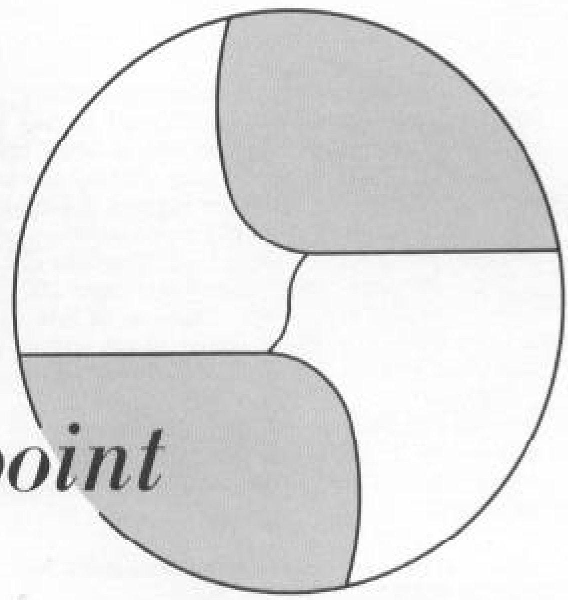


the spiral point

A NEW CONCEPT IN
DRILL POINT GEOMETRY
FROM CINCINNATI

CINCINNATI LATHE AND TOOL CO.
Cincinnati 9, Ohio U. S. A.

introduction

In all of the metalworking industry, drilling is one of the most common metal removing operations. It is difficult to find even one component of a finished metal product which has not had at least one, if not many, holes drilled or punched in it. In fact, in many plants, the cost of producing holes in metal is proportionately one of their highest manufacturing expenses. Approximately 20% of the machine tools in this country are drilling machines. And this figure does not include the hundreds of thousands of electric and pneumatic hand drills. It is conservatively estimated that over 100 million drills are employed in this country in one year alone. In view of this paramount importance of the drill, it is surprising that the design of its cutting surface, the point geometry, has remained virtually unchanged for over 100 years.

Now, a completely new drill point geometry has been developed which can be economically applied to the twist drill. Termed the "spiral point", this new concept in drill design has many significant advantages over the standard chisel point drill.

1. It produces a rounder, straighter hole, which is truer to size.
2. It increases drill life.
3. It eliminates center punching.
4. It reduces drill thrust force as much as 34%.
5. It produces less work piece distortion because of cooler cutting and reduced thrust force.
6. It maintains accuracy in hole positioning.
7. It reduces the need for secondary operations, such as reaming, in many instances.
8. When applied to sheet metal, it produces a round, practically burr free hole.

Supporting evidence for these advantages will be presented from the standpoint of theory, laboratory testing and field testing.

drill point design

In view of the claimed advantages of the spiral point drill, it is important that the functions of drill point geometry be clearly understood.

In analyzing the action of a drill, it must be realized that cutting conditions vary along the entire cutting edge of the drill. The cutting surfaces and the cutting speed of one section of the point will vary from that of another section. The cutting surfaces of the conventional chisel point drill may be divided into two categories, the primary cutting edge and the chisel edge (Fig. 1). At the periphery of the drill, (Fig. 2), the geometry of the cutting edge of a chisel point drill results in good cutting action. The cross section shows a good positive rake angle and effective clearance angle resulting in efficient chip flow and removal. Cutting speed at the periphery is, of course, at its maximum. The resulting efficiency of the combination of these conditions is shown in the photomicrograph of this area of the cutting edge (Fig. 3).

It is the chisel edge, at the center of the drill, where the main limitations of the chisel point drill are found (Fig. 1). The advancing face of this area has a very large negative rake angle. The space ahead of this face into which the chip can escape is greatly restricted. Furthermore, cutting speed is very low. These factors result in extremely bad cutting conditions as shown in the photomicrograph (Fig. 3). There is no possibility of free chip flow or efficient metal cutting action. In fact, the action of the chisel edge may be considered in part, a cutting action and in part, an extrusion action (Fig. 4).

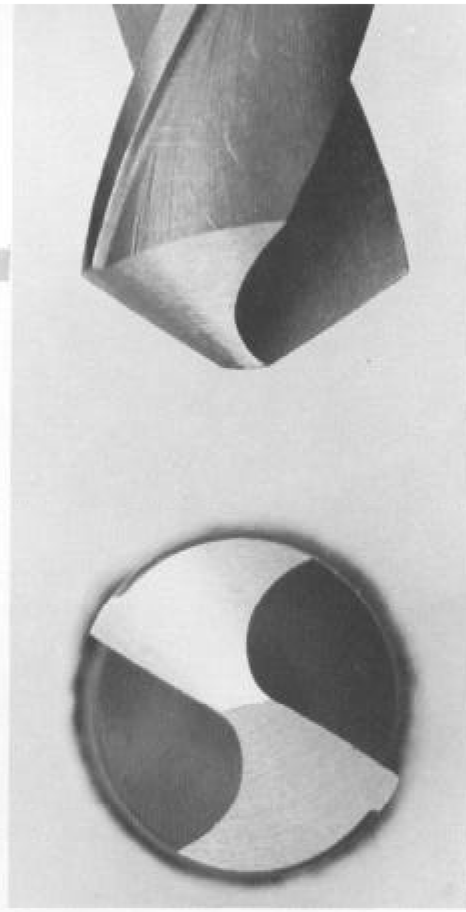
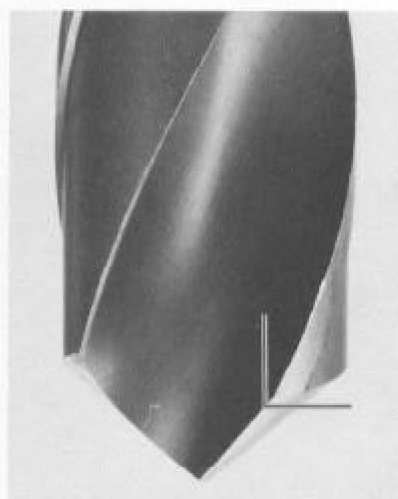


Fig. 1—Chisel point drill.



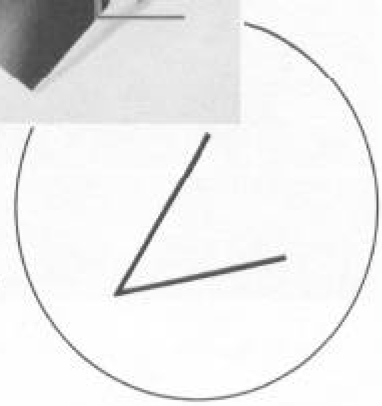


Fig. 2—Peripheral cutting area of the chisel point drill.

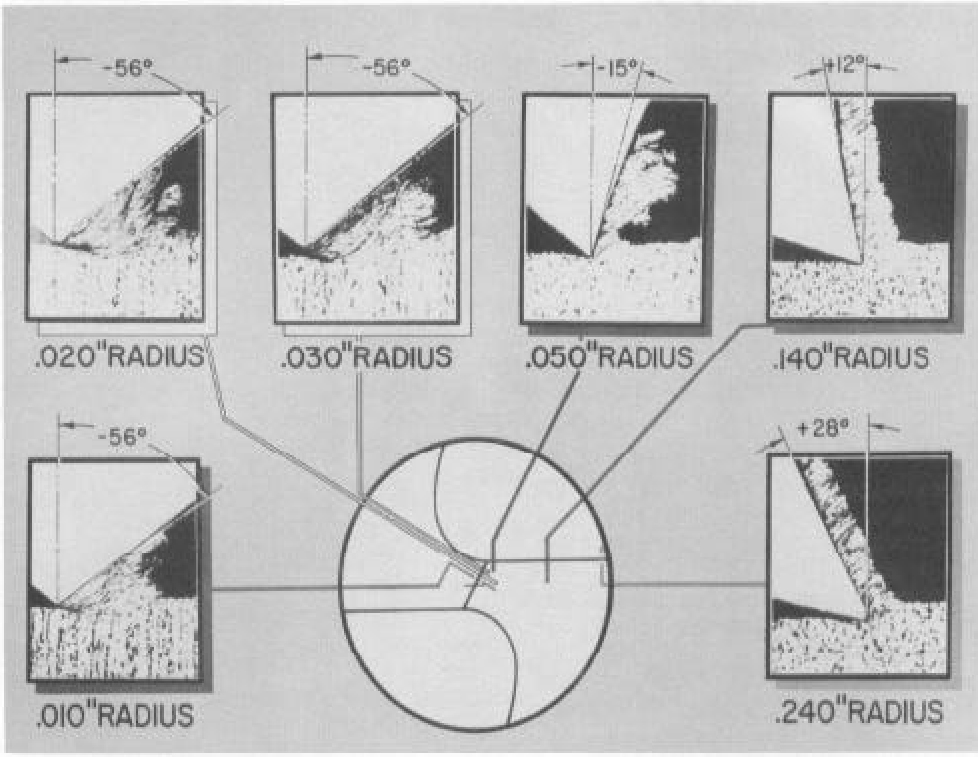


Fig. 3—Photomicrographs of sections through the chisel point drill and partly formed chips, at successive points along the cutting edge.

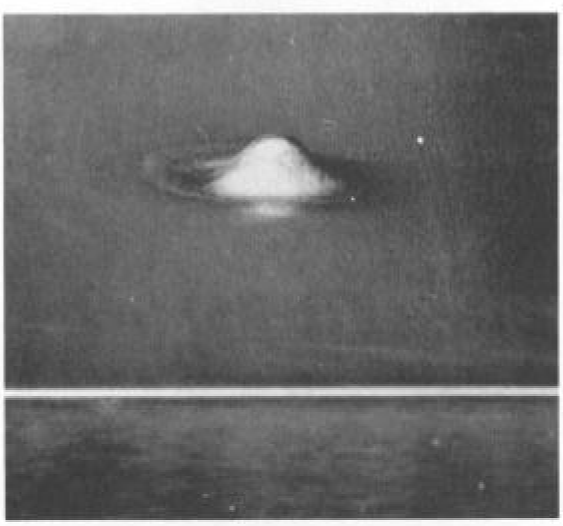


Fig. 4—Extruding action of the chisel point drill.

One of the greatest disadvantages of the chisel edge arises from the fact that it presents almost a straight edge parallel to the surface of the work. Consequently, it has no self-centering action when it engages the workpiece. In practice, one end of the chisel edge is often slightly higher than the other due to small imperfections in the symmetry of grinding. As a result, the drills usually tend to "walk" to one side of the desired hole location unless restrained by guide bushings or fixtures, or by the use of a center punched hole in the workpiece.

spiral point design

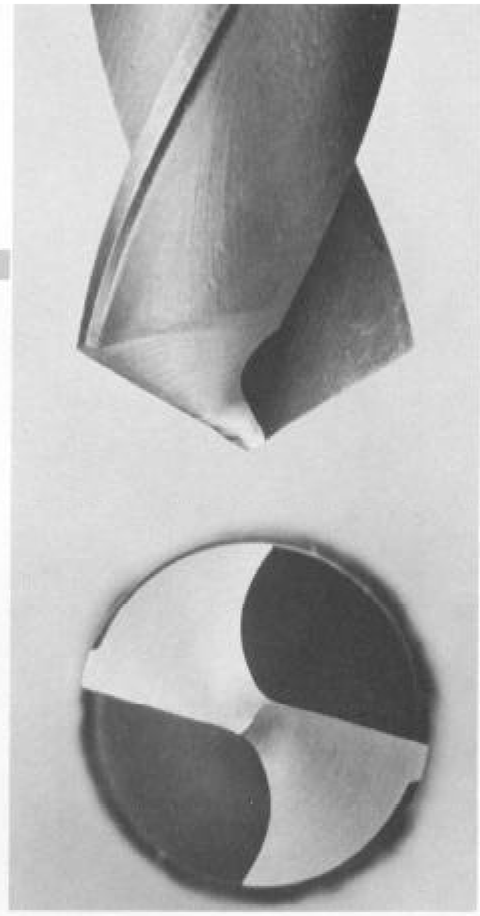


Fig. 5—Spiral point drill.

From the description of the chisel point drill, it is apparent that the following areas must be improved in overcoming its limitations. First, the center of the drill must be of a form to provide a true self-centering action. Secondly, the large negative rake angle at the center of the drill must be improved. Finally, a proper clearance angle must be provided along the entire surface of the cutting edge. All of these requirements have been met by the spiral point drill (Fig. 5).

A cross section of the cutting edge taken at the periphery of the drill shows basically the same efficient rake and clearance angles as are present on the chisel point drill (Fig. 6). The photomicrograph (Fig. 7) shows the efficiency of the metal cutting action.

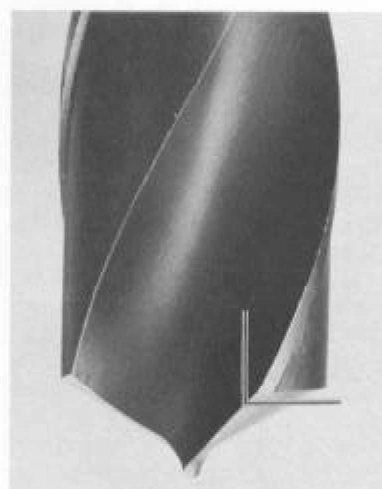


Fig. 6—Peripheral cutting area of the spiral point drill.

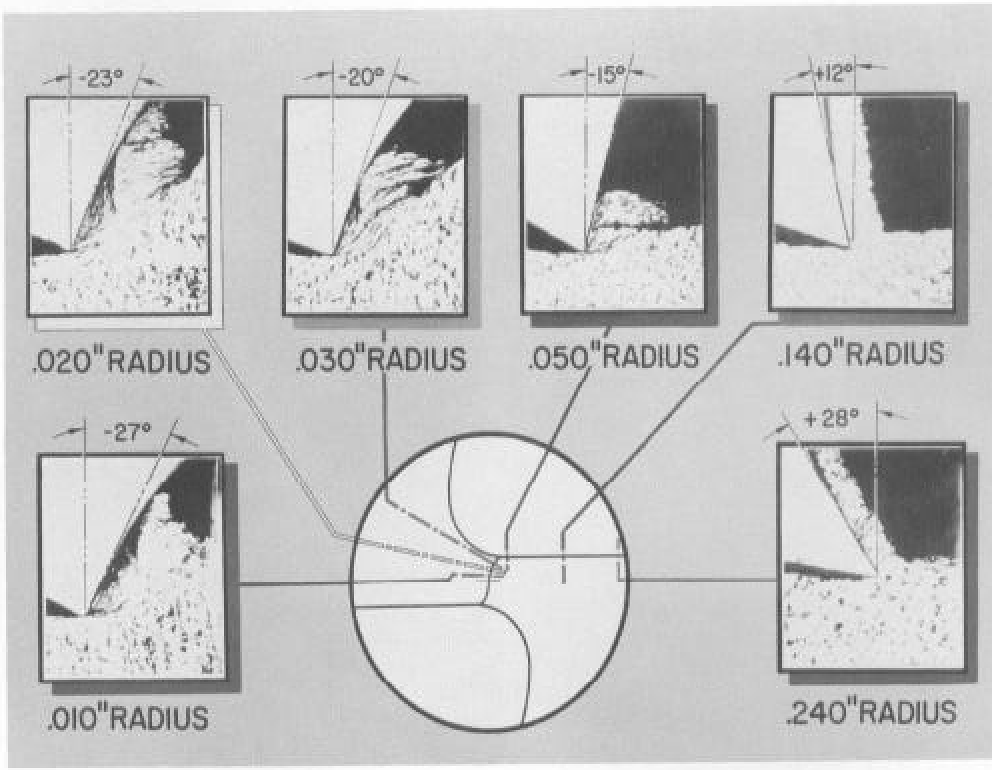


Fig. 7—Photomicrographs of sections through the spiral point drill and partly formed chips, at successive points along the cutting edge.

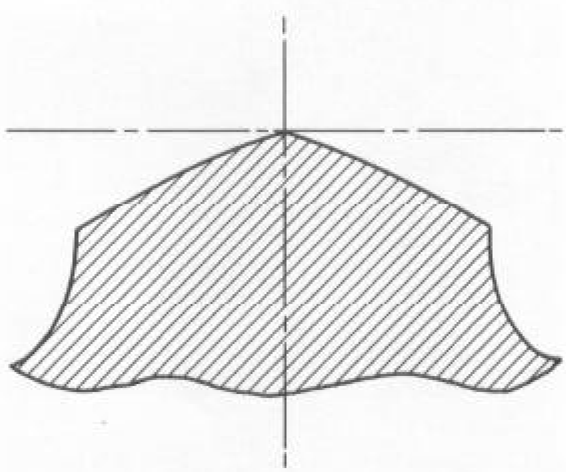


Fig. 8—The point of the spiral point drill.

The remarkable advantages of the new drill geometry are found at its point. The spiral point terminates at its center in a sharp point (Fig. 8). It therefore automatically centers itself on the axis of the drill when first engaging the workpiece. Wherever the spiral point touches the work, it enters and remains in that location. There is no tendency whatever to travel or "walk" to one side or the other as in the case of the chisel point. Therefore, it is usually unnecessary to use center punched holes or guide bushings to maintain the proper location of a hole. In addition, the large negative rake angle found on the chisel point is greatly reduced. A photomicrograph of the cutting action in this area (Fig. 7) when compared with the same area on the chisel point drill demonstrates the improved efficiency.

spiral point performance

Self-centering action . . .

One of the most important aspects of drilling a hole is how well the drill centers itself upon contact with the workpiece. It has been clearly shown that the central cutting edges of the spiral point form a point terminating on the axis of the drill thus giving a centering action to the drill. This is in direct contrast to the chisel edge of a conventional point which lies in a straight line perpendicular to the axis of the drill and therefore gives no centering action to the drill.

The centering action of the spiral point drill as compared to the chisel point drill is clearly shown in Fig. 9. Note that the hole produced with the spiral point drill is smooth, round, and shows no sign of erratic motion of the drill axis, whereas the hole produced with the chisel point drill shows a large amount of erratic motion of the drill axis.

Another effect of the centering action of the spiral point is to eliminate the bell mouth condition which is common in holes produced with chisel point drills. This is shown in Fig. 10 where two identical 1/2" mandrels are inserted in two holes, one produced by a 1/2" chisel point drill and one by a 1/2" spiral point drill. A gap between the mandrel and mouth of the chisel point drilled hole is clearly visible but no gap is visible between the mandrel and the mouth of the spiral point drilled hole.

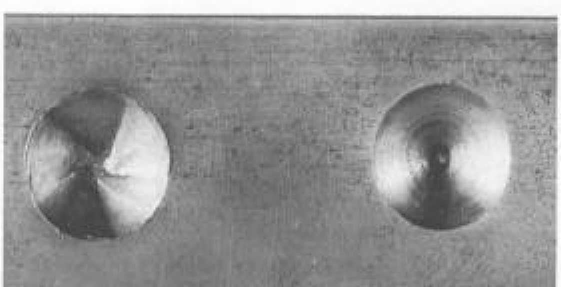


Fig. 9—Drilling action of the chisel point drill (left), spiral point drill (right).

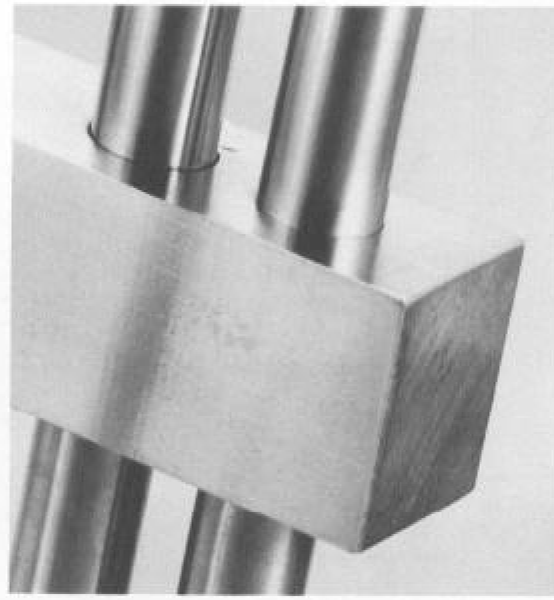


Fig. 10—Mouths of holes drilled with chisel point and spiral point drills.

Hole oversize . . .

The amount of hole oversize is affected by the centering action of the drill point and therefore it is to be expected that the holes produced with spiral point drills will be closer to the drill size than those produced with chisel point drills. In order to demonstrate this, a series of comparative tests for oversize of holes was made with 10 chisel point and 10 spiral point drills in each of four different sizes. Three holes were drilled with each drill making a total of 30 holes for every size and point geometry tested, or 240 holes in all. The values obtained were averaged and plotted graphically (Fig. 11) showing the hole oversize and spread of values. Considerable improvement in both hole oversize and spread was obtained with the spiral point drill.

Another demonstration of the improvement in hole size with spiral point drills is shown in Fig. 12 where the 1/2" mandrel with .006" taper per ft. goes much further through the chisel point drilled hole than the spiral point drilled hole.

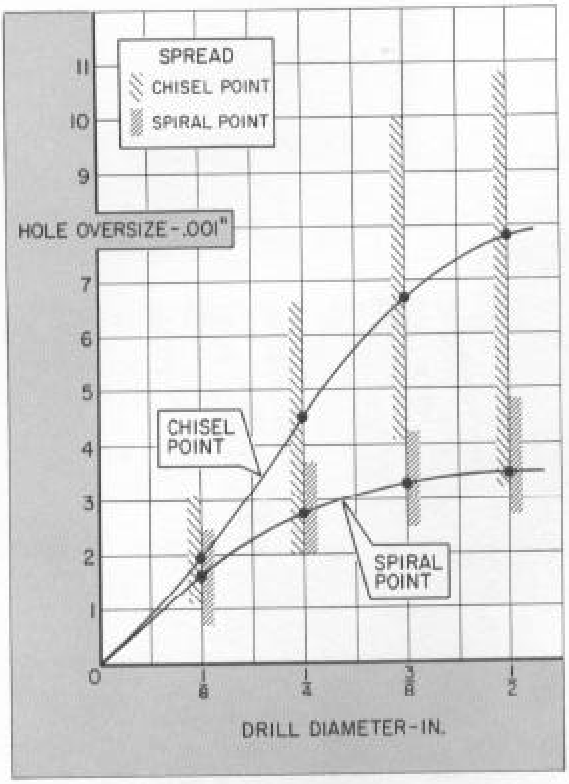


Fig. 11—Comparison of hole oversize for spiral point and chisel point drills.

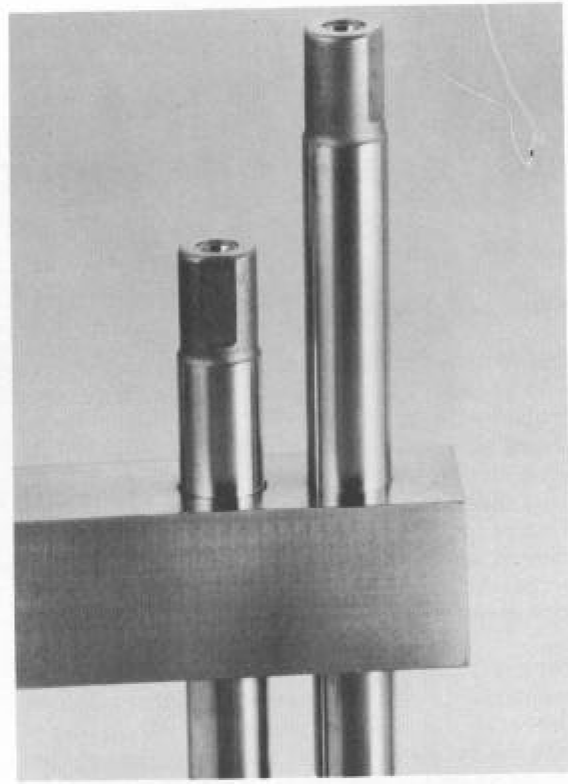


Fig. 12—Identical mandrels in holes drilled by chisel point and spiral point drills.

Drilling forces . . .

The values of torque and thrust for the spiral point and chisel point drills are shown in Fig. 13 for five different analyses of steel, as measured on a strain gage type of dynamometer.

As expected the values of torque for the spiral point drill were found to be about equal to those for the conventional drill because of the small influence of the chisel edge on this component, the average torque of the spiral point drill being 4% lower than that of the chisel point drill.

However, there was a significant difference in the thrust values, those of the spiral point ranging from 15 to 34% lower, the improvement being greatest for the lower feeds.

A considerably lower thrust force is expected for the spiral point drill because of the effective cutting edges and adequate chip space in the area close to the drill axis of the spiral point drill in contrast to the ineffective cutting edge and very small chip space for the chisel edge of the conventional drill.

Material	Hardness BHN	Feed in/rev	THRUST		TORQUE	
			Spiral Point Measured	Chisel Point Measured	Spiral Point Measured	Chisel Point Measured
CMM 320	132	.004	205	310	45	40
		.007	300	410	60	75
		.010	425	500	85	95
AISI 1112	153	.004	195	290	40	40
		.007	310	410	60	55
		.010	410	510	80	80
AISI 1018	150	.004	275	350	45	45
		.007	400	485	70	80
		.010	520	610	100	115
AISI 4150	200	.004	260	350	40	45
		.007	380	490	70	70
		.010	500	610	95	105
AISI 4340	200	.004	300	400	50	50
		.007	460	575	85	85
		.010	600	750	115	125

Fig. 13—Torque and thrust values for spiral point and chisel point drills.

spiral point performance

Drill life . . .

The life of a drill point between grinds is very difficult to determine because of the complexity of the drilling process. In fact, the drill life should be considered only in terms of a statistical distribution of results obtained with a very large number of drills tested under identical conditions.

Ascertaining the relative performance in drill life tests is made more laborious because of the difficulty in selecting an appropriate end point. Different criteria apply in different cases. In one case the hole size may be the determining factor for resharpening the drill, while in another case the increase in hole roughness may indicate the resharpening time. Other criteria for resharpening drills are lack of hole straightness, increase in thrust and torque, and lack of hole position relative to drill axis. Consequently, the improvement in drill life credited to any particular drill geometry will depend greatly on which of the above parameters is of paramount importance.

Bearing in mind these limitations of comparative drill life studies, it may still be of interest to introduce some examples of improvements obtained with the spiral point drill under both laboratory and repetitive manufacturing conditions.

In the laboratory, comparative life tests were conducted with spiral point and chisel point drills in cast iron and steel under various speeds and feeds. In all of these tests, the end point in drill life was determined when a rapid increase in the cutting forces occurred. The resulting values from these tests indicated the average drill life when using spiral point drills, under these conditions, was in all cases as good as that of chisel point drills and in many cases was better.

As might be expected, because of the self-centering action of the spiral point, the cases in competitive manufacturing where the greatest improvements have been cited are those where the end point is determined by the quality of the hole, as in Case I.

Case I - Automatic nut drilling machine. Material, SAE 8650 steel; drill diameter, 21/64"; speed, 800 RPM; feed, .005"/rev. Chisel point drill - 250 to 300 parts per grind. Spiral point drill 1600 to 1800 parts per grind. This machine has now been operating with spiral point drills for about 12 months. The drill life has averaged about six times that previously obtained with chisel point drills and has effected a saving of two complete drill changes per day (96 min.).

Case II - Automatic machine drilling hole for pivot pin in master brake cylinder block; material - cast iron; drill diameter 25/32"; cutting speed 80 ft. per min; feed, .006"/rev.; chisel point drill (average)-1500 pieces per grind; spiral point drill (average) 3000 pieces per grind.

Case III - Standard upright drill, drilling 1/8" hole in piston pin; material, SAE 8650; speed, 1200 RPM; feed, hand. The 1/8" hole had to be within ± .001" of the piston pin centerline. When using chisel point drills it is virtually impossible to maintain this limit. In one lot of 5000 pins, all were above this tolerance. However, when using spiral point drills, less than 5% of these parts were over the desired limit.

Case IV - precision machine drilling accurately located holes in cast iron broach holder with 13/16" diameter drill running at 136 R. P. M. spiral point drills have been used in this operation for the past 12 months. With chisel point drills, all holes had to be spotted before drilling. Using a feed rate of 1 inch per minute, difficulty was experienced in holding a tolerance of ± .005" in hole location. With spiral point drill, the spotting operation was eliminated. Using a feed rate of 1 inch per minute, all holes were held within .0015"; even with a feed rate of 2 inches per minute, all holes were held within .003". This operation is therefore now being run at 2"/min., or twice the original feed rate. In addition, the number of holes drilled per grind is now four times as great as with the chisel point drill.

point angle for drilling sheet metal

The spiral point drill is not limited to one particular point angle or clearance. Both of the dimensions may be easily changed to give better performance for a particular material, or for a job which is difficult for drills having spiral points with standard point angle and clearance. One such modification is found to be very advantageous for drilling sheet metal.

In the drilling of sheet metal, the self-centering action of the spiral point drill has been found particularly helpful, as with chisel point drills it is extremely difficult to obtain a truly round hole, especially with thin, soft metal such as sheet aluminum, or when the drill is held by hand. However, a further problem in drilling sheet metal, both with chisel point drills and with the spiral point drill as described thus far, is the "grabbing" of the drill as it breaks through the hole. This usually results in a large burr on the underside of the hole.

It was found that by modifying the point both the burr and grabbing on breakthrough could be virtually eliminated, while still retaining the advantages of the spiral point.

This modification consists of merely changing the point angle of the drill from 118^{o} to 180^{o} (Fig. 14). The central portion of the drill point, however, retains its characteristic spiral point extended ahead of the periphery and therefore contacts the work surface first thus centering the drill. Just before breaking through the bottom of the hole, a thin layer of the surface material is bulged forward by the spiral point; the peripheral portions of the cutting edges then act as trepanning tools to eliminate the burr as shown in Fig. 15.

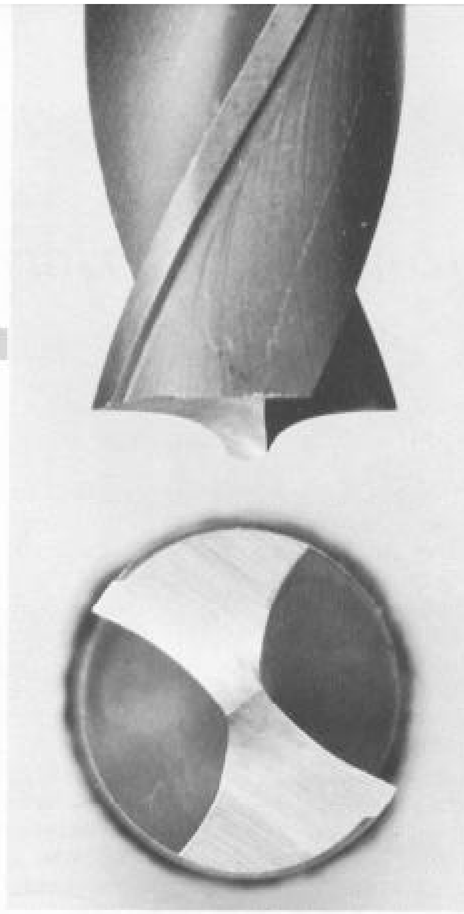


Fig. 14—Spiral point sheet metal drill.

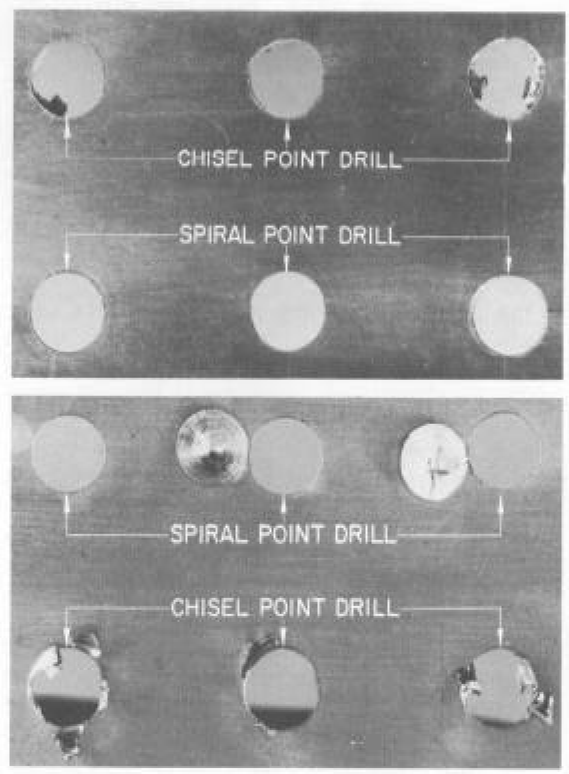


Fig. 15—Top side (above) and underside (below) of sheet metal drilled with spiral point and chisel point drills. Left to right—machine drilled, handfeed; machine drilled, power feed; hand drilled.

spiral point drill grinding

THE NEW SPIROPOINT DRILL SHARPENER

The new spiral point may be economically ground on a standard twist drill in a matter of seconds with the new precision Spiropoint Drill Sharpener. Though this grinder applies a fairly complex shape to the point of the drill, it may be operated easily and rapidly to produce a precision drill point. In several shop tests, it has been found that drills are re-pointed more rapidly on the Spiropoint than by hand. No special operator skill or training is required. The correct machine motion is automatically obtained by the setting of simple control dials.

The Model 500 Spiropoint grinds from 1/8" to 1/2" drills. The Model 750 Spiropoint grinds from 1/8" to 3/4" drills. An attachment is available which enables both models to grind from No. 60 (.040") to 1/8" drills.

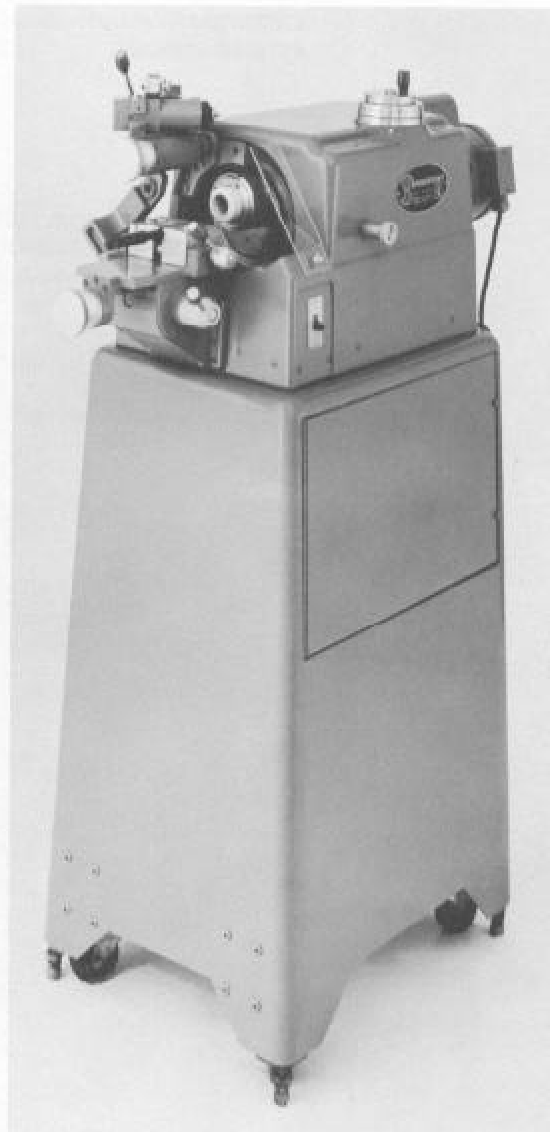


Fig. 16—The Spiropoint Drill Sharpener

spiral point drill grinding

OPERATING THE SPIROPOINT

The Spiropoint is designed so that the drill is held in a stationary position while a tubular type grinding wheel gyrates around it.

1. Prior to grinding, the Spiropoint is adjusted for the specific drill diameter by setting the dial, graduated in 1/32" increments, on top of the unit.

   Adjustment for clearance angles above or below the conventional 10 degrees, as may be required for special applications, is provided by setting a second dial on top of the unit (Fig. 17).

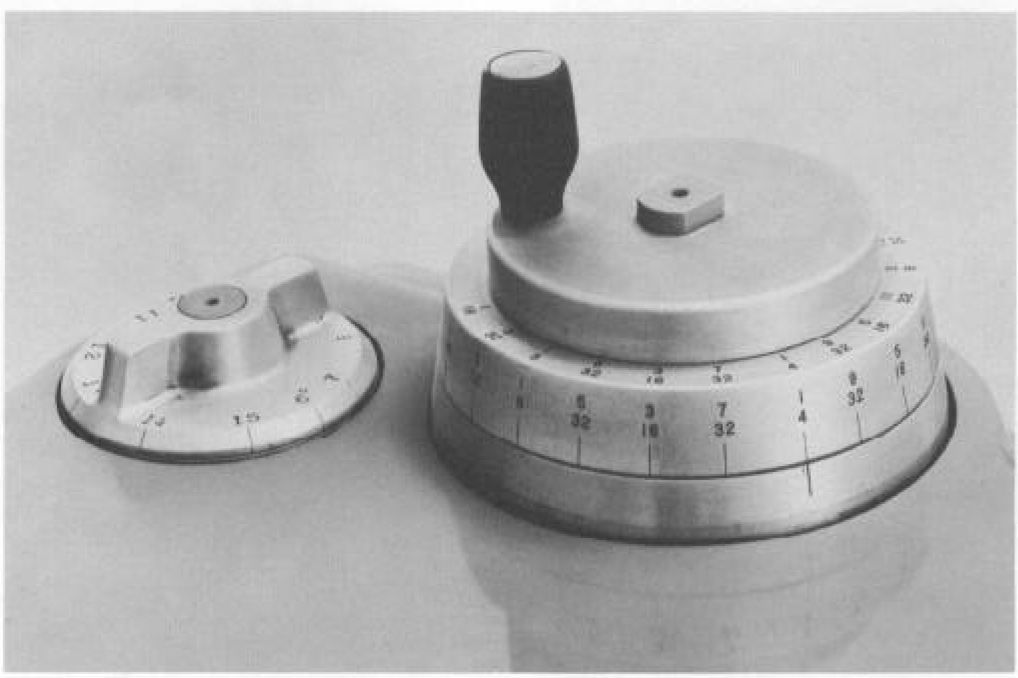


Fig. 17—Drill diameter and clearance angle dials

2. Drill point angle is determined by the shape of the grinding wheel. It may be varied by changing the wheel or dressing the wheel (Fig. 18).

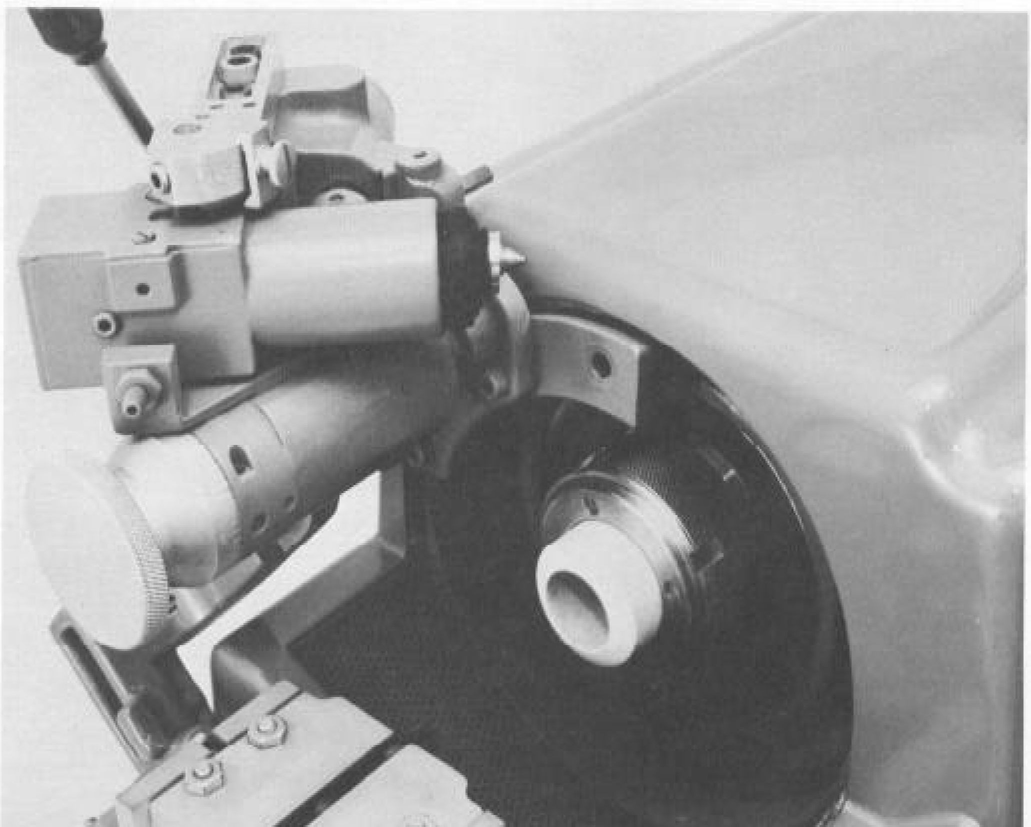


Fig. 18—Spiropoint grinding wheel

spiral point drill grinding

3. To grind drills, a locator bushing mounted on a swiveling arm is swung to a positive stop which positions it at the center of wheel gyration (Fig. 19). The drill is then radially positioned in the locator bushing. It is centered and securely held by vise jaws which are actuated by a single lever (Fig. 20). The slide is then retracted slightly which removes the drill from the locator bushing and in turn releases the spring loaded swiveling arm to its retracted position. The drill is rapidly advanced to the wheel with a convenient lever. Once it has reached the grinding wheel, the feed rate is controlled by a micrometer dial (Fig. 21).

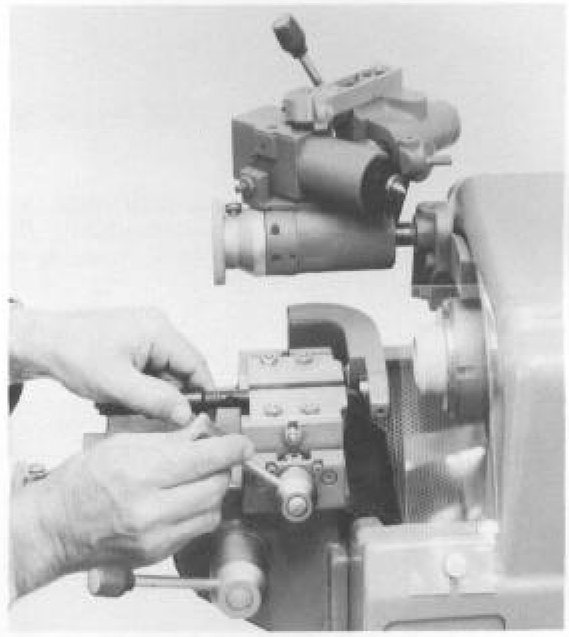


Fig. 20

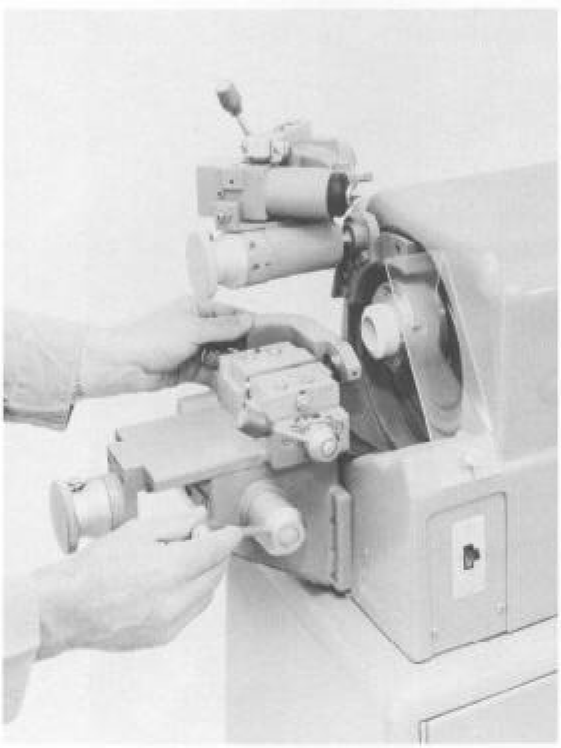


Fig. 19

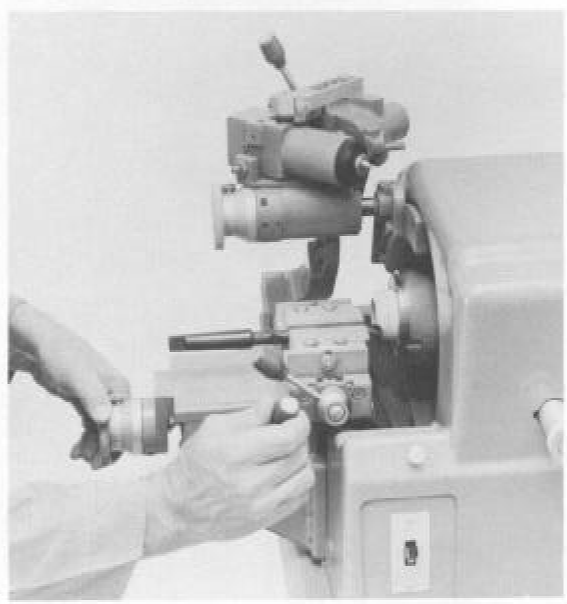


Fig. 21

4. The Spiropoint is equipped with an adjustable truing device for the grinding wheel so that the point angle of the drill may readily be varied from about 90° to 180°. Figure 22 shows the truing device swiveled to its truing position. Figure 23 shows it in its retracted position. Wheel gyration is stopped at a positive location for truing by operation of a control knob on the side of the unit.

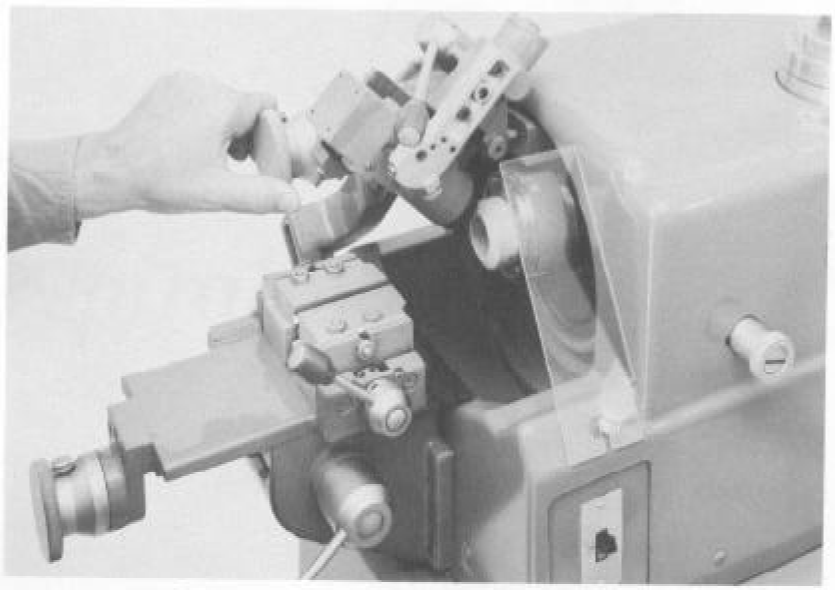


Fig. 22

5. The Spiropoint is a portable type unit supplied with cord plug-in connections for single phase electrical operation. It is mounted on casters and is equipped with screwjacks to provide leveling on uneven floors. The Spiropoint contains an individually motor driven dust collector and air coolant system which is conveniently located in the cabinet base.

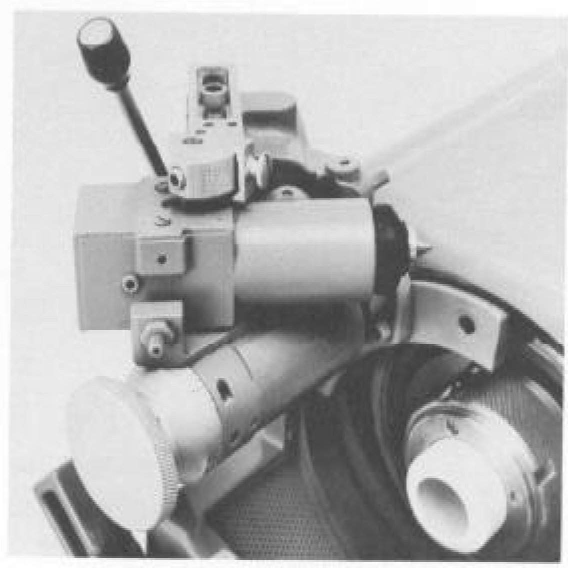


Fig. 23