A STUDY OF PRINTING INKS

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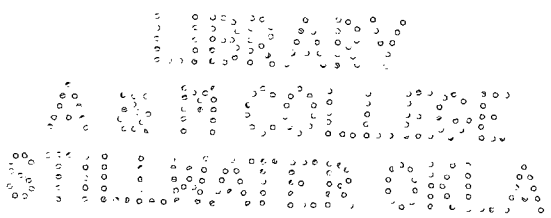

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O. D. P.

CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The purpose of this thesis is to give a brief history of printing ink, its composition and manufacture; to determine the right kind and amount of ink to use on a job; to discover remedies for ink troubles that occur in a printshop; and to be of service to the printing industry by passing along useful information that will shorten the long and costly road which the average printer has to take to acquire this knowledge through first-hand experience.

Although the manufacture of printing ink is not a part of the printing trade, a slight knowledge will help immensely in the proper use of inks. Many printers know which inks to use on certain jobs, but do not know why they do so. Others use the same inks on all jobs and wonder why they do not get results. The progressive printer wants to understand why he does things so that he can act intelligently in case of trouble. There is as much difference between inks as there is between the papers on which they are used and, unless the right kind and color of ink is used, the job never looks well. Much wasted time in trying to get a good impression can also be saved if the pressman is able to trace the trouble in the ink.

Materials have been secured from printshops, textbooks on printing, periodicals, sample books of printing ink, and ink companies.

The writer has interviewed printers and pressmen in twenty printshops in Oklahoma and Kansas regarding tips and shortcuts in the proper use and care of printing ink. In these visitations notice was also made of the different inks used, the ones used most, and how they were cared for. Samples of printing were studied whenever possible to see how much ink was used and how it suited the paper. Representatives from ink companies were contacted in reference to ink pointers in general. Letters were sent to thirteen leading ink manufacturing companies in the United States and the replies they sent were very gratifying. They showed every courtesy possible and sent much valuable printed matter as well as numerous booklets and pamphlets to illustrate in detail the various steps used in the manufacture of printing ink.

Various books on printing have been studied and compared with the view to condense the material and put in one volume the ideas and suggestions made by the different authors.

Although some consideration is given to inks for offset, lithographic, and intaglio printing, most of the material in this study is limited to inks for letterpress printing only, since that is the phase which concerns the majority of the students interested in printing in the high schools at the present time.

CHAPTER II

COLLECTION AND TREATMENT OF INFORMATION

History of printing ink. The history of printing and the history of ink begin at the same time. Before the birth of Christ, the ancient Chinese, who first discovered the art of transferring a relief impression to a paper surface, were derived from natural substances--the roots of plants, colored earths, soot, and in some parts of the world, from insects. In 400 A. D., Wei Tang,[1] a Chinese printer, is believed to have invented a kind of ink from lampblack. It was first made by the burning of oil, tar, or resin, which was then commingled with gum and honey and pressed into small wafers or cakes, to which water could be added when wanted for use.

Carvalho[2] states that the ancients used a number of tinctures as ink, among them a brown color sepia. As a natural ink its origin antedates every other ink, artificial or otherwise, in the world. It is a black-brown liquor, secreted by a small gland into an oval pouch, and through a connecting duct is ejected at will by the cuttle fish which inhabits the seas of Europe, especially the Mediterranean. These fish constantly employ the contents of their "ink bags"

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[1] I. T. U. Lessons in Printing, Design for Printers (Indianapolis: International Typographical Union, 1939), Job Unit IV, Lesson 8, p. 31.

[2] David N. Carvalho, Forty Centuries of Ink (New York: The Banks Law Publishing Co., 1904), p. 5.

to discolor the water, when in the presence of enemies, in order to facilitate their escape from them. The black broth of the Spartans was composed of this product. The Egyptians sometimes used it for coloring inscriptions on stone. It is the most lasting of all natural ink substances.

It remained for Gutenberg and the early German printers to first use boiled linseed oil and lampblack about 1440 when movable type was invented. The early part of the nineteenth century brought the introduction of soap and waxes to make a clean, sharp impression. Next came the development of the aniline dye industry, and a long series of oils, including resin oil, mineral oil, China, or tung oil, and the semi-drying oils.

Charles Johnson established one of the first printing ink manufacturing plants in America in Philadelphia in 1804. The business has continued to the present time, the firm name now being Charles Eneu Johnson.

From such humble beginnings has developed the vast printing industry of today. In the United States, the graphic arts is now the fifth largest single industry, employing a quarter of a million wage earners and turning out products valued at more than two billion dollars annually.[3]

Ink plants today supply inks to 20,000 newspapers and magazines, thousands of package and label printers, and to

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[3] Inks of Today (New York: National Association of Printing Ink Makers, 1939), p. 4.

scores of subdivisions of the giant printing industry. As an indication of the tremendous quantities of printing ink required in modern printing, it is interesting to note that one large New York newspaper consumes 186,000 pounds of ink for a single Sunday edition. Yet one pound of ink will cover approximately 100,000 square inches. The complexities of and the scope of the printing industry today necessitate a great variety of printing inks, made from hundreds of ingredients to fit a thousand special purposes.

Composition of printing ink. Ink is composed mainly of vehicles or carriers, pigments or coloring matter, and driers and compounds.

Linseed oil and resin oil form the vehicle in the majority of inks. However, chinawood, perilla, soya-bean, cotton seed, fish oil, mineral oil, and many others are used for special purposes. Numerous gums and resins, waxes, and greases, both natural and synthetic, are cooked into some of these oils to impart special qualities.

The pigments are derived by chemical precipitation from three main sources--the mineral, vegetable, and animal kingdoms.

Some of the pigments obtained from the mineral kingdom are ultramarine blue, yellow ochre, raw umber, raw sienna, and Indian red. These are extracted largely from imported earths. Some of the artificial mineral pigments are Chinese white, pure scarlet, and emerald green. They are derived by chemical action. Almost any pigment can now be closely dupli-

cated by artificial means. Among the pigments secured from the vegetable kingdom are gamboge, a gum from a tree grown in Ceylon; indigo, from the leaves of the indigo plant; and yellow lake, from quercitron bark. Those obtained from the animal kingdom are India yellow, a deposit from the urine of a camel; sepia, from a secretion of the cuttle fish; carmine, from the cochineal insect; and indirectly, lampblack, the soot of burning vegetable oils.[4]

Nearly all black inks are made with carbon. Carbon black is made from natural gas, produced over a petroleum gusher, as in the oil fields of Texas, by burning the natural gas under a cold revolving drum and scraping the resulting soot from the surface into tanks. It requires about one thousand feet of gas to produce one pound of carbon black. The next most important carbon black, called lampblack, is a gray soot gathered from burning oil. Bone black is obtained by burning bones and animal matter. All carbon blacks dry poorly. Special driers must be mixed with these inks to overcome this defect.

Lead and chromium produce yellow pigments while iron yields blues. Numerous other organic pigments such as reds, oranges, purples, and all the so-called lake colors are aniline products derived by complicated processes from coal tar.

Previous to the World War of 1914-18, the best colors for inks came from Germany. When importation ceased, American

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[4]C. W. Hague, Textbook of Printing Occupations (Milwaukee: The Bruce Publishing Co., 1922-23), p. 200.

manufacturers set to work, and within two years a very fine line of coal-tar colors of home make was on the American market. The coal-tar products are less permanent than the earth bases, however.

Driers encourage quick oxidation and setting of the ink. Without the addition of driers, it would take a linseed varnish weeks to dry, instead of minutes.

Driers are usually metallic compounds of lead, manganese, and cobalt. They are used to make ink print smoothly. Those in the paste form include siccative, linoleates, resinates, tungates, and oleates. Liquid driers consist of lead, manganese, liquid cobalt, double boiled oil, turpentine, naphtha, and Japan. Paste driers should be given preference in all cases where colors are over-printed, as in process work.

Non-drying reducers such as beeswax, lard, raw linseed oil, olive oil, soap, sperm oil, tallow, thin varnish, and vaseline are used in small quantities on soft absorbent stocks.

All driers work best in a warm pressroom with a temperature of 70 degrees, and worst in a damp, cool pressroom.

Manufacture of printing ink. The manufacture of ink is quite a complicated matter and involves many scientific processes which are not exposed to the public. In the old days printers mixed their own inks on a slab with dry color and varnish and could make them crudely to suit themselves, but today inks are mixed by machines, insuring a more even coverage of the printed form.

The varnishes used are mainly linseed and resin oils, which are boiled until proper consistency or viscosity is obtained. Varnishes are named from No. 00000 to No. 10, according to the various consistencies. No. 00000 to 0 is thin, 1 to 4 is medium, and 5 to 10 is heavy. No. 10 is a very heavy sticky and gummy liquid, almost a solid.

Linseed oil is used in the better grade of inks on account of the property it possesses for absorbing oxygen from the air. When printed in a thin film, it forms a smooth, hard coating, dries rapidly, and does not rub off. Resin varnish is used in cheaper inks, dries much more slowly, and is intended for softer paper where it may soak into the stock. Both of these varnishes are made in America. The linseed oil with which they are mixed is very often adulterated, causing a great deal of trouble in the working of the inks. The adulterants are usually fatty or mineral oils, such as cotton seed and fish oils. These are much cheaper than linseed oil and account for variations in prices of inks.

The drying varnishes are of two kinds: oxidizing and penetrating.[5] Oxidizing varnish, as the name implies, dries by the action of air without soaking in the stock. The penetrating varnish penetrates into the paper, carries the pigment and varnish with it, fixing it firmly.

Ink is made by grinding the pigments and varnishes together in a machine, with massive hollow iron rollers, known

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[5] Ibid., p. 200.

as an ink mill. The substances are poured into this machine in proper proportions and ground until thoroughly mixed, sometimes requiring six or seven grindings. The cheaper the ink the less grinding. It is a highly technical operation and one which requires special training and expensive equipment to do well. Hackleman[6] tells of a simple red ink on the market--containing one dry color, the necessary varnishes, and a drier--which is composed of twenty-three substances and represents thirty-three processes from raw material to finished product. For that reason, printers seldom make their own inks, preferring to secure their supplies from established manufacturers.

Different mills are kept for different colors because it is difficult to wash all of the color out of them. The least speck of one color will throw the next color off shade. Some inks must be ground hot and others cold, and for this reason the rollers are hollow so that water of the proper temperature may be run through them. But even then the mills heat under the pressure and friction on the rollers when grinding is continued too long to remove the last vestige of grit. As the grinding continues, the ink thickens and becomes so pasty that it has to be thinned down before it will flow through the fountain of a printing press.

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[6]Charles W. Hackleman, Commercial Engraving and Printing (Indianapolis: Commercial Engraving Publishing Company, 1921, 1924), p. 574.

Manufacturers of printing inks are required to produce very thin, cheap ink for rapid printing on newspaper presses, and whole series of better grades of black adapted to presses operating at speeds varying from 500 to 20,000 impressions an hour. They are also called upon to supply all conceivable shades of color in all quantities, and adapted to all varieties of paper. The result is an almost infinite number of grades and kinds of ink for typographic and lithographic work. An ink maker must be a chemist, a dyer, a color printer, and above all have a perfect eye for colors. If given a sample color, he must be able to make ink to match exactly, and at the same time have it suitable for the particular kind of work for which it is to be used. One day he may be called upon to formulate an ink for some new and complicated printing machine; and the next, to supply a product to be printed upon documents for deposit in the corner stone of a public building, and which he is prepared to guarantee will remain legible and unchanged for a hundred years or more.

All ink makers have their secret formulas. Long experience has taught them how to grind and prepare the pigments, the exact temperature at which to add the varnish, tallow, soap, castor oil, beeswax, or other vehicle or drier, and when to introduce the various lead and manganese compounds used as driers. All ink factories employ expert chemists who are trained to cope with problems peculiar to the industry and who are prepared to handle almost any requirement of the printer for special inks.

Among the qualities that a printing ink must possess are a capability for distributing evenly, drying with just the proper slowness without leaving oil on the surface, and durability of color. While every ink manufacturer has his own standard line of colors and varieties, they all find it necessary to do more or less special mixing and grinding to meet new problems which may arise; as well as to satisfy customers who have their own ideas as to their ink requirements.

The chemicals used in some of the colored inks affect the metal in plates made of zinc and copper, but plates of aluminum and nickel are not affected.

Printing ink is manufactured with a view to its use in three different kinds of printing: from raised surfaces, or letterpress printing; from flat surfaces, or lithographic printing; and from depressed lines, or intaglio engraving. There are many kinds of ink in each of these main divisions, manufactured with a view to their use on some particular kind of paper, or in connection with some particular printing device.

The temperature of the pressroom much affects the working of ink. A desirable ink must not dry readily on the type from the ink rollers, but must dry quickly on the paper. In recent years it is common in high-grade printing to pass the freshly printed sheet quickly over a gas flame to set the ink.

Selecting the right kind of ink. The kind of ink used on any job should be determined by the paper stock. No ink

works equally well on all kinds of paper. To print well and economically, each kind of paper requires an ink especially adapted to its peculiar surface. Rough, heavy, colored stocks need an entirely different kind of ink from smooth paper. The colored papers require an opaque ink; that is, ink made from such pigments that no light is able to penetrate through it. A heavy cover ink has about twice as much pigment in it as the ordinary transparent ink.

If the stock is bond paper, a stiff tacky ink is necessary for good results. The surface of this kind of paper is hard, and a soft ink will not adhere evenly. An enameled stock has a sensitive coating, and a soft ink must be used to prevent the tack of the ink from pulling off the coating. Different kinds of paper also require different amounts of ink, depending upon their absorbing qualities.

Halftone cuts are usually printed on a smooth, coated stock and, therefore, require a soft ink with great covering ability. The best results in halftone black printing are obtained by carrying the body of the ink as heavy as the surface of the paper will stand without picking. This will leave a black impression by carrying very little ink. Many pressmen reduce halftone inks with varnish to prevent picking the stock. Hague[7] says this is altogether wrong because varnish is colorless and, while it lessens the tack, it also destroys the color. The ordinary halftone ink is mixed with a No. 1

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[7]Hague, op. cit., p. 202.

varnish because this grade is best suited for high finished papers. The same ink ground in No. 000 varnish, three grades softer, is best for reducing in case the ink picks. If this is added gradually, it will adapt itself to the surface of the paper and will not destroy the coloring quality of the ink.

The very best grade of halftone ink should be used for platen presswork, because the distribution is not nearly as good as on cylinder presses.

Bond ink, which has a heavy, tacky, short body, is made for hard stocks. It is made of a stiff linseed-oil vehicle and the best grade of carbon-black pigment. Bond ink is especially suited to letterpress printing on bond, ledger, writing, parchment, vellum, celluloid, and other hard surfaces. A little cobalt liquid drier is sometimes added to prevent offset.

Job inks work successfully on cheap bonds, office and factory forms, circulars, booklets, and the like, such as are usually printed on platen presses. Job inks are made from the same ingredients as bond ink, but with a thinner varnish and some liquid drier. If thickening is necessary, a little bond ink may be added; if thinning is indicated, a little reducing ink will be found useful. Job inks, both black and colored, are made opaque to print in one impression, but not to over-print, as in process work.

Cover inks have a heavy body to print on rough cover papers and cloth-bound books. They are available in any

desired color, including a very valuable white. With this cover white, the pressman can mix tints of any opaque color by simply adding a little of the bright color to the mixing white.

For book papers, book ink works best. There are several grades of book ink intended to be used on such stocks as sized and calendered, sized and supercalendered, coated, antique, English finish, and the like. Book inks are ideal for use on cylinder and rotary presses. A special book ink is made for use on antique stocks; also for printing from halftone engravings. A little toner is sometimes added to book ink to provide a slight luster.

The modern newspapers are printed with news ink which is manufactured in large quantities. It is the thinnest and cheapest ink made, although it prints type and coarse-screen halftones with remarkable clarity on the new mammoth high-speed presses. The best grade of news ink is made from lamp-black, resin varnish, and a little cyanide toner. Cheaper grades are made from carbon black, with asphaltum oil as a vehicle. No driers are ever added to news ink, as it dries by absorption and the driers would be wasted.

Inks for process-color work are entirely different from those used for ordinary color work; metallic inks cannot be used for water-color effects; doubletone inks will not yield high gloss effects; and regular inks will not take the place of the new "flash" inks.

Lithograph and offset inks contain the same general ingredients as for regular oil printers' inks, except that special pigments are required which do not bleed or scum or wash in water or fountain acids. Also special varnishes are necessary which will not mix or emulsify with water or acid solutions.

Water-color inks are much different from oil inks, in that they contain as a vehicle or carrier a liquid which is soluble in water. The drier also is soluble in water and does not act by oxidation but by absorption and evaporation only. This is why water colors will not dry on the extremely hard non-porous surfaces. Water-color inks usually carry full flat artistic effects of greater brilliancy and are faster drying on soft papers than the oil inks. Water colors do not dry on the press, offset and stick a great deal less, and are usually easy to over-print other colors. The vehicles in them are usually quite hygroscopic, especially when the humidity is high. This is why water colors are affected more by atmospheric conditions than oil inks. In damp weather they have a tendency to become soft and a little drier is often added to correct this. Water-color and oil inks cannot be mixed, and when changing from oil ink to water color, a cleaning of rollers, platen, and type is necessary; usually alcohol makes the best cleaner.

Metallic inks provide the gold and silver effects in printing. However, gold ink contains no gold, but a combination of brass and bronze powders; silver ink has an aluminum base. These inks were first put on the market in 1901,

but it was not until 1930 that they became popular with national advertisers, label and carton manufacturers, and printers of Christmas cards.[8]

Metallic inks may be obtained ready-mixed from the ink maker or as separate varnish and powder to be mixed by the pressman as needed. Considerable skill is required to secure satisfactory results with either form. Although some very good ready-mixed inks are on the market, best results are obtained by mixing the ingredients as needed. Most inks improve by moderate aging, but this is not true of metallic inks because the metal powders have no affinity for varnish. Freshly mixed metallic inks retain their brilliance, and, too, the pressman may vary the ingredients to meet the particular needs of the job. Coated papers give best results with metallic inks.

The recent introduction of new quick-drying or flash inks eliminates many of the worries regarding drying and promises to establish new standards in the trade for speedy letterpress printing.[9] "Instead of drying slowly by oxidation, these new inks use the principle of instantaneous vaporization, whereby the volatile vehicle is quickly evaporated by heat, leaving a layer of rich pigment on the paper. The heat is applied by rows of radiant burners or steam-heated drum

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[8] I. T. U. Lessons in Printing, op. cit., p. 14.

[9] Ibid., p. 17.

cylinders attached to the rotary press. Magazine speeds on color work approach those of rapid web newspaper presses. The printed sheets do not have to be racked for drying, but may be handled the instant they leave the press."

The beauty of high-gloss inks is making them increasingly popular among advertisers, packagers, and magazine publishers. The new gloss inks closely resemble the results formerly obtained by an extra impression of over-print varnish. They are available for single-color or four-color process work.

Gloss inks and over-print varnish contain a high percentage of linseed varnish which dries on the surface of the paper by oxidation. For that reason, the stock to be printed must be chosen with extreme care. Generally, the best results will be obtained with smooth, hard, non-absorbent coated papers. Soft, porous stocks are much more difficult to use because they absorb too much ink. If such porous papers must be used, the addition of a paste drier will help to hold the ink on the surface and hasten drying.

Since gloss is best obtained on a smooth surface, the gloss ink should be free-flowing and capable of leveling out on the paper before drying. Waxes or greases should be avoided, as these tend to shorten the ink and retard its free-flowing qualities.

Gloss ink has a disposition to cause picking. This fault may be overcome by the addition of a little kerosene. Sticking may be avoided by the use of a spray gun. Slip-sheeting and the use of gas heaters should be avoided, as

they are sure to mar the gloss surface.[10]

Among the different kinds are inks for one color or monotone work, duotone or two-color work, halftone and process halftone inks; lithographic ink for stone and metal plates, and for offset presses; inks for bond papers and for glazed papers; opaque inks for dark cover papers; inks for butter wrappers; the alkali proof or soap wrapper inks; alcohol and ether proof inks for pharmaceutical labels, permanent non-fading inks; the safety inks used for printing checks, etc.; stamping inks; copying inks; bookbinders' ink; inks for printing on wood, metal, glass celluloid, cloth, leather, and rubber; and many others, and all of those in various colors, shades, and tones.

In discussing the inks of today, the National Association of Printing Ink Makers says:

> Inks for special stocks of all sorts have been developed to such a degree that the special needs of the printer or the lithographer are nearly always met. The solution of the proper compounding of inks for special stocks, however, was not arrived at without many hours of painstaking research. Inks for lacquered stocks are vastly different from those required for foils. Fortunately, the ink maker, from his vast experience in handling such problems, knows just what lines to follow. Lacquered stocks vary widely in their reaction to inks. Many foil stocks are particularly difficult to handle, due to certain manufacturing differences. Inks for glassine, for high rag content bonds, for cellophane, pliofilm, acetate, and many other stocks, all require special formulation.
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> Food wrapper inks fall into another special class. As a rule most parchment printing is done for food wrap purposes. In many cases butter wraps, fish wraps,

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[10] Ibid., p. 18.

oleo wraps, celery wraps, and other food containers, must each be printed with inks designed for the specific use to which the wrap is to be put. A butter or oleo wrap will come in close contact with these greasy materials. Under certain requirements of shipping, packing, and storing, conditions may arise wherein a bleed may develop if the ink is not planned for the purpose. Fish wrap printing presents circumstances that are still more difficult to contend with than those encountered in butter wraps. Rapid changes from freezing to thawing and then to freezing again may completely destroy an ink if the formulation is not properly constructed. Celery wraps must withstand continual water soaking; labels for cake icings must be butter, lard, and sugar fast; candy, cooky, and biscuit inserts must have properly formulated inks to withstand the rigor to which such printed matter is subject. Odor is another consideration with which the ink maker must contend in all of these cases. The printer and the lithographer both must take great care to see that the ink maker is informed on all inks used for food wrap purposes. Many ink formulations have been developed and tested particularly for this use and only such inks can be used successfully on this type of special application. Other types of package inks must stand up in alkali, in acid, in alcohol, in soap sandwiches, in lacquers, and many other dhemicals and solvents, and the ink maker must call on all his experience and knowledge in order to produce such inks. In addition to all of which due caution must be observed in regard to food and drug legislation.

In recent years, many new discoveries have helped the ink maker in formulating resistant inks. Both pigment and vehicle must be carefully selected and compounded so that the action of both the soap and alkali are rendered ineffective. The ink maker must consider the solvent action of alcohol, lacquer solvents, chemical plasticizers, and a host of other materials used in finishing products to make various printed surfaces glossy or grease-proof; and even in laminating other films, such as acetate and cellophane. Very few of the ordinary ink formulations will stand up under the conditions prevailing during such processing. Yet the ink maker can be depended upon to furnish the proper inks for such work.

Specialty inks are almost too numerous to cover in detail, yet there are a few which should be mentioned here to give the reader an idea of the scope of this field. One of the prominent specialty inks is the so-called Spot Carbon ink. By the use of this ink it is possible to spot carbon for copying purposes at any desired location. Nearly everyone is

familiar with the work done in stamp cancelling of letters and also of the printing done by means of the postage meter machines. These cancellation inks can in no way be compared with any other type employed in the usual commercial printing. Stamp-pad inks function somewhat like stamp cancelling and postage meter inks; however, their formulations are again different. Mimeograph inks fall into this classification.

The all-important news inks dry by penetration and depend on the stocks on which they are run to give the results which we see in our daily newspapers. The news ink maker has developed a science of ink making far different from that employed in the oxidizing inks. Many recent advances in this field can be attributed entirely to untiring efforts to give the public a better newspaper. The increasing use of petroleum derivative vehicles for news ink has improved their quality and reduced the problems of strike-through, smudging, and rubbing. Color in newspaper work has skyrocketed, and today, more than half of the 1,900 daily newspapers in the United States offer advertisers some form of color--run-of-paper, comic, or rotogravure. The ink maker has kept pace with these advances in newspaper color, and he has developed suitable inks for all types of news color printing. Improvements in comic inks and their increasing effectiveness are recent contributions of the ink industry in this field.

The printing of fiber board and all types of rough paper containers consumes a very considerable amount of ink, and special formulations are required for this branch of printing. The inks usually dry by penetration, since the stocks are generally absorbent.

For many years, housewives have found use for the cloth containers in which foodstuffs and other supplies are purchased. It was desirable that the trade marks and other markings be of such a nature that they could be readily washed out, and yet they must also be water-proof, so that the commodities contained therein should not be damaged in transit. Inks made to conform to these unusual specifications are now available.[11]

The increasing use of decalcomania has brought improvements in inks for this field. Many "decals" are made either

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[11] Inks of Today, pp. 14-18.

partially or entirely by means of the silk screen process. The inks employed for these "decals" are built essentially on a lacquer or synthetic base.

The inks used in the production of outdoor posters must have certain properties not generally required of letterpress or lithographic inks. Work for exposed conditions must employ inks that are extremely resistant to sunlight and weathering. All the pigments used must be bleed-proof to paste and to rain water.

Many other types of specialty inks have been improved, or developed, to meet needs outside the sphere of ordinary printing. Among these are special inks for paper napkins which dry instantly without heat; inks for milk bottle caps and wax containers which dry upon contact with hot wax; inks for printing on glass and on plastics; inks for the photo-gelatin process; and inks for meat and food stamping.

Synthetic inks for lithographic work have already proved to be superior to the linseed varnish inks in many respects and their development, with much improved possibilities for quick drying, may be instrumental in bringing high-speed web offset printing.

Offset printing has found an important use outside of the graphic arts for the labeling and decorating of tin cans. Obviously it would not be very satisfactory to print from metal type or metal cylinders on tin sheets, since the latter's lack of resilience and softness would not allow good printing. On the other hand, the softness and give of the offset rubber

blanket is ideally suited for hard surfaces. Within the last twenty years, the development of the rotary offset press for tin printing has opened a large and fertile field for decorating tin packages. Synthetic varnishes which dry by oxidation are used in this kind of printing. They print sharper, being less subject to emulsification, and dry faster. The vehicle in some of the inks consists of solutions of synthetic resins in very high boiling solvents. Drying is not accomplished by oxidation, but by evaporation of the solvents with shorter exposure of the lithographed tin sheets to high temperatures.

Gravure printing demands an ink that is made up of a resin, a pigment, and a solvent. Drying depends upon evaporation. The application of nitro-cellulose and other synthetic lacquers has stepped up production from three or four hundred feet per minute in the early stages to 1,400 feet a minute.

Paper printing by the gravure method is even now in its infancy. Inks for use with engraved rolls or plates are so far developed as to anticipate further progress in gravure printing. So many applications, such as cellophane, oil silk, oilcloth, wallpaper, and fabrics, are suited to this process, that its scope is almost limitless. Each phase, however, demands an ink that is designed for a particular use. Printing of awnings by the gravure process was not included in the above group for the inks used are vastly different from the others. Awning inks depend on oxidation for their drying.

Wallpaper printing from engraved rollers is again quite different. Inks for printing on textiles, such as cottons or silks, fall into still a different classification and relate to synthetics that dry by polymerization. Permanency, non-penetration, and flexibility must be an integral part of these inks.

For best results, inks should be suited to the job for which they are intended. Failure to suit the ink to the material is the chief source of ink trouble.

Ink and rollers. Good rollers are among the most important of all the aids to printing of the better kind. Good rollers are the only ones that should be considered at any time. Printers who have found themselves without a sufficient supply of usable rollers have ruined jobs because of the unfitness of the rollers they were compelled to use.

Printers' rollers consist of a soft, elastic composition cast around steel cores. The material of a used roller closely resembles rubber. However, rubber is not used in making them. Glue is the principal ingredient, and it forms the body of the composition. Syrup in some form is added to give the rollers "tackiness," or power to take up and spread ink. Glycerin is added to give them greater durability and a longer period of freshness and elasticity, as it absorbs moisture and keeps the composition from becoming hard and dry. Varnish, paraffin, wax, borax, and castor oil are

also used in rollers, according to Polk.[12] Each manufacturer has his own formula, the proportions of which he varies according to the season of the year.

Rollers are very susceptible to changes in temperature and humidity. Therefore, it is impossible to make a composition roller that will be in perfect condition at all times. Heat will soften the composition and cold will harden it. It will absorb moisture from the air and become "tacky." A roller in perfect condition for printing yields slightly under a firm pressure of the finger, and has enough "tackiness" to cause the ball of the hand to drag, when it is rubbed over its surface. If the hand slides, it lacks suction. If the finger sinks into the roller, the roller is too soft; if it does not dent the roller at all, the roller is too hard.

Summer rollers and winter rollers are cast for the different seasons, and each kind is made to give the best results in the temperatures and weather conditions that prevail in its season. Summer rollers are more solid, and contain less glycerin, to withstand the heat and humidity of summer days. Winter rollers, on the other hand, are of softer composition so that they will remain sufficiently soft and tacky during the cold winter season.

Henry[13] warns that hot, humid weather is especially trying

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[12] Ralph W. Polk, The Practice of Printing (Peoria: The Manual Arts Press, 1926), p. 107.

[13] Frank S. Henry, Essentials of Printing (New York: John Wiley and Sons, Inc., 1924), p. 159.

on a composition roller; the atmospheric heat and the frictional heat sometimes being sufficient to cause the composition to "run down." Rollers should be carefully watched on hot, damp days.

Some inks have a very injurious effect on composition rollers, many of them possessing an astringent property which takes all the suction out of the roller.

Trucks and ink rollers must be kept at the same diameter. If the rollers are larger or smaller in diameter, the revolution of the roller does not move at the same speed with the trucks. As a consequence, the rollers drag over the type, leaving a light streak around the edges of the type faces, or a blur on a halftone cut. Rollers gradually shrink, necessitating adjustment of the trucks. Expansion roller trucks help the adjustment of platen press rollers.

The ink plate on a press is there to permit rollers to work ink into a film. Rollers come up on the plate, take on a film of ink, and carry this film downward to be deposited on the type faces. The rollers should pass over the type with very little pressure, just so they touch the type. Then, if the rollers are right, and the ink is of the proper consistency, the type will pick up the film and transfer it to the paper with a nice, clean, sharp outline.

Condition of rollers is reflected in consumption of ink. Old rollers, hard rollers, lifeless rollers, all require more ink to get a uniform color on the form and sheet. A greater film of ink is necessary when printing with a set of uneven

rollers. The last roller to leave the form before it prints should be the best roller in the set as this roller evens the ink before the form is printed. Old rollers which contain cracks in the surface cannot be run on a light color job after once having been used for black ink. The ink which has gotten into the cracks will constantly affect the color of such ink by making it dirty or darker as the run progresses.

Rollers are easily injured, and should receive the best of care. They should always be thoroughly cleaned with kerosene after a run, or at the close of the day, and it is a good practice to cover them with a thin film of oil for the night, to keep them from drying out. Unlike gasoline or benzine, kerosene leaves a certain amount of oiliness on the rollers that is conducive to long life. Benzine evaporates quickly, and frequently takes the suction with it. If the ink has dried hard on the rollers, a little crude carbolic acid will quickly remove the dried ink without harming the composition; in fact, it will tend to revive the face of the rollers. The ends of rollers should be given special attention when oiling and washing.

When rollers are new, they are said to be "green," in which condition they sometimes refuse to take ink. If possible, they should be seasoned a few days before being used, by standing on end in a cool, dry, well-ventilated place, away from steam pipes. To retard the aging of seasoned rollers, cover them, when not in use, with a coating of vaseline, cup grease, or a mixture of glycerin and vaseline.

The rollers must never be left up on the disc, even for only a few minutes, as this will flatten them. Also, they should never be left against any part of the type form in the chase. The proper position for the rollers at all times when the press is not in motion is at the extreme bottom of the track, below the form. When rollers are removed from the press, if there is no roller rack they should be placed in a perpendicular position, and no pressure should be put on the composition.

Civilization owes much to the simple composition roller. Without it high-speed presses were impossible until quite recently, for no other known substance had such an affinity for printing ink or lended itself so readily to the peculiar needs for which it was used. Ben Foster, a printer of Waybridge, England, was the first to suggest the adaptability of this material to printing in 1807.[14] He found the potters of Straffordshire using "dabbers" made of the composition. Two years later, Bryan Donkin, an engineer, cast the composition into the form of rollers, by melting and pouring it around a steel core inserted in the center of a metal cylinder. In 1813, composition rollers were used successfully on the first cylinder press, invented by Friedrich Koenig two years previously. Recent experiments with vegetable oils and

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[14] I. T. U. Lessons in Printing, Elements of Composition (Indianapolis: International Typographical Union, 1939), Job Unit I, Lesson 8, p. 11.

synthetic rubbers have resulted in the production of press rollers which seem to have several points of superiority over composition rollers, chief among which is that they do not expand or contract with the seasons and, therefore, last longer.

Color mixing. Mixing of inks is usually left to the ink manufacturer who is supplied with all the information necessary for his purpose, but many special colors and tints must be made up as needed in the pressroom. Inks are mixed on a clean, smooth surface, with a spatula, or ink-knife. Ordinarily, a marble slab, a piece of thick glass, or a cardboard, is used as a mixing-board. Glass is best, as ink cannot penetrate it, and it is easily cleaned.

To avoid wasting, it is well to mix a small trial batch of ink, noting the proportion of each color. It is best to start with white, or the lightest color to be used, and then add other colors sparingly. If the lighter color should be added last, it would take much more ink to secure the proper proportions, and would result in an over-supply of the mixture.

The mixing-board and knives must be absolutely clean when mixing colors. A small speck of coloring substance may throw the whole mixture off. If inks are mixed on glass, it is well to place a sheet of white paper under the glass as an aid in visualizing the color that is being made up.

In order to ascertain the exact color of the mixture, a very small quantity should be spread out thin on a white sheet,

for examination, as the ink in the mass will appear slightly darker than the color will prove to be when it is printed on the sheet. If the ink is to be printed on colored paper, the test should also be made on a sheet of the stock that is to be used.

Tints are made by adding the body color to mixing white ink, never the reverse. Add a little at a time, experimenting until the proper tint is secured. If a shade is desired, add black, or some darker color to a volume of the lighter color. Mix thoroughly until the new color is uniform throughout.

Of all the colors of the spectrum, red, yellow, and blue are the only ones which cannot be obtained by mixing other colors, but by which, on the other hand, all other colors may be obtained. The I. T. U. Lessons in Printing[15] credit this theory to Sir David Brewster. They state further that many color students, especially Young, Helmholtz, Andrews, and Munsell, contend that the three primary colors are red, green, and ultramarine blue, and the corresponding secondaries, yellow, blue-green, and violet. They prove their contention by using rapidly revolving color disks. These, unfortunately, have no counterpart in inks which shine by reflected light and with which the printer and advertising man must render color. The so-called red-yellow-blue theory seems to be the simplest, most widely used, best understood, and most practical

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[15] I. T. U. Lessons in Printing, Design for Printers, Job Unit IV, Lesson 9, p. 3.

for educational purposes. It is the only theory which can be proved by the use of pigments.

Various peoples seem to be influenced by the nature of their surroundings, the atmosphere, climate, vegetation, etc. The Italians, as a race, are fond of the bright colors and the bright hues, which correspond with the sunshine and brilliant tones of their native land. In England, the land of fog and mist, dull, drab colors prevail. The Indians like red of almost the same hue as their skin; the black and brown races from equatorial regions love the gorgeous colors of the tropics.

The colors to which the average man or woman are most sensitive are red, green, and black. Black on a white background is more effective than white on a black background. Some strong colors will attract attention but they will not hold it. Too many colors simply confuse the eye and too bright colors produce a sense of shock. The best result is obtained by the use of the definite color scheme, but with the lower tones predominating. The object to which attention is to be directed should be printed in a strong color, the background in a tint.

Some color combinations, according to Hackleman[16] which are good from an artistic standpoint and which will result in artistic and attractive printed matter are:

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[16]Hackleman, op. cit., p. 585.

Color of Paper	Color of Ink
Black	Dark red, gold and white, light blue and silver
Light blue	Purple, dark blue, light yellow and yellow brown
Dark blue	Light blue and white, green and yellow-red, dark red and gold
Light brown	Green, gray and lilac, dark brown and silver
Dark brown	Light drab, yellow-red, black and white
Light green	Gold, dark brown, yellow-red, dark green
Dark green	Gold and white, black and light brown
Light gray	Dark blue and gold, dark gray and red
Light red	Rich green, blue and white, olive-brown and gold
Dark red	Dark green, yellow-red and dark blue, white and gold
Light yellow	Red, light blue
White	Emerald green, navy blue, crimson red

Some color combinations that are offensive to the artist's eye and tend to create a disagreeable sensation in the mind of most observers are red or yellow-red with violet; yellow-red with blue-green; yellow-red with purple; chrome-yellow with green; yellow with green; greenish-yellow with turquoise; yellowish-green with blue-green; normal green or blue-green with turquoise.

Three color combinations that are considered strong are red, yellow, and blue; yellow-red, green, and purple; and green-yellow, purple, and purple-blue.

While the process colors, red, yellow, and blue, harmonize with each other, more pleasing results are obtained when these colors are combined to form different tones. A black page increases in interest with a touch of red, preferably vermilion. The colder colors should always form the predominating tone. Backgrounds of bright red and bright yellow do not admit of the use of any color in printing excepting black, if harmonious results are wanted.

In the use of contrasting colors they should be of the same shade or tint in order to give a pleasing appearance. A deep red should not be used with a light blue, nor should a heavy black border be used with headlines set in light face type, as the body of the text will form sufficient contrast. However, to call especial attention to some particular feature, the color may be intensified in that part.

Any small object imprinted in color on a large background of a different color will be given a different color tone by simultaneous contrast.

Most of the colored inks used in job printing are semi-transparent or transparent, excepting those especially made for use on colored stocks, such as covers, and those are opaque. The difference between opaque and transparent inks is not noticeable on the ordinary printed page, unless the tone or shade of the ink is affected by the color of the paper, or unless one color has been used in over-printing another. When a tint is printed to appear as underneath another color, it is necessary to print the tint first, if the tint is an

opaque ink, although it may be printed last if it is transparent.

Ink coverage and estimating. An experienced pressman quickly learns to judge the amount of ink to carry in order to secure a clear print and without danger of offset and other troubles. No more ink is ever carried than is actually necessary to secure a clean, readable impression. The exact amount can be determined by looking at the wet film with the light striking it an an angle. One learns to be guided by the manner and speed of setting and drying. He also can tell much by rubbing his finger lightly across the wet ink. Such knowledge must be acquired by actual experience and the development of good judgment.

A trifle less ink than will be required on the run should be used in starting a makeready on coated paper. On other paper, use the same amount of ink for makeready that is used on the run. Offset will result if more ink is used on the makeready than will be required on the job.

The amount of ink required to print a job will depend upon the character of the stock, its absorbency, area of surface to be printed, amount of ink carried, color and specific gravity of the ink, and other factors. Rough stock requires two to three times the ink that smooth or coated stock requires. Cover white ink is very heavy and, if run on a coarse stock, is consumed rapidly. A light tint spreads thinly and will go four or five times as far if printed on smooth paper.

Table I[17] shows the approximate coverages for various inks on different kinds of paper. The figures show the approximate covering in square inches of a pound of ink on ordinary solid type matter, including allowance for waste and washups. For opaque greens and oranges, use the same scale as for yellow inks; for transparent browns, oranges, greens, and purples, use the blue scale.

TABLE I

INK-COVERAGE TABLE SHOWING APPROXIMATE NUMBER OF SQUARE INCHES OF TYPE MATTER COVERED BY A POUND OF LETTERPRESS INKS

Stock	Black	Blue	Red	Yellow
Coated	2,000,000	1,700,000	1,600,000	1,200,000
S. and S. C.	1,600,000	1,500,000	1,400,000	1,100,000
M. F., news	1,400,000	1,300,000	1,200,000	990,000
Offset	1,300,000	1,100,000	1,000,000	930,000
Bond	1,200,000	1,100,000	1,100,000	960,000
Rough cover	930,000	870,000	840,000	820,000
Cellophane	2,300,000	2,300,000	2,200,000	2,000,000

For a solid tint block, divide above figures by .0857.

Using a machine-finish stock, halftone black ink, and a type page of medium gray tone, it will be found from the table that one pound of ink will cover approximately 1,400,000 square inches of paper. Hence, to find the quantity of ink required to print a job of average weight, multiply the square inches of printed matter in the job by the total number of

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[17] I. T. U. Lessons in Printing, op. cit., p. 29.

impressions and divide by 1,400,000. The result will be the number of pounds of ink needed for the job.

An example will probably help to explain the table:

> A book contains 312 pages of type, 27 x 40 picas. How much black ink on M. F. stock will be required to print 15,000 copies?

$$\frac{27 \times 40}{36} = 30 \text{ sq. in. per page.}$$

$$\frac{312 \times 30 \times 15{,}000}{1{,}400{,}000} = 100.28 \text{ lbs.}$$

The cost of the ink varies with the kind and quality; reds, blues, greens, etc., in the better grades are more expensive than blacks. Karch[18] says that 5 per cent is usually added to the cost if printing is done in black ink; 10 per cent if colored.

The care of ink. Most inks form a scum quickly when exposed to air, and if the exposure is continued for a considerable length of time, they will become livered and there will be a needless waste of ink. For this reason, the lid should always be replaced at once whenever the can is used. This same rule should apply to inks in tubes. When a can of ink is placed on the shelf for an indefinite period, an oiled paper should be drawn across the top of the ink can and the lid pressed down over it, to further seal it. Some pressmen pour a film of oil over the top of the ink, or fill

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[18] R. Randolph Karch, Printing and the Allied Trades (New York: Pitman Publishing Corporation, 1939), p. 169.

the can up with water, to prevent deterioration, and scumming.

In removing ink from the can, do not dig deeply into the can, but take it from the top without disturbing the lower mass of ink. Always leave the surface smooth, so that air cannot penetrate it. The ink knife should not be left in the ink.

Care should be used not to bend the lid or the can; otherwise, it will be unsuited for further use as a container because air admitted, even through a small crack, will cause the ink to harden.

If care is not exercised in moving ink from the ink can to the fountain, particles of "skin" may be taken. Or, if the ink cans are left standing open, dust and dirt get into them, and again this foreign matter is carried to the fountain. Dirt may produce an effect on the printed sheet similar to picking, and dirt and skin fill up type, and the screen in cuts.

Ink remainders should be carefully labeled if modified by reducers, driers, and the like; otherwise future troubles may be expected.

Overcoming ink troubles. The doctoring of inks with prepared liquids and pastes should be avoided as much as possible. In a few cases the patent chemicals may be helpful, but, unless the pressman knows what the result will be, he will most likely destroy some of the working properties of the ink. None but a chemist can tell what the reaction of chemicals will do, and what may help one ink may be absolutely wrong for

another. The best method is to have two grades of the same ink for reducing and adding tack.

Enameled and coated papers pick easily if the ink is too tacky. Sometimes this happens because the press is being run too fast. The reason can be detected by running the press slowly. If the paper still picks, the trouble is in the ink, and ink with shorter body should be added to cut down the tack.

Ink for bond and book papers is made to dry principally on the surface of the paper; the penetrating element in ink is to open up the paper coating so ink can take hold. Ink is not intended to soak into paper. This fact should be kept in mind; it accounts for offset. Ink is intended to be laid on paper in the merest film. Squeezing ink into paper with a heavy impression is not a remedy for offset--it indicates lack of study of the problem.

If the ink does not lay smooth, but looks mottled or freckled, add heavy varnish, a little at a time, until the ink is right.

If a medium-grade black ink has a tendency to offset on high-grade stock, and proper ink is not available, the ink should be toned with deep bronze or reflex blue; that is, work in this blue a little at a time until the black ink works out right. Blue can be added up to nearly 15 per cent before it begins to throw a bluish cast into the black.

In transferring printed sheets from the delivery board to the drying racks, pick up the stock without rolling it. Do not attempt to jog the pile while the sheets are "wet."

Rolling or jogging before the sheets are thoroughly dry, usually cracks the delicate film that has begun to form, exposing wet ink with consequent offset.

One of the difficulties of printing and handling wet sheets is the tendency of the ink to transfer to the back of the sheet just above when piled. This often necessitates the use of slipsheets, a slow and costly process of inter-leaving the printed sheets with pieces of oiled or porous stocks; of spraying with a wax preparation, if such equipment is available; or of doctoring and manipulating the ink to prevent the offset.

Offset may be caused by too much ink, improper make-ready, static electricity, improper handling of sheets, and using an ink not suited to the paper.

If the cause is too much ink, the sheet should be held to the light or rubbed with the finger to test the amount of ink and its distribution on the sheet. If too much ink is being used, reduce the film of ink by strengthening the color, double-roll the form between impressions to hold sufficient color, or give the sheet two impressions. The addition of a small amount of a greasy substance, such as lanolin or vaseline may help; if not, slipsheet the job.

Double-rolling a form will sometimes save ink and money as compared with an attempt to run full color and one impression, a method which does not always work out economically or satisfactorily. Heavy forms requiring two impressions need 60 per cent more ink than is necessary for one printing.

Double-rolling the form takes 20 per cent more ink than is required for single-rolling. Double-rolling a job, then, is more economical than the double impression so far as ink consumption is concerned.

Improper makeready may cause offset. Too little impressions on the solids and too much on the type will cause the sheets to rub and offset. A hard packing will help to overcome this difficulty. Sheets coming off the press should drop in the jigger box with a minimum of sliding and with as much air between the sheets as possible.

Static electricity is one of the main causes of offset. The remedy is to raise the temperature of the pressroom to 70 or 75 degrees Fahrenheit and the humidity to 50 degrees or higher. Seasoning the stock for a few days under similar conditions will help greatly. If these fail, a gas or electric neutralizer or wax spray system should be used. Loomis[19] suggests stringing a piece of ordinary Christmas-tree tinsel across the press, between the platen and the delivery board, where sheets will drag over it as they are removed from the press. With copper wire, ground the tinsel to a water pipe. If tinsel cannot be obtained, cut some tin foil into long shreds, wrap this around a copper wire so a great many ends stick up presenting a fuzzy surface. Make a clean ground, the same as for tinsel. The line across the

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[19] R. A. Loomis, Printshop Practice (Milwaukee: The Bruce Publishing Company, 1928), p. 95.

press should be placed so it will not interfere with feeding, nor with removing the sheets from the platen. It should be in such position that the sheets will brush over the line and so sweep out the static.

In handling freshly printed stock, the sheets should be lifted by opposite corner margins and piles should be held to 100 sheets or less.

The ink should be suited to the paper; that is, a soft ink should not be used on hard-surfaced papers, or other impossible combinations attempted. If the ink is slow in drying, add a bit of paste drier to speed it up.

Offset is sometimes caused by ink that is too soft. Such ink encourages the rollers to slide and slur over the form. The addition of a little No. 6 varnish will frequently pull the ink together and remove the trouble.

Offset may be entirely eliminated by the use of machines which spray liquid paraffin or volatile drying preparations on the printed sheet, as it passes through the press. The paraffin mist solidifies into pin-point particles, as it touches the stock, thus preventing direct contact of the wet ink with paper piled upon it. The spray particles are practically invisible on the printed stock, but may be detected by passing the finger tips over the slightly waxy surface.

Driers are substances which hasten oxidation and prevent offset and sticking. There are three kinds of driers--paste, liquid, and Japan. Ink manufacturers always include from 3 to 5 per cent of drier in their inks, to which the pressman

is sometimes required to add one-half an ounce to the pound to meet special needs. Too little drier in an ink may jeopardize the speedy completion of a job; too much may cause offset, sticking, crystallization, and other troubles.

Japan driers are thin, quick-drying varnishes, such as dammar, copal, and balsam of copaiba. They prevent chalking and are fairly satisfactory driers for black, inexpensive magazine and book inks, but are not so desirable as either paste or liquid driers for colored inks. In reducing the body, they also reduce the color strength of the ink.

Reducers are oils and varnishes of considerable vigor. They soften and lengthen stiff, tacky inks, cause them to work better, and help to prevent sticking and picking. Balsam of copaiba, castor oil, olive oil, linseed oil, and the varnishes do not affect the luster of the ink quite as much as some of the other reducers. Paraffin oil or wax and vaseline are especially useful in preventing sticking when piling sheets, and picking on the press. Kerosene destroys tack, hastens penetration, and increases coverage. Four or five drops of citronella oil are also a valuable reducer.

Reducers have one weakness. In addition to softening the ink, they tend to weaken the color. For that reason, it is better to use a reducing ink rather than the reducer itself if maintenance of color is essential. A reducing ink is very thin and liquid, but it is made with a maximum amount of color pigment. It is available in black and colors.

The stiffeners retard drying and provide a dull finish. They consist of oils and greases, chalk, and magnesia powders.

Some of the common ink stiffeners are: beeswax, cornstarch, boiled linseed oil, powdered magnesia, paraffin wax, precipitated chalk, stiffer ink of same color, and varnishes 5, 6, 7, 8, and 9.

A proper appreciation of the changeable composition of a printing ink and of the multitude of variable conditions that arise during its use usually leads to the best ways of overcoming ink troubles.

Tables II and III on the following pages outline some of the major ink troubles, giving the nature, possible cause, and possible remedy for each one as prepared by the International Typographical Union in their lessons on printing. Although the list is far from complete, it will give the printer a working basis and perhaps start him on the road to the solution of his own problems. Nearly every ink problem has to be solved in the light of its own surroundings.

TABLE II

CAUSES AND REMEDIES FOR IMPROPER DRYING*

Name of trouble	Nature	Possible cause	Possible cause
1. Drying too fast.	Rollers get tacky; possible picking; poor, uneven print which becomes worse with continued running.	1. Too much drier in ink. 2. Too fast drying vehicle or pigments in ink.	1. Add non-drying compounds. 2. Add paraffin oil. 3. If too severe, the ink should be replaced.
2. Drying too slow.	Prints smear; ink feels wet.	1. Not enough drier in ink. 2. Too much non-drying oil or compounds in ink.	Add suitable drier, depending on stock or length of run.
3. Crystallization	Subsequent colors do not take well on previous colors. Last color can be rubbed off easily.	1. Base colors do not penetrate stock sufficiently. 2. Subsequent colors do not set into base colors. 3. Previous colors have dried too hard. 4. Wrong drier used.	Use oversize compound, or 5 oz. beeswax, 5 oz. paraffin wax, 5 oz. No. 5 varnish; heat; use 1 oz. to 1 lb. of ink. Rubbing of crystallized ink with dry or damp rag.

*Source: I. T. U. Lessons in Printing, op. cit., p. 18.

TABLE III

CAUSES AND REMEDIES FOR IMPROPER INKING*

Caking

Nature: Screen and fine work filled in. Ink piles up in spots on plate or form.

Possible cause: 1. Ink too short. 2. Too much ink run. 3. Ink too soft. 4. Ink too heavy. 5. Ink reduced too much. 6. Not enough varnish to pull color along.

Possible remedy: 1. If ink is heavy-bodied, reduce with varnish No. 0 or No. 1. 2. If ink is soft and soupy, add varnish No. 5 or No. 8 or body gum.

Chalking

Nature: Ink is dry, but does not hold to stock on rubbing under pressure. Color remains on top.

Possible cause: 1. Not enough binder to ink for stock run. 2. Vehicle penetrates stock too much. 3. Ink too short.

Possible remedy: 1. Add long varnish or body gum. 2. Add good drying varnish.

Filling Up

Nature: Screen and fine work fills in. Form fills up. Rollers pick dirt from plate and air.

Possible cause: 1. Ink too tacky. 2. Poor stock. 3. Very fine pick. 4. Collection of dust in air, in stock, or in brush.

Possible remedy: 1. Reduce ink with good reducer like boiled oil or compound. 2. Endeavor to keep air in pressroom free from dust. 3. Protect rollers with canvas apron.

Poor Distribution

Nature: Ink does not work out smoothly on rollers or table; print is uneven.

Possible cause: 1. Ink too heavy. 2. Water-logged rollers. 3. Poorly set rollers. 4. Hard rollers.

Possible remedy: 1. Add a suitable varnish to increase or decrease body as required. 2. Use tacky rollers.

Mottling

Nature: Print "pebbly" and not smooth; shows more ink in some spots than others.

Possible cause: 1. Improper consistency, if the ink is soft, gives a squashy, smeary, mottled print. 2. Earth pigments may give a mottle that cannot be helped by manipulation. Brown, green, sienna, etc.

Possible remedy: 1. If ink is soft and smeary, add long varnish or body gum. 2. Magnesia powder, added to ink helps

TABLE III--Continued

CAUSES AND REMEDIES FOR IMPROPER INKING

mottle on solid form. 3. Strengthen color and run less ink. 4. Reduce amount of machine oil or kerosene. 5. Use a drying compound.

Printing Not Sharp

Nature: Slur on edge of print; lack of detail; fine work is not clean enough.

Possible cause: 1. Ink too short. 2. Work may be worn away by poor working ink. 3. Body of ink soupy.

Possible remedy: 1. Improve body of ink. 2. Eliminate greasy materials. 3. Add body gum.

Picking

Nature: Large or small particles of paper are torn off. Particles collect on plate and print.

Possible cause: 1. Too much body to ink. 2. Too much impression. 3. Ink dries too fast. 4. Coating of stock poor. 5. Rollers too hard. 6. Temperature too low.

Possible remedy: 1. Use a softer ink. 2. Use a retarder. 3. Good rollers. 4. More impression on solids. 5. Raise temperature.

Rubbing, Especially on Dull-Finished Papers

Nature: Ink, although dry to touch, smudges. Stock dirties from rubbing.

Possible cause: 1. Generally occurs with solids on dull-coated stocks and on highly absorbent papers.

Possible remedy: 1. Make ink longer. 2. On dull-coated stock, the likelihood of entirely eliminating this trouble is remote. 3. Extra-careful handling.

Smearing

Nature: Impressions not sharp; edges of print are slurry; generally bad offset.

Possible cause: 1. Ink too short and tackless. 2. Too much ink run. 3. Rollers not set correctly.

Possible remedy: 1. Run less ink. 2. Use better-bodied ink and add long varnish. 3. Change rollers.

Smudging in Folder or Cutter

Nature: Ink not thoroughly dry. Ink does not adhere to stock firmly enough.

TABLE III--Continued

CAUSES AND REMEDIES FOR IMPROPER INKING

Possible cause: 1. Not enough drier in ink. 2. Not enough binder in ink. 3. Did not surface dry.
Possible remedy: 1. Add more powerful drier. 2. Add either a longer varnish to ink, or a good-holding, fast-drying varnish.

Sticking of Sheet

Nature: Sheets stick solidly together; sheets stick partially together and tear as separated.
Possible cause: 1. Too much gloss in ink. 2. Inks do not penetrate enough into stock. 3. Too much ink run. 4. Too much liquid drier.
Possible remedy: 1. Run less ink. 2. Add setting compound. 3. Use less drier. 4. Use shorter varnishes. 5. Add cornstarch.

Color Lacks Snap

Nature: Weak in color value.
Possible cause: 1. Ink too thin. 2. Not enough color. 3. Cheap ink. 4. Too much reducer.
Possible remedy: 1. Add stronger color. 2. Add powders: blue--blues and blacks; red--reds and browns; green--greens and yellows.

Backing away from Fountain

Nature: Ink does not follow fountain roller; print is light and dark in spots; cannot keep color uniform.
Possible cause: 1. Ink too short. 2. Not free-flowing enough.
Possible remedy: 1. If complaint is mild, stir ink occasionally. 2. If complaint is serious, add fairly good-bodied varnish; lay weight in fountain against ink.

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*Source: I. T. U. Lessons in Printing, op. cit., pp. 24-25.

Trends in printing ink. Back of printing ink today is modern scientific research. Advances in printing ink mean advances in printing, and the last few years have produced changes in ink manufacture which have revolutionized the graphic arts. New inks have made possible faster printing and finer printing.

For many years, paper makers have tried to develop some satisfactory process for removing printers' ink from old papers. Reasonably successful processes have been developed from time to time but in general, the problem of removing the finely divided carbon black, which constitutes the basis of most printers' ink, involves such expensive washing treatments that it hardly pays to reclaim the paper fibers.

Buchanan tells of an experiment which was carried out with the purpose of reclaiming old papers.[20] The most ideal publication for the purpose proved to be telephone directories. Arrangements were made with telephone companies to print their directories with a special ink developed by the Hilton Davis Company of Cincinnati, Ohio, which contained no carbon black and which could be bleached with hypochlorite solution and "discharged" with reducing agents such as sulfur dioxide.

The old books are first fed into a machine which rips off the covers, tears apart the pages, and separates the white paper from the colored. The paper is then ground up to fibers

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[20] A. E. Buchanan, "New Ink to Permit Reclamation of Paper," Scientific American, 151 (July, 1934), 42.

in rod mills, which it leaves in the form of a pulp suspension. This pulp is then treated with sulfur dioxide gas which discharges the ink, leaving a clean white pulp which can be fed directly to the paper machines to produce new paper of perfectly satisfactory quality.

This process is adapted primarily for the reclamation of wood-pulp papers whose permanency is not important.

In the Scientific American for February, 1936,[21] Buchanan describes a chemical spray which will enable increased press speed up to 40 per cent. It covers each printed sheet with a microscopic film that prevents offsetting, thus eliminating the slow laborious method of hand slipsheeting.

One gallon of solution, known as "No-Offset," has a covering capacity of from 60,000 to 200,000 square feet, depending on the type of ink and stock used. One automatic airgun will cover paper widths from one to 42 inches. Two guns, the most ever required, will cover up to 84 inches.

The solution as it comes out of the airgun, is broken into a fine mist which covers the sheet with countless tiny particles and serves to separate the sheets so that the wet ink cannot touch the next sheet as it enters the delivery pile. This coating is so fine it can be detected only with the aid of a magnifying glass, and does not interfere with the drying of the ink nor affect the color in any way. It

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[21] A. E. Buchanan, "Chemistry Speeds Up Printing," Scientific American, 154 (February, 1936), 108.

appears further to counteract the effect of the static electricity in the paper, which tends to draw the sheets together. The solution is misted on the printed side only and has no effect on subsequent impressions as it is said that the particles dissolve when touched with inks or varnish.

The limiting factor on printing speed today is the time required for liquid ink to dry. Heat, more heat at a higher temperature, has been applied until the paper has been tried to the limits of its endurance in many cases.[22]

A new approach to the problem of high-speed printing and better printing is now offered in the form of ink and apparatus combined in a printing process which sets or dries ink by cold, not heat. It promises to relieve the paper manufacturer of many of the problems which he now faces as a consequence of too much penetration and too much heat.

Cold-set printing is the process of drying ink by freezing instead of by absorption, evaporation, oxidation, or polymerization. All inks when dry on the paper are solid mixtures of color and binder. In the process of printing, however, the ink must be fluid in order to feed from the fountain to the relief printing surface in controlled amounts. In ordinary printing, this fluidity is obtained by using fluids and a fluid mixture of color and binder is deposited on the paper. This creates the printer's major problem--drying.

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[22] "Printing Process Freezes Ink," Scientific American, 162 (April, 1940), 226.

In the cold-set process, the fluidity of the ink necessary to feed it properly from the fountain to the relief surfaces is done simply by melting the solid which is finally wanted as a deposit on the paper. The fountain, the ink carriage steels, and the plate cylinder are all heated by hot water from within. This keeps the normally solid ink fluid and controllable. When the hot ink touches the cold paper (that is, cold as compared with the temperature of ink) the ink freezes or solidifies without penetration and remains as a solid deposit in relief on the top of the fibers. The paper fibers may be loose or tight. They may be uncoated or coated. The cold-set ink from a halftone dot always sits on top of the fibers or coating in sharp relief where it was deposited. There is no lateral spread or vertical penetration due to fiber suction as with liquid inks.

This same process is discussed briefly in the Science News Letter for March 2, 1940, as follows:

> A new kind of printers' ink that is sold in chunks, looks like coal when broken up for use, and may revolutionize printing by speeding up the process and turning out clearer print for reading, was described recently.
>
> A "cold-setting" ink, the new printing material dries instantly on paper as it comes through the presses. The faster the paper goes through the press, the greater is the setting effect, it is claimed. It appears then that the only limitations on speed of commercial presses would be those of the machinery itself.
>
> Cold setting reverses the usual tactics of heating the paper in order to dry the ink when the printed sheet runs over high-speed rotary presses. Instead, the ink is first melted and applied to type which is heated and when hot ink touches cold

paper, it freezes and remains as a solid deposit in relief on the fiber.[23]

In melting and then solidifying, the ink undergoes no chemical change. It does not dry by absorbing oxygen from the air, or by evaporation of volatile solvents, or by penetration into the paper.

The printing plates are left clean after each impression for the touch of the cold paper freezes the ink and lifts it bodily from the plates. This plus the fact that the ink does not gum or harden on the press makes washups unnecessary except to change color.

This "Velo Cold Set Process," as it is called, has been developed by J. M. Huber, Inc., 460 West 34th St., New York, N. Y., and is now available for rotary presses to which it is particularly adapted. Its release for flat-bed presses is expected soon.

A further step in the search for smudge-proof printing inks is the development of a plastic base, Aruba Bitumen, which in effect, puts a plastic impression on paper.[24] Ordinarily, printing inks are manufactured with linseed oil, resin oil, rosin, varnish, or a similar heavy oil as a base, in combination with lampblack or other pigment. The Aruba Bitumen merely takes the place of the heavy oil in the formula.

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[23] "New Printers' Ink Comes in Lumps Like Coal," Science News Letter, XXXVII (March 2, 1940), 137.

[24] "Plastic-base Ink," Business Week, No. 603 (March 22, 1941), 62-63.

Aruba-base ink achieves its "smudge-proof" qualities by cooling. The drop in temperature when it is spread thin enough for printing is sufficient to form a hard coat, according to its distributors. Aruba ink is printed at room temperatures and does not require a special ink fountain or well on presses. Wilson Carbon Co., 122 East 42nd St., New York, N. Y., the new product's distributor, also says that Aruba is of a more uniform consistency than natural oils, has a high melting point (400 degrees), and in solution is free of solids. While Aruba is in no sense a pigment, in manufacturing rotogravure inks, it possesses another advantage--little additional pigment is necessary since it already has a dark brown color.

The plastic is produced from Venezueland crude oil on Aruba Island, where the western hemisphere's largest oil refineries south of the United States are located. This is just twelve miles off the coast of Venezuela. Developed by a subsidiary of the Standard Oil Co., the process of manufacturing Aruba is one of isolating a special group of hydrocarbons. Through heating and chilling, the plastic is changed from a heavy liquid to crystals which resemble 2-inch slack coal. It is then bagged and shipped to the United States, where it is sold to ink manufacturers and fabricators by Wilson Carbon. Before use, it is again changed to a semi-liquid by solvents or by heating process for letterpress inks.

Late in July or early in August, the printing industry is going to know a lot more than it does now about a new

"water-based carbon ink" which will be tested for three months in printing the Charleston, W. Va., Gazette.[25] It is hoped the new product, a development of the Charleston laboratories of United Carbon Co., will improve, if not entirely cure, "second impression offset," a problem which has always vexed newspaper publishers.

The experimenters seek to obtain still faster drying by the substitution of water and other chemicals which theoretically will eliminate offset. Technicians who have used previous water-base inks in fine magazine production and have yet to see the new ink in action are wondering whether the faster drying will not add to the difficulty of getting the proper ink distribution that is essential to a clean impression.

One run of 65,000 copies of the Gazette was witnessed early in May by representatives of the Scripps-Howard papers, General Printing Ink Corporation, R. Hoe and Co., manufacturer of presses, and the International Printing Pressmen and Assistants Union.

If this experiment is a success it will be a boon to the printing industry.

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[25] "Water-Based Ink," Business Week, No. 609 (May 3, 1941), 49-50.

CHAPTER III

RESULTS

Printing ink educates, entertains, informs, and sells. As the ingredient which transforms a blank page into recorded thought, ink is the world's most important medium of expression. Our civilization is dependent on ink for its very existence. Without ink, we would have no history of the past. Without ink, there could be no records for the future.

From the pages of countless books, magazines, newspapers, and publications of every sort, ink transmits and records man's thoughts. Through printing, ink brings delight and relaxation to millions. The entire wealth of man's knowledge is preserved in printing ink.

Today, ink is a vital force in commerce. It tells us where to buy; it tells us what to buy. On billboards and posters it carries the advertiser's message to the consumer. On packages and containers, ink adds sales appeal and color and protects the contents.

Back of printing ink today is modern scientific research. From a close guarded art, ink has progressed to a forward-looking industry--an industry which moves ahead with the developments which this research has brought forth. Advances in printing ink mean advances in printing, and the last few years have produced changes in ink manufacture which have revolutionized the graphic arts. The value of printing ink

products sold annually now exceeds fifty million dollars.

The record of man's attitude toward the surface treatment of the things he wears or uses in his everyday living is an index to his civilized progress. Man first used surface materials to decorate the walls of caves and to paint designs on some of his garments with colors laboriously made from earth materials. Later he began to realize that paint had other uses than those of decoration or self-expression. It could protect the surface and preserve the material underneath. With the invention of printing, he adapted similar materials to transfer a coating from movable type to the surface of paper. When more machines were invented, his interest in the protection and decoration of surfaces began to grow, until today chemical coatings for protection, decoration or utility, perform indispensable services in making modern man's living more comfortable, enjoyable, and useful. Protective and decorative coatings are found in a multitude of forms, so many that we hardly realize their scope. There are printing inks for every purpose, such as newspapers, magazines, packages, labels, milk cartons, beverage and food cans, decorated metal objects, and wallpaper. Things coated with paints, lacquers, and enamels are all around us. Gay prints and dress fabrics are the result of new colors for textile printing and finishing; wood graining materials make plain surfaces look like precious wood; industrial finishes protect and improve the appearance of refrigerators, washing machines, automobiles, bicycles, venetian blinds, and many other items.

CHAPTER IV

CONCLUSIONS

This study of printing inks has revealed the following facts:

1. Printing ink is valuable to the progress of the human race. With the invention of movable types by Gutenberg, man began to learn the power of an idea when multiplied. All the freedom we have or ever have had, traces to the power of the printed word to move men to concerted action. Patrick Henry delivered his famous "Give me liberty or give me death" speech in a church to fewer than one hundred people. It was the printed pamphlet that multiplied the force of his message and made his words immortal. Thomas Paine, whose ideas fathered the Declaration of Independence, was a pamphleteer. So were Martin Luther, John Knox, and Oliver Cromwell. They depended upon the multiplying power of a drop of ink to make their millions think. Without Gutenberg and his movable types, these men who changed the course of the world, would have been bound tongue and brain, their persuasion paralyzed, their ideas able to influence but a mere handful of followers.

2. Research holds an important place in the manufacturing of printing ink. From a crude and unscientific craft, ink making has become a chemically specialized industry. It may be said with all truthfulness that ink making has progressed as much in the last twenty-five years as it has in the five

centuries previous. The cause of this sudden spurt forward may be summed up in a single word--research. Printing ink companies employ hundreds of highly-trained men to study ink problems, analyze new substances for ink compounds, concoct new mixtures--all to meet the increasing demands of their customers. Then in one pound lots--and in tank cars--ink goes to serve the countless purposes of the graphic arts. On billboards, on packages, cans, magazines, newspapers, books, calendars, catalogs, and in a hundred other forms of printing, ink finally reaches the consumer.

3. Manufacturers of printing ink exercise great secrecy regarding the formulas of their products. Competition is the main reason for their utmost secrecy but it has been the means of increasing the industry rather than holding it in check. With every company intent on outselling its competitors, they have put to work research workers to investigate thousands of substances and make countless experiments trying to find inks that will please the most customers. As a consequence, the development of the printing ink industry has seen an unprecedented growth since about 1920.

4. Untold opportunities lie ahead in the development of printing ink. Imbued with the spirit of fundamental research and impelled by the force of the expanding printing industry, ink making is forging ahead to new importance in the graphic arts. The revolutionary ink developments of the past decade predict new wonders and further progress for the user of printing inks. An industry in which only the bare beginning

has been made, seemingly, ink making points to a bright future for as new types of presses are invented, ink makers will keep pace with them through their own inexhaustive research work.

APPENDIX

The printing ink companies listed below furnished valuable pamphlets and circulars for this study:

International Printing Ink, Division of Interchemical Corporation, Kansas City, Mo. Ink Secrets for Pressmen, Inks of Today, Back of the Printed Word (Illustrated), "More Than Meets the Eye" (Illustrated), Printing Ink (Reprinted from pages 361-62, Vol. 12, of the Encyclopaedia Britannica, 1941).

J. M. Huber, Inc., Chicago, Ill. In-Stock Printing Inks (Ink sample book), Inks of Today.

Martin Driscoll & Co., Chicago, Ill. Inks of Today.

The Braden Sutphin Ink Co., Cleveland, Ohio. History of Printing Ink, The Roycrofter, December, 1931.

The Acme Printing Ink Co., Chicago, Ill., Lewis Roberts, Inc., Newark, N. J., and Howard Flint Ink Company, Houston, Texas, each sent addresses where books on printing inks could be obtained.

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Typist:

Geraldine Brett

Education Office