J Forensic Sci, Jul. 1972, Vol. 17, No. 3

Irby Todd[1]

Handwriting Examinations from Electronic Images

Although the document examiner would always prefer to have the originals of documents that he is called upon to analyze, he sometimes must do the best he can with copies. A copy may be in the form of a photograph, microfilm print, photocopy, or carbon copy. In the case of sales slips it is not unusual to be forced to work from a third or fourth carbon of the original. Soon, if not already, the examiner may be called upon to make examinations from electronically-produced copies, most of which are called "facsimiles." (Indeed, upon the day of completion of this paper there was received in the Questioned Document Laboratory of the Metropolitan Police Department, Washington, D.C. the first case that included ten such documents which were transmitted from Kansas City to Washington via Telecopier.)

Facsimiles and other images transmitted electronically are becoming more prevalent owing to the needs of business and government to have immediately available faithful copies of important documents. Inaccuracies that result from narrative description of documents, delays and losses caused by sending copies by mail, and the expense of sending someone to a distant point to examine a document all give impetus to the increased use of this new method for transmitting copies of material.

The purpose here will be to consider electronically-transmitted copies from four standpoints: history, methods, costs, and quality. Document examiners are most interested in the quality but since price is always a factor, it is a legitimate consideration in this discussion. The history of the developments in this field may be of value when the age of such a document comes into question.

The thought that inspired this survey is that eventually State and Federal law enforcement agencies may want to transmit copies of questioned and known material from various points in their jurisdictions to a central laboratory for preliminary, speedy reports about handwriting identification. Such initial reports could be given over the telephone by the document examiner.

History

The following history of facsimile reproduction closely follows information provided by the Magnavox company [*1*].

Facsimile copying was invented by Alexander Bain, a Scotchman, in 1842. He used pendulums in synchronism and scanned metal letters with a wire. Invention of the telegraph by Samuel Morse in 1844 pre-empted interest in the technique. In 1865, Giovanni

Presented at the Twenty-fourth Annual Meeting of the American Academy of Forensic Sciences, Atlanta, Ga., 3 March 1972. Received for publication 3 March 1972; accepted for publication 13 March 1972.

[1] Document analyst, Metropolitan Police Dept., Washington, D.C.

Caselli initiated commercial use of facsimile in France with a rotating drum system. In 1875, William Sawyer in New York perfected a motor, drum, and clutch system containing provisions for framing. This drum system is called "classical facsimile." In 1873, Willoughby Smith discovered the photoconducting properties of selenium. In 1881, Shelford Bidwell suggested optical scanning and, in 1902, Arthur Korn made a practical selenium cell optical scanner. In 1908, Hans Knudsen reproduced facsimile copy via wireless and by 1910 there was press picture service connecting London, Paris, and Berlin.

In 1926, RCA initiated transatlantic commercial radio-photo and in 1935 the Associated Press started the present newspaper wire photo service. In 1936, Maurice Artizi of RCA built a drum and helix recorder using carbon paper and John V. L. Hogan perfected the drum and helix method, using moist electrolytic paper. The Hogan process is used today by Stewart Warner, Telautograph, Muirhead, LitCom, Nippon Electric, Alden, and other companies throughout the world. The electrolytic process has the disadvantages that the paper must be wet, it seldom dries flat, and the mark tends to bleed.

During the same period, Wise of Western Union developed Teledoltos paper, which consists of a conducting sheet, a layer of carbon, and a zinc oxide (paint) surface cover. A spark from a tungsten stylus would blow a crater through the surface zinc oxide, revealing the black carbon underneath. This method is called "sparking paper" in facsimile, and was further developed by Western Union, Timesfax, and Litton, and is still in use. It produces noxious fumes which must be removed by filtering and has the disadvantage that it can continue to be marked by scratches or folds after the copy is rendered.

During World War II facsimile was used extensively for transmission of weather maps using the Timesfax TXC-1, a classical facsimile machine using sparking paper.

After World War II, the Hogan laboratories experimented extensively with Broadcast facsimile. The signal was transmitted multiplexed on FM radio stations, and was received in homes. This was technically successful, but economically a failure because it coincided with the rise of television, which pre-empted the home market.

In 1960, a Facsimile Committee was established and wrote a standard for facsimile equipment using the switched telephone network. The Magnavox Research Laboratories began a facsimile project in 1961 and established the feasibility of key techniques by early 1963.

The design objectives were to create a continuous facsimile transceiver printing on plain paper and using the switched telephone network as its transmission medium. Access to the telephone was to be by acoustic coupling which had never before been attempted in the facsimile field. The Magnavox Company went through several design models during the years and in 1965 decided upon production of the Magnafax 840.

Owing to certain marketing requirements, Magnavox entered into an agreement with the Xerox Corporation. Under this agreement Xerox marketed the Magnafax 840 under the name of "Telecopier," and regular production began 30 June 1966. The arrangement between Magnavox and Xerox continued until May of 1967, by which time 5000 Telecopiers had been built. Xerox then exercised an option in the agreement, made certain styling and engineering changes in the unit, and brought out its own unit called "Telecopier II" which was placed on the market in July 1968.

On the other hand, Magnavox went its separate way, and made changes designed to improve the unit's reliability, consistency, and producibility and introduced it to the market in August 1968 as the Magnafax 850. Among other things, Magnavox concentrated upon the improvement of the record medium, developing the Magnafax Copyset Eleven, in collaboration with the Columbia Ribbon and Carbon Company. This "carbon" paper employs a true ink, rather than carbon, is smudge-resistant, and prints on #20 bond paper.

Methods

Most electronic transmissions of facsimiles work in the same way. The document is placed in a transmitting device, where it is scanned by a light the signals of which are moved through a photoelectric cell that changes the light into audio-electronic signals. These signals are picked up by the telephone line, transmitted to another receiving telephone still in the form of audio-electronic signals. At that point, inside the receiving device, the signals activate a printing stylus against paper and the copy is thus produced (Fig. 1).

There are several types of records media. The machines employing the telephone handsets use two basic types of paper for recording the images. In the one, previously referred to as sparking paper, the receiving machine uses a stylus that burns off the top layer of paper leaving the carbon outline below. The other type uses almost any kind of paper with a carbon paper overlay, the image being produced by impacting through the carbon paper onto the paper beneath.

The paper used in the PolicePhotoFax system and in the traditional wirephoto (to be further described) is almost of photographic quality which, in part, accounts for the high quality of copying achieved by these methods.

Costs

Interviews were held with representatives of several companies to witness demonstrations of their systems and to learn of their methods and operating costs. Information was also received from James J. Horan, document examiner with the New York City Police Department [*2*].

No real costs can be given for several methods of electronic transmission of documents. For example, the PicturePhone that is under development by American Telephone and Telegraph does not have any tariffs, as they call them, except within the Washington, D.C. area. United Press International (UPI) manufactures its own machines for picture transmission and no commercial models of their machines are known to be available. Some

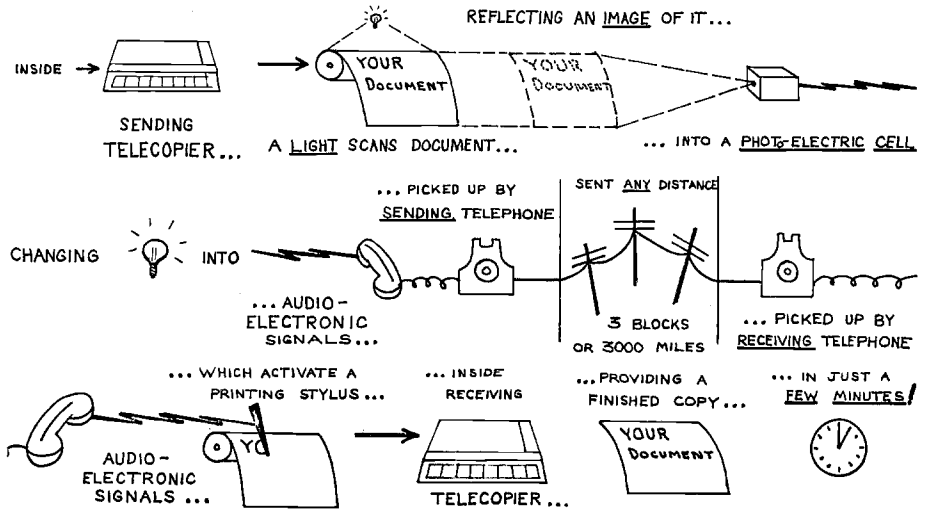

FIG. 1—*Schematic diagram of how facsimile transmission works.*

preliminary figures on television transmission indicated that costs were so high, it was not considered advisable to explore full-scale costs of such a possible operation. As a matter of interest, though, the "interconnectors" that would be needed for each site would cost $1000 per month [3]. This figure does not include cost of TV cameras, monitors, or line charges between sites. Notwithstanding the very high cost of such a system, a demonstration of closed-circuit TV transmission was arranged and photographs of the images were taken off the TV monitor [4]. A tape of this experiment was obtained for future demonstrations.

The following costs were those obtained for mid-1971. They refer to the costs at each site. The companies that manufacture the devices have other models, but the ones listed are the least expensive. Each of the machines described can also be purchased outright. Line charges are not given since these would vary in direct relation to the distances between points. Not every company that produces facsimile transmitters was contacted. These distributors were the most convenient to contact.

Name of Device	Manufacturer	Rental Cost, per month	Paper Cost Per Sheet, 500 sheets
Magnafax 850	Magnavox	$42.75	3.5¢
Dex I	Graphic Sciences	55.00	5.0
Telecopier 400	Xerox	38.00	5.2
DataFax	Stewart Warner	99.00	2.5

A system called PolicePhotoFax, manufactured by Stewart Warner, makes use of a separate line or cable, involves a transmitter and receiver at each site, and has a different type of paper from that typically used by the above systems. In the PolicePhotoFax system the rental cost for a transmitter is $89.50/month and the receiver cost is $195.00/month. The cost per sheet of paper is $0.13.

There is a nationwide facsimile mail network already in existence, using Dex I machines. The network is called Faxmail. Presently there are 260 cities serviced by this network in the 50 states, the District of Columbia, and in the Canadian provinces of British Columbia, Ontario, and Quebec. For what is said to be a modest fee, facsimile copies can now be sent and received in those cities. Further information and a copy of the current directory of stations can be obtained from Facsimile Transmission Network, Inc., 3868 State Street, Santa Barbara, California 93105.

Quality

In the lower priced machines, the quality of the facsimile reproduction is primarily a function of the transmission times involved. Taking resolution as the criterion for quality, the following information was offered by the companies.

Name of Device	Transmission Time Basis: 8 ½ by 11 in. sheet	Resolution, lines/in.
Magnafax 850	4 min	65
	6	96
Dex I	6	88
Telecopier 400	4	65
	6	96
DataFax	4 ½	96[a]
	6	96

[a] This resolution is possible since each line is scanned 3 times, whereas other devices scan each line only once.

PolicePhotoFax, which has a separate cable and thus differs from the methods above, which use regular telephone lines, has a transmission time of 13 min with a resolution of 200 lines/in.

Magnavox also produces a machine, Magnafax 852, which uses a separate, conditioned line. The resolution is reported to be 220 lines/in., with a transmission time of 18 min, and a rental cost of $100/month. Paper costs are the same as the Magnafax 850.

During original talks with Graphic Sciences, Inc., it was stated that they have a Dex 5 machine, also using telephone hand-sets as an integral part of the system, which produces a copy with a resolution of 176 lines/in., time of transmission being 14 min. In a more recent conversation, their representative stated the resolution to be approximately 210 lines/in. No demonstration of this machine was witnessed, since the closest site of operation is Danbury, Connecticut. Rental cost for the Dex 5 is said to be $75/month, with the same type of paper that is used on the Dex 1.

Another highly regarded system is the Xerox LDX. It is understood that this system makes use of a separate cable for transmission, very much like that used for TV signals. The stated resolution is 220 lines/in. in the copy with 5-s transmission time. No costs are readily available for this system, but it is believed they are considerably higher than those already mentioned.

Demonstrations were witnessed of the PicturePhone which is being developed by AT&T, of wirephotos produced by UPI, and of closed-circuit TV transmission, the latter by courtesy of WRC-TV in Washington, D.C. Photographs were made of the images from the screen of the TV monitor and of the wirephotos. It was not practicable to make a photograph from the small (5 by 5½ in.) screen of the PicturePhone. A disadvantage of wirephoto transmission is that a photograph of the original must first be made and a copy of that is transmitted. The quality of the copy, however, is quite high.

The photographs taken from the TV monitor cannot, of course, convey the quality of the images as seen directly on the set. The images on the PicturePhone were comparable to the TV images, but with the present configuration of this device, it would not be practical for use by the document examiner. In order to achieve the images referred to, it was necessary to hand-hold a magnifier over the document to be transmitted. More recently however, engineers in the Bell laboratories have developed a method for interchanging lenses in this system, which would include a wide-angle capability, and this could eliminate the necessity for the magnifier mentioned. Furthermore, it is stated that it is possible to modify the receiver so that a large TV-size screen could be used [*5*]. With these modifications, it would appear that the PicturePhone renditions would be comparable to those achieved on closed-circuit TV, and, of course, would be just as appropriate for examination.

Several other systems for transmitting copies of documents also exist. Included is one called Trans-A-File; another is Videofile [*6*], and still another is produced in Japan by Kokusai Denshin Denwa [*7*]. It is believed that the Trans-A-File system is still in the development stage and will make use of magnetic tape as part of its function [*8*]. According to a news story, the Japanese system will permit, for the first time, the simultaneous transmission of both voice and facsimiles.

Recently there has been some publicity about the Postal Service's experimental use of facsimile transmission between Washington, D.C. and New York City. It has been learned that these were DataFax, Magnafax, and a Telecopier [*9*], all of which have been mentioned herein.

A study of the copies with resolutions of 65 to 96 lines/in. indicates that they would be useful for making preliminary determinations about authorship of handwriting. Virtually all features of handwriting can be evaluated from such copies. About the only elements not

susceptible to complete evaluation are minute adjustments of the writing instrument within letters or at connecting points between letters, and the delicate variation in pressure in the writing line. In addition, a study of images that show a resolution of 200 lines/in. or more, such as with the PolicePhotoFax system, wirephotos, TV pictures, and images on the PicturePhone, indicates that more extensive analyses of handwriting can be made from them. The probability of the 200 line/in. picture revealing the deliberation in writing that is usually found in tracings and careful simulations is high. When such deliberation is noted, of course, it would be a signal for the examiner to call for the original documents before a final opinion is rendered. (See Fig. 2 for a composite photograph of several facsimile transmissions.)

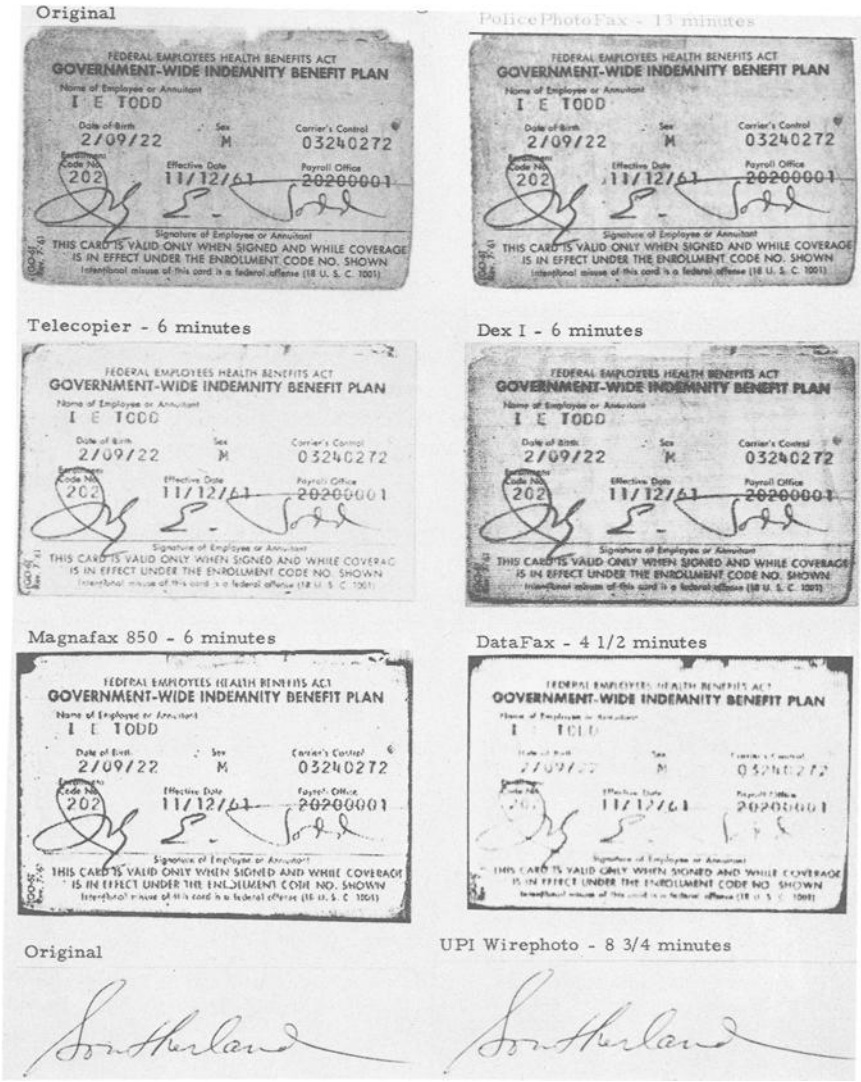

FIG. 2—*Composite photograph of several facsimile transmissions.*

The Future

It is not difficult to envision the following possibility for document examiners vis-a-vis investigators who have questioned document problems. In a central city of each state or at the site of a regional Federal laboratory serving a large area of the country, document examiners will monitor several transceivers, perhaps of the PicturePhone type. An investigator hundreds of miles away calls the laboratory and exhibits on the device the writing of the suspect along side the questioned item, for example, a check endorsement. After a brief examination, the document examiner reports orally that the matter looks promising enough to send it in for a more complete study and formal report. On the other hand, he might indicate that the writer cannot be identified, implying that the investigator should look for another suspect. In other instances, the examiner may tell the investigator that the writing is disguised or give other information of value in just a few minutes. The saving in paper work at each end of the line, mail time, and savings in other areas would be substantial. Investigations would certainly be facilitated. Examination time and time required to prepare formal reports in the laboratory would also be significantly reduced. The astonishing increase in technology suggests that this speculation may be translated into a reality in the near future.

There is a pressing need for reducing the time between submission of documents to a laboratory and receipt of reports. In one instance, for example, there are approximately 700 cases on hand, a large number of which have been in the laboratory for about three months. Although this type of problem can be avoided or solved by greatly increasing staff, it may be that managers would be more amenable to expenditures on equipment that would tend to serve the same purpose, and which might be less costly in the long run.

It is apparent that more research, development, and study is needed. If funds could be obtained to set up a small experimental network, the efficacy of the proposed application of the method could be further evaluated.

Summary

The history, method of operation, cost, and quality of electronically-transmitted facsimiles have been reviewed. The utility of such images in handwriting examinations has been evaluated. A possible future operative arrangement using such images was described.

References

[1] Private communication with Keith Douglas, Marketing Representative, Magnavox Systems, Inc., Rosslyn, Va.
[2] Private communication with J. J. Horan, Document Examiner, Crime Laboratory, New York.
[3] Private communication with Floyd Hobbs, Accounts Manager, ISC, Chesapeake and Potomac Telephone Company, Washington, D.C.
[4] Private communication with Mark Wenley, Manager of Production Facilities, WRC-TC, Washington, D.C.
[5] Private communication with R. E. Bessom, Accounts Manager-Data Communications, Chespaeake and Potomac Telephone Company, Washington, D.C.
[6] *Reader's Digest*, Nov. 1971, p. 167.
[7] *Washington Post*, Washington, D.C., 7 Oct. 1971.
[8] Private communication with E. J. Dion, Supervisor, Latent Fingerprint Section, Metropolitan Police Department, Washington, D.C.
[9] Private communication with Ronald M. Powell, Communications and Public Affairs Department, U.S. Postal Service, Washington, D.C.

11210 Ashley Drive
Rockville, Maryland 20853