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A New Serial Number Marking System Applicable to Firearms Identification

The serial numbers of stolen or misused items are sometimes removed to prevent their identification [*1*]. Since these serial numbers are generally recorded on metal items by being stamped into the metal, the marking is only present on the surface and can be readily removed by filing or grinding. Such removal of the number generally does not affect the usefulness of the item, since the number is usually stamped in a noncritical region of the outer surface.

A more desirable encoding system would record an identifying number which could not be readily removed. The marking effect would extend into the item, rather than being associated only with a surface. For particular situations, the number would be located in a region where its removal would destroy the usefulness of the item.

This note reports on the development of a marking system meeting the above criteria.

Proposed Marking System

It is proposed that the serial number be represented by a group of small holes extending well into the item. An encoding procedure would provide a one-to-one relationship between the relative placement of the holes and the serial number. Different encoding systems using arrangements of holes can be envisioned. The holes could be concentrated in a very small area, arranged in a long line, or spread over a large region of the item.

In each case the holes would need to be small enough so as to not affect the function or structural integrity of the item. In many cases, very small holes on the order of several thousandths of an inch in diameter would be desirable. Such holes can be produced within a second by using a high-powered laser [*2,3*]. Small holes with a depth to diameter ratio of 50 can be formed using laser drilling; for example, a hole with a maximum diameter of 0.005 in. and a depth of ¼ in. can be produced [*4*].

As a specific example of such possible encoding systems, consider the grid shown in Fig. 1. A ten-digit number can be represented by drilling a hole at the appropriate position in each of the tem columns. The uppermost point in each column would represent a 1, the next a 2, etc., as in well-known punch card codes. Thus, ten holes can distinguish 10^{10}, or ten billion, items. In each case the number of digits in the serial number determines the number of columns in the grid. Alternatively, some digits could

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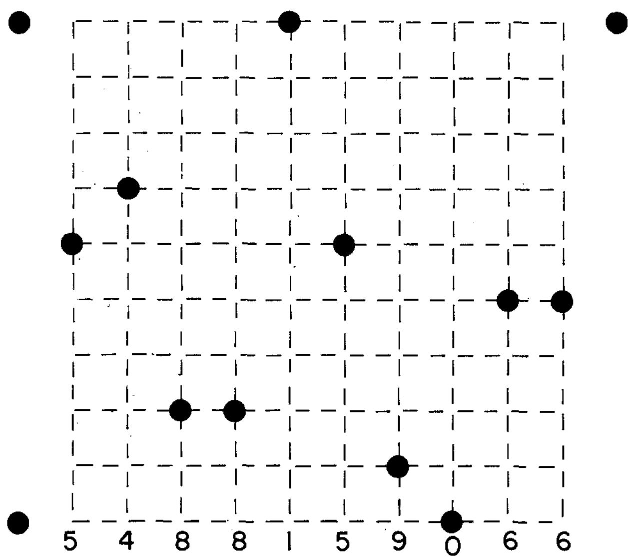

FIG. 1—*Example of a possible encoding system for the hole-grid identification procedure. The three holes flanking the 10 by 10 grid define the grid, while the ten holes superimposed on the grid record the number 5488159066.*

be used to record additional information, such as a model number. The encoding system could be generalized to allow the use of letters as well as numbers.

The number 5488159066 is represented by the holes shown in Fig. 1. The grid itself would not be present on a marked item. The three holes shown flanking the 10 by 10 grid are reference holes which would be drilled in each case to define and locate the grid. They would also define a distorted grid to be used in reading out the hole positions if they are viewed on an intersecting surface which is not perpendicular to the holes, or if a perpendicular surface is viewed from an angle.

Figure 2 displays photographs from an AMR 1000 scanning electron microscope of the entry (Fig. 2*a*) and exit (Fig. 2*b*) surfaces of a $\frac{1}{8}$-in. thick piece of steel, in which the pattern shown in Fig. 1 has been formed by laser-drilled holes. (The exit pattern is a mirror image of the entry pattern, since the laser beam travels in a straight line.)

The holes were produced at the Raytheon Co.'s Laser Advanced Development Center, Waltham, Mass., using their Model SS 347 laser driller. The holes were formed by intense pulses of light from the laser which are focused to a very narrow beam, so as to boil off the material which it strikes. The holes have a conical shape, the diameter of which is 0.009 in. at the entry surface and 0.004 in. at the exit surface. For this sample the grid points are 0.010 in. apart, so that the entire pattern is recorded within a square surface area approximately $\frac{1}{8}$ by $\frac{1}{8}$ in. Smaller holes could be spaced more closely, thus making the overall size less.

A low magnification optical microscope is totally suitable for reading the pattern. This is demonstrated in Fig. 3, where the pattern representing 5383158068 has been drilled. The surface was abraded lightly with 400-grit paper to facilitate reading by removing the splashed metal visible in Fig. 2*a*. The digit 2 of the $\frac{1}{8}$-in. size commonly used for serial numbers has been stamped onto the sample and included in Fig. 3 for comparison. Figure 4 shows a different encoding system. Here each digit is represented by one

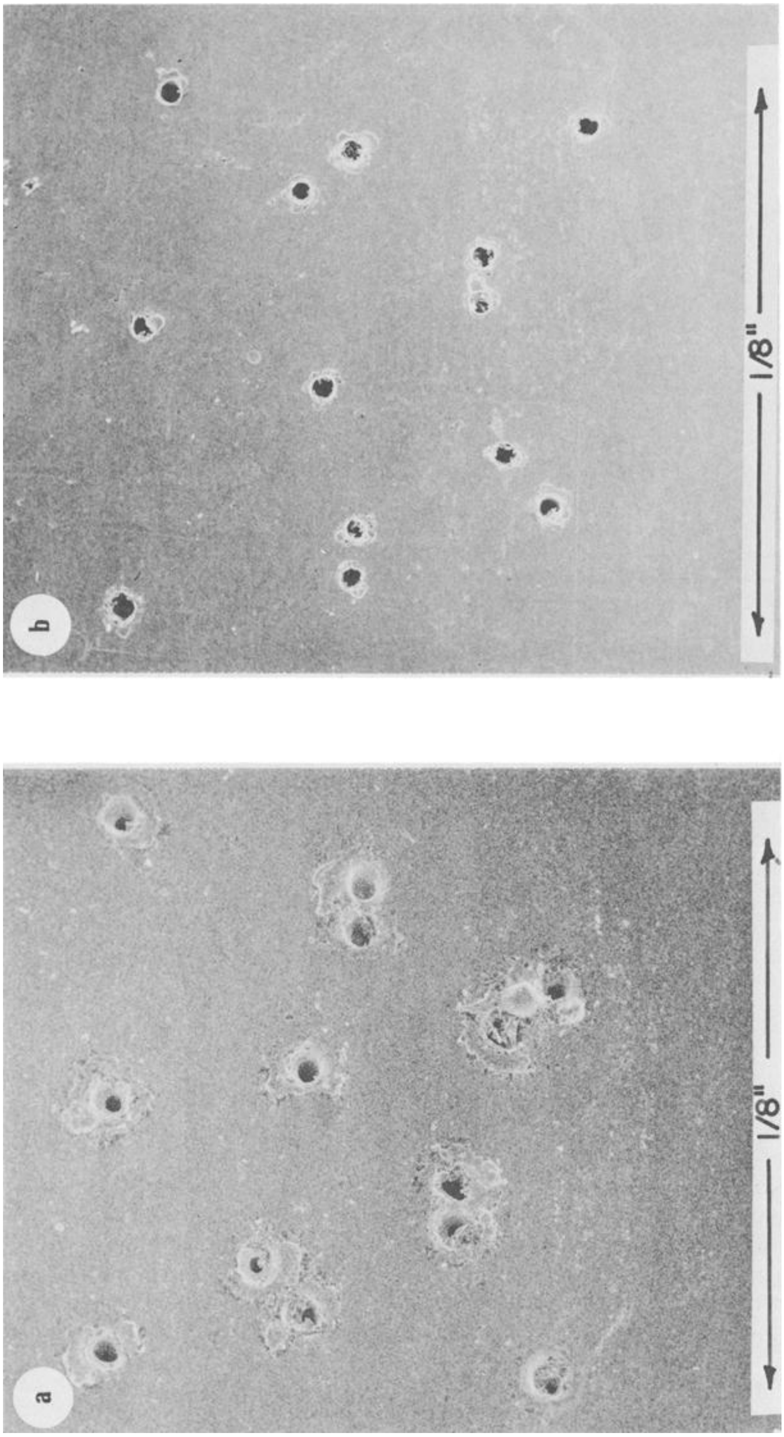

FIG. 2—(a) *An array of laser-drilled holes having the pattern of Fig. 1 in a ⅛-in.-thick piece of steel. This scanning electron microscope photograph highlights the debris in the vicinity of each hole produced by the hole-forming process.* (b) *The back side of the sample shown in Fig. 2a. The pattern is preserved as a mirror image of that on the entry surface.*

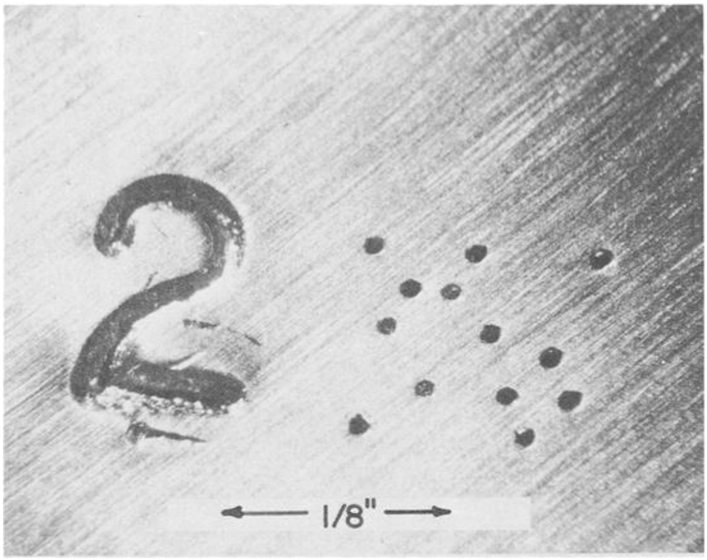

FIG. 3—*An optical photograph of a pattern representing 5383158068 using the code of Fig. 1. The 1/8-in. digit, a size frequently used to record serial numbers, is shown for comparison.*

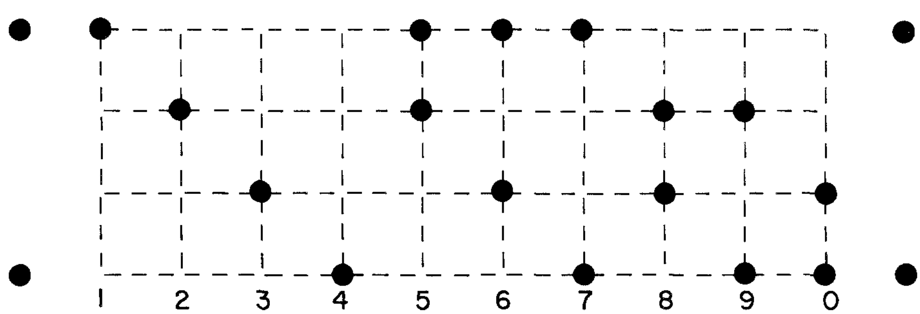

FIG. 4—*An example of an encoding system which would be well suited to direct optical interpretation.*

or two holes in a column having four potential hole sites. As before, reference holes are drilled. While the system of Fig. 1 requires 1 hole per digit, this system requires, on the average, 1.6. However, since there are only four possible positions in each column, one could recognize each number without having to superimpose a grid on a photograph. Such a system with somewhat larger holes than discussed above could be used to record numbers which could be read by the unaided eye.

Alternatively, laser drilling could be used to record regular arabic digits by stylizing the numbers in such a way that from two to seven holes would form a recognizable pattern representing each digit. On the average, five holes would be required for each digit.

Discussion

Ideally, the identifying holes would be located in a critical area of an item so as to make it impossible to remove the number without destroying the usefulness of the item. Such an approach, using the miniaturized marking exemplified by Fig. 2, is ideally suited to marking small mechanical items such as firearms, especially handguns. We will be doing additional testing to further evaluate its potential in this area. Variations on the procedure could be adapted to items such as motor vehicles.

Items without critical areas might best be marked with a system which spreads the holes over a large part of the surface. In other cases, a part which becomes inaccessible after permanent assembly could be marked.

An attempt to conceal the location of the holes may be all that is possible in some situations. Unlike stamped numbers, small laser-drilled holes need not be readily visible to the unaided eye. Light surface grinding could make them fully invisible. Other surface treatments, such as painting, can be used to conceal the location of the pattern or the holes could be filled with a material of different composition. When such concealment techniques are used, the array could be observed after metallurgical polishing of the area.

Another advantage of the laser drilling system is that an identifying mark could not be readily forged or duplicated, since few people would have access to the necessary highly specialized laser apparatus and mechanical drilling of such fine holes is not possible. Additionally, the characteristics and shape of laser-drilled holes are different from holes formed by electrodischarge machining, for example. Laser drilling could also be used for tagging items other than by serial number identification. For example, a very valuable item, such as a collectible coin, could be identified by putting one hole into it and taking a magnified photo of that region; if stolen, the coin would be distinguishable from all other "identical" coins and could not be traded.

Whether for property identification or for other purposes, this marking system would be especially useful when normal labeling is difficult. Very small items or items with irregular or rough surfaces could be marked, as well as very hard or very brittle items not easily inscribed otherwise.

For ease of normal handling and processing, most items numbered by means of the new miniaturized hole-grid system would also be marked in a conventional way such that the serial number could be read by the unaided eye. The drilled number would be read if the other was removed or of doubtful authenticity. A photograph of the array would be taken and the number determined either directly for the array in Fig. 4, or by superimposing the grid defined by the reference holes onto the photograph for arrays such as those shown in Figs. 1 through 3.

The procedure is easily adaptable to automation during manufacture or can be used to mark any individual item after manufacture. The production of holes for a hole-grid identification system using laser drilling is commercially feasible. The item to be drilled would be translated automatically to each position where a hole is required. With the power output of presently commercially available lasers, each hole would be drilled in less than a second. Thus, items could be processed at a rate of approximately 120 per hour. For a laser drilling apparatus in regular use, the cost of marking would be \$0.05 per item for machine operation and depreciation (over six years), plus the cost of an operator and overhead for ½ minute.

Summary

A new system for physically recording serial numbers on individual items is proposed. Each serial number is converted to a unique array of points, and this array is recorded

on the item by drilling a set of holes having the arrangement of the array into the item. Laser drilling can be used to produce holes of small diameter for the array. The identifying marks extend into the item and cannot be as readily removed as surface stampings. In some cases the serial number can be marked in a critical area, so that its removal would destroy the usefulness of the item. This system is particularly suitable for the marking of firearms.

Acknowledgments

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