Duplicating Techniques*

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During the past decade, manufacturers of printing and duplicating equipment have made many important improvements, ones that have led to both better reproduction and lower costs. Techniques considered adequate in the thirties and forties can no longer compete with the newer machinery and methods of the fifties and sixties. While few if any entirely new techniques have been invented, many that have been in use for some time have become far more sophisticated.

The processes covered in this discussion are: spirit, electrostatic, diazo, offset (both direct and photo-image), and letterpress. All of these processes have had many improvements in their methodology. Perhaps the most significant changes have occurred in the electrostatic process; these have brought it to the forefront, challenging many older office-copying methods.

For the purpose of establishing a common discussion base, the principles of each of the major processes are briefly defined here, although many variations exist among the competing manufacturers.

In *spirit duplication*, the original is typed or drawn on heavy paper, while a second (dye) carbon sheet, underneath, deposits a reversed carbon image on the back of the master. Copies are reproduced through contact transfer of small amounts of this carbon material to copy paper which has been dampened with a solvent, usually an alcohol. The special carbon paper is available in five colors, and it is possible to reproduce all of them at the same time from a master so prepared.

The principle of the *electrostatic process* can be readily understood from some common experiences—the development of static charges by rubbing a hard rubber rod with cats fur, or the development of charges as one slides across some plastic seat covers in an automobile. Electrostatic duplication uses a flat photoconductive surface which can be charged statically. Any photoconductive flat plate can be used, including paper. When the charged master plate is exposed to a projected image of the original, the light dissipates the charge in the non-image areas and moderates the charge in areas of varying image strength. In the next step, negatively charged particles of pigment are applied to the plate; these cling to the positively charged latent image in direct proportion to the charges still present. Finally, the pigmented image is then transferred to some positively charged paper (or other material) and is fixed, usually by heat from an incandescent, infrared, or high-frequency source.

The process described in the preceding paragraph is specifically that for the Xerox method, which is the only one employing a reuseable master plate. In all other electrostatic processes the actual surface on which the copy is desired is the plate, and there is no image-transfer step. The copy paper employed usually has zinc oxide held in a resin binder on a paper substrate.

The more refined electrostatic machines permit enlargement or reduction, but the bulk of those on the market copy the same size only. An important feature of this process is its ability to copy originals containing images in most of the colors without appreciable loss of definition.

The earliest of the processes related to diazo copying—blueprinting—is rapidly being supplanted by brown-and-white and black-and-white diazo processes. For this reason, blueprinting will not be described here. Current *diazo processes* are either dry or semidry. In the dry process, a base material is coated with a light-sensitive diazo compound and a dye-forming coupler. When the sensitized base (usually paper) is exposed to strong ultraviolet light, in contact with a translucent line-copy original, the light disintegrates the diazo compound where the original had translucent areas. In the image areas, the diazo compound then reacts with the dye-forming coupler when the exposed copy is developed by passing it through an alkaline ammonia vapor, producing the dye image.

In the semidry process, the sensitized material is coated only with the diazo emulsion. The dye coupler is in a liquid developer which contains alkaline salts for the combination of the diazo compound and the coupler. This solution is applied after the sensitized material has been exposed.

Since requirements for the original copy (master) are the same for both blueprint and whiteprint—an opaque image on one side only of a translucent "paper"—and since both processes are of the contact type, this is a boon to those changing from one process to the other or using both.

The *offset process* is based on the non-mixing properties of water and grease. The process gets its name from the method of inked-image transfer involved—from the printing plate to a rubber blanket to the paper to be printed. The plates used in this process can be made of many materials; paper, plastic, and metal are the common ones. The image is placed on these plates in a variety of ways, chiefly either directly or by photographic transfer (photo-offset, photolith, etc.). The direct-image plate is prepared by typing, writing, or drawing with carbon, grease-base, or reproducing ink directly on the (ink-repellant, when dampened) coated surface of a paper or plastic plate. This master is then ready for reproduction without further processing. Photolith plates are exposed by contact or projection photography and processed by various methods before reproduction. On the press, the plate is alternately contacted with water and ink rollers and the inked image then offset-transferred to the printing paper as described.

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The *letterpress-printing process* is a "relief" one, reproducing the image from raised type and/or "cuts" (for illustrations) which are inked and pressed against the receiving surface. This is the heavy-duty process in the printing field, and is normally used for long-run printing. However, because of the high quality involved, the process is sometimes used on shorter runs when the material demands the best printing obtainable. Typesetting costs are high, however, and the "cuts" for illustrations cost more than the equivalent step in photo-offset printing. Because the difference in good offset and letterpress printing is hard to see—a top-flight offset man can often produce quality that will match an average letterpress run—letterpress printing is not used very often in technical-information work. However, proofs from type-set composition are sometimes employed as photo-offset originals, especially when many illustrations are involved and can be "stripped in."

Table I presents an analysis of the properties of these various processes. From these properties it should usually be possible to determine the best process from the standpoint of demand and economy for any given situation. Unusual cases can weight more heavily those properties which deserve special consideration.

In general, it is apparent that use of the spirit process is indicated when a few hundred copies of usually acceptable quality are required at reasonable cost. For limited production below 100 units (usually a few dozen), the electrostatic or diazo processes may be used. The electrostatic process is much used for office copying, whereas the diazo process would be suitable for a short run of 50 copies of, for example, a sales brochure employing limited use of color and halftones. The same brochure with a requirement of 5000 copies would probably be handled by photo-offset printing, and a run of 500,000 copies would dictate letterpress printing.

The offset process deserves some extra discussion because it is suitable for many of our medium and larger duplicating problems. As mentioned earlier, two types of offset plates are available for general use. The first, the widely used direct-image paper plate (examples are the Multilith Duplimat, the Dav-A-Mat, etc.), can produce excellent copies up to several thousand impressions. The process is fast and less expensive than its companion, the photo-offset plate. The direct-image plate can be prepared by any good typist and is ready for immediate duplication. Although "line" illustrations can be drawn on and reproduced from these plates, it is more practical to use the photo-offset plate for all but the very simplest illustrations. The photo-offset plate must be employed to reproduce "halftones" (photographs, etc.), and should be used for all masters beyond several thousand impressions.

It should be noted that letterpress printing is generally the forte of the commercial printer, where either an extremely large run is required or quality considerations dictate its use. Its use is rare in the company or laboratory reproduction shop.

The development of cost figures for these processes is a difficult problem, even from actual experience. Overhead figures vary so widely with various accounting that any reasonable approach requires that they be disregarded. For each of the processes, however, Fig. 1 shows a cost area (range) for labor and material and relates this to the number of units produced from one original sheet or

Table I
Analysis of Reproduction Methods

Method	Spirit	Electrostatic	Diazo	Photo-Offset	Letterpress
		Master Properties			
Copy preparation	Definite limits	Some limits	Many possibilities	Broad possibilities	Broad possibilities
Set-up time	Negligible	Negligible	Negligible	Minutes to hours	Hours
Reuse	Limited	No practical limit	No practical limit	Limited by plate	Limited only by wear
		Ability to Reproduce			
Text	Good	Good	Excellent	Excellent	Excellent
Line work	Limited	Good	Excellent	Excellent	Excellent
Halftones	Poor	Poor	Excellent	Excellent	Excellent
		Properties of Copies			
Maximum run	400	Limited as office copier	No limit	5000 to no limit	No limit
Size	16½ × 18 in.	24 in. × any length	54 in. × any length	To 54 × 64 in.	Limited only by economics
Color	5 colors available	B and W	Limited	Any colors	Any colors
Normal paper	Glazed	Any paper	Diazo-coated paper	Any paper	Any paper
Enlargement or reduction	No	Some	Some	Yes	Yes
Running speed[a]	Up to 50 copies/min.	Up to 400 copies/min.	Up to 100 copies/min.	Up to 800 copies/min.	Up to 800 copies/min.
Quality	Good	Good	Excellent	Excellent	Excellent
Cost/copy	$0.01/copy	$0.06/copy	$0.06/copy	$0.02/copy	$0.01/copy
Skill required	None	None	Moderate	High	Highest
Supervision	Routine	Routine	Moderate	High	Highest

[a] Based on 8.5 × 11 in. copy or multiples thereof.

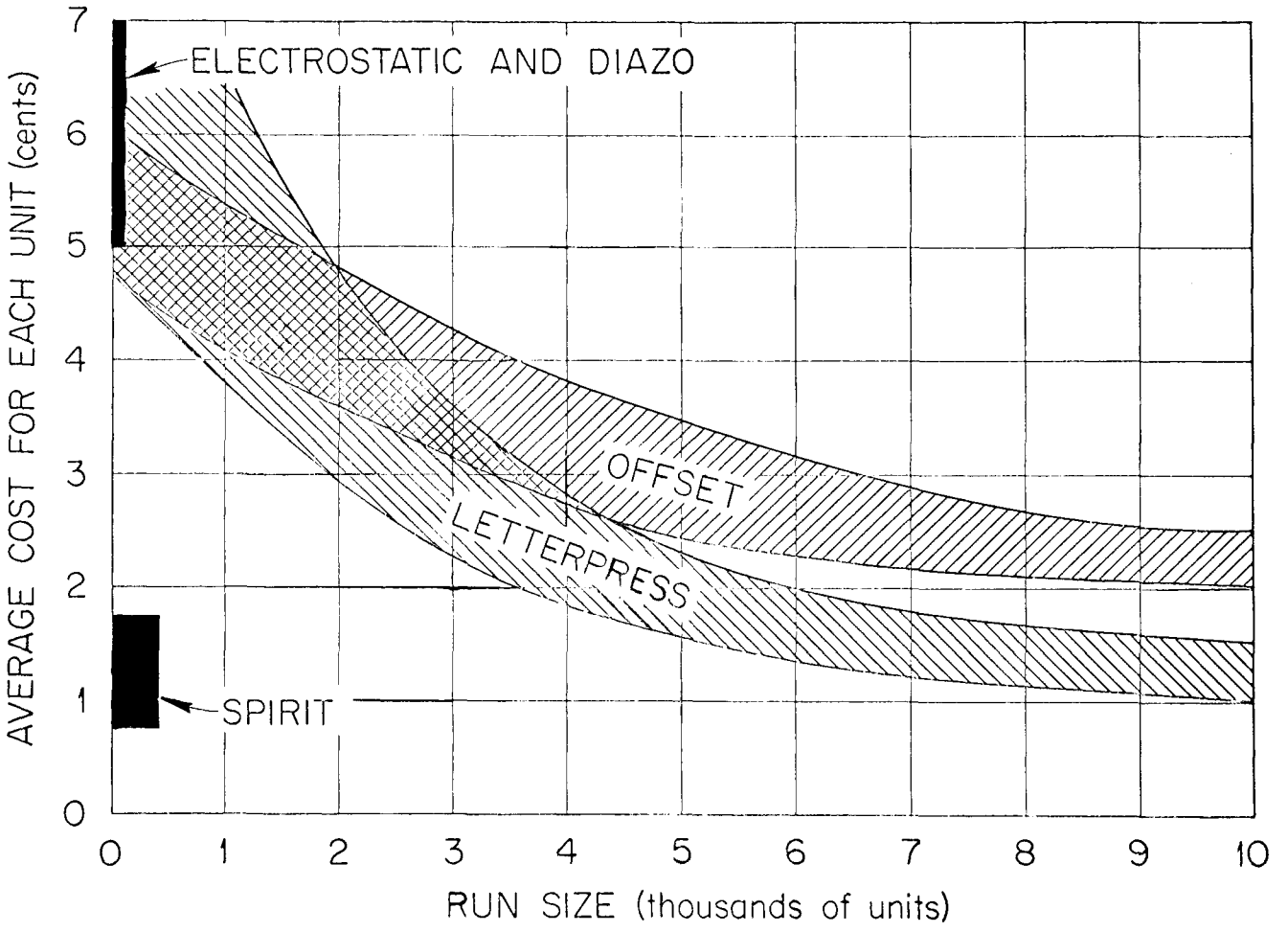

Fig. 1.—Unit costs for various processes.

master. The wide differences in cost between office copying and offset or letterpress printing are graphically portrayed. Quality and illustration limits are related to cost and other considerations in Table I.

A number of other important subjects are not covered here in detail because they are highly specialized and because their relative significance is dependent upon the reproduction-shop load. These include offset plates (direct image and presensitized), facsimile master machines, process cameras (vertical and horizontal), dimensionally stable films, folding machines, paper cutters, paper drills, and binding equipment.

Published information on costs is scarce or outdated, except for manufacturers' brochures. For this reason, reference is made in the bibliography to only a few current publications on equipment and accessories used in the "printing" trade. Competing trade journals undoubtedly have equally current listings.

This paper has briefly covered the reproduction picture and has summarized the effects of some of the advances during the past decade. It may be interesting, now, to look ahead and to make a few prognostications for the next decade.

At the beginning of this decade, a few medium-size printing plants (producing 0.5–1 million units per month) began to use continuous-flow Xerox duplicating units which produce copies on a continuous roll of paper at very favorable speeds. Work is progressing on further automation of this type of equipment, and it is predicted that a programmed machine of this type will be available in this decade. Such a machine could take a stack of master sheets and make the required number of copies of each sheet, in turn, delivering finished copies to a receiving tray in proper order, ready to collate and bind.

A second prognostication relates to the large amount of information that is flooding technical and other areas, presenting formidable problems of information storage and retrieval. These problems could be reduced if each "printer" also produced a standard microfilm roll (or other microform) for storage. These would be of sufficient quality for rerun needs, and the original masters would be used only for the initial hard copy run. The necessary machines should be available in this decade.

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