PROTECTION OF THE DIGITAL INFORMATION IN PAPER DOCUMENTS

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(Received 27 June 2008)

Abstract

The electrodigit technology on formation of an individual matrix that makes it possible to build a database in a new mode by combining the digital and wave approaches is proposed. It is shown that the electrodigit identification having all attributes of quantum identification basically is not the subject of counterfeiting and can be used as protective technology for the document production of the strictest reporting including the national money currency.

Introduction

Here is some short excursus into the history of physical experiment resulted in the origin of quantum mechanics. It was Thomas Yung who observed the interference of light in two slits. C.D. Davison and L.H. Dgermer (and independently D.P. Thomson) viewed the diffraction of electrons on nickel single crystals (later on these scientists got Nobel prize in 1937 for these investigations). The nature of the observed periodic peaks was similar to the character of peaks in the two-slit experiment.

Such tests were iteratively repeated, hypotheses on interaction of electrons were sifted when electrons were "piecemeal" emitted with time interval of 30 minutes but the result remained the same; namely, there appeared the interferential pattern.

Physicists began to carry out experiments with larger particles. In 2003 there was conducted a classic two-slit experiment [1] and obtained the interferential pattern on the simultaneous passage through two slits of a very big (to quantum measures) molecule of tetraphenylporphyrin. What is the principal distinction of our experiment from previous ones? At first glance there are no "slits". There is usual air under normal conditions between the source of electrons and the target. But there are always some fluctuations of electric conductivity (tiny airborne particles, ionized zones of space radiation, nonuniformities of temperature and moisture, etc.) acting as "slits" in the test. Electron clusters (electron avalanches consisting of the infinite number of electrons) are analyzed instead of single electrons. And we obtain an interferential pattern again.

Having estimated energy of the separate discharge in 0,025 - 0,03 Dj, time of the discharge in 10^{-3} with, a current of the discharge in 10^{-3} A and knowing a charge of electron ($1{,}6 \cdot 10^{-19}$ Cl), is easy to estimate number of electrons in an avalanche. It is roughly appreciated in 10^{12} of electron.

We are not going to state that the electric discharge, hitting into a target particular section (recorded with the aid of various equipment), behaves as a quantum particle but we can suppose that the preconduction streamer (impossible to be registered experimentally) generates according to wave principles; namely, this fact ensures the interferential pattern on the

matrix. The streamer as though participates in the primary location of those "slits" through which the discharge will pass. The wave nature of processes taking place at streamer discharge is noted by many authors [2-3]. The discharge itself develops along the trajectory formed previously by a streamer and behaves as a classic solid.

For state coherence demolition and interferential pattern disappearance only the presence of information on which "slit" the streamer passed through is important. If there is no such data (or we have no such information) the interferential pattern will always arise on the target irrespective of whether a single electron flies and hits the target during 30 minutes or hundreds of millions electrons do the same simultaneously as an electron avalanche. In other words, interferential pattern can appear both in the study of microcosm phenomena (motions of a single electron through two "slits") and in the investigation of macrocosm phenomena (motions of an electron avalanche through many "slits", that was shown by the example of electrodischarge identification technology).

Experiment

Nonreproductivity (individuality) of a matrix obtained by means of electric discharges is examined in this work. The conduction scheme of the experiment is extraordinary simple. Small holes are pierced in paper by the electrodischarge method. Then the obtained specimens are scanned through the openings by an ordinary scanner with resolution 600 dpi and are kept in the JPG format. The pictures are read with computer, and there is calculated the relative area of the pierced holes on the ring with the matched diameter (see mathematical treatment of the obtained results). The outcome is presented in the form of area versus ring number diagram.

Primary experiments carried out on the scheme with positive point and negative plane and vice versa show that utilization of the high direct voltage source is not optimum to get an individual pattern in paper probably owing to the accumulation of charges on the dielectric glass. Therefore, the whole following information concerns the source with high alternating voltage. The results obtained with the help of sphere-plane electrodes are not optimum as well (the number of pierced holes in the paper is many times less than the number of discharges; in other words, a discharge often follows the path of the previous discharge and does not cause the individual matrix complexification). The best results have been obtained by means of point-plane electrodes. The majority of experimental works in this sphere [4] describe the peculiarities of physical processes in the interelectrode space; information abilities of these technologies have not attracted sufficient attention of the investigators.

Interelectrode space being small (point-to-plane distance is 5 mm) the number of electrodischarge spots does not exceed 20-25. The quantity of discharges is about 4000 recorded with the aid of an oscillograph. This discordance is attributable to the fact that a discharge often hits a hole made by previous discharges. Identification mark treatment time is maintained constant and is about sixty seconds. Interelectrode space increasing up to 7.5 mm the number of electrodischarge spots in the paper rises sharply. Figure 1 presents a typical individual picture (without a numeric code) for gap 10 mm; it is seen that not only the picture as a whole is unique, but every spot as well.

Mathematical treatment of the obtained results

To treat the obtained patterns there has been written a program performing the following operations to imitate the classic experiment with the aim to verify Maxwell distributions.

Search for the distribution center of holes in order to correct the specimen inaccurate centration at the breakdown in the device is carried out according to the following algorithm:

a) at first the image projection on the X and Y axes is calculated;

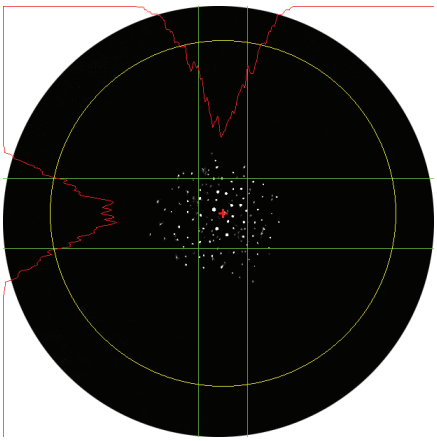

Fig. 1. Algorithm for mass center search.

b) the point whose coordinates are central values of the width interval in the maximum half on each axis is taken as a center.

Figure 1 shows that the physical center (needle electrode is mounted over it) differs from geometrical one but the estimation of the needle electrode position error with respect to the target geometrical center does not go beyond the circle with a diameter of 1.5 mm allowing us to state that tip effects are minimum.

The pattern is separated into the mentioned number of rings in regard to the found center.

The relative area of holes on the ring with the given radius is calculated (now we take into account not the spot as a unit but its contribution to the total area of the relevant ring spots).

The results are output into a file for further manipulations.

The curves plotted for the obtained data are presented in next figures. Every curve shows the result got on a new target, the electrode gap being the same.

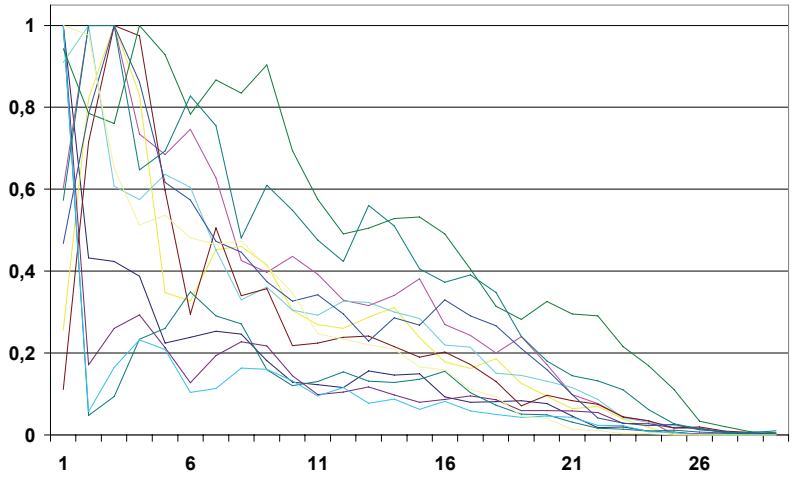

Fig. 2. Hole density distribution with a gap of 10 mm.

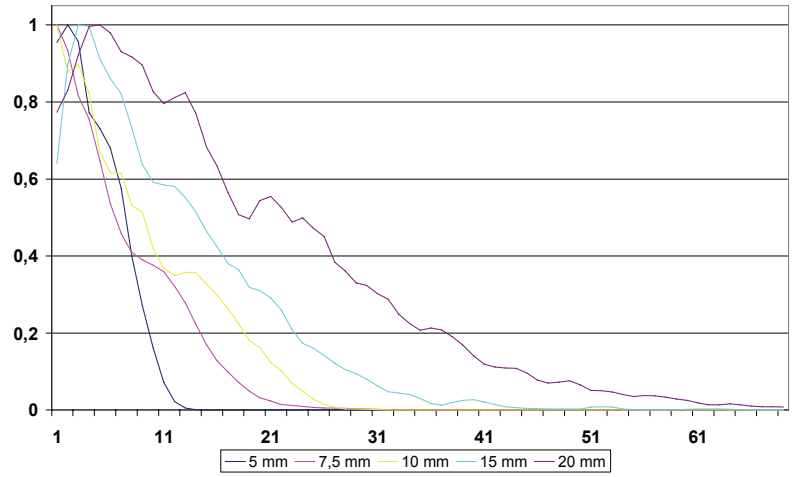

Fig. 3. The average distribution of hole density at different gaps.

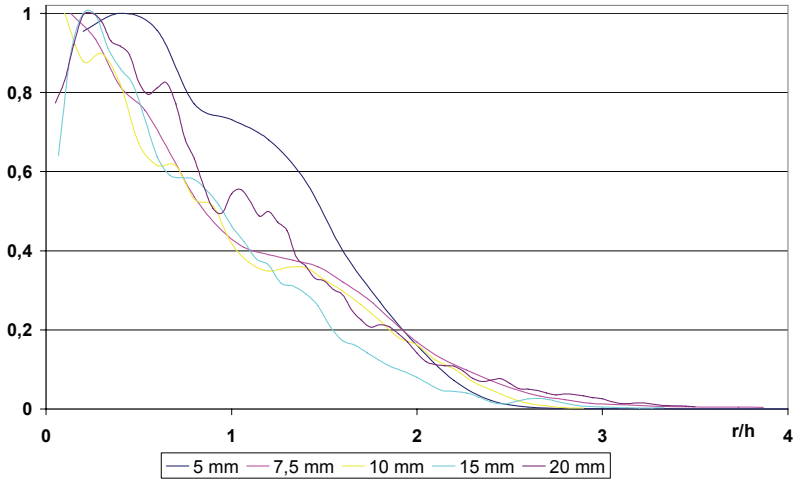

Fig. 4. The average distribution of hole density at different gaps. Along the X axis the ring radius is normalized in accordance with interelectrode space value.

To facilitate scanning of the electric breakdown places, a black circle is printed on the paper. Inside this circle (hypothetically the document of the strictest report being created), the individual numeric code is also drawn. This individual numeric code being absent it is impossible to build the database because of the insuperable mathematical obstacles occurring at the discernment of images. The database is constructed as a result of combining numeric and wave (individual matrix) information. The document is found in the database in accordance with its numeric individual code, its authenticity is tested by the individual matrix. At electric discharge, not only a hole appears in the paper (it is rather difficult to register it by means of a traditional scanner) but also the evaporation of the conducting black paint occurs (estimation of electron component photon emission density confirms such possibility) eliminating all technological problems of recording.

12 targets were worked in every interelectrode space for the purpose of statistics.

Results and discussion

The obtained data show that the holes on the target are located irregularly forming peaks in the curves. Owing to the used algorithm of determining the center of distribution there hits no spot into the central ring, the diameter of which is small enough explaining the dip of the first point in some diagrams. Peaks in the curves do not disappear even after great averaging shown in Fig. 3 (averaging for all targets with the given gap). It is also seen that distance between the electrodes growing the curve slope diminishes, turning from bell-shaped one for small distances up to nearly straight one for large distances. After the averaged curves are rebuilt using the radius normalized along the X axis for the interelectrode space value, it is seen that at a gap of 5 mm the curve trend differs from the behavior of the curves for other gaps. It may be explained by the substantial change of the field distribution in this case as the scale of the plasma generation on the needle electrode becomes comparable with the gap size.

Technological application

The experience of experts-criminalists shows that a text on an institution blank, along with a signature and seal, could be corrected by malefactors who employ modern methods of computer graphics. Virtual documents could be easily protected with the assistance of the so

called electrodigit signature. Paper ones are protected using traditional methods such as special polygraphic products (excise marks and the strictest report blanks), providing with various kinds of holograms (unigrams), latent raster images, introducing marking with the help of machine-read ordinal or occasional numbers. But all these measures do not lead to the noticeable reduction of the damage caused by offences.

The modern level of the state document circulation could be achieved only in the case when the uniformity in protection of documents both virtual and analog (paper) ones is provided. For that, it is necessary not only to impart every paper document, as a marketable product unit, with its own unique identification code assisting to control its travel route during its whole life, but to safeguard the numeric code as well being included into the database together with some unique matrix which could not be repeated twice. The necessity to create such unique identifier is discussed in terms of philosophy in [5]; in [6], the description of a patent is presented that permits obtaining of the best informational protection of the individual numeric code with the help of the electrodischarge technology.

This technology somewhat resembles new approaches to biometric identification [7], when instead of typical patterns (papillary lines) on finger skin (classic dactyloscopy) another individual feature (location of skin pores situated between these lines) is introduced into the database. Unlike such approaches requiring usage of the additional information programs removing distortion caused by the possible rotational deformation at the skin extension, the electrodischarge method of spot (pore) tracing on the metal or paper surface has no such drawbacks [8]. Such an approach using the database is built not on the graphical information but only taking into account the parameters (coordinates, area, shape, etc.) of the obtained spots. Identification with the database consisting of millions of electrodischarge pictures could be carried out within a few seconds.

A typical document containing an individual numeric code (generated, as a rule, by means of random number generator) and individual picture obtained with the assistance of electric breakdowns looks as follows.

Fig. 5. Strict report document with the individual numeric code protection by electrodischarge procedure.

Conclusions

1. The electric discharge forms an individual matrix on the target permitting one to create an irreproducible mark.
2. The simultaneous presence of the numeric code and individual matrix in the identification mark allows one to find quickly the studied object in the database and to carry out its identification according to the coincidence (or non-coincidence) of the individual matrix (for instance, to recognize an illegal good).
3. Electrodischarge identification possessing all features of quantum identification could not be tampered with and can be used as a protective technology in the process of creation of the documents of the strictest reporting, even national currency.
4. It is impossible in principle to product two identical individual matrixes under the common code.

5. The presence of numeric and wave information in the identification mark allows one to build the multipurpose database of material resources in a new fashion (papers, metals, thin sheet plastics, etc.).
6. The presence of the features of an interferential pattern in the target proves the streamer wave properties.
7. The presence of peculiar features in the form of an interferential matrix in the mark allows hoping that the numerical code (and the document as a whole) would be fully protected.

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