that admit air to the motor for a prescribed period of time and then shut off the air. Some have an adjustable air restriction that limits the speed and impacting power of the impact wrench. Another has a torque-limiting bar that is an extension between the impact wrench and socket, which, because of its length and diameter, will twist and keep the torque within a predesigned range. A combination torque and turn control impact wrench is also available. While bolt tightening cannot generally be controlled as closely with an impact wrench as with a torque-controlled nutsetter, good control can be achieved by the operator in many applications by careful attention and skilled use.

Riveters

Portable riveters fall into two general categories: rivet hammers and rivet squeezers. The latter are commonly referred to as compression riveters. Rivet hammers, as shown in Figs. 5.22 are applied to one end of a rivet, and a heavy metal object known as a bucking bar is held against the other end. Thus, they can be used to drive rivets anywhere in an assembly providing there is space to get the hammer and the bar on the rivet. Squeeze riveters are limited to driving rivets located within a certain distance from the edge of the assembly, since the yoke of the riveter must pass over the edge to engage the rivet between a stationary die on one face of the yoke and a moving die that advances from the other face (Fig. 5.23).

Practically all rivet hammers are air operated since air cylinders and valves provide the necessary, fast-acting, reciprocating motion of the hammer in a compact, cool-running assembly. Several types of rivet hammers are available. The most common is the small, aircraft-style riveter, which delivers a series of rapid blows as long as the throttle is held down. One-shot rivet hammers, which deliver one hard blow each time the throttle is opened, are used where rivet material tends to work-harden under repeated blows.



Figure 5.22: A riveting hammer for aircraft assembly.



Figure 5.23: A compression riveter with a C-yoke that can be used to fasten a hinge to a metal frame.

A rivet squeezer, or compression riveter, consists of an air cylinder with one or more pistons that drive a cam or toggle mechanism. This, in turn, drives a ram in which a rivet die is positioned. The cam or toggle arrangement multiplies the force exerted by the piston, resulting in a force at the rivet die that is many times greater than the force that could be developed by the piston and cylinder alone.

Squeeze riveters can be equipped with C-type yokes in which one die is located on one leg of die C with the ram advancing from the other leg. They are also available with alligator-type yokes, as shown in Fig. 5.24, in which the moving jaw becomes the ram. Location and orientation of the rivet are the factors that determine the type and size of yoke that must be used.

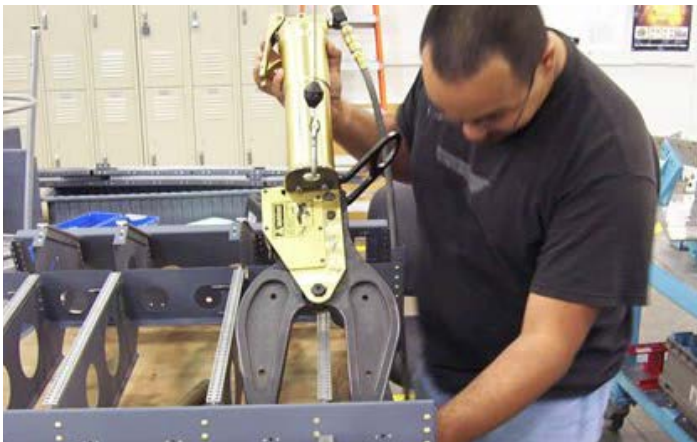
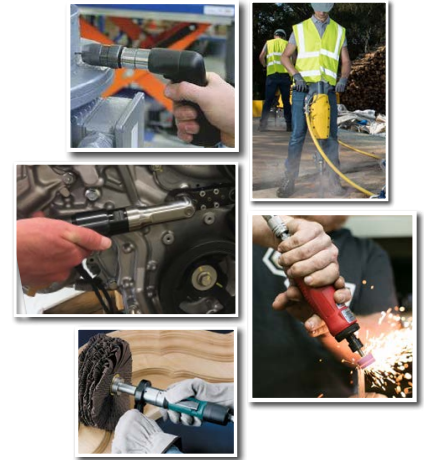


Figure 5.24: A squeeze riveter with an alligator-type yoke being used on aircraft frame assembly.

Riveters are available in sizes to drive rivets from 3/32 to 1 1/4 in. in diameter. They can be hand held, balancer suspended, bench mounted, or pedestal mounted and can be equipped with a hand throttle on the tool or with foot valve actuation. They are used for steel fabrication, railroad car building, ship building, aircraft manufacturing, truck building, and the manufacture of many other products that require a strong, permanent assembly.



ABRASIVE TOOLS

Air tools are widely used for grinding, sanding, wire brushing, burring, rotary filing, sawing, and other similar applications. They can be fitted with a variety of attachments (Fig. 5.25), depending on the requirements of the job. Care must be taken to ensure that current safety standards are followed with regard to wheels and attachments, as well as mounting flanges, arbor lengths, diameters, throttles, and guards.

Forgings, castings and weldments often have burrs or other surface irregularities removed by grinding, sanding or wire brushing.



Figure 5.25: A grinder being used in an industrial application.

Safety Standards

Recommended safety standards are published by the American National Standards Institute, Inc. (ANSI). The two publications applicable to abrasive tools are:

1. B7.1: "Safety Requirements for Use, Care, and Protection of Abrasive Wheels"
2. B186.1: "Safety Code for Portable Air Tools"

Both publications are evaluated and updated periodically. The most up-to-date copy should be used as a reference.

These codes enable manufacturers to design their products in accordance with clearly defined standards and enable users to establish proper procedures and rules for the use and care of these products. Users should refer to grinding wheel blotters for the maximum safe rpm of their wheels (Fig. 5.26), in addition to making absolutely sure that the other requirements for the safe operation of abrasive tools are strictly adhered to.



Figure 5.26: The maximum safe operating speed of a grinding wheel as marked should never be exceeded.

Abrasive Tool Speeds

Maximum tool speeds must be controlled with close limits. Abrasive tool speeds are maintained by the following:

- 1. Governor control:** Larger tools are usually designed with built-in governors or speed controllers that restrict the flow of air to the motor as the speed increases to the rated speed of the tool. Over-speed shutoff devices linked to the governor are available on some tools. Their use results in the tool shutting off if the rated speed of the tool is exceeded.
- 2. Adjustable speed regulators:** Sometimes found on smaller grinders, the adjustable speed regulator is usually a needle valve or similar air flow restriction (Fig. 5.27). Care must be taken to ensure that wheels or attachments larger than those rated for the maximum safe speed of the tool are never used.
- 3. Air-line pressure regulators:** An air-line pressure regulator can be used to change the inlet pressure of the air supply to the tool. This change in pressure will result in a corresponding change in speed. This method, however, will also affect the power produced by the tool.

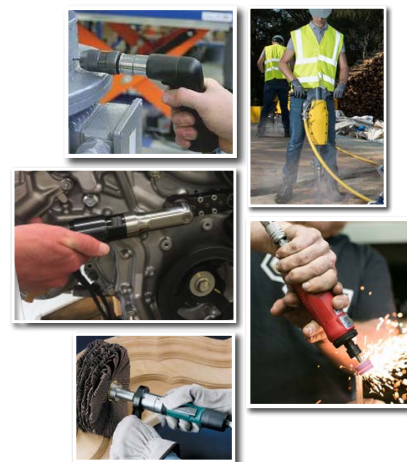


Figure 5.27: Die grinders with built-in speed regulator and lock-off start/stop device.

Abrasive Tool Throttles

As a variety of types of throttles are available, the one selected should depend on the design and purpose of the tool. In almost all cases, throttles must be self-closing. The only exceptions are throttles on small wheel tools under conditions prescribed in the B186.1, "Safety Code for Portable Air Tools, referred to earlier. The use of lock-off-type throttle levers is becoming more prevalent. These throttles prevent inadvertent starting of the tool while it is attached to an air line but is not in use. Other available throttles are self-closing button or thumb types and self-closing grip types.

Abrasive Tool Guards and Options

Current safety standards call for the use of guards on all large grinders (Fig. 5.28). The guard is intended to protect the operator from wheel fragments if the wheel breaks while running, deflects sparks and chips, limits wheel size, and keeps the operator from accidentally touching the wheel. Exhaust can be from the front, rear, or side. Piped away exhaust attachments are available on many tools for jobs where low noise levels are required or where contaminants in the exhaust air are objectionable. Vacuum pickup of material removed by the abrasive wheel is also available on some tools.



Figure 5.28: A wheel guard protects the operator from sparks and chips, and from wheel fragments if a wheel breaks.

TYPES OF ABRASIVE TOOLS

Die Grinders

Die grinders (Fig. 5.29) are the smallest and fastest tools available. They are used for the finest kind of tool and die finishing, rapid metal and burr removal, and other comparable work. They are usually furnished with 1/8- to 1/4-in. female collet spindles, although for some die grinders male-threaded arbors and guards are available so that small-diameter wheels can be used. Care must be exercised to select small wheels and burs that have speed ratings compatible with the high speeds of these grinders. There are two types of die grinders: turbine powered and vane powered.

Turbine powered die grinders rely on their high speed, up to 100,000 rpm, to achieve metal removal. They are usually hand-held, as in Fig. 5.30, but are sometimes fastened by an appropriate fixture to a bench or to the turret of a lathe. Because of their high speed, turbine grinders are equipped with high-precision collets. Grinders of this type are generally fitted with a twist-type or screw-type throttle. This feature frees the operator from the need to manipulate a throttle. Some manufacturers furnish turbine grinders with a length of air hose and a cartridge filter to give extra protection to the motor and bearings by removing airborne contaminants.

Most turbine grinders have a single-stage rotor driven by compressed air. Some grinders have two rotors separated by a stator. This feature allows more efficient use of the air and provides increased torque.



Figure 5.29: Die grinders are used for tool and die finishing, rapid removal of metal and burrs, and some weld finishing.



Figure 5.30: Turbine grinders are used for light metal removal where precision is important.

Vane-powered die grinders have speeds ranging from 10,000 to 60,000 rpm. They are usually hand held. They are more widely used than turbine grinders because of the torque available at optimum wheel speeds. As load is applied to a vane-motor grinder, its speed does not decrease as rapidly as that of a turbine-driven tool.

Small Wheel Grinders

Small wheel grinders normally use straight arbor-hole wheels or shank-mounted cone wheels (Fig. 5.31). Speeds may be as high as 40,000 rpm and are usually governor controlled. Weights range from 1 1/2 lb (0.7 kg) to approximately 6 lb (2.7 kg). There is no firm delineation between these tools and the smaller die grinders or the larger horizontal grinders, but they do have many applications in industry and construction and warrant separate classifications as abrasive tools. These tools can also be used with rotary files or wire wheels, and models are available with extended spindles for use in places with limited access.



Figure 5.31: Small-wheel grinders, equipped with plug, cone, type-I or wire brush wheels are used in a variety of operations, primarily foundry work.

Angle Grinders

Angle grinders (Fig. 5.32), with speeds up to 20,000 rpm, have spindles mounted at right angles to the motor housing. Power is transmitted to the spindle through a set of gears in the angle head. As with die grinders, they are furnished with either female collets from 1/8 to 1/4 in. or threaded male arbors and guards. Weights range from 1 to 3 1/2 lb (0.45 to 1.6 kg). Most angle grinders are in the small, ungoverned, higher-speed sizes, although larger sizes having a governed motor and speeds as high as 7500 rpm are available.

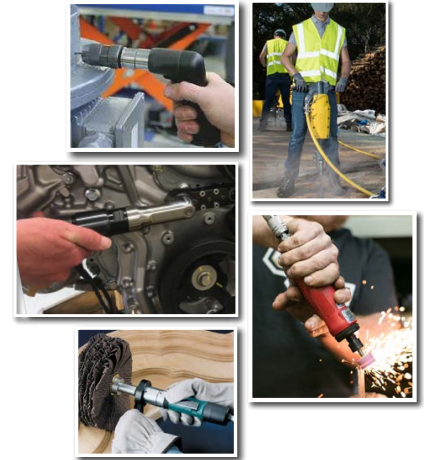




Figure 5.32: Right angle grinder being used to remove weld spatter from a fabricated part.

Large Wheel Grinders

These are heavier-duty tools that may be classified as either horizontal grinders or vertical grinders. The horizontal tools have the motor and handle aligned and are used for fast, heavy-duty metal removal (Fig. 5.33). Speeds range from 3100 to 10,800 rpm. Weights without wheels average 10 lb (4.5 kg). Arbors are male threaded for use with wheels from 5 to 8 in. (127 to 203 mm) in diameter. The handle is usually either of the spade type or the straight type with an integral lever throttle. Figure 5.34 shows a horizontal grinder with a straight handle.



Figure 5.33: A horizontal grinder.



Figure 5.34: Horizontal grinders are usually equipped with a straight or spade-type handle. A straight handle is pictured here.



Figure 5.35: Vertical grinders are considered to be the most versatile and widely used of large-wheel grinders.

Vertical grinders (Fig. 5.35) are perhaps the most widely used for all large-wheel grinders. They are so named because the motor is mounted in a vertical position to grind surfaces perpendicular to the axis of the motor. They are most often used for rapid removal of metal from castings and weldments, but can be used with the proper wheels and guards for finishing concrete and other heavy-duty applications. Cup-type wheels up to 6 in. (152 mm) in diameter and depressed-center or flat-disc wheels up to 9 in. (228 mm) in diameter, with the proper guards and flanges, are most often used with these tools. Most vertical grinders are ungeared and rated at 4500 to 6000 rpm, although speeds of 12,000 rpm are available. Weights range from 4 to 12 lb (1.8 to 7.3 kg); the average weight without wheel is approximately 8 lb (3.6 kg). Most vertical grinders have a dead handle, and many such handles can be positioned in one of two angular locations for ease of operation.

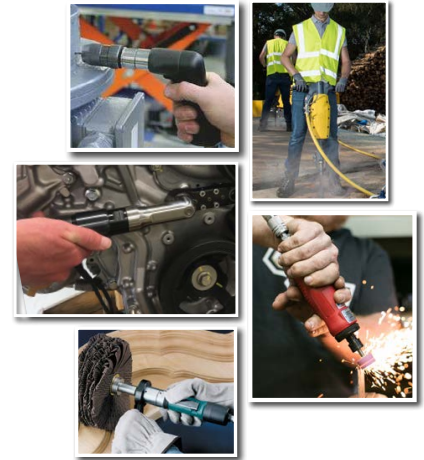
SANDERS AND POLISHERS

Sanders use coated abrasive materials in the form of discs, belts, or sheets. Support for such materials is provided by flexible backup pads, sponge-rubber pads, or platens. The proper selection of a portable air tool for sanding or polishing is determined by the nature of the work, such as metal removal, feather edging, wet sanding, or dry sanding. In selecting the speed, the user should be guided by the recommendations of the abrasive manufacturer.

A polisher is basically a sander equipped with a polishing bonnet (Fig. 5.36) instead of an abrasive disc. A maximum speed of 4800 rpm is recommended for polishing, with those running in the 1800- to 2500-rpm range being more generally used.



Figure 5.36: A polisher being used to put a final luster on an automobile.



It is a generally accepted standard that the most efficient sanding speed is 9500 surface feet per minute (2900 m per minute) on the perimeter of the disc. Such a speed is considered to provide the best combination of economical disc life and effective material removal.

There are four general styles of sanders available to industry: vertical, right angle, belt, and palm.

Vertical Sanders

Vertical sanders (Fig. 5.37) are so named because the motor and spindle are in a vertical position relative to the pad and coated abrasive disc. A vertical sander is normally equipped with two handles. One has an air inlet and throttle, and the other is called the support handle. Some vertical sanders are designed so that the support handle may be adjusted to several radial positions relative to the throttle handle. Live handles on some tools can be repositioned to place the throttle at the bottom or on either side.



Figure 5.37: Vertical sanders are capable of a high rate of material removal from composite materials. They are also used to finish metal products.

The speed of a vertical sander is established by gear reduction or controlled by a governor or air regulator. The nature of the work usually determines the choice between gearing or governing. Where rough material removal is required, a geared tool would probably be the best choice because of its high-torque output. But, if it is more desirable to maintain a uniform peripheral speed within narrow limits, a governor-controlled tool would probably be more suitable. Tools are available that are both geared and governed to achieve both of these advantages.

Belt Sanders

Belt sanders (Fig. 5.38) use wheels and sometimes a platen or flat plate to support a continuous abrasive belt. The width of the belts ranges from 1/2 to 3 in. (13 to 76 mm). These produce a fine-quality, in-line finish free of swirl marks. They are usually equipped with a forward exhaust stream that blows away the dust and grit, giving the operator a clear view of the work surface.



Figure 5.38: Belt sanders are used for fast removal of material, usually from wood parts.

Palm Sanders

Palm sanders are available in two types: orbital sanders and random orbital sanders. Orbital sanders (Fig. 5.39) are small, one-hand tools with a platen and clips to hold several pieces of abrasive paper. The tool moves the abrasive rapidly in a small orbit from 3/16 to 3/8 in. (4.75 to 9.5 mm) in diameter. Speeds are as high as 10,000 cycles per minute.

Random orbital sanders (Fig. 5.40) provide a combination rotary and orbital movement. These tools are used for fine finishing primarily in the woodworking, automotive, and plastic industries, and can provide a swirl-free finish. Wet sanding and vacuum pickup attachments are available.

Adhesive-backed abrasive and hook and loop discs are available for quick attachment and removal.



Figure 5.39: Palm sanders provide easy, single-hand control for finishing work on wood, metal and plastic composite parts.

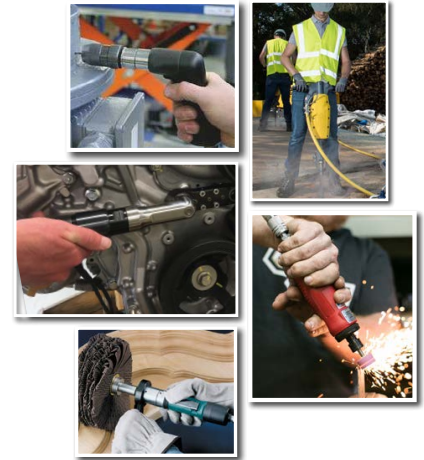




Figure 5.40: Random orbital sanders have a good operator control and provide a smooth, swirl-free finish.

SPECIAL SANDING ATTACHMENTS

Mandrel

A mandrel can be attached to a straight grinder and fitted with a cylindrical abrasive sleeve. It is used on tight-access work or a double-contoured surface. The mandrel is made of rubber and is slotted in such a way that the slots expand under centrifugal force. Such mandrels are available in a variety of sizes.

Radial Flap Wheel

The radial flap wheel (Fig. 5.41) carries a series of radially inserted abrasive papers. Under load, the papers fall back to present a powerful abrasive face. Such wheels are used primarily in the woodworking industry for sanding complex shapes that would otherwise be difficult to finish.



Figure 5.41: Sanding of double curved contours is made easy using a die grinder equipped with a flap wheel.

PERCUSSION TOOLS

Chapter 5

Chipping Hammers

The chipping hammer is used for gouging and cutting away base material. It can be used for such operations as slag removal, peening, rock breaking, core busting, riser cutoff, fin removal, and weld-bead removal. Chisel inserts have hex, slotted, or round shanks.

Scaling Hammers

Scaling hammers (Fig. 5.42) are high-speed, lightweight percussion tools used for removing flux and spatter after welding. They deliver a somewhat lighter blow than chipping hammers. Other uses are to chip heavy paint, remove scale and rust, break sand molds, and process sheet metal. They are preferred where a light blow is required. Some manufacturers offer reduced sound and vibration models. These hammers are furnished as straight or pistol-grip models. They can also be furnished without a manual throttle delivering their reciprocating action when pressure is applied to the chisel.



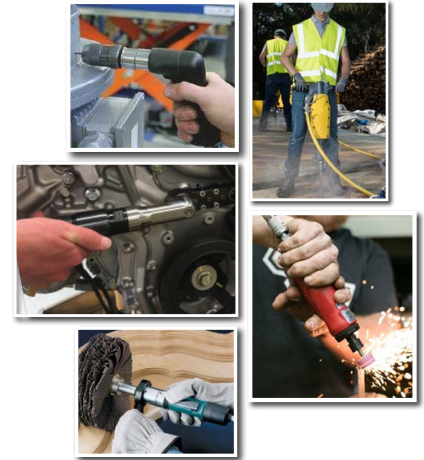
Figure 5.42: A scaling hammer.

Needle Scalers

The needle scaler is a hammer in which the blow is transmitted through a group of floating needles or metal rods (Fig. 5.43). It is especially well suited to cleaning away weld flux, rust, scale, paint, weld spatter, and other residues from irregular surfaces in shipyards, fabrication shops, refineries, foundries, and construction sites.



Figure 5.43: Needle scalers are well suited for cleaning weld flux, scale, paint and weld spatter.



Sand Rammers

In the preparation of molds for casting, it is necessary to compact the sand to a proper density. The sand rammer is used for this purpose and is available in a variety of sizes. It has an integral piston and rod to which the tamping device is attached. These tools can also be used for backfilling and for tamping refractory material in furnaces.

SPECIAL-PURPOSE AIR TOOLS

Many industrial applications cannot be handled by standard air tools. Whenever these unusual requirements arise, modifications and specially designed tools often solve the problem. A wide variety of such tools is available in industry. Some of these will be described in detail.

Reciprocating Saws

Many air tool manufacturers offer reciprocating saws (Figure 5.44) that accept standard power tool saw blades and are used for a wide variety of materials and applications.



Figure 5.44: A reciprocating saw.

Routers

Routers are high-speed rotary tools (Fig. 5.45) fitted with cutting bits and used for the trimming and edging of wood, metal, synthetics, and other materials. Routers are available for cutting wood, metal, and fiberglass. They are available with a selection of handles and throttle controls and with speeds ranging from 750 to 25,000 rpm.

One type of router resembles a die grinder and is often called a stylus router. The nose housing accepts a template guide bushing through which a cutting bit protrudes. A metal template is laid against the work. The operator then follows the edge of the template, with the template guide bushing of the router producing a clean, precise cut. Special guide attachments are also available for use in trimming plastic laminates.



Figure 5.45: A stylus router.

Shears

Air-powered shears are usually standard air tools fitted with various kinds of cutting attachments. One type of attachment (Fig. 5.46) has a scissors action for cutting and trimming sheet metal. Its cutting rate may vary from 8 ft/minute (2.4 m/minute) for 10-gauge metal to 16 ft/minute (4.9 m/minute) for light-gauge metal.



Figure 5.46: Air powered reciprocating shears are used to cut and trim sheet metal.

Concrete Vibrators

Concrete vibrators (Fig. 5.47) are used in construction work. The air motor and eccentric weight are mounted in the vibrator head and attached to a long hose handle. When inserted in freshly poured concrete, the vibrator will cause the mixture to settle rapidly for greater density.

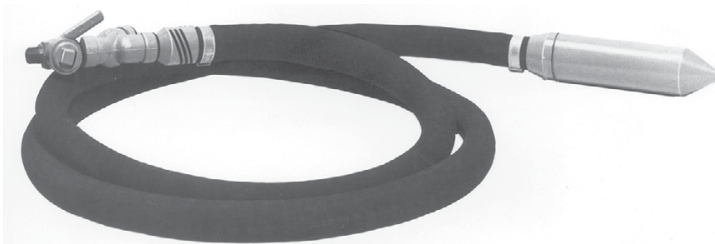
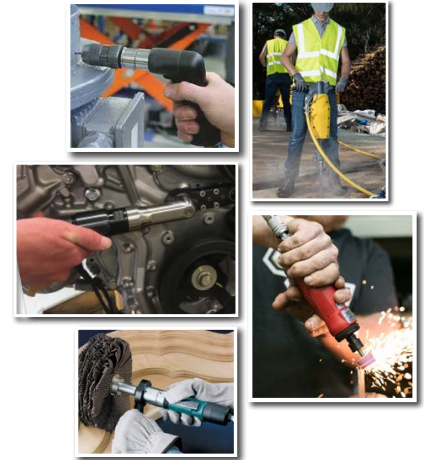


Figure 5.47: Concrete vibrators cause freshly poured concrete to settle and achieve greater density.



Electrode Dressers

Electrode dressers (Fig. 5.48) are designed to recondition electrode tips. They are available with a wide variety of interchangeable cutters to match the specific shape of the electrode being dressed. An electrode dresser eliminates the need for removing the electrode. It can be reconditioned on the spot by a welder.



Figure 5.48: Electrode dressers quickly reshape electrodes to their original form for more effective welding.

Air Starters or Cranking Motors

An air starter (Figure 5.49) is an air motor and reduction gear that drives a pinion engaged during startup with the engine's ring gear. It provides the high torque and speed required to start the engine.

Maintenance costs are low, and reliable hot-engine restarts as well as cold-weather starts are achieved. Gas-sealed starters for use with a natural gas energy source are available. Air starters are used for starting highway trucks, off-highway construction vehicles, buses, stationary power plants, pumps, locomotives, marine engines, and oil-field equipment.



Figure 5.49: An Air Starter.

AIR-POWERED AUTOMATIC PRODUCTION TOOLS

An air-powered production tool is one that automatically feeds a cutting tool into the workpiece and then retracts it. It uses an air or electric motor for rotary motion, an air piston or lead screw for forward and reverse feed of the cutting tool, and internal or external valving to control the forward and retract modes. Automatic production tools (Fig. 5.50) are among the most versatile production tools available to industry. They are used for drilling, boring, tapping, countersinking, counterboring, and spotfacing. They are used in place of manual operations to achieve greater uniformity, speed, and accuracy, to reduce operator fatigue, and to perform multiple operations simultaneously, and they can be part of tooling that is built around nearly any part. These air-powered units are more compact than their

electric-powered counterparts, and they can be utilized in any required position. Many units can be employed in a limited space, and they can be permanently mounted or portable with fixtured mountings.

The four basic categories of air-powered automatic production tools are fully air operated, air hydraulic, air mechanical, and air electric.



Figure 5.50: An automatic production tool.

Fully Air Operated

This design incorporates a single- or double-acting air piston, an air motor, reduction gearing to achieve speeds from 450 to 19,000 rpm, and a drill chuck or tapping chuck up to 3/4-in. (19-mm) capacity. Units with built-in valves to control air supplied to the piston and motor are called valve-in-head tools (Fig. 5.51).

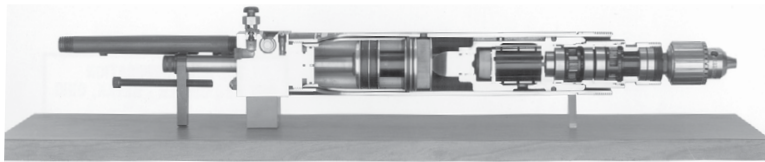


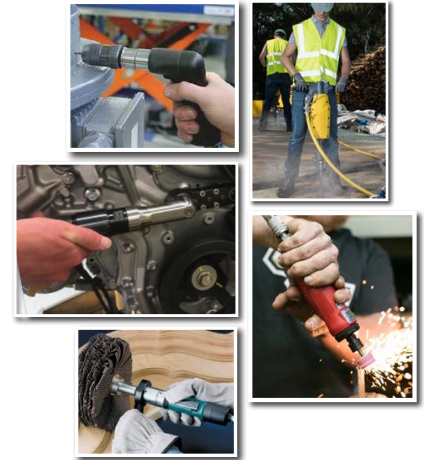
Figure 5.51: Cross-sectional view of a fully automatic production tool.

Those requiring external valves are referred to as through-head tools. Both types have needle valves that control the feed rate of the tool by regulating the exhaust air from the piston. Valve-in-head models also have needle valves to control the retract rate. External hydraulic-check assemblies are available for use with air operated units to provide hydraulic feed control to produce a higher-quality hole with minimal breakout. Fully air operated units are considered general-purpose tools, and they find application in wood, composite plastics, and sheet, plate, and cast metals.

A specifically equipped automatic production tool that falls into the fully air operated category is the peck drill. These tools are used for deep-hole drilling where hole depth exceeds four times the drill-bit diameter. The peck drill feeds rapidly to the work, drills for a preset stroke, retracts to clear chips, feeds, and then continues to recycle until the total preset hold depth is drilled. Speeds range from 500 to 17,000 rpm and maximum drilling capacity is 5/16 in. (7.9 mm) in mild steel.

Air-Hydraulically Operated

Air-hydraulic tools are similar to the fully air operated units described previously, but instead of an external hydraulic check assembly, they have a built-in hydraulic oil chamber with an adjustable orifice to control the rate of feed. This feature



allows rapid traverse and skip-feed operation. These tools incorporate internal valves for feed and retract modes, while rotational speeds are controlled by gears. They find application primarily where feed control is critical, as in the control of breakthrough.

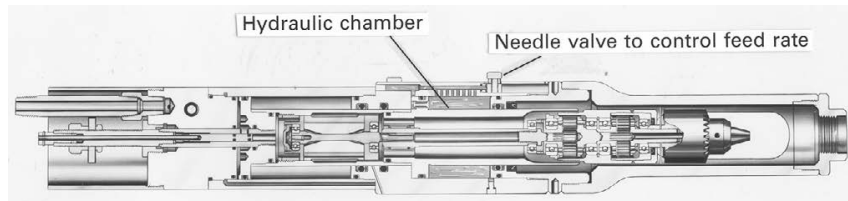


Figure 5.52: Cross-sectional view of an air-hydraulic operated automatic production tool.

Air-Mechanically Operated

Air-mechanically operated tools are sometimes called positive feed tools. Drills of this type (Fig. 5.53) are operated by air but differ from other self-feed drills in that the drive spindle is fed mechanically. Mechanical-feed drills generally have a screw thread on the drive shaft by which they are fed forward and, in some cases, retracted. Speeds range from 50 to 1200 rpm, and feed rates range from 0.0002 to 0.16 in. (0.005 to 4.0 mm) per revolution. These drills generally find application where large holes are drilled in thick common metals or where holes of any size are drilled in exotic composite plastics and high-tensile-strength metals.

For tapping units, mechanical feed is provided by a lead screw and nut (Fig. 5.54). The thread of the lead screw is precision ground to the same pitch as the cutting tap. In operation, it is fed forward and retracted through a stationary nut by a reversible air motor. The air motor is controlled by valves within the tool. Lead screw and nut assemblies are interchangeable and are available from 11 through 80 threads per inch and in metric sizes.

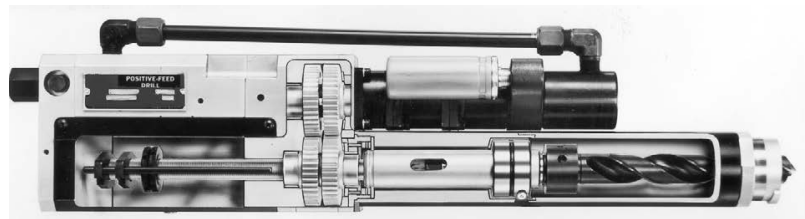


Figure 5.53: Cross-sectional view of an air-mechanically operated automatic production tool.

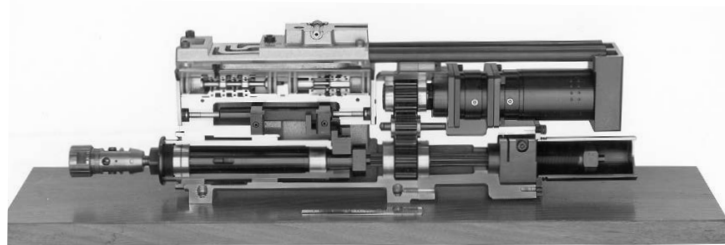


Figure 5.54: Cross-sectional view of a tapping unit.

Air-Electrically Operated

The air-electric design incorporates an electric motor for rotational motion and an air piston for feed and retract modes. Internal valves control the air flow to the air piston, while electric switches turn the motor on and off.

Optional Head Assemblies

Automatic production drill units can be provided with head assemblies other than standard drill chucks. Most models can be equipped with collets, taper shank adapters, other jaw-type chucks, fluid chucks, and multiple-spindle drill heads. The multiple-spindle heads are capable of drilling two to six holes simultaneously (Fig. 5.55).

An offset drill head assembly (Fig. 5.56) places the standard drill chuck approximately 2 1/2 in. (63 mm) out from the axis of the tool. This permits grouping of tools to achieve holes with extremely close centerline distances.

Some drill units come equipped with self-reversing jaw-type or clutch-type tapping heads to accommodate from number 0 to 1/2-in. tap sizes.

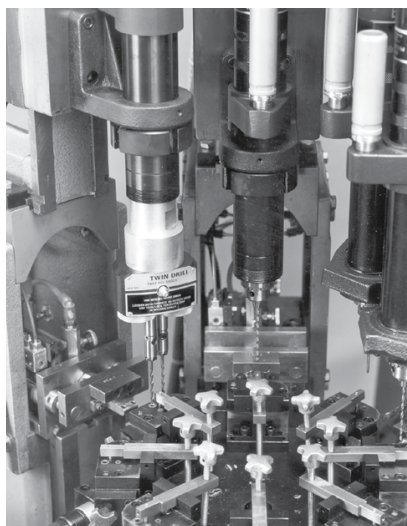
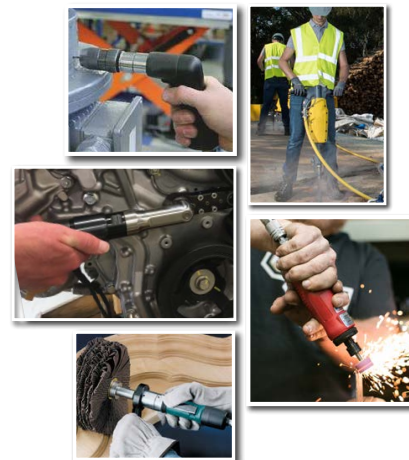


Figure 5.55: Multiple spindle drills allow two or more holes to be produced by one automatic production drill.

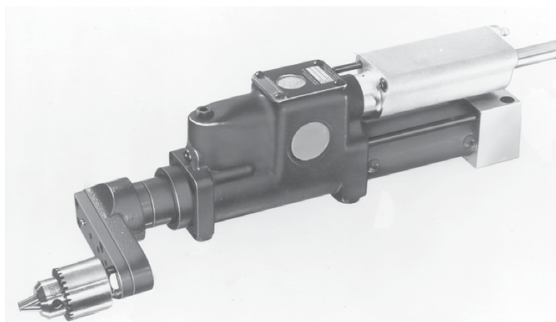


Figure 5.56: Offset drills allow closer tool groupings where holes are close together.

Mounts

Automatic production tools can be mounted in a variety of ways. A nose housing (Fig. 5.57) provides a means of mounting the automatic production tool to the fixture plate and, in some cases, to hold a guide bushing for the drill bit. The nose housing can be mounted to a fixture plate either by threading or by a portable bayonet-type mount.

Split block clamps, collet-type foot clamps, and standard and heavy-duty foot brackets can be used to mount the drills to machine plates. Tubular mounting systems (Fig. 5.57) provide the flexibility for mounting multiple tools at any orientation from one machine plate.



Figure 5.57: A nose housing provides a convenient means of mounting a tool where the part is too big to move to a machine.

OVERHEAD AIR HOISTS

Manufacturing depends heavily on transfer and handling of materials. There are many kinds of material-handling equipment available, but one of the most versatile and widely used types is the overhead hoist (Fig. 5.58). Although overhead hoists are available in hand-chain, electric, and air operated models, air hoists offer many inherent advantages over hand-chain and electric hoists. When lifting loads, hand-chain hoists require substantial human effort, resulting in operator fatigue. This is not the case with air hoists. Furthermore, air hoists offer much faster lift and descent rates than those offered by hand-chain hoists.

Air hoists also offer two major advantages over electric hoists. First, air hoists are self-cooling and will not burn out even when overloaded to a stall. This advantage also makes them applicable in extremely hot environments. Second, standard air hoists offer continuously variable lift and descent speeds, while standard electric hoists offer no more than two different speeds in a given hoist.



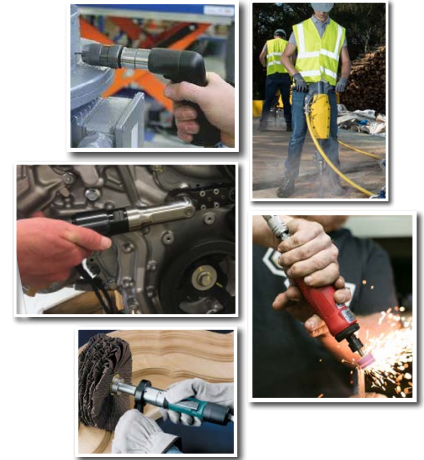
Figure 5.58: Overhead hoists are widely used to move and position parts in nearly any operating environment.

HOIST SAFETY

Air operated hoists are designed to provide increased productivity, long service life, and safe operation. But, as with any type of hoist or material-handling equipment, these advantages can only be fully realized through proper application and maintenance. To be sure that an air hoist always provides maximum performance and operator safety, the following practices should be followed:

1. Air hoists should be selected by a person who is knowledgeable about hoists and their proper application. Hoist selection must take into account the particular factors in a given application that will affect hoist performance.
2. Air hoist suspension is extremely important. Before a hoist is hung from a jib, crane, or structural member, the maximum load-carrying ability of the device should be evaluated carefully and never exceeded.
3. Air hoists should be operated only by qualified personnel who have been trained in their proper operation.
4. An air hoist should never be used to lift or transport humans.
5. No attempt should be made to lift a load greater than that for which the hoist was designed.
6. Air hoists, like any other hoist, must undergo periodic inspection and routine maintenance to ensure that they are operating properly.

These guidelines are to be considered only general in nature. Additional specific guidelines on safe hoist installation and use are available from the American National Standards Institute, ASME B30.16 / ASME B30.11 / ANSI/ASME B30.17 - Hoists Package.



AIR HOIST CAPABILITIES

Air hoists are available in rotary vane, axial piston, and rotary piston construction. These three styles offer broad application capabilities. They can lift loads up to 10 tons (9.2 metric tons) and, at the rated loads, can lift at speeds from 106 ft/minute (32 m/minute) for smaller hoists down to about 10 ft/minute (3.05 m/minute) for larger hoists.

Continuously variable control of lift and descent is possible on air hoists with either of two available control methods, a pendant control or a pull chain. The pendant uses pressurized air controlled by a hand-held pendant to shift the valve inside the hoist. The pull chain control is attached to an external lever that shifts the valve. If it is important to control either the lift or descent to a certain speed, adjustable exhaust valves on an air hoist will keep the speed within set limits. Air hoists can be hung from a stationary hook, from a manually traversed trolley, or from a powered trolley. Drum brakes, disc brakes, and worm-gear brakes are available to stop effectively and hold the rated load suspended, even when there is a loss of power (Fig. 5.59). Although all air hoists have an inherently spark resistant motor, some are available that offer added spark-resistant features, such as stainless steel load chain and copper-beryllium wheels. All air hoists offer a relatively long service life.



Figure 5.59: Air hoists are available with disc, drum or worm gear brakes.

Rotary Vane Air Hoists

Rotary vane air hoists (Fig. 5.60) are the most common type of air hoist and are the smallest of any powered hoists. They utilize a rotary vane motor and are capable of lifting loads of up to 5 tons (4.6 metric tons). At rated load and 90-psig (6.2-bar)

air pressure, a rotary vane hoist is capable of lifting at a rate of up to 106 ft/minute (32 m/minute). Control is exercised by the operator using either the pull chain or pendant control. Speed control within specified limits can be set using adjustable exhaust control valves.

A load is lifted by a cable, roller chain, or link chain. The cable method uses a grooved drum powered by the motor, which raises and lowers the cable. The roller chain method uses a sprocket on the shaft of the motor to raise and lower the roller chain. The link-chain type uses a pocket wheel instead of the sprocket to move the chain. Each rotary vane air hoist uses one of the three previously explained braking methods: disc, drum, or worm gear, and uses either a hook, manual trolley, or power trolley suspension.



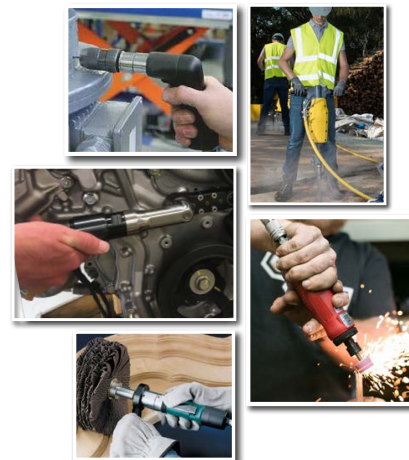
Figure 5.60: Rotary vane air hoist.

A rotary vane air hoist is comparatively light, and because it has few parts it can be repaired quickly and easily.

PISTON AIR HOISTS

Piston air hoists use compressed air to drive pistons that then rotate a drive shaft. Piston air hoists (Fig. 5.61) can be one of two types: axial piston or radial piston. The radial piston air hoist has the pistons mounted perpendicular to the drive shaft. The axial piston air hoist has its pistons mounted parallel to the drive shaft, with axial motion converted to rotary motion in the drive shaft by the use of a socket plate.

Like rotary vane air hoists, piston air hoists can operate in contaminated environments unsuitable for electric hoists because air is brought in by hose and then exhausted from the hoist. The piston air hoist can operate in hot environments, it can be worked constantly, and when too heavy a load is attempted it will simply stall, causing no motor damage. The operator can control hoist speed at the control pendant and, with the piston hoist, the operator has superior jogging capabilities. In fact, it is the best hoist to use in very critical jogging applications.



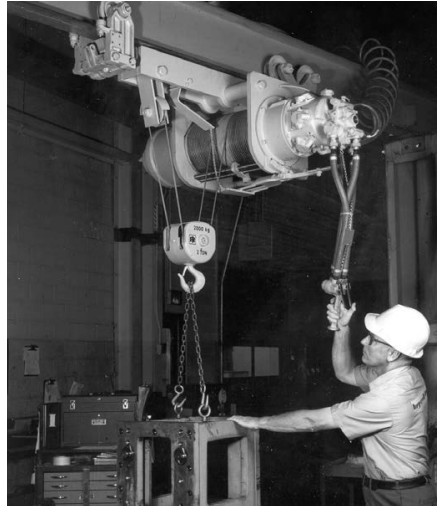


Figure 5.61: Radial piston air hoist being used to lift a heavy machine assembly.

The air piston hoist is usually specified in applications of 3 tons (2.75 metric tons) or more where variable-speed control or jogging capabilities are desired or where very heavy tonnage must be lifted and the danger of sparks from an electric hoist is unacceptable.

MOUNTING OR INSTALLING HOISTS

Hoists can be mounted by any of several methods depending on the requirements of a specific application. For stationary applications, hoists are usually hook mounted. The hook allows the hoist to pivot so it is properly oriented relative to the load.

For applications where the load must be transferred, the hoist can be trolley mounted to an I-beam, jib, or crane bridge. The trolley allows the hoist to travel on the beam to move the load to the desired location. Power trolleys and tractors (Fig. 5.62) are available to move the load with minimal human effort.

The air supply can be connected to the hoist in a number of ways. On stationary hoists, the air hose need only be long enough to allow the hoist to swivel. On trolley mounted hoists, the hose must be long enough to allow the hoist to travel along the trolley. The hose can be supported on separate hose trolleys or wound up on a take-up reel to keep it from hanging down in the way. Another common practice is to use self-storing hose coiled around a length of plastic-coated cable that runs along the beam (Fig. 5.63). Special air supply devices such as these are used for air tools as well as hoists.



Figure 5.62: Power tractor-mounted hoist frees the operator from having to pull or push the load.

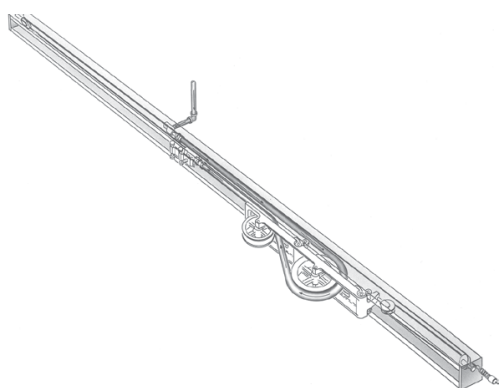
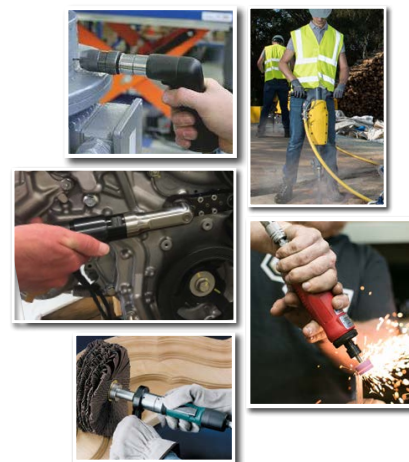


Figure 5.63: Freedom of movement of air-driven devices, including air hoists, is greatly increased by a carrier which takes up slack in the hose as the outlet point is moved.

APPLICATIONS OF OVERHEAD HOISTS

Applications for air-powered overhead hoists are limited only by the availability of compressed air and the maximum capacity of such hoists. All manufacturing plants need to raise and lower loads in many different departments. For instance, heavy bar stock or large castings must be placed in machines (Fig. 5.64) for secondary operations. Often, they are too heavy or awkward to be handled by an operator alone, so a hoist is used. Another area where hoists are popular is in maintenance departments for lifting heavy repair equipment and bulky components that must be removed, repaired, or replaced.



Figure 5.64: Overhead hoist used to lift heavy loads.

In plating, where it is important to prevent operator contact with caustic solutions directly or through splashing, the inching ability of an air hoist is invaluable. An air hoist allows the load to be carefully lowered into the solution while the operator is a safe distance away. In addition, air hoists are more suitable than electric hoists in plating operations because they are inherently non-sparking.

Other applications for air hoists include raising and lowering parts such as castings, heavy ladles, molds, and large car parts.

AIR WINCHES AND UTILITY HOISTS

Air winches and utility hoists are available in many sizes with capacities ranging from 500 to 10,000 lb (227 to 4500 kg) of single-line rope pull. They incorporate spool-type rope drums with capacities for up to several hundred feet. They are mounted on substantial bases that allow them to be installed on floors, walls, or ceilings. This type of construction also makes them portable. The smaller varieties are available for mounting on poles or rock drill columns for construction, mining, and oil derrick operations. The hoist can be used for pulling in almost any direction approximately perpendicular to the drum axes for dragging, hauling, or hoisting (Fig. 5.65). The direction of the pull may be determined by guide sheaves or snatch blocks, and the pulling capacity may be increased by the use of multiple sheaves. Units are rated at 90 psig (6.2 bars) at the motor inlet, and speeds for rated rope pull range from 40 to approximately 200 ft/minute (12 to approximately 61 m/minute).



Figure 5.65: Utility hoist on the drill floor of an offshore drilling rig to handle drilling tools.

Essentially, a winch or a utility hoist consists of an air motor, a gear drive, and a spool hoist drum mounted on a substantial base. The air motor construction characteristics and control are similar to those of overhead piston hoists except that hand-lever-operated throttles are commonly used. Dynamic braking or recompression is a normal means of controlling the descent of a suspended or overhauling load. A hand-lever-operated locking brake operating on one flange of the rope drum is usually included on most makes. An automatic, air-release, spring-applied brake controlled by the main throttle, as on an overhead hoist, can be furnished as a substitute. Motor-disengaging clutches are available on most units to permit the rope to be pulled out from the drum for attachment to the load without losing the coils left on the drum. Some units incorporate a clutch to permit starting the motor before applying power to the drum or to permit lowering the suspended or overhauling load under control of the hand brake only.

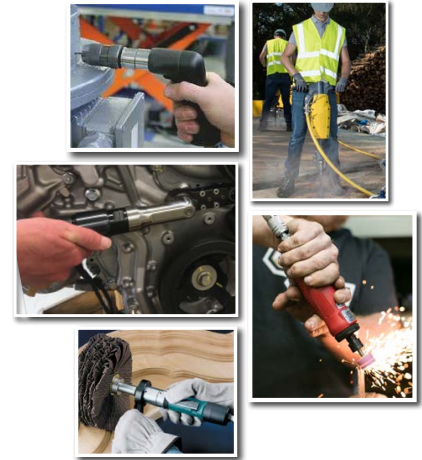
ROCK DRILLS AND ASSOCIATED EQUIPMENT

The latter part of the nineteenth century saw mechanized rock drilling in the final stages of replacing the old hand methods. This important scientific advancement was accelerated by the need for tunnel driving in the rapidly developing railroad systems and by the depletion of bonanza metal deposits in the West with the consequent desirability of working ore deposits of lower grades. Engineers of that time estimated that hand drilling for blasting had constituted more than two thirds of the cost of earlier mining operations. The power rock drill was not entirely new, even in those days. It was plain that cutting the costs of mining lay in complete mechanization of the rock-drilling phase of the work.

As early as 1813, Trevithick and Brunton, business associates in Cornwall, England, had tried mechanical drilling; and Brunton had even suggested the use of compressed air, maintaining that the exhaust from the boring machine would aid in ventilating mine passages. In America, Couch and Fowle of Boston had taken out a patent on a percussion drill with the steel clamped to the piston, perhaps one of the earliest examples of the piston drill.

Contemporary developments in Europe were the patenting of a compressed air drill by Fountaineau in 1855 and the further work by Bartlett on a machine that was tried out in the Mount Cenis Tunnel. Bartlett's drill, improved by Sommeiller, was used in the final boring of that tunnel. It was necessary for the drillers to keep on hand 200 of the Bartlett-Sommeiller machines in order to maintain 16 in constant operation. The vast improvements made since then are indicated by the experience of any user of a present-day rock drill.

About the same time the Mount Cenis Tunnel was constructed, the St. Gotthard Tunnel was being bored with drills developed by Haupt and Taylor. The same design of machine was improved by Burleigh and was used in the Hoosac Tunnel in Massachusetts, completed in 1875. In the West, the importance of power drilling was demonstrated by the performance of Burleigh drills in the Sutro Tunnel of the Comstock lode, this project having been finished in 1874. By that year, other makes of drills were coming into use, one of which was instrumental in the boring of the Musconetcong Tunnel.



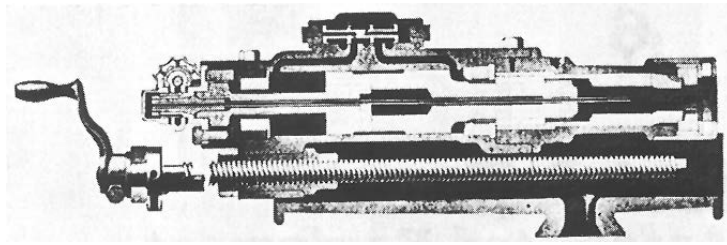


Figure 5.66: Section through a self rotating hammer drill of the type introduced by George Leyner in 1897.

All the early piston drills were of the same general type, consisting essentially of a cylinder in which a piston reciprocated, with the drill steel clamped in a chuck that formed the forward end of the piston. Steam operation was restricted to drilling on the surface. Compressed air was the sole medium for powering underground drills with the exception of a few electric models beginning about the year 1950. The air was admitted into the cylinder by a mechanically actuated valve. In the early 1980's, the air-thrown valve came into use; this type had no metallic contact with the piston. Rotation of the piston and drill steel was accomplished through the now-familiar rifle bar and nut combined with the ratchet and pawl.

One of the most important improvements in the early history of rock drill design was the introduction of the self-rotating hammer drill (Fig. 5.66) by J. George Leyner in 1897. Refinements have been made by many designers and engineers, some of whom are still continuing this work.

The most recent advance in rock drilling is the use of hydraulically powered rock drills (Fig. 5.66). The design of a hydraulic drill makes it possible to transmit the energy more effectively to the bit. The result is that these drills can normally drill 50 percent faster than the equivalent pneumatic drill. The other advantages of hydraulic drills are that they are less noisy, create no oil mist or fog, and, because of the more effective energy transfer, drill steel and bit life are, in many cases, improved.

Hand-Held Rock Drills

The hand-held, self-rotating hammer drill (Fig. 5.67) is commonly known in the United States as a sinker or rotator, depending on the locality and the usage. In some localities, the name sinker is applied only to the heavier machine used for shank sinking. In quarry language, the smaller machines are frequently referred to as block-hole drills.

Common weight classifications for the hand-held type of machines are the 30 to 40-lb class for the smaller types used for hitch cutting, drilling anchor holes, and coal mining; the 41- to 54-lb class for secondary more difficult jobs.



Figure 5.67: Hand-held sinker drill in the 30 to 50 lb weight range.

The utility drill, better known as the plug drill, weighing about 20 lb, is used for plug and feather work in dimension stone quarries or for light block-hole drilling. Lighter-weight utility hammer drills weighing 8.5 lb are used to install fastener anchors and for general maintenance work. A large variety of drill bits and chisel accessories are available for these applications.

The 30 to 40 lb class drill is ordinarily applied to a depth of approximately 6 to 8 ft. The 41 to 54 lb class is good for depths up to 16 ft, and the 55- to 64-lb machine will drill to 24 ft if suitable steels and bits are provided.

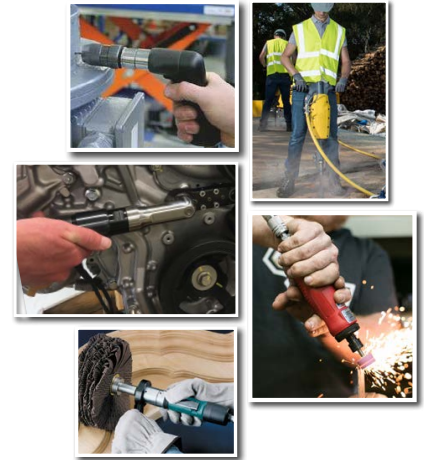
The heavier shank sinkers, weighing about 62 lb or more, are not ordinarily used for depths greater than 25 ft. Steels 7/8 in. or 1 in. hexagon, quarter-octagon, or round types are most frequently used in these drills. The more powerful hammer blows of the 62-lb sinker fit it for use with larger steels. The 1-1/4 in. round is commonly utilized with this larger drill.

By far, the most common shanks for hand-held rock drills are the collared type in sizes 7/8 x 3-1/4 in., 7/8 x 4 1/4 in., and 1 x 4-1/4 in., either hexagon or quarter-octagon. Hand-held drills are generally classified into two groups, dry and wet, depending on the method used for cleaning the drill hole.

Dry Machines

Dry machines are further divided into three types:

1. The plain dry machine is the accepted type for general surface operations and shallow holes where good hole cleaning is not difficult to accomplish. The hole cleaning is done by supplying a pulsating flow of air through the steel during drilling. The air is supplied in puffs, once or twice during each cycle of the piston hammer.
2. The blower machine is used for the same application as the plain dry machine particularly where deeper holes or more difficult conditions require a stronger blowing action. The blower machine, while drilling, supplies a constant stream of air into the drill steel through a tube running down the central axis through the hollow rifle bar and piston. Some dry and blower



machines are equipped with a choker valve that permits maximum blow air to be passed down the drill steel to get maximum hole-cleaning effect with the hammering action stopped.

3. Dry drilling with air feed leg drills is accomplished either by pulling the dust through a special bit and through the hollow drill steel into a dust-collecting box or bag or pulling the dust through the annulus of the hole into a flexible cup at the collar of the hole, which is connected to the dust-collecting system.

Wet Machines

Wet machines are universally used in underground operations, particularly where dust conditions are objectionable, in extremely hard rock, or where water flushing is more efficient than dry blowing for cleaning the holes. The wet machine resembles the blower type, but water rather than air is supplied under pressure from an outside source through the central tube or through a rotary swivel at the fronthead of the drill. In some situations, normal water flushing or dry drilling is unacceptable. In these cases, mist drilling is done using a small quantity of water injected into the flushing air.

Air Feed Leg Drills

Another type of mounting for hand-held drills is a feed leg (Fig. 5.68). This is a telescoping air feed having its own control throttle. It is attached to the drill with a friction-loaded knuckle joint at the point of attachment. For horizontal drilling, it may be adjusted and controlled so that it both supports and feeds the drill. The operator needs only to hold it steady while drilling and to adjust the thrust of the feed. The point, or sinker, has a spur designed to dig in and take the thrust of the feed when drilling lifters. Advantages claimed for the feed leg include its ability to bottom a drift or stope hole without a steel change when using carbide insert type bits. As the bit penetrates the rock, the feed is collapsed and advanced to take a new bit each time it runs out to its limit until the hole is at the bottom. The time required for setting up and tearing down is reduced to the minimum. In headings that are too small for a jumbo, in inaccessible workings such as sublevels, and in some types of stopes, the sinker and feed leg are practically universally applied.



Figure 5.68: Feed leg mounting for a hand-held drill.

Feed leg drills have become integrated units in which the leg and drill are compatible designs developed especially for feed leg drill applications.

Stoppers

Stoppers are used, as the name implies, for stoping, raising, roof bolting, or any work on which the holes look up at a steep angle. These rock drills are available in weights ranging from 75 lb to around 100 lb (45 kg) and are generally used with 7/8- or 1-in. hollow steel and bits from 1 3/8- to 1 5/8-in. gage. For use in narrow seams, such as coal mines, telescopic, offset-leg stoppers are available. Here the rock drill is attached to the side of the air feed instead of being an extension of it to shorten its overall length. A stopper application is illustrated in Fig. 5.69.

In most stoppers, the piston of the air feed remains stationary and the cylinder attached to the rear of the rock drill propels it forward and feeds the bit into the rock. In some reverse-feed designs, the cylinder is the stationary member. A sharp point, referred to as a stinger, keeps the feed from slipping against the supporting rock or timber.

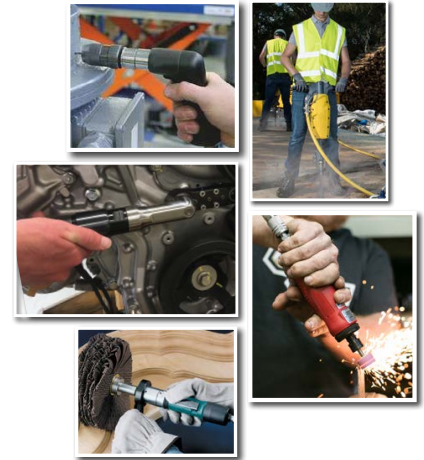
To reduce spare parts inventory, many stoppers can be converted to air-leg machines, drifters, or sinker-type drills.



Figure 5.69: Stopper drill in use in a roof bolting operation.

There are also muffled versions which considerably decrease the noise heard by the miner. These machines are equipped with automatic water valves to do wet drilling and provide for dust suppression. The water is automatically turned on with the throttle. Stoppers with feed legs of various lengths, as well as telescopic feed legs, are available to suit varying needs. Some telescopic versions extend up to 64 in.

In selecting a set of steel for use with stoppers, attention must be paid to the length of travel of the stopper feed. The permissible length of change will be less than travel by the length of steel in the stopper chuck. This is usually 6 to 7 in. For example, a 25-in. feed will use an 18-in. steel change. Stoppers can be equipped with frontheads for use with shanked or shankless steel. With shanked steel, the fronthead has a steel holder to assist in removing the steel from a tight hole.



PAVING BREAKERS

Hand-operated pneumatic paving breakers (Figs. 5.70 and 5.71) have a wide variety of uses in general construction and demolition work and in industrial plants. Breakers in the heavy class are used to break concrete pavement, to demolish concrete foundations and walls, to cut pavement and sub base, and to remove slag from furnaces and ladles. They are also used for trenching in hard ground and for breaking boulders in mill grizzlies or elsewhere when it is impractical to blast. Breakers in the medium class are applied to breaking light concrete pavement and floors, macadam, frozen ground or gravel, and to paving-breaker work of average nature.



Figure 5.70: Silenced, vibration damped paving breaker.



Figure 5.71: Silenced paving breaker being used on highway.

Breakers in the light class are useful for light demolition work on floors, paving, and masonry walls. They are particularly adaptable for work from a scaffold, for trimming, and for similar jobs requiring the operator to handle the tool continually. The very light class breakers are utility tools for use on light trimming, in steel mill maintenance and in close-quarter work.

Heavy-class breakers may be converted into sheeting drivers by removing the fronthead and substituting a sheeting-driver attachment. Thus modified, they are used to drive 2-, 2 1/2-, and 3-in. sheeting, light steel piles, and spiling in mine shafts and drifts. Round tools of small diameter may be driven by shaping the ends to fit the driving attachment.

Both heavy-weight and medium-weight breakers may be converted into railroad spike drivers by substituting a spike-driver head in place of the regular fronthead. Lightweight paving breakers may be similarly converted by substituting suitable fronthead parts.

Paving breakers use solid steel accessories and are not equipped with automatic rotation. Various designs of tool retainers are used, such as the latch and spring loop, located on the frontheads. Chuck sizes vary according to the class of breakers from 3/4 x 2 3/4 in. on the very light machines to 1 1/4 x 6 in. on the heavy class. All types and classes include automatic built-in lubricators located in the handles. In addition to moil points, other paving breaker tools can be furnished, such as narrow and wide chisels, digging blades, frost wedges, asphalt cutters, clay spades and scoops, tamping pads and pile, and pipe or sheeting driver heads. The very light breakers usually use 1/2 in. hose, while the medium and heavy breakers require 3/4 in. except where lengths exceed 100 ft, in which case, the next larger hose size, 1 in., should be used.

As for all air tools, it is important for paving breakers to be properly lubricated. Although they are equipped with built-in lubricators, the use of a line oiler is recommended.

Mufflers to lower the air exhaust noise are available for most paving breakers, either as an integral part of the tool or as an easily attached device. The process noise, the tool striking the material to be broken, and other limitations or devices to further silence the breaker itself means that the noise levels are still somewhat above allowable levels for eight hours of exposure. Care should be taken to be sure that operators use approved ear-protection devices.

Advancements are being made in the reduction of hand/arm vibration transmitted to the operator. Methods used to reduce the vibration normally include isolation devices in the handles of the breaker. These isolation devices may utilize mechanical or pneumatic spring systems to reduce the vibration transmitted to the operator.

Boom-mounted, heavy-duty breakers for concrete breaking, demolition work, and boulder breaking have gained wide use where high productivity is required. These boom-mounted breakers can be powered pneumatically or hydraulically, and the booms can be mounted on a mobile carrier or a stationary pedestal. The energy per blow and per unit of time is considerably higher for these tools than for hand-held breakers. Breaking is faster and harder materials can be broken. In some applications where the transmission of the vibration to the surroundings is a problem, these breakers may be limited in use.

BACKFILL TAMPERS

The backfill tamper (Fig. 5.72), originally adapted from the pneumatic floor hammer used in foundries, is still finding wide use in construction and utility work. In the tamper the piston rod connects the butt (available with diameters ranging from 3 to 6 in.) rigidly to the piston, which lifts it off the ground on its return stroke to carry it down and full force on the power stroke.

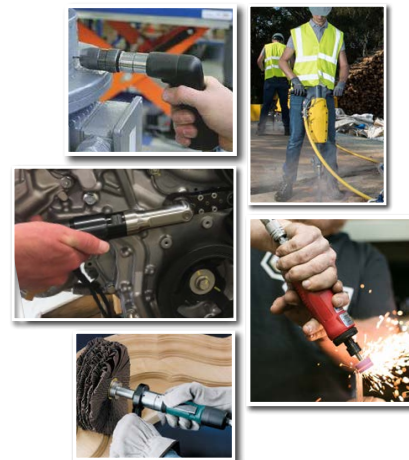




Figure 5.72: Backfill tamper with tamping pad.

Tampers are classified by weight and are currently available in three main weight classifications: light, up to 25 lb; medium, 26 to 35 lb; and heavy, over 35 lb. Application depends to a great degree on the type of soil and the depth of fill to be compacted. The tamper is generally ideally suited for compacting backfill in lifts of 6 to 9 in. in trenches, service openings, and around foundations, poles, and footings. Compacting with tampers enables immediate repairs to be made to pavement, sidewalks, and the like, after excavation and installation of services, without fear of further settling of the fill and necessity of returning to do repairs.

Where wider areas of backfill require tamping, the triplex tamper will provide savings in time and manpower. The triplex tamper consists of three single tampers on a common frame with a handlebar and single throttle valve for one-man operations.

SUMP PUMPS

Pneumatic sump pumps are built as centrifugal (Fig. 5.73), diaphragm (Fig. 5.74), or venturi-ejector pumps. They are normally used to remove water from sumps, basements, manholes, pools, ship holes, and the like, or wherever water interfaces with the progress or work, as seen in Fig. 5.75.

The centrifugal pump consists of a housing enclosing an air motor, generally of the vane type, that drives an impeller. The flow capacity of this type of pump ranges up to 370 gpm and hydraulic head up to 200 ft, depending on the type of impeller. This type of pump can also be used for pumping other lower viscosity fluids such as oil and gasoline. Bronze parts may be required when pumping explosive fluids.

The diaphragm or venturi pump is suitable for pumping extremely polluted, viscous, highly abrasive and flammable fluids, and is not hindered by large obstacles in the fluid. A flow capacity in excess of 100 gpm can be attained at under 30 ft of hydraulic head. Reduced flow rates are possible up to about 200 ft of head.



Figure 5.73: Centrifugal Sump Pump.

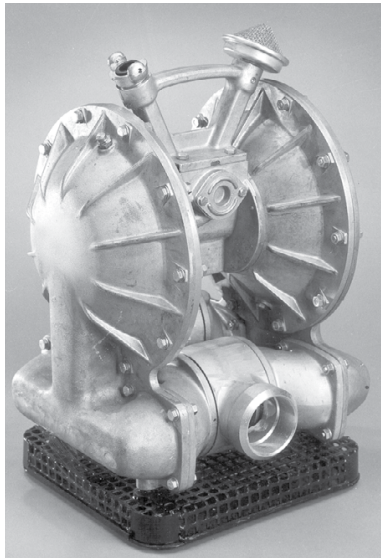


Figure 5.74: Diaphragm Sump Pump.



Figure 5.75: Centrifugal sump pump in use in construction application.

