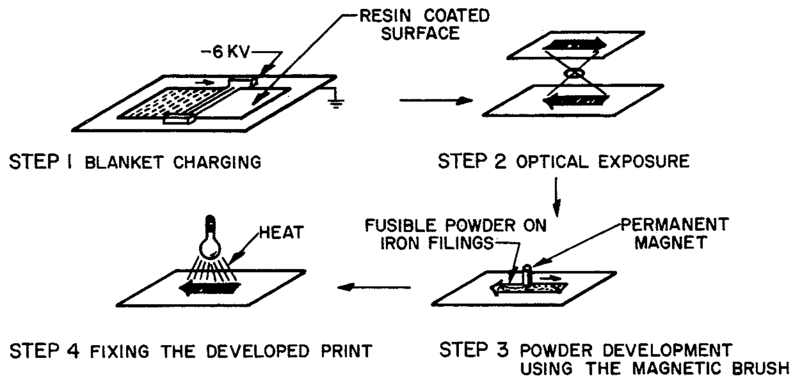



Fig. 1—Basic steps of Electrofax process.

# ELECTROFAX—TODAY AND TOMORROW

*by* **D. J. PARKER, Mgr.**
*Applied Physics Group*
*Applied Research*
*DEP, Camden, N. J.*

Electrofax is an RCA trademark for an optical printing process utilizing a photoconductive surface. The main ingredient of this surface is zinc oxide, and the surface has the property of being an insulator in the dark and a conductor when illuminated. Even in the presence of light, however, the conductivity is through the surface; there is little lateral leakage across the surface.

These properties are seen to be grossly similar to an array of element-size, insulated capacitors whose internal resistance may be made to suddenly and greatly decrease by shining light on them. Hence, electrostatic charge may be placed on opposing sides of the surface, and exposure to light will cause an internal current to flow, equalizing these charges and removing the charge from the areas of the surface thus exposed. If the light exposure is an optical image, such as a projected lantern slide, the charge remaining on the dark portions of the image constitutes an electrostatic image of the projected optical image. This electrostatic image may be made instantly visible by bringing tiny black or colored particles having an opposite electrostatic charge in contact with the surface; the particles stick to the electrostatic image but not to the exposed portion of the image. The result is a visible, positive reproduction of the projected slide.

### BASIC ELECTROFAX

Fig. 1 depicts the basic steps of the Electrofax process. The photo-conductive surface is normally applied to a paper base as a thin coating. An electrostatic charge is placed across the surface in the dark. A corona discharge (fine wires at high negative potential in front of the surface, a ground plate in contact with the rear of the paper) bombards the surface uniformly with negative ions. The charged paper is then exposed to a projected image or is contact printed. The result is a latent electrostatic image. Dusting of the image with charged resin particles coated with carbon black yields an immediately visible image that can be made permanent by fusing the resin into the surface with heat.

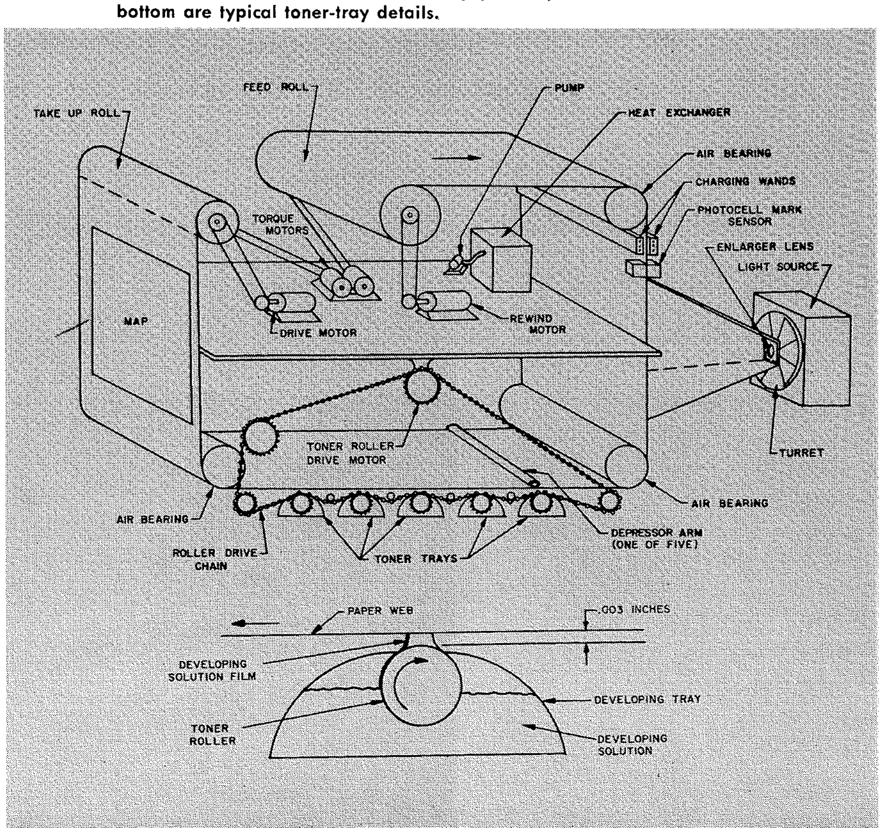
The simple behavior described above masks the complicated solid-state phenomenon producing the results. The capacitor analogy doesn't begin to explain the complete performance of the Electrofax surface. Articles that recently appeared in the *RCA Review* give an up-to-date description of the solid-state model for Electrofax. (J. Amick, "A Review of Electrofax Behavior" and "A Volume-Charge Capacitor Model for Electrofax Layers" *RCA Review*, December 1959.)

### CHARACTERISTICS

Electrofax paper has two major advantages as a photographic material: rapid development of the image, and a much lower cost than silver halide and similar processes. In addition, it is an extremely versatile medium in that it can be developed positive or negative by interchanging the sign of the paper and toner electrostatic charge. After development, the unfused toner image may be transferred to another base material such as glass or plastic. Or, once an image has been fused, the paper may be recharged and other images overlaid. Other advantages are that the paper is not subject to accidental exposure during storage, since it is charged just prior to use; all the materials are nontoxic and noncorrosive. The resolution is good: 300 TV-lines/inch in normal machine development and up to 1000 TV-lines/inch with hand processing.

Excellent reproduction of multi-tonal copy may be obtained with Electrofax by the use of a halftone screen, as used in newspaper photographs. This process, in which a fine screen (e.g. 150 lines to the inch) is placed in front of the paper, changes the density varia-

Fig. 2—Operation of the five-color map printer pictured on the cover of this issue. At bottom are typical toner-tray details.



tions in the image into variations in the dot sizes produced by the screen shadowing. Screening reduces the resolution in the photograph, of course, and for this reason is not universally acceptable.

The pertinent engineering characteristics of one common Electrofax paper are:

1) In photographic terminology, the sensitivity of this Electrofax paper rates about ASA 1 for incandescent light, and about ASA 4 for light that is a better color match to the paper, which has strong blue sensitivity. P-11 phosphor and mercury arc lamps are sources giving such a color match.
2) The photographic *gamma* (slope of the density vs. log exposure curve) is steep, about 2.5 to 3, as a minimum. This has two very significant results: (a) The tonal range which may be reproduced on the paper is reduced from that available in normal input material such as photographic transparencies; reproduced tonal range (highlight to shadow) corresponds to an object brightness ratio of about 3:1. (b) The tolerance-to-exposure variation is proportionally less than with lower-gamma photographic materials—a major consideration in machine design.
3) When the paper is stored at low relative humidity (20 percent or less) its conductivity drops greatly and satisfactory charging of the paper may be difficult to obtain. This can be avoided by insuring proper moisture at the time of manufacture, and keeping the paper tightly wrapped until use. The paper base can also be made conductive permanently by other means such as metallic coatings.

## APPLICATIONS

The above characteristics point up applications appropriate for Electrofax: rapid and cheap reproduction of material in black and white or color, and with successive over-prints if desired. There are several excellent military and commercial applications where these characteristics are highly desirable: 1) tactical map printing, 2) high-speed computer output, 3) letterpress and lithographic plates, 4) military large-screen displays, 5) bank-book and credit-card recording, and 6) library and office copiers.

### Printing Tactical Maps in Color

The overprinting characteristics of Electrofax mentioned above made possible the design of an electrostatic color map printer (see front cover). This machine produces maps from miniature film separations, and since maps are primarily line copy with a limited gray scale, this is almost an optimum application for Electrofax.

The color map printer was built under a contract from the United States Army Engineer Research and Development Laboatories, Fort Belvoir, Virginia, as a feasibility model to demonstrate the usefulness of electrostatic map-reproduction techniques. Technical map reproduction from miniature color separations is a very attractive alternative to large-scale transport and storage of maps. The electrostatic printer allows the rapid reproduction of maps in the field on specific demand. The RCA Electrofax map printer prints 22½″ by 29″ maps in five colors by sequential optical exposure and development. The Electrofax paper is exposed to the enlarged image of a 70-mm color separation by electronic flash. The paper moves continuously through the machine at rates as high as 16 inches per second.

The map printer uses liquid Electrofax development techniques in which the developing pigments are suspended in an insulating fluid. The fluid is applied to the exposed paper surface by a simple roller technique illustrated in Fig. 2. This liquid development technique has been found to be excellent from point of view of ease of mechanization, overprinting characteristics, exposure tolerance, and background cleanliness.

DEP Applied Research is just beginning the design of a feasibility model of a shipboard map printer for the

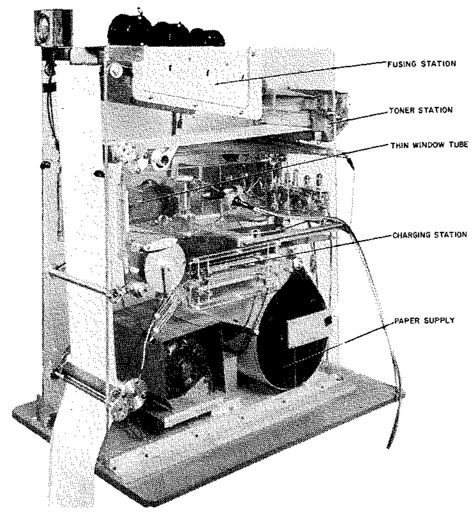


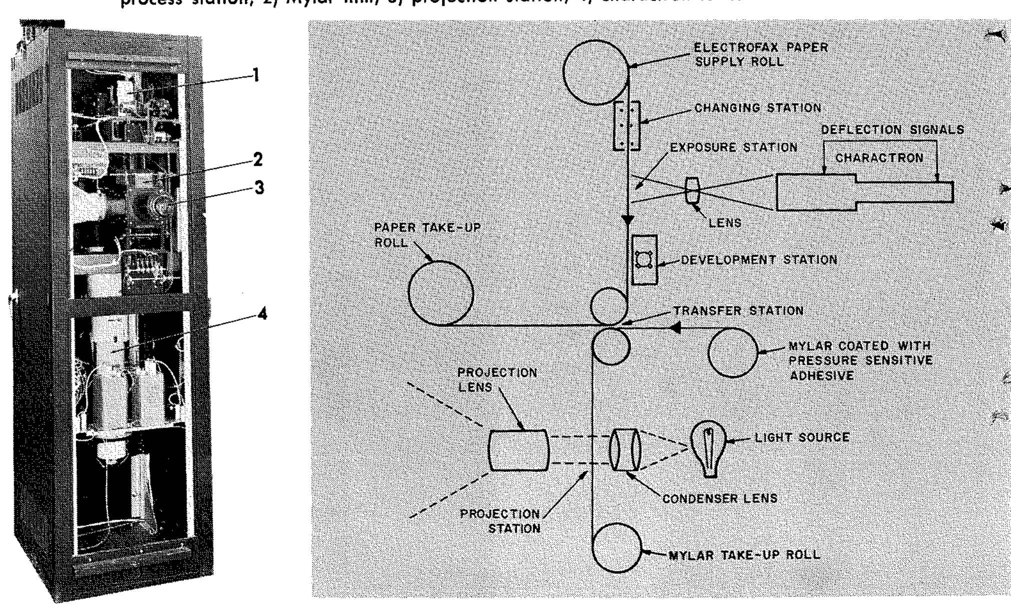

Fig. 3—Thin-window Electrofax printer.

Bureau of Ships, United States Navy. This machine is designed to fulfill the same functions as the Army Printer, with the exception that the paper will remain stationary throughout the five sequential exposure and development cycles. This mode of operation will be somewhat slower than the Army machine but has two significant advantages: 1) there are no problems in registering the paper at successive exposure stations, and 2) the machine size is greatly reduced for shipboard installation.

### High Speed Computer Output

It is generally recognized that data output rates from computers and communication systems are growing to the point where mechanical printers cannot operate synchronously. There are

Fig. 4—Electrofax transparency projection system. In photo; 1) Electrofax paper and process station; 2) Mylar film; 3) projection station; 4) charactron tube.



already applications for electronic printers capable of printing in the range 5,000 to 20,000 characters per second. Electrofax is a good basic tool to realize such high-speed printers. Its basic sensitivity may be effectively increased by the use of new optical tools, such as the fiber-optics high-speed printing tube described by L. J. Krolak in Vol. 4, No. 1 of RCA ENGINEER ("Fiber Optics—Valuable Engineering Principle") or by thin-window tube techniques as pioneered by Princeton Laboratories. The thin-window printer (Fig. 3) has already been operated, in facsimile printing, at rates in excess of 20,000 characters per second. Both the fiber-optics tube and the thin-window tube achieve an effective optical exposure increase of the order of 50 to 1.

The use of Electrofax as a high-speed printing medium is basically desirable because electro-optical output devices, such as the cathode ray tube, have far higher maximum writing rates than competitive electrical printing techniques.

#### Letterpress and Lithographic Plates

RCA has developed an Electrofax surface and a development technique which promises to be a major breakthrough in newspaper and offset lithography applications. Finished letterpress and lithographic plates are presently produced by photo-etching techniques in which photosensitive resins protect the areas of the surface which are not to be etched. The resin surface for the metal plates must be prepared at the printing plant because the resin has a very short shelf life. Since the photosensitivity of the plates is very low. the copy to be printed must be first photocopied onto a negative film. This negative film in contact with the photosensitive resin is exposed with carbon arc lamps for about four minutes. The plate is then etched to bring out the image.

The significant features of the Electrofax process are the elimination of the negative film step and the reduction of exposure time from four minutes to just a few seconds. With the Electrofax system, any hard copy can be exposed directly by contact or projection onto the plate. The electrostatic image is toned and fused, and the Electrofax coating in the nonimage areas is removed with a solvent. The plate is ready to etch in the same manner as regular plates.

#### Military Large Screen Displays

A major need in military systems is an automatic technique for large situation displays. Such displays must have high brightness and resolution. The information presented on display must be generated automatically and rapidly from electrical data. Electrofax fulfills all the requirements for such a medium, since it can take information photographically from electrical data in a fashion similar to high-speed printing from a cathode ray tube, and it has good resolution and rapid processing. It is not possible, however, to project the information developed on the Electrofax surface onto a large screen display because the Electrofax surface itself is not transparent. To overcome this difficulty, techniques have been developed for transferring the powder image developed on the Electrofax surface to a transparent base medium. A breadboard machine to accomplish this transfer automatically has been constructed and is shown in Fig. 4. This machine prints information onto 70-mm-wide Electrofax paper from a Charactron tube. The exposed paper is developed and the powder image then transferred to an adhesive-coated Mylar base. This base material has sufficient stability and transparency to allow bright projection on very large screens.

In this application, Electrofax is competitive with rapid-processing photographic film systems and has the advantage of large film size, low cost, and simple processing techniques.

#### Bank Book and Credit Card Recording

It would be very advantageous to the banking industry to be able to insert the subscribers signature in coated form into a bank book. An optical technique has been developed for scrambling the signature, and Electrofax gives the cheap and rapid processing necessary to allow economical recording of the optically scrambled signature.

Such a scrambled signature recorded on Electrofax is shown in Fig. 5. Since bank books or credit cards get extreme handling, a technique has been developed for this application in which the Electrofax surface is covered with a very thin protective Mylar sheet.

In these applications, Electrofax is extremely important, since the Electrofax surface may be printed directly into the bank book or on the credit card, the books and cards may be stored indefinitely, and yet the signature may be recorded and be available with a very short processing cycle. These characteristics are not possessed by other recording mediums.

#### Library and Office Copiers

Electrofax characteristics are also very suitable for use as a general copying medium. The low paper cost, rapid processing cycle, and high quality are great advantages in these applications. An outstanding example is the library copier developed by RCA Laboratories. This machine optically copies pages from books onto Electrofax paper using reflective illumination. The processing is done by liquid techniques and the finished print is thermally fused. This machine has been in use for many months. It is fully automatic, and its performance has been outstanding relative to conventional copiers.

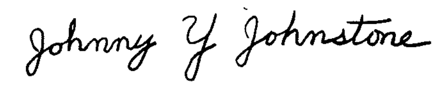



Fig. 5—Electrofax print of scrambled signature.

#### FUTURE DEVELOPMENTS

RCA has invested many man-years of research and development in the Electrofax process over the past decade. The excellent potential of the military and commercial applications referred to here gives testimony to the wisdom of this investment. The challenge now is the engineering and marketing transformation of models into products.

In the near future, there is the attractive prospect of increased capability for the Electrofax medium. Increased sensitivity, much greater tonal range, increased fidelity of color reproduction, lower-cost materials, and transparent color toners are some of the characteristics that will be available. The range of new applications will be virtually unlimited.

For Mr. Parker's biography, see Vol. 6, No. 1; p. 21.