

1957

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Recommended Citation

Ordway Hilton, Characteristics of the Ball Point Pen and Its Influence on Handwriting Identification, 47 J. Crim. L. Criminology & Police Sci. 606 (1956-1957)

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CHARACTERISTICS OF THE BALL POINT PEN AND ITS INFLUENCE ON HANDWRITING IDENTIFICATION

ORDWAY HILTON

The author, an examiner of questioned documents and Police Science Editor of this Journal, has made an extensive study of the ball point pen. His first research was undertaken in 1947 when he undertook an extensive survey and study of this writing instrument for the annual meeting of the American Society of Questioned Document Examiners. In 1948 as co-author with Elbridge W. Stein he published an early article on the ball point pen in the *American Bar Association Journal*. Mr. Hilton is the author of the *Scientific Examination of Questioned Documents* (Callaghan and Company, 1956), a Fellow in the American Academy of Forensic Sciences, and a Designated Member of its Executive Committee, and the author of a number of articles which have appeared in this and other technical journals.—MANAGING EDITOR.

Over ten years have elapsed since the ball point pen was first introduced in quantity to the American writing public. Publicity coupled with certain desirable features of the pen has led to its acceptance as another class of writing instrument. Where in 1945 many pens were purchased because it was something new, today pens are used because many writers like the convenience of a large supply of ink or the particular feel of the pen as it writes. Yet despite its widespread use very little has been written on its influence on handwriting identification.

HISTORICAL DATA

Before looking at the writing qualities and peculiarities of the ball point pen, let us review briefly its history. Like so many successful Americans, the ball point pen is a "naturalized citizen." Its origin is Europe, and it came to the United States by way of South America.¹ Relatively few pens were manufactured in Europe prior to 1940, and these were not well accepted by the writing public. In the early 1940's Biro moved to Argentina and set up manufacturing of his ball point pens. Apparently, it was 1944 before any quantity of the pens had been sold, and this number was limited compared to early sales in this country. Thus, it was near the end of World War II when the first pens were brought to the United States by traveling citizens. Stimulated in part by the military's desire to obtain a writing instrument that would function well at high altitudes, several domestic pen companies started investigating the ball point pen.

It was Reynolds who realized the potentialities of this writing instrument and the available market of a public craving new and different products, good or bad, to substitute for the rationing of the war economy. Amid great publicity and fanfare

¹ Two excellent sources of early historical data regarding the ball point pen are to be found in *Fortune*, July 1946, p. 144, and in the *Readers Digest*, December 1946, p. 60.

Thomas Whiteside in the *New Yorker*, Feb. 17, 1951, wrote a most readable article, "Where Are They Now? The Amphibian Pen." This article not only reviewed the early history of the pen but described the almost fantastic sales promotion and exaggerated claims of the first pens and brought the commercial history of the ball point pen up to the date of writing.

in the last days of October, 1945, the first pens were sold in New York City at \$12.50 each. They were a poor writing instrument, many of them failing to write at all. The next two years saw fantastic marketing claims and a huge volume of sales with a steady lowering of prices until by the summer of 1948, 25¢ and 50¢ pens were common.

Today there are numerous ball point pen manufacturers. Some of the larger, established companies have carried out extensive research, and for the most part the pen is a much better writing instrument than those sold during the first two years. Prices range from about 25 cents to several dollars, but even today there is no definite assurance that the more expensive pens are going to write with absolute satisfaction.²

HOW THE PEN WRITES

The ball point pen simply rolls ink onto the paper by means of a small ball bearing. ~~Despite the fact~~ that several earlier papers have dealt with the mechanical operations of the ball point pen, it is necessary to look briefly at the construction and operation so that the inherent peculiarities of its writing qualities will be better understood.³

The ball bearing is held in place at the tip of the pen by means of a housing which is crimped over the widest portion of the ball. Thus, a little less than one-half of the ball is exposed at any one time. Within the housing the ink supply is packed around the ball. With this construction the ball is free to rotate in any direction. As it moves through the ink chamber a thin film of ink adheres to its surface; as it rolls across the paper the ink is pressed onto the paper surface.

The ink is a viscose paste-like material, not the usual fluid writing ink of the conventional fountain pen or the old-fashioned dip pen. Detailed consideration of the composition of these inks has been discussed by others and are unnecessary in our study.⁴ It is only necessary to know that the ink is pressed on the paper rather than

² Two reports by consumer rating publications show the comparative worth of ball point pens in 1954. They are, "Ball Point Pens," *Consumer Reports*, Sept. 1954, pp. 412-414, and "Ball Point Pens," *Consumer Research Bulletin*, Nov. 1954, pp. 17-21. The latter advises that each customer personally test a pen before buying it.

³ A very simple and clearly illustrated article on how the ball point pen operates appeared in *Science Illustrated*, August, 1946, titled "Points on Pens", pp. 44-45.

A more detailed discussion appeared in the *American Bar Association Journal*, vol. 34, May 1948, pp. 376-8, in an article, "Behavior of Ball Point Pens and Inks as Seen by a Principal Manufacturer." The authors, C. H. Lindsly and Robert S. Casey, are research specialists with the W. A. Shaeffer Pen Company, Fort Madison, Iowa.

Other data will be found in an accompanying article in the same journal by Elbridge W. Stein and Ordway Hilton, "Questions Raised by Examiners of Signatures and Documents," pp. 373-6, while a recent publication of Wilmer Souder, "Composition, Properties, and Behavior of Ball Pens and Inks" appeared in the *Journal of Criminal Law, Criminology, and Police Science*, vol. 45 (March-April 1955), pp. 743-7.

⁴ A discussion of the early inks used in ball point pens appeared in the articles by Stein and Hilton and by Lindsly and Casey cited in note 3. Souder discusses these inks in present-day pens in his article cited in the same note. Also see, "Ball Pens and Expert Appraisal of Written Documents" by Jacques Mathyer, *International Criminal Police Review*, Dec. 1950, and for testing techniques in identifying these inks, Charlotte Brown and Paul L. Kirk, "Horizontal Paper Chromotography in the Identification of Ball Point Pen Inks," *Journal of Criminal Law, Criminology, and Police Science*, vol. 45 (Sept-Oct. 1954), pp. 334-9.

flowed on and that once on the paper there is a gradual penetration of the fibres due to the sluggish flow of the viscose ink.

Let us examine more closely the action of the ball as it rolls across the paper. After it is charged with the ink, it remains charged until it contacts the paper surface. Once discharged the ball area must again pass through the ink chamber to pick up more ink. The change in the direction of the pen means a change in the direction of the rotation of the ball. If there is no ink on the particular area of the ball when it touches the paper, no ink can be deposited, and a skip or break occurs in the stroke. If there is an unduly large quantity of ink on a portion of the ball, a heavy deposit, a dark spot or blob, is left. Normally, the thickness of the ink layer on the ball is measured in units of a few microns.⁵

IDENTIFYING ITS WORK

In order to determine the ball point pen's influence in a handwriting identification problem, it is necessary to be able to recognize every specimen written with this writing instrument. This is possible because of the quality of ink used in the pen and also because of the way it is applied to the paper. Ball point pen inks are not water soluble or at least have a very low solubility in water. Thus, the simple application of a drop of distilled or slightly acidified water to the ink stroke distinguishes it from fluid, synthetic dye inks of a comparable color, which are readily soluble. Most ball point pen inks are blue or purple, some few green and red, and only occasionally black. Certainly this test combined with microscopic study leaves no doubt as to whether the writing is with a ball point pen.

The rolling of the ball across the paper tends to leave a small track or depression in the center of the line. Only a very hard writing surface completely eliminates it in the heavy downstrokes. This characteristic groove or depression of microscopic dimensions further distinguishes ball point pen writing. Examination with a low power microscope and side lighting reveals the indentation.

Microscopic examination of the pen stroke and particularly the weaker portions discloses a characteristic aspect of ball point pen writing. The ink does not flow into the fibres but only stains the raised portions of them (figure 1). Even in the heavier strokes there is a tendency for the top fibres to be more deeply stained. Thus, the matted surface of the paper is clearly visible and often slightly intensified. These conditions are not encountered with fluid inks. In some ways the ball pen inks adhere to the matted paper surface in a manner similar to pencil writing.

Occasionally, with a heavy stroke which has been on the paper for several days or more there is a slight halo effect along its edge where some of the ink has migrated out. This migrating quality of ball point pen inks cause in some instances a pronounced penetration even with good quality paper. Either condition, a halo or penetration, is a very important indication of ball point pen writing.

Typical Defects of Strokes. The qualities just discussed might be classified as defects in the ball point pen stroke, but more objectionable and highly characteristic are the short microscopic skipings and the heavy spots or blobs of ink found along the lines. Both defects were very common in the early pens, but today still occur to some extent even with pens of the best manufacturers.

⁵ Measurements of thickness of the ink film between one quarter and five microns is reported by Souder in the article cited in note 3.



Figure 1

These characteristics, matted strokes are caused by the ball point pen ink rubbing off on the top and upper front edges of the paper fibers. Because of the limited flow the ink does not penetrate into the fiber crevices except with very heavy deposits. Note the ink blob or dark spot at the top of the loop (arrow), a "trademark" of many ball pens.



Figure 2

Skipping and irregular ink deposits are common to many ball pens. The arrow at the base of the "a" indicates a typical skip suggesting an interruption. The ball track is continuous in this area, however.

The skipping is simply due to the fact that in the course of writing certain letters a portion of the ball contacts the paper twice without reinking. It is also conceivable that these breaks might be caused by the housing scraping off a small portion of the ink from the surface of the ball as it leaves the ink chamber. This mechanical action, however, is more likely reflected in the split stroke suggesting nib tracks, a defect which will be considered more in detail below. In any event, from time to time perfectly continuous writing shows apparent interruptions or breaks in the line (figure 2). Examination of the stroke under the binocular microscope, particularly with side lighting, should reveal that the pen moved continuously in this area but merely failed to mark.

The other common defect is the dark spot or ink blob caused by an usually heavy deposit of ink in the course of writing. Such a deposit is most apt to be found after an abrupt turn (figure 1). With all pens there is a tendency for ink to accumulate around the outside edge of the housing, and it would appear that a certain portion of this unused ink is pulled away from the housing with a sharp change in direction of ball rotation and deposited on the paper. Regardless of the cause, the presence of these small dark deposits in the writing stroke is a further indication of a ball point pen writing.

With the more defective pens, and particularly when there is an accumulation of ink around the housing, dark blots and streaks of ink will be found adjacent to the stroke (figure 3). This ink has undoubtedly rubbed off the housing, possibly due to position in which the pen is held, and while the writing appears defective and suggests tampering, it may only be due to the poor writing quality of the pen. This defect can be reduced by periodic wiping of the tip.

The ball point pen has no nibs, just the single rotating ball. Thus, it would seem that any writing which displays nib tracks—that is two parallel ink strokes with a slight gap or light area between—must have been written with a nib pen, either a conventional fountain pen or a steel pen. Such is not always the case. Some defective



Figure 3

The inner, broken stroke was caused by ink rubbing off the housing of the ball, a defect encountered with some pens.



Figure 4

The apparent nib track in a ball pen stroke occurs in this case in an upstroke rather than on a downstroke as it would with a nib pen held in the usual position. Note that the light "track" starts near the left edge and finally slides off on the right near the top of the stroke, an impossible situation with a nib pen.

ball point pens seem to contain "nib tracks" where only the edges of the stroke are inked, and the central area is without color (figure 4). Careful examination of these strokes under the microscope will reveal the central depressed ball track and also the characteristic qualities of the ball point pen ink. Sometimes the central white area wanders off the edge of the stroke interrupting one "nib track," a condition never encountered with a nib pen. Furthermore, most pens which contain this "phantom nib track" quality likewise reveal frequent ink blobs and skips leaving no question as to what class of pen was used.

Every handwriting examiner should make a careful study of ball point pen writing in order to learn to recognize it with certainty. Its recognition is essential to accurate handwriting identification.

ITS INFLUENCE ON HANDWRITING

The non-flexible quality of the ball point should produce a handwriting entirely devoid of shading or evidence of pen emphasis. This is not entirely the case. Granted, the pen does give a more uniform width line, but some writers can nevertheless produce handwriting with a ball point pen which reveals clearly differences in writing pressure. Shading with a ball point pen is effected in the same way as with a pencil. The very light strokes are a narrow line; the heavier strokes, a wider, more fully inked line (figure 5). The light ball pen strokes, generally upstrokes, have a further distinctive quality in which the groove of the ball may be lost and in which the ink adheres only to the upper surfaces of the paper fibers and is not found in the deeper, microscopic hollows between fibers.

Nevertheless, there is a tendency to lose evidence of shading and pen emphasis in ball point pen writing and for the writing to be made up of strokes of uniform intensity. This is an important consideration, for if the known writing had been prepared with a flexible nib pen and contains subtle shading, the lack of shading in a disputed ball point pen signature may well be due to the writing instrument.

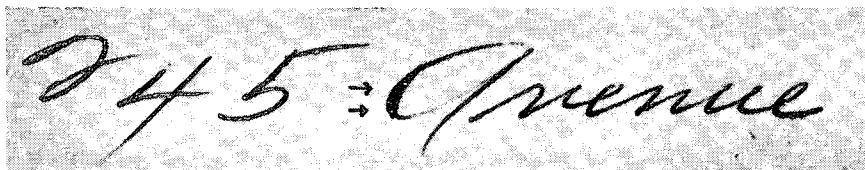


Figure 5

Shading with a ball pen is brought about by variation in pressure producing light, narrow to dark, slightly wider strokes. The heavy shading in the "A" (arrows) was added by a second stroke.

The detection of pen lifts and interruptions in the writing requires some re-evaluation. Pen lifts, where the ball pen is accurately replaced to resume the writing may defy detection although if a fountain pen had been handled with the same degree of accuracy, there might be evidence of the fact. In the latter case the ink is apt to accumulate at the joining, but with a ball point pen there is no such accumulation, because of the paste-like quality of the ink, or if there is, it would be extremely difficult to distinguish from a defective "line blob." Actually, it is the exceptional case where the joining is perfect. Careful examination with a low powered binocular microscope, and especially with side lighting, is necessary to determine whether the ball track is continuous (figure 6). Remember, a break in the stroke may be due only to the skipping of the pen, but a sudden interruption in the ball groove is a clear cut indication that the pen was lifted. So are two microscopic ends of a stroke not completely joined, or a double track of the ball running side by side for a short distance. These are the criteria which disclose pen lifts and careful splicings.

Hesitations in the writing movement takes on particular significance when there is suspicion of forgery. Here again the ball point pen fails to leave the classical indications found with writing from a nib pen and fluid ink—heavier ink accumulations at points of hesitation. When a ball point pen moves rapidly or when it moves slowly over the paper, the same amount of ink is deposited. This amount depends only upon the quantity which adheres to the surface of the ball and how heavily it is pressed onto the paper. It is not significantly influenced by the speed of rotation of the ball. If the movement is stopped while in contact with the paper, no additional ink runs out such as occurs with a nib pen with which there is a continuous flow onto the paper leading to unduly heavy deposits at points of hesitation. Of course, if



Figure 6

A portion of a forged will signature displays badly executed, patched up writing. Note the two short ball tracks on the left side of the "k"; the ending strokes, two in the "P", three in the "t-crossing"; and the projecting strokes at the top of the "k" and "c". Not only is the signature filled with faults, but the will was dated in 1940, five years before the introduction of these pens in this country.

rapid writing is accompanied by lighter pressure on the pen, which is often the case, the free, light strokes would be revealed in the lighter, finer lines, and this condition is never found in a slow, hesitant, plodding writing.

Study of fraudulent signatures written with a ball pen do reveal that hesitations and stops may be reflected in the written stroke. This is particularly true when one is imitating another person's signature. The pause at the end of a down stroke, for example, may be accompanied by an unconscious increase in pressure, causing a small circular depression at the base of the stroke. This is not found in natural, free writing, especially with a skillful writer, and these "hesitation holes" are clear cut evidence of a pen stop.

A slow, hesitant stroke, whether written with a nib pen or pencil, often is accompanied by a wavering uncertainty, particularly when there has been careful imitating. Since the ball pen accurately records its course, this same wavering may occur in a forgery prepared with a ball point pen.

Here are the key characteristics of ball point pen writing and their relationship to the identification problem. With this class of writing unusually heavy blobs or deposits in the ink stroke are not indications of stops and hesitations or line splicing. Normally, they are merely defects typical of the ball point pen. Small microscopic breaks in the stroke likewise may not be indications of interruptions in the writing movement, of a lifting and replacing of the pen but should always be examined minutely to determine whether the groove of the ball continues through this area where there is no ink. If it did, then here again is a typical defect in the ball point pen. In fact, careful tracing and study of the ball track frequently is a controlling factor in establishing facts about the continuity of these writings. In this way pen lifts and hesitations can be discovered. If these modifications are employed in conjunction with the usual criteria of genuineness or forgery, correct conclusion should be reached.

BALL POINT PENCILS

Late in January, 1955, Scripto introduced the first ball point pencil. The marking substance is known as fluid lead, and the stroke can be erased in much the same way that ordinary pencil writing can. Following shortly after the introduction of this writing instrument the Parker Pen Company started marketing a similar product.

Specimens of writing from these ball point pencils reveal exactly the same quality of writing stroke as the ball point pen. The principal defects of skipping, of heavy deposits of graphite, and of split strokes are common to these writing instruments. It is by means of these defects and sometimes the heavy ball groove when the writing was prepared on a soft backing that one is able to recognize the work of these writing instruments.

The influence which the ball point pencil has on handwriting is similar to that of the ball point pen. Consequently, further discussion of this class of writing instrument is unnecessary.

BALL PENS WITH LIQUID INK

It has recently come to the attention of this writer that a German-made ball point pen is being marketed in this country which writes with ordinary fluid ink. It writes

in exactly the same manner as an ordinary ball point pen, by rolling the ink on the paper.

The quality of stroke obtained from this writing instrument differs somewhat from that of an ordinary ball point pen filled with the thicker, viscous ink. For one thing the fluid ink penetrates the paper fibers just as it does when used in an ordinary fountain pen. Furthermore, the defects of heavy line blobs or deposits do not occur with fluid ink although occasional short microscopic skips do. Failure to write at the start of strokes is common. It would appear, however, that because of the ink's tendency to flow dry spots on the ball surface are at least partially reinked by the ink's spreading.

When used against a soft backing, the ball leaves a very pronounced central channel or depression. This is eliminated completely when the writing is done on a hard backing such as a desk top. When present the back of the sheet reveals the indentations clearly. Flowbacks seem to occur at the end of many strokes, and naturally, the writing contains no traces of any nib tracks. The defect of a split stroke or phantom nib track fails to occur. The edges of the stroke are not sharply defined, but are irregular and serrated, a condition sometimes found with fountain pen writing as well. Thus, under some conditions it becomes extremely difficult to recognize the work of these pens readily. There is some question as to whether one could say with absolute certainty that an unknown specimen of writing was prepared with a fluid ink ball point pen unless the ball track was prominent and continuous.

The width of the writing stroke is influenced by the backing, the softer backing giving the wider stroke. Occasionally, the pen writes a wider stroke when first starting than it does subsequently, but this may be a defect of the particular pen tested. The ink reacts on the paper in much the same way as it does with an ordinary fountain pen except that it does not run out onto the paper when the point is held stationary. Thus, splicings of lines may show up in the traditional manner, but stops within strokes, as in traced forgeries, are not as readily detected.

Like the ordinary ball point pen shading is only brought about by a variation in pressure on the paper, and not by any spreading of the nibs. Shaded strokes can be produced with this pen despite the fact that theoretically it should write a uniform stroke. In some ways the pen writes much like the old fashioned stylographic pen.

It is rather early to determine whether this kind of ball pen is merely another fad in the ball point pen history or whether it will grow in popularity and figure more prominently in handwriting identification problems.

SUMMARY

The American writing public has accepted the ball point pen as another class of writing instrument. Because of the peculiarities of its construction and of the ink used in it, it has a highly distinctive stroke. It likewise has brought about some modification in the interpretation of details in the ink stroke. These modifications must be thoroughly understood and must be applied in every identification problem in which they come into play. If they are neglected, errors may occur. If, however, they are recognized and considered, identification of the handwriting will be accurate and complete.