

MANUAL OF

**LATHE
OPERATION**



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LATHE OPERATION and MACHINISTS TABLES



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LATHE OPERATION AND MACHINISTS TABLES

ENGINEERING DEPARTMENT

ATLAS PRESS COMPANY

1822 North Pitcher Street
Kalamazoo, Michigan, U. S. A.

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ATLAS PRESS COMPANY
Printed in U. S. A.

Price One Dollar
in U. S. A.

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PREFACE

PREFACE

This Manual of Lathe Operation has been prepared to provide authentic, up to date, and complete operating information for owners of all types of metal cutting lathes.

Fundamental and concrete theory, as well as operating procedure, is included in order to make this book suitable for students, apprentices and vocational schools. Much of the data will prove invaluable to the machinist and the more experienced lathe operator.

It is our hope that this Manual will further the advancement of the lathe user in all walks of industry. If we have helped him, even in a small way, the research and labor involved in the preparation of this book will have been well worth while.

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PREFACE

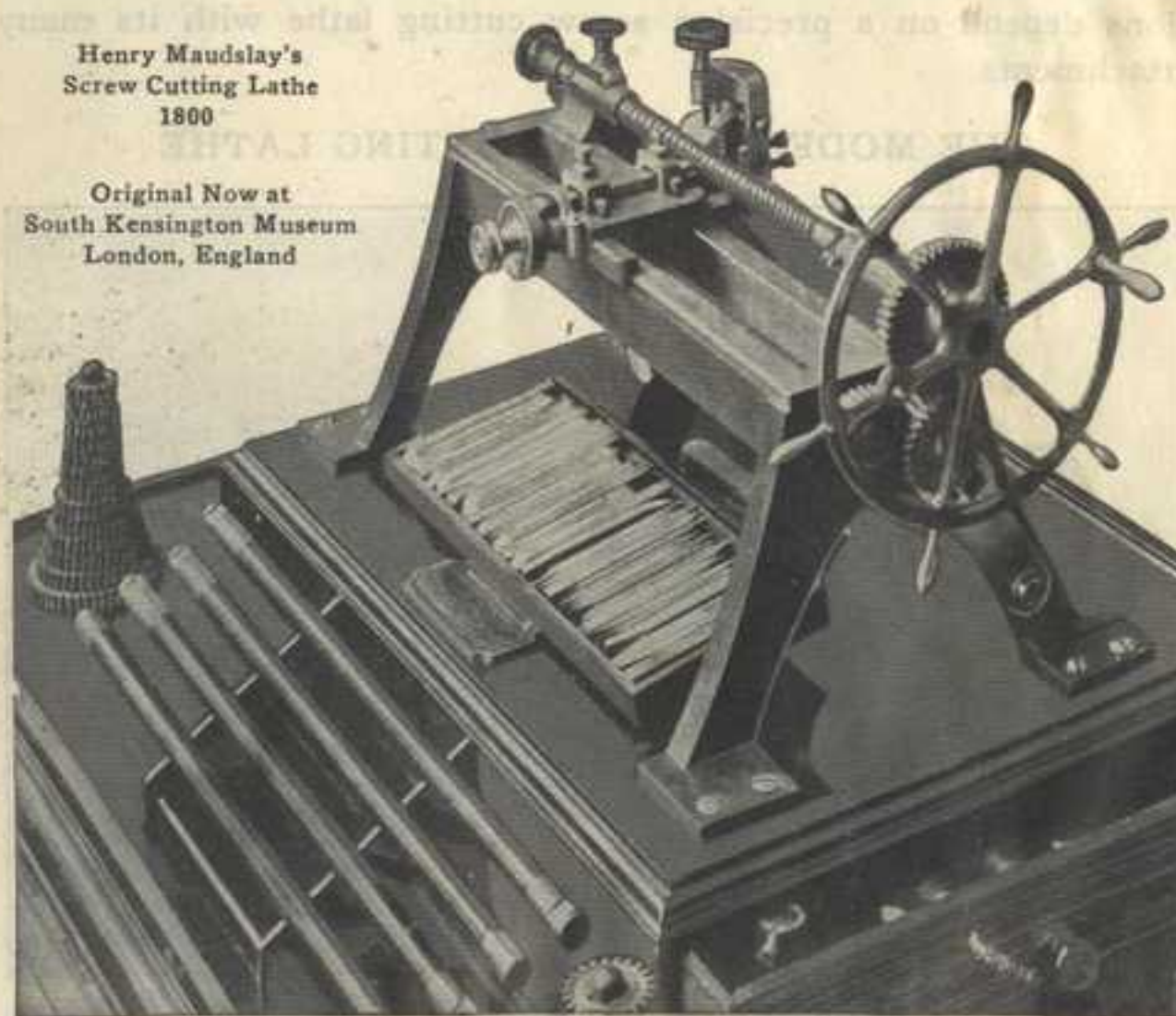
We wish to extend our sincere appreciation to the many manufacturers, engineers and machinists who have assisted in the preparation of the technical material in this manual. If the reader desires further information on any of the metals or plastics mentioned, we will gladly furnish the name and address of the manufacturer.

FOREWORD

The history of modern machinery started in the last years of the eighteenth century when Henry Maudslay, an Englishman, built the first practical screw-cutting lathe. When compared with a modern precision lathe, this machine was slow and clumsy, but from the basic principles of Maudslay's lathe have come nearly all modern machine tools. The skill of early New England machinists in developing his theories soon put the United States in the front rank among industrial nations of the world.

Henry Maudslay's
Screw Cutting Lathe
1800

Original Now at
South Kensington Museum
London, England



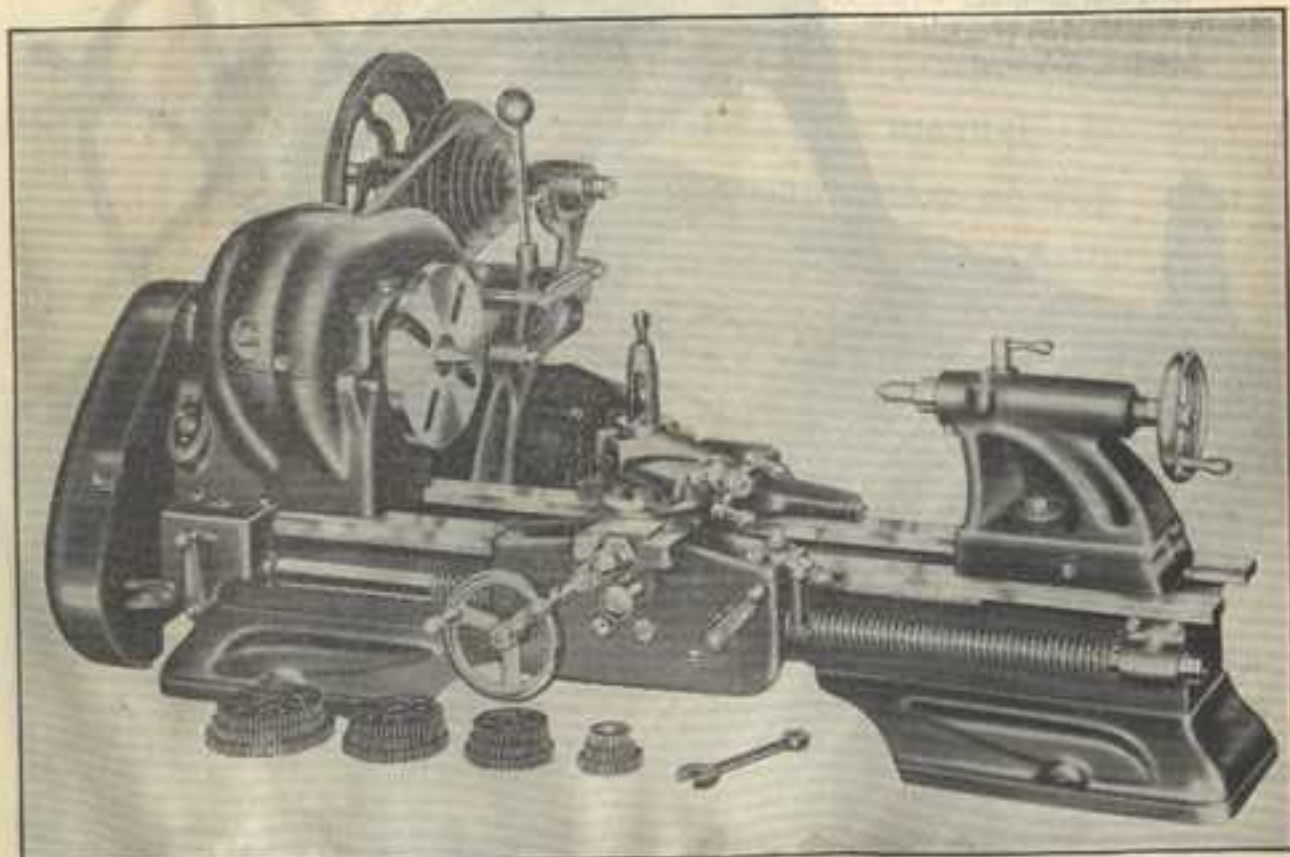
Courtesy Popular Mechanics Magazine

Today, nearly 150 years after Maudslay, the screw-cutting lathe is still the heart of industrial manufacturing. It seems odd to consider the lathe so vitally important when large batteries of automatic machines are used in every modern factory. But pay a visit to the factory tool room where the machining is done which makes possible the construction of these huge automatic machines. There you will find a lathe, easily the most important tool, busy at

the hands of an expert machinist turning the plans of designers and engineers into new tools and machines for modern industry.

The lathe is the "King of All Tools"—more jobs of a mechanical nature can be done on a lathe than with any other dozen tools. In the machine shop, experimental shop, or home workshop, the metal lathe is called upon for many operations. Turning, milling, grinding, drilling and boring must be performed on iron and steel; wood, plastics, alloys and soft metals must be shaped into form; springs and coils wound; threads of all sizes and shapes have to be cut; and machine parts need repairing or replacing. Manufacturers, tool and die makers, experimenters, automotive men, model builders, inventors—thousands of businesses, hobbies, and professions depend on a precision screw cutting lathe with its many attachments.

THE MODERN SCREW-CUTTING LATHE



A Modern Backgeared Screw-Cutting Lathe.

For years a screw-cutting lathe required an investment of several hundred dollars—a huge demand existed for an accurate, popular-priced lathe. The lathe shown above was built to meet this demand—backed by a manufacturer with over a quarter-century of experience in the producing of precision tools and machinery for industry. In planning this lathe, designing engineers, who for years had been intimately connected with the modern methods of automotive manufacturing, cooperated with practical machinists of long experience in lathe operation. A sizeable fortune was spent

x

on tools and dies for its manufacture. Machine tool builders were called upon to furnish special machinery so that modern precision methods of manufacturing could be employed. As a result of all these combined efforts, this modern lathe was introduced.

From the very first, hundreds of shops in all parts of the world found that an investment in such a lathe quickly paid for itself. Factories and tool rooms soon learned that it performed a large percentage of their work faster, cheaper and more accurately; inventors discovered that it was just the tool for the development of their ideas.

* * *

THE MODERN LATHE IN OPERATION



Vocational School



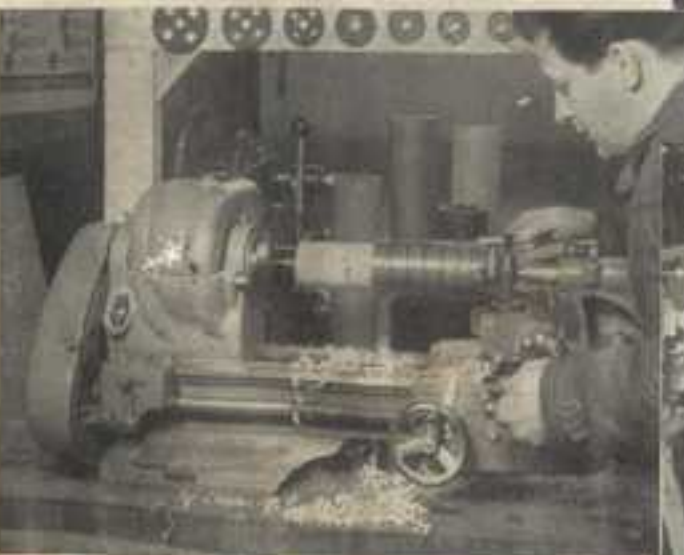
Inventor



Garage



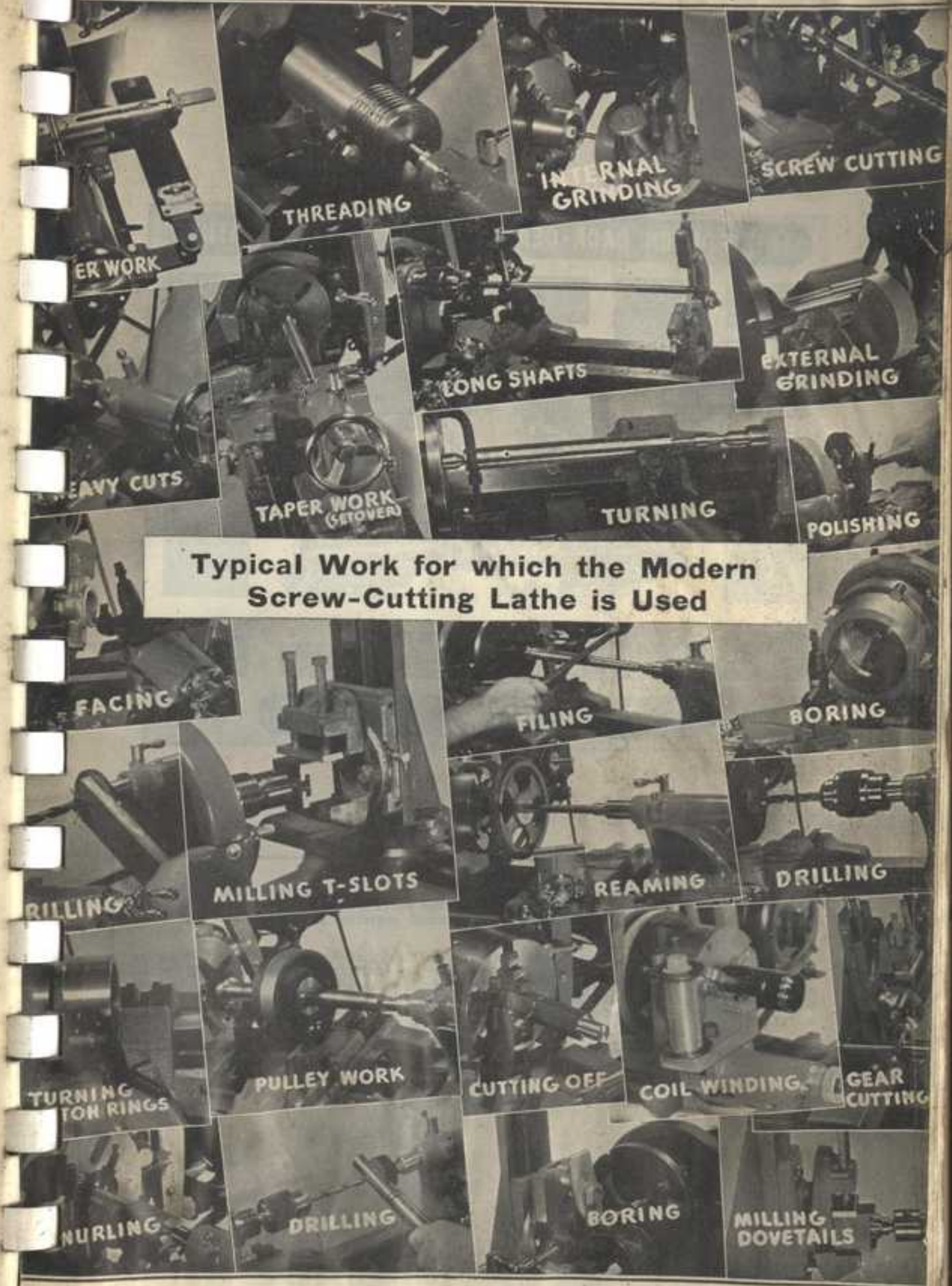
Laboratory



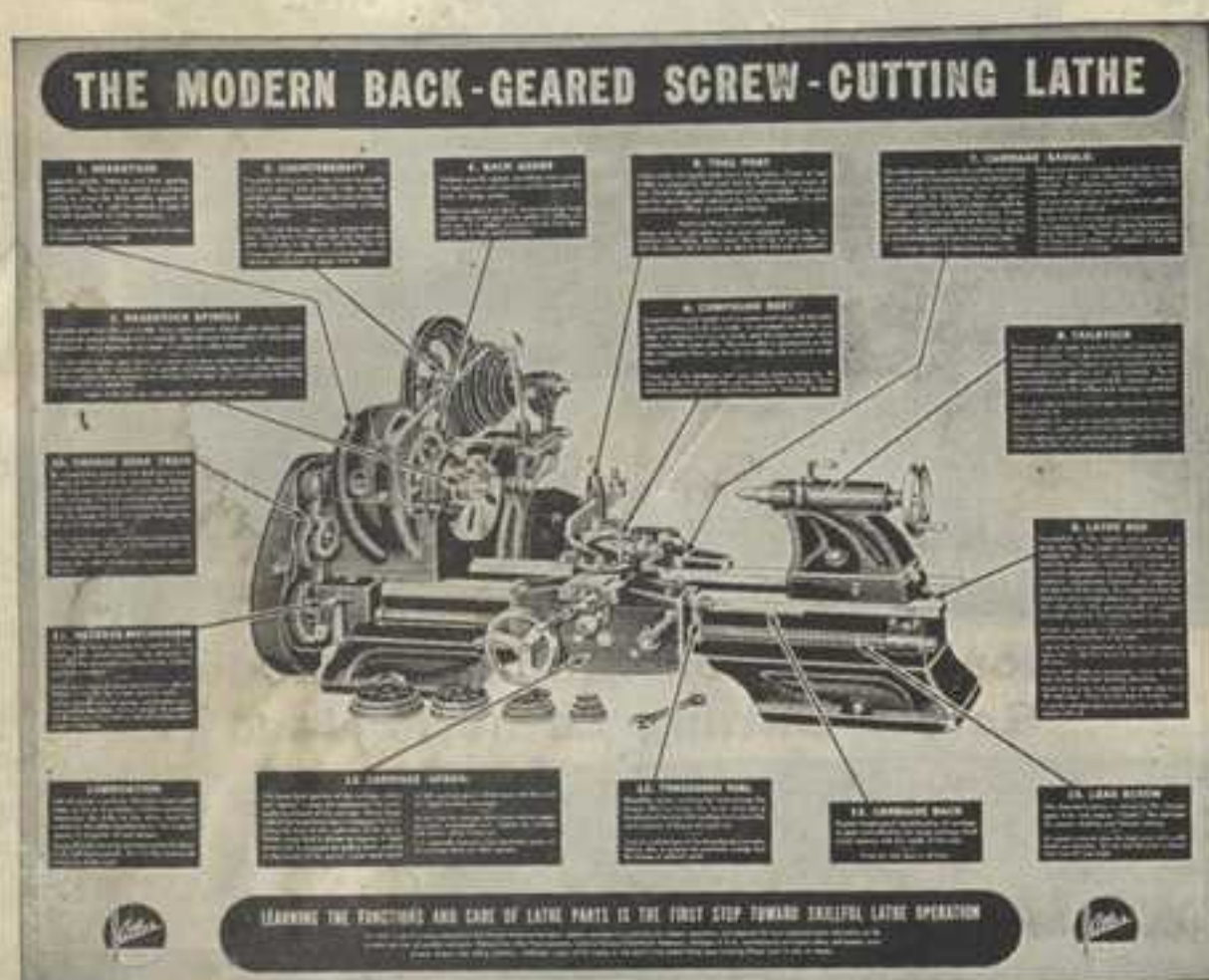
Production Shop (Plastics)



Tool and Die Shop



Typical Work for which the Modern Screw-Cutting Lathe is Used



WALL CHART

This large blueprint chart (31½" wide, 25½" high) presents the most important basic information on the function and care of lathe parts and makes a useful wall piece for machinist, apprentice and student. Technical material in this chart has been adapted from "Manual of Lathe Operation."

The wall chart shown above is one of a series published by Atlas Press Company, Kalamazoo, Michigan. The complete series, covering important phases of lathe operation and machine shop practice, will be mailed upon request to any point in the United States. When ordering, enclose twenty-five cents for each set in coin or stamps to cover costs of printing and postage.

Part 1

LATHE CARE AND CONSTRUCTION

PART 1

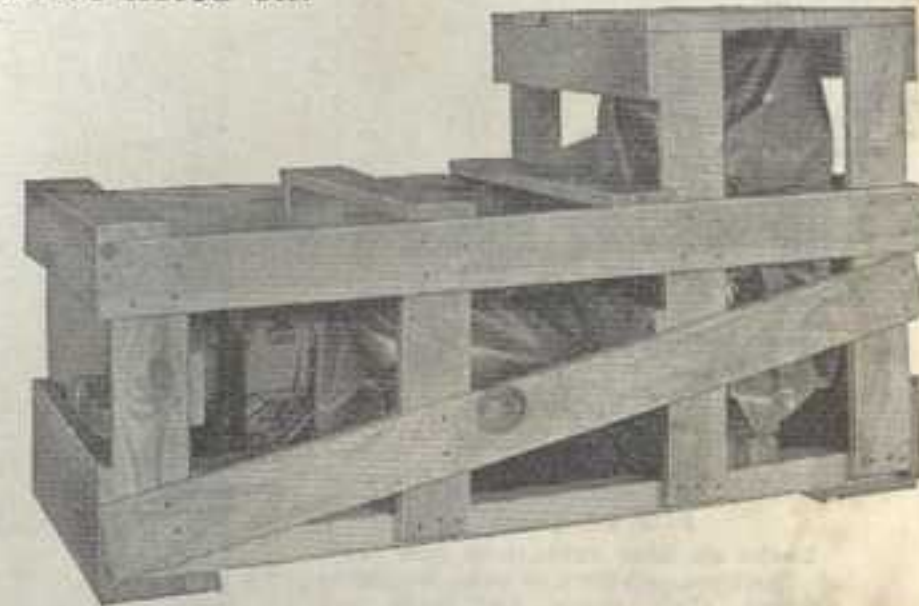
LATHE CARE AND CONSTRUCTION

SETTING UP THE LATHE

Most bench lathes are shipped completely assembled. All unpainted surfaces have been greased thoroughly and wrapped in oil paper, and the entire lathe strongly crated. Take care in removing the crate—a crow bar or hammer can slip easily and damage some part of the lathe. If the inside cross braces of the crate are first removed and the side boards loosened at the bottom, the entire top of the crate can be lifted off.

FIG. 1

Bench Lathe ready for domestic shipment. All machined surfaces are greased, and the completely assembled lathe is then wrapped in oil paper and solidly crated.



As soon as the lathe is unpacked, oil it completely and thoroughly at all points shown on the Oiling Chart on pages 6 and 7. Choose a well lighted location that is dry and with enough room for maximum efficiency and convenience.

Floor stands and cabinets (page 2) make ideal supports for the lathe. If the lathe is to be mounted on a bench, use one that is solidly built, well braced and with a good dry lumber top at least two inches thick. The precision of any lathe, regardless of size, depends a great deal upon the rigidity of the base under the lathe bed—a flimsy, warping bench top can, in a few days, spoil a careful mounting of the lathe and in time will impair its accuracy.

A bench height of 32 to 34 inches is correct for the man of average height. Adjacent edges of the top boards should be carefully joined and planed smooth. It is suggested that the top boards either be heavily dowelled, or that four or five $\frac{3}{8}$ " steel rods, threaded at both ends, be run edgewise through all of the top boards and pulled up tight. This latter method is preferred and calls for an accurate boring job. The top should also be planed smooth and level.



FIG. 2 (Left)
Lathe on floor stand. This type of mounting provides a rigid support and avoids imperfections of many shop benches.

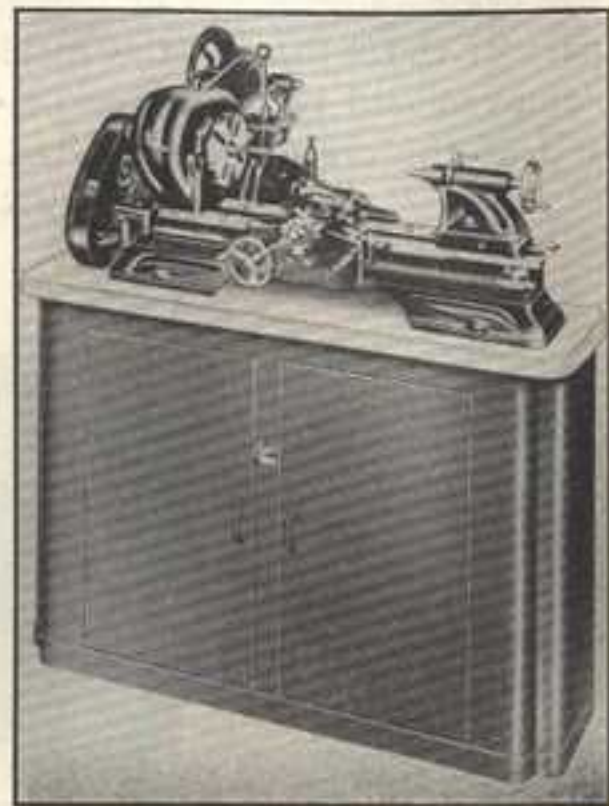


FIG. 2A (Right)
Lathe on floor cabinet—a new style of machine support which furnishes covered shelf space for tools and attachments.

LEVELING THE LATHE

The first step in successful lathe operation is to keep the lathe perfectly level at all times. When carelessly mounted any lathe bed will become twisted or bent, and with a slight amount of twist the centers become out of alignment and accurate work is impossible. Expert machinists agree that the better the leveling, the more accurate the lathe.

Here is the proper way to mount and level the lathe: With the lathe in position on the bench, mark and drill six $\frac{3}{8}$ " holes for machine bolts under the corresponding holes in the legs. Differences in height must then be detected with a good machinists level. Be sure the lathe bed is level ALL WAYS, including crosswise and longitudinally near both the headstock and tailstock ends (see Fig. 3). Differences in height are then taken up by the use of wide

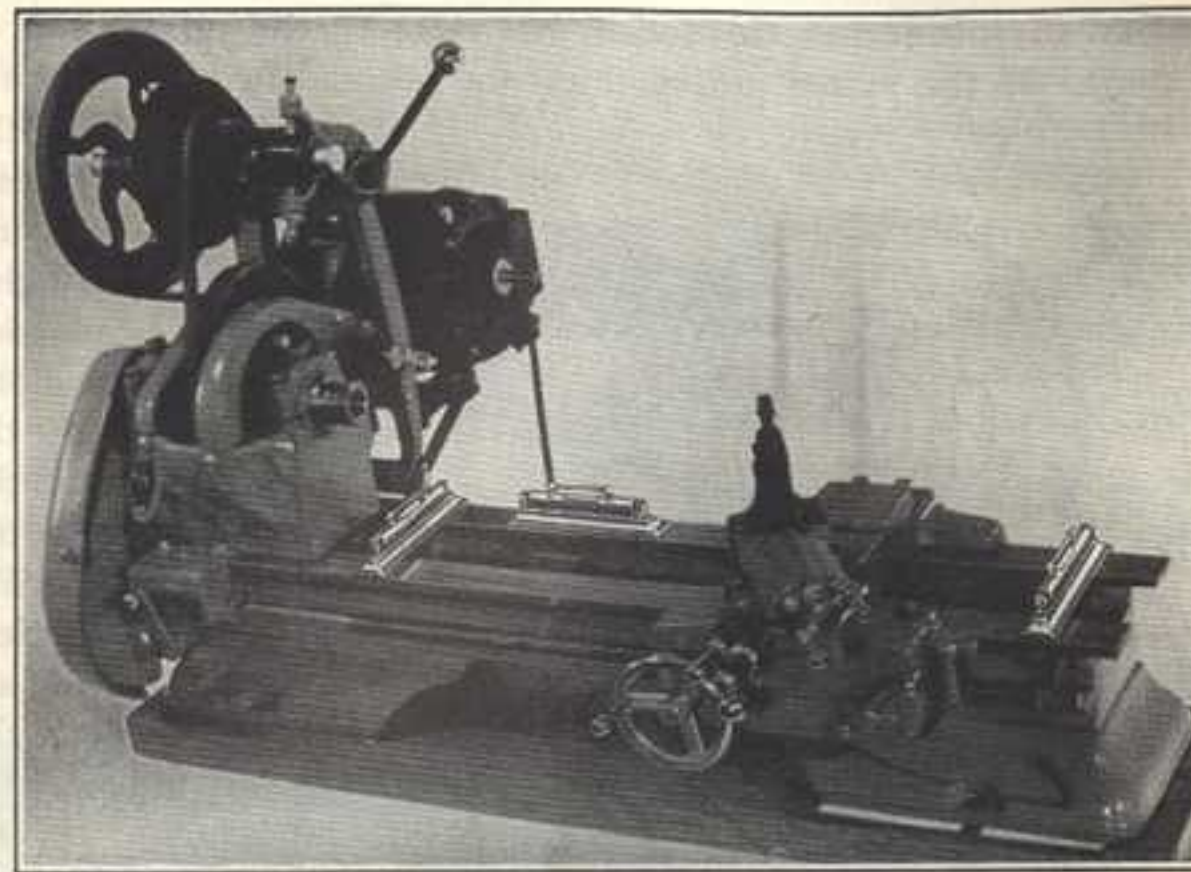


FIG. 3. Three Different Level Positions (only one level is required).

shims to insure a firm base. Shims should be thin metal or cardboard strips, preferably metal.

Repeat the checking operation after the legs have been bolted down tightly. It may be necessary to relax the bolts and adjust height by adding more shims. Most machinists check these leg shims regularly and whenever the lathe is expected to be in use for a long period of time. Before heavy work or whenever the lathe is moved to a new shop location, it is advisable to repeat the checking of the level position.

Do not slight the leveling of your lathe. In order to make precision cuts on long work it is absolutely necessary to have the bed perfectly aligned and horizontal. The precision built into a lathe can be made entirely useless by faulty, uneven mounting. Extra care and time spent in installation and leveling will give the lathe every chance to perform the accurate work for which it is built.

MOUNTING THE MOTOR

These lathes are designed to be run from a 1740 R.P.M. motor, either $\frac{1}{3}$ or $\frac{1}{2}$ H.P., depending upon the type of work being handled. With the lathe in place, mount the motor on the motor bracket and connect the switch wires as shown in Fig. 4. Before bolting down the motor, run it for a moment to make sure that the

direction of rotation is clockwise when facing the pulley end of the shaft. If the motor pulley does not fit readily on the motor

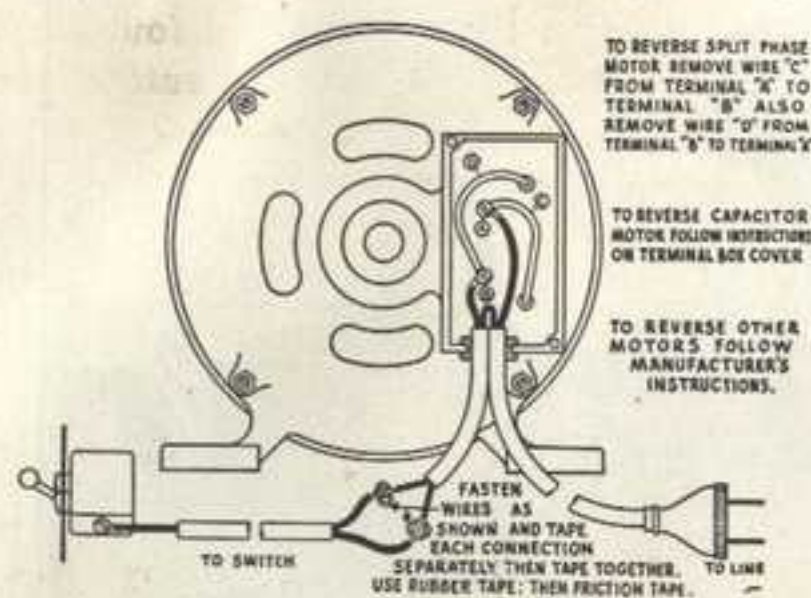


FIG. 4
Connecting the switch wires to the motor.

drives require only medium tension, and the motor drive belt should be adjusted with the tension lever in the middle position.

KEEP YOUR LATHE WELL OILED

Before using the lathe, oil it thoroughly at the points shown in the chart on pages 6 and 7. It is well to memorize the exact order of the chart. Use a good grade of machine oil—automotive oil, S.A.E. No. 10, is excellent for general lathe use. Automotive cup grease is suitable for the countershaft grease cups.

Both top and side surfaces of the bed ways should be oiled whenever using the lathe. These ways, as well as all other unpainted surfaces, should be covered with a generous film of oil when the lathe is not in use. Keep the lathe completely covered when it is in a dusty location or standing idle for a long time. Some types of gritty dust or soot are nearly as hard as emery dust and will cause wear unless lathe bearing surfaces are protected. Be sure to cover the bed ways during grinding operations.

Form the habit of oiling your lathe regularly.

BREAKING IN THE NEW LATHE

The high-speed, close-fitting babbitt bearings pictured on page 9 are similar to those of large industrial machine tools and automobile motors. Before the lathe is used, these bearings must be "run-in" carefully to insure long and accurate service.

To run-in bearings properly fill the two headstock bearing cups

with a good grade of machine oil no heavier than S.A.E. No. 10 and adjust the belts to obtain a speed of 164 R.P.M. (see page 47). Operate the lathe at this speed for about an hour, keeping the bearings well flushed with oil. An especially good lubricant for running-in bearings is a mixture of one part Pyroil and four parts S.A.E. No. 10. "Pyroil" is the trade name of a special automotive oil made for breaking in new bearings (also supplied under other trade names).

Use plenty of clean oil during the running-in period. If the bearings heat abnormally, reduce the spindle speed for a short time. Always keep the wicking in the oil caps loose so that oil can be readily absorbed as needed.

CAUTION: Do not use speeds over 500 R.P.M. until the lathe has been run at least 10 hours.

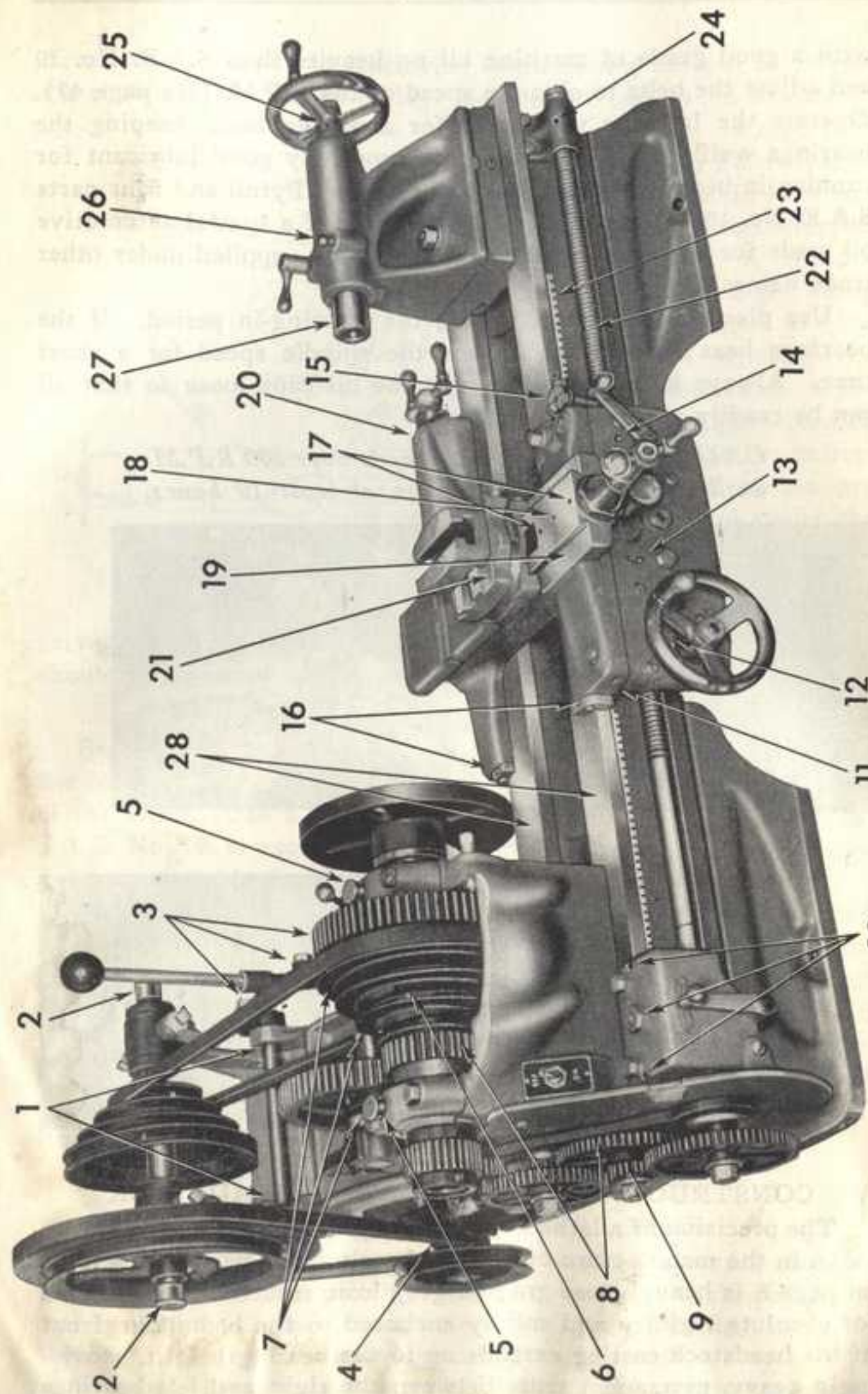


Modern Lathe Production Lines.



CONSTRUCTION OF THE LATHE HEADSTOCK

The precision of a lathe depends to a great extent upon the care taken in the manufacture of the headstock. The headstock shown on page 8 is heavy, close-grained grey iron, ribbed and reinforced for absolute rigidity and solidly anchored to the bed. The front of the headstock casting extends up to the bearing height, providing a heavy, permanent truss between the right and left bearings



OILING CHART

- 1 Place a few drops of oil on the rockshaft bearings and cam every time the lathe is in use.
- 2 Countershaft Roller Bearings—Fill both grease cups with automotive cup grease every two weeks. Give the grease cup caps a turn or so every time the lathe is used.
- 3 Place a few drops of oil on the rockshaft lever bearings and lever fulcrum bearing every time the lathe is used.
- 4 Motor bearings—Sleeve type motors have two oil cups which should be filled once a week with S.A.E. No. 10 Motor Oil or equivalent. Ball bearing motors have a sealed-in type bearing—every six months the small headless screw in these bearings should be removed and a moderate quantity of automotive cup grease forced around the bearing.
- 5 Left and Right Headstock Bearings—Oil with No. 10 motor oil or equivalent every time the lathe is used.
- 6 Spindle Pulley—Every time the lathe is used in backgear, remove the small screw in the bottom of the second step of the idler pulley and oil freely with No. 10 motor oil or equivalent. Replace screw.
- 7 Back Gear Spindle—Every time the back gears are used, remove the small screw in the center of the back gear spindle and oil freely with No. 10 motor oil or equivalent. Replace screw.
- 8 Back Gears and Change Gears—A small amount of Keystone No. 123 heavy outer gear lubricant or equivalent applied to the gear teeth will aid in obtaining smoother, more quiet operation. Be sure to remove all oil in the gear teeth before applying this lubricant or it will not adhere.
- 9 Change Gear Bearings—Put a few drops of No. 10 motor oil or equivalent on the change gear bearings each time the lathe is used.
- 10 Lead Screw Stub Bearing and Reversing Gears—Put a few drops of No. 10 motor oil or equivalent in the three oil holes on the top of the reversing gear box every time the lathe is used.
- 11 Carriage Traverse Gear Case—Every time the lathe is in use, put a few drops of No. 10 motor oil in oil hole on top of gear case on back of carriage apron.
- 12 Carriage Hand Wheel Bearing—Put a few drops of No. 10 motor oil or equivalent in the ball spring oil hole every time the lathe is used.
- 13 Cross Feed Mitre Gear Bearing—Put a few drops of oil in the ball spring oil hole every time the lathe is used.
- 14 Half-Nut Lever Bearing—Put a few drops of No. 10 motor oil or equivalent in the ball spring oil hole every time the lathe is used.
- 15 Thread Dial—Once a week put a few drops of No. 10 motor oil or equivalent around the rim of the top of the thread dial.

Keep all lathe bearing surfaces perfectly clean.

- 16 Wipers (front and back)—Oil-saturate the felts in the four bed wipers, one at each corner of the carriage saddle, every time the lathe is used.
- 17 Cross Slide Screw—Put a few drops of No. 10 motor oil or equivalent in the oil hole above the front cross slide screw bearing after removing the small screw. Replace the screw. This should be done every time the lathe is used. Clean the cross slide screw regularly with a small stiff brush. Oil the screw threads by running the compound rest back and forth.
- 18 Cross Feed Gears—Put a few drops of oil in the oil hole above the cross feed screw after removing the small screw. Replace the screw. This should be done every time the lathe is used.
- 19 Cross Slide Ways—Clean regularly and apply a liberal quantity of No. 10 motor oil or equivalent to the ways whenever the lathe is used.
- 20 Compound Slide Screw—Every time the lathe is used put a few drops of No. 10 motor oil or equivalent in the oil hole on top of the compound rest and above the compound screw bearing.
- 21 Compound Slide Ways—Clean regularly and apply a liberal quantity of No. 10 motor oil or equivalent to the ways whenever the lathe is used.
- 22 Lead Screw—About once a month clean the lead screw threads with kerosene and a small stiff brush and apply a small amount of No. 10 motor oil or equivalent.
- 23 Rack (on bed, under front way)—About once a month apply a small amount of cup grease to the rack after cleaning with kerosene and a small stiff brush.
- 24 Lead Screw Bearing (Right End of Lathe)—Put a few drops of No. 10 motor oil or equivalent in the oil hole on top of the bearing every time the lathe is used.
- 25 Place a few drops of oil between the handwheel and screw bearing whenever using lathe.
- 26 Tailstock Center Lubricant—Fill the small cup on the tailstock with a mixture of white lead and oil and apply to the tailstock center whenever turning between centers. If white lead is not available, use a liberal amount of cup grease on the center.
- 27 Tailstock Ram—Keep the outside surface of the tailstock ram well oiled.
- 28 Lathe Bed Ways—Keep the bed ways oiled at all times with No. 10 motor oil or equivalent and free from chips. Wipe off the ways before using and cover with fresh oil. Always leave a generous film of oil on the ways when the lathe is not in use. The lathe should be completely covered when not in use. During all grinding operations cover bed ways with canvas or cardboard.

Dirt is the natural enemy of accurate lathe work.



FIG. 5
Lathe Headstock.

and insuring perfect alignment even under the heaviest loads. A switch to start and stop the motor is built into the headstock casting.

HEADSTOCK SPINDLE



FIG. 6
Headstock Spindle, Take-up Nut and Collar,
Ball Thrust Bearing, Center and Sleeve.

The headstock spindle is special alloy steel — accurately ground and polished to extremely close tolerances to provide a perfect surface for the bearing. The spindle diameter is $1\frac{1}{2}$ " — the nose has 8-pitch National Form threads. A $\frac{25}{32}$ -inch hole is bored through its entire length, allowing full-sized $\frac{3}{4}$ -inch stock to be fed through the spindle (see Fig. 188). The spindle nose is reamed for a No. 3 Morse Taper, and a reducing sleeve is furnished to permit the use of a standard No. 2 Morse Taper center.

SPINDLE BEARINGS



Bearing Cap

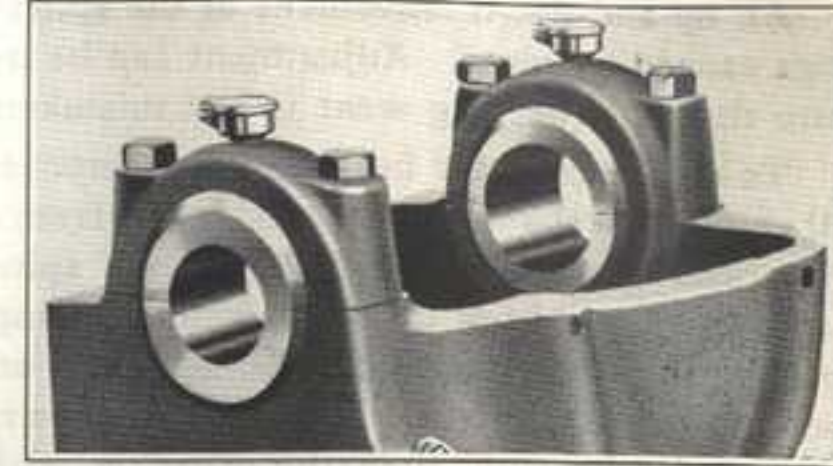


FIG. 7

Exceptionally fine spindle bearings are required in the headstock of the modern lathe. The bearings shown above are made of special high-speed, copper-hard babbitt — precision line boring equipment insures a true bearing fit and perfect alignment of spindle and bed (see Fig. 8). This type of bearing is being used universally in automobile main bearings and maintains its original accuracy and alignment under heavy loads. Among lathe and machine tool builders, bearings of this kind have been a custom of the trade for many years. A removable bearing cap and shims with five .002-inch lam-

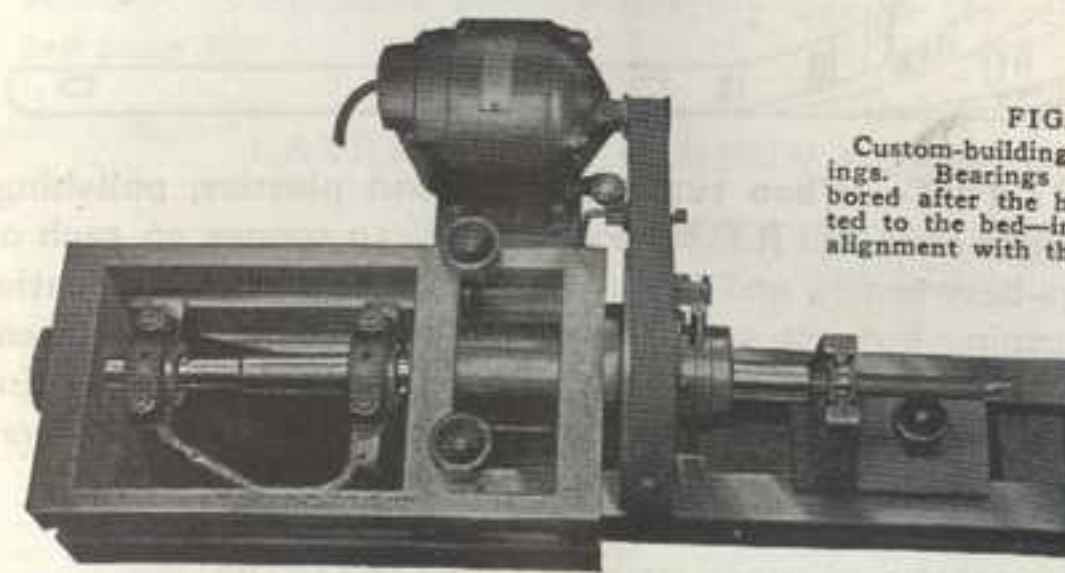


FIG. 8
Custom-building spindle bearings. Bearings are precision-bored after the headstock is fitted to the bed—insuring positive alignment with the ways.

inations are provided—adjustment for wear is made easily without special equipment or destroying the alignment of the spindle.

For metal turning, a rather tight bearing is essential. After the lathe has been broken in, the spindle should turn with a slight "drag," which can be felt when rotating the spindle by hand. No adjustment of the bearings should be necessary for hundreds of hours.

BEARING ADJUSTMENT

An up-and-down movement of the spindle indicates loose bearings caused by wear. Adjustment can be made easily, but first be sure that this bearing wear is not mistaken for end play.

To compensate for bearing wear, remove both bearing caps and all shims. Peel a lamination, or layer, from one of the shims in the right bearing and reassemble. If the spindle still turns loosely, remove a layer from the other right bearing shim. The proper fit will be indicated by a noticeable "drag" on the spindle after the bearing cap is tightened in place. Always remove shims from one side of the bearing, then the other, so as to keep the total shim thickness on both sides as nearly equal as possible. The bearing cap should be replaced and the fit tested after each layer of shim is removed.

To adjust the left bearing, loosen the right bearing just enough to allow the spindle to turn freely—make adjustment in the same manner as with the right bearing.



FIG. 9
Laminated shims appear solid, but the laminations, or layers, can be peeled off easily with a sharp knife.

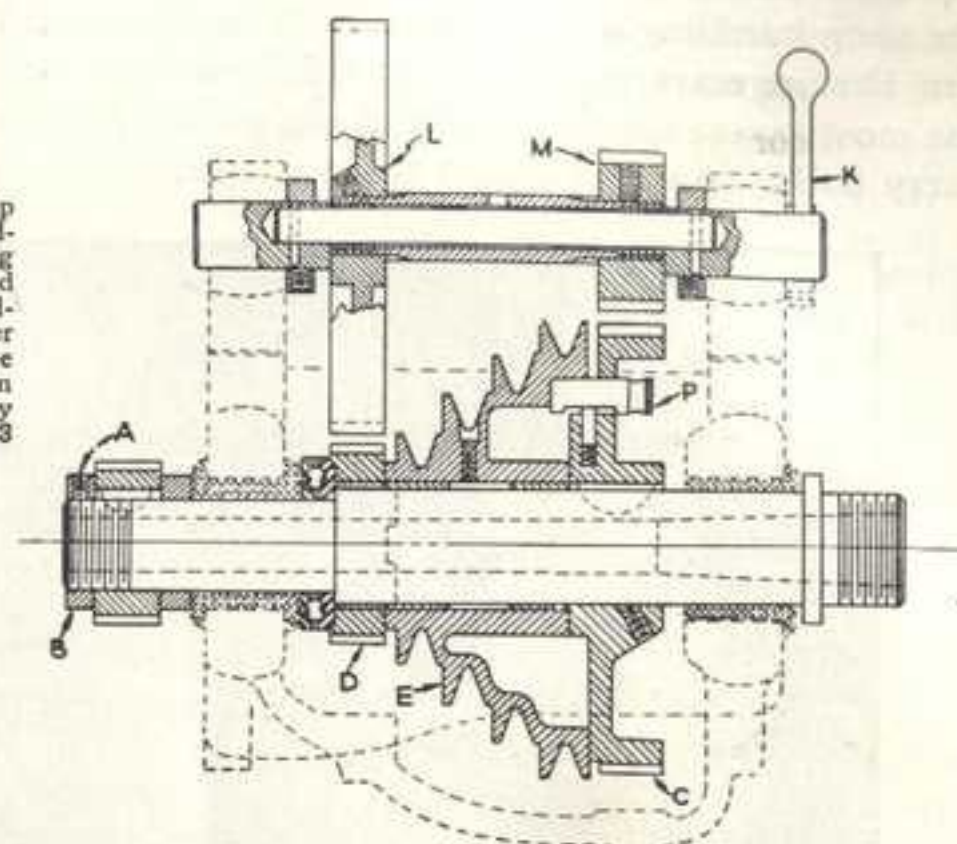
IMPORTANT—When turning wood and plastics, polishing, or using speeds over 805 R.P.M., loosen the cap screws on each of the bearings between $\frac{1}{8}$ and $\frac{1}{4}$ turn. A tight bearing is essential for metal turning but not satisfactory for higher speeds. Loosening the cap screws provides the proper bearing clearance for higher speeds. When changing back to lower speeds for heavier work, do not forget to tighten the cap screws.

SPINDLE END PLAY ADJUSTMENT

Adjustment of the ball bearing (Fig. 10) to absorb spindle end thrust requires simply loosening the set screw (A) in the threaded collar (B), and turning it to give a minimum of end play. By pulling this collar up tight, then backing it off a little, the spindle is given just enough play to turn freely. Whenever end play can be felt by pulling lengthwise on the spindle, this adjustment should be made in order to eliminate chatter and inaccuracy which

would otherwise result. Oil the end thrust bearing every time the lathe is in use.

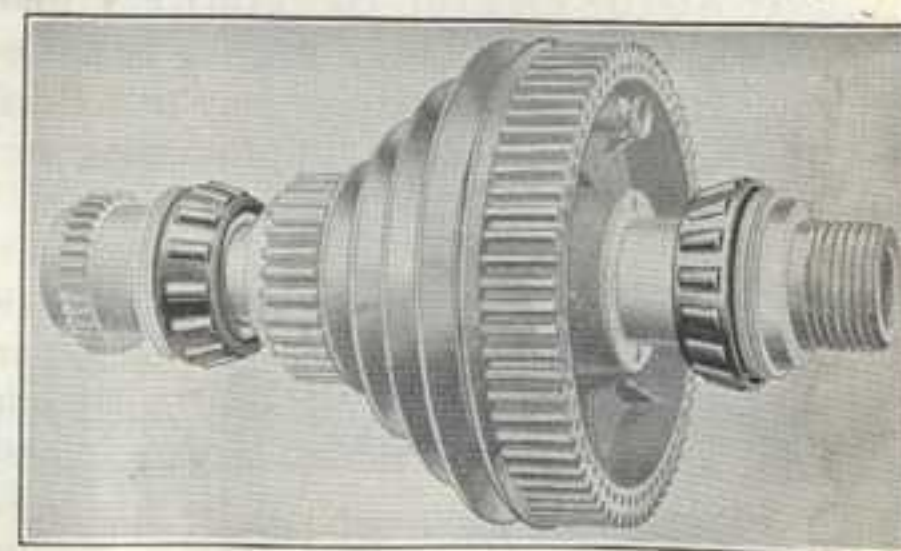
FIG. 10
Cross Section (top view) of the lathe headstock and back gearing mechanism. Note end thrust bearing and adjusting nut, spindle idler pulley and bronze sleeve bearing. The operation of back gears is fully explained on pages 13 and 14.



Adjustment of end play on lathes equipped with babbit thrust bearings is made in the same way as on those with the ball thrust bearing. To remove Timken Bearing spindle for replacing belts, see page 16.

LATHES WITH TIMKEN BEARINGS

FIG. 11
Lathe Headstock Spindle equipped with Timken Tapered Roller Bearings. The tapered design and positively aligned rolls mean that both radial and thrust loads are carried with minimum of friction.



Lathes equipped with Timken Tapered Roller Bearings are recommended whenever the lathe spindle speed must be exceptionally high for long intervals. These anti-friction bearings are ideal for continuous production jobs, wood turning and metal

spinning as well as the usual work at normal speeds. A Timken-equipped lathe also makes an excellent "combination machine" for the shop handling quantities of both wood and metal work. Timken Bearings are pre-loaded to insure a tight bearing even under the most severe use—the tapered design and positively aligned rolls carry both radial and thrust loads with minimum of friction.



FIG. 12
Timken-equipped lathe handling continuous high speed production operations.

ADJUSTMENT OF TIMKEN BEARINGS

Adjustment of the Timken Bearing is not often necessary, but if the spindle spins too freely or play is noticeable when the spindle is pushed back and forth, the following simple procedure will adjust the headstock bearings:

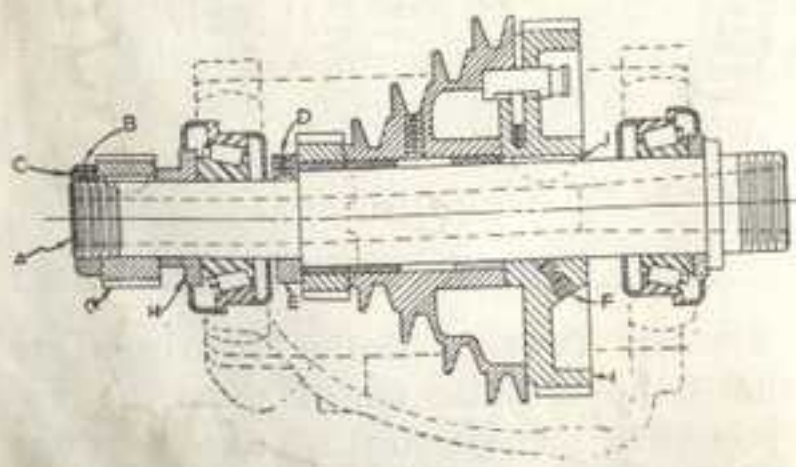


FIG. 12A

Run the lathe between thirty minutes and an hour to warm up the spindle (a temperature rise of 50° Fahr. increases the length of the spindle about .002 inch between bearings). Then loosen the set screw B (in

Fig. 12A) on the thrust nut, C, at the extreme left end of the spindle, A, and turn it up to a point where no play can be detected in the spindle. Advance this thrust nut 1/16 turn past that point (equal to two teeth on the spindle gear) in order to provide the correct pre-load. Tighten the set screw.

CARE OF TIMKEN BEARINGS

Lathes equipped with Timken Bearings can be set to work immediately. Oil the bearings every time the lathe is in use with S.A.E. No. 10 motor oil or a good grade of machine oil.

OPERATION OF THE BACK GEARS

The back gears reduce the lathe spindle speed, providing power for heavy cuts and correct surface speeds for large-diameter work. The back gear ratio is approximately 6 to 1. The back gears are conveniently located, easily used and take up very little space. Iron guards provide a safety covering. The mechanism for changing from direct drive to back geared drive is quick and simple in operation. Adequate bearings and good gears are both vitally important in lathe construction.

The lathe back gearing mechanism is pictured in Figure 13, and Figure 10, page 11, explains the details of operation. The "bull gear," C, is keyed solidly to the spindle. The small gear, D, and the spindle pulley, E, are fastened together rigidly—they have wide, perfectly fitting bronze bearings for rotation on the spindle. This small gear and pulley assembly is free to rotate unless the pin, P, is pushed in, locking the pulley to the bull gear and spindle. In this locked position with the back gears disengaged, the spindle is driven directly from the countershaft.

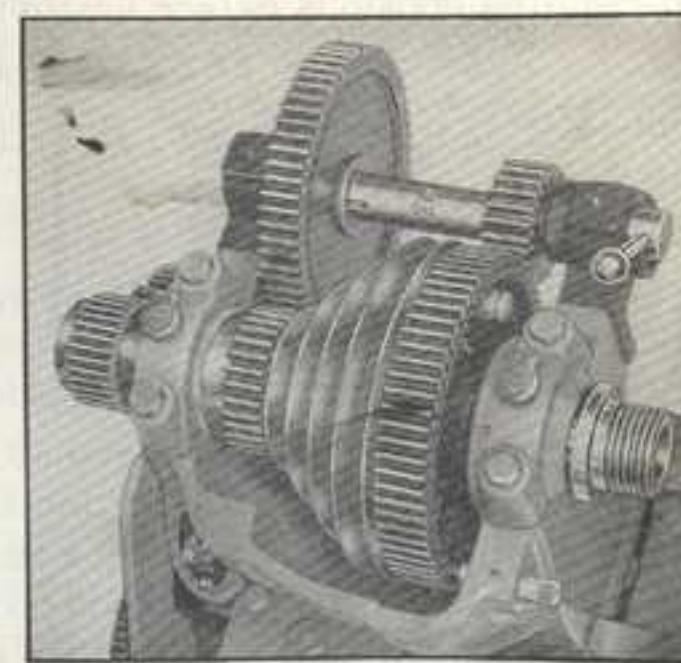


FIG. 13
Top view of lathe headstock showing the back gears.

When the pin, P, is pulled out of the bull gear and the back gears are engaged by pulling forward the eccentric shaft lever, K, the belt from the countershaft drives the small gear and pulley assembly, D and E, the small gear meshes with and drives the large back

gear, L, and the small back gear, M, meshes with the bull gear, C, turning the spindle.

The back gear spindle should be oiled as shown in the Oiling Chart on pages 6 and 7. A small amount of Keystone No. 122 gear lubricant on the gear teeth will sometimes give more quiet operation. Back gear drive is usually more noisy than direct drive, and the use of the back gears with the motor pulley belt in the high speed position is not recommended or necessary for general use. These high speeds are shown in Figure 55, page 47.

INDEXING MECHANISM

The face of the front spindle gear has 60 evenly spaced indexing holes for such dividing operations as fluting, reeding, serrating, sprocket- and spoke-spacing.

To divide the circumference of a piece of work into a given number of equal divisions, mount the work and engage one of the indexing holes by pressing lock pin through headstock. Perform operation, release pin and, after consulting indexing table below, rotate gear the proper number of indexing holes. Engage hole and repeat operations until circle has been completed. **NOTE:** When using lathe dog be sure that tail of dog fits tightly in slot of face plate. In layout work it is advisable to use a pencil to mark all required divisions *before* beginning the actual operation.

INDEXING TABLE					
Divisions Desired	No. of Spaces	Degrees of Arc	Divisions Desired	No. of Spaces	Degrees of Arc
1	60	360	10	6	36
2	30	180	12	5	30
3	20	120	15	4	24
4	15	90	20	3	18
5	12	72	30	2	12
6	10	60	60	1	6

THE LATHE COUNTERSHAFT

Two styles of lathe countershaft are illustrated in Figures 14 and 15. The support bracket for the horizontal countershaft is mounted on the lathe bench; the vertical countershaft is attached directly to the headstock and bed. Both types are "quick change," with the belt tension lever within easy reach for speed changes. Sixteen speeds are available, ranging from 28 to 2,072 R.P.M.

These modern countershaft designs do away with the irritating disadvantages of a cumbersome, space-taking flat belt drive with its limited speed range and difficulties of adjustment. They provide a smooth, even flow of power to the spindle at the exact speed most efficient for the work being done.

The countershaft spindle revolves on roller bearings, amply lubricated through the hollow spindle. These fine bearings transmit maximum power to the spindle and give years of trouble-free performance.

FIG. 14 (Right)
Support bracket for horizontal countershaft is mounted on the lathe bench or stand.



FIG. 15 (Left)
Vertical countershaft is attached directly to headstock and bed, making lathe a self-contained unit.

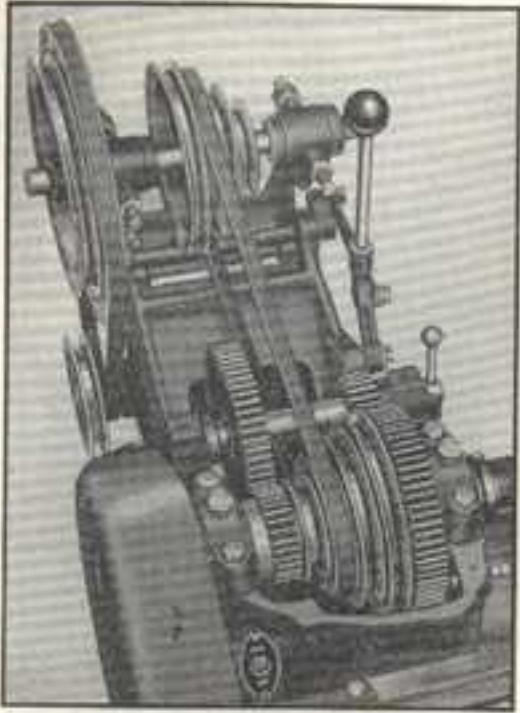
ADJUSTING BELTS

The driving belt is adjusted easily and accurately by means of the four countershaft adjusting screws. Make the countershaft belt adjustments with the belt tension lever in the middle position so that the center of the belt can be pushed in about one inch with a moderate amount of pressure. V-belts do not have to be tight in order to drive normal loads, and belt life will be lengthened by running them fairly loose. The tightest position of the belt tension lever is for very heavy loads only, not for ordinary turning.

In tightening the four countershaft adjusting screws, it is not necessary to draw them up too tightly—the compressing of the outer sleeve will distort the bearing and might cause permanent damage. Turn these screws up until they are finger tight, then about $\frac{1}{8}$ turn more, and lock.

The motor drive belt is adjusted by moving the motor bracket

up or down. This adjustment should also be made with the belt tension lever in the middle position—a moderate amount of pressure should depress the center of the belt about $1\frac{1}{2}$ inches.



THE V-BELT DRIVE

V-belt drives, due to their many advantages, are used in practically all modern machinery installations. This type of power transmission is ideal for metal lathes because it assures smoother operation, less slippage and maximum power.

V-belts of the type shown at the left have been scientifically designed to give long, efficient service, and if properly used and cared for will serve for hundreds of hours of operation.

V-BELT OPERATION

Do not run V-belts too tight. Relax belts when lathe is idle. Keep belts free from oil—oil shortens belt life. Keep pulley sheaves smooth. If accidentally nicked or marred, dress them down with a file and polish with emery cloth. Do not try to shift belt positions while the lathe is running, or without loosening the belts with the belt tension lever.

Replacing belts: The motor drive belt is easily replaced. When replacing spindle drive belt, remove spindle, and after installing new belt, see that the bearing caps and shims are placed exactly as they were originally. Safety belt guards are recommended for industrial and educational use. See page 2.

To remove Timken Bearing Spindle for replacing belts: See Fig. 12A. Remove gear guards. Loosen set screw B, 2 set screws D, and set screw F. Remove thrust collar C, feed gear G, and flanged collar H. Place 2 pieces of wood between head and large spindle gear I. Hold piece of wood on left end of spindle and tap firmly with hammer. Continue tapping spindle from left to right until key J comes out of gear I. Remove key with pliers. Remove burr from spindle beneath F. Continue to drive spindle until there is sufficient room for belt. To reassemble, reverse process.

THE LATHE BED

The accuracy of the lathe bed is most important from the standpoint of precision and good lathe work. The use of specially designed milling and grinding machinery and extreme care in manufacture and inspection, has succeeded in producing lathe beds today with a degree of precision previously unknown in popular-priced lathes.

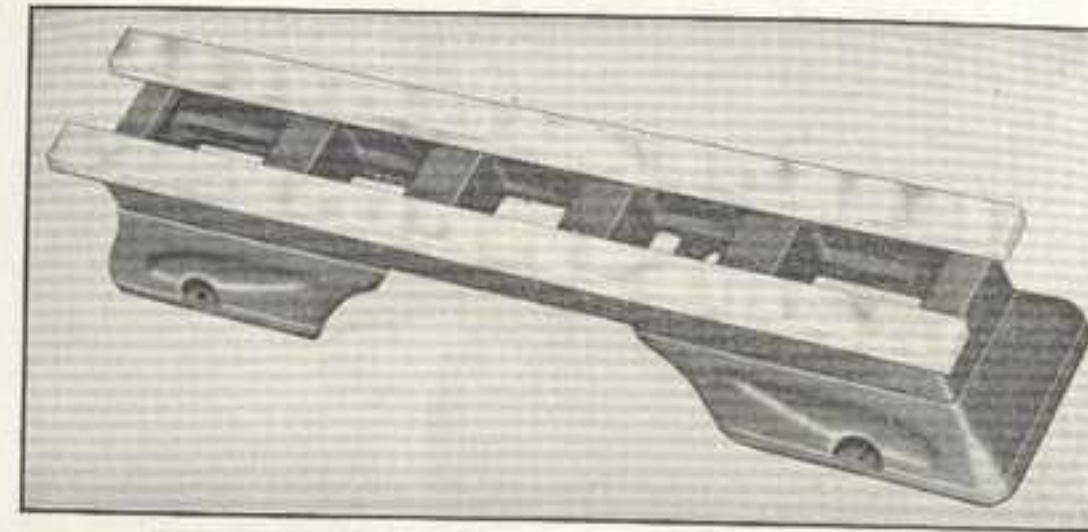


FIG. 16
The finished lathe bed—seasoned, milled, precision-ground and ready for the assembly line.

The accuracy of the bed, regardless of design, is almost entirely dependent upon the finish it receives in the process of manufacture. The milling or planing operations used to reduce lathe beds to approximately final shape, do not give accuracy of more than two or three thousandths of an inch. The bed-way surfaces must then be either hand scraped or machine ground.

Modern industry has proved conclusively that surfaces can be precision-finished by grinding to unbelievably close limits—a production accuracy undreamed of ten years ago. Old fashioned, expensive methods of hand scraping have nearly disappeared—better and more adequate equipment is now being produced by machine grinding at a more moderate cost than ever before.

A precision grinding machine (Fig. 18) made especially to produce the accurate finish on the ways of the lathe bed shown above requires a huge expenditure of money, but a precision lathe demands a precision bed—there can be no compromise.

Lathe beds are made from selected close-grained semi-steel iron castings. The entire bed, comprising the cross ribs, ways and base,

TWO STEPS IN THE MACHINING OF A LATHE BED

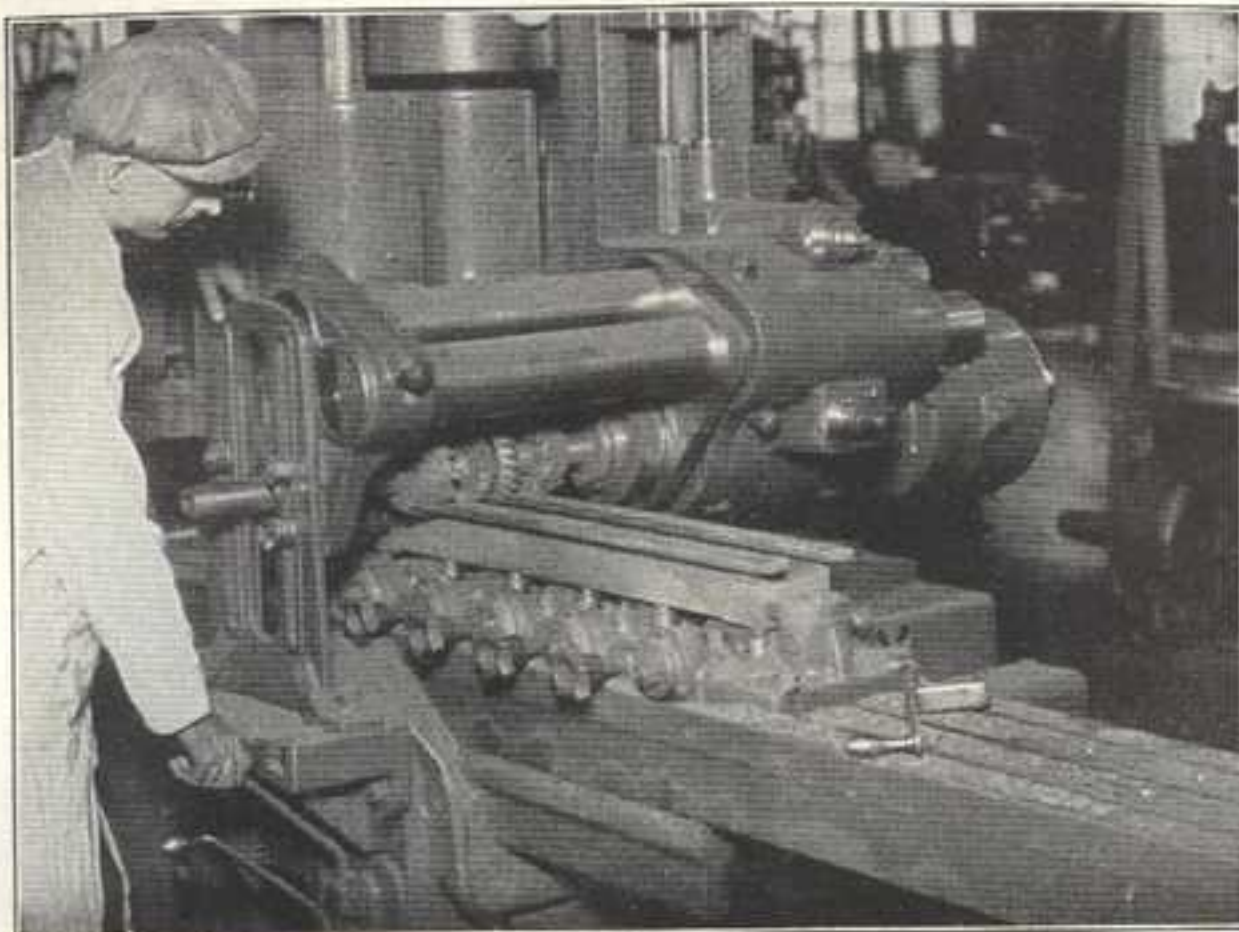


FIG. 17

A huge Kearney-Trecker Milling Machine designed and built especially for milling Lathe Beds.

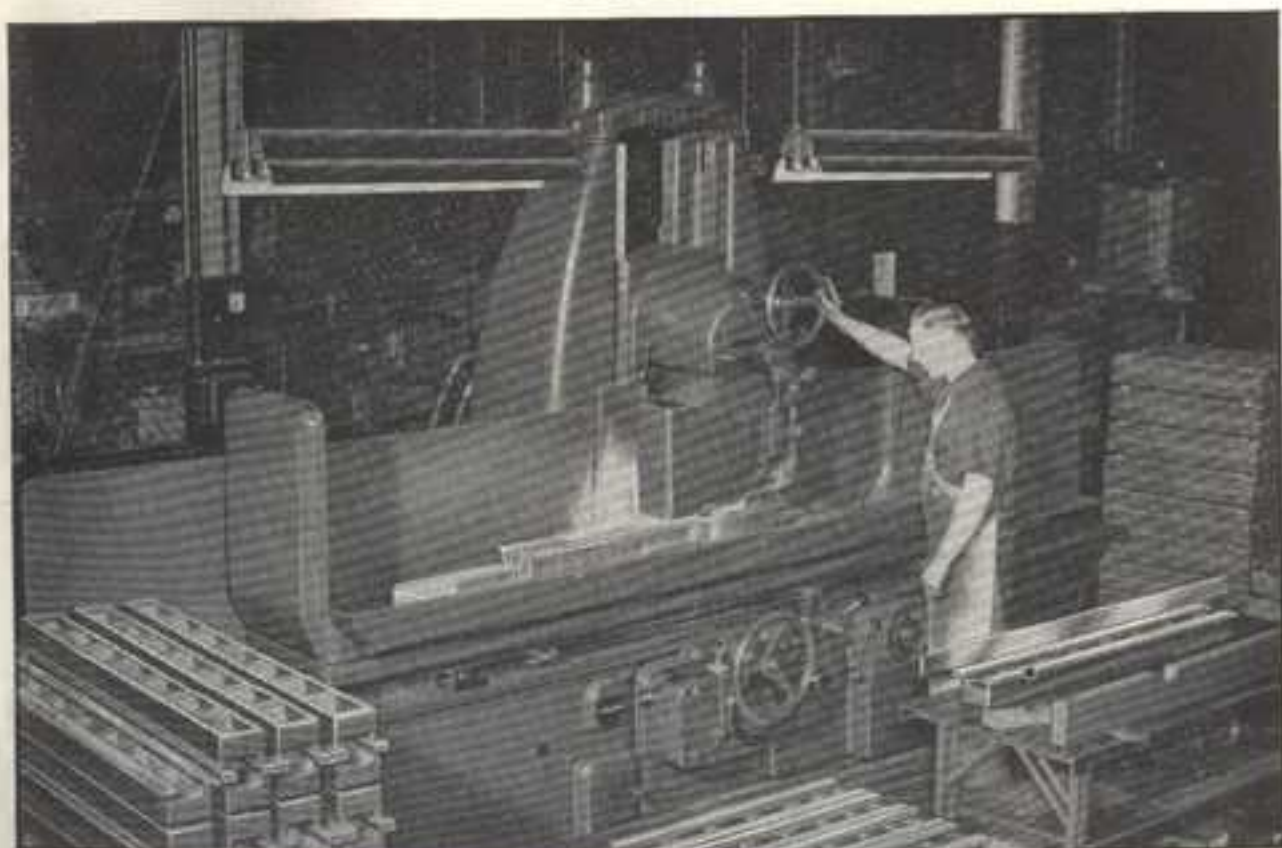


FIG. 18

Special-built modern grinding equipment of the type shown above gives the final precision finish to the lathe bed ways.

is made in one piece. The heavy box-type cross ribs, spaced every four inches, rigidly brace the bed ways against heavy turning forces. The heavy ways on top and the inner bead at the bottom resist longitudinal stress. The heavy streamlined legs with cross-braces have a total bearing surface of 48 inches on the bed. This unusually large bearing surface provides a sturdy base for the entire lathe and keeps vibration at a minimum.

After the bed is cast, it is first rough-milled and allowed to season, or age, for a number of months. This permits internal strains in the metal to become normalized, so that warping and twisting will not occur in the finished bed. After seasoning, a finish milling cut is taken, and the ways are then finish-ground on especially designed surface grinders. The completed bed is checked thoroughly, inspected innumerable times during the assembly of the lathe, and carefully checked again by the final inspectors.

BE CONSIDERATE OF THE LATHE BED

With normal use no appreciable bed wear will occur even over a period of years, but any finely finished metal surface can be damaged by abuse, and your lathe bed is no exception.

Tools or other objects should not be dropped on the ways.

Do not use the lathe bed as an anvil.

Do not drop chucks on the bed when removing them from the spindle.

Do not allow chips to accumulate on the bed. When filing or grinding on the lathe, remove the fine dust and oil the ways liberally as soon as the operation is finished. Better still, keep the lathe bed covered during such operations.

Keep the bed well oiled when not in use—when ready to use the lathe, wipe the ways and cover them with clean oil.

CHECK LEVEL POSITION OF LATHE AT REGULAR INTERVALS

CARRIAGE AND COMPOUND REST

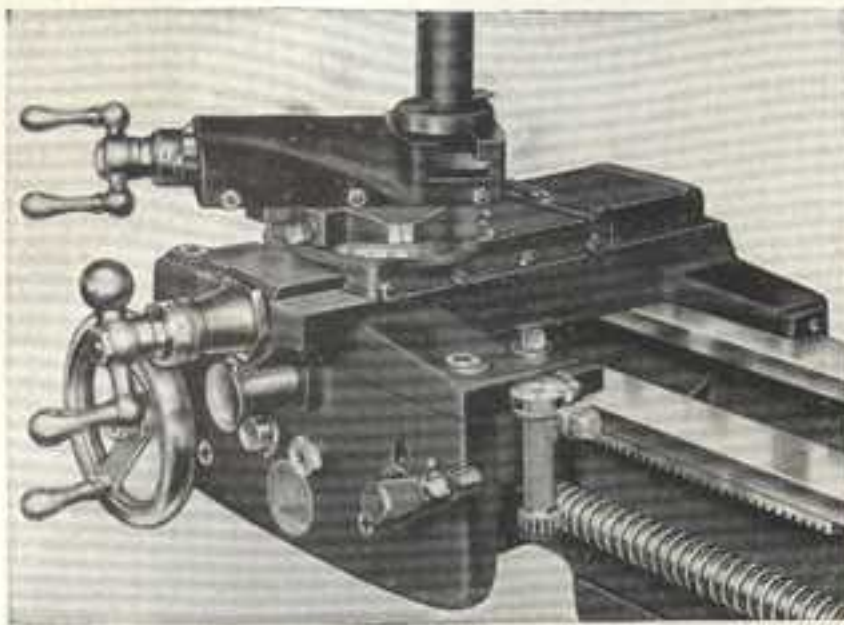


FIG. 20
Carriage and Compound Rest Assembly.

While the accuracy of cuts parallel to the bed depends upon the accuracy of the lathe bed, the accuracy of cross and compound feeds depends upon the accuracy of the carriage and compound ways. Consequently, a great amount of care is taken in the machining of these ways.

The carriage is a heavy, well proportioned grey iron casting, with six wide bearing surfaces, each $9\frac{1}{2}$ inches long, in contact with the bed. This large amount of bearing surface minimizes wear and results in more permanent accuracy. The front of the carriage, called the "apron," contains the power feed mechanisms. These parts are described in a later paragraph (page 22).

Pulling the knob control on the carriage apron engages the power cross feed. The lever at the right engages longitudinal feed. Both may be reversed by shifting lever on the gear box at the headstock end of the lead screw. The compound feed can be turned in a complete circle, and it is graduated in degrees from 0 to 180, so that any angle can be cut with the compound rest.

ADJUSTMENTS OF THE CARRIAGE

Four gib screws are located on the back of the carriage for adjusting horizontal play between the carriage and the bed—these screws should be tightened just enough to give a firm sliding fit between carriage and bed. Bearing plates on the carriage, which bear on the under side of both the front and the back bed ways, anchor the carriage firmly to the bed in a vertical direction. These bearing plates have laminated shims for adjustment of possible wear (see Fig. 9).

The large carriage hand wheel on the front of the apron operates a set of gears, the last of which meshes with the rack on the bed. These gears can be adjusted for play by loosening the screws on the front of the apron, moving the gear case toward the rack, and tightening the screws.

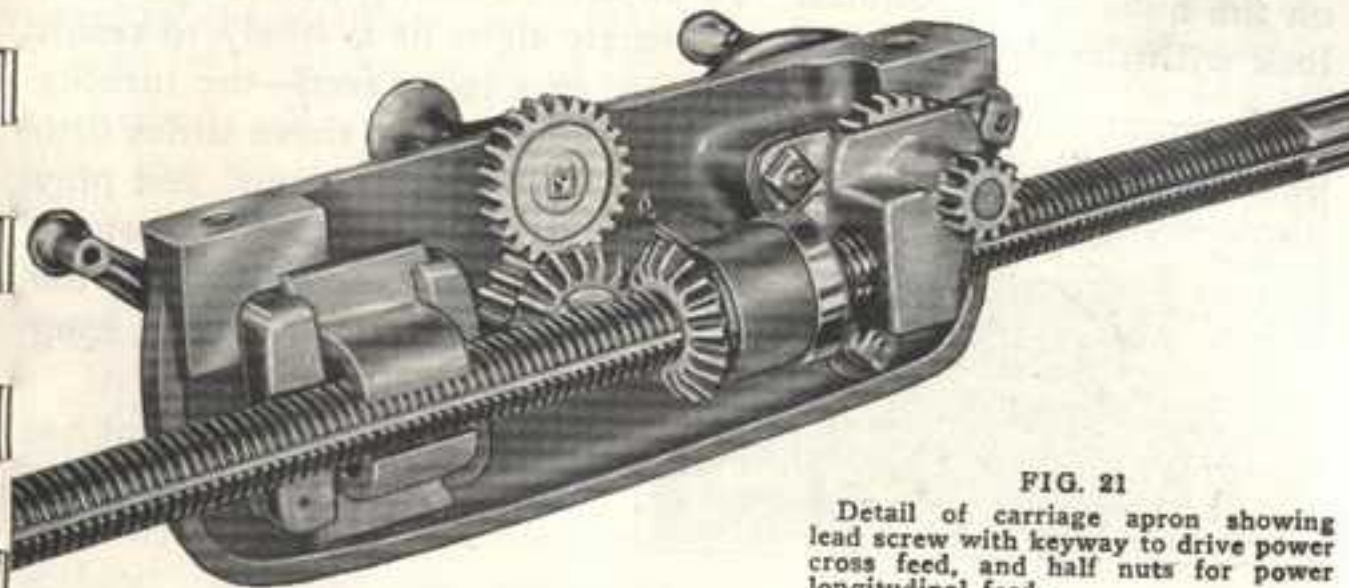


FIG. 21
Detail of carriage apron showing lead screw with keyway to drive power cross feed, and half nuts for power longitudinal feed.

REMOVING THE CARRIAGE FOR CLEANING AND ADJUSTING

In order to clean or make adjustments on the inside of the apron, it is preferable to take the carriage completely off the bed. First remove the tailstock, then unbolt the bearing on the right end of the lead screw and remove the lead screw (half-nut lever must be up). One of the bevel gears in the reversing gear box will come out with the lead screw—watch its position so that it can be put back correctly. With the lead screw out, it is a simple matter to loosen the gibs on the back of the carriage, and slide the carriage off the bed.

When reassembling, turn the lead screw until the keyway slips into the reverse shift collar in the reversing gear box.

ADJUSTING CROSS FEED AND COMPOUND FEED GIBS

The gibs on the cross feed slide and the compound feed slide should be adjusted at regular intervals. The cross slide gibs should always fit snugly, because the cross slide is in almost continual use. The compound slide gibs should be kept tight unless using the compound feed.

For best results, do not take heavy cuts or use the cut-off tool with the compound rest overhanging the compound rest slide.

Be sure to loosen the two square-head set screws whenever changing the position of the compound rest.

The ball and crank handles on the cross feed screw and the compound feed screw can be adjusted for play with the two nuts on the hubs of the handles. To adjust, tighten the inner nut and lock with the outer nut. An extremely tight fit is likely to result in a jerky feed—the turning force keeps these slides firm against the screw, and play in the handles does not affect the accuracy of the work. A nice working, snug fit is ideal.

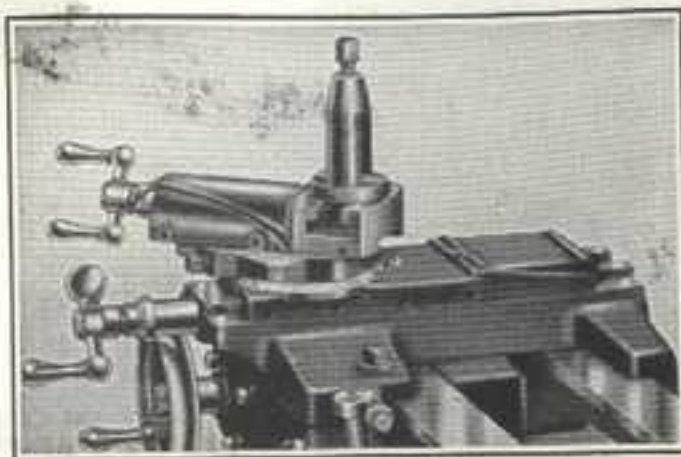


FIG. 22. Cross Slide and Compound Rest.

POWER FEED MECHANISM AND LEAD SCREW

The automatic longitudinal power feed consists of the gear train, reversing gear box, lead screw and half-nut mechanism. For detailed operation of the feed gears, together with the set-ups for cutting various threads, refer to the Threading Supplement.

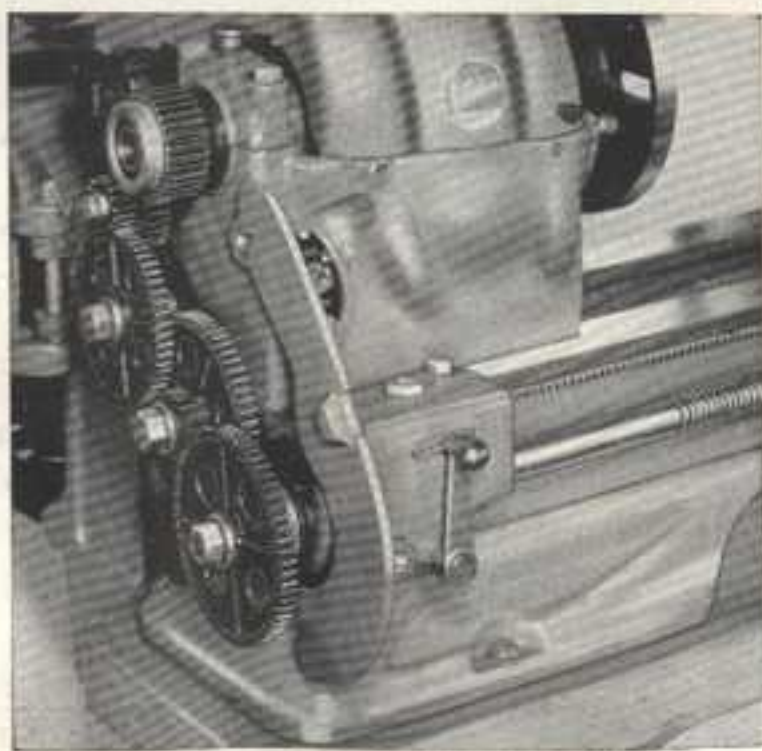


FIG. 23
Arrangement of the Feed Gears, Reversing Gear Box and Lead Screw.

Instead of the feed gears driving the lead screw directly, a reversing mechanism is sometimes built between the two as shown in Figure 24. This mechanism makes it possible to reverse the direction of the lead screw rotation, and consequently the direction of the power feeds, while the lathe is running. The shifting of gears to obtain this change of feed is done at the point of lowest speed. The usual method of reversing the power feed consists of two small gears between the spindle gear and the rest of the gear train, which is at the point of highest speed and necessitates stopping the lathe to avoid injury to the gears.

In boring, knurling, finishing cuts, and many other lathe operations, it is advantageous to reverse the power feed without stopping the lathe and without changing the setting of the tool. With the above reversing mechanism the feed can be reversed quickly by simply shifting the lever.

Figure 24 makes clear the operation of the reversing mechanism. Notice that the center notch of the reverse lever is a neutral position—when the reverse lever is shifted, it takes only an instant for the shift collar to align and mesh with the slots in one of the bevel gears. Do not try to force the lever into either side position—push it firmly toward one side or the other and it will immediately mesh into place.

The lead screw is accurately cut with a pitch of $\frac{1}{8}$ inch, (eight threads per inch). Its accuracy is maintained by keeping it clean and free from chips. Once a month or oftener clean the threads with a stiff bristle brush and kerosene, and oil freely along its entire length.

The lead screw bearing on the tail end of the lathe serves as a "safety valve" protecting the lead screw. One of the most common accidents on the lathe is letting the power feed drive the car-

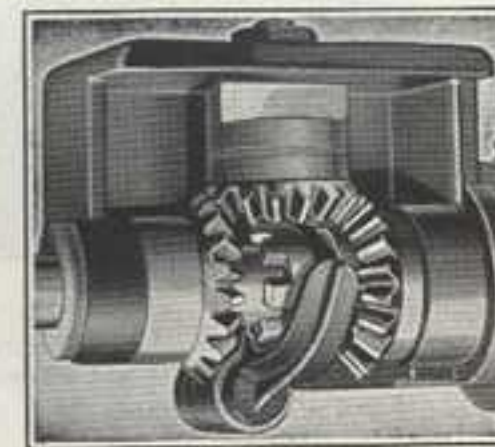


FIG. 24

An inside view of the lead screw reversing mechanism. The feed reverse lever engages the shift collar with either of the two reverse gears, reversing instantly the lead screw rotation which changes travel of power feeds.



FIG. 25

Closeup of a lead screw (8 Acme threads per inch). A high degree of accuracy is essential for precision thread cutting.

riage into the headstock or tailstock. Serious and expensive results from such an accident are prevented by the light construction of this bearing. The lead screw simply forces itself out and breaks the bearing casting. In this way the light bearing prevents what would otherwise be an expensive break-down.

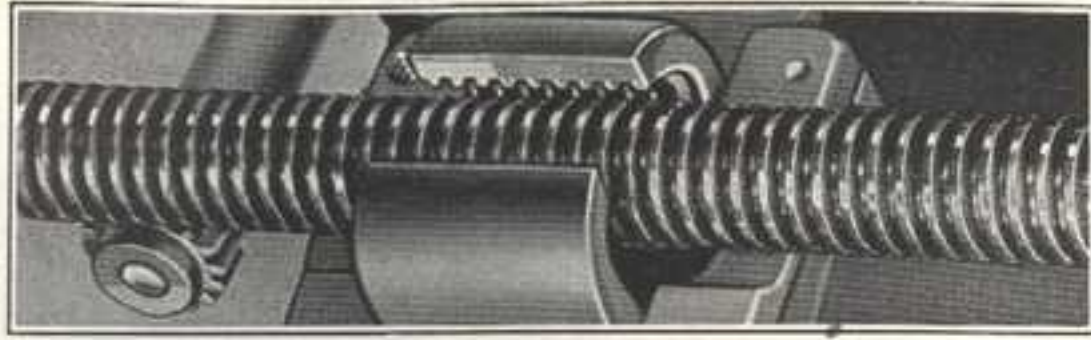


FIG. 26

A view of the half-nuts and their closing mechanism. Positive closing action, combined with the use of two half-nuts, insures smooth and accurate threads.

Figure 26 shows the construction of the half-nuts and their closing mechanism. Two half-nuts, closing on both sides of the lead screw, prevent strain on the lead screw and insure a smooth feed. In order to minimize wear on the lead screw, the half-nuts are made of a metal softer than steel. The carriage should be removed at regular intervals and the half-nuts, closing mechanism and rack cleaned thoroughly and greased. Dirt or chips will damage the half-nuts and the lead screw. Oil regularly.

THE TAILSTOCK

The tailstock of a lathe must line up perfectly with the headstock at any point on the lathe bed. The precision of the ground ways and the extra care taken in the fitting of the tailstock assure accurate alignment at any position.

The ram is made of special steel, finish ground, and has an accurately reamed No. 2 Morse Taper hole for the tailstock center. Turning the tailstock hand wheel in a counter-clockwise direction to the end of its travel automatically ejects the center. Accurate graduations on the tailstock ram (Figure 27) simplify accurate boring and drilling. The inside tailstock bearing on the rear bed way is gibbed for take-up adjustment. Two gib screws, one on

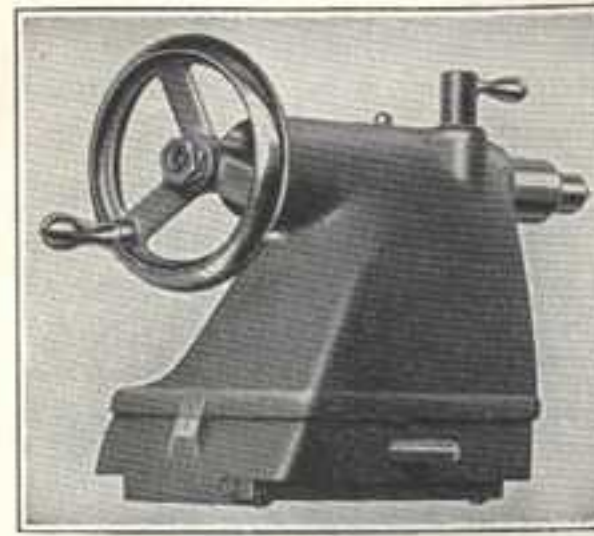
Rear View of Tailstock
Showing Gib

FIG. 27

View of lathe tailstock showing graduated ram and self-ejecting center. The heavy, well braced, grey iron casting assures plenty of strength for accurate turning between centers.

each end of the gib, regulate the tightness of the tailstock between the bed ways. These two screws should be adjusted evenly so that both ends of the gib will bear against the way with the same amount of pressure.

The tailstock can be set over $\frac{3}{4}$ inch for turning tapers. This is done by simply adjusting the two headless screws after loosening the tailstock clamp nut. Taper turning and the proper realigning of the tailstock are explained in Part 8 of this Manual. Keep the ram well oiled on the outside only. Before inserting the center in the tailstock ram, clean both tapers thoroughly with a dry cloth.

LATHE CENTERS

FIG. 28

Both the headstock and the tailstock centers are hardened and ground carbon tool steel—No. 2 Morse taper.



A sleeve is furnished to adapt the standard No. 2 Morse Taper Center to the No. 3 Morse Taper headstock spindle nose. Before placing centers in the lathe, clean both external and internal tapers thoroughly with a dry cloth. Any dirt or chips between these tapers will score both and destroy their accuracy. Do not oil the tapers. Even a slight film of oil will prevent a firm fit and cause trouble in turning.

It is vitally important to keep all tapers very clean.

THREADING GEARS

All threads, either right or left hand, from 4 to 96 per inch in the following standards can be cut with the change gears and threading dial furnished as standard equipment: all National Form threads including National Coarse (U.S.S.), National Fine (S.A.E.), Acme, Square and Whitworth. All standard metric threads from .5 to 7 mm. can be cut with the change gears furnished.



FIG. 29
Threading Gears.

Feeds are available for spring making, wire winding and electrical coil winding with all sizes of wire between No. 12 and 40 B. & S. and all types of magnet wire insulation. Multiple threads, machine screws, pipe-type threads and special screws can also be cut with the standard gears furnished. Complete set-ups and directions for the most common threads and feeds are given in the Threading Supplement.

ZAMAK PARTS

An outstanding improvement in screw cutting lathe manufacture was the use of the modern alloy "Zamak." Gears, pulleys, handwheels, reverse mechanism, lead screw bearing, and other small parts are made of this metal. Radical improvements in design and added strength have resulted.

Zamak is an alloy composed of aluminum, magnesium, copper and zinc. Its tensile strength is over twice that of cast iron. Its impact strength is over four times that of cast iron. Exhaustive

EQUIPMENT USED IN MANUFACTURING ZAMAK PARTS

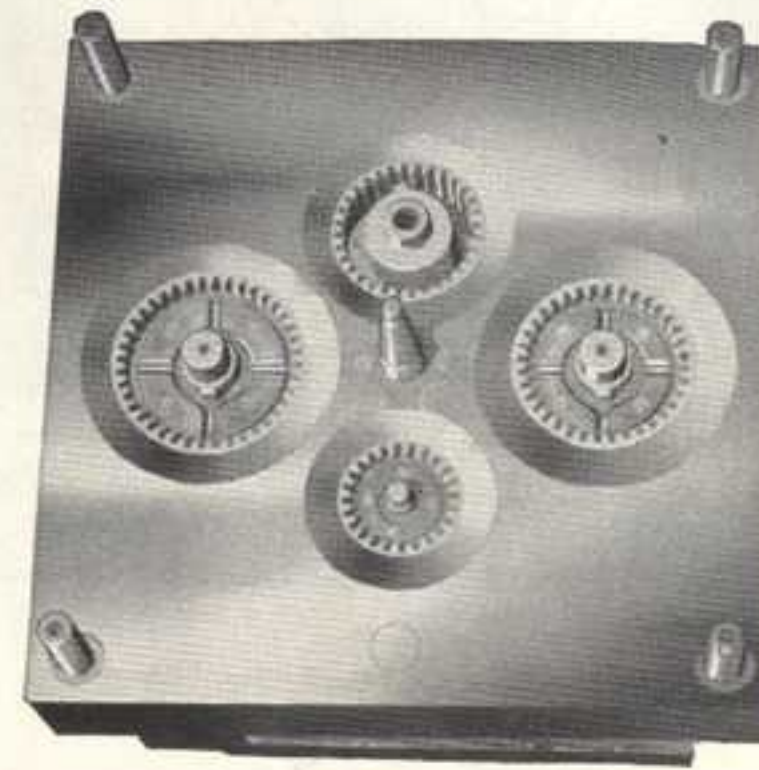


FIG. 31
The type of precision, hand made dies used in the manufacture of Zamak parts.

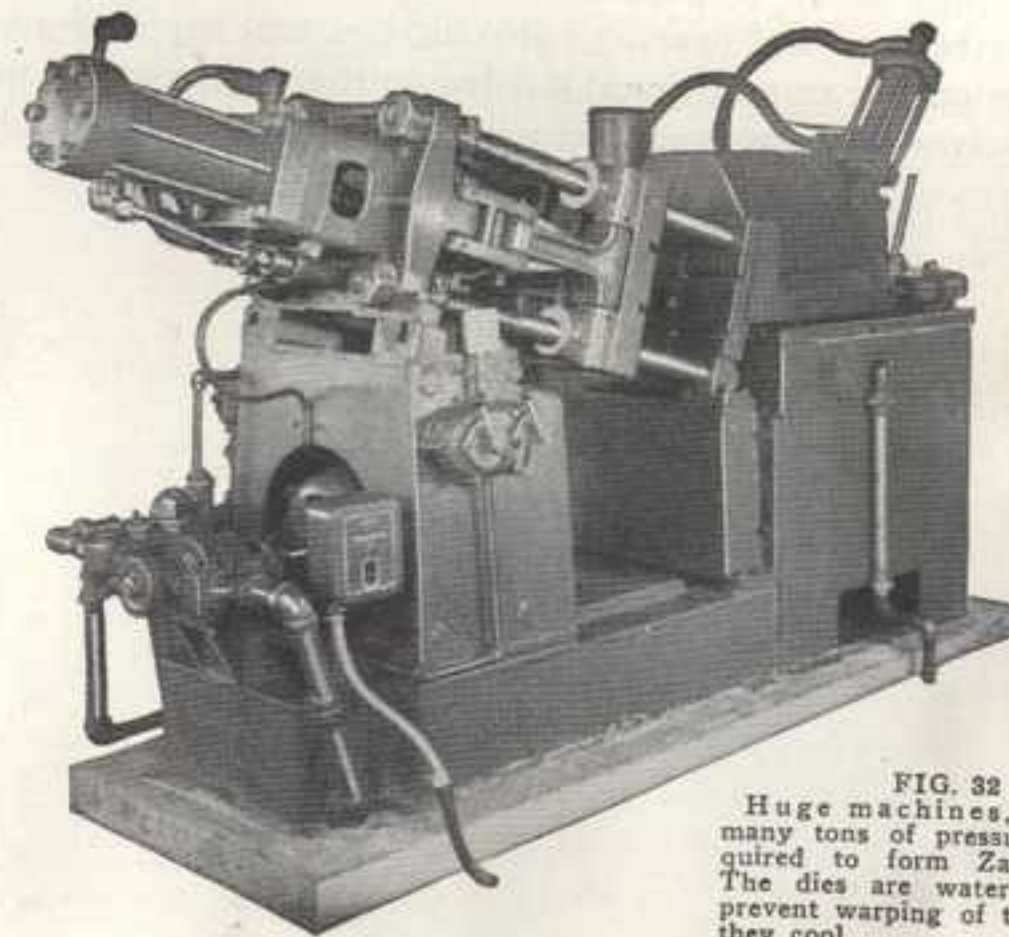


FIG. 32
Huge machines, exerting many tons of pressure, are required to form Zamak parts. The dies are water cooled to prevent warping of the parts as they cool.

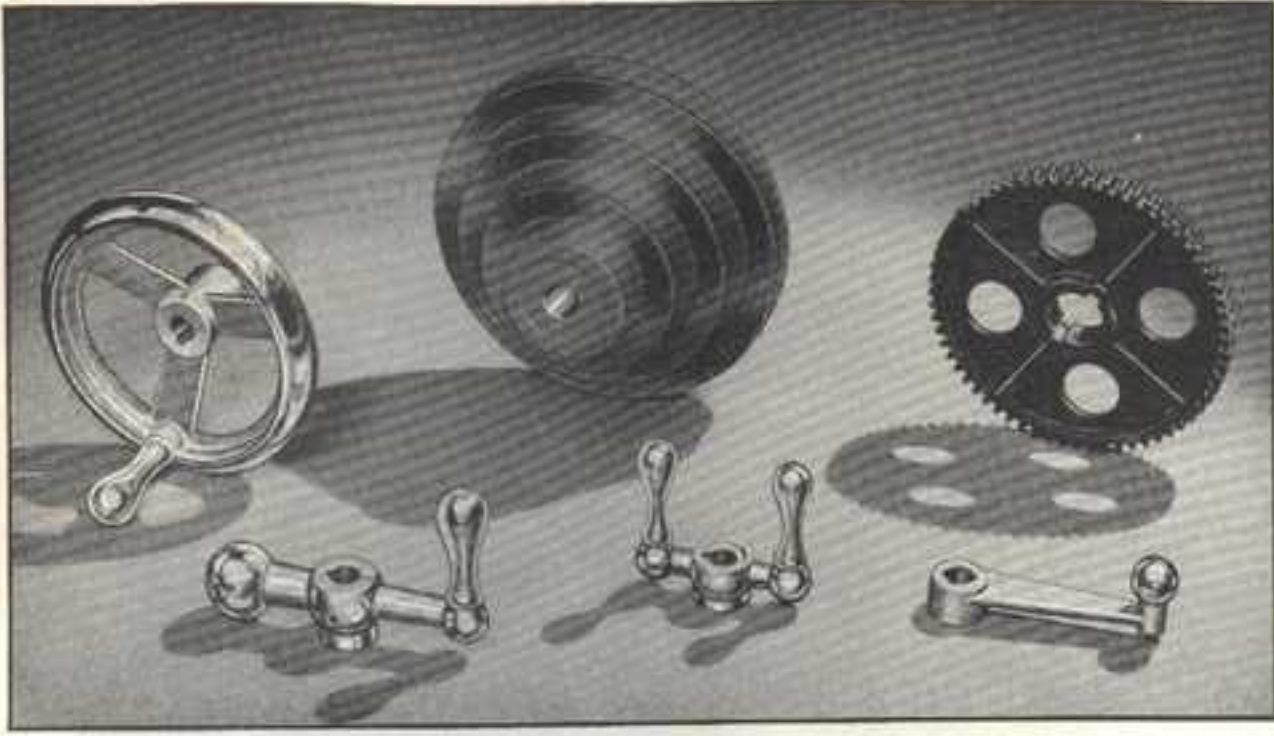


FIG. 30
Lathe parts made of the rugged alloy, "Zamak."

laboratory research and the practical experience of lathe owners have proved the superior wearing qualities of Zamak.

Small part production costs are lowered by the use of Zamak. These savings make it possible to supply more complete equipment, a better bed and bearing construction, and superior accuracy without imposing an additional burden on the purchaser. A modern lathe requires modern manufacturing methods and materials.

Part 2

THEORY OF METAL CUTTING

THEORY OF METAL CUTTING

Every lathe owner should have a basic knowledge of the cutting action of the tool bit. With this knowledge the lathe tool can be properly ground and applied to the work. Extreme care is taken in the design and manufacture of the modern lathe to provide maximum accuracy and rigidity. Clean, accurate lathe work results only when equal care is taken in the grinding and use of the cutting tool. In the next three sections of this Manual are given actual "reasons why" tool bits are ground to certain angles, how tools are set into the work and what tools are used for different types of work. One important point must always be remembered — *Use Sharp Tools!* Nothing is more essential for clean, accurate lathe work or does more to lengthen lathe life.

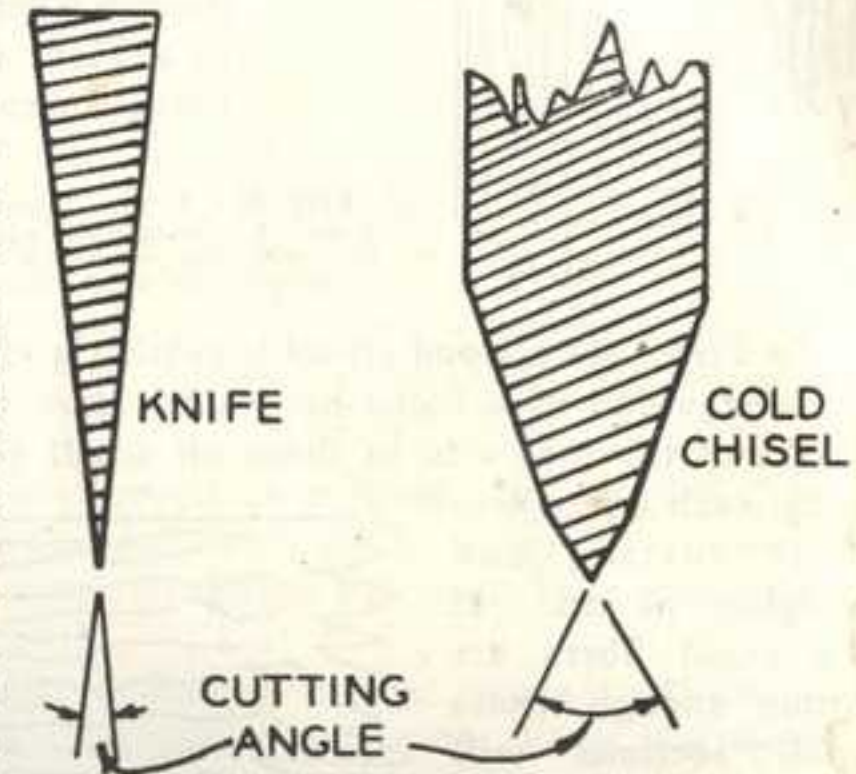


FIG. 33
Cross sections of a knife and a cold chisel, showing the great difference in cutting angles.

THE WEDGING ACTION OF CUTTING TOOLS

All cutting tools employ a wedging action. The differences are in the angle of the two sides of the tool which form the cutting edge and the manner in which the tool is applied to the work. The edge of a pocket knife would be ruined in trying to cut a nail, even though the metal in the knife is much harder than that in the nail. A cold chisel, however, shows no signs of damage in cutting the same nail, although the chisel is usually a poorer grade of steel than the knife. Obviously, the difference lies in the angle of the tool. Figure 33 shows these two tools in profile.

COMPARISON WITH WOOD TOOLS

Figure 34 shows the action of a knife in cutting a piece of wood. Notice that the cutting edge of the tool is used only in the first entering cut. All wood cutting tools operate on this principle, although when cutting across grain in a piece of hardwood, the action is more complex.

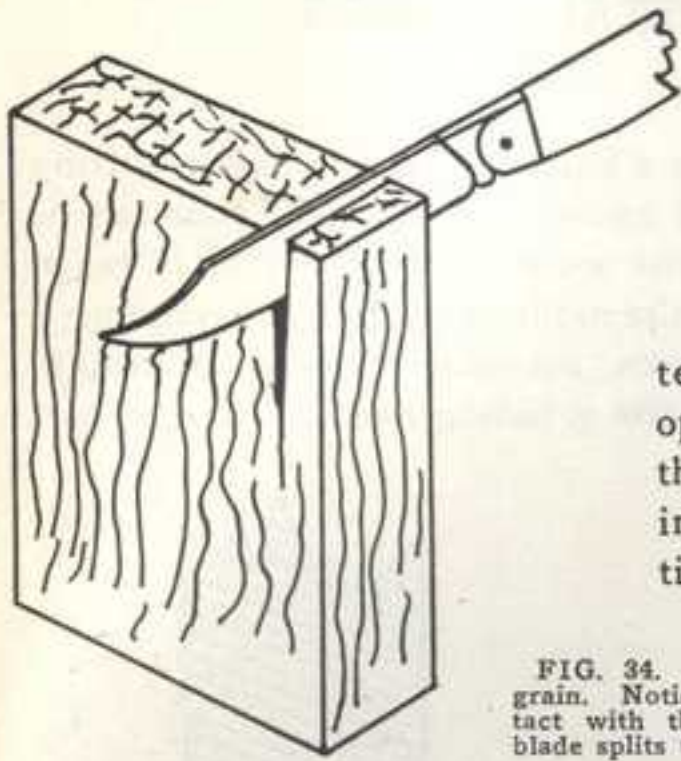


FIG. 34. A knife slicing a block of wood with the grain. Notice that the edge of the knife is not in contact with the wood—the wedging action of the knife blade splits the wood ahead of the edge.

In Figure 35 a wood chisel is cutting a slice across the end of a block of wood. Here the wedge of the tool acts to shear off small sections, each one a separate cutting and wedging action. If the wood fibers are strong enough, these small sections will cling together and result in a curled chip.

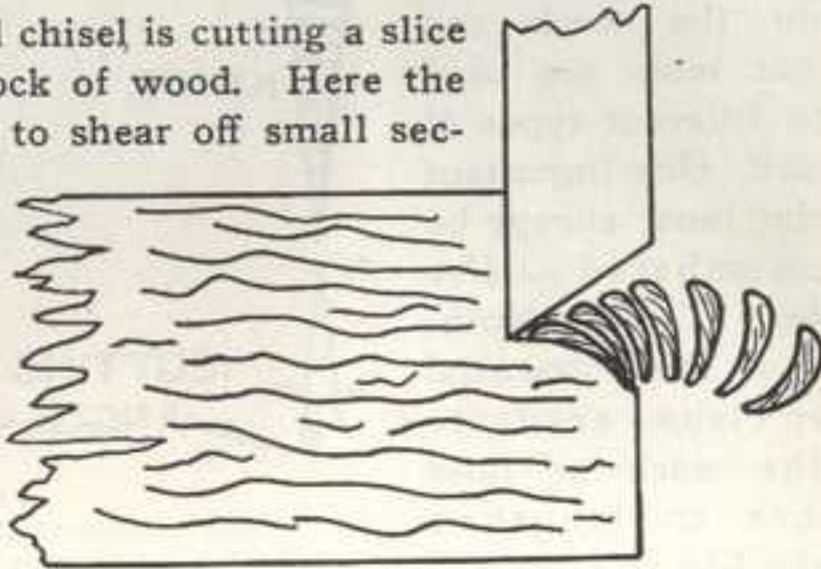


FIG. 35
A wood chisel cutting across the end of a block of hard wood. The small sections are exaggerated in size.

DIFFERENCES BETWEEN WOOD and METAL-CUTTING

Wood cutting tools are usually not clamped in a fixed position, but guided by the operator. Metal cutting, on the other hand, requires holding both the work and the tool as firmly as possible. Absolute rigidity is impossible to attain, but every effort should be made to approach it.

The cutting edge of a lathe tool for metal turning is ground to an angle of between sixty and ninety degrees. This wedge angle must be large because the tool edge must stand up under enormous pressure—an actual downward pressure as high as 250,000 pounds per square inch has been measured on a lathe tool in turning steel.

METAL CUTTING ACTION

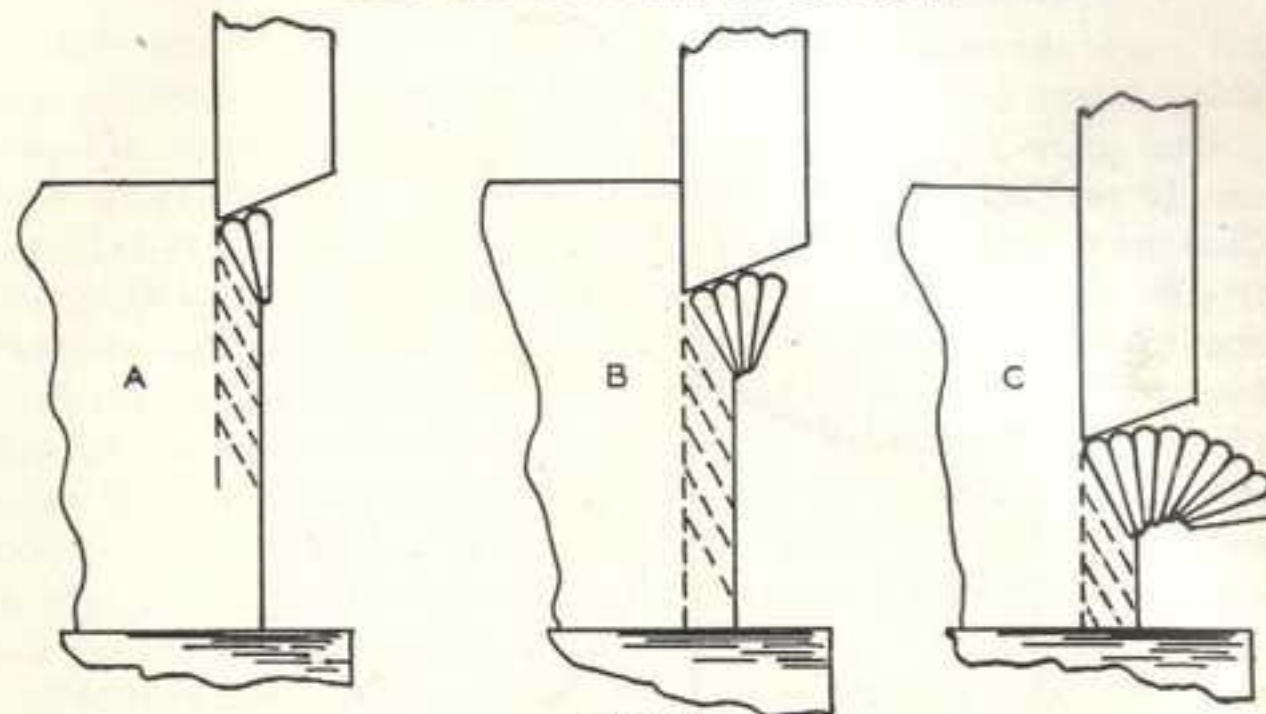


FIG. 36

Progressive steps in metal cutting. At "A" the tool is just entering the metal; at "B" the cut has progressed to a point where the triangular shape of the small sections can be seen. "C" shows the start of the curled chip. For clearness, a straight shear cut is illustrated and the size of the small sections greatly exaggerated.

Figure 36 shows the action of a metal cutting tool. It is assumed that both the tool and work are held rigidly. A shearing cut is pictured—lathe cuts are similar but made on a rounded surface.

The first action, Figure 36A, is that of the tool edge forcing into the metal—an entering cut. Figure 36B shows the wedging action more clearly, the angle of the tool forcing the metal apart and the compression squeezing the small sections into triangular shapes. Figure 36C illustrates the tool further advanced, with the sheared sections forming the start of a curled chip.

There is sufficient force from the wedge of the tool to shear off small sections of the work at short intervals. The cut is not continuous but has a finite fluctuation period measured in small fractions of a second. The wedging force rises to the shearing limit of the small section, drops and gradually rises again until the next section shears, and so on. If this fluctuation time happens to synchronize with the natural vibration period of any part of the tool, holder, or work, a vibration called "chatter" occurs.

It must be realized that the chip and the small sections in Figure 36 are greatly exaggerated in size. Actually, the chip is only several thousandths of an inch in thickness. The deformation of the metal on the inside of a reasonably thick chip can be seen clearly.

FALSE CUTTING EDGE ON THE TOOL

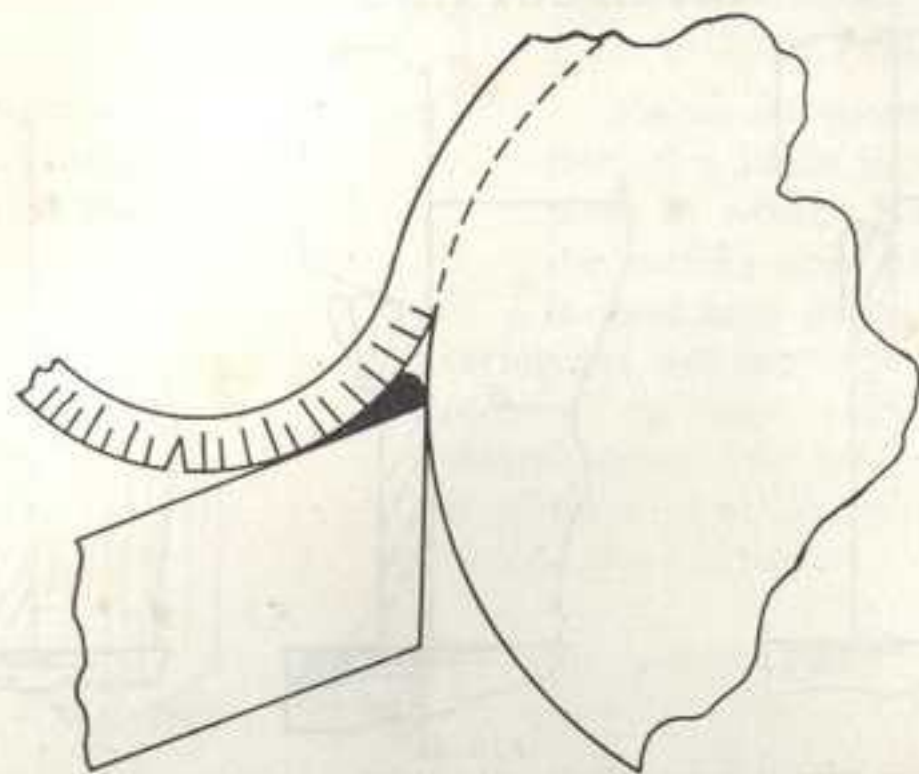


FIG. 37
The false cutting edge formed at the tip of a tool bit. The dark portion is deposited on the tool when taking heavy cuts. The wedging or cutting is done with this bit of metal, not the edge of the tool bit.

A tool bit that has been used on rather heavy cuts has a small ridge of metal directly over the cutting edge. This bit of metal is much harder than the metal being cut and is almost welded to the edge of the tool, indicating that an immense amount of heat and pressure was developed at this point.

This "false cutting edge" acts as the actual cutting edge in turning. It is a decided advantage in heavy turning because it relieves the edge of the tool bit from most of the work of cutting and lengthens tool life. For continuous heavy cuts, the speed should be kept low enough, and the rake of the tool small enough in order to build up this false edge. However, in taking fine finishing cuts, this built-up edge should be avoided by taking finer cuts at higher speeds and with larger rake angles.

There are several theories as to the forming of this false cutting edge. It is generally agreed, however, that the cutting action, aided by the heat and pressure at the end of the tool bit, causes the metal particles to deform or flow which produces what is called "work hardening" of the metal. Whether it is due to the compression of a small strip of metal ahead of the edge of the tool itself, or is simply a work-hardened portion of the main chip is a debated question. The important point to remember is that the false cutting edge is desirable for heavy cuts—on fine finish cuts it should be avoided.

THE SHARPNESS OF THE TOOL EDGE

How fine the edge of a tool bit should be depends upon the class of work (roughing or finishing) and upon the metal being cut. For heavy roughing cuts in steel, there is no point in honing the edge of the tool. A fine edge lasts for only a few feet of cutting, then it rounds off to a more solid edge and remains in approximately this same condition until the tool breaks down. A 60 grit wheel is satisfactory for grinding tools for heavy roughing cuts.

For fine finishing cuts, the tool should be ground to shape and then honed with a reasonably fine stone. In most instances, the finish is directly dependent upon the keenness of the edge of the tool. Tools for soft metals should be honed carefully to as fine an edge as possible—both the cutting action and the finished surface depend upon the edge of the tool.

For threading tools, grinding on a 60 grit wheel is sufficient for roughing cuts, but the edge of the tool should be honed before taking the finish cuts.

HEAT DEVELOPED IN CUTTING METAL

All of the power used in cutting metal is ultimately expended in heat. The shearing of the chip by the wedging action of the tool, the small sections of metal sliding over each other, the back of the chip rubbing on the face of the tool bit, the compression at the point of the tool—all of these actions generate heat which must be dissipated. The tool should have a large cutting angle to help carry this heat away from the cutting edge as rapidly as possible.

In production work, where high speed is important, coolants composed of various chemical mixtures help absorb this heat from the edge of the tool—a steady stream of cutting compound is directed at the point of the tool so that it spreads and covers both the tool and the work. A large pan under the lathe bed collects this compound, carries it to a settling tank and then to a pump.

Coolants are seldom used in small lathe work. Ordinary cutting is done dry, or sometimes with the aid of a cutting oil for lubrication only. It must be remembered when cutting dry, that the work will heat considerably higher than the surrounding temperature, often as much as 100° Fahr. This increase in temperature causes the work to expand, and the tightness of the lathe centers should be watched carefully. In taking measurements with a caliper or micrometer, be sure to cool the work before measuring to a final dimension.

Part 3

CUTTING TOOLS

PART 3

CUTTING TOOLS

LATHE TOOL BIT DESIGN

The angles of the top and sides of lathe tool bits, together with their official A.S.M.E. designations, are shown in Figures 38A, 38B and 38C.

TOP RAKE ANGLES

In the preceding section of this Manual it has been shown that the wedge or cutting angle should be as large as possible for maximum strength at the edge and to carry heat away from the cutting edge. On the other hand, the larger the wedge angle the greater the power required to force it into the work. Thus, there are two opposing factors and a compromise between them is necessary in arriving at the best rake angles. There has been a great amount of experimental work in this connection, notably by F. W. Taylor and O. W. Boston. Recommended values of both back and side rake for the various kinds of metal have been determined. Rake angles for general use with many types of metals and plastics are given in Part 4 of this Manual.

CLEARANCE ANGLES

Clearance angles allow the part of the tool bit directly under the cutting edge to clear the work while taking a chip. Too much clearance weakens the cutting edge, and the high pressure exerted downward on the tool bit demands that clearance be as small as possible and still allow the tool to cut properly.

A tool with excessive clearance also has a tendency to chatter. Taylor's experiments showed that for hand ground tools a side clearance of 12° and a front clearance of 8° is satisfactory for general turning of steel. The larger side clearance is necessary because the lathe tool feeds and cuts at the same time, making the actual path of the tool helical, or spiral, instead of straight. Recommended angles of clearance for metals other than steel are given in Part 4 of this Manual.

Whenever the tool digs into the work or refuses to cut unless forced, check the clearance of the tool bit. Digging-in occurs most often during facing and threading operations. For light turning it is usually better to allow just a little more than enough clearance rather than to risk having too little.

LATHE TOOL BIT DESIGN OFFICIAL A.S.M.E. DESIGNATIONS OF TOOL BIT ANGLES

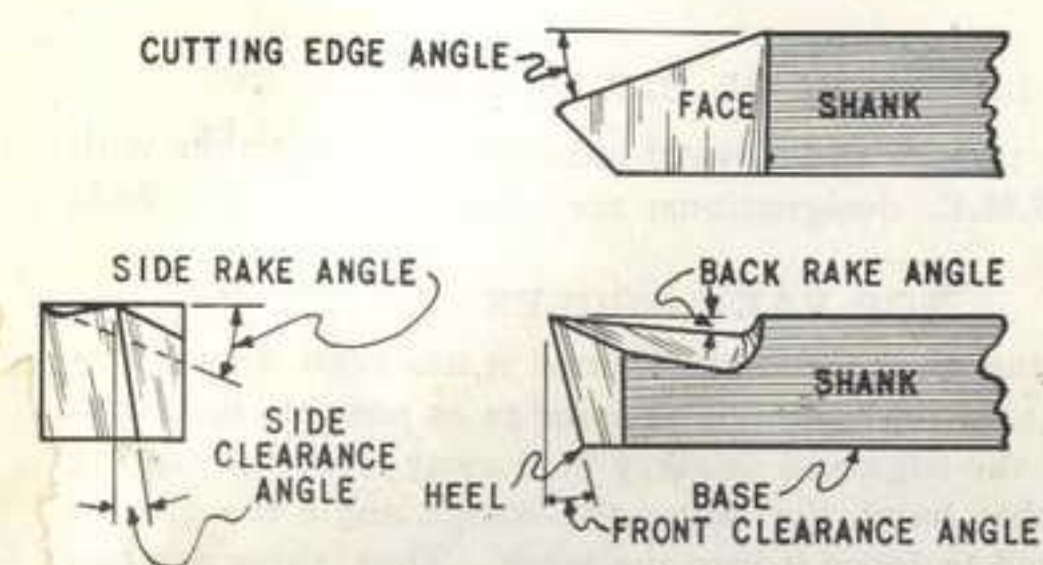


FIG. 38A

Tool bit angles with the tool bit horizontal and at a right angle with the centerline of the work.

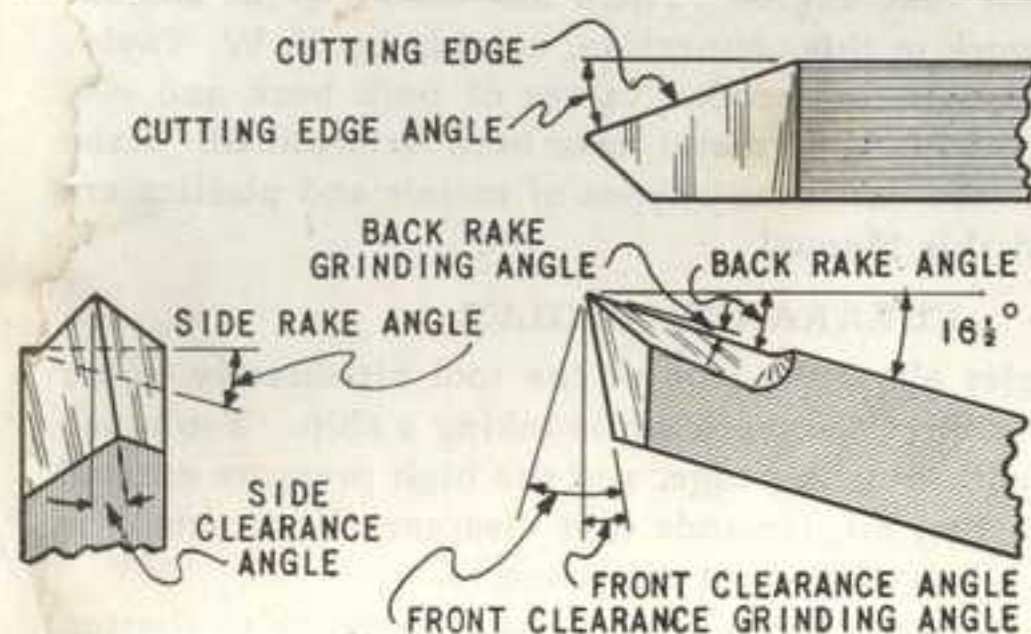


FIG. 38B

Tool bit angles as designated for use in the tool holder.

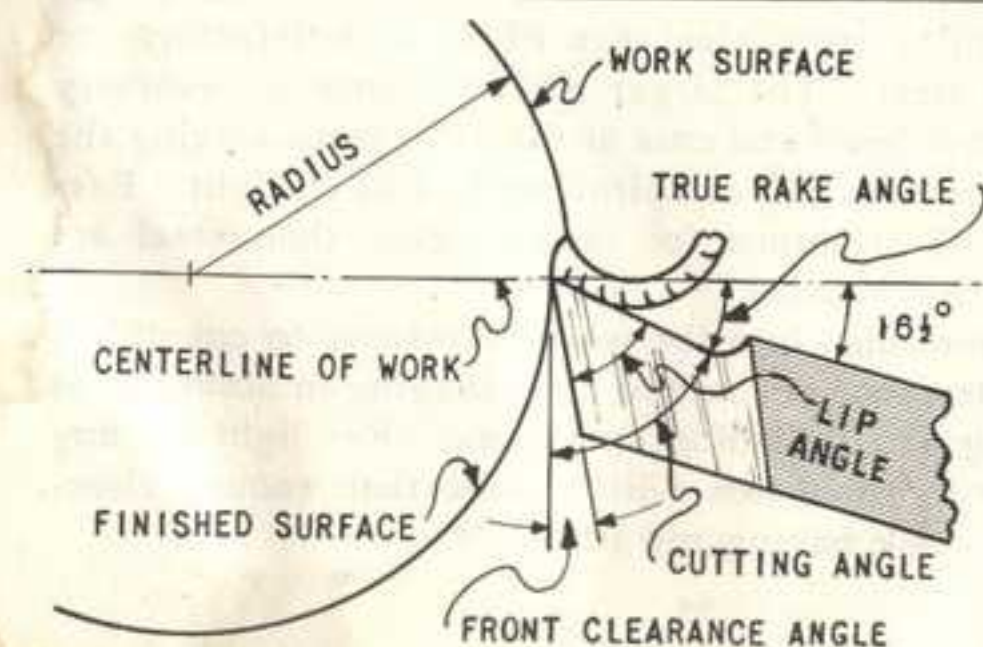


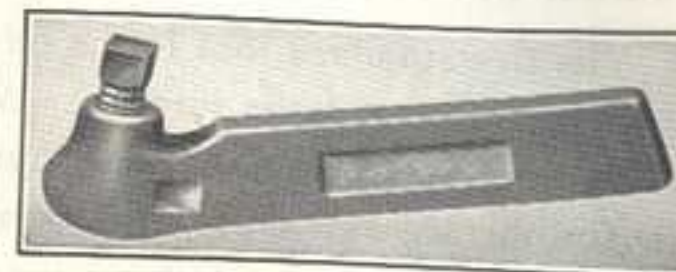
FIG. 38C

Angles of the tool bit in relation to the work.

THE TOOL HOLDER

FIG. 39

A tool holder for holding $\frac{1}{4}'' \times \frac{1}{4}''$ tool bits. This holder makes unnecessary the use of larger forged tools of expensive high speed steel and provides a $16\frac{1}{2}^\circ$ front rake angle without spoiling the entire end of the tool.



Tool holders of the type shown in Figure 39 are used universally on engine lathes, permitting the use of small, inexpensive and replaceable tool bits. The tool bit is set at an angle of $16\frac{1}{2}^\circ$. This angle serves two purposes: it provides a front rake angle without spoiling the entire end of the tool, and it directs a large portion of the cutting pressure directly toward the base of the tool post. Allowance for this $16\frac{1}{2}^\circ$ angle must be made when grinding tool bits for use in the tool holder. All of the angles and diagrams in this and the following section take this angle into account.

In order to avoid undesirable overhang, tool bits should be clamped so that the cutting end of the tool bit is as close to the tool holder as the work will permit — also the end of the tool holder which holds the tool bit should be as close to the tool post as possible.

GRINDING TOOL BITS

Figures 40 through 44 show five forms of tool bits for use in the tool holder. These shapes are suitable for practically all lathe turning and the cutting of 60° V-type threads. Part 4 includes correct clearance and rake angles for using these tool shapes in the machining of many different metals, alloys and plastics. Threading and boring tools are described in detail in later sections of this Manual.

A good tool grinder is essential, preferably motor driven such as the one shown in Figure 45. The grinder should have one medium grit wheel (about 60 grit) on which high speed tool bits can be ground. Some practice is necessary before tools can be properly ground but by following carefully the directions given in this section, the beginner will soon become adept at this important part of lathe operation.

The tool can be sharpened on either the side or the face of the wheel, although the regular cutting face is used by most machinists and generally considered better grinding practice. Grind the shapes and angles as directed to within reasonable limits. Be careful not to burn the edges—a cup of water should be kept handy to cool the tool and avoid spoiling the temper of the steel.

Always keep tools sharp.

TOOL BIT SHAPES FOR USE IN THE TOOL HOLDER

The five standard tool forms on these two pages will be found suitable for most lathe turning. When grinding tools for special work, simply keep in mind the shapes and angles recommended for general turning and apply these principles to the special tool being ground. See the examples on page 41.

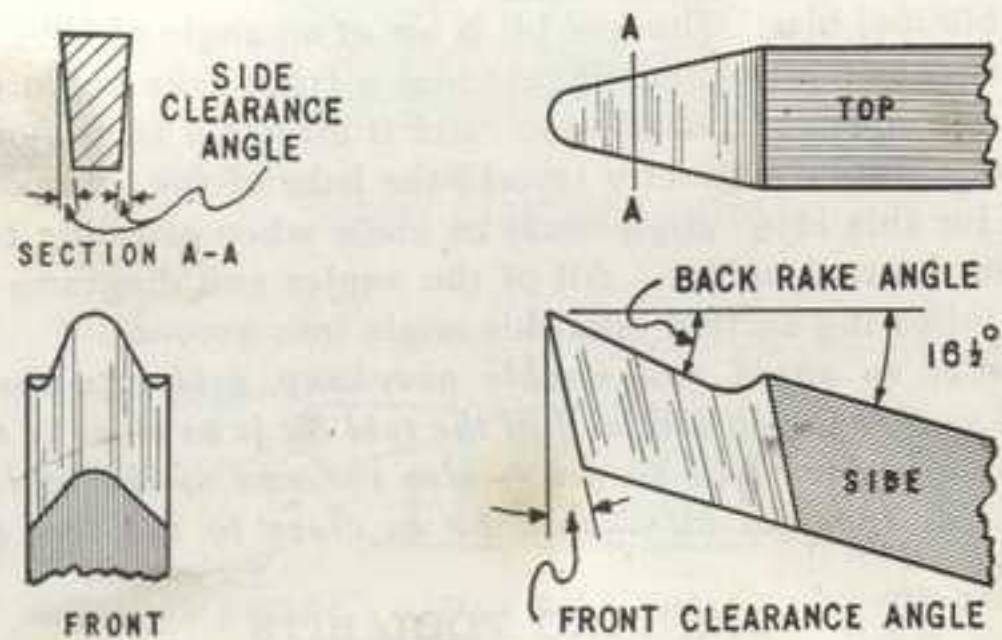


FIG. 40. Round Nose Cutting Tool suitable for roughing and general purpose turning.

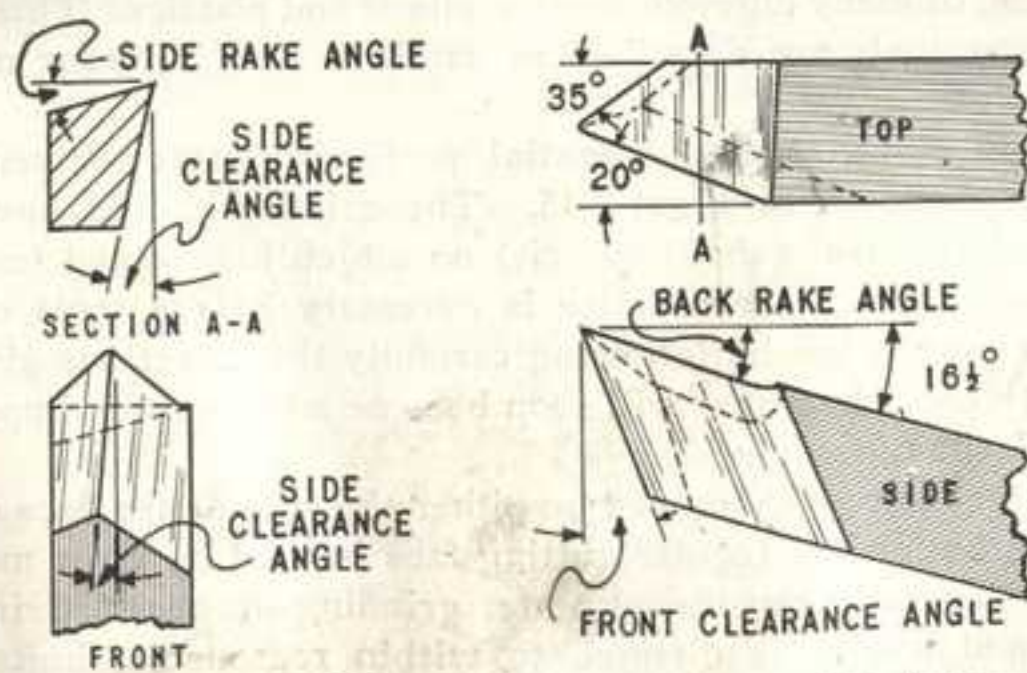


FIG. 41. Excellent R. H. Tool for general turning and shouldering toward headstock; also facing. Point should be rounded for finishing work.

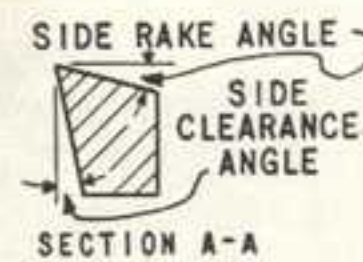


FIG. 42

Excellent L. H. Tool for general turning and shouldering toward tailstock; also facing. Point should be rounded for finishing work.

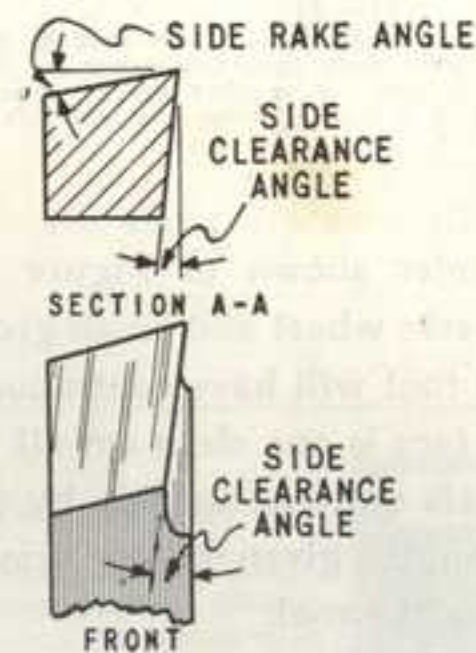
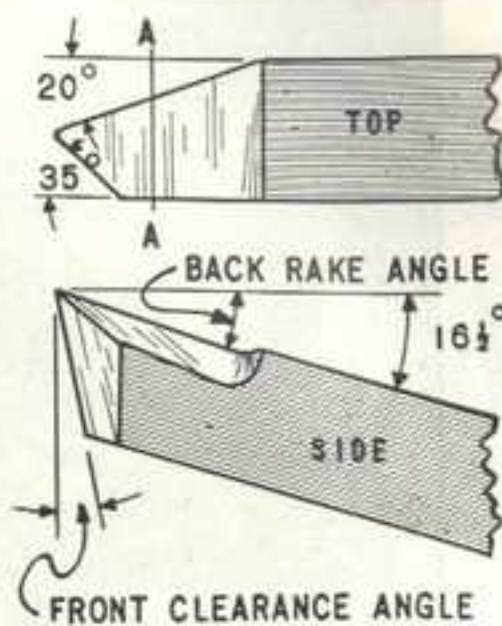
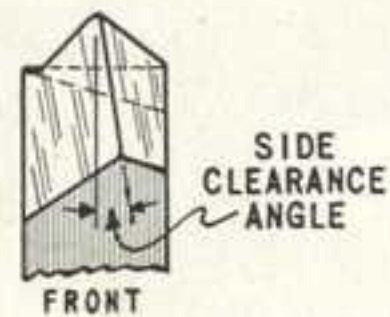


FIG. 43

Heavy Duty R. H. Roughing Tool for taking deep cuts toward headstock. Clearance and rake angles should be reversed for L. H. turning.

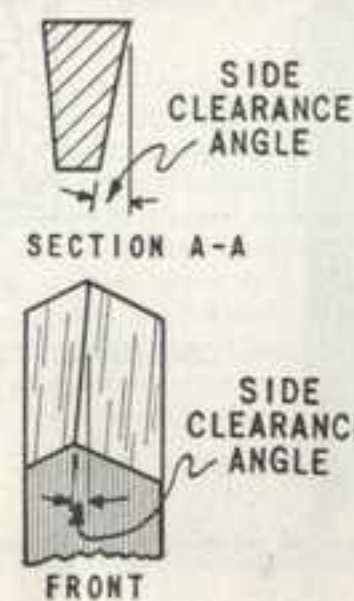
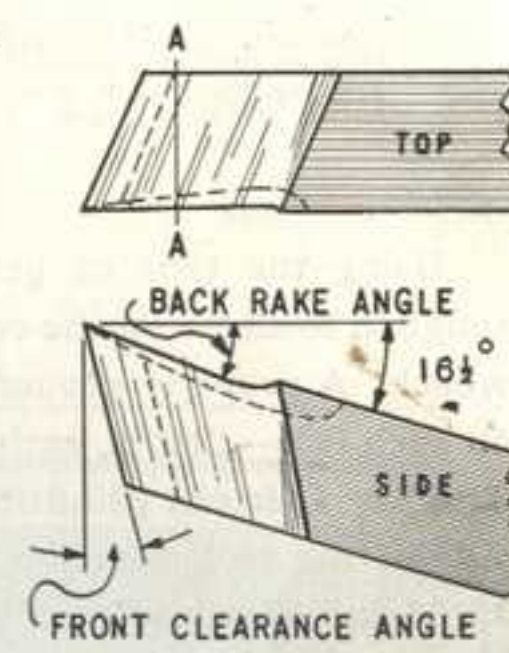
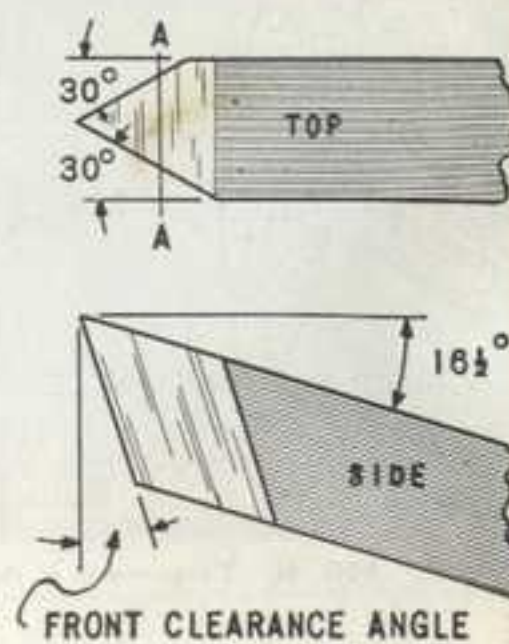


FIG. 44

R. H. 60° V-Type Threading Tool for cutting toward headstock. Side clearance angle should be reversed for L. H. threading.



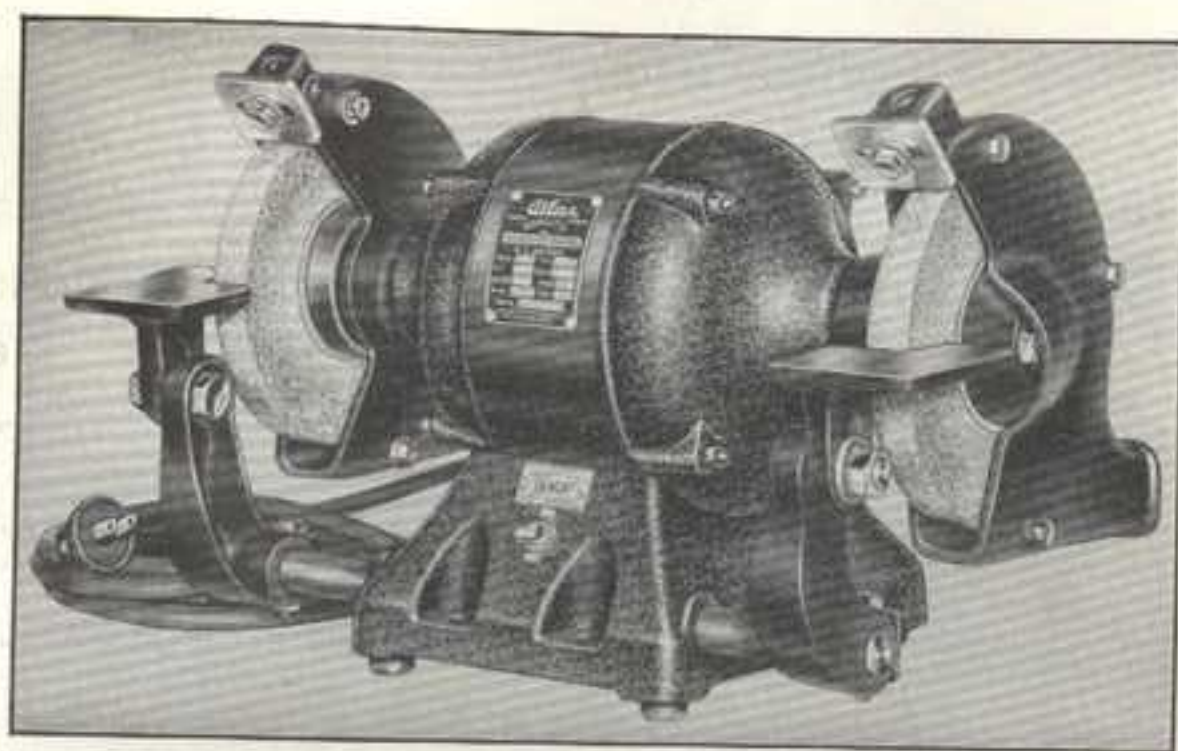


FIG. 45

An ideal type of tool grinder. A $\frac{1}{2}$ or $\frac{3}{4}$ H. P. 3450 R. P. M. motor, fully enclosed and protected from dust, furnishes power for fast, accurate grinding. The right wheel is used for rougher grades of work and the left for smooth finishing. Floor pedestals, water pot and safety eyeshields are available.

Using the type of grinder shown in Figure 45, the tool is roughed to shape on the coarse wheel and finish ground on the fine wheel. A properly ground tool will have continuous wheel marks on each face—that is, each face is one clean cut all the way across. The beginner can grind tools quite accurately by comparing each side of the tool with the angles given in the drawings on pages 36, 38 and 39, while grinding the tool.

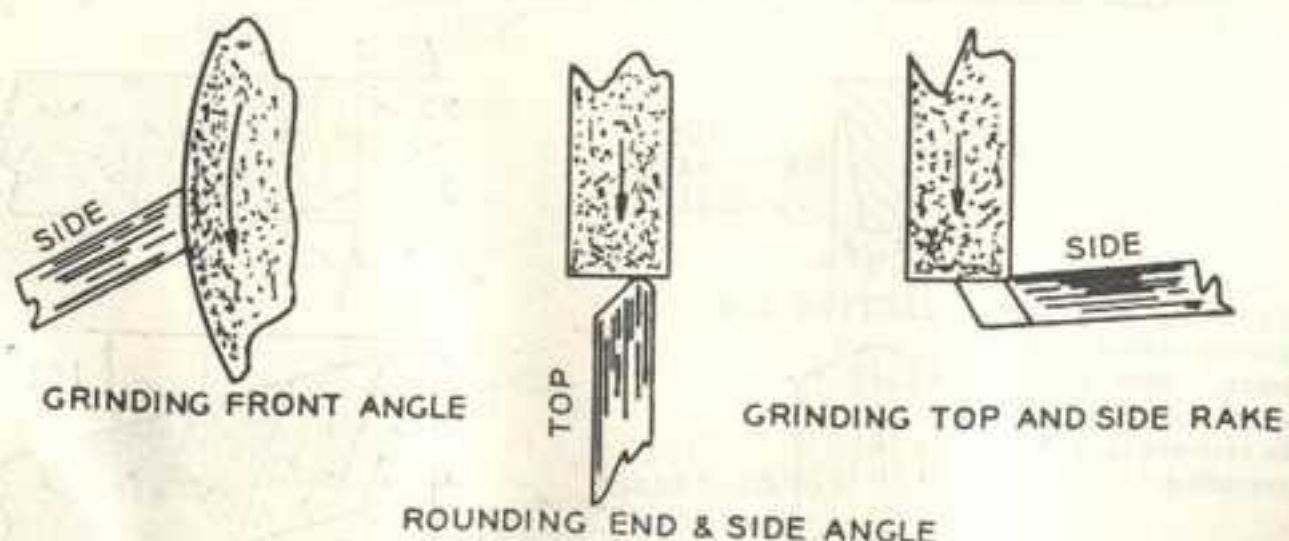


FIG. 46. Three views of the process of grinding a R. H. turning tool bit.

SPECIAL FORM-CUTTING TOOLS

In using form tools with side faces such as shown in Figures 47A and 47D, side rake is out of the question. Front rake, however, should be used except when turning brass. It is recommended that tools wider than $\frac{1}{8}$ " never be used on steel. Form cutting tools as wide as $\frac{1}{2}$ " can be used on brass, aluminum and similar metals.

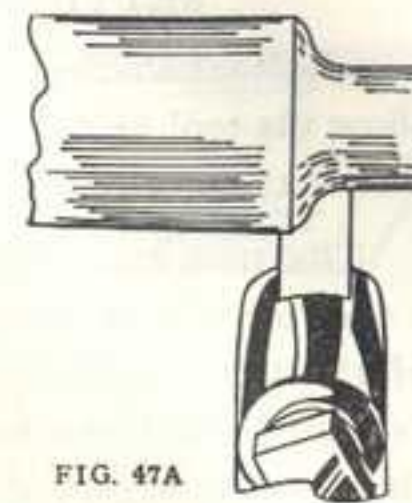


FIG. 47A

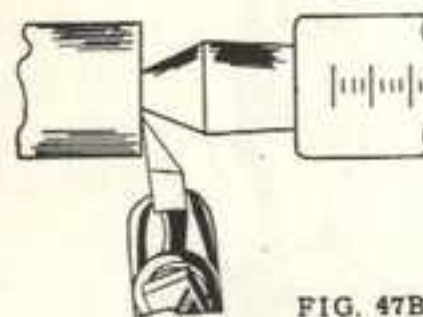


FIG. 47B

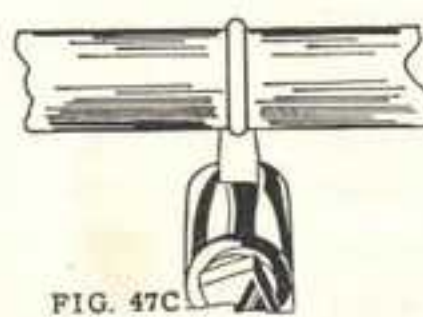


FIG. 47C

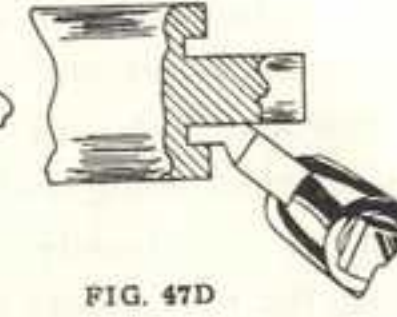


FIG. 47D

FIG. 48 WALL CHART

This large blueprint chart (18 $\frac{1}{4}$ " wide, 21" high) displays valuable reference data on lathe cutting tools and makes a useful wall piece for machinist, apprentice and student. Technical material in this chart has been adapted from "Manual of Lathe Operation."

"Lathe Cutting Tools" is one of a series of blueprint wall charts published by Atlas Press Company, Kalamazoo, Michigan. The complete series, covering important phases of lathe operation and machine shop practice, will be mailed upon request to any point in the United States. When ordering, enclose twenty-five cents for each set in coin or stamps to cover costs of printing and postage.



SETTING THE TOOL TO THE WORK

The tool shapes and angles appearing on the following pages show the tool being set approximately at right angles to the center line of the work (the line between the lathe centers).

The true rake angle of a tool bit is a combination of the front and side rake (see Fig. 38C) and can be changed slightly by swinging the tool at an angle with the work. For some cuts it is necessary to set the tool at an angle, and occasionally it will result in cleaner cuts and less chatter. Generally, however, the tool should be set directly into the work or at a slight angle as shown in Figure 49.

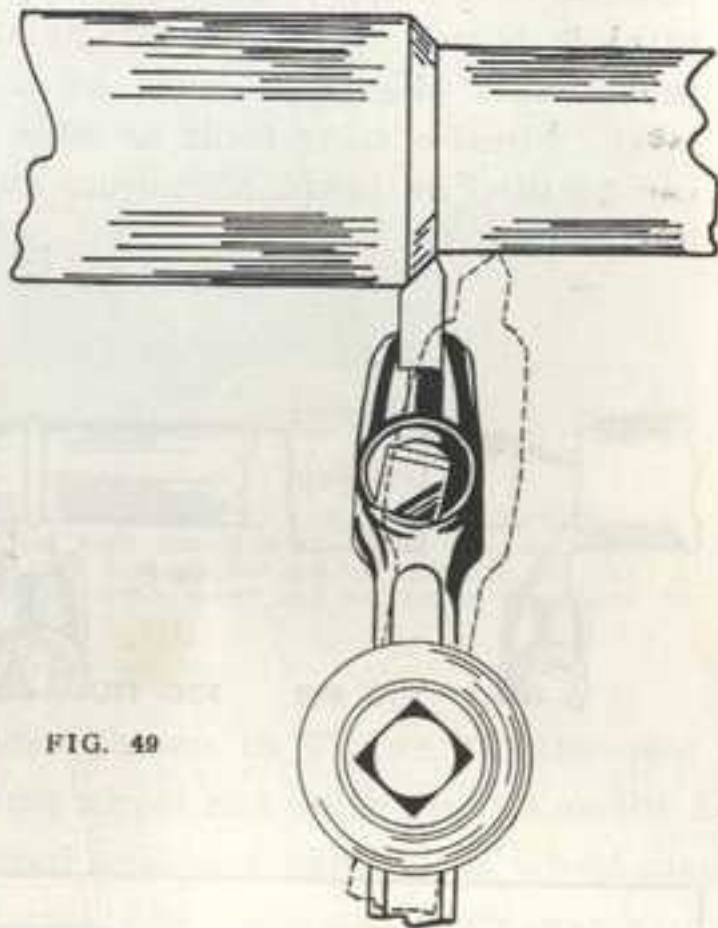


FIG. 49

TYPES OF TOOL HOLDERS



FIG. 50A

Top view of a R. H. Tool Holder. Used for cutting up to chucks, face plate, dogs, etc. at the headstock end of the work.



FIG. 50B

A Straight Tool Holder. Used for general cutting where no clearance is needed.

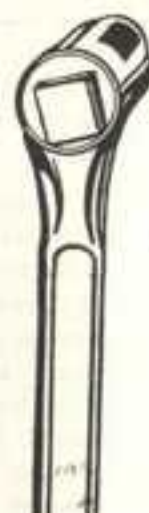
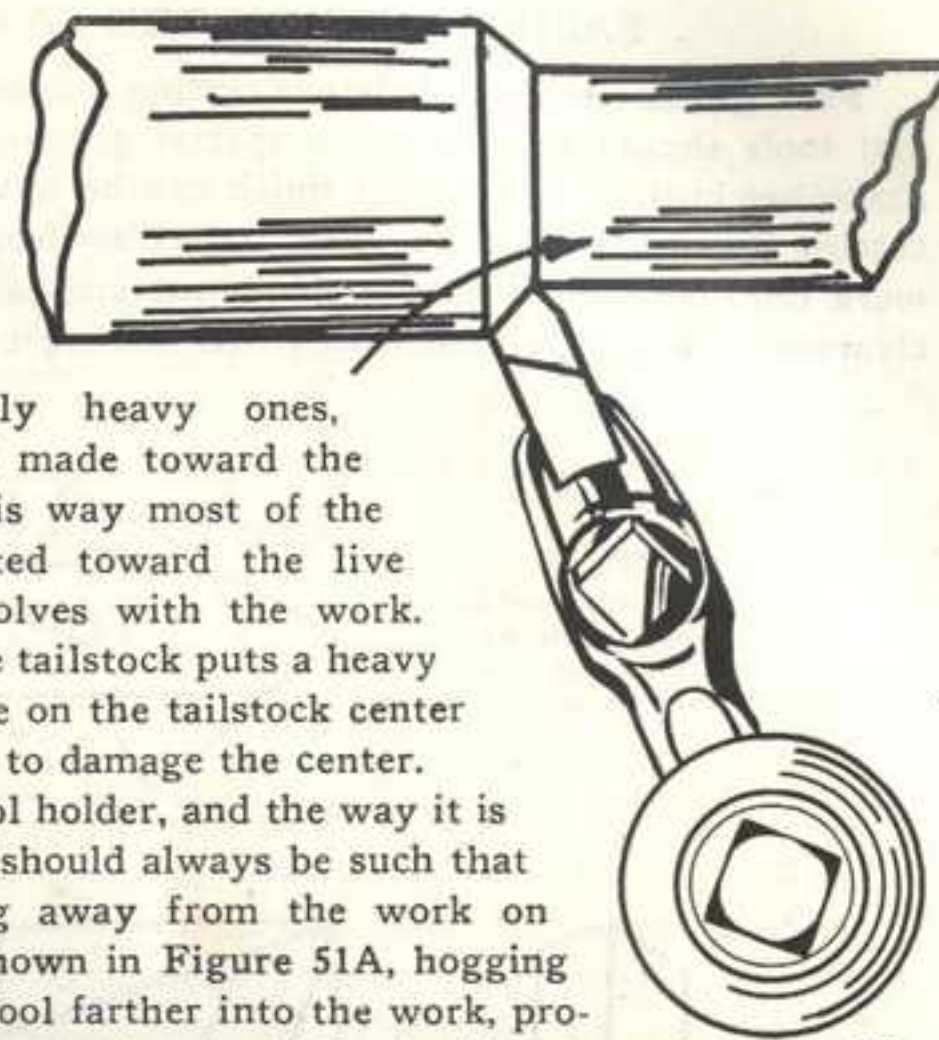


FIG. 50C

A L. H. Tool Holder. Used for cutting up to shoulders, projections, etc., at the tailstock end of the work.

FIG. 51A

When the tool is set like this, it tends to swing into the work on heavy cuts, producing rough work.



Cuts, especially heavy ones, should always be made toward the headstock. In this way most of the pressure is directed toward the live center which revolves with the work. Cutting toward the tailstock puts a heavy additional pressure on the tailstock center and is quite likely to damage the center.

The type of tool holder, and the way it is set into the work, should always be such that it tends to swing away from the work on heavy cuts. As shown in Figure 51A, hogging tends to pull the tool farther into the work, producing a rough, inaccurate cut. If the tool is set as shown in Figure 51B, it swings out away from the work. When cutting at an

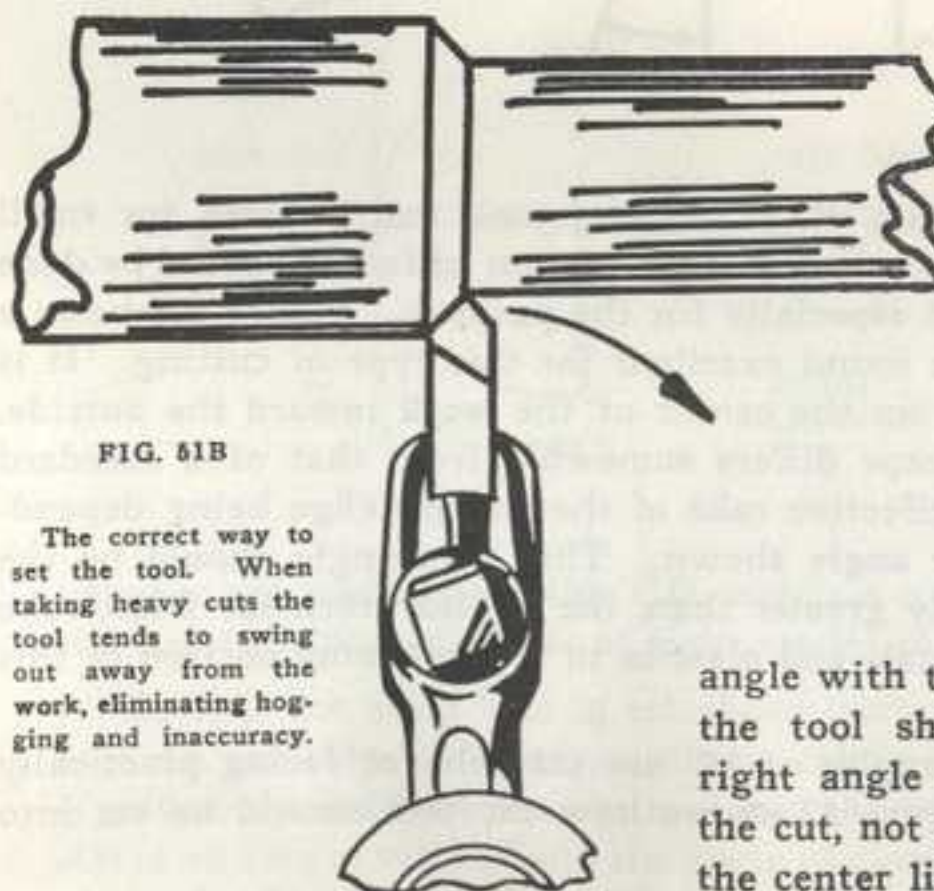


FIG. 51B

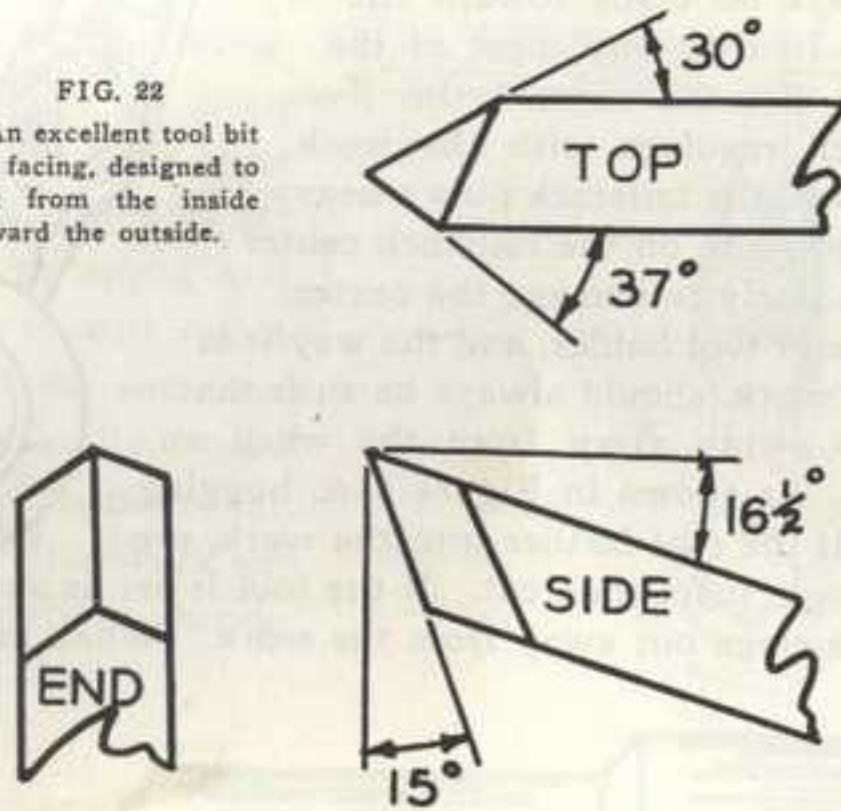
The correct way to set the tool. When taking heavy cuts the tool tends to swing out away from the work, eliminating hogging and inaccuracy.

angle with the compound rest, the tool should be set at a right angle to the surface of the cut, not at a right angle to the center line of the lathe.

FACING CUTS ON THE LATHE

Facing cuts represent different cutting relations and tool angles, and tools should preferably be special ground for that purpose. Smoother cutting and a finer finish can be obtained generally by cutting toward the outside—that is, feeding from the center of the work out. Inasmuch as the tool must cut to the center, larger clearances should be used than when turning cylindrical work.

FIG. 22
An excellent tool bit for facing, designed to cut from the inside toward the outside.

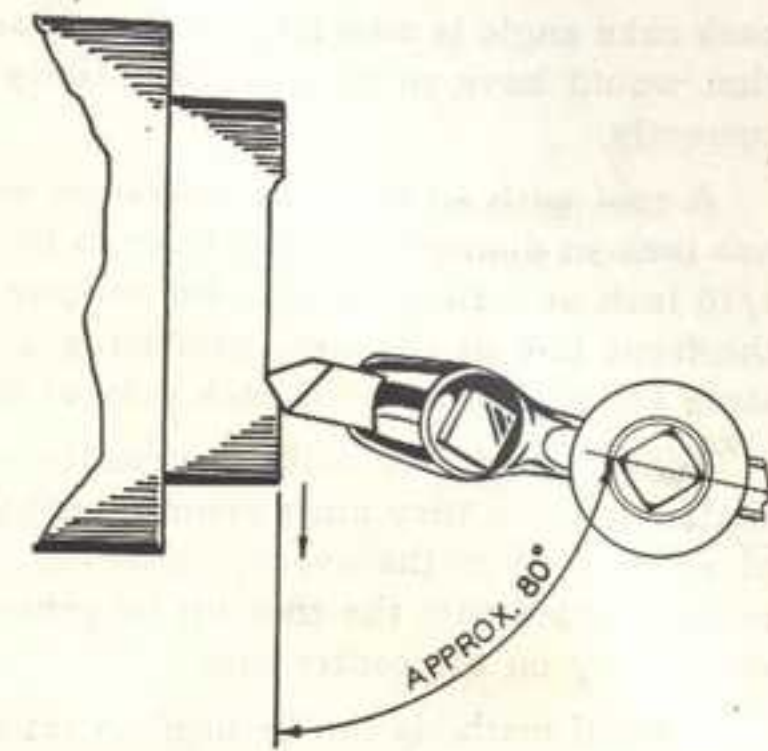


Although ordinary R. H. cutting tools can be used for small amounts of facing work, any large amount of facing should be done with a tool ground especially for the purpose. Figure 52 shows a tool which will be found excellent for this type of cutting. It is designed to cut from the center of the work toward the outside. Notice that the shape differs somewhat from that of a standard turning tool, the effective rake of the cutting edge being dependent upon the rake angle shown. This rake angle should be the same as, or slightly greater than, the angles given for front rake for the various metals and plastics in the following section of this Manual.

The clearance angles of 15° are suitable for facing practically any material. Figure 53 shows how the tool should be set into the work.

FIG. 53

When facing with a tool of the type shown in Figure 52, the tool should be set to the work in this manner. The angle of 80° is approximate and can be changed for the different types of facing tools.



SET THE POINT OF THE TOOL ON THE CENTER LINE

If the tool is ground properly, the point of the tool will not have to be set above or below the center line of the work. Figure 54A shows a tool bit with an 8° front clearance set into a piece of work exactly on the center line. The clearance angle is measured between the tool and the line AB, which is tangential to the work at the point of contact of the tool. The front rake is measured

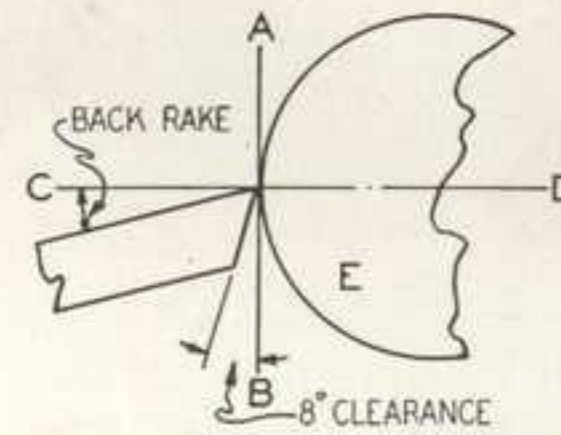


FIG. 54A

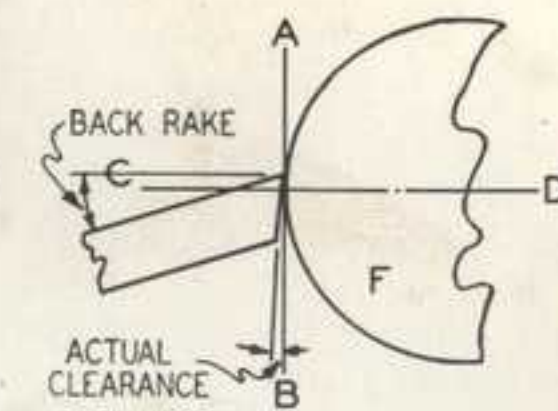


FIG. 54B

between the tool and the line CD, which is a radius of the work to the point of contact and is at right angles to the line AB.

Now, if the same tool is set above center as shown in Figure 54B, an entirely different condition exists. The front clearance is still measured between the tool and the tangential line AB, but AB is no longer vertical and the angle of clearance has been greatly reduced. The radius line CD has also been moved so that the

back rake angle is now larger. A tool set to the work in this position would have to be ground entirely different in order to cut correctly.

A tool with an 8° front clearance, working on a piece of stock one inch in diameter, would have to be set only a trifle more than $1/16$ inch above center in order to have the line AB coincide with the front line of the tool, producing a zero clearance. With the same setting, an original back rake of 20° would become 28° .

Some machinists make a practice of setting tools above the center line, but they must grind their tools especially for that type of setting. For the average operator, student or beginner, it is recommended that the tool bit be ground to the given angles and set exactly on the center line.

Several methods can be used to set the tool on the center line. The point can be lined up with either of the lathe centers, or the distance from the bed way to the headstock center can be measured and transferred. Another excellent method is to scribe a line along the tailstock ram: set a sharp pointed tool sidewise in the tool holder and align it with the headstock center. Then use this pointed tool to scribe a light line along the side of the tailstock ram (remove burr). This line will serve as a guide to set the tool, even when the work is in position between centers.

Part 4

THE MACHINING OF VARIOUS MATERIALS

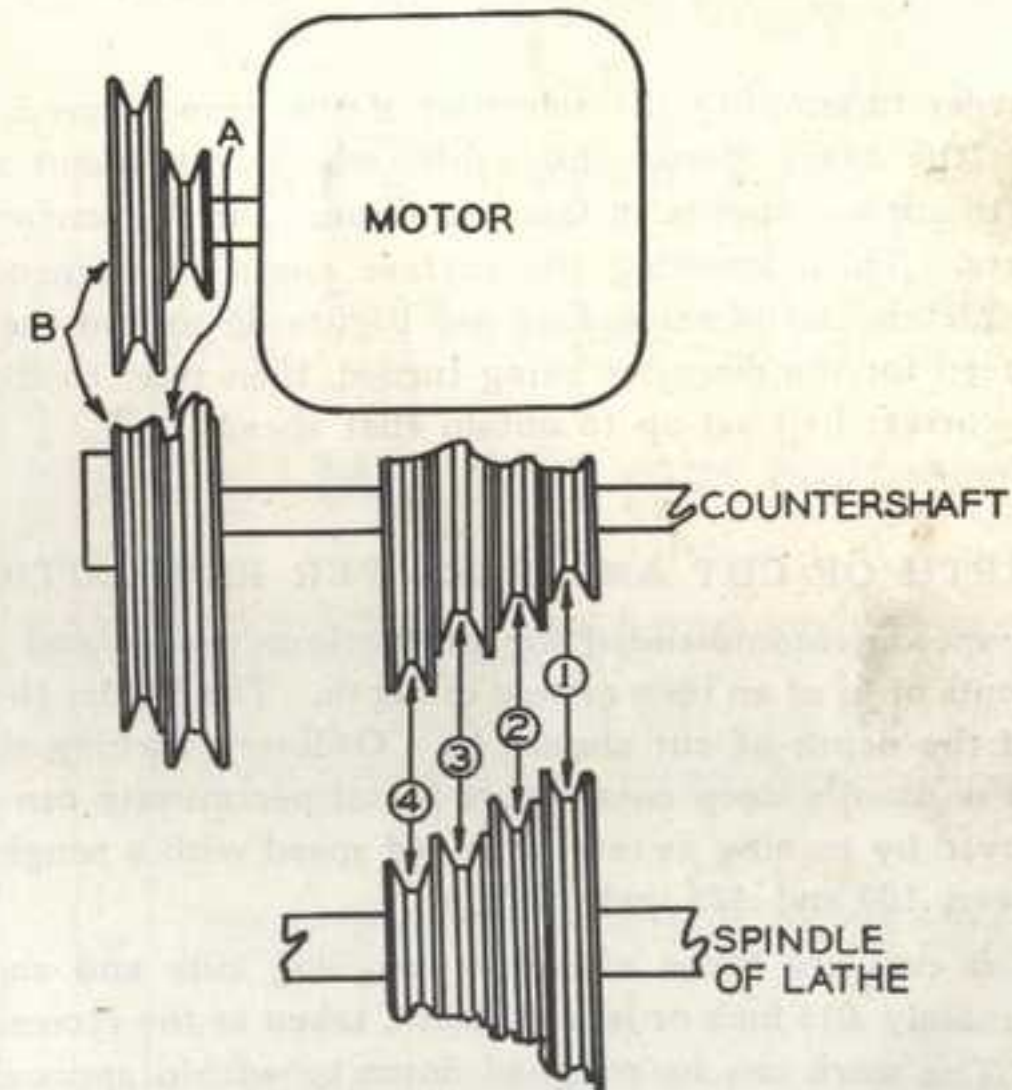
PART 4

THE MACHINING OF VARIOUS MATERIALS

PROPER CUTTING SPEEDS

Much of the success in metal cutting depends upon the choice of the cutting speed. Too slow a speed not only wastes time, but leaves a rough finish—too high a speed burns the tool. Of the sixteen speeds listed below, eight are on direct drive and eight on backgear drive. Figure 55 lists these speeds and shows how they are obtained.

FIG. 55. SPINDLE SPEEDS IN REVOLUTIONS PER MINUTE
ATLAS 10-INCH BACK GEARED LATHE



BACK GEAR DRIVE					DIRECT CONE DRIVE				
Motor Belt Position	Spindle Belt Position				Motor Belt Position	Spindle Belt Position			
	1	2	3	4		1	2	3	4
A	28	45	70	112	A	164	266	418	685
B	83	134	211	345	B	500	805	1270	2072

inches per spindle revolution. Ordinary cutting, where the final finish can be touched up by filing and with emery cloth, should be done with the .0087 inch feed. The .0050, .0035 and .001877 inch feeds are used for a fine finish and for working on tough, hard-to-machine metals. The .0035 inch feed is ideal for taking trueing cuts on commutators. The .0060 inch feed is an intermediate feed often useful for work not falling into these other classes. Gear set-ups for the various carriage feeds are given in Part 7.



FIG. 57
Reducing the diameter of a steel shaft $\frac{1}{4}$ " in one cut. Except for the experienced machinist cuts like this should never be taken—use the speed recommended for the metal being turned and take cuts of about $\frac{1}{4}$ of an inch for roughing.

CUTTING COMPOUNDS

Ordinary turning on the lathe is done dry. During threading operations the use of a cutting compound, oil or fluid results in a better class of work. Lard oil or any one of the general purpose cutting fluids should be kept handy for this purpose. Continuous production work usually requires the use of liberal quantities of a cutting compound to carry the heat away from the tool bit.

MACHINING STEEL

Steel is manufactured in hundreds of grades, each with a different carbon and alloy content. The grades of steel listed and described in this Manual are carried in stock by most steel suppliers. They are purchased from the warehouse by their S.A.E. (Society of Automotive Engineers) numbers, listed in detail in Part 10. Some of the harder grades should be purchased annealed for machining purposes.

The tool angles and cutting speeds given in Figure 59 are approximate and will be found suitable for average work. They



FIG. 58
A small alloy steel grinder shaft being turned in the lathe. The finished shaft is also shown. Note the grooves made by the cut-off tool for blocking out the work for roughing (see page 162).

represent the consensus of opinion of a large number of factories, steel companies and machinists. It is impossible to give precisely the tool angles and speeds most satisfactory for each grade of steel, since feeds, depths of cuts, temper of work and other conditions vary for each job. Some experimenting may be necessary for production work, form tools and special shapes.

The machinability rating of each steel is an arbitrary figure determined by averaging machining time over hundreds of jobs and operations. Using S.A.E. 1112 steel as a basis and rating it 100%, the percentages given for the other steels indicate the ease of machining, or machinability—the lower the rating the more difficult is the machining.

In general, for steel, the clearance angles of the tool should be as small as can be used without hogging or having the tool edge break down too soon. The front clearance of 8° and side clearance of 10° to 12° are fairly standard for hand ground tools. Smaller clearance angles can be used in some cases, but are not recommended except for production work.

On screw machine work where a long, curled chip is undesirable, the rake angles of the tools should usually be reduced in order to break up the chips. More power will be required when using these smaller rake angles.

FIGURE 59

TOOL ANGLES AND SPEEDS FOR MACHINING STEEL

These Angles Refer to Tool Shapes on Pages 38-39

Description of Steel	S.A.E. No.	Machinability	Speed feet per minute	Side Clearance Angle	Front Clearance Angle	Back Rake Angle	Side Rake Angle
Bessemer Screw Stock	1112	100%	120	12°	8°	16½°	22°
Special Screw Stock X1112		120	150	12°	8°	16½°	22°
High Manganese Screw Stock	X1314	95	100	12°	8°	16½°	22°
High Manganese Screw Stock	X1315	95	100	12°	8°	16½°	22°
High Manganese Screw Stock	X1335	75	100	12°	8°	16½°	18°
Open Hearth Screw Stock	1120	80	100	12°	8°	16½°	18°
Carbon Steel	1020	60	80	12°	8°	16½°	14°
Carbon Steel	X1020	70	80	12°	8°	16½°	14°
Carbon Steel	1035	62	80	12°	8°	16½°	14°
Carbon Steel	1040	61	80	12°	8°	16½°	14°
Nickel Molybdenum	4615	60	80	12°	8°	16½°	14°
Carbon Steel	1045	55	70	10°	8°	12°	14°
3½% Nickel Alloy	2315	50	80	10°	8°	12°	14°
3½% Nickel Alloy	2320	50	80	10°	8°	12°	14°
3½% Nickel Alloy	2330	50	80	10°	8°	12°	14°
3½% Nickel Alloy Annealed	2335	50	70	10°	8°	12°	14°
Nickel Chromium Alloy	3115	50	70	10°	8°	12°	14°
Nickel Chromium Alloy	3120	50	70	10°	8°	12°	14°
Chrome Molybdenum	4140	50	70	10°	8°	12°	14°
Manganese Alloy	T1335	50	60	10°	8°	12°	14°
3½% Nickel, Annealed	2340	45	70	10°	8°	10°	12°
3½% Nickel, Annealed	2345	45	60	10°	8°	10°	12°
3½% Nickel, Annealed	2350	40	50	10°	8°	10°	12°
Nickel Chromium	3130	45	70	10°	8°	10°	12°
Nickel Chromium, Annealed	3135	45	60	10°	8°	10°	12°
Nickel Chromium, Annealed	3140	45	60	10°	8°	10°	12°
Chrome Vanadium, Annealed	6140	40	60	10°	8°	10°	12°
High Carbon Steel	1095	35	50	10°	8°	8°	12°
Nickel Chromium, Annealed	3250	35	50	10°	8°	8°	12°
Chrome Vanadium, Annealed	6145	35	50	10°	8°	8°	12°

High speed tool bits are perfectly satisfactory for turning any of the steels listed in Figure 59. As mentioned before, tools for roughing cuts can be ground satisfactorily on a 60 grit wheel without honing. For finish cuts, the tool should be honed to as fine an edge as possible.

The cutting speeds are given in surface feet per minute; for the correct lathe spindle speed see Figure 56. Speeds shown are for machining dry. For best results and easier machinability, lard oil, or equivalent should be used, especially with the harder-to-machine steels. A lubricant also permits approximately 25% higher cutting speeds. For production and automatic screw machine work, commercial types of sulphurized mineral oils, or base compounds mixed with mineral oil or water are used both as coolants and for their lubricating properties.

In machining the softer grades of steel, roughing cuts can be taken with the .0087 inch feed, with depths of cuts of about 1/16 to 1/8 inch when turning at the rated speed. Deeper cuts can be taken easily at slower speeds, but it is recommended that the machinist never take roughing cuts of more than 1/8 inch—deeper cuts at rated speeds require a larger driving motor than the size recommended for the lathe. Finish cuts can be taken with any of the four feeds available, the finer feeds producing the smoothest finish. The depth of the finish cut should be .015 inch or less.

A little experimenting soon tells the operator the proper feed and depth of cut for a given steel. The figures in Figure 59 are suggestions only, and the machinist can usually tell from experience and "feel" just how much cut and feed to use.

MACHINING TOOL STEELS

It is impossible to group the many hundreds of tool steels or give definite tool angles or any description of their properties. Only annealed tool steels should be machined on the lathe. Some experimenting is necessary to determine the proper rake and clearance angles for tool bits. The harder grades, such as high speed tool steel or high carbon steel, will machine best with tool angles similar to those given for S.A.E. 1095 steel in Figure 59. Some of the die steels, while exceptionally hard when tempered

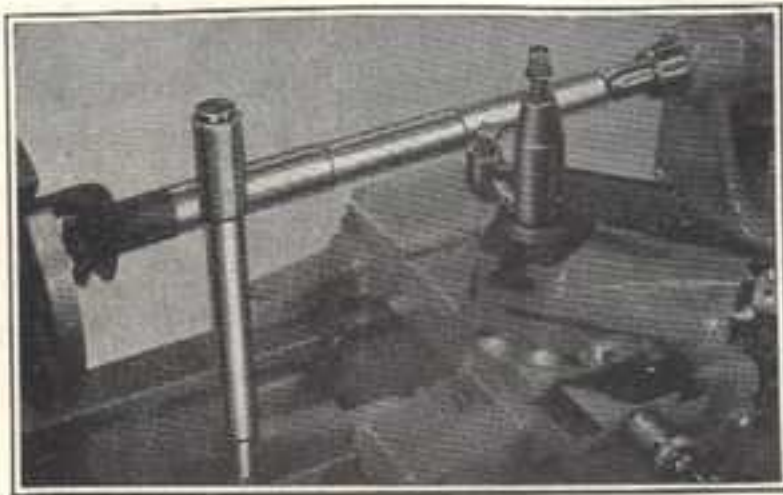


FIG. 60

Machining a bushing driver from tool steel. The finished tool is also shown. Tool angles for tool steel will require some experimenting on the part of the operator—there are hundreds of grades, each having different characteristics.

are furnished annealed. These steels can be machined best with rake angles as large as those recommended for S.A.E. 1112 steel in Figure 59.

MACHINING FORGED STEEL PARTS

Forgings are made from practically any type of steel and are usually annealed after forging. They are machined in the same manner as the bar stock from which they are made (see Fig. 59). Cuts should be deep enough to cut through the scale.

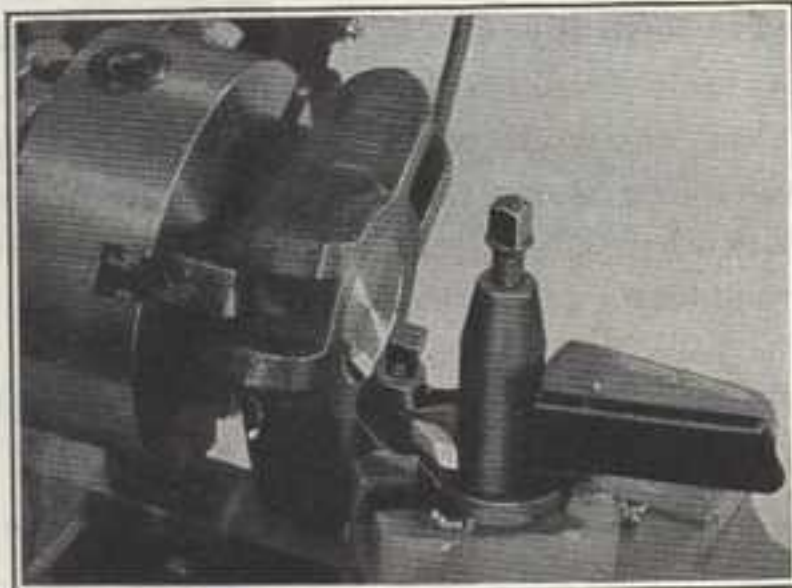


FIG. 61
Machining a forged machine part on the lathe.

MACHINING CAST IRON

Common cast iron, sometimes called "grey iron," is not so easy to machine as soft steel, nor can it be turned at so high a speed. The structure of this metal causes the chips to break out in small sections, not in a continuous chip. Rake angles must be smaller than for the softer steels. The tool nose should be sharper than for steel.

Approximate Tool Angles for Cast Iron

Front Clearance	8°
Side Clearance	10°
Back Rake	5°
Side Rake	12°

Tool Bit Shapes, Pages 38-39

A turning speed of 50 feet per minute is generally satisfactory for cast iron, although higher speeds are sometimes used in production or with special tool bits.

CUTTING BENEATH THE SCALE

A hard scale containing sand particles forms on the outside of iron castings. Unless the first cut is taken deep enough to cut through this scale and into the softer metal, the cutting edge of the tool will be dulled quickly. First cuts on castings should be at least $1/16$ or .0625 inch in depth. A speed slower than 50 feet per minute may be necessary for this depth of cut, but the speed should be reduced, not the depth of cut.

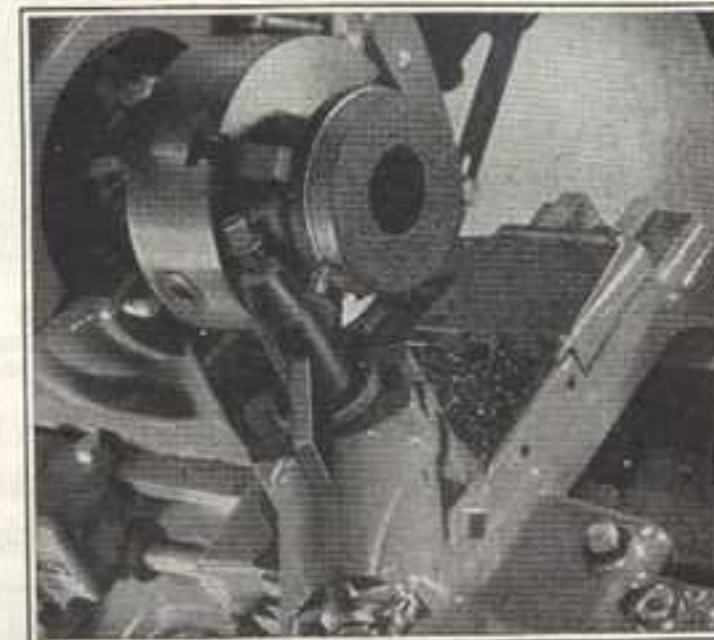


FIG. 62

Machining a cast iron collar on the lathe. Note that the cut is deep enough to get beneath the scale.

The .0087 inch feed can be used for turning most cast iron, with a depth of cut of between $1/16$ and $1/8$ inch running at rated speed after the scale is removed.

In this connection it is interesting that much superior finishes can be obtained on cast iron by the use of high speeds and shallow cuts. Exceptionally fine finishes have been produced with speeds as high as 150 feet per minute, a depth of cut of .015 inch and the .0087 inch feed.

Cast iron is machined dry, with no lubricant or cutting oil. The structure of the metal contains a great deal of free carbon which provides the needed lubrication.

Cast iron parts that are to be machined to very accurate limits should be rough turned to within .015 to .030 inch of their finished size, and then allowed to age for three months or longer. Internal strains are set up in the metal while it is being cast, and if time is not allowed for these strains to normalize, the casting will warp after it is machined.

MACHINING STAINLESS STEEL

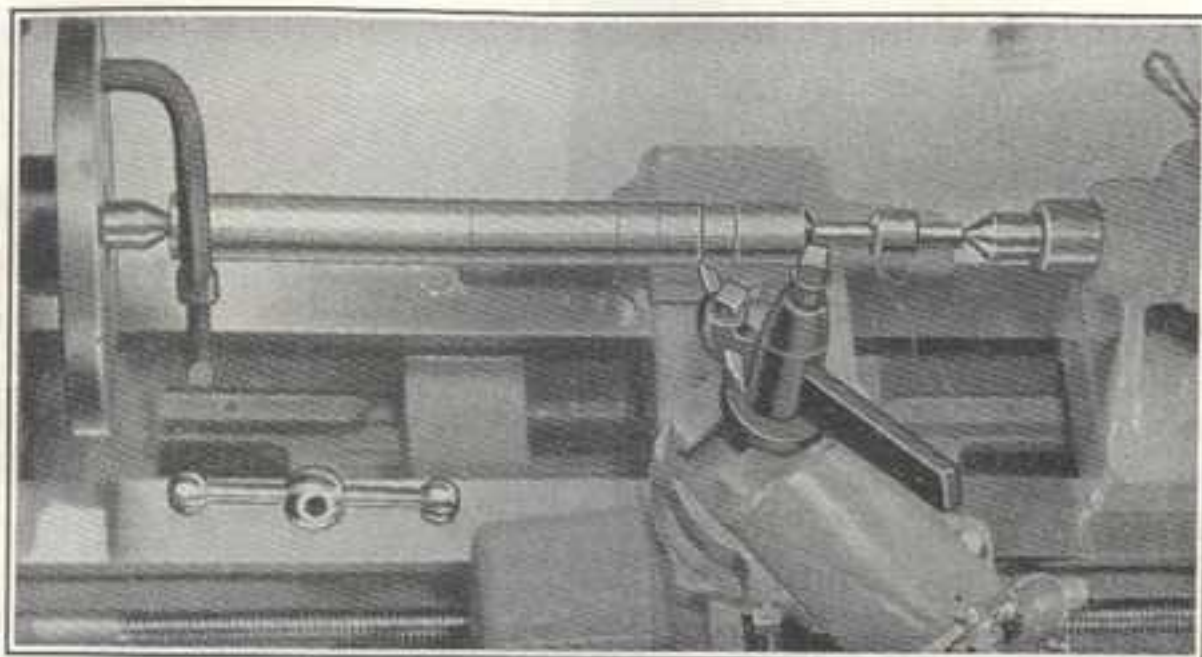


FIG. 63

Machining a stainless steel handle for use on a creamery plant machine. These steels are often used where corrosion must be avoided.

Stainless steels are either high chromium (12 to 14% chromium) or chrome-nickel (18% chrome, 8% nickel). The addition of this alloy makes stainless steels highly resistant to corrosion as well as unusually tough and strong—they are being used more and more wherever these qualities are desired. Some stainless steels are hard to machine, but if proper grades are selected they will machine fairly well. Two grades, No. 303 and No. 416, are furnished as "Free Machining Quality" in rod and bar form and can be obtained from your steel supply house.

Stainless steel is a tough, draggy metal and requires more rake than would be expected. Small rake angles will invariably cause hogging, and the material will "work-harden" badly, that is, the action of the tool in cutting causes the surface of the finished work to harden.

To prevent rubbing, clearance angles are slightly more than standard. Threading tools should have a pronounced side rake of 5° to 10°. Chips produced when turning stainless steel are stringy and hard to manage and should be pulled away from the work. They will be hot and sharp and should be handled with heavy cotton gloves or a thick cloth.

Tool angles suitable for most grades of stainless steel:

Front Clearance	10°	Back Rake	16½°
Side Clearance	12°	Side Rake	10°

Tool Bit Shapes, Pages 38-39

The tool angles on page 56 and the following speeds and feeds apply to both Nos. 303 and 416. Some experimenting may be necessary for other grades. These figures can be changed somewhat if conditions are unusual.

Slow speeds and heavy cuts are best for turning stainless steel. Speeds of 40 feet per minute will be satisfactory in most cases—much higher speeds cause the tool to break down after a short time. For roughing, the .0087 inch feed should be used with depths of cuts of between 1/16 and 1/8 inch. Finish cuts should be taken with a well rounded tool, preferably using the .0050 inch feed, and with a depth of cut of .010 to .015 inch or more. If possible, only one finish cut should be taken—the work-hardening of the metal makes a second shallow cut difficult.

Both No. 303 and No. 416 can be cut dry, but a standard lubricant results in a better finish and easier cutting. High-sulphur cutting compounds, lard oil or equivalent will be found satisfactory. A lubricant should always be used when threading.

CAUTION: When machining stainless steel, check the tightness of the work between centers after each cut. When heated, stainless steel expands approximately twice as much as ordinary steel, especially when cut dry. The tailstock center can be ruined quickly if extreme care is not taken in keeping just the right amount of pressure between the centers.

This tendency to heat up must be remembered when turning pieces to an exact size, and measurements should not be taken while the work is hot. A good method is to rough down to within about .015 inch of the finished diameter, remove the work and cool it with water or oil, then mount it and proceed to take the finishing cuts.

MACHINING COPPER

Copper, due to its combination of toughness and softness, requires different tools than brass or other copper alloys. These tool angles will generally prove satisfactory:

Front Clearance	12°	Back Rake	16½°
Side Clearance	14°	Side Rake	20°

Tool Bit Shapes, Pages 38-39

MACHINING COPPER (Continued)



FIG. 64
Machining a solid copper electrode on the lathe. A finished electrode is also shown.

A turning speed of 120 surface feet per minute is recommended for copper, although slightly lower speeds may sometimes be necessary with wide faced tools. The .0087 inch feed should be used except for fine finish cuts, where the .0035 inch feed is best. The depth of cut for roughing can be .030 to .050 inch, and for finishing about .010 inch. Rather deep cuts at rated speed will generally be most satisfactory. On finish cuts, use a round nose tool with about 1/16 inch radius. To produce a smooth finish on copper, tools should be honed to as keen an edge as possible. Chips are tough and stringy and should be pulled away from the work—wear gloves or use a thick cloth to prevent burning your hands.

No lubricant is necessary, but it is suggested that lard oil or paraffin oil be used for threading.

Using the cut-off tool on soft copper is unusually difficult, due to the tendency of the chip to spread and jam in the groove. A method recommended by many machinists is to start a groove wider than the cut-off blade and move the cut-off tool back and forth continually as it is fed into the work, allowing the chip to clear the work without jamming. Allowance for the extra width of the groove should be made when laying out the work.

MACHINING BRASS AND COPPER ALLOYS

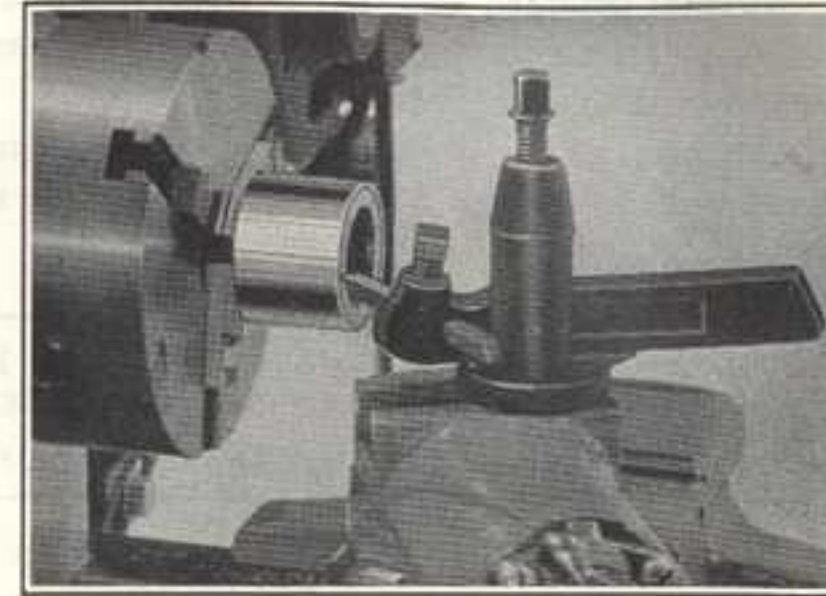


FIG. 65
A brass bushing being turned on the lathe. On many production jobs brass will be found more economical than steel, due to increased production and higher scrap value.

Free cutting brass, commercial bronze, commercial yellow brass, red brass, cast bronze, and other of the softer copper alloys are machined quite differently than steel. Because the tool has a tendency to hog into the soft metal, tool angles are required as follows:

Front Clearance	8°	Back Rake	0°
Side Clearance	10°	Side Rake	0°

Tool Bit Shapes, Pages 38-39

A very slight side rake of not more than 5° can often be used on the free-machining grades of brass and bronze. On some of the tougher alloys, a negative side rake of 2° to 4° is sometimes used to prevent hogging. If hogging and a rough finish occurs, check the clearance angles and try a slight amount of negative rake.

On production work free-machining brass is turned at speeds as high as 600 feet per minute. For small lathe work when production is not important, these speeds are recommended:

Free Cutting Brass	300 feet per minute
Yellow Brass	200 feet per minute
Commercial Bronze	80 feet per minute
Cast Bronze	50 feet per minute

Use light cuts at rated speeds rather than deep cuts with slower speeds. For roughing, depths of cuts should be from 1/16 to 1/8 inch. The .0087 inch feed can be used for roughing, and the .0035 inch feed for finishing. Lubricants are not generally used, although paraffin oil or equivalent will assist in threading.

THE HARDER COPPER ALLOYS

Special bronzes and nickel silvers, which contain elements giving high strength, hardness and toughness, are more difficult to machine than the freer cutting brasses. Phosphor bronze and silicon bronze are in this class. Experiment with tool angles for these metals if large amounts of work are to be done. Suggested angles:

Front Clearance	12°	Back Rake	10°
Side Clearance	10°	Side Rake	0° to -2°

Tool Bit Shapes, Pages 38-39

If hogging occurs, indicated by a rough irregular finish, reduce the rake angles.

Speeds may vary from 80 to 120 feet per minute. A feed of .0087 inch is recommended for roughing, .0035 for finishing. Take cuts of .015 inch to .125 inch in depth at rated speeds. No lubricant is necessary, although paraffin oil or equivalent will be found helpful for both turning and threading.

Some of these alloys have a small percentage of lead in their composition which improves their machinability. Rake angles of 0° should be used in turning the leaded copper alloys.

MACHINING HARD BRONZE

The alloy known commercially as hard bronze is sold under various trade names. It is used for such purposes as non-sparking wrenches and tools and has many applications where inflammable materials are handled. Its strength is comparable to tempered mild steel. Tool bits should be ground to these angles:

Front Clearance	8°	Back Rake	0°
Side Clearance	10°	Side Rake	0° to -2°

Tool Bit Shapes, Pages 38-39

Cutting speeds for the various grades of hard bronze range between 40 and 100 feet per minute—the manufacturer's recommendations should be followed. Use the .0087 inch feed with moderately deep cuts about .030 inch in depth. No lubricant is necessary, although, in turning some of the harder grades, kerosene will be helpful.

MACHINING ALUMINUM

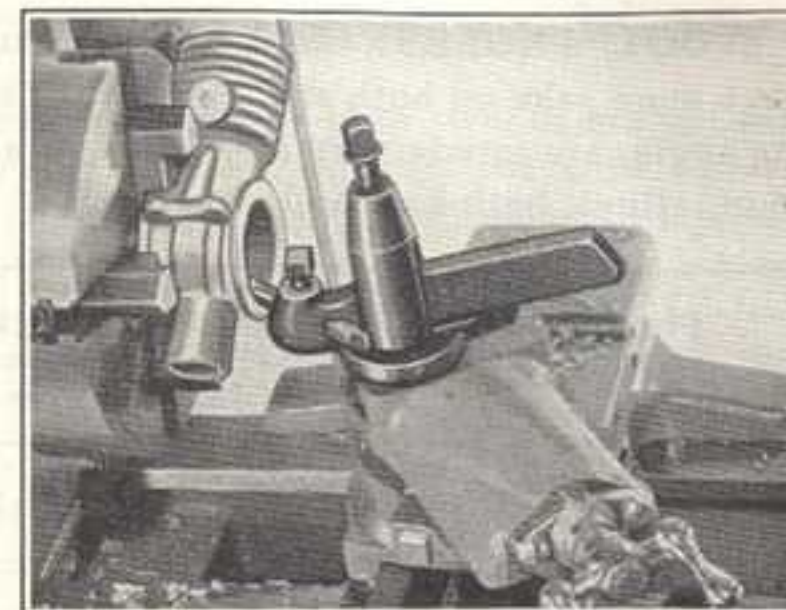


FIG. 66

Machining an alloy aluminum cylinder for a model gas engine. Engines for model airplanes and motor boats are generally made of aluminum to reduce weight.

Aluminum especially with high scrap or silicon content is difficult to machine, due to its tendency to hog and pile up in front of the tool. However, free-machining aluminum alloys have been developed and are available at most warehouses.

Two of these alloys, Alcoa 17S-T and Alcoa 11S-T3, are particularly interesting to the machinist. No. 17S-T has been on the market for some years, while No. 11S-T3 is comparatively new. Both have a tensile strength approximately equal to that of mild steel—the highest strength of any of the aluminum alloys available in rod form. Similar alloys have been marketed under various trade names, such as "Duraluminum" and are used wherever strength and lightness are desired, such as in automobiles, airplanes and dirigibles. Both Alcoa 17S-T and 11S-T3 are easily machined on the lathe with only a few special precautions.

Cast aluminum alloys have lower tensile strengths than the wrought aluminum alloys mentioned above and are ordinarily more difficult to machine. Most of the reputable foundries casting aluminum use pure alloys and turn out castings that can be machined without trouble. However, if large percentages of scrap are used or if the silicon content of the metal is allowed to become too high, there is considerable difficulty in machining.

Alcoa alloys No. 12 and No. 112 are quite easy to machine, and if castings are made from these alloys, they can be worked satisfactorily. High silicon aluminum alloys can be turned better with

special tool bits—higher speeds can be used and the cutting edge of the tool stands up longer.

TOOL ANGLES: Tool bits for turning aluminum usually have more rake on both side and front than for steel. The following angles are satisfactory for turning practically all types of aluminum alloys, both cast and wrought:

Front Clearance 8°	Back Rake 35°
Side Clearance 12°	Side Rake 15°

Tool Bit Shapes, Pages 38-39

The edge of the tool in contact with the work should be rounded but not too bluntly. If chatter occurs, decrease the radius of the tool point. Cut-off tools for aluminum should have about 15° back rake and only 4° to 5° front clearance.

The proper cutting speed is very important in turning aluminum, and in many cases trouble can be traced to the use of too low a cutting speed. While surface speeds for turning steel vary between 75 and 150 feet per minute, aluminum is turned best at speeds from 200 feet to as high as 800 feet per minute. For general work, it is recommended that wrought aluminum alloys such as 17S-T and 11S-T3 be cut at surface speeds of 300 to 500 feet per minute, while cast aluminum should be turned between 200 and 300 feet per minute, depending upon the composition of the casting. To determine actual spindle speeds for various diameters of work refer to Figure 56.

Both Alcoa 17S-T and 11S-T3 can often be turned dry, but for best results on all aluminum some form of cutting oil should be used. Equal parts of kerosene and lard oil or equivalent make a very satisfactory cutting compound. Pure lard oil is quite satisfactory for heavy cuts and slow feeds. Alcohol and some commercial cutting compounds produce excellent finishes.

GENERAL PRECAUTIONS: Light cuts and feeds and higher speeds give best results with aluminum. The .0050 inch feed, with a depth of cut of about .020 inch, will produce excellent work, but finishing cuts should be shallower. On finishing cuts, the edge of the tool bit should be honed very sharp and smooth. Even slightly rough tool edges will leave marks on the work.

Roughing cuts will often leave a built-up "false cutting edge" of work-hardened material on the edge of the tool bit. This edge should be removed and the top of the tool bit honed before it is used for finishing cuts.

When heated, aluminum expands more than steel or brass. Care should be taken when turning between centers—the lathe should be stopped frequently to check the tightness of the work against the centers. The work should be allowed to cool before taking measurements with a caliper or micrometer. *This is important when turning aluminum.*

MACHINING MONEL METAL AND NICKEL

Due to the toughness of monel metal and nickel, the proper tool angles, speeds and feeds are especially important. A special quality of monel metal, Type R, is available and will prove fairly easy to machine. A round-nose tool with a radius of about 1/16 inch is best with the following rake and clearance angles:

Front Clearance 13°
Side Clearance 15°
Back Rake 8°
Side Rake 14°

Tool Bit Shapes, Pages 38-39

Tool bits should be honed after grinding. A good cutting lubricant should be used for turning and drilling as well as for threading. Cutting speed should be about 100 feet per

minute for cast monel metal and nickel and 120 feet per minute for rolled monel metal. Take cuts of not more than .020 to .030 inch, using the .0087 inch feed. For smooth finishing cuts use the .0050 inch feed. Deeper cuts can be taken at lower speeds but are not recommended. Tough, stringy chips are produced when machining these metals and should be kept clear of the work—use gloves or a heavy cloth in handling.



FIG. 67

Machining a monel metal hand wheel for use on a dyeing machine. A finished hand wheel is also shown. After being machined to approximate size, the hand wheel is drilled and reamed and pressed on a mandrel for finishing (see page 81).

MACHINING PLASTICS

The term "plastic" applies to many types of artificially produced solids. One of the earliest plastics was celluloid—it has been followed by various other plastics, moulded and cast from such materials as phenol, urea, casein and cellulose acetate.

For machining purposes plastics can be divided into two groups: Group I includes molded Bakelite, Formica and Durez, all of which are phenol plastics moulded under heat and pressure. Group II includes all of the cast and formed plastics of various bases, sold under such trade names as Catalin, Plaskon, cast Bakelite (called Bakelite Transparent), Marblette, Joanite, Beetle, Ameroid, Pyralin, Celluloid, Tenite and Trafford.



FIG. 68

Machining a salt shaker from one of the more commonly used plastics. The finished shaker is also shown. Note the stringy appearance of the chip.

MACHINING PLASTICS IN GROUP I

The machining of plastics in Group I is done best with special tool bits, and if any quantity of plastic turning is necessary, such tools will save both time and money. For a small amount of machining, high speed tool bits may be used, although it may be necessary to resharpen them several times before the job is finished. The tool should be ground to these angles:

Front Clearance 8°	Back Rake 0°
Side Clearance 12°	Side Rake 0°

Tool Bit Shapes, Pages 38-39

Cutting speeds of 100 to 120 feet per minute should be used. No lubricant is necessary or advisable. Take rather heavy cuts, using the .0087 inch feed.

Because of the heat generated when drilling plastics, the finished hole becomes smaller than the drill. For an exact sized hole, use an oversized drill or a drill ground slightly off center. Apply

plenty of oil when drilling and back out the drill frequently to remove chips. Special drills for Bakelite are available if any quantity of drilling is done.

MACHINING PLASTICS IN GROUP II

Regulation high speed tool bits are perfectly satisfactory for the general turning of plastics in Group II. Tool bit angles:

Front Clearance 10°	Back Rake 0° to -5°
Side Clearance 14°	Side Rake 0°

Tool Bit Shapes, Pages 38-39

For most turning the 0° angle of back rake will be satisfactory, but where there is evidence of hogging, grind a negative rake of about -5°.

The cutting speed should be around 200 feet per minute. No lubricant is necessary or advisable for turning. Light cuts of about .010 inch or less should be taken, using the .0087 inch feed, or, for a finer finish, the .0050 inch feed. If the work is being turned between centers, watch the tightness of the work against the tailstock center, as these plastics expand considerably when heated. For threading, use plenty of good cutting lubricant and reasonably high speeds.

When drilling these plastics, refer to the information listed for Group I plastics.

MACHINING FORMICA GEAR MATERIAL

Formica is a laminated plastic made of cotton duck impregnated with a phenolic resin. Tools with the following angles will be satisfactory:

Front Clearance 10°	Back Rake 16½°
Side Clearance 15°	Side Rake 10°

Tool Bit Shapes, Pages 38-39

The best cutting speeds are between 200 and 300 feet per minute with the .0050 inch feed. Depths of cuts of about .020 inch or less should be used. No lubricant is necessary. Special tool bits are advisable if any quantity is to be turned. Grind drills to an included angle of 55°.

MACHINING MICARTA

Grind tools as for Formica gear material. High speeds around 200 to 300 feet per minute are recommended, using the .0050 inch feed, and light cuts of .010 to .020 inch. Machine dry.

MACHINING TEXTOLITE

Use tools ground as for Group II plastics. A very keen edge must be maintained and special tool bits should be used if any quantity of this material is to be machined. Cutting speed should be around 200 feet per minute when using high speed tool bits and 300 feet per minute with special tool bits. The .0050 inch feed is recommended with depths of cuts of .015 to .025 inch. All machining is done dry.

MACHINING FIBER

Fiber is an extremely hard, tough material, made in the form of sheets, rods and tubes and is used extensively due to its relatively low cost. It is not commonly termed a plastic. Tools should be ground with these angles:

Front Clearance	12°	Back Rake	0°
Side Clearance	15°	Side Rake	0°

Tool Bit Shapes, Pages 38-39

Cutting speed should be about 80 feet per minute, using the .0087 inch feed and cuts of .010 to .025 inch. Keep the tool edge honed sharp with a rather broad nose at the point. Machine dry.

MACHINING HARD RUBBER

Tools should be ground to the following angles:

Front Clearance	15°	Back Rake	0°
Side Clearance	20°	Side Rake	0°

Tool Bit Shapes, Pages 38-39

If the type of hard rubber used causes hogging or tearing, make the back rake negative, about -5° .

High speed tool bits are perfectly satisfactory. Speeds of about 150 feet per minute should be used when cutting dry, but care must be taken that the work does not become too warm. The .0087 inch feed is satisfactory with depths of cuts of about .010 to .020 inch.

FINISHING AND POLISHING

Figures 69 and 70 show two steps in obtaining a finely finished surface. First, the work is filed until the tool marks disappear. Never hold the file stationary while the work is revolving. Take full-cutting strokes across the work with a slow spindle speed so that the "bite" of the file can be felt. Always file dry and keep the file perfectly clean and free from oil. Filing is also a favorite method for such jobs as rounding work corners, smoothing concave cuts, finishing off handwheels and similar jobs.

FIG. 69
Filing a taper before polishing with emery cloth.

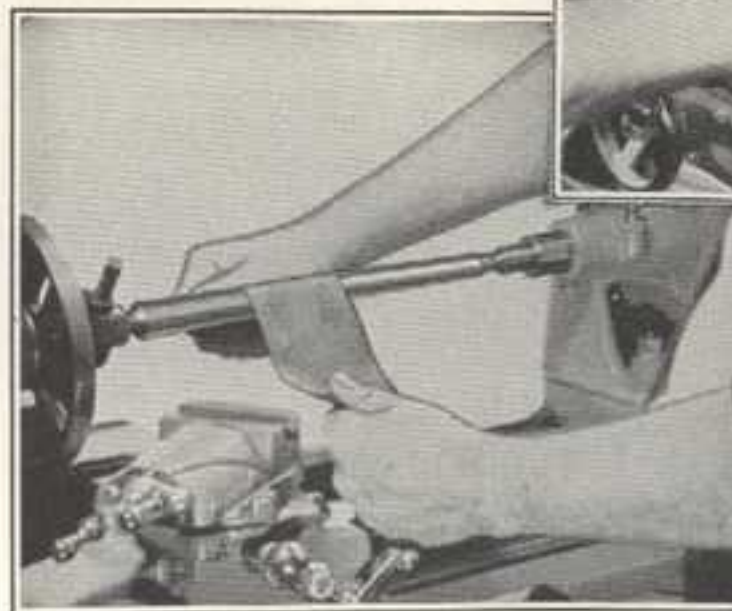
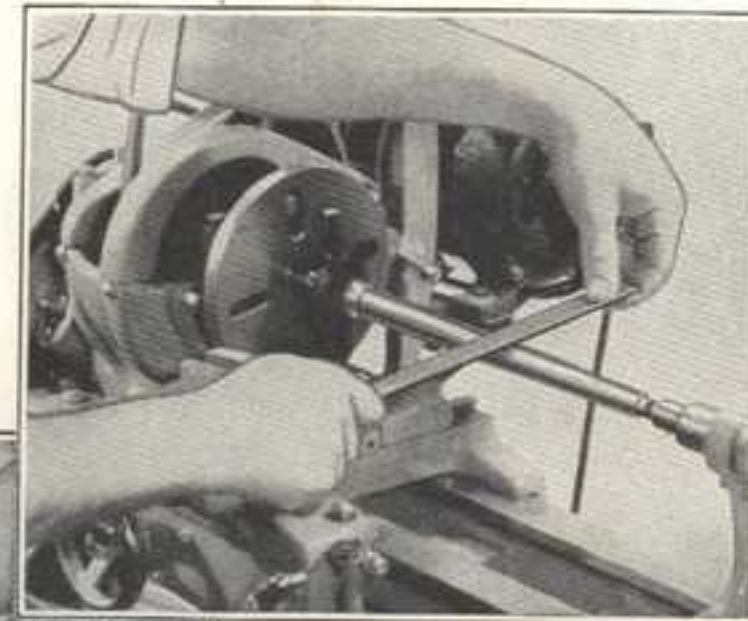


FIG. 70
Polishing steel with abrasive cloth—the emery is not held in one place but moved back and forth continually.

After filing, the work can be further polished with emery or some other abrasive cloth. See that the work is turning at a rather rapid speed. Do not hold the emery in one place—keep moving it back and forth. A few drops of oil placed on the work tends to give a better finish and eliminates scratches. Crocus cloth is also recommended for a highly polished finish.

Part 5

HOLDING THE WORK

PART 5

HOLDING THE WORK

This section describes the most common methods of holding the work in the lathe: between centers, in a chuck, on the face plate, in a collet, and on a mandrel.

BETWEEN CENTERS

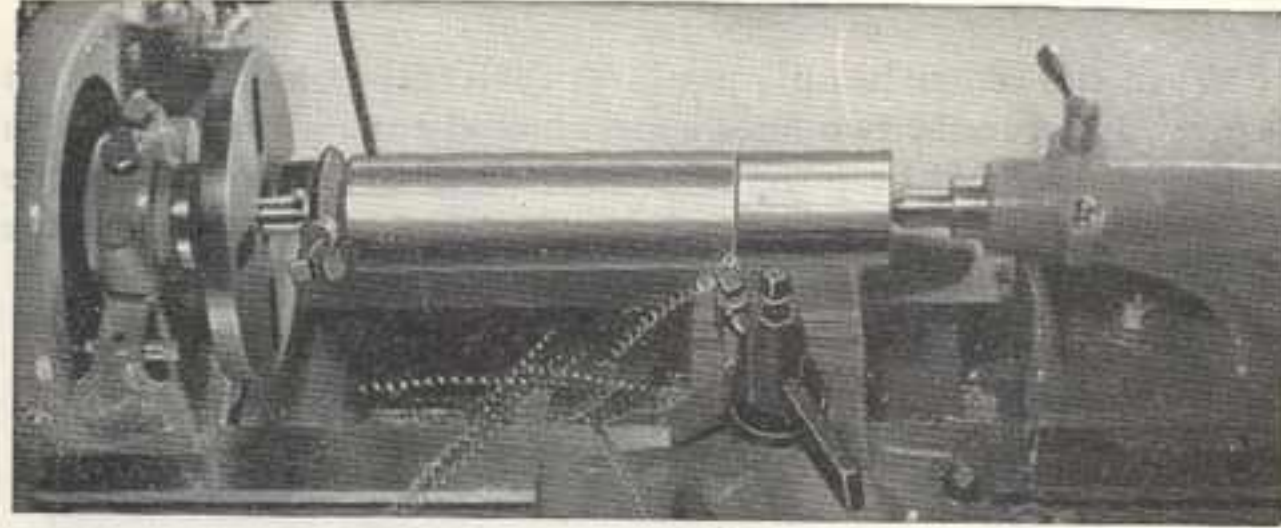


FIG. 71

Turning a piece of bar steel between centers, showing positions of the lathe dog, work and centers.

Whenever practicable, the work is held between centers. This method is usually more accurate and has the advantage of permitting removal and replacement of the work without affecting accuracy. There are two steps in mounting work between centers: locating the center points at each end of the work, and counter-sinking and drilling the ends to accommodate the lathe centers.

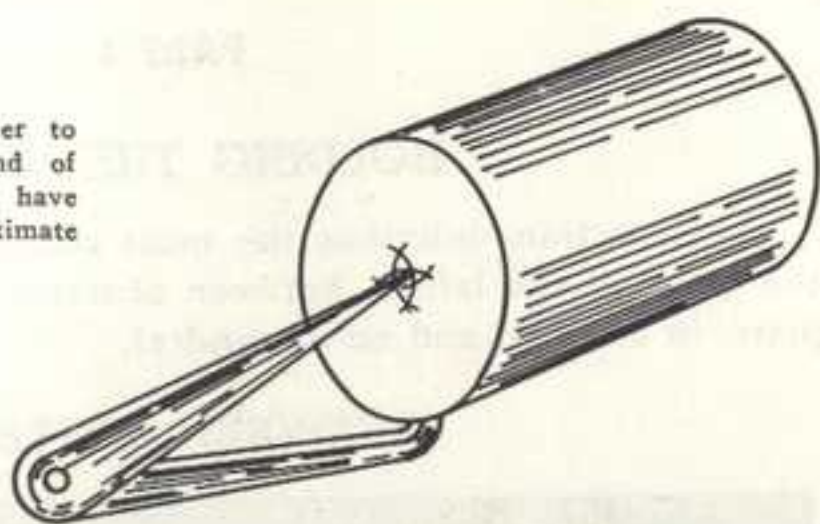
LOCATING THE CENTERS

On round work, centers are usually located with either the hermaphrodite caliper or the center head attachment for a steel scale. In the centering of square, hexagon and other regular-sided stock, lines are scribed across the ends from corner to corner. The work is then center punched at the point of intersection.

In using the hermaphrodite caliper, set the caliper to a little more than half the diameter of the work and scribe four lines as shown in Figure 72. Hold the work in a vise and center punch as accurately as possible in the center of these marks. A little chalk rubbed over the end of the work before scribing makes the marks easily seen.

FIG. 72

Using the hermaphrodite caliper to locate center points on the end of round shafting. The four lines have been scribed to mark the approximate center position.



When the center head is used, set the center head as shown in Figure 73 and scribe two lines approximately at right angles. Use a sharp scriber and keep the lines as close to the edge of the scale as possible. Then hold the work in a vise and center punch at the intersection of the two lines.

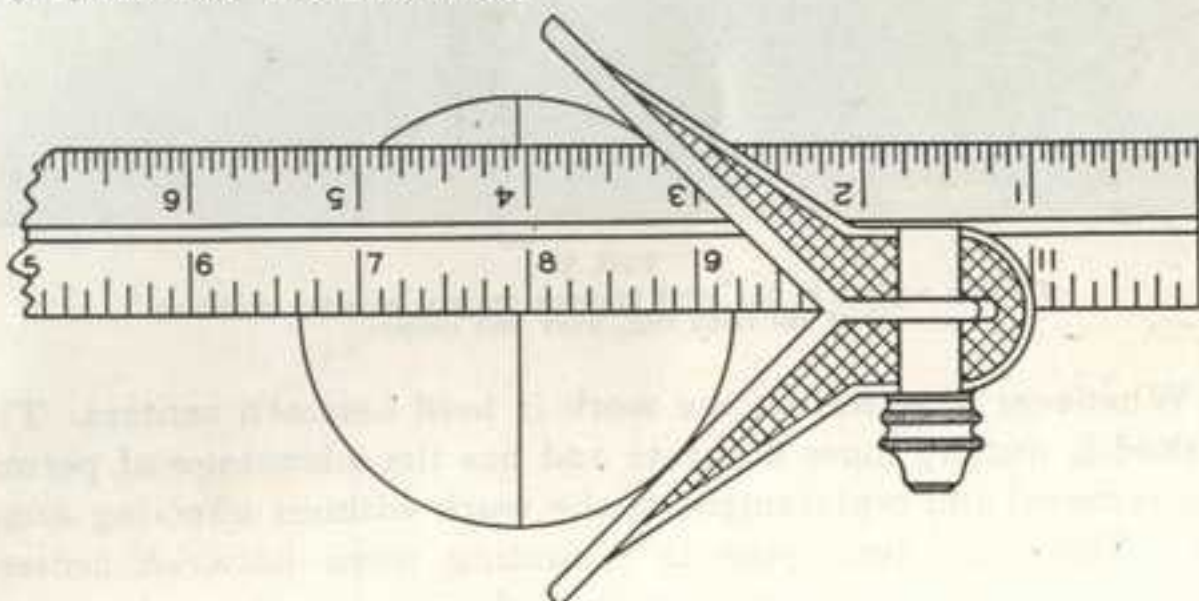


FIG. 73

Using the center head to locate work center.

If the rough stock is large enough to permit a trueing cut, the ends may be countersunk after punching. However, when the finished diameter is smaller than the stock by only a few thousandths of an inch, it is necessary to check for trueness before countersinking.

Figure 74 shows the most common method for checking trueness: Mount the work on lathe centers. Hold a piece of chalk so that it just touches the high spots of the work as it is rotated by hand. A tool bit mounted in the tool post can be used in place of chalk. Make marks close to each end, then remove the work. Hold the work in a vise and drive the two center-punched marks toward the chalk marks by striking at an angle with the center punch and then slowly bringing it back to a straight position.

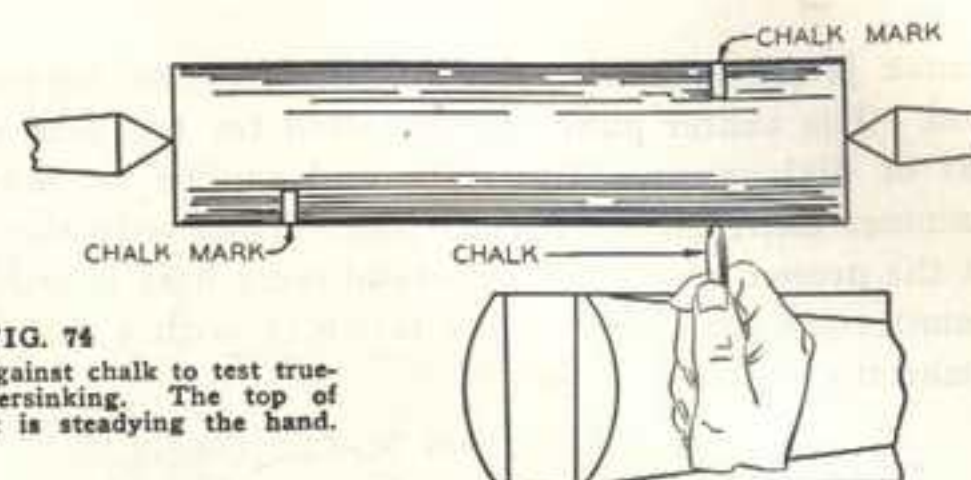


FIG. 74

Rotating work against chalk to test trueness before countersinking. The top of the compound rest is steadying the hand.

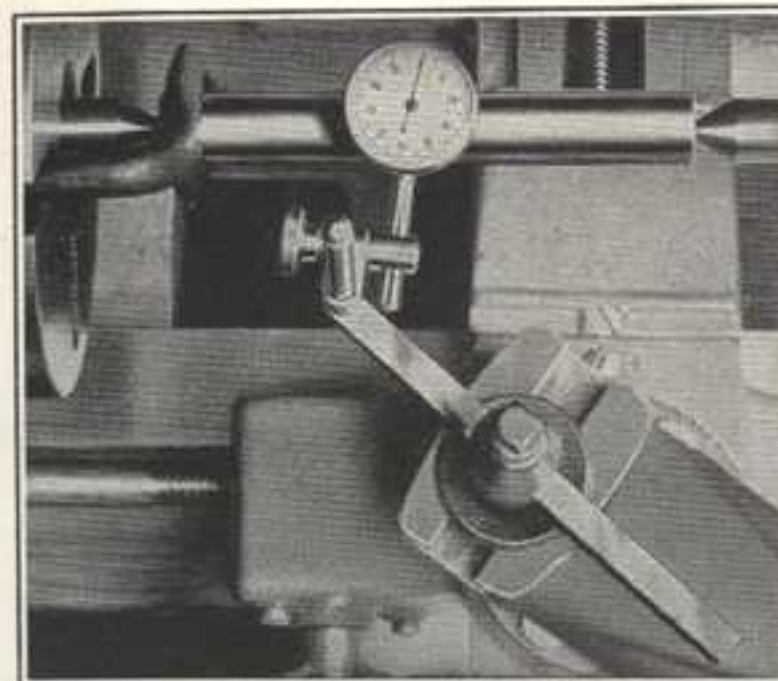


FIG. 75

Using a dial gauge to check trueness of work before countersinking.

When the center must be accurate to within one or two thousandths of an inch or when the diameter of the work is too small to permit a trueing cut, check trueness with the dial gauge before countersinking. The dial gauge is mounted in the tool post as shown in Figure 75.

COUNTERSINKING

There are three methods of countersinking the ends of the work after center punching. If a drill press is available, the work is held firmly on the table during the countersinking operation. The other two methods are illustrated in Figures 77 and 78. The size and shape of the work usually determine which method is better.

FIG. 76. 60° countersink drill for accurate centering of work to be mounted between lathe centers. The sides of the drill form an angle of 60° which exactly matches the angle of the lathe centers and provides the proper bearing surface.



Figure 77 shows the quickest and probably the most common way to countersink centers for stock up to three inches in diameter. The left end of the work is mounted in a three-jaw universal chuck. If the work is more than ten or twelve inches long, the right end is held in position with the steady rest, relieving strain from the

chuck jaws—otherwise there is no need for supporting the right end. The center punching is tested for trueness with chalk, tool bit or dial gauge. The right end can be tapped lightly with a hammer until the work runs true. Then with the spindle turning at the proper speed, the countersinking hole is bored with the 60° countersink drill held in the tailstock with a drill chuck. Do not make the centers too large.

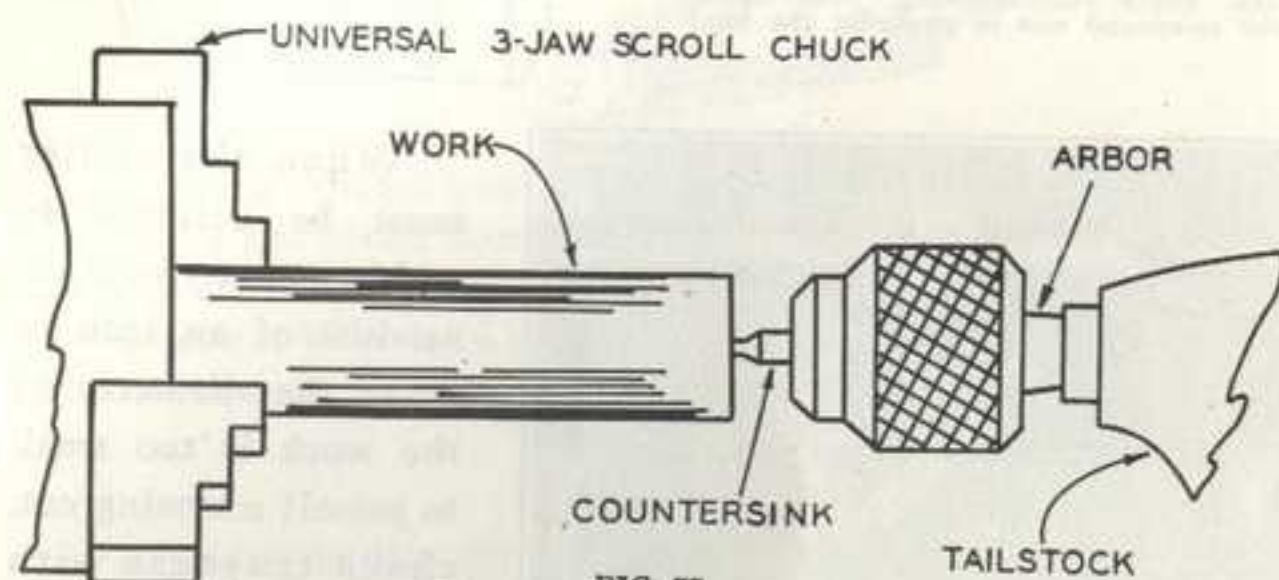


FIG. 77
The quickest way to countersink.

Another method of countersinking is illustrated in Figure 78. The countersink drill is chucked in the headstock and supports the left end of the work. The right end is supported by the tailstock. With the spindle turning at 685 or 805 R.P.M., the work is fed to the countersink drill from the tailstock and kept from turning with the left hand. Do not force the drilling or feed too fast—the advance can be felt when turning the tailstock hand wheel. If the countersink is forced and breaks off, the simplest way to remove the broken piece is to cut about one-half inch from the end of the stock. If the work cannot be shortened, heat the piece of countersink, cool slowly by covering with ashes or annealing compound, and drill out.

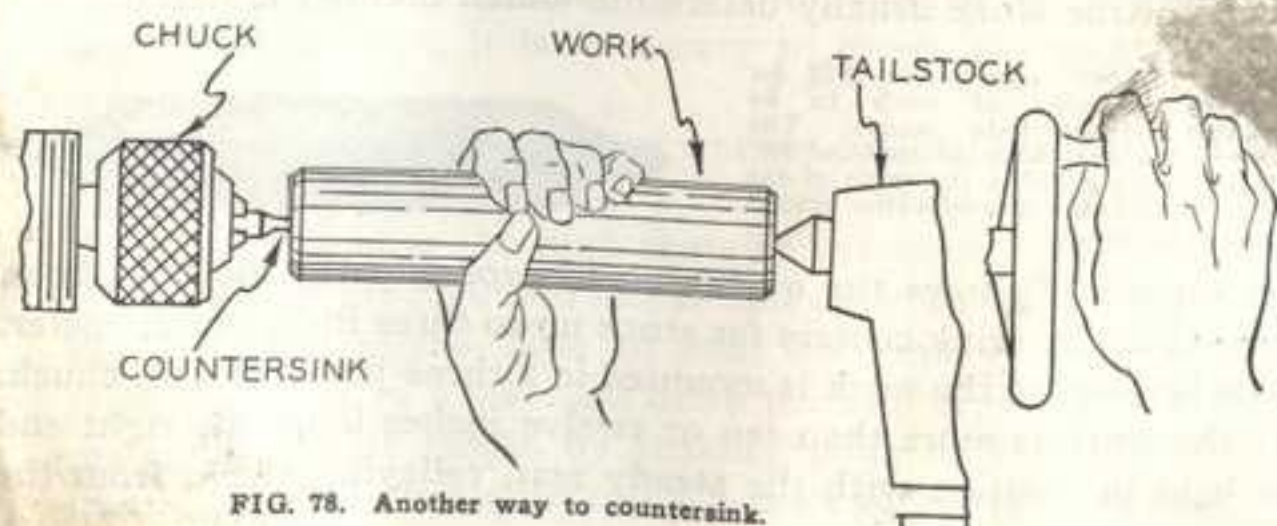


FIG. 78. Another way to countersink.

MOUNTING WORK BETWEEN CENTERS

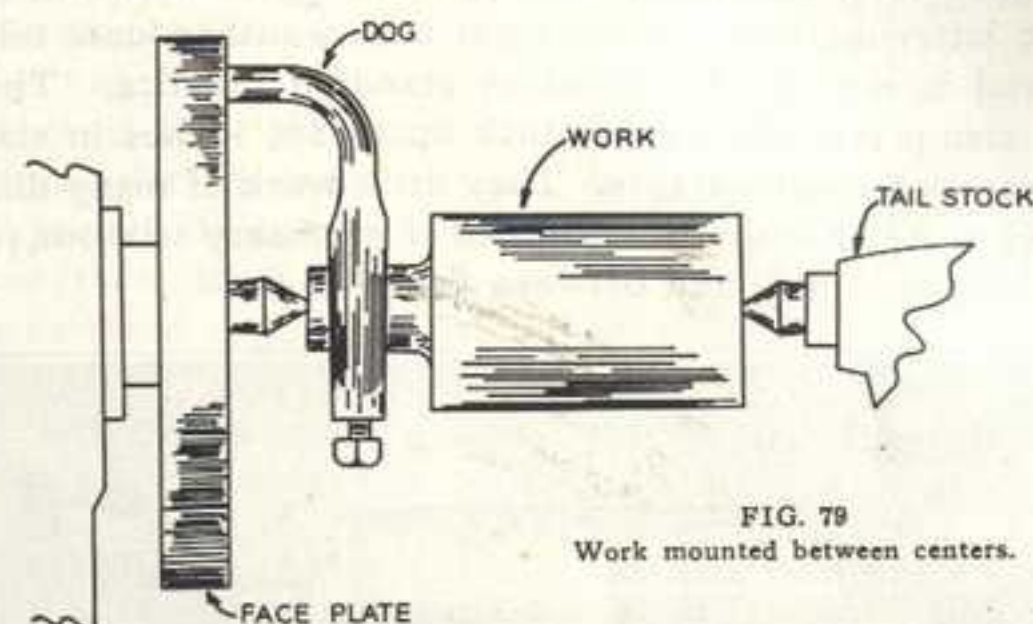


FIG. 79
Work mounted between centers.

Figure 79 shows how work is mounted between centers after the ends have been countersunk. The set of four dogs in Figure 80 handles diameters up to $1\frac{1}{2}$ inches. Care must be taken in the selection of the size of the dog. The "tail" or bent portion must fit into the face plate slot without resting on the bottom of the slot. Figure 81 shows the result of making this mistake. The dog tail rests on the face plate at A and the headstock center does not "seat" properly in the countersunk hole at B.

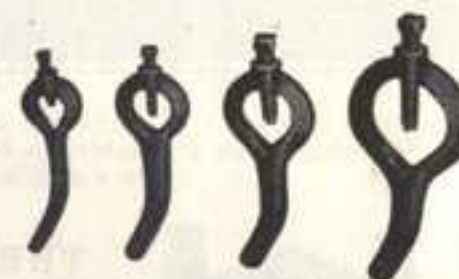


FIG. 80
Lathe dogs for driving work up to $1\frac{1}{2}$ inches in diameter.

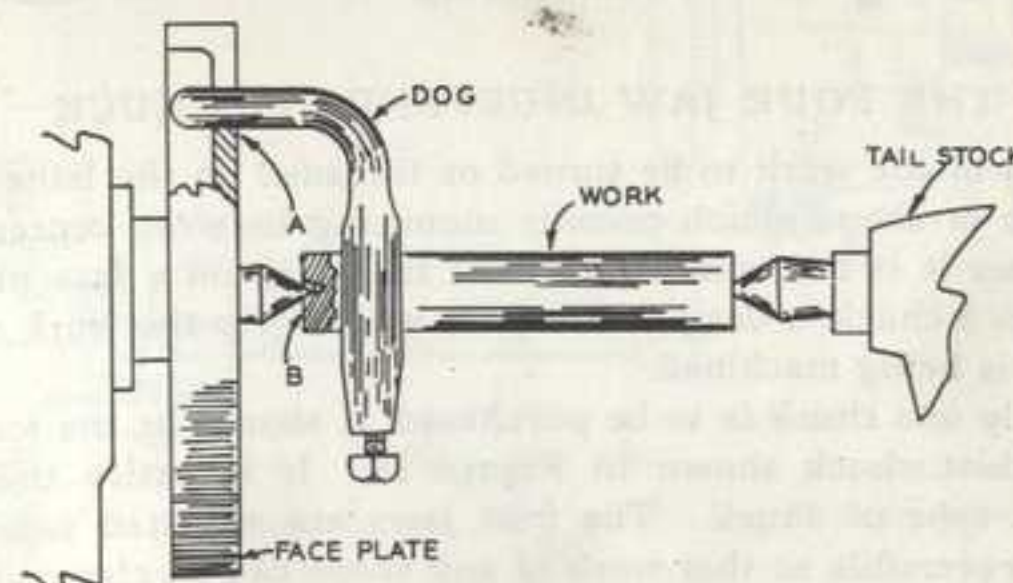


FIG. 81
Result of choosing the wrong size dog.

Work over $1\frac{1}{2}$ inches in diameter can be held in the clamp type dog (Fig. 83A) or adapted to the $1\frac{1}{2}$ inch dog as shown in Figure 82. The latter method requires light cuts, a rather loose tailstock center and is not recommended as standard practice. The two sizes of clamp type dogs hold stock up to $3\frac{1}{2}$ inches in size and have several other advantages. They drive work of many different shapes (Fig. 83B) and can be applied if necessary without removing work already mounted between centers.

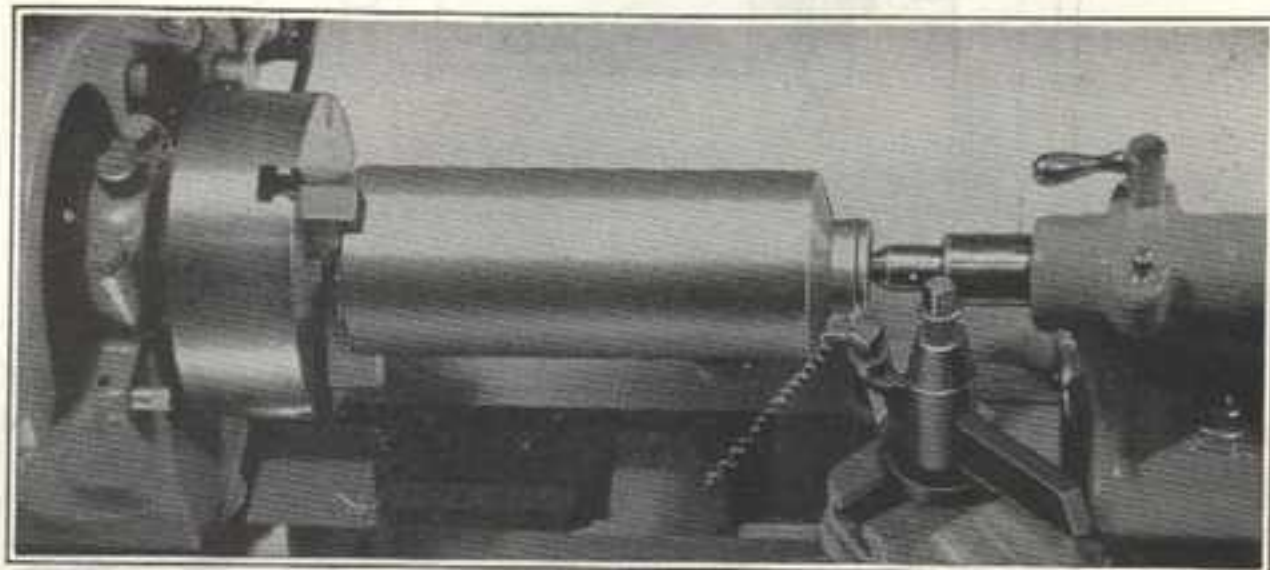


FIG. 82

Turning down a shoulder to fit the $1\frac{1}{4}$ " dog. This method of adapting large work to a dog is not advisable for general turning.



THE CLAMP TYPE DOG

FIG. 83A

(Left) Clamp Type Dog.



FIG. 83B

Holding rectangular work in the clamp-type dog.

THE FOUR JAW INDEPENDENT CHUCK

Much of the work to be turned or threaded on the lathe is not of a size or shape which permits mounting between centers. In such cases it is customary to mount the work on a face plate or hold it in a chuck, a device with jaws which grip the work rigidly while it is being machined.

If only one chuck is to be purchased, it should be the four-jaw independent chuck shown in Figure 84. It is easily the most versatile type of chuck. The four jaws are adjusted separately and are reversible so that work of any shape can be clamped from the inside or the outside. Some independent chucks are threaded

to fit directly on the spindle nose, others are bolted to an adapter plate which fits the spindle.

Mounting work in the four-jaw chuck is largely a matter of centering. Determine the portion of the rough work that is to run true, then clamp the work as closely centered as possible, using as a guide the concentric rings on the face of the chuck. Test for trueness, marking the high spots with chalk rested against the tool post or a tool bit mounted in the tool post (see Fig. 85). The chuck jaws should be adjusted until the chalk or tool bit contacts the entire circumference of the work.

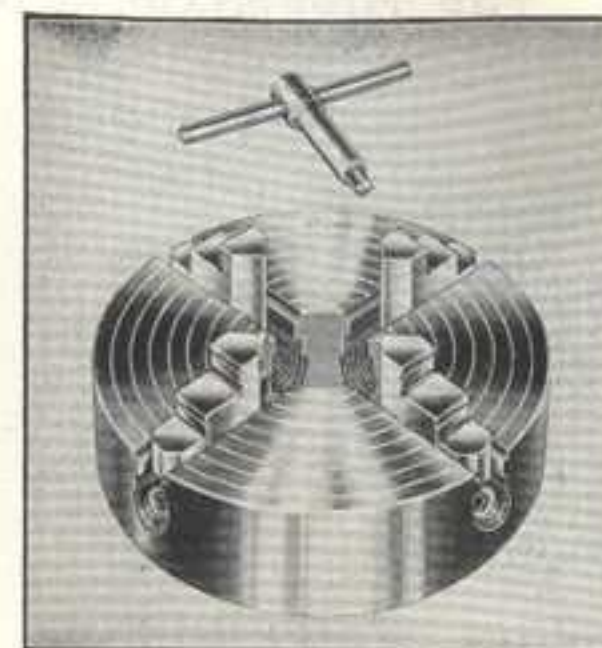


FIG. 84

The four-jaw independent chuck. The concentric rings on the face aid in adjusting the position of the work.

If especially accurate centering is desired, the trueness of the work should be checked with the tailstock center by means of an instrument called a center tester (see Fig. 86).

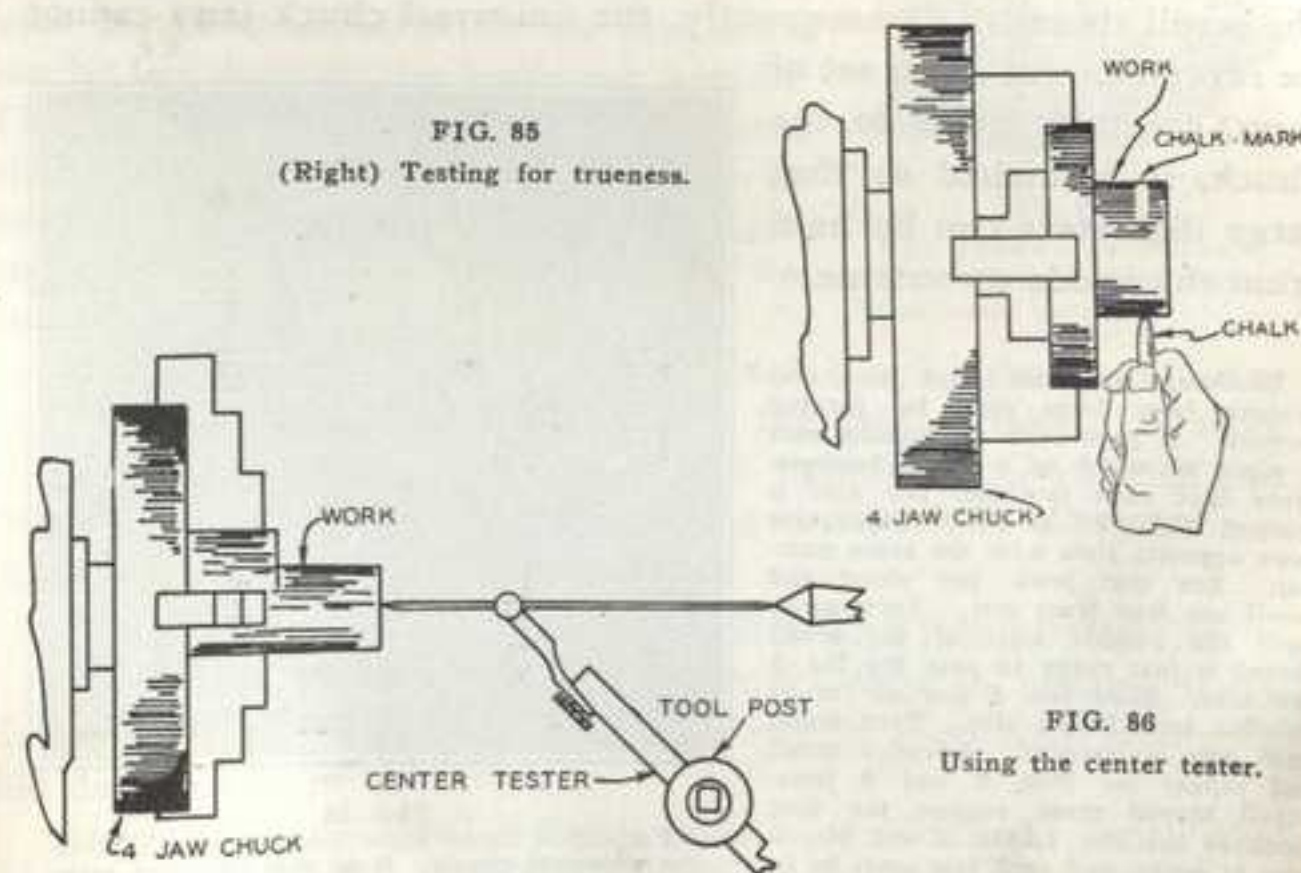


FIG. 85

(Right) Testing for trueness.

FIG. 86

Using the center tester,

THE THREE-JAW UNIVERSAL SCROLL CHUCK

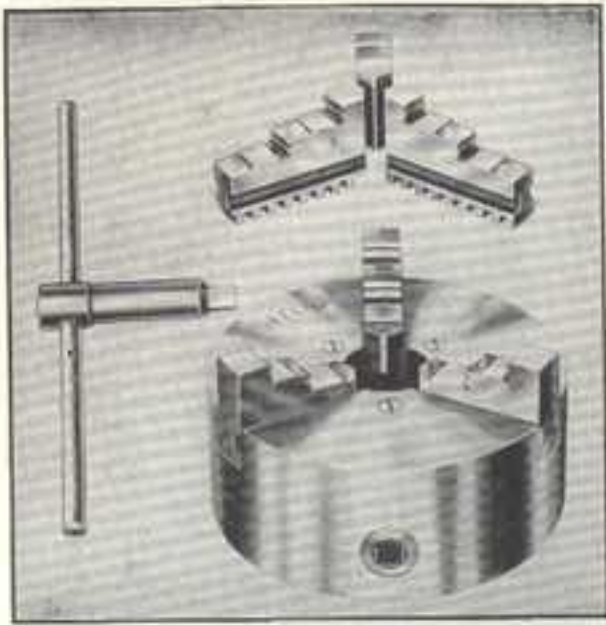


FIG. 87

The three-jaw universal scroll chuck.

The three jaws of the universal scroll chuck are self centering and adjusted by turning one screw. This construction saves time in the centering of round or hexagon work, but means that the universal chuck cannot be used for square or irregular shapes. $\frac{3}{4}$ inch stock can be fed through the headstock spindle and held in the universal chuck for turning or drilling.

Careful machining of the scroll controlling the jaws makes most universal chucks accurate to within .003 inch. For extremely accurate work, check for trueness with chalk and place shims over one of the jaws until the work runs true. To insure accuracy, the piece being machined should never be removed or reversed until all operations have been completed.

The teeth of the jaws are cut in a circular shape to mesh with the scroll threads. Consequently, the universal chuck jaws cannot be reversed. An extra set of jaws, carefully fitted to the chuck, is furnished so that large diameters can be held from the inside or outside.

To change universal chuck jaws, first remove jaws from slots by turning wrench. If jaws stick tap lightly with a piece of wood or a brass hammer. Note that each jaw and jaw slot is marked "1," "2," or "3." Place new jaws opposite slots with the same number. See that jaws, jaw slots, and scroll are free from dirt. Turn scroll until the outside start of the scroll thread is just ready to pass the No. 1 jaw slot. Slide No. 1 jaw as far as possible into No. 1 slot. Turn scroll until jaw is engaged. Advance scroll and repeat for Nos. 2 and 3 jaws. Scroll thread must engage the first tooth in the No. 1, No. 2 and No. 3 jaws in order, and each jaw must be in its own slot.

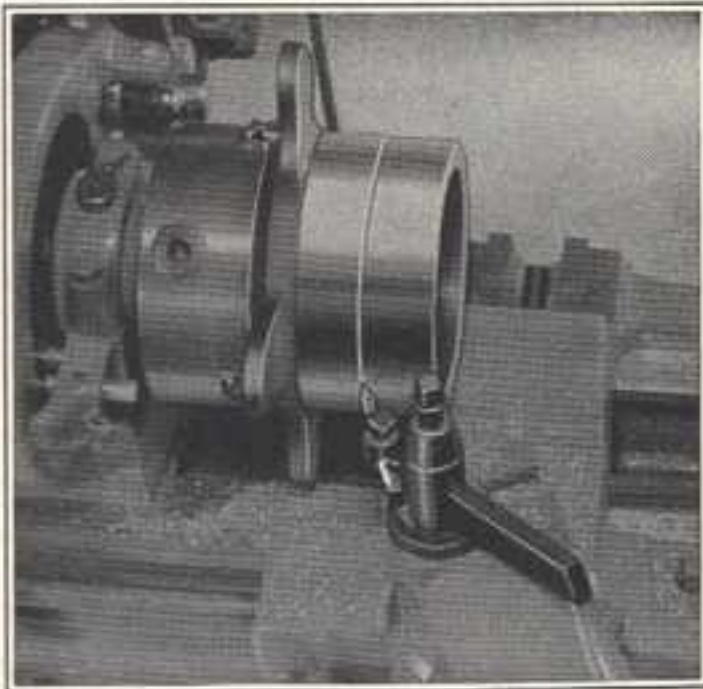


FIG. 88

Turning a large brass hydrant cap held in the universal chuck. Note that jaws are gripping the inside of the work.

THE JACOBS HEADSTOCK CHUCK

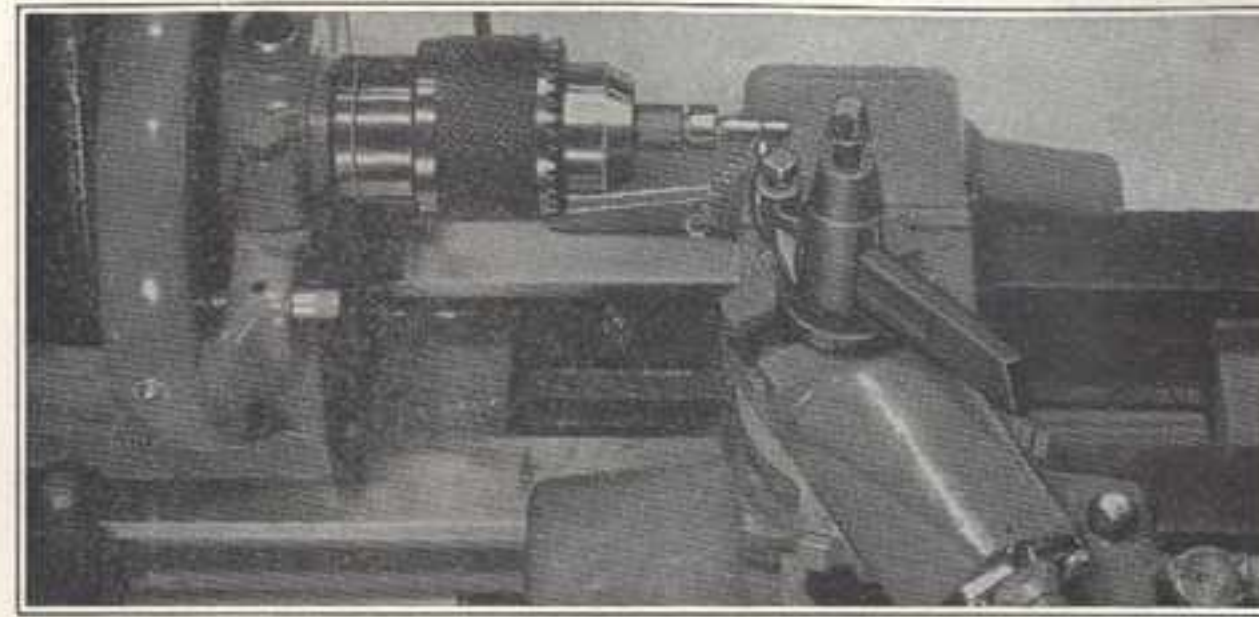


FIG. 89

Turning a small screw held in the headstock chuck.

The Jacobs headstock chuck is a most versatile chuck for holding small work in the lathe. Its accuracy is surpassed only by precision-made collets. The machinists handling any quantity of small work usually considers the headstock chuck an essential part of his equipment.

The headstock chuck is furnished in two sizes: capacities, $\frac{1}{8}$ to $\frac{5}{8}$ inch and $\frac{3}{16}$ to $\frac{3}{4}$ inch. Both are key-type chucks with a hollow construction so that work can be fed through the headstock spindle. They are threaded to fit the spindle nose of the lathe. The smaller size can also be used as a drill chuck, the inner section being tapered to fit an arbor adapter for mounting in the tailstock.



FIG. 90

The Jacobs headstock chuck showing internal taper for tailstock mounting.

When mounting work in the headstock chuck, take special care to clean between the jaws as well as the jaw surfaces. Always remove lathe center and sleeve. Never tighten the jaws until the work has been centered—keep twisting the work as the jaws are tightened.

REMOVING CHUCKS FROM THE LATHE SPINDLE

Almost every machinist has a favorite way to remove lathe chucks. The following method, illustrated in Figure 91, is simple and does not harm the chuck:

Turn the chuck until wrench hole is at the top. Lock the spindle in position by engaging the back gears without pulling out

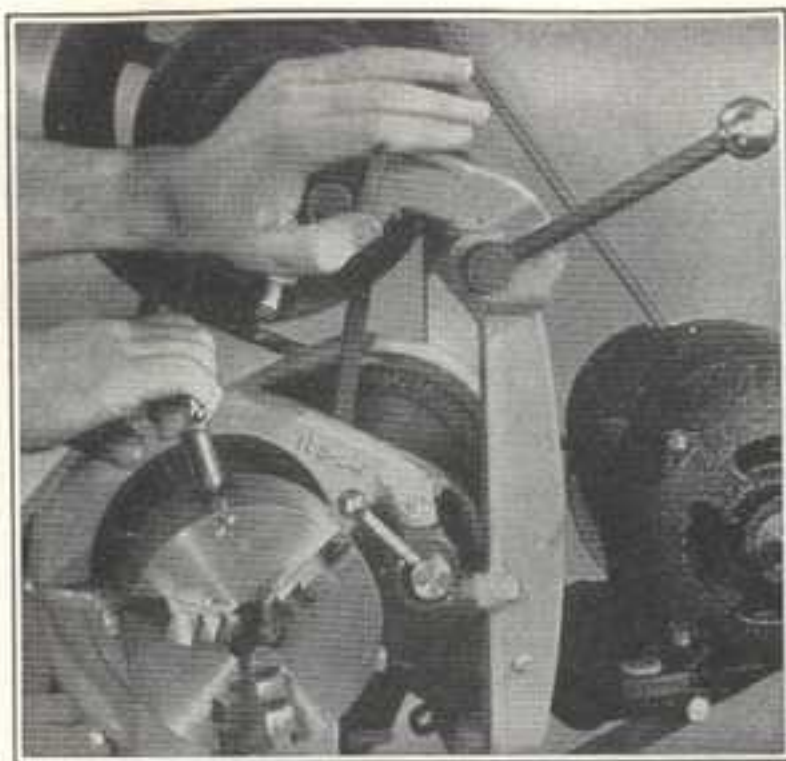


FIG. 91
A proper method for removing
a chuck.

the lock pin on the face of the front spindle back gear. Put the chuck wrench in its hole and pull as shown in Figure 91. If necessary, tap the jaws with a piece of wood or a brass hammer. Do not remove the chuck carelessly. You may damage the spindle or chuck threads or drop the chuck on the bed ways.

GENERAL RULES FOR USING CHUCKS

Keep the chuck clean and do not oil excessively—a light film on all working parts is ample. Before mounting work, clean the threads in both the chuck and the lathe spindle with a piece of bent wire. Clean the face of the shoulder on the spindle nose and the back face of the chuck. Put a few drops of oil on spindle nose.

Mount the chuck carefully and not too tight, first removing the center and sleeve from the spindle. When the chuck is about 1/32 inch from the shoulder, finish with one more turning motion. The soft thud indicates a good firm seating against the shoulder. Running a chuck suddenly against the shoulder strains the spindle and makes removal difficult.

Be careful when tightening work in the chuck jaws. Too much pressure on the jaws will affect the accuracy of the chuck and may spring the work if a light piece is being turned. Try to have the jaws tighten around the more solid parts of the work. Always use the wrench which comes with the chuck. When chucking work in the universal or headstock chuck, turn the work as the jaws are tightened—an accurate "form fit" will result.

Small diameter work should not project from the chuck jaws

more than four or five times its diameter—cuts should be short and light. Heavy cutting pressures will often cause small work to spring out and "ride the tool." In some instances, extra long work can be supported in the tailstock center.

Do not force a chuck to carry work larger than the diameter of the chuck body. Repeated overloading may damage the chuck.

If the jaws stick, tap lightly with a piece of wood or a brass hammer. "Sticky" jaws indicate that the chuck should be taken apart for a thorough cleaning. An old toothbrush makes an excellent chuck cleaner. Wash and brush chuck parts in a pan of kerosene. When reassembling, do not apply too much oil. Oil collects dust and chips which sooner or later clog the chuck mechanism.

Chuck jaws are carefully fitted to the chuck at the factory and are not interchangeable. When new jaws are necessary, return the complete chuck to the manufacturer. Inspect the chuck regularly to see that all parts are in good working order.

Keep the chuck protected when not in use. Dirt, dust, chips and falling tools can cause much damage.

THE FACE PLATE

Many types of lathe work which cannot be machined on centers or in a chuck are fastened to a face plate with bolts, studs or clamps. Some of the most accurate tool and die operations are handled in this way. Face plate work also includes the turning of large, flat or irregular shaped pieces such as jigs. The 8½ inch face plate shown in Figure 92 is recommended for all types of face plate turning or boring.

The face plate should be mounted carefully in the same manner as a chuck (see page 78). For ordinary turning the work is simply bolted or clamped directly to the face plate.

When maximum accuracy is desired, a light trueing cut is

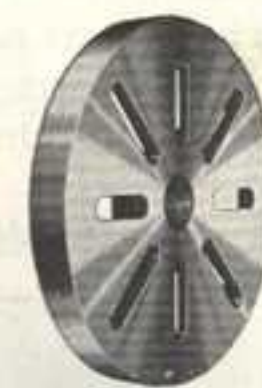


FIG. 92
8½ inch Face
Plate

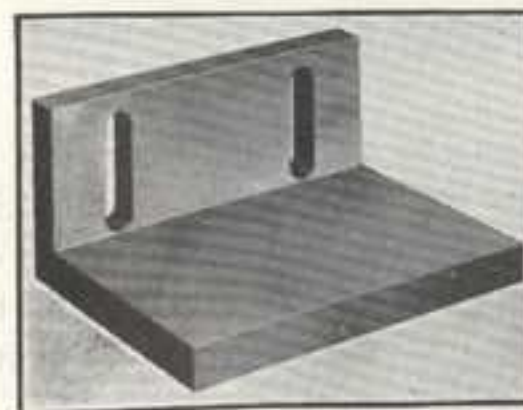


FIG. 93
Angle Plate

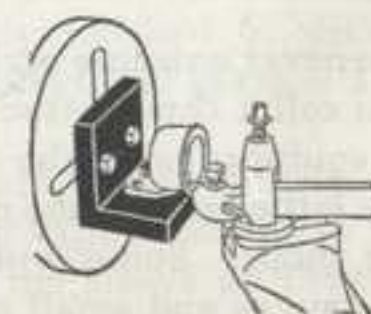


FIG. 94
Using the Angle Plate

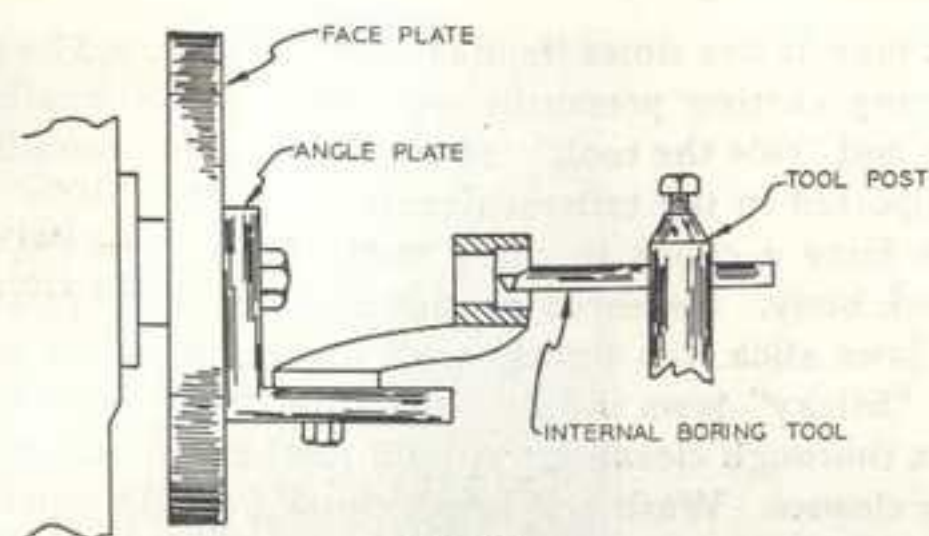


FIG. 95
How the angle plate centers a portion of an irregular piece of work.

first taken across the face of the face plate. The face plate can be removed by tapping the slot at the outside edge with a piece of wood or a brass hammer.

The angle plate shown in Figure 93 is bolted to any point on the face plate for machining irregular shapes and for off-center drilling and boring. Figures 94 and 95 show two typical jobs.

Note: When heavy pieces are mounted off center, bolt a counter-balance of equal weight on the opposite edge of the face plate. The counter-balance protects lathe accuracy by equalizing pressure on the bearings and reduces excessive vibration caused by out-of-balance turning.

DRAW-IN COLLET CHUCK ATTACHMENT

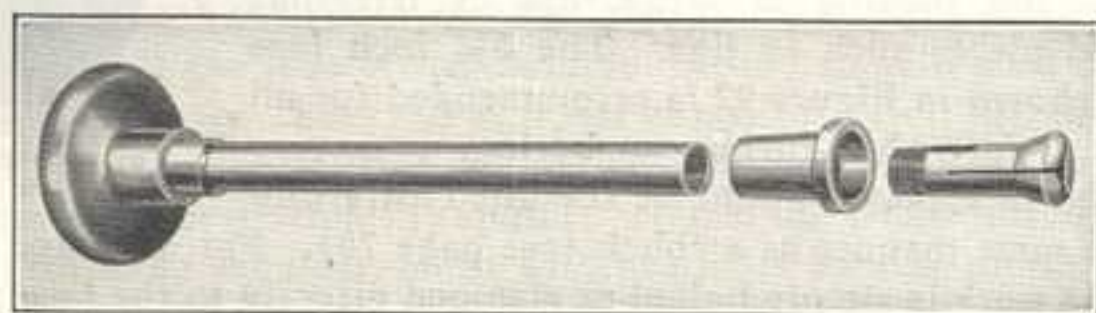


FIG. 96
Draw-in collet chuck attachment showing units in order of their assembly into the lathe headstock: draw-in spindle, tapered closing sleeve, and split holding collet.

Whenever extreme accuracy is required on small diameters, the draw-in collet chuck attachment is the logical method of chucking. When equipped with the collet assembly and the various size collets, the lathe handles the most exacting work in tool rooms and tool and die shops. Some typical collet work: precision tools, instruments, gauges and small production parts.

The collet attachment, as shown in Figure 96, includes a hollow

draw-in spindle which extends through the lathe headstock spindle, a tapered holding sleeve and the split holding collets. The collets are released or tightened on the work by turning the hand wheel (see Fig. 97). Work can be fed through the lathe headstock spindle. The individual collets are furnished in all 32nds between 1/32 and 1/2 inch. Special sizes and shapes including metric diameters are also available.

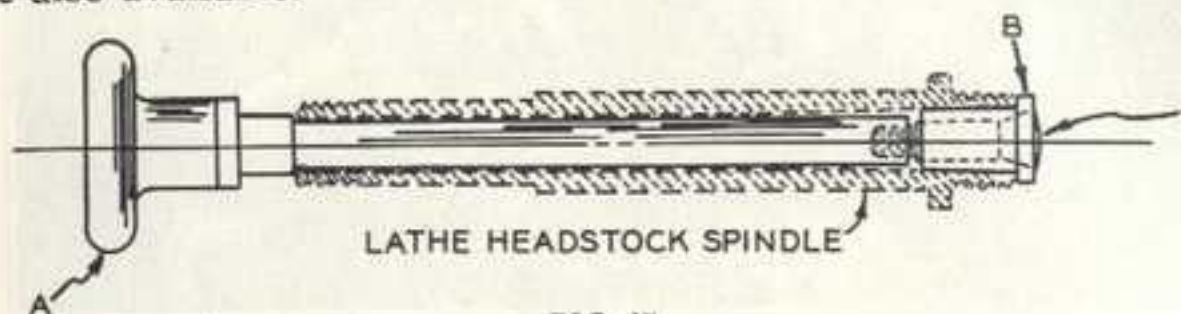


FIG. 97
Cross section showing draw-in collet assembly in lathe headstock. Turning handle A pulls collet C into sleeve B, tightening collet on work.

There are two important rules for the use of the draw-in collet chuck attachment—first, absolute cleanliness and, second, selection of the proper size collet. The collets, tapered sleeve, and the inside of the spindle nose *must* be wiped clean and dry. A collet must never be used to hold work which is more than .005 inch larger or smaller than the rated diameter of the collet. A collet attachment is the most accurate type of precision chucking and must be treated with greatest care.

MOUNTING WORK ON THE MANDREL OR ARBOR

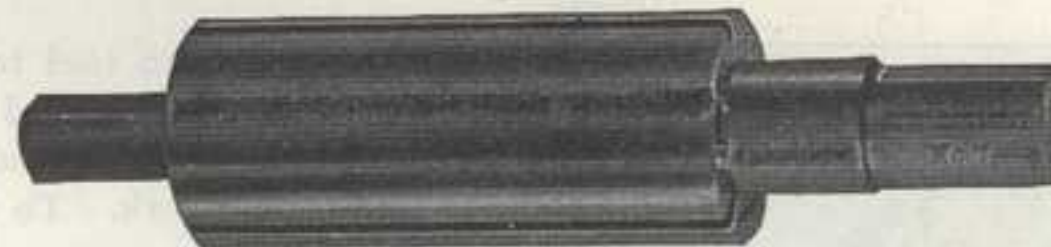


FIG. 98
Expanding mandrel.

Figure 98 shows a commercial type of expanding mandrel or arbor designed to provide work centers for facing or turning the outside diameter of work that is nearly finished or difficult to mount in a chuck. The machining of pulleys and gears is a typical mandrel job.

The mandrel consists of the ground and hardened body, tapered through its entire length, and a cast iron expansion sleeve with an internal taper to fit the body. Forcing the sleeve on the mandrel causes it to expand and hold the work firmly in position.

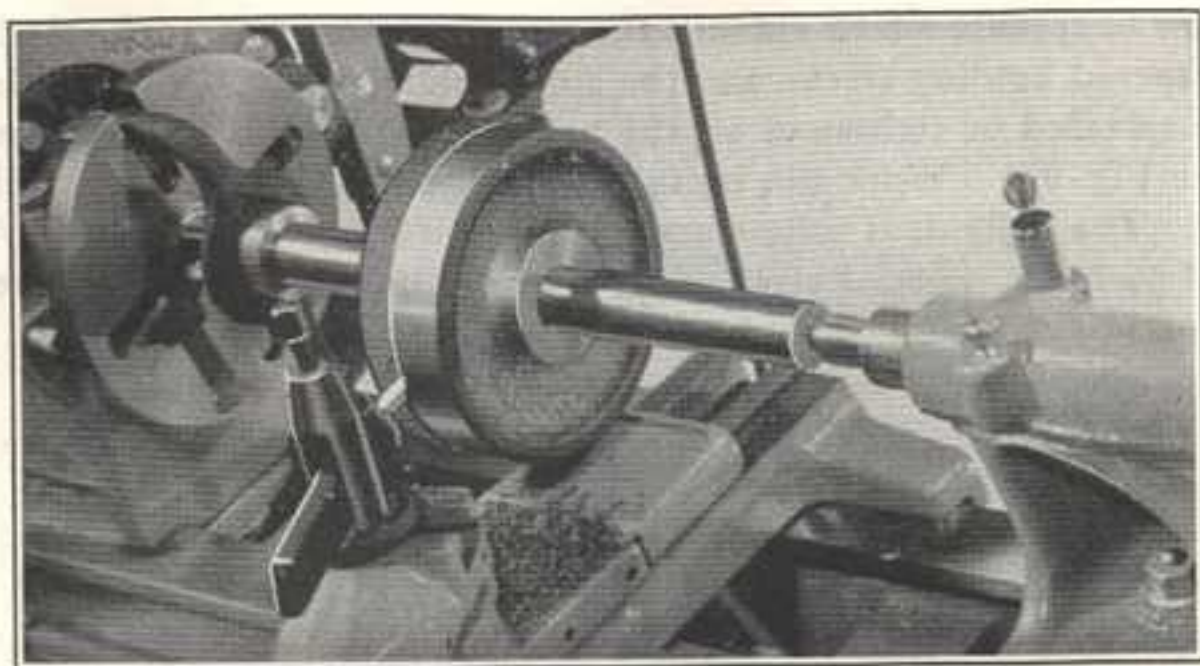


FIG. 99
Turning a cast iron pulley on a mandrel.

A mandrel, such as the one used in Figure 99, is often made on the lathe for any special piece of work. These mandrels are turned from round bar machine steel stock and the ends case-hardened if possible. Cast iron, with hardened tool steel plugs for the ends, is often used in making a mandrel for large work. The mandrel should be tapered about .006 or .008 inch per foot and polished or ground. When finished, the mandrel diameter should be a force fit for the hole in the work and the tailstock end should be .003 or .004 inch smaller. It is recommended that the mandrel be turned undersized at both ends for about $\frac{3}{4}$ inch to prevent damage.



FIG. 100
Pressing mandrel on bushing
before machining.

A mandrel is a precision tool for accurate work and must be handled with care. The ends are centered and counter-sunk exactly like other work. To make removal easier, put a drop or two of oil on the portion of the mandrel which will grip the work. Never drive a mandrel with a steel hammer without protecting the end. The best tool for forcing a mandrel in or out of the work is an arbor press, or mandrel press (Fig. 100). Be sure the work is started perfectly straight and on the entering end of the mandrel. Do not allow the tailstock center to become too hot during the machining operation.

Part 6

DRILLING AND BORING

PART 6

DRILLING AND BORING

DRILLING

Lathe drilling can be handled in two ways. Figure 101 shows the work revolving while the drill is held stationary in the tailstock. This method results in a straighter hole and insures greater accuracy than any other method. The second method of drilling is shown in Figures 114 and 115—the work is held rigid while the drill turns in the headstock. The shop with considerable drilling, reaming and tapping will find a drill press a profitable investment, because the lathe requires special attachments for production drilling.

FIG. 101

Drilling with the work revolving in the headstock. This type of set-up insures maximum accuracy. Note use of graduated tailstock ram to indicate depth.

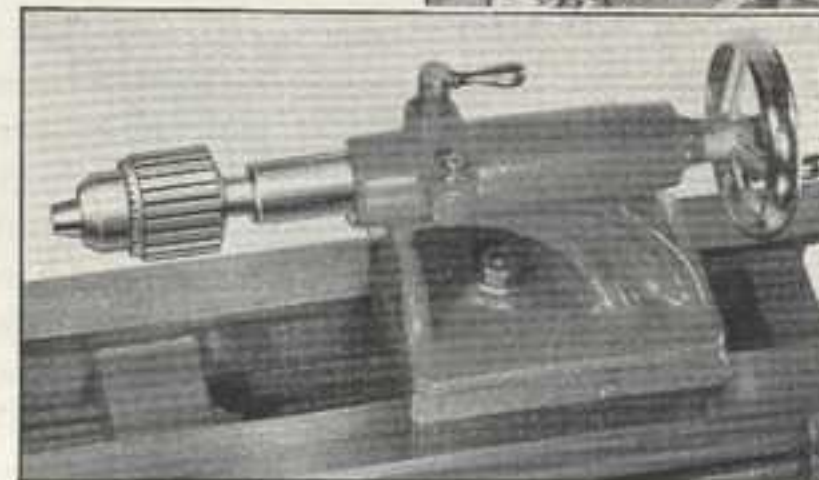
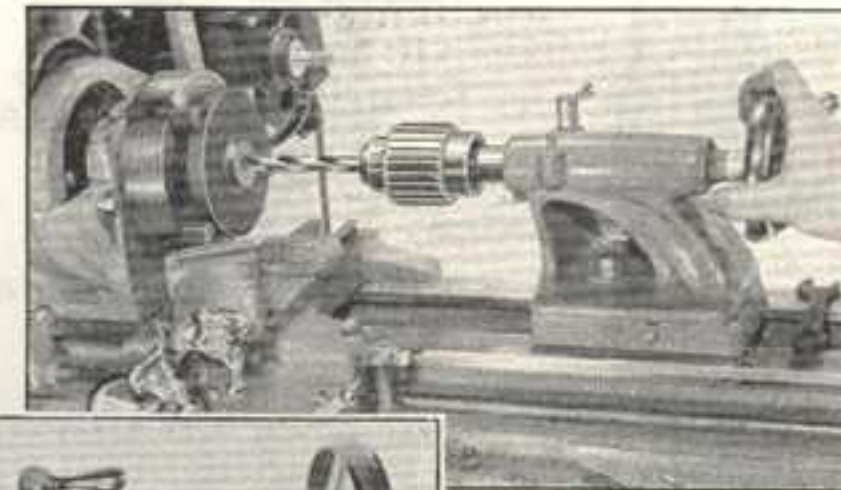


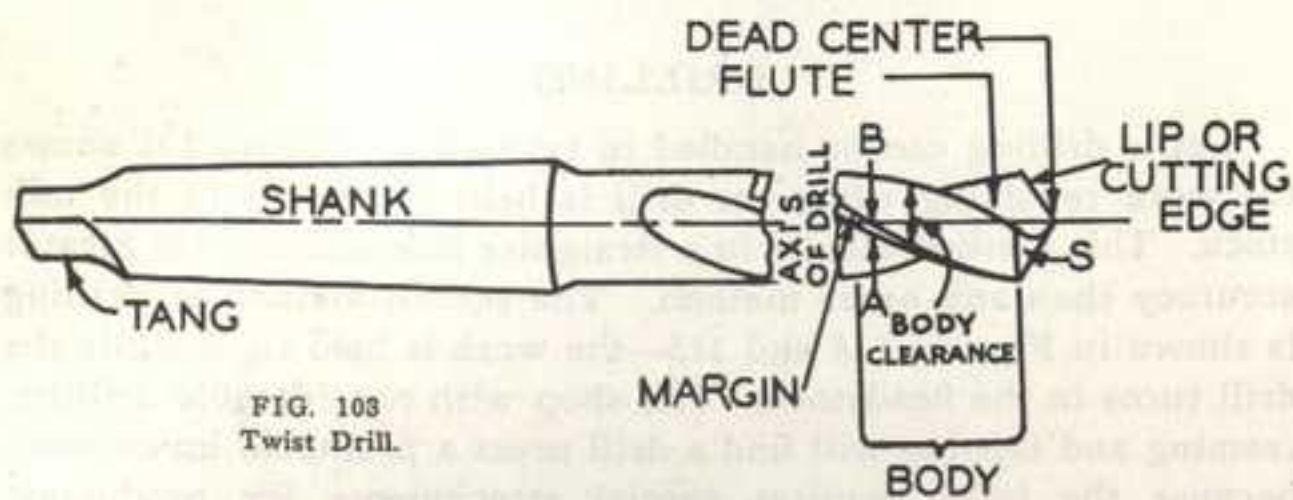
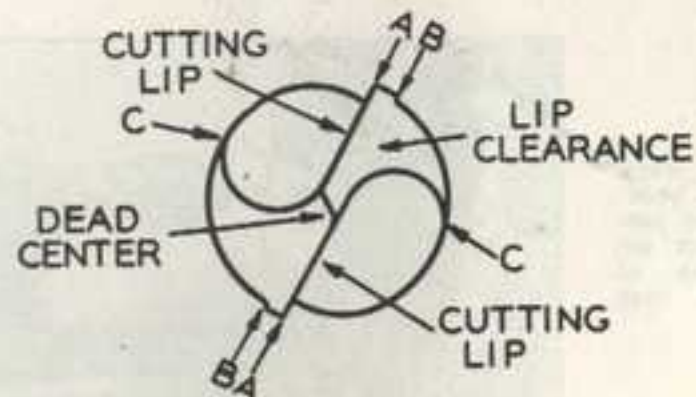
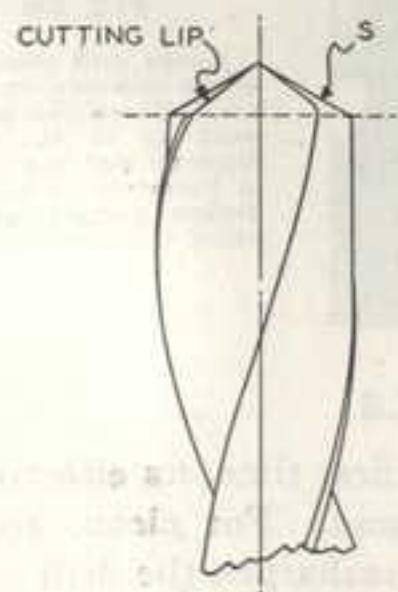
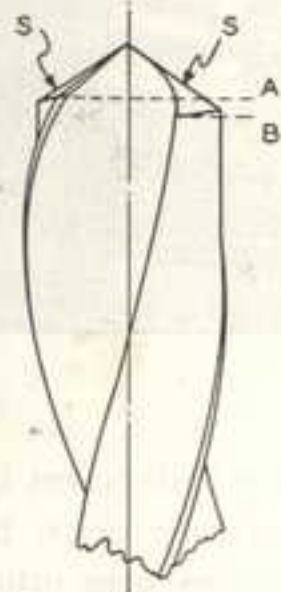
FIG. 102

Jacobs drill chuck held in the tailstock on an arbor. These chucks hold work up to $\frac{1}{2}$ inch in diameter and can be used in headstock or tailstock. Follow general rules for using chucks—Part 5.

TWIST DRILLS

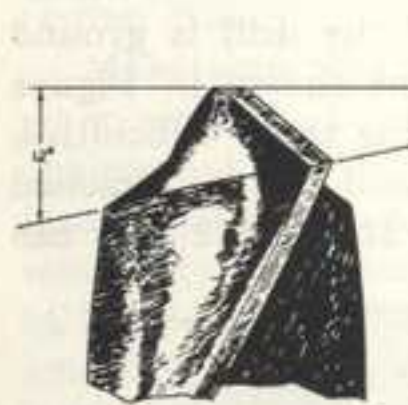
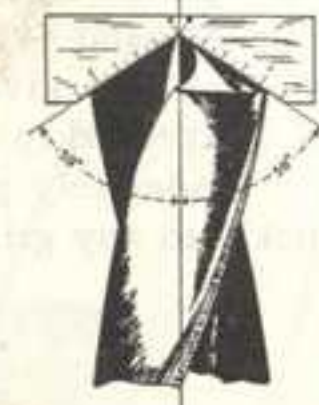
After the drill point is dulled for the first time, its effectiveness depends entirely upon how it is reground. For clean, accurate drilling, the operator must know how to resharpen the drill properly. Figures 103 and 104 give the usual shop terms used in drill grinding. The cone-shaped surface at the end of the drill is called the "point," and the edge at the extreme tip end is the "dead center."

THE TWIST DRILL

FIG. 103
Twist Drill.FIG. 104
Point of Twist Drill—End View.FIG. 105A
Drill without lip clearance.
The cutting lip and heel, S,
are in the same plane.FIG. 105B
Drill with proper lip clearance.
Heel line, B, is lower than cutting
lip line, A. Distance between A
and B measures amount of lip clear-
ance.

Basically, a drill cuts metal exactly like a lathe tool. In order to penetrate the work, the cutting edge must have the correct cutting angle and "lip clearance" at the center of the drill (Fig. 104). Figure 105B shows how the "heel," the part directly back of the cutting edge, must be ground away. The word "heel," when used in this sense, includes the entire surface back of the cutting edge, not the circumference only.

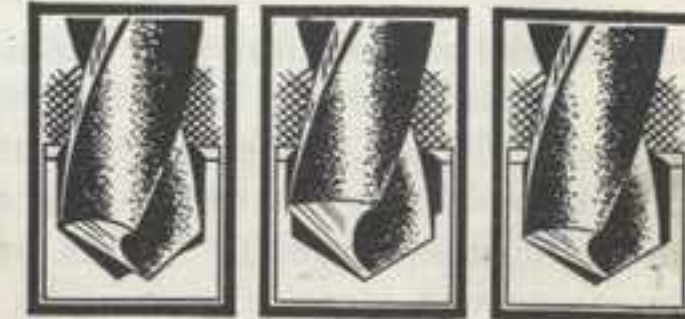
FIG. 106. THE PROPERLY GROUND DRILL

FIG. 106A
Drill point showing
proper lip clearance an-
gles at the circumference
of the drill.FIG. 106B
End view of drill point
showing proper angle be-
tween point and lip.FIG. 106C
Drill point with lips
ground identically. Lips
are of equal length, clear-
ance and angle.

Two rules are especially important when grinding drill points. First, the lip clearance angle (Fig. 106A) should be between 12 and 15 degrees. Second, the two cutting edges must be of equal length and angle. Figure 107 (below) shows the unsatisfactory results of disregarding these two rules. In Figures 106A, B and C, the properly ground drill point is shown—note lip clearance, angle between point and lip, and the identical lips. Refer to these drawings while the drill is being ground—they will aid in grinding drills which will cut true-sized holes with a minimum of drill wear. The angle of 59° given in Figure 106C is satisfactory for the general drilling of steel, iron and brass—larger angles are used frequently in production work and on softer metals. Both lip angle and lip length should be checked with a drill gauge (Fig. 108).

FIG. 107

Common mistakes of drill grinding. Note that in each case the resulting hole must be oversize. (Left) Lips of unequal angle and unequal length. Drill point actually travels AROUND the center of the hole. (Center) Lips of unequal angle. The right lip is doing all the work. (Right) Lips of equal angle, but unequal length, causing excessive wear on right lip.



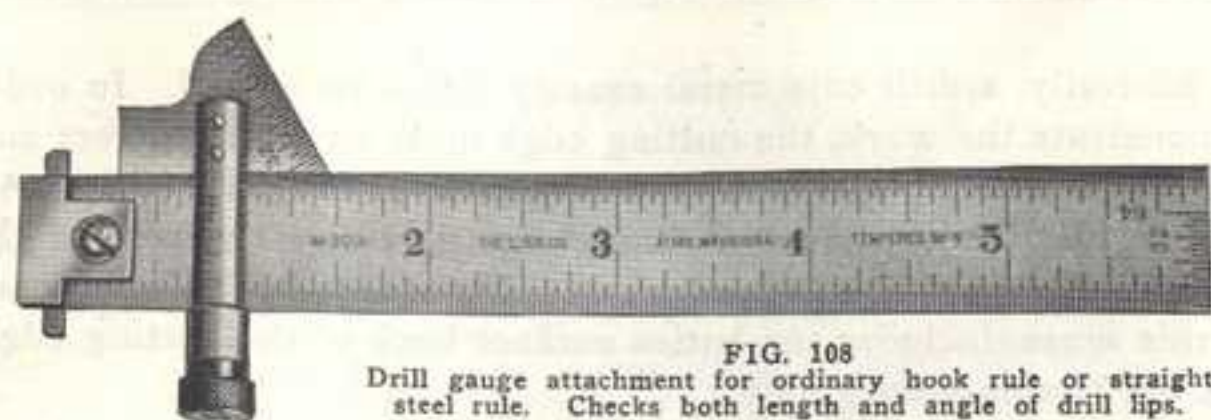


FIG. 108
Drill gauge attachment for ordinary hook rule or straight steel rule. Checks both length and angle of drill lips.

DRILL GRINDING ATTACHMENT

Shop men agree that it is difficult to grind a small drill accurately by hand—very often a good portion of the drill is ground away without giving service. The attachment shown in Figure 109 has proved to be a great help in overcoming these difficulties. It is moderately priced, simple in operation and can be attached quickly to any grinder. Any drill between 3/32 and 1/2 inch can



FIG. 109
Drill Grinding Attachment.

be centered automatically in the novel chuck and V-block. Lip angle is controlled by adjusting the swivel base with the ball handle at the left. The design of this attachment allows the drill to be turned in an exact half circle and accurately rechucked after one lip has been ground. In this way, the two lips of the drill are always ground identically.

DRILLING SPEEDS

When high speed drills are used, drilling speeds in surface feet per minute for the various metals are the same as the speeds for general turning given in Part 4. The upper portion of the Table of Cutting Speeds, page 49, will assist in the selection of the proper drilling speed. The figures in the column below "Diameter of Work" can be considered as drill sizes. Belt positions are determined by locating the proper spindle speed in Figure 56 and then referring to Figure 55, page 47. The speed should be reduced one-half with carbon drills.

Make sure that the drill runs true when starting—it may be necessary to countersink the work (see page 71). Small drills should be fed into the work carefully since they are designed to be run at very high speeds. Avoid too high a speed, especially with the larger drills—Figure 110 shows how an excessive speed wears off drill corners. Too high a speed also draws the temper of the drill and may even burn or break the drill tip.

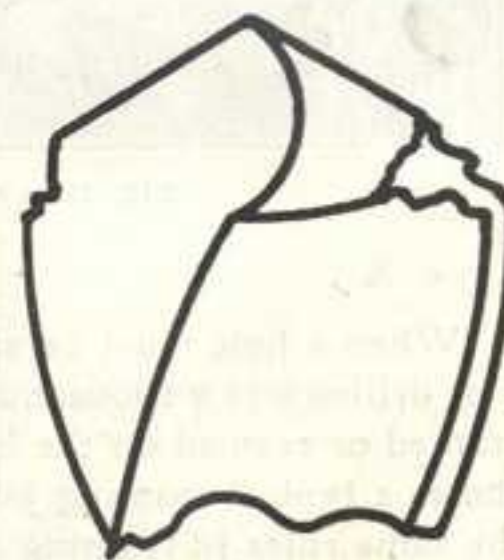


FIG. 110
Drill with edges burned by excessive heat from high speeds or drilling hard material.

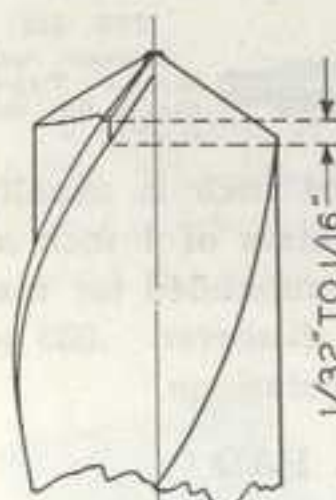


FIG. 111
Drill point for drilling brass.

NOTE: When drilling brass, aluminum, lead and other soft materials which cause the tool to "hog in," reduce the rake angle of the cutting edge by grinding as shown at the left. This reduced rake angle is also desirable when drilling very hard materials because it lessens the strain on the drill. This change makes drilling easier and smoother and results in a more accurate drilled hole.

LUBRICATION

A cutting compound is essential when drilling practically any metal. The following compounds will give best results:

Hard, tough steels.....	Turpentine or kerosene
Softer steels.....	Lard oil or equivalent
Aluminum and other soft alloys.....	Kerosene
Brass.....	Drill dry or use paraffin oil
Die castings.....	Drill dry or use kerosene
Cast iron.....	Drill dry

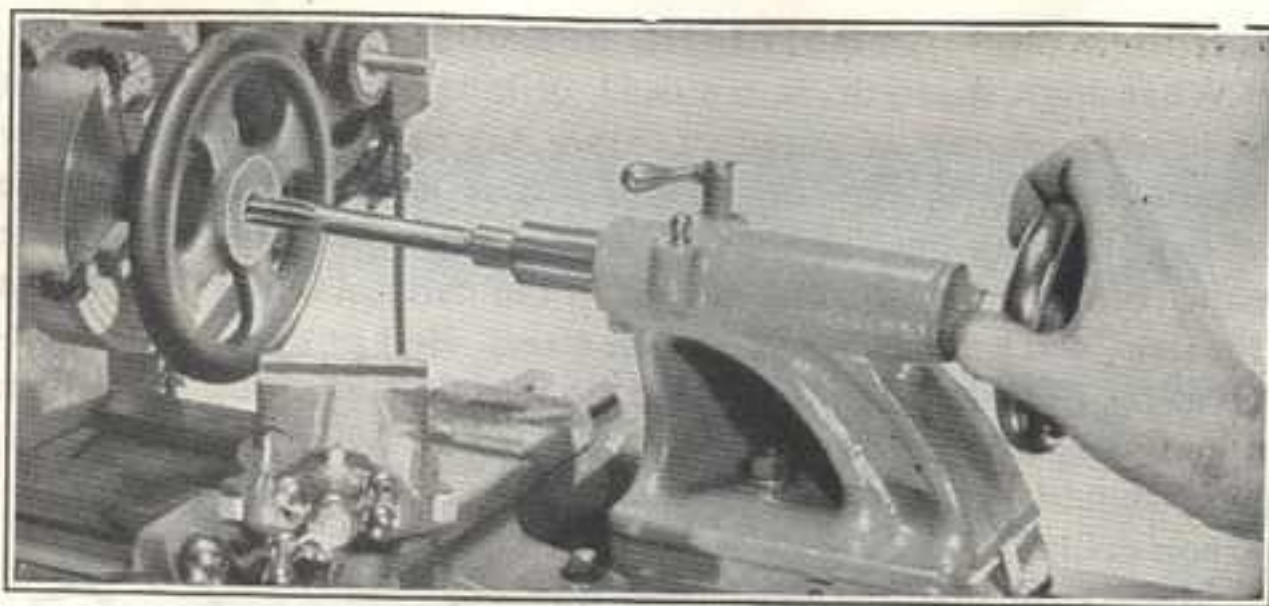


FIG. 112. Reaming a cast iron handwheel.

REAMING

When a hole must be accurate to within .002 inch or less, it is first drilled a few thousandths of an inch undersize and then hand-reamed or reamed on the lathe to the finish-diameter. Figure 112 shows a typical reaming job on the lathe. For best results, follow the same rules in reaming as in drilling and general turning. Use slow speeds, feed in evenly and be sure there are no burrs on the reamer teeth. The type of reamer shown in Figure 113 is generally used in the lathe.



FIG. 113. Reamer with Morse Taper shank for tailstock.

A reaming allowance between .010 and 1/64 inch is usually sufficient for machine-reaming holes with diameters of 1 inch or less—an allowance of 1/64 to 1/32 inch is recommended for machine-reaming holes between 1 and 2 inches in diameter. .003 to .005 inch is usually allowed for hand reaming operations.

CROTCH CENTER AND DRILL PAD

The crotch center and drill pad are two important attachments recommended for drilling work that cannot be chucked in the lathe. Both are mounted in the tailstock ram as shown in Figures 114 and 115.

The drill pad serves as a table for flat or square work and is especially valuable for drilling large holes when a drill press is not available. The crotch center automatically centers round work for cross drilling. The work is held in the left hand and advanced against the drill by turning the tailstock handwheel. The left

FIG. 114. Using the drill pad to support flat work while drilling a large hole.

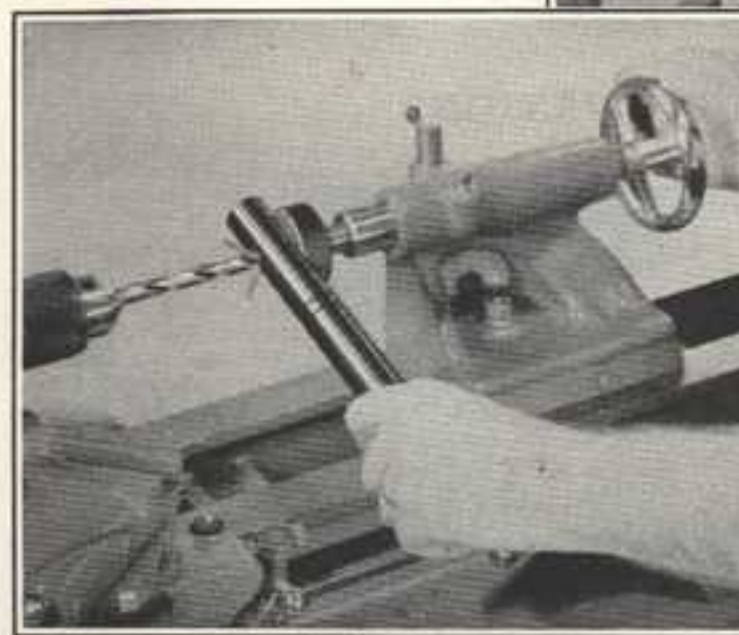
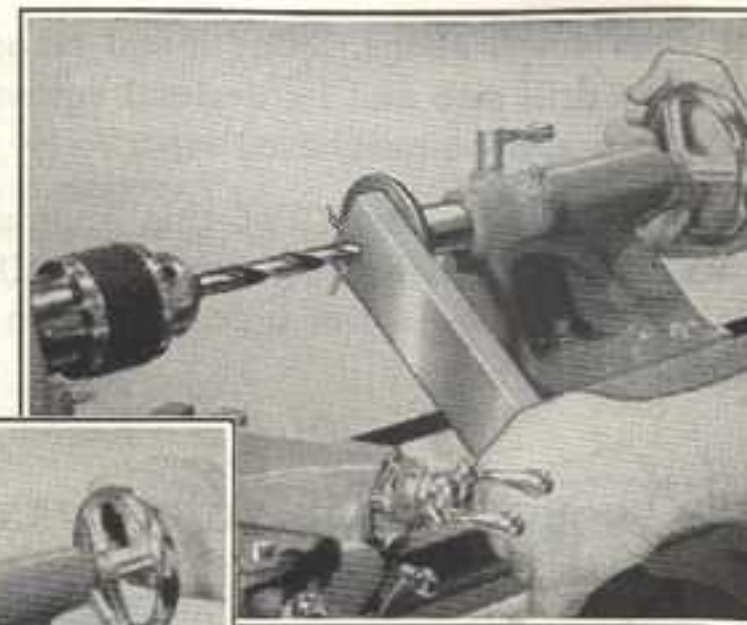


FIG. 115. Cross drilling a round shaft centered in the v-slot of the crotch center.



hand and work can be rested on a piece of wood to steady the work and protect the bed way as shown in Figure 114 above.

DRILL SETS

Every shop requires an assortment of the more commonly used drills. The sizes necessary depend upon the amount and character of the operations ordinarily performed. There is a marked trend toward the high speed drill in preference to the carbon drill. The drill set in Figure 116 includes high speed or carbon drills between 1/16 and 1/2 inch by 64ths and is adequate

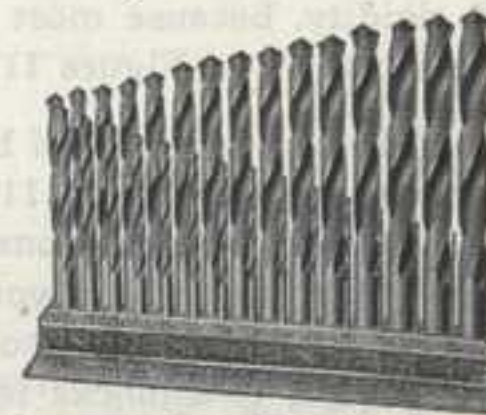


FIG. 116. Drill set including metal carrying case and stand for 29 drills.

for most small shops. The metal stand has a hole for each drill with the drill size and its decimal equivalent clearly marked. The drills can also be purchased separately.

The tables in Part 10 of this Manual give the decimal equivalents of the numbered and lettered drills and the proper drills for use with various sizes of taps. Drills in metric sizes are also available.

BORING OPERATIONS



FIG. 117
Boring the inside of a large steel bushing. Note high-speed boring tool mounted directly in tool post for maximum rigidity.

Boring operations require only slightly different tools and methods than those for external turning. The big problem is that of tool rigidity, because most internal tools project considerably from their support. Figure 117 shows a typical boring operation.

There are several types of boring tools and mounting methods. The tools shown in Figure 119 are mounted directly in the tool post. The solid one-piece construction adds to rigidity by eliminating the extra joint which would result if the tool were held in a separate holder. In addition to five internal tools, this set includes a small v-block, two blocks for height spacing, and two $\frac{3}{8}$ -inch heavy-duty external tools for use directly in the tool post.

TOOL SHAPES FOR BORING

Although boring tool angles in relation to the work are somewhat different than those of an external tool, the terms in Figures 118A and 118B are fairly standard and will aid in proper tool grinding.

BORING TOOLS

FIG. 118A

This drawing shows construction and angles of the boring tools shown in Figure 119 below. These angles make this type of tool extremely practical for all-around boring.

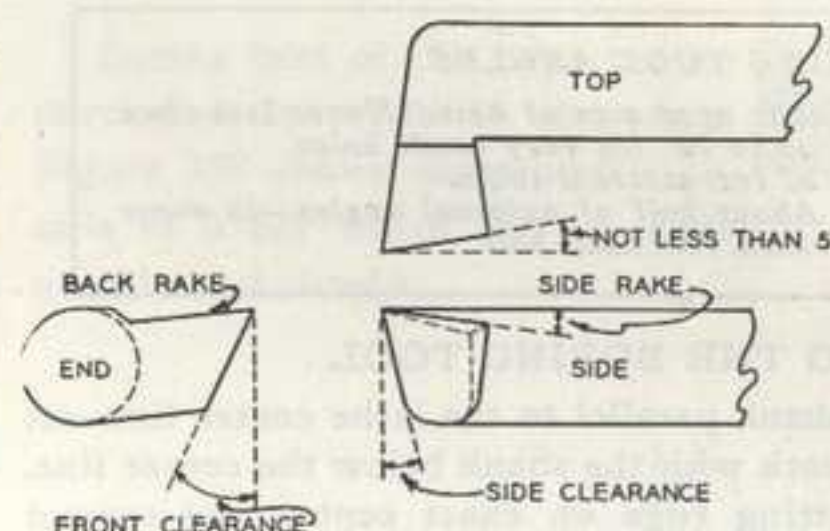
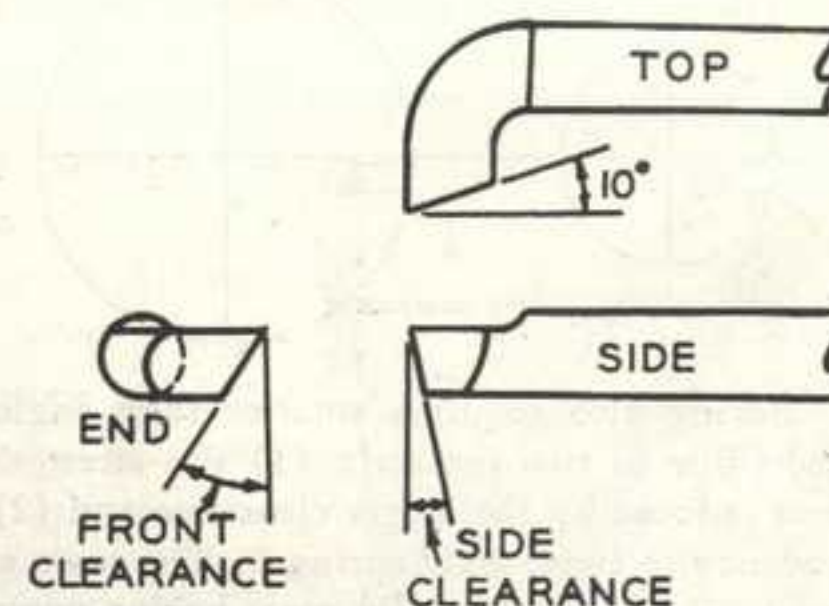
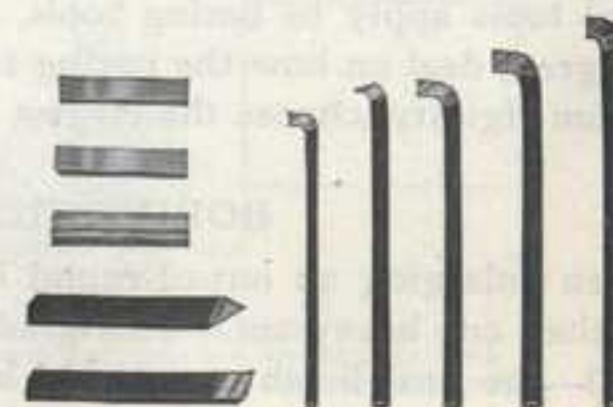


FIG. 118B

The boring tool angles shown in Figure 118A often resemble angles like these after continued grinding. New angles, such as the rake angles shown here, may be ground as desired for special jobs.

FIG. 119

Set of tools for use directly in the tool post. This set includes four boring tools, one inside threading tool, two spacers, v-block, $\frac{3}{8}$ inch high-speed threading tool, and $\frac{3}{8}$ inch high-speed turning tool.



TOOL SHAPES FOR BORING (Continued)

Front clearance must be increased in order to prevent the heel from rubbing on the surface of the cut. The exact amount of front clearance depends upon the size of the hole being bored. Figure 120 shows how a front clearance angle can be too small for one hole but satisfactory for a larger hole.

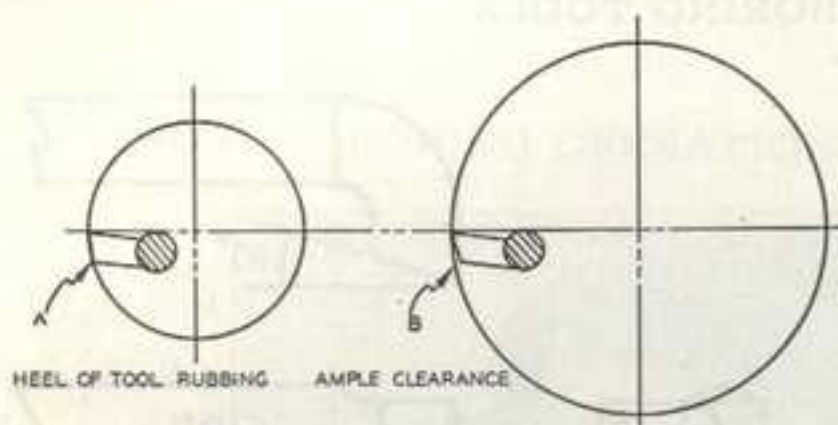


FIG. 120
This drawing shows how a certain angle of front clearance may be too small for one hole but satisfactory for a larger hole. At "A" the heel of the tool is rubbing. At "B" in the larger hole there is ample clearance.

Boring also requires smaller rake angles, and finer cuts and feeds, due to two reasons: (1) the strength of the tool edge has been reduced by the larger clearance and (2) the boring tool has a tendency to twist and "spring." The tools shown in Figures 118A and 118B are excellent for most boring operations.

BORING TOOL ANGLES

Front Clearance: Depends upon size of hole. Never less than 10° ; up to 20° for very small holes.
Side Clearance: Same as for external tools.
Back and Side Rake: About half of external angles—in some cases, less than half.

SETTING THE BORING TOOL

With the round tool shank parallel to the lathe center line, set the boring tool into the work with the shank below the center line. Then by putting the cutting edge on exact center, the correct amount of back rake is provided. The general rules for the use of external tools apply to boring tools, except that rake angles depend a great deal on how the boring tool is set in the holder. For maximum rigidity, choose the largest possible boring tool.

BORING HINTS

When enlarging an out-of-round hole, take several small cuts rather than one heavy cut. This gradual process avoids spring in the tool—the final finish cut should be continuous.

After the last finish cut it is common practice to shift the reversing lever at the end of the forward cut and take a last fine shaving cut with the tool coming out of the work. This last cut is taken without resetting or disturbing the tool and avoids a slightly undersized hole which might otherwise result from tool spring.

Use the .0035 or .0050 inch feed and take shallow cuts.

BORING WITH THE WORK HELD STATIONARY

Figure 121 shows a method of taking long or heavy boring cuts. The work is clamped rigidly in a boring table and vise on the carriage, and a boring tool bit is set into an arbor mounted between centers. The tool bit is reset after each cut. Larger rake angles and heavier feeds and cuts may be used, since the tool has less spring.



FIG. 121
Boring a small grinder spindle bearing housing held in the boring table and vise.

Boring bars of this type can be purchased or made in the shop. Figure 122 shows construction details of a bar which can be made quickly and simply.

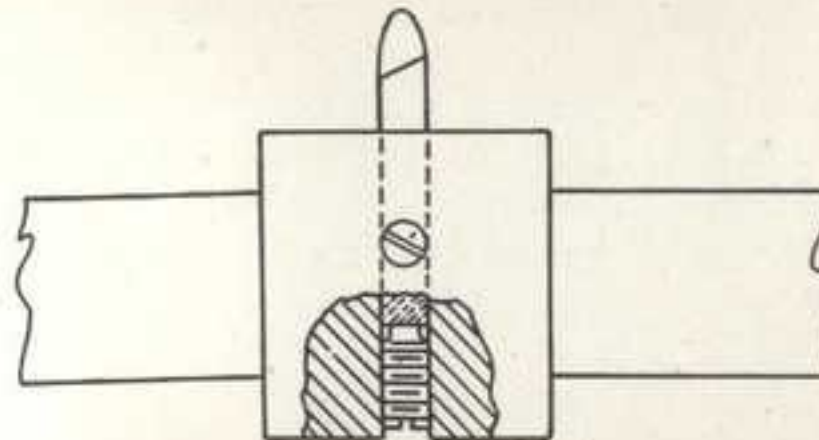


FIG. 122
A boring bar that can be made easily in the small shop. One set screw feeds the tool bit into the work after each cut—the other locks the tool bit in place.

Part 7

THREAD CUTTING

THREAD CUTTING

on the

Atlas F-SERIES TEN-INCH LATHES



Atlas Press Company

KALAMAZOO 13D, MICHIGAN, U. S. A.

THREAD CUTTING ON THE ATLAS F-SERIES TEN-INCH LATHE

No phase of lathe operation is more interesting or profitable than the cutting of screws and threads; and no operation requires more care and study. The thread cutting range of the Atlas is practically unlimited—a few sample threads are shown in Fig. 1.

This section deals with the two classes of thread cutting problems: (1) those connected with the change gear train and its proper set-up for cutting the various sizes of threads, and (2) the actual cutting of the many thread forms.

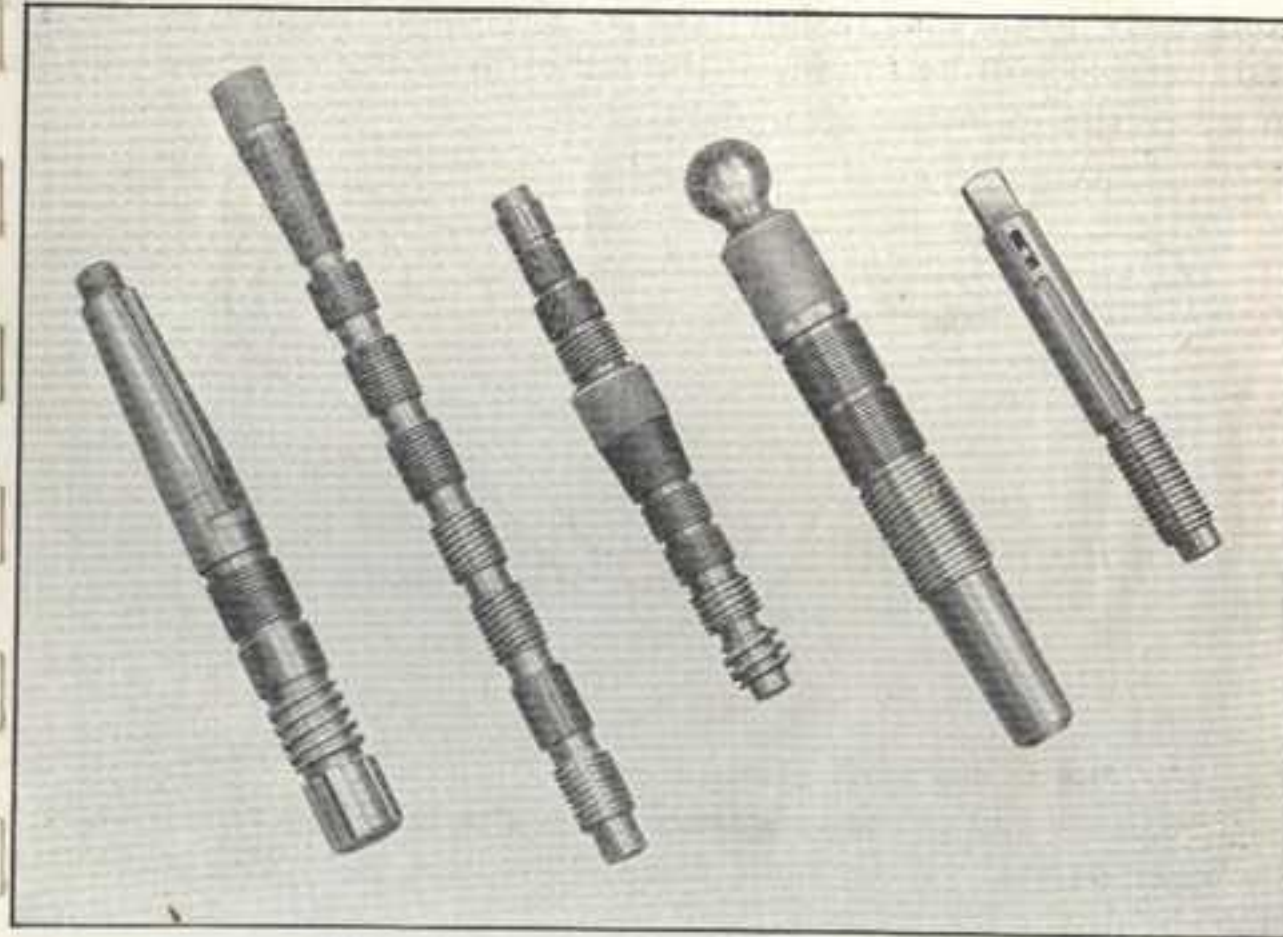


FIG. 1. A few of the threads that can be cut on the lathe.

Every Atlas lathe comes equipped with change gears and threading dial for cutting threads in the following standards: National Coarse (U.S.S.), National Fine (S.A.E.), Acme, Square, and Whitworth. Gear set-ups for standard threads are shown on the pictorial threading chart on the inside of the change-gear guard. (Fig. 2). Figure 4 is an actual-size reproduction of this threading chart. Gear data for odd-size threads are given in Table I, page 38. Metric threads may also be cut with the standard change gears furnished.

THE FOLLOWING PAGES comprise Part 7 (Pages 95-156)
of "Manual of Lathe Operation and Machinists Tables."

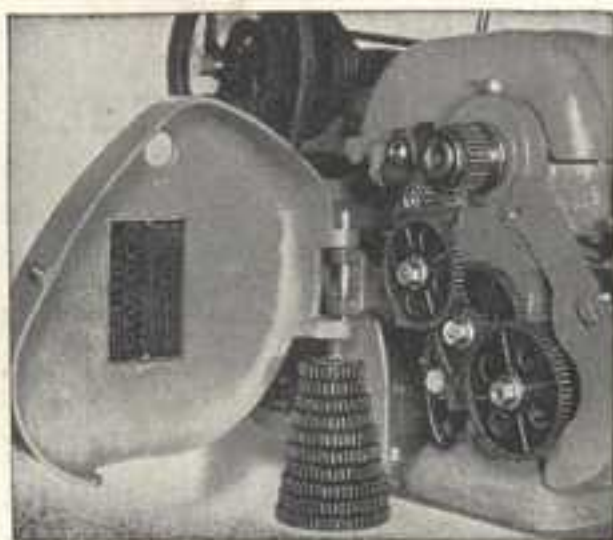


FIG. 2
Left end of lathe with gear guard open, showing change gears, gear train, and location of threading chart.

READING THE GEAR CHARTS

To simplify gear set-ups, the three different gear bracket positions have been assigned letters as shown in Figure 3. These designations will be found on the lathe threading chart as well as in all of the following gear data.

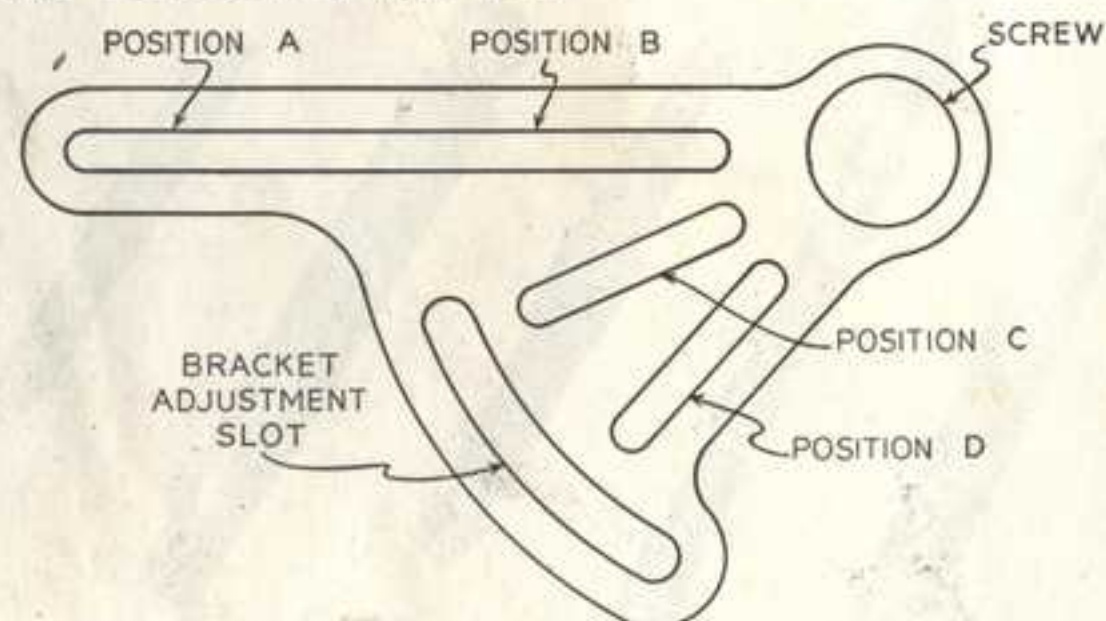


FIG. 3. Gear bracket positions.

The outer end of the longest bracket slot is called "Position A," the inner portion of the same slot is "Position B." The short slot adjacent to the long slot is Position "C," and the next short slot is Position "D." These gear positions are approximate—they will vary with the size and number of the gears composing the train (see diagrams in Fig. 4 and on the following pages).

CHANGE GEAR STUD ASSEMBLY

Before setting up a train of change gears, examine one of the change gear stud assemblies which hold the change gears to the gear bracket (Fig. 5). Each stud assembly has an outer gear bushing long enough to accommodate two gears. The gear bushing has a double key which fits into the keyways in the gears. The gear bushing and two gears fit over a stud bushing, and the assembly is bolted to the gear bracket. The washer is a bearing for the outer end of the gear bushing.

THREADING CHART

A-B-C-D ARE GEAR STUD POSITIONS
 B = BACK POSITION (TOWARD HEADSTOCK)
 F = FRONT POSITION (AWAY FROM HEADSTOCK)
 I = IDLER GEAR S = SPACER — = BLANK
 X = 24 TOOTH GEAR IN BACK POSITION (S) = DOUBLE KEYWAY SPACER

THREADS PER INCH	SCREW	POSITION D D	POSITION C C	POSITION B B	POSITION A A	SPINDLE STUD GEAR	FIG.
4	32F	—	—	24	48	64I 20S	32
4.5	36F	—	—	32	64	64I 20S	32
5	40F	—	—	32	64	64I 20S	32
5.5	44F	—	—	32	64	64I 20S	32
6	48F	—	—	32	64	64I 20S	32
6.5	52F	—	—	32	64	64I 20S	32
7	56F	—	—	32	64	64I 20S	32
8	32B	—	—	48I 20S	46I 24S	32	2
9	36B	—	—	32I 20S	64I 24S	32	2
10	40B	—	—	32I 20S	64I 24S	32	2
11	44B	—	—	32I 20S	64I 24S	32	2
11.5	46B	—	—	32I 20S	64I 24S	32	2
12	48B	—	—	32I 20S	64I 24S	32	2
13	52B	—	—	32I 20S	64I 24S	32	2
14	56B	—	—	32I 20S	64I 24S	32	2
16	64B	—	—	32I 20S	64I 24S	32	2
18	36F	—	—	20S 64I	64	32	3
20	40F	—	—	20S 64I	64	32	3
22	44F	—	—	20S 64I	64	32	3
23	46F	—	—	20S 64I	64	32	3
24	48F	—	—	20S 64I	64	32	3
26	52F	—	—	20S 64I	64	32	3
27	54F	—	—	20S 64I	64	32	3
28	56F	—	—	20S 64I	64	32	3
32	64F	—	—	20S 56I	48	24	3
36	36B	—	—	64I 20S	24	48	16
40	40B	—	—	64I 20S	32	64	16
44	44B	—	—	64I 20S	32	64	16
48	48B	—	—	64I 20S	32	64	16
56	56B	—	—	64I 20S	32	64	16
64	64B	—	—	64I 20S	24	48	16
72	36F	20S 64I	—	64	32	24	48
80	40F	20S 64I	—	64	32	24	48
96	48F	40 20	—	64I 24S	32	64	16

FEED	SCREW	POSITION D D	POSITION C C	POSITION B B	POSITION A A	STUD	FIG.
.001877	64B	—	—	20 64	52 20	24 48	16
.0035	64F	—	—	64 20	20 56	16	7
.005	64F X	52 20	—	54I (S)	20 48	16	—
.006	64F	52 20	—	54I (S)	24 48	16	—
.007	64B	—	—	20 64	56 20	32	—
.0087	64F	56 20	—	36 46	20S 64I	16	—

PITCH IN MILLIMETERS	GEAR ON SCREW	POSITION D D	POSITION C C	POSITION B B	POSITION A A	SPINDLE STUD GEAR	FIG.
.5	48F	40 44	—	52I (S)	24 56	16	8
.75	64F	40 32	—	52 44	20S 56I	16	—
1.00	44F	40 32	—	52 48	20S 64I	16	—
1.25	44B	—	—	52 48	20S 64I	16	—
1.50	44B	—	—	52 40	20S 64I	16	—
1.75	44F	48 52	—	56 40	20S 64I	16	—
2.00	40F	44 48	—	52 36	20S 64I	16	—
2.5	44B	—	—	52 24	20S 64I	16	—
3.0	44B	—	—	52 20	24S 64I	16	—
3.5	44F	48 56	—	52 20	24S 64I	16	—
4.0	20F	44 48	—	52 36	24S 64I	16	9
4.5	20F	44 54	—	52 36	20S 64I	16	—
5.0	24F	44 52	—	40 20	20S 64I	16	—
5.5	20F	—	—	48 52	46I 24S	32	—
6.0	20F	44 52	—	48 24	32S 64I	16	—
7.0	48B	52 44	—	20 56	64I 24S	32	—

FIG. 4. Threading chart for cutting all standard threads between 4 and 96 per inch and standard metric threads between .5 and 7 mm. Additional gear train information is included in Table 1, page 38.

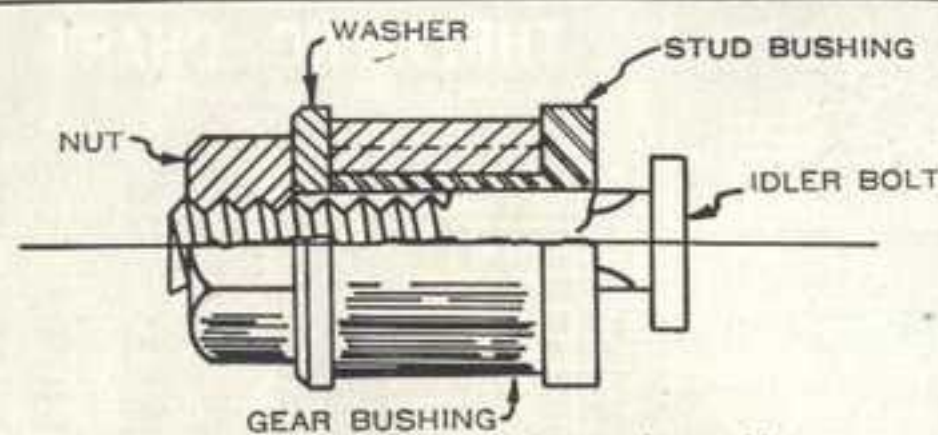


FIG. 5. Cross section of change gear stud assembly.

Notice that in order to make this assembly complete, two gears must be mounted on the gear bushing at one time. When both of the gears on a gear bushing mesh with other gears in the train, they form a "compound" gear assembly. When only one of two gears on a gear bushing meshes with the other gears in the train, it is called an "idler." The smaller gear, which is mounted on the gear bushing with an idler, is called a "spacer" gear and does not mesh with any gear in the train (see Fig. 7).

GEAR CLEARANCE

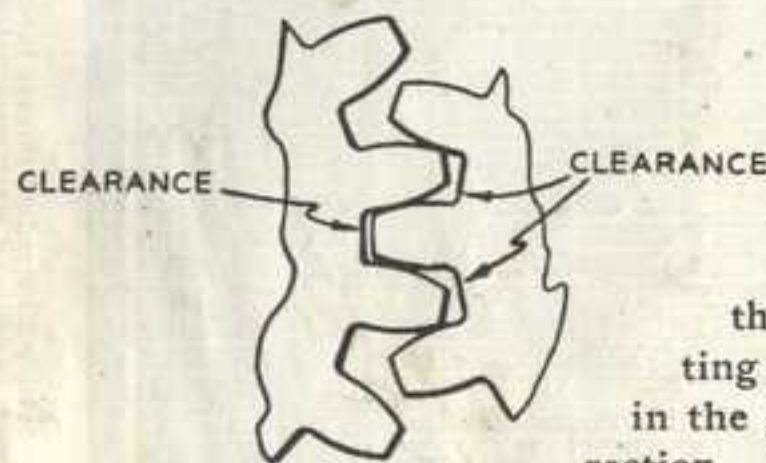


FIG. 6. Proper gear clearance.

When setting up the gear train, be sure to allow sufficient clearance between two meshing gears (Fig. 6). Gear clearance does not reduce the accuracy of a thread cutting operation, because all play in the gears is taken up in one direction. A method often used to obtain proper gear clearance is: (1) Place a sheet of thick writing paper between the teeth of the two meshing gears, (2) tighten gears in position, and (3) remove paper. A small amount of grease, preferably graphite grease, applied to gear teeth will often aid in obtaining smoother, more quiet operation.

THE REVERSING MECHANISM

Right hand threads are cut with the carriage traveling toward the headstock. Left hand threads are cut with the carriage traveling toward the tailstock.

Whenever a new gear train has been set up, shift the reverse feed lever to test the direction of the carriage travel. Because some set-ups are simple-geared and some are compounded, the carriage travel will not necessarily be to the right when the reverse lever is shifted to the right. *Always test the direction of carriage travel before starting to cut a thread.*

After the reversing lever has been shifted to the proper position, it should not be moved until the thread has been completed. *This is especially important because a shift in the lever position destroys the relation between the threading dial and the lathe spindle and causes splitting of the thread.*

GEAR TRAINS FOR STANDARD THREADS

The following pages give detailed instructions for mounting gears for the more common thread sizes. Refer to these pages and the lathe threading chart when making set-ups. "Back Position" of a bushing or the screw stub means the position *toward* the headstock. "Front Position" is the position *away from* the headstock. The gear bracket is tightened in position by locking the nut behind large washer on the inside of the "Bracket Adjustment Slot" (Fig. 3).

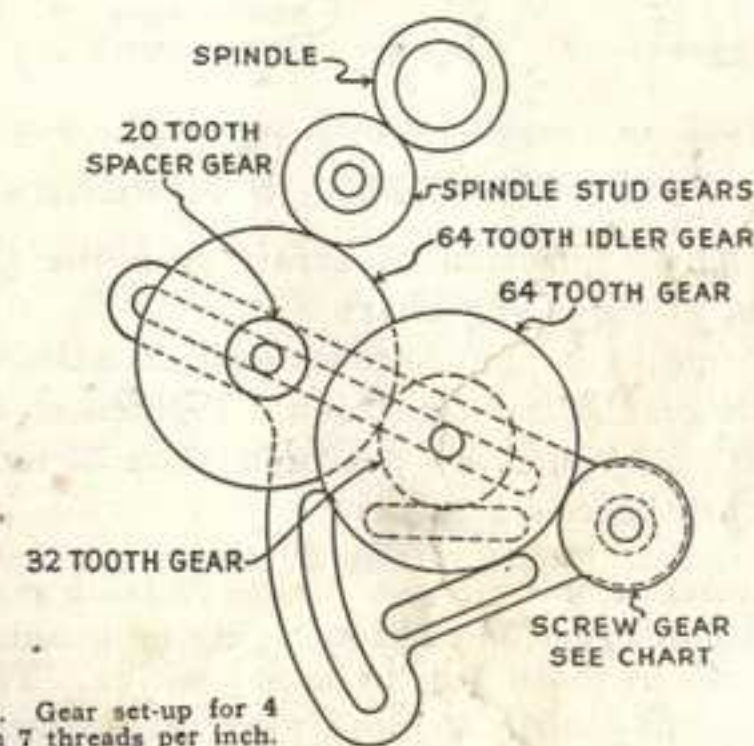


FIG. 7. Gear set-up for 4 through 7 threads per inch.

GEAR TRAIN FOR 4 THROUGH 7 THREADS PER INCH

1. Place on front position of screw stub the gear listed in "Screw" column of threading chart.

2. Place 32 tooth gear and 64 tooth gear on bushing and mount in Position B on gear bracket with 32 tooth gear in back position. Tighten so that 64 tooth gear meshes with gear in screw position.

Exception: When cutting 4 threads per inch, the 32 tooth gear and 64 tooth gear are replaced by 24 and 48 tooth gears respectively.

3. Place 64 tooth gear and 20 tooth gear on a bushing and mount in Position A with 20 tooth gear in front position. Tighten so that 64 tooth gear meshes with the 32 tooth gear in Position B. The 64 tooth gear is an idler; the 20 tooth gear is a spacer.

4. Swing entire gear bracket upward and tighten so that 64 tooth gear in Position A meshes with 32 tooth spindle stud gear.

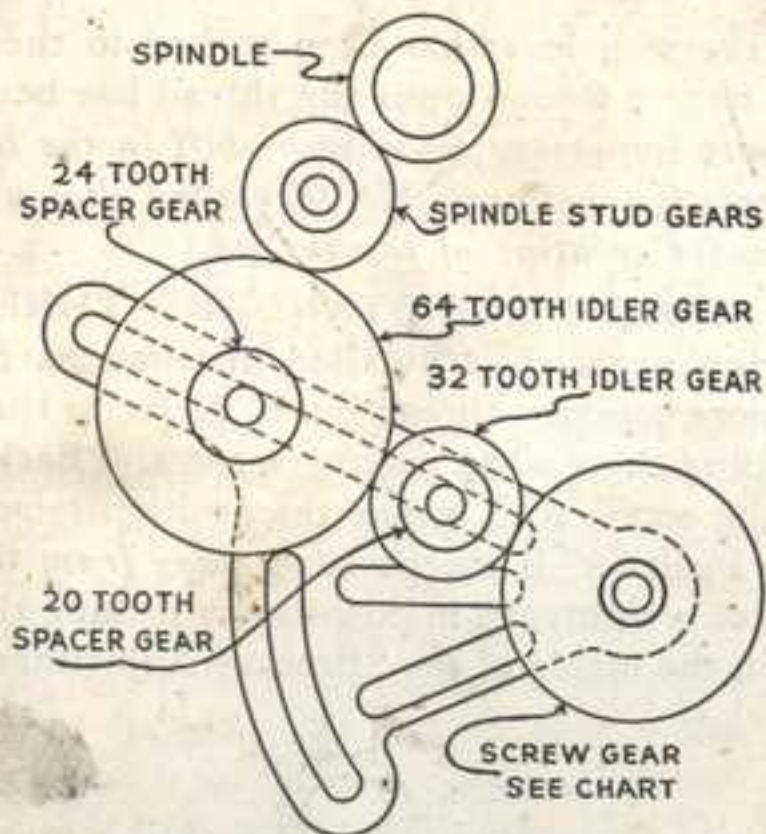


FIG. 8. Gear set-up for 8 through 16 threads per inch.

GEAR TRAIN FOR 8 THROUGH 16 THREADS PER INCH

1. Place on back position of screw stub the gear listed in "Screw" column of threading chart.
2. Place 32 tooth gear and 20 tooth gear on bushing in Position B with 32 tooth gear in back position. Tighten so that 32 tooth gear meshes with gear in screw position. The 32 tooth gear is an idler; the 20 tooth gear is a spacer.

Exception: When cutting 8 threads per inch, substitute a 48 tooth gear for the 32 tooth gear.

3. Place 64 tooth gear and 24 tooth gear on bushing and mount in Position A with 64 tooth gear in back position. Tighten so that 64 tooth gear meshes with 32 tooth gear in Position B. The 64 tooth gear is an idler; the 24 tooth gear is a spacer.

Exception: When cutting 8 threads per inch, substitute a 46 tooth gear for the 64 tooth gear.

4. Swing entire gear bracket upward and tighten so that 64 tooth gear in Position A meshes with 32 tooth spindle stud gear.

GEAR TRAIN FOR 18 THROUGH 32 THREADS PER INCH

(See Fig. 9, page 9.)

1. Place on back position of screw stub the gear listed in "Screw" column of threading chart.
2. Place 20 tooth gear and 64 tooth gear on bushing and mount in Position C with 20 tooth gear in back position. Tighten so that 64 tooth gear meshes with gear in screw position. The 64 tooth gear is an idler; the 20 tooth gear is a spacer.

Exception: When cutting 32 threads per inch, substitute a 56 tooth gear for the 64 tooth gear.

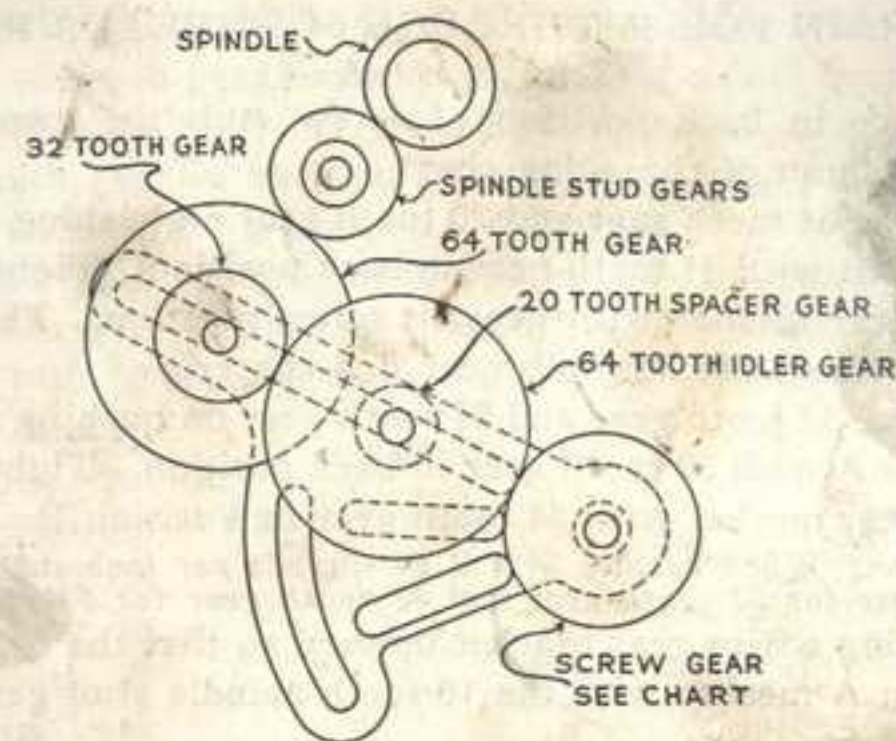


FIG. 9. Gear set-up for 18 through 32 threads per inch.

3. Place 64 tooth gear and 32 tooth gear on bushing and mount in Position A with 64 tooth gear in back position. Tighten so that 32 tooth gear meshes with 64 tooth gear in Position B.

Exception: When cutting 32 threads per inch, substitute 48 tooth gear for 64 tooth gear and 24 tooth gear for 32 tooth gear.

4. Swing entire gear bracket upward and tighten so that 64 tooth gear in Position A meshes with the 32 tooth spindle stud gear.

GEAR TRAIN FOR 36 THROUGH 64 THREADS PER INCH

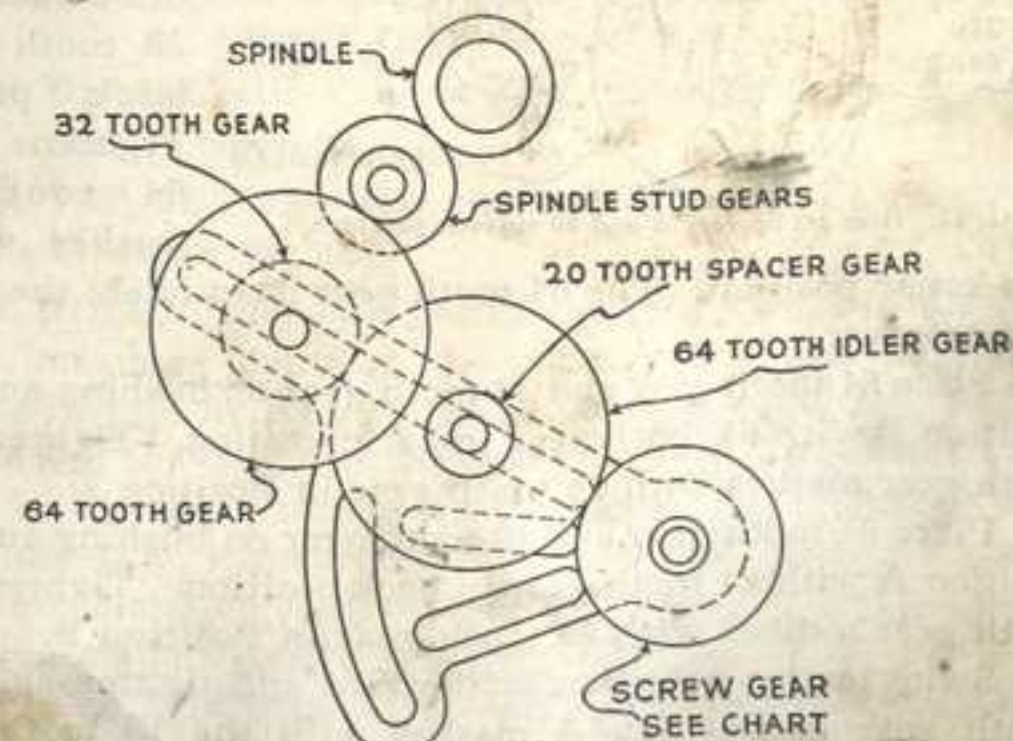


FIG. 10. Gear set-up for 36 through 64 threads per inch (see page 10).

GEAR TRAIN FOR 36 THROUGH 64 THREADS PER INCH

(See Fig. 10, page 9)

1. Place in back position of screw stub the gear listed in "Screw" column of threading chart.

2. Place 64 tooth gear and 20 tooth gear on bushing and mount in Position B with 64 tooth gear in back position. Tighten so that 64 tooth gear meshes with gear in screw position. The 64 tooth gear is an idler; the 20 tooth gear is a spacer.

3. Place 32 tooth gear and 64 tooth gear on bushing and mount in Position A with 32 tooth gear in back position. Tighten so that 32 tooth gear meshes with 64 tooth gear in Position B.

Exception: When cutting 36 and 64 threads per inch substitute 24 tooth gear for 32 tooth gear and 48 tooth gear for 64 tooth gear.

4. Swing entire gear bracket upward so that the 64 tooth gear in Position A meshes with the 16 tooth spindle stud gear.

GEAR TRAIN FOR 72 AND 80 THREADS PER INCH

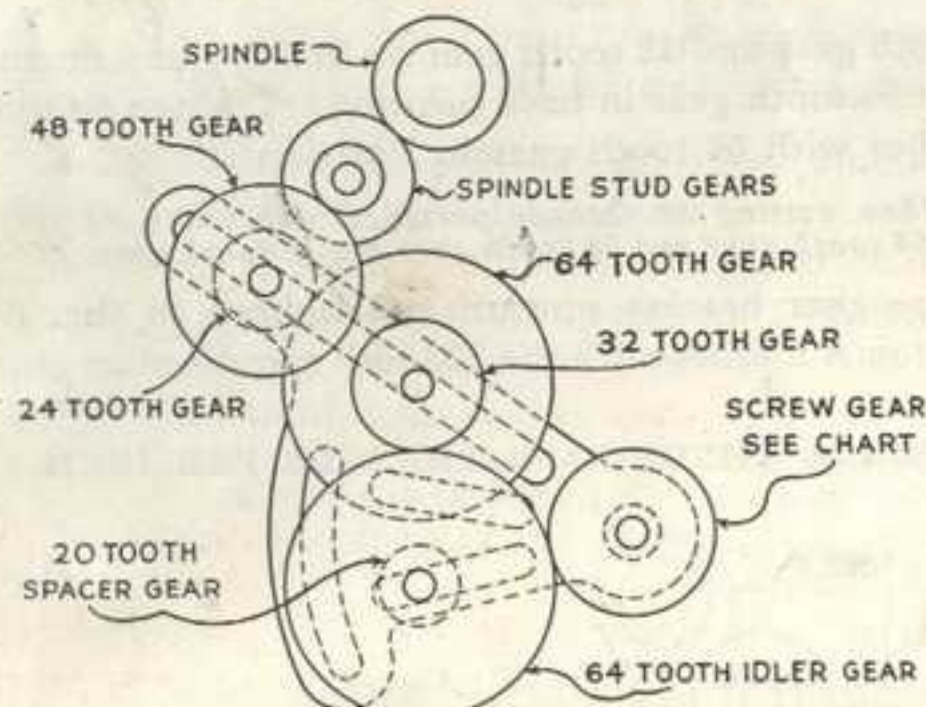


FIG. 11. Gear set-up for 72 and 80 threads per inch.

gear in screw position. The 64 tooth gear is an idler; the 20 tooth gear is a spacer.

3. Place 64 tooth gear and 32 tooth gear on bushing and mount in Position B with 64 tooth gear in back position. Tighten so that 32 tooth gear meshes with 64 tooth gear in Position D.

4. Place 24 tooth gear and 48 tooth gear on bushing and mount in Position A with 24 tooth gear in back position. Tighten so that 24 tooth gear meshes with 64 tooth gear in Position B.

5. Swing entire gear bracket upward and tighten so that the 48 tooth gear in Position A meshes with the 16 tooth spindle stud gear.

GEAR TRAIN FOR 96 THREADS PER INCH

1. Place 48 tooth gear on front position of screw stub.

2. Place 40 tooth gear and 20 tooth gear on bushing in Position D with 40 tooth gear in back position. Tighten so that 20 tooth gear meshes with 48 tooth gear on screw stub.

3. Place 64 tooth gear and 24 tooth gear on bushing in Position B with 64 tooth gear in back position. Tighten so that 64 tooth gear meshes with 40 tooth gear in Position D. The 64 tooth gear is an idler; the 24 tooth gear is a spacer.

4. Place 32 tooth gear and 64 tooth gear on bushing in Position A with 32 tooth gear in back position. Tighten so that 32 tooth gear meshes with 64 tooth gear in Position B.

5. Swing entire gear bracket upward and tighten so that 64 tooth gear in Position A meshes with the 16 tooth spindle stud gear.

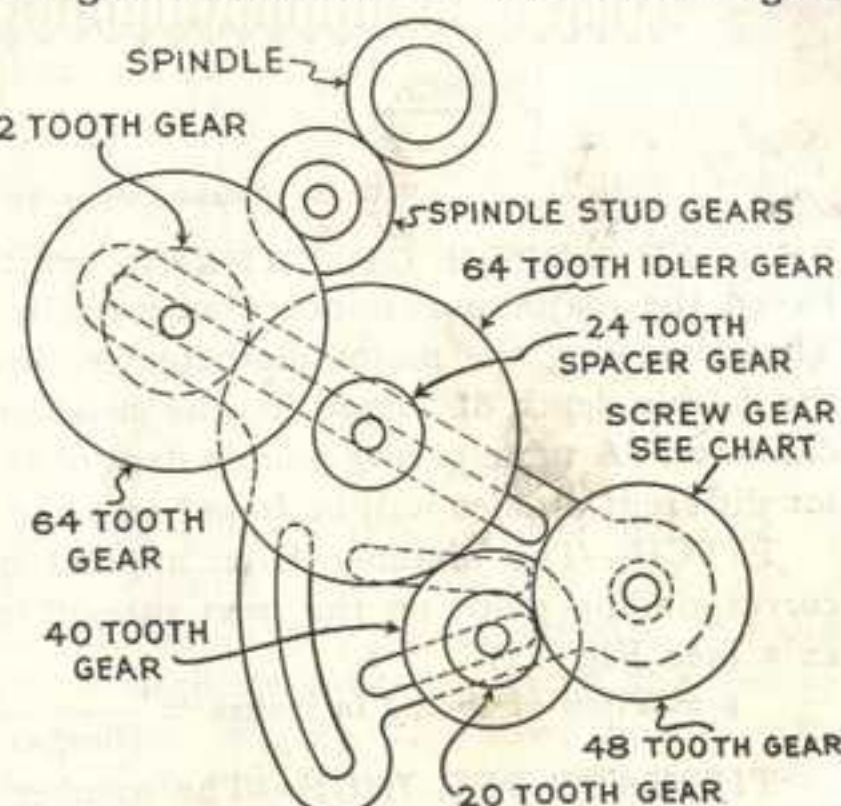


Fig. 12. Gear set-up for 96 threads per inch.

THREAD CUTTING TERMS

(Refer to Figure 13, page 12)

MAJOR DIAMETER—The largest diameter of the thread of either the screw or the nut.

MINOR DIAMETER—The smallest diameter of the thread of either the screw or the nut.

PITCH DIAMETER—On a straight screw thread, the diameter of an imaginary cylinder, the surface of which would pass through the threads at such points as to make equal the width of the threads and the width of the spaces cut by the surface of the cylinder. In Figure 13 the lines representing the diameter "PD," are located so as to make spaces "aa" and "bb" equal. On a 60° Vee-type thread and on National Form threads, the pitch diameter is simply the major diameter less the depth of the thread.

DEPTH OF THREAD—One-half the difference between the major diameter and the minor diameter. In lathe work, the

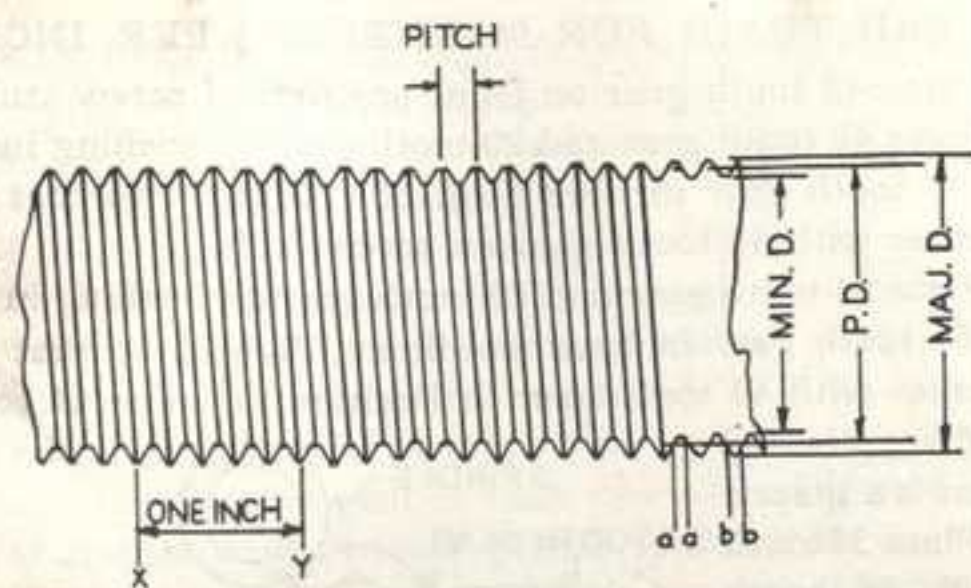


FIG. 13. Thread Cutting Terms.

DOUBLE DEPTH OF THREAD, which is the difference between the major and minor diameters, is a quite common term. Thus, knowing the major diameter required, subtracting from it the double depth of thread for the required pitch, gives the minor diameter. A table giving double depths of National Form threads for different pitches will be found on page 42.

PITCH—The distance from a point on a screw thread to a corresponding point on the next thread, measured parallel to the axis (see Fig. 13).

$$p = \text{Pitch of thread in inches} = \frac{1}{\text{Number of threads per inch}}$$

THREADS PER INCH—The number of complete threads in the space of one inch. In Figure 13, the distance between points X and Y represents one inch, and there are five threads per inch.

$$n = \text{Number of threads per inch} = \frac{1}{\text{pitch}}$$

LEAD — The distance a screw thread advances axially in one turn. On a single thread screw, the lead and the pitch are identical; on a double thread screw, the lead is twice the pitch; on a triple thread screw the lead is three times the pitch, etc.

Figure 14 shows a double thread screw.

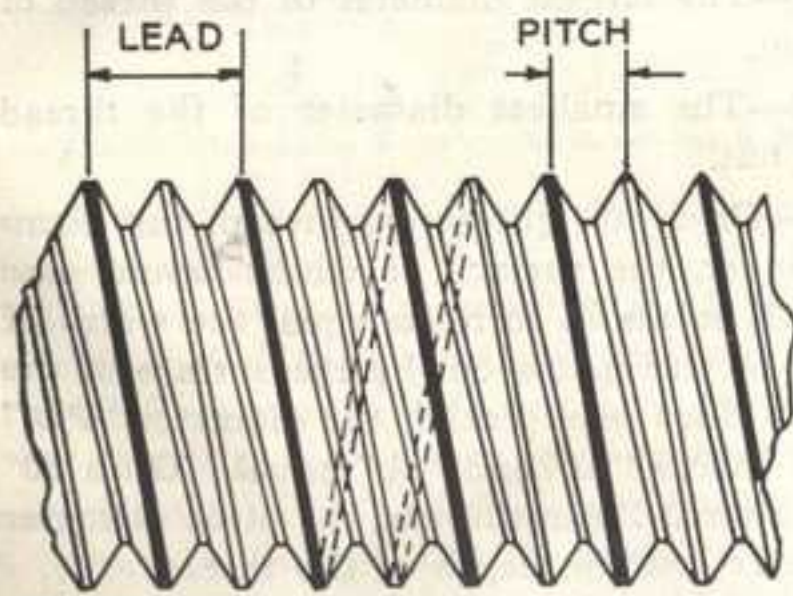


FIG. 14

Double Thread Screw. The lead is double the pitch.

There are two separate grooves or helices around the screw, each of which advances twice the pitch in a single turn. If the pitch of this screw is $\frac{1}{8}$ inch, the lead is $\frac{1}{4}$ inch.

THREAD CUTTING TOOLS

Thread cutting tools must be ground to the form of thread desired. Clearance must be increased because of the rapid advance of the tool. (See Φ , Fig. 40). Otherwise the grinding of thread

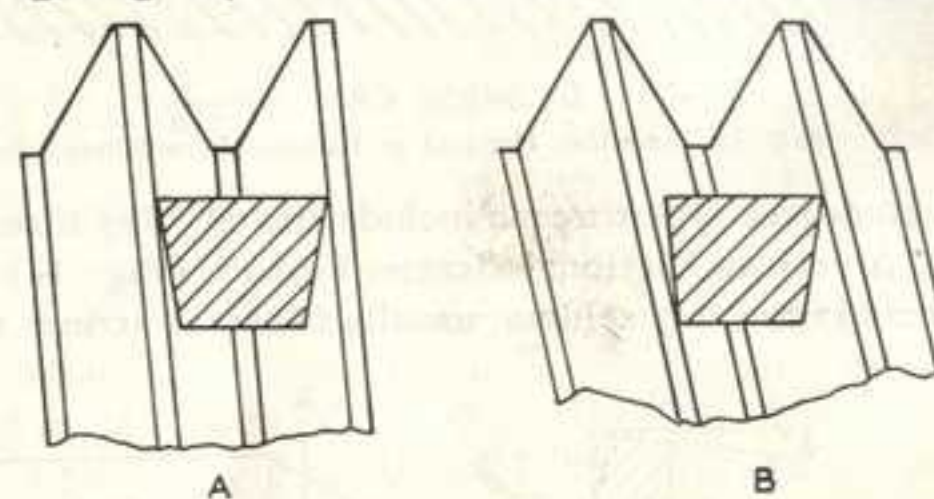


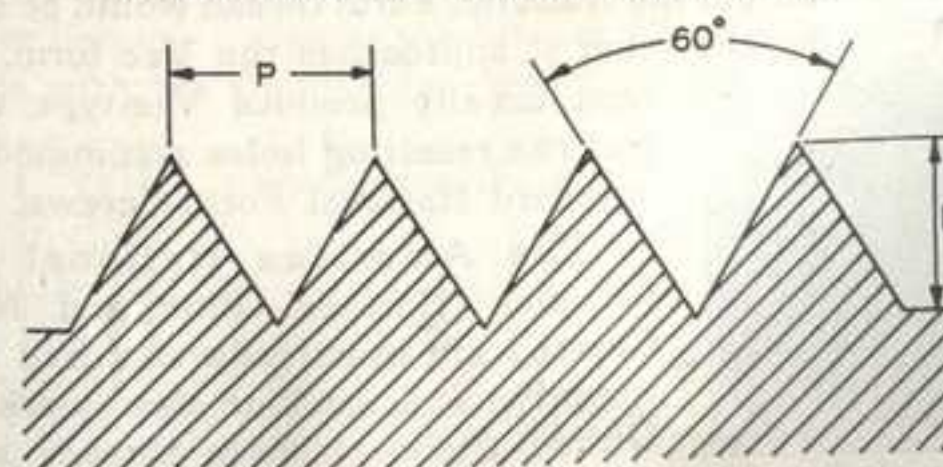
FIG. 15
"A" shows tool with sufficient clearance. When thread pitch is increased, as at "B," same tool has inadequate clearance.

cutting tools follows the same general rules as the grinding of external tools (Manual Parts 3 and 4).

Clean, accurate threads are impossible unless one side and the front of the tool are given enough clearance to permit the tool to advance as the work revolves. Figure 15 shows how a tool which is satisfactory for cutting a fine thread may not have enough clearance to cut a coarse thread. "Hogging" and rough threads are usually the result of insufficient clearance.

Thread tools are ground nearly flat across the top. When the tool is fed into the work at an angle, as with National Form threads, the tool should have a few degrees of side rake. When the tool is fed into the work at right angles, as with square threads, it should have a small amount of back rake.

CUTTING 60° TYPE THREADS



$D = .866 \times P$
FIG. 16. 60° Vee Thread and Formula (see page 14).

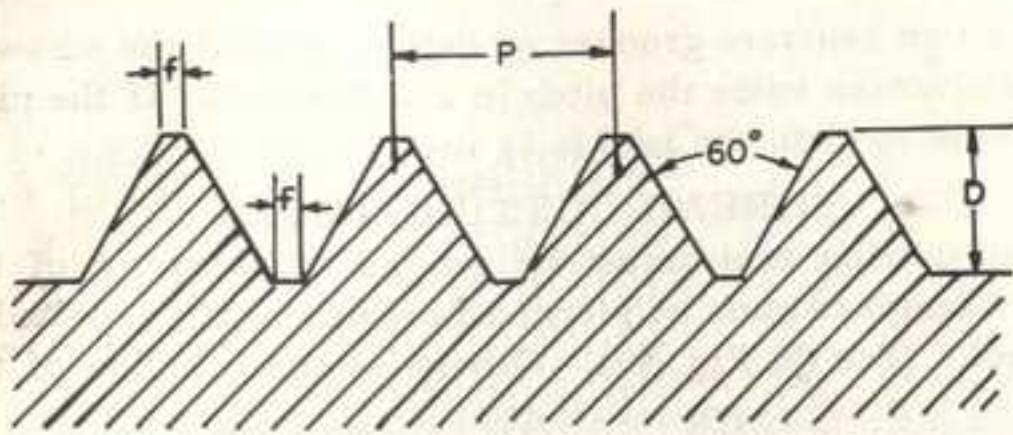


FIG. 17. American National or National Form Thread and Formulas.

60 degree type threads include the 60° Vee thread (Fig. 16) and the American National Screw Thread (Fig. 17). The 60° Vee thread is cut very seldom, usually for small screws on which the flat

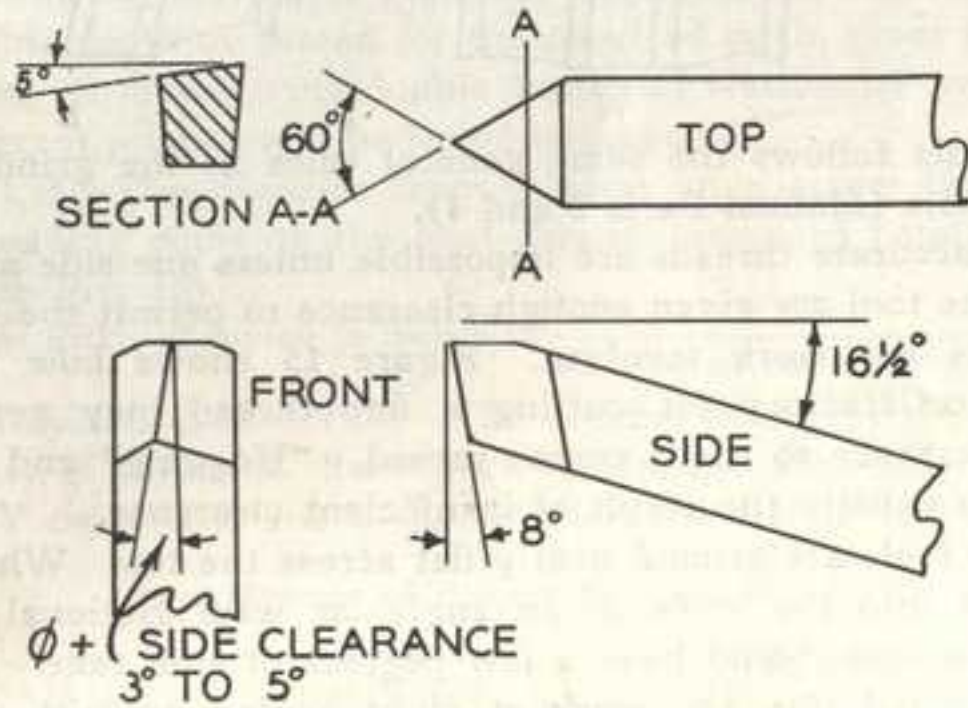


FIG. 18. Tool for cutting 60° type threads. Fig. 40 explains how angle ϕ must be determined.

at the top and bottom of the National Form thread would be so small that it approaches the Vee form. Small taps usually produce Vee-type threads, and the resulting holes accommodate the standard National Form Screws.



FIG. 19. N. F. Thread Gauge.

The American National Screw threads, (National Fine and National Coarse) are practically standard for automotive and machine shop work in the United States. These threads are 60° Vee threads with the points cut off so

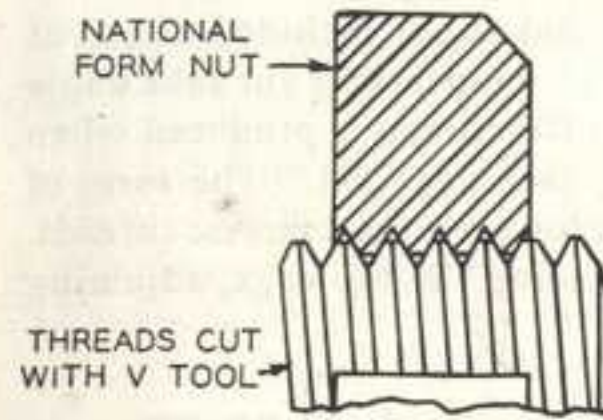


FIG. 20. The National Form nut fits the screw cut with a 60° Vee tool.

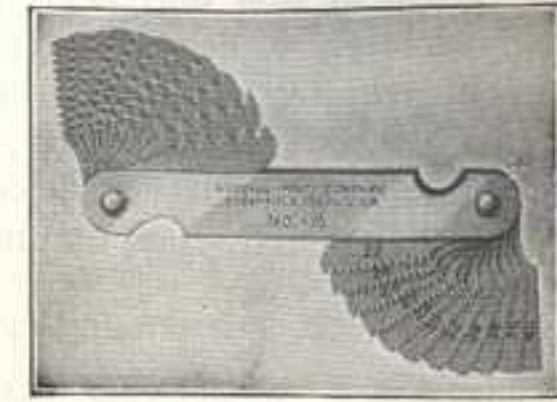


FIG. 21. National Screw Pitch Gauge.

that the depth is 75% of the depth of a Vee thread of the same pitch.

Figure 18 shows a tool bit ground for cutting sharp pointed Vee threads. This tool will also cut an exact National Form Screw thread when the point is ground flat to fit the proper slot in the National Form thread gauge (Fig. 19). Generally, however, the tool is left sharp pointed and the thread is cut with the regulation Vee bottom, but the top is left with the proper amount of flat. Figure 20 shows how a screw cut in this manner fits a National Form nut. Only when desiring absolute maximum strength is the tool ground to the exact National Form.

The screw pitch gauge shown in Figure 21 is used to determine the exact pitch of a V-thread screw or nut. This gauge has thirty separate leaves with pitches between 4 and 42 per inch.

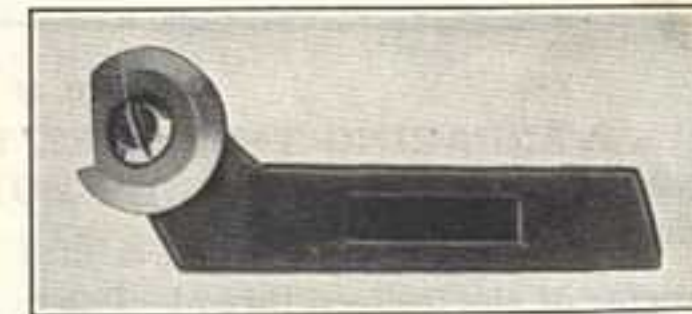


FIG. 22. Threading Tool.

THREADING TOOL

The threading tool shown in Figure 22 has become extremely popular because it can be used to cut all pitches of National Form threads with the slight difference in form mentioned above.

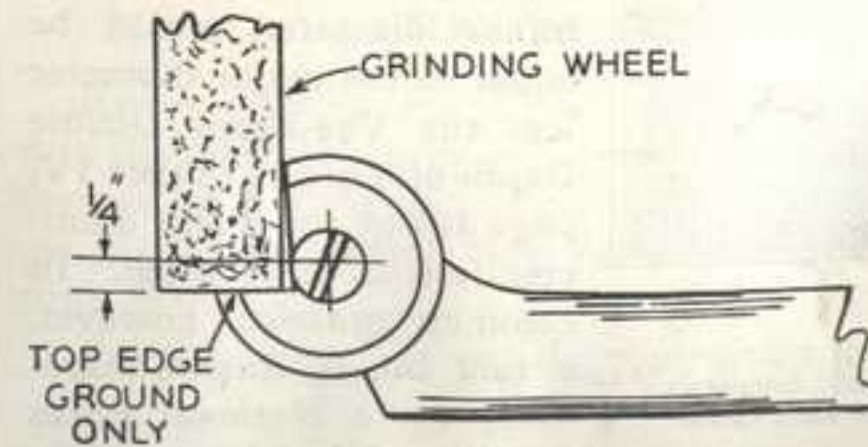


FIG. 23. Proper method of grinding the threading tool shown in Figure 22. The side faces are never ground.

The sides of this tool are ready ground to an included angle of approximately 65 degrees. The extra 5° compensates for rake angle and the grinding of the tool—a perfect 60° thread is produced when the tool is set into the work properly (see page 17). The form of this tool also provides ample clearance for even the coarsest threads. The tool is resharpened by simply grinding the top edge, adjusting the tool as it wears.

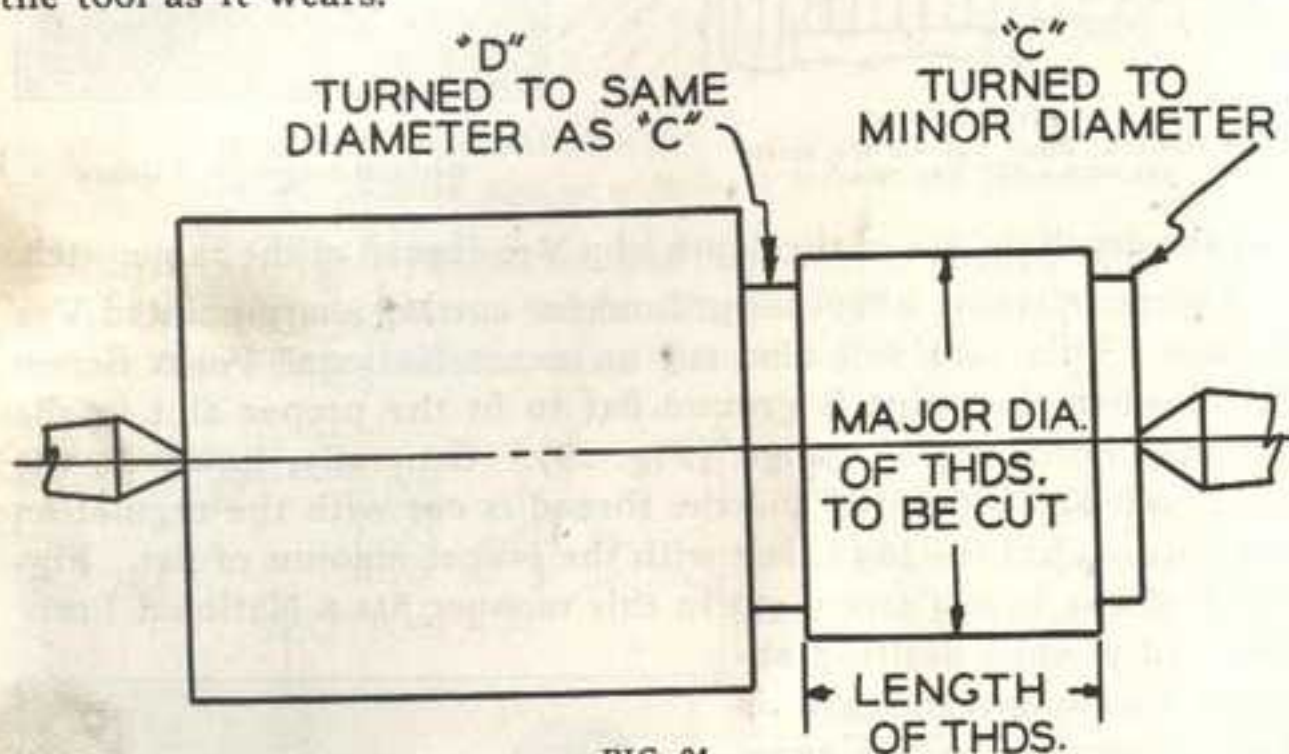


FIG. 24

PREPARING THE WORK FOR AN EXTERNAL 60° NATIONAL FORM THREAD

The work to be threaded is first turned to the exact major diameter of the desired thread. The beginner often finds it helpful to turn the grooves C and D (Fig. 24) to the exact minor diameter. The size of the minor diameter depends upon the form of the threading tool. Theoretically, if the thread were to be cut with a sharp pointed 60° tool, the minor diameter would be equal to the major diameter less the Vee-Form Double Depth of Thread (Table IV, page 42) or the major diameter less $1.732 \times \text{pitch}$. In common practice, however, a tool bit is formed especially for a National Form thread, and the correct minor

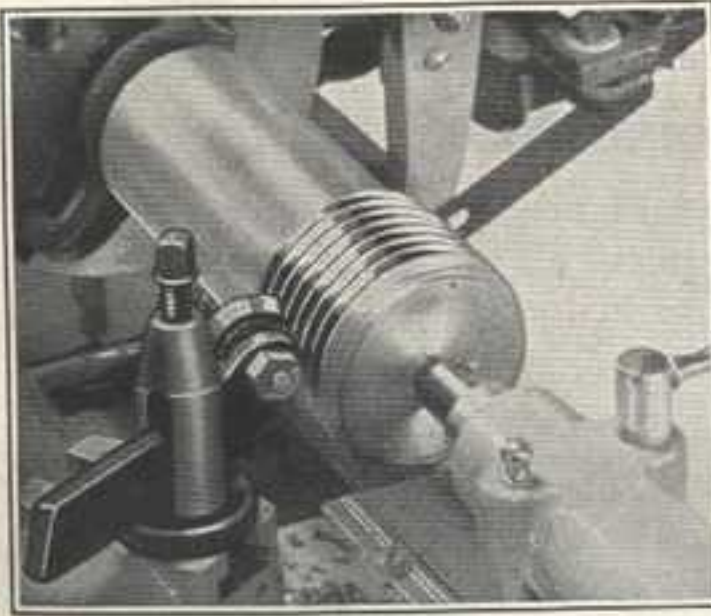


FIG. 25

Correct setting of tool and compound rest when cutting a 60° right hand thread

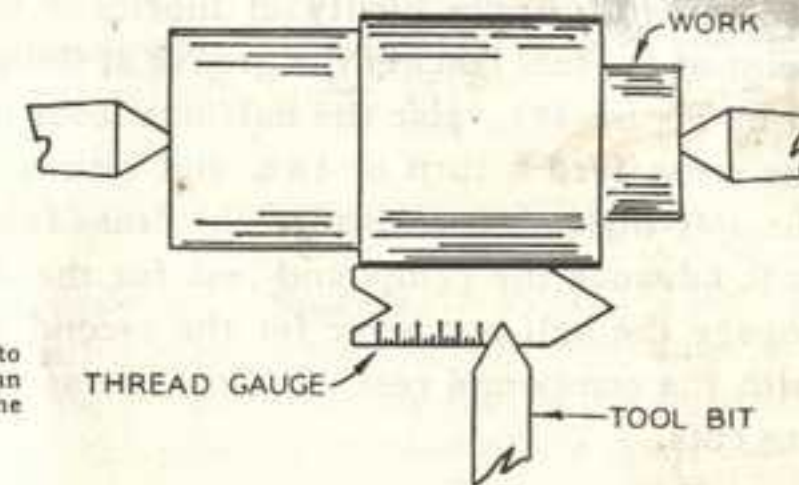
diameter is listed in Table V or Table VI, pages 43 and 44 (major diameter less $1.299 \times \text{pitch}$).

Groove C permits accurate measurement with a micrometer of the bottom of the thread. When the tool point has cut to the depth of the groove C, the thread has been finished. Groove D permits the work to revolve freely at the end of each cut. As soon as the beginner has become a little more familiar with threading practice, these grooves can be omitted.



FIG. 26. Center Gauge.

FIG. 27 (Right)
Using the center gauge to set the threading tool at an exact right angle to the work.



SETTING THE 60° THREADING TOOL

After the work has been properly prepared for threading, set the compound rest at the 29° angle shown in Figure 25. Mount the tool holder in the tool post so that the point of the tool is exactly on the lathe center line—tighten tool post screw just enough to hold the tool holder. Then use a center or thread gauge (Fig. 26) to set the tool point at an exact right angle to the work as shown in Figure 27. Tap lightly on the back of the tool holder when bringing it into position. A piece of white paper placed under the center gauge will aid in checking the fit of the tool in the Vee of the gauge. With the tool point at an exact right angle to the work, recheck the center line position and tighten tool post screw.

THE CUTTING OPERATION

Before starting the actual cutting of a right hand thread, be sure that the change gear train is assembled properly and that the reverse lever is in the correct position to feed the carriage toward the headstock. Adjust belts for a speed of 28 R.P.M. (see Manual, page 47).

Set the compound rest approximately in the center of its ways

and advance the cross feed so that it is set at 0 with the tool close to the work. With the point of the tool about an inch to the right of the start of the thread, advance the tool with the compound rest so that the first cut will be about .003 inch.

Start the lathe and engage the half-nut lever on the carriage as described on page 19. The 29° angle of the compound rest should allow the back of the tool to take a fine chasing cut on the finished side of the thread while the cutting edge does the work of forming the thread. Apply plenty of lubricant to the work. When the point of the tool reaches the groove at the end of the thread (groove D in Figure 24), raise the half-nut lever on the carriage, back out the cross feed a turn or two, and return the carriage by hand to the starting point. Advance the cross feed to its original position at 0, advance the compound rest for the desired depth of cut, and engage the half-nut lever for the second cut. All feeding is done with the compound rest. Follow the same routine on all succeeding cuts.

DEPTH OF CUT: The first two or three cuts should be approximately .005 inch advance of the compound feed and the following cuts gradually reduced until the last few cuts taken are only .001 inch or even .0005 inch. A final pass through the thread with no advance whatever will often clean up any remaining high spots. Take the last cuts with extreme care. Heavier cuts can be taken on soft metals such as brass or aluminum, but if a fine finish is desired, the last cuts should be very light.

LUBRICANTS: When cutting steel use liberal quantities of a commercial cutting compound, lard oil or equivalent. With other metals use the type of lubricant recommended for general turning operations.

THREAD CUTTING SPEEDS: The beginner in thread cutting should adjust belts to obtain a speed of 28 R.P.M. (Manual, page 47). This slow speed allows plenty of time to engage and disengage the half-nut lever. After more experience in cutting threads, higher speeds can be used up to approximately 1/3 or 1/2 the speeds recommended for turning the various materials (Manual, Part 4).

THE THREADING DIAL

The threading dial (Figs. 28 and 29) performs an important function by indicating the proper time to engage the half-nut lever so that the tool will enter the same groove of the thread for each cut. Without the threading dial it would be necessary to reverse the motor at the end of each cut and "wind" the tool out of the thread — a cumbersome method little used except when cutting metric and special fractional threads (page 28).



FIG. 28
Threading Dial.

RULES FOR THE USE OF THE THREADING DIAL

When cutting an *even-numbered thread* (such as 12, 14, 16, 32, etc. per inch), engage the half-nut lever for the first cut when the stationary mark on the outside of the threading dial is in line with any one of the four marks on the rotating portion of the dial. Any one of the four dial markings may be used for following cuts.

When cutting *odd-numbered threads* (such as 7, 9, 11, 23, 27, etc. per inch), engage the half-nut lever for the first cut when the stationary mark on the threading dial is in line with *either "1" or "2"* on the rotating portion. Either the "1" or "2" dial marking may be used for following cuts.

When cutting *half-numbered threads* (such as 4½, 5½, 6½, 11½, etc. per inch), engage half-nut lever *at the same mark* on the threading dial for each cut of the thread.

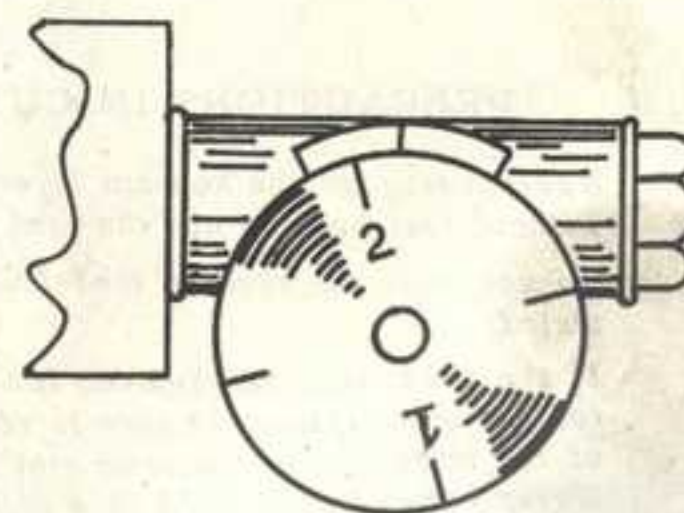


FIG. 29
Threading dial showing main markings. Other markings may be made by the operator as needed.

CUTTING INTERNAL 60° NATIONAL SCREW THREADS

The tool shown in Figure 30 is designed for cutting internal 60° form threads and is mounted directly in the tool post exactly like a boring tool. Such a tool is included in the set of boring tools

described on Manual page 91. The angles shown are typical and satisfactory for threads as coarse as 12 per inch and holes as small as $\frac{5}{8}$ inch. The point is ground to 60° and has a slight side rake as shown in the front view.

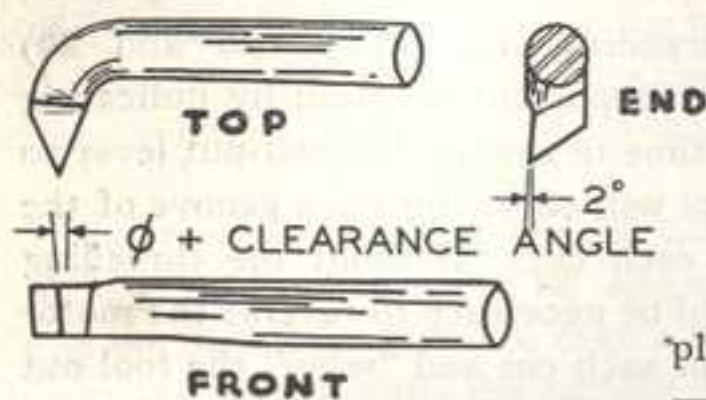


FIG. 30

Tool for cutting internal 60° threads. (When threading brass and plastics, omit side rake.) Fig. 40 explains how the angle ϕ must be determined.

PREPARING THE WORK FOR INTERNAL NATIONAL FORM THREADS

Work to be threaded internally is prepared much in the same manner as for cutting an external thread (see page 16). The work is first bored to the exact minor diameter. Beginners often turn grooves C and D to the exact major diameter as shown in Figure

PRECAUTIONS IN CUTTING THREADS

Never disengage the half-nut lever in the middle of the thread without first backing out the tool with the cross feed.

Do not shift the reverse feed lever until the thread is completed.

If the work must be removed for checking the fit of a cut or for any other reason, be sure to replace the work with the tail of the lathe dog in the same slot of the face plate as before. Never remove work held in a chuck until the thread is completed.

When a long, heavy thread is being turned, considerable heat may be generated, causing the work to expand. If the work is mounted between centers, stop the lathe at regular intervals and check the tightness of the work against the centers. Take a light cut after checking in this way, because the work may have shifted a trifle in relation to the position of the tool bit. If the tool has a tendency to "hog in," check tool clearance.

31. If the thread is to be cut with a sharp pointed 60° tool, the major diameter is equal to the minor diameter plus the Vee-form Double Depth of Thread (Table IV, page 42). If the tool bit is formed especially for a certain National Form thread, the correct major diameter is listed in Table V or Table VI, pages 43 and 44.

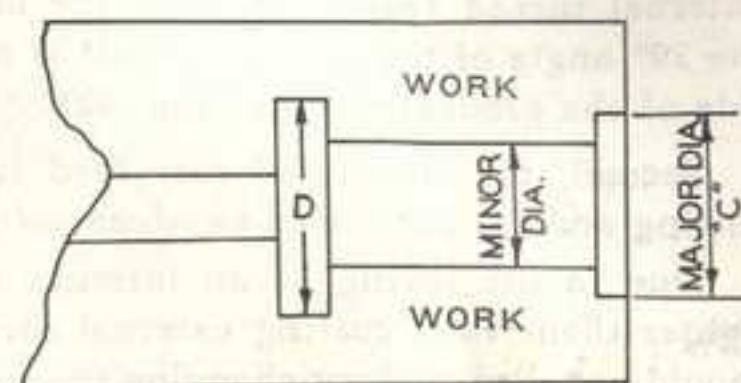


FIG. 31

Grooves C and D help the beginner when threading internally.

Groove C permits the beginner to measure accurately the bottom of the thread with a micrometer or caliper and serves as a guide for depth. When the tool point has cut to the depth of groove C, the thread has been finished. This outer groove

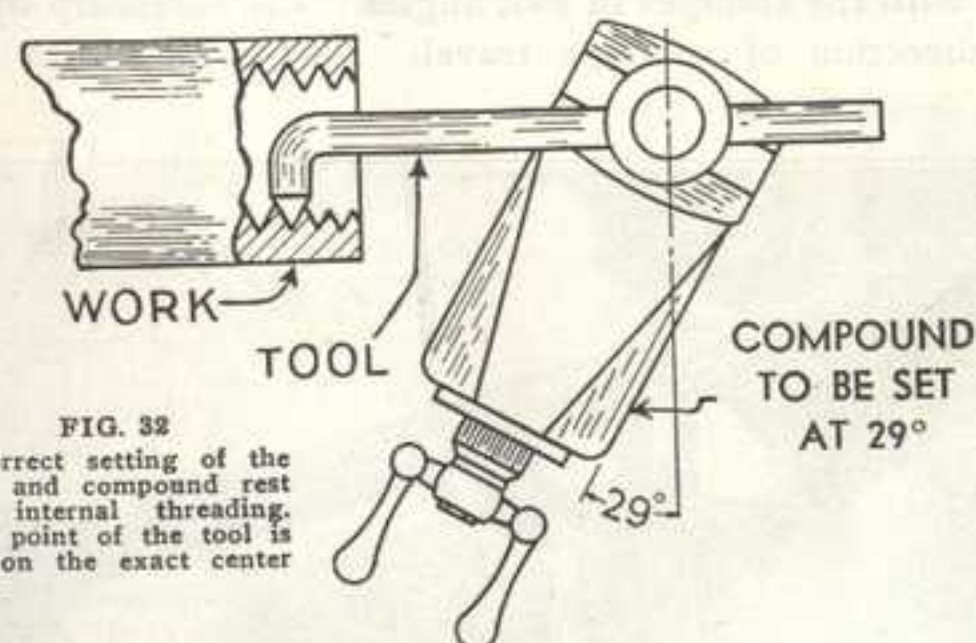


FIG. 32

Correct setting of the tool and compound rest for internal threading. The point of the tool is set on the exact center line.

is not necessary if the thread is being cut to fit a certain screw—the proper depth is then reached when the screw fits the thread correctly.

Groove D should be about twice as wide as the thread pitch and a few thousandths larger than the major diameter. This groove provides a brief interval at the end of each cut during which the work can revolve freely while the half-nut lever is disengaged. The grooves C and D can be omitted after the operator has learned internal thread cutting operations.

CUTTING INTERNAL THREADS

The internal cutting operation is the same as the cutting of an external thread (page 17), with the following exceptions: First, the 29° angle of the compound rest is measured from the opposite side of the graduated base (Fig. 32).

Second, the compound rest feed is *toward* the operator for cutting and the cross feed is *advanced* to clear the work.

Due to the spring of an internal tool, cuts should be much lighter than when cutting external threads. The last finish cuts should be taken without changing the setting of the compound rest.

CUTTING LEFT HAND THREADS

Figure 33 shows the cutting of a left hand thread. The direction of carriage feed is toward the tailstock. Gear set-ups and general cutting procedure are exactly the same as for right hand threads with the changes in tool angles made necessary by the different direction of carriage travel. Clearance angles and side

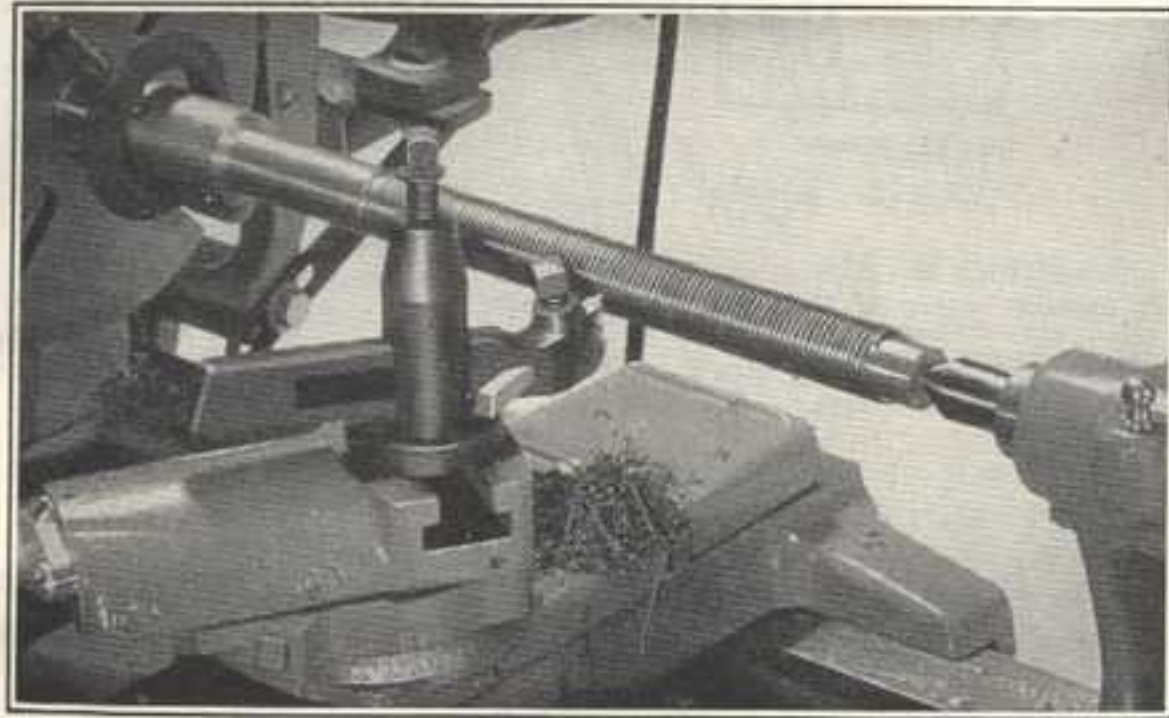
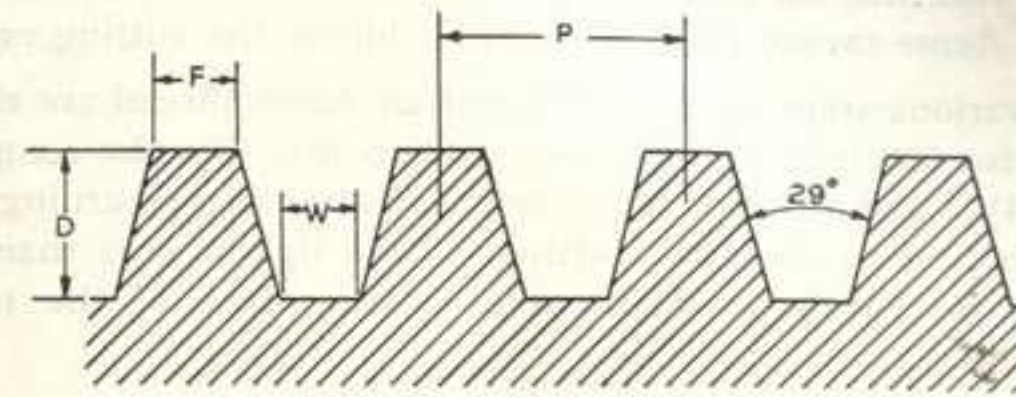


FIG. 33. Cutting a left hand thread.

rake should be the opposite of those shown in Figure 18. In cutting left hand 60° type threads, the compound rest should be set at 29° in the direction shown in Figure 33 which is opposite that for right hand threads.

CUTTING ACME THREADS



$$D = \frac{P}{2} + .010" \quad F = .3707 \times P$$

$$W = .3707 \times P - .0052" \quad \text{MINOR DIA.} = \text{MAJOR DIA.} - (P + .020)$$

FIG. 34. Acme Screw Thread and Formulas.

The Acme screw thread (Fig. 34) is often found in power transmissions, where heavy loads necessitate close-fitting threads. Another common application is in the lead screws and feed screws of precision machine tools. The lead screw, cross feed and compound rest feed screw of most lathes have Acme threads.

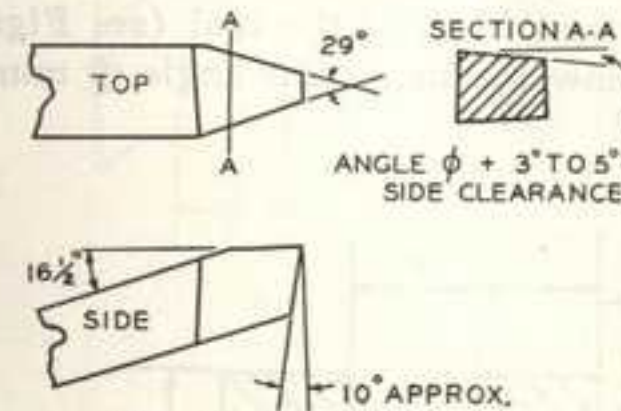
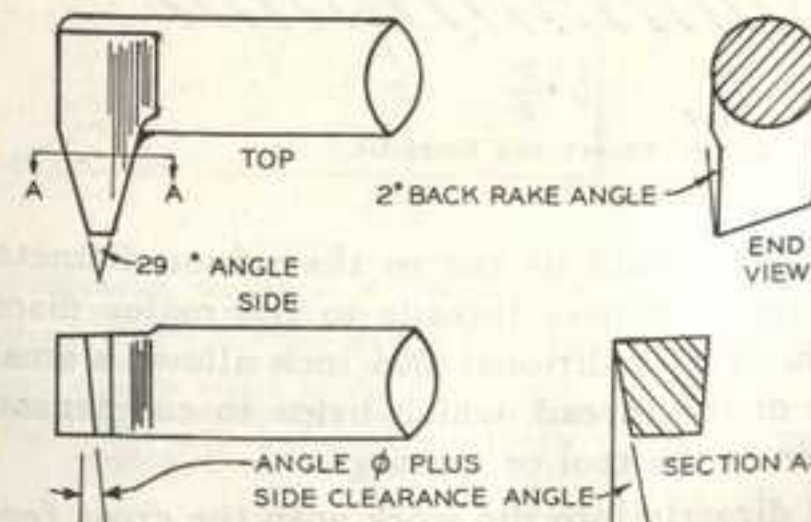
FIG. 36. Tool bit formed for cutting an external Acme thread. To determine angle ϕ , refer to Figure 40, page 25.

FIG. 35. Acme Thread Gauge.

FIG. 37 (Left) Tool bit formed for cutting an internal Acme thread. To determine angle ϕ , refer to Figure 40, page 25.

Figures 36 and 37 show the proper tool forms for cutting external and internal Acme threads. The forms must be checked with the Acme thread gauge (Fig. 35) during the cutting process.

The various steps in the cutting of an Acme thread are similar to those for 60° type threads (pages 13 to 19). Set the compound rest at 14½° and advance compound feed after cut, returning cross feed each time to the same setting. Take lighter cuts than with 60° type threads because the total cutting face of the tool is longer.

CUTTING SQUARE THREADS

The square thread (Fig. 38) is rarely cut because it is a difficult job and results in a thread which is not so strong as the Acme. It is cut, however, for many vise and clamp screws and other worm-screw forms. The Acme thread is recommended for all such applications—it is stronger, easier to cut, and capable of closer fits.

In cutting a square thread with a large lead, the tool angles must be absolutely correct. Clearance should be allowed on two sides, tapering from both the top and front of the tool (see Figs. 39 and 41). Figure 40 explains how the important angle Φ must be determined.

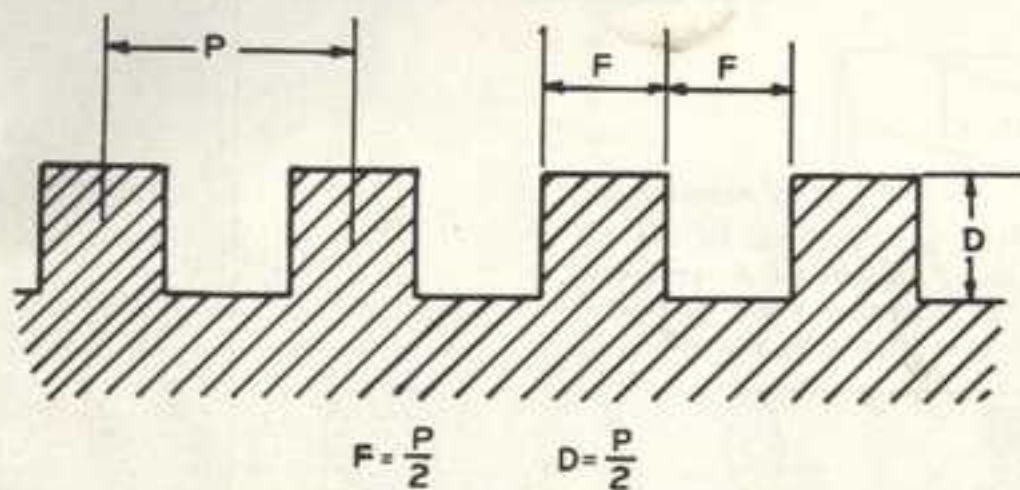


FIG. 38. Square Thread and Formulas.

External square threads should be cut to the minor diameter plus about .005 inch, internal square threads to the major diameter plus about .005 inch. The additional .005 inch allows a small clearance at the bottom of the thread, which helps to compensate for any small inaccuracies in the tool or cutting.

The tool must be fed directly into the work with the cross feed

(or compound rest feed), and care must be taken to avoid chatter and "hogging-in." The simplest method is to set the compound rest at 0°, feed in with the compound, and back out and return the tool with the cross feed. Take very light cuts when turning or boring a square thread.

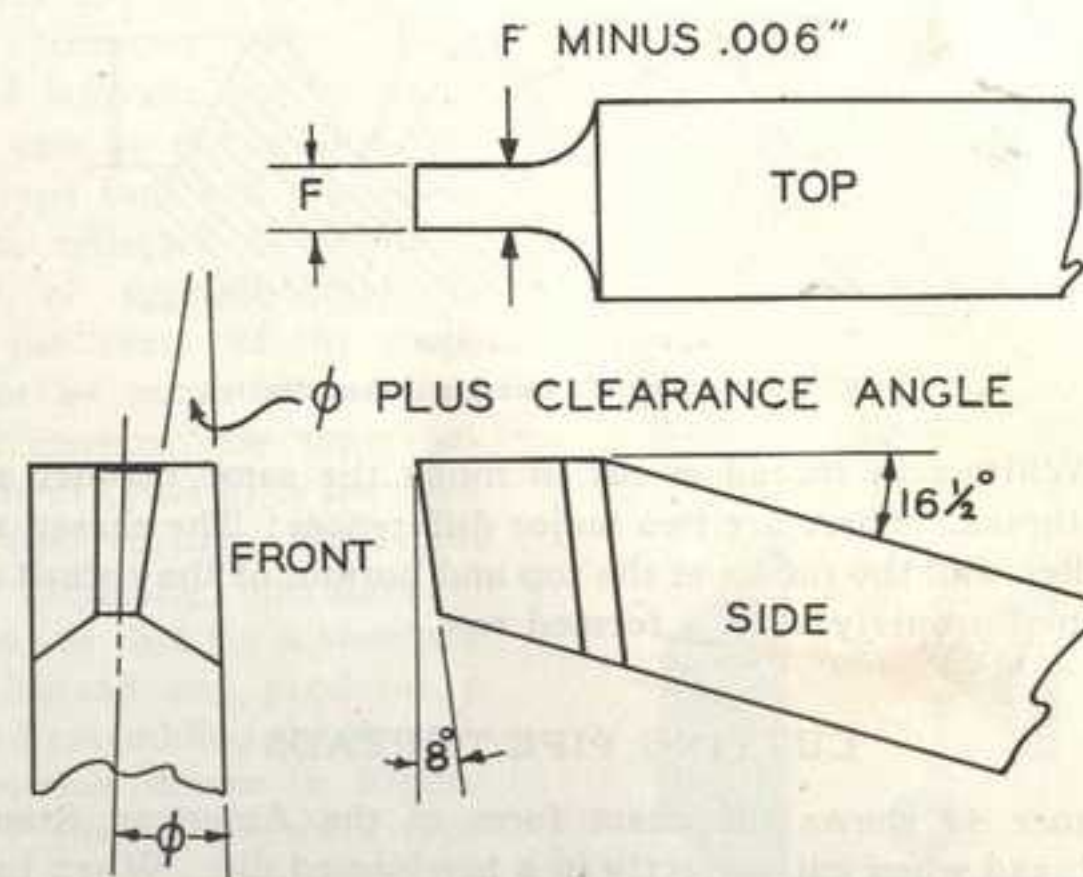


FIG. 39. Tool bit for cutting external square threads.

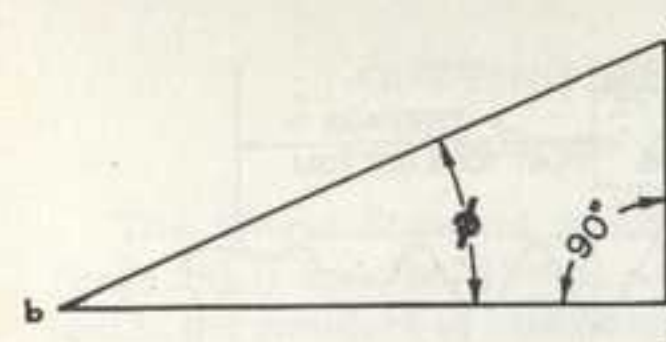


FIG. 40

Determining the angle Φ . Draw line "ab" equal to the circumference of the thread (3.1416 \times major diameter). Then draw line "ac" at right angles to "ab" and equal in length to the thread pitch (or lead, if a multiple thread). Draw line "bc." The angle Φ is equal to the angle made by lines "ba" and "bc."

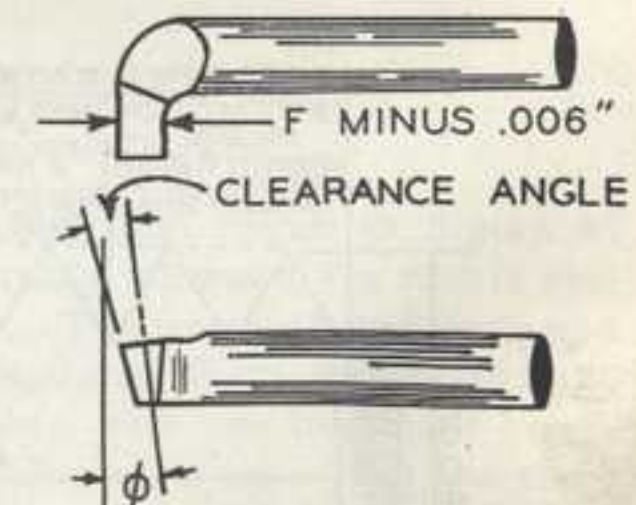


FIG. 41
Tool bit for cutting internal square threads.

WHITWORTH FORM THREAD

Figure 42 shows the Whitworth thread, a form which is standard in the British Isles for nearly all types of threads. The smaller sizes of the Whitworth form are called British Standard Fine.

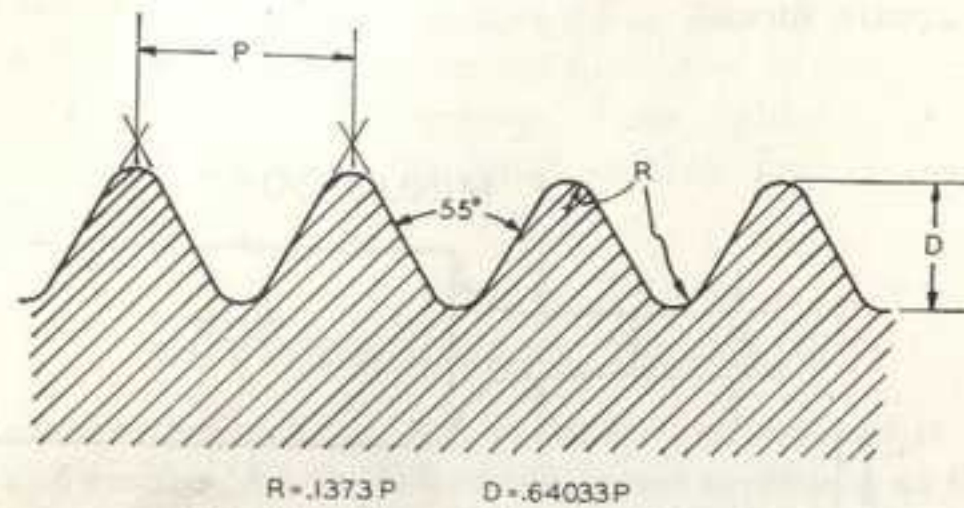


FIG. 42. Whitworth Thread and Formulas.

A Whitworth thread is cut in much the same manner as an Acme thread. There are two major differences: The thread angle is smaller, and the radius at the top and bottom of the thread must be shaped properly with a formed tool.

CUTTING PIPE-THREADS

Figure 43 shows the exact form of the American Standard Pipe thread when cut correctly in a pre-formed die. When turned into the receiving nut, the tapered lines cause the tight "jamming" for which the pipe thread is so well known. In a straight form this thread is used in oil cups and several types of electrical fittings.

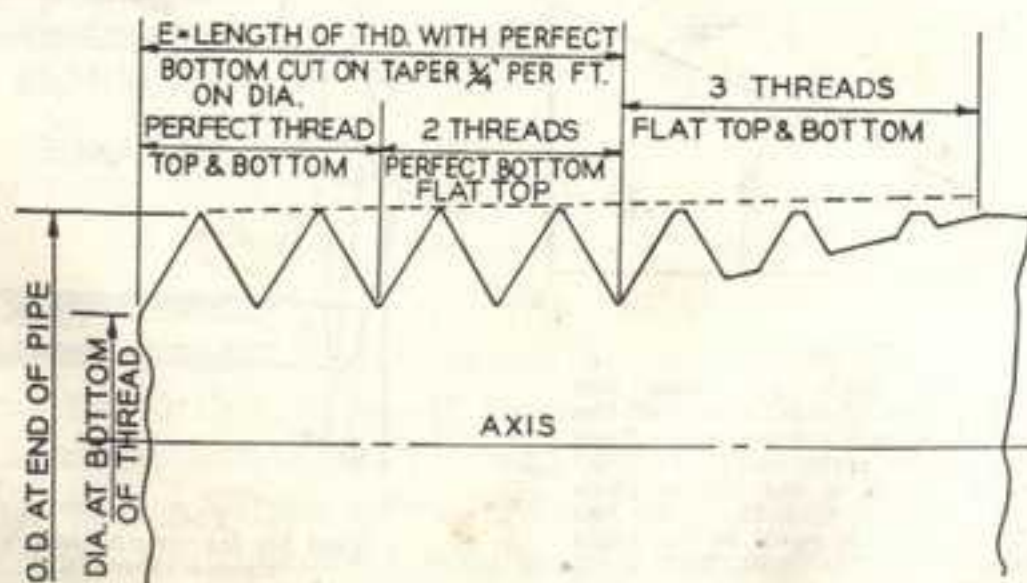


FIG. 43. American Standard Pipe Thread and Formulas.

In order to cut the American Standard Pipe thread on the lathe without special dies or equipment, some variation in form is necessary. Excellent pipe-type threads, satisfactory for commercial use and having the same jamming effect when forced into the nut or coupling, can be cut with a 60° Vee type tool and a set-over of the tailstock to obtain a taper of approximately $\frac{3}{4}$ inch per foot. If the stock cannot be mounted between lathe centers, the taper attachment (Part 8) is required for the cutting operation. The threading operation is similar to that for a standard Vee thread and produces a thread resembling the threaded portion shown in Figure 44. Figure 45 shows a type of pipe center recommended for supporting the stock while cutting pipe type threads.

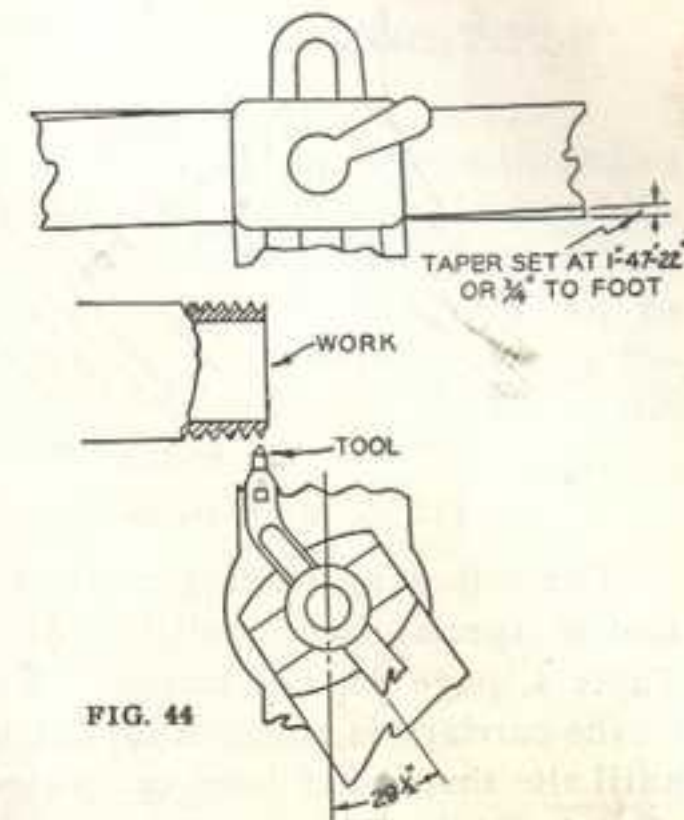


FIG. 44

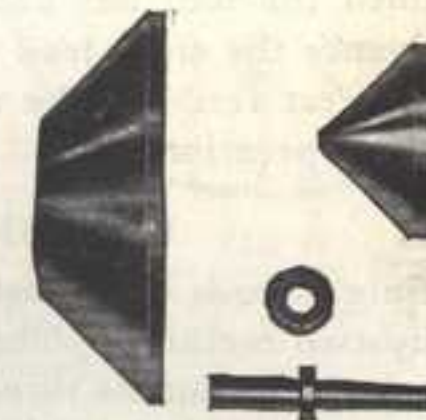


FIG. 45. Pipe Centers.

CUTTING METRIC THREADS

(Also Special Fractional Threads)

The Metric Standard screw thread form shown in Figure 46 (page 28) is accepted almost universally wherever the metric system is the standard of measurement. The metric thread angle and form is identical to that of the National Form thread, and the cutting operation is exactly the same, with one important exception: the motor must be reversed after each cut. This procedure is necessary because metric threads have no definite relation to the threading dial.*

*F-series lathes are available with metric-pitch threads for cross and compound feed screws and feed screw collars graduated in .02 mm.

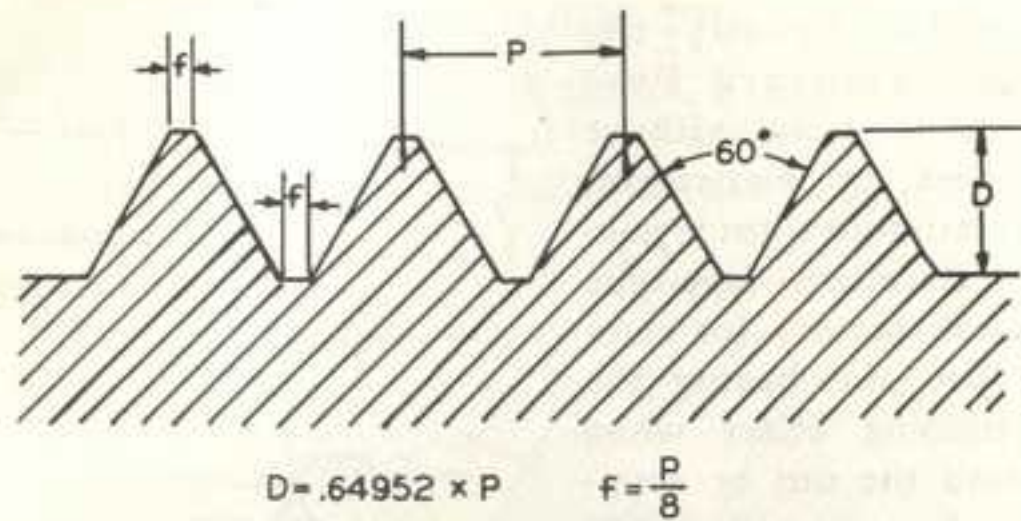


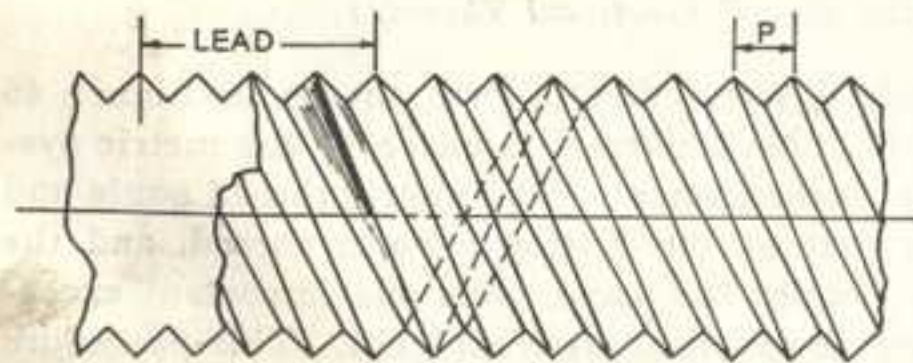
FIG. 46. Metric Standard Screw Thread Form and Formulas.

The following cutting method applies to metric threads and also to special fractional threads, wire feeds, and the threads in Table I, page 38, not marked "Exact": After the half-nut lever on the carriage is engaged for the first cut, it should not be moved until the thread has been completed. As the tool reaches the end of each cut, back out the cross feed, stop the lathe, and reverse the motor until the tool has been returned to the starting position. Then advance the cross feed to its original 0 position, turn in the compound rest feed for the next cut, start the motor and repeat the cutting operation.

MULTIPLE THREADS

Multiple threads of almost any pitch and number of starts can be cut by two methods. The threading dial is quick, simple and accurate for some double threads and some quadruple or "multiple-four" threads. Multiple threads can also be cut by "slipping teeth" on either the spindle gear or the screw gear (see page 30).

Multiple threading requires larger tool clearance angles. Figure 14 shows a double screw thread and Figure 47 shows a

FIG. 47
Quadruple screw
thread. The lead is
four times the pitch.

quadruple or multiple four thread. These drawings illustrate how the angle of advance has been increased—the tool clearance must be sufficient for the lead, not merely the pitch.

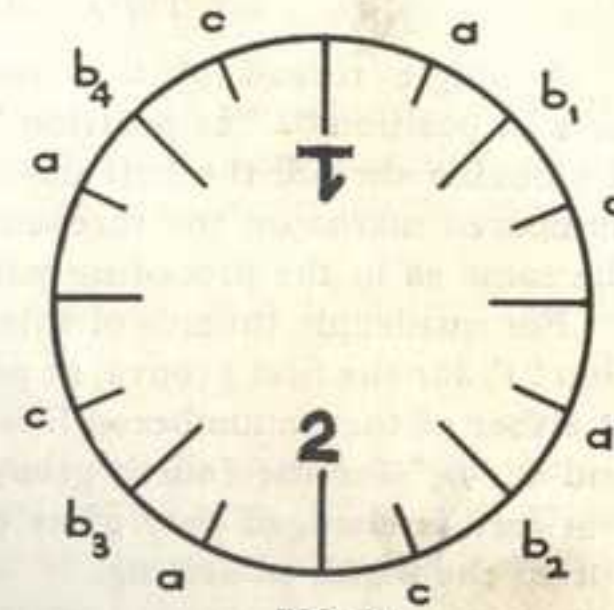
USING THE THREADING DIAL FOR MULTIPLE THREADS

Although only four marks are cut into the top of the threading dial, there are actually sixteen different positions at which the half-nut lever can be engaged. Figure 48 shows the intermediate points between the four main markings. These points can be marked with pencil, or the positions easily estimated. In the following paragraphs, Lead in Threads Per Inch is equal to 1 divided by Lead in Inches.

CUTTING DOUBLE THREADS WITH LEAD IN THREADS PER INCH DIVISIBLE BY FOUR, BUT NOT BY EIGHT (4, 12, 20, 28, etc.)

A single thread of this lead is cut by engaging the half nuts at any of the four main markings on the threading dial or at any of the four "b" positions. To cut the second groove of a double thread, the half nuts are engaged at any of the "a" or "c" positions.

Example: To Cut a Double Thread with a Pitch of 1/24 inch and a Lead of 1/12 inch. Set up the change gears for the lead in threads per inch (12, not 24). Engage the half nut lever for the first cut when the stationary mark on the outside of the threading dial is in line with any one of the four main marks on the rotating portion of the dial. Then return to the starting point and engage half nuts at any one of the "a" or "c" positions, taking the first cut on the second groove of the thread. The compound rest feed remains at one setting until both grooves have been cut to the same depth.

FIG. 48
Intermediate positions on threading
dial which can be used for cutting.
The numbers "1" and "2" are marked;
the lettered positions may be marked as
needed.

CUTTING DOUBLE AND QUADRUPLE THREADS WITH LEADS IN THREADS PER INCH DIVISIBLE BY TWO, BUT NOT BY FOUR (6, 10, 14, 18, etc.)

A single thread of this lead is cut only by engaging the half nut lever at any one of the four main markings on the threading dial. To cut the second groove of the double thread, the half nuts are engaged at any one of the "b" positions, and the cutting operation is the same as in the preceding paragraph.

For quadruple threads of this lead engage the half nuts at any of the four mainmarkings for the first groove, at any of the "a" positions for the second groove, at any of the "b" positions for the third groove, and at any of the "c" positions for the fourth groove. The setting of the compound rest feed is changed only after each of the four grooves has been cut to the depth of setting.

CUTTING DOUBLE AND QUADRUPLE THREADS WITH LEAD IN THREADS PER INCH DIVISIBLE BY ONE, BUT NOT BY TWO (ODD NUMBERS)

A single thread of this lead is cut by engaging the half nuts in position "1" or position "2." To cut the second groove of the double thread, the half nuts are engaged at either of the unnumbered marks on the threading dial. The cutting operation is the same as in the preceding paragraph.

For quadruple threads of this lead engage the half nuts at position "1" for the first groove, at position "b₁" for the second groove, at either of the unnumbered lines on the dial for the third groove, and at "b₂" for the fourth groove. The setting of the compound rest feed is changed only after each of the four grooves has been cut to the depth of setting.

CUTTING MULTIPLE THREADS BY SLIPPING TEETH ON THE SPINDLE GEAR

Double and quadruple threads can also be cut by "slipping teeth" on the compound gear. This practice is not so common as the use of the threading dial, but is not complicated.

To cut multiple threads by slipping teeth on the compound gear: cut the complete first groove to a minor diameter dependent upon pitch of the desired thread. The change gear train should be arranged for the desired lead. It is important to use the same 0 point of reference to cut each thread—be sure to remember this point during the cutting operations.

Refer to the table on page 31, then slip the required number of teeth by marking adjacent teeth on the compound gear and the gear meshing with the compound gear. Drop the entire gear bracket low enough to disengage the gears and turn the compound gear forward the proper number of teeth by rotating spindle by hand. Raise the gear bracket so that the previously marked gear tooth meshes with the newly selected compound gear tooth.

To Cut Double Threads:—Slip 16 teeth to cut the second groove.

To Cut Quadruple Threads:—Slip 8 teeth to cut the second groove, 8 teeth more to cut the third groove, and 8 teeth more to cut the fourth groove.

Each thread groove is cut to its complete depth and finished before starting the next groove.

GEAR TRAINS FOR CARRIAGE FEEDS

The automatic longitudinal carriage feed per spindle revolution is obtained by setting up the gear train in the same manner as for thread cutting (pages 3 to 11). The feed in inches is equal to

$\frac{1}{\text{threads per inch}}$ For example, a feed of .0078 inch requires the gear set-up as 114.9 threads per inch.

The six most common carriage feeds, as shown in the threading chart (page 5), are .0087, .0070, .0060, .0050, .0035, and .001877 inch per spindle revolution. Refer to the threading chart and the six following paragraphs when changing these gear set-ups. Table II on page 40 includes gear set-ups for other carriage feeds obtainable with the standard set of gears.

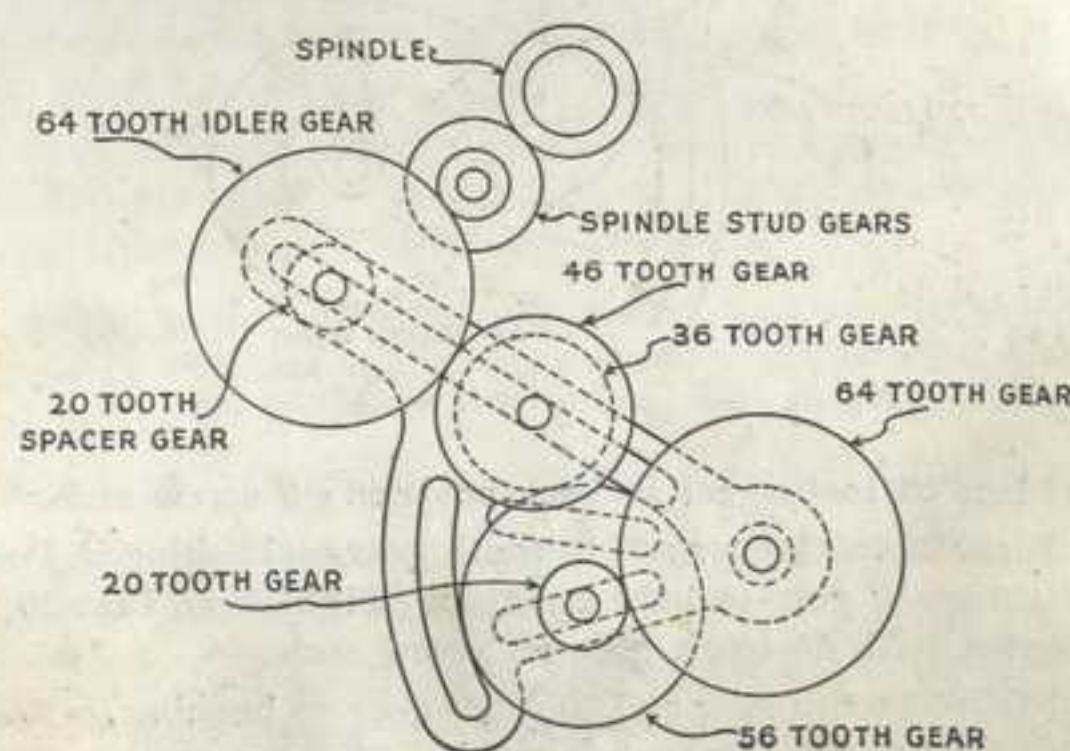


FIG. 49. Gear set-up for .0087 inch carriage feed (see page 32).

GEAR TRAIN FOR .0087 INCH CARRIAGE FEED

(See Fig. 49, page 31)

1. Place 64 tooth gear in front position on screw stub.
2. Place 56 tooth gear and 20 tooth gear on bushing in Position B, with 56 tooth gear in back position. Tighten so that 20 tooth gear meshes with 64 tooth gear on screw stub.
3. Place 36 tooth gear and 46 tooth gear on bushing in Position B, with 36 tooth gear in back position. Tighten so that 36 tooth gear meshes with 56 tooth gear in Position D.
4. Place 20 tooth gear and 64 tooth gear on bushing in Position A with 20 tooth gear in back position. Tighten so that 64 tooth gear meshes with 46 tooth gear in Position B. The 64 tooth gear is an idler; the 20 tooth gear is a spacer.
5. Swing entire gear bracket upward and tighten so that 64 tooth gear in Position A meshes with 16 tooth spindle stud gear.

GEAR TRAIN FOR .0070 INCH CARRIAGE FEED

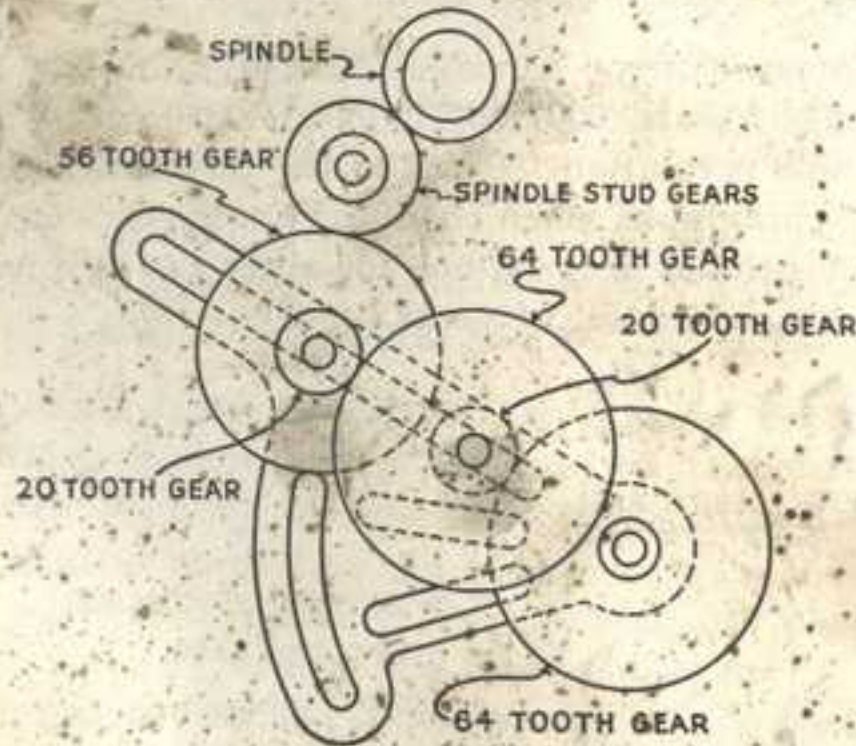


FIG. 50. Gear set-up for .0070 inch carriage feed.

1. Place 64 tooth gear in back position on screw stub.
2. Place 20 tooth gear and 64 tooth gear on bushing in Position B, with 20 tooth gear in back position. Tighten so that 20 tooth gear meshes with 64 tooth gear on screw stub.
3. Place 56 tooth gear and 20 tooth gear on bushing in Position A, with 56 tooth gear in back position. Tighten so that 20 tooth gear meshes with 64 tooth gear in Position B.
4. Swing entire gear bracket upward and tighten so that 56 tooth gear in position A meshes with 32 tooth spindle stud gear.

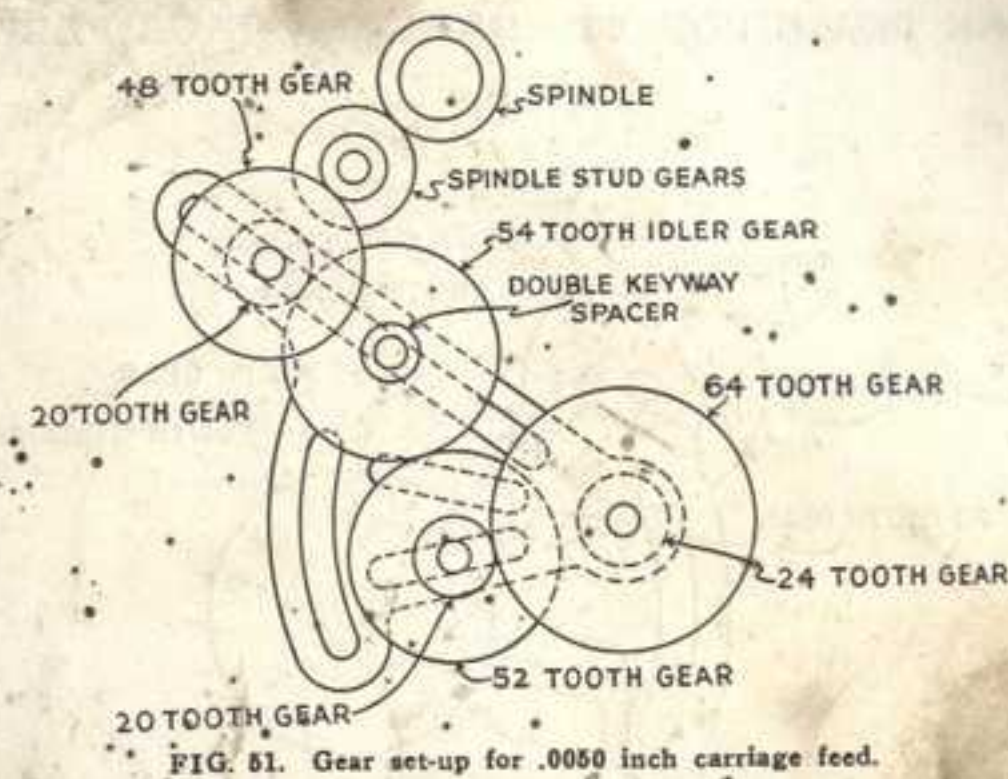


FIG. 51. Gear set-up for .0050 inch carriage feed.

GEAR TRAIN FOR .0050 INCH CARRIAGE FEED

1. Place 64 tooth gear in front position on screw stub and substitute 24 tooth gear for steel spacer in back position on screw stub.
2. Place 52 tooth gear and 20 tooth gear on bushing in Position D, with 52 tooth gear in back position. Tighten so that 20 tooth gear meshes with 64 tooth gear on screw stub.
3. Place 54 tooth gear and steel spacer from screw stub on bushing in Position B, with 54 tooth gear in back position. Tighten so that 54 tooth gear meshes with 52 tooth gear in Position D. The 54 tooth gear is an idler.
4. Place 20 tooth gear and 48 tooth gear on bushing in Position A, with 20 tooth gear in back position. Tighten so that 20 tooth gear meshes with 54 tooth gear in Position B.
5. Swing entire gear bracket upward and tighten so that 48 tooth gear in Position A meshes with 16 tooth spindle stud gear.

GEAR TRAIN FOR .0060 INCH CARRIAGE FEED

The gear set-up for .0060 inch carriage feed is the same as that for the .0050 inch feed except:

- (1) Substitute 20 tooth gear for 24 tooth gear in back position on screw stub.
- (2) Substitute 24 tooth gear for 20 tooth gear in back position at A.

GEAR TRAIN FOR .0035 INCH CARRIAGE FEED

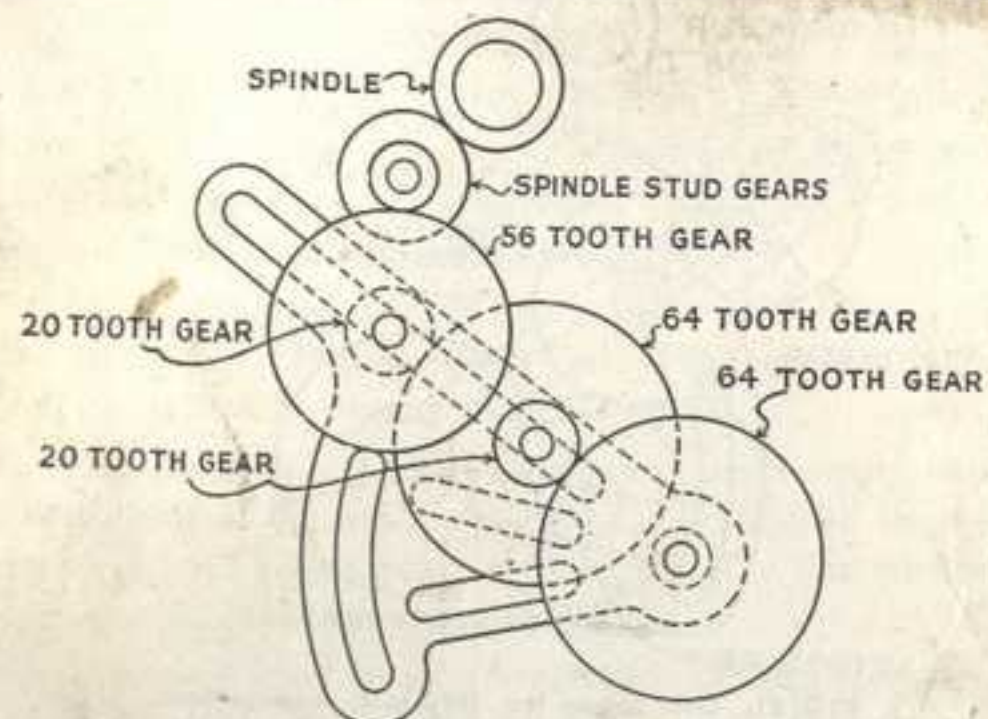


FIG. 52. Gear set-up for .0035 inch carriage feed.

1. Place 64 tooth gear in front position on screw stub.
2. Place 64 tooth gear and 20 tooth gear on bushing in Position B, with 64 tooth gear in back position. Tighten so that 20 tooth gear meshes with 64 tooth gear on screw stub.
3. Place 20 tooth gear and 56 tooth gear on bushing in Position A, with 20 tooth gear in back position. Tighten so that 20 tooth gear meshes with 64 tooth gear in Position B.
4. Swing entire gear bracket upward and tighten so that 56 tooth gear in Position A meshes with 16 tooth spindle stud gear.

GEAR TRAIN FOR .001877 INCH CARRIAGE FEED

(See Fig. 53, page 35)

1. Place 64 tooth gear in front position on screw stub.
2. Place 20 tooth gear and 64 tooth gear on bushing in Position C, with 20 tooth gear in back position. Tighten so that 20 tooth gear meshes with 64 tooth gear on screw stub.
3. Place 52 tooth gear and 20 tooth gear on bushing in Position B, with 52 tooth gear in back position. Tighten so that 20 tooth gear meshes with 64 tooth gear in Position C.
4. Place 24 tooth gear and 48 tooth gear on bushing in Position A, with 24 tooth gear in back position. Tighten so that 24 tooth gear meshes with 52 tooth gear in Position B.
5. Swing entire gear bracket upward and tighten so that 48 tooth gear in Position A meshes with 16 tooth spindle stud gear.

GEAR TRAIN FOR .001877 INCH CARRIAGE FEED

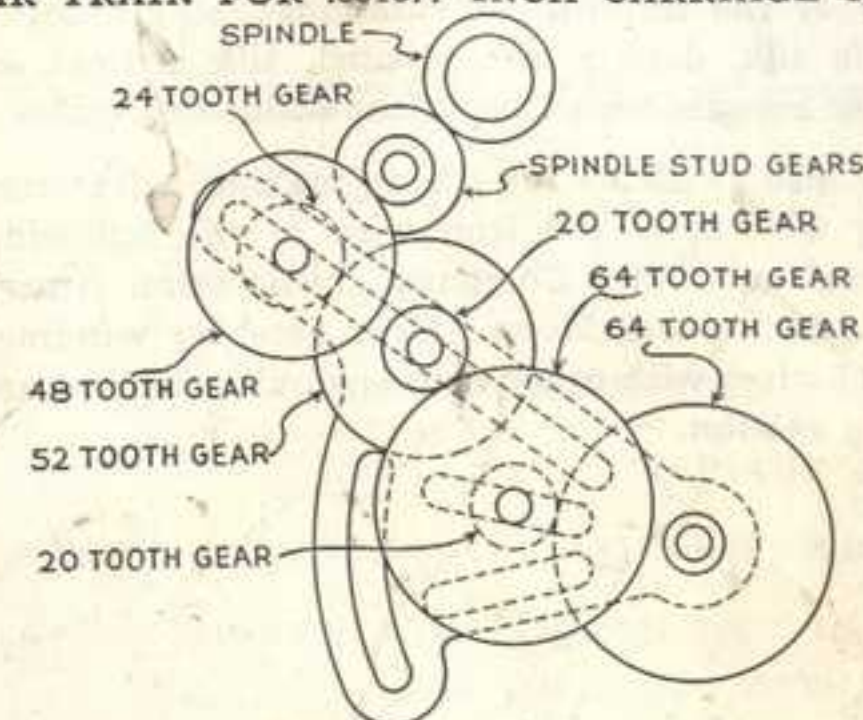


FIG. 53. Gear set-up for .001877 inch carriage feed (see page 34).

SPECIAL THREADS AND FEEDS

Engineers have charted over a thousand threads and feeds between the coarsest thread and the finest feed. Tables I and II in the following section give proper gear set-ups for a wide variety of special threads and feeds. Most of these set-ups are exact—some are accurate to the limits mentioned. Table III gives set-ups for metric threads with pitch between 0.5 and 7.0 millimeters.

ELECTRICAL COIL WINDING

Figure 54 shows a coil winding operation with a simple guide mounted in place of the tool post on the compound rest. This set-up is very popular with electrical shops and has done much to make coil winding on the lathe a simple job. This guide is available at the Atlas factory.

Feeds are available to match the diameter of B & S magnet wire in sizes between 12 and 40, using bare

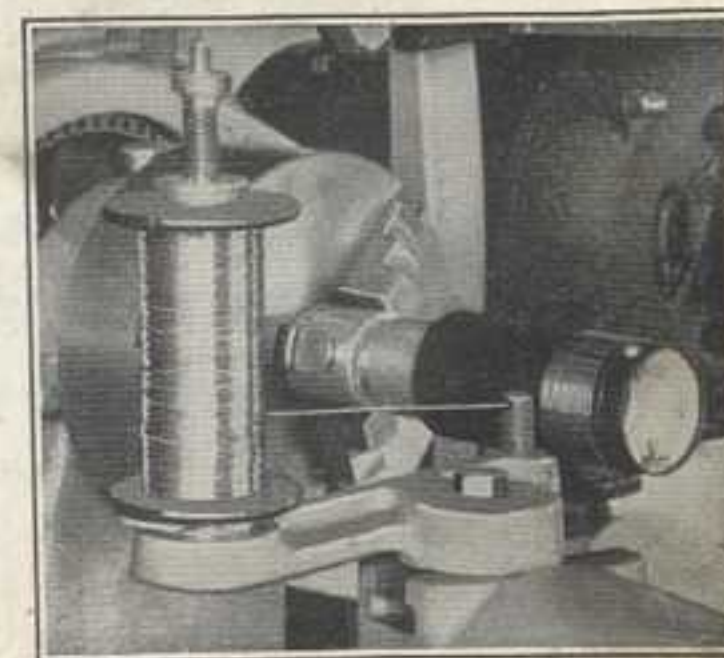


FIG. 54. Winding a coil.

wire or any of the following insulations: single cotton, double cotton, single silk, double silk, enamel, silk enamel, and cotton enamel. Gear set-ups are given in the following tables.

Feeds are also available for spring making, wire wrapping and coil winding with steel and iron wire in the following gauges: American Steel and Wire Company, music wire, American or B & S, and Washburn and Moen. Gear data for winding iron and steel wire and wires with other than enamel insulation are given in the following section.

TABLES FOR THREAD CUTTING

I.....	ODD-PITCH THREADS
II.....	CARRIAGE FEEDS
III.....	METRIC THREADS
IV.....	DEPTH AND DOUBLE DEPTH OF NATIONAL FORM THREADS
V.....	NATIONAL COARSE THREAD DIMENSIONS
VI.....	NATIONAL FINE THREAD DIMENSIONS
VII.....	FRACTIONAL SIZE THREAD DIMENSIONS
VIII.....	MACHINE SCREW THREAD DIMENSIONS
IX.....	WHITWORTH THREAD DIMENSIONS
X.....	BRITISH ASSOCIATION THREAD DIMENSIONS
XI.....	INTERNATIONAL STANDARD THREAD DIMENSIONS—METRIC
XII.....	FRENCH STANDARD THREAD DIMENSIONS
XIII.....	ACME STANDARD THREAD DIMENSIONS
XIV.....	SQUARE THREAD DIMENSIONS
XV.....	STRAIGHT PIPE THREAD DIMENSIONS
XVI.....	STOVE BOLT THREAD DIMENSIONS
XVII to XXVI....	GEAR SET-UPS FOR COIL WINDING

TABLE I—GEAR SET-UPS FOR THREADS FROM 1.25 THROUGH 79 PER INCH NOT SHOWN ON THE THREADING CHART

The threading dial can be used when cutting threads below marked "Exact" in the column under "Accuracy per inch", except for the 1.25, 2.25, 2.75, 3.25, and 3.75 threads. These threads and all others must be cut in the same manner as metric threads (See Page 28). Extra gears available from the factory at nominal cost.

Threads per inch	Accuracy per inch	Gear on Screw	Position D B	Position C F	Position B B	Position A F	Spindle Stud Gear	Note
1.25	Exact	20B	—	—	40	20	32 64	64I 24S 32
1.5	Exact	24B	40	20	—	—	32 64	64I 20S 32
2.0	Exact	32B	40	20	—	—	32 64	64I 20S 32
2.25	Exact	36B	40	20	—	—	32 64	64I 20S 32
2.5	Exact	20F	—	—	24S	44I	20 40	64I 32S 32
2.75	Exact	44B	48	24	—	—	32 64	64I 20S 32
3.0	Exact	24F	—	—	20	40	64I 32S	— 32
3.25	Exact	52B	40	20	—	—	32 64	64I 20S 32
3.5	Exact	56B	40	20	—	—	32 64	64I 20S 32
3.75	Exact	20F	48	24	—	—	64I 24S	— 32
7.5	Exact	40F	—	—	—	—	24 32	64I 20S 32
8.5	1/3500	44B	36	20	—	—	24S 64I	64 46 32 †
9.5	1/2000	52B	40	24	—	—	20S 64I	56 46 32 †
10.5	Exact	56F	—	—	—	—	48 64	64I 20S 32
12.5	Exact	40F	—	—	—	—	40 32	64I 20S 32 d
13.5	Exact	54B	—	—	—	—	48I 20S	64I 24S 32
15	Exact	54F	—	—	—	—	40 36	64I 20S 32
17	1/3000	40B	36	44	—	—	24S 54I	64 46 32 †
19	1/1500	40B	54	44	—	—	SS 64I	56 24 32 †
21	Exact	56F	—	—	—	—	54 36	64I 20S 32
25	Exact	40B	32	40	—	—	20S 64I	64 32 32 d
29	1/1500	46B	40	36	—	—	SS 64I	56 20 32 †
30	Exact	54B	—	—	—	—	36 40	20S 64I 16
31	1/2000	56B	20	36	—	—	24S 54I	64 52 32 †
33	Exact	48B	—	—	—	—	32 44	24S 64I 16
34	1/1100	48B	20	46	—	—	SS 44I	64 52 32 †
35	Exact	56B	32	40	—	—	SS 54I	64 32 32
37	1/1300	54B	—	—	—	—	20 48	64 56 32 †
38	1/2000	52B	—	—	—	—	20 48	56 46 32 †
39	Exact	48B	—	—	—	—	32 52	20S 64I 16
41	1/1000	64B	20	32	—	—	24S 56I	64 40 32 †
42	Exact	48B	—	—	—	—	32 56	20S 64I 16
43	1/2000	46B	32	46	—	—	SS 56I	52 20 32 †g

Table I—Continued

Threads per inch	Accuracy per inch	Gear on Screw	Position D B	Position C F	Position B B	Position A F	Spindle Stud Gear	Note
45	Exact	54B	24	40	—	—	20S 64I	64 32 32
46	Exact	48B	—	—	—	—	24 46	32S 64I 16
47	1/1000	48F	40	24	—	—	46 54	20S 64I 16 †
49	Exact	56B	—	—	—	—	32 64	56 32 32 hk
50	Exact	40F	40	32	—	—	44I SS	24 48 16 d
51	1/950	48F	36	20	—	—	44 52	24S 54I 16 †
52	Exact	48B	—	—	—	—	24 52	32S 64I 16
53	1/3000	48F	36	20	—	—	44 54	24S 48I 16 †
54	Exact	48B	—	—	—	—	64I 20S	24 54 16
55	Exact	64F	44	24	—	—	36I SS	24 40 54 48 32 *df
57	1/3000	56B	20	56	—	—	24S 52I	64 44 32 †h
58	1/1400	46B	20	36	—	—	SS 64I	56 20 32 †c
59	1/1800	46B	24	44	—	—	20S 64I	56 20 32 †
60	Exact	48F	48	24	—	—	32 40	20S 54I 16 l
61	1/1500	48F	54	46	—	—	56I 20S	24 52 16 †
62	1/3000	48F	44	20	—	—	46 54	20S 52I 16 †
63	Exact	64B	—	—	—	—	24 54	56 32 32
65	Exact	48F	40	24	—	—	64I SS	32 52 16
66	Exact	64B	24	44	—	—	20S 56I	54 24 32
67	1/1400	64F	—	—	—	—	40 24	32 40 20S 52I 16 †d
68	1/1100	48F	46	20	—	—	52 64	24S 56I 16 †
69	Exact	64B	24	46	—	—	20S 56I	54 24 32 f
70	Exact	48F	40	24	—	—	64I SS	32 56 16
71	1/630	48F	48	20	—	—	52 64	24S 56I 16 †l
73	1/730	48F	36	20	—	—	64I 24S	32 54 16 †
74	1/120	64F	56	48	—	—	54I SS	32 64 16 †
75	1/625	52B	20	36	—	—	SS 64I	64 20 32 †c
76	1/2200	48F	56	46	—	—	54I SS	20 52 16 †
77	Exact	48F	44	24	—	—	56I 20S	32 56 16 h
78	Exact	48F	40	20	—	—	46I 20S	32 52 16
79	1/3100	54B	—	—	—	—	20 54	52 24 32 †j

SYMBOLS:

c—extra 20 tooth gear
d—extra 40 tooth gear
f—extra 24 tooth gear
g—extra 46 tooth gear
h—extra 56 tooth gear
j—extra 54 tooth gear

k—extra 32 tooth gear
l—extra 48 tooth gear
F—position away from headstock
B—position toward headstock
I—idler gear (page 6)
S—spacer gear (page 6)

SS—double keyway spacer

*—extra change gear stud assembly—available at the factory.

†—Follow cutting procedure described at top of page 28.

TABLE II—GEAR SET-UPS FOR CARRIAGE FEEDS

Six different carriage feeds between .00157 and .0085 inch per spindle revolution are available on the Atlas lathe in addition to the six most common feeds which are pictured and described in detail between pages 31 and 35. When the material or job requires a certain feed, refer to the table below. Extra gears are available from the factory at nominal cost. Feeds for electrical coil winding begin with Table XVII.

Feed Inches	Threads per inch	Gear on Screw	Position D B F	Position C B F	Position B B F	Position A B F	Spindle Stud Gear	Note
.0085	118.8	48F	44 20	— —	52I SS	24 54	16	
.008	124.8	48F	48 20	— —	54I SS	24 52	16	I
.004	250.88	64F	56 20	— —	54I SS	20 56	16	ch
.00288	348.15	56B	— —	20 56	54 24	24 46	16	hf
.002045	489.2	56B	— —	20 56	52 20	20 48	16	cc
.00157	639.0	64B	— —	20 64	52 20	20 48	16	cc

SYMBOLS:

c—extra 20 tooth gear
 f—extra 24 tooth gear
 h—extra 56 tooth gear
 I—extra 48 tooth gear
 F—position away from headstock
 B—position toward headstock
 I—idler gear (page 6)
 S—spacer gear (page 6)
 SS—double keyway spacer

TABLE III—GEAR SET-UPS FOR METRIC THREADS

Two of the standard change gears furnished with the Atlas Lathe, the 52 tooth gear and the 44 tooth gear, combine to give a ratio of 44/52 or .846154, which is an almost exact function of 2.54, the English to Metric ratio. Thus, it is possible to cut metric threads accurate to the extremely close limits of 1 part in 3000.

Refer to page 28 when cutting metric threads.

Pitch in Millimeters	Gear on Screw	Position D B F	Position B B F	Position A B F	Spindle Stud Gear
.5	48F	40 44	52I SS	24 56	16
.75	64F	40 32	52 44	20S 56I	16
1.00	44F	40 32	52 48	20S 64I	16
1.25	44B	— —	52 48	20S 64I	16
1.50	44B	— —	52 40	20S 64I	16
1.75	44F	48 52	56 40	20S 64I	16
2.00	40F	44 48	52 36	20S 64I	16
2.5	44B	— —	52 24	20S 64I	16
3.0	44B	— —	52 20	24S 64I	16
3.5	44F	48 56	52 20	24S 64I	16
4.0	20F	44 48	52 36	24S 64I	16
4.5	20F	44 54	52 36	20S 64I	16
5.0	24F	44 52	40 20	20S 64I	16
5.5	20F	— —	48 52	64I 24S	32
6.0	20F	44 52	48 24	32S 64I	16
7.0	48B	52 44	20 56	64I 24S	32

SYMBOLS:

F—position away from headstock
 B—position toward headstock
 I—idler gear (page 6)
 S—spacer gear (page 6)
 SS—double keyway spacer

Note: position C is not used in any of the above set-ups.

TABLE VIII
MACHINE SCREW SIZES
THREAD DIMENSIONS AND TAP DRILL SIZES
NATIONAL SPECIAL THREAD SERIES

Nominal Size	Threads per Inch	Major Diameter Inches	Minor Diameter Inches	Pitch Diameter Inches	Tap Drill for 75% Thread	Clearance Drill Size*
1	56	.0730	.0498	.0614	54	47
4	32	.1120	.0714	.0917	45	31
4	36	.1120	.0759	.0940	44	31
5 (1/8)	36	.1250	.0889	.1070	40	29
6	36	.1380	.1019	.1200	34	25
7	30	.1510	.1077	.1294	31	21
7	36	.1510	.1149	.1330	3/8"	21
8	30	.1640	.1207	.1423	30	16
8	40	.1640	.1315	.1478	28	16
9	24	.1770	.1229	.1499	29	13
9	30	.1770	.1337	.1553	27	13
9	32	.1770	.1364	.1567	26	13
10	28	.1900	.1436	.1668	23	13/64"
10	30	.1900	.1467	.1684	22	13/64"
12	32	.2160	.1754	.1957	13	7/32"
14	20	.2420	.1770	.2095	10	17/64"
14	24	.2420	.1879	.2149	7	17/64"

*Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE IX
BRITISH STANDARD — WHITWORTH FORM
THREAD DIMENSIONS AND TAP DRILL SIZES

Nominal Size	Threads per Inch	Major Diameter Inches	Minor Diameter Inches	Pitch Diameter Inches	Tap Drill for Full Thread	Clearance Drill Size*
1/16"	60	.0625	.0412	.0518	57	51
3/32"	48	.0938	.0671	.0804	50	40
1/8"	40	.1250	.0930	.1090	40	29
5/32"	32	.1563	.1162	.1362	31	19
3/16"	24	.1875	.1341	.1608	28	8
7/32"	24	.2188	.1654	.1921	17	1
1/4"	20	.2500	.1860	.2180	9	17/64"
9/32"	26	.2813	.2321	.2566	C	19/64"
5/16"	18	.3125	.2414	.2769	1/4"	21/64"
3/8"	16	.3750	.2950	.3350	5/16"	25/64"
7/16"	14	.4375	.3460	.3918	T	29/64"
1/2"	12	.5000	.3933	.4466	Z	33/64"
9/16"	12	.5625	.4558	.5091	15/32"	37/64"
5/8"	11	.6250	.5086	.5668	17/32"	41/64"
11/16"	11	.6875	.5711	.6293	19/32"	45/64"
3/4"	10	.7500	.6219	.6860	41/64"	49/64"
13/16"	10	.8125	.6844	.7485	45/64"	53/64"
7/8"	9	.8750	.7327	.8039	3/4"	57/64"
1"	8	1.0000	.8399	.9200	55/64"	1- 1/64"
1 1/8"	7	1.1250	.9420	1.0335	31/32"	1- 9/64"
1 1/4"	7	1.2500	1.0670	1.1585	1- 3/32"	1-17/64"
1 3/8"	6	1.3750	1.1616	1.2683	1- 3/16"	1-25/64"
1 1/2"	6	1.5000	1.2866	1.3933	1- 5/16"	1-33/64"
1 5/8"	5	1.6250	1.3689	1.4969	1-13/32"	1-41/64"
1 3/4"	5	1.7500	1.4939	1.6219	1-17/32"	1-49/64"
2"	4 1/2	2.0000	1.7154	1.8577	1- 3/4 "	2- 1/32"
2 1/4"	4	2.2500	1.9298	2.0899	1-31/32"	2- 9/32"
2 1/2"	4	2.5000	2.1798	2.3399	2- 7/32"	2-17/32"

TABLE X
BRITISH ASSOCIATION STANDARD
THREAD DIMENSIONS AND TAP DRILL SIZES

Number Size	Pitch m/m	Major Diameter m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for Full Thread	Clearance Drill Size*
0	1.00	6.0	4.80	5.400	10	F
1	.90	5.3	4.22	4.760	17	1
2	.81	4.7	3.73	4.215	24	7
3	.73	4.1	3.22	3.660	29	15
4	.66	3.6	2.81	3.205	32	21
5	.59	3.2	2.49	2.845	37	27
6	.53	2.8	2.16	2.480	43	30
7	.48	2.5	1.92	2.210	46	32
8	.43	2.2	1.68	1.940	50	37
9	.39	1.9	1.43	1.665	53	42
10	.35	1.7	1.28	1.490	55	44
11	.31	1.5	1.13	1.315	56	48
12	.28	1.3	.96	1.130	60	50

*Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

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FRENCH STANDARD THREADS — METRIC
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Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

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THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

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FRENCH STANDARD THREADS — METRIC
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Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

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THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

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FRENCH STANDARD THREADS — METRIC
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Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

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THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

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FRENCH STANDARD THREADS — METRIC
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Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

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THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

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FRENCH STANDARD THREADS — METRIC
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Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

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THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XI
INTERNATIONAL STANDARD—METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size†
2.0	.40	1.48	1.740	1.6	1/16	41
2.3	.40	1.78	2.040	1.9	48	36
2.6	.45	2.02	2.308	2.1	45	31
3.0	.50	2.35	2.675	2.5	40	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.70	3.09	3.545	3.3	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.80	3.96	4.480	4.2	19	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.25	6.38	7.188	6.8	H	11/32"
9.0	1.25	7.38	8.188	7.8	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
11.0	1.50	9.05	10.026	9.6	V	29/64"
12.0	1.75	9.73	10.863	10.5	Z	1/2"
14.0*	1.25	12.38	13.188	13.0	33/64"	9/16"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0*	1.50	16.05	17.026	16.5	41/64"	47/64"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
27.0	3.00	23.10	25.051	24.0	15/16"	1- 3/32"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
33.0	3.50	28.45	30.727	29.5	1-11/64"	1-21/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
39.0	4.0	33.80	36.402	35.0	1- 3/8 "	1- 9/16"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
45.0	4.50	39.15	42.077	40.0	1-37/64"	1-13/16"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-29/32"

* Special Spark Plug Sizes

† Clearance drill makes hole with standard clearance for diameter of nominal size.

TABLE XII
FRENCH STANDARD THREADS — METRIC
THREAD DIMENSIONS AND TAP DRILL SIZES

Major Diameter m/m	Pitch m/m	Minor Diameter m/m	Pitch Diameter m/m	Tap Drill for 75% Thread m/m	Tap Drill for 75% Thread No. or Inches	Clearance Drill Size*
1.5	.35	1.05	1.273	1.1	57	48
2.0	.45	1.42	1.708	1.5	53	41
2.5	.45	1.92	2.208	2.0	47	32
3.0	.60	2.22	2.610	2.4	3/32"	29
3.5	.60	2.72	3.110	2.9	33	23
4.0	.75	3.03	3.513	3.25	30	16
4.5	.75	3.53	4.013	3.75	26	10
5.0	.90	3.83	4.415	4.1	20	3
5.5	.90	4.33	4.915	4.6	14	15/64"
6.0	1.00	4.70	5.350	5.0	9	1/4"
7.0	1.00	5.70	6.350	6.0	15/64"	19/64"
8.0	1.00	6.70	7.350	7.0	I	11/32"
9.0	1.00	7.70	8.350	8.0	5/16"	3/8"
10.0	1.50	8.05	9.026	8.6	R	27/64"
12.0	1.50	10.05	11.026	10.5	Z	1/2"
14.0	2.00	11.40	12.701	12.0	15/32"	9/16"
16.0	2.00	13.40	14.701	14.0	35/64"	21/32"
18.0	2.50	14.75	16.376	15.5	39/64"	47/64"
20.0	2.50	16.75	18.376	17.5	11/16"	13/16"
22.0	2.50	18.75	20.376	19.5	49/64"	57/64"
24.0	3.00	20.10	22.051	21.0	53/64"	31/32"
26.0	3.00	22.10	24.051	23.0	57/64"	1- 3/64"
28.0	3.00	24.10	26.051	25.0	63/64"	1- 3/64"
30.0	3.50	25.45	27.727	26.5	1- 3/64"	1-13/64"
32.0	3.50	27.45	29.727	28.5	1- 1/8 "	1- 9/32"
34.0	3.50	29.45	31.727	30.5	1-13/64"	1-23/64"
36.0	4.00	30.80	33.402	32.0	1-17/64"	1- 7/16"
38.0	4.00	32.80	35.402	34.0	1-21/64"	1-33/64"
40.0	4.00	34.80	37.402	36.0	1-27/64"	1-19/32"
42.0	4.50	36.15	39.077	37.0	1-29/64"	1-43/64"
44.0	4.50	38.15	41.077	39.0	1-17/32"	1-3/4"
46.0	4.50	40.15	43.077	41.0	1-39/64"	1-53/64"
48.0	5.00	41.50	44.752	43.0	1-11/16"	1-13/16"
50.0	5.00	43.50	46.752	45.0	1-49/64"	2"

* Clearance drill makes hole with standard clearance for diameter of nominal size.