Audel™
Mechanical Trades Pocket Manual

All New Fourth Edition

Thomas Bieber Davis
Carl A. Nelson, Sr.

Wiley Publishing, Inc.

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Contents

Introduction

Mechanical Trades Pocket Manual is a concise reference for maintenance and mechanical craftspersons. It provides information for preventive maintenance and mechanical repair, and includes tricks of the trade that will help mechanics expected to perform the impossible to "get production running." While the book is primarily concerned with installation, maintenance, and repair of machinery and equipment, it also covers other fields of activity. Current methods, procedures, equipment, tools, and techniques are presented in plain, easy-to-understand language to aid the mechanic in the performance of day-to-day activities. New sections on lubrication, vibration measurement, and PM inspection show troubleshooting techniques and help the mechanic fix the real problem — not just treat the symptoms of troublesome equipment.

Drawings, photographs, and tables are used throughout this book to illustrate the text and help you perform these activities. Discussions of principles and theory are limited to the key information necessary to understand the subject matter.

While this book covers topics from shafting to bearings, carpentry to welding, measurement to machine assembly; it is impossible to give the depth of detail for each and every subject in a small pocket manual. Readers who wish to learn more about these topics should consider the *Audel Millwrights and Mechanics Guide: All New Fifth Edition*, published by Wiley Publishing, Inc. This larger format book allows each subject to be explored to a greater depth.

—Thomas Bieber Davis
Maintenance Troubleshooting

1. SAFETY

It's hard to walk past the plant gate or the security office without seeing a sign indicating how many days since the last lost-time accident at the facility. Most employers take great pride in their safety record and preach safety as a way of life. This section includes some tips and information for keeping your operations safe.

OSHA

The *Occupational Safety and Health Act* (OSHA) in the United States covers workplace conditions for employees. If you are engaged in maintenance, repair, or installation activities, your employer probably has details on the particular parts of the OSHA standards that apply to you.

As a mechanical tradesperson, you might find yourself involved in many activities that require you to think out particular safety issues for your own special type of work. For example, you might be servicing a pump and have all the parts and the manufacturer's manuals, but it would make a great deal of difference in your approach to the job if the pump were handling acid instead of water. You have to consider the safety details for each job, using your trade skills combined with your knowledge of the process, location, or conditions.

Lock Out and Tag

When you shut down a machine, process, pipeline, or electrical apparatus to inspect or perform a repair, you need to *lock out and tag* a piece of equipment so that it cannot be accidentally started or energized. Usually, the start/stop of the switchgear controlling the piece of equipment is physically disabled with a lock (Fig. 1-1).

The employee working on the equipment usually holds the key to the lock. The lock itself has a tag identifying whose lock is being used. In the case of a pipeline, the valve controlling the flow into the line is closed and a lock placed

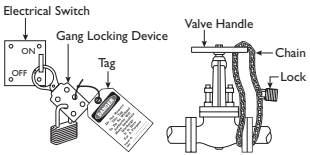

Fig. 1-1 Lock out and tag.

on the handle or bonnet with an appropriate tag attached. If two or more people are working at the same machine, then each additional person also places a lock on the equipment. A gang-locking device can be used to hold many locks on the job. In addition, it's a smart idea to try the local start/stop switch at the machine site or open the valve downstream from the locked main valve as a double check to make sure that the machine or process is "safed-out."

MSDA

Another safety issue for maintenance or installation personnel is the use of chemicals or hazardous materials. In the United States, *Material Safety Data Sheets* (MSDA) are used to identify the details of each particular chemical and list safe handling techniques. These sheets, usually available in the workplace, indicate if rubber boots, face shield, respirator, dust mask, or goggles might be required to work safely around a substance. Keep in mind that chemicals can be oil or grease, too. Removed parts of a machine often need to be cleaned after disassembly and require chemical degreasers or solvents.

Use of Protective Equipment

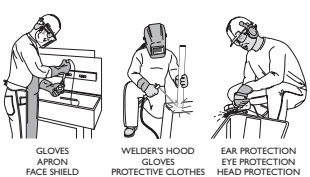

Fig. 1-2 Protective safety gear.

Often the maintenance worker needs gloves, a hard hat, steel-toe shoes, earplugs, or other articles of apparel to guard against injury to the eyes, feet, head, or ears. Jobs such as grinding, drilling, nailing, painting, or welding mandate protective gear (Fig. 1-2).

2. THE BASIC TOOLBOX

The proper use of hand tools is the key to accomplishing many successful jobs. While each mechanical trade might require specialized tools, a group of basic tools will be the heart and core of any craftsperson's toolbox. This set will allow the mechanic to perform most basic repair and installation jobs.

Wrenches — Open End, Box, Combination

Wrenches are one of the most widely used hand tools. They are used for holding and turning bolts, cap screws, nuts, and various other threaded components of a machine. It is important to make sure the wrench holds the nut or bolt with an exact fit. Whenever possible, it is important to *pull* on a wrench handle and keep a good footing to prevent a fall if parts let go in a hurry. Typical types of wrenches needed in the basic toolbox include box wrenches, open-end wrenches, and combination box/open-end wrenches from ¼ to 1¼ in. in increments of 1/16 in. to accomplish most standard jobs (Fig. 2-1). The same types of wrenches in metric openings would span from 7 to 32 mm. Metric wrenches are stepped in 1-mm increments, but the basic toolbox would usually omit the 20-, 29-, and 31-mm openings because they are used so infrequently.

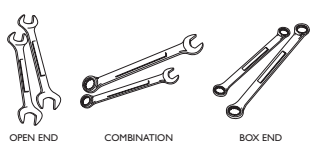

Fig. 2-1

Socket Wrenches

Socket wrenches greatly speed up many jobs. The basic toolbox should contain sockets ranging from 5/16 to 1¼ in. in 1/16-in. increments. Usually socket wrenches are sold in sets where the square drive of the ratchet is used to identify the set. Ratchets are typically made with ¼-, ⅜-, ½-, ¾-, and 1-in. square drivers. The larger the drive, the greater the capacity of the wrench set. For most work, the basic toolbox needs to have a

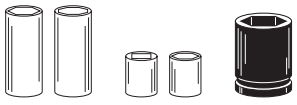

Fig. 2-2

¼-in. drive set, a ⅜-in. drive set, and a ½-in. drive set. Larger drives, like the ¾ and 1 in., can be stocked in a central tool crib or kept with a supervisor for use by any craftsperson when the need for these larger units is merited. Sockets are made in regular depth and extra deep (Fig. 2-2). Openings may be 12-, 8-, 6-point, or square for the type of work that the wrench set must handle. In addition, jobs that involve the use of an electric or pneumatic impact wrench need extra-heavy wall sockets that will hold up under heavy pounding from the tool.

Nut Drivers

Nut drivers are a must for electricians, but they are also handy for other jobs. A nut driver looks like a screwdriver but has a socket at the end of the shank (Fig. 2-3). The basic toolbox should have a nut driver set, which includes the 3/16-, ¼-, 5/16-, 11/32-, ⅜-, 7/16-, ½-, 17/32-, 9/16-, ⅝-, 11/16-, and ¾-in. sizes. Often overlooked, these tools speed up the repair or adjustment of equipment and surpass the ability of a ratchet set for loosening or tightening light- to medium-duty assemblies.

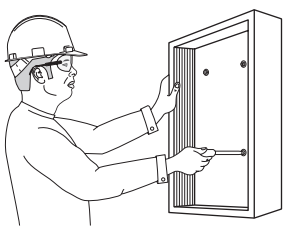

Fig. 2-3

Adjustable Wrenches

Adjustable wrenches are sometimes called "fits all" wrenches because they cover such a wide range of jobs. These tools are open-end wrenches with an expandable jaw that allows the wrench to be used on many sizes of bolts or nuts. They are available in lengths from 4 to 24 in. Some adjustable wrenches allow the jaw to be locked. These are available in lengths from 6 through 12 in. When using an adjustable wrench, always make sure you apply the force to the fixed jaw (Fig. 2-4).

Practically all manufacturers supply parts and repair kits to refurbish adjustable wrenches. The kits are relatively inexpensive, compared to the purchase of a brand new wrench. The basic toolbox should include adjustable wrenches with lengths of 4, 6, 8, and 12 in. These four sizes can cover a wide range of jobs.

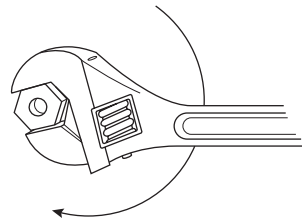

Fig. 2-4

Screwdrivers

Screwdrivers are the most used tools in a toolbox. They are intended for one simple use: driving and withdrawing threaded fasteners such as wood screws, machine screws, and self-tapping screws. Correct use of a screwdriver involves matching the size of the screwdriver to the job and matching the type of screwdriver to the head of the screw. The first screws that were developed had slotted heads. The proper screwdriver for these types of screws is called a conventional screwdriver, and it can be classified by tip width and blade length. Generally, the longer the screwdriver, the wider the tip — but not always. Cabinet screwdrivers have long shanks but narrow tips because they are used to drive screws into recessed and counterbored openings that are found in furniture and cabinets. Stubby screwdrivers are available that have very wide tips for use in tight spaces. Most conventional screwdriver tips are tapered. The tip thickness determines the size of the screw that the screwdriver will drive without damaging the screw slot. The taper permits the screwdriver to drive more than one size of screw.

The world of screwdrivers has radically changed since the slotted head screw. Probably the first "new" screw that was developed was the Philips head screw — a recessed slot design. The recessed slot screw allows a more positive non-slipping drive-up while attaching the fastener. The most common

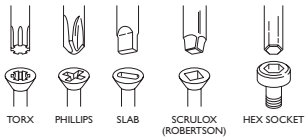

Fig. 2-5

style of recessed head is the Philips screw. Other recessed screws and screwdrivers are shown in Fig. 2-5.

Essential screwdrivers for the basic toolbox are a set of slotted screwdrivers, Philips screwdrivers, and Torx screwdrivers.

Vises

While a vise would not necessarily be part of the basic toolbox, it certainly would be essential on the tool bench. There are four basic categories of vises: machinist's vise, woodworker's vise, pipe vise, and drill press vise. Each has its purpose and benefits.

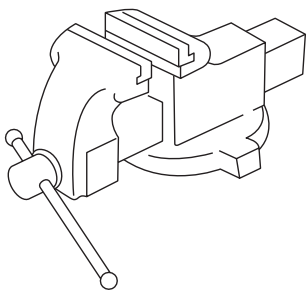

Fig. 2-6 Machinist's vise.

The *machinist's vise* is the strongest vise made (Fig. 2-6). It is designed to withstand the great strains in industrial work. Models are made with stationary bases and swivel bases and can be equipped with pipe jaws as well as interchangeable jaws. Usually jaw widths start at 3 in and go to 8 in for large jobs. Copper (or brass) jaw caps are available to prevent marring of the work.

The *woodworker's vise* is a quick-acting vise that bolts to the underside of the workbench (Fig. 2-7). These vises are equipped with a rapid-action nut that allows the movable jaw to be moved in and out quickly with the final tightening by turning the handle a half-turn or so. The jaws on the vise are large, often 7 to 8 in. The jaws are usually metal, but they are intended to be lined with wood (which allows replacement) to protect the work.

A *pipe vise* is designed to hold pipe or other round material. Most can hold pipe up to 8 in. in diameter. They are usually available with a tripod mount to allow the vise to be portable, but they can be bolted to a workbench as well. The most popular type uses a chain for clamping and can also be used to hold irregular work (Fig. 2-8).

The *drill press vise* is made to accept round, square, or oddly shaped work and hold it firmly in place for drilling (Fig. 2-9). The better vises often have a quick release movable jaw that allows them to be moved up to the work or away from the work without turning the handle. The handle is used for the final half-turn or so to loosen or tighten the jaws.

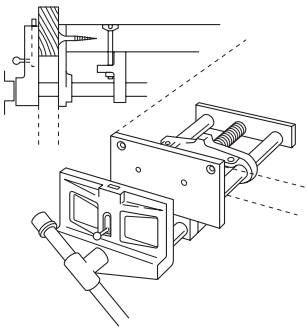

Fig. 2-7 Woodworker's vise.

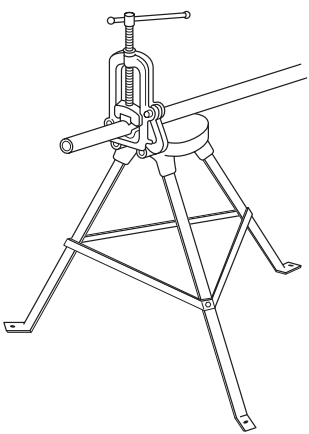

Fig. 2-8 Portable pipe vise.

Clamps

Clamps serve as temporary devices for holding work securely in place. They are first cousins to vises and are often used in a field location where vises are not available. Clamps are vital for such jobs as locking two pieces of metal together for welding (Fig. 2-10), securing two pieces that need to be held while gluing, or creating a third hand to allow ease of sawing, drilling, or other mechanical processes.

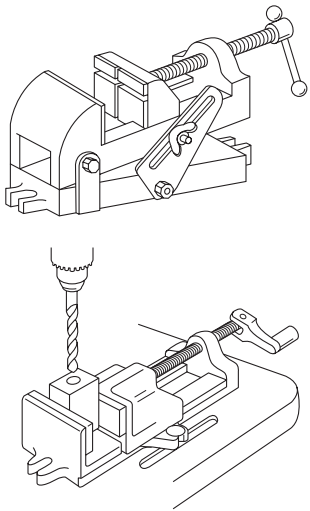

Fig. 2-9 Drill press vise.

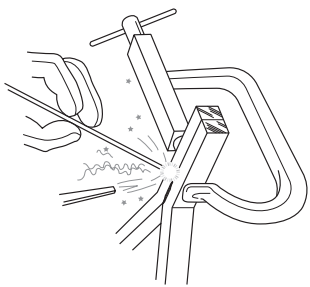

Fig. 2-10

Mechanical Trades Tool List

Following is a detailed tool list that can be used for stocking the basic toolbox. While it is certainly possible to add more tools, this list represents the minimum needed in most industrial or commercial work to perform basic installation, repair, or modification work.

Box and Traveling Pouch

1 Toolbox — 10-drawer top cabinet and 8-drawer bottom roll-away
1 Leather Tool Pouch with belt

Wrenches

1 set Open-End Wrenches (¼ in. × 5⁄16 in. – 1 in. × 1¼ in.)
1 set Box Wrenches (¼ in. × 5⁄16 in. – 1 in. × 1¼ in.)

1 set Combination Wrenches (¼ – 1 5/16 in.)
1 set Open-End Metric Wrenches (7 – 25 mm)
1 set Box Metric Wrenches (7 – 25 mm)
1 set Combination Metric Wrenches (6 – 22 mm, 24 mm)
1 set Flare Nut Wrenches (⅜ in. × 7/16 in. – ¾ in. × ⅞ in.)
1 set Flare Nut Metric Wrenches (9 × 11 mm – 19 × 21 mm)
1 Folding Allen Wrench Set (small)
1 Folding Allen Wrench Set (large)
5 Adjustable Wrenches (4, 8, 10, 12, 18 in.)

Sockets

1 set ¼-in Drive Socket Set

- With shallow sockets — 5/32 – ¾ in.
- With deep sockets — 3/16 – ¾ in.
- With metric shallow sockets — 4, 5, 5.5, 6–15 mm
- With metric deep sockets — 4–15 mm

1 set ⅜-in Drive Socket Set

- With shallow sockets — 5/16 – 1 in.
- With deep sockets — 5/16 – 1 in.
- With metric shallow sockets — 9–19 mm, 21 mm
- With metric deep sockets — 4–15 mm
- With Allen Head sockets — metric and English
- With 8-point sockets (for square heads) — ¼ – ½ in.

1 set ½-in Drive Socket Set

- With shallow sockets — ⅜ – 1¼ in.
- With deep sockets — ⅜ – 1¼ in.
- With metric shallow sockets — 9–28 + 30 mm + 32 mm
- With metric deep sockets — 13–22 mm + 24 mm

Pliers

3 pair Slip Joint Pliers (6¾, 8, 10 in.)
2 pair Arc Joint (7, 9½ in.)
2 pair Locking Pliers (8-in. Straight Jaw)
2 pair Locking Pliers (6-in. Curved Jaw)
1 set Snap Ring Pliers

Screwdrivers and Nutdrivers

1 set Straight Screwdrivers (⅛ in. × 2 in., 3⁄16 in. × 6 in., ¼ in. × 8 in., ¼-in. stubby)
1 set Phillips Head Screwdrivers (#1, #2, #3)
1 set Torx Screwdrivers (T-10, T-15, T-20, T-25, T-27, T-30)
1 set Nut Drivers

Alignment and Prying

1 Double-Faced Engineer Hammer (48 oz)
1 Rolling Wedge Bar (16 in.)
1 set Screwdriver Type Pry Bars

Scraping, Filing, Extracting, Punching

1 Complete Set — Thread Files, metric and English
1 set Screw Extractors
1 set Punches
1 set Cold Chisels
1 set Files (for filing metal)
1 Center punch
1 Gasket Scraper (1½-in. face)

Hammers

4 Ball Peen Hammers (8, 12, 16, 30 oz)
1 Claw Hammer — Curved Claw (16 oz)
2 Soft Faced Mallets (24 and 12 oz)

Leveling and Measuring

1 Line Level
1 Torpedo Level (9 in.)
1 Level (24 in.)
1 Machinist's Scale (6 in.)
1 English/Metric Dial Caliper (0–6 in., 0–150 mm)
1 Micrometer (0–1 in.)
1 Plumb Bob (4½ in. with line)
1 Chalk Line Reel
1 Combination Square

1 Carpenter's Square
1—25 ft Tape (¾-in. wide)
1 set Feeler Gauges (combination inch and metric)

Cutting and Clamping

1 Utility Knife
1 pair Pipe and Duct Snips (compound action)
1 Hack Saw with blades
2 "C" Clamps (3 in.)
2 "C" Clamps (4 in.)
2 "C" Clamps (6 in.)

Pipe and Tubing

2—10-in. Pipe Wrenches (Aluminum Handle)
2—14-in. Pipe Wrenches (Aluminum Handle)
2—18-in. Pipe Wrenches (Aluminum Handle)
2 Strap Wrenches (6 and 12 in.)
1 Tubing Cutter (¼ in. × 1 in.)
1 Set Pipe Extractors

Electrical

1 pair Side Cutters (9¼ in.)
1 pair Wire Strippers
1 pair Diagonal Cutting Pliers (8 in.)
1 pair Long-Nosed Pliers (8 in.)
1 pair Needle-Nosed Pliers (6 in.)
1 pair Bent Needle-Nosed Pliers (4½ in.)
1 Electrical Multi-Tester (Volts, Ohms, Continuity)
1 Flashlight

Troubleshooting

1 Mechanics Stethoscope
1 Infra-Red Thermometer

3. POWER TOOLS — PORTABLE

The field of portable power tools covers everything from small electric hand tools to heavy-duty drilling, grinding, and driving tools. Tool manufacturers have made the largest strides in the field of battery-powered tools.

Battery-Powered Tools

Cordless tools were a novelty when they first arrived on the scene. Some of the earliest entrants to the battery-powered tool market were lightly made and ineffective.

Fig. 3-1 Cordless drill kit.
Courtesy Milwaukee Electric Tools.

Perhaps the first successful battery-operated portable power tool used in industry was the drill motor, first introduced with two batteries and a charger (Fig. 3-1). One battery charged while the other was in use with the tool. Mechanics, recognizing the usefulness of cordless tools, demanded longer battery life between recharging and more power from the tool, but they also wanted lighter weight to promote ease of use. They also sought tools that provided more functions than just drilling.

The tool industry responded with drastic and rapid improvements. Currently, battery-powered tools are popular because of their portability, increased power, longer battery life, and overall convenience. Cordless tools are particularly effective where work must be done overhead or in hard-to-reach locations. Their weight and size have been reduced as battery technology has advanced.

The list of effective cordless tools includes screwdriver/drill, saber saw, jigsaw, grinder, sander, soldering iron, and impact wrench. Many tools are now available in kits where the same battery provides power to a range of different tools (Fig. 3-2).

Fig. 3-2 Multi-purpose kit.
Courtesy Milwaukee Electric Tools.

Run time from any cordless tool is directly proportional to the amp-hour rating of the battery. The amp-hour rating is like the size of a gas tank in a truck — the larger the tank (amp-hours), the farther the truck can go.

Cordless tools are usually powered by nickel-cadmium batteries (called NI-CADs) or nickel metal-hydride batteries (abbreviated Ni-Mh). A battery pack has individual cells, each putting out 1.2 volts, soldered together in series.

The working life of a cordless tool battery depends, in large part, on how that battery is charged, and especially on how the cells in a battery pack rise in temperature while charging (Fig. 3-3). Heat is the enemy of both Ni-Mh and NI-CAD. Too much internal heat, and battery lifespan drops to less than half the potential 1,200 to 1,500 charge/discharged cycles. Battery chargers for heavy-duty industrial tools are now surprisingly sophisticated, monitoring dozens of parameters during each charge cycle. There are two reasons for this. The first is to minimize damaging heat build-up in cells so the battery cycle life will meet its potential. The other

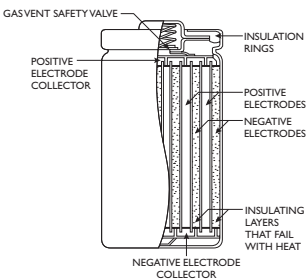

Fig. 3-3 Cutaway of a rechargeable battery.

reason is to provide a troubleshooting diagnostic service for that time when the inevitable battery problem does arise.

To extend battery life, avoid anything that boosts tool load and current draw beyond what's necessary, thus reducing excessive cell temperatures. Keeping bits and blades sharp helps achieve this, but it's especially important to avoid prolonged stall conditions with any cordless tool; this is when the motor is loaded but the bit or blade it's driving has become stuck. This battery-frying situation can cause momentary current draw to spike up as high as 70 or 80 amps, with a corresponding drop in battery pack life.

Many "old timers" in the mechanical trades business suggest that tools should be purchased with a total of three rechargeable batteries. One battery can be in use with the tool, the recently discharged battery can sit and cool off, and the third battery (already cooled off) can be in the charger. The cost incurred by the purchase of the third battery is more than offset by the increase in the lifespan of all three batteries because they are never placed in the charger until they cool off.

Electric-Powered Tools

Most mechanics have experience with the more common types of electric-powered tools, and they are knowledgeable in their correct usage and safe operation. There are, however, some more specialized types that mechanics may use only occasionally. Because these specialized tools — as well as all other power tools — are relatively high speed, using sharp-edged cutters, safe and efficient operation requires knowledge and understanding of both the power unit and the auxiliary parts, tools, and so on.

Electromagnetic Drill Press

The *electromagnetic drill press* is the basic equipment used for magnetic drilling. It can be described as a portable drilling machine incorporating an electromagnet, with a capability of fastening the machine to ferrous metal work surfaces

(Fig. 3-4). The magnetic drill allows you to bring drilling equipment to the work, rather than bring the work to the drilling machine. A major advantage over the common portable drill motor is that it is secured in positive position electromagnetically, rather than depending on the strength and steadiness of the mechanic. This feature allows drilling holes with a much greater degree of precision in respect to size, location, and direction, with little operator fatigue.

Magnetic drilling is limited to flat metal surfaces large enough to accommodate the magnetic base in the area where the hole or holes are to be drilled. The work area should be cleaned of chips and dirt to ensure good mating of the magnetic base to the work surface. The unit is placed in the appropriate position, and the drill point is aligned with the center point location. When proper alignment has been established, the magnet is energized to secure the unit. A pilot hold is recommended for drilling holes larger than ½-in. diameter. The operation proceeds in a manner similar to a conventional drill press. Enough force should be applied to produce a curled chip. Too little force will result in broken chips and increased drilling time; too great a force will cause overheating and shorten the drill life.

Fig. 3-4 Magnetic drill press.
Courtesy Milwaukee Electric Tools.

You can expand the capacity of magnetic drilling equipment by using carbide-tipped cutters. These tools are related to "hole saws" used for woodworking, but they possess much greater capacity and strength. These are tubular-shaped devices with carbide-tipped multiple cutting edges, which are highly efficient. The alternating inside and outside cutting edges are ground to cut holes rapidly with great

precision. Hard carbide cutting tips help them outlast regular high-speed twist drills. They are superior tools for cutting large diameter holes because their minimal cutting action is fast and the power required is less than when removing all the hole material. Approximately a ⅛-in. wide kerf of material is removed and a cylindrical plug of material is ejected on completion of the cut. When used in conjunction with the magnetic drill, they enable the mechanic to cut large-diameter holes with little effort and great accuracy. Fig. 3-5 shows a magnetic drill with a hole-cutting attachment.

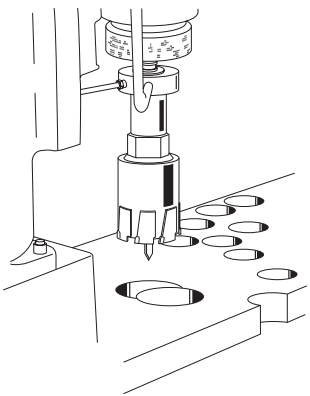

Fig. 3-5 Magnetic drill with hole-cutting attachment.

The hole cutter makes possible operations in the field that could otherwise be performed only on larger fixed machinery in the shop. The arbor center pin allows accurate alignment for pre-marked holes. As with most machining operations, a cooling and lubricating fluid should be used when cutting holes with this type of cutter. Ideally, it would be applied with some pressure to furnish a cutting action as well as cooling and lubricating. This may be accomplished by applying a fluid directly to the cutter and groove or by using an arbor lubricating mechanism. With a special arbor, it is possible to introduce the fluid under pressure. The fluid can be force-fed by a hand pump, which is part of a hand-held fluid container. Introducing the fluid on the inside surfaces of the cutter causes a flushing action across the cutting edges, which tends to carry the chips away from the cutting area and up the outside surface of the cutter.

Diamond Concrete Core Drilling

Diamond concrete core drilling is used to make holes in concrete structures. The tool that is used is the *diamond core bit*. Prior to the development of this tool, holes in concrete structures required careful planning and form preparation, or breaking away of sections of hard concrete and considerable patch-up. The tool is basically a metal tube, on one end of which is a matrix crown embedded with industrial-type diamonds distributed throughout the crown and arranged in a predetermined pattern for maximum cutability and exposure. Bits are made in two styles of construction, the closed back and the open back (Fig. 3-6).

There is a decided cost advantage in using the open-back bit, in that the adapters are reusable, offering savings in cost on each bit after the first. Also, if a core is lodged in the bit, removing the adapter makes the core removal easier. The closed-back bit offers the advantage of simplicity. Installation requires only turning the bit onto the arbor thread, without positioning or alignment issues. As the bit is a single, complete unit, there is no problem with mislaid, lost, or damaged parts.

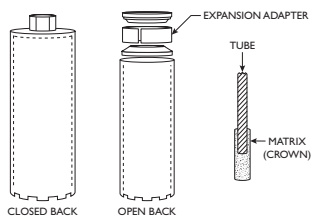

Fig. 3-6 Diamond core bits.

Successful diamond core drilling requires that several very important conditions be maintained: rigidity of the drilling unit, adequate water flow, and uniform steady pressure. Understanding the action, which takes place when a diamond core bit is in operation, will result in better appreciation of the importance of these conditions being maintained. Fig. 3-7 illustrates the action at the crown end of a diamond core bit during drilling. Arrows indicate the water flow inside the bit, down into the kerf slot and around the crown as particles are cut free and flushed up the outside surface of the bit.

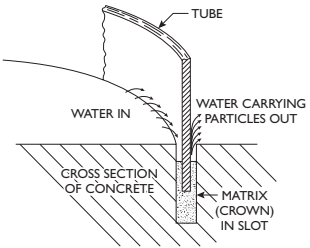

Fig. 3-7 Diamond bit cutting action.

The diamond concrete core-drilling machine is in effect a special drill press. The power unit is mounted in a cradle, which is moved up and down the column by moving the operating handles. The handles rotate a pinion gear, which meshes with a rack attached to the column. To secure the rig to the work surface, the top of the column includes a jackscrew to lock the top of the column against the overhead with the aid of an extension. Fig. 3-8 shows a concrete core-drilling rig equipped with a vacuum system, which makes attaching the rig directly to the work surface possible.

The power unit is a heavy-duty electric motor with reduction gears to provide steady rotation at the desired speed. The motor spindle incorporates a water swivel, which allows introduction of water through a hole in the bit adapter to the inside of the core bit. The power unit shown in Fig. 3-9 attaches to the cradle of the rig shown in Fig. 3-8. The diamond core bits (both open- and closed-back styles) fit the threaded end of the motor spindle.

Fig. 3-8 Diamond concrete core drilling rig. *Courtesy Milwaukee Electric Tools.*

The rigidity of the drilling rig plays a critical part in successful diamond core drilling. The rig must be securely fastened to the work surface to avoid possible problems. Slight movement may cause chatter of the drill bit against

the work surface, fracturing the diamonds. Greater movement will allow the bit to drift from location, resulting in crowding of the bit, binding in the hole, and possible seizure and damage to the bit.

An easy way to anchor the unit is with the jackscrew provided at the top of the column. A telescoping extension, pipe, 2×4, or other material cut to the appropriate length may be used. This allows the rig to be braced against the opposite wall.

The versatility of a diamond core-drilling rig may be greatly increased with a vacuum system. With this device it is possible to anchor the unit directly to the work surface, eliminating the need for extensions, braces, or other securing provisions. The rig in Fig. 3-8 is equipped with such a system. It consists of a vacuum pump unit and auxiliary hose, gauge, fittings, and more.

To use the vacuum system of attachment, first clean the area where the work is to be performed. Remove any loose dirt or material that might cause leakage of the seal of the pad to the work surface. Place the rig, with the diamond core bit on the spindle, in the desired location. Loosen the pad nuts to allow the pad to contact the work surface without restraint. Start the vacuum pump to evacuate the air from inside the pad. This produces what is commonly called the "suction," which holds the pad in place. A vacuum gauge indicates the magnitude of the vacuum produced. The graduated gauge face is marked to show the minimum value

Fig. 3-9 Diamond drill power unit. *Courtesy Milwaukee Electric Tools.*

required for satisfactory operation. A clean, relatively smooth surface should allow building the vacuum value to the maximum. Should the gauge register a value below the minimum required, do not attempt to drill. Check for dirt, porous material, cracks in the surface, or any other condition that might allow air to leak past the pad seal. When the gauge reading indicates that the pad is secure, tighten the pad nuts to fasten the rig base firmly to the vacuum pad. Standing on the base of the rig is not a substitute for good pad fastening. While additional weight will add a little to the downward force, it will not prevent the rig from floating or shifting out of position.

Water — which is vital to the success of diamond core drilling — is introduced through the water swivel, a component of the lower motor housing. The swivel has internal seals, which prevent leakage as the water is directed into the spindle and into the inside of the bit. The preferred water source is a standard water hose (garden hose), which provides dependable flow and pressure. When a standard water hose is not available, a portable pressure tank (used for garden sprayers or gravity feed tanks) can be used. Whatever the arrangement, take care to ensure adequate flow and pressure to handle the job. Depending on the operating conditions, you may need to make provisions to dispose of the used water. On open, new construction, it may be permissible to let the water flow freely with little or no concern for runoff. In other situations, it will be necessary to contain runoff and find a way to dispose of the used water. You can make a water collector ring and pump for this purpose, or you can use the common wet-dry shop vacuum and build a dam with rags or other material.

When the rig is secured and water supply and removal provisions are made, drilling may commence. Starting the hole may present a problem because the bit crown has a tendency to wander, particularly when starting in hard materials and on irregular and inclined surfaces. At the start, the crown may contact only one spot, and thrust tends to cause